GEOLOGIC AND GEOTECHNICAL DATA REPORT

DEVIL'S SLIDE TUNNELS PROJECT

VOLUME 1 – MAIN TEXT

FINAL

Prepared for
Caltrans
and
HNTB Corporation

Feb. 14, 2003

By
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February 14, 2003
EMI Project No. 02-134

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Attention: Mr. Skip Sowko, Project Manager

Subject: **Final Geological and Geotechnical Data Report**
Devil's Slide Tunnels Project
Contract 59A0234, Task Order 2B

Dear Mr. Sowko:

Attached is the Final Draft Geological and Geotechnical Data Report for the Devil's Slide Tunnels Project. This report represents the GDR for this project. Pursuant to your request, this report was prepared to present all test methods and test results obtained from field exploration and in-situ and laboratory testing in a concise, ready-to-use format. It also provides an overview of regional and project site geology and seismicity.

This GDR was developed from our Draft Report submitted December 11, 2002 which had been prepared as a general site characterization report. The GDR addresses review comments by the HNTB's Peer Advisory Panel, Caltrans Geotechnical Design (West) and the structural designers HNTB/ILF. The details of the field work by Earth Mechanics, Inc. (EMI) under Task Order 2B of the subject contract authorized by Caltrans in June 2002 are documented in an appendix. The summary data plots provide engineering properties of the subsurface materials and incorporate findings from prior geological studies by EMI performed under Task Order 2A authorized by Caltrans in January 2001 and from the 1996 feasibility study.

The prior Task Order 2A represented a preliminary site characterization phase that included a site reconnaissance exploration consisting of field geological mapping and aerial photography performed by EMI in the fall of 2001. EMI prepared and submitted a Technical Memorandum in October 2001. EMI then performed additional studies and prepared and submitted a second Technical Memorandum in March 2002. The data collected was used to plan the Phase 2B geotechnical site exploration.

The subject Task Order 2B exploration was conducted to finalize site characterization and included a total of 33 soil and rock borings with in-situ field testing, laboratory testing, and additional field geological mapping performed by EMI in Summer/Fall 2002. This exploration included an on-site logistics office and a temperature-controlled rock core storage trailer. All

fieldwork was conducted under a SWPPP plan developed by CH2M Hill and Hanford ARC, and administered by CH2M Hill and URS Corp. Several site walks were conducted with participation of Caltrans and the Technical Advisory Panels for inspection of field equipment and work procedures, and discussion of findings.

This GDR contains extensive field and laboratory test data and is divided into four volumes:

- Volume 1 contains the body of the GDR with main text and maps, figures, photos, and Logs of Test Boring plans;
- Volumes 2 and 3 contain in-situ testing reports (video imaging, pressuremeter, seismic suspension logging, packer testing, piezometer data); and
- Volume 4 contains various laboratory testing data on rock, soil, water and air.

The data Volumes 2 and 3 have already been submitted to you and remain unchanged. Data Volume 4 has also been submitted already, but an Appendix G-4 has now been added on rock abrasion testing per your request. Appendix A-4 is enclosed as an insert to be added to the end of each Volume 4 binder that you received in December 2002.

On behalf of the project geotechnical team, we appreciate the opportunity to provide geotechnical and geological engineering services on the subject project. If you have questions or comments regarding this report, please contact our offices.

Sincerely,
EARTH MECHANICS, INC.

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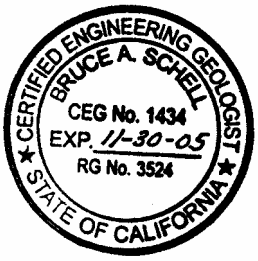

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VOLUME 1 – MAIN TEXT

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EXECUTIVE SUMMARY

Project Background and Study Description

Geotechnical studies, including both geologic and geotechnical investigation, for the Devil's Slide Tunnels Project were conducted by Earth Mechanics, Inc. (EMI) under California Department of Transportation Contract No. 53A0234. The subject report constitutes the geotechnical data report (GDR) with the exploration findings needed for geotechnical design of the proposed tunnel located along Route 1 in San Mateo County between the cities of Pacifica and Montara. The project area is shown on the site map of Figure 1-1. The portions of the project investigated by EMI include two proposed tunnel bores approximately 1,200 m long, north and south portal areas, a highway rock cut, and a spoil disposal site with an operations building.

Report Purpose

The purpose of this GDR is to present factual test data and results collected during geotechnical site exploration and laboratory testing for characterization of geological and geotechnical conditions at the project site.

Report Organization

This GDR is divided into four separate volumes. The contents of each volume are summarized below:

- Volume 1 contains the main text with maps, figures, and borehole and trench logs,
- Volumes 2 and 3 contain in-situ testing reports (video imaging, pressuremeter, seismic suspension logging, packer testing), and records of piezometer installation and initial readings
- Volume 4 contains laboratory test results for rock, soil, water and air.

The main text of Volume 1 comprises the following sections:

- Section 1.0 provides an introduction and a project description.
- Section 2.0 presents a general description of the regional geology and seismicity of the project site based on surface geologic mapping performed under Phase 2A and 2B explorations, and the 1996 feasibility investigation.
- Section 3.0 describes the field exploration and in-situ data acquisition

performed under Task Order 2B. This section presents logs of test borings and trenches.

- Section 4.0 describes the methodology of sampling and laboratory testing, and test results for rock, soil, water and air.

Site Exploration

The site exploration program consisted of two phases:

A non-invasive "Phase 2A" site investigation was conducted in Fall 2001 under Task Order 2A. This non-invasive investigation consisted of surface geologic and discontinuity mapping, aerial photography of the site using a light helicopter, and planning of the drilling program. This work was documented in two prior reports by EMI for preliminary site characterization.

An invasive "Phase 2B" exploration was performed from July to October, 2002 under Task Order 2B for final site characterization. This work is described in this report. This exploration consisted of drilling, trenching, and testing accompanied by additional geologic surface mapping. Drilling included 33 rock and soil borings performed in a multiple-crew operation with concurrent rock in-situ field testing, and laboratory testing of rock, soil, water and air. The schedule of mobilizations for these activities was controlled by availability of right-of-entry and environmental permits.

The Phase 2B exploration program involved difficult site access which required establishment of two new access roads, hillside workpads, slope ladders, helicopter support and Route 1 highway closures. The exploration included an on-site logistics office and temperature-controlled rock-core storage trailer. All fieldwork was conducted under a storm-water pollution prevention plan (SWPPP) developed by CH2M Hill and Hanford ARC, and administered by CH2M Hill and URS Corp., and under permits and inspections by Caltrans as well as other public and governmental regulatory agencies. SWPPP was managed by URS Corp. Several Caltrans site walks were conducted with participation by Caltrans, design consultants, and Technical Advisory Panel members, to inspect equipment and work procedures and to discuss findings.

All borehole locations are shown on the site exploration map of Figure 3-1. Table ES-1 presents a summary of Phase 2B borehole depths and in-situ tests performed. The field and test data documented in this report also include data from the 1996 feasibility study.

Subsurface Conditions

The subject report presents data that characterize the existing geological and geotechnical conditions at the Devil's Slide Tunnels site for the following five segments

of the project:

- tunnel bores,
- north portals area,
- south portals area
- south rock cut, and
- spoil disposal site.

These features are depicted on the Exploration map of Figure 3-1.

Bedrock. The project site is underlain by sedimentary bedrock and crystalline igneous bedrock. The sedimentary bedrock consists of interbedded conglomerate, sandstone, siltstone and claystone. The crystalline igneous rock are generally granodiorite, quartz diorite and quartz monzonite exposed in outcrops at the south tunnel portal, in slopes descending steeply along the coast, and in the present roadcut of the coast highway. Small exposures are scattered on slopes along the project alignment but dense vegetation and slopewash obscure most geological relationships.

Bedding in the sedimentary rock dips steeply southerly in the northern part of the alignment, but is generally at low to moderate northerly dips throughout the central part of the alignment. The southern part of the alignment and the south rock cut area are underlain by granodiorite / quartz diorite.

The rocks in the northern part of the alignment are generally laminar to very thinly bedded and intensely fractured with extensive shear zones and several faults. Rocks in the central part are less fractured but also have numerous intensely fractured zones. Rock Quality Designation (RQD) values are generally low with only a few zones of high RQD. The bedrock is commonly decomposed and / or intensely weathered to depths of 10 m to 20 m, but is mostly relatively fresh at tunnel grade.

Artificial fill occurs in the form of two embankment road fills and some local backfill in the southern part of the project area between the south portal and the spoil disposal area. These materials consist of loose to dense sands with silts, gravels, cobbles and boulders derived from local diorite rock and soil sources.

Groundwater Conditions. Water outflow from borings was encountered in the north portal area and severely affected the drilling program there. Maximum outflow rates from two subhorizontal borings reached several hundred liters per minute.

A series of ten (10) piezometers were installed which are now part of a groundwater monitoring program. That program includes the piezometers installed during the 1996 feasibility study by Woodward Clyde and those installed by Caltrans in 2002 in the

proposed approach bridge area.

Faulting

The area is transected by several faults which separate areas of differing lithology and rock conditions. Three of these faults can be observed in exposures along the coastal seacliff. However, colluvial (slopewash) soil cover and dense coastal scrub vegetation obscures these faults toward the proposed tunnels alignment. Trenches were excavated at strategic locations to help locate these faults near the tunnel alignment. Drilling encountered several major shear zones, some of which are probably related to the faults observed in the coastal exposures.

Table ES-1. Summary of Exploration

Borehole	Meter-age	Incli-nation*	Access	P-S Logging	Video Logging**	Pressure-meter	Piezo-meters	Packer Testing
South Portal Area								
02-2	60.7	0°	Helicopter support	X	-	4 Tests	-	-
02-2A	92.1	33°		-	-	-	-	-
02-2B	86.3	30°		-	-	-	1 Point	-
02-19	26.8	0°	On Rte 1 shoulder	-	-	-	-	-
02-21	162.2	40°	On exist. trail P-3a/b	-	-	-	-	4 Tests
Tunnel Segment								
02-5	255.6	0~4°	On exist. trail P-3b	X	X	4 Tests	3 Points	9 Tests
02-6	139.6	15°	On new road P-2	X	X	-	1 Point	5 Tests
02-6A	266.2	47°		-	-	-	-	-
02-7	123.6	45°		-	X	-	1 Point	7 Tests
02-7A	36.1	33°		-	-	-	-	-
02-8A	52.4	33°		-	-	-	-	3 Tests
02-8B	100.9	56°		-	X	-	-	-
02-8C	68.9	40°		-	X	-	1 Point	-
North Portal Area								
02-11	125.8	90°	On exist. lower trail P-1a	-	-	-	-	-
02-11A	174.4	90°		-	-	-	-	-
02-12	50.0	40°	On new foot trail P-2	-	-	-	-	-
02-16	21.2	80°	Helicopter support	-	-	-	-	-
02-18A	40.1	32°	*On new foot trail P-2*	X	X	-	1 Point	-
02-18B	45.4	13°		X	X	-	1 Point	-
Rock Cut								
02-13	29.3	90°	On Rte 1 shoulder	-	-	-	-	-
02-14	50.3	30°	Helicopter support	-	-	-	-	-
02-15	54.9	34°	Helicopter support	X	X	-	-	-
Disposal Site								
02-20	22.0	0°	On Rte 1 shoulder	-		-	1 Point	-
02-ST1 to ST10	1.6 to 18.8	0°	In drainage basin	-	-	-	-	-
Totals:	***33 Boreholes ~2,012***			***6 Borings (~170 m)***	***8 Borings (680 m)***	***8 Tests***	***10 Point***	***28 Tests (~346 m)***
Trenches								
02-T1	*21 (Length)*		On exist. trail P-3a	-	-	-	-	-
02-T2A/B	*16 (Length)*		On exist. trail P-3b	-	-	-	-	-
02-T3	*170 (Length)*		On exist. trail P-1b	-	-	-	-	-

Note:
** Inclination angle is from vertical.*
*** Video logging included optical and acoustic televiewers.*

SECTION 1.0

INTRODUCTION

1.0 INTRODUCTION

1.1 Purpose and Scope of Work

This report presents a characterization of the existing geological and geotechnical conditions found at the Devil's Slide Tunnels site in Pacifica, California, for the following five segments of the subject bypass project:

- the proposed tunnels,
- the north portal area,
- the south portal area
- the south rock cut, and
- the spoil disposal site.

The characterization presented in this report is based on geological and geotechnical data from geologic mapping, drilling, in-situ testing, and trenching conducted at the project site, and off-site laboratory testing. This report documents the field exploration and testing programs, compiles the factual data collected, and summarizes geological conditions and engineering properties.

1.2 Project Description

The proposed Devil's Slide tunnels are located along the coast of the San Francisco Peninsula in San Mateo County, California (see Figure 1-1), approximately 2.4 km south of the city of Pacifica. The proposed tunnels extend southerly from Highway 1 just south of the city of Pacifica, to the east of Devil's Slide, and meet Highway 1 just south of Devil's Slide.

The lengths of the proposed Devil's Slide Tunnels are about 1,200 m. Each tunnel has a width of about 9 m and a vertical dimension of about 4.75 m. The tunnel construction method is expected to be sequential excavation utilizing drilling and blasting. A new two-lane roadway will connect to the existing Route 1 on new twin bridges across Shamrock Ranch Valley to the North Portal. The limit of the project presented in this report extends from the North Portals to the south extent of the Disposal Site. This report does not address the proposed new approach bridges in the north portal area.

1.3 Background

The geology of the Devil's Slide area has been studied by Darrow (1963), Nilsen and Yount (1981) and Pampeyan (1994). Locally, Caltrans performed more detailed mapping, supplemented by deep test borings and some near-shore marine geophysical surveying. This work was done in connection with efforts to stabilize the Devil's Slide reach of Route 1 and with the investigation of the feasibility of constructing the "Marine Disposal Alternative" during the 1980's and early 1990's. More recently, Caltrans conducted a study to investigate the feasibility of improving the stability of the existing road by dewatering the landslide.

The 1996 Feasibility Investigation concentrated on the geology along the proposed tunnel bores and approaches. The site investigation work for the 1996 study included surface mapping of the inland and south portal areas, drilling 14 core borings, and geophysical refraction surveying at the north and south portal site. Results of this work were used to compile a geologic map and prepare a geologic cross section along the proposed tunnel bore. The map synthesized the geologic data gathered from the Feasibility Investigation mapping of the tunnel alignment with the 1980 Caltrans map of the seaward slope in the main slide area, prepared by Caltrans geologists Beeston and Gamble (1980).

In 2001, EMI conducted additional geological mapping of the project site. Samples of representative rock types from several of the core borings were subjected to thin-section petrographic studies to better understand the rock fabric, mineralogy, and alteration. This work was used to describe the overall site geology and faulting, and to design the subsequent exploration program.

In summer and fall of 2002, EMI conducted a geotechnical field exploration described in this report, to define geologic and geotechnical conditions along the tunnel alignment for the purpose of design of the tunnel, rock cut and disposal sites. This work consisted of borings, in-situ testing and laboratory testing. During the same time frame, Caltrans performed an exploration in the northern area for design of the bridge foundations and northern tunnel approach.

1.4 Datum

All elevations and coordinates in this report are given in meters per the following horizontal and vertical datum as specified by Caltrans and as surveyed by Geotopo:

- Horizontal Datum: California Coordinate System NAD 83, Zone 3 (meters)
- Vertical Datum: NAVD 88 (meters)

1.5 Report Organization

This report is divided into four separate volumes. The contents of each volume are summarized below.

Volume 1: Main Text and Logs of Borings and Trenches. The main text in this Volume 1 is composed of the following sections:

- Section 1.0 provides an introduction to the project;
- Section 2.0 discusses general site geologic conditions encountered at the project site including the regional and seismic setting and site geology based on surface geologic mapping performed under Task Order 2A.
- Section 3.0 describes the field exploration and in-situ testing performed under Task Order 2B, and presents the Logs of Test Borings plans and Logs of Trenches (see below).
- Section 4.0 summarizes the methodologies and test results from laboratory testing on bedrock, soil-like materials and fills, and from air and water sampling performed under Task Order 2B;
- Section 5.0 provide the list of references.

Each section is followed by tables and / or figures consisting of maps and data plots.

Volume 1 also contains the following appendices:

- Appendix A-1 documents description of the organization and operation of the field exploration and includes a selection of photos of the exploration operations;
- Appendix B-1 contains all tabloid-size Logs of Test Borings by EMI;
- Appendix C-1 contains a reference to the 1996 test boring logs from the feasibility study by Woodward-Clyde Consultants; and
- Appendix D-1 contains logs of trenches by EMI.

Volumes 2 and 3: In-Situ Testing. These two volumes document in-situ down-hole testing by specialty subcontractors and EMI that were conducted in selected borings as part of Task Order 2B.

Volume 2 consists of the following:

- Appendix A-2 presents a report and all logs obtained from digital imaging (video) by Norcal..

Volume 3 contains the following:

- Appendix A-3 contains a report of Pressuremeter testing by Hughes In-situ Engineering;
- Appendix B-3 contains a report of seismic suspension P- and S-wave velocity logging by Geovision;
- Appendix C-3 contains the packer test results by EMI; and
- Appendix D-3 contains the piezometer installation records and initial measurements.

Volume 4: Laboratory Testing. This volume documents all laboratory testing of rock and soil samples. They contain procedures, sample pictures and test results. Volume 4 consists of two appendices:

- Appendix A-4 contains all soil test data by EMI;
- Appendix B-4 contains a report on rock core testing conducted by GeoTest Unlimited (GTU);
- Appendix C-4 presents a report of petrographic analyses performed on rock samples by Spectrum Petrographics;
- Appendix D-4 contains potential reactivity test data of aggregate and evaluation by Smith Emery;
- Appendix E-4 addresses chemistry test data of water samples by Severn Trent;
- Appendix F-4 presents chemistry test results of air samples tested by Air Toxic; and
- Appendix G-4 presents rock abrasion tests performed by GTU at the end of this project.

1.6 Previous Reports

The following existing data reports document previous studies of interest to this project:

- "Phase 2A, Supplemental Geologic Investigation, Devil's Slide Tunnels," Addendum Technical Memorandum to Caltrans by EMI (2002).
- "Phase 2A, Geologic Investigation, Devil's Slide Tunnels," Technical Memorandum to Caltrans, by EMI (2001b).
- "Seismic Hazard Study, Devil's Slide Tunnels," Final Report to Caltrans" by EMI (2001a).
- "Devil's Slide Tunnel Study," Final Report to Caltrans by Woodward Clyde Consultants (1996).
- "Devil's Slide Tunnels Project, Aesthetics Committee Report, Phase 1", Final Report to County of San Mateo Board of Supervisors, Pacifica City Council, Midcoast Community Council, Half Moon Bay City Council, by Devil's Slide Tunnels Project Aesthetics Committee (2002).

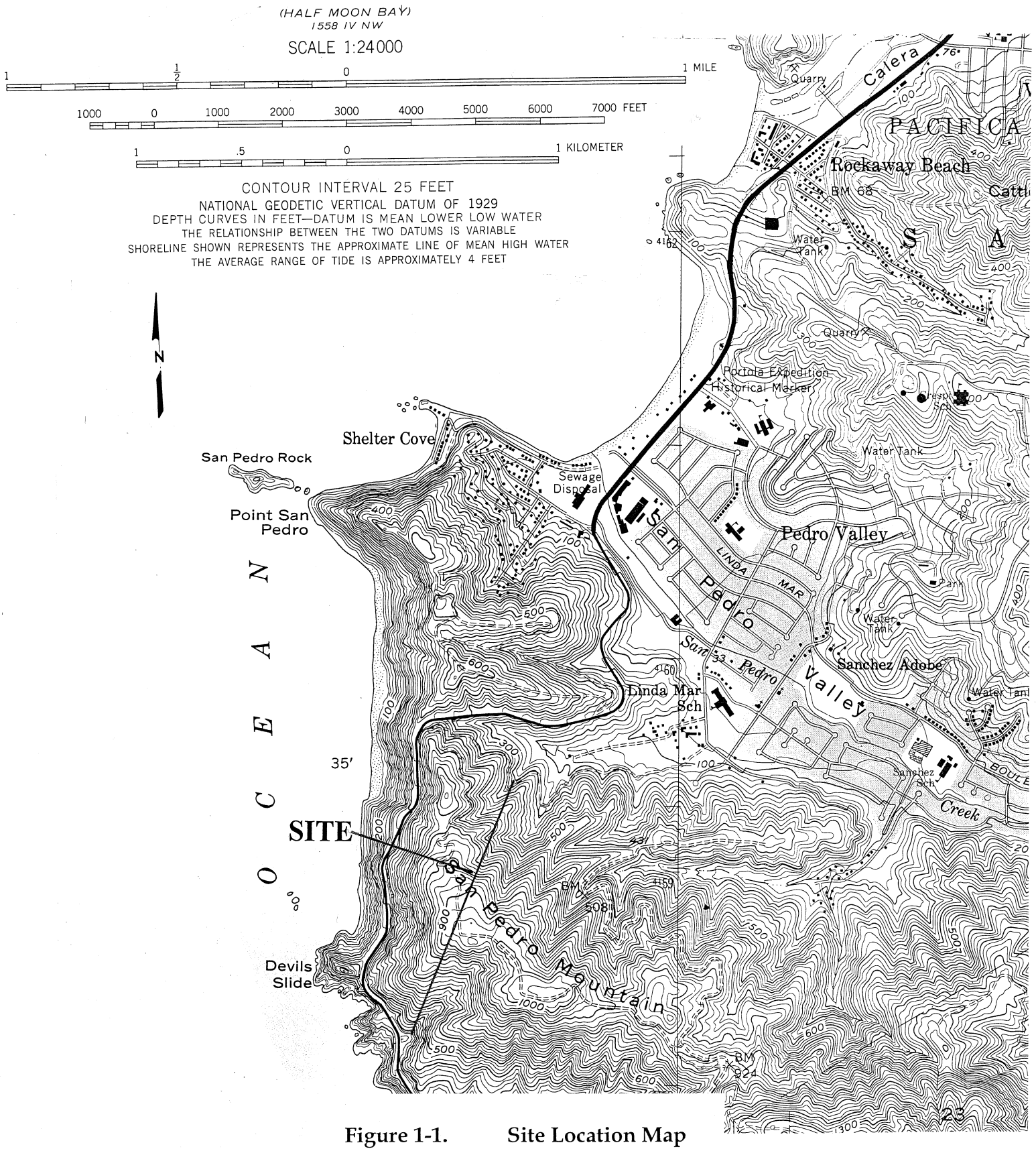


Figure 1-1. Site Location Map

SECTION 2.0

REGIONAL AND SITE GEOLOGY AND SEISMICITY

2.0 REGIONAL AND SITE GEOLOGY AND SEISMICITY

2.1 Regional and Site Geology

The regional geologic setting of the Devils Slide Tunnels (DST) project is shown on the geologic map of Figure 2-1, which is part of the California State Geologic Map compiled by C.W. Jennings (1977). The project site is situated a few hundred meters inland from the coast about 1.2 km south of Point San Pedro. This places the site near the north end of a structural block that lies generally between the San Andreas fault on the east and its major branch, the San Gregorio-Palo Colorado fault, on the west. This block, referred to as the La Honda block by Pampeyan (1994) includes the Santa Cruz Mountains onshore and continues offshore to both the north and to the south, where it extends beneath Monterey Bay. The block's northward offshore extension narrows progressively as the San Andreas and San Gregorio faults coverage north of the Golden Gate.

At the latitude of Montara Mountain, the La Honda block is separated from the San Andreas fault by the Pilarcitos fault, an older fault which is relatively inactive but is considered to represent a former main trace of the San Andreas fault. The Pilarcitos fault forms the local boundary between the two principal basement rock terranes consisting of the Franciscan Complex to the east of the San Andreas and the Salinian Complex to the west. The San Andreas fault proper is the most continuous fault trace within the San Andreas fault system and also is the main locus of relative translational movement between the North American and the Pacific lithospheric plates. The combined Pilarcitos and La Honda structural blocks are situated along the east margin of the Pacific Plate and are moving northward at an average rate of several centimeters per year relative to the North American plate across the San Andreas fault, where the inland part of the San Francisco Bay region is located.

The geology in the vicinity of the DST project is shown on the geologic map of Figure 2-2, which is part of USGS Map I-2390 (Geologic Map of the Montara Mountain and San Mateo 7.5-Minute Quadrangles, San Mateo County, California) by E.H. Pampeyan (1994). The map of Figure 2-2 is centered on San Pedro Mountain, through which the DST twin tunnel bores will pass. San Pedro Mountain is the northwestern-most part of the Montara Mountain Salinian basement terrane of Mesozoic-age crystalline igneous and metamorphic rock.

Along the crest and north flank of San Pedro Mountain the igneous basement rock is overthrust by a sequence of Paleocene-age clastic sedimentary rocks that range in composition from claystone and siltstone to coarse boulder conglomerate. The contact between igneous basement and the overlying sedimentary rock sections is a gently north-dipping fault identified in Figure 2-2 as the San Pedro Mountain Fault. Other

faults, major joint traces in the igneous basement, and faults and fold axes in the overlying sedimentary section are also shown on the map. The approximate outline of the major slump block complex commonly referred to as "Devil's Slide", which occupies much of the coastal bluff at the seaward truncation of San Pedro Mountain, is also shown on the map (unit Qyl).

The twin tunnel bores of the DST project will pierce San Pedro Mountain a short distance inland from the landslide area (Figure 2-2). The northerly part of the project will be constructed in the sedimentary rock section, the southerly part in the igneous rock section.

2.2 Regional Seismicity

The regional seismicity of the DST project area is shown on Figure 2-3, which reproduces part of the map "Earthquakes in California and Nevada" by Goter and others (1994). This map shows estimated and recorded epicenters of larger earthquakes during the period of historic record dating back to 1836 (black open circles in Figure 2-3), and instrumentally well-located epicenters of smaller earthquake ($\geq$M.2.5) recorded between 1980 and 1994. The hachured zones annotated "1906 Earthquake M8.25", "1989 Loma Prieta M7.1", "1868 Hayward M7", and "1984 Morgan Hill" identify zones of rupture along the San Andreas, Hayward and Calaveras faults during significant historic earthquakes.

In addition to the annotated earthquake epicenters and rupture zones shown on Figure 2-3, other significant earthquakes are shown as smaller open black circles and red dots. Paleoseismic studies have provided evidence of large prehistoric earthquakes throughout the region, including along the Seal Cove–San Gregorio fault, the northern offshore reach of which passes within 1.5 km of the DST project area (Figure 2-1).

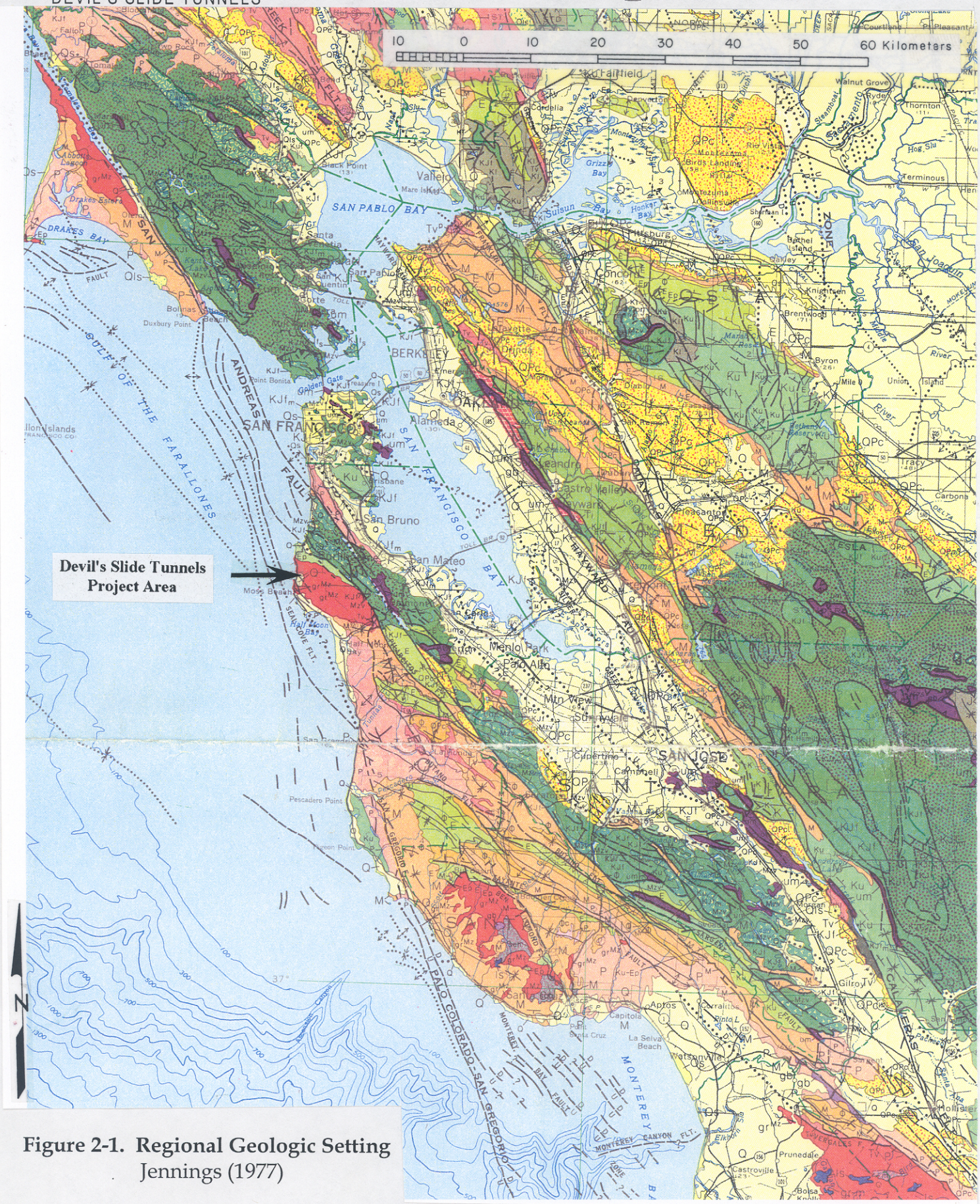
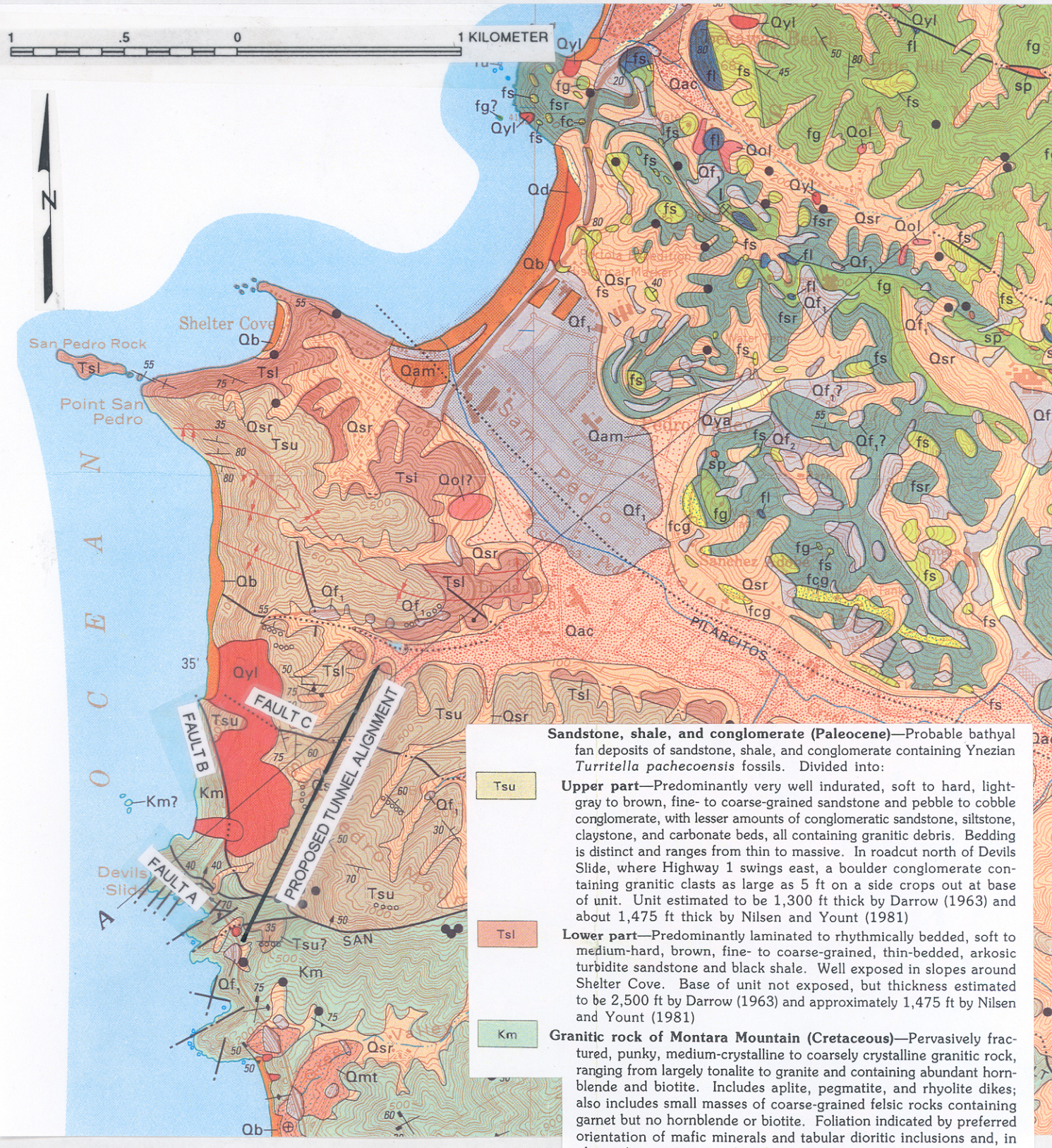


Figure 2-1. Regional Geologic Setting
Jennings (1977)



Sandstone, shale, and conglomerate (Paleocene)—Probable bathyal fan deposits of sandstone, shale, and conglomerate containing Ynezian *Turritella pachecoensis* fossils. Divided into:

Tsu — **Upper part**—Predominantly very well indurated, soft to hard, light-gray to brown, fine- to coarse-grained sandstone and pebble to cobble conglomerate, with lesser amounts of conglomeratic sandstone, siltstone, claystone, and carbonate beds, all containing granitic debris. Bedding is distinct and ranges from thin to massive. In roadcut north of Devils Slide, where Highway 1 swings east, a boulder conglomerate containing granitic clasts as large as 5 ft on a side crops out at base of unit. Unit estimated to be 1,300 ft thick by Darrow (1963) and about 1,475 ft thick by Nilsen and Yount (1981)

Tsl — **Lower part**—Predominantly laminated to rhythmically bedded, soft to medium-hard, brown, fine- to coarse-grained, thin-bedded, arkosic turbidite sandstone and black shale. Well exposed in slopes around Shelter Cove. Base of unit not exposed, but thickness estimated to be 2,500 ft by Darrow (1963) and approximately 1,475 ft by Nilsen and Yount (1981)

Km — **Granitic rock of Montara Mountain (Cretaceous)**—Pervasively fractured, punky, medium-crystalline to coarsely crystalline granitic rock, ranging from largely tonalite to granite and containing abundant hornblende and biotite. Includes aplite, pegmatite, and rhyolite dikes; also includes small masses of coarse-grained felsic rocks containing garnet but no hornblende or biotite. Foliation indicated by preferred orientation of mafic minerals and tabular dioritic inclusions and, in places, by orientation of dikes. Jointing is common and best seen in sea cliffs; epidote alteration occurs along some joint surfaces. Exposures of hard unfractured rock are rare, and commonly the rock is weathered to depths of 100 ft. Southwest flank of Montara Mountain is pockmarked by numerous small shallow landslides (shown by small dots) in weathered rock (grus) or in colluvium developed on weathered rock

Figure 2-2. Geology of the Point San Pedro – Devil's Slide Area
Pampeyan (1994)

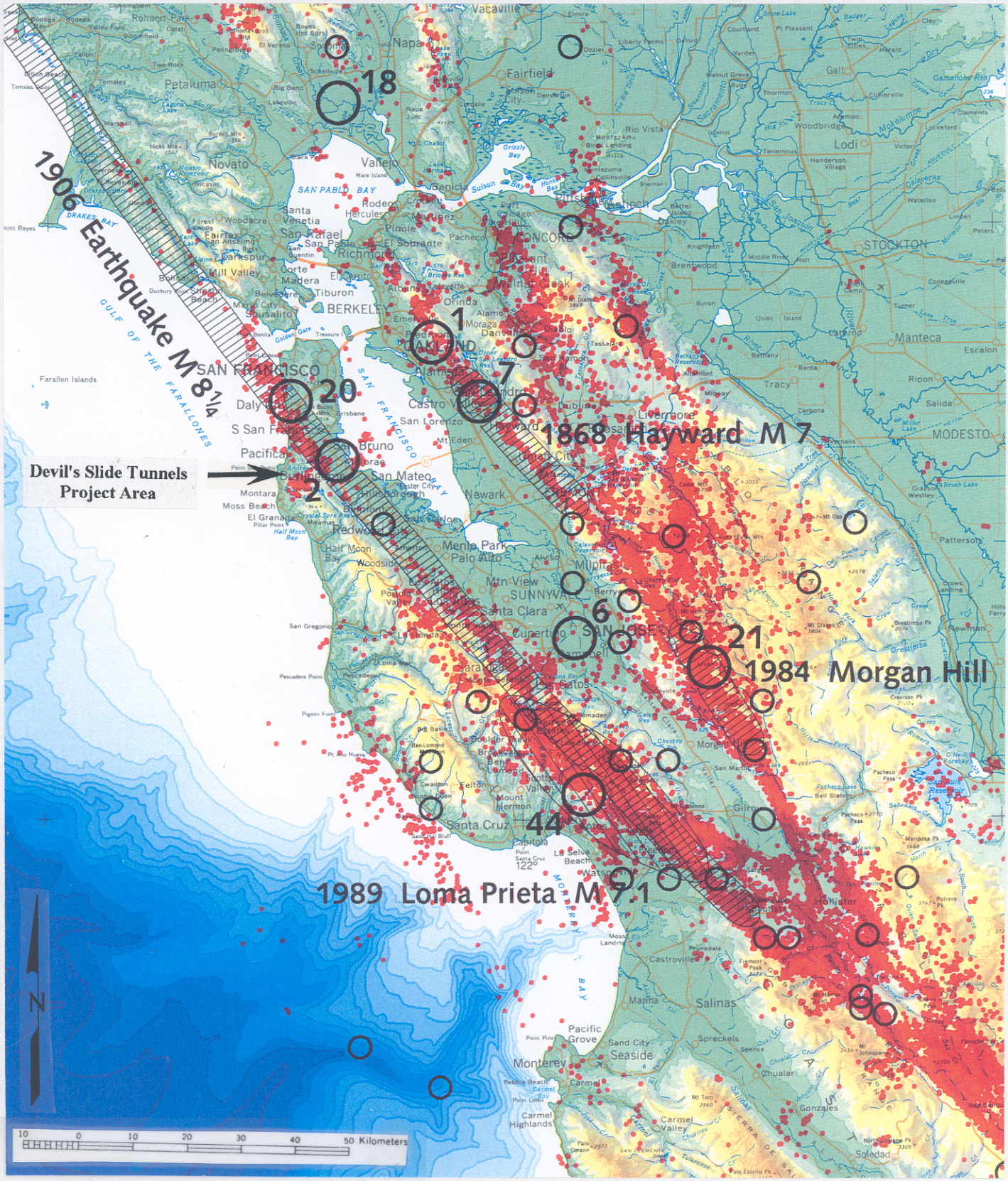


Figure 2-3. Regional Seismicity
(Goter et al, 1994)

SECTION 3.0

FIELD EXPLORATION AND IN-SITU TESTING

3.0 FIELD EXPLORATION AND IN-SITU TESTING

3.1 Previous Investigations

3.1.1 Feasibility Investigation

In 1996, a feasibility study was performed by Woodward Clyde Consultants (WCC, 1996) that consisted of a series of rock borings and piezometer/standpipe installations (see Section 3.5.5). The locations of these boreholes are shown on the site map in Figure 3-1. The field exploration included inclinometer and piezometer installations.

3.1.2 Phase 2A Investigation

In the fall of 2001, EMI conducted a geological reconnaissance of the project site and adjacent coastal slopes to ascertain surficial rock conditions. EMI performed extensive geologic mapping to determine geologic conditions over the greater area of the planned Devil's Slide Tunnel project under Task Order 2A (Walkabout phase). Three principal investigation activities were conducted:

1. Compilation and review of data from previous investigations, primarily the 1996 WCC Investigation, but also investigations by Caltrans in 1980 and 1993, and other Caltrans data and articles published in the literature on various aspects of the project area geology.

2. Reconnaissance land geologic mapping of the project area, including accessible areas of the San Pedro Mountain seaward slope for the subject Phase 2A geologic investigation.

3. Detailed mapping and plotting of data regarding rock discontinuities (bedding, jointing, fracturing) and condition (lithology, shearing, weathering) from available exposures in the vicinities of the north and south portals and planned rock cut approaching the south portal.

4. Additional mapping and interpretation, preparation of addendum Geological Report.

The work for activities (2) and (3) above was facilitated by interpretation of stereoscopic vertical aerial photographs of the project area taken at scales ranging from 1:36,000 to 1:3,000 in 1967 to 1997. Additionally, oblique stereoscopic photographs that provided detailed stereoscopic images of the project portals, rock cut, disposal area, and the adjacent seaward slope along Route 1 were acquired during a helicopter flight on September 6, 2001. The geological mapping activities, preliminary discontinuity data

(stereograms and statistical distribution), photographs and geologic evaluation are presented in two reports by EMI (2002, 2001b).

The Phase 2A reports present data and discussion of geological mapping activities used to collect this data for the preliminary walkabout phase of the Devil's Slide tunnels investigation. They present stereograms and statistical distribution of the discontinuity data as well as selected aerial photos.

The reconnaissance-level geologic mapping confirmed some of the 1996 Feasibility Investigation geological interpretations but also revealed significant differences, especially in the location and pattern of block-boundary faults and consequently, in the lithology and geologic structure expected to be present in the northerly part of the tunnel.

3.2 Phase 2B Exploration

3.2.1 Scope

EMI conducted a geotechnical and geologic exploration program in one mobilization extending from June 26 to Oct. 9, 2002. The purpose of the exploration was to provide geologic and geotechnical data for the tunnels, rock cut, and disposal site (the exploration was not designed to address the northern Shamrock Ranch area underlying the proposed approach bridge.) The exploration program consisted of the following elements:

- Job walk-about;
- Develop invasive field exploration program based on Task 2A findings;
- Initial borehole survey;
- Access road preparation / stabilization;
- Mobilization of equipment, setup logistics office;
- Geotechnical drilling and testing;
- Geological trenching & additional geological surface mapping;
- Demobilization of equipment and logistics office;
- Final borehole survey;
- Post logging, field point-load testing; and
- Analysis of test data and preparation of a data report.

Borings. The exploration consisted of a series of rock and soil borings, in-situ testing, piezometer installations, and trenches. The locations of the exploratory test sites are shown on the large exploration map of Figure 3-1, and on a set of 4 tabloid-size detail maps of Figure 3-2 to Figure 3-5. A total of 21 boreholes were drilled into rock with depths ranging from 21.2 m to 255.6 m along the tunnel alignment. A total of 12 borings were drilled into soil fills and soil-like native materials along or near Route 1 with depths ranging from 1.6 m to 26.8 m.

Testing. In-situ and laboratory testing was performed to obtain mechanical and hydraulic properties of the rock. In-situ testing consisted of:

- Digital video imaging and caliper logging (in 7 borings),
- Pressuremeter (8 tests),
- Seismic velocity logging (in 5 borings);
- Permeability (Packer) (28 tests); and
- Standard penetration in soil-like materials.

A total of 10 piezometers were installed in 8 boreholes.

Table 3-1 presents a summary of the borehole program along with key borehole information such as length drilled and orientation, and type and depth of in-situ testing.

Laboratory testing consisted of:

- Point load index (147 tests);
- Rock properties / strength;
- Rock petrography;
- Soil characterization / strength;
- Groundwater chemistry; and
- In-hole air chemistry.

Trenching and Geologic Mapping. Under Task Order 2B, a total of four trenches were excavated at locations where major geologic contacts were expected. The purpose of these trenches was to investigate faults traversing the tunnel alignment, and major geologic units in proximity to the fault. The trench locations are shown on the exploration maps of Figure 3-1 to Figure 3-5.

Analysis & Report. The scope of work included preparation of a data report documenting the field work, testing, and providing a characterization of site conditions

and interpretation of soil and rock properties to support design of the four project elements (South Disposal Area, South Rock Cut, the tunnel segment, North Portal). On December 11-13, a Draft Geological and Geotechnical Data Report was submitted to Caltrans. After receipt of review comments, Caltrans instructed EMI to present this information in its final form as a GDR, and to present interpreted information in a separate GIR. The subject GDR includes log-of-test-boring and log-of-trench plans intended for inclusion in the PSE submittal.

3.2.2 Field Operations

This section provides a brief description of Phase 2B field operations. Field operations are described in detail in Appendix A-1. In particular, Appendix A-1 describes the organization of task leaders and entities directly involved in the field work, supervision and worker's safety, permits, field logistics, site preparation, construction staging (including installation of water system), equipment used, site visits, airlifting, traffic control, overall progress of the exploration including difficulties encountered, field records, and limitations of the data.

Permits. Caltrans obtained the necessary right-to-enter permits to perform field operations from the landowners, public and governmental regulatory agencies (including California Coastal Commission, U.S. Fish and Wildlife), the County of San Mateo and the local California Highway Patrol. In June 2002, Caltrans obtained all encroachment permits and authorized Task Order 2B. Utility companies, cities and counties were notified by Underground Service (Dig) Alert prior to drilling or excavation.

Field Logistics. Field logistics were coordinated by EMI with support from CBC from a project office on San Pedro Road in Pacifica. Rock cores and soil samples were stored on sturdy wooden shelving in a leased trailer-container equipped with air-conditioning for temperature / moisture-control.

The investigation was supervised by a full-time EMI engineer. EMI held kick-off meetings and safety meetings to establish work procedures in general accordance with OSHA requirements prior, during and after drilling in an areas, proper handling and disposal procedures for the borehole cuttings and drill fluids, points of contact, and emergency procedures. A basic Safety Plan was prepared by CH2M Hill (2002b), and safety meetings were held at the Project logistics office.

Erosion control measures were implemented by Hanford ARC and Sierra Equipment Rentals as established by a project SWPPP plan developed by CH2M Hill (2002c) and Caltrans. All Phase-2B field work was under constant observation by URS Corp. and CH2M acting on behalf of Caltrans.

Caltrans and Technical Advisory Panel members conducted several field inspections of equipment, work procedures and findings.

Site Preparation. Establishment and maintenance of access roads and of workpads was conducted by Hanford ARC, Sierra Equipment Rentals, and Ruen Drilling using D4 and D6 dozers, brushcutters, weedwackers and chippers. Existing trails P-1a, 1b and 3a required ground conditioning and minor removal of vegetation in some areas. The first 150 m of the steep access trail P-1a was conditioned by placement of tensar grids within a layer of gravel. In work areas on steep slopes, wooden cribbing was used to level drill rigs. Hanford ARC installed a temporary wooden retaining wall along the downslope edge of a 5-m segment-long of path P-1a, which had shown signs of yielding.

Erosion control measures were implemented per Caltrans direction and included barrier fences, fiber mats and straw bales. During drilling, protective absorbent pads, plastic sheeting were used cover ground or equipment. Earthen burrows were used to conduct drill fluid to settlement tanks.

After completion of geotechnical and geological field work, Hanford ARC began site restoration efforts under Caltrans direction.

Site Access and Air Lifting. The complexity of the field exploration required a multitude of equipment. On difficult-access terrain such as on new path P-2 and existing Path 3b, two track-mounted Marooka vehicles were used for general-purpose transport of equipment, waste tanks, and personnel. Geologists and drill crews used 4WD vehicles to travel existing paths P-1, 2, 3b and 4. New path P-2 could not be driven safely with tired vehicles. The Path P-4 is a hiking trail traversing steep terrain and was too narrow to be traveled by vehicle. Photos of equipment are presented in Appendix A-1.

Drill rigs and other equipment were airlifted to sites 02-16, 02-2, 02-14 and 02-15 by ARIS Helicopters using the hilltop site 02-5 as the hub location. A typical airlift required ten to fifteen trips. Route 1 was closed during airlift activities from site 02-2 and 02-14 as these two sites were on a steep slope directly above Route 1.

3.3 Rock Borings

3.3.1 General

Locations and Orientations. Rock borehole locations designated 02-2 to 02-21 are shown on the map of Figure 3-1. The locations were selected above or as near as possible to the surface trace of the tunnel alignment. Location selections were influenced by accessibility and avoidance of biological/environmental buffer zones as required by the project's Biological Impact Report developed by CH2M Hill (2002) under subcontract to HNTB, the permittees, and Caltrans. Utilities did not control

selection of locations. Table 3-1 lists the borings grouped by area, along with key borehole information.

Equipment. Drilling was performed by Ruen Drilling headquartered in Clark Fork, Idaho. Ruen Drilling deployed two portable LF-70 drill rigs and one CS-1000 skid-mounted drill rig, all equipped with rotary wash and wireline core retrieval systems. Drilling was performed using a 124 mm (4.8") tricone bit through the soil cover and a triple-barrel HQ core barrel with 96 mm (3.8") OD through the rock. In two of the borings, an NX core barrel with 76 mm (3") OD was also used.

A orientation tool was used in subhorizontal borings to measure the borehole inclination and heading at selected depths. The orientation and inclination of the boreholes are summarized in Table 3-1.

A system of flexible high-pressure water hoses and pumps was installed to deliver water to the bore sites. Water was pumped from a 10,000-gal raised source water tank at the staging area TA-3 at the South Portal turn-out to a holding tank at the hilltop staging area TA-2 at site 02-5. The water system was later expanded at the north portal by a 6,900-gal water tank at Shamrock Ranch, and a 6,900-gal and 20,000-gal water tank Route 1 near the north bridge abutment. Bore cuttings and fluids were transported to a dumpster at TA-3 and were later transported offsite to a certified disposal area.

Rock Coring. Continuous coring was performed using triple-barrel HQ equipment with the wireline core retrieval system on all three drill rigs. The rotating outer barrel with diamond-impregnated bits at its end produced a borehole size of about 110 mm. With the wireline system, a retriever is lowered by wireline through the drill rod to release a locking mechanism in the inner barrel head. The inner barrel containing the core is then lifted with the wireline to the surface, the core removed and the barrel returned to the bottom. This system eliminates the necessity of removing the string of drill rods for sampling and coring, thereby optimizing drilling efficiency. Drilling fluid was used to cool the drill bit, to flush the cuttings and to provide lateral support to the borehole wall.

Rock logging generally conformed to Caltrans guidelines (1996). Generally, core runs of 1.52 m (5 ft) were performed, but the actual length of the core varied as a function of rock characteristics such as discontinuities and degree of weathering. The retrieved rock core was characterized (i.e., recovery, RQD, rock type, weathering, discontinuities, geological description, etc.), photographed, and stored in sturdy wooden core boxes. Selected specimens were wrapped in plastic wrap. Several intact 1.5 m-long core were retrieved and preserved intact.

In-hole testing equipment was delivered to the site using 4WD jeep-type or utility vehicles, hand-carried or airlifted. Such equipment consisted of in-hole logging probes

or support components such as power winches, and additional borehole rods.

3.3.2 Coring Rates

Coring rates varied greatly depending the degree of weathering and rock type encountered. Coring rates within the fresh rock were typically in the range of 15 to 45 min/m, with the highest coring rate of 3 to 4 min/m recorded for the weathered granodiorite of the South Block. In moderately to slightly weathered granitic rock, drilling generally proceeded rapidly at a typical rate of 1.5 m of run in 5 to 15 minutes (about 3 to 10 min/m).

3.3.3 Rock Quality Designation

The rock quality designation (RQD) of a rock is evaluated by determining the percentage of intact core pieces within a run that have lengths greater than 10 cm. Measured RQD's from the borings are presented in the boring logs in Appendix A-2. The RQD profiles plotted along all borings are shown in the longitudinal cross section of Figure 3-7. A summary plot illustrating the frequency of RQD values among the rock types is given in Figure 3-8.

The figures depict a broad scatter in the data due to lithology and discontinuities (including faults, local shear zones joints and fractures) throughout the depth penetrated by the borings.

The logs indicate that RQD correlates fairly well with the degree of weathering, rock type, and amount of fracturing within the various bedrock units. Also, numerous zones of intensely fractured rock were encountered within the bedrock. Many of those zones were associated with faulting and shearing.

3.3.4 Drilling Obstructions and Difficulties

3.3.4.1 General

As a result of difficult drilling and ground conditions encountered as described further below, considerable additional efforts were spent upon Caltrans authorization to determine the extent of a shear zone in the North Portal Area. The following describes the additional field work authorized and performed.

The original drilling program considered the potential for premature termination of boring 02-11 and hence borings 02-8B and 02-6A were included as a contingency plan to investigate tunnel segments beyond the final termination point in 02-11. When redrilling borehole 02-11 was proposed, EMI proposed to replace contingency borehole 02-8B by new boring 02-7A at site 02-7, and 02-6A. Borehole 02-7A was designed to

target the tunnel grade about 40 m south of the terminated tip of borehole 02-11 (125.8 m), and would explore the rock conditions in the tunnel halfway between boresites 02-7 and 02-8. With approval by Caltrans, EMI began contingency borings 02-7A, and then 02-6A (Aug. 17). Figure 3-2 and Figure 3-3 show the orientations and terminated lengths of the two contingency boreholes 02-6A and 02-7A in relation to 02-11 and 11A.

After drilling of 02-11A commenced, borehole 02-7A was terminated because it had not advanced very far, and it was expected that boring 02-11A would achieve more than 166 m (e.g., 125.8 m + 40 m) of penetration . Borehole 02-6A advanced concurrently with 02-11A. Because it was not certain whether 02-11A could penetrate beyond 230 m depth, borehole 02-6A was extended in stages from 188 m to 210 m, then 250 m, and ultimately to 266 m depth, each time with Caltrans prior approval.

After termination of borehole 02-6A, borehole 02-8B was drilled through the 30-m interval between 02-11A and 02-6A. A primary objective of 02-8B was to evaluate the nature and location of Fault C projected to be between 85 to 100 m.

3.3.4.2 Groundwater in North Portal Area

During drilling of boreholes in the north portal area, borehole advancement rates were variable depending on the rock formation encountered. Borehole 02-11 was drilled subhorizontal along the tunnel pillar centerline (as verified by three downhole surveys indicating only minor deviations). Difficult drilling was experienced in this borehole beyond 85 m depth, accompanied by large water outflow from the borehole collar. For several days, water and black muds consisting of ground-up rock as well as angular rock particles were retrieved from the borehole, and were collected in temporary rig-side holding tanks. Upon Caltrans approval, clear water was allowed to drain into the adjacent swale. The flowing water washed out clay and allowed the borehole to collapse. The churned-up clay-like rock material could not be removed with the HQ core barrel system at a fast enough to keep the hole open to allow reentry with the drill bit and advancement to the original hole "bottom".

After several unsuccessful retries and upon Caltrans approval, borehole 02-11 terminated at 125 m depth and grouted; a new subhorizontal boring 02-11A was begun at an alignment 4° easterly from the tunnel centerline. Drilling occurred in 10- to 12-hour day and night shifts. Figure 3-2 and Figure 3-3 show the orientations and terminated lengths of the two boreholes.

Near the problem area, a shear zone / fracture zone at about 91.5 m, water pressures and water volumes built up during shutdown periods of about 6 hours between shifts. Zones of dark sheared claystone material were encountered. This material could be placed in the core box due to the presence of clay, however it can easily be disintegrated

and crushed down into small rock particles, sand and clay by hand and with application of water.

Upon Caltrans approval, a Schedule 40 drainage line was installed from the rig-side holding tank to a large 26,000 liter (6,900 gal) water tank on Shamrock Ranch below. Excess water from the borehole was then pumped to a 26,000 liter (6,900 gal) tank.

A week later, the borehole had advanced to 117 m depth and water flow increased again to 115-155 l/min (30 to 40 gpm). An additional 76,000 liter (20,000 gal) water tank at the Route 1 turnout area. Water outflow was about 110-150 l/min (30-40 gpm).

After drilling successfully to about 174 m within several days, drilling of Borehole 02-11A was shut down because water was flowing from the hole at a rate of up to 380-450 l/min (100-120 gpm) from the 100-mm size steel collar pipe. That rate of flow was faster than could be pumped and the water storage tanks became filled to capacity. The hole collapsed at a depth of about 97.6 m and was terminated.

Appendix A-1 contains a diary of day-by-day activities, the water outflow occurrences and the accompanying difficulties experienced, and the measures implemented to continue the borehole.

3.3.4.3 Squeezing Clay

In inclined boreholes 02-8A/B/C, 02-18A/B and 02-16 a condition was encountered where ground soft rock similar to clay-like gouge squeezed into the borehole and the borehole advancement would slow dramatically and eventually would not advance. Based on the drilling history in borings 02-11, 02-11A this material appears to be the same or very similar clayey shear zone material encountered in the tunnel region between NB Tunnel Sta. 130+15 to 130+35 and 130+66 to 130+76 or approximately 54-64 m and 94-114 m south of the present north portal slope face. Continued working of this material washed away the clayey fraction and allowed the sand-sized sheared fragments to collapse into the borehole. This condition resulted in continual caving into the bottom portion of all these boreholes, disallowing advancement of the hole and entry of downhole logging tools such as the video, seismic, and pressuremeter probes.

3.3.4.4 Loss of Circulation

In many of the rock boreholes throughout the project, imported water was continually added during drilling. A total of 1.1 million liters (about 290,000 gallons) was imported throughout the duration of the project, nearly most of which was used for drilling. Water consumption was highest in the weathered rock in the north portal area and in the granodiorite rock slopes in the south portal areas.

For example, Boring 02-2B located in the granitic rocks of the South block, was oriented subparallel to the slope surface at the South Portal in order to investigate the rock slope stability of the South Portal headwall as well as intercept the north-bound tunnel and Fault A. For the first 11.6 m, the rock was intensely to moderately weathered and intensely fractured and recovery was generally poor. At 13.1 m depth, the driller reported loss of water return.

3.3.5 Logs of Test Borings

The Log of Test Boring Sheets from the subject Phase 2B are presented in Appendix A-2. Due to large total meterage and the space and readability constraints, only the most the pertinent geologic and geotechnical information could be represented in the Log of Test Boring plans that would be useful to contractors. Information that is not represented in the LOTB's include: graphical representation of the core geologic features such as joints and bedding, numerical downhole seismic logging, laboratory test results, coring rates, and the progress of drilling operations. Significant effort was spent to reduce and simplify the rock descriptions while still capturing the key features of the rock encountered, especially conditions that cause drilling difficulties in some boreholes. The set of LOTB's in Appendix A-1 consist of the following:

- The first general plan provides a project plan of all borehole locations, existing Route 1 and the tunnel stationlines. This plan allowed maximization of space and reduction of total number of sheets on the subsequent LOTB sheets.

- The second general plan provides a summary of all rock and soil descriptors used to classify the type and properties of the rock and soil encountered. This also provides the datum, and references to this report and all test data as presented in this report.

- A set of 58 rock borehole LOTB plans, in Caltrans' common format used in many other projects. Each sheet contains one rock boring only, and the log may continue on subsequent sheets for long borings. The borings are ordered by borehole number (not from south to north).

All boreholes are referenced by northing and easting coordinates rather than tunnel station and offset, because many boreholes are located much off the tunnel alignment stationlines both vertically and horizontally.

Nearly all boreholes are inclined and some are subhorizontal. The borehole orientation (deviation) was measured only in some of the boreholes. For boreholes in which orientation was measured, the LOTB's provide the representative (average) borehole bearing and inclination from vertical (the borepaths of those borings were found to be

nonlinear). For the two boreholes in which deviation was measured, the LOTB's provide the initial bearing and inclination from vertical at the borehole collar. All logs were plotted along a slant depth scale of 1:25 to 1:100 measured along the borehole path beginning at the borehole collar because the slant depths are known exactly. Borehole elevations could not be exactly derived from the actual borepath with certainty; the borepaths would result in nonuniform elevation scales and the elevation scale would be different for each borehole.

3.4 Auger Borings

3.4.1 General

Drilling program for soil borings consist of 12 borings (designated 02-ST1 to ST10) in the proposed disposal site, and two borings (designated 02-19 and 02-20) in the south portal and disposal area for proposed modification of the Route 1 roadway section.

Borings 02-ST1 to ST10. A total of ten soil borings were drilled in the proposed disposal area. Surface elevations differed with approximately 55 m between them. Surfaces were very steep at some locations, with high brush or weeds. The borings were performed by Clearheart Drilling of Santa Rosa, California using a track-mounted limited-access auger drill rig equipped with 100 mm-diameter solid flight augers, and a track-mounted support vehicle to access the locations inaccessible to conventional rubber-tired drilling equipment.

Several bulk samples were collected near the surface at various locations. Subsurface samples were taken alternating between a standard penetration test split-spoon sampler and a thin-walled split barrel soil sampler (drive-sampler).

Standard Penetration Tests (SPT) were performed in accordance with ASTM 1586 using a standard rope and cathead technique and automatic trip hammer. Soil samples were taken generally at depth intervals of 1.52 m (5 ft), using the standard split spoon sampler and EMI's California drive sampler. Profiles of SPT and equivalent–SPT blowcounts are shown in Figure 3-13 for three units of soil-like materials encountered. The SPT sampler with an outside diameter of 50.8 mm and the bit's inside diameter of 34.93 mm, was able to obtain blow counts and collect disturbed samples. The drive sampler used consists of a thin-wall brass ring-lined barrel with an outside diameter (OD) of 76.2 mm and a barrel inside diameter of 63.5 mm and bit inside diameter of 61.37 mm. The 25.4 mm-high filler rings stacked to fit inside the sample barrel to collect soil samples had an inside diameter of 61.37 mm and outside diameter of 63.5 mm.

All subsurface samples were collected using a standard 63.5 kg hammer and a 762-mm drop from a cathead pulley. Only relatively undisturbed samples were used to

determine the in-situ density and to perform strength tests. Typically, the bottom 152 mm (or less) portion of the recovered sample was retrieved for laboratory testing. Drilling was conducted during the day from Sept. 16, 2002 through Sept. 19, 2002. Soil logging generally conformed to Caltrans guidelines (1996).

Borings 02-19 and 02-20. These borings were drilled on the shoulder area on existing Pacific Coast Highway. The area near boring 02-20 was very narrow and one of the two lanes needed to be closed for drilling. This drilling was conducted between 9:00 p.m. and 7:00 a.m. for both nights of September 27 and 28, 2002. Boring 02-19 had a very wide shoulder area available and so drilling was performed during the day on September 30, 2002.

Ruen Drilling conducted drilling using the rotary mud wash method with a 125 mm (5") tri-cone bit. SPT and Drive sampler were used, alternating at every 1.52 m. Both boreholes were drilled to firm bedrock until the drill capacity of the bit was reached. Two runs of rock coring were made, starting at rock contact at boring 02-19. Due to time constraints during Route 1 closures, no rock core taken for boring 02-20, but rock contact was reached. Borehole 02-19 was backfilled with cement-mixed grout, while boring 02-20 was converted into a piezometer.

3.4.2 Borehole Grouting

For rock boreholes, temporary steel or PVC collar casing was inserted at the top of most boreholes to protect against hole caving. At the completion of each boring and in-situ testing, some of the completed boreholes were converted to monitoring wells (see Section 3.5.5).

Rock boreholes were backfilled using a high-density Portland cement-bentonite-water grout mixture up to existing grade. The bentonite used is environmentally safe, provides a permanent seal against surface water from percolating into the former borehole soil, and prevents cross-contamination of soils. On earthen ground, the ground cover was restored.

Soil boreholes were backfilled using in-situ borehole cuttings. At shallow depth, cuttings were mixed with cement and tamped down.

3.4.3 Log of Test Borings

A set of four (4) Log of Test Boring plans for these borings are presented at the end of Appendix A-2 in Caltrans' standard format for soil borings. Multiple, adjacent borings are presented on each sheet. ordered from south to north.

The first general plan in Appendix A-2 provides a project plan of all borehole locations,

existing Route 1 and the tunnel stationlines. This plan allowed maximization of space and reduction of total number of sheets on the subsequent LOTB sheets.

All boreholes are referenced by northing and easting coordinates rather than tunnel station and offset, because most soil boreholes are located much off the tunnel alignment stationlines both vertically and horizontally.

3.5 In-Situ Testing

In-situ (downhole) testing was performed in selected borings. Pressuremeter testing was performed by Hughes Insitu Engineering, geophysical logging was performed by Geovision, digital video imaging and deviator logging by Norcal, and packer testing by EMI. The complete reports from the subcontractors are presented in Volume 4 of this report. Summary descriptions of the procedures and test results are given below.

3.5.1 Downhole Digital Imaging

Digital optical and acoustical imaging was performed in eight borings (02-5, 6, 7, 8B/C, 15, 18A/B) by Norcal, Inc. of Petaluma, California. The probes were lowered down-hole after the drilling mud has been flushed out. The instruments record continuous digital images of the boring walls providing information on the rock type and discontinuity orientation. Norcal post-processed the images to determine true attitudes of bedding and jointing.

Both probes also contain a magnetic deviation tool to measure the deviations along the actual (inclined) borepath. The general orientation and inclination of the boreholes are summarized in Table 3-1. The imaging system and recording procedures are presented in Appendix A-2. The video logs and interpreted fracture attitudes and deviation data are also presented in that appendix, grouped by borehole.

3.5.2 Downhole Pressuremeter Testing

3.5.2.1 Testing

Pressuremeter testing was performed by Hughes Insitu Engineering of Vancouver, B.C., Canada to measure horizontal stress-strain response of the bedrock. A total of 8 tests were performed in Borings 02-5 and 02-2 at selected depth intervals as tabulated in Table 3-2. The pressuremeter tests were performed to assist in the evaluation of the in-situ shear moduli of the bedrock mass. The rock mass tested by the pressuremeter is about 1 m^3 in volume and as a result, this type of test represents a measure of the behavior of rock joints.

The device used was a mono-cell pressuremeter, with three electronic displacement

sensors spaced 120° apart at its center. In this configuration, a flexible membrane covering the sensors is enclosed in a tubular stainless steel shield and hydraulically pressurized to deform the adjacent rock radially. The average radial expansion and the pressure applied to the rock are measured by sensors and transmitted to the surface, so that the horizontal in-situ stress-strain relationship for the rock mass can be developed.

In the field, the pressuremeter was lowered into the drilled hole by means of the drilling rods. The testing depth was determined on-site upon inspection of the retrieved core. Since the device is designed to fit an NX-size (76 mm OD) hole, the HQ (96 mm OD) holes were under-cored to accommodate the pressuremeter for the testing depth and subsequently reamed out to advance drilling. During selection of the testing depths, particular emphasis was given to weaker rock within the weathered zone and within highly fractured zones, but also to the relatively intact rock at the proposed pile tip elevation. Testing details and measured results are presented in Appendix A-3.

3.5.2.2 Shear Moduli

The shear moduli were determined from the borehole pressures versus borehole deformation curves. For each pressuremeter test, two values of shear modulus were estimated: a "mass" value and a "maximum" value. The “mass” shear modulus obtained from the virgin curve represents an elastic property of the rock-mass (including joints), while the “maximum” modulus obtained from the unloading/reloading curve is more representative of intact rock, as the initial loading would close the potential joints. A detailed description of the methodology used to interpret the shear modulus is given in the report by Hughes Insitu Engineering in Appendix A-3. The resulting shear moduli of the in-situ rock are summarized in Table 3-3, categorized by RQD as well as rock type.

The ratio of the mass to “intact” moduli ranged from 1:7 to 1:17. It is noted that these ratios correlate well with the ratio given by Beiniawski (1984, Figure 5.11) for RQD values less than about 60%.

3.5.3 Downhole Seismic Logging

3.5.3.1 Logging Procedures

Geophysical logging was performed by Geovision of Corona, California, in 6 borings using the suspension method. This logging provided in-situ compressional (P, or primary) and shear (SV, or vertical secondary) wave velocity measurements of the bedrock for Borings 02-2, 02-5, 02-6, 02-15, 02-18A and 02-18B.

Geophysical logging was performed after completion of the borings using the OYO Model 170 Suspension Logging system to obtain in-situ horizontal shear and

compressional wave velocity measurements at 0.5 or 1 m intervals. This system consists of a logging recorder and a suspension logging probe that is lowered into the borehole filled with fresh water. The probe, 6.8 m long, contains an impact source in the tip that generates an acoustic wave and at its top receivers that detect the wave. The source creates a pressure wave in the water that is transformed into P and S waves at the borehole walls into the surrounding medium. These waves propagate through the soil or rock and cause in turn a pressure wave to be generated in the fluid surrounding the receivers. This system directly determines the average wave velocity of the soil surrounding the borehole walls by measuring the elapsed time between arrivals of a wave propagating upward through the soil column.

Geovision's report on testing equipment, procedures, analysis and charts of velocities are presented in Appendix B-3.

Seismic velocity information can be used for a variety of purposes such as to aid the interpretation of stratigraphic information, characterization of ground response to earthquake motion as well as development of ground stiffness for foundation design. It also provides means to assess weathering conditions and "rippability" of the rock-mass.

3.5.3.2 Seismic Velocity Test Results

Seismic compression (P-) and shear (S-) wave velocities of the bedrock units were measured in 6 borings 02-2, 02-5, 02-6, 02-15, 02-18A and 02-18B using the suspension method. A summary plot of all measured P- and S-wave velocity profiles versus depth is shown in summary plot of Figure 3-9.

Typically, these velocity profiles show that the velocities increase with depth in approximately the upper 40 to 50 m, and then remain relatively uniform at deeper depths except where fractured / sheared zones were encountered.

In the igneous rocks of borings 02-2 and 02-5, the S-wave velocity (v_s) ranges from about 350 to 1,200 m / sec in intensely to moderately weathered conditions, in boring 02-15 to about 1,400 to 3,000 m / sec in slightly weathered to fresh conditions.

By comparison, in sedimentary rocks in all other borings, the S-wave velocity (v_s) range from about 500 to 1,350 m / sec in intensely to moderately weathered conditions and about 1,400 to 2,500 m / sec in slightly weathered to fresh conditions.

3.5.4 Packer Testing

3.5.4.1 Testing

Packer testing is a common in-situ method of measuring hydraulic conductivity of rock.

The purpose of this testing was to provide in-situ transmissivity of the different rock formations in the region of the tunnel bores and portal areas, and to aid design of rock excavation, support, the tunnel lining and dewatering systems for the proposed tunnels.

Packer testing was performed by EMI in five rock borings (02-5, 02-6, 02-7, 02-8A and 02-21) at selected depth intervals. A total of 28 tests were performed with a total linear length of 346.5 m of borehole. The depths and rock types tested are summarized in Table 3-4 along with the borehole orientation.

The testing procedures generally followed ASTM guidelines for the Constant Head Injection Test (ASTM designation D4630–96). In each borehole, packer testing was performed after completion of drilling and after video logging when possible. Upon reaching the selected depth intervals, the borehole was flushed with clear water until the return water ran clear of any cuttings by visual observation. The test sections were then internally sealed or "packed" by inflatable rubber packers at selected depths and water pumped into each test section. Two rubber packers (0.25-m long when deflated) were used to isolate a test section. The lengths of the test sections were typically 3 m or they were varied after inspection of the rock core retrieved in that depth range. The water inflow quantity versus time was measured until steady-state flow was reached. The test sections were selected by EMI to test different rock conditions and types, aiming to characterize the hydraulic properties of different lithotypes.

The constant water pressure was applied to the water in the sealed interval through the tubing string and the resulting changes in flow rate (if any) were recorded. The constant pressures applied (total of three for each test) were calculated so that they were not exceeding the anticipated overburden stress at each testing depth in order to avoid hydrofracturing.

Testing details and measured test results are presented in Appendix C-3 for each tested section with the applied pressures, measured water flow quantities, and photos showing the core retrieved at the testing interval.

3.5.4.2 Permeability

The equations used for calculation of the coefficient of permeability are as follows (Das, M.B., 1983):

$$k = \frac{q}{2plh}\log\frac{l}{r} \qquad \text{for } l \geq 10\,r$$

and

$$k = \frac{q}{2plh}\sinh^{-1}\frac{l}{2r} \qquad \text{for } 10r > l \geq r$$

where

k = coefficient of permeability of the rock,

q = constant rate of water injected into borehole,

l = length of test hole interval,

r = radius of borehole in test hole interval, and

h = differential head of groundwater in casing to ground surface.

The differential head of groundwater h is the total of injection pressure at the pressure gauge at the surface plus the gravity head of water (in the steel tubing) between the center of the packer test interval to the pressure gauge.

Based on this approach, calculated rock bulk permeability ranges from 22 tests were valid are summarized in Table 3-5. That table also shows data from 12 tests by WCC (1996). The lower bound is usually representative of moderately to intensely fractured conditions, while the upper bound of slightly fractured and fresher conditions. The data indicates that flow rates increase with increasing pressure. In depth interval 150.9 to 154 m in borehole 02-5, it was observed that the flow rate reduced when a higher pressure stage was applied; this may have been caused by closing up ("clogging") of fractures by fines washed into the fractures at lower-pressure stages. The k-values developed indirectly from the packer test represent only an estimate of rock permeability and should be cross-checked with other data and measurements.

3.5.5 Piezometers

3.5.5.1 Installation and Readings

Vibrating-wire (VW) piezometers were installed during the field exploration in 10 boreholes to measure pore-water pressures at the depth of the piezometers. The locations of all piezometers are shown on Figure 3-1.

Figure 3-11 and Figure 3-12 schematically show typical single- and multiple-level piezometer installations. During the installation, the borehole was first grouted up to 1 to 2 m below the design depth and the grout was allowed to set. Coarse Sand No. 3 was tremied up to 1.5 to 2.5 m above the grout to the design depth. The piezometer was then saturated with water and slowly lowered to the top of sand level. Coarse sand was tremied again up to 1.5 to 2.5 m above the piezometer. Bentonite pellets were used to place a seal up to 15 to 30 cm above the sand and the remainder of the borehole was grouted. The height of the sand zone and placement of bentonite seal varied depending

on the inclination, depth and water level of the boreholes. At the ground surface, the electric cables connecting to the piezometer tranducers were protected by riser pipe or flush-mounted monuments. Table 3-6 provides the summary of key piezometer installation data.

The vibrating-wire piezometer tranducers and cables installed by EMI were manufactured by Slope Indicator Company in Washington. The VW piezometer converts water pressure to a frequency signal via a diaphragm and a tensioned steel wire. The piezometer is designed so that a change in pressure on the diaphragm causes a change in tension of the wire. When excited by a magnetic coil, the wire vibrates at its natural frequency. The vibration of the wire in the proximity of the magnetic coil generates a frequency signal that is transmitted to the readout device. The VW Data Recorder manufactured by Slope Indicator Company was used.

Calibration factors that establish a relationship between pressure applied to the diaphragm and the frequency signal returned to the readout device are used to convert data to the desired engineering units. The calibration data sheets containing these factors for each serialized piezometer transducer and data record sheets with initial readings are attached in Appendix D-3.

3.5.5.2 Groundwater Data

Three of the original standpipe piezometers installed by WCC as part of the 1996 Feasibility Study have been monitored regularly since 1996 by Sigma Prima Geosciences. The ten piezometers installed by EMI have been incorporated into this monitoring program. The three conventional piezometer in Caltrans borings installed by Caltrans in the area of the proposed northern approach bridge were also adopted into the program. The locations of all piezometers are shown on Figure 3-1.

Table 3-7 summarizes the groundwater elevations correlated from these piezometers and standpipes, both from initial installation and from the most recent available monitoring cycle conducted by CBC. The groundwater data and groundwater tables are also plotted on the cross section of Figure 3-6.

Little variation in groundwater levels was measured between 11/4/02 and 11/26/02 (less than 1 m). It should be noted that in EMI borehole 02-5, where three levels of piezometers A, B and C were installed, three pore-water pressure heads were recorded, both after installation and in monthly cycles thereafter, that do not correlate to one groundwater level. This may be due to the presence of impervious or low-permeability zones between the transducers, as evidenced by the packer test results (see Section 3.5.4).

3.6 Trenching

3.6.1 General

Exploratory trenches were excavated in three locations as part of the Task 2B Site Exploration. The trench plan at each location is plotted on the Site Exploration Maps of Figure 3-1 to Figure 3-5. Trench logs of the trenches are shown in Appendix D-1.

The layout of the trenching program was developed with the objective of providing exposures of geologic features and conditions identified from preliminary Phase-2A mapping as being important to the geotechnical evaluation of various elements of the project. These were:

- the 02-T1 location and near-surface condition of Fault B,
- the 02-T2A/B locations and near-surface condition of Fault C, and
- the 02-T3 detailed geologic structure and stratigraphy of the North Portals area.

The approximate traces of faults is shown in Figure 2-2.

The approximate location and estimated maximum extent of each trench was established during the exploration planning phase. Following this each site was inspected by a team including Caltrans management together with landscape and biology specialists, EMI personnel, and trenching and restoration contractors. Several operational constraints were identified at this time, including a prohibition on leaving any trench open overnight. This established a schedule of trenching operations such that each increment of trench exploration had to be completed during one working shift. In practice this required that the operation was paced to allow excavation, stationing, plotting, logging, photographing and sampling and finally backfilling of an increment of trench length, typically about 30 m, during the day's shift.

Following the initial field inspection each trench site was carefully checked by Caltrans biology specialists for listed plants and animals, and in the case of trench 02-T3, the setback from the adjacent ravine bottom wetland was established.

The trenches were all excavated along the inner edges of access roads, so that the resulting trench-wall exposure extended upward to include the lower margin of the road cut-bank. The excavation was accomplished using a track-mounted rubber-tired back-hoe type excavator equipped with a 60-cm wide toothed bucket.

The trenches were plotted with reference to existing surveyed drill hole casings (02-T1, 02-T3) or to topography along the access road (02-T2A/B). Plotting was done by tape

and compass at a scale of 1:100, with logging of the vertical trench-wall exposure at the same scale. In the following, observations from the trenches at the three locations are described.

3.6.2 Trench 02-T1

Trench 02-T1 was planned so as to establish the outcrop location of Fault B along the hillside upslope from the tunnels South portal. This trench is located at the site of borehole 02-21. A sketched log of this trench is shown in Appendix D-1.

The approximate location of the trace of this fault was known from geologic mapping of isolated road cut-bank outcrops and by projection from 1996 boreholes but neither the exact surface location nor the near-surface character of the fault was known. The selected location for trench 02-T1 was along the old ranch road extending east from the 1996 boring P-14-96. This boring was logged as extending through about 0.6 m of colluvial soil directly into "yellowish brown, poorly graded sand" that graded down into intensely weathered quartz diorite, which seemingly established it as being altogether in the footwall of Fault B. Surface mapping had established that weathered quartz diorite was exposed in the ranch road cut-bank about 40 m west of boring P-14-96. The initial segment of trench 02-T1 was therefore started 3.5 m east of the casing of the boring and extended eastward, at about 1.25 m depth. The trench wall and floor exposed yellowish brown, dense clayey sand containing scattered well-rounded pebbles.

In order to test the possibility that Fault B might cross the trench alignment further east, the trench was extended to a total length of 21 m, and the eastern end was deepened to 3.3 m below the road surface, all in the same material. This section of trench was then logged and backfilled. A second segment of trench 02-T1 was started the following day from a point 15 m west of boring P-14-96 and close to an exposure of granitic rock in the road cut-bank. This trench segment was excavated to an average vertical depth of 1.8 m. The trench passed from colluvial soil into intensely weathered quartz diorite bedrock at about 0.4 m depth. However, as it was extended east back toward P-14-96 and the first trench segment, a gently NE-dipping thin gray clayey shear separating weathered quartz diorite in the lower part of the trench from weathered light brown clayey sand in the upper part, was encountered about 11 m west of P-14-96. This dipped gradually to about 1.1 m depth at the east end of the second day's trench increment.

The third segment of trench 02-T1 was excavated in the 5 m gap between the west end of Segment 1 and the east end of Segment 2. This segment was carried down to 2 m. depth, and exposed the same shear-contact between weathered clayey sand with rounded pebbles and intensely weathered quartz diorite as was seen in the segment in the west. At the east end of the third segment the shear contact was about 0.1 to 0.2 m below the bottom of the original trench segment. It was concluded that the gray clay

shear contact was the local expression of Fault B, thereby fixing its outcrop location on the slope above the tunnels South Portals. Review of the log of boring P-14-96 suggests that this boring passed through, but did not adequately sample or permit recognition of, the shear contact at a depth of about 0.6 m.

3.6.3 Trenches 02-T2A/B

Trench 02-T2 is located along existing trail P-3a. Sketched logs of these trenches are shown in Appendix D-1.

This trench was intended to intersect and expose the inland (eastward) continuation of the major Fault C discontinuity present in the nearby coastal sea cliff. The projected fault trace intersected the ranch road in an area of discontinuous cut-bank exposures of massive weathered gray claystone-siltstone. The obvious vertical boundary between massive hard sandstone on the south and thinly interbedded claystone-siltstone and sandstone seen in the sea cliff exposure was not evident along the ranch road but drilling along the tunnels alignment had shown than the inland expression of the coastline Fault C might be altogether in claystone-siltstone.

The initial trench (02-T2A) was excavated parallel to the ranch road and across a saddle located inland from Fault C near the top of the coastal cliff. This trench, 16 m long and 1.5 m deep, was entirely in rock logged as "siltstone-argillite" the bedding in the southerly part of which had the structure of a broad arch; the northerly part was essentially horizontally bedded. Several distinct fractures, but no significant appearing shears, were observed.

The second trench (02-T2B) was excavated opposite the break in slope above the north side of the 02-T2A saddle, and separated from 02-T2A by about 38 m. Trench 02-T2B was found to cut across a buried swale filled with a maximum (below road level) of 2.4 m. of colluvial soil. The swale was eroded along a zone of moderately to steeply north dipping shear surfaces developed in grey poorly bedded to massive siltstone. Indistinct layered structure (possibly bedding) in the rock at the north end of this trench dipped 62° north. This possible bedding was about 20 m north of the zone of shearing in the rock beneath the buried swale.

3.6.4 Trench 02-T3

Trench 02-T3 was excavated in the existing road P-1, along the toe of the existing rock wall. A sketched log of this trench is shown in Appendix D-1. This trench was planned to expose the rock conditions along the ranch road crossing the tunnels North Portal area. The area where this trench was to be located had been explored by mapping the discontinuous rock exposures along the road cut-bank, and by two 1996 borings P-6-96-6 and P-7-96. Boring P-7-96 was of particular interest because it encountered several

thick sheared intervals in siltstone, located nearly beneath the south bound tunnel bore.

The trench was started 2 m north of boring P-7-96 casing, at the boundary of the setback from the adjacent wetlands exclusion zone, and extended 156 m northward along the inner edge of the ranch road. An additional 14 m of exposure was obtained by scraping the road cut-bank, to give a total of 168 m of logged exposure. The trench was excavated to an average depth of 1 m below road grade level with locally as much is 2 m height of cut-bank exposure above road grade level. Although the trench 02-T3 stationing started with Sta. 0+00 at the P96-7 casing, the excavation was carried from its northern end at Sta. 170+00 southward. This was required by the excavator machine configuration. The north end of the actual trench was placed at about Sta. 158+00 and the south end was at Sta. 2+00. For reference the north bound portal side walls will be approximately between Sta. 85+00 and 100+00 and the southbound portal sidewalls approximately between Sta. 28+00 and 52+00. The collar of near-horizontal Borings 02-11 and 02-11A into the pillar between tunnel bores was at Sta. 72+00.

In general, two types of geologic conditions were exposed along the 170 m. extent of trench 02-T3. Between Sta. 20+00 and the north end of the trench at the nose of the North Portal ridge, at Sta. 170+00, the trench revealed a mostly intact section consisting of thin to thick-bedded, moderately to steeply south to locally west dipping sandstone, with one approximately 28 m. thick sandy conglomerate interbed. The sandy conglomerate was present between Sta. 92+00 and 132+00.

Structural discontinuities were identified at four locations within the entire length of trench (Sta. 20+00 to 170+00). These consisted of (1) a fault at Sta. 28+00 marked by a 10-cm thick zone of tight fault gouge with shear fabric parallel to the N85^{o}W, vertical orientation of the fault; (2) a fault oriented E-W and dipping 55° south, also marked by a 10 cm thick gouge zone, at Sta. 52+50, (3) a small fault oriented N40^{o}E, dipping 30° SE at Sta. 70+00, and (4) a complex of faults, shears, and local folding between Sta. 148+00 and 153+00.

More deformation was evident in the Sta. 2+00 to 20+00 interval of trench 02-T3. There a partly overturned fold with axis striking approximately N30^{o}W is present in a structural block isolated between two pronounced fault zones. The northerly zone, present between Sta. 16+00 and 19+00, is oriented N75^{o}E, dips about 70° SE and consists of a 1.5-m thick shear-gouge zone. The southerly zone at Sta. 4+00, is oriented about parallel to the former one but only contains 5 to 10 cm of gouge. The bedding at the extreme south end of the trench is oriented similarly to that north of the rotated structure between the faults at Sta. 4+00 and 20+00, striking N80^{o}E and dipping 50° SE.

Subsequent to logging and backfilling of trench 02-T3, drilling of boreholes 02-11, 02-11A and 02-16 commenced in this area. Information gained from the drilling program from these boreholes and other boreholes in the northern tunnel area indicates that the

fault-shear-gouge zones exposed at Sta. 4+00, 20+00, 28+00 and 52+50 are part of a wide zone of faulting and deformation that mostly lies south of the ground exposed by trench 02-T3. This zone is referred to herein as the North Block Shear Zone.

Table 3-1. Summary of Boreholes

Bore-hole	GSE (m)	As-drilled Length (m) [ft]	Dip / Inclina-tion*	Azimuth	Easting (m)	Northing (m)	Location / Site Access	Purpose	Pressuremeter Testing (Depths in m)	Televiewer Logging (Depth in m)	Packer Testing (Depths in m)	P&S Logging (Depths in m)	Piezometer (Depth in m)
Disposal Area													
02-20	58.0	22.0 [72]	90° / 0°	N/A	1,822,087.3	620,453.8	On Rte 1 shoulder	Explore fill thickness and embankment stability.	-	-	-	-	21.3
02-ST1	66.3	10.7 [35.2]	90° / 0°	N/A	1,822,082.6	620,533.2	In drainage basin	Explore depth, distribution and nature of existing soil cover. Soft soil will be removed before placement of landfill	-	-	-	-	-
02-ST2	56.3	15.3 [50.1]	90° / 0°	N/A	1,822,163.0	620,477.8			-	-	-	-	-
02-ST3	103.7	1.6 [5.2]	90° / 0°	N/A	1,822,195.1	620,622.8			-	-	-	-	-
02-ST4	65.4	7.7 [25.2]	90° / 0°	N/A	1,822,137.8	620,531.6			-	-	-	-	-
02-ST5	63.8	13.8 [45.1]	90° / 0°	N/A	1,822,218.3	620,477.1			-	-	-	-	-
02-ST6	65.16	6.4 [20.9]	90° / 0°	N/A	1,822,179.4	620,515.8			-	-	-	-	-
02-ST7	94.3	7.7 [25.3]	90° / 0°	N/A	1,822,048.4	620,616.6			-	-	-	-	-
02-ST8	91.1	4.8 [15.7]	90° / 0°	N/A	1,822,175.2	620,589.3			-	-	-	-	-
02-ST9	84.8	18.8 [61.7]	90° / 0°	N/A	1,822,109.3	620,611.6			-	-	-	-	-
02-ST10	104.0	14.0 [45.8]	90° / 0°	N/A	1,822,114.7	620,674.3			-	-	-	-	-
South Rock Cut Area													
02-13	73.5	29.3 [96]	0° / 90°	S53°E	1,821,938.6	620,754.4	On Rte 1 shoulder	Rock/slope stability	-	-	-	-	-
02-14	118.8	50.3 [165]	60° / 30°	N36°W	1,822,005.5	620,771.3	Helicopter support	Provide information on rock slope excavation and stabilization requirements.	-	-	-	-	-
02-15	125	54.9 [180]	56° / 34°	N73°W	1,822,005.2	620,714.5	Helicopter support	Provide information on rock slope excavation and stabilization requirements.	-	1.5~15.5	-	43.9	-
South Portal Area													
02-2	131.4	60.7 [199]	90° / 0°	N/A	1,821,997.4	620,930.2	Helicopter support	Drill Fault A hanging wall block. Intercept northbound tunnel. Findings used for rock slope stability.	46.2; 46.6; 52.6; 53.0	-	-	13.4	-
02-2A		92.1 [302]	57° / 33°	S37°W				Intercept southbound tunnel. Rock slope stability.	-	-	-	-	-
02-2B		86.3 [283]	60° / 30°	S9°W				Intercept NB tunnel and Fault A. Rock slope stability.	-	-	-	-	54.9
02-19	74.0	26.8 [88]	90° / 0°	N/A	1,821,946.1	620,844.0	On Rte 1 shoulder	Explore fill thickness and embankment stability.	-	-	-	-	-
02-21	186.1	162.2 [532]	50° / 40°	N25°E	1,822,069.2	621,056.6	On exist. trail P-3b	Drill through Fault A footwall block	-	-	117.4; 123.5; 128.0; 146.0	-	-
Tunnel Segment													
02-5	292.2	255.6 [838.5]	90~86° / 0~4°	N79°W	1,822,201.7	621,357.2	On exist. upper trail P-3a/b	Intercept Fault B at the tunnel level. Measure permeabilities of sandstone to be representative for central tunnel segment.	102.7; 103.2; 168.6; 169.2	67.5~194.4 [2] 6.4~96.5 [3]	83.8; 115.9; 152.4; 167.7; 195.1; 198.2; 207.3; 204.3; 210.2	<30; 19.5	61.0 ("A"); 213.4 ("B"); 182.9 ("C");
02-6	223.8	139.6 [458]	75° / 15°	S66°E	1,822,293.7	621,719.8	On new road P-2	Explore nature of horizontally bedded sandstone and shale. Parting of bedding could affect excavation & stability of rock support at tunnel crown. Measure permeabilities of sandstone representative for central tunnel segment.	-	66.2~139.2 [2] 11.5~66.5 [3]	42.7; 86.9; 120.6; 137.7; 128.5	-	115.5
02-6A		266.2 [873]	43° / 47°	N43.5°E				Intercept Fault zone C.	-	-	-	-	-
02-7	183.0	123.6 [405.5]	45° / 45°	S25°W	1,822,407.1	621,846.1		Intercept Fault C at tunnel level. Geologic mapping is uncertain as to location of Fault C. This boring should resolve this uncertainty. Measure permeabilities of deformed rock near Fault C.	-	16.7~115.5 [3]	73.2; 83.8; 91.5; 97.6; 105.2; 113.0; 120.6	-	97.6
02-7A		36.1 [118.5]	57° / 33°	N25°E					-	-	-	-	-
02-8A	162.8	52.4 [172]	53° / 37°	N29°W	1,822,453.9	621916.8		Intercept SB Tunnel. Rock has some contorted sections and some vertically bedded shale. Measure permeabilities of this shale to be representative for north tunnel segment.	-	-	14.3; 28.0; 39.5	0	-
02-8B		100.9 [331]	44° / 56°	S23°W				Intercept NB Tunnel. Otherwise similar to 02-8A.	-	43.1~67 [2] 1.3~36.2 [3]	-	-	-
02-8C		68.9 [226]	50° / 40°	N8.5°E				Investigate shallow rock slope mat'l. Explore geometry of shear zone in P-7-96.	-	50.9~66.6 [2] 9~52 [3]	-	-	49.1

Table 3-1. Summary of Exploration Program (Cont'd)

Bore-hole	GSE (m)	As-drilled Length (m) [ft]	Dip / Inclination[1]	Azimuth	Easting (m)	Northing (m)	Location / Site Access	Purpose	Pressuremeter Testing (Depths in m)	Televiewer Logging (Depth in m)	Packer Testing (Depths in m)	P&S Logging (Depths in m)	Piezometer (Depth in m)
North Portal Area													
02-11	107.7	125.8 [412.5]	0-6.5° / 83.5-90°	S22.5°E	1,822,510.1	622,047.1	On exist. lower trail P-1a	Intercept Fault C. Evaluation of rock within north block for tunnel excavation and support system.	-	-	-	-	-
02-11A		174.4 [572]	0-4° / 86-90°	S21.5°E					-	-	-	-	-
02-12	123.3	50.0 [164]	50° / 40°	N22°W	1,822,531.0	622,022.9	On new foot trail P-2	Explore rock at NB tunnel exit portal. Used for slope stability evaluation. Current rock interpretation is based on outcrops along existing trail and by analogy with slope above SB entrance portal where rock is widely exposed. Explore geometry of shear zone in P-7-96.	-	-	-	-	-
02-16	124.2	21.2 [69.5]	10° / 80°	S8°E	1,822,429.6	621,971.1	Helicopter support	Explore shallow rock at the north portal and rock conditions near crown of NB tunnel. Explore geometry of shear zone in P-7-96.	-	-	-	-	-
02-18A	136.0	40.1 [131.5]	58° / 32°	N46°W	1,822,509.3	621,987.0	On new foot trail P-2	Explore near-surface rock above outer part of pillar between tunnel bores (future equipment chamber). Determine geometry and condition of zone of shearing encountered in boring P-7-96, if that zone is oriented so as to extend into the portals area. Will also be used for slope stability evaluation.	-	10~24.5[3]	-	<30	24.1
02-18B		45.4 [149]	77° / 13°	N56°W				Explore rock adjacent to and within NB bore, a short distance inside North Portal where cover is only 3-4 times tunnel diameter. Confirm presence or absence and orientation of shear zone found in P-7-96 in this reach of NB bore.	-	21.2~44.5[2] 10.2~32[3]	-	32.6	26.5
33 Bores	-	***2,011.7***	-	-	-	-	-	-	***8 Tests***	***7 Holes (680.2 m)***	***28 Tests (346.5 m)***	***5 Holes***	***10 Points***

Notes:

[1] Dip angle is from horizontal, Inclination angle is from vertical
[2] Using accoustic televiewer
[3] Using optical (video) televiewer
All depths shown are slant depths along borehole paths
Coordinates and elevation datum are per Section 1.4
N/A = not applicable

Table 3-2. Summary of Pressuremeter Testing

Borehole	*GSE (m)*	*As-drilled Length (m) [ft]*	*Dip / Inclination*	*Azimuth*	*Rock Type at Testing Depths*	*Pressuremeter Testing (Depths in m)*
02-2	131.4	60.7[199]	90° / 0°	-	Granodiorite, Granitic rocks	46.2,46.6, 52.6, 53.0
02-5	292.2	255.6 [838.5]	90~86° / 0~4°	N79°W	Sandstone, Siltstone/Claystone	102.7, 103.2, 168.6, 169.2

Table 3-3. Summary of Shear Moduli from Pressuremeter Tests

Rock Condition	*Range of Maximum Shear Modulus[1] G (GPa)*	*Range of Mass Shear Modulus[2] G (GPa)*
By RQD		
Fractured Rock with RQD < 50% (3 tests)	2 to 3.7	.12 to .4
"Intact" Rock with RQD ≥ 50% (5 tests)	3.5 to >20	.45 to 1.4
By Lithology		
Sandstone (2 tests)	3.5 to 20	.45 to .65
Siltstone/Claystone (2 tests)	2.2 to 3.7	.25 to .4
Granitic (4 tests)	2 to 20	.12 to 2.6

Notes:

[1] *from unloading-reloading curve*
[2] *from virgin loading curve*

Table 3-4. Summary of Packer Testing

Borehole	*GSE (m)*	*As-drilled Length (m) [ft]*	*Dip / Inclination*	*Azimuth*	*Rock Type*	*Packer Testing (Depths in m)*
02-5	292.2	255.6 [838.5]	90~86° / 0~4°	N79°W	Sandstone, Siltstone, Claystone and Granodiorite	83.8; 115.9; 152.4; 167.7; 207.3; 204.3; 210.2; 198.2; 195.1
02-6	223.8	139.6 [458]	75° / 15°	S66°E	Sandstone, Siltstone, Claystone	42.7; 86.9; 120.6; 137.7; 128.5
02-7	183.0	123.6 [405.5]	45° / 45°	S25°W	Sandstone, Siltstone, Claystone	73.2; 83.8; 91.5; 97.6; 105.2; 113.0; 120.6
02-8A	162.8	52.4 [172]	53° / 33°	N29°W	Sandstone, Siltstone, Claystone	14.3; 28.0; 39.5
02-21	186.1	162.2 [532]	50° / 40°	N25°E	Granodiorite, Granitic rocks	117.4; 123.5; 128.0; 146.0
5 Bores			-	-	-	*28 Tests (346.5 m)*

Table 3-5. Summary of Coefficient of Permeabilities

Rock Type	*Coefficients of Permeability Derived from Packer Tests k (cm/sec)*		
	EMI Data (22 Tests)	*WCC Data (1996) (12 Tests)*	*Combined Data (34 Tests)*
Sandstone	8×10^{-6} to 2×10^{-4}	3.9×10^{-5} to 3.9×10^{-4}	8.0×10^{-6} to 3.9×10^{-4}
Sandstone with "Shale"	-	9.8×10^{-6} to 8.5×10^{-5}	9.8×10^{-6} to 8.5×10^{-5}
Sandstone with Conglomerate	-	5.0×10^{-5}	5.0×10^{-5}
Siltstone/Claystone	5×10^{-5}	-	5.0×10^{-5}
"Shale" with Sandstone	-	9.5×10^{-5}	9.5×10^{-5}
Conglomerate	1×10^{-6} to 1×10^{-4}	3.7×10^{-6}	1.0×10^{-6} to 1.0×10^{-4}
Granitic Rock	2×10^{-7} to 2×10^{-5}	1.1×10^{-5} to 1.2×10^{-4}	2.0×10^{-7} to 1.2×10^{-4}

Table 3-6. Summary of Piezometer Installations

Borehole	*Piezometer Serial No.*	*Date Installed*	*Transducer Depth Along Borehole (m)*	*Elevation of Piezometer Transducer (m)*
02-2B	74659	10/04/02	54.9	+83.9
02-5 (Piezometer A)	74661	10/03/02	61.0	+231.2
02-5 (Piezometer B)	74664	10/02/02	182.9	+109.3
02-5 (Piezometer C)	74665	10/02/02	213.0	+79.2
02-6	74663	08/16/02	115.5	+112.2
02-7	74662	08/23/02	97.6	+114.0
02-8C	74660	08/26/02	49.1	+125.2
02-18A	73866	08/24/02	24.1	+115.6
02-18B	73865	08/23/02	26.7	+110.0
02-20	74658	09/28/02	21.3	+45.0

Table 3-7. Summary of Groundwater Data

Borehole	Measured or Interpreted Groundwater Elevation (m)				Temperature (^{o}C) All Dates
	Initial	on Nov. 4, 2002	on Nov. 26, 2002	on Dec. 2, 2002	
2002 Piezometers by EMI					
02-2B	NM on 10/04/02	below +83.9*	below +83.9*	below +83.9*	15
02-5 (Lower Level A)	NM on 10/03/02	+241.1	+240.6	+239.5	20
02-5 (Middle Level B)	NA on 10/02/02	+121.5	+118.8	+115.0	20
02-5 (Upper Level C)	NA on 10/02/02	+79.6	+79.6	+79.6	14
02-6	+158.9 on 8/16/02	+157.5	+157.1	+156.8	16
02-7	+158.9 on 8/23/02	+155.1	+154.7	+154.3	15
02-8C	NM on 8/26/02	below +125.2 [1]	below +125.2 [1]	below +125.2 [1]	13
02-18A	NM on 8/24/02	below +115.6 [1]	below +115.6 [1]	below +115.6 [1]	13
02-18B	NM on 8/23/02	+112.5	+112.3	+112.2	13
02-20	NM on 9/28/02	+45.3	+45.7	+46.8	15
2002 Wells by Caltrans					
B-5	NM on 7/24/02	+86.6	+86.6	NM	NM
B-7	NM on 7/29/02	+76.5	+76.5	NM	NM
B-9	NM on 8/15/02	+64.9	+64.9	NM	NM
1996 Standpipes by WCC					
P-2-96	+67.7 on 7/31/96	+67.0	+67.0	+69.8	NM
P-7-96	+112.8 on 8/07/96	+114.3	+114.3	+114.3	NM
P-9-96	+129.9 on 8/07/96	+130.0	+130.0	+130.1	16
P-10-96	+61.6 on 8/07/96	+61.0	+61.0	+62.0	17
P-11-96	+66.8 on 8/07/96	+66.3	+66.3	+67.6	16
P-12-96	+157.0 on 8/07/96	NA	NA	NA	15
P-13-96	+163.4 on 8/07/96	NA	NA	NA	15
P-14-96	+149.4 on 8/07/96	NA	NA	NA	16

Note:
[1] No water pressure recorded at piezometer level, suggesting groundwater to be below that level.
NM = Not measured
NA = Not available (questionable reading or non-functional well)

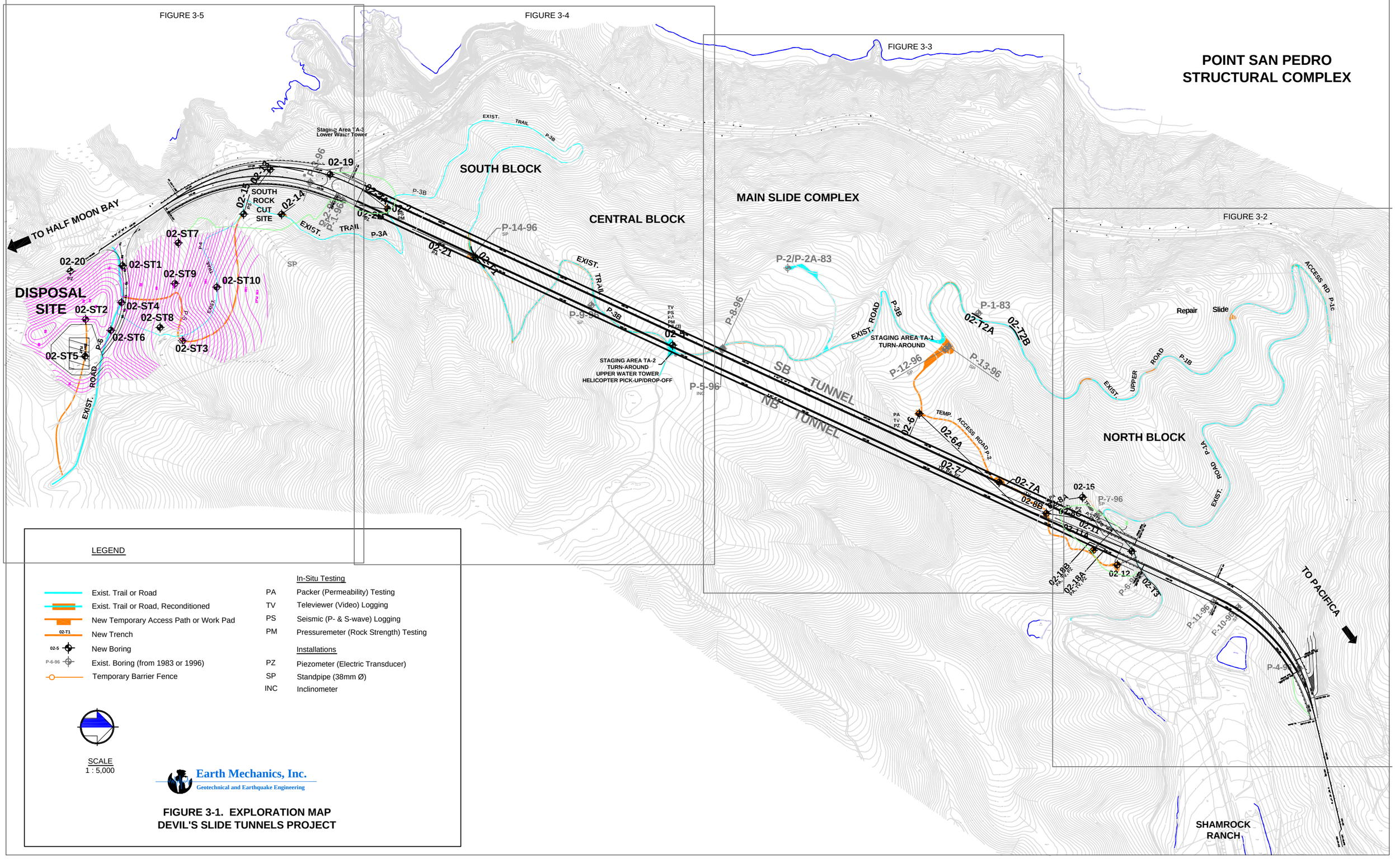
FIGURE 3-5

FIGURE 3-4

FIGURE 3-3

FIGURE 3-2

POINT SAN PEDRO STRUCTURAL COMPLEX



LEGEND

- Exist. Trail or Road
- Exist. Trail or Road, Reconditioned
- New Temporary Access Path or Work Pad
- 02-T1 New Trench
- 02-5 New Boring
- P-6-96 Exist. Boring (from 1983 or 1996)
- Temporary Barrier Fence

In-Situ Testing

PA	Packer (Permeability) Testing
TV	Televiewer (Video) Logging
PS	Seismic (P- & S-wave) Logging
PM	Pressuremeter (Rock Strength) Testing

Installations

PZ	Piezometer (Electric Transducer)
SP	Standpipe (38mm Ø)
INC	Inclinometer

SCALE
1 : 5,000

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FIGURE 3-1. EXPLORATION MAP
DEVIL'S SLIDE TUNNELS PROJECT

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FIGURE 3-2. DETAIL EXPLORATION MAP OF NORTH PORTAL AREA DEVIL'S SLIDE TUNNELS PROJECT

SCALE
1 : 2,000

- Exist. Trail or Road
- Exist. Trail or Road, Reconditioned
- New Temporary Access Path or Work Pad
- 02-T1 New Trench
- 02-5 New Boring
- P-6-96 Exist. Boring (from 1983 or 1996)
- Temporary Barrier Fence

In-Situ Testing

PA	Packer (Permeability) Testing
TV	Televiewer (Video) Logging
PS	Seismic (P- & S-wave) Logging
PM	Pressuremeter (Rock Strength) Testing

Installations

PZ	Piezometer (Electric Transducer)
SP	Standpipe (38mm Ø)
INC	Inclinometer

Repair Slide
P-1C
EXIST. UPPER ROAD
P-1B
NORTH BLOCK
EXIST. ROAD P-1A
02-16
P-7-96 SP
TEMP. STEPS P-1B
02-8C TV, PZ
02-11
02-11A
02-18B TV, PZ
02-18A PA, TV, PZ
02-12
P-6-96
02-T3
P-11-96 SP
P-10-96 SP
WATER
P-4-96
TO PACIFICA

MAIN SLIDE COMPLEX

P-2/P-2A-83

P-8-96

EXIST. ROAD

P-3B

STAGING AREA TA-1
TURN-AROUND

P-1-83

02-T2A

02-T2B

P-12-96
SP

P-13-96
SP

SB TUNNEL

NB TUNNEL

PA
TV
PZ
02-6

TEMP. ACCESS ROAD P-2

02-6A

02-7
TV, PA, PZ

02-7A
TV

02-8B

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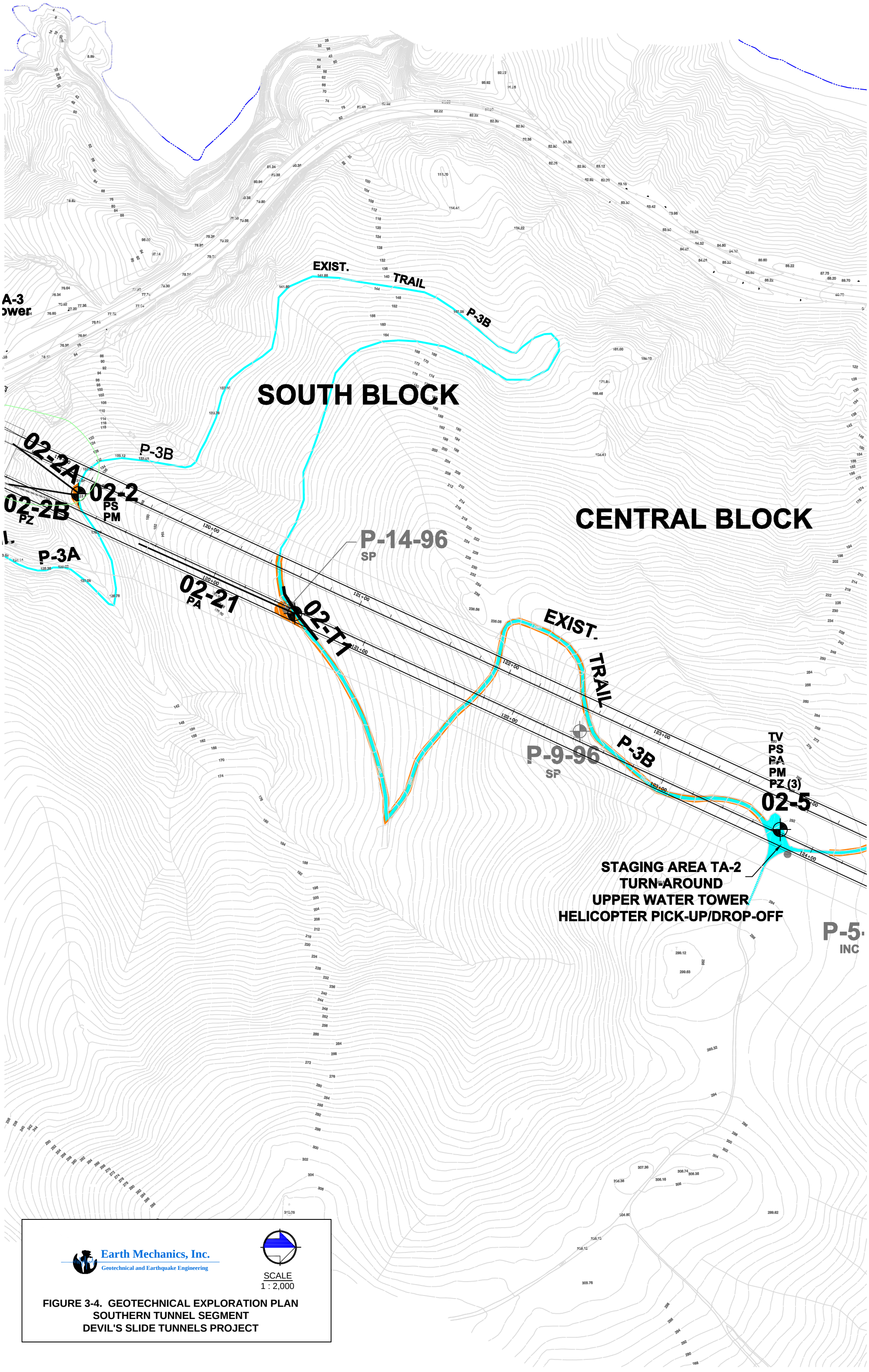
SCALE
1 : 2,000

FIGURE 3-3. DETAIL EXPLORATION MAP
OF NORTHERN TUNNEL SEGMENT/NORTH PORTAL AREA
DEVIL'S SLIDE TUNNELS PROJECT



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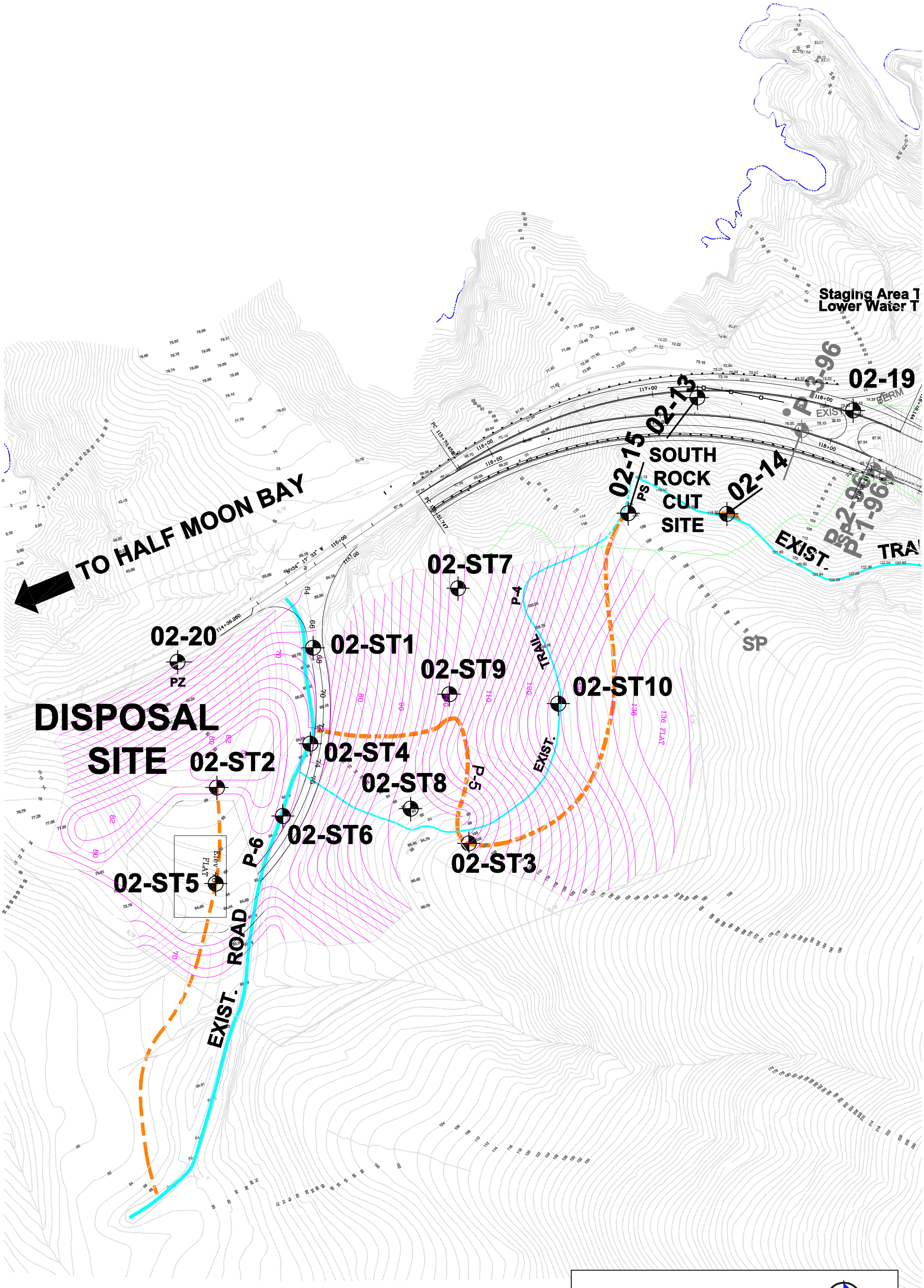
SCALE
1 : 2,000

FIGURE 3-4. GEOTECHNICAL EXPLORATION PLAN
SOUTHERN TUNNEL SEGMENT
DEVIL'S SLIDE TUNNELS PROJECT



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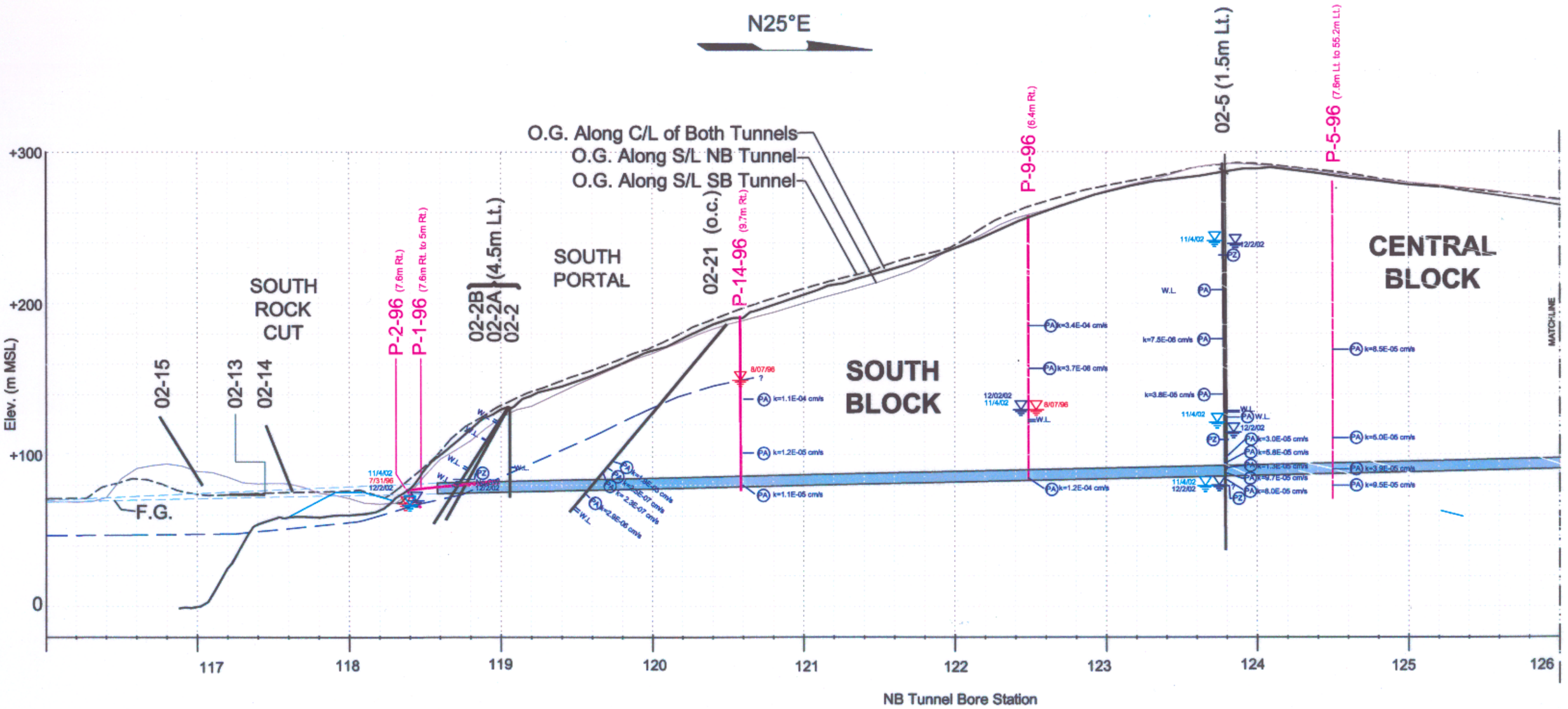
SCALE
1 : 2,000

FIGURE 3-5. DETAIL EXPLORATION MAP OF DISPOSAL/ROCK CUT/SOUTH PORTAL AREAS DEVIL'S SLIDE TUNNELS PROJECT



LEGEND

02-11	2002 Boring by EMI
02-T3	2002 Trench by EMI
B-1	2002 Boring by Caltrans
P-7-96	1996 Boring by WCC

Groundwater data

PA	Packer Test Location (with rock permeability k)
PZ	Piezometer Location
W.L.	Water Loss (drill fluid) During Drilling

Last available groundwater data

Initial groundwater data

1996 groundwater data

SCALE
1:2,500

Figure 3-6. Cross-Section Along Tunnels Alignment With Groundwater Data

Sheet 1 of 2
Devil's Slide Tunnels Project

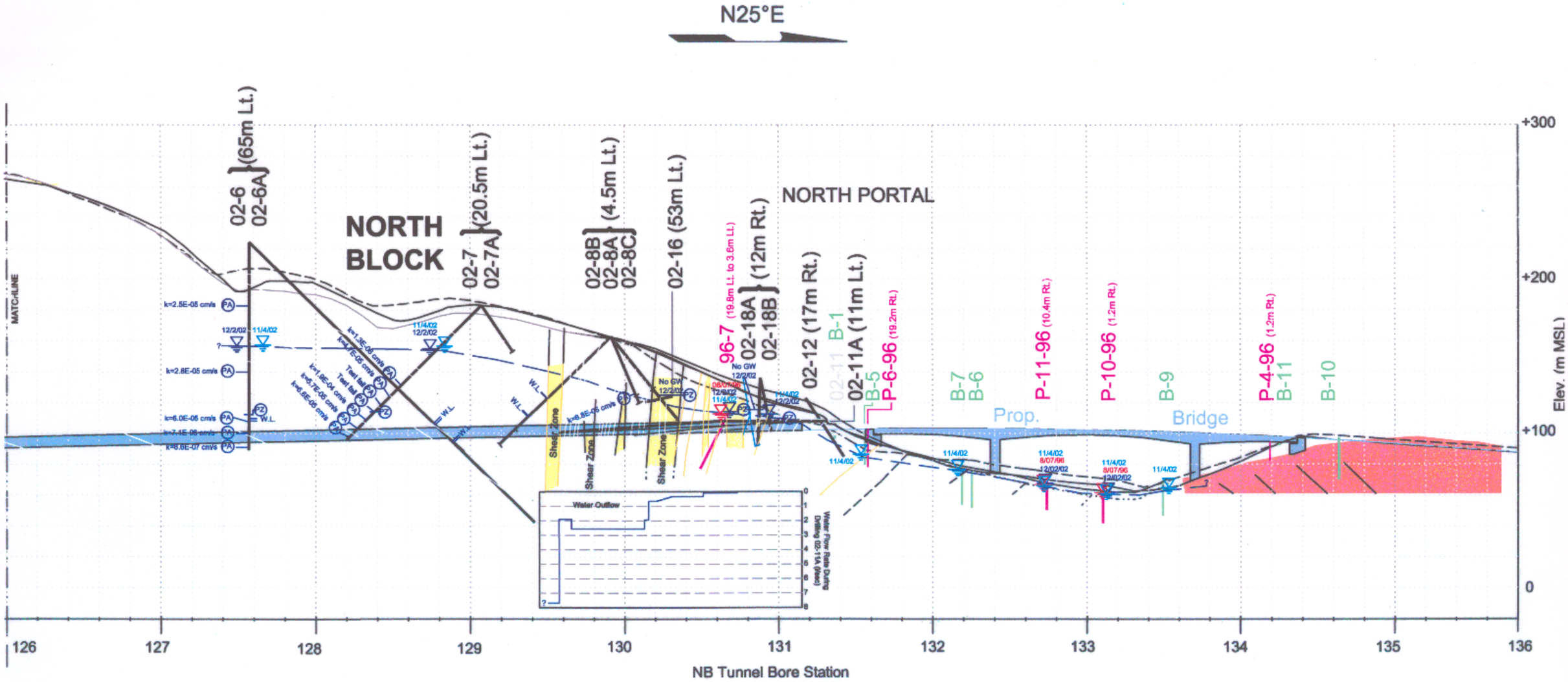
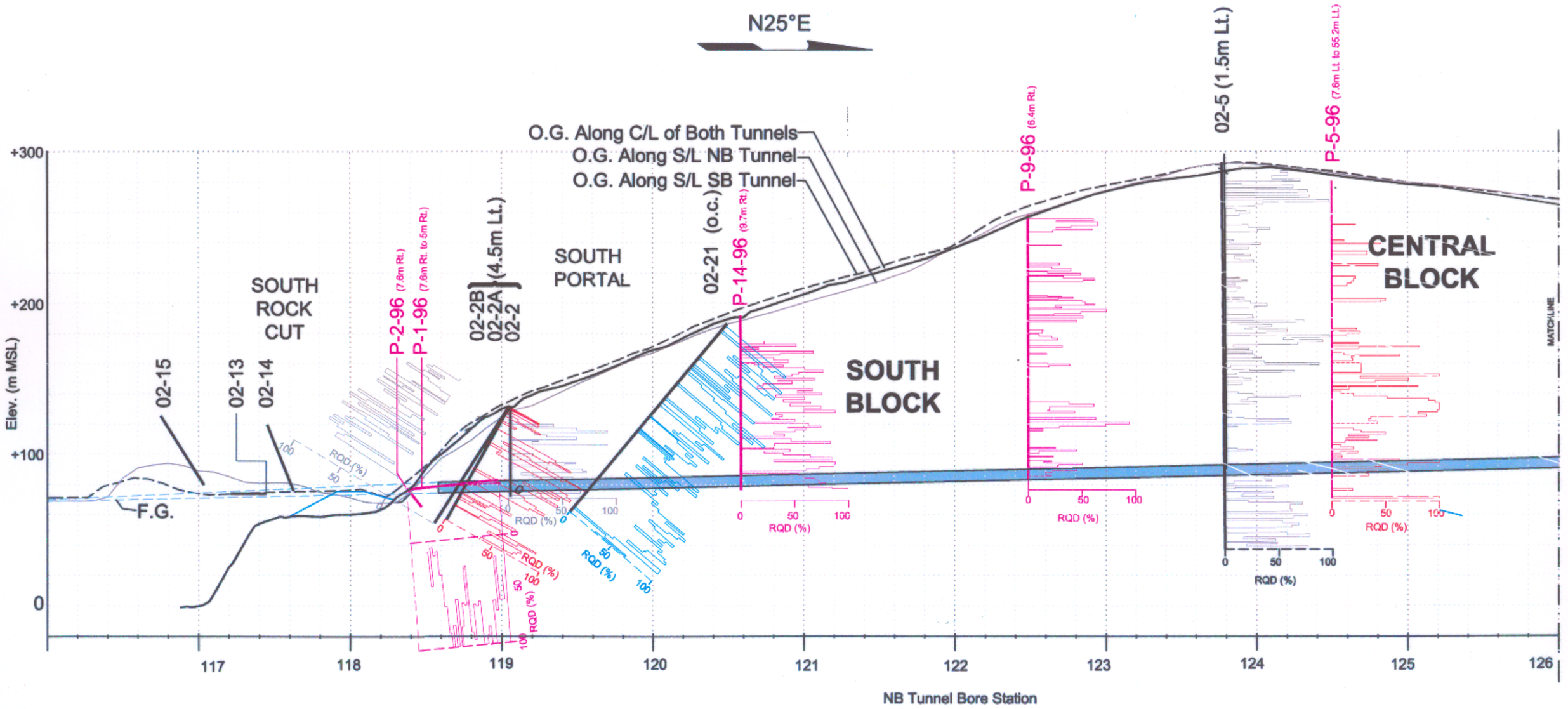


Figure 3-6. Cross-Section Along Tunnels Alignment With Groundwater Data

Sheet 2 of 2
Devil's Slide Tunnels Project



LEGEND

02-11	2002 Boring by EMI
02-T3	2002 Trench by EMI
B-1	2002 Boring by Caltrans
P-7-96	1996 Boring by WCC

SCALE
1:2,500

Figure 3-7. Cross-Section Along Tunnels Alignmer With RQD Data

Sheet 1 of 2
Devil's Slide Tunnels Project

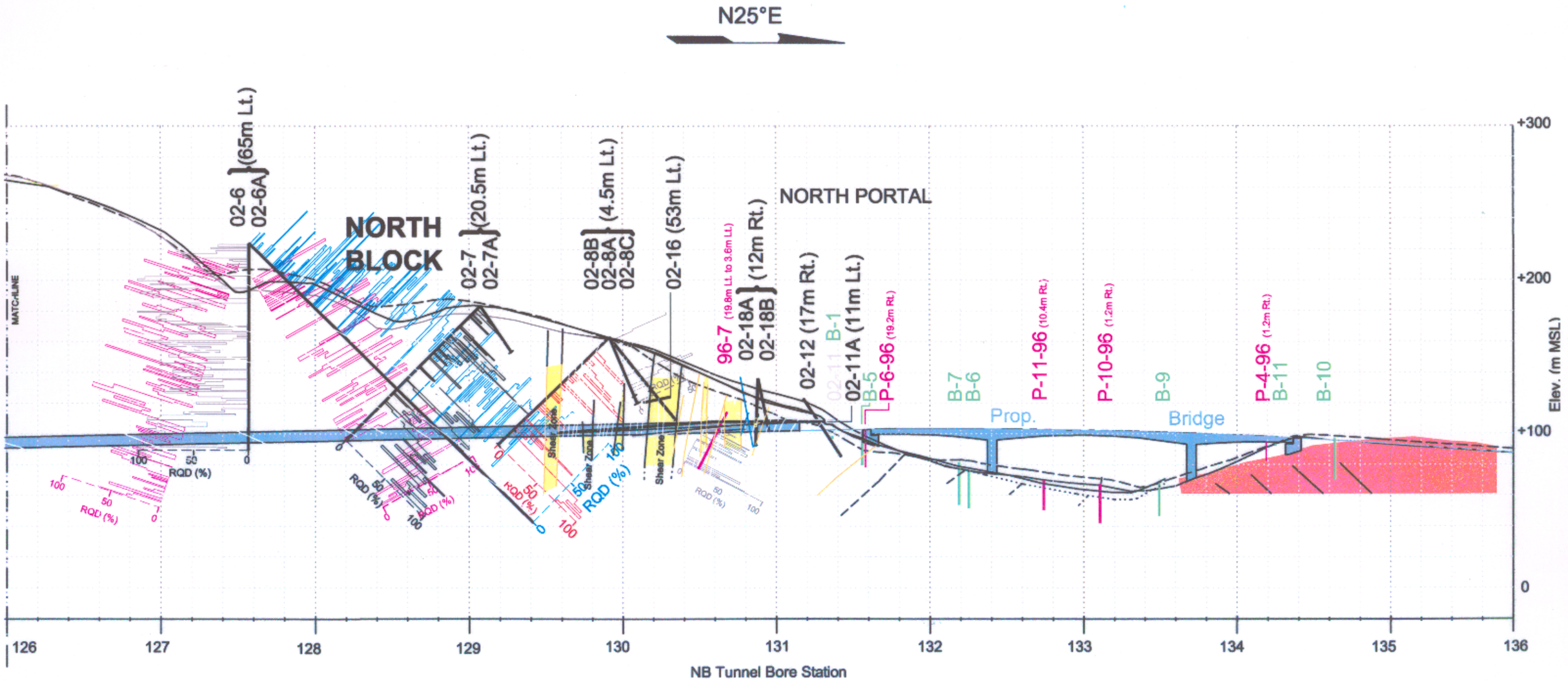


Figure 3-7. Cross-Section Along Tunnels Alignment With RQD Data

Sheet 2 of 2
Devil's Slide Tunnels Project

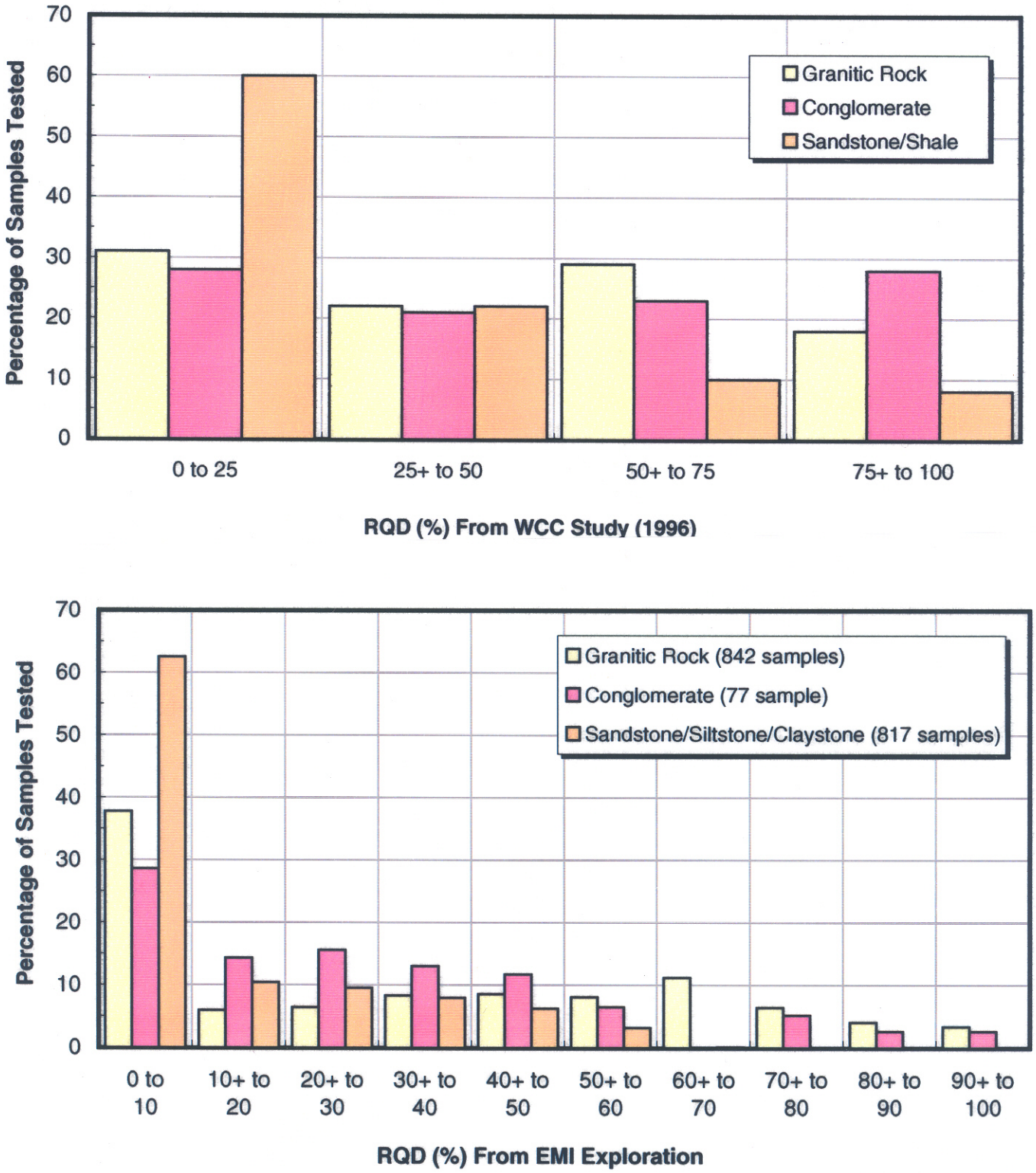


Figure 3-8. Summary of Rock RQD Values

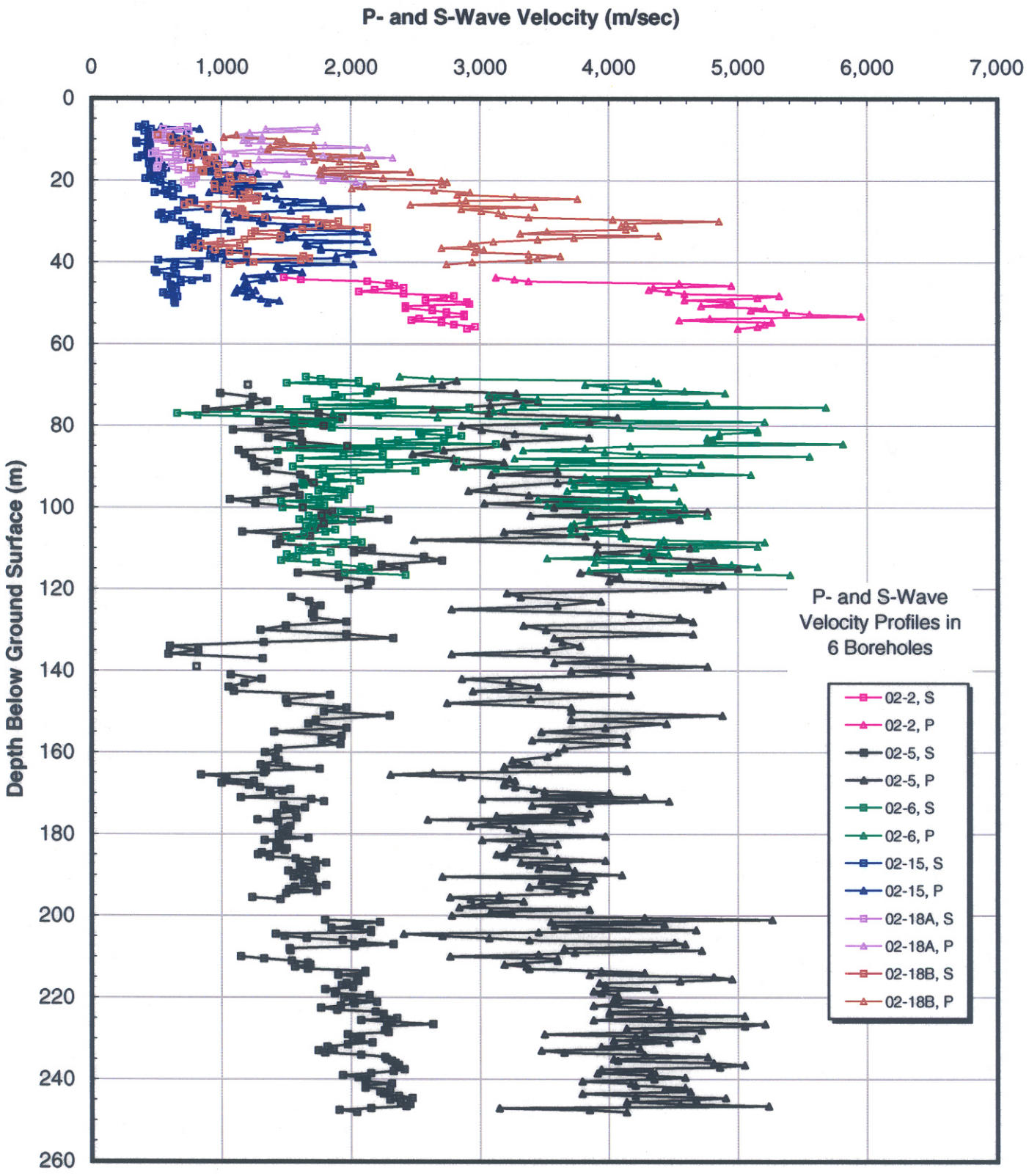


Figure 3-9. Summary of Rock Compression and Shear Wave Velocities

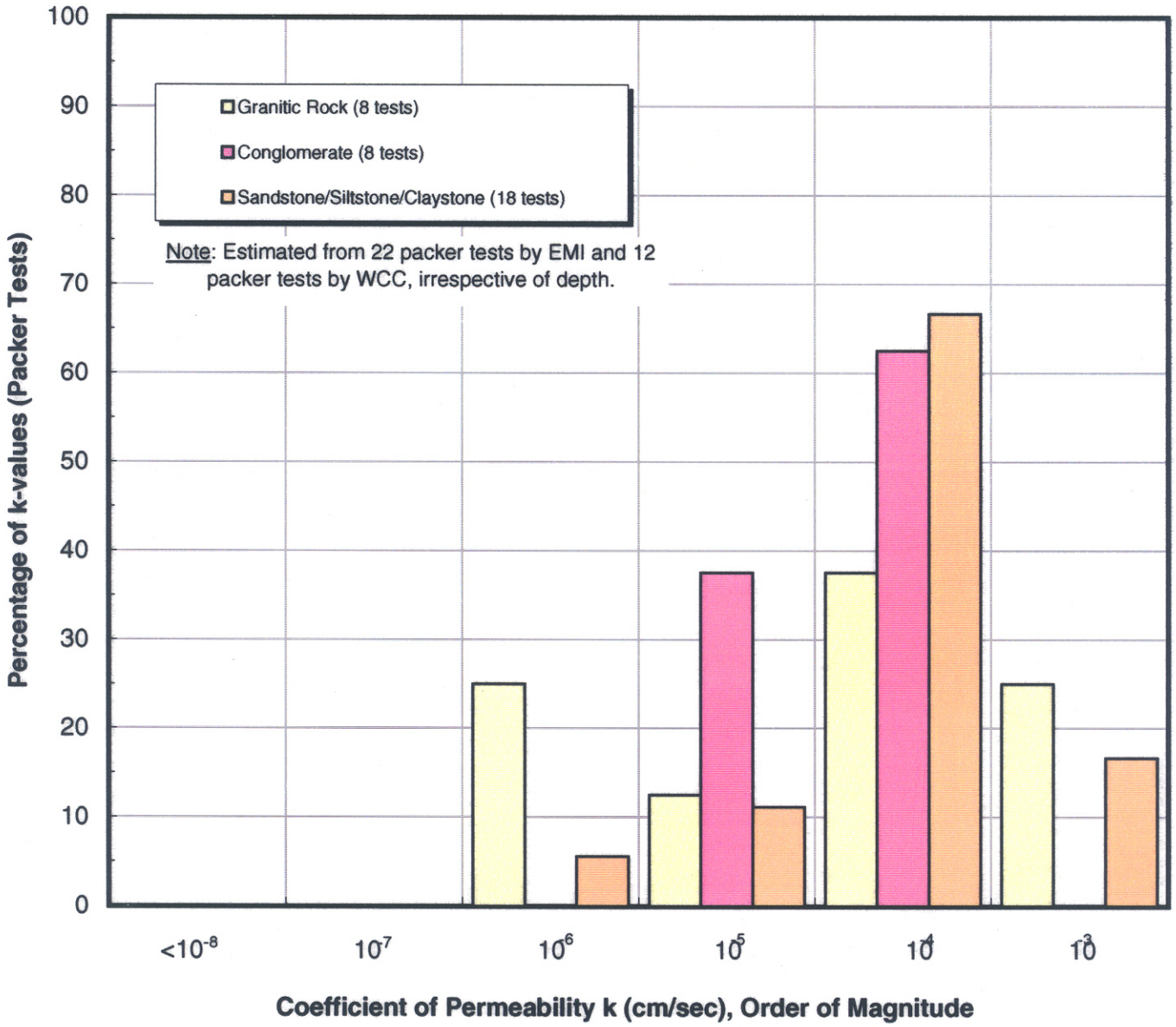


Figure 3-10. Summary of Rock Coefficients of Permeability

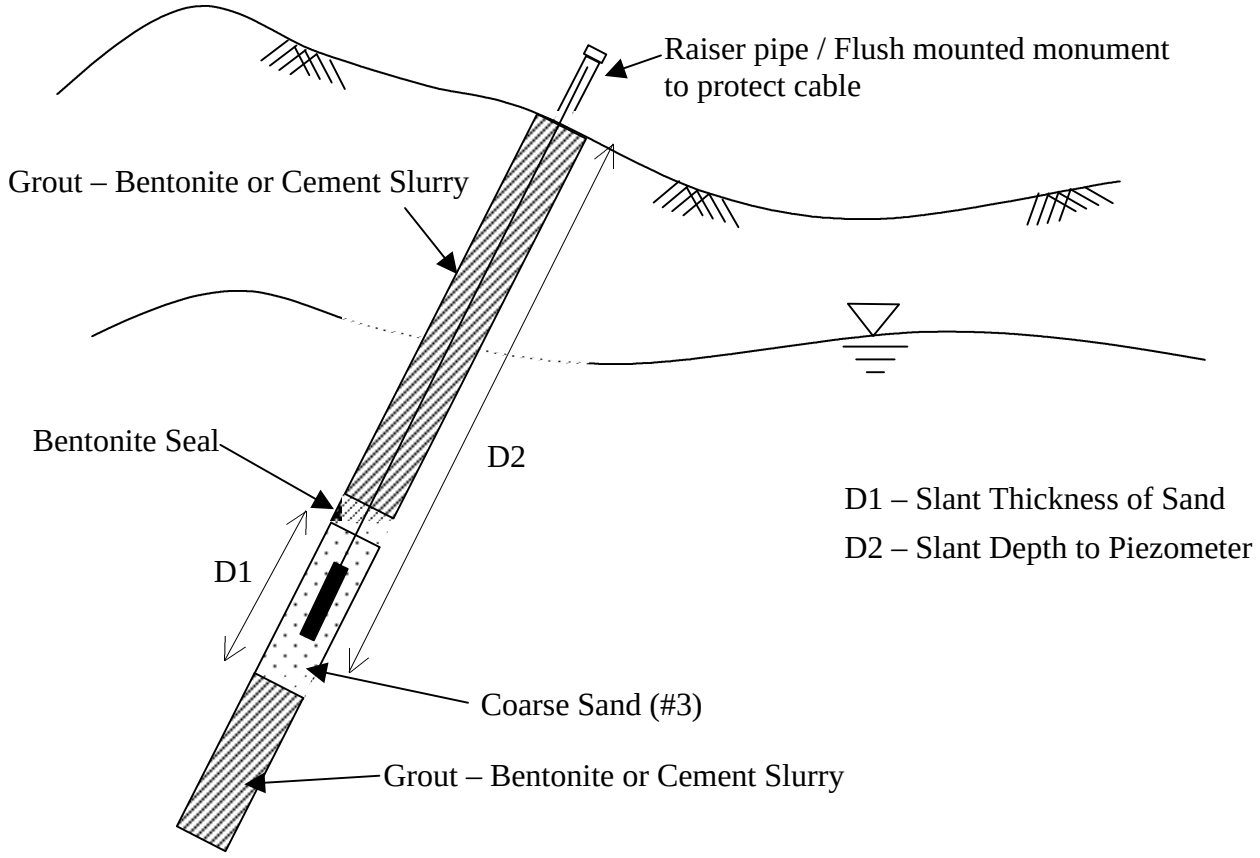


Figure 3-11. Schematic of Single Piezometer Installation

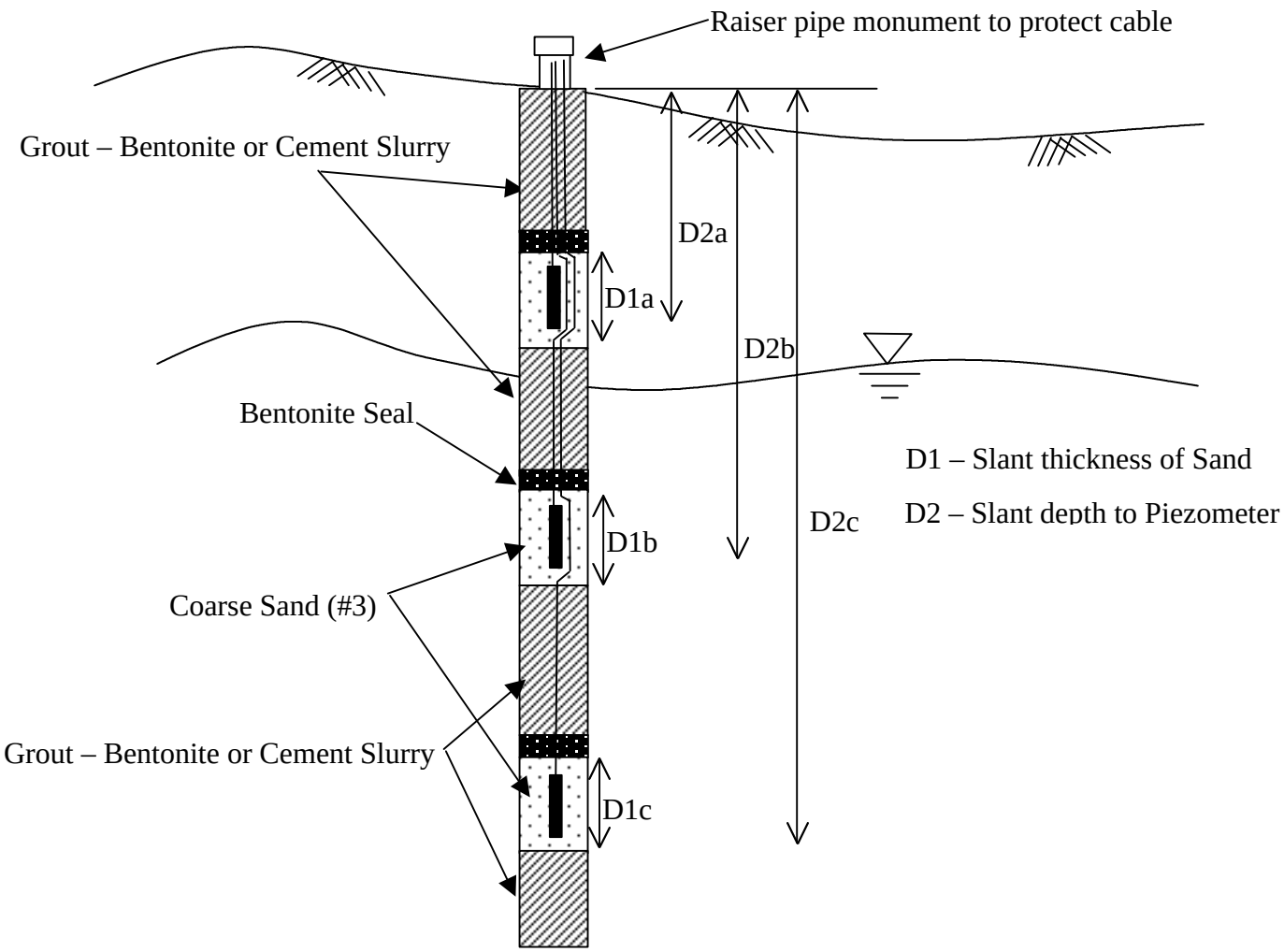


Figure 3-12. Schematic of Multi Piezometer Installation

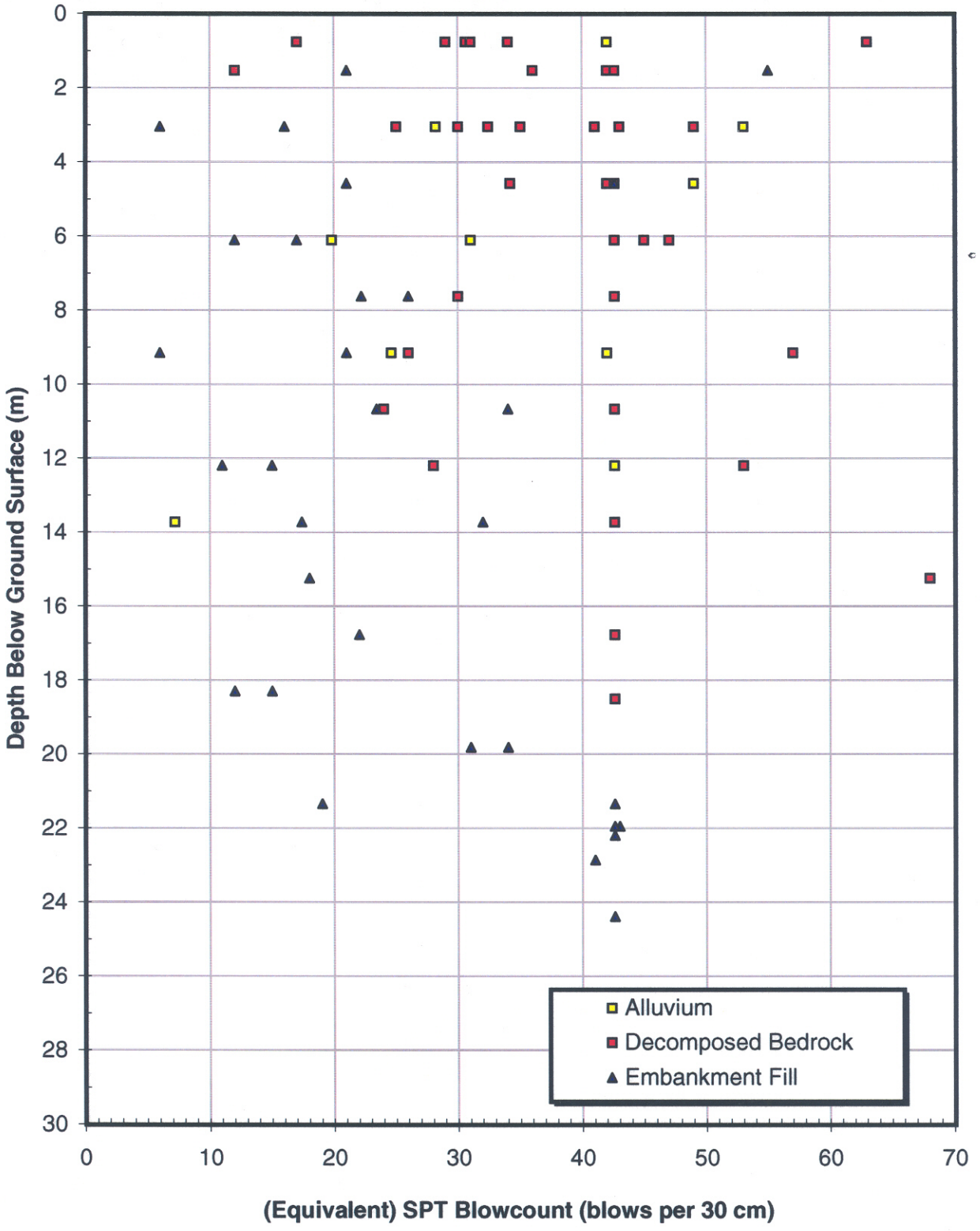


Figure 3-13 Summary of "Soil" Penetration Blowcounts

SECTION 4.0

LABORATORY TESTING

4.0 LABORATORY TESTING

A laboratory testing program was performed by EMI to characterize the on-site rock, soil, water and air, and to permit development of geotechnical parameters for engineering analysis and design. Laboratory testing from prior investigations (WCC, 1996) are documented in that report. The summary tables and plots in this section include the test results from those investigations as noted.

4.1 Rock Testing

4.1.1 General

GeoTest Unlimited (GTU) of Nevada City, California conducted laboratory testing on selected rock specimens. Testing consisted of density and in-situ moisture content tests of every sample tested, unconfined compression and Young's modulus strength tests of intact cores and cores with healed joints, direct shear tests of cores with well-defined joints, and single-stage and one multi-stage triaxial tests. Finally, a suite of rock abrasion tests was performed. The tests were performed in accordance with the American Society for Testing and Material (ASTM, 2001) and International Society for Rock Mechanics (ISRM, 1985) guidelines, unless otherwise noted.

The selection of the cores for testing was based on the rock type, weathering characteristics as well as the foundation design aspects. Unconfined compression tests were performed on cores collected near the proposed tunnel. Direct shear tests where performed on samples collected where excavations might trigger instability along discontinuity planes in the rock mass.

The laboratory tests of rock core are summarized in Table 4-1. Testing procedures and results are presented in Appendix B-4. Interpretation and evaluation of the test results is given in Section 4.1.

4.1.2 Unit Weight

The total unit weights from lab testing are plotted in the histogram of Figure 4-1. The ranges for crystalline/granitic rock and sedimentary rock are tabulated in Table 4-2. The data indicates that the weathered rock generally has a slightly lower unit weight than the fresh rock.

4.1.3 Unconfined Compression Tests

A total of 81 unconfined compression (UC) tests were performed on cores collected near

the proposed tunnel bores. The ranges of unconfined compressive strengths q_u are tabulated in Table 4-3 by rock type. A summary plot of the data is presented in Figure 4-2. The samples exhibited a large range in strengths.

4.1.4 Point Load Tests

A total of 135 point load tests (PLT's) on selected rock specimens were performed at the core storage trailer site in the City of Pacifica. Testing was performed in the field using a Rocktest Model PIL-5 point load tester in general accordance with the suggested method for PLT by the ISRM (1985). The test measures the point load strength index $I_{s(50)}$ and strength anisotropy index $I_{a(50)}$ of rock specimens. The PLT is used as an index test for the strength classification of rock materials.

Core selection was made by an EMI geologist/engineer for the purpose of characterizing strength for different rock types and conditions encountered. Only 100 tests met the ISRM criteria and were evaluated. The HQ core diameter for all tests was nearly 61 mm. The failure mode of each core specimen was carefully recorded in order to obtain an accurate point load strength index measurement.

Key test information of the 100 valid tests are listed in Table 4-4, classified by lithology type and failure mode. The data was separated by two failure modes: (1) breakage along existing fracture surfaces I_f , and (2) breakage of intact samples per standard PLT criteria I_s established by the ISRM (1985).

The PLT is also correlated with other rock strength parameters such as the unconfined compressive strength q_u for strength classification of rock materials. Values of q_u were estimated per ISRM (1985) using a factor of 24 times the corrected point load strength $I_{s(50)}$. The resulting ranges of estimated q_u are summarized in Table 4-5 and plotted in the histogram of Figure 4-3, classified by lithology type and condition. For the moderately to intensely weathered siltstone/claystone, only a few samples of this category were suitable for testing; range may not be representative of strength for these rock conditions. These estimated q_u values are considered only approximate due to the nature of PLT testing.

4.1.5 Young's Modulus

Elastic Young's moduli *E* were derived from 20 unconfined and 11 triaxial compression tests, and are plotted on Figure 4-4. Young's moduli were obtained from the tests by determining the slope of the axial stress versus axial strain curve. The elastic Young's Modulus values are representative of moduli for intact rock materials (see Appendix B-4). The figure presents Young's moduli from these fairly intact laboratory specimens.

The ranges of typical Young's moduli for each lithology type are tabulated in Table 4-6.

For conglomerate, only a single value (59.1 GPa) was measured.

4.1.6 Poisson's Ratio

Values of Poisson's ratio *n* were obtained from 20 unconfined compression tests on samples from borings and are plotted in the histogram of Figure 4-5. Values of Poisson's ratio for bedrock materials were determined by measuring radial strains in the same unconfined compression tests for which modulus values were measured and then calculating the ratio of radial to axial strain (see GTU report in Appendix B-4).

The ranges of Poisson's ratios ν for each lithology type are tabulated in Table 4-7. For siltstone / claystone, Poisson's ratios in excess of 0.5 appear to be in contradiction with isotropic elastic theory but this discussed in GeoTest's report in Appendix B-4. For conglomerate a single value of Poisson's ratio equal to 0.21 was measured.

4.1.7 Triaxial Compression Tests

A set of 10 single-stage triaxial tests were performed on different rock types. However, the test results exhibited a large amount of scatter (see Appendix B-4) and no clear, useful failure envelope could be traced.

In addition, two multistage triaxial compression tests were performed on a rock core from 195.1 m depth in borehole 02-5 to help evaluate the shear strength of the fault gouge material, which mainly consists of sheared claystone (see Appendix B-4). The range of shear strength parameters for gouge material developed from these tests are given in Table 4-8.

4.1.8 Direct Shear Tests

A total of 20 direct shear tests were performed to evaluate the shear strength along existing discontinuity planes in the granitic rocks, sandstone and siltstone / claystone. Samples were collected from locations where excavations might trigger instability along discontinuity planes in the rock mass. The ranges of derived peak and post-peak strength parameters are given in Table 4-9. The direct shear test results are plotted on Figure 4-6 for claystone, Figure 4-7 for sandstone, and Figure 4-8 for granitic rock. The peak shear strength values are shown as solid symbols, and the post-peak values are shown as open symbols.

As described in Appendix B-4, the direct shear testing program evaluated a variety of joint / fracture conditions including roughness (smooth to moderately rough), filling type / thickness (calcite / quartz), and fracture inclination / dip.

Review of test data for the granitic core samples (10 tests) indicates that the peak values

show fairly high angles of internal friction (in the 40° range) and fairly wide range of shear intercept (S_j). The post-peak values indicate a tighter grouping and lower friction angle (in the 30° range). The sandstone and siltstone/claystone samples tested generally had lower friction angles, generally in the mid to upper 20° range. As expected, the gouge material had lower friction angles, in the 15° range.

4.1.9 Abrasion Tests

A suite of 25 rock abrasion tests was performed by GTU according to the Cerchar procedure as described by West (1989). The purpose of these tests was to measure for abrasive rock cutting tools during tunnel boring.

Many of these cores tested were adjacent core subjected to unconfined compressive strength (see Section 4.1.3). The test procedure and test results are outlined in Appendix G-4. The test results were categorized by tunnel segment and rock type and are summarized in Table 4-10.

4.1.10 Petrographic Analysis (Mineralogy)

A total of 15 samples of representative rock types from several of the core borings and trenches were selected for a petrographic study of 16 thin sections in order to better understand the rock fabric. Table 4-11 lists the samples selected for the sedimentary rocks and Table 4-12 lists the granitic rocks samples.

Testing procedures and a scientific interpretation of the test results were performed by Spectrum Petrographics of Roseburg, Oregon and are presented in Appendix C-4. The mineral percentages of the sedimentary rocks samples and granitic rock samples are tabulated in Table 4-11 and Table 4-12, respectively. The tables include petrographic analyses performed on rock outcrop samples as part of the Phase 2A investigation (see Section 3.1.2), as well as the analyses from the feasibility study (WCC, 1996).

4.1.11 Aggregate Potential Reactivity

Potential alkali-silica reactivity of aggregates was conducted for two rock specimens. The alkali aggregate reaction is a chemical reaction between reactive aggregate and free alkalis in the concrete pore water. The testing was conducted in accordance with ASTM Standard (ASTM C289 Chemical Method) on one sample of massive, fine-grained sandstone with a calcite-silt matrix from borehole 02-6 at 11.8m depth, and one sample of micro-conglomeratic medium-grained sandstone with a calcite-silt matrix from borehole 02-7 at about 123.4 m depth.

The testing procedures and test results are given in Appendix D-4. Based on the ASTM C289, Figure 2, the two core samples tested are considered potentially deleterious.

4.2 Soil Testing

4.2.1 General

Fill and native soil samples from the boreholes drilled through Route 1 embankment areas (02-19 and 02-20),, and in native soil-like materials derived from rock in the disposal basin (02-ST1 through 02-ST10) were tested for soil classification, strength parameters and corrosion potential at EMI's laboratory. A bulk sample was taken from near the 02-19 location to determine R-value for roadway pavement design.

All soil testing was performed in general accordance with California Test Methods and applicable American Society for Testing and Materials (ASTM) standards. Table 4-14 summarizes the types of tests performed, the corresponding test methods and the intended testing purpose. The individual test results are presented in Appendix A-4.

Environmental laboratory testing was performed on selected samples of excess cuttings and water (not controlled soil samples) by Universal Environmental under contract to Ruen Drilling for the purpose of characterization for proper waste disposal. These test results and accompanying chain of custody forms are presented at the end of Appendix A-4. It should be noted that it is beyond the scope of this investigation to characterize site contamination, and therefore the suite of chemical test results included in Appendix A-4 does not represent a complete study of site soil chemistry.

In the following, test results are described by geologic unit encountered.

4.2.2 Existing Artificial Fills

4.2.2.1 Moisture and Unit Weights

Based on borings 02-19 and 02-20, the moisture content of the existing embankment fill soils ranged from about 10.8 to 22.3%; the total unit weight ranged from about 20.9 to 22.4 kN/m^3; and the dry unit weight ranged from about 17.1 to 19.8 kN/m^3. The water contents are shown in the histogram of Figure 4-13. The unit weights are shown in the histogram of Figure 4-14.

4.2.2.2 Soil Strength Parameters

Direct shear tests were performed on six samples of silty and clayey sand collected from borings 02-19 and 02-20. Ultimate strength values ranged as follows: friction angles ranged from 31.1° to 34.2° with the average value equal to about 32.7°, and cohesion ranged from 0 to 17.8 kPa with the average cohesion equal to about 11.6 kPa. Peak strength values ranged as follows: friction angles ranged from 33.2° to 42.1° with the average value equal to about 36.9°, and cohesion ranged from 24.7 to 54.3 kPa with the

average equal to about 34.2 kPa. Results of the direct shear tests are summarized in Table 4-16.

In addition, SPT blowcounts and "equivalent" SPT blowcounts (from the California Drive Sampler) were used to estimate shear strength using published correlations (the SPT profiles are shown in Figure 3-13). The uncorrected SPT and "equivalent" SPT blowcounts in the sandy soils, in boring 02-19 between El. +60 m and +44.9 m, ranged between 6 and 28 blows per 30 cm, with the average value equal to about 16 blows per 30 cm. Blowcounts indicate that the majority of the fill soils are medium dense with a few thin localized loose layers. Based on the range of blowcounts, the friction angles range from about 28° to 34°. Using the average blowcount of 16, the friction angle is estimated to be 32° for the overall fill mass.

The uncorrected SPT and "equivalent" SPT blowcounts in the silty and clayey sands, in boring 02-20 between El. +60 m and +44.9 m, ranged between 15 and 48 blows per 30 cm, with the average value equal to about 23 blows per 30 cm. Based on the range of blowcounts, the friction angle is estimated to range between 32 and 36°. Using the average blowcount of 23 blows per 30 cm, the friction angle is estimated to be 32° for the fill mass.

The uncorrected SPT and "equivalent" SPT blowcounts in the sandy lean clay layer, in boring 02-20 between El. +44.9 m and +41.3 m, ranged from 12 to 18 blows per 30 cm, with the average equal to about 15 blows per 30 cm. Based on the average blowcount of 15 blows per 30 cm, the undrained shear strength is in the range of 72 to 95 kPa.

4.2.2.3 Settlement Characteristics

Soils encountered in boring 02-19 and the majority of soils observed in boring 02-20 are not susceptible to long-term consolidation settlement because of their granular (sandy) nature. In addition, based on SPT blowcounts, recorded in the two borings, the sandy soils are generally medium dense, in terms of consistency, with localized thin dense layers. Consequently, "immediate" settlement that may occur in the sandy soils, due to proposed fill placed against the embankments, is anticipated to be negligible.

Based on one consolidation test, the sandy clay, encountered in boring 02-20 between El. +44.9 m and +41.3 m, has a compression ratio (C'_c) of about 0.06 and a recompression ratio (C'_r) of about 0.008.

4.2.2.4 Soil Corrosivity

Two representative samples of the fill soils were tested to determine minimum resistivity, pH, soluble sulfate content, and soluble chloride content using the procedures described in California Test methods 417, 422, 532, and 643. The results of

the tests are summarized in Table 4-17.

According to Caltrans criteria (Memo to Designers 3-1, 1996), soils are corrosive if the minimum resistivity is less than 1,000 ohm-cm, or the chloride content is greater than 500 parts per million (ppm), or soluble sulfate content is greater than 2,000 ppm. Based on the test results and the Caltrans criteria, the fill soils are not corrosive to bare metal or concrete.

4.2.3 Soil-Like Materials

4.2.3.1 Moisture and Unit Weights

Based on borings 02-ST1 through 02-ST10, the moisture content of the decomposed Montara Formation (soil-like materials) within the disposal area ranged from about 7.1 to 19.5%; the total unit weight ranged from about 18.9 to 21.8 kN/m^3; and the dry unit weight ranged from about 17.4 to 20.1 kN/m^3. The water contents are shown in the histogram of Figure 4-13, and the unit weights are shown in the histogram of Figure 4-14, categorized by alluvium and decomposed bedrock.

4.2.3.2 Soil Strength Parameters

Direct shear tests were performed on numerous samples of the decomposed Montara Formation collected from borings 02-ST1 through 02-ST10. The ultimate strength values were ranged as follows: friction angles ranged from 18.5° to 41.9° with the average value equal to about 29.4°, and cohesion ranged from 1.7 to 80.1 kPa with the average cohesion equal to about 28.9 kPa. Peak strength values were ranged as follows: friction angles ranged from 11.6 to 46.9° with the average value equal to about 30.4°, and cohesion ranged from 12.4 to 154.6 kPa with the average equal to about 65.3 kPa. Results of the direct shear tests are summarized in Table 4-18.

4.2.3.3 Settlement Characteristics

Based on the consolidation test results, the upper 4.6 m of soil-like material generally is overconsolidated, with the overconsolidation ratio (OCR) ranging from about 1.2 to 2.4. Below a depth of 4.6 m, materials appear to be normally-consolidated with OCR's equal to about 1.0 and less. OCR's significantly less than 1.0 indicate disturbed samples. The compression ratio (C'_c) was determined to range between about 0.032 and 0.07, with the average equal to about 0.05. The recompression ratio (C'_r) was determined to range between about 0.008 and 0.04, with the average equal to about 0.017.

4.2.3.4 Soil Corrosivity

Five representative samples of soil-like materials were tested to determine minimum

resistivity, pH, soluble sulfate content and soluble chloride content using the procedures described in California Test methods 417, 422, 532 and 643. The results of the tests are summarized in Table 4-20.

According to Caltrans criteria (Memo to Designers 3-1, 1996), soils are corrosive if the minimum resistivity is less than 1,000 ohm-cm, or the chloride content is greater than 500 ppm, or the soluble sulfate content is greater than 2,000 ppm. Based on the test results and the Caltrans criteria, the fill soils are not corrosive to bare metal or concrete.

4.3 Groundwater Chemistry

This section summarizes the chemical analyses conducted on groundwater samples collected from two boreholes during the site investigation program at various times.

Sampling and Analysis. Groundwater samples were collected from horizontal borehole 02-11A, located at north portal area, on September 11, 2002 and from vertical borehole 02-5, located in the central block, on September 27, 2002. Groundwater samples from borehole 02-11A were collected by means of flow directly into laboratory-supplied containers. Water sampling was attempted in south portal area in borehole 02-2, but was unsuccessful due to dry holes.

These samples were collected in the morning before the beginning of any drilling activities to avoid any contamination due to the drilling fluid. Water samples from borehole 02-5 were collected using a new, clean disposable bailer. The samples were decanted from the bailer into the laboratory-supplied containers. After the samples were collected from the boreholes and labeled, they were delivered in the same day under EMI's chain-of-custody procedure to Severn Trent Labs, a California-certified analytical laboratory located in San Francisco, California. The samples were transported to the laboratory in ice-cooled, insulated chests. Groundwater samples were analyzed for the following constituents in accordance with the following EPA methods:

- Total Petroleum Hydrocarbons quantified against a gasoline standard (TPHg) by modified EPA Method 8015;
- Dissolved Methane by EPA 3810;
- Polynuclear Aromatic Hydrocarbons (PNAs) by EPA Method 8270C; and
- pH by EPA Method 9040.

Quality control / quality assurance samples included an equipment blank sample and a laboratory control spike.

Test Results. A summary of groundwater test results is provided in Table 4-13. The laboratory analytical reports and chain of custody records are provided in Appendix E-4. Dissolved methane was not detected in either groundwater sample tested.

4.4 Air Chemistry

Chemical analyses were conducted on air samples collected from six boreholes at various times during the site investigation program.

Sampling and Analysis. On August 8, 2002, air samples were collected from borehole 02-18A, located close to the North Portal area, boreholes 02-8A, 02-7, 02-6 located in central block area. On October 2, 2002, air samples were collected from borehole 02-5 in the Central Block area and borehole 02-2 in South Portal area. Air samples from these boreholes were collected directly into laboratory-supplied Tedlar bags by means of a small Thomas vacuum pump. The air was sucked from the boreholes at around 4.6 m below the top of the boreholes using a long tube connected to the vacuum pump. To remove residual air in the tube and pump, the pump was operated and sucked air was released for a few minutes before sampling.

The samples were collected after the boreholes had achieved their target depths and activities had been completed to avoid any cross-contamination and to detect possible release of any toxic air from bottom of the holes. After the samples were collected from the boreholes and labeled, they were delivered the same day (under EMI chain-of-custody procedures, to Air Toxic Ltd., a California-certified analytical laboratory located in Folsom, California).

Air samples were analyzed for the following constituents in accordance with the following EPA / ASTM standards:

- TO-15 compounds by Modified EPA method TO-15;
- Hydrogen Sulfide by Modified ASTM D-5504; and
- Methane by Modified ASTM method D-1946.

Quality control / quality assurance samples included an equipment blank sample and a laboratory control spike.

Test Results. The laboratory analytical reports and chain of custody records are provided in Appendix E-4. Methane was detected in a small amount in all samples and hydrogen sulfide was not detected in any air samples.

Table 4-1. Summary of Rock Laboratory Tests

Type of Test	*Applicable Test Method*	*Purpose*	*Total No. of Tests*
Dry Density	ASTM D-4543	In-Situ Density	91
Unconfined Compression	ASTM D-2664 & D-2938	Unconfined Compressive Strength	81
Direct Shear	ASTM D-5607	Friction Angle and Cohesive Strength of Joint	10
Young's Modulus	ASTM D-3148	Modulus of Elasticity	20
Poisson's ratio		Deformability	20
Triaxial	ASTM D-4767	Strength	10 single-stage 1 multi-stage
Abrasion	Cerchar	Abrasiveness	25

Note:
ASTM = American Society for Testing and Materials

Table 4-2. Summary of Rock Unit Weights

Rock Type	*Range of Total Unit Weight* γ *(kN/m^3)*
Sedimentary Sandstone/Siltstone/Claystone/ Conglomerate, fresh to slightly weathered	26.8 to 27.4
Sedimentary Sandstone/Siltstone/Claystone/ Conglomerate, weathered/sheared	23.1 to 26.0
Granitic Rock, fresh to slightly weathered	26.8
Granitic Rock, weathered/sheared	23.5 to 26.7

Table 4-3. Summary of Rock Unconfined Compressive Strengths

Rock Type	*Range of Unconfined Compressive Strength q_u (MPa)*	*Range of Total Density (kN/m^3)*
Sandstone, fresh to moderately weathered	14 to 195	26.8 to 27.3
Sandstone, moderately to intensely weathered	0 to 14	23 to 26
Siltstone/Claystone, fresh to slightly weathered	14 to 120	26.8 to 27.4
Siltstone/Claystone, mod. to int. weathered	0 to 14	23.1 to 26
Conglomerate, fresh to slightly weathered	4 to 152	25.9 to 26.2
Conglomerate, moderately to intensely weathered	0.1 to 0.3	25.6 to 25.9
Granodiorite/granitic, fresh to slightly weathered	24 to 49	26.8 to 27.4
Granodiorite/granitic, moderately to intensely weathered	0.6 to 24	23.5 to 26.7

Table 4-4. Summary of Point Load Tests

Boring No.	Sample Depth (m)	Sample Description	Strength Index, $I_{s(50)}$ (MPa)	Unconf. Compr. Strength q_u (MPa) [b]	Failure Mode[a]
		Granitic Rock			
02-2B	47.73	QUARTZ DIORITE, moderately weathered, coarsely crystalline, calcite veining	1.01	24.3	2
02-2B	78.88	QUARTZ DIORITE, fresh / slightly weathered	2.86	68.7	2
02-2B	76.05	QUARTZ DIORITE, moderately weathered, fracture surface irregular	2.43	58.2	2
02-2A	48.55	QUARTZ DIORITE, slightly to moderately weathered, incipient fractures along length	3.81	91.4	2
02-2A	57.85	QUARTZ DIORITE, slightly weathered, irregular surface follows incipient fractures	2.86	68.7	2
02-21	112.47	QUARTZ DIORITE, fresh, fine grained, numerous veins throughout material	2.70	64.7	2
02-21	111.34	QUARTZ DIORITE, cataclastic, well cemented	9.43	226.4	2
02-05	245.49	DIORITE, fresh, 40% dark minerals	0.84	20.2	2
02-2B	82.75	QUARTZ DIORITE, slightly weathered, numerous calcite veins	0.40	9.7	1
02-2A	83.00	QUARTZ DIORITE, slightly weathered, some incipient fractures	0.81	19.4	1
02-05	254.97	DIORITE, few calcite veins	1.48	35.6	1
02-05	254.97	DIORITE, retest, few calcite veins	0.00	0.0	1
02-05	207.57	DIORITE, fresh, unweathered, abundant calcite veins and incipient joints	0.44	10.5	1
02-05	206.14	DIORITE, calcite veining	1.68	40.4	1
02-05	110.19	QUARTZ DIORITE BOULDER within CONGLOMERATE, calcite cemented joints	2.09	50.1	1
02-21	91.99	QUARTZ DIORITE, cataclastic, some incipient fractures	0.00	0.0	1
02-6A	76.05	QUARTZ DIORITE BOULDER within CONGLOMERATE, foliated, oxidized incipient joints	2.86	68.7	1
02-6A	76.11	QUARTZ DIORITE BOULDER within CONGLOMERATE, foliated, oxidized incipient joints	3.47	83.3	1
		Conglomerate			
02-05	131.77	SANDSTONE CONGLOMERATE, matrix supported, rounded to subrounded clasts, some calcite veining.	1.08	25.9	2
02-05	142.19	SANDSTONE CONGLOMERATE, coarse grained, poorly sorted matrix, subangular clasts	1.95	46.9	2
02-05	153.01	CONGLOMERATIC SANDSTONE, coarse grained, poorly sorted.	3.71	88.9	2
02-05	113.23	CONGLOMERATE, sandstone matrix, fresh	0.88	21.0	2
02-05	115.85	CONGLOMERATE, fresh, rounded clasts 2-4 cm diameter	0.13	3.2	2
02-05	128.26	CONGLOMERATE, fresh, rounded to subrounded clasts up to 5 cm diameter, incipient joints	0.88	21.0	2
02-05	144.23	SANDSTONE CONGLOMERATE, matrix supported, incipient joints	0.17	4.0	2
02-6A	51.21	CONGLOMERATE, gray, pebble size clasts, calcite veins	1.01	24.3	2
02-6A	51.33	CONGLOMERATE, gray, pebble size clasts, calcite veins, slightly weathered incipient joints	1.25	29.9	2
02-6A	95.49	CONGLOMERATE, gray, pebble size clasts, calcite veins, slightly weathered incipient joints	2.19	52.6	2
02-6A	94.34	CONGLOMERATE, gray, pebble size clasts, calcite veins, slightly weathered incipient joints	0.94	22.6	2

Table 4-4. (Cont'd)

Boring No.	Sample Depth (m)	Sample Description	Strength Index, $I_{s(50)}$ (MPa)	Unconf. Compr. Strength q_u (MPa) [b]	Failure Mode[a]
02-6A	74.07	CONGLOMERATE, cobble sized clasts, oxidized incipient joints	1.52	36.4	2
02-6A	178.46	SANDSTONE CONGLOMERATE, coarse grained, few hairline calcite veins	7.75	186.0	2
02-6A	184.71	CONGLOMERATE, pebble to cobble size clasts, sandstone matrix, coarse grained, poorly sorted	6.77	162.5	2
02-6A	182.15	CONGLOMERATIC SANDSTONE, coarse grained, poorly sorted.	2.46	59.0	2
02-6A	209.40	CONGLOMERATE, yellow-brown, intensely weath., pebble sized clasts	3.00	72.0	2
02-11A	121.31	CONGLOMERATE, pebble to cobble size clasts	9.97	239.3	2
02-8B	98.45	CONGLOMERATE, pebble to cobble size clasts	1.85	44.5	2
02-8B	98.57	CONGLOMERATE, pebble to cobble size clasts	0.67	16.2	2
02-8B	93.36	CONGLOMERATE, pebble to cobble size clasts	2.83	67.9	2
02-8B	96.53	CONGLOMERATE, pebble to cobble size clasts	3.03	72.8	2
02-12	48.31	CONGLOMERATE, clasts up to 2.5 cm	1.85	44.5	2
02-06	50.69	CONGLOMERATE, clasts up to 2.5 cm	3.03	72.8	2
02-05	137.40	SANDSTONE CONGLOMERATE, clast supported, subrounded to subangular clasts, incipient fractures	0.61	14.6	1
02-06	94.31	CONGLOMERATE, clasts up to 5 cm, matrix supported, hairline calcite veins	3.20	76.8	1
		Sandstone			
02-05	162.85	SANDSTONE, coarse grained, poorly sorted, calcite veining and incipient fractures	1.48	35.6	2
02-05	63.00	SANDSTONE, coarse grained, poorly sorted, massive bedding, incipient fractures	0.98	23.4	2
02-05	104.39	SANDSTONE, coarse grained, calcite veins	3.03	72.8	2
02-05	106.31	SANDSTONE, medium grained, thin calcite veins	2.16	51.7	2
02-05	121.86	SANDSTONE, fine to medium grained, fresh, calcite veins, incipient fractures	1.92	46.1	2
02-12	41.51	SANDSTONE, fine to medium grained, light gray, faintly bedded	9.77	234.5	2
02-06	91.32	SANDSTONE, medium to coarse grained, light gray with trace black claystone clasts, weak calcite veining	7.08	169.8	2
02-06	116.83	SANDSTONE, medium grained, light gray, few calcite veins	4.38	105.1	2
02-6A	53.86	SANDSTONE, coarse grained, slightly weathered	2.36	56.6	2
02-07	58.22	SANDSTONE, gray, several calcite veins	5.15	123.7	2
02-07	57.30	SANDSTONE, gray, numerous calcite veins	5.12	122.9	2
02-18B	10.33	SANDSTONE, medium grained, moderately weathered, thin calcite veins cutting across bedding	3.03	72.8	2
02-6A	210.16	SANDSTONE, fine grained, light gray, hairline calcite veins	5.59	134.2	2
02-6A	215.80	SANDSTONE, fine grained, light gray, hairline calcite veins	4.31	103.5	2
02-06	134.90	SANDSTONE, medium to coarse grained, calcite veins	7.41	177.9	2
02-06	130.82	SANDSTONE, medium to coarse grained	8.93	214.3	2
02-06	126.08	SANDSTONE, fine to medium grained, calcite veins	6.23	149.6	2
02-06	130.09	SANDSTONE, fine to medium grained, calcite veins	8.76	210.2	2
02-06	128.14	SANDSTONE, fine to medium grained, calcite veins	11.12	266.8	2
02-06	135.18	SANDSTONE, medium to coarse grained	7.75	186.0	2
02-06	135.39	SANDSTONE, medium to coarse grained	8.09	194.1	2
02-06	125.32	SANDSTONE, 5% coarse grains, pebbles, thin calcite veins	8.51	204.2	2

Table 4-4. (Cont'd)

Boring No.	Sample Depth (m)	Sample Description	Strength Index, $I_{s(50)}$ (MPa)	Unconf. Compr. Strength q_u (MPa) [b]	Failure Mode[a]
02-6A	159.96	SANDSTONE, medium grained, several thin calcite veins	2.90	69.5	2
02-6A	163.62	SANDSTONE, medium grained, several thin calcite veins	4.51	108.4	2
02-6A	170.08	SANDSTONE, coarse grained, small pebbles	2.36	56.6	2
02-6A	173.89	SANDSTONE, medium grained, abundant intersecting calcite veins	1.85	44.5	2
02-6A	182.67	SANDSTONE, coarse grained, 5% small pebbles, few hairline calcite veins	6.44	154.4	2
02-6A	188.21	SANDSTONE, coarse grained, 5-10% pebbles	5.96	143.1	2
02-6A	196.50	SANDSTONE, medium grained, abundant thin calcite veins	8.96	215.1	2
02-05	43.28	SANDSTONE, coarse grained, few small pebbles, gray, oxidized joints	0.00	0.0	2
02-05	57.91	SANDSTONE, fine to medium grained, fresh, few thin calcite veins	3.37	80.9	2
02-11A	123.35	SANDSTONE, medium grained, 5 mm thick calcite vein	11.79	283.0	2
02-11A	121.95	SANDSTONE, medium grained, 5 mm thick calcite vein	9.77	234.5	2
02-8B	91.41	SANDSTONE, medium to coarse grained, random, discont. calcite veins	1.68	40.4	2
02-12	46.15	SANDSTONE with CLAYSTONE laminae, fine grained	3.87	93.0	2
02-06	49.29	SANDSTONE, fine to coarse grained, massive hairline calcite veins	4.21	101.1	2
02-06	47.76	SANDSTONE, fine to coarse grained, massive	6.57	157.7	2
02-06	82.60	SANDSTONE, fine to coarse grained, massive hairline calcite veins	5.56	133.4	2
02-06	84.34	SANDSTONE, fine grained massive	4.72	113.2	2
02-11	80.59	SANDSTONE, gray, medium grained, oxidized incipient joint, calcite veins	5.22	125.3	2
02-8C	38.40	SANDSTONE, fine grained, thin black laminae, several calcite veins	2.53	60.6	2
02-11	123.05	SANDSTONE, fine to medium grained, hairline calcite veins	1.01	24.3	2
02-05	157.98	SANDSTONE, fine to medium grained, mod. sorted, thin calcite veins	4.45	106.7	1
02-05	64.07	SANDSTONE, coarse grained, poorly sorted, massive bedding, incipient fractures	1.42	34.0	1
02-05	123.60	SANDSTONE, medium to fine grained, calcite veins, incipient fractures	0.91	21.8	1
02-6A	160.02	SANDSTONE, medium to coarse grained, few thin calcite veins	4.31	103.5	1
02-6A	159.96	SANDSTONE, medium grained, few thin calcite veins	4.31	103.5	1
02-6A	192.63	SANDSTONE, medium grained, few calcite veins	7.75	186.0	?
02-6A	196.38	SANDSTONE, retest, medium grained, few calcite veins	4.51	108.4	1
02-6A	201.05	SANDSTONE, medium grained, abundant intersecting calcite veins	9.40	225.6	1
02-6A	203.15	SANDSTONE, medium grained, few calcite veins	0.17	4.0	1
02-05	35.81	SANDSTONE, medium to coarse grained, gray with yellow-brown oxidation, moderately weathered, incipient joints	0.37	8.9	1
02-11A	125.88	SANDSTONE, medium grained, hairline calcite vein	3.07	73.6	1
02-11A	123.29	SANDSTONE, retest, medium grained, hairline calcite vein, gauge maximum exceeded	8.25	198.1	1
02-8B	85.86	SANDSTONE, medium grained, calcite veins	4.65	111.6	1
02-8B	80.92	SANDSTONE, medium grained, calcite veins	3.74	89.8	1
02-8B	69.04	SANDSTONE with CLAYSTONE laminae, fine grained	1.25	29.9	1
02-12	45.17	SANDSTONE with CLAYSTONE laminae, fine grained	8.42	202.1	1
02-12	47.95	SANDSTONE with CLAYSTONE laminae, fine grained	3.87	93.0	1
02-06	79.13	SANDSTONE, coarse grained with pebbles, hairline calcite veins	5.39	129.4	1
02-07	22.77	SANDSTONE, medium to coarse grained, calcite veins, partly healed fractures	1.68	40.4	1

Table 4-4. (Cont'd)

Boring No.	Sample Depth (m)	Sample Description	Strength Index, $I_{s(50)}$ (MPa)	Unconf. Compr. Strength q_u (MPa) [b]	Failure Mode [a]
		Siltstone			
02-11	32.67	SILTSTONE/SANDSTONE, very fine grained, interbedded, CLAYSTONE laminae, oxidized, calcite cemented joint	0.17	4.0	2
02-11	75.04	SILTSTONE, bedded	1.82	43.7	2
02-11A	134.66	SILTSTONE, dark gray with SANDSTONE, very fine grained, calcite cemented joints	2.83	67.9	1
02-11	27.95	SILTSTONE/SANDSTONE interbedded, moderately weathered, oxidized	8.59	206.2	1
		Claystone			
02-05	171.08	CLAYSTONE, very fine grained	3.13	75.2	2
02-05	171.85	CLAYSTONE, bedding inclined 60 deg	2.70	64.7	2
02-05	189.52	CLAYSTONE, with siltstone laminae, poorly developed bedding	2.83	67.9	2
02-8C	28.80	CLAYSTONE/SILTSTONE, thick bedded, black to very dark gray	1.42	34.0	2
02-8C	28.04	CLAYSTONE/SILTSTONE, thick bedded, black to very dark gray	1.60	38.4	2
02-11	70.01	CLAYSTONE/SILTSTONE, thick bedded, black to very dark gray	1.18	28.3	2
02-05	102.41	CLAYSTONE/SILTSTONE, black, calcite cemented joints	9.91	237.7	2
02-8B	80.99	CLAYSTONE/SILTSTONE/SANDSTONE, very fine grained, bedding inclined 70°	3.94	94.6	2
02-8C	25.76	CLAYSTONE, black, bed 10 cm thick	0.17	4.0	2
02-11	38.95	CLAYSTONE/SILTSTONE, interbedded	5.39	129.4	2
02-11	39.75	CLAYSTONE, black, slightly weathered, inversely graded, 7 cm thick bedding, incipient joints	2.56	61.5	2
02-11	40.33	CLAYSTONE, black with some SILTSTONE interbeds, and thin calcite veins, faintly bedded	2.16	51.7	2
02-11	68.21	CLAYSTONE, black, 10 cm thick bed	0.17	4.0	2
02-11	86.32	CLAYSTONE/SILTSTONE, interbedded	2.19	52.6	2
02-11	90.34	CLAYSTONE/SILTSTONE, interbedded	3.96	95.0	2
02-8C	59.38	CLAYSTONE, few thin calcite veins, crudely bedded, inclined 90 deg	1.01	24.3	2
02-8C	64.34	CLAYSTONE, massive	2.02	48.5	2
02-11	85.25	CLAYSTONE, thin sandstone beds and laminations, calcite veins	1.68	40.4	2
02-11	49.77	CLAYSTONE, graded SANDSTONE interbeds	1.18	28.3	2
02-18B	15.39	CLAYSTONE, black, slightly weathered, faintly bedded	0.34	8.1	1
02-8B	76.05	CLAYSTONE/SILTSTONE, interbedded, calcite veins	1.18	28.3	1
02-06	38.56	CLAYSTONE, black	6.74	161.7	1
02-11	54.32	CLAYSTONE, black, thinly bedded with SILTSTONE and SANDSTONE	2.36	56.6	1
02-8A	31.39	CLAYSTONE, gray, faintly bedded	2.32	55.8	1
02-11	81.26	CLAYSTONE, gray, faintly bedded	3.84	92.2	1
02-11	95.74	CLAYSTONE, black with thin SILTSTONE interbeds, inclined 40 deg, healed joints	3.17	76.0	1
02-11	118.32	CLAYSTONE, thin sandstone beds and laminations, calcite veins	2.70	64.7	1

Notes:

[a] *Failure Mode: 1 = Failed along discontinuity*
2 = Failed through intact core

[b] *Unconfined Compressive Strength is based on factor of 24.*

Table 4-5. Summary of Rock Equivalent UC Strengths From PLI

Rock Type	*Point Load Strength Index* $I_{s(50)}$ *(MPa)*	*Derived Unconfined Compressive Strength*[1] q_u *(MPa)*
Sandstone, moderately to intensely weathered	0.37 to 11.1 (61 tests)	9 to 73
Sandstone, slightly weathered to fresh		23 to 267
Siltstone/Claystone, slightly weathered to fresh	0.16 to 9.9 (31 tests)	24 to 238
Siltstone/Claystone, moderately to intensely weathered		4 to 34
Conglomerate, slightly weathered to fresh	0.125 to 9.9 (25 tests)	3 to 239
Quartz diorite, slightly weathered to fresh	0 to 9.4 (18 tests)	10 to 226
Quartz diorite, moderately to intensely weathered		0 to 91

Note: [1] *Based on factor of 24.*

Table 4-6. Summary of Rock Young's Moduli

Rock Type	*Range of Young's Modulus from Laboratory Tests* *E (GPa)*	*Range of Young's Modulus from Pressuremeter* [1] *E (GPa)*
Sandstone (11 samples)	21.8 to 87.6	8.7 to 50
Siltstone/Claystone (14 samples)	7.7 to 30	5.5 to 9.25
Conglomerate (1 sample)	59.1	NA
Granitic rock (8 samples)	16.6 to 23.9	5 to 50

Note:
[1] *Based on "intact" shear modulus in Table 3-3 using assumed poisson's ratio of 0.25 for all rock types.*
NA = not available

Table 4-7. Summary of Rock Poisson's Ratios

Rock Type	*Range of Poisson's Ratio, n*
Sandstone	0.16 to 0.36
Siltstone/Claystone	0.31 to 0.63
Conglomerate	0.21
Granitic rock	0.24 to 0.30

Table 4-8. Summary of Rock Strengths from Triaxial Compression Tests

Soil Type	*Range of Interpreted Shear Strength Parameters*	
	Friction Angle	*Cohesion, S_i (kPa)*
Gouge	13° to 18°	41 to 69

Note:
Friction Angles and cohesion intercepts are straight-line fit of test data in Appendix B-4.

Table 4-9. Summary of Rock Strengths from Direct Shear Tests

Rock/Soil Type	*Estimated Peak Strengths*		*Estimated Post-Peak Strength*	
	Friction Angle	*Cohesion Sj (kPa)*	*Friction Angle*	*Cohesion Sj (kPa)*
North Portal				
Sandstone	33° to 53°	8 to 103	27° to 38°	11 to 31
Siltstone/Claystone	37°	4 to 210	25° to 30°	9 to 57
Gouge	7° to 35°	3 to 51	11° to 34°	6 to 101
Tunnel Segment				
Sandstone, weathered	22°	51	20°	46
Granitic rock	35° to 45°	8 to 191	28° to 38°	0 to 54
South Portal/Rock Cut				
Granitic rock	35° to 45°	8 to 191	28° to 38°	0 to 54

Note:
Friction Angles and cohesion intercepts are straight-line fit of test data shown in Appendix B-4 and plotted in Figure 4-6 to Figure 4-8.

Table 4-10. Summary of Rock Abrasion Tests

Rock Type (Total 25 Samples)	Borings	Depth Range (m)	Cerchar Index
North Portal			
Clayey siltstone (5 samples)	02-11, 02-11A	55.3-172.4	0.9 to 1.7
Tunnel Segment			
Clayey siltstone (2 samples)	02-5, 02-6	70.0-186.4	0.1 to 0.7
Conglomerate with hard clasts up to 25 mm (2 samples)	02-5, 02-6	109.3-145.0	4.0 to 4.3
Sheared and recemented fine-grained sandstone (2 samples)	02-6	108.3-108.6	2.4 to 4.0
Medium grained sandstone (7 samples)	02-6, 02-6A, 02-7	96.2-253.2	3.8 to 4.5
South Portal/Rock Cut			
Altered granodiorite (7 samples)	02-2, 02-2A, 02-2B, 02-21	59.8-213.8	4.0 to 4.7 (6 samples) 1.8 (1 sample)

Table 4-11. Summary of Petrographic Tests - Mineralogy of Sedimentary Rock

Boring No.	Depth (m)	Rock Name	Constituent Minerals (Approximate Percentage of Total)									
			Quartz	Feldspars[2]	Intermediate Clay	Calcite	Mica[3]	Clinozoisite	Sericite	Chlorite	Carbonaceous Matter	Other[1]
Phase 2B (this report, Vol. C-4)												
02-6	115.9	Altered sandstone	28	58	-	2	<1	2	5	2	-	3
02-8B	86.0	Altered sandstone	26	52	-	1	-	-	16	<1	-	5
02-11	34.1	Altered sandstone	30	35	-	-	2	10	15	-	-	8
	37.6	Altered claystone	15	1	70	-	1	-	1	1	5	6
	69.7	Altered silty claystone	20	3	62	-	2	-	2	-	3	8
02-11A	146.6	Altered silty claystone	19	3	52	-	3	-	2	-	3	19
	158.5	Altered claystone	13	1	74	-	1	-	-	-	5	6
	161.0	Altered silty claystone	23	2	60	-	-	-	-	-	5	10
	165.7	Altered claystone	15	2	70	-	-	-	-	-	5	8
TR-2A	< 3	Altered claystone	15	-	78	-	-	-	-	-	5	2
Phase 2A (EMI, 2001b)												
DST-8	Surface	Altered sandstone	56	15	15	-	<2	5	-	5	-	3
DST-9	Surface	Altered sandstone	35	55	10	3	<1	-	-	2	-	3
DST-10	Surface	Altered heterolithologic pebble conglomerate	30	60	-	2	1	2	3	2	-	1
DST-11	Surface	Altered sandstone	36	49	12	-	<1	-	-	-	-	4
DST-12	Surface	Altered sandstone	35	33	4	-	<1	-	13	<1	-	15
Feasibility Study (WCC, 1996, Table II-G2)												
P-5-96	196.5	Altered carbonaceous silty claystone to sandstone (Tsh)	32	5	35	12	1	-	5	-	5	5
	209.1	Altered carbonaceous silty claystone to sandstone (Tsh)	32	5	33	10	5	-	5	-	5	5
	185.1	Altered sandstone (Tss)	34	30	15	8	<1	<1	8	<1	-	5
	194.7	Altered sandstone (Tss)	34	30	IS	8	<1	<1	8	<1	-	5
	128.7	Heterolithologic conglomerate (Tc)	37	30	3	8	2	3	-	5	-	<1
	151.1	Heterolithologic conglomerate (Tc)	20	33	10	-	.S	10	10	10	-	2
P-7-96	30.6	Altered carbonaceous silty claystone to sandstone (Tsh)	32	5	38	4	5	-	-	-	5	5
P-12-96	159.5	Altered fine sandy limestone (Tsh)	8	12	-	78	-	-	-	-	2	<1
	176.8	Altered carbonaceous claystone to sandstone (Tsh)	20	14	50	-	5	-	-	2	4	5
	114.0	Altered sandstone (Tss)	30	49	6	1	1	1	4	8	-	<1
	121.3	Altered sandstone (Tss)	30	51	7	2	<1	1	3	6	-	<1
	157.0	Altered sandstone (Tss)	35	49	7	5	<1	-	3	-	-	1
	135.1	Heterolithologic conglomerate (Tc)	28	50	10	1	-	-	3	6	-	2

Notes:
[1] *Includes opaques, dolomite, ferroan dolomite, FeOH (includes iron oxy-hydroxide, sphalerite, realgar, orpinent, jarosite, and manganese oxy-hydroxide), zircon, leucoxene, sphene, barite, and epidote*
[2] *Includes both plagioclase and K-feldspar*
[3] *Includes biotite, muscovite, actinolite*

Table 4-12. Summary of Petrographic Tests - Mineralogy of Granitic Rock

Boring No.	Depth (m)	Rock Name	Constituent Minerals (Approximate Percentage of Total)				
			Quartz	Feldspars[2]	Epidote	Chlorite	Other[1]
Phase 2B (this report, Vol. C-4)							
02-2B	68.8	Altered granodiorite	32	39	-	-	29
02-13	27.6	Altered granodiorite	28	38	-	4	30
02-21	90.7	Altered quartz diorite	38	41	-	<1	21
		Altered quartz diorite	25	44	-	2	29
	135.2	Altered quartz diorite	37	51	-	1	11
Phase 2A (EMI, 2001b)							
DST-1	Surface	Altered quartz diorite	27	33	-	8	31
DST-2	Surface	Altered quartz diorite	30	41	-	8	21
DST-3	Surface	Altered quartz diorite	25	52	-	12	11
DST-4	Surface	Altered quartz diorite, multiple cataclasite	3	18	-	3	76[3]
DST-5	Surface	Altered quartz diorite, multiple cataclasite	33	43	-	<1	24
DST-6	Surface	Altered quartz diorite, multiple cataclasite	40	5	-	2	53[4]
DST-7	Surface	Altered quartz diorite, multiple cataclasite	78	12	-	3	7
Feasibility Study (WCC, 1996, Table II-G3)							
P-1-96	18.0	Altered granodiorite - multiple cataclastic breccia	20	66	-	4	10
	42.6	Altered granodiorite - multiple cataclastic breccia	20	68	-	3	9
P-14-96	62.8	Altered quartz diorite	15	51	12	12	10

Notes:
[1] *Includes apatite, biotite, clinozoisite, dolomite, gypsum, intermediate clay, iron oxide, opaques, sericite, tourmaline, zircon*
[2] *Includes both plagioclase and K-feldspar*
[3] *Includes 70% clinozoisite, 2% sericite, 2% calcite and ferroan calcite, 1% sphene, and <1% opaques*
[4] *Includes 40% clinozoisite, 6% clay (possibly smectite), 5% calcite and ferroan calcite, 1% sericite and 1% opaques*

Table 4-13. Summary of Groundwater Chemistry

Borehole	Sample No.	Date Sampled	TPH as Gasoline [1] (mg/l)	Dissolved Methane [2] (mg/ml)	PNA [3] (mg/l)	pH
02-11A	1	09/11/02	250 [4]	ND	ND	7.1
Laboratory Blank	-	-	ND[5]	ND	ND	7.02
02-5	2	09/27/02	490 [4]	ND	ND	6.5
Laboratory Blank	-	-	ND	ND	ND	7.01

Notes:

[1] *Total Petroleum Hydrocarbons (TPH) quantified against a gasoline standard in accordance with modified EPA Method 8015.*

[2] *Dissolved methane analyzed in accordance with modified EPA Method 3810.*

[3] *PNA = Polynuclear aromatic compounds analyzed in accordance with EPA Method 8270C.*

[4] *Hydrocarbon reported in the gasoline range does not match the laboratory's gasoline standard.*

[5] *ND = Not Detected.*

Table 4-14. Summary of "Soil" Laboratory Tests

Type of Test	*Applicable Test Method*	*Purpose*	*Total No. of Tests*
Pocket Penetrometer	SoilTest CL-700A	Unconfined soil compressive strength	1
Torvane Shear	Humboldt Model E-285, ASTM 4648	Shear strength	1
Dry Density	ASTM D-2937	In-situ soil density	51
Moisture Content	ASTM D-2216	In-situ soil moisture content	103
Atterberg Limits	CT 204	Plasticity, confirm logged soil classification	36
Grain Size Distribution • Sieve • #200 Wash • Hydrometer	CT 202, 203	Gravel, sand and fines content, confirm logged soil classification	218
Direct Shear	ASTM D-3080	Friction angle and cohesive strength	19
Unconsolidated Undrained Triaxial	ASTM D-2850	Undrained shear strength	1
Compaction Test	CT 216	Maximum density and optimum moisture content	4
R-Value	ASTM D-2844	Design parameter for pavement design	1
Soil pH	CT 532/643	Corrosion potential	6
Minimum Electrochemical Resistivity	CT 532/643		6
Soluble Sulfate Content	CT 417		6
Soluble Chloride Content	CT 422		5

Notes:

CT = California Test Method

ASTM = American Society for Testing and Materials

Table 4-15. Summary of Corrosion Tests for Existing Fills

Boring	Sample Depth (m)	Sample Elev. (m)	"Soil" Type	Minimum Resistivity (ohm-cm)	pH	Soluble Sulfate Content (ppm)	Soluble Chloride Content (ppm)
02-19	1.5	+72.5	SC	3,400	7.5	20	285
02-20	1.5	+56.5	SP-SM	5,200	7.4	31	250

Table 4-16. Summary of Direct Shear Tests for Existing Fills

Boring	Sample Depth (m)	Sample Elev. (m)	"Soil" Type	Ultimate Strength		Peak Strength	
				Friction Angle	Cohesion (kPa)	Friction Angle	Cohesion (kPa)
02-19	1.5	+72.5	Clayey Sand	34.2°	3.5	38.9°	25.6
02-19	13.7	+60.3	Sand with Silt	34.0°	0	38.9°	26.4
02-19	16.8	+57.2	Silty Sand	33.0°	13.8	34.1°	41.1
02-20	7.6	+50.4	Clayey Sand	31.1°	16.9	42.0°	24.7
02-20	13.7	+44.3	Clayey Sand	32.0°	17.2	33.0°	54.3
02-20	19.8	+38.2	Clayey Sand	31.8°	17.8	34.0°	33.0
			Average:	***32.7°***	***11.5***	***36.8°***	***34.2***

Note:
Friction Angles and cohesion intercepts are straight-line fit of test data in Appendix A-4.

Table 4-17. Summary of Corrosion Tests for Existing Fills

Boring	Sample Depth (m)	Sample Elev. (m)	"Soil" Type	Minimum Resistivity (ohm-cm)	pH	Soluble Sulfate Content (ppm)	Soluble Chloride Content (ppm)
02-19	1.5	+72.5	SC	3,400	7.5	20	285
02-20	1.5	+56.5	SP-SM	5,200	7.4	31	250

Table 4-18. Summary of Strengths from Direct Shear Tests for Disposal Site

Boring	Sample Depth (m)	Sample Elev. (m)	"Soil" Type	Ultimate Strength		Peak Strength	
				Friction Angle	Cohesion (kPa)	Friction Angle	Cohesion (kPa)
02-ST1	4.6	+61.7	Sand with Silt	41.9°	9.5	46.9°	33.9
02-ST2	4.6	+51.7	Sandy Clay	25.9°	35.1	24.3°	63.5
02-ST2	13.7	+42.6	Sandy Clay	30.8°	13.2	32.6°	12.4
02-ST4	1.5	+63.9	Silty Sand	35.3°	1.7	40.6°	41.9
02-ST4	4.6	+60.8	Clayey Sand	36.0°	3.7	38.1°	53.4
02-ST5	4.6	+59.2	Clayey Sand	27.9°	30.5	25.4°	58.0
02-ST6	1.5	+63.7	Sandy Clay	22.3°	67.2	24.9°	109.2
02-ST7	1.5	+92.8	Clayey Sand	30.4°	19.8	25.3°	72.1
02-ST8	4.6	+86.5	Sand with Silt	27.6°	23.8	35.0°	61.8
02-ST9	4.6	+80.2	Clayey Sand	27.7°	36.8	24.2°	83.3
02-ST9	16.8	+68.0	Clayey Sand	31.5°	21.0	31.9°	61.5
02-ST10	1.5	+102.5	Sandy Clay	18.5°	80.1	11.6°	154.6
02-ST10	10.7	+93.3	Clayey Sand	27.9°	57.8	31.8°	80.2
			Average:	***29.4°***	***28.9***	***30.4°***	***65.3***

Note:
Friction Angles and cohesion intercepts are straight-line fit of test data in Appendix A-4.

Table 4-19. Summary of Consolidation Tests for Disposal Site

Boring	Sample Depth (m)	Sample Elev. (m)	"Soil" Type	Existing Overburden Stress (kPa)	Pre-consolidation Pressure (kPa)	Overcon-solidation Ratio, OCR	Com-pression Ratio, C'_c	Recom-pression Ratio, C'_r
ST-1	1.5	+64.8	Sandy Clay	33	72	2.2	0.04	0.015
ST-2	1.5	+54.8	Sandy Clay	33	77	2.4	0.04	0.023
ST-2	4.6	+51.7	Sandy Clay	100	120	1.2	0.055	0.04
ST-4	1.5	+63.9	Silty Sand	33	43	1.3	0.05	0.013
ST-5	4.6	+59.2	Clayey Sand	100	72	0.7	0.05	0.015
ST-9	1.5	+83.3	Lean Clay	33	72	2.2	0.048	0.012
ST-10	4.6	+99.4	Clayey Sand	100	96	1.0	0.048	0.013

Table 4-20. Summary of Soil Corrosion Tests for Disposal Site

Boring	*Sample Depth (m)*	*Sample Elev. (m)*	*"Soil" Type*	*Minimum Resistivity (ohm-cm)*	*pH*	*Soluble Sulfate Content (ppm)*	*Soluble Chloride Content (ppm)*
ST-1	0.76	+65.5	SC	3,500	6.3	31	252
ST-5	3.0	+60.8	SC	1,200	6.6	21	304
ST-7	0.76	+93.5	SC	1,900	6.5	19	-
ST-7	6.1	+88.2	SP-SM	3,100	7.2	42	272
ST-10	3.0	+101.0	CL	1,100	6.8	55	50

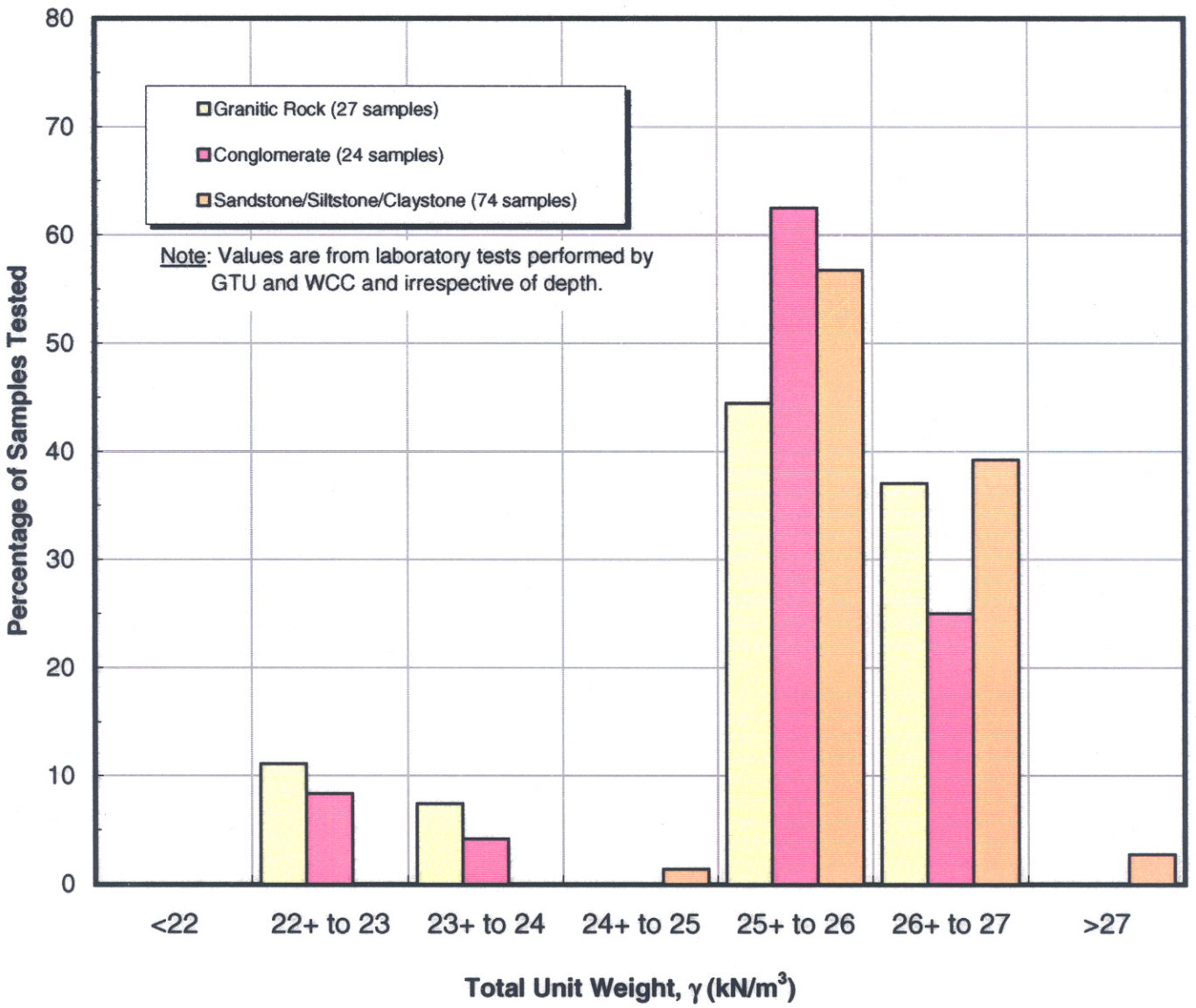
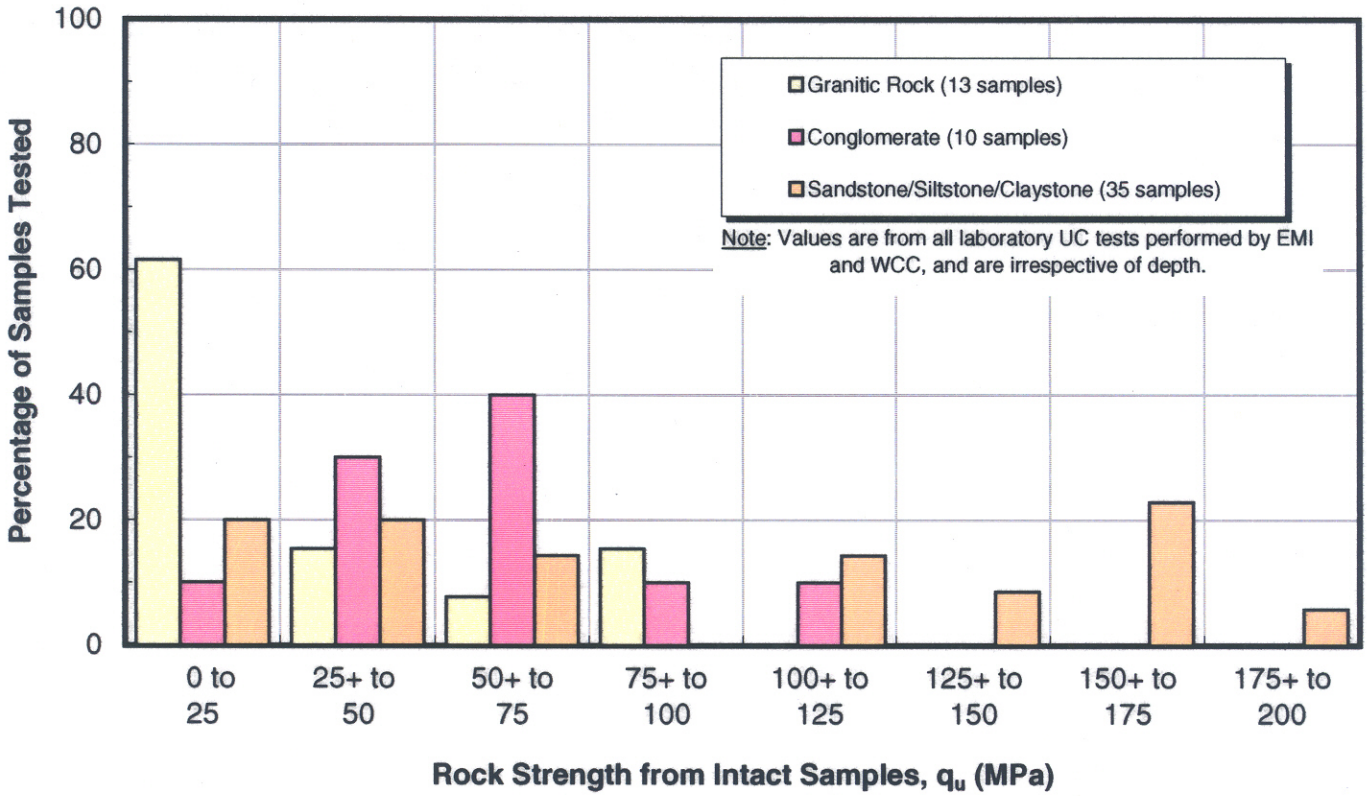


Figure 4-1. Summary of Rock Unit Weights



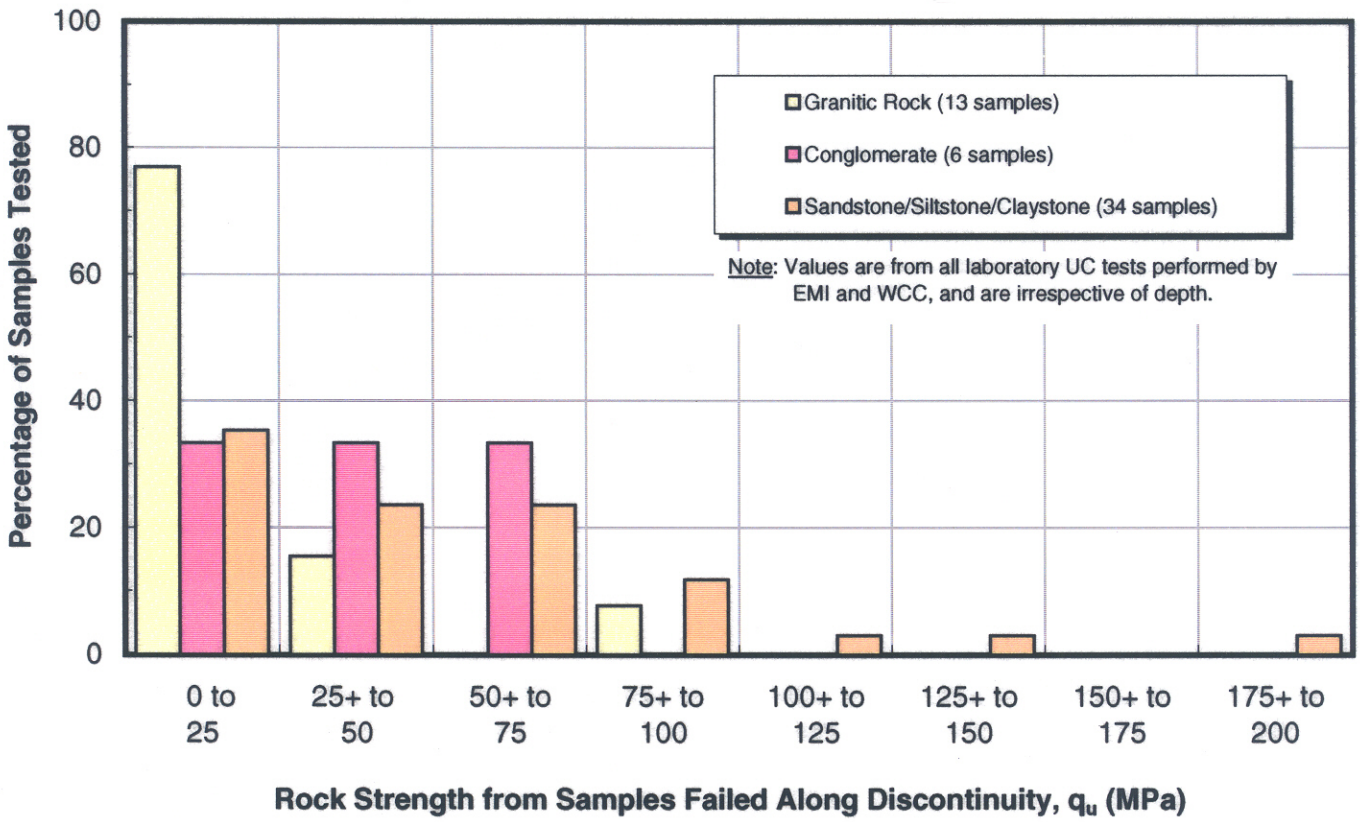
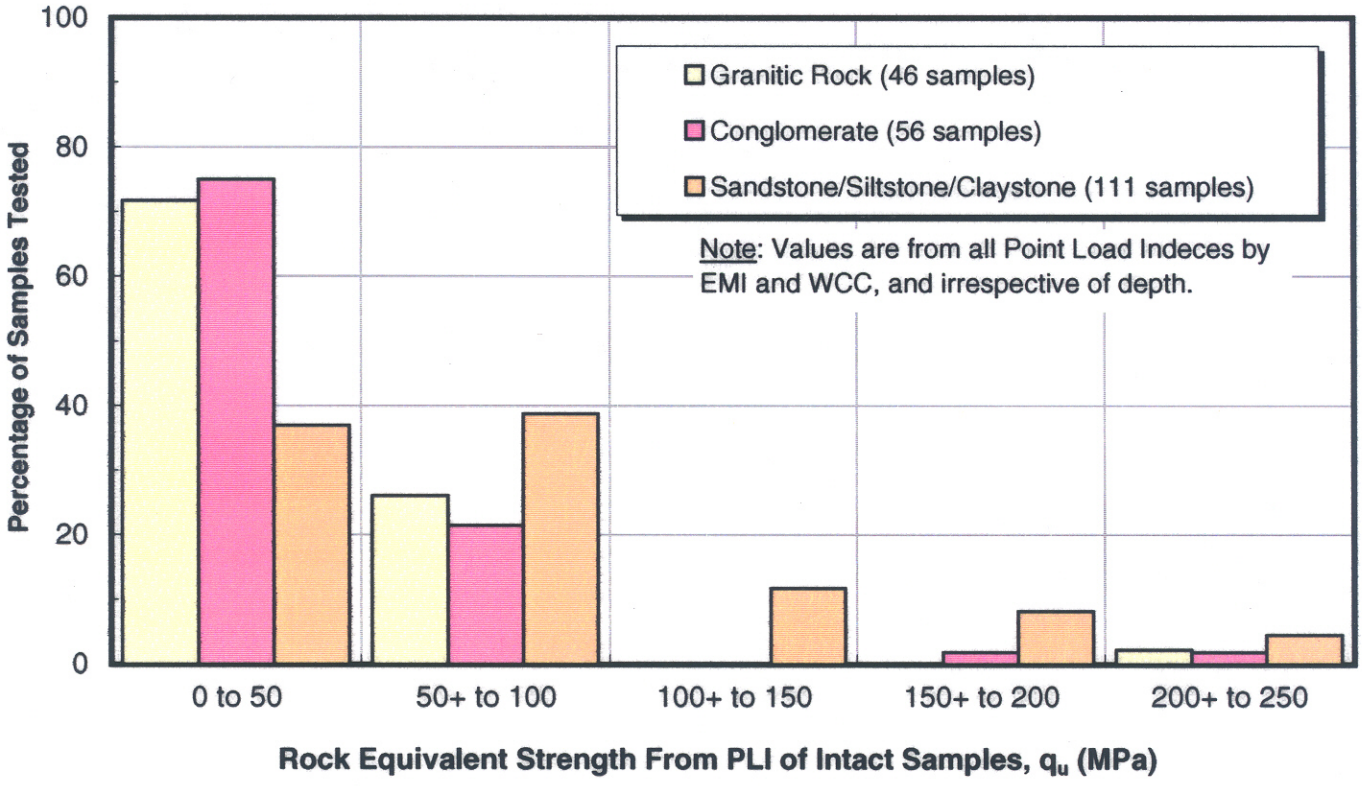


Figure 4-2. Summary of Rock Unconfined Compressive Strengths



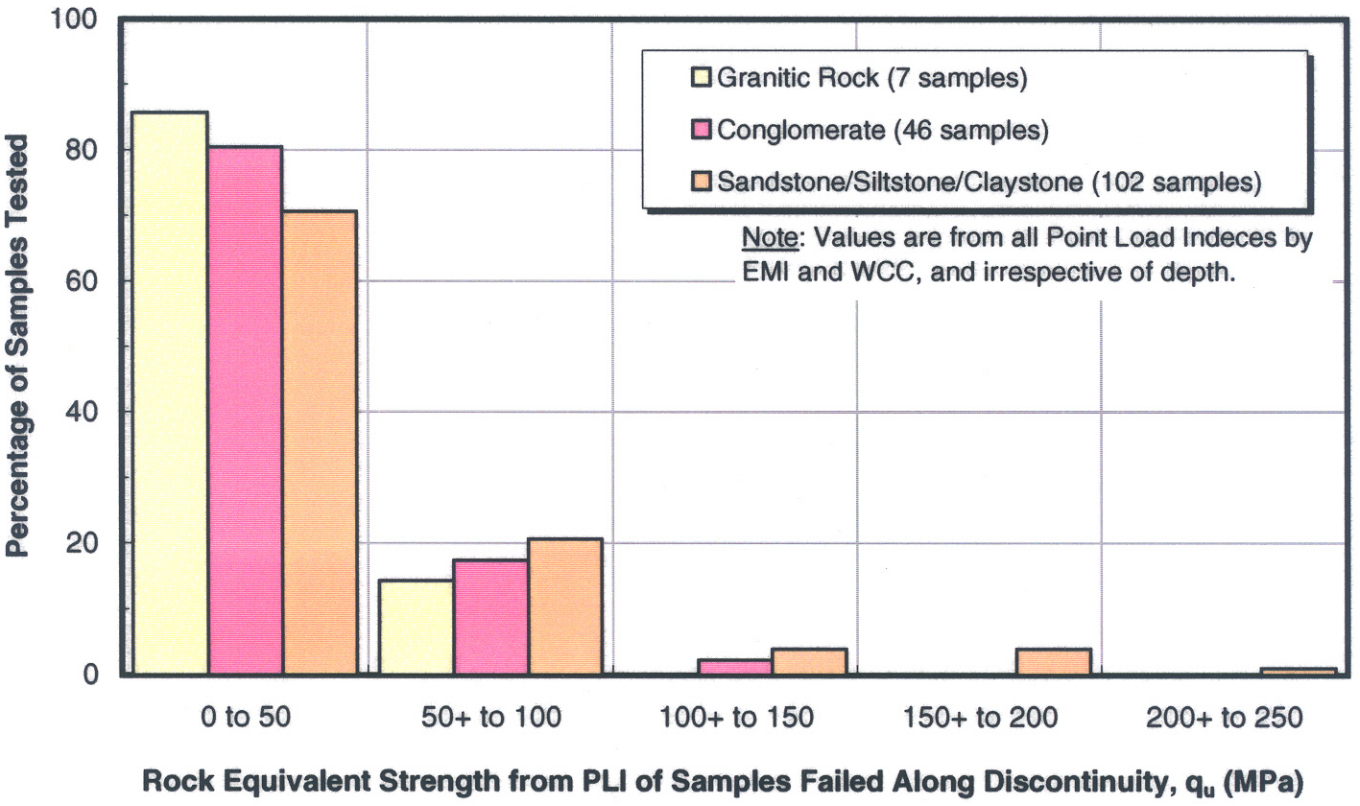


Figure 4-3. Summary of Rock Equivalent UC Strengths From PLI

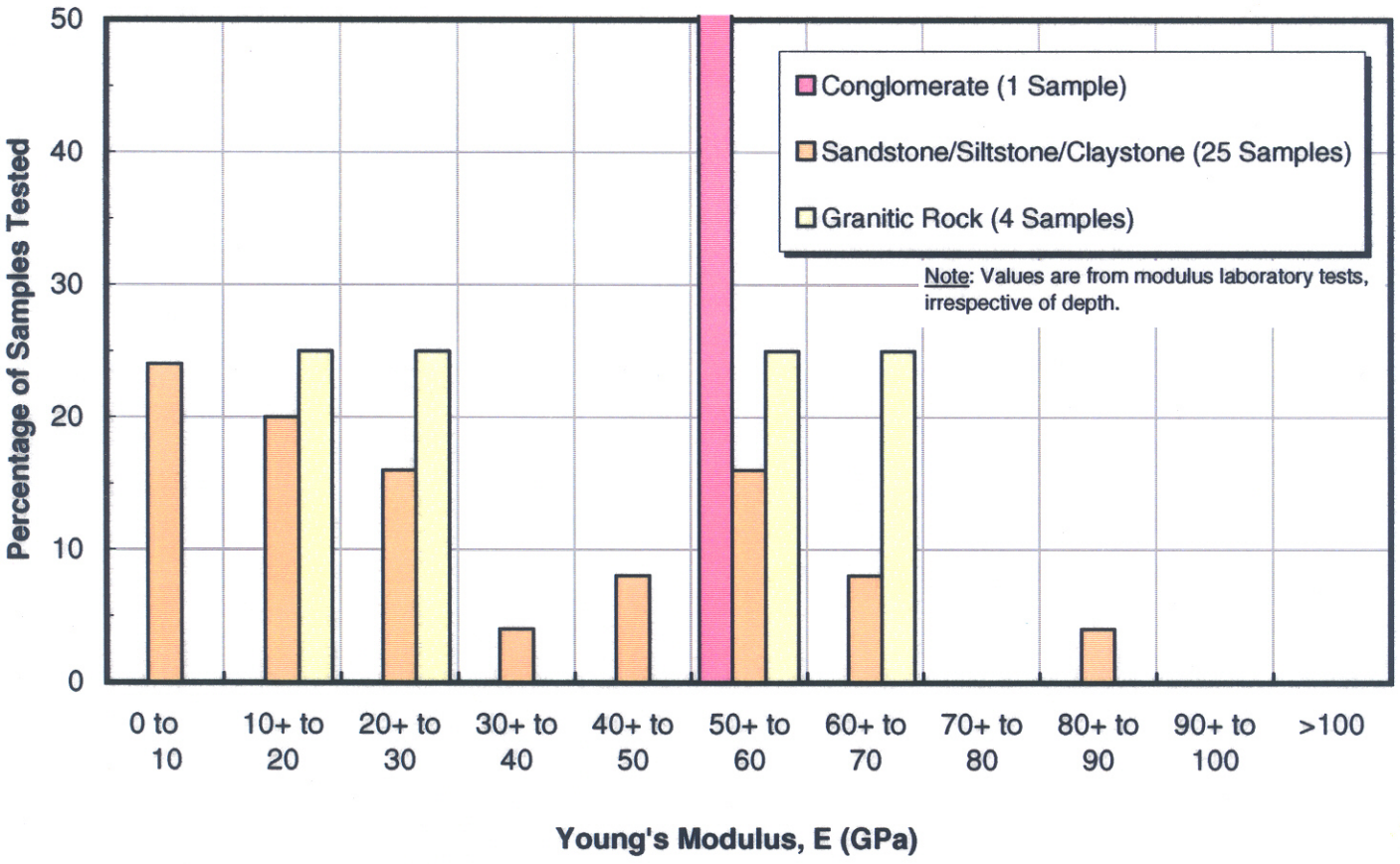


Figure 4-4. Summary of Rock Young's Moduli

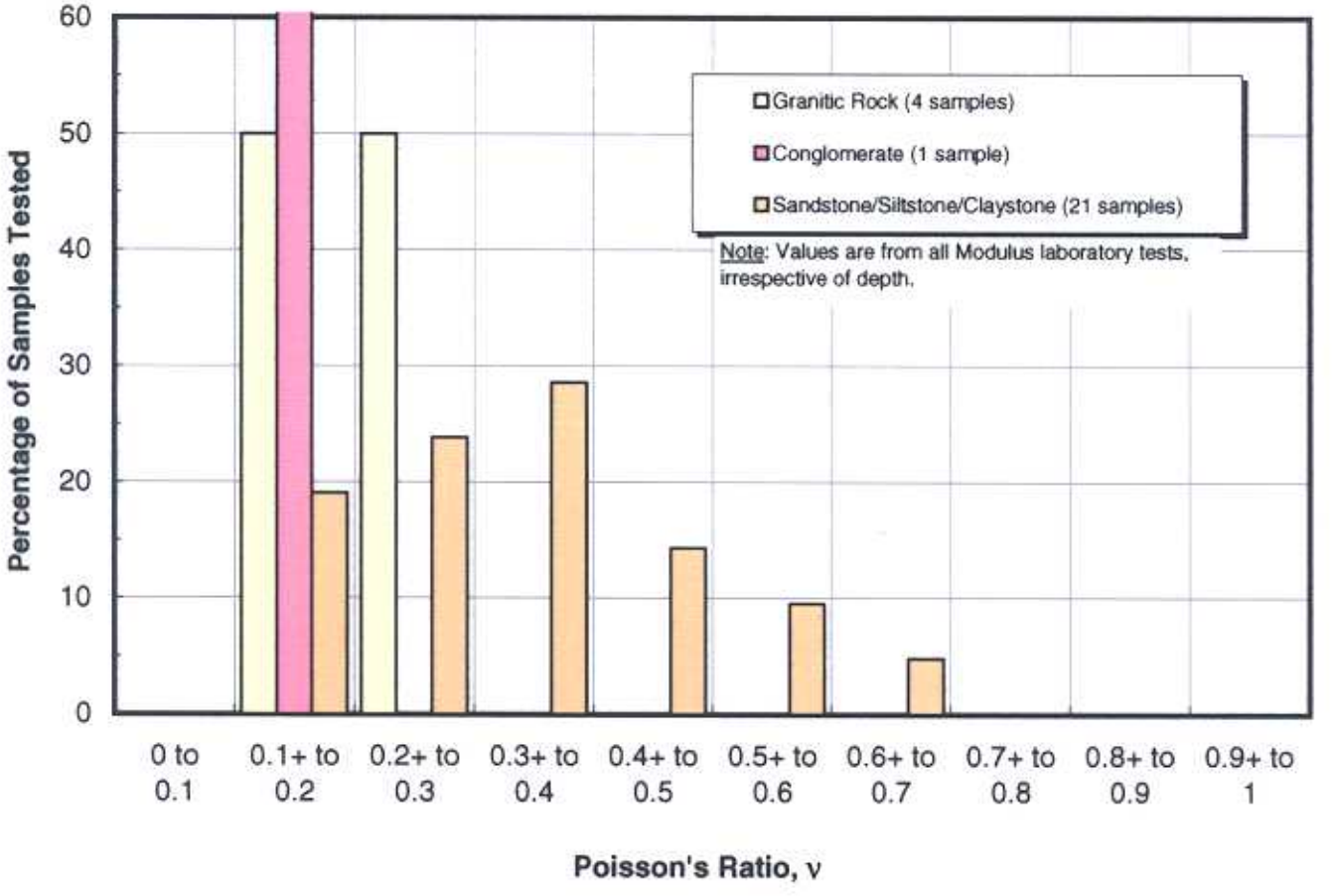


Figure 4-5. Summary of Rock Poisson's Ratios

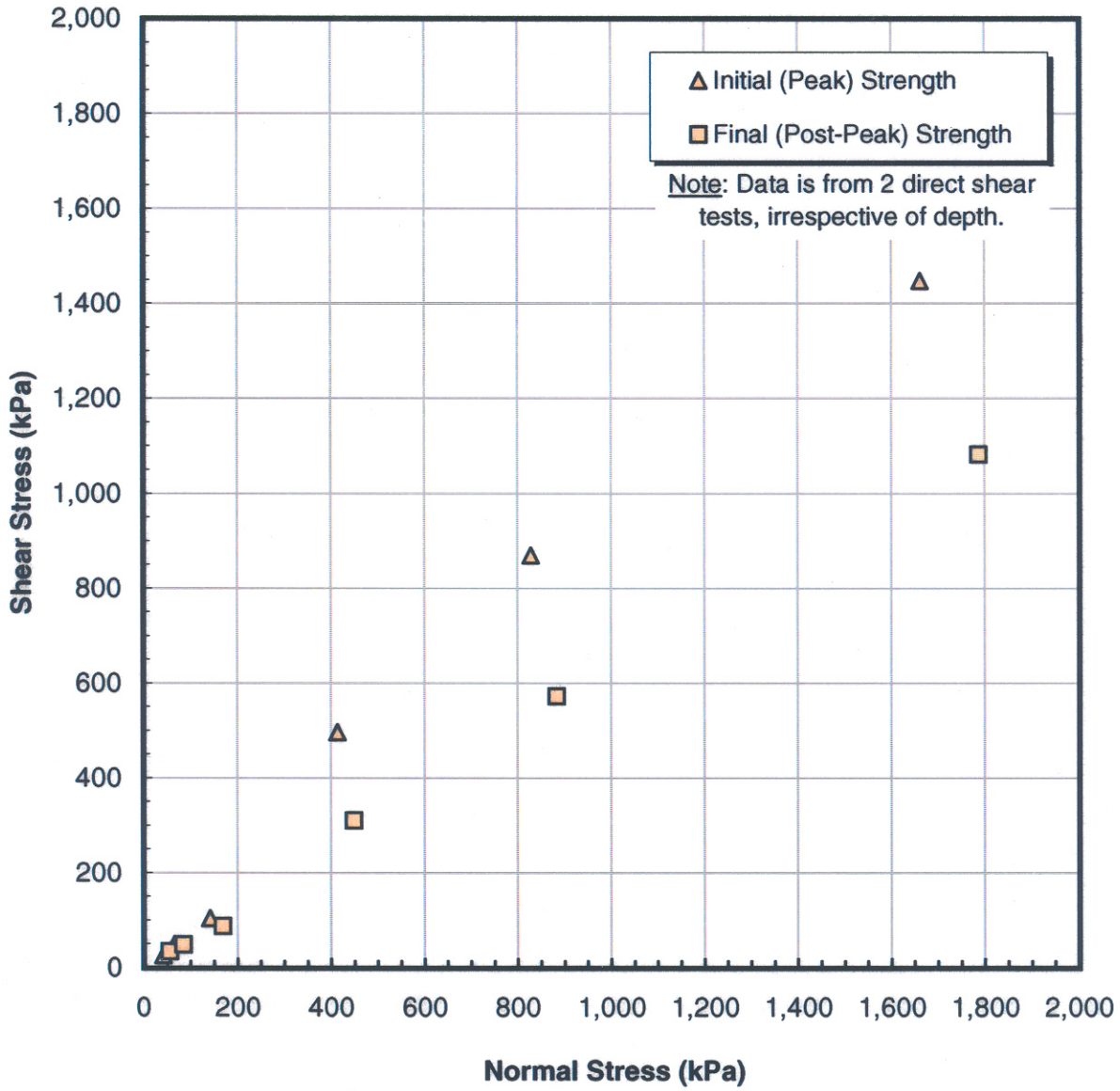


Figure 4-6. Summary of Rock Shear Strengths of Claystone

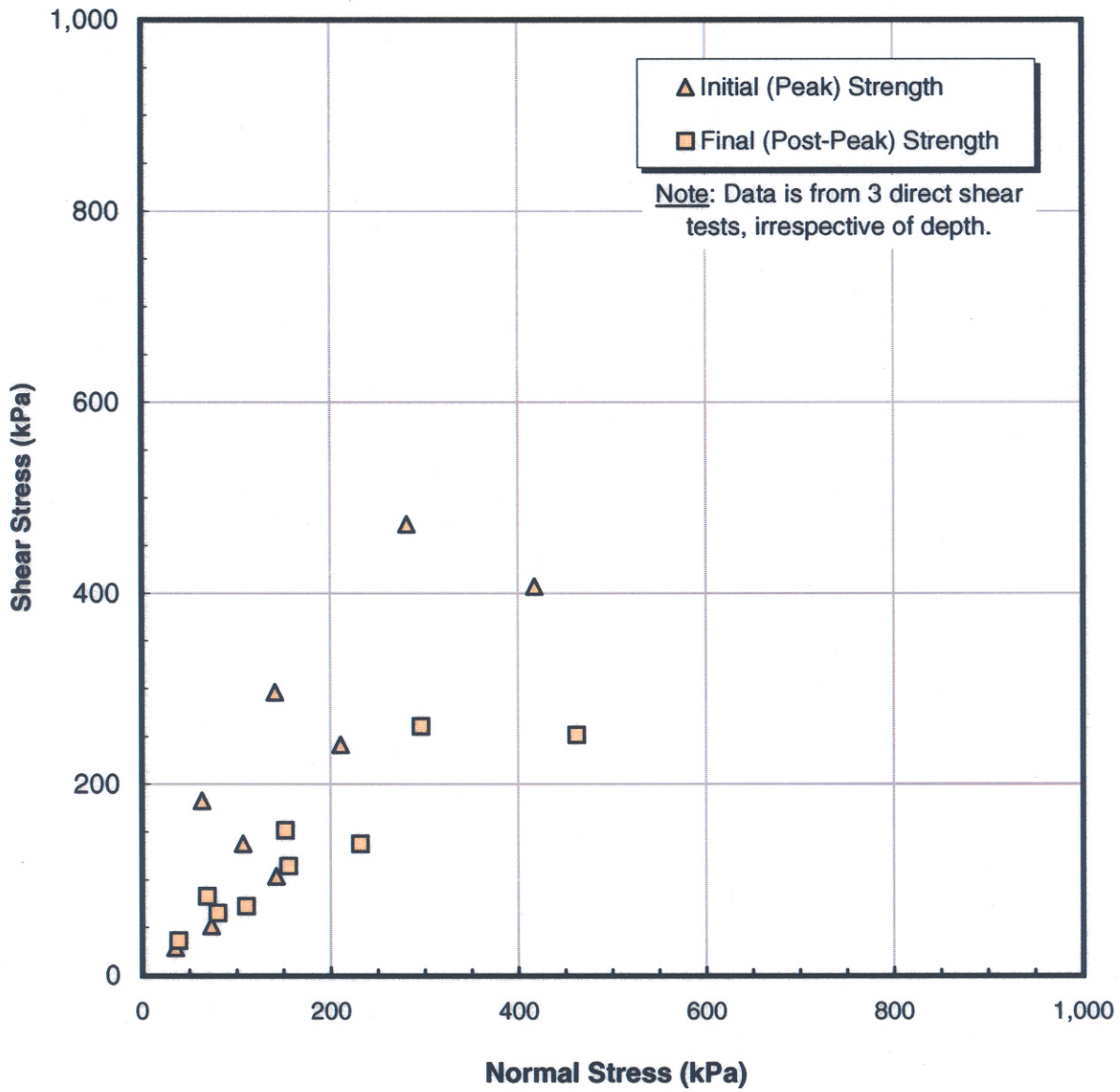


Figure 4-7. Summary of Rock Shear Strengths of Sandstone

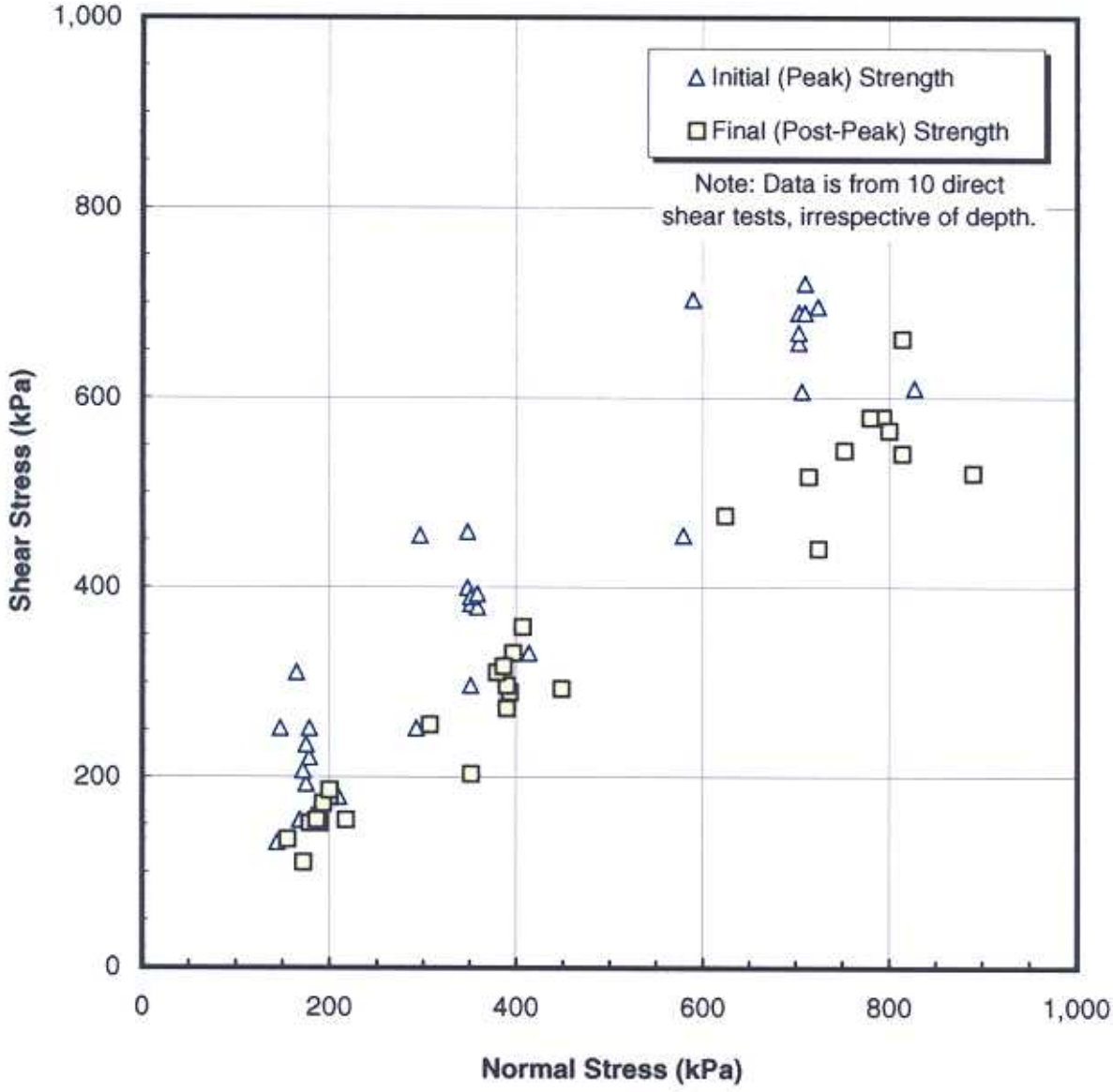


Figure 4-8. Summary of Rock Shear Strengths of Granitic Rock

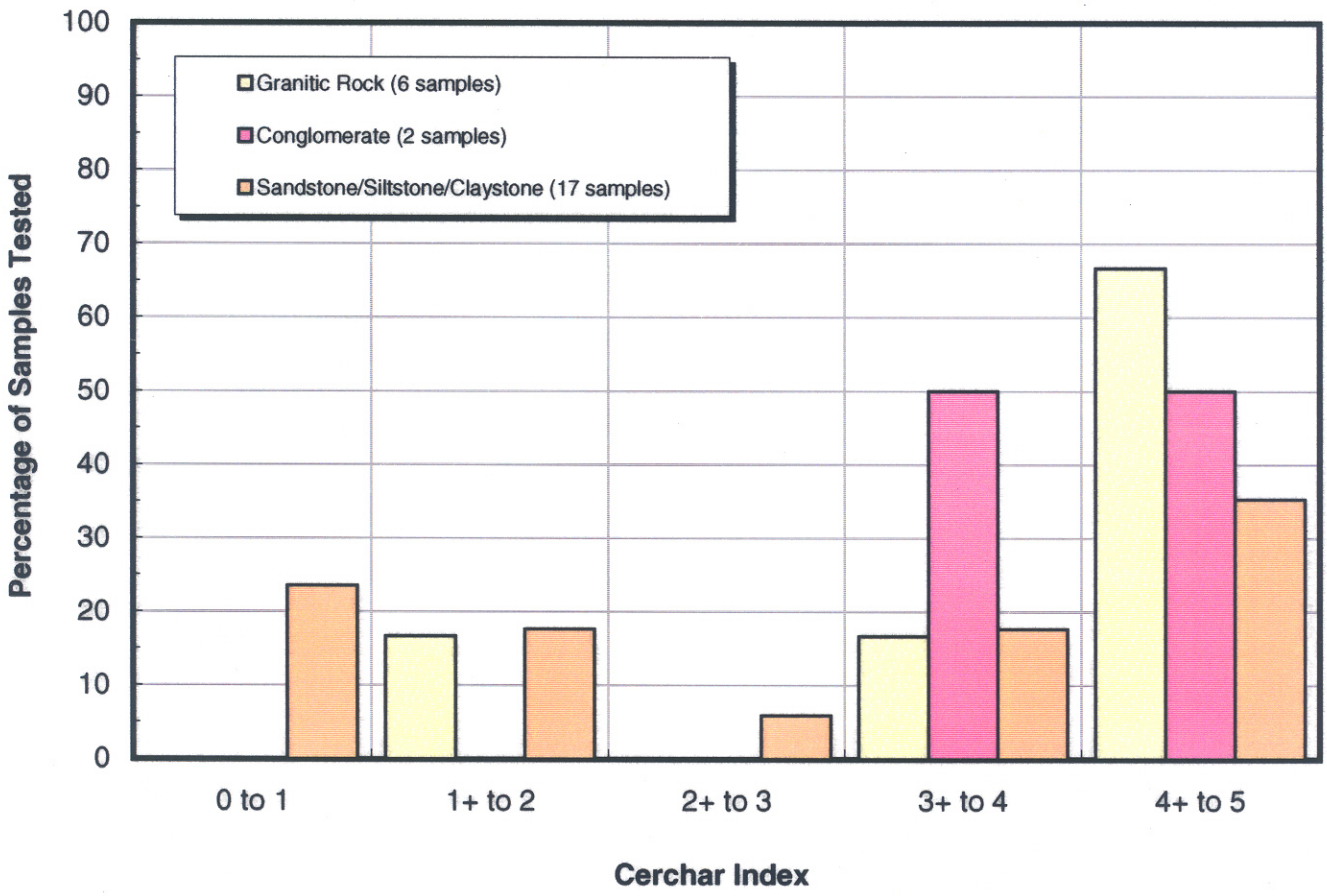


Figure 4-9. Summary of Rock Abrasion Indeces

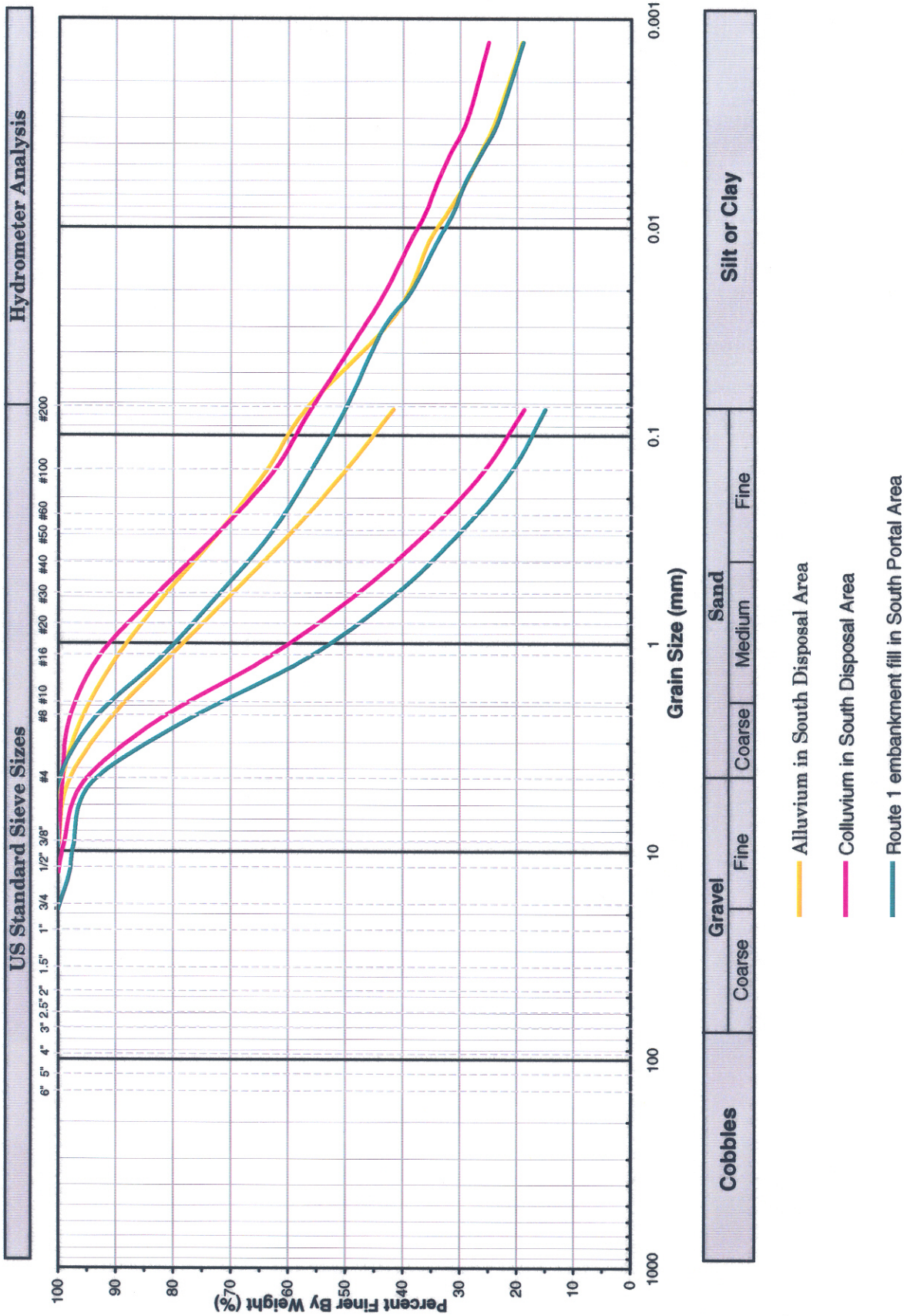


Figure 4-10. Summary of "Soil" Grain Size Distributions

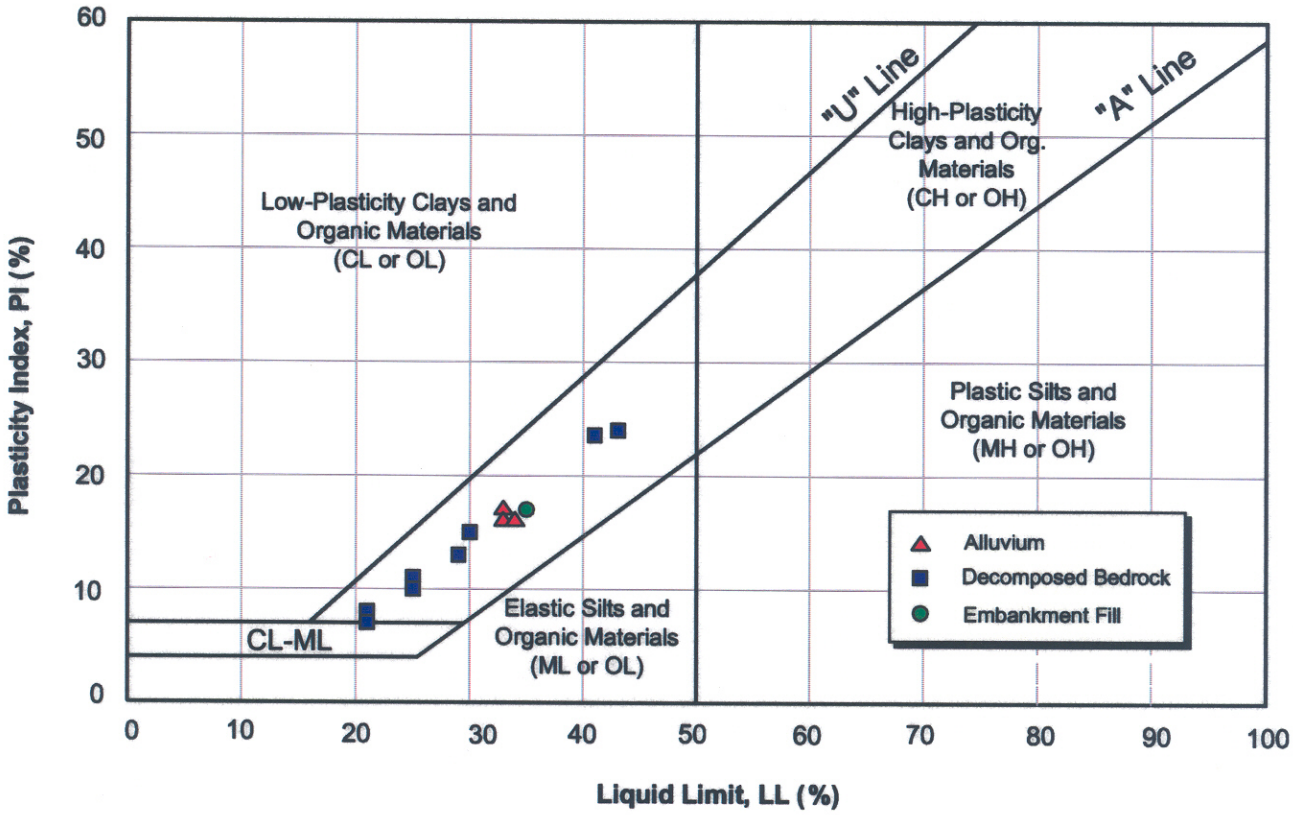


Figure 4-11. Summary of "Soil" Plasticities

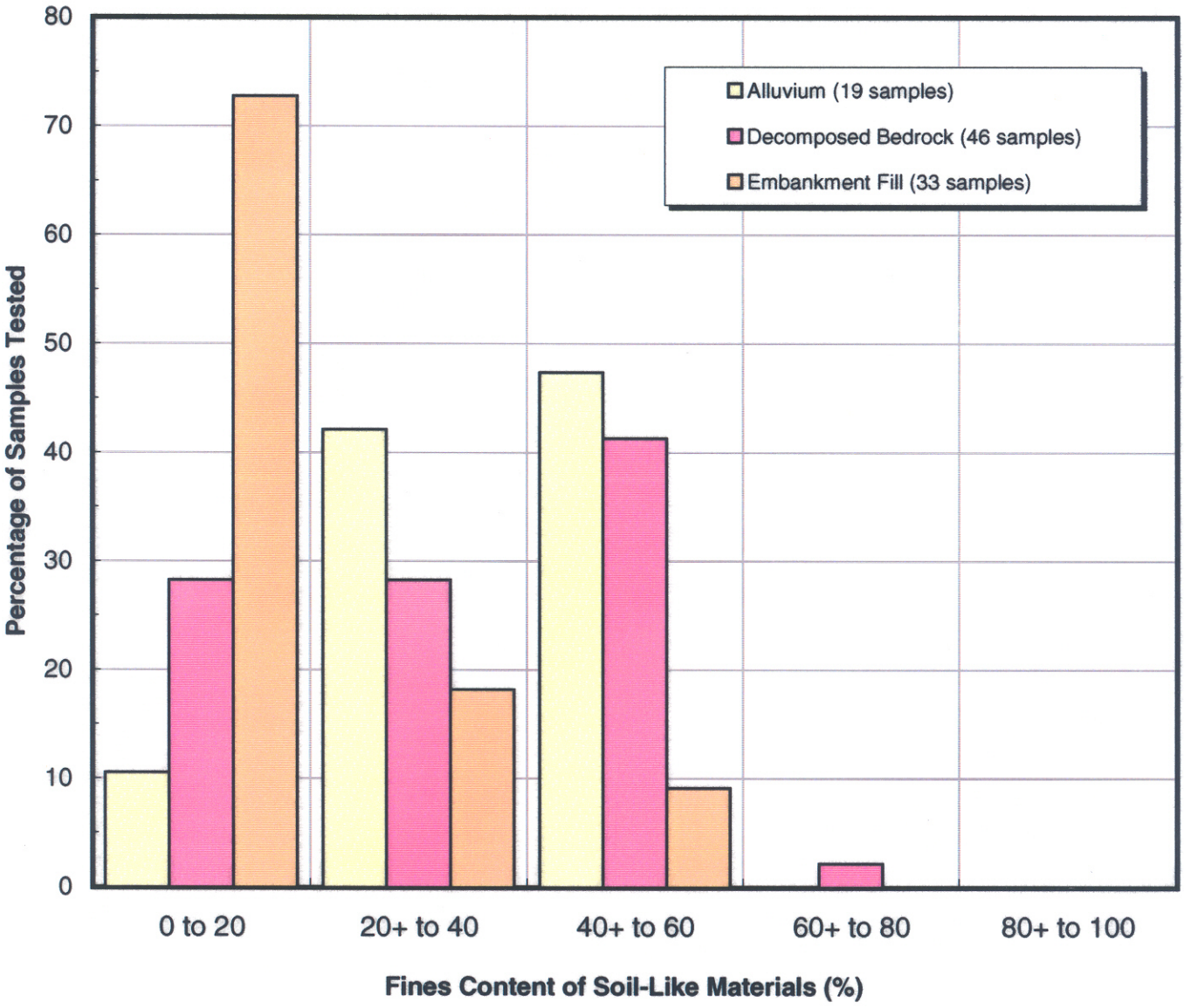


Figure 4-12. Summary of "Soil" Fines Contents

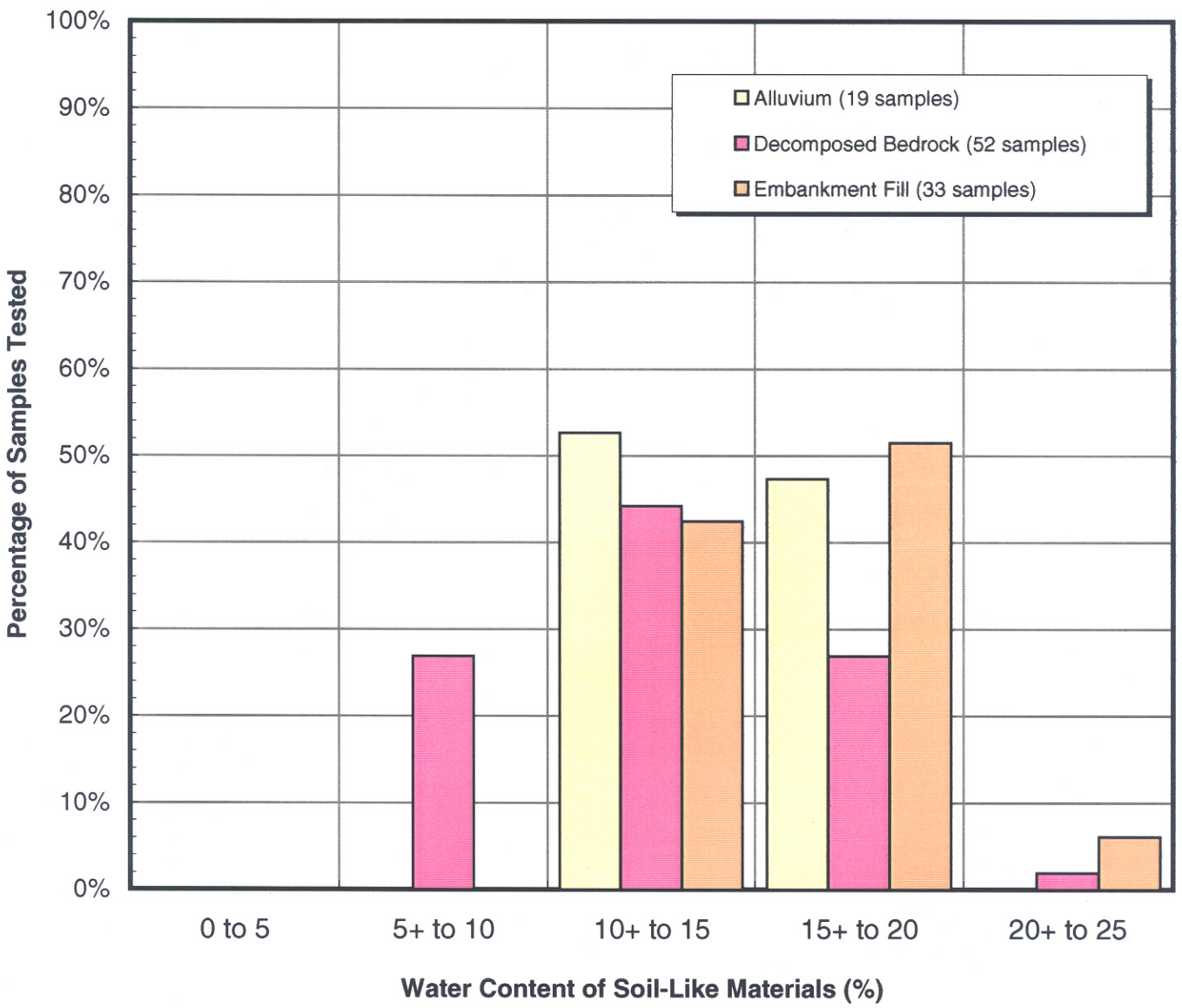


Figure 4-13. Summary of "Soil" Water Contents

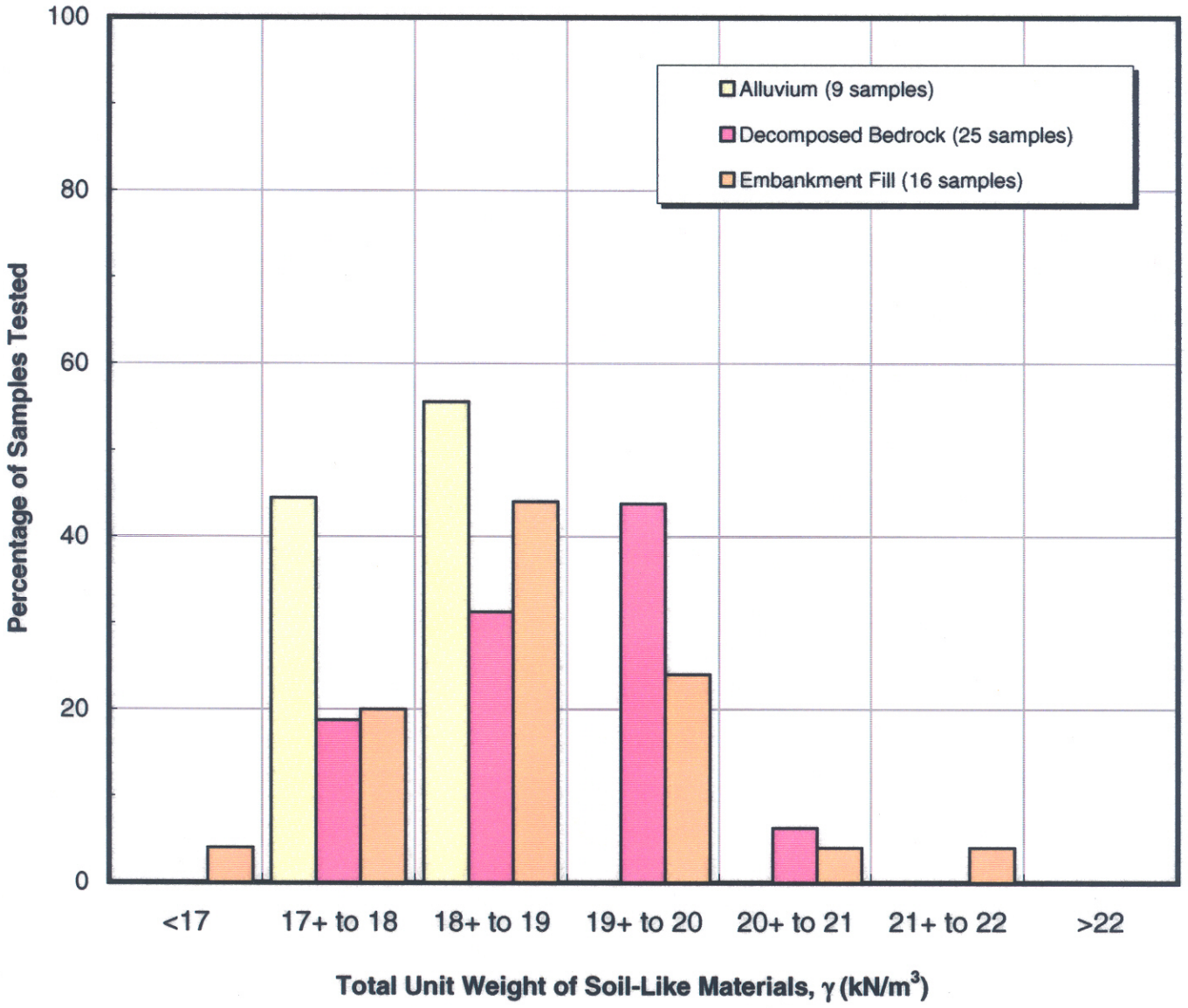


Figure 4-14. Summary of "Soil" Unit Weights

SECTION 5.0

REFERENCES

5.0 REFERENCES

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APPENDIX A-1

DOCUMENTATION OF FIELD OPERATIONS

ADDITIONAL DOCUMENTATION OF FIELD OPERATIONS

This Appendix documents additional background information related to the organization and operation of Phase 2B field exploration that would be beyond the scope of the main text. of the GDR.

Project Organization and Authorization

The Phase 2B was performed in accordance with the Agreement for Subconsultant Services between Earth Mechanics, Inc. (EMI) and HNTB Corporation (HNTB). HNTB serves as the prime consultant for the California Department of Transportation (Caltrans) on the subject project. The field exploration was led by EMI, the geotechnical subconsultant.

Caltrans issued two task orders for the overall site investigation program under Contract No. 59A0234: Task Orders 2A and 2B. Task Order 2A was authorized in January 2001 and was limited to non-invasive site exploration. The Phase-2A exploration included acquisition of aerial photos using a light helicopter, surface geologic and joint mapping, and planning of the drilling program. Upon obtaining encroachment permits from the County of San Mateo and the Coastal Commission, Task Order 2B was authorized in June 2002. The field and laboratory data gathered from both Task Order 2A and the WCC feasibility study was used to plan the Phase 2B exploration. The subject GDR documents the field work of the Task Order 2B exploration.

The attached organization chart illustrates the agencies, coordinators and contractors physically involved in Task Order 2B field work. This work was coordinated and managed by

- Mike Kapuskar, EMI, Geotechnical Engineer;
- Douglas Hamilton, EMI, Lead Geologist;
- Hubert Law, EMI, Geotechnical Engineer; and
- Ignatius Po Lam, EMI, Geotechnical Engineer;

with the following key individuals:

- Skip Sowko, Caltrans (Project Management);
- Francis Mensah, Caltrans (Project management, permitting);
- Moe Amini, Caltrans (CCMB);
- Tinu Mishra, Caltrans (Geotechnical Design);

- David Yam, Caltrans (Landscape Architecture);
- Nien Wang, HNTB (Civil Engineer);
- Richard Vonarb, Caltrans (Biology);
- James Gorham, Caltrans (Biology);
- Gilbert Verdugo, URS Greiner Corp. (Inspection, SWPPP);
- Mike Wolf, James Yee, CH2M Hill (Inspection, SWPPP); and
- Catalino Cecilio, CBC (Field logistics/logging support, accounting).

Permits

Caltrans obtained the necessary right-to-enter permits to perform field operations from the landowners, public and governmental regulatory agencies (including California Coastal Commission, U.S. Fish and Wildlife), the County of San Mateo and the local California Highway Patrol. In June 2002, Caltrans obtained all encroachment permits and authorized Task Order 2B. Utility companies, cities and counties were notified by Underground Service (Dig) Alert prior to drilling or excavation.

Environmental Reviews and Constraints

Erosion control measures were implemented by Hanford ARC and Sierra Equipment Rentals as established by a project SWPPP plan developed by CH2M Hill (2002c) and Caltrans. All Phase-2B field work was under constant observation by URS Corp. and CH2M acting on behalf of Caltrans.

Caltrans and Technical Advisory Panel members conducted several field inspections of equipment, work procedures and findings.

EMI Personnel

The Task Order 2B field work was performed between June 24 and Oct. 9, 2002. Testing, data evaluation and plans and preparation of this report followed through to December 9. M. Kapuskar led the planning and administration of field work and report preparation, D. Hamilton led the overall geologic effort, and C. B. Consulting (CBC) provided logistics support, additional geologists, and accounting services.

The following EMI and CBC personnel participated in the field activities (in alphabetical order):

Person	*Position (Company)*	*Task*
Eric Brown	Geotechnical Engineer (EMI)	Plans
Jody Castle	Geologist (EMI)	Logging, data analysis
Douglas Hamilton	Lead Geologist (EMI)	Lead Geological mapping & analysis, lead author
Reynold Jie	Field Technician (EMI)	Field logging, coordination, soil testing
Mike Kapuskar	Geotechnical Engineer (EMI)	Project lead, coordination, management, analysis, lead author
Andy Korkos	Geotechnical Engineer (EMI)	Plans & Spec's, analysis, report preparation
Hubert Law	Engineer (EMI)	Project management, analysis, author
Po Lam	Geotechnical Engineer (EMI)	Project review
S. Varatharaj	Engineer (EMI)	Assist field coordination, analysis
Bruce Schell	Engineering Geologist (EMI)	Geological mapping & analysis, report preparation
Saverio Siciliano	Engineer/Geologist (EMI)	Field logging & testing, assist coordination, analysis, report preparation
Catalino Cecilio	Accountant/Hydrologist (CBC)	Accounting, logistics
Julie Cecilio	Clerical (CBC)	Accounting, logistics
Tim Bodkin	Geologist (CBC)	Field logging & testing
Phillip Frame	Geologist (CBC)	Field logging
Marc Hachey	Geologist (CBC)	Field logging & testing
Larry Patzkowski	Geologist (CBC)	Field logging

Field Logistics

The field operations were coordinated from a project logistics office on San Pedro Road in Pacifica equipped with phone and power. Rock cores and soil samples were stored on sturdy wooden shelving in a leased 12-m long trailer-container near the project office. The trailer was equipped with air-conditioning for temperature/moisture-control. Core storage near the project site allowed for efficient and convenient extraction of a large number of selected core boxes for inspection, point load testing, post-logging, photographing, and selection for laboratory testing, while minimizing sample

disturbance and reduce testing time.

Supervision and Safety

Geotechnical activities of the exploration were supervised by one or two EMI engineer full-time on a rotating schedule, either on-site or on-call from the Pacifica logistics office. EMI field personnel include 40-hour (HAZWOPER)-training. Because environmentally impacted soils and groundwater were not likely to be encountered, a standard site-specific Health and Safety Plan was not in EMI's scope of work and a site-specific hazardous materials management plan was not required. A Health and Safety plan defines any physical and chemical hazards, type and potential for encountering hazardous materials, exposure limits, worker safety and emergency procedures. EMI held kick-off meetings and safety meetings to establish work procedures in general accordance with OSHA requirements prior, during and after drilling in an areas, proper handling and disposal procedures for the borehole cuttings and drill fluids, points of contact, emergency procedures. A basic Safety Plan was prepared by CH2M Hill (2002b), and safety meetings were held at the Project logistics office.

Site Preparation

Site preparation was conducted by Hanford ARC, Sierra Equipment Rentals, and Ruen Drilling using the following equipment:

- D4 Dozer;
- D6 Dozer;
- Brushcutter, weedwacker, chipper.

The boresites were surveyed by Geotopo under subcontract to HNTB.

Existing trails P-1a, 1b and 3a required conditioning of the earthen ground and minor removal of vegetation in some areas. The first 150 m of the steep access trail P-1a was conditioned by placement of tensar grids within a layer of gravel.

Erosion control measures were implemented per Caltrans direction. Such measures included barrier fences, fiber mats, straw bails. During drilling, protective absorbent pads, plastic sheeting were used cover ground or equipment. Earthen burrows were used to conduct drill fluid to settlement tanks.

Water bars were planned and budgeted for as part of the erosion control measures but were not installed.

In work areas on steep slopes, wooden cribbing was used to level drill rigs.

Air Lifting

Drill rig and other equipments were airlifted to sites 02-16, 02-2, 02-14 and 02-15 that

had severe access problem. Equipments were airlifted and dropped off back from site 02-5. A typical airlift required ten to fifteen trips. Route 1 was closed during airlift activities from site 02-2 and 02-14 as these two sites were slope of Route 1. The Aris helicopter company was hired for this job.

Slide repair

A 5-m segment of path P-1a showed signs of yielding at the downslope side. Hanford ARC installed a temporary wooden retaining wall which was anchored into the bedrock according to the directions from Caltrans. Complete slide repair including gabion baskets was budgeted for but not performed during the exploration program.

K-barrier

At the South Portal turn-out area, a string of about 70 m of concrete K-barriers was placed By Sierra to enclose the turn-out area. The turn-out area included a water tank, a water pump and a disposal tank to store waste drilling fluid. The intension of the K-barriers was to protect these tanks and LF-70 rig and crew during drilling activities at 02-13 and 02-19.

Site Restoration

After completion of geotechnical and geological field work, Hanford ARC began site restoration efforts by under Caltrans direction.

Equipment

The complexity of the field exploration required a multitude of equipment. Key equipment comprised the following:

- (3) HQ3 coring/rotary-wash drill rigs
- (1) auger drill rig
- (2) Marooka vehicles
- Utility trucks
- 6,900-gal water tank (at Shamrock Ranch & Route 1 North bridge abut)
- 10,000-gal raised water tank (at South Portal staging area)
- 20,000-gal water tank (at Route 1 North bridge abut)
- Environmental drill fluid/cuttings dumpster (at South Portal staging area)
- Tool shed/yard
- System of water hoses and pumps
- Settlement tanks (2 per rig)
- Light plant

- Grout plant
- Core storage trailer
- Project logistics office
- (3) ATV vehicles
- Geologist vehicles
- Hole deviation survey tool
- Downhole test equipment and utility vehicles

The attached photos depict some of this equipment.

Drilling equipment consisted of portable LF-70 drill rigs and one CS-1000 truck-mounted drill rig, all equipped with rotary wash and wireline core retrieval systems. Clearheart Drilling used a track-mounted auger drill rig and a track-mounted support vehicle to access the locations inaccessible to conventional rubber-tired drilling equipment.

On difficult-access terrain such as on new path P-2 and existing Path 3b, two track-mounted Marooka vehicles were used for general-purpose transport of equipment, waste tanks, and personnel.

A water supply system was installed by Ruen Drilling consisting of network of 25 mm flexible hosing with couplings wire-shut at critical connection points. Sierra installed a upper black polyethylene water tank at the upper staging area TA-2, and a large, raised lower steel feeder tank in the South Portal turnout area TA-3. Sierra was subcontracted by Ruen to provide water delivery via Route 1 from the City of Pacifica to the feeder tank. Ruen operated a water pump at the area TA-3 to pump up water to the upper holding tank.

Geologists and drill crews used 4WD vehicles to travel existing paths P-1, 2, 3b and 4. New path P-2 could not be driven safely with tired vehicles. The Path P-4 is a hiking trail traversing steep terrain and was too narrow to be traveled by vehicle.

In-hole testing equipment was delivered to the site using 4WD jeep-type or utility vehicles, hand-carried or airlifted. Such equipment consisted of in-hole logging probes or support components such as power winches, and additional borehole rods. A time-triggered magnetic borehole survey tool was used in horizontal boring 02-11 and 11A to verify the dip and orientation of the actual drill path at selected slant depths.

Groundwater Condition

During drilling of a series of boreholes in the north portal area, borehole advancement was variable depending on the rock formation encountered. Difficult drilling was experienced in subhorizontal boreholes 02-11 beyond 85 m depth, accompanied by

excessive water outflow from the borehole collar. For several days, water and black muds consisting of ground-up rock as well as angular rock particles were retrieved from the borehole using the barrel or washed out, and were collected in storage holding tanks set up on the trail. Upon Caltrans approval, clear water was allowed to drain into the adjacent swale. This allowed the borehole tip to continually collapse and the churned up clay-like rock material could not be removed with the HQ core barrel system at a fast enough rate to clear the hole and allow reentering the drill bit.

Borehole 02-11 had been drilled along the tunnel pillar centerline (as verified by three downhole surveys indicating less than one degree offset). After several unsuccessful retries and upon Caltrans approval, the borehole terminated at 125 m depth and grouted, and the drill rig rotated about 1° east off the tunnel centerline and the borehole redrilled subhorizontal as boring 02-11A. Drilling occurred in 10- to 12-hour day and night shifts. In early September, after drilling quite successfully to about 174 m within several days, drilling of Borehole 02-11A was shut down because water was flowing from the hole at a rate of up to 380-450 l/min (100-120 gpm) from the 100-mm size steel collar pipe. That rate of flow was faster than could be pumped and the water storage tanks became filled to capacity. One of the attached photos shows typical water outflow encountered.

Upon Caltrans approval, a line of high-pressure Schedule 40 was installed from the 02-11 site down across the valley in the western reach of Shamrock Ranch, and up the slopes to the an existing turn-out area (the proposed northern bridge abutment) along Route 1. A large 26,000 liter (6,900 gal) water tank was set up in the valley and connected to the pipe to two large 26,000 liter (6,900 gal) and later a 38,000 liter (10,000 gal) tank that were setup in that area. The excess water was pumped to the large storage tank along Route 1 using a high-pressure water pump at the valley bottom. The attached photos depict some of this equipment.

The following summarizes the day-by-day activities in more detail, and describes the water outflow and accompanying difficulties experienced, and the measures implemented to continue the borehole:

- On Monday 8/19, Mike Kapuskar and Bruce Schell provided a status report on the non-progress and proposed course of action, consisting of drilling two contingency holes and possible options to redrill 02-11. Grouting operations at Borehole 02-11 began.

- On Tuesday 8/20, Mike Kapuskar developed and submitted a cost proposal for drilling a new "flat hole" 02-11A. At the depth of the encountered caving zone beginning at 100 m penetration depth, the borehole path would be 7 m east from the pillar centerline. As a result, the new borehole would pass by the caved zone at a 7 m distance to the center of the zone. At the depth of the

122 m, the borehole path would be 8.5 m from the pillar centerline. At the maximum target depth of 250 to 350 m (the borehole path would be 17.5 to 24.5 m from the pillar centerline. According to Figure 3.6 of the Aesthetics Committee Report (2002), the width of the pillar is about 17 to 19 m measured between the inside finished faces of the two bores. As a result, the borehole path would remain in the pillar in the first at 122 m of penetration, then straddle the NB tunnel wall and enter the NB tunnel bore, with the tip of the borehole (if completed) up to 1.5 to 4.6 m inside the NB tunnel bore.

EMI also considered offsetting the new borehole to the east by 6.1 m to pass by the caving zone while remaining in the pillar material, and offsetting even further to pass through the NB tunnel borehole or parallel to the east of the NB tunnel bore. These options would have required additional budget and time and were not selected for the following cost proposal due to present constraints for both.

EMI expected to encounter the same kind of caving situation in the sheared claystone as in terminated borehole 02-11. A reverse circulation system using water could be used to remove the caving materials through the inside of the casing rather than the borehole annulus. However, the CS-1000 rig is not equipped with such a system and it would take precious time to obtain and setup a workable recirculation system. EMI proposed boring using the present rig with the following procedure of telescoping casings implemented:

(a) Perform continuous coring and advance the HQ casing to beyond the initial 125.8 m (412.5 ft) of penetration depth. This avoids caving and hole collapse experienced when the hole was drained into the tanks or the adjacent swale, and water pressure build-up that occurred when the hole was shut-off. Continuous rig operation will require two 12-hour shifts per day, 7 days a week.

(b) After penetration through the problem zone of sheared claystone beyond 125.8 m, advance the HQ casing into the firm rock material as far as it will enter.

(c) Continue in a reduced NQ size borehole without casing. Should a second problem zone be encountered after 137 m, NQ size casing would be installed full-length to beyond the end of the second zone (we will assume NQ casing to 198 m. The next smaller size casing would be BQ casing at the expense of additional time (such as 3 days) and cost, hoping not more than two of these zones would be encountered. Beyond the NQ casing, the cost of the borehole will be prohibitive.

(d) After passing through the problem zone(s), we expect drilling to advance at a rate of 25 to 35 m (~80 to 120 ft) per day based on drill rates achieved in the prior boring 02-11. It would be attempted to continue the hole to the 250 to 350 m target depth depending on geologic findings and available time and resources.

At completion of borehole, attempt would be made to remove all (HQ and NQ) casing, although it was expected that NQ casing beyond the second zone and HQ casing beyond the first zone would not to be retrievable.

- On Wednesday 8/21, Caltrans approved continuation of drilling a new hole 02-11A.

- On Thursday 8/22, the rig was repositioned at an alignment 4° easterly from boring 02-11 and preparations were made for drilling. The last grouting stage was completed at borehole 02-11.

- On Friday 8/23, drilling of the new hole began with day and night shifts.

- On Saturday 8/24, borehole 02-11A had achieved 45.7 m depth after total of four shifts.

- On Sunday 8/25, no drilling.

- On Monday 8/26, reached 68.4 m in the night shift.

- On Tuesday 8/27, reached 70+ m penetration in the day shift and 97 m in the night shift. Drilling was conducted in two 10-hour shifts quite successfully until we approached near the problem area (shear zone/fracture zone). At about 91.5 m, great water pressures and water volumes built up after shutting the hole at the end of the day. These shutdown periods actually were about 6 hours long because it takes about an hour to shut down drilling at the end of the day and about an hour to get the hole conditioned and the drill stem back in the hole upon startup at the beginning of the next day.

- On Wednesday 8/28, claystone was encountered at 99.7 m (327 ft) (compared to 99.4 m (326 ft) in boring 02-11), and the penetration depth advanced to 337 ft. Drilling penetrated about 3 m into the dark claystone material. The material retrieved could be placed in the core box due to the presence of clay, however it can easily be disintegrate and crushed down into small rock particles, sand and clay by hand and with application of water. We had very strong winds in the afternoon and the night shift. During the night shift, the hole progressed through the shear zone another 12 to 15 m. The water pump

broke during hauling of drill muds. Water outflow was 4 to 20 l/min (1 to 5 gpm).

- On Thursday 8/29, 117 m was reached. Water flow increased again, to 115-155 l/min (30 to 40 gpm). The water tanks have filled about 38,400 liters (10,000 gal)of muddy water. Universal Environmental disposal service was called on site but the water pump was not ready for deployment. Drilling stopped just short of the expected problem shear zone. As in borehole 02-11, large volumes of water were encountered. The volumes were large enough that the water storage tanks filled much more quickly than anticipated. EMI did not want to penetrate the shear zone and get into a larger water-producing zone until a sufficient tank capacity was available to accommodate it. Hanford ARC installed the larger tanks at that time due to the Labor Day holiday, the following day, EMI decided to wait to proceed with drilling until after the break. Because the previous borehole 02-11 was lost after sitting for an extended period of time, EMI wanted uninterrupted drilling on boring 02-11A until the problem area was penetrated through. As a result, the borehole was capped off.

- On Friday 8/30, there was no progress; the rig remained idle. Mike Kapuskar submitted a proposal and obtained approval from Moe Amini and Francis Mensah to move in an additional 76,000 liter (20,000 gal) water tank at the abutment turnout area. The tank and mud pump were moved in.

- Between Saturday and Wednesday 8/30-9/4, there was no drilling (extended Labor day weekend).

- On Thursday 9/5, borehole 02-11A was not advanced. The day shift crew was not on site. The night crew worked on a mechanical problem involving the gear box. Water outflow was about 110-150 l/min (30-40 gpm) and 9,500 liter (2,500 gal) of muddy water was diverted into the tanks.

- On Friday 9/6, upon return from the break, 24-hour drilling resumed in conjunction with the increased tank capacity. Drilling continued from a depth (distance) of 117 m from noon to 7 pm, and through the 12-hour night shift ending 7 am, making significant progress and reaching 111 m. We were able to drill through the shear zone consisting of sheared claystone, siltstone and sandstone first encountered at 99 m, and the following fractured zone behind it that produced water. Water outflow was about 150 l/min (40 gpm) and 5,800 liters (1,500 gal) of muds was diverted into the tanks.

- On Saturday 9/7, drilling continued in a 12-hour day shift and through the 12-hour night shift. We were able to drill through the shear zone (first

encountered at 99.4 m). Another 3,800 liters (1,000 gal) of muddy water was drained into the tanks. At a depth of 121 m, we entered relatively good rock, but then found several shear zones and fractured zones between 131 to 140 m. Relatively good rock (but still with low RQD's of less than 25%) continued from about 140 m, with an occasional narrow shear zone (i.e. less than 30 cm). Due to the significant progress, we decided at noon to perform continuous drilling using two 12-hours shifts on Sunday. We obtained clearance from Shamrock Ranch for drilling this Sunday, and notified Caltrans again. In the night shift, we encountered "good" rock with occasional thin shear zones several inches to about a foot thick. At 169 m, we encountered heavy water flow that increased as the hole advanced.

- On Sunday 9/8, at 173.7 m depth water was flowing at a rate of 385 to 460 l/min (100-120 gpm). We encountered difficulty reinserting the core sampler back inside the drill pipe. At 4:30 am in the morning, the lower tanks were filled with waste water. Drilling was shut down at 174.4 m depth because water was flowing from the hole at a rate of about 385 to 460 l/min (100-120 gpm). This rate and force of flow was faster and stronger than could be pumped and the water storage tanks became filled to capacity. We decided to halt drilling until those tanks were emptied and another water pump could be hooked up to handle the significant water outflow. This water (16,000 gal) was pumped to the large storage tank at Route 1 turn-out area (the site of the proposed bridge north abutment). We allowed the clear borehole water to drain via 1" hose into the adjacent swale overnight, to relieve water pressure in the borehole and avoid water from washing through the annulus of the collar casing (between casing and borehole wall).

  Analysis of the boring data and borehole geometry indicated that at a depth of about 174.4 m, borehole 02-11A would be very close to borehole 02-6A which was being drilled concurrently and entirely within the good rock of the Central Block. This suggested that 02-11A should encounter the good rock of the Central Block within the next 1 ft or so. It was thought very possible that the shear zone at 174.4 m in 02-11A is the target fault zone that separates the Central Block from the Northern Block, but this determination would require drilling into and staying within sound sandstone/conglomerate rock for about 9 to 18 m.

- On Monday 9/9, we waited for the water pump. Ruen's foreman, Jerry Schroeder, left the project in order to tend to a personal emergency. Water was still being pumped to the large storage tank at Route 1 abutment turn-out area. Mike Kapuskar contacted Universal Environmental and notified Ben Goody of Ruen to haul off 16,000 gal of water from the upper tank. The CS-1000 drill crew helped prepare for airlifting from 02-16 to 02-15. Mr. Ruen

was expected to arrive and act in Mr. Schroeder's place. Doug Hamilton visited and inspected drilling progress.

- At 1 pm, drill rods were reentered into the borehole and 64 m of depth was easily achieved by within 1-1/2 hour's time. Within the next hour, a depth of 100.6 m was reached, but water outflow occurred from the hole at 115 l/min (30 gpm). The rest of borehole had caved from 110.6 to 109.8 m. Subsequent to caving, the day shift and the night shift tried to advance the drill string through this blockage without success.

- On Tuesday 9/10, the large tank was partly pumped out and drilling was resumed. At a penetration depth of about 85.4 m in the hole, the water coming from the hole became muddy with black particles and clay. At about 97.6 m, the drilling rods encountered an obstruction; the hole appears to have collapsed at this point. EMI (Bruce Schell and Mike Kapuskar) discussed the situation and decided to pull out all casing at the end of the shift (5 pm) and shut off the hole. They notified Caltrans in writing of the progress and borehole termination. Water was left draining into the adjacent swale via 25-mm flexible hose.

- On Wednesday 9/11, activities including grouting the hole and demobilizing the rig.

- On Thursday 9/12, the rig was moved to hilltop site 02-5 in day and night shifts.

Other Issues

During drilling of the rock borings, the local public showed a heightened awareness of the project. Visitors were observed hiking through the project site on existing trails or new trail P-4, including narrow trail P-3b above the steep portal slopes, passing across workpads in operation. Per request by Caltrans and Shamrock Ranch owners, trespassing signs were posted at designated borderline locations.

There have been several occurrences of vandalism during the operation of the project. Caltrans was notified of such occurrences, which may or may not be linked with the Devil's Slide Tunnel Project. Manifestations that had some effect on the exploration included (1) placement of acid liquid on water pump at TA-3 (this caused skin injury to a Ruen worker and delay of two drill rig operations, and Route 1 closure to allow HAZMAT clean-up); (2) graffiti on equipment including water tanks, dumpster and logging tables; (3) demolition of mock security camera mounted in raised water tank at TA-3; and (4) scattering and piling of trash and oil waste fluid at staging area TA-3. At the end of the project, a chemical portapotty has been taken from the Route 1 pick-up

site by unknown party.

Field Records

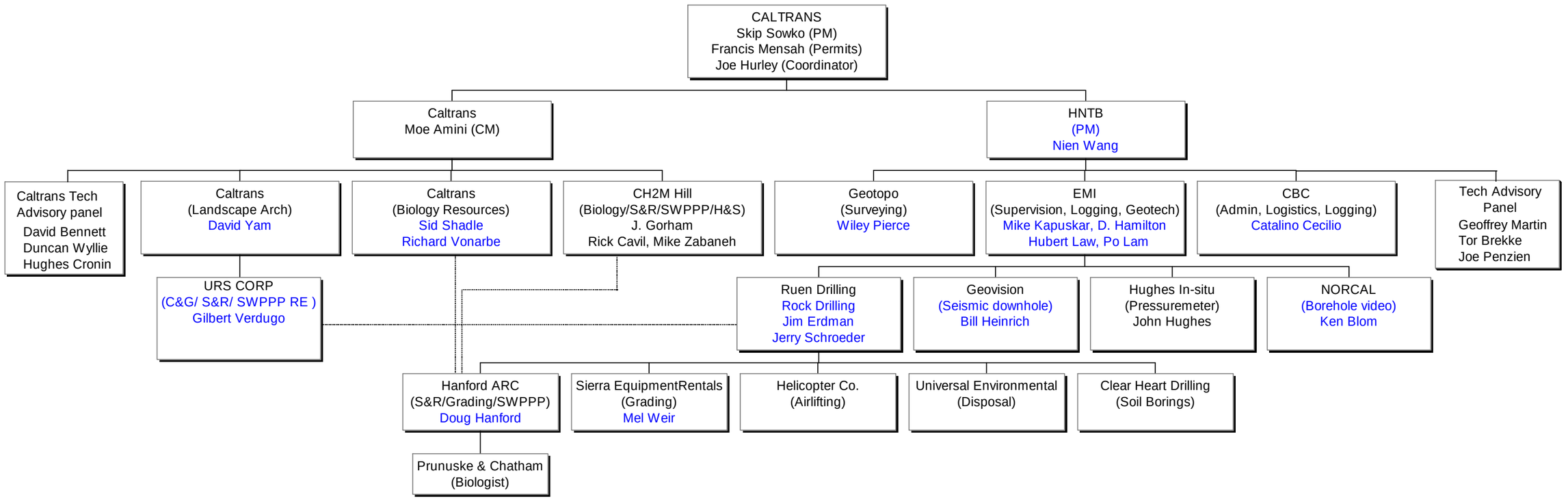
Field personnel kept daily reports and generated core log sheets. The daily reports describe general information such as:

- Date, time, weather conditions
- List of attendees, time of attendance
- Time and description of field activities and events to track progress, delays, manhours, equipment usage etc.

Core log sheets were used in the field to record the logged data:

- General information such as date and time (shift), geologist on schedule
- Core run number and depths, core box numbers
- Logged core in general accordance with Caltrans Rock Classification manual
- Beginning and end time of runs

This information was then collected and translated into EMI's geologic borehole database.



LEGEND

Report/Contract ————

Supervision ·····

Organization Chart
Geotechnical Exploration T.O. 2B
Devil's Slide Tunnels Project

Tensar grids laid down on access road P-1c (7/30/02)

Gravel top on access road P-1c (8/01/02)

Earthwork on road P-1c

Trail Preparation

Clearing of brush to create access road P-2

Slide repair at Trail P-1a

Drilling at Sites 02-8 (top) and 02-18B on Road P-2

Drilling at Sites 02-18 (front) and 02-12 (back) on Road P-2

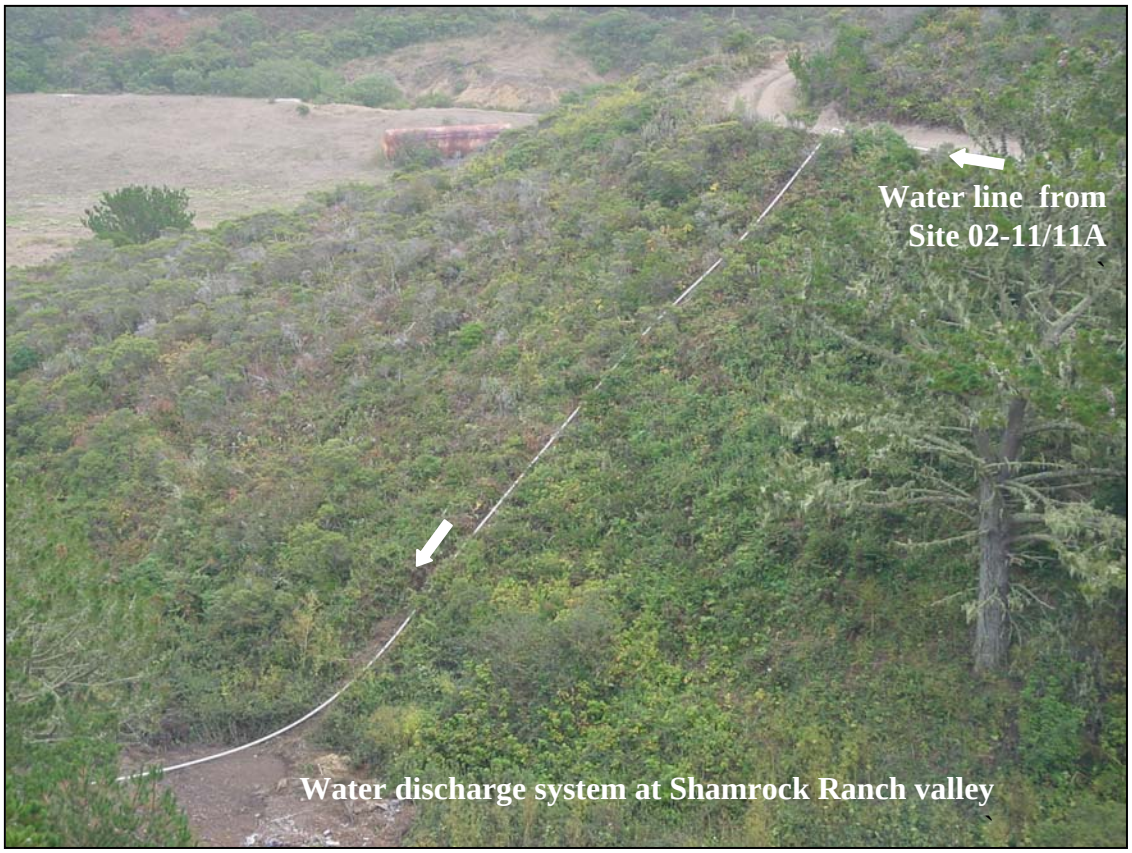
Drilling at Borehole 02-12

Borehole Sites at North Portal (from top: 02-18B, 12, and 11/11A)

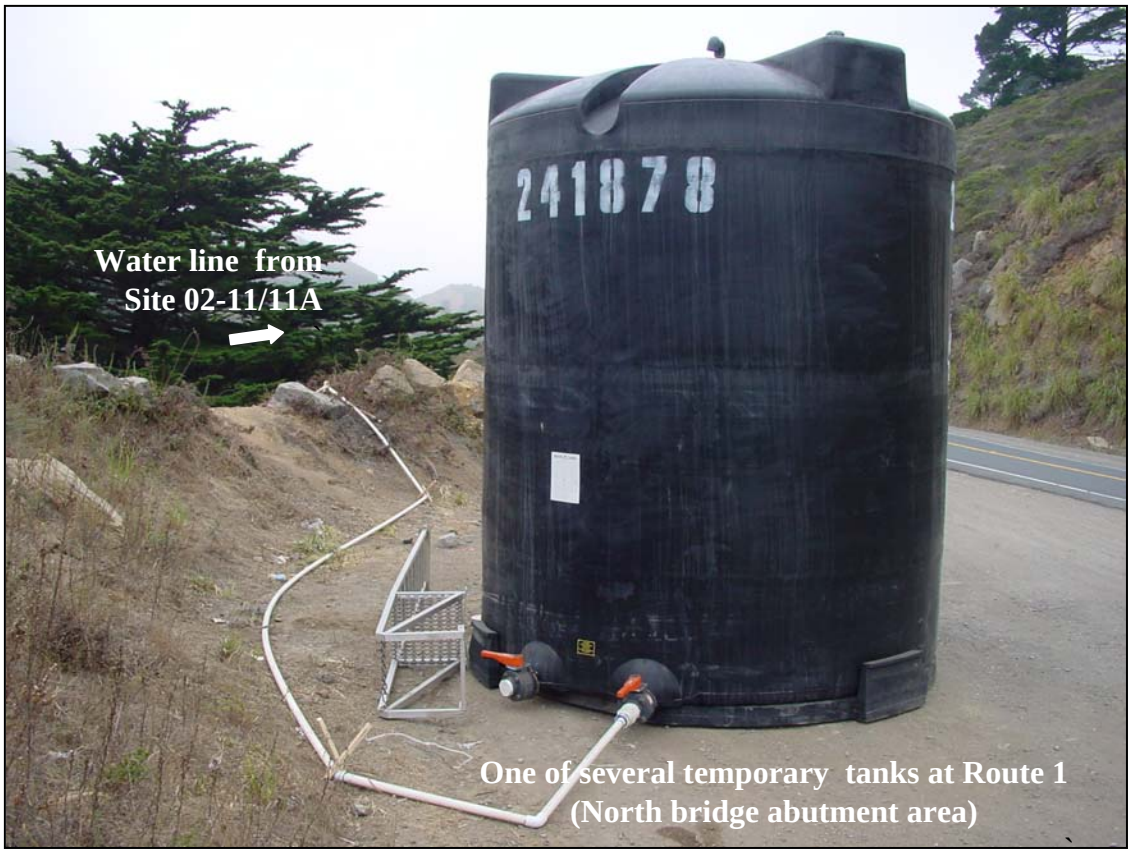
Drill Rig CS-1000 at Borehole Site 02-11

Drill Rig CS-1000 at Borehole Site 02-11

Water outflow from 100 mm dia. collar pipe at Borehole Site O2-11



Water discharge system at Shamrock Ranch valley

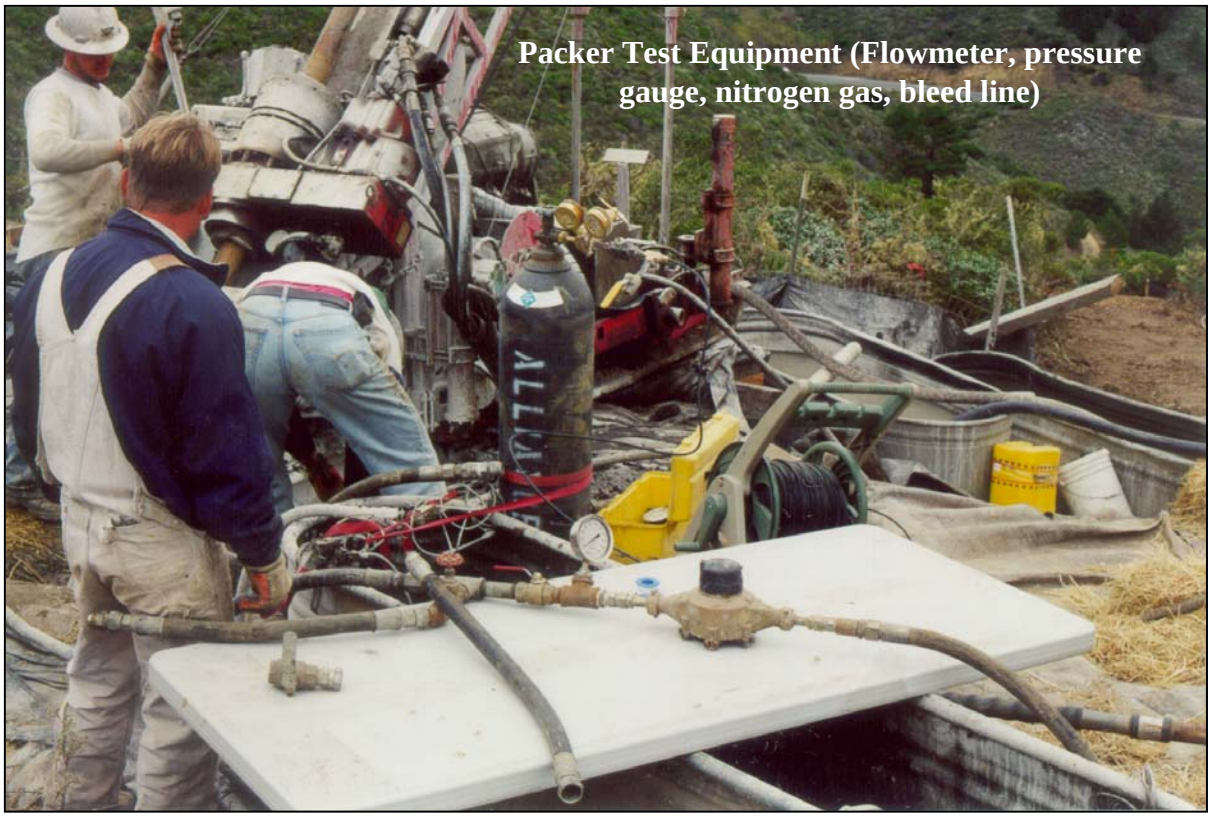


One of several temporary tanks at Route 1
(North bridge abutment area)

Field review on 8/12/02

Field core inspection

Packer Testing at Borehole 02-7



Packer Test Equipment (Flowmeter, pressure gauge, nitrogen gas, bleed line)

Boresite 02-8B

Drilling at Site 02-8B

Video logging at 02-8B

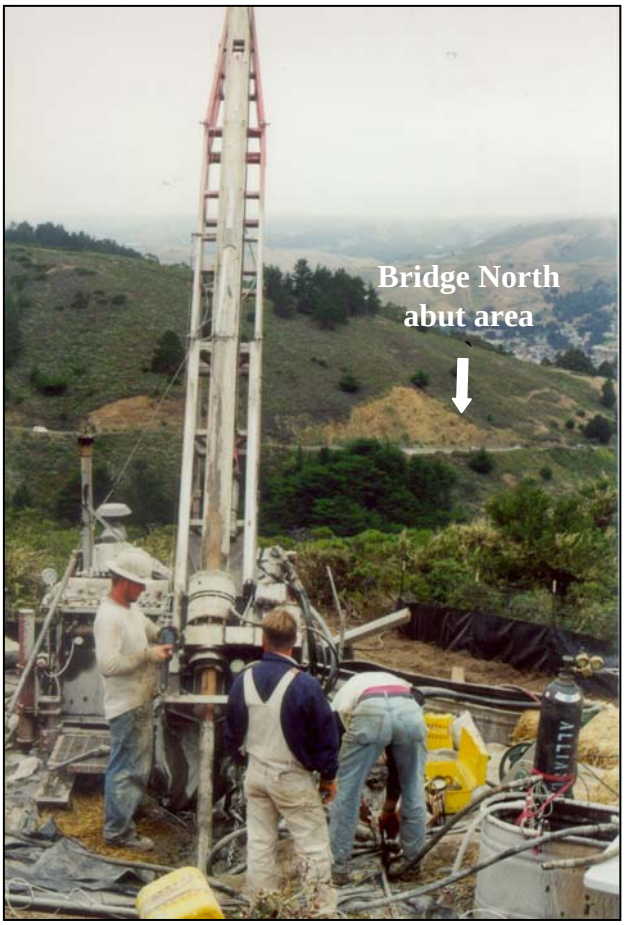
Optical televiewer probe

LF-70 Drill Rig on 02-16 platform (airlifted)

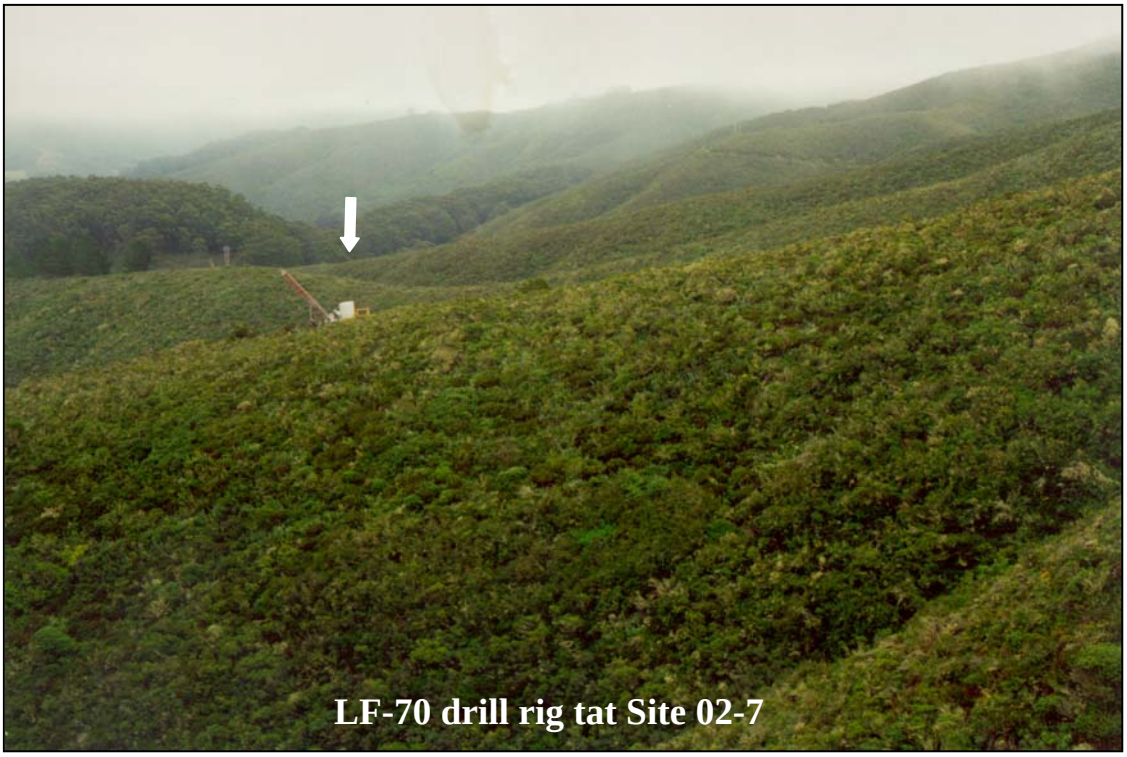
Slope ladder access to work pad at Site 02-16

Site 02-11/11A
Trench 02-T3
Site 02-16
North Portal

Trench 02-T3



LF-70 rig at Site 02-7 (looking upstation)



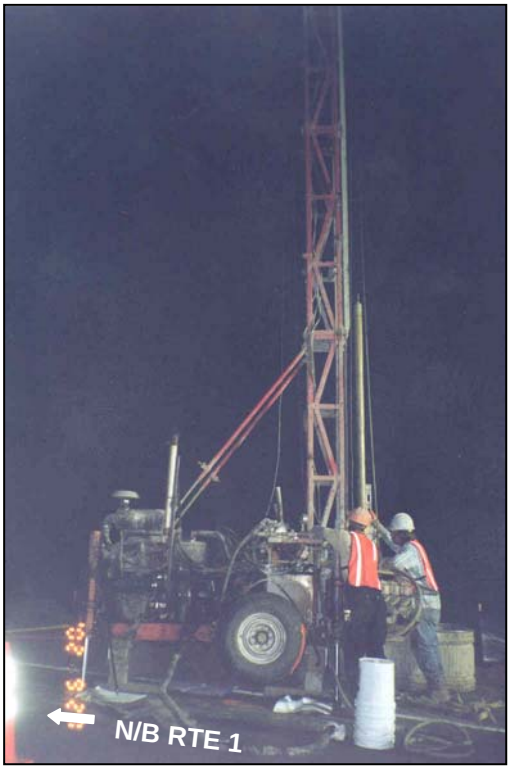
Track-mounted MST-600 dry stem auger drill rig

Prop. OMC Bldg Site

Site 02-ST2

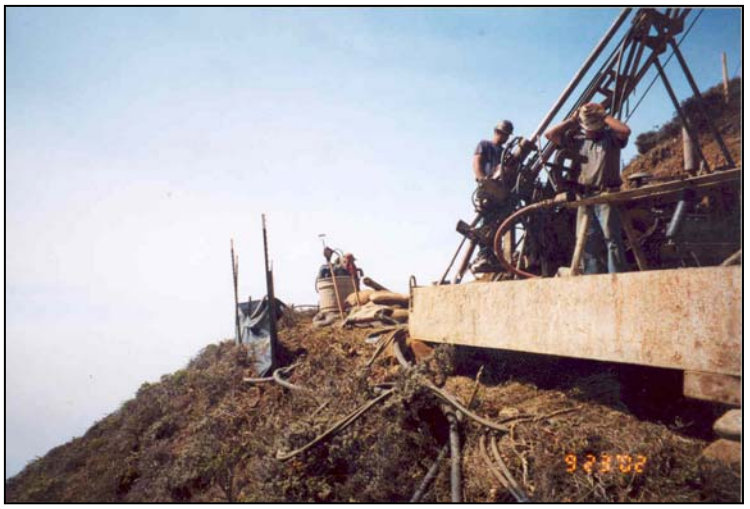
Auger drill rig at 02-ST2

Site 02-20 at Route 1 embankment in South Disposal Site



Night time drilling at Site 02-21

NE'ly View of South Portal & Rock Cut Area



Drilling at Sites 02-2/2A/2B on trail above South Portal

Core storage trailer core and post-logging of cores – 460 boxes

Post-logging and point load testing of core

Core selection and preservation for laboratory rock testing

APPENDIX B-1

LOG OF TEST BORING PLANS (2002 PHASE 2B EXPLORATION)

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

REGISTERED GEOTECHNICAL ENGINEER

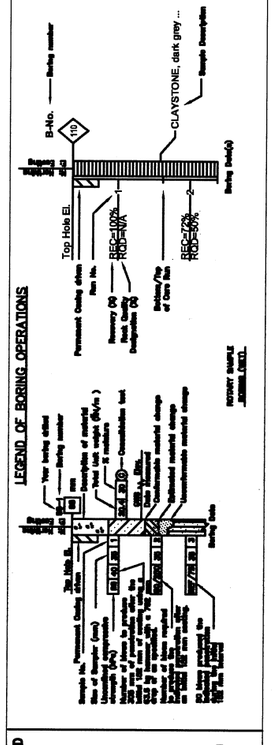
REGISTERED PROFESSIONAL ENGINEER — MIKE KAPUSKAR — NO. GE 2364 EXP. 12-31-04 — GEOTECHNICAL — STATE OF CALIFORNIA

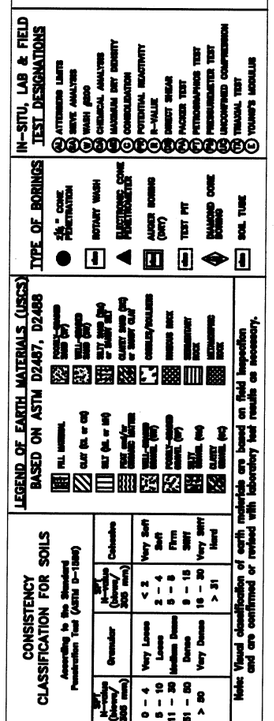
PLAN APPROVAL DATE

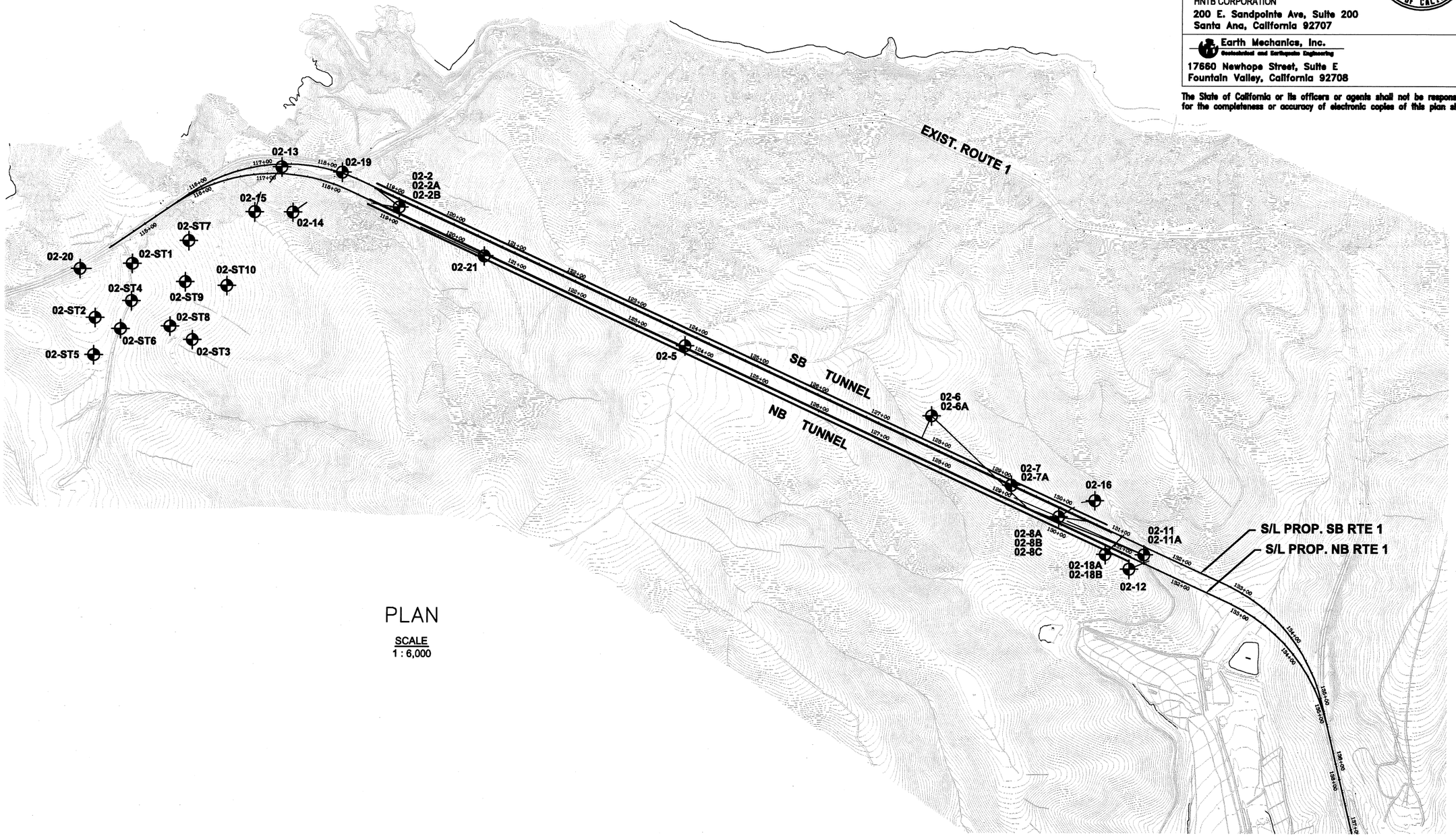
HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

The State of California or its officers or agents shall not be responsible for the completeness or accuracy of electronic copies of this plan sheet.







PLAN

SCALE
1 : 6,000

DESIGN	BY S. SICILIANO	12/04/02	VARIOUS/GEOLOGIST FIELD INVESTIGATORS/TITLE	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	M. KAPUSKAR PROJECT ENGINEER
CHECKED	BY M. KAPUSKAR	12/6/02	DATE 7/25/02 to 10/04/02		

DESIGN OVERSIGHT KEYHAN MOGHBEL
SIGNOFF DATE

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

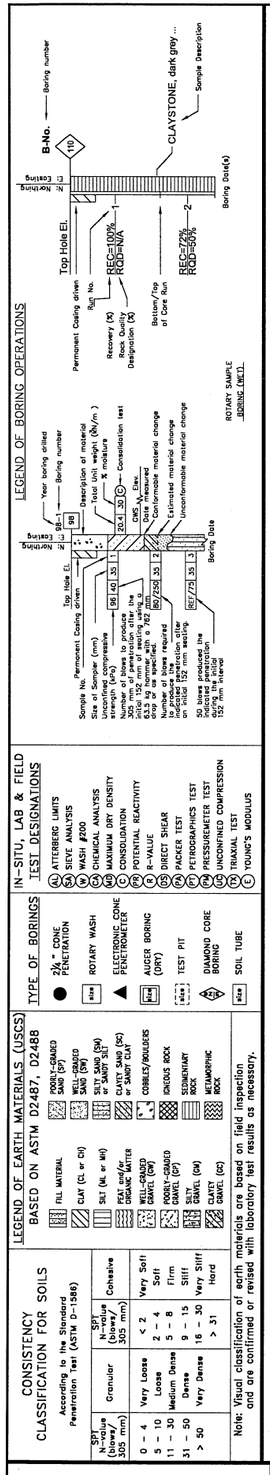
BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) 8/13/03

SHEET OF



IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (R) R-VALUE
- (PR) POTENTIAL REACTIVITY
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (P) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

TYPE OF BORINGS

- 2¼" CONE PENETRATION
- ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- AUGER BORING (DRY)
- TEST PIT
- DIAMOND CORE BORING
- SOIL TUBE

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- FINE GRAINED SOILS OF HIGH ORGANIC CONTENT
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SW)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

RELATIVE ROCK WEATHERING

Descriptors and Abbreviations	Diagnostic Features: Chemical Weathering-Discoloration, Oxidation — Body of Rock	Chemical Weathering-Discoloration, Oxidation — Fracture Surfaces	Mechanical weathering–grain boundary conditions (primary for granitics and some coarse–grained sediments)	Texture	Solutioning	General characteristics (strength, excavation, etc)
Fresh	No discoloration, or oxidization	No discoloration or oxidation	No separation, intact (tight)	No change	None	Hammer rings when crystalline rocks are struck, except for naturally weak or weakly cemented rocks such as siltstones, or shales
Slightly Weathered	Discoloration or oxidation limited to surface of or short distance from fractures; some feldspar crystals are dull	Minor to complete discoloration or oxidation of most surfaces	No visible separation, intact, tight	Preserved	Minor leaching of some soluble minerals	Hammer rings when crystalline rocks are struck. Body of rock not weakened. With few exceptions, such as siltstones or shales
Moderately Weathered	Discoloration or oxidation extends from fractures usually throughout; Fe–Mg minerals are rusty, feldspar crystals are cloudy	All fracture surfaces are discolored or oxidized	Partial separation of boundaries visible	Generally Preserved	Soluble minerals may be mostly leached	Hammer does not ring when rock is struck. Body of rock is slightly weakened.
Intensely Weathered	Discoloration or oxidation throughout; all feldspars and Fe–Mg minerals are altered to clay to some extent; or chemical alteration produces in situ disaggregation, see Grain Boundary Conditions	All fracture surfaces are discolored or oxidized, surfaces friable	Partial separation, rock is friable; in semi–arid conditions granitics are disaggregated	Texture altered by chemical disintegration (hydration, argillation)	Leaching of soluble minerals may be complete	Dull sound when struck with hammer, usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness such as incipient or hairline fractures, or veinlets. Rock is significantly weakened.
Decomposed	Discolored or oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe–Mg minerals are completely altered to clay		Complete separation of grain boundaries (disaggregated)	Resembles a soil, partial or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete		Can be granulated by hand. Resistant minerals such as quartz may be present as stringers or dikes.

ROCK HARDNESS/STRENGTH DESCRIPTORS

Rock Hardness	Criteria
Extremely Hard	Can't be scratched with knife or sharp pick, can only be chipped with repeated heavy hammer blows.
Very Hard	Can't be scratched with knife or sharp pick. Core or fragment breaks with repeated heavy hammer blows.
Hard	Scratch with knife or sharp pick with difficulty (heavy pressure). Heavy hammer blow required to break specimen.
Moderately Hard	Scratch with knife or sharp pick using light or moderate pressure. Breaks with moderate hammer blow.
Moderately Soft	Grooved 2mm deep by knife or sharp pick with moderate or heavy pressure. Breaks with light hammer blow or heavy manual pressure.
Soft	Grooved or gouged easily by knife or sharp pick with light pressure, can be scratched with fingernail. Breaks under light to moderate manual pressure.
Very Soft	Readily indented, grooved, or gouged with fingernail, or carved with a knife. Breaks under light manual pressure.

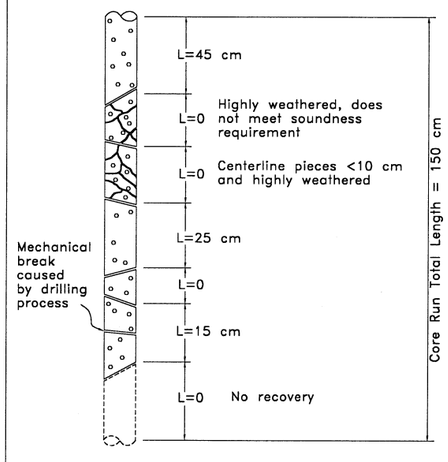
DISCONTINUITY SPACING/DENSITY

Spacing/Density	Spacing	Density
< 3cm	Very closely spaced	Very intensely fractured
3 – 10 cm	Closely spaced	Intensely fractured
10 – 30 cm	Moderately spaced	Moderately fractured
30 cm – 1 m	Widely spaced	Slightly fractured
1 – 3 m	Very widely spaced	Very slightly fractured (> 1 m)
> 3 m	Extremely widely spaced	
can use either but not necessary to use both		

BEDDING

Degree of Development	Thickness	
Well expressed (obvious)	Laminated	< 1 cm
Moderately	Very thinly bedded	1 – 3 cm
Poorly (difficult to see, weak)	Thinly bedded	3 – 10 cm
	Moderately bedded	10 – 30 cm
	Thickly bedded	30 cm – 1 m
	Very thickly bedded	1 – 3 m
	Massive	> 3 m

ROCK QUALITY DESIGNATION (RQD) LOGGING



$$RQD = \frac{\sum \text{Length of sound core >10 cm pieces}}{\text{Total core run length}}$$

$$= \frac{45 + 25 + 15}{150}$$

= 57% (Fair)

RQD	Description
0 – 25%	Very Poor
25% – 50%	Poor
50% – 75%	Fair
75% – 90%	Good
90% – 100%	Excellent

NOTES:

1. All elevations shown refer to NAVD 88 (meters).
2. Discontinuities inclinations are measured with respect to the core axis.
3. Color designation and numbers are from the Munsell® soil color charts for soils.
4. Pressuremeter tests are from Appendix A–3 of GDR (Earth Mechanics, Inc., 2003).
5. Laboratory soil test data are from Appendix A–4 of GDR (Earth Mechanics, Inc., 2003).
6. Laboratory rock test data are from Appendix B–4, C–4 & D–4 of GDR (Earth Mechanics, Inc., 2003).

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

Caltrans Metric

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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DISCONTINUITY SURFACE OR ROUGHNESS DESCRIPTORS

Descriptor	Criteria
Stepped	Near–normal steps and ridges occur on the fracture surface.
Rough	Large, angular asperities can be seen.
Moderately Rough	Asperities are clearly visible and fracture surface feels abrasive.
Slightly Rough	Asperities or steps present; height of asperity should be estimated or measured.
Smooth	No asperities, smooth to the touch.
Polished	Extremely smooth and shiny.
Slickensided	With scratches or grooves.

DISCONTINUITY APERTURE DESCRIPTORS

Opening (Aperture)	Description: with filling	Description: without filling
none	clean	tight
<1 mm	very thin	slightly open
1–3 mm	moderately thin	moderately open
3–10 mm	thin	open
10–30 mm	moderately thick	moderately wide
>30 mm	thick	wide

DESIGN OVERSIGHT KEYHAN MOGHBEL

SIGNOFF DATE

DESIGN BY S. SICILIANO 11/6/02

CHECKED BY M. KAPUSKAR 11/9/02

NA
FIELD INVESTIGATOR(S)/TITLE
DATE

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) 02/03/03

SHEET OF

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According to the Standard Penetration Test (ASTM D-1586)

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		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

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2½" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Top Hole El.; N: Northing; E: Easting; Sample No.; Permanent Casing driven; Size of Sampler (mm); Description of material; Total Unit weight (kN/m³); % moisture; Unconfined compressive strength (kPa); Consolidation test; Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified.; Number of blows required to produce the indicated penetration after an initial 152 mm seating.; 50 blows produced the indicated penetration during the initial 152 mm interval; CWS; Elev.; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date

ROTARY SAMPLE BORING (WET)

B-No.; Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%); Rock Quality Designation (%); REC=100% RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ...; Sample Description; Boring Date(s)

02-2

N: 620,930.2 E: 1,821,997.4 — El. +131.4 m — 63 — Vertical

PENETRATION DEPTH (m)

Run	REC	RQD
1	13%	0%
2	72%	0%
3	100%	0%
4	92%	0%
5	100%	0%
6	87%	0%
7	83%	0%
8	40%	0%
9	100%	0%
10	100%	0%
11	100%	42%
12	98%	13%
13	100%	63%
14	80%	73%
15	100%	28%
16	100%	35%
17	100%	63%
18	83%	0%
19	92%	28%
20	95%	22%
21	100%	92%
22	94%	0%
23	100%	0%
24	100%	0%
25	98%	0%
26	100%	0%
27	100%	21%
28	102%	23%
29	80%	0%
30	100%	11%
31	100%	22%
32	100%	63%
33	104%	52%
34	89%	0%
35	100%	0%
36	100%	35%
37	85%	68%
38	100%	72%
39	100%	12%
40	73%	23%
41	100%	60%
42	100%	83%
43	100%	0%
44	100%	100%
45	98%	98%
46	100%	48%
47	100%	55%
48	100%	67%
49	92%	25%
50	50%	19%

NCR.
@2.1m: QUARTZ DIORITE, greenish-gray, weathered but not strongly oxidized, mostly closely fractured, core largely held together by clay in fractures.
@5.2m: reddish clay in fractures.
@5.5m: broken zone.
very closely fractured, core shatters when disturbed.
@6.1m: grayish-brown.
@7.6m: gray, fine-grained.
greenish-yellow-brown, intensely weathered to decomposed, soft.
@9.1m: NCR.
@9.5m: NCR.
intensely weathered, disaggregated quartz diorite, relict quartz granules held together by clay. Fractures obscured by weathering alteration.
@11.3m: quartz diorite grades to less weathered, becoming more rock-like. Very coarse-grained with quartz masses from 6-25mm size.
moderately hard to hard, core rings slightly when struck.
@12.2m: slightly weathered.
very quartz-rich, hard quartz diorite. Slight crackled or mosaiced aspect. Locally shattered.
(PM) @14.1m
(PM) @14.2m
QUARTZ DIORITE, grayish-green, moderately weathered, hard, coarse-grained.
@14.8m: Clayey zone, up to 8 cm wide, beginning at 14.8 m depth.
@14.9m: joints, inclined 55° and 70°, no filling, tight aperture.
@15.2m: joints, inclined 35-40°, very thin calcite coatings, rough surfaces, very thin aperture.
@15.5m: joints inclined 40-65, rough.
@15.9m: joints, inclined 50-55°, calcite coatings, very rough surfaces, moderately thin apertures.
(PM) @16m
(PM) @16.2m: stepped joints, inclined 30-50°, no filling, rough to stepped surfaces, tight apertures.
@16.5m: joints inclined 25-50°, stepped, tight.
@16.8m: joints inclined 35°.
@17.1m: joints inclined 30°.
@17.5m: 25mm clay gouge inclined at 50°.
weathered locally to brownish-orange, partial weathering of felsdspars. Joints, inclined 35-40°, subraralIel, no filling, very rough to rough, 0-6mm aperture.
@18m: joints inclined 30-35° in opposing directions, moderately rough, 0 to 5 mm aperture
@18.3m: Joints, inclined 65-80°, subparallel, no filling, very rough surfaces, 1 mm aperture.
@18.6m: joint, inclined 75°, very thin calcite coating and clay filling, slightly rough, 1mm aperture, very poorly developed striations on joint surface; other joints 30-80°, smooth to very rough, 0-4mm aperture.
@18.9m: joints, inclined 30-85°, clay filling, smooth to rough, very thin aperture.
joint, inclined 50°, no filling, moderately rough, tight aperture, located at 19.4 m depth. Below joint, 25cm wide fracture zone, no filling.
@19.5m: joint, inclined 50°, clay filling, moderately rough, very thin aperture.
@19.8m: stepped joints/mechanical breaks.
@20.1m: joints inclined 50 and 90°, located at 20.2 m depth.
joint, inclined 30°, clay filling, very thin aperture, located at 20.6 m depth
@20.7m: 30° joint.
@21m: 90° joint.
@21.3m: 80-90° joints.
@21.6m: 0-90° joints.
hard to very hard rock; fracture zone with some healed fractures. Joints inclined 35° to random orientation.
@22.3m: NCR.
hard rock; joint, inclined 30°, no filling, polished surface, located at 22.6 m depth. Joint, inclined 75°, no filling, slightly rough, located at 22.7 m depth.
@22.9m: partially healed joint, inclined 20°, dark brown, clay filling, slightly rough, moderately thin aperture.
@23.2m: numerous mechanical breaks at end of recovered core.
45° joints witth clay and brecciated quartz fill.
@24.1m: joint inclined 25° with clay, iron oxide, and breccia fill, thin aperture. Zone of healed fractures, randomly inclined, up to 2mm wide, from 24.3-24.4m depth.
@24.4m: 0, 35, 65° joints.
@24.7m: joint inclined 85°; rock is slightly weathered and very hard.
recovered most of lost core from previous run - depths adjusted. Joint inclined 85°, no fill, moderately rough surface, tight aperture. Joint inclined 60°, no fill, moderately rough, moderately open. Joints at 25.1 m inclined 75-85°, no fill, rough to very rough, moderately open.
@25.3m: random joints.
very coarse grained. Core thoroughly fractured.
@25.9m: joints, inclined 25-65°, platy clay filling, polished to slightly rough surfaces, very thin apertures, some surfaces with moderately developed striations inclined 35°.
@26.2m: numerous incipient fractures and partially healed fractures. Joint inclined 70°, no fill, rough, moderately open.
@26.5m: incipient joints, randomly inclined.
moderately weathered hard to soft rock; joints inclined 45°, some with polished striations at 20° rake.
@27.1m: joint inclined 45°, yellowish-brown clay and quartz breccia fill up to 5 mm wide. Shear zone, up to 18cm wide, inclined 40-45°, yellowish-brown clay and breccia filling, beginning at 27.3 m depth.
@27.4m: shear zone inclined 40-45°, brecciated quartz in yellowish-brown clay matrix..
@27.7m: numerous healed fractures, most feldspars are weathered out.
hard rock; random fractures with clay and sand fill.
@28.4m: joints, inclined 40-75°.
fracture zone, 56 cm wide, intensely weathered, moderately soft, pervasively sheared and fractured, partially disaggregated, beginning at 28.7 m depth.
@29.3m: joints inclined 20-70°, clay filling, 3 mm aperture.
@29.6m: joints inclined 55°, no fill, rough, 1 mm aperture. Joint inclined 10°, calcite fill, smooth surface, moderately thin.
@29.9m: weathered feldspars.
moderately hard, partially disaggregated, resistant quartz grains in clay matrix. Joints inclined 25-40°, clay and sand filling.
recovered 69 cm-adjusted depths-recovered lost core from previous run. Moderately weathered, hard. Stepped joint, clean, located at 31.1 m depth.
@31.4m: joints inclined 50-55°, no fill, moderately rough; joint inclined at 40°, clay fill, tight aperture, polished.
QUARTZ DIORITE, grayish-green weathering to yellowish-brown, moderately weathered, hard, very coarse grained. Joint inclined 10°, clay and sand fill.
@32m: joints inclined 70°, subparallel, clay fill, moderately rough.
@32.3m: joints inclined 75-80°, subparallel, clay fill, moderately rough to rough.
@32.6m: joint inclined 30°, calcite fill; polished surface, well-developed slickensides with 60° rake.
joint, inclined 25°, no fill, very rough.
Fracture zone, 8 cm wide, filled with brown clay and quartz granules, beginning at 33.5m depth. Numerous partially healed fractures below fracture zone.
@33.8m: joints, inclined 75-85°, no fill, rough to very rough surfaces.
@34.1m: joints, inclined 40-55°, no fill.
@34.5m: NCR.
fracture zone 51 cm wide, intensely weathered, very soft, crushed/disaggregated zone of yellowish-brown clay and quartz granules, beginning at 34.8m depth.
@35.1m: joint inclined 60°, slightlty rough, clay fill.
@35.4m: moderately weathered, very hard, joints inclined 40-50°, no fill, moderately rough to rough, moderately open.
joint inclined 40°, moderately rough.
@36m: joints inclined 10 and 40°, moderately rough.
@36.3m: joints inclined 35-45°, very rough, clay fill.
@36.6m: joints inclined 50 to 90°, very rough.
@36.9m: joint iclined 55°, very rough..
joint, inclined 55°, calcite coating, polished surface, very thin aperture; joint inclined 35°, very rough, moderately open aperture.
@37.5m: joint inclined 70°, moderately rough, 1 mm aperture.
fracture/crushed zone brecciated quartz diorite, 38 cm wide,soft, intensely weathered zone with yellowish-brown clay and quartz granules, beginning at 37.8 m depth.
@38.1m: hard to very hard quartz diorite, moderately to slightly weathered. Joints inclined 35-90°, calcite fill, slighty rough to rough, very thin aperture.
@38.4m: joints inclined 80-85°, no fill, rough surfaces, 1-3 mm apertures.
@38.7m: joint inclined 55°, rough, 2 mm aperture.
quartz dike, light green weathering to yellow. Joints inclined 40-55°, no fill, slightly rough to rough.
@39.3m: joint inclined 30°.
@39.6m: fracture zone, 13 cm wide, partially disaggregated; intensely weathered to orange-brown, soft to moderately soft, beginning at 39.6 m depth.
very hard quartz diorite, slightly to moderately weathered. Recovery greater than 100%.
QUARTZ DIORITE, light green, slightly weathered, hard to very hard, moderately fractured. Thin vertical (0°) vein 1-2mm thick; Quartz vein at tip about 3-4mm thick, light green, inclined 50°.
@40.5m: joints 45-70°, rough.
@41.2m: fractured zone.
@41.8m: joints, inclined 45-50°, rough surfaces, moderately open to open apertures.
@42.1m: joint inclined 50°, rouough, 4 mm aperture.
@42.4m: joint inclined 90°, rough, 2 mm aperture.
@42.7m: joint inclined 35°, no fill, 3 mm aperture, located at 57.9 m depth.
joint, rough, 1 mm aperture and fracture zone, 8 cm wide, beginning at 43.2 m depth.
@43.3m: joint, 90°, rough, 3 mm aperture.
@43.6m: joints 90°, rough, 1 mm aperture.
moderately weathered, hard. Joints inclined 35°, rough surface.
@44.2m: joints 35-45°, rough.
@44.5m: fracture zone, rough, some mechanical breaking, rough.
@44.8m: joints, 15-50°, rough, 2 mm aperture.
@45.1m: joint inclined 35°, rough.
NQ size core. Slightly weathered, hard. Joint inclined 15°, no fill, rough surface, 1 m
@45.7m: joints, inclined 60°, rough.
(PM) @46m: joints 40-45°, rough.
@46.3m: fracture zone, 8 cm wide, beginning at 46.6 m depth..
(PM) @46.6m: joint 80°, rough.
QUARTZ DIORITE, greenish-gray, slightly weathered to fresh, hard to very hard, moderately jointed with generally tight, generally clean, generally rough joints at all orientations.
@47.3m: joints inclined 35-55°, no fill, rough surface..
@47.6m: joint inclined 45°, rough surface..
@47.9m: joints inclined 0-90°, rough.
@48.2m: joints inclined 35-45°, rough.
greenish-gray, fresh, very hard quartz diorite. Thin vertical formation. Rough fracture surfaces.
@48.8m: joints inclined 45-90°, rough.
@49.1m: joint inclined 50°, rough.
@49.4m: joints inclined 45-70°, rough.
fracture zone 5 cm thick, with quartz veins, joints inclined 45° rough.
recovery greater than 100%.
@50.9m: calcite vein, subparallel to core axis.
@51.2m: joint inclined 90°, rough.
@51.8m: fine grained, hairline cracks.
(PM) @52.7m
(PM) @53m: very hard quartz diorite, rough fracture surfaces with iron oxide coating.
iron oxide on some fracture surfaces.
@55.2m: joints inclined 35-45°.
@55.5m: joints inclined 35°.
@55.8m: joints inclined 45°.
joints inclined 55°, no fill, rough surfaces.
@56.4m: joints inclined 40-90°.
@56.7m: joint incline 60°.
@57m: joints inclined 35-75°.
@57.3m: joints inclined 40-45°, iron oxide stain on some.
@57.9m: fracture zone, up to 46 cm wide, beginning at 58.1 m depth.
@58.8m: iron oxide on fracture surfaces.
@59.8m: possible quartz or calcite layer located at 60 m depth.
@60.7m: bottom of hole.

9/14/02 to 9/19/02

VERTICAL SCALE
1 : 50

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY E. BROWN 11/20/02
CHECKED BY S. SICILIANO 1/15/03

J. CASTLE, D. HAMILTON & S. VARATHARAJ
FIELD INVESTIGATOR(S)/TITLE
DATE 9/14/02 to 9/19/02

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2½" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

02-2A

N: 620,930.2 E: 1,821,997.4

El. 131.4 m — (63) S37°W, 33° Inclination

PENETRATION DEPTH (m): 0 – 33

Run	REC	RQD
1	50%	0%
2	0%	0%
3	89%	0%
4	90%	0%
5	75%	33%
6	100%	0%
7	100%	33%
8	0%	N/A
9	89%	0%
10	100%	15%
11	100%	39%
12	100%	0%
13	83%	0%
14	100%	0%
15	100%	0%
16	75%	0%
17	75%	17%
18	78%	0%
19	100%	0%
20	100%	0%
21	100%	0%
22	35%	0%
23	100%	0%
24	100%	63%
25	100%	81%
26	100%	58%
27	93%	20%
28	100%	13%
29	100%	42%
30	100%	100%

- QUARTZ DIORITE, yellowish brown (10YR 5/6), intensely weathered to decomposed, soft. Clayey gravel, stiff, moist, abundant granitic rock fragments.
- @.6m: yellowish brown (10YR 5/4) clayey sand.
- yellowish brown (10 YR 5/6).
- increase in granitic rock fragments.
- intensely weathered and intensely fractured, soft to very soft, with abundant clay filled fractures.
- less fractured, moderately soft. Joints inclined 70°, clay filled, slightly rough, moderately thin aperture.
- @6.4m: crushed zone, up to 3 cm wide at end of run.
- QUARTZ DIORITE, white to black, moderately weathered, moderately hard. Intensely fractured, joints inclined 30-40°, clay filling with iron oxide staining, slightly rough, moderately thin aperture.
- moderately soft, intensely weathered, intensely to closely fractured.
- @7.6m: joints, inclined 50°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- @7.9m: joint, inclined 22°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- @8.2m: random fractures, some clay filled fractures.
- @8.5m: joints, inclined 45-55°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- moderately to intensely weathered, moderately hard, closely to intensely fractured, pervasive iron-stained fractures. Joint, inclined 60°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- @9.1m: Joints, inclined 35-50°, sand and clay filling, slightly rough, moderately thin to thin apertures. Very fractured internally in addition to the major joints. Most grains apear to be broken and laced with a network of hairline fractures.
- first 8 cm of run is crushed. Some greenish staining. Joint, inclined 65°, sand and clay filling, slightly rough, moderately thin to thin aperture, located at 10m depth.
- @10.1m: joint, inclined 58°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- (DS) @10.4m: joints, inclined 35-65°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- moderately weathered, intensely fractured, random fractures.
- @11m: joints, inclined 50-60°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- random fractures, sand and clay filled.
- crushed to intensely fractured.
- (DS) @13.4m: joints, inclined 45-75°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- first 15 cm of run is crushed. Clay and sand filled joints.
- crushed to intensely fractured. Joints inclined 50-70°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- moderately weathered, moderately hard, intensely fractured. Joints inclined 30-45°, sand and clay filling, slightly rough, thin aperture.
- moderately hard to hard. Joints inclined 50°, clay filling, slightly rough.
- (DS) @16.5m: Joints inclined 30-40°, clay filling, slightly rough.
- Joints inclined 45-75°, sand and clay filling.
- (DS) @18m: crushed below 17.9 m depth.
- (DS) @18.3m: intensely to moderately weathered, moderately hard, intensely fractured. Joints inclined 30-70°, no filling, slightly rough, moderately open to open.
- joint, inclined 75°, clay filling, slightly rough, moderately thin to thin aperture.
- joint, inclined 70°, clay filling, slightly rough, moderately thin to thin aperture.
- pervasive, near vertical open and closed fractures.
- joints, inclined 20-50°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- @21m: no core recovery below 21 m depth.
- intensely fractured. Joints inclined 35-50°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- QUARTZ DIORITE, fresh to slightly weathered, hard, moderately to closely fractured. Joint, inclined 55°, sand filling, slightly rough, thin aperture.
- @23.8m: joint, inclined 60°, sand and clay filling, slightly rough, thin aperture.
- little fracturing. Joint, inclined 60°, iron oxide staining, slightly rough, moderately thin aperture.
- @24.4m: joint, inclined 40°, sand and clay filling, slightly rough, thin aperture.
- fresh to slightly weathered, hard. Joints inclined 30-45°, no filling, slightly rough, moderately open aperture.
- @25.3m: joint, inclined 53°, no filling, slightly rough, moderately open aperture.
- @25.6m: random fractures.
- @26.2m: joint, inclined 25°, no filling, slightly rough, moderately open aperture.
- becomes intensely fractured from 26.5 to 26.8 m depth.
- @26.8m: becomes closely to moderately fractured.
- @27.1m: thin calcite filled fractures. Joint, inclined 60°, slightly rough, thin aperture.
- @27.4m: joint, inclined 30°, slightly rough, thin aperture.
- joint, inclined 60°, slightly rough, moderately open to open apertures.
- @28.4m: joints, inclined 40-45°, no filling, slightly rough, moderately open to open apertures.
- @29m: joints, inclined 50-55°, no filling, slightly rough, open apertures.
- slightly weathered, hard. Joint, inclined 45°, no filling, slightly rough, moderately open to open aperture, located at 29.3m depth. Fractured quartz pegmatite, white, 25cm wide, beginning at 29.3m depth.
- becomes coarse grained, with iron staining along fractures. Joint, inclined 35°, no filling, slightly rough, moderately open to open aperture.
- @29.9m: joint, inclined 45°, no filling, slightly rough, moderately open to open aperture.
- gray, little fracturing. Random fracture, no filling, slightly rough, moderately open aperture.
- random fracture, sand and clay filling, slightly rough, moderately thin aperture.

PENETRATION DEPTH (m): 31 – 58

Run	REC	RQD
31	100%	78%
32	100%	0%
33	57%	15%
34	73%	12%
35	100%	78%
36	100%	88%
37	100%	93%
38	100%	70%
39	100%	83%
40	100%	47%
41	100%	67%
42	100%	85%
43	100%	30%
44	90%	27%
45	100%	13%
46	100%	55%
47	100%	68%

- random fracture, sand and clay filling, slightly rough, moderately thin aperture.
- @31.4m: closely fractured. Joint, inclined 20°, sand and clay filling, slightly rough, moderately thin aperture.
- @31.7m: joints, inclined 20-50°, sand and clay filling, slightly rough, moderately thin aperture.
- intensely fractured throughout core run with abundant iron and algal stained fractures.
- @32.9m: vertical fractures along length of core run.
- @33.5m: joints, inclined 20°, sand and clay filling, slightly rough, moderately thin aperture.
- fresh to slightly weathered, moderately hard to hard, closely fractured.
- @34.8m: joint, inclined 40°, sand and clay filling, slightly rough, moderately thin aperture.
- no core recovery below 35 m depth..
- intensely fractured, iron stained, closed fractures.
- @36m: closely fractured, joints inclined 20-25°, sand and clay filling, moderately thin aperture.
- @36.3m: intensely fractured, lichens, algal growths, and minor clay along fractures.
- @36.9m: no core recovery below 36.8 m depth.
- little fracturing below 37.2 m depth, some calcite filled, closed fractures throughout run. Joint, inclined 10°, no filling, slightly rough, moderately open aperture.
- @37.5m: joint, inclined 70°, calcite filled, slightly rough, moderately thin aperture.
- @37.8m: joints, inclined 10-20°, sand and clay filling, slightly rough, moderately thin aperture.
- fresh, hard, little fracturing.
- @39m: calcite filled fracture.
- @39.3m: joints, inclined 20-25°, clean, no filling, slightly rough, moderately open apertures.
- gray-green, fresh, hard, llittle fracturing, coarse grained. Joint, inclined 50°, no filling, slightly rough, moderately open aperture.
- @40.9m: random fractures.
- moderately weathered, intensely fractured from 41.8 to 42.1 m depth. Joints inclined 30-35°, no filling, slightly rough, open apertures.
- @42.1m: abundant iron oxide staining, closed fractures. Increase in grain size.
- @42.4m: some quartz pegmatite crystals.
- @43m: fracture, subparallel to core axis, calcite filling, lichens and algal growth present.
- fresh to slightly weathered, hard, little fracturing. Thin calcite veining, inclined 60-70°, lichens and algal grown, some iron oxide staining.
- @43.6m: lichens and algal growth, some iron oxide staining.
- @43.9m: random fractures.
- @44.2m: becomes fine to medium grained.
- sharp contact at 44.6 m depth, coarse grained below 44.6 m.
- white to light gray, fresh, hard, moderately spaced fractures. Joints inclined 35-55°, no filling, slightly rough, open apertures.
- pervasive, closed, thin calcite-filled fractures. Joint, inclined 20°, no filling, slightly rough.
- @46.6m: fracture zone, 20 cm wide, beginning at 46.8 m depth.
- @47m: becomes closely fractured, joints inclined 15-35°, no filling, slightly rough.
- @47.3m: calcite filled seams.
- gray, little fracturing, coarse grained. Joints, inclined 20-30°, no filling, slightly rough.
- @48.5m: joint, inclined 30°, no filling, polished.
- closely to intensely fractured. Joints, inclined 65-80°, no filling, moderately open apertures. Olive-green staining.
- @49.7m: calcite coating along joint.
- joints, inclined 30°, sand and clay filling, slightly rough, moderately thin apertures.
- @51.2m: joint, inclined 60°, sand and clay filling, slightly rough, moderately thin aperture.
- @51.8m: joints, inclined 20-30°, sand and clay filling, slightly rough, moderately thin aperture.
- becomes closely to intensely fractured. Joints inclined 40°, no filling, slightly rough, open aperture.
- @53m: joint, inclined 20°, no filling, slightly rough, open aperture.
- @53.4m: random fractures.
- @53.7m: calcite seam, up to 5 cm wide, beginning at 53.8 m depth.
- moderately fractured.
- @54.3m: joint, inclined 10°, no filling, slightly rough, moderately open aperture.
- @54.6m: joints, inclined 20-40°, no filling, slightly rough, moderately open aperture.
- @54.9m: joints, inclined 15-20°, no filling, slightly rough, moderately open aperture.
- @55.2m: joints, inclined 25-30°, no filling, slightly rough, moderately open aperture.
- joint, inclined 15°, no filling, slightly rough, moderately open aperture.
- @55.8m: random fractures.
- @56.4m: joints, inclined 30-35°, no filling, slightly rough, moderately open aperture.

Boring 02-2A Continued on LOTB Sheet of

VERTICAL SCALE 1 : 50

Caltrans Metric

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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DESIGN OVERSIGHT	KEYHAN MOGHBEL	
SIGNOFF DATE		
DESIGN	BY S. VARATHARAJ	11/20/02
CHECKED	BY S. SICILIANO	12/6/02

T. BODKIN, J. CASTLE — FIELD INVESTIGATOR(S)/TITLE — DATE 9/26/02 to 9/28/02

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No. — KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240 EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

DESIGN OVERSIGHT
KEYHAN MOGHBEL
SIGNOFF DATE

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

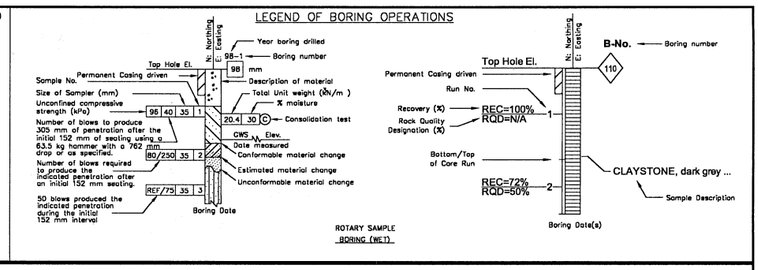
TYPE OF BORINGS

- 2½" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- size DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-2A Continued from LOTB Sheet of

PENETRATION DEPTH (m)

57
- fresh, hard, little fracturing.

58 — REC=88% RQD=78% — 48
- @57.9m: joints inclined 30°, lichens along fractures, iron oxide staining, clay and sand filling, slightly rough, moderately thin to thin aperture.
- @58.2m: no core recovery below 58.4 m depth.
- greenish-gray, coarse grained. Joint, inclined 50°, no filling, slightly rough.

59
- @58.8m: joint, inclined 75°, no filling, slightly rough, open aperture. Joint, calcite filled.

REC=100% RQD=63% — 49

60
- @59.8m: random fracture, no filling, slightly rough, open aperture.
- slightly weathered, hard, abundant closed fractures and iron stained open fractures. Joints inclined 25-40°, sand and clay filling, slightly rough, moderately thin to thin aperture.

61 — REC=100% RQD=33% — 50
- @60.4m: joint, inclined 53°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- @60.7m: joint, inclined 55°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- @61m: joints, inclined 40°, sand and clay filling, slightly rough, moderately thin to thin aperture. Becomes fresh below 61.2m depth.

62
- intensely fractured, abundant iron oxide stained open and closed fractures. Joint, inclined 60°, no filling, slightly rough, moderately thin aperture.

REC=90% RQD=0% — 51
- @61.9m: joint, inclined, 45°, no filling, slightly rough, moderately thin aperture.

63
- @62.2m: joints, inclined 25-55°, no filling, slightly rough, thin apertures.
- @62.5m: joints, inclined 35°, no filling, slightly rough, thin aperture.
- @62.8m: no core recovery below 63 m depth.

64 — REC=48% RQD=0% — 52
- moderately to intensely weathered, moderately hard, pervasive iron staining and closed fractures. Joints inclined 23-30°, sand and clay filled, slightly rough to rough, moderately thin to thin apertures.
- @63.7m: no core recovery below 63.4 m depth.

65
- intensely fractured, fine-grained, pervasive iron-stained fractures.

REC=58% RQD=0% — 53
- @64.9m: joint, inclined 50°, sand and clay filling, slightly rough, moderately thin aperture. Crushed zone, 8cm wide, beginning at 65.1m depth.
- @65.2m: no core recovery below 65.2 m depth.

66 — REC=100% RQD=0% — 54
- intensely weathered, moderately soft. joints, inclined 60-75°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- crushed zone of clayey sand, 13 cm wide, beginning at 66.2 m depth.

REC=67% RQD=0% — 55

67
- @66.5m: random fractures, sand and clay filled, slightly rough, moderately thin to thin apertures.
- @66.8m: no core recovery below 66.8 m depth..
- moderately hard, becomes coarse grained with pervasive iron oxide staining.

REC=100% RQD=21% — 56
- @67.4m: joints, inclined 45-55° , sand and clay filling, slightly rough, moderately thin to thin apertures.

68
- intensely to slightly weathered, moderately hard, intensely fractured. Joints, inclined 60°, sand and clay filled, slightly rough, moderately thin aperture.

REC=90% RQD=52% — 57
- @68m: moderately to intensely weathered. Little open fracturing below 68.1 m depth, abundant closed fractures with calcite filling.
- @68.6m: slightly weathered, intensely fractured below 68.8 m depth.

69
- fresh to slightly weathered, hard, closely to intensely fractured, abundant closed, healed fractures. Joints are slightly rough with moderately open apertures.

70 — REC=100% RQD=30% — 58
- @69.8m: open fracture.

71
- hard to moderately hard, intensely fractured. Joint, inclined 70°, no filling, slightly rough, moderately open to open aperture.

REC=83% RQD=0% — 59
- @71m: abundant closed fractures.
- @71.3m: no core recovery below 71.5 m depth.

72
- fresh to slightly weathered. Joints, inclined 55-60°, sand and clay filling, slightly rough, moderately thin to thin aperture.

REC=83% RQD=28% — 60

73
- hard, intensely to closely fractured, coarse-grained. Joints, inclined 50°, sand and clay filling, slightly rough, moderately thin to thin aperture.
- @72.9m: joint, inclined 60°, sand and clay filling, slightly rough, moderately thin to thin aperture.

REC=100% RQD=15% — 61
- @73.2m: joints, inclined 35-45°, sand and clay filling, slightly rough, moderately thin to thin aperture.

74
- closely to moderately fractured. Joints, inclined 20-70°, no filling, slightly rough.
- @74.1m: random fractures.

REC=100% RQD=32% — 62
- @74.4m: joints, inclined 40-50°, no filling, slightly rough.
- @74.7m: open fracture.

75
- @75m: joints, inclined 33-60°, no filling, slightly rough.
- moderately spaced fractures. Joints, inclined 20-35°, clay filled, slightly rough, moderately thin aperture.

76

REC=100% RQD=62% — 63

77
- fine grained.
- @77.1m: joints, inclined 40-50°, clay filling, rough to slightly rough, moderately thin aperture.

REC=100% RQD=37% — 64
- @77.4m: coarse grained below 77.6 m depth. Joints, inclined 40-60°, clay filling, rough to slightly rough, moderately thin aperture.

78
- @78m: joints, inclined 20-70°, clay filling, rough to slightly rough, moderately thin aperture.

79
- fresh to slightly weathered, hard to moderately hard, closely spaced fractures, coarse-grained. Joints, inclined 55-60°, clay and sand filling with iron oxide staining, slightly rough, moderately thin to thin apertures.

REC=100% RQD=27% — 65
- @79m: joints, inclined 10-45°, clay and sand filling with iron oxide staining, slightly rough, moderately thin to thin apertures.
- @79.3m: joints, inclined 45°, clay and sand filling with iron oxide staining, slightly rough, moderately thin to thin apertures.

80
- orange-brown, intensely weathered, very soft, disaggregated to clay and quartz granules. Joint, inclined 15°, clay filling slightly rough, very thin aperture, located at 80.1m depth. Below 80.1m depth, moderately weathered, moderately hard.

REC=108% RQD=0% — 66
- @80.2m: joint, inclined 60°, no filling, polished, moderately open aperture.

81
- gray, weathering to orange-brown. Joint, inclined 90°, no filling, moderately open aperture.

REC=103% RQD=50% — 67
- @80.8m: moderately healed fracture, inclined 40°. Joint, inclined 80°, no filling, tight aperture.

82
- @81.1m: joint, inclined 45°, no filling, polished, moderately open aperture.
- @81.4m: joint, inclined 20°, orange clay filling.

REC=89% RQD=89% — 68
- @81.7m: slightly weathered, joints, subparallel, inclined 60°, no filling, polished with slickensides.

83
- gray-green, chloritized, weathering to orange. Fracture surfaces oxidized to dark brown and green. Joint, inclined 30°, no filling, moderately rough, moderately open aperture.

REC=103% RQD=70% — 69
- @82.3m: joint, inclined 70°, no filling, polished with well developed slickensides, moderately open apertures.
- @82.6m: moderately healed fracture, inclined 15°.

84
- joint, inclined 70°, no filling, polished with moderately developed slickensides, moderately open aperture.
- @83.5m: joints, inclined 50°, no filling, polished with well developed slickensides inclined 50°, moderately open aperture.

85
- @83.8m: moderately soft below 84.1 m depth, joints, subparallel, inclined 45-60°, no filling, rough to moderately rough, slightly open apertures.

REC=97% RQD=40% — 70
- very little to no oxidation on fracture surfaces. Joint, inclined 60° , no filling, smooth, moderately open aperture.
- @84.8m: joint, inclined 25° , calcite coating with moderately developed slickensides inclined 15°, smooth, very thin aperture.

86
- @85.1m: joint, inclined 55°, no filling, polished, moderately open aperture.

87 — REC=103% RQD=77% — 71
- @85.4m: joint, inclined 85°, no filling, slightly rough, moderately open aperture. Joints, inclined 55°, no filling, polished with slickensides inclined 15°, moderately open to open apertures.
- @85.7m: mechanical breaks.
- QUARTZ DIORITE, green-gray, fresh, moderately hard, coarse grained, little fracturing.

88
- @86.3m: joint, inclined 35°, no filling, slightly rough, moderately open aperture, poorly developed slickensides.
- @86.6m: stepped joint, inclined 90°, no filling, moderately rough, moderately open aperture.

89
- @86.9m: fully healed fracture, inclined 30°. Joint, inclined 75°, no filling, smooth to polished, tight aperture.
- @87.2m: joint, inclined 5°, calcite filling, polished with moderately developed slickensides inclined 55°, very thin aperture.
- joints, inclined 65-80°, no filling, moderately to slightly rough, open apertures.

90

87
- joints, inclined 65-80°, no filling, moderately to slightly rough, open apertures.

88
- @87.8m: incipient joints.

REC=100% RQD=73% — 72
- @88.1m: joints, inclined 50° , no filling, moderately rough to smooth, moderately open apertures.

89
- @88.7m: joints, inclined 25-30°, calcite coating, smooth, moderately thin aperture. Fracture zone, beginning at 88.9 m depth, moderately soft, greenish, sandy clay filling.

90 — REC=102% RQD=70% — 73
- green-gray, chloritized, fresh to slightly weathered, moderately hard to hard. Joint, inclined 85°, no filling, moderately rough, open aperture.
- @89.3m: joint, inclined 90°, no filling, moderately rough, open aperture.
- @89.6m: joint, inclined 5-10°, calcite and green mineral filling, smooth to polished, very thin aperture.
- @89.9m: fully healed fracture, connects to joint above.
- fully healed fracture, inclined 5° , up to 8 mm width.

91
- @90.9m: joint, inclined 20°, no filling, polished with poorly developed slickensides, tight aperture.

REC=98% RQD=37% — 73
- @91.2m: joints, inclined 30-55°, no filling, rough to very rough, tight apertures.

92
- @92.1m: bottom of borehole.

93

9/26/02 to 9/28/02

VERTICAL SCALE
1 : 50

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY M. KAPUSKAR 12/6/02
DATE FIELD INVESTIGATOR/TITLE T. BODKIN, J. CASTLE 9/26/02 to 9/28/02

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

KILOMETER POST
BRIDGE NO.

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

Caltrans Metric

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Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST
DOUGAS HOLMES HAMILTON
NO. EGG 31
EXP. 7/31/04
STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

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Santa Ana, California 92707

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Caltrans Metric

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Top Hole El.; Permanent Casing driven; Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Elev.; Conformable material change; Estimated material change; Unconformable material change; Boring Date

ROTARY SAMPLE BORING (WET): B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%); Rock Quality Designation (%); REC=100% RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

02-2B

N: 620,930.2 E: 1,821,997.4

El. +131.4 m — (63) S9°W, 30° Inclination

PENETRATION DEPTH (m)

- 0 m: No core recovery above 1.5 m depth.
- Run 1: REC=0% RQD=N/A
- @1.5m: GRANODIORITE/QUARTZ DIORITE, orange brown, intensely weathered, moderately hard, surfaces oxidized to dark brown. Partial separation of grain boundaries and alteration of feldspars to clay. Core is intensely fractured.
- very soft, disaggregated to orange-brown clay and quartz granules up to 4 mm in diameter.
- @2.7m: soft to moderately soft, intensely weathered. Joint, inclined 20°, clay and iron oxide filling; polished with slickensides inclined 30°.
- Run 2: REC=65% RQD=0%
- @3m: joint, inclined 50°, clay filling, polished with possible striations in dip direction. Joint, inclined 30°, clay filling, polished.
- @3.4m: no core recovery below 3.4 m depth.
- core can be broken manually. Joints, inclined 75-80°, clay filling, slightly rough, very thin apertures.
- @4.3m: random fractures.
- @4.6m: joint, inclined 25°, clay filling, slightly rough to smooth, very thin aperture.
- Run 3: REC=60% RQD=0%
- @4.9m: no core recovery below 4.9 m depth.
- first 18 cm of run very soft, consists of mud/clay. Below 5.7 m depth, soft to moderately soft, intensely fractured, orange brown clay matrix with gravel and quartz granule filling.
- @5.8m: below 5.9 m depth, green-gray weathering to orange brown, moderately soft, fracture surfaces oxidized to dark brown.
- Run 4: REC=38% RQD=0%
- @6.1m: no core recovery below 6.1 m depth.
- yellow-brown, intensely weathered, moderately hard pieces within very soft matrix.
- @7.3m: partially disaggregated and sheared. Some separation of grain boundaries. Quartz granules in yellow-brown clay matrix.
- Run 5: REC=67% RQD=0%
- @7.6m: gray-green weathering to yellow brown, intensely to moderately weathered, moderately hard, coarse grained. Joints, inclined 50-60°, clay filling, moderately rough.
- @7.9m: no core recovery below 7.8 m depth.
- joints, inclined 50-85°, clay and quartz granule filling, moderately rough to polished, very thin apertures.
- Run 6: REC=97% RQD=0%
- @8.5m: zone of incipient fractures, 15 cm wide; beginning at 8.7 m depth, inclined 40°.
- @8.8m: joints, inclined 30-35°, clay filling, moderately rough to polished, very thin apertures.
- Run 7: REC=78% RQD=0%
- intensely weathered, moderately hard to moderately soft, very fractured. Joint, inclined 20°, clay filling, smooth, very thin aperture.
- @9.5m: joint, inclined 10°, clay filling, smooth to polished, very thin aperture.
- @9.8m: no core recovery below 9.8 m depth.
- intensely weathered, therefore RQD is not a reliable indicator of rock quality. Joints, inclined 40-45°.
- Run 8: REC=100% RQD=28%
- @10.4m: joints inclined 60-90°.
- @10.7m: sheared zone, beginning at 10.7 m depth. Joints inclined 20-30°.
- green-gray weathering to yellow-brown, moderately weathered, moderately hard to moderately soft, rock breaks with light pressure. Joint inclined 5°.
- (DS) @12.5m: joint, inclined 70°, no filling, polished to smooth.
- Run 9: REC=92% RQD=33%
- @12.8m: driller lost water return at end of this run.
- moderately hard. Joint, inclined 35°, no filling, polished.
- @13.4m: stepped joint, inclined 35°, clay filling, very rough.
- @13.7m: Fracture zone, up to 18 cm wide, clay and brecciated quartz diorite filling, bounded at base by a joint, inclined 40°, slightly rough.
- Run 10: REC=98% RQD=13%
- @14m: joints, inclined 15-40°, clay filling, slightly rough to polished.
- core was dropped prior to logging, actual RQD may have been higher. Joints, inclined 55°.
- @14.6m: joints, inclined 5-50°, calcite filling, slightly rough to polished.
- Run 11: REC=110% RQD=29%
- @14.9m: core is jumbled from being dropped.
- slightly weathered. Zone of incipient and moderately healed fractures. Joints, inclined 55-90°, some calcite filled.
- Run 12: REC=79% RQD=17%
- random fractures. Fracture surfaces oxidized to olive-green.
- @17.1m: joints, inclined 40-60°, no filling, rough to slightly rough.
- Run 13: REC=100% RQD=33%
- @17.4m: joints, inclined 10-40°, no filling, slightly rough to polished with moderately developed striations inclined 15°.
- greater than 100% recovery, joint, inclined 40°, thin calcite coating, smooth, moderately developed slickensides inclined 15°. Stepped joint, inclined 25°, no filling.
- @18.3m: joint, inclined 25°, no filling, polished with slickensides inclined 25°.
- Run 14: REC=105% RQD=50%
- @18.6m: joints, inclined 70-75°, no filling, slightly rough to rough. Aphanitic vein, 10 mm wide, beginning at 18.7 m depth.
- @18.9m: numerous mechanical breaks.
- joint, inclined 45°, dark brown-green oxidation, slightly rough.
- @19.5m: joint, inclined 35°, no filling, slightly rough, with subparallel fully healed fractures. Joint, inclined 55°, no filling, slightly rough.
- @19.8m: joint, inclined 30°; calcite filling, polished.
- Run 15: REC=90% RQD=25%
- @20.1m: joint, inclined 20°, dark brown-green oxidation and calcite fillling, smooth to polished.
- gray-green weathering to tan, slightly weathered, moderately hard. Fracture surfaces oxidized to dark brown, slightly rough.
- @21m: joint, inclined 10°, calcite filling, polished with slickensides inclined 25°, very thin aperture.
- Run 16: REC=83% RQD=11%
- moderately healed fracture, subparallel to core axis. Joints inclined 40-70°.
- @22m: joints inclined 40-90°.
- @22.3m: joint, inclined 10°, calcite filling, polished with slickensides inclined 30°.
- Run 17: REC=100% RQD=0%
- @22.6m: joints inclined 30-60°.
- core mostly fractured. Most joints inclined 40-50°.
- (DS) @23.5m
- Run 18: REC=88% RQD=0%
- @24.1m: joint inclined at 40°, slickensides inclined at 70°.
- most joints inclined 60-80°.
- Run 19: REC=114% RQD=0%
- very fractured core. Joint, inclined 60°, clay filling with orange and dark green oxidation, smooth to polished. Joints, subparallel, inclined 45-55°, clay filling with orange and dark green oxidation, smooth to polished, closely fractured.
- Run 20: REC=78% RQD=0%
- @25.6m: shear zone, beginning at 25.7 m, intensely fractured, most fractures inclined 30-45°.
- @25.9m: no core recovery below 25.9 m depth.
- Run 21: REC=96% RQD=38%
- coarse grained, chloritized. Joints inclined 80-90°, no filling, rough surfaces.
- @26.5m: joints, inclined 50-80°, no filling, moderately rough. Driller reported water loss.
- joint, inclined 25°, no filling, polished with slickensides inclined 35°, tight aperture.
- Run 22: REC=52% RQD=0%
- @27.1m: joint, inclined 25°, no filling.
- @27.4m: joint, inclined 60°, clay and brecciated quartz diorite filling, located at 27.5 m depth. Below joint, moderately weathered, soft. No core recovery below 27.6 m depth.
- green-gray, moderately weathered, moderately hard. Quartz diorite appears to have been hydrothermally altered. Joint inclined 40°, clay filling, slightly rough, very thin aperture.
- Run 23: REC=100% RQD=63%
- @28.7m: joints, inclined 65-75°, no filling, slightly rough, tight apertures.
- (DS) @29m: joints, inclined 70°, some clay filling, slightly to moderately rough, tight to very thin apertures.
- @29.3m: stepped joints, inclined 45-50°, no filling, moderately rough, tight apertures.
- (DS) @29.6m: joints, inclined 65-70°, no filling, smooth to slightly rough, tight to open apertures.
- Run 24: REC=102% RQD=63%
- joint, inclined 70°, no filling, smooth to polished, moderately open to open aperture.
- @30.2m: stepped joint, inclined 55°, no filling, rough, tight aperture. Fully healed fractures, noticable due to weathering along surface.
- @30.5m: joint, inclined 45°, no filling, moderately rough, tight aperture.
- Run 25: REC=108% RQD=31%
- @30.8m: joints, inclined 30-60°, no filling, smooth to moderately rough, tight aperture.
- @31.1m: joints, inclined 25-35°, no filling, slightly rough to rough, tight apertures.
- joints, inclined 30-50°, clay filling, smooth to rough, moderately thin to thin apertures.
- @31.7m: joints, inclined, 50-65°, no filling, polished with slickensides inclined 15°, tight apertures.
- @32m: joints, inclined 40-50°, no filling, slightly rough to polished, tight apertures.

(continued, 32–59 m)

- slightly weathered, moderately hard. Joint, inclined 30°, no filling, polished, located at 32.4 m depth.
- @32.6m: joints, most inclined 55-65°.
- Run 26: REC=100% RQD=42%
- joints, inclined 60-70°, no filling, slightly rough, open apertures.
- Run 27: REC=108% RQD=63%
- @34.8m: joints inclined 50-60°.
- Run 28: REC=92% RQD=20%
- @35.4m: closely fractured, most joints inclined approximately 50°.
- QUARTZ DIORITE, yellow-brown, intensely weathered, very soft, composed of quartz granules in sand/clay matrix.
- Run 29: REC=54% RQD=0%
- @36.9m: below 36.9 m depth, moderately weathered, moderately hard. Joints, inclined 60-90°, clay filling, slightly rough.
- Run 30: REC=67% RQD=0%
- weathered to yellowish brown. Joints, inclined 60-70°, clay filling, smooth to slightly rough, very thin apertures.
- @37.8m: joint, inclined 70°, no filling, smooth, moderately open aperture. Fracture zone, 8 cm wide, beginning at 38 m depth, broken quarz diorite, no matrix.
- Run 31: REC=100% RQD=65%
- @38.1m: light yellow-green, slightly to moderately weathered, hard to moderately hard, some grain boundaries indistinct.
- @38.4m: mechanical breaks, inclined 80-85°.
- (UC) @38.7m: joint, inclined 70°, no filling, smooth, tight aperture.
- (DS) @39m: gray-green weathering to orange-brown, slightly weathered, hard to moderately hard, moderately to closely spaced fractures. Multiple healed fractures throughout core. Joint, inclined 55°, no filling, slightly rough, moderately open aperture.
- Run 32: REC=93% RQD=32%
- @39.3m: joints, inclined 70-75°, no filling, polished to slightly rough, tight to moderately open apertures.
- @39.6m: joints, inclined 55-90°, no filling, slightly to moderately rough, tight to moderately open apertures.
- @39.9m: joints, inclined 40-50°, calcite filling, smooth to polished, very thin apertures.
- Run 33: REC=103% RQD=55%
- moderately weathered. Stepped joint, inclined 50°, no filling, moderately rough. Joint, inclined 40°, no filling, polished.
- @40.9m: joint, inclined 35°, no filling, polished with slickensides inclined 20°.
- @41.5m: joint, inclined 20°, orange-brown oxidation on fracture surfaces, polished.
- stepped joint, inclined 85°.
- @42.4m: joint, inclined 35°, clay filling, polished, very thin aperture.
- Run 34: REC=97% RQD=37%
- @42.7m: joints, inclined 50-55°.
- @43m: joints, inclined 45-55°, no filling.
- @43.3m: joint, inclined 30°, no filling, polished, tight aperture.
- green-gray weathering to orange-brown, moderately weathered, moderately hard, coarse grained, closely fractured. Joints, inclined 50-60°, no filling, slightly rough.
- @43.9m: joints, inclined 45-60°, no filling, slightly rough.
- Run 35: REC=87% RQD=8%
- @44.2m: shear zone, 11 cm wide, beginning at 44.3 m depth, soft, filled with orange-brown clay and quartz granules.
- @44.5m: joints, inclined 30-45°, no filling, slightly rough. Below 44.7 m depth, soft and easily friable, breaks under manual pressure.
- @44.8m: no core recovery below 44.9 m depth.
- greater than 100% recovery, mechanical breaks.
- @45.4m: joint, inclined 55°, iron oxide filling, polished with slickensides inclined 10°.
- Run 36: REC=102% RQD=20%
- @45.7m: joint, inclined 55°, no filling, slightly rough. Joints, inclined 30-50°, iron oxide and clay filling, polished with slickensides inclined 45°.
- @46m: joints, inclined 25-50°, clay filling, smooth.
- @46.3m: joint, inclined 40°, iron oxide and clay filling, polished.
- greater than 100% recovery, first run with "truly" 100% RQD. Very good core, slightly weathered, hard to moderately hard. Joint, inclined 40°, iron oxide coating on fracture surface, polished.
- Run 37: REC=103%
- @47m: joint, inclined 35°, clay and calcite filling, polished with slickensides inclined 15°.
- (UC) @47.3m: joint, inclined 85°, no filling, rough.
- @47.9m: joint, inclined 50°, no filling, polished with slickensides in dip direction. Joint, inclined 40°, no filling, slightly rough.
- driller was not getting any water return during this run. Core has been rotated, most fracture surfaces cannot be matched together tightly. Fractures generally inclined 80-90°, no filling, slightly to moderately rough, moderately open to open apertures.
- Run 38: REC=98% RQD=40%
- green-gray weathering to yellowish brown, slightly weathered, moderately hard. Joint, inclined 8
- (UC) @50m: joint, inclined 60°, no filling, slightly rough, tight aperture.
- @50.3m: joint, inclined 85°, no filling, smooth to polished, tight aperture.
- Run 39: REC=97% RQD=75%
- @50.6m: joints, inclined 40-55°, clay filling, slightly rough.
- @50.9m: below 51.2 m depth, orange-brown, intensely weathered, soft, very friable, disaggregated to clay and quartz granules.
- gray-green, moderately weathered, moderately hard, closely fractured. Joints, inclined 45-60°, clay and calcite filling, smooth to polished, moderately thin apertures. Fracture zone up to 15cm wide, beginning at 51.5m depth, intensely weathered, very soft, orange-brown clay and quartz granule filling.
- Run 40: REC=92% RQD=0%
- Run 41: REC=58% RQD=0%
- @51.5m: joint, inclined 30°, slightly rough, separates shear zone from more competent rock, located at 51.6m depth. Below joint, moderately weathered, moderately hard.
- orange-brown, intensely weathered, soft, easily broken under manual pressure. Mostly disaggregated to clay and quartz granules.
- @52.1m: no core recovery below 52.3 m depth.
- greater than 100% recovery, gray-green, slightly weathered, moderately hard. Joint, inclined 20°, calcite coating oxidized brown-orange, polished with striations inclined 60°. Joint inclined 50°, no filling, smooth.
- Run 42: REC=105% RQD=63%
- @53m: joint, inclined 35°, no filling, smooth.
- @53.4m: joint, inclined 40°, calcite filling, smooth with poorly developed slickensides.
- @53.7m: joints, inclined 75°, no filling, smooth to polished.
- @54m: joint, inclined 75°, no filling, moderately rough.
- Run 43: REC=102% RQD=80%
- greater than 100% recovery, joint, inclined 60°, no filling, smooth, open aperture.
- @54.6m: joint, inclined 80°, no filling, polished with slickensides inclined 70°, tight aperture.
- @54.9m: fully healed joint, inclined 60°. Below 55 m depth, green, finer grained.
- @55.2m: joint, inclined 40°, partial calcite filling, break cuts across previously healed
- Run 45: REC=95% RQD=8%
- @55.5m: stepped joint, inclined 70°, no filling, moderately rough, tight aperture.
- gray-green, moderately weathered, moderately hard. Joint, inclined 70°, no filling, slightly rough.
- @56.1m: closely fractured, joints inclined 30-50°, some clay filling, smooth to polished with striations in dip direction.
- @56.4m: below 56.5 m depth, general alignment of joints changes. Joints, inclined 0-15°, iron oxidation, smooth.

Boring 02-2B Continued on LOTB Sheet of

VERTICAL SCALE 1 : 50

DESIGN	BY E. BROWN	11/20/02	J. CASTLE & T. BODKIN — FIELD INVESTIGATOR(S)/TITLE
CHECKED	BY S. SICILIANO	1/9/03	DATE 9/23/02 to 9/26/02

DESIGN OVERSIGHT: KEYHAN MOGHBEL

SIGNOFF DATE

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.

KILOMETER POST

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

Boring 02-2B Continued from LOTB Sheet of

PENETRATION DEPTH (m) — 57 to 87

Run	REC / RQD
46	REC=105%, RQD=68%
47	REC=103%, RQD=0%
48	REC=92%, RQD=32%
49	REC=104%, RQD=63%
50	REC=105%, RQD=82%
51	REC=102%, RQD=55%
52	REC=105%, RQD=28%
53	REC=86%, RQD=0%
54	REC=108%
55	REC=100%, RQD=65%
56	REC=100%, RQD=72%
57	REC=102%, RQD=42%
58	REC=102%, RQD=82%
59	REC=100%, RQD=70%
60	REC=100%, RQD=83%
61	REC=100%, RQD=73%
62	REC=100%, RQD=10%
63	REC=100%, RQD=63%
64	REC=100%, RQD=70%
65	REC=100%, RQD=70%
66	REC=100%, RQD=50%
67	REC=67%, RQD=0%
68	REC=17%, RQD=0%

joints, inclined 45-70°, no filling, polished, moderately open apertures.
@57.6m: joint, inclined 75°, no filling, polished, moderately open aperture.
@57.9m: joints, inclined 40°, no filling, polished.
@58.2m: joint, inclined 65°, no filling, smooth. Quartz diorite altered to light yellow-green and crystalline arrangement altered around fracture. Numerous fully healed fractures below joint.
gray weathering to orange-brown, intensely weathered, intensely fractured, brown sandy clay matrix.
gray, hard, coarse grained, fracture surfaces oxidized to dark orange brown. Joint, inclined 45°.
@60.1m: joints, inclined 25°, 40°, and 75°, clay filling.
@60.4m: joint, inclined 25°.
@60.7m: joints, inclined 20-60°.
greater than 100% recovery, core has been rotated, no longer fits together at joints. Joints, inclined 75-85°, no filling, rough, open to moderately wide apertures.
@61.6m: incipient fractures, weathering to orange-brown.
greater than 100% recovery, green-gray weathering to brown orange, slightly weathered, hard. Drillers continue to lose water during run.
@62.2m: joint, inclined 50°, no filling, polished, moderately open aperture. Fully healed fracture, inclined 40°, 4mm wide.
@62.5m: joint, inclined 35°, green-orange oxidation on fracture surface, polished with slickensides inclined 20°, very thin aperture.
@62.8m: joint, inclined 80°, no filling, slightly rough, moderately open aperture.
@63.1m: joints, inclined 50-60°, no filling, polished to smooth, slightly open to moderately open apertures.
mechanical breaks.
@63.7m: joint, inclined 70°, no filling, slightly rough, moderately thin aperture.
@64m: joints, inclined 30-45°, no filling, slightly rough.
@64.3m: closely fractured, joints generally inclined 30-60°.
joint, colored yellow-green, inclined 35°, no filling, tight aperture, healed fractures subparallel to joint.
@65.2m: joint, inclined 70°, no filling, moderately open aperture.
@65.5m: joint, inclined 30°, calcite filling, moderately open aperture.
@65.9m: joints, inclined 85°, no filling, moderately open apertures.
@66.2m: joint, inclined 15°.
fracture zone, 33 cm wide, beginning at 66.5 m depth, broken, angular quartz diorite, no filling.
@66.8m: joints, inclined 20-40°, no filling. Shear zone, 11 cm wide, beginning at 67 m depth.
mechanical break.
@67.7m: fully healed fractures inclined 20-40°. Joint, inclined 80°, no filling, slightly rough, tight aperture.
joint, inclined 65°, no filling, slightly rough, tight aperture.
@68.3m: joints, inclined 75-90°, no filling, slightly rough, moderately open to tight aperture.
(PT) @68.6m: joint, inclined 70°, no filling, moderately rough, moderately open aperture.
@68.9m: fully healed fracture, yellow-green, 4 mm wide. Joint, inclined 50°, no filling, slightly rough, tight aperture.
@69.2m: joints, inclined 40°, clay filling, slightly rough, very thin apertures.
core was dropped prior to logging, actual RQD may be higher. Joint, inclined 45°, no filling, polished with slickensides inclined 40°.
@69.8m: joint, inclined 30°, no filling, slightly rough. Healed fracture parallel to joint.
@70.4m: mechanical breaks. Joint, inclined 50°, no filling, moderately rough, tight aperture.
@70.7m: joint, inclined 35°, no filling, slightly rough.
joint, inclined 50°, no filling, slightly rough.
@71.3m: joint, inclined 50°, no filling, moderately rough.
@71.6m: joint, inclined 60°, no filling, polished with slickensides inclined 65°. Joints, inclined 30-40°, no filling, slightly rough.
@72.3m: joint, inclined 15°, no filling, rough.
joint, inclined 60°, no filling, slightly rough.
@73.2m: joints, inclined 60-65°, no filling, smooth.
@73.8m: joint, inclined 25°, no filling, polished.
QUARTZ DIORITE, white to light gray-green, slightly weathered to fresh, hard, closely to moderately fractured, abundant green algal growth, pervasive chlorite staining. Joints, inclined 80°, no filling, slightly rough, moderately open apertures.
@74.4m: becomes medium to coarse grained below 74.6 m depth. Closed fractures.
@75m: joint, inclined 45°, no filling, slightly rough, moderately open aperture.
@75.3m: iron oxide and chlorite stained fractures.
less open fracturing, some closed fractures. Joint, inclined 45°, sandy clay filling, slightly rough, moderately thin aperture. Joint, inclined 60°, sandy clay filling, slightly rough, moderately thin aperture.
@76.2m: random fracture.
@76.5m: random fracture.
little open fracturing, iron staining along open fractures. Closed fracture, inclined 60°
(PT) @77.7m
@78.4m: joint, inclined 35°, sandy clay filling, slightly rough, moderately open aperture
gray-green, slightly weathered, hard, medium grained, less quartz in ground mass. Random fractures, sandy clay filling, slightly rough, moderately open apertures.
@79m: joint, inclined 35°, slightly rough.
@79.3m: becomes fine grained. Whitish green (algal growth) and iron stained along fractures between 79.4 and 79.7 m depth.
@79.6m: becomes moderately to deeply weathered, pervasive iron staining and clay filling in fractures. Below 79.7m depth, moderately hard to moderately soft. Joints, inclined 35-65°, clay filling, slightly rough.
slightly weathered, hard, fine grained, closely to moderately fractured, iron stained fractures. Joints, inclined 40-60°, sandy clay filling, slightly rough, moderately thin aperture.
@80.5m: joints, inclined 55-65°, clay filled.
@80.8m: little fracturing below 80.9 m depth.
@81.1m: joint, inclined 45°.
@81.4m: below 81.6 m depth, brecciated conglomerate, gray-green.
brecciated conglomerate, gray-green, medium grained, abundat subangular to subrounded quartz clasts that are very coarsely grained, fresh to slightly weathered, hard, little to moderate fracturing. Joint, inclined 55°, no filling, slightly rough, moderately open aperture.
@82m: joint, inclined 40°, no filling, polished.
@82.3m: thin calcite filled healed fractures.
@82.6m: joint, inclined 40°.
@82.9m: below 83 m depth, intensely fractured to crushed. Iron stained.
gray-green, coarse grained, fresh to slightly weathered, hard, little fracturing. Some calcite filled fractures.
@83.8m: calcite filled fractures.
closely fractured. Random fractures, no filling, slightly rough, moderately open apertures.
slightly to moderately weathered, moderately hard, intensely fractured, clayey sand filled fractures, iron stained.
@85.7m: no core recovery below 85.8 m depth.
no core recovery below 86 m depth.
@86.3 m: Bottom of boring.

9/23/02 to 9/26/02

VERTICAL SCALE 1 : 50

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2½" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date; Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Permanent Casing driven; Top Hole El.; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON, NO. CEG 31, EXP. 7/31/04, STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

The State of California or its officers or agents shall not be responsible for the completeness or accuracy of electronic copies of this plan sheet.

Caltrans Metric

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY E. BROWN 11/20/02
CHECKED BY S. SICILIANO 1/9/03

J. CASTLE & T. BODKIN — FIELD INVESTIGATOR(S)/TITLE
DATE 9/23/02 to 9/26/02

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

DESIGN OVERSIGHT
SIGNOFF DATE
KEYHAN MOGHBEL

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According to the Standard Penetration Test (ASTM D-1586)

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		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

- 2¼" CONE PENETRATION
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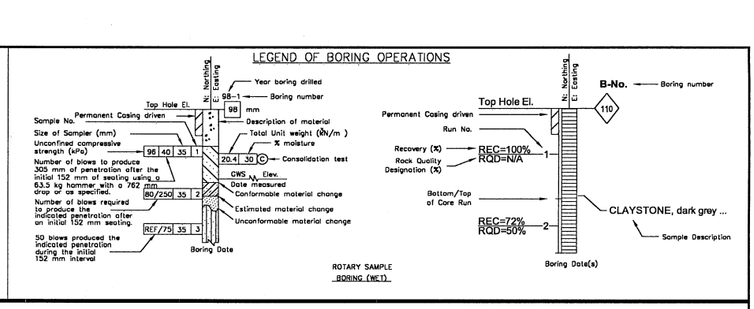
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



N: 621,357.2
E: 1,822,201.7

02-5

El. +292.2 m; 63; N79°W, 0°~4° Inclination

PENETRATION DEPTH (m)

0 — SILT, black.

1 — REC=100% RQD=20% — 1 — SANDSTONE, yellowish/orangeish brown, intensely weathered to decomposed, soft to very soft.
@.3m: fractures inclined 50-60°, clay and oxidation filling, rough, moderately thin aperture.
@1.2m: fracture inclined 45°, clay and oxidation filling, rough, moderately thin aperture.

2 — REC=100% RQD=17% — 2 — SANDSTONE, molted yellowish brown to dark brown with some rusty coloration, intensely weathered, soft to very soft. Joint inclined 55°, silt and iron oxidation filling, rough to smooth, moderately thin aperture.
@2.1m: joint inclined 50°, silt and iron oxidation filling, rough to smooth, moderately thin aperture.

3

4 — REC=100% RQD=70% — 3 — SANDSTONE, becoming coarser grained, dark brown to mottled yellow-brown, moderately weathered, soft. Fractures randomly inclined and inclined at 50°, silt and iron oxidation filling, rough, moderately thin aperture.
@4.3m: fracture inclined 5°.

5 — SANDSTONE, coarse grained, mottled reddish brown, yellow brown, and dark brown, moderately to intensely weathered, soft, fracture inclined 40°, silt and iron oxidation filling, rough, moderately thin aperture.

REC=100% RQD=55% — 4
@5.5m: fracture inclined 40°.
@5.8m: fracture inclined 70°.

6 — medium to fine grained.
@6.4m: fractures inclined 50 - 70°.

7 — REC=95% RQD=62% — 5 — @7m: fracture inclined 60°.

8 — medium to coarse grained, moderately soft, fracture inclined 60°.
REC=100% RQD=47% — 6 — @7.9m: random fractures inclined 20°.

9 — random fractures, silt and iron oxidation filling, rough, moderately thin aperture.
REC=100% RQD=47% — 7

10 — CONGLOMERATE / COARSE-GRAINED SANDSTONE, gray, intensely weathered, moderately soft. Random fracture inclined 70°, clay and iron oxidation filling, rough.

11 — REC=100% RQD=73% — 8 — @10.4m: fracture inclined 55°.
@10.7m: fractures inclined 45°.
@11m: fractures inclined 40-60°.

12 — SANDSTONE, black weathering to orange-brown with patchy white calcite coating along fractures, intensely weathered, moderately soft to moderately hard. Randomly inclined fractures, calcite, silt, and iron oxidation filling, rough, tight aperture.

REC=100% RQD=0% — 9

13 — random fractures, silt and iron oxidation filling, smooth to rough, moderately thin aperture.

14 — REC=100% RQD=19% — 10 — @13.7m: fracture zone beginning at 13.9 m depth.

15 — SANDSTONE, yellow brown to dark brown, moderately to intensely weathered, moderately soft. Random fracture inclined 60°, silt and oxidation filling, rough, moderately thin aperture.
REC=83% RQD=67% — 11 — @14.6m: blue-gray, moderately to slightly weathered, moderately hard.
@14.9m: black to yellow brown, moderately to intensely weathered.
@15.2m: moderately soft with small shear zone, up to 0.05 m width, at 15.4 m depth.

16 — @15.5m: no core recovery from 15.6 to 15.8 m depth.
SANDSTONE, medium to coarse grained, brown, moderately weathered, moderately hard. Joints inclined at 55-60° with iron oxide coating, rough to stepped. Coarse grains are black claystone fragments and igneous rock fragments up to 1 cm in size.

REC=53% RQD=0% — 12

17 — @16.2m: core pieces have been rotated at fractures, indicating lost core segments of indeterminate length.
@16.8m: no core recovery from 16.9 to 17.4 m depth.
joint inclined at 60°, oxidized.
@17.7m: joint inclined at 55°, oxidized.

18 — REC=100% RQD=80% — 13 — @18m: joints inclined at 30 and 65°, smooth to slightly rough.
@18.3m: joints inclined at 65-75°, gray unoxidized zone beginning at 18.5 m.
@18.6m: joints inclined at 35 and 70°.

19 — REC=100% RQD=33% — 14 — joints inclined at 25-70°, clay and iron oxidation filling, rough.

@19.5m: numerous intersecting incipient joints with random orientation.

20 — REC=88% RQD=42% — 15 — @20.1m: gap from ~20.1 to ~20.3 m. During drilling, rods dropped approximately 0.3 m and water pressure disappeared.
@20.4m: highly fractured zone with yellow-brown sandy clay filling, up to 2-3 cm thick, in several joints.

21 — clay filled joints, probably continuation of fracture zone.
@21.2m: possible bedding laminae inclined at 55-60°.

22 — REC=100% RQD=81% — 16 — @21.5m: SANDSTONE, 5-10% coarse grained, moderately weathered, moderately hard with claystone and igneous fragments 2-5 mm in size. Joints inclined at 35 to 65°, filled with iron oxidation, slightly rough to rough.
highly fractured zone with abundant intersecting tight joints filled with yellow-brown clay beginning at 22.4 m depth.

23 — REC=100% RQD=0% — 17

@23.5m: clayey crushed zone.

24 — random intersecting joints with yellow-red clay filling. Dark laminae indicate bedding inclined at 55-60°. Core is intact, but easily breaks during transfer to core box. RQD is not indicative of rock strength.
REC=100% RQD=100% — 18 — @24.1m: abundant intersecting random jointing with yellow brown or yellow red clay fill. Abundant random black streaks, possibly oxidation. Largest grains 1-2 mm in size.

25 — white to very pale brown, highly fractured zone, partly altered to stiff clay.

26 — REC=100% RQD=38% — 19 — @25.6m: SANDSTONE, medium to coarse grained, brown with white and red-yellow stain, moderately weathered, moderately hard to soft. Numerous incipient joints and dark lines that are possible incipient joints. Fractures inclined 20-45° with calcite films

27 — @27.1m: 50mm thick highly fractured zone with clay fill beginning at 27.2 m depth.

REC=98% RQD=31% — 20 — @27.4m: highly fractured zone with clay fill and clay alteration beginning at 27.5 m depth.

28 — few claystone and granitic grains up to 5mm.

29 — REC=100% RQD=0% — 21 — @28.4m: zones of brown-gray sandstone, joint inclined at 30°, clay filling, rough to moderately rough.
@28.7m: joints inclined from 25-40°, clay filling.
@29m: red-brown joints inclined from 40-55°, clay filling. Joint inclined at 85°, clay filling.

30 — 8 cm thick clayey fracture zone beginning at 29.7 m depth.
@29.9m: fracture inclined at 35°, with clay filling, abundant random intersection joints.

REC=100% RQD=13% — 22

31 — @30.5m: coarser grained.
@30.8m: less fractured, very pale brown, medium to coarse grained. Two fractures inclined at 45-40°, clay filling, slightly rough.
joints inclined at 50-60°, clay filling, with moderately rough to rough.
@31.4m: voids of 1-2 mm in joint inclined at 85°. During drilling, lost water at 31.7 m.

32 — REC=92% RQD=27% — 23 — @31.7m: 15cm thick clayey zone starting at 31.5m depth.
@32m: abundant intersecting clay-filled joints. Joint inclined at 30°.
@32.3m: clayey fracture zone. Joint inclined at 30°.

33

PENETRATION DEPTH (m)

33 — SANDSTONE, coarse grained, average size 2-3 mm, black and white grains, moderately weathered, moderately hard, no bedding visible, numerous clay filled joints.

REC=93% RQD=17% — 24 — @32.9m: joint, inclined at 50°, up to 1 cm thick, clay filling, rough/stepped.

34 — @33.2m: joint, inclined at 55°, clay filling, rough/stepped, up to 1 cm thick. Three other joints inclined at 45-65°.
@33.5m: open joints inclined at 25 and 85°, clay filled; rough/stepped.
@33.8m: open joints inclined at 45-50°, clay filled, rough/stepped. Mechanical breaks at end of run due to removal of core from tip.

35 — REC=98% RQD=N/A — 25 — PEBBLE CONGLOMERATE, gray weathering to brown and red-yellow, moderately to intensely weathered, moderately hard to soft. Most clasts in 0.5 to 2 cm size range in coarse sand matrix, grain-supported in zones. Clasts include black claystone, white igneous rocks, quartzite, and fine grained sandstone. Much clay alteration. Most grains are hard, but rock can be disaggregated by hand, even some clasts, due to some clay alteration.

36 — @34.5m: 45cm fracture zone beginning at 34.3m depth.
up to 30% small pebbles from 5-8 mm in diameter.

REC=88% RQD=0% — 26 — @36m: 8 cm wide zone of black stain beginning at 36.4 m depth.
@36.3m: joints inclined at 50-55°, filled with clay and iron oxide, rough to moderately rough.

37 — @36.6m: fracture zone, 71 cm wide, altered to sandy clay, beginning at 36.7 m depth. Brown with black and white pebbles, some black stain, possibly manganese oxide, and stiff clay.

38 — REC=98% RQD=0% — 27

39 — highly weathered and altered, weathered to yellow brown, easy to bend, soft, core totally disaggregated when moved to core box.
@39m: 9 cm wide clayey zone beginning at 39.3 m depth.

REC=100% RQD=0% — 28

40 — @39.9m: thin black clay layer, 1-2 cm wide, inclined at 35°, in sharp contact with gray sandstone with brown oxidation and clay alteration at 40.1 m depth.
CLAY, yellow-brown with darker iron oxidation, intensely weathered to decomposed.

41 — REC=100% RQD=25% — 29 — SANDSTONE, yellow-brown to light gray, moderately weathered and locally intensely weathered to decomposed, moderately hard to locally soft, moderately fractured.

42 — @40.9m: joint inclined at 40°, clay and iron oxide filled.
@41.2m: joints inclined at 40-50°.
@41.5m: intensely weathered to decomposed beginning at 41.6 m depth.
joint inclined at 60°, clay filled.

REC=100% RQD=45% — 30 — @42.1m: joint inclined at 30°, clay filled.

43 — @42.7m: locally light gray, less weathered sandstone.
@43m: fracture zone beginning at 43 m depth, clay and iron oxide filled, soft.

44 — REC=100% RQD=33% — 31 — @43.9m: intensely weathered to decomposed zone, 61 cm wide, beginning at 43.9 m depth. Within zone is an 8 cm wide soft clay-rich sand interval.

@44.5m: moderately weathered and intensely fractured.

45 — SANDSTONE, medium to coarse grained, blue-gray weathering to orange, moderately weathered, moderately soft to moderately hard, massively bedded. Joints generally inclined at 25-45°, clay and calcite filled, moderately rough.

REC=100% RQD=0% — 32

46

intensely weathered, hard.

47 — @46.6m: shear zone at 46.7 m depth. Sandstone is partially disaggregated, sandy clay gouge present.
REC=78% RQD=0% — 33 — @47m: less oxidation, moderate weathering to yellow brown, soft.
@47.3m: moderately hard.
@47.6m: no core recovery from 47.5 to 47.7 m depth.

48 — core is intensely fractured, very soft with moderately hard pieces of fractured sandstone within the core, no oxidation on fracture surfaces, very rough.

REC=100% RQD=0% — 34

49 — REC=100% RQD=0% — 35 — SANDSTONE, light gray, slightly to moderately weathered, moderately hard, moderately fractured with joints inclined at 65°, clay and sand filling, rough, very thin apertures.

REC=103% RQD=0% — 36 — subparallel joints inclined at 50-60°, no filling, very rough.
SANDSTONE, light gray weathering to yellow-gray, moderately weathered, soft and very friable, very poorly lithified. During drilling, water loss noted at 49.7 m.

50

REC=92% RQD=11% — 37 — SANDSTONE, very coarse grained, light gray, slightly weathered to fresh, very hard, massively bedded, with less than 5% subangular quartz gravel up to 4 mm in diameter.
@50.3m: joints inclined at 35-55°, no filling, very rough, tight aperture.
@50.6m: joints inclined at 45-60°, no filling, very rough, moderately open aperture.

51 — grains up to 5mm, very fine gravel. Joints inclined at 40°, no filling, slightly rough.

REC=106% RQD=7% — 38 — @51.2m: moderately hard, can be scratched with knife with moderate pressure.

52 — @51.8m: beginning at 51.9 m depth, 15 cm zone of very friable, soft sandstone. Can be reduced to soil with finger pressure.
@52.1m: joint inclined at 35°, no filling, slightly rough.
moderately fractured, well graded, grains up to 2.5mm.

53 — REC=100% RQD=31% — 39 — @52.4m: joints inclined at 40-50°, no filling, smooth, moderately open.
@ @52.7m
@53m: numerous mechanical breaks at end of run.
intensely fractured, friable, locally crushed to sandy soil. Joints inclined at 50-70°, closely spaced, some with minor clay coatings, slightly rough.

54

REC=111% RQD=0% — 40 — @54.3m: 5 cm wide fracture zone beginning at 54.4 m depth, filled with rock fragments and clayey sand.
@54.6m: 7.5 cm wide fracture zone beginning at 54.8 m depth.

55 — fresh, moderately fractured, moderately hard to hard. Joints generally inclined 40-50°, some with minor clay coatings, slightly rough to smooth, moderately thin aperture.

REC=91% RQD=23% — 41 — @55.5m: fracture zone up to 7.5 cm wide, beginning at 55.7 m depth, with some minor clay.

56 — @55.8m: fracture zone up to 5 cm wide, beginning at 56 m depth, with some minor clay.
@56.1m: can be scratched with a knife with difficulty.

57 — @56.7m: joints inclined at 50 and 20°, clay filled, slightly rough, open apertures.

REC=100% RQD=0% — 42 — @57.3m: joint inclined at 30°, minor clay coating, slightly rough, moderately thin aperture. Joint inclined at 40°, clay filling, slightly rough, open aperture.

58 — @57.6m: Joint inclined at 50°, slightly rough, clay filled, contact between sandstone and soft clay and sand interval, up to 20 cm wide, beginning at 57.7 m depth.

59 — REC=100% RQD=25% — 43 — fracture zone. Rock is crushed into sandy soil and rock fragments. Joint inclined at 50°, contact between fracture zone and sandstone, open aperture.
SANDSTONE, coarse grained, light gray, fresh, moderately hard, subangular grains up to 0.5 cm.
@58.8m: fracture zone up to 5 cm wide, located at 59.1 m depth.
@59.1m: minor clay coatings on fracture surfaces.
abundant quartz. Joint inclined at 40°, no filling, slightly rough, open aperture, located at 59.6 m depth.

60

Boring 02-5 Continued on LOTB Sheet of

VERTICAL SCALE
1 : 50

Caltrans Metric

The State of California or its officers or agents shall not be responsible for the completeness or accuracy of electronic copies of this plan sheet.

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Geotechnical and Earthquake Engineering
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Fountain Valley, California 92708

HNTB CORPORATION
200 E. Sandpointe Ave. Suite 200
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PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HOLMES HAMILTON No. CEG 631 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/6/03
DRAWN BY J. CASTLE, M. HACHEY, B. SCHELL & S. SICILIANO
DATE 9/12/02 to 9/25/02
FIELD INVESTIGATORS/TITLE

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE No.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

DESIGN OVERSIGHT
KEYHAN MOGHBEL

SIGNOFF DATE

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL
CLAY (CL or CH)
SILT (ML or MH)
PEAT and/or ORGANIC MATTER
WELL-GRADED GRAVEL (GW)
POORLY-GRADED GRAVEL (GP)
SILTY GRAVEL (GM)
CLAYEY GRAVEL (GC)
POORLY-GRADED SAND (SP)
WELL-GRADED SAND (SW)
SILTY SAND (SM) or SANDY SILT
CLAYEY SAND (SC) or SANDY CLAY
COBBLES/BOULDERS
IGNEOUS ROCK
SEDIMENTARY ROCK
METAMORPHIC ROCK

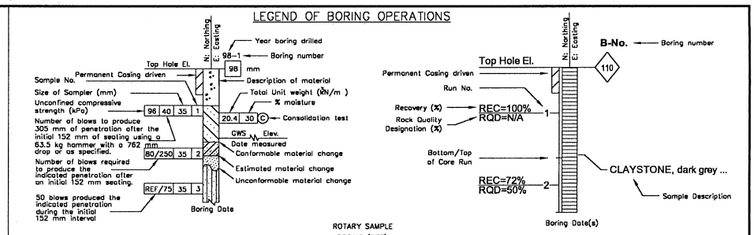
TYPE OF BORINGS

- 2½" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS
- (PZ) VW PIEZOMETER

LEGEND OF BORING OPERATIONS



Boring 02-5 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

60
REC=100% RQD=27% 44
@59.6 m: joint inclined at 40°, no filling, slightly rough, open aperture, located at 59.6 m depth.
@59.8m: joint inclined at 40°, no filling, slightly rough, open aperture, located at 60 m depth.
61
REC=100% RQD=12% 45
@60.1m: can be scratched with difficulty with knife, hammer rings when struck, but locally still friable. Joint inclined at 60°, minor clay filling, slightly rough, open aperture, located at 60.4 m depth.
@60.7m: joints inclined at 20 and 70°, no filling, slightly rough, moderately open apertures.
(PZ) @ 61.0
62
REC=100% RQD=17% 46
joints inclined at 40-60°, no filling, slightly rough, open aperture.
@61.3m: fracture zone up to 5 cm wide, beginning at 61.6 m depth, filled with clayey sand and rock fragments, friable.
@61.6m: joint inclined at 30°, clay filling, slightly rough, moderately thin aperture, located at 61.7 m depth. Fracture zone up to 7.5 cm wide, beginning at 61.74 m depth, filled with clayey sand and rock fragments.
63
REC=80% RQD=30% 47
(DS) @61.9m
@62.2m: joint inclined at 20°, no filling, slightly rough, moderately open aperture, located at 62.2 m depth.
very closely spaced fractures, more than 30 per meter.
@62.8m: open voids, 1-2 mm in size, common. Joint inclined at 65°, no filling, slightly rough, moderately open aperture, located at 63 m depth.
64
REC=0% RQD=0% 48
@63.1m: shear zone, up to 25 cm wide, beginning at 63.2 m depth, filled with sandy clay and rock fragments, soft.
some very subtle textures suggest bedding inclined at 45-50°. Joint inclined at 60°, filled with sandy clay, slightly rough, moderately thin aperture, located at 63.8 m depth.
65
REC=61% RQD=0% 49
@63.9m: coarse grained, generally 1-2 mm grain size, but 5% 3-4 mm and occasional 1 cm size. Open voids common, open to 2-3 mm.
@64.2m: joint inclined at 60°, no filling, slightly rough, open aperture, located at 64.4 m depth.
66
REC=100% RQD=0% 50
@64.5m: zone of soft clayey sand, up to 8 cm wide, beginning at 64.5 m depth.
@64.6m: No core recovery, soil-like portion washed away.
No core recovery. During drilling, water circulation was lost.
intensely fractured. Only sandstone fragments up to 2 cm size in soft clay matrix recovered.
67
REC=100% RQD=0% 50
@65.9m: sandstone fragments up to 5 cm size.
@66.2m: No core recovery from 66.1 m to 66.6 m.
SILTSTONE, black, fresh, moderately hard, soft in fracture zone. Rock is very poor quality, locally crushed and reduced to clay. Fragments up to 3 cm, subrounded, probably caved in.
68
REC=60% RQD=0% 51
@66.9m: fracture zone, 5 cm wide, located at 67 m depth.
@67.2m: bedding inclined at 45-50°. Fracture zone, up to 8 cm wide, beginning at 67.3 m depth. 13 cm wide zone of soft black clay with some iron oxidation.
69
REC=89% RQD=N/A 52
SANDSTONE/SILTSTONE, interbedded, gray and black, fresh, moderately hard, locally soft in gouge, thinly bedded at 20-25°. Indications of folding and tectonic shear.
@67.8m: siltstone beds are warped and plastically bent to 90° orientation. Fracture zone, up to 15 cm wide, filled with rounded rock fragments up to 2 cm size, beginning at 67.9 m depth.
@68.1m: shear zone, up to 13 cm wide, filled with soft clay-gouge, beginning at 68.3 m depth.
70
REC=81% RQD=0% 53
@68.4m: no core recovery from 68.4 to 69.1 m depth.
fracture zone, up to 25 cm wide, beginning at 69.2 m depth.
@69.4m: SANDSTONE/SILTSTONE, interbedded, gray and black, fresh, moderately hard to soft, thinly bedded inclined at 45-60°. Sandstone interbeds up to 5mm thick, siltstone beds up to 5mm thick.
(CS) @69.7m
71
REC=76% RQD=0% 54
(CS) @70m: calcite vein cross-cuts bedding.
@70.3m: no core recovery from 70.3 to 70.4 m depth.
SILTSTONE, dark gray, slightly weathered, soft to very soft. Highly fractured, with clay filling and pockets of calcite, smooth fracture surfaces.
@71.3m: no core recovery from 71.3 to 71.5 m depth.
72
REC=61% RQD=0% 55
SANDSTONE, fine grained, light gray, slightly weathered, moderately soft to moderately hard with thin calcite veins. Fracture zone up to 10 cm wide, beginning at 71.6 m depth.
@72.1m: mostly siltstone with some sandstone.
73
REC=40% RQD=0% 56
@72.4m: shear zone, clay filled. No core recovery from 72.3 to 72.6 m depth.
intensely fractured core, calcite and clay filling within the fractures, moderately hard to hard.
@72.9m: moderately soft to moderately hard.
74
REC=83% RQD=17% 57
@73.2m: no core recovery from 73.1 to 73.5 m depth.
SANDSTONE/SILTSTONE, interbedded, gray and dark gray, slightly weathered, moderately hard to hard, bedding at 40° orientation. Sandstone beds are very fine grained. Joints inclined at 35-60°, with clay and calcite filling, smooth to rough.
75
REC=48% RQD=0% 58
@73.8m: fracture zone up to 33 cm wide, clay and calcite filling, beginning at 73.8 m depth.
@74.1m: no core recovery from 74.1 to 75 m depth.
abundant calcite veins in first 15 cm of run. Fractures inclined at 35°, with calcite filling, rough, moderately thin aperture. Fracture zone up to 0.3 m wide, clay filling, beginning at 75.1 m depth.
76
REC=100% RQD=24% 59
@75.3m: no core recovery from 75.5 to 75.6 m depth.
thin calcite veins. Bedding joints inclined at 40-50°, calcite and clay filling, rough, moderately thin aperture.
@76.2m: no core recovery from 76.3 to 77 m depth.
SANDSTONE, gray, slightly weathered, moderately hard to hard. Bedding joints filled with calcite, rough to smooth.
(CS) @77.6m
77
REC=83% RQD=0% 60
@77.9m: becoming interbedded with claystone. Shear zone, at least 25 cm wide, beginning at 77.8 m depth.
SANDSTONE/SILTSTONE, interbedded, light gray and dark gray, slightly weathered, moderately hard to hard, bedding inclined at 40°. Intensely fractured. Abundant calcite veins in sandstone. Random fractures, clay and calcite filling, rough.
78
REC=67% RQD=13% 61
@78.4m: joint, inclined at 70°, clay filled, located at 78.6 m depth. Siltstone sheared into sandstone.
@78.7m: no core recovery from 78.8 to 79 m depth.
random fractures, clay and calcite filling, rough, moderately thin aperture.
79
REC=100% RQD=0% 62
@79.3m: shear zone with clay filling, located at 79.4 m depth.
@79.6m: SANDSTONE, coarse grained, light gray, slightly weathered, moderately soft to soft, calcite veining. No core recovery from 79.8 to 80.2 m depth.
SANDSTONE/SILTSTONE, interbedded, dark gray, fresh to slightly weathered, hard, highly fractured. Medium grained sandstone beds with abundant calcite veining.
@80.8m: soft, thinly interbedded, beds inclined at 20°, moderately fractured.
80
REC=89% RQD=17% 63
@81.1m: intensely fractured.
SILTSTONE, fresh to slightly weathered, moderately hard to moderately soft, thinly interbedded with fine grained sandstone, inclined at 30°, beds are 2-3 mm thick. Random fractures, rough, with apertures ranging from tight to slightly open.
81
REC=92% RQD=14% 64
@81.7m: fractures inclined at 35 and 40°, rough, with apertures ranging from tight to slightly open.
@82m: shear zone.
highly fractured, hard.
82
REC=100% RQD=14% 65
@82.9m: some gouge present, moderately hard to moderately soft.
bedding joints inclined at 40-50°, closely spaced, calcite and silt filling, rough, tight apertures.
@83.8m: shear zone, clay filled, at least 8 cm wide, beginning at 84.1 m depth.
83
REC=50% RQD=0% 66
(PA) @ 83.8
SILTSTONE/CLAYSTONE, black, fresh, moderately hard to soft, with calcite veins and sandstone interbeds up to 1 cm thick inclined 60°. Fracture zone, up to 8 cm wide, beginning at 84.6 m depth.
84
REC=43% RQD=0% 67
@84.8m: CLAY, black, fresh, soft, from 84.6 to 84.9 m depth.
@85.1m: no core recovery from 84.9 to 85.5 m depth.
@85.4m: switched to NX size core in preparation for pressuremeter test.
CLAY, black, fresh, soft to very soft. Small fragments of siltstone, claystone, and sandstone with the clay, probably gouge. No rock structure is identifiable.
85
REC=0% RQD=N/A 68
@86.4m: softer, light clay portion, probably remnants of calcite vein, 5 cm wide, beginning at 86.5 m depth.
86
REC=50% RQD=0% 69
SILTSTONE/CLAYSTONE, black, fresh, moderately hard to soft, with interbedded very fine grained sandstone. Intensely fractured, rock fragments up to 3 cm alternating with intact rock sections up to 8 cm long.
@87.2m: CLAY, black, fresh, soft, with siltstone fragments beginning at 87.3 m depth.
87
@87.5m: no core recovery from 87.3 to 88.1 m depth.
SILTSTONE/CLAYSTONE, black and light gray, fresh, moderately hard to locally soft, with interbedded very fine grained sandstone. Moderately to intensely fractured.
88
REC=100% RQD=21% 70
@88.4m: SANDSTONE, fine grained, light gray, fresh, hard, bedding contact between siltstone and sandstone inclined at 60°, located at 88.6 m depth. Hairline calcite vein.
89
REC=100% RQD=0% 71
@88.7m: SILTSTONE/CLAYSTONE, black and light gray, fresh, moderately hard to soft, with interbedded very fine grained sandstone. Moderately fractured, bedding contact between siltstone and sandstone inclined at 60°, located at 88.9 m depth.
@89m: fracture zone/probable fault zone, from 89.1 to 90.7 m depth, black rock fragments up to 6 cm in soft clay matrix.
90
REC=100% RQD=0% 72
joint, inclined at 30°, clay filled, polished with slickensides.
@90.5m: SANDSTONE, fine grained, light gray, fresh, moderately hard to hard, beginning at 90.7 m depth.
91
REC=100% RQD=27% 73
SANDSTONE, fine grained, light gray, fresh, moderately hard to locally soft, with siltstone interbeds. Fracture zone, 15 cm wide beginning at 91 m depth, in siltstone interbed, rock fragments in soft clay matrix.
@91.2m: joint inclined at 40°, no filling, slightly rough, open aperture, located at 91.3 m depth.
92
@91.5m: joint inclined at 50°, no filling, slightly rough, open aperture, located at 91.5 m depth. Bedding contacts between sandstone and siltstone interbeds inclined at 70°.
Siltstone interbed up to 5 cm wide.
@92.1m: random fractures and mechanical breaks.
93

PENETRATION DEPTH (m)

92
joint inclined at 25°, no filling, moderately open aperture, located at 92.5 m depth.
93
REC=100% RQD=42% 74
@92.7m: joint inclined at 30°, no filling, moderately open aperture, located at 92.9 m depth.
@93m: siltstone/claystone interbeds up to 2 cm inclined at 60°.
(DS) @93.3m: siltstone/claystone interbeds inclined at 70°.
94
siltstone/claystone interbed, 4 cm wide, inclined at 60-70°, located at 94.1 m depth.
@94.2m: joint, inclined at 60°, calcite coated, slightly rough, located at 94.3 m depth. Joint, inclined at 20°, no filling, slightly rough, located at 94.4 m depth.
95
REC=88% RQD=30% 75
@94.5m: fracture zone, up to 23 cm wide, in siltstone interbed beginning at 94.6 m depth. Siltstone interbeds inclined at 60-70°.
@94.8m: joints, inclined at 45-50°, no filling.
96
REC=100% RQD=0% 76
@95.1m: CLAY, light gray, fresh, locally hardened. Fault, inclined at 50°, abrupt contact between sandstone and clay gouge, located at 95.1 m depth. No core recovery from 95.2 to 95.4 m depth.
SANDSTONE, light gray, fresh, hard to soft, bedding attitude is not clear due to intense fracturing. Granitic allochthonous sections in core. Probable fault zone.
97
REC=100% RQD=0% 77
fault zone, fragments of igneous and sedimentary rock in soft clay matrix. Quartz diorite intrusion cuts siltstone beds, likely a dike.
@96.6m: quartz diorite sand dike injected in siltstone.
98
REC=100% RQD=0% 78
mostly siltstone with quartz diorite and minor clay.
@97.9m: mostly quartz diorite with some siltstone. No attitude of beds recognizable due to intense fracturing. Joint, inclined at 30°, located at 98.1 m depth.
99
REC=67% RQD=0% 79
zone of quartz diorite fragments, probable granitic sand dike, 10 cm wide, beginning at 98.5 m depth. 10 cm wide zone of soft black clay, beginning at 98.7 m depth.
@98.8m: fault zone in siltstone, 28 cm wide, beginning at 98.9 m depth.
@99.1m: SANDSTONE, light gray, fresh, with black siltstone interbeds and quartz diorite fragments.
100
REC=125% RQD=35% 80
@99.4m: no core recovery from 99.5 to 99.7 m depth.
(CS) @100m: bedding inclined at 65°. Color change from darker gray to light gray at 100.2 m depth.
@100.3m: joints inclined at 40°, minor calcite filling, slightly rough.
@100.6m: hairline calcite veining to 5 mm width.
101
REC=100% RQD=29% 81
@100.9m: siltstone interbed, 5 cm thick, inclined at 60°, beginning at 100.8 m depth.
joints inclined at 20-30°, minor calcite filling.
102
REC=100% RQD=85% 82
@102.1m: fault zone, in siltstone interbed, up to 8 cm wide, composed of rock fragments up to 1 cm in size in a clay matrix, beginning at 102.1 m depth. Joints inclined at 50-60°, no filling, slightly rough, moderately open aperture. Second pressure tes
103
@102.4m: joint inclined at 30°, no filling, moderately open aperture, located at 102.7 m depth.
(PM) @102.7m: siltstone interbed 1cm thick, inclined at 60°, slightly rough, closed aperture.
104
REC=100% RQD=76% 83
(C) @103m
(PM) @103.4m: fine grained.
@103.7m: CONGLOMERATIC SANDSTONE, very coarse grained, light gray, fresh, hard, clasts up to 1 cm, slightly fractured, beginning at 103.9 m depth.
@104m: joint, inclined at 40°, clay filling.
105
(CS) @104.3m
(CS) @104.6m
SILTSTONE/SANDSTONE, interbedded, dark gray to light gray, fresh, moderately hard, bedding inclined at 30°. Joints inclined at 40°, filled with calcite and silt, smooth, moderately thin aperture.
106
REC=100% RQD=8% 84
@105m: SANDSTONE, fine to medium grained, light gray, fresh, hard, no visible bedding indicators, moderately fractured. Joints inclined at 50°, calcite filled, rough, moderately thin aperture.
@105.6m: sandstone becoming medium to coarse grained. Shear zone, up to 8 cm wide, filled with clay gouge, beginning at 105.7 m depth.
@105.9m: weak zone.
107
REC=111% RQD=46% 85
joint inclined at 35°, calcite filled, rough, moderately thin aperture, located at 106.3 m depth.
@106.4m: joint inclined at 20°, calcite filled, rough, moderately thin aperture, located at 106.6 m depth.
highly fractured zone from 107.8 to 108.4 m depth. Fractures are calcite filled, rough, moderately thin aperture.
108
REC=83% RQD=21% 86
@108.2m: CONGLOMERATE, very coarse grained, light gray, fresh to moderately weathered, hard to very hard. Joints inclined at 45-50°.
109
increase in conglomerate clast size with depth. Clasts include quartz, granodiorite, and greenstone.
110
REC=100% RQD=60% 87
@110.2m: abrupt contact between granodiorite cobble and conglomerate, inclined at 50°.
@110.5m: fracture zone, up to 15 cm wide, beginning at 110.7 m depth.
conglomerate is clast-supported, very little matrix present.
111
REC=95% RQD=40% 88
@111.4m: CONGLOMERATIC SANDSTONE, very coarse grained, light gray, fresh, hard.
112
CONGLOMERATE, very large clasts, up to cobble size, clast-supported, fresh, very hard, slightly fractured. Claystone interbed, 10 cm wide, beginning at 112 m depth.
REC=0% RQD=N/A 89
113
114
REC=100% RQD=100% 90
@113.7m: random fractures, calcite filled, rough to stepped, moderately thin apertures.
115
random fractures, calcite filled, rough to stepped, moderately thin apertures.
116
REC=100% RQD=57% 91
(PA) @ 115.9
@116.2m: slightly sheared/fractured.
117
@116.8m: fracture inclined at 40°, calcite filled, rough to stepped, moderately thin aperture.
118
REC=100% RQD=93% 92
@118.3m: granodiorite boulder, up to 96 cm wide, beginning at 118.4 m depth.
119
REC=125% RQD=88% 93
@118.6m: fracture inclined at 65°.

Boring 02-5 Continued on LOTB Sheet of

VERTICAL SCALE
1 : 50

Caltrans Metric

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Earth Mechanics, Inc.
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PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

STATE OF CALIFORNIA — CERTIFIED ENGINEERING GEOLOGIST
DOUGLAS HAMILTON
No. EGS 31
EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/6/03

J. CASTLE, M. HACHEY, B. SCHELL & S. SICILIANO
FIELD INVESTIGATOR(S)/TITLE
9/12/02 to 9/25/02
DATE

ORIGINAL SCALE IN inch FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

DESIGN OVERSIGHT
KEYHIAN MOGHBEL
SIGNOFF DATE

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

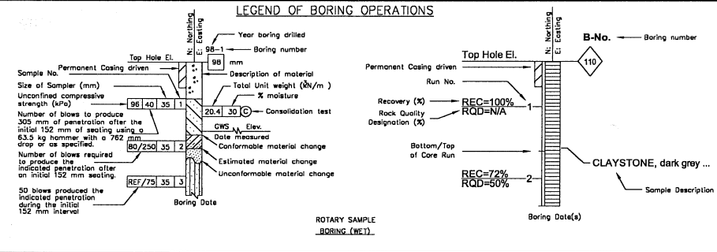
TYPE OF BORINGS

- 2½" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



ROTARY SAMPLE BORING (WC')

Boring 02-5 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

119
120 — REC=83% RQD=10% — 94 — SANDSTONE, gray, fresh, very hard, highly fractured with abundant calcite veining, beginning at 120 m depth.
@120.1m: fractures inclined at 55-60°, closely spaced, calcite filling, rough to stepped, moderately thin aperture.
@120.4m: no core recovery from 120.7 m depth.
121 — highly fractured sandstone.
@121.3m: joint inclined at 60°, calcite filled, rough, moderately thin aperture, located at 121.6 m depth.
122 — REC=100% RQD=25% — 95
highly fractured sandstone.
123 — REC=100% RQD=0% — 96 — @122.9m: joint inclined at 75°, calcite filling, rough, moderately thin aperture, located at 122.9 m depth.
@123.2m: joint inclined at 65°, calcite filling, rough, moderately thin aperture, located at 123.2 m depth.
moderately fractured sandstone.
124 — @123.8m: joints inclined at 40-60°, calcite filling, rough, up to moderately thin aperture.
REC=100% RQD=28% — 97 — @124.4m: joints inclined at 20-45°, calcite filling, rough, up to moderately thin aperture.
125 — @124.7m: joint inclined at 65°, calcite filling, rough, moderately thin aperture.
CONGLOMERATIC SANDSTONE, coarse grained, gray, fresh, hard, clasts up to 13mm, highly fractured with calcite filling.
REC=78% RQD=0% — 98 — @125.6m: no core recovery from 125.7 m depth.
126 — medium to coarse grained. Joint inclined at 60°, calcite filling, rough.
CONGLOMERATE, gray, fresh, hard, sandstone matrix, medium sized clasts, beginning at 126.2 m depth. Fracture inclined at 70°, calcite filling, rough, moderately thin aperture.
REC=100% RQD=30% — 99
127 — SANDSTONE, medium to coarse grained, gray, fresh, hard, fractured, beginning at 127 m depth.
SANDSTONE CONGLOMERATE, gray, slightly weathered, hard, poorly sorted, clast size increasing with depth, highly fractured. Joints generally inclined at 65-80°, calcite filling, rough.
128 — REC=100% RQD=96% — 100
subrounded to subangular clasts up to 2.5 cm in size. Joint inclined at 30°, located at 128.6 m depth.
129 — REC=100% RQD=0% — 101 — SANDSTONE, fine grained, light gray, fresh, hard, bedding contact between conglomerate and sandstone inclined at 40°, located at 129 m depth. Joints inclined at 20°, minor calcite coating, slightly rough, open apertures.
130 — REC=100% RQD=0% — 102 — intensely fractured.
@129.9m: fracture zone composed only of rock fragments, no clay, beginning at 130 m depth.
@130.5m: quartz diorite boulder in sandstone matrix, at least 25 cm in diameter, beginning at 130.5 m depth. Joint inclined at 20°, no filling, slightly rough, open aperture, cutting through boulder, located at 130.7 m depth.
131 — REC=96% RQD=39% — 103 — @130.8m: becoming coarser grained with depth, grading into conglomerate, clasts up to 0.25 cm.
CONGLOMERATE, light gray, fresh, hard, igneous and sedimentary clasts up to 7 cm in size.
132 — @131.4m: joint, inclined at 30°, calcite coated, slightly rough, open aperture, located at 131.5 m depth.
REC=100% RQD=90% — 104 — very good quality rock, igneous and sedimentary clasts, multicolored, up to 5 cm in size.
@131.9m: joint, inclined at 70°, no filling, located at 131.9 m depth.
133 — @132.2m: calcite veining, hairline.
@132.5m: joints inclined at 40-60°, no filling
slightly fractured, breaks along clast boundaries.
REC=100% RQD=7% — 105
134 — @134m: fracture zone, filled with clay-rich coarse sand, located at 134.2 m depth.
@134.3m: fracture zone, at least 55 cm wide, filled with clay-rich coarse sand and rock fragments, beginning at 134.3 m depth.
@134.8m: joint, inclined at 60°, no filling, slightly rough, open aperture, located at 135 m depth.
135 — REC=0% RQD=N/A — 106 — @135.1m: subrounded clasts up to 4 cm. Mechanical breaks go around clasts.
@135.4m: joint, inclined at 40°, no filling, rough, open aperture, located at 135.5 m depth.
136 — REC=100% RQD=25% — 107 — slightly to moderately fractured. Subrounded igneous and sedimentary clasts up 5 cm. Joint inclined at 60°, no filling, slightly rough, located at 135.8 m depth.
@136m: joint, soft clay filling up to 1 cm thick, located at 136.3 m depth.
@136.3m: joint, inclined at 60°, no filling, slightly rough, located at 136.5 m depth.
137 — REC=100% RQD=67% — 108 — fracture zone, up to 28 cm wide, filled with coarse sand and rock fragments.
@136.9m: joint, inclined at 60°, no filling, slightly rough, open aperture, located at 136.9 m depth.
@137.2m: joint, inclined at 60°, no filling, slightly rough, open aperture, located at 137.3 m depth.
138 — fault zone up to 5 cm wide, beginning at 137.8 m depth.
REC=78% RQD=13% — 109 — @138m: joint, inclined at 50°, no filling, slightly rough, moderately open aperture, located at 138.2 m depth, and several mechanical breaks.
@138.3m: joint, inclined at 30°, no filling, slightly rough, moderately open aperture, located at 138.4 m depth.
139 — @138.6m: joint, inclined at 40°, no filling, slightly rough, moderately open aperture, located at 138.6 m depth. No core recovery from 138.7 m depth.
REC=67% RQD=0% — 110 — moderately hard conglomerate. Joint, inclined at 60°, clay and sand filling, slightly rough, moderately thin aperture.
@139.3m: fracture zone, up to 33 cm wide, filled with clayey sand.
140 — @139.6m: no core recovery from 139.6 m depth.
REC=80% RQD=0% — 111 — joints inclined at 30°, no filling, slightly rough, tight apertures.
fracture zone, up to 15 cm wide, beginning at 140.7 m depth, conglomerate, gray, brecciated, with igneous and sedimentary clasts, sand and gravel. Joint, inclined at 65°, no filling, slightly rough, moderately open aperture, located at 140.9 m depth.
141 — REC=69% RQD=19% — 112 — @141m: joint, inclined at 45°, clay filled, slightly rough, moderately thin aperture, located at 141.2 m depth.
@141.3m: joint, inclined at 40°, clay filled, slightly rough, moderately thin aperture, located at 141.5 m depth.
142 — REC=100% RQD=27% — 113 — subangular to rounded clasts from pebble to boulder size. Joint inclined at 60°, no filling, located at 141.8 m depth.
@141.9m: joint inclined at 75°, no filling, located at 142.1 m depth.
143 — @142.2m: joint inclined at 80°, no filling, located at 142.2 m depth. Fracture zone, up to 10 cm wide, beginning at 142.3 m depth.
@142.5m: joint, inclined at 50°, no filling, located at 142.7 m depth, at the contact between granitic boulder and conglomerate.
@142.8m: joints, inclined at 70°, no filling.
144 — REC=0% RQD=N/A — 114 — joints inclined at 70-80°, no filling.
@143.4m: joints inclined at 45°, no filling.
@143.8m: fracture zone, gravel filled, up to 8 cm wide, beginning at 143.8 m depth.
145 — @144.4m: joint, inclined at 25°, clay filled, aperture of 1 mm.
REC=100% RQD=18% — 115 — moderately fractured, joints inclined at 25-45°, slightly rough, apertures of 1 mm.
146 — joints inclined at 25-30°, filled with silty sand, slightly rough, moderately thin aperture.
@146.3m: fracture zone, crushed, clay filled, 8 cm wide, beginning at 146.5 m depth.
147 — REC=40% RQD=0% — 116 — @146.6m: no core recovery from 146.6 m depth.
CONGLOMERATE, gray, fresh, hard, cobble to boulder size clasts, subrounded to subangular, brecciated, igneous to sedimentary. Joints inclined at 25-35, no filling, slightly rough, moderately open apertures.
148 — REC=92% RQD=0% — 117 — @148.2m: fracture zone, 92 cm wide, beginning at 148.2 m depth, clayey sand and clay filling.
moderately hard.
149 — REC=88% RQD=0% — 118 — joint, inclined at 40°, no filling, slightly rough, moderately open aperture, located at 149.3 m depth.
@149.4m: joint, inclined at 60°, no filling, slightly rough, moderately open aperture, located at 149.5 m depth.
150 — REC=100% RQD=0% — 119 — @149.7m: some clay filled fractures.
@150m: hard conglomerate. Joints inclined at 45°, clay filled, slightly rough, moderately-open apertures.
151 — gravel to boulder size clasts. Joints inclined at 50-80°.
@150.9m: joint, inclined at 80°, no filling, slightly rough, moderately open aperture, located at 151 m depth.
REC=92% RQD=15% — 120 — @151.2m: joint, inclined at 25°, no filling, moderately open aperture, located at 151.3 m depth. White boulders/cobbles of granodiorite with little iron or magnesium minerals.
152 — @151.5m: joint, inclined at 40°, clay filling, slightly rough, moderately thin aperture, contact between conglomerate and fracture zone. Fracture zone, 28 cm wide, clay and breccia filled, beginning at 151.6 m depth.

PENETRATION DEPTH (m)

152
REC=100% RQD=28% — 121 — @152.1m: granodiorite boulder, up to 41 cm diameter, beginning at 152.1 m depth, cut by the following joints: two joints, inclined at 25°, no filling, very rough, one joint, inclined at 35°, clay filling, rough, tight aperture, very poorly developed
153 — (PA) @ 152.4m
@152.4m: numerous incipient fractures and calcite veins.
@152.7m: subrounded clasts.
@153m: numerous mechanical breaks at end of run.
REC=103% RQD=72% — 122 — SANDY CONGLOMERATE, medium to coarse grained, light gray, fresh, hard, rounded to subrounded clasts, approximately 5% dark gray siltstone, 20% fine grained sandstone, 25% quartz, and less than 5% quartz diorite
154 — @154m: joint, inclined at 50°, no filling, rough, moderately open aperture, located at 154 m depth. Joint, inclined at 40°, the contact between the conglomerate and underlying fracture zone, located at 154.2 m depth. Fracture zone, 8 cm wide, filled
REC=95% RQD=23% — 123
155 — joints, inclined at 25-45°, closely spaced, filled with clay and breccia, rough, tight apertures.
@155.2m: fracture zone, 8 cm wide, inclined at 60°, filled with angular breccia in a gray clay matrix, beginning at 155.3 m depth.
REC=85% RQD=17% — 124 — subangular clasts, up to 3 cm diameter. No imbrication. Joint, inclined at 40°.
156 — @156.1m: calcite veins up to 4mm width.
@156.4m: joints, inclined at 10-15°, no filling, rough, moderately open aperture, passing both through and around clasts.
REC=90% RQD=32% — 125 — @156.7m: no core recovery from 156.8 m depth.
157 — CLAY, black, very soft, possible slight organic/sulfur smell. Bedding contact, inclined at 55°, located at 157.1 m depth.
SANDSTONE, fine grained, light gray, fresh, hard, well sorted, beginning at 157.1 m depth. Joints, inclined at 10-30°, thin calcite coatings and clay filling, moderately rough, with hairline calcite veins subparallel to joints.
158 — @157.6m: fine to medium grained.
REC=63% RQD=0% — 126 — @157.9m: becoming very coarse grained at 158 m depth, bedding inclined at approximately 80°. Joint, inclined at 20°, no filling, rough, moderately open aperture.
159 — @158.2m: becoming fine grained at 158.3 m depth, bedding inclined at approximately 80°.
REC=94% RQD=0% — 127 — interbeds of dark gray siltstone. Bedding inclined at 70-80°. Closely spaced, subparallel joints, generally inclined at 30-40°, minor clay and calcite filling, tight apertures. Joints cut across bedding.
160 — @159.1m: sandstone becoming coarse to medium grained at 159.2 m depth.
REC=117% RQD=0% — 128 — fine to medium grained sandstone, very fractured. Joints tend to be inclined at 30-45°, clay, calcite, and breccia filled, moderately rough.
161 — REC=71% RQD=0% — 129 — @160.1m: coarse to medium grained.
@160.4m: calcite veins up to 6 mm width.
@160.7m: disaggregated sandstone.
162 — fine grained, coarsening with depth, bedding inclined at 85°. Calcite veins up to 1 mm width.
REC=47% RQD=0% — 130
core is completely broken, unable to match pieces together. Minor dark gray/black clay clinging to surfaces.
163 — REC=142% RQD=0% — 131 — joint, inclined at 60°, clay filled, smooth, contact between fine grained sandstone and fracture zone, located at 162.1 m depth. Fracture zone, 5 cm wide, filled with subrounded breccia in a dark gray clay matrix.
@162.2m: no core recovery from 162.3 m.
164 — REC=70% RQD=8% — 132 — very coarse grained to fine gravel sized. Poorly sorted. Joint inclined at 75°, open aperture, located at 163 m depth. Fine grained below the joint with numerous incipient fractures.
fracture zone, 13 cm wide, with clay filling, beginning at 163.1 m depth. Calcite veins up to 1.5 cm wide, inclined at 50°.
165 — REC=100% RQD=0% — 133 — @163.4m: closely spaced joints, inclined at 25-50°, no filling, moderately rough, moderately open aperture.
@163.7m: joints inclined at 25-30°, clay and calcite filling, slightly rough. Striations on joint surface, inclined at 90°.
REC=38% RQD=0% — 134 — @164m: no core recovery from 164.2 m depth.
166 — CLAYSTONE, dark gray, fresh, moderately hard to soft, highly fractured, white calcite veins, clay filled fractures and crushed zones.
REC=78% RQD=0% — 135 — driller reported caving below 164.9 m depth.
@165.2m: slickensided surfaces along claystone fractures. No core recovery from 165.4 m depth. Driller reported washout. Crushed rock fragments and sand being removed from borehole.
167 — crushed clayey gravel.
REC=68% RQD=0% — 136 — @166.5m: no core recovery from 166.5 m depth.
SANDSTONE, fine grained, gray, fresh, hard, moderate to highly fractured, beginning at 166.8 m depth.
168 — @166.9m: fracture, inclined at 60°, clay filling, slightly rough, slickensides, located at 167 m depth.
REC=100% RQD=20% — 137 — @167.2m: fracture, inclined at 90°, clayey sand and clay filling, slightly rough, moderately thin aperture, located at 167.2 m depth. No core recovery from 167.4 m depth.
169 — REC=100% RQD=81% — 138 — fracture zone, 8 cm wide, crushed claystone with clay filling, beginning at 167.7 m depth. Sandstone below fracture zone is closely fractured. Joints inclined at 30°, clay and calcite filling, slightly rough, moderately thin aperture.
(PA) @ 167.7m
@168m: fracture zone, 11 cm wide, crushed claystone with clay filling, beginning at 168.1 m depth. Sandstone below the fracture zone contains brecciated, elongated claystone clasts and calcite seam.
170 — REC=79% RQD=31% — 139 — @168.3m: joint inclined at 30°, clay filling, slightly rough, moderately thin aperture.
little to moderate fracturing. Angular, gravel-sized claystone clasts up to 6 mm. Calcite veins subparallel to core axis.
171 — (PA) @168.8m: sandstone becomes medium grained.
REC=100% RQD=83% — 140 — (PA) @169.1m: clay filled fractures, crushed zone beginning at 169.3 m depth.
SILTSTONE, dark gray, fresh, moderately soft, moderately fractured with laminae interbeds of fine grained sandstone. Possible trace pyrite.
172 — @169.7m: joints inclined at 20°, clay and calcite filling, smooth, moderately thin aperture.
@170m: fracture zone, beginning at 170.1 m depth with joint inclined at 45°, minimum of 5 cm wide, no core recovery beyond 170.2 m depth.
REC=95% RQD=0% — 141 — joints, inclined at 40-50°, clay and calcite filling, slightly rough, moderately thin aperture.
173 — @171m: joint inclined at 60°.
moderately hard to moderately soft.
@172.3m: moderately fractured.
@172.6m: shear zone, clay filled, 8 cm thick.
174 — REC=58% RQD=14% — 142 — SANDSTONE, light gray, fresh, hard, calcite veining, beginning at 172.9 m depth.
SILTSTONE, dark gray, fresh, soft, platy, highly fractured with clay filling beginning at 173.6 m depth.
175 — @173.8m: no core recovery from 174 m depth.
REC=40% RQD=0% — 143 — @175m: no core recovery from 175 m.
176 — extremely poor recovery. No core recovery from 175.9 m depth.
REC=6% RQD=0% — 144
only claystone/siltstone fragments recovered.
177 — REC=17% RQD=0% — 145 — due to poor quality rock conditions and continued collapse of sand-sized material into borehole, run was drilled with tricone bit, thus no core was recovered.
REC=0% RQD=N/A — 146
178
179

Boring 02-5 Continued on LOTB Sheet of

VERTICAL SCALE
1 : 50

Caltrans Metric

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PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

STATE OF CALIFORNIA — CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HAMILTON — No. CEG 31 — EXP. 12/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/6/03
DATE FIELD INVESTIGATORS/TITLE: 9/12/02 to 9/25/02 J. CASTLE, M. HACHEY, B. SCHELL & S. SICILIANO

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR PROJECT ENGINEER

CU 240 EA 11237E

BRIDGE NO. KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

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LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS; (PZ) VW PIEZOMETER

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date. Sample No.; Permanent Casing driven; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Top Hole El.; CWS Elev.; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

Boring 02-5 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

- 179: drilled with tricone bit.
- @181.4m: some intermittent drill rig chatter; driller reports thin harder zones encountered.
- @181.7m: Driller reports same bedrock material as at 177.1 m depth.
- Run 147, REC=0% RQD=N/A: @182.9m: rig chatter at 182.9 m depth, but bedrock becomes less competent with easier drilling below 183.1 m. (PZ) @ 182.9m
- Run 148, REC=80% RQD=13%: SILTSTONE, light gray, fresh, moderately hard to soft, trace calcite and clay filling, highly fractured.
- Run 149, REC=100% RQD=28%: CLAYSTONE, black, fresh, hard to locally soft, siltstone interbeds, moderately fractured, no clear bedding planes identifiable. Soft zone, 4 cm wide, beginning at 189 m depth.
- @189m: slickensides and chlorite on all joint surfaces.
- @189.3m: joint, inclined at 40°, chlorite filling, slightly rough, open aperture. Soft zone, 8 cm wide, located at 189.5 m depth.
- fault zone, black gouge filling, 23 cm wide, beginning at 189.7 m depth.
- Run 150, REC=79% RQD=0%: @189.9m: bedding inclined at 75°. All joint surfaces are slickensided and have chlorite mineralization.
- @190.2m: thin interbeds inclined 75°.
- @190.5m: no core recovery from 190.6 m depth.
- subhorizontal interbeds and calcite filling.
- Run 151, REC=67% RQD=0%: @191.2m: fracture zone, 20 cm wide, beginning at 191.3 m depth, calcite veining within.
- @191.5m: no core recovery from 191.5 m depth.
- CLAYSTONE/SILTSTONE/SANDSTONE interbeds, black and light gray, fresh, hard, fine grained sandstone. Bedding inclined at 75°.
- Run 152, REC=67% RQD=0%: @192.1m: subhorizontal bedding planes. Soft clay gouge, 2.5 cm thick, beginning at 192.3 m depth.
- @192.4m: no core recovery from 192.4 m depth. Likely, soft clay gouge washed away during drilling.
- Run 153, REC=100% RQD=0%: soft gouge, 5 cm wide, beginning at 192.8 m depth. Subhorizontal bedding, 75-90°.
- @193m: fracture zone, 13 cm wide, beginning at 193 m depth.
- Run 154, REC=56% RQD=0%: highly fractured, calcite veining and fault gouge throughout.
- @193.6m: no recovery from 193.8 m depth.
- Run 155, REC=67% RQD=0%: fault gouge, gray siltstone/claystone, closely fractured to crushed, moderately soft, appears as clayey gravel and clayey sand with sandstone fragments. No core recovery below 194.5 m depth.
- CLAYSTONE, dark gray, fresh, moderately soft to soft, intensely fractured to crushed, abundant clay-filled fractures, appears sheared.
- (TX) @195m
- Run 156, REC=88% RQD=0%: (PA) @ 195.1m
- @195.6m: becomes moderately soft. Claystone/siltstone structure becomes more pervasive below 195.6 m depth with calcite filled veins and fractures.
- @195.9m: crushed zone beginning at 195.9, no core recovery from 196 m.
- @196.5m: sandstone interbed, gray, fresh, moderately hard, 8 cm wide, beginning at 196.6 m depth, bedding inclined at 30°.
- Run 157, REC=73% RQD=0%: @196.8m: some sandstone clasts, appears sheared, slickensided along fractures. From 197 to 197.1 m, resembles clayey gravel. No core recovery from 197.1 m depth.
- Run 158, REC=100% RQD=0%: CLAYSTONE/SILTSTONE, dark gray, fresh, moderately hard, bedding inclined at 45°, intensely fractured, sheared, some clay-filling along bedding, slickensided.
- SANDSTONE, fine grained, light gray, fresh, hard, intensely fractured, with closed fractures, calcite filled seams, beginning at 197.7 m depth.
- Run 159, REC=100% RQD=15%: CLAYSTONE/SILTSTONE, dark gray, fresh, moderately soft to soft, intensely fractured, sheared, appears as clayey gravel. Color change to light grayish-green sandstone clasts at end of run. (PA) @ 198.2m
- SANDSTONE, gray, fresh, moderately hard, intensely fractured, brecciated, some sheared interbedded claystone/siltstone seams.
- CONGLOMERATE, light gray to gray-green, fresh, hard, closely to intensely fractured, with subangular to rounded gravel clasts of granitic and claystone/siltstone, claystone filled fractures, beginning at 198.3 m depth.
- Run 160, REC=100% RQD=43%: GRANODIORITE, fault breccia, some foliation/wavy banding, contact between granodiorite and claystone at 198.5 m depth.
- @198.8m: abundant granitic and claystone/siltstone clasts.
- @199.1m: appears more granitic.
- CONGLOMERATE, gray to light gray, fresh, hard, closely to intensely fractured, black claystone/siltstone wavelike banding, foliated, sheared, beginning at 199.4 m depth. Joint, inclined at 60°, clay filled, moderately thin aperture, located at 199.7 m d
- Run 161, REC=97% RQD=40%: @199.7m: becomes coarse grained, less sheared. Joint, inclined at 60°, no filling, moderately open aperture, located at 199.7 m depth.
- @200m: joints inclined at 10-20°, no filling, rough, moderately open aperture.
- QUARTZ MONZONITE, white to light gray, fresh, hard, medium grained, little fractured, clean fractures. Appears to be a boulder based on run 161. Joint inclined at 50°, no filling, slightly rough, moderately open aperture, located at 200.5 m dep
- Run 162, REC=100% RQD=50%: @200.6m: joint, inclined at 50°, no filling, slightly rough, less than moderately open aperture, located at 200.8 m depth.
- CONGLOMERATE, white to light gray, fresh, hard, little to closely fractured, alterating dark and light colored brecciated zones. 5 cm wide zone of dark banding with shearing beginning at 201.2 m depth.
- @201.2m: aphanitic to fine grained in light-colored zone from 201.2 to 201.4 m depth. Dark banding from 201.4 to 201.5 m depth.
- Run 163, REC=100% RQD=28%: @201.5m: increase in coarse grained and gravel sized clasts below 201.5 m, becomes closely fractured. Random fractures inclined at 45°, no filling, slightly rough, moderately open aperture.
- @201.8m: 6 cm wide olive-green colored shear zone beginning at 201.8 m depth. Both open and closed fractures. Random fracture, inclined at 70°, no filling, slightly rough, moderately open aperture.
- Run 164, REC=100% RQD=63%: @202.1m: random fractures, inclined at 60-70°, no filling, slightly rough, moderately open aperture.
- (UC) @202.4m: abundant subangular to subrounded granitic and claystone/siltstone gravel-sized clasts.
- @202.7m: random fractures, inclined at 40°, no filling, slightly rough, moderately open aperture, located at 202.8 m depth. Sandstone cobble, 20 cm in diameter, beginning at 202.9 m depth. Fracture within the cobble inclined at 70°, no filling, sligh
- Run 165, REC=100% RQD=38%: @203m: becomes closely fractured, some chlorite staining.
- @203.4m: closed fractures.
- @203.7m: becomes moderately fractured.
- brecciated conglomerate, moderately to intensely fractured with some chlorite stained granitic clasts. 6 cm wide crushed zone beginning at 204.2 m depth.
- @204.3m: claystone/siltstone banding from 204.4 to 204.6 m depth.
- (PA) @ 204.3m
- @204.6m: 5 cm wide crushed zone beginning at 204.7 m depth, above granitic boulder, 61 cm wide. Boulder is sheared with open, clay-filled fractures and healed fractures.
- (E) @204.9m
- QUARTZ MONZONITE, light gray, fresh to slightly weathered, hard to very hard, little fracturing, 10-20% dark minerals, some chloritization. Rig chatter noted at 205.3 m depth. 5 cm wide intensely fractured zone beginning at 205.6 m depth.
- joint, inclined at 70°, no filling, slightly rough, moderately open aperture.
- (PA) @ 207.2m
- @207.2m: random fractures.
- @207.5m: intensely fractured zone, 5 cm wide, beginning at 207.5 m depth, filled with poorly-graded sand with gravel, slightly rough, moderately open aperture.
- @207.8m: fractures, inclined subparallel to core axis, some silt and clay filled with moderately thin apertures, some closed and healed, from 208 to 208.3 m depth.
- @208.1m: joint, inclined at 70°, clay and silt filling, slightly rough, moderately thin aperture, located at 208.3 m depth.
- joint, inclined at 60°, no filling, slightly rough, moderately open aperture, located at 208.4 m depth.

PENETRATION DEPTH (m)

- joint, inclined at 60°, no filling, slightly rough, moderately open aperture, located at 208.4 m depth.
- Run 166, REC=100% RQD=45%: (UC) @208.7m: intensely fractured zone, 4 cm wide, beginning at 208.8 m depth.
- (UC) @209m: joint, inclined at 70°, clay filling along joint with some chlorite staining, 4 cm wide crushed zone immediately above joint.
- @209.3m: numerous closed fractures.
- @209.6m: random fracture, inclined at 50°, no filling, slightly rough, moderately open aperture.
- quartz phenocrysts present. Joint inclined at 30°, clay filling, slightly rough, moderately open aperture.
- Run 167, REC=100% RQD=10%: @210.2m: joint, inclined at 80°, no filling, slightly rough, moderately open aperture. (PA) @ 210.2m
- @210.8m: fracture zone, crushed, 8 cm wide, beginning at 210.5 m depth, pervasive calcite-filled fractures below 210.7 m depth.
- @211.1m: becomes intensely fractured with calcite-filled, healed fractures. Joints inclined at 50°, no filling, slightly rough, moderately open apertures.
- Run 168, REC=0% RQD=N/A: moderately hard to moderately soft. joints, inclined at 35-40°, sand and clay filled, slightly rough, moderately thin aperture.
- @211.7m: joint inclined at 50°, no filling, slightly rough, moderately thin aperture, located at 211.9 m depth. 4 cm wide crushed to intensely fractured zone, beginning at 212 m depth.
- Run 169, REC=100% RQD=60%: @212m: joint, inclined at 70°, no filling, slightly rough, moderately thin aperture, located at 212.1 m depth. 4 cm wide crushed zone at end of run. No core recovery from 212.2 m depth.
- moderately to closely fractured, abundant closed, healed fractures. Most joints inclined at 50°, no filling, slightly rough, moderately open aperture.
- (UC) @213.4m (PA) @ 213.4m
- Run 170, REC=89% RQD=11%: GRANODIORITE, whitish-green, slightly weathered, hard, closely fractured with sand and silt filling, chloritic staining.
- @214.3m: joints, inclined at 55°, sand and silt filling, slightly rough, moderately thin aperture.
- @214.6m: joints, inclined at 60°, no filling, slightly rough, moderately open aperture.
- Run 171, REC=100% RQD=50%: increased amount of Fe-Mg minerals, approximately 30%. Closely fractured. Joint, inclined at 45°, sand and silt filling, slightly rough, moderately thin aperture, located at 215.2 m depth.
- @215.5m: joints, inclined at 30-40°, sand and silt filling, slightly rough, moderately thin aperture.
- @216.2m: joints, inclined at 35°, sand and silt filling, slightly rough, moderately thin aperture.
- Run 172, REC=100% RQD=46%: gray-green granodiorite. Joint, inclined at 50°, sand and silt filled, slightly rough, moderately open aperture, located at 216.7 m.
- @216.8m: joint, inclined at 50°, sand and silt filled, slightly rough, moderately thin aperture, located at 216.9 m.
- @217.1m: Joint, inclined at 45°, sand and silt filled, slightly rough, moderately thin aperture, located at 217.1 m.
- Run 173, REC=100% RQD=19%: closely to intensely fractured, clay and sand filled joints, slightly rough, moderately thin aperture.
- Run 174, REC=63% RQD=17%: @219.5m: crushed to intensely fractured below 219.5 m. Clay seam at 219.6 m depth.
- @220.1m: joints, inclined at 35°, no filling, slightly rough, moderately open aperture.
- Run 175, REC=100% RQD=47%: @220.4m: joints, inclined at 45-60°, no filling, slightly rough, moderately open aperture.
- @221m: sand and silt filled joints.
- Run 176, REC=100% RQD=0%: QUARTZ DIORITE, gray-green to white, slightly weathered, moderately hard, chlorite stained, intensely fractured.
- @221.6m: joints, inclined at 25-55°, sand and silt filling, slightly rough, moderately thin filling.
- fresh to slightly weathered, intensely to closely fractured.
- Run 177, REC=100% RQD=23%: @222.9m: joints, inclined at 50-70°, no filling, smooth to slightly rough, occasional slickensides.
- slightly fractured. Post-logged, therefore RQD may be underestimated because of fractures due to handling of core. Abundant chlorite, rock is "powdery", but hard.
- Run 178, REC=98% RQD=61%: @224.1m: joint, inclined at 40°, no filling, smooth, located at 224.2 m depth.
- @224.4m: joint, inclined at 50°, no filling, smooth, located at 224.5 m depth.
- Run 179, REC=132% RQD=98%: joint, inclined at 50°, no filling, smooth, located at 224.8 m depth.
- GRANODIORITE, light greenish gray, fresh, hard, porphyritic texture, slightly fractured. Post-logged, actual RQD may be higher.
- Run 180, REC=100% RQD=62%: @226.2m: joints inclined at 60-70°, joint surfaces becoming less smooth and slightly rough.
- joints, inclined at 60-70°, no filling, rough. Post-logged, actual RQD may be higher.
- Run 181, REC=100% RQD=62%: @227.4m: fracture zone, 5 cm wide, beginning at 227.7 m depth.
- post-logged, actual RQD may be higher.
- @228.7m: joints, inclined at 30-50°, no filling.
- Run 182, REC=100% RQD=63%: @229.3m: joint inclined at 30°, no filling.
- joints inclined at 40-70°, abundant chlorite and some slickensides on joint surfaces.
- Run 183, REC=100% RQD=55%: @231.1m: fracture zone, 15 cm wide, beginning at 231 m.
- fracture zone, 13 cm wide, beginning at 231.5 m. Post-logged, actual RQD may be higher.
- @231.7m: slightly fractured to intact, good quality rock.
- Run 184, REC=100% RQD=78%: @232m: joint, inclined at 60°, no filling, located at 232.1 m depth.
- @232.3m: joint, inclined at 50°, no filling, located at 232.5 m depth.
- @232.6m: joint, inclined at 50°, no filling, located at 232.7 m depth.
- quartz/plagioclase minerals up to 1 cm. Good quality rock. Post-logged, actual RQD may be higher.
- @233.2m: fracture zone, 5 cm wide, beginning at 233.4 m.
- Run 185, REC=100% RQD=65%: @233.5m: joints, inclined at 40-70°, no filling, moderately open aperture.
- @234.1m: joint, inclined at 50°, no filling, moderately open aperture.
- very good quality rock, post-logged, actual RQD may be higher.
- @234.8m: aphanitic section inclined at 40° (looks like sedimentary rock inclusion), green, may be small fault because of mineral alignment around indicate dragging.
- Run 186, REC=100% RQD=73%: @235.1m: joint inclined at 60°, no filling, moderately open aperture.
- @235.7m: joint inclined at 60°, no filling, moderately open aperture.
- salt and pepper texture, abundant chlorite. Post-logged, actual RQD may be higher.

Boring 02-5 Continued on LOTB Sheet of

VERTICAL SCALE 1 : 50

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

The State of California or its officers or agents shall not be responsible for the completeness or accuracy of electronic copies of this plan sheet.

Caltrans Metric

DESIGN OVERSIGHT	KEYHAN MOGHBEL
SIGNOFF DATE	

DESIGN	BY S. VARATHARAJ	11/20/02	J. CASTLE, M. HACHEY, B. SCHELL & S. SICILLIANO — FIELD INVESTIGATOR(S)/TITLE	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION
CHECKED	BY S. SICILIANO	2/6/03	DATE 9/12/02 to 9/25/02	

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.

KILOMETER POST

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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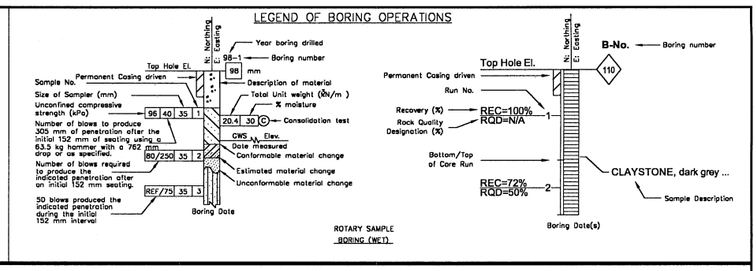
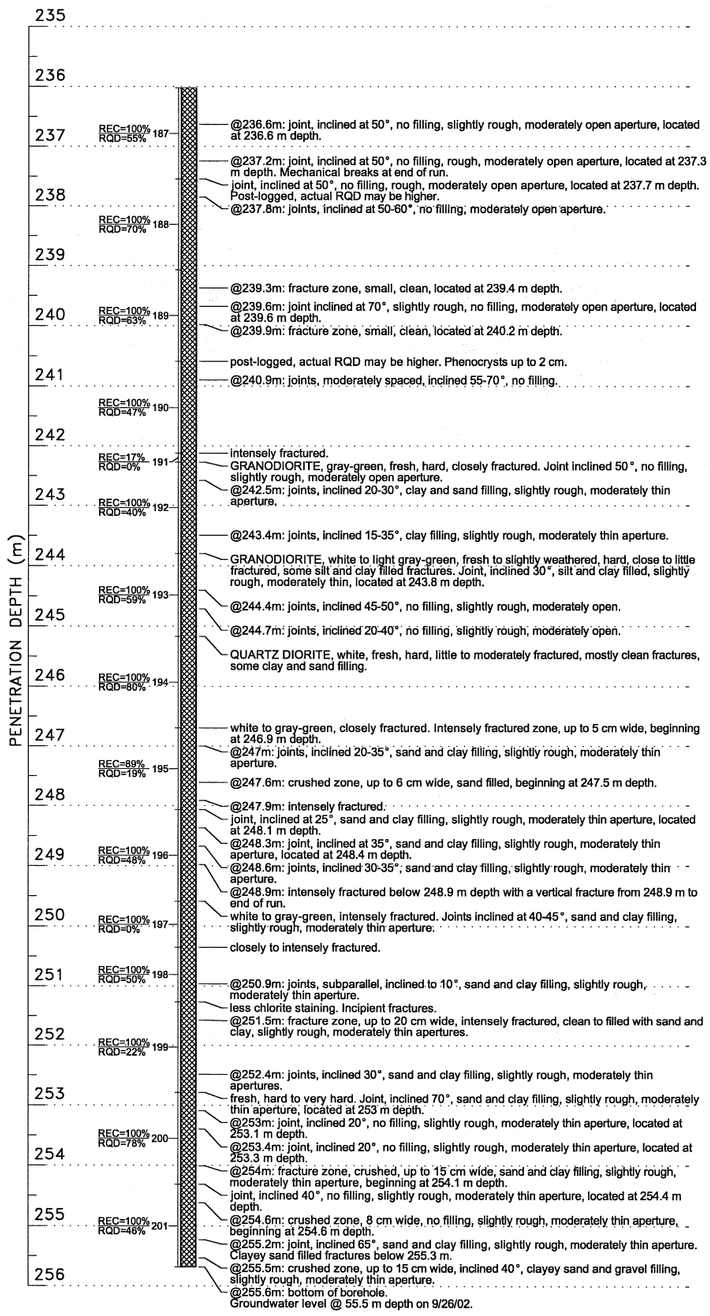


Boring 02-5 Continued from LOTB Sheet of



9/12/02 to 9/25/02

VERTICAL SCALE
1 : 50

Caltrans Metric

DESIGN OVERSIGHT: KEYHAN MOGHBEL
STIGNEFF DATE:

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/6/03
DRAWN BY J. CASTLE, M. HACHEY, B. SCHELL & S. SICILIANO
DATE FIELD INVESTIGATOR(S)/TITLE 9/12/02 to 9/25/02

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE No.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave. Suite 200
Santa Ana, California 92707

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★
DOUGLAS HAMILTON
NO. CEG 31
EXP. 7/31/04

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DESIGN OVERSIGHT
KEYHAN MOGHBEL
SIGNOFF DATE

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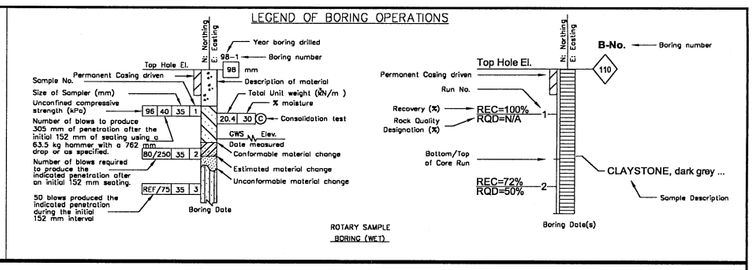

N: 621,719.8
E: 1,822,283.7

02-6

El. +223.8 m

63 S66°E, 15° Inclination

SILTSTONE: yellowish brown, decomposed, very soft, silt filling.

REC=100% RQD=0%

SILTSTONE/CLAYSTONE: yellow-brown to dark gray, moderately to intensely weathered, soft to very soft, intensely fractured at top to 3 fractures per 30cm.
@1.1m: joint with 30° inclination to the core axis.
@1.2m: bedding with 50° inclination to the core axis, no fractures.

REC=92% RQD=27%

@1.5m: joint with 75° inclination to the core axis, 1 fracture per 30cm.
@1.8m: joint with 75° inclination to the core axis.
@1.9m: 3.8 cm thick joint with clay filling, 1 fracture per 30cm.

REC=100% RQD=0%

bedding with 80° inclination to the core axis, fractures along bedding.

REC=100% RQD=0%

very soft.
@2.8m: bedding with 85° inclination to the core axis.
@2.9m: intensely weathered clay.

REC=94% RQD=33%

@3m: SILTSTONE: soft, moderately weathered, moderately soft.
@3.2m: bedding with 85° inclination to the core axis.
@3.4m: bedding with 85° inclination to the core axis.
@3.6m: 7.6cm thick fracture zone with clay filling, joint with 20° inclination to the core axis.
@3.7m: soft, with 2mm thick aperture.

REC=83% RQD=0%

intensely weathered, very soft.
@4.1m: SILTSTONE: dark gray to tan yellow, moderately weathered, moderately soft, with bedding.
@4.3m: disaggregated SILTSTONE with clay filling, intensely weathered.

REC=89% RQD=0%

@4.6m: fault with 90° inclination.
disaggregated SILTSTONE with clay filling, intensely weathered.
@4.8m: SILTSTONE: dark gray, moderately weathered, partially fractured, fault with 85° inclination.
@5m: yellow-brown broken fragments, intensely weathered, in clay matrix.
@5.3m: SILTSTONE: gray, moderately hard, bedding with 85° inclination.
@5.3m: fractured zone.

REC=94% RQD=29%

@5.6m: SILTSTONE: gray, moderately hard, bedding with 85° inclination.
@5.8m: fault with 55° inclination.
@5.9m: yellow-brown broken fragments, intensely weathered, in clay matrix.
SILTSTONE: dark gray, moderately weathered, partially fractured, joints with 40, 85° inclination.
@6.3m: bedding with 85° inclination.

REC=100% RQD=28%

@6.9m: joint with 60° inclination , slightly rough to smooth.
slightly weathered, moderately hard, clay filling.
@7.3m: joint with 55° inclination , smooth.
@7.4m: bedding with 85° inclination , smooth.

REC=95% RQD=52%

@7.6m: bedding with 80° inclination , smooth.
moderately soft to moderately hard.
@8.2m: slightly weathered, fault with 55° inclination.
@8.3m: bedding with 85° inclination.
@8.4m: yellow-brown broken SILTSTONE with clay filling.

REC=100% RQD=47%

@8.7m: gray fractured SILTSTONE, bedding 85° inclination , slightly rough.
@8.8m: gray broken SILTSTONE, moderately weathered, clay filling.
@9.1m: joint with 85° inclination , smooth.
@9.3m: slightly weathered, partially fractured, 3 mm aperture.

REC=93% RQD=60%

@10m: moderately weathered, joints with 55, 10° inclination , slightly rough, clay filling.
gray broken SILTSTONE, moderately weathered, moderately rough, joint with 10° inclination.
@10.3m: SILTSTONE: gray, disaggregated in clay matrix, very soft.

REC=61% RQD=0%

@11.1m: SILTSTONE: gray, moderately weathered, moderately fractured, moderately soft, joint w/ 70° inclination.
@11.3m: bedding with 85° inclination.

REC=93% RQD=17%

@11.4m: joint with 70° inclination.
@11.6m: joint with 50° inclination.
@11.7m: SILTSTONE: gray, disaggregated in clay matrix, moderately soft.
@11.8m: cross fracture yet intact.
@11.9m: 55° joint, clay filling.

REC=100% RQD=13%

@12m: SILTSTONE, intensely fractured with inter beds of v.fine grained tan SANDSTONE, bedding with 75° inclination.
@12.2m: joint with 50° inclination.
@12.3m: SILTSTONE, gray, intensely weathered, disaggregated in clay matrix.
@12.7m: moderately weathered, bedding with 80° inclination , slightly rough.

REC=83% RQD=0%

@12.8m: SILTSTONE, gray, intensely fractured with clay filling joint and with 90° inclination
moderately soft.
@13.2m: bedding with 80° inclination.
@13.3m: joint with 60° inclination.
@13.4m: joint with 30° inclination , slightly rough, 2 to 6 mm thick calcite filling.

REC=83% RQD=0%

@13.6m: joint with 55° inclination , clay filling.
@13.7m: joint with 55° inclination , calcite filling.
@14.2m: joint with 20° inclination , calcite filling.
@14.3m: joint with 20° inclination , slightly rough, calcite, Clay filling.
@14.4m: SILTSTONE, gray, intensely weathered, disaggregated with calcite in clay matrix.

REC=92% RQD=17%

@14.9m: SILTSTONE: gray, calcite in fractures, joint with 55° inclination.

REC=67% RQD=0%

@15.1m: bedding with 85° inclination , smooth, calcite filling.
intensely weathered, angular/subangular SILTSTONE in clay matrix.
@15.7m: CLAY: very soft, dark gray, calcite veins up to 6 mm thick, some disaggregate siltstone, bedding with 85° inclination.

REC=67% RQD=0%

@15.9m: disaggregate siltstone/v.fine light gray sandstone, bedding with 85° incl.
clay filling.
@16.3m: joint with 75° inclination , calcite, clay filling in fractures.

REC=108% RQD=29%

@16.6m: moderately soft, joint with 30° inclination , calcite filling.
frag. of siltstone, moderately hard, calcite, clay filling.
@17.1m: joint with 50° inclination , calcite filling.

REC=72% RQD=0%

@17.3m: disaggregate siltstone in clay matrix, 3 to 6 mm thick calcite filling.
@17.5m: SILT/SANDSTONE: gray, joint with 75° inclination , calcite filling in fractures parallel and normal to bedding.
SILTSTONE, dark gray w/ interbeds of fine grained SANDSTONE, intensely fractured , moderately soft.

REC=87% RQD=0%

@18m: SANDSTONE: light gray, med. grained, moderately hard, bedding wit 75° inclination , calcite, clay filling.
@18.3m: SANDSTONE: coarse grained.
moderately Hard, joint w/ 30° inclination , clay filling.

REC=94% RQD=0%

@18.6m: SAND/CLAY GOUGE: gray to yellow-brown, intensely weathered,.
@18.8m: SANDSTONE: light gray, med. grained, oxidized surfaces, joint with 30° inclination.
moderately hard.

REC=113% RQD=0%

@19.2m: disaggregated SANDSTONE in clay matrix.
@19.3m: joint with 55° inclination.
moderately rough.

REC=88% RQD=0%

@19.8m: poorly sorted, coarse grained, angular sandstone, orange brown fracture surface.

REC=56% RQD=0%

@20.2m: SANDSTONE: light gray, fine grained, moderately weathered, moderately hard, joint with 70° inclination , slightly rough, calcite veins, oxidized surface.
@20.7m: slightly weathered.

REC=52% RQD=0%

@21m: bedding with 30° inclination.

REC=94% RQD=0%

@21.8m: joint with 30° inclination , slightly rough.
moderately hard to hard.

REC=100% RQD=50%

@22.4m: joint with 50° inclination , calcite filling.
hard, calcite veins up to 3mm thick.

REC=100% RQD=93%

@23.2m: moderately spaced joint, rough.
@23.5m: SANDSTONE: light gray, brecciated with angular- sub rounded feldspar and reworked siltstone clasts up to 7.5 cm.
@23.7m: joint with 60° incl..
@23.8m: joint with 60° incl. , calcite, clay filling.
CONGLOMERATIC SANDSTONE: light gray, 1 to 10 cm subangular clasts of sandstone, siltstone and feldspar.
@24.4m: calcite veins up to 3 mm thick , sub parallel to fractures, joint with 60° inclination , slightly rough.

REC=100% RQD=100%

@24.8m: joint with 55° inclination , slightly rough, calcite, clay filling.
slightly weathered to fresh, hard.
@25.5m: joint with 85° inclination.

REC=100% RQD=80%

@25.9m: step joint, rough.
@26.2m: step joint, rough.
@26.5m: 7.5 cm thick SILTSTONE, dark gray.
slightly weathered, hard, granodiorite clasts up to 6cm diameter.

REC=100% RQD=67%

@27.3m: clay filling.
calcite veins up to 3 mm thick oriented at 60° inclination.

REC=100% RQD=89%

@27.8m: joint with 30° inclination.
joint with 60° inclination.
@28.5m: joint with 50° incl.

REC=100% RQD=48%

@28.7m: joint with 30° incl. , stepped.
@29m: fracture, slightly rough.
CONGLOMERATE: light gray, fresh, moderately hard, bedding slightly rough, with sub-rounded SANDSTONE clasts from1 to 7.5 cm diameter.

REC=100% RQD=17%

hard to moderately hard, joint with 60° inclination , slightly rough.

PENETRATION DEPTH (m)

Boring 02-6 Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/10/03
DATE
J.CASTLE, B.SCHELL, S.VARATHARAJ, S.SICILIANO
FIELD INVESTIGATOR(S)/TITLE
8/6/02-8/13/02

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

Caltrans Metric

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

The State of California or its officers or agents shall not be responsible for the completeness or accuracy of electronic copies of this plan sheet.

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HOWARD HAMILTON No. EG535 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

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04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

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Caltrans Metric

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

$2\frac{1}{4}$" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Conformable material change; Estimated material change; Unconformable material change; Sample No.; Permanent Casing driven; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Top Hole El.; N: Northing; E: Easting; Boring Date; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

Boring 02-6 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

30
- Run 38: REC=100% RQD=0%
- @30.4m: yellow-brown oxidation on fracture surfaces.
- @30.5m: set of perpendicular joints, clay filling.

31
- Run 39: REC=100% RQD=83%
- 10 cm thick SANDSTONE, light gray, med. to coarse grained, slightly weathered, moderately hard to hard, bedding with 70° inclination , slightly rough, closely spaced fractures.
- Run 40: REC=100% RQD=56%
- slightly weathered to fresh, moderately hard
- @31.7m: joint with 70° inclination , slightly rough.

32
- @32m: joint with 30° inclination , slightly rough.
- Run 41: REC=100% RQD=87%
- @32.3m: joint with 60° inclination , slightly rough.
- @32.6m: SANDSTONE: light gray, coarse grained matrix, 1 to 5 cm clasts, joint with 60° inclination , slightly rough.

33
- hard, occasional sandstone/siltstone clasts up to 2.5 cm diameter.
- @33.2m: bedding with 85° inclination , slightly rough.
- Run 42: REC=98% RQD=98%
- @33.5m: joint with 70° inclination , moderately rough.

34
- @33.8m: bedding with 85° inclination , slightly rough, closely spaced fractured.
- @34.1m: random fracture with 85° inclination.
- @34.1m: bedding with 85° inclination , rough, calcite veins up to 3 mm thick.
- incipient joint with 10° inclination.
- @34.6m: joint with 30° inclination , rough.
- @34.6m: joint with 90° inclination , moderately rough.

35
- Run 43: REC=100% RQD=81%
- @34.9m: bedding with 85° inclination , moderately rough.
- @35.1m: bedding with 85° inclination.
- CONGLOMERATIC SANDSTONE: light gray, sub rounded clasts of partially weathered sandstone and granodiorite from 5 to 10 cm diameter, coarse grained matrix, slightly weathered to fresh, hard.
- @35.7m: moderately spaced, joint with 70° inclination , slightly rough.
- @35.8m: fine to med grained matrix, calcite veins up to 2mm thick.

36
- Run 44: REC=100% RQD=87%
- @36m: joint with 50° inclination , slightly rough.
- @36.1m: joint with 30° inclination , smooth, clay filling.
- joint with 70° inclination , slightly rough.
- @36.7m: joint with 20° inclination , slightly rough.
- @36.8m: single GRANODIORITE boulder, bedding with 85° inclination.

37
- Run 45: REC=100% RQD=78%
- @37.3m: joint with 70° inclination , slightly rough.

38
- @37.9m: joint with 60° inclination , slightly rough.
- @38m: incipient fracture with 30° inclination.
- Run 46: REC=0% RQD=N/A
- @38.4m: joint with 55° inclination , slightly rough.
- @38.5m: joint with 70° inclination , slightly rough.
- @38.8m: bedding, GRANODIORITE boulder.

39
- fracture zone with composite of mech. breaks, joints, bedding with general trent of 70 and 10° inclination , fractures cut across and around clasts, some filled with calcite up to 3 mm thick.

40
- Run 47: REC=100% RQD=0%
- joint with 85° inclination , slightly rough.

41
- Run 48: REC=96% RQD=54%
- @41.3m: incipient joint with 60° inclination.
- @41.5m: brecciated fracture zone 6 to 12 mm width, clasts filled with clay and calcite, brecciate platy.
- @41.8m: calcite veins up to 6 mm thick.

42
- @42.1m: joint with 75° inclination, slightly rough.
- @42.4m: GRANODIORITE BOULDER.
- Run 49: REC=97% RQD=43%
- @42.7m: foliation, slightly rough, clay filling, poorly developed slickensides oriented at 36° inclination rake.
- (PA) @42.7m

43
- @43.1m: med. to coarse grained SANDSTONE, calcite vein of 3mm thick and 20 cm long parallel to core axis.

44
- Run 50: REC=114% RQD=71%
- @44.1m: joint with 30° inclination, slightly rough, oxidized orange-brown surface.
- @44.4m: joint with 60° inclination, slightly rough, oxidized orange-brown surface.
- 3 mm thick calcite veins at 30° inclination.

45
- @44.9m: joint with 85° inclination, slightly rough.
- Run 51: REC=100% RQD=60%
- @45.7m: joint with clay filling, moderately lithified, slightly rough.

46
- thin layer of very soft clay and sand gouge.
- @46.2m: joint with 60° inclination, slightly rough.
- Run 52: REC=100% RQD=100%
- @46.3m: joint with 90° inclination.
- oxidation on fracture surfaces, calcite filled.

47
- @47.3m: calcite vein at 10° inclination.
- Run 53: REC=100% RQD=67%

48
- @47.7m: joint with 60° inclination, slightly rough.
- @48m: joint with 70° inclination, slightly rough.
- @48.6m: joint with 30° inclination, slightly rough.

49
- @48.9m: mechanical break at 90° inclination.
- Run 54: REC=90% RQD=80%
- @49.5m: clay, calcite vein at 40° inclination.

50
- @50.2m: mechanical break at 90° inclination at 50.1m, 50.4m, 50.6m , 50.7m depths.
- Run 55: REC=100% RQD=83%

51
- @50.9m: joint with 30° inclination, slightly rough, clay filling, oxidized surface.
- @51.1m: joint with 30° inclination, slightly rough, clay filling, oxidized surface.
- CONGLOMERATE: lt. gray (N7) to (N6) with white to black clasts predom. 1 to 2 cm size max. size 3 cm, well-rounded to subangular, clasts are mix of sandstone and igneous coarse sand matrix, fresh except for oxidation along some joints

52
- @51.8m: joints with 80°, 30°, 65°, 90° inclination.
- Run 56: REC=100% RQD=74%
- @52.4m: very hard, iron oxide, manganese.
- @52.6m: incipient joint at 50 to 15° inclination.

53
- fresh, mechanical break, stepped surface.
- Run 57: REC=83% RQD=83%
- gray clasts with max size 4 cm, 5% white (quartz diorite) , 10% black rock contains oxide, manganese oxide, sand matrix include quartz, feldspar and graywake rock fragments, med to coarse grained, 50-70% sand
- Run 58: REC=100% RQD=56%
- @53.4m: joints with 10° inclination at 53.5 m depth, thin clay film and discontinuous, hairline calcite veins.

54
- @53.7m: joints with 60, 45° inclination stepped, iron oxide, calcite.
- larger clasts 6-7 cm range, closely spaced joints with clay, iron oxide filling, rough to stepped.
- Run 59: REC=100% RQD=21%
- @54.3m: closely spaced fractures.
- fresh, hard, joint with 40° inclination, stepped, open aperture.

55
- @54.8m: CONGLOMERATIC SANDSTONE gradually turning to SANDSTONE - fine to coarse grained, with contact angle of 45° inclination.
- Run 60: REC=100% RQD=69%
- @55m: calcite healed joints at 40° inclination, closed aperture.
- @55.2m: fresh rock, joint with 70° inclination, closely spaced, stepped, open aperture, iron oxide on surface.
- @55.3m: 4 cm angular siltstone fragment.
- SANDSTONE with siltstone/claystone interbeds, very closely spaced fractures.

56
- Run 61: REC=100% RQD=17%
- @55.9m: fracture zone - 6 cm thick black siltstone/claystone small fragments.
- @56m: fracture zone.
- fine grained SANDSTONE, calcite veins, closely spaced fractures, joint with 85° inclination.
- Run 62: REC=100% RQD=0%
- @56.4m: fracture zone - 6 cm thick black siltstone/claystone small fragments.
- joint with 50° inclination, stepped, calcite filling.
- @56.7m: joint with 45° inclination, stepped, calcite filling.

57
- @57m: closely spaced fractures.
- Run 63: REC=100% RQD=45%
- @57.3m: moderately spaced fractures.
- @57.5m: joint with 30° inclination, stepped, calcite filling.
- @57.6m: joint with 30° inclination, stepped, calcite filling.

58
- very hard.
- Run 64: REC=100% RQD=30%
- @58.5m: 1 cm thick siltstone/mudstone layer.

59
- @59.1m: 10 cm thick siltstone/claystone layer.
- Run 65: REC=100% RQD=14%
- @59.5m: 0.3 m fracture zone, yellowish gray.
- slightly weathered, very hard, very closely spaced fracture.

60

Boring 02-6 Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

DESIGN OVERSIGHT	KEYHAN MOGHBEL
SIGNOFF DATE	

DESIGN	BY S. VARATHARAJ	11/20/02	J. CASTLE, B. SCHELL, S. VARATHARAJ, S. SICILIANO — FIELD INVESTIGATOR(S)/TITLE
CHECKED	BY S. SICILIANO	2/10/03	DATE 8/6/02-8/13/02

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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		> 31	Hard

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- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

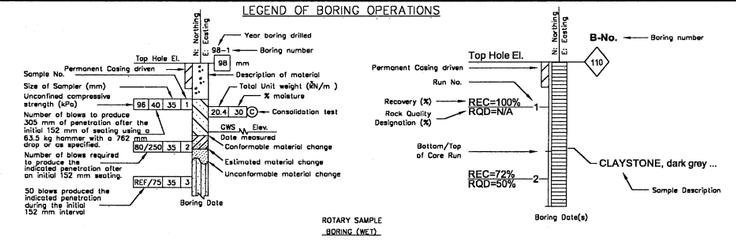
TYPE OF BORINGS

- 2¼" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-6 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

60
- REC=100% RQD=0% — 66
- calcite, iron oxide minerals, closely spaced fracture.

61
- REC=100% RQD=61% — 67
- @61.3m: very closely spaced fracture.
- extremely hard, joints with iron oxide, clay filling, rough to stepped with 10 to 30° inclination, very closely spaced fracture.

62
- REC=100% RQD=0% — 68
- @61.9m: joint with 30° inclination, closely spaced fracture.
- yellow-brown oxidation on fracture surfaces, thin <1 mm clay film coating, no bedding observed.

63
- REC=100% RQD=10% — 69
- @62.8m: joint with 20° inclination, 10 cm zone with network of incipient joints.
- @63.1m: joints with 75, 25, 15, 40° inclination.
- extremely hard, very closely spaced fracture, oxidation on fracture surface.

64
- REC=100% RQD=0% — 70
- clay film in joints.
- @64.6m: hairline calcite veins, closely spaced fracture.

65
- REC=100% RQD=13% — 71
- @65.5m: closely spaced fracture.

66
- extremely hard, several white calcite veins parallel to each other at 55° inclination, joint with 55° inclination, closely spaced fracture.
- @66.2m: joint with 55° inclination.
- REC=100% RQD=92% — 72
- @66.8m: joint with 50° inclination.

67
- @67.1m: joint with 50° inclination.
- joint with 20, 15° inclination, calcite veins, iron oxide on surfaces.
- @67.7m: joints with 40, 10° inclination.

68
- REC=100% RQD=19% — 73
- @68m: very closely spaced fracture.

69
- REC=100% RQD=75% — 74
- @69.2m: hairline calcite veins.

70
- @69.8m: closely spaced fracture.
- closely spaced fracture.

71
- REC=100% RQD=33% — 75
- @70.4m: hairline calcite veins.
- @70.7m: closely spaced fracture.
- light gray, fine to medium grained sandstone.
- @71.3m: closely spaced fractures.
- @71.6m: closely spaced fractures.

72
- REC=100% RQD=48% — 76
- @72m: extremely hard, 0.4 m fracture zone, mostly mechanical break.
- fresh, extremely hard, rough, calcite veins.

73
- @72.9m: closely spaced fracture.
- @73.2m: closely spaced fracture.
- REC=100% RQD=25% — 77
- @73.5m: closely spaced fracture.
- @73.8m: rough joint surfaces, calcite veins.

74
- fresh, no oxidation, extremely hard, hammer blows rebound without breaking, white calcite veins, closely spaced joints with 50, 25, 35, 90° inclination, no aperture.
- @74.4m: closely spaced joints with 90, 80, 20° inclination.
- @74.7m: closely spaced joints with 90-60, 20° inclination.

75
- REC=100% RQD=62% — 78
- @75.5m: closely spaced joints with 40, 50° inclination.
- bedding with 85° inclination, joints with 35, 60° inclination, hairline calcite veins.

76
- @75.9m: closely spaced joints with 10, 60, 85° inclination.
- @76.2m: joints with 30, 85° inclination.
- REC=100% RQD=72% — 79
- @76.5m: joints with 40° inclination.

77
- @76.8m: joints with 20° inclination.
- thoroughly fractured with 10 and 40° inclination.

PENETRATION DEPTH (m)

77
- REC=100% RQD=0% — 80
- hard to moderately hard, broken incoherent rock with random fractures, clay filling.

78
- REC=67% RQD=0% — 81
- slightly weathered, very hard, no oxidation on fracture surfaces, hairline calcite veins, closely spaced fractures.

79
- @79m: closely spaced joints with 20, 70, 80° inclination, slightly rough.
- @79.3m: joints with 20, 90° inclination, rough.
- REC=100% RQD=38% — 82
- @79.6m: joints with 20, 80° inclination, moderately rough.

80
- @79.9m: mechanical break.
- slightly weathering, hard, joint with 20, 60° inclination, slightly rough.
- @80.5m: incipient fractures.

81
- REC=95% RQD=21% — 83
- @80.8m: closely spaced fractures.
- @81.1m: broken, disaggregated, moderately weathered rock fragments with clay filling.
- calcite veins up to 2mm thick.

82
- @81.9m: very coarse grained SANDSTONE, stepped joints with 20, 60° inclination, calcite veins up to 6mm sub parallel to bedding and crossing bedding.
- REC=100% RQD=80% — 84
- @82.5m: joint with 50° inclination, slightly rough.

83
- feldspar sub rounded siltstone clasts from 6 to12 mm dia, 6mm calcite veins with 90° inclination.
- @83.1m: joint with 90° inclination.

84
- REC=94% RQD=70% — 85
- @83.4m: joints with 30, 20° inclination, slightly rough.
- @83.7m: closely spaced joints with 30, 25, 75° inclination, mod. rough.
- @84m: bedding with 75° inclination, dark gray SILTSTONE layer.
- dark gray SILTSTONE up to 8 cm thick.
- @84.2m: SANDSTONE: light gray, slightly weathered, mod. to very coarse grained, calcite veins up to 3 mm thick, rare clasts of siltstone from 1 to 3 cm diameter, joint with 30° inclination, slightly rough.
- @84.5m: joints with 40, 10° inclination.

85
- REC=100% RQD=33% — 86
- @84.8m: joint with 40° inclination.
- @85.1m: fracture zone of 25 cm thick with clay filling.
- poorly developed calcite veins on fracture surfaces, joints with 60, 10° inclination, slightly rough, calcite, clay filling.
- REC=100% RQD=0% — 87
- @85.7m: joints with 75, 60° inclination.

86
- CONGLOMERATIC SANDSTONE: lt. gray, slightly weathered, moderately hard, very coarse grained with 6 to 12 mm diameter feldspar, sandstone, siltstone sub rounded to subangular clasts, joints with 30° inclination, slightly rough.
- @86.6m: joints with 85, 60 ,0° inclination, moderately rough.

87
- REC=100% RQD=68% — 88
- @86.9m: thin fracture zone.
- (PA) @86.9m
- joints with 80, 20° inclination.

88
- @87.8m: joint with 30° inclination, rough, sub parallel calcite veins at 60° inclination with 2 to 3 mm thick.
- @88.1m: joints with 30, 40° inclination.
- REC=47% RQD=48% — 89
- @88.4m: joints with 40, 20° inclination, clay, calcite filling.
- @88.7m: joint with 30° inclination, clay filling.

89
- SANDSTONE: light gray, slightly weathered, med to very coarse grained, occasional clasts of siltstone from 1 to 3 cm diameter, incipient fracture.
- @89.3m: joints with 60° inclination, clay filling, calcite veins up to 3 mm oriented at 60° inclination.
- @89.6m: joints with 30, 35° inclination, calcite filling.

90
- REC=100% RQD=32% — 90
- @89.9m: massive med to coarse grained sandstone, no clasts, joints with 60, 50° inclination, clay filling, slightly rough.
- @90.2m: fracture zone with joint and mechanical breaks.

Boring 02-6 Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

DESIGN OVERSIGHT
KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/10/03
DATE
J. CASTLE, B. SCHELL, S. VARATHARAJ, S. SICILIANO
FIELD INVESTIGATORS/TITLE
8/6/02-8/13/02

ORIGINAL SCALE IN mm FOR REDUCED PLANS
0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES	PRELIMINARY STAGE ONLY	SHEET	OF

Caltrans Metric

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Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave., Suite 200
Santa Ana, California 92707

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HOLMES HAMILTON NO. CEG 836 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS
(SA) SIEVE ANALYSIS
(W) WASH #200
(CA) CHEMICAL ANALYSIS
(MD) MAXIMUM DRY DENSITY
(C) CONSOLIDATION
(PR) POTENTIAL REACTIVITY
(R) R-VALUE
(DS) DIRECT SHEAR
(PA) PACKER TEST
(PT) PETROGRAPHICS TEST
(PM) PRESSUREMETER TEST
(UC) UNCONFINED COMPRESSION
(TX) TRIAXIAL TEST
(E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Conformable material change; Estimated material change; Unconformable material change; Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Top Hole El.; Permanent Casing driven; Boring Date; ROTARY SAMPLE BORING (WET)

Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run REC=72% RQD=50%; B-No. (110) Boring number; CLAYSTONE, dark grey ... Sample Description; Boring Date(s)

Boring 02-6 Continued from LOTB Sheet of

PENETRATION DEPTH (m) 91 – 107

- slightly weathered, hard.
- 91 — @90.9m: joint with 50° inclination, 15 cm fracture zone, bedding at 85° inclination, moderately rough.
- REC=88% RQD=69% — 91 — @91.2m: joint with 15° inclination, calcite filling.
- @91.5m: joint with 60° inclination, calcite filling.
- 92 — fractures with well developed calcite coatings, slickensides oriented at 55, joint with 5° inclination, moderately rough.
- @92.1m: multi small fractures, two large fractures.
- REC=106% RQD=0% — 92 — @92.4m: joints with 45°, 90°, 30° inclination, rough, clay, calcite filled.
- moderately Healed fractures with calcite filling.
- 93 — @93m: several fractures with calcite veins.
- REC=77% RQD=23% — 93 — @93.3m: 4 cm thick brecciated sandstone in very soft dark gray clay, sand matrix.
- @93.4m: 0.5 m disaggregated sandstone with clay filling.
- 94 — massive bedding, joint with 60°, 20° inclination, calcite filling.
- @94.2m: incipient fractures, partially healed.
- REC=100% RQD=39% — 94 — @94.5m: joints with 60°, 10° inclination, smooth, clay filling, many small fractures.
- 95 — @94.8m: joints with 55°, 20° inclination, many small fractures.
- @95.1m: 15 cm zone of broken and fractured fragments.
- slightly weathered, hard, joints with 70°,85°, 90° inclination, slightly rough.
- @95.6m: joints with 50°, 10°, 80°, 75° inclination, clay, calcite filling.
- 96 — REC=100% RQD=52% — 95 — @95.9m: 2 cm thick dark gray claystone.
- @96.2m: joints with 35°, 70°, 85° inclination, clay filling.
- @96.3m: 2 cm thick clay gouge with angular sandstone breccia up to 6 mm dia.
- moderately hard, mechanical breaks, clay filling, calcite veins up to 3 mm thick.
- @96.6m: joint with 60°, 90° inclination, clay filling.
- 97 — REC=95% RQD=21% — 96 — @97m: 1 cm thick platy brecciated siltstone in clay matrix at 75° inclination.
- @97.3m: joint with 40°, 55° inclination, long incipient fracture.
- @97.4m: 0.15 m broken and fractured rock fragments.
- slightly weathered, hard, fine grained SANDSTONE, joint with 20°, 90° inclination, clay filling.
- 98 — REC=100% RQD=33% — 97 — @97.9m: joints with 85°, 50° ,60° inclination, slightly rough / smooth, calcite filling.
- @98.2m: joint with 50°, 60° inclination, calcite filling.
- @98.3m: angular, brecciated sandstone up to 3 cm diameter in very soft, dark gray clay matrix.
- slightly weathered, hard, lt. gray, sandstone with calcite veins up to 3 mm wide, joints with 50°, 60° inclination, clay filling.
- 99 — REC=117% RQD=71% — 98 — @98.8m: joints with 85, 40° inclination.
- joints with 60° inclination, clay filling, multiple small fractures.
- REC=92% RQD=33% — 99 — @99.4m: joint, stepped joint with 60°, 40° inclination, slightly to mod rough.
- 100 — slightly weathered, moderately hard to hard, joint with 60° inclination, slightly rough, clay filling.
- REC=100% RQD=0% — 100 — @100m: joint with 40° inclination, moderately rough.
- @100.3m: joints with 30° inclination, rough.
- (UC) @100.6m: clasts of siltstone, sandstone and feldspar 5 mm to 20 mm diameter, joints with 50° inclination, moderately rough, clay filling.
- 101 — REC=100% RQD=75% — 101 — @100.9m: sub parallel calcite veins up to 3 mm wide oriented at 60° inclination, joint with 70° inclination, clay filling.
- @101.2m: joint with 80°, 10° inclination, slightly rough.
- CONGLOMERATIC SANDSTONE: lt. gray, slightly weathered, hard, medium grained matrix, granodiorite, sandstone, siltstone sub rounded to subangular clasts, joints with 85, 20° inclination, slightly Rough, iron oxide hairline calcite veins.
- 102 — @101.8m: joint with 20° inclination, clay filling.
- @102.1m: joint with 35° inclination, clay filling.
- REC=100% RQD=55% — 102 — (MD) @102.4m: joint with 60° inclination, moderately rough.
- 103 — @102.7m: calcite vein at 10° inclination.
- @103.4m: joint with 10°, 40° inclination, moderately rough, clay filling.
- REC=86% RQD=45% — 103 — @103.7m: joint with 20°, 35° inclination, slightly rough, calcite filling.
- 104 — joint with 30°, 40° inclination, moderately rough.
- @104.4m: widely spaced joint with 35° inclination, slightly rough.
- 105 — REC=83% RQD=24% — 104 — (UC) @104.7m: thin angular brecciated sandstone up to 3 mm diameter in sandy clay matrix, moderately spaced, joints with 60° inclination, slightly rough, clay filling.
- fresh conglomeratic sandstone, joints with 40, 50, 30° inclination, rough.
- @105.5m: joints with 40, 60° inclination, moderately rough.
- 106 — REC=96% RQD=N/A — 105 — @105.8m: joints with 60° inclination, moderately rough, smaller clasts size avg. <1 cm.
- @106.1m: joint with 45°, 55° inclination, calcite, clay filling.
- @106.4m: light gray, fine grained, SANDSTONE, randomly oriented calcite veins up to 3 mm thick.
- (UC) @106.6m: massive bedding, closely spaced thin platy brecciated sandstone/siltstone in clay matrix oriented at 60°, 65°, 40° inclination.
- 107 — REC=100% RQD=19% — 106 — @107m: joint with 40° inclination, calcite filling.
- @107.3m: 0.15 m thick soft, angular to sub angular brecciated sandstone up to 2.5 cm diameter in sandy clay matrix.
- medium grained, massive bedding, partially healed very thin joints with 30 , 50° inclination.

PENETRATION DEPTH (m) 108 – 121

- 108 — @107.8m: intensely weathered sandstone, thin dark gray / black clay layer oriented at 40° inclination.
- REC=100% RQD=47% — 107 — (E) @108.1m
- (UC) @108.4m: joint with 40° inclination.
- @108.7m: joint with 40° inclination.
- 109 — moderately spaced joints with 45°, 10°, 60° inclination, smooth, calcite filling.
- REC=100% RQD=0% — 108 — @109.3m: moderately spaced joints with 60°, 45°, 75°, 40° inclination, slightly rough, calcite, clay filling.
- 110 — @109.8m: fractured zone.
- closely spaced joints with 60° inclination, 75° inclination, smooth.
- REC=100% RQD=0% — 109 — @110.2m: moderately spaced joints with 85°, 60°, 70°, 45° inclination, smooth, clay, calcite filling, moderately healed hairline fracture at 110.6 m.
- 111 — slightly to moderately weathered, completely fractured with surfaces calcite coated, small amount of clay filling, slightly to mod rough surface.
- REC=100% RQD=0% — 110
- fractured zone, slightly rough, calcite, clay filling, fractures are oriented generally 70° inclination and 10° inclination.
- 112 — REC=67% RQD=0% — 111
- lt. gray, medium grained, sandstone, few very thin calcite veins, closely spaced joints with 75°, 20°, 45°, 40° inclination, moderately rough, small siltstone inclusions up to 3 mm diameter.
- @112.3m: closely spaced joints with 60° inclination, 50° inclination, calcite filling.
- REC=100% RQD=24% — 112 — @112.7m: moderately spaced joints with 40°, 30° inclination, slightly rough, calcite filling.
- 113 — @113m: very closely spaced mechanical breaks.
- closely spaced joints 60°, 15°, 40°, 30° inclination, slightly rough, sub parallel moderately thin calcite veins oriented at 20° inclination.
- @113.4m: closely spaced joints 70°, 60° inclination, slightly rough.
- 114 — REC=100% RQD=21% — 113 — @113.7m: moderately spaced joints with 15°, 45° inclination, moderately thin clay filling.
- @114m: moderately spaced joints with 20° inclination, clay filling.
- slightly to moderately weathered, hard, fine grained sandstone, moderately spaced joints with 40, 60, 50° inclination, calcite filling.
- 115 — @114.6m: moderately spaced joints with 25°, 30°, 45° inclination, moderately rough, calcite filling.
- REC=100% RQD=58% — 114 — @115.2m: very closely spaced, slightly open fractures, clay, calcite filling.
- (UC) @115.5m: medium to fine grained sandstone, moderately thin calcite veins, sub rounded, rounded clasts of siltstone, sandstone, quartz diorite up to 1 cm diameter.
- 116 — hard to very hard, moderately spaced joints with 60°, 40°, 20° inclination, slightly rough, clay filling.
- REC=100% RQD=11% — 115 — @116.2m: moderately spaced joints with 40° inclination, slightly rough, zone of partially healed very thin fractures generally oriented at 20° inclination.
- @116.5m: moderately spaced joints with 60° inclination, slightly rough, clay filling.
- 117 — moderately spaced joints with 40° inclination, clay, orange brown very minor iron oxide filling.
- @117.1m: moderately spaced joints with 40°, 30° inclination.
- REC=100% RQD=80% — 116 — @117.4m: moderately spaced joints with 30° inclination.
- (UC) @117.7m: moderately spaced joints with 75° inclination.
- 118 — @118m: moderately spaced joints with 60°, 40° inclination, thin well developed calcite layer oriented at 10° inclination.
- widely spaced joint with 45°, 30° inclination, calcite filling, moderately thin calcite veins oriented between 30° inclination and 60° inclination.
- (UC) @118.4m
- 119 — REC=100% RQD=92% — 117 — @118.9m: moderately spaced joints with 50°, 35° inclination, clay, calcite filling.
- @119.2m: widely spaced joint with 50° inclination, calcite filling.
- (E) @119.4m
- 120 — very hard, widely spaced joint, moderately thin calcite veins oriented between 30° inclination and 60° inclination.
- REC=78% RQD=50% — 118 — @120.6m: dark gray siltstone, bedding oriented at 75° inclination.
- 121 — @120.8m: moderately thick black sandy clay gouge.
- @120.9m: dark gray siltstone.

Boring 02-6 Continued on LOTB Sheet of

VERTICAL SCALE 1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST — (Stamp: CERTIFIED ENGINEERING GEOLOGIST, DOUGLAS HOLMES HAMILTON, NO. CEG 31, EXP. 7/31/04, STATE OF CALIFORNIA)

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
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Caltrans Metric

DESIGN OVERSIGHT KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/10/03

J. CASTLE, B. SCHELL, S. VARATHARAJ, S. SICILIANO — FIELD INVESTIGATOR(S)/TITLE
DATE 8/6/02-8/13/02

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
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11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

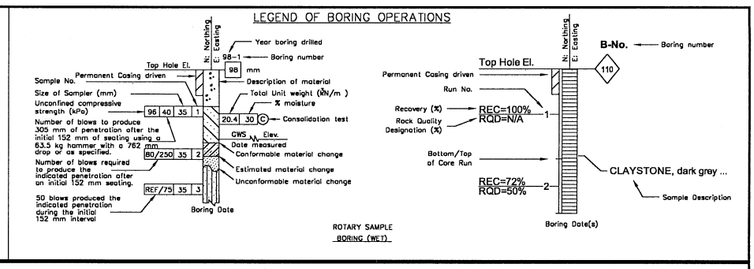
TYPE OF BORINGS

- 2½" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

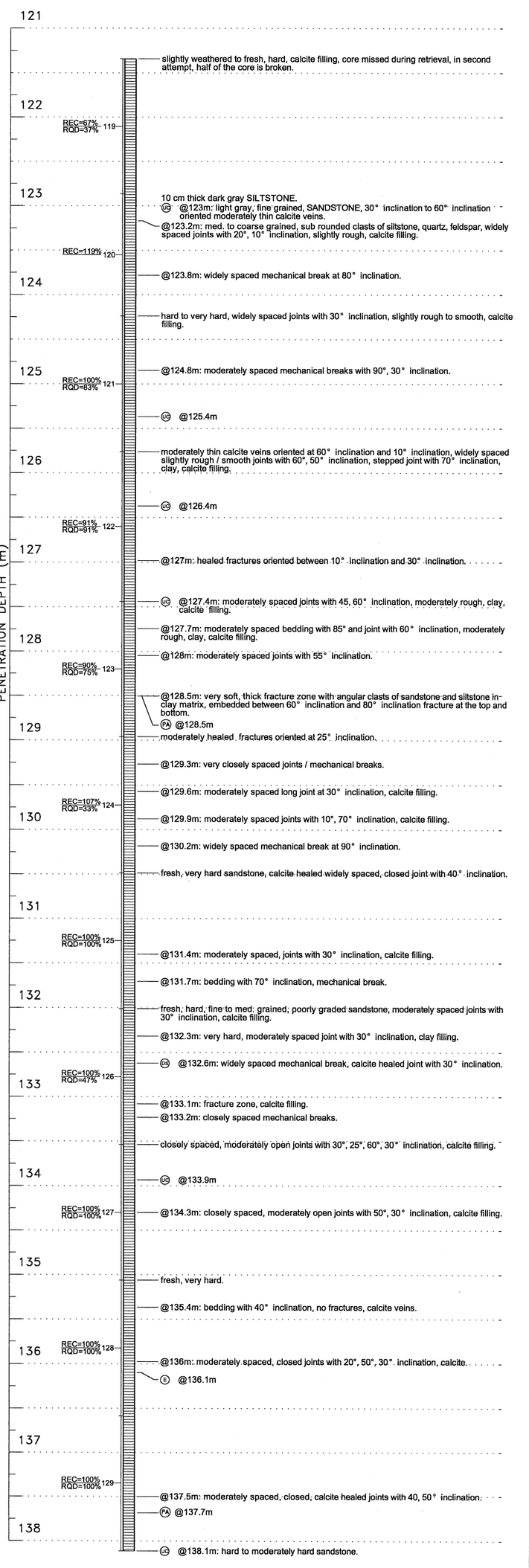
IN-SITU, LAB & FIELD TEST DESIGNATIONS

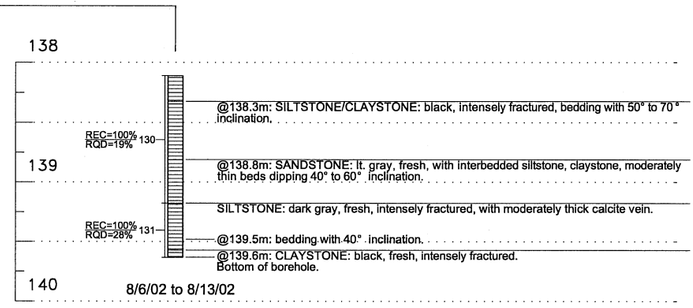
- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-6 Continued from LOTB Sheet of





VERTICAL SCALE
1 : 25

DESIGN BY S. VARATHARAJ 11/20/02
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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET OF

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PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

DOUGLAS HOLMES-HAMILTON
NO. CEG 831
EXP. 7/31/04
STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

TYPE OF BORINGS

- 2¼" CONE PENETRATION
- ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- AUGER BORING (DRY)
- TEST PIT
- DIAMOND CORE BORING
- SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Top Hole El.; N: Northing; E: Easting; Permanent Casing driven; Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Description of material; Total unit weight (kN/m³); % moisture; Consolidation test; Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; GWS Elev.; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date

ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%); Rock Quality Designation (%); REC=100% RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ...; Sample Description; Boring Date(s)

Boring 02-6A

E: 1,822,293.7 N: 621,719.8

El. +223.8 m — N43.5E, 47° Inclination

PENETRATION DEPTH (m)

Core runs

Run	REC	RQD
1	25%	14%
2	32%	0%
3	42%	0%
4	97%	17%
5	183%	0%
6	100%	0%
7	73%	0%
8	79%	0%
9	96%	9%
10	104%	0%
11	106%	0%
12	73%	0%
13	57%	0%
14	83%	0%
15	83%	0%
16	50%	0%
17	200%	0%
18	83%	14%
19	100%	58%
20	0%	N/A
21	0%	N/A
22	92%	0%
23	80%	13%
24	23%	0%
25	70%	0%
26	100%	0%
27	71%	0%
28	88%	0%
29	78%	0%
30	87%	0%
31	63%	0%
32	83%	19%
33	100%	38%
34	93%	0%
35	46%	9%
36	70%	0%
37	63%	29%
38	75%	0%
39	50%	0%
40	122%	50%
41	58%	21%
42	100%	0%
43	100%	0%
44	100%	0%
45	100%	17%
46	100%	0%
47	100%	0%
48	100%	0%
49	100%	0%
50	100%	17%
51	67%	0%
52	0%	0%
53	40%	0%
54	100%	0%
55	100%	0%
56	100%	0%
57	100%	0%
58	75%	10%
59	100%	0%
60	100%	0%
61	100%	28%
62	100%	0%
63	94%	48%
64	100%	43%
65	64%	0%
66	100%	0%
67	100%	50%
68	96%	48%
69	100%	46%
70	68%	0%
71	111%	89%
72	100%	100%
73	83%	17%
74	93%	23%
75	103%	77%
76	100%	33%
77	90%	0%
78	123%	43%
79	100%	0%

Description (0 – 34 m)

- SILTSTONE, dark gray, moderately to intensely weathered, moderately soft, oxidized surfaces, thin bedding inclined at 40°.
- closely spaced mechanical fractures.
- @1m: completely broken core, all surfaces weathered, oxidized.
- intensely weathered.
- soft to very soft, fracture zone.
- @3.2m: closely spaced joints declined at 50°, 30°, 45°, clay filling.
- @3.7m: CLAY, very soft to stiff, brown-orange.
- SILTSTONE, dark gray, soft, weathered, oxidized, joint inclined to 50°.
- @4m: CLAY, very soft to stiff, brown-orange.
- @4.4m: SILTSTONE, dark gray, weathered, oxidized, closely joint inclined to 20°, 35°, 45°, 25°.
- @4.7m: disaggregated siltstone in clay matrix, very soft.
- moderately soft, decomposed/intensely weathered.
- @5.3m: CLAY/decomposed SILTSTONE, very soft, brown-orange.
- @6.3m: SILTSTONE/CLAYSTONE, brown/gray to orange-brown, intensely weathered to decomposed, moderately soft to soft, closely spaced joints inclined at 45°, 60°, 45° with clay filling.
- @7.2m: moderately spaced joints inclined at 45°, clay filling.
- @7.6m: closely spaced joints inclined at 45°, 90° clay filling.
- moderately soft, moderately weathered, moderately spaced joints inclined at 45°, 40° clay filling.
- @8.8m: intensely weathered.
- 0.3 m thick broken fracture zone, closely spaced joints inclined at 45°, 20°, 30°, with clay filling.
- moderately spaced joint inclined at 55°, smooth, with clay filling.
- @10.1m: CLAY GOUGE, yellow-brown with angular brecciated siltstone up to 3 to 6 mm dia..
- @10.2m: SILTSTONE, dark gray, intensely weathered to orange-brown color.
- @10.4m: moderately spaced joints inclined at 25°, 40°, 25°, 30°, clay filling.
- dusky brown (5 YR 2/2), mod hard, minor thin sandstone and claystone beds, joint, fault inclined at 53°, 50°, slightly rough, clay, iron oxide filling.
- @11.3m: SHEAR ZONE, dark yellowish brown (10 YR 4/2), clayey gravel, 0.15m thick, moderately weathered.
- @11.4m: no recovery.
- moderately hard, moderately spaced joints inclined at 38°, 41°, 81°, mechanical breaks, clay, iron oxide filling.
- moderately weathered.
- @12.5m: thin fracture zone.
- @12.7m: moderately spaced joints inclined at 24°, 36°, 56°, clay, iron oxide filling.
- incipient fracture inclined at 25°, slightly rough.
- joint with iron oxide filling.
- slightly to moderately weathered, moderately opened random fracture with iron oxide on surfaces.
- @13.9m: thin fracture zone.
- moderately spaced, moderately open bedding inclined at 0°, iron oxide on surfaces.
- @14.6m: bedding inclined at 0° with iron oxide filling, tight random fracture.
- no recovery.
- no recovery.
- soft to moderately soft, random fractures, beddings inclined at 20°, 10°, iron oxide and silt filling, slightly rough to rough, tight aperture.
- @16.2m: moderately spaced bedding inclined at 10°.
- soft to moderately soft, moderately weathered, closely spaced random fracture with clay, iron oxide filling, slightly rough to rough, bedding inclined at 20°.
- @16.8m: moderately spaced random fracture, bedding inclined from 10° to 20°.
- random fracture.
- closely spaced, tight, random fractures, slightly rough to rough, silt and iron oxide filling, visible horizontal lamination.
- closely spaced, tight, random fractures inclined at 45°, 60°, 55°, slightly rough to rough, silt and iron oxide filling.
- @19.2m: fracture zone.
- dark to yellowish brown, highly fractured siltstone fragments.
- @19.5m: closely spaced fractures inclined at 30°, 40°, 25°, 40°, 50°, slightly rough to rough, silt and iron oxide filling.
- lt. brown, highly fractured.
- @20.7m: closely spaced, platy fractures inclined at 70°, silt, iron oxide filling.
- lt. brown, highly fractured.
- @21.3m: very closely fractured, weak and platy, silt and iron oxide filling.
- lt. brown, moderately weathered, soft to moderately soft, highly fractured, smooth to rough, iron oxidation, silt filling.
- @22.3m: moderately spaced fractures inclined at 5°, 40°, 20°.
- moderately spaced tight, random fractures inclined at 60°, 80°, silt and iron oxide filling.
- @23.2m: very closely spaced fractures, silt and iron oxide filling.
- closely spaced fractures, silt and iron oxide filling.
- @24.2m: closely spaced fracture inclined at 25°, 30°, 20°, silt and iron oxide filling.
- moderately spaced fracture inclined at 50°, 10°, smooth to rough, silt and iron oxide filling.
- lt. brown, moderately weathered, moderately soft, moderately spaced, tight fractures inclined at 35°, 55°, 30°, smooth to rough, iron oxidation, silt filling.
- moderately spaced, tight, fracture inclined at 15°, 40°, smooth to rough, silt and iron oxide filling.
- moderately spaced, tight, fracture inclined at 40°, 50°, smooth to rough, silt, clay and iron oxide filling.
- moderately weathered, soft to moderately soft, moderately spaced, tight, fracture inclined at 70°, 25°, smooth to rough, silt, clay and iron oxide filling, possible sandstone at bottom.
- SANDSTONE, pale yellowish brown (10yr 6/2), hard, slightly weathered, fine to medium grained, angular to subangular fragments of rock.
- fragments of sandstone.
- SILTY SANDSTONE, medium dark gray (N4), fine grained, angular, moderately hard, moderately spaced joints inclined at 56°, 58°, moderately to slightly rough, iron oxide filling.
- hard, closely spaced joints inclined at 65°, slightly rough.
- @30.1m: joint inclined at 56°, slightly rough.
- moderately weathered, fragments of sandstone, slightly rough, iron oxide filling, joints on unfractured rock inclined at 14°, 31°.
- fragments of sandstone.
- @30.9m: soft shear zone.
- @31m: CLAYSTONE, SANDSTONE, interbedded, moderately hard,.
- @31.1m: SILTSTONE, dark gray (N3), slightly weathered, moderately spaced, bedding joint inclined at 29°, 36°, clay, iron oxide filling.
- SANDSTONE, hard, slightly weathered, closely spaced joints inclined at 31°, 52°, slightly rough, iron oxide filling, bedding joint inclined at 46°, moderately rough, iron oxide filling.
- @31.7m: moderately spaced joint, slightly rough, iron oxide filling.
- medium dark gray (N4), with black claystone laminations, fine grained, silty, hard, slightlyweathered, moderately spaced joints and bedding joint inclined at 68°, 34°, slightly rough, iron oxide filling.
- @32.3m: fracture zone, slightly rough, iron oxide filling.
- very closely spaced joints inclined at 18°, 40°, 26°, slightly rough, iron oxide filling.

Description (34 – 60 m)

- very closely spaced joints, bedding joints inclined at 44°, 66°, 42°, slightly rough, rough, iron oxide, calcite filling.
- very closely fractured, slightly rough, iron oxide filling.
- SHALE, black (N1), crushed.
- SANDSTONE, hard, closely spaced joint inclined at 37°, slightly rough, iron oxide filling, bedding joints inclined at 60, 0°, slightly rough, iron oxide filling.
- @34.5m: moderately spaced joint, fault inclined at 53°, 58°, moderately rough to rough.
- SHEAR ZONE, olive black (5Y2/1), sheared claystone matrix, clayey gravel, 0.15 m thick.
- SANDSTONE, moderately spaced joints inclined at 22°, 34°, slightly rough.
- SHEAR ZONE, sheared clay, soft.
- SANDSTONE, hard, closely spaced fractures.
- SHEAR ZONE, dark gray (N3), dark yellowish brown (10YR 4/2), clayey sand, soft.
- no recovery.
- soft, crushed.
- SILTSTONE, dark gray (N3), hard, fine grained sand, calcite veins, closely spaced joints, slightly rough, iron oxide filling.
- fragments of siltstone, slightly weathered.
- SANDSTONE, medium dark gray (N4), fine grained, silty, fragments of rocks, iron oxide filling.
- fragments of sandstone.
- @38m: thin shear zone.
- @38.1m: fracture zone of sandstone and siltstone.
- closely spaced bedding joints inclined at 31°, 21°, slightly rough, joints inclined at 60°, 52°, moderately rough.
- moderately spaced joints inclined at 70°, 29°, 42°, 24°, 57°, slightly to moderately rough, calcite, iron oxide, clay fillings in some joints.
- @39.5m: fracture zone/ shear zone with clay filling.
- hard, fragments of sandstone.
- CLAYSTONE, black (N1), pyrite on shear surface.
- moderately hard, with siltstone.
- SANDSTONE, medium light gray (N6), fine to coarse grained, angular to subangular, hard, slightly weathered.
- @41.2m: closely spaced bedding joint, joints inclined at 41°, 67°, 43°, 63°, slightly rough, iron oxide filling.
- hard, slightly weathered, moderately spaced joints inclined at 38°, 29°, 37°, slightly rough, iron oxide filling in lower joint.
- light gray (N7), coarse grained, hard, slightly weathered, widely spaced joint inclined at 62°, moderately rough, iron oxide filling.
- @42.4m: widely spaced joint inclined at 15°, rough, iron oxide, clay filling.
- @42.7m: moderately thick shear zone, clay.
- @43m: moderately hard, widely spaced joint inclined at 23°, slightly rough, clay filling.
- @43.6m: hard, slightly weathered, moderately spaced joints inclined at 43°, 24°, moderately rough, iron oxide filling in lower joints.
- CLAYSTONE, black (N1), fragments of rock.
- SANDSTONE, medium light gray (N6), hard, slightly weathered, fine to medium grained, fragments of rock, iron oxide filling.
- moderately spaced joints inclined at 26°, 43°, 47°, 0°, 30°, moderately to slightly rough, iron oxide filling.
- moderately spaced joints inclined at 31°, 63°, 37°, 57°, 30°, moderately to slightly rough, iron oxide filling.
- widely spaced joints inclined at 5°, 43°, 53°, 38°, moderately to slightly rough, iron oxide filling.
- @47.9m: closely spaced joints inclined at 55°, 45°, 25°, slightly rough, iron oxide filling.
- moderately spaced joints inclined at 35°, 38°, 33°, 41°, moderately to slightly rough, iron oxide filling.
- closely spaced joints inclined at 60°, 30°, 45°, slightly rough, clay filling, thin calcite veins, incipient fracture oriented at 30°.
- @49.1m: closely spaced joints/fractures, inclined at 30, 55, 35, 60, 60, 30, 15, 55°, clay filling.
- @49.4m: extensively fractured.
- @49.5m: moderately thick clayey sand, unconsolidated, tan, very coarse grained conglomeratic sandstone.
- CONGLOMERATIC SANDSTONE, gray, very coarse grained, sub rounded to rounded, clasts of sandstone, quartz diorite feldspar, siltstone up to 7 cm dia., mechanical break inclined at 60°, very rough.
- @50.8m: calcite veins.
- @50.9m: extensively fractured zone, fractures both through and around clasts.
- stepped joint inclined at 45° and 40°, rough, clay filling.
- moderately thick angular brecciated quartz diorite in sandy clay matrix.
- @51.8m: joint inclined at 25°, clay/sand filling.
- @52.4m: moderately spaced joints inclined at 15°, 30°, rough to smooth.
- @52.7m: moderately thick angular brecciated quartz diorite in sandy clay matrix.
- SILTSTONE, dark gray, very soft, slightly weathered, bedding/joint, clay filling.
- SANDSTONE, lt. gray, hard, medium to fine grained, extensively veined with calcite.
- SILTSTONE in clay matrix, dark gray, angular brecciated, very soft, smooth, up to 12 mm dia.
- SANDSTONE, lt. gray, medium hard, slightly weathered to orange-brown, very coarse grained, angular to subangular, moderately sorted, calcite veins up to 3 mm wide, widely spaced joint inclined at 80, very rough.
- @54.3m: moderately spaced joints inclined at 70°, 60°, 40°, slightly to very rough, clay filling.
- moderately healed fracture.
- @54.8m: medium grained, moderately spaced joints inclined at 35°, 75°, 50°, moderately rough, incipient fractures.
- @55.2m: very coarse grained, closely spaced joints inclined at 75°, moderately healed fracture.
- @55.5m: medium grained, moderately spaced joints inclined at 45°, 55°, 60°, moderately rough, calcite veins up to 3 mm wide, clay filling.
- SILTSTONE, black, platy brecciated, bedding inclined at 30°.
- SANDSTONE, lt. gray, hard, medium grained, slightly weathered (orange-brown surface), joints, random fractures inclined at 55°, 50°, 35°, 55°, rough, clay filling.
- SILTSTONE, dark gray, very soft, brecciated, grading to very fine grained, lt. gray SANDSTONE, bedding inclined at 40°.
- SANDSTONE, lt. gray, hard, closely spaced joints inclined at 30°, 40°, clay, calcite filling, smooth.
- fine grained, subangular clasts of quartz, siltstone, orange-brown weathered surfaces, moderately spaced joints inclined at 40°, 50°, 75°, 25°.
- @57.5m: very hard, joints inclined at 50°, 20°, 30°, clay, calcite filling.
- moderately hard, moderately weathered, closely spaced joints inclined at 50°, 90°, 70°, rough to slightly rough, clay filling at lower fracture.
- @57.9m: fracture zone.
- @58.2m: closely spaced joints inclined at 30°, 40°, smooth, clay, calcite filling.

Boring 02-6A Continued on LOTB Sheet of

VERTICAL SCALE 1 : 50

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST — CERTIFIED ENGINEERING GEOLOGIST, DOUGLAS HOLMES HAMILTON, NO. CEG 31, EXP. 7/31/04, STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT	KEYHAN MOGHBEL		
SIGNOFF DATE			
DESIGN	BY S. VARATHARAJ	11/20/02	
CHECKED	BY S. SICILIANO	2/10/03	
FIELD INVESTIGATOR(S)/TITLE	J. CASTLE, M. HACHEY, P. FRAME, S. SICILIANO & L. PATZKOWSKI	DATE	8/17/02 to 8/30/02

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER: M. KAPUSKAR

BRIDGE No. — KILOMETER POST

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Conformable material change; Estimated material change; Unconformable material change; Sample No.; Permanent Casing driven; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Boring Date; Top Hole El.; Run No.; Recovery (%); Rock Quality Designation (%); Bottom/Top of Core Run; B-No. — Boring number; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s); REC=100% RQD=N/A; REC=72% RQD=50%

ROTARY SAMPLE BORING (WET)

Boring 02-6A Continued from LOTB Sheet of

PENETRATION DEPTH (m)

- Run 80 (REC=100%, RQD=50%): moderately spaced joints inclined at 60°, 15°, 60°, 35°, slightly rough, calcite, clay filling, subparallel up to 18 mm thick calcite veins oriented at 45° to 60°.
- @59.8m: closely spaced joints inclined at 70°, 60°, calcite, clay filling.
- Run 81 (REC=104%, RQD=96%): very hard, medium to coarse grained, slightly weathered, up to 3 mm thick calcite veins oriented at 30° to 40°, moderately spaced joints inclined at 70°, 30°, smooth, calcite, clay filling.
- @61.1m: SILTSTONE in clay matrix, dark gray.
- @61.3m: SANDSTONE, lt. gray, fine to medium grained, moderately spaced joints inclined at 60°, 65°, 45°, 75°, slightly rough.
- Run 82 (REC=88%, RQD=35%): @61.7m: closely spaced joints inclined at 55°, 50°, 40°, 50°, 60°, moderately rough to rough, calcite filling in few joints.
- very hard, widely spaced joints inclined at 30°, 35°, moderately rough, clay filling.
- Run 83 (REC=105%, RQD=40%): @62.8m: moderately spaced joints inclined at 80°, 60°, 65°, 40°, 60°, 15°, 60°, 20°, smooth to rough, clay, calcite filling.
- hard to moderately hard, moderately spaced joints inclined at 70°, 65°, rough, calcite lens up to 8 cm dia.
- Run 84 (REC=108%, RQD=29%): @64.3m: closely spaced joints inclined at 55°, 45°, 75°, 30°, 90°, moderately rough to rough, calcite, clay filling in few joints.
- moderately spaced joints inclined at 65°, 55°, 50°, moderately rough to rough, clay, calcite filling.
- Run 85 (REC=100%, RQD=52%)
- Run 86 (REC=111%, RQD=0%): hard, coarse grained, poorly sorted, closely spaced joints inclined at 60°, 40°, 80°, slightly rough to smooth, clay filling in few joints.
- very hard, slightly weathered, thin vein of calcite, moderately spaced joints inclined at 40°, 55°, 60°, slightly rough to moderately rough.
- Run 87 (REC=100%, RQD=56%): @67.5m: moderately spaced joints inclined at 30°, 55°, moderately rough to smooth, clay filling.
- @67.6m: thin fault zone with brecciated sandstone in yellow/tan clay matrix.
- Run 88 (REC=117%, RQD=0%): closely spaced joints inclined at 50°, 30°, 40°, 50°, 55°, moderately rough, calcite, clay filling in few joints.
- hard, coarse grained, poorly sorted, closely spaced joints inclined at 50°, rough.
- Run 89 (REC=100%, RQD=54%): @69.5m: bedding inclined at 20°, closely spaced joints inclined at 50°, 53°, clay filling.
- closely spaced joints inclined at 60°, 70°, 80°, 45°, 35°, slightly rough, clay filling in few joints.
- Run 90 (REC=93%, RQD=0%)
- Run 91 (REC=100%, RQD=0%): CONGLOMERATE, pale yellowish brown (10YR 6/2), moderately soft, slightly weathered, sub rounded clasts to 2.5 cm, iron oxide filling, fragments of rock.
- Run 92 (REC=100%, RQD=60%): medium gray (N5), sub round clasts up to 5 cm dia. in coarse sand matrix, moderately spaced joints inclined at 18°, 31°, 43°, iron oxide filling.
- @72m: SANDSTONE, medium gray (N5), fine to medium grained, calcite veins faulted and recemented.
- @72.4m: CONGLOMERATE, as above.
- @72.5m: SANDSTONE, as above, closely spaced joints inclined at 57°, 75°.
- @72.6m: CONGLOMERATE, as above.
- Run 93 (REC=100%, RQD=50%): @72.7m: moderately spaced joints inclined at 18°, 60°, 67°, moderately rough to rough, iron oxide filling.
- @73.7m: closely spaced joints inclined at 39°, 31°, slightly rough, iron oxide filling.
- Run 94 (REC=100%, RQD=60%): moderately spaced joints inclined at 40°, 51°, slightly rough to moderately rough, iron oxide filling.
- @74.3m: SANDSTONE, white to medium gray (N5), hard, slightly weathered, coarse grained.
- @74.5m: conglomerate lens.
- Run 95 (REC=100%, RQD=0%): @74.7m: moderately spaced joints inclined at 37°, 40°, moderately rough, iron oxide filling.
- CONGLOMERATE, as above, fracture zone, slightly rough, iron oxide, sand filling.
- @75.3m: SANDSTONE, as above, closely spaced joints inclined at 33°, 37°, clay, iron oxide filling.
- Run 96 (REC=100%, RQD=57%): CONGLOMERATE, as above, moderately spaced joints inclined at 36°, 44°, 60°, 33°, 65°, 35°, 60°, 31°, 33°, 30°, moderately rough to rough, iron oxide filling, clay filling in few joints.
- Run 97 (REC=97%, RQD=53%): moderately spaced joints inclined at 38°, 34°, 80°, 45°, 30°, 38°, slightly rough to rough, iron oxide, clay fillings in few joints.
- moderately spaced joints inclined at 30°, 46°, 22°, 32°, 42°, 32°, 70°, 65°, slightly rough to rough, iron oxide filling.
- Run 98 (REC=102%, RQD=38%)
- joint inclined at 21°, slightly rough, iron oxide filling.
- @79.1m: Fracture zone.
- Run 99 (REC=100%, RQD=22%): clasts up to 8 cm dia., matrix supported, moderately spaced joints inclined at 53°, 60°, 56°, 18°, slightly rough to rough, iron oxide, clay fillings in few joints.
- Run 100 (REC=100%, RQD=80%): @80.5m: shear zone.
- @80.8m: moderately spaced joints inclined at 58°, 50°, slightly rough to moderately rough, iron oxide filling.
- moderately spaced joints inclined at 75°, 74°, 86°, 32°, 67°, 25°, 58°, slightly rough to rough, iron oxide fillings in few joints.
- Run 101 (REC=100%, RQD=75%)
- moderately spaced joints inclined at 52°, 72°, 64°, 34°, 58°, slightly rough to rough, iron oxide fillings in few joints.
- Run 102 (REC=100%, RQD=67%)
- @84.3m: closely spaced joints inclined at 60°, 62°, 50°, slightly rough, iron oxide, clay filling.
- Run 103 (REC=100%, RQD=61%): moderately spaced joints inclined at 65°, 50°, 68°, 34°, slightly rough to rough, iron oxide fillings in few joints.
- moderately spaced joints inclined at 50°, 65°, 64°, 67°, 78°, 56°, slightly rough to rough.
- Run 104 (REC=100%, RQD=68%)
- widely spaced joints inclined at 58°, 86°, 60°, 56°, slightly rough.
- Run 105 (REC=98%, RQD=79%)
- moderately spaced joints inclined at 58°, 48°, 72°, slightly rough, calcite, clay filling in few joints,.
- Run 106 (REC=102%, RQD=74%)
- @89.1m: strike-slip slicks.
- @89.3m: foliation, smooth, dip-slip slicks, clay filling.
- @89.5m: SILTSTONE/CLAYSTONE, black (N1).
- Run 107 (REC=100%, RQD=80%): @89.6m: SILTY SANDSTONE, medium dark gray (N4), fine to coarse grained sand, scatter pebbles near base, joint inclined at 37°, iron oxide filling.
- @89.9m: CONGLOMERATE, same as above, moderately spaced joints inclined at 43°, 60°, 36°, 39°, moderately rough to rough, iron oxide filling.
- moderately spaced joints, slightly rough to moderately rough, iron oxide filling.
- Run 108 (REC=100%, RQD=45%): @91.5m: fracture zone.
- @91.6m: moderately spaced joints inclined at 12°, 35°, 33°, 24°, 39°, 47°, 41°, slightly rough to rough, iron oxide filling in few joints.

PENETRATION DEPTH (m)

- moderately spaced joints inclined at 4°, 32°, slightly rough to rough.
- Run 109 (REC=67%, RQD=0%): @92.5m: fracture zone.
- moderately soft to moderately hard, slightly weathered to moderately weathered, moderately spaced random fractures inclined at 50°, iron oxide filling, quartz.
- Run 110 (REC=100%, RQD=60%): @93.3m: moderately spaced joints inclined 0°, 55°.
- @93.6m: closely spaced joints inclined at 65°, 70°, 20°, 10°, 50°.
- fresh to slightly weathered, widely spaced random fracture inclined at 25°, calcite, iron oxide, quartz filling.
- Run 111 (REC=93%, RQD=70%): @94.8m: moderately spaced, moderately open joints inclined 45°, 40°, 40°.
- @95.6m: soft to moderately soft, mechanical break, weak zone.
- SANDSTONE, moderately soft to moderately hard, slightly weathered, random fractures, calcite, iron oxide filling.
- Run 112 (REC=52%, RQD=24%): CONGLOMERATE, same as above, moderately spaced joints inclined at 20°, rough, iron oxide, calcite filling.
- CLAYSTONE/SILTSTONE, bedding inclined at 5°, quartz filling.
- Run 113 (REC=100%, RQD=42%): @96.3m: lost core.
- CONGLOMERATE, same as above, moderately soft to moderately hard, moderately spaced fracture inclined at 50°, rough to moderately rough, iron oxide, calcite filling.
- Run 114 (REC=100%, RQD=0%): SILTSTONE, soft, slightly to mod weathered, tight highly fractured, smooth to rough, calcite, silt filling.
- Run 115 (REC=92%, RQD=0%): CONGLOMERATE, highly fractured.
- SILTSTONE, highly fractured.
- Run 116 (REC=75%, RQD=21%): moderately soft, highly fractured, some foliation at fractures, random quartz and greenstone clasts, but not conglomerate trace, very smooth concoidal surfaces on some fractures, possible slicks.
- Run 117 (REC=88%, RQD=42%): CONGLOMERATE, moderately soft, clasts size increases from top to bottom, random fractures inclined at 40°, rough, calcite filling.
- fresh to slightly weathered, moderately open, closely spaced random fractures inclined at 30°, 0°, 30°, 20°, rough, calcite filling.
- Run 118 (REC=90%, RQD=52%): SILTSTONE, soft, silt filling, weak zone.
- moderately soft, horizontal bedding with one lamination.
- CONGLOMERATE, moderately hard, fine clasts, highly fractured.
- Run 119 (REC=67%, RQD=0%): @99.8m: shear zone, thin, very visible.
- SILTSTONE, bedding overturned, inclined downward at 35°, fractures along bedding.
- Run 120 (REC=108%, RQD=63%): CONGLOMERATE, larger clasts, poorly graded, closely spaced random fractures, rough.
- CONGLOMERATE and SILTSTONE, moderately soft, slightly weathered, too fractured to see boundaries, calcite filling.
- Run 121 (REC=89%, RQD=89%): CONGLOMERATE, soft to moderately soft, slightly weathered to moderately weathered, random fracture, calcite and silt filling.
- @101.2m: moderately hard, fresh to slightly weathered.
- SILTSTONE, bedding inclined at 30°, calcite filling, slicks.
- Run 122 (REC=100%, RQD=33%): moderately hard, slightly weathered, foliation inclined at 40°, slightly rough.
- CONGLOMERATE, moderately hard, clasts up to 6 cm dia., moderately open random fracture, rough.
- SILTSTONE, dark gray.
- Run 123 (REC=82%, RQD=60%): moderately hard, slightly weathered, random fracture inclined at 40°, smooth, moderately open.
- CONGLOMERATE, finer clasts in depth, better grading, abundant quartz.
- SILTSTONE, dark gray, slightly weathered, highly fractured, foliated and crumbly.
- CONGLOMERATE, moderately hard, fresh to slightly weathered, moderately open random fracture/ foliation inclined at 40°, smooth to rough.
- Run 124 (REC=100%, RQD=43%): SILTSTONE, horizontal bedding, random fracture inclined 45°, calcite filling.
- CONGLOMERATE, larger clasts, abundant quartz.
- @104.3m: joint inclined at 65°, 15 cm long quartz clasts.
- Run 125 (REC=100%, RQD=100%): moderately hard, closely spaced random fractures one inclined at 30°, moderately open, smooth to rough, calcite filling.
- SANDSTONE, lt. gray in white, moderately hard to hard, fairly coarse grained, closely spaced fractures inclined at 70°, 55°, 55°, calcite filling.
- Run 126 (REC=100%, RQD=52%): fresh, moderately spaced random fractures inclined at 30°, 40°, moderately open, rough, calcite filling.
- fresh, moderately hard to hard, closely spaced random fractures one inclined at 50°, moderately open, rough, calcite filling.
- @107.2m: closely spaced random fractures inclined at 10°, 20°, 60°, 30°.
- Run 127 (REC=100%, RQD=85%): medium gray (N5), fresh, fine to coarse grained, poorly graded, angular to surrounded, locally silty, common calcite veins, moderately spaced joint inclined at 22°, slightly rough, clay filling.
- @108.2m: bedding joint inclined at 43°, slightly rough.
- @108.5m: joint inclined at 37°, slightly rough, clay filling.
- @108.8m: bedding joint inclined at 44°, slightly rough.
- @109m: joint inclined at 44°, moderately rough.
- @109.4m: fault inclined at 32°, oblique-slip slicks, slightly rough.
- fracture zone with fractures inclined at 5°, 28°, 67°, moderately to slightly rough, clay filling.
- Run 128 (REC=100%, RQD=72%): @109.8m: widely spaced joints inclined at 75°, 27°, 27°, 39°, slightly to moderately rough.
- @110.9m: fault inclined at 39°, strike-slip slicks, slightly rough, clay filling.
- Run 129 (REC=100%, RQD=100%): moderately to widely spaced joints inclined at 24°, 38°, 55°, 54°, 48°, 37°, slightly to moderately rough, clay, calcite filling in some joints, mechanical break grades less coarse grained at bottom.
- moderately spaced joints inclined at 75°, 52°, faults inclined at 45°, 38°, slightly rough, faults are dip-slip grooves and slicks.
- Run 130 (REC=97%, RQD=60%): @113.6m: moderately spaced joints inclined at 26°, 36°, 37°, slightly to moderately rough.
- closely spaced joints inclined at 53°, 66°, 50°, slightly rough, calcite filling.
- @114.2m: fracture zone, slightly rough.
- Run 131 (REC=83%, RQD=45%): @114.3m: hard, moderately spaced joints inclined at 23°, 52°, 43°, rough to smooth, calcite filling.
- CONGLOMERATE, sub rounded clasts to 5 cm, mostly 1 cm, clasts supported, sand matrix, faults inclined at 43°, 42°, clay, pyrite filling.
- SILTSTONE, dark gray (N3), grades to claystone with depth, oblique-slip slicks, crushed rock fragments.
- Run 132 (REC=90%, RQD=35%): GRAVELLY SANDSTONE, medium gray (N5), fine to medium grained, sandstone matrix with 0-40% scatter gravel, sub rounded, up to 2.5 cm size, moderately spaced joints inclined at 28°, 80°, moderately to slightly rough, fault inclined at 37°, dip-slip
- @116.2m: fracture zone, rough to slightly rough.
- CONGLOMERATE, medium gray (N5), sub rounded, oblique-slip slicks clasts up to 10 cm size, fine grained sand matrix.
- widely spaced joint inclined at 42°, slightly rough, calcite filling.
- Run 133 (REC=111%, RQD=87%): @117.4m: bedding inclined at 71°.
- GRAVELLY SANDSTONE, medium gray (N5), fine to coarse grained, pebbly recemented faults.
- SANDSTONE, medium gray (N5), fine to coarse grained, angular to sub rounded, poorly graded, common thin calcite veins, moderately spaced joint inclined at 83°, slightly rough, faults inclined at 83°, 25° dip-slip slicks.
- @118m: moderately spaced joint inclined at 53°, fault at 48°, slightly rough, strike-slip slicks.
- hard, fresh, moderately spaced joints inclined at 64°, 16°, 39°, 28°, 15°, 15°, 58°, 30°, 73°, 22°, moderately to slightly rough, calcite filling in one joint.

Boring 02-6A Continued on LOTB Sheet of

VERTICAL SCALE 1 : 50

Caltrans Metric

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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DESIGN OVERSIGHT KEYHAN MOGHBEL

SIGNOFF DATE

DESIGN BY S. VARATHARAJ 11/20/02

CHECKED BY S. SICILIANO 2/10/03

J. CASTLE, M. HACHEY, P. FRAME, S. SICILIANO & L. PATZKOWSKI — FIELD INVESTIGATOR(S)/TITLE — DATE 8/17/02 to 8/30/02

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.

KILOMETER POST

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

CONSISTENCY CLASSIFICATION FOR SOILS (According to the Standard Penetration Test (ASTM D-1586))			
SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Conformable material change; Estimated material change; Unconformable material change; Top Hole El.; Sample No.; Permanent Casing driven; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Boring Date; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ...; Sample Description; Boring Date(s)

Boring 02-6A Continued from LOTB Sheet of

PENETRATION DEPTH (m)

- fresh, hard, moderately spaced joints inclined at 64°, 16°, 39°, 28°, 15°, 15°, 58°, 30°, 73°, 22°, moderately to slightly rough, calcite filling in one joint.
- 119 — REC=96% RQD=56% 134
- 120 — fresh, hard, fault at 117 m, dip-slip slicks, moderately spaced joints inclined at 20°, 28°, 88°, 0°, moderately to slightly rough.
- REC=100% RQD=24% 135
- @120.7m: mechanical breaks, gouge material.
- moderately spaced joint inclined at 42°, 28°, 58°, 56°, 29°, slightly rough to rough, clay filling in some joints, faults inclined at 84°, 50°, around 121.3m, slightly rough, dip-slip slicks.
- 121 — REC=100% RQD=55% 136
- 122 — moderately spaced faults inclined at 28°, 26°, 48°, slightly rough to rough, clay, calcite filling in some faults, dip-slip slicks.
- 123 — REC=100% RQD=65% 137 — @122.7m: moderately spaced fault inclined at 39°, slightly rough, calcite filling, dip-slip slicks.
- @122.9m: moderately spaced joints inclined at 47°, 28°, 64°, 68°, slightly rough to moderately rough, clay, calcite filling in some joints.
- scattered fine gravel, widely spaced fault, slightly rough, clay filling.
- 124 — REC=100% RQD=62% 138 — @124.1m: fracture zone, fault with slicks, rough.
- SILTSTONE, dark gray (N3), hard to moderately hard, sandy, contains thin lenses of fine grained sandstone, moderately spaced joints inclined at 38°, 58°, bedding joints 30°, 35°, slightly rough to smooth.
- 125 — moderately spaced bedding, bedding joints both inclined at 46°, smooth.
- @124.8m: CONGLOMERATE, medium dark gray (N4), hard, sub rounded to round, clasts up to 5 cm size, sand matrix, bedding inclined at 57°, faults at 34, 46°, strike-slip slicks, clay filling.
- REC=100% RQD=62% 139 — @125.3m: siltstone lens, bedding joint inclined at 68°, moderately rough.
- 126 — SANDSTONE, medium gray (N5), fine to coarse grained, angular to sub rounded, poorly graded, bedding inclined at 80°, moderately spaced joint inclined at 61°, 64°, slightly rough, faults inclined at 40°, 71°.
- 127 — REC=100% RQD=60% 140 — moderately spaced joints inclined at 51°, two at 84°, 38°, 44°, 43°, 42°, fault with slicks inclined at 72°, slightly rough.
- 128 — moderately spaced joints inclined at 58°, 50°, 48°, 32°, 45°, slightly rough to moderately rough, fault with strike-slip slicks inclined at 72°, slightly rough.
- REC=100% RQD=60% 141 — @128.5m: moderately spaced joints inclined at 65°, 30°, slightly rough, fault with dip-slip slicks inclined at 62°, slightly rough.
- 129 — closely spaced joints inclined between 50° and 85°, one at 39°, slightly rough to moderately rough, calcite filling in two joints.
- 130 — REC=100% RQD=44% 142
- 131 — fresh to slightly weathered, very hard, fine grained, moderately spaced fractures inclined at 45°, 70°, 30°, 75°, smooth, calcite, clay coated fracture surface.
- REC=83% RQD=53% 143 — extensive calcite veins up to 3mm wide, moderately spaced joints, mechanical breaks inclined at 45°, 90°, 60°, 50° 90°, 80°, 30°, moderately rough to slightly rough, calcite/clay filling.
- 132 — REC=103% RQD=85% 144 — @132.3m: moderately spaced joints inclined at 35°, 90°, 70°, smooth to slightly rough, calcite/clay filling.
- 133 — moderately spaced tight joints inclined at 75°, 35°, 55°, 90°, 50°, slightly rough, calcite, clay filling.
- REC=100% RQD=98% 145
- 134 — joint inclined at 60°, slightly rough, calcite filling.
- @134.2m: moderately soft, fracture zone - fully healed fractures with calcite filling.
- REC=102% RQD=80% 146 — @134.3m: mod. hard, moderately spaced tight joints inclined at 60°, 35°, 70°, 45°, 50°, moderately rough to slightly rough, calcite, clay filling in few joints.
- 135
- fresh, very hard, thin calcite veins generally oriented between 40° and 60°.
- 136 — REC=100% RQD=97% 147 — @136m: moderately spaced tight joints inclined at 20°, 40°, 40°, rough to smooth, calcite filling in one joint.
- 137 — @136.9m: tight mechanical break inclined at 40°, very rough.
- moderately spaced tight to moderately open joints inclined between 40° and 75°, one at 25°, rough to slightly rough, calcite filling in some joints.
- REC=102% RQD=70% 148
- 138 — moderately spaced tight joints inclined at 30°, 70°, 55°, 50°, rough to smooth, well developed striations in calcite filling.
- 139 — REC=97% RQD=97% 149
- 140 — fresh, very hard.
- @140.2m: tight joint inclined at 35°, smooth, calcite filling.
- REC=96% RQD=65% 150 — @140.5m: closely spaced joints inclined between 50° and 85°, one at 30°, rough, calcite filling in two joints, thin fracture zone at 140.7m.
- 141 — closely spaced tight joints, smooth to slightly rough.
- 142 — REC=103% RQD=38% 151 — @142.1m: closely spaced joints inclined at 65°, 85°, rough, calcite filling in one joint.
- @142.6m: stepped joint inclined at 90°, rough, incipient joints.
- 143 — fresh, very hard, medium grained, closely spaced tight to moderately open, joints generally inclined between 55° and 85°, one inclined at 35°, 10°, calcite, clay filling.
- REC=72% RQD=0% 152
- 144 — CONGLOMERATIC SANDSTONE, lt. gray, slightly weathered to fresh, very hard, sub rounded to subangular clasts of siltstone, sandstone, quartz, diorite up to 7 cm dia., mechanical breaks, 60 % sandstone, 40 % clasts.
- REC=119% RQD=90% 153 — @144.5m: moderately spaced joints inclined at 50°, 60°, 60°, moderately open, rough, poorly developed calcite filling.
- 145 — fresh, very hard, mechanical break inclined at 90°.
- REC=108% RQD=98% 154 — @145.4m: moderately spaced tight joints inclined three at 55°, one at 45°, rough.
- 146 — moderately spaced tight joints inclined at 45°, 70°, 60°, 50°, rough to smooth, calcite filling in one joint.
- 147 — REC=100% RQD=77% 155 — @146.8m: widely spaced two joints inclined at 60°, moderately rough to rough.
- @147.3m: zone of randomly oriented fractures, large siltstone clasts.
- fresh, very hard, clasts up to 1 cm dia., coarse to medium matrix.
- 148 — @147.9m: moderately spaced joints, tight, inclined at 40°, 80°, 80°, 90°, 25°, smooth to rough, clay filling in some joints.
- REC=88% RQD=77% 156 — @148.6m: brecciated siltstone bedding inclined at 40°.
- 149 — PEBBLY SANDSTONE, medium lt. gray, fresh, hard, fine to medium grained sandstone matrix, scattered coarse grained sand and gravel, sub rounded siltstone, sandstone blobs.
- @149.4m: bedding with claystone laminations.
- 150 — REC=100% RQD=68% 157 — SANDSTONE, medium gray (N5), fine to coarse-grained sand, angular to subangular to sub rounded, abundant lenses of silty sand, common hairline calcite veins.
- @149.7m: moderately spaced joint inclined at 65°, fault at 69° with oblique-slip slicks, slightly rough.
- 151 — @149.8m: fracture zone.
- @150.2m: moderately spaced joint inclined at 75°, 62°, fault at 57°, 74° with oblique-slip slicks, slightly rough to smooth.
- REC=100% RQD=55% 158 — moderately spaced incipient fracture, joint inclined at 28°, rough.
- @150.9m: moderately spaced faults inclined at 42°, 75°, 58°, slightly rough, dip-slip slicks.
- 152 — @151.2m: moderately spaced joints inclined two at 48°, one at 40°, rough to slightly rough.
- @151.5m: moderately spaced faults one inclined at 49° with oblique-slip slicks, one at 32° with dip-slip slicks and clay filling, both slightly rough.
- 153 — @151.8m: moderately spaced fault inclined at 63° with strike-slip slicks, joint at 33°, fault at 49° with dip-slip slicks, slightly rough to moderately rough.

PENETRATION DEPTH (m)

- moderately spaced joints inclined at 60°, 80°, moderately rough, fault at 44°, slightly rough.
- 153 — REC=100% RQD=65% 159 — @152.7m: moderately spaced joints inclined at 10°, 63°, moderately rough, incipient fracture at 44°, rough, calcite filling, joint at 72°, moderately rough.
- 154 — moderately spaced joints inclined at 32°, 47°, 4°, 67°, 74°, moderately rough slightly rough, incipient fracture at 30°, moderately rough, joint at 72°, moderately rough, calcite filling.
- REC=73% RQD=45% 160 — @154.5m: moderately spaced joint inclined at 34°, slightly rough, fault at 56°, moderately rough, joint at 57°, moderately rough.
- 155
- 156 — @155.5m: widely spaced joint inclined at 39°, 73°, moderately rough to rough, calcite filling.
- REC=100% RQD=75% 161 — @156.1m: moderately spaced fault inclined at 40° with oblique-slip slicks, joint at 50°, 59°, 63°, slightly rough to moderately rough, clay filling in one joint.
- 157 — fresh, hard, fragments of rock, incipient fracture inclined at 62°.
- REC=100% RQD=0% 162 — moderately spaced joint inclined at 32°, slightly rough, fault at 66°, dip-slip slicks, smooth, joints at 62°, 60°, 45°, 30°, 51°, slightly rough to moderately rough.
- 158 — REC=100% RQD=75% 163
- @158.2m: fault inclined at 72°, oblique-slip slicks, slightly rough.
- moderately spaced joint inclined at 46°, two at 84°, 52°, 63°, 75°, slightly rough to rough, clay and calcite filling in one joint.
- 159 — REC=100% RQD=63% 164
- @159.5m: joint inclined at 53°, slightly rough.
- 160 — @159.6m: fracture zone.
- @160.1m: fault inclined at 80°, dip-slip slicks, slightly rough.
- REC=100% RQD=43% 165 — @160.3m: moderately spaced joint inclined at 75°, 80°, 70°, 0°, 40°, 64°, slightly rough to rough, clay and calcite filling in few joints.
- 161 — @160.8m: fault inclined at 30°, oblique-slip slicks, slightly rough, calcite filling.
- @161m: moderately spaced joint inclined at 48°, 60°, 45°, slightly rough to moderately rough, clay and calcite filling in few joints.
- 162 — moderately spaced joint inclined between 45° and 75°, slightly rough to moderately rough, calcite filling in few joints, two faults at 55°, oblique-slip slicks.
- REC=100% RQD=77% 166 — (UC)(E) @161.6m
- (UC)(E)(TX)(DS) @162.5m
- 163 — moderately spaced joint inclined between 45° and 75°, slightly rough to rough, calcite, clay filling in few joints, a fault with oblique-slip slicks.
- 164 — REC=100% RQD=43% 167
- moderately spaced joint inclined at 35°, 58°, rough.
- 165 — @164.5m: fracture zone.
- @164.6m: moderately spaced joint inclined at 35°, 58°, rough.
- REC=100% RQD=52% 168 — @164.8m: fracture zone.
- 166 — @164.9m: moderately spaced joint inclined at 85°, 80°, slightly rough to moderately rough, calcite, clay filling in one joints, a fault at 65 with dip-slip slicks.
- @165.4m: moderately spaced joint inclined at 72°, faults at 70, 67° with oblique-slip slicks, slightly rough.
- @165.6m: joint inclined at 51°, smooth, calcite filling.
- 167 — REC=100% RQD=55% 169 — moderately spaced joint inclined between 75° and 85°, slightly rough to moderately rough, calcite filling in few joints, incipient fracture at 46°, two faults at 66° and 75°, dip-slip slicks, slightly rough to smooth.
- @167m: SHEAR ZONE, clayey sand, medium gray (N5), soft, no shear fabric.
- 168 — SANDSTONE, medium gray (N5), hard, fine to coarse grained, well graded, angular to sub rounded, fault inclined at 70°, smooth, joint at 46°, slightly rough.
- REC=100% RQD=47% 170 — joint inclined at 73°, s. rough, moderately spaced mechanical breaks, lost drilling fluid circulation entirely.
- 169 — @167.7m: scattered gravel clasts, moderately spaced joints mostly inclined between 50° and 80°, few joints inclined at 6°, 8°, 12°, slightly rough to rough, calcite filling in few joints.
- moderately spaced joints mostly inclined between 50° and 80°, some joints inclined at 32°, 0°, slightly rough to moderately rough, calcite, clay, silt filling in few joints, constant head fluid flow test average is 16.7 gpm.
- 170 — REC=100% RQD=57% 171 — @170m: poorly graded sandstone, fault inclined at 62°, smooth, calcite, clay filling.
- REC=58% RQD=0% 172 — fresh, hard, fragments of rock.
- 171 — moderately hard, fracture zone.
- @171m: moderately spaced faults inclined at 66° with strike-slip slicks, fault at 52° with dip-slip slicks, slightly rough, joints inclined at 53°, 50°, moderately rough to rough, clay filling in one fault.
- 172 — REC=98% RQD=47% 173 — @171.6m: moderately spaced faults inclined at 44° with dip-slip slicks, fault at 39°, 52°, slightly rough, joint inclined at 38°, moderately rough, clay filling.
- moderately spaced joints mostly inclined between 50° and 90°, one joint inclined at 38°, slightly rough to rough, clay filling in one joint, a fault inclined at 55°, oblique-slip slicks, slightly rough, rock type grades to CONGLOMERATE at 172m depth.
- 173 — REC=102% RQD=75% 174
- joint inclined at 54°, moderately spaced faults inclined at 43°, 45°, 33° with strike-slip slicks, slightly rough, joint inclined at 65°, moderately rough.
- 174 — REC=100% RQD=23% 175 — @174.2m: fault inclined at 65° with strike-slip slicks, slightly rough, moderately spaced joints inclined between 45° and 70°, moderately rough.
- 175 — moderately spaced joints inclined between 35° and 85°, slightly rough to moderately rough, clay, calcite filling in few joints, occasional faults inclined at 57°, 73° with oblique-slip slicks, moderately rough to slightly rough.
- 176 — REC=100% RQD=57% 176
- 177 — moderately spaced faults inclined between 50° and 85° with slicks, slightly rough to moderately rough, occasional joints inclined between 43° and 65°, slightly rough to moderately rough.
- REC=102% RQD=52% 177
- 178 — widely spaced faults inclined at 52° with oblique-slip, 82°, 77° with dip-slip, slightly rough, one with polished surface.
- 179

Boring 02-6A Continued on LOTB Sheet of

VERTICAL SCALE 1 : 50

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/10/03

J. CASTLE, M. HACHEY, P. FRAME, S. SICILIANO & L. PATZKOWSKI
FIELD INVESTIGATOR(S)/TITLE
DATE 8/17/02 to 8/30/02

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2½" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Top Hole El.; Permanent Casing driven; Sample No.; Size of Sampler (mm); Description of material; Unconfined compressive strength (kPa); Total unit weight (kN/m³); % moisture; Consolidation test; Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; CWS Elev.; Date measured; Conformable material change; Number of blows required to produce the indicated penetration after an initial 152 mm seating; Estimated material change; Unconformable material change; 50 blows produced the indicated penetration during the initial 152 mm interval; Boring Date; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

Boring 02-6A Continued from LOTB Sheet of

PENETRATION DEPTH (m)

Depth (m)	Run	Description
178		widely spaced faults inclined at 52° with oblique-slip, 82°, 77° with dip-slip, slightly rough, one with polished surface.
179	REC=100% RQD=100% 178	@179.1m: bedding or recent fault inclined at 41°. GRAVELLY SANDSTONE, medium lt. gray (N6), fine to coarse grained, scattered sub rounded gravel clasts up to 5 cm in size.
180	REC=100% RQD=63% 179	@179.5m: fault at 80° with strike-slip slicks, slightly rough. moderately spaced joints inclined between 50° and 70°, slightly rough to rough, occasional faults inclined at 79°, 70°, 74 with dip-slip slicks, 48°, 78° with oblique-slip slicks, slightly rough.
181		fracture zone. SANDSTONE, medium gray (N5), fresh, hard, fine to coarse grained, poorly graded, angular to sub rounded, moderately spaced joints inclined at 31°, 37°, slightly rough to moderately rough.
182	REC=100% RQD=73% 180	GRAVELLY SANDSTONE, medium lt. gray (N6), fine to coarse grained, scattered sub rounded gravel clasts, bedding inclined at 33°, fault at 65° with strike-slip, moderately spaced joints inclined at 48°, 30°, rough.
183		widely spaced joint inclined at 66°, rough, calcite filling.
	REC=100% RQD=72% 181	@183.2m: moderately spaced joints inclined between 30° and 60°, moderately rough, occasional faults inclined at 74°, 58°, slightly rough, clayey sand filling in one fault.
184		moderately spaced joints inclined at 57°, 15°, 60°, slightly rough, clay filling in one joint.
185	REC=90% RQD=33% 182	SANDSTONE, medium gray (N5), fresh, hard, fine to coarse grained, poorly graded, angular to sub rounded, locally silty, fault inclined at 70°, moderately rough, sand filling, moderately spaced joints inclined at 0°, 63°, 57°, moderately open. CONGLOMERATIC SANDSTONE, medium lt. gray (N6), fine to coarse grained, scattered sub rounded gravel clasts.
186	REC=100% RQD=28% 183	rounded to subangular clasts up to 1 cm dia. of sedimentary and igneous origin, moderately spaced joints inclined between 30° and 60°, rough to slightly rough, calcite and clay filling in some joints.
187		fresh, hard, fine to coarse grained, less clasts than above, moderately spaced joint inclined at 70°, slightly rough, open, calcite filling.
	REC=100% RQD=52% 184	@187.4m: bedding inclined at 40°, closed.
188		@187.7m: black sub rounded shale clasts, joint inclined at 20°, rough, moderately open. lt. gray, fresh, hard to very hard, sub rounded clasts up to 2 cm, mostly 1cm, moderately spaced joints inclined between 50° and 70°, rough.
189	REC=100% RQD=60% 185	
190		very hard, widely spaced joints inclined at 50°, stepped, slightly open, at 80° slightly rough, at 70°, slightly rough, slightly open, calcite filling, few mechanical fractures.
	REC=100% RQD=73% 186	
191		sub rounded clasts up to 0.5 cm dia., moderately spaced beddings two inclined at 40°, slightly rough, moderately spaced fractures.
192	REC=100% RQD=70% 187	@192.1m: moderately spaced joints inclined at 60°, 10° and 25 cm long, slightly rough, moderately open. smaller clasts up to 3 mm, moderately spaced joints two inclined at 40°, one at 50°, slightly rough.
193	REC=100% RQD=55% 188	@193.4m: intensely fractured.
194		SANDSTONE, lt. gray, fresh, hard, fine to coarse grained, intensely fractured. @194.2m: moderately spaced joints two inclined at 70°, rough.
195	REC=95% RQD=0% 189	@194.7m: soft sheared rock structure locally reduced to clayey sand to sandy clay soil. @194.9m: SHEAR ZONE, lt. gray gouge, sandy clay, soft, no structure identifiable.
196	REC=100% RQD=67% 190	SANDSTONE, lt. gray, fresh, hard, fine grained, random fractures. @195.5m: very hard, widely spaced joints two inclined at 60°, one at 50°, rough, hairline calcite veins.
197	REC=100% RQD=31% 191	fresh, hard, joint inclined at 90°. @196.9m: fracture zone, rock locally crushed, moderately soft, random fractures, clay filling. @197m: moderately spaced joints one inclined at 70°.
198		@197.6m: very closely spaced random fractures. @197.7m: thin fracture zone, rock locally crushed, moderately soft, random fractures, clay filling. hard to very hard, moderately spaced joints inclined between 50° and 60°, rough, moderately open to closed.
199	REC=100% RQD=78% 192	hard, moderately spaced joints inclined between 60° and 80°, rough to slightly rough, moderately open, calcite veins.
200	REC=100% RQD=35% 193	@200.4m: fracture zone. @200.5m: closely spaced fractures.
201		hard, moderately spaced joints inclined between 40° and 80°, slightly rough, calcite veins.
202	REC=100% RQD=72% 194	hard, moderately spaced joints inclined between 40° and 70°, slightly rough to rough, one stepped joint, slightly open, calcite veins up to 3mm thick at the beginning.
203	REC=100% RQD=57% 195	
204		fine grained sandstone, moderately spaced joints inclined at 50°, 40°, slightly rough, calcite veins up to 1 cm thick.
205	REC=100% RQD=70% 196	@204.6m: two 10 cm thick fracture filled with soft clay inclined at 50°, 30°. @204.9m: coarse grained sandstone, bedding inclined at 70°. @205.2m: fine grained sandstone, bedding inclined at 70°, calcite veins. 5 cm thick fracture zone.
206	REC=100% RQD=53% 197	@205.9m: moderately spaced joints inclined between 50° and 70°, slightly rough, slightly open, calcite filling in many joints, black siltstone interbeds inclined at 30°, up to 6 mm thick.
207		two thin fracture zones.
208	REC=100% RQD=60% 198	@207.5m: moderately spaced joints inclined at 70°, 50°, 60°, 70°, two at 20°, slightly rough, slightly open, hairline calcite veins.
209	REC=100% RQD=40% 199	moderately spaced joints inclined at 60°, three at 30°, 40°, 20°, slightly rough, hairline calcite veins.
210		fine grained, hairline to 2 mm thick calcite veins, incipient fracture inclined at 80° to 90°, slightly rough, slightly open.
211	REC=105% RQD=65% 200	@210.7m: fracture zone. @211m: moderately spaced joints inclined at 5°, 84°, 60°, 60°, moderately open. @211.4m: 2 to 5 cm thick calcite band, fracture zone below with clay filling.
212		

PENETRATION DEPTH (m)

Depth (m)	Run	Description
212	REC=100% RQD=52% 201	moderately spaced joints inclined at 50°, 80°, 45°, 30°, 10°, two at 15°, rough, abundant thin calcite veins inclined at 30°, two long subparallel near vertical joints with 4 cm apart.
213		moderately spaced joints inclined at 60°, 85°, rough, slightly open, hairline calcite veins. @213.5m: moderately spaced joints inclined at 30°, 15°, rough, slightly open, incipient fracture inclined at 70°, slightly open, joint at 25°, rough, slightly open.
214	REC=100% RQD=42% 202	@213.8m: fracture zone. @214m: joint inclined at 70°, rough, slightly open. @214.3m: moderately spaced two joints inclined at 40°, rough, slightly open, fracture zone with clay filling.
215	REC=100% RQD=65% 203	moderately spaced joints inclined at 15°, 80°, rough, slightly open, incipient fracture inclined at 70°, slightly open, joint at 65°, rough, slightly open, hairline calcite veins. @215m: fracture zone, rough, moderately open, thin clay filling.
216	REC=100% RQD=0% 204	@215.2m: moderately spaced joints inclined at 70°, 60°, 30°, rough, slightly open, incipient fracture inclined at 40°, hairline opening, joint inclined at 50°, two at 40°, rough to very rough, slightly open. closely spaced joints inclined at 40°, 80°, 40°, fragments of rock. @216.4m: shear zone, moderately soft, disaggregation with lean clay. moderately spaced joints inclined at 65°, 5°, hairline calcite veins.
217	REC=100% RQD=68% 205	@216.7m: fracture zone. @217m: moderately spaced joints inclined at 20°, 10°, slightly rough to rough, slightly open, incipient fracture inclined at 30°, hairline opening.
218		@217.4m: widely spaced joint inclined at 30° to 50°, 65°, 45°, rough, slightly open. fresh, hard sandstone, moderately spaced joints inclined at 40°, 30°, 70°, 90°, 60°, 30°, 90°, slightly rough, open, hairline calcite veins.
219	REC=100% RQD=79% 206	thin fracture zone, joint inclined at 50°, moderately open, calcite filling.
220	REC=100% RQD=80% 207	@219.7m: shear zone, localized, rock is intact but softer and can reduced to gravel by finger pressure. @219.9m: moderately to widely spaced joints inclined at 40°, 30°, 50°, slightly open.
221		moderately spaced bedding joints inclined at 85°, smooth, joint inclined at 55°, rough, both slightly open.
222	REC=100% RQD=77% 208	@221.6m: moderately spaced joint inclined at 45°, 12°, 40°, 22°, rough, slightly open, clay filling in two joints. moderately spaced bedding joint inclined at 76°, joints inclined between 30° and 50°, rough, slightly open.
223	REC=103% RQD=92% 209	
224	REC=100% RQD=17% 210	@223.7m: moderately spaced bedding joint inclined at 85°, rough, slightly open. moderately spaced joints mostly inclined at 70°, one at 45°, one at 30°, few bedding joints inclined at 80° to 85°, rough, slightly open, calcite filling in some joints, locally sheared zone from 224.3m to 224.6m.
225		moderately spaced joints mostly inclined at 10° and 45°, few bedding joints inclined at 80° to 85°, rough, slightly open, calcite filling, one bedding joint is smooth, one is slightly rough.
226	REC=103% RQD=57% 211	
227	REC=100% RQD=67% 212	moderately spaced joints mostly inclined between 45° and 60°, one joint inclined at 15°, rough, calcite, clay filling in some joints, slightly open, few bedding joints inclined at 80°, smooth to rough, slightly open, calcite filling.
228		moderately spaced joints mostly inclined between 30° and 50°, one joint inclined at 10°, one at 15°, rough, calcite, clay filling in some joints, slightly to moderately open, few bedding joints inclined at 80° to 85°, rough, moderately open.
229	REC=100% RQD=40% 213	
230		moderately spaced bedding joints inclined 80°, joint inclined at 10°, rough, calcite filling, slightly open, incipient fracture inclined at 80°, hairline open.
231	REC=100% RQD=67% 214	@230.3m: incipient fracture inclined at 60°, hairline open, moderately spaced joints inclined at 40°, 35°, 42°, 30°, 65°, rough, calcite filling in one joint, slightly open. @230.9m: sheared zone, soft to moderately hard, black shaley silt to lean clay filling, rough to smooth, local slicken sides. dark gray, intensely to mod weathered, moderately hard, moderately spaced joints inclined at 5°, 30°, bedding joints inclined at 85°, 80°, clay filling, rough, moderately open.
232	REC=100% RQD=21% 215	SHEAR ZONE, black claystone, shale with sandstone fragments, moderately to intensely weathered, moderately hard to moderately soft, all surfaces are slick and polished, disaggregated clay gouge.
233	REC=100% RQD=68% 216	gray, intensely to moderately weathered, med. to fine grained sandstone with calcite veins, moderately spaced joints mostly inclined between 40° and 65°, one inclined at 25°, rough, slightly open, clay, calcite filling, thin shear zone at 232.5 m.
234		sparse angular shale clasts up to 6 mm dia. size, moderately spaced joints two inclined at 60°, rough, moderately open, hard 8 mm wide calcite seam between the joints.
235	REC=103% RQD=78% 217	@234.3m: bedding joint inclined at 85°, calcite filling, slightly rough, slightly open. @234.7m: fresh, hard, moderately spaced joints inclined between 45° and 75°, one joint inclined at 0°, rough, moderately open, calcite filling in many joints.
236	REC=100% RQD=75% 218	@235.3m: bedding joint inclined at 80°, moderately open. moderately spaced joints inclined at 45°, 60°, 17°, rough to slightly rough, calcite, clay filling, moderately open, bedding joint inclined at 82°, rough, wide open, incipient joints inclined at 10° to 20°, slightly open.
237		@236.1m: moderately spaced joint inclined at 70°, slightly rough, slightly open, bedding joints inclined at 85°, 80°, rough, moderately open, calcite filling. widely spaced joint inclined at 60°, rough, calcite filling, moderately open.
238	REC=102% RQD=73% 219	@237.8m: moderately spaced joints inclined at 15°, 50°, 60°, rough, clay filling, slightly to moderately open.

Boring 02-6A Continued on LOTB Sheet of

VERTICAL SCALE 1 : 50

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

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DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/10/03

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FIELD INVESTIGATOR(S)/TITLE
DATE 8/17/02 to 8/30/02

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Boring 02-6A Continued
from LOTB Sheet of

PENETRATION DEPTH (m)

Depth (m)	Core run	Description
238		
		widely spaced bedding joint inclined at 80°, slightly rough, calcite filling.
239	REC=102% RQD=72% 220	@239m: moderately spaced joints inclined at 60°, 55°, 20°, 70°, rough, clay, calcite filling, slightly to moderately open.
		@239.4m: moderately spaced bedding joint inclined at 80°, rough, calcite filling, incipient joints inclined at 10°, 70°, slightly open.
240		@239.8m: thin fracture zone, rough, slightly open, bedding joint inclined at 80°, slightly open.
		hard, fresh, calcite veins.
241	REC=96% RQD=72% 221	@240.6m: moderately spaced joints inclined at 45°, 60°, 20°, 15°, rough, clay, calcite filling in some joints.
		moderately spaced joints inclined at 70°, rough, bedding joint inclined at 87°, slightly rough, calcite filling.
242	REC=98% RQD=62% 222	@241.8m: fracture zone, fractures generally inclined between 30° and 60°.
		@242.3m: joint inclined at 20°, rough, slightly open.
243		@242.7m: bedding joint inclined at 85°, rough, hard clay filling.
		widely spaced joints inclined at 60°, rough.
	REC=100% RQD=60% 223	@243.4m: fracture zone, joints generally inclined 50°.
244		moderately spaced joints inclined between 50° and 55°, one bedding joint inclined at 85°, rough to slightly rough, clay filling in one joint.
	REC=114% RQD=56% 224	@244.4m: joint inclined at 60°, smooth, 1 cm thick black silt / lean clay gouge filling.
245		@244.5m: shear zone, polished rock fragments, abundant dark gray lean clay gouge, 3 mm calcite veins.
		widely spaced joint inclined at 15°, slightly rough, thin clay filling.
	REC=100% RQD=75% 225	@245.1m: moderately spaced joints mostly inclined between 50° and 70°, one joint inclined at 35°, one at 30°, rough to slightly rough, clay, calcite filling in some joints, thin soft to moderately hard shear zone at 245.4 m with black clay/silt
246		@246m: SHEAR ZONE, soft to moderately soft, black silt/clay, broken sandstone, polished fractures.
247	REC=85% RQD=35% 226	@246.4m: hard, moderately spaced joints inclined at 50°, 75°, rough, clay, calcite filling, bedding joint inclined at 85°, rough, thin calcite filling.
		@247m: SHEAR ZONE, intensely to moderately weathered, soft to moderately soft, black silt/clay, broken sandstone, polished fractures.
		gray to dark gray, moderately weathered, moderately hard to soft, med. to fine grained, local thin calcite veins.
248	REC=110% RQD=57% 227	@247.6m: fresh, moderately hard, moderately spaced joints inclined at 15° to 30°, 40°, slightly rough to rough, clay filling.
		@247.8m: moderately hard to soft.
		@248m: moderately hard, moderately spaced joints inclined at 25°, 60°, slightly rough to rough, clay filling.
249	REC=93% RQD=10% 228	mod. weathered, moderately hard to soft, moderately spaced joints inclined at 60°, 50°, 20°, slightly rough, clay filling, slight slicken sided and polished.
250		@248.8m: fracture zone, fractures and joints generally inclined at 60°, clay filling, some disaggregation and shearing.
		@249.2m: moderately spaced joints inclined at 10°, 20°, 15°, slightly rough, clay filling, bedding joint inclined at 85°, rough.
251	REC=95% RQD=70% 229	fresh, hard, moderately spaced joints inclined at 60°, 70°, 45°, rough, moderately open, clay filling in one joint, bedding joints inclined at 80°, 85°, clay filling, slightly rough to rough, moderately open.
		@250.5m: moderately spaced mechanical break inclined at 80°, rough, joints inclined at 40°, 20°, 30°, slightly rough to rough, clay filling in one joint, moderately open.
252		moderately weathered, moderately hard, moderately spaced joints inclined at 30°, 20°, slightly rough, clay filling.
	REC=125% RQD=90% 230	@251.8m: thin fracture zone with fractures inclined subparallel at 60°.
		@252.1m: CLAYSTONE, dark gray, moderately weathered, moderately hard to soft, local breccia fragments of sandstone, moderately spaced joints inclined at 45°, 70°, slightly rough to rough, clay filling, moderately open.
253		SANDSTONE, gray, moderately weathered, moderately hard, med. fine grained, calcite veins, mod spaced joints inclined at 5°, 35°, smooth to rough, sheared and polished fragments, clay filling.
	REC=98% RQD=57% 231	@253.2m: moderately spaced joints inclined at 80°, 60°, 20°, rough, moderately calcite filling.
254		@253.8m: fracture zone, broken, polished claystone fragments.
		moderately spaced joints inclined between 45° and 70°, rough to slightly rough, clay, calcite filling in most joints, bedding joints inclined at 80° to 85°, rough to slightly rough, clay, calcite filling, faint slicks on one bedding joint.
255	REC=100% RQD=75% 232	
		@255.3m: SHEAR ZONE, moderately soft, black shale streaks along minor shears.
256		CONGLOMERATIC SANDSTONE, gray, fresh, hard, very coarse grained, abundant lithic clasts up to 1 cm dia., widely spaced joints inclined at 40°, 25°, 50°, 75°, slightly rough to rough, clay filling in three joints, calcite in one joint.
257	REC=51% RQD=48% 233	@257m: lt. gray, hard to mod. hard, moderately spaced joints inclined at 70°, 80°, 85°, 15°, 35°, 52°, 10°, 85°, rough to slightly rough, thin clay filling in one joint.
258		
		moderately spaced joints inclined between 65° and 80°, rough to slightly rough, clay filling in many joints, moderately open.
259	REC=88% RQD=73% 235	
260		dark gray, fresh, hard, widely spaced joints inclined at 35°, 60°, 25°, 50°, slightly rough to rough, clay filling, moderately open, one joint is moderately weathered.
261	REC=102% RQD=87% 236	
262		gray, very coarse grained, very widely spaced joints inclined at 57°, 40°, rough to slightly rough, slightly open, thin clay filling in one joint.
	REC=103% 237	
263		very widely spaced incipient joint inclined at 68°, joint at 40°, smooth, moderately open, thin clay, calcite filling in the joint, slightly slickensided.
264	REC=100% RQD=97% 238	
265		widely spaced joint inclined at 37°, 25°, 50°, slightly rough to rough, moderately open, thin clay filling.
		@264.6m: Bottom of borehole.

8/17/02 to 8/30/02

VERTICAL SCALE
1 : 50

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

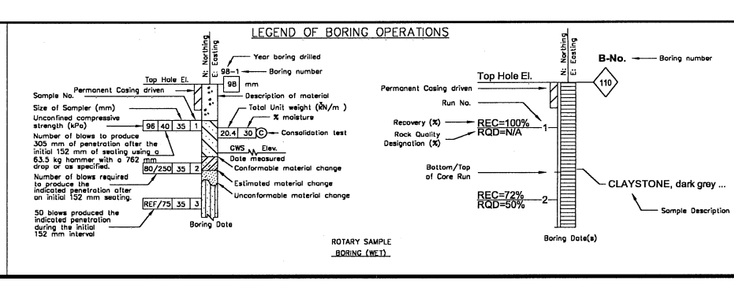
TYPE OF BORINGS

- 2½" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- HQ DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



N. 621,846.1
E. 1,822,407.1

02-07

El. 183 m

110 S25°W, 45° Inclination

PENETRATION DEPTH (m)

0
CLAYSTONE, dark gray to black, intensely weathered, moderately soft, brecciated, greater than 100 fractures per m, diameter up to 50 mm, clay infilling, angular, non-fissile.
REC=94% RQD=0% 1 @.6m: joint inclined 30° .
1
same CLAYSTONE with clay, black, intensely to moderately weathered, moderately soft, intensely fractured to 50 mm in diameter, angular.
REC=100% RQD=0% 2
2
black, intensely weathered, moderately soft, greater than 100 fractures per m, clay fill, brecciated, non-fissile.
REC=100% RQD=0% 3 @2.2m: shear zone, abundant clay infill, angular fragments, diameter up to 50 mm.
@2.3m: black, intensely weathered, moderately soft, intensely fractured.
@2.6m: shear zone, abundant clay infill, angular fragments, diameter up to 50 mm.
@2.7m: black, intensely weathered, moderately soft, intensely fractured.
3
CLAYSTONE, dark gray to black, moderately weathered, moderately soft, fracture zone with greater than 100 fractures per m, clay fill, non-fissile.
REC=100% RQD=14% 4 @3.2m: joint inclined 30° , smooth surface with clay filling.
@3.3m: fracture zone.
@3.4m: 15 cm intact core of SHALE, no apparent bedding, non-fissile.
@3.5m: joint inclined 90° .
@3.6m: joint inclined 45° .
SHALE, dark gray to black, intensely weathered, moderately soft, intensely fractured, clay fill, breccia, angular with diameter up to 50 mm.
4
@4m: fracture zone.
@4.1m: joint inclined 20° , oxidation on surface, planar, 30 fractures per m.
REC=100% RQD=30% 5 @4.3m: fracture zone, rock is crushed an reduced to clay.
@4.5m: intact core.
@4.6m: intact core.
5
same, CLAYSTONE, dark gray to black, intensely weathered, moderately soft, 30 fractures per m, some clay fill.
@5.1m: fracture zone, clay fill.
@5.2m: joint inclined 20° .
@5.3m: fracture zone, rock is crushed to clay.
REC=63% RQD=0% 6 @5.5m: joint inclined 35° .
@5.6m: 20 fractures per m.
@5.7m: no core recovery.
6
dark gray to black, intensely to moderately weathered, moderately hard, oxidized joint surfaces, blocky.
REC=19% RQD=0% 7 @6.5m: no core recovery.
7
CLAYSTONE, (as above).
@7m: fracture zone, crushed zone, clayey material.
@7m: greater than 100 fractures per m.
@7.2m: fracture zone.
REC=88% RQD=12% 8 @7.3m: joint inclined 30° .
@7.4m: open fractures with reddish-brown oxidation.
@7.5m: joint inclined 90° .
@7.7m: greater than 100 fractures per m.
8
CLAYSTONE with SILTSTONE interbeds, dark gray to black, intensely weathered, very soft to moderately hard with soft CLAY zones, intensely fractured.
REC=96% RQD=0% 9 @7.8m: fracture zone, rock is crushed into fine gravel size in a clay matrix.
@8.1m: SILTSTONE fragment.
@8.3m: SILTSTONE, moderately hard.
@8.4m: entire run (7.8 to 8.5 m depth) probable fault gouge.
CLAYSTONE, dark gray to black, intensely weathered, moderately hard, intensely fractured, non-fissile.
REC=100% RQD=0% 10 @8.6m: fracture zone.
@8.7m: all open joint surfaces are oxidized.
9
@9m: fracture zone.
fractured CLAYSTONE up to 25 mm in diameter, sub-rounded.
REC=93% RQD=23% 11 @9.3m: CLAYSTONE with SILTSTONE interbeds (same as above), moderately weathered, moderately hard.
@9.4m: reddish-brown oxidation on joint surfaces, slightly rough to smooth.
@9.5m: joint inclined 50° .
@9.6m: SILSTONE, dark gray, moderately hard, intact.
@9.7m: black SHALE gouge at top, moderately soft, joint inclined 30° .
10
CLAYSTONE, dark gray to black, moderately weathered, intensely fractured, non-fissule, brecciated nature prevent from distinguishing structure, cone is reduce to gravel with diameter up to 50 mm, sub-angular.
@10.4m: joint inclined 30° , iron-oxide on joint surface, planar.
REC=57% RQD=0% 12 @10.6m: open joint, 70° dip, iron-oxide surface, smooth.
@10.6m: no core recovery.
11
CLAYSTONE, same as above, very poor recovery.
REC=13% RQD=0% 13 @11.4m: no core recovery.
12
fracture zone, small cherts (15 mm) of SHALE and SILTSTONE in clayey matrix.
@12.1m: CLAYSTONE, dark gray and black, moderately weathered, moderately soft, black shale interbeds (50 mm thick), smooth.
REC=100% RQD=0% 14 @12.3m: black CLAYSTONE clasts in yellowish clay matrix (gouge), small fault cutting shale bed, 60° inclined 60° , iron-oxide surface.
@12.5m: CLAYSTONE bed at 50° inclined 50° , iron-oxide on surface.
@12.6m: joint inclined 45° .
@12.7m: gravel size SILTSTONE cherts up to 15 mm diameter in CLAYEY MATRIX.
@12.7m: fracture zone.
13
@12.8m: (1st run where rock structure is clearly identifiable).
REC=100% RQD=0% 15 fracture zone, angular grave up to 50 mm diameter made of SILTSTONE, moderately weathered, moderately hard, smooth.
@13m: bedding plane inclined 50° , iron-oxide coating.
@13.1m: bedding plane inclined 45° .
REC=22% RQD=0% 16 CLAYSTONE, dark gray and black, moderately weathered, moderately hard, clay fill, smooth, angular gravel up to 50 mm diameter.
@13.3m: joint inclined 45° .
@13.3m: no core recovery.
14
CLAYSTONE (same as above), slightly weathered to moderately weathered, moderately hard. Very hard and slow coring, cone broke off..
REC=100% RQD=0% 17 @14.3m: bedding at 40° , only CLAYSTONE gravel up to 50 mm recovered.
CLAYSTONE, dark gray, slightly weathered, moderately hard, intensely fractured, non-fissile.
@14.6m: planar joint surface inclined 65° , slightly rough with minor iron-oxide on surface.
@14.7m: joint inclined 20° .
15
@14.8m: bedding plane inclined 40° .
REC=67% RQD=0% 18 @14.9m: fracture zone, fractures inclined 40° , yellowish clay matrix.
@15.2m: fracture zone, rock is ground to fine gouge, black.
@15.3m: no core recovery.
16
no core recovery.
REC=0% RQD=0% 19 @16.1m: only a few rounded gravel (cave in) in barrel.
@16.2m: extremely hard drilling, core bit cannot advance in cobble/gravel in clayey matrix.

PENETRATION DEPTH (m)

17
CLAYSTONE (same as above), angular gravel up to 50 mm made of SILTSTONE, (no structure identifiable).
REC=44% RQD=0% 20 @17m: no core recovery.
18
CLAYSTONE, dark gray to black, slightly weathered, moderately hard, slightly rough.
@17.8m: bedding joint inclined 90° , no filling, slightly rough, closed..
REC=100% RQD=17% 21 @17.9m: cross joint inclined 25° .
@18m: fracture zone, rock is crushed into black gouge, reducible into soil with finger pressure.
@18.2m: iron-oxide on joint surface inclined 60° , slightly rough, clay filled.
REC=44% RQD=44% 22 CLAYSTONE, black, fresh, hard, bedding inclined 40° , slightly fractured, slightly rough.
19
@18.4m: joint inclined 90° , smooth.
@18.5m: no core recovery.
@18.6m: (trying shorter run to see if recovery improves).
REC=25% RQD=0% 23 only gravel up to 65 mm recovered, SHALE, with quartz and calcite veins (in one fragment slickensides are observable along joint surface, along with some green re-crystallization material).
@18.9m: no core recovery.
CLAYSTONE, same as above but hard to soft in shear zones, also fresh to decomposed in CLAY shear zones.
REC=100% RQD=36% 24 @19.4m: bedding plane inclined 90° , iron-oxide on surface.
@19.5m: calcite filled bedding plane inclined 40° .
20
@19.5m: fracture zone, rock is reduced to CLAY, some calcite.
@19.8m: fracture zone, frew fragments of rock in black CLAYEY matrix.
CLAYSTONE (same as above).
REC=100% RQD=17% 25 @19.9m: quartz/calcite vein 15 mm thick inclined 40° (bedding), 18 fractures per m, slightly rough.
@20m: smaller vein.
@20.1m: fracture zone, soft.
@20.3m: small fault offsetting calcite filled bedding at 65° .
@20.4m: slightly rough joint inclined 70° , with iron-oxide surface.
21
@20.5m: intact 130 mm core.
CLAYSTONE (same as above), fresh to decomposed in shear zones, hard.
@20.7m: joint inclined 60° , iron-oxide staining, 9 fractures per m.
@20.8m: joint inclined 75° , iron-oxide staining.
@20.9m: bedding inclined 35° , calcite filled.
REC=89% RQD=9% 26 @20.9m: joint inclined 90° .
@21m: joint inclined 60° .
@21m: hard, 19 fractures per m.
@21.1m: fracture zone.
@21.2m: bedding inclined 40° , iron-oxide on surface.
@21.4m: hard, bedding inclined 90° , hairline calcite filled.
22
@21.4m: soft.
@21.6m: fracture zone (bottom 55 cm of sample). Rock is crushed into gravel size fragments in a yellowish brown clay matrix..
CLAYSTONE, black, fresh, hard, slightly to moderately fractured, non-fissile.
@22.2m: bedding inclined 40° , shear zone, gouge-yellowish brown clay.
@22.2m: 50 mm quartz/calcite vein.
@22.5m: joint inclined 65° , quartz calcite filled, 3 fractures per m, iron-oxide.
REC=100% RQD=63% 27 @22.6m: joint inclined 70° , quartz calcite filled, iron-oxide.
23
@22.8m: joint inclined 70° , quartz calcite filled, 12 fractures per m, iron-oxide.
@23m: 9 fractures per m.
@23.1m: joint inclined 60° , quartz calcite filled, 3 fractures per m, iron-oxide.
@23.3m: 100 mm fracture zone, yellowis-brown clay with shale fragments.
same CLAYSTONE, hard, 9 fractures per m.
24
@23.7m: 2 joints inclined 50° , calcite filled, closed.
@23.9m: joint inclined 70° , calcite filled, closed, 3 fractures per m.
@24.1m: joint inclined 70° , calcite filled, closed.
REC=100% RQD=50% 28 @24.2m: joint inclined 60° , calcite filled, iron-oxide, stepped surface, 9 fractures per m.
@24.4m: joint inclined 60° , calcite filled, closed.
@24.5m: 25 mm fracture zone, clay filled, 9 fractures per m.
25
@24.8m: 30 fractures per m.
same CLAYSTONE, only angular fragmented shale recovered, hard.
REC=100% RQD=0% 29 @25.4m: 75 mm thick clayey gouge, yellowish-brown.
CLAYSTONE (same as above), hard, 9 fractures per m.
@25.5m: 75 mm thick fracture zone.
26
@25.8m: mechanical break.
@25.8m: joint inclined 70° , calcite filled, iron-oxide, 12 fractures per m.
@26m: joint inclined 30° , iron-oxide.
REC=100% RQD=31% 30 @26.1m: joint inclined 40° , 15 mm thick calcite bed.
@26.2m: joint inclined 40° , greater than 100 fractures per m.
@26.4m: joint inclined 40° , 15 mm thick calcite bed.
@26.6m: 225 mm thick fracture zone, gouge, yellowish-brown.
27
CLAYSTONE (same as above), moderately soft to moderately hard, intensely fractured, gravel size fragments.
REC=100% RQD=0% 31
@27.4m: 225 mm thick fracture zone.
CLAYSTONE (same as above), fresh, hard, open bedding joint inclined 40° , stepped surface, iron-oxide, calcite.
REC=100% RQD=100% 32 @27.8m: 2 joints approx 75 mm apart, closed, calcite filled (probably bedding but no change in lithology observable).
28
CLAYSTONE (same as above), hard, 3 fractures per m.
@28m: bedding joint inclined 30° , calcite filled, slightly rough.
@28.2m: 50 mm thick fracture zone, re-healed, small shale fragments in yellowish brown clayey matrix, soft.
@28.3m: joint inclined 60° , 5 fractures per m.
@28.4m: joint inclined 65° .
REC=100% RQD=45% 33 @28.6m: 125 mm thick fracture zone, re-healed (as above).
29
@28.9m: 150 mm thick fracture zone, re-healed (as above).
@29m: long shear plane, apparently offsetting 50 mm calcite vein, semi-parallel to core axis.
@29.1m: 150 mm thick fracture zone, re-healed (as above).
@29.3m: joint inclined 65° .
CLAYSTONE, black, fresh to decomposed in shear zones, soft to hard, moderate to intensely fractured.
30

Boring 02-7 Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

Caltrans Metric

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Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

DOUGLAS HAMILTON NO. CEG 31 EXP. 7/31/04
STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/10/03
J. CASTLE, P. FRAME, M. HACKETT, L. SICILIANO
DATE 8/17/02 to 8/30/02 FIELD INVESTIGATION/TITLE

DESIGN OVERSIGHT KEYVAN MOGHBEL
SIGNOFF DATE

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

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> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Boring 02-7 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

30

- @29.5m: joint inclined 70°, slickensided.
- @29.6m: 100 mm fracture zone, at bottom is 15 mm bedding plane, decomposed, slickensided.
- @29.7m: 75 mm fracture zone.
- @29.9m: bedding plane.
- @30m: joint inclined 40°, fresh, slickensided.
- @30.1m: joint inclined 60°.
- @30.2m: hairline bedding plane inclined 40°, calcite filled, slickensided.

REC=87% RQD=0% — 34

31

- @30.9m: bedding plane inclined 40°, 9 fractures per m, calcite filled, iron-oxide, slickensided.

REC=100% RQD=29% — 35

- @31.3m: 2 bedding plane inclined 50°, 21 fractures per m, clay and iron-oxide filled.
- @31.6m: 50 mm fracture zone.
- @31.6m: joint inclined 40°, calcite filled.

32

- CLAYSTONE (same as above), hard, intensely fractured, only angular fragments of shale recovered, iron-oxide on surfaces.

REC=100% RQD=0% — 36

- CLAYSTONE (same as above), intensely fractured, only pebbles of shale recovered, hard, clay filled.
- @32.7m: bedding joint inclined 40°, calcite filled.

33

REC=67% RQD=0% — 37

- @33m: shale fragments, gouge, soil like, yellowish brown with black.
- @33.1m: no core recovery.
- CLAYSTONE, black and yellowish brown (shear zone and gouge), moderately to intensely weathered, soft to moderately hard, intensely fractured.
- @33.5m: 150 mm thick fracture zone, yellowish-brown gouge, moderately to intensely weathered, fractures mostly inclined 40°, shale fragments and recrist. calcite.

34

REC=100% RQD=0% — 38

- @33.7m: calcite veining, hairline, mostly parallel to core axis.
- @33.9m: 125 mm thick fracture zone (as above).
- @34m: bedding plane inclined 40°.
- @34m: rock structure is still visible but can be reduced to soil with finger pressure, black shale fragments in gouge.
- CLAYSTONE, hard, slightly weathered, intensely fractured, non-fissile.
- @34.2m: joint, inclined 30°, iron-oxide wavey surface, clay filling, calcite.

REC=100% RQD=0% — 39

35

- @34.4m: joint inclined 70°, stepped, iron-oxide.
- @34.5m: planes inclined 40°, iron-oxide, calcite, planar surface-probably bedding but no change in lithography evident to confirm.
- @34.7m: 115 mm thick fracture zone, rock is intensely fractured, clay fill.
- CLAYSTONE with interstitial clay, slightly weathered, hard, interstitial clay.
- @34.9m: SHALE, black, slightly weathered to fresh, hard to soft in shear zones (where rock is locally decomposed), intensely fractured.
- @35.1m: slightly weathered, joint inclined 60°, 9 fractures per m, slightly rough, iron-oxide.

REC=9% RQD=26% — 40

36

- @35.4m: 50 mm fracture/shear zone, decomposed, clay filled rock is decomposed, 9 fractures per m.
- @35.5m: joint inclined 60°, slightly weathered, slightly rough, iron-oxide.
- @35.6m: joint inclined 70°, slightly rough, iron-oxide.
- @35.7m: joint inclined 70°, slightly rough, iron-oxide.
- @35.8m: 25 mm calcite vein.
- @35.9m: closed fractures.
- @36m: 50 mm thick fracture zone, clay filled, rock is decomposed.
- @36.2m: 75 mm thick fracture zone, clay filled, rock is decomposed.
- CLAYSTONE (same as above), 15 fractures per m.
- @36.5m: joint inclined 60°.

37

REC=100% RQD=17% — 42

- @36.6m: flat joint, iron-oxide, almost parallel to core axis, slightly rough.
- @36.8m: mechanical break, fresh surface.
- @36.9m: bedding plane inclined 70°.
- @36.9m: mechanical break.
- @37m: 25 mm fracture zone, iron-oxide, almost parallel to core axis.
- CLAYSTONE, black, moderately weathered, hard to soft (in shear zones), intensely fractured, non-fissile.
- @37.5m: 300 mm fracture zone bounded by joints at 60°, black shale fragments with yellowish-brown clay gouge, no rock structure identifiable.

REC=100% RQD=11% — 43

38

- @37.8m: 125 mm fracture zone (same as above).
- @38m: series of joints inclined from 40 to 60°, all joints have clay and iron-oxide fill, slightly rough, no calcite.
- CLAYSTONE (same as above), top 75 mm is gravel size, angular.
- @38.3m: 2 joints inclined approximately normal to each other (40 and 60° to core axis), slightly rough, iron-oxide.

REC=83% RQD=0% — 44

- @38.4m: joint inclined 85°, slightly rough.
- CLAYSTONE (same as above), hard.
- @38.7m: intact core (205 mm).
- @38.8m: closely spaced joints inclined 60°, 50°, clay fill, slightly rough, 9 fractures per m.

39

- @38.9m: 75 mm fracture zone.
- @39.1m: joint inclined 55°, clay fill, slightly rough, 50 mm fracture zone.

REC=100% RQD=19% — 45

- @39.3m: joint inclined 70°, clay fill, slightly rough, calcite veining, iron-oxide, 30 fractures per m.
- @39.4m: long joint, sub-parallel to core axis, calcite filled, iron-oxide.
- @39.5m: joint inclined 60°, clay fill, slightly rough.
- @39.6m: angular shale fragments.
- SHALE, black (same as above).
- @39.7m: closed joint inclined 60°, calcite filled, slightly rough, low fissility.

40

REC=100% RQD=0% — 46

- @39.8m: 30 mm thick calcite vein inclined 60°, 160 mm fracture zone.
- @40.1m: joint inclined 30°, iron-oxide, slightly rough.
- CLAYSTONE, black, slightly to moderately weathered, soft to hard, light reddish brown SANDSTONE interbeds, intensely fractured.
- @40.3m: joint inclined 40°, iron-oxide staining, smooth.
- @40.6m: 100 mm SANDSTONE interbed, coarse grained, contact hard to define due to breaks (about 60 to 70°).
- @40.8m: joint inclined 60°, calcite infilling.

41

REC=56% RQD=0% — 47

- @41.1m: 380 mm fracture zone, shale fragments, angular, well graded in yellowish-brown clay matrix.
- @41.3m: no core recovery.
- @41.5m: CLAYSTONE, black, moderately weathered, moderately hard to soft, intensely fractured.
- @41.5m: sereis of three bedding joints (about 50 mm apart) inclined 60°, clay and iron-oxide filled, slightly rough.
- @41.8m: closely joints two inclined at 50°, clay fill, stepped.
- @42m: 125 mm fracture zone.
- CLAYSTONE (same as above), 15 fractures per m.

42

REC=100% RQD=17% — 48

- @42.6m: joint inclined 30°, clay filled, slightly rough, calcite veining mostly parallel to core axis.

43

- @42.9m: joint inclined 40°, clay filled, slightly rough, 125 mm thick fracture zone.
- CLAYSTONE (same as above), greater than 100 fractures per m.
- @43.1m: joint inclined 70°, slightly rough.
- @43.3m: 210 mm fracture zone.

REC=95% RQD=0% — 49

- @43.5m: closely spaced closed bedding three inclined 70°.

44

- @43.8m: 100 mm thick fracture zone.
- @44m: joints, open, slickensided with greenish recrystallized mineral, possibly chlorite.
- CLAYSTONE, black, moderately to intensely weathered, soft to medium hard, intensely fractured, with SANDSTONE interbeds.

REC=100% RQD=0% — 50

- @44.1m: black gouge, still rock structure but clay consistency, joint inclined at 60°.
- @44.2m: SILTSTONE, light gray, moderately hard, bedding plane at 60° with core axis.

45

- @44.3m: black gouge (CLAYSTONE), rock structure but clay consistency, joint inclined 40°, slightly rough.
- @44.4m: closely spaced joints two inclined 40°, iron-oxide staining, slightly rough.
- @44.7m: 455 mm fracture zone, rock structure apparent, but soft, iron-oxide staining.
- CLAYSTONE, black and brown, moderately to intensely weathered, soft to moderately hard, intensely fractured, non-fissile.

PENETRATION DEPTH (m)

REC=100% RQD=0% — 51

- @45.1m: intensely weathered, soft, angular fragments of black shale up to 50 mm in clayey matrix (black and yellowish-brown).
- @45.4m: intensely weathered, soft, iron-oxide.

46

REC=100% RQD=0% — 52

- CLAYSTONE, black moderately weathered, medium hard with soft shear zones, intensely fractured, light gray SILTSTONE interbeds.
- @45.6m: SANDSTONE bedding plane, inclined 65°, closed.
- @45.8m: 25 mm fracture zone, intensely weathered, black clay matrix with angular rock fragments, joint inclined at 70°, iron-oxide.
- @46m: 75 mm fracture zone, intensely weathered, rock is chipped into fine gravel in black clay matrix.

REC=86% RQD=40% — 53

- @46.1m: 25 mm fracture zone, intensely weathered (as above).

47

- CLAYSTONE, black, slightly to moderately weathered, medium hard with some locally soft zones, moderately fractured, non-fissile.
- @46.2m: closely spaced closed joints inclined 50°, 70°, bedding plane at 60°, color change.
- @46.4m: joint inclined 50°, clay fill, smooth, 3mm aperture, calcite veins.
- @46.8m: 50 mm fracture zone, soft, soil-like, joint inclined 70°, bedding joint at 65°.
- CLAYSTONE (same as above), decomposed locally.

REC=100% RQD=0% — 54

- @47.3m: shale is decomposed, still rock structure is visible bur clay consistency.

48

- @47.5m: closely spaced joint two inclined 50°, one at 60°, iron-oxide staining, slightly rough.
- @47.8m: 155 mm zone chipped into gravel.
- CLAYSTONE (same as above), moderately weathered to slightly weathered, intensely fractured, interbedded with light gray SANDSTONE.
- @48m: 75 mm fracture zone, closely spaced joints two inclined at 40°, iron-oxid, slightly rough.

REC=86% RQD=0% — 55

- @48.2m: two bedding planes inclined 75°, interbedded SILTSTONE, slightly rough.

49

- @48.3m: 25 mm fracture zone.
- @48.4m: open joint, sub-parallel to core axis, iron-oxide, stepped.
- @48.5m: 50 mm fracture zone.
- @48.5m: open joint inclined 30°, iron-oxide, stepped, calcite veins.

REC=133% RQD=0% — 56

- SANDSTONE, gray, moderately weathered, moderately hard, intensely fractured, greater than 30 fractures per m.
- @49m: closely spaced joints two inclined at 0°, two at 50°, one at 30°, iron-oxide, slightly rough to stpped, calcite veins.
- SANDSTONE/CLAYSTONE interbedded, light gray and black, moderately weathered, moderately hard, intensely fractured.

REC=100% RQD=0% — 57

50

- @49.4m: joint inclined 50°, iron-oxide on surface, stepped.
- @49.5m: SANDSTONE (75 mm), bedding plane inclined at 70°, shale (75 mm).
- @49.6m: joint inclined 50°, iron-oxide on surface, stepped.
- @49.8m: SANDSTONE, gravel size pieces up to 50 mm.

REC=100% RQD=0% — 58

- SANDSTONE, light gray, slightly weathered, moderately hard, intensely fractured, fine-grained but clearly visible grains.
- @50m: closely spaced joint inclined 25°, 70°, stepped, 50 mm thick calcite veins.

REC=100% RQD=0% — 59

- CLAYSTONE/SANDSTONE interbedded, black and light gray, intensely weathered, soft to moderately hard, intensely fractured.

51

- @50.5m: only gravel sized angular fragments recovered up to 75 mm diameter.
- @50.8m: joint inclined 50°, slightly rough.
- @51m: 150 mm zone of gravel sized SANDSTONE.

REC=100% RQD=0% — 60

- @51.1m: 50 mm fracture zone, CLAYSTONE fragments in clayey matrix, joint inclined at 50°, stepped.
- @51.3m: 10 mm fracture zone, CLAYSTONE fragments in black clayey matrix.
- SANDSTONE/SHALE interbedded incined at 60° (same as above).
- @51.7m: gravel size rock fragments up to 50 mm, calcite fragments.

52

REC=100% RQD=0% — 61

- @51.9m: joint inclined 70°, slightly rough.
- @52m: bedding plane inclined 60°, slightly rough.
- @52.2m: SANDSTONE, fine grained, no iron-oxide on surfaces, joint inclined 70°, 30 fractures per m.
- @52.3m: bedding plane inclined 65°, slightly rough, joint inclined at 30°, slightly rough.
- SANDSTONE with CLAYSTONE interbeds, light gray and black, fresh to slightly weathered (no iron-oxide), moderately hard to hard, fracture zones located in shale.

53

REC=100% RQD=0% — 62

- @52.5m: 50 mm thick shale bedding planes inclined 70°.
- @52.7m: series of three closed joints inclined 50°, 25 mm apart.
- @52.8m: hairline calcite veining, joint inclined at 30°, stepped.
- @52.9m: 175 mm fracture zone, soft, rock fragments in clayey matrix.
- SANDSTONE with CLAYSTONE interbeds (same as above), fresh to slightly weathered, intensely fractured tectonically, no iron-oxide on joint surfaces.

REC=100% RQD=0% — 63

- @53.1m: gravel size fragments up to 50 mm diameter.
- @53.3m: hard, joint inclined 20°, calcite vein 50 mm thick.
- @53.4m: 50 mm thick CLAYSTONE interbed, soft, clayey consistency, large calcite fragments.

54

- @53.7m: fracture zone, ground up rock, very small fragments of rock, coarse sand size in a clayey matrix, dark gray with abundant calcite fragments.
- SANDSTONE with CLAYSTONE interbeds (same as above), fine-grained.
- @53.9m: black CLAYSTONE interbed, clay consistency with SANDSTONE, inclined 60°.

REC=57% RQD=0% — 64

- @54m: calcite vein, hairline to 30 mm.
- @54.1m: 100 mm fracture zone in sandstone.
- @54.3m: bedding plane inclined 65°, 50 mm thick, calcite filled.
- @54.4m: black CLAYSTONE interbed, clay consistency with SANDSTONE.

55

- SANDSTONE with CLAYSTONE interbeds, light gray and black, fresh, moderately hard, intensely fractured, fine to coarse grained sandstone, shale consists of about 1-5 % of run.

REC=100% RQD=19% — 65

- @55m: 100 mm thick fracture zone.
- @55.1m: 30 mm thick CLAYSTONE interbed inclined 60°.
- @55.2m: 30 mm thick CLAYSTONE interbed inclined 60°.
- @55.3m: SHALE inclusions in SANDSTONE, 50 mm thick calcite vein parallel to core axis.

56

REC=100% RQD=0% — 66

- @55.4m: coarser grained SANDSTONE, 30 mm thick fracture zone with SHALE interbeds.
- SANDSTONE with CLAYSTONE interbeds (same as above).
- @55.6m: gravel size fragments up to 15 mm.
- @55.8m: closely spaced joint inclined 20°, 70°, 50 mm thick calcite vein.
- @56m: 100 mm thick fracture zone, calcite vein up to 25 mm thick.
- SANDSTONE with CLAYSTONE interbeds, light gray and black, fresh, slightly fractured, 10 to 15 fractures per m, sandstone is fine to coarse grained with pervasive calcite veins.

57

Boring 02-7 Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT	KEYHAN MOGHBEL
SIGNOFF DATE	
DESIGN	BY S. VARATHARAJ 11/20/02
CHECKED	BY S. SICILIANO 2/10/03
FIELD INVESTIGATOR(S)/TITLE	J. CASTLE, P. FRAME, M. HACHEY, L. PATZKOWSKI, & S. SICILIANO
DATE	8/17/02 to 8/30/02
PREPARED FOR THE	STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION
PROJECT ENGINEER	M. KAPUSKAR
BRIDGE No.	
KILOMETER POST	

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

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0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

TYPE OF BORINGS

2½" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Top Hole El.; Permanent Casing driven; Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; GWS Elev.; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date

ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

Boring 02-7 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

56

- SANDSTONE with CLAYSTONE interbeds, light gray and black, fresh, slightly fractured, 10 to 15 fractures per m, sandstone is fine to coarse grained with pervasive calcite veins.
- @56.2m: closley spaced joints inclined 60°, 40°, slightly rough, 2mm aperture.

57 — REC=100% RQD=70% — 67

- @56.5m: bedding plane between fine and coarse grained SANDSTONE inclined 60°, slightly rough (below is coarse grained).
- @56.7m: joint inclined 80°, slightly rough.
- @57.1m: 50 mm thick interbed, black, soft, clay (decomposed).
- @57.3m: intact SANDSTONE, medium grained with pervasive calcite veining.
- SANDSTONE, light gray, fresh, hard to very hard, slightly fractured, 3 to 5 fractures per m, fine to medium grained.

58

- @57.8m: closely spaced joints inclined 40°, 30°, bedding plane at 60°, 50 mm thick calcite vein.

REC=100% RQD=81% — 68

- @58.2m: massive SANDSTONE, no shale interbed, good quality rock, stepped fractures.
- @58.5m: joint inclined 75°.
- SANDSTONE (same as above), massive, fine to coarse grained.

59

- @58.9m: closely spaced closed joints inclined 40°, 80°, calcite veins up to 10 mm thick.

REC=100% RQD=53% — 69

60

- @59.8m: mostly fine grained above, coarse grained with 40% calcite inclusions below.
- @60m: joint inclined 40°.
- SANDSTONE, light to medium gray, fresh, hard, slightly fractured to massive, 6 fractures per m, mostly coarse grained with pervasive calcite veins.
- @60.2m: mechanical break.
- @60.4m: shale interbed inclined 75°, slightly rough.
- @60.7m: joint inclined 30°, few small black clasts of shale trapped in a sandstone matrix.

61 — REC=100% RQD=78% — 70

- @61m: mechanical break.
- @61.1m: joint inclined 60°, 50 mm thick calcite vein.
- SANDSTONE (same as above).
- @61.6m: joints inclined 30°, 40°, stepped.

62

- @61.8m: CONGLOMERATE, light gray with multicolored clasts, fresh, hard, slightly fractured, bedding plane inclined 70°, rough.

REC=100% RQD=54% — 71

- @61.9m: 25 mm fracture zone.
- @62m: calcite veins.
- @62.2m: clasts of sedimentary rocks of different colors, limited in a coarse sandstone matrix, size of clasts is up to 50 mm, well graded, clasts are generally rounded indicating transport.
- @62.2m: joint inclined 40°, rough.
- @62.6m: joint inclined 20°, rough.

63

- CONGLOMERATE, light gray with multicolored clasts, fresh, hard, moderately fractured, clasts of sedimentary and igneous rocks up to 50 mm, rounded.
- @62.9m: grandorite clast (white quartz minerals/plagioclase, non reactive to HCL).
- @63m: 60 mm fracture zone.
- @63.2m: calcite vein up to 15 mm thick inclined 50°.
- @63.2m: calcite vein up to 15 mm thick inclined 50°.

REC=100% RQD=60% — 72

- @63.3m: large clast (75 mm) of sedimentary rock, rounded.
- @63.5m: joint normal to core axis, stepped.
- @63.5m: clasts made of sandstone, siltstone, shale and igneous rocks, no oxidation on joints.

64

- @63.6m: joint normal to core axis, stepped.
- @63.7m: joint inclined 85°.
- @64m: joint inclined 30°, stepped.
- @64.2m: joint inclined 30°, stepped.
- CONGLOMERATE (same as above), with shale interbeds, hard.
- @64.4m: clasts in conglomerate made of multicolored sedimentary and in minor proportions, igneous (granodiorite) rocks, rounded.
- @64.6m: 25 mm fracture zone.
- @64.7m: break along clast contact.

65

- @64.9m: break along clast contact, no oxide, fresh rock.

REC=100% RQD=47% — 73

- @65.1m: joint inclined 30°, stepped, 5 mm aperture.
- @65.2m: joint inclined 30°, joint re-healed with calcite.
- @65.3m: two fresh, 50 mm thick, black shale interbeds inclined 60°.
- @65.6m: shale interbed inclined 60°.
- @65.8m: shale interbed inclined 60°.

66

- CONGLOMERATE (same as above), less clasts in fine grained matrix and more shale interbeds.
- @65.9m: joint inclined 40°, stepped.
- @66m: fewer rounded clasts than above, in medium grained sandstone (matrix of conglomerate).
- @66.1m: open joint inclined 40°, stepped.

REC=100% RQD=58% — 74

- @66.4m: bedding plane inclined 75°.
- @66.5m: 150 mm fracture zone in shale/sandstone.
- @66.8m: series of CLAYSTONE interbeds with fine to coarse SANDSTONE matrix (300 mm thick), inclined 60°.

67

- SANDSTONE/CLAYSTONE interbeds, light gray and black, fresh, intensely fractured, pervasive calcite veining, shale is slightly fissile.

REC=100% RQD=0% — 75

- @67.1m: 25 mm thick fracture zone in interbedded shale.
- @67.2m: joint inclined 40°, stepped, calcite filled joint.
- @67.4m: CLAYSTONE, fresh bedding plane inclined 70°.
- @67.6m: series of bedding planes inclined 70°, claystone appears to be fissile, fractures parallel to bedding.

68

- @67.7m: 25 mm fracture zone in claystone.
- SANDSTONE/CLAYSTONE interbeds, (same as above).
- @67.9m: joint inclined 70°, slightly rough.
- @68m: bedding plane between SANDSTONE (above) and CLAYSTONE (below), inclined 60°.

REC=100% RQD=10% — 76

- @68.1m: 300 mm fracture zone bounded by joints inclined 60°.
- @68.3m: 50 mm thick bed of claystone inclined 60°.
- @68.4m: 75 mm thick coarse grained sandstone bed inclined 60°.
- @68.5m: 100 mm thick bed of claystone inclined 60°.
- @68.6m: 100 mm thick bed of sandstone inclined 60°.

69

- @68.8m: 230 mm thick fracture zone in shale.
- @69.1m: CONGLOMERATE, light gray with multicolored clasts, fresh, hard, slightly fractured, clasts composed primarily of rounded sedimentary rocks.
- @69.5m: 600 mm intact core, clasts up to 50 mm, mostly rounded, the matrix appears to be medium to coarse SANDSTONE.

REC=100% RQD=62% — 77

70

- @69.9m: joint, parallel to core axis, open.
- @70.1m: joint inclined 60°, stepped.
- @70.2m: joint inclined 60°, stepped.
- @70.3m: joint inclined 70°, stepped.
- CONGLOMERATE (same as above).
- @70.5m: joint perpendicular to core axis.
- @70.7m: 100 mm thick fracture zone, breaks along clast boundries.

71

- @71.1m: small faults offsetting large clasts.

REC=100% RQD=85% — 78

- @71.2m: calcite vein up to 65 mm thick.
- @71.4m: joint inclined 40°, slightly rough.
- @71.5m: larger, rounded clasts than above, composed primarily of sedimentary rocks, 5% of igneous (granitic).
- @71.7m: joint inclined 40°, slightly rough.

72

- CONGLOMERATE (same as above), one shale interbed.

73

PENETRATION DEPTH (m)

72

- CONGLOMERATE (same as above), one claystone interbed.
- @72m: 25 mm thick fracture zone.
- @72.2m: 75 mm thick fracture zone, clasts break along boundaries.
- @72.4m: fresh, closed joint inclined 70°.
- @72.6m: 75 mm zone of shale interbeds inclined 60°, slightly rough, some fissility.

REC=100% RQD=77% — 79

73

- @72.8m: 400 mm long intact conglomerate core.
- @73.1m: joint inclined 60°.
- @73.1m: joint inclined 60° (uncertain, may be mechanical break).
- @73.3m: 325 mm long intact conglomerate core.
- CONGLOMERATE (same as above), no interbedded shale.
- @73.6m: clasts vary in color from green to yellow to black to red, subrounded in shape, mostly sedimentary but also granitic 95%).
- @73.8m: fracture perpendicular to core axis, fresh, stepped, 5 mm aperture.

74

- @74m: 50 mm fracture zone, breaks along clast boundaries.

REC=100% RQD=75% — 80

- @74.2m: no evident calcite veining.
- @74.4m: joint perpendicular to core axis, stepped, 10 mm aperture.
- @74.6m: 380 mm long intact core.

75

- @74.9m: 75 mm fracture zone (may be mechanical breaks).
- CONGLOMERATE (same as above).
- @75m: mechanical break.
- @75.2m: granitic boulder, white.
- @75.3m: bedding plane inclined 60°, clasts in conglomerate make joint surfaces stepped.
- @75.3m: joint inclined 60°, stepped.
- @75.6m: joint inclined 40°.

76 — REC=100% RQD=92% — 81

- @76m: break along cobble perimeter.
- @76.1m: 40 mm fracture zone, breaks along clast boundaries.
- @76.5m: fracture zone, probably mechanical.
- CONGLOMERATE (same as above).
- @76.8m: joint inclined 20°, stepped.
- @76.8m: 25 mm thick fracture zone.

77

- @77.1m: joint inclined 50°, stepped.

REC=100% RQD=57% — 82

- @77.3m: joint perpendicular to core axis, stepped.
- @77.4m: joint inclined 20°, stepped.

78

- @77.7m: SANDSTONE, light gray, fresh, hard, moderately fractured, coarse grained with coarse gravel size black angular shale fragments.
- @77.8m: fracture zone, probably mechanical breaks due to drilling, all joint surfaces are fresh.
- SANDSTONE (same as above).
- @78m: joint inclined 20°, stepped, closed.

REC=100% RQD=31% — 83

- @78m: shale fragments are angular (versus rounded conglomerate clasts) indicating no transport (or less), black, up to 5 mm.
- @78.5m: joint inclined 30°, stepped.
- @78.6m: 180 mm thick fracture zone.

79

- SANDSTONE (same as above), moderately hard, moderately to intensely fractured.
- @79.1m: fracture sub parallel to core axis.
- @79.2m: joint perpendicular to core axis, stepped.
- @79.3m: few (1-5%) clasts up to 25 mm, still well graded sandstone.

REC=100% RQD=0% — 84

- @79.4m: joint perpendicular to core axis.
- @79.5m: 150 mm thick fracture zone.
- @79.6m: 40 mm thick calcite vein.
- @79.7m: joint perpendicular to core axis.

80

- @79.8m: 150 mm thick fracture zone, poor cementation.
- SANDSTONE (same as above).
- @80m: series of hairline calcite veining 300 mm length of run interrupted by 50 mm fracture zone.

REC=100% RQD=37% — 85

- @80.6m: joint inclined 20°, stepped, 10 mm aperture.
- @80.6m: 200 mm fracture zone, poor cementation, slickensided joint surfaces.

81

- @80.9m: generally rock exhibits poor cementation and consequently low strength.
- @81m: fresh bedding joint inclined 60°, stepped.
- @81.2m: joint inclined 40°, stepped.
- @81.3m: joint inclined 40°, stepped.
- SANDSTONE (same as above), uniform fine grained.

82

- @81.9m: steep joint sub paralles to core axis, may be mechanical, no oxidation or calcite filling.
- @82.1m: 120 mm fracture zone, poor cementation.

REC=100% RQD=25% — 86

- @82.2m: calcite filled joint inclined 15°, slightly rough, 5 mm aperture.
- @82.3m: 25 mm thick fracture zone.
- @82.5m: series of hairline calcite veins inclined 30°.
- @82.6m: calcite filled joint inclined 30°, slightly rough.

83

- @82.9m: 175 mm thick fracture zone, probably mechanical at end of run.
- SANDSTONE (same as above), moderately hard, moderately to intensely fractured.
- @83m: joint inclined 50°, stepped.
- @83.2m: series of flat, calcite filled joints inclined from 20 to 30° over 300 mm of core length, stepped.
- @83.5m: joint inclined 35°, stepped.

REC=100% RQD=18% — 87

- @83.7m: joint inclined 70°, stepped.

84

- @83.9m: joint inclined 40°, stepped.
- @84m: joint inclined 40°, stepped.
- @84.4m: 100 mm thick fracture zone.
- SANDSTONE (same as above).

Boring 02-7 Continued on LOTB Sheet of

VERTICAL SCALE 1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
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J. CASTLE, P. FRAME, M. HACHEY, L. PATZKOWSKI, & S. SICILIANO — FIELD INVESTIGATOR(S)/TITLE	DATE 8/17/02 to 8/30/02		

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No. / KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

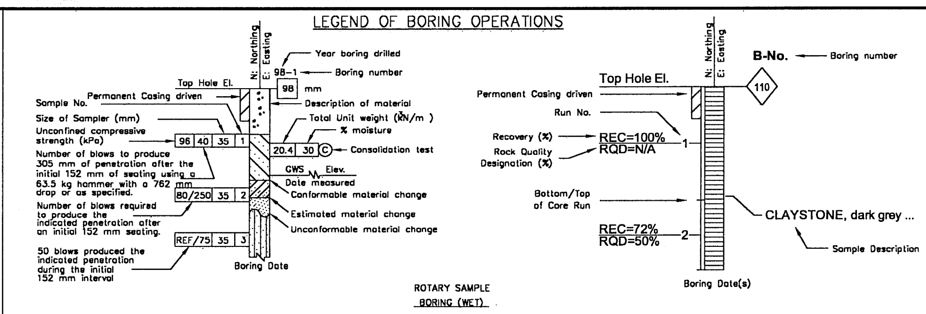
TYPE OF BORINGS

2½" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-7 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

- @84.5m: joint inclined 50°, slightly rough, open.
- 85
- REC=100% RQD=29% — 88
- @85m: joint inclined 20°, stepped, 5 mm aperture.
- @85.1m: 150 mm thick fracture zone.
- @85.3m: joint inclined 25°, stepped, planar, no filling with associated cross-joints, stepped surface.
- @85.5m: joint inclined 30°, stepped, planar, no filling with associated cross-joints, stepped surface.
- @85.6m: 75 mm thick fracture zone.
- 86
- SANDSTONE (same as above), light gray, slightly weathered, soft to moderately hard, intensely fractured, crushed in shear zones.
- @85.8m: fresh bedding plane inclined 60°, change in grain size.
- @85.9m: joint inclined 20°.
- REC=100% RQD=39% — 89
- @86.1m: joint inclined 40°, stepped, 50 mm aperture.
- @86.2m: decomposed soil-like consistency, dark gray clay, beginning of fault zone, tectonically crushed into soft clay.
- @86.3m: decomposed joint inclined 20°, clay filled, slightly rough.
- @86.4m: decomposed joint inclined 20°, clay filled, slightly rough.
- @86.5m: some slickensides on joint.
- 87
- SANDSTONE, dark gray, slightly weathered, soft, intensely fractured, locally reduced to uncemented soil.
- REC=69% RQD=0% — 90
- @86.7m: rock structure is still visible, bur rock is decomposed into soil-like material by tectonic fracturing.
- @87m: 50 mm zone of uncemented sand.
- @87.2m: decomposed joint inclined 40°.
- @87.2m: no core recovery (poor recovery due to washing away of soil portion).
- SANDSTONE (same as above), dark gray, intensely weathered, soft, intensely fractured, locally reduced to uncemented soil.
- 88
- REC=100% RQD=0% — 91
- @87.7m: intensely weathered to decomposed, still joints recognizible but mostly uncemented soil, joint inclined 30°, stepped.
- @87.9m: joint inclined 30°, stepped.
- @88.1m: joint inclined 30°, stepped.
- SANDSTONE (same as above), slightly weathered, medium hard, fine to coarse grained, less weathering than previous run.
- @88.1m: 75 mm thick fracture zone.
- REC=100% RQD=11% — 92
- @88.3m: joint inclined 30°, slightly rough, clay fill.
- @88.3m: joint inclined 40°, slightly rough, clay fill.
- 89
- @88.4m: joint inclined 40°, slightly rough, clay fill.
- @88.5m: joint inclined 50°, slightly rough, clay fill.
- @88.6m: joint inclined 40°, slightly rough, clay fill.
- @88.8m: joint inclined 50°, slightly rough, clay fill.
- @88.9m: joint inclined 40°, slightly rough, clay fill.
- SANDSTONE, light gray, fresh, moderately hard, moderately fractured, fine to coarse grained.
- @89.1m: no evident change in grainsize/lithology, difficult to distinguish bedding.
- @89.3m: joint inclined 50°, stepped, 5 mm aperture.
- 90
- REC=100% RQD=28% — 93
- @89.3m: joint inclined 30°, stepped, 5 mm aperture.
- @89.5m: probable mechanical break.
- @89.6m: joint inclined 40°, stepped, 5 mm aperture.
- @89.6m: joint inclined 40°, stepped, 5 mm aperture.
- @89.8m: joint inclined 30°, stepped, closed.
- @90.1m: joint inclined 30°, slightly rough.
- @90.3m: joint inclined 10°, slightly rough, clay filled, moderately thin.
- SANDSTONE (same as above), locally decomposed and poorly cemented.
- 91
- @90.8m: beding plane inclined 60°, stepped.
- @90.9m: joint inclined 40°, stepped.
- @91.1m: joint inclined 40°, clay filled, steppped.
- REC=100% RQD=46% — 94
- @91.2m: 100 mm racture zone, rock is decomposed to clayey sand, coarse.
- @91.4m: joint inclined to 50°, clay filled (joints in proximity of fault zone are clay filled).
- @91.7m: 175 mm thick fracture zone, rock is decomposed to clayey sand, coarse.
- 92
- SANDSTONE, light gray, slightly weathered to fresh, moderately hard, slightly fractured, well indurated, well graded with clasts up to 25 mm.
- @91.9m: fresh bedding pland inclined 60°, stepped, change into sandstone with angular to subrounded clasts up to 25 mm.
- @92.3m: joint inclined 30°, slightly rough.
- REC=100% RQD=72% — 95
- 93
- @92.9m: joint inclined 40°, slightly rough, open.
- @92.9m: calcite vein inclined 40°, hairline thick, closed.
- @93m: joint inclined 20°, stepped.
- @93.1m: joint inclined 20°, stepped.
- SANDSTONE (same), light gray, fresh, slightly fractured, hard, well indurated.
- @93.4m: joint inclined 50°, stepped, closed.
- @93.5m: fresh bedding plane inclined 60°, stepped, closed.
- @93.6m: fresh bedding plane inclined 60°, stepped, open.
- 94
- @93.7m: joint inclined 30°, calcite filled, stepped, closed.
- @93.8m: fresh bedding plane inclined 70°, closed, coarse grained above, fine grained below, 15 mm thick calcite veins.
- REC=100% RQD=60% — 96
- @94.4m: 450 mm long intact core.
- @94.7m: joint inclined 60°, open.
- 95
- SANDSTONE (same as above).
- @95m: joint inclined 20°, closed, 480 mm long intact core.
- REC=100% RQD=77% — 97
- @95.4m: joint inclined 60°.
- @95.4m: joint inclined 60°.
- @95.5m: joint inclined 50°.
- 96
- @95.8m: three 5 mm thick calcite veins approximately 50 mm apart.
- SANDSTONE (same as above), moderately fractured to locally intensely fractured.
- @96.1m: joint inclined 40°, calcite filled, closed.
- @96.3m: bedding plane inclined 60°, fine grained above, coarse grained below.
- REC=100% RQD=36% — 98
- @96.5m: joint inclined 30°, calcite filled, closed.
- @96.6m: joint inclined 60°.
- 97
- @96.8m: 200 mm thick fracture zone, rock is fresh but intensely fractured (probably due to drilling).
- SANDSTONE, medium gray, fresh, moderately hard, slightly fractured with locally intensely fractured zones, fine to coarse grained, well indurated.
- @97.1m: 20m mlong intact core.
- @97.2m: joint inclined 70°, smooth, moderately thin.
- (UC)(E) @97.2m
- REC=100% RQD=67% — 99
- (UC)(E) @97.3m
- @97.4m: 380 mm long intact core.
- @97.6m: 50 mm fracture zone, joints at either end inclined 60°, slightly rough, 5 mm aperture (no evidence such as chane in lothography, grain size to suggest bedding).
- 98
- @97.7m: two joints inclined 60°, slightly rough, 5 mm aperture.
- @97.9m: series of calcite veins, 5 mm thick.
- @98.1m: joint inclined 40°.
- SANDSTONE (same as above).
- @98.2m: bedding plane inclined 60°, slightly rough.
- @98.3m: joint inclined 40°, slightly rough.
- (UC)(E) @98.4m
- 99
- (UC)(E) @98.5m: joint inclined 40°.
- REC=100% RQD=53% — 100
- @98.7m: joint inclined 40°, slightly rough.
- @98.9m: joint inclined 30°, slightly rough.
- @99m: mechanical break.
- @99.1m: joint inclined 60°, slightly rough.
- @99.3m: joint inclined 40°, smooth.
- @99.5m: mechanical break.
- @99.6m: joint inclined 40°, smooth.
- SANDSTONE (same as above), pervasive calcite veining.
- 100
- @100m: joint inclined 40°, rough, 10 mm aperture.
- @100.1m: 25 mm thick calcite vein.
- @100.2m: joint inclined 40°, slightly rough, calcite filled.
- REC=100% RQD=52% — 101
- @100.3m: joint inclined 20°, slightly rough.
- @100.3m: 15 mm thick calcite vein.
- @100.5m: joint inclined 50°, slightly rough, 25 mm thick calcite vein.
- 101
- @100.8m: joint inclined 40°, slightly rough, calcite filled.
- @101m: joint inclined 30°, slightly rough.
- SANDSTONE, light gray, fresh, moderately hard, fresh to slightly fractured, fine to coarse grained with coarse particles up to 5 mm, well graded.
- 102

PENETRATION DEPTH (m)

- 101
- @101.3m: joint inclined 60°, stepped, open.
- @101.4m: mechanical break.
- REC=100% RQD=73% — 102
- @101.4m: joint inclined 70°, stepped, open.
- @101.7m: joint inclined 60°, calcite filled, 10 mm aperture.
- @101.8m: joint inclined 40°, calcite filled, 10 mm aperture.
- 102
- @101.9m: calcite vein inclined 20°, hairline to 50 mm thick.
- SANDSTONE (same as above), moderately to intensely fractured.
- @102.4m: 50 mm thick fracture zone.
- @102.6m: joint inclined 40°, stepped, 20 mm thick calcite vein.
- REC=100% RQD=35% — 103
- @102.7m: joint inclined 40°, stepped.
- @102.7m: joint inclined 30°, stepped.
- 103
- @103m: 15 mm thick clay filled joint, stepped.
- @103.2m: joint inclined 50°, stepped, calcite filled.
- @103.3m: joint inclined 30°, stepped.
- SANDSTONE (same as above).
- @103.6m: closed parallel joints, no change in lithology evident.
- @103.8m: joint inclined 50°, rough, open, 10 mm aperture.
- 104
- REC=100% RQD=100% — 104
- @103.9m: joint inclined 40°, rough, open, 10 mm aperture.
- @104.2m: 5 mm calcite veins inclined 40 - 50°.
- SANDSTONE (same as above).
- @104.4m: hairline calcite veins inclined 40°.
- @104.4m: hairline calcite veins inclined 50°.
- @104.5m: joint inclined 40°, rough, moderately thin.
- @104.6m: joint inclined 50°, rough, moderately thin.
- 105
- REC=100% RQD=75% — 105
- @105.2m: joint inclined 60°, rough, 20 mm aperture.
- @105.7m: 50 mm thick fracture zone.
- SANDSTONE (same as above), angular clasts up to 15 mm diameter.
- 106
- @105.9m: few angular clasts of shale, indicating no or little transport.
- @106m: joint perpendicular to core axis, slightly rough, 2mm aperture.
- @106.2m: a few angular clasts of shale.
- @106.3m: a few angular clasts of shale.
- REC=100% RQD=80% — 106
- @106.7m: joint perpendicular to core axis, slightly rough, moderately thin.
- 107
- @107m: joint inclined 30°, slightly rough, moderately thin.
- @107.2m: joint inclined 30°, slightly rough, 2mm aperture, calcite filled.
- SANDSTONE (same as above), moderately hard, massive conglomerate with on apparent bedding.
- @107.7m: 50 mm rectangular clast.
- 108
- @107.9m: joint inclined 70°, rough, open.
- @108m: slight increase in conglomeratic clasts.
- REC=100% RQD=68% — 107
- @108.1m: 3mm thick calcite vein inclined 40°.
- @108.2m: 2mm thick calcite vein inclined 50°.
- @108.3m: joint inclined 40°, slightly rough, 2mm aperture.
- @108.7m: 100 mm thick fracture zone.
- 109
- SANDSTONE (same as above), with 25 mm clasts aligned about 55° with core axis.
- @109.1m: 40 mm fracture zone, joint inclined 40°, rough, moderately thin.
- @109.3m: joint inclined 50°, rough, moderately thin.
- @109.4m: joint inclined 35°, rough, moderately thin.
- REC=100% RQD=27% — 108
- @109.5m: joint inclined 15°, rough, moderately thin.
- @109.7m: joint inclined 20°.
- @109.7m: joint inclined 20°.
- 110
- @110m: joint inclined 30°, rough, moderately thin filled with clayey sand.
- @110.3m: joint inclined 40°, rough, moderately thin.
- SANDSTONE (same as above), light gray, fresh, hard, slightly fractured, fine to coarse grained, conglomertic, small angular clasts up to 4mm.
- @110.7m: joint inclined 25°, rough, moderately thin.
- 111
- @110.9m: predominatley fine grained SANDSTONE, joint inclined 70°, rough, moderately thin.
- REC=100% RQD=77% — 109
- @111m: joint inclined 60°, rough, moderately thin, calcite veins, 5 mm thick.
- @111m: joint inclined 60°, rough, moderately thin.
- @111.2m: joint inclined 40 and 50°, rough, 10 mm aperture, 15 mm calcite border and clay filled.
- @111.5m: grading back to CONGLOMERATE, clasts up to 40 mm, rounded, similar in nature to conglomerate but still SANDSTONE, contact is gradual, clasts aligned about 60° with core axis.
- 112
- (UC)(E)(TX)(DS) @111.6m
- SANDSTONE (same as above), slightly fractured, conglomeritic, clasts are up to 40 mm and subrounded, multicolored, mostly sedimentary.

Boring 02-7 Continued on LOTB Sheet of

VERTICAL SCALE

1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT KEYHAN MOGHBEL

SIGNOFF DATE

DESIGN BY S. VARATHARAJ 11/20/02

CHECKED BY S. SICILIANO 2/10/03

J. CASTLE, P. FRAME, M. HACHEY, L. PATZKOWSKI, & S. SICILIANO — FIELD INVESTIGATOR(S)/TITLE

DATE 8/17/02 to 8/30/02

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.

KILOMETER POST

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
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- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

TYPE OF BORINGS

- 2¼" CONE PENETRATION
- ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- AUGER BORING (DRY)
- TEST PIT
- DIAMOND CORE BORING
- SOIL TUBE

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- (W) WASH #200
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- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Top Hole El.; Permanent Casing driven; Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified.; Number of blows required to produce the indicated penetration after an initial 152 mm seating.; 50 blows produced the indicated penetration during the initial 152 mm interval; Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date; ROTARY SAMPLE BORING (WET)

Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; B-No. — Boring number; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

Boring 02-7 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

112

@112.1m: joint inclined 30°, stepped, 2mm aperture.

113 — REC=100% RQD=88% 110

@112.7m: fresh, hairline joint inclined 30°, calcite filled.
(UC)(E) @112.8m
(UC)(E) @112.8m: mechanical break.
@113.1m: 10 mm thick calcite vein.
@113.1m: joint inclined 30°, stepped, grading into fine-grained sandstone.

SANDSTONE (same as above).

114

@113.6m: mechanical break.
@113.7m: joint inclined 45°, rough, moderately thin, fine grained above, coarse grained with clasts up to pea gravel size below.
@113.9m: joint inclined 30°, closed, calcite filling.
@114m: joint inclined 20°, stepped, moderately thin, calcite filling, offsetting 10 mm calcite vein.

REC=100% RQD=67% 111

@114.2m: joint inclined 30°, stepped, thin.
@114.3m: closed joint sub parallel to core axis.
@114.4m: joint inclined 40°, stepped, moderately thin.

115

@114.7m: joint inclined 50°, stepped, moderately thin.
@114.8m: joint inclined 40°.
@114.9m: joint inclined 50°.
SANDSTONE, light gray, fresh, hard, slightly to moderately fractured, brecciated with angular clasts up to 40 mm.
@115.1m: sandstone os locally brecciated (I.e. clasts are angular vs conglomerate which has rounded clasts).
@115.3m: joint inclined 60°, moderately thin, calcite filling.
@115.4m: joint inclined 60°, slightly rough, moderately thin.
@115.4m: joint inclined 40°, slightly rough, moderately thin.
@115.6m: 10 mm thick chloride filled joint.

116 — REC=100% RQD=72% 112

@116.1m: 50 mm thick calcite bed.
@116.1m: 15 mm thick fracture zone.
@116.2m: joint inclined 40°, moderately thin.
@116.4m: joint inclined 50°, moderately thin.
SANDSTONE (same as above), brecciated.
@116.6m: clasts in breccia are up to pea gravel in size, angular and composed mostly of black claystone.
@116.7m: joint inclined 40°, stepped, moderately thin.

117

REC=100% RQD=95% 113

@117.5m: mechanical break.

118

@117.8m: joint inclined 50°, stepped, moderately thin.
@117.9m: joint inclined 50°, stepped, moderately thin.
SANDSTONE (same as above).
@118m: joint inclined 40°, slightly rough, moderately thin.

REC=100% RQD=73% 114

@118.4m: joint inclined 50°, slightly rough, moderately thin.
@118.4m: joint inclined 50°, slightly rough, moderately thin.

119

SANDSTONE, light gray, fresh, hard, slightly fractured, few claystone clasts in sandstone matrix, subrounded, up to pea gravel size.
@119m: hairline joint, closed, calcite filling.

REC=100% RQD=77% 115

@119.1m: joint inclined 30°, slightly rough, very thin.
@119.3m: joint inclined 30°, slightly rough, very thin.

@119.4m: joint inclined 40°, slightly rough, open.
SANDSTONE, light gray, fresh, hard, slightly to moderately fractured, with angular to subrounded fragments of rocks (brecciated).
@119.6m: mechanical breaks, angular, non-planar.

120

@119.9m: mechanical break.
@120m: joint inclined 20°, stepped, moderately thin.

REC=100% RQD=55% 116

@120.3m: mechanical break.
@120.4m: joint inclined 50°, stepped, moderately thin.
@120.5m: joint inclined 50°, stepped, moderately thin.
@120.6m: no apparent change of lithography/grain size or universal alignment of joints to indicate bedding.

121

@120.7m: joint inclined 40°, stepped, moderately thin.
@120.8m: joint inclined 50°, slightly rough, moderately thin.
@120.9m: joint inclined 50°, slightly rough, moderately thin.
SANDSTONE (same as above), massive sandstone, conglomeratic with clasts up to 5 mm diameter, angular, no indication of bedding.
@121.1m: joint inclined 50°, stepped, moderately thin.
@121.2m: joint inclined 80°, stepped, moderately thin.

REC=100% RQD=57% 117

@121.3m: joint inclined 50°, stepped, moderately thin.
@121.4m: joint inclined 50°, stepped, closed.

122

@121.5m: joint inclined 50°, stepped, closed.
@121.5m: joint inclined 50°, stepped, closed.
@121.6m: joint inclined 60°, stepped, moderately thin.
@121.8m: joint inclined 60°, stepped, moderately thin.
@121.8m: joint inclined 80°, stepped, moderately thin.
@121.9m: joint inclined 80°, stepped, open.
@122.1m: joint inclined 60°, stepped, open.
SANDSTONE (same as above).
@122.4m: three fresh, calcite healed joints inclined 60°, hairline to moderately thin, aligned with clasts, probable bedding.

123 — REC=100% RQD=100% 118

(UC)(E)(TX)(R) @122.7m: mechanical break.
@123m: joint inclined 55°, slightly rough, moderately thin.

@123.2m: joint inclined 50°, stepped.
@123.3m: joint inclined 60°, stepped.
@123.5m: joint inclined 40°, stepped.
@123.6m: Bottom of boring.

124

8/17/02 to 8/30/02

VERTICAL SCALE
1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

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PLAN APPROVAL DATE

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Caltrans Metric

DESIGN OVERSIGHT KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN	BY S. VARATHARAJ	11/20/02
CHECKED	BY S. SICILIANO	2/10/03

J. CASTLE, P. FRAME, M. HACHEY, L. PATZKOWSKI, & S. SICILIANO
FIELD INVESTIGATOR(S)/TITLE
DATE 8/17/02 to 8/30/02

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

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REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
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- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

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- (W) WASH #200
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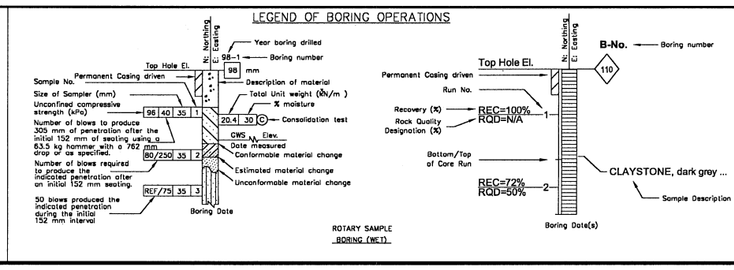
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-7 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

112
- @112.1m: joint inclined 30°, stepped, 2mm aperture.

REC=100% RQD=88% 110
113
- @112.7m: fresh, hairline joint inclined 30°, calcite filled.
- @112.8m
- @112.8m: mechanical break.
- @113.1m: 10 mm thick calcite vein.
- @113.1m: joint inclined 30°, stepped, grading into fine-grained sandstone.
- SANDSTONE (same as above).
- @113.6m: mechanical break.
- @113.7m: joint inclined 45°, rough, moderately thin, fine grained above, coarse grained with clasts up to pea gravel size below.

114
- @113.9m: joint inclined 30°, closed, calcite filling.
- @114m: joint inclined 20°, stepped, moderately thin, calcite filling, offsetting 10 mm calcite vein.

REC=100% RQD=67% 111
- @114.2m: joint inclined 30°, stepped, thin.
- @114.3m: closed joint sub parallel to core axis.
- @114.4m: joint inclined 40°, stepped, moderately thin.
- @114.7m: joint inclined 50°, stepped, moderately thin.
- @114.8m: joint inclined 40°.

115
- @114.9m: joint inclined 50°.
- SANDSTONE, light gray, fresh, hard, slightly to moderately fractured, brecciated with angular clasts up to 40 mm.
- @115.1m: sandstone os locally brecciated (I.e. clasts are angular vs conglomerate which has rounded clasts).
- @115.3m: joint inclined 60°, moderately thin, calcite filling.
- @115.4m: joint inclined 60°, slightly rough, moderately thin.

REC=100% RQD=72% 112
- @115.4m: joint inclined 40°, slightly rough, moderately thin.

116
- @115.6m: 10 mm thick chloride filled joint.
- @116.1m: 50 mm thick calcite bed.
- @116.1m: 15 mm thick fracture zone.
- @116.2m: joint inclined 40°, moderately thin.
- @116.4m: joint inclined 50°, moderately thin.
- SANDSTONE (same as above), brecciated.
- @116.6m: clasts in breccia are up to pea gravel in size, angular and composed mostly of black shale.

117
- @116.7m: joint inclined 40°, stepped, moderately thin.

REC=100% RQD=95% 113
- @117.5m: mechanical break.

118
- @117.8m: joint inclined 50°, stepped, moderately thin.
- @117.9m: joint inclined 50°, stepped, moderately thin.
- SANDSTONE (same as above).
- @118m: joint inclined 40°, slightly rough, moderately thin.

REC=100% RQD=73% 114
- @118.4m: joint inclined 50°, slightly rough, moderately thin.
- @118.4m: joint inclined 50°, slightly rough, moderately thin.

119
- SANDSTONE, light gray, fresh, hard, slightly fractured, few claystone clasts in sandstone matrix, subrounded, up to pea gravel size.
- @119m: hairline joint, closed, calcite filling.

REC=100% RQD=77% 115
- @119.1m: joint inclined 30°, slightly rough, very thin.
- @119.3m: joint inclined 30°, slightly rough, very thin.
- @119.4m: joint inclined 40°, slightly rough, open.
- SANDSTONE, light gray, fresh, hard, slightly to moderately fractured, with angular to subrounded fragments of rocks (brecciated).

120
- @119.6m: mechanical breaks, angular, non-planar.
- @119.9m: mechanical break.
- @120m: joint inclined 20°, stepped, moderately thin.

REC=100% RQD=55% 116
- @120.3m: mechanical break.
- @120.4m: joint inclined 50°, stepped, moderately thin.
- @120.5m: joint inclined 50°, stepped, moderately thin.
- @120.6m: no apparent change of lithography/grain size or universal alignment of joints to indicate bedding.

121
- @120.7m: joint inclined 40°, stepped, moderately thin.
- @120.8m: joint inclined 50°, slightly rough, moderately thin.
- @120.9m: joint inclined 50°, slightly rough, moderately thin.
- SANDSTONE (same as above), massive sandstone, conglomeratic with clasts up to 5 mm diameter, angular, no indication of bedding.
- @121.1m: joint inclined 50°, stepped, moderately thin.
- @121.2m: joint inclined 80°, stepped, moderately thin.

REC=100% RQD=57% 117
- @121.3m: joint inclined 50°, stepped, moderately thin.
- @121.4m: joint inclined 50°, stepped, closed.

122
- @121.5m: joint inclined 50°, stepped, closed.
- @121.5m: joint inclined 50°, stepped, closed.
- @121.6m: joint inclined 60°, stepped, moderately thin.
- @121.8m: joint inclined 60°, stepped, moderately thin.
- @121.8m: joint inclined 80°, stepped, moderately thin.
- @121.9m: joint inclined 80°, stepped, open.
- @122.1m: joint inclined 60°, stepped, open.
- SANDSTONE (same as above).
- @122.4m: three fresh, calcite healed joints inclined 60°, hairline to moderately thin, aligned with clasts, probable bedding.

123 REC=100% RQD=100% 118
- @122.7m: mechanical break.
- @123m: joint inclined 55°, slightly rough, moderately thin.
- @123.2m: joint inclined 50°, stepped.
- @123.3m: joint inclined 60°, stepped.
- @123.5m: joint inclined 40°, stepped.
- @123.6m: bottom of hole at 123.6 m depth.

124

8/17/02 to 8/30/02

VERTICAL SCALE
1 : 25

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Caltrans Metric

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

CERTIFIED ENGINEERING GEOLOGIST
PLAN APPROVAL DATE
STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HAMILTON No. CEG 31 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN OVERSIGHT KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/10/03

J. CASTLE, P. FRAME, M. HACHEY, L. PATZKOWSKI, & S. SICILIANO
FIELD INVESTIGATION/TITLE
DATE 8/17/02 to 8/30/02

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE No.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

DESIGN OVERSIGHT
SIGNOFF DATE
KEYHAN MOGHBEL

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
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11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

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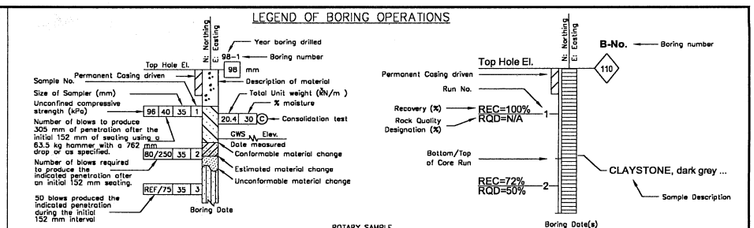
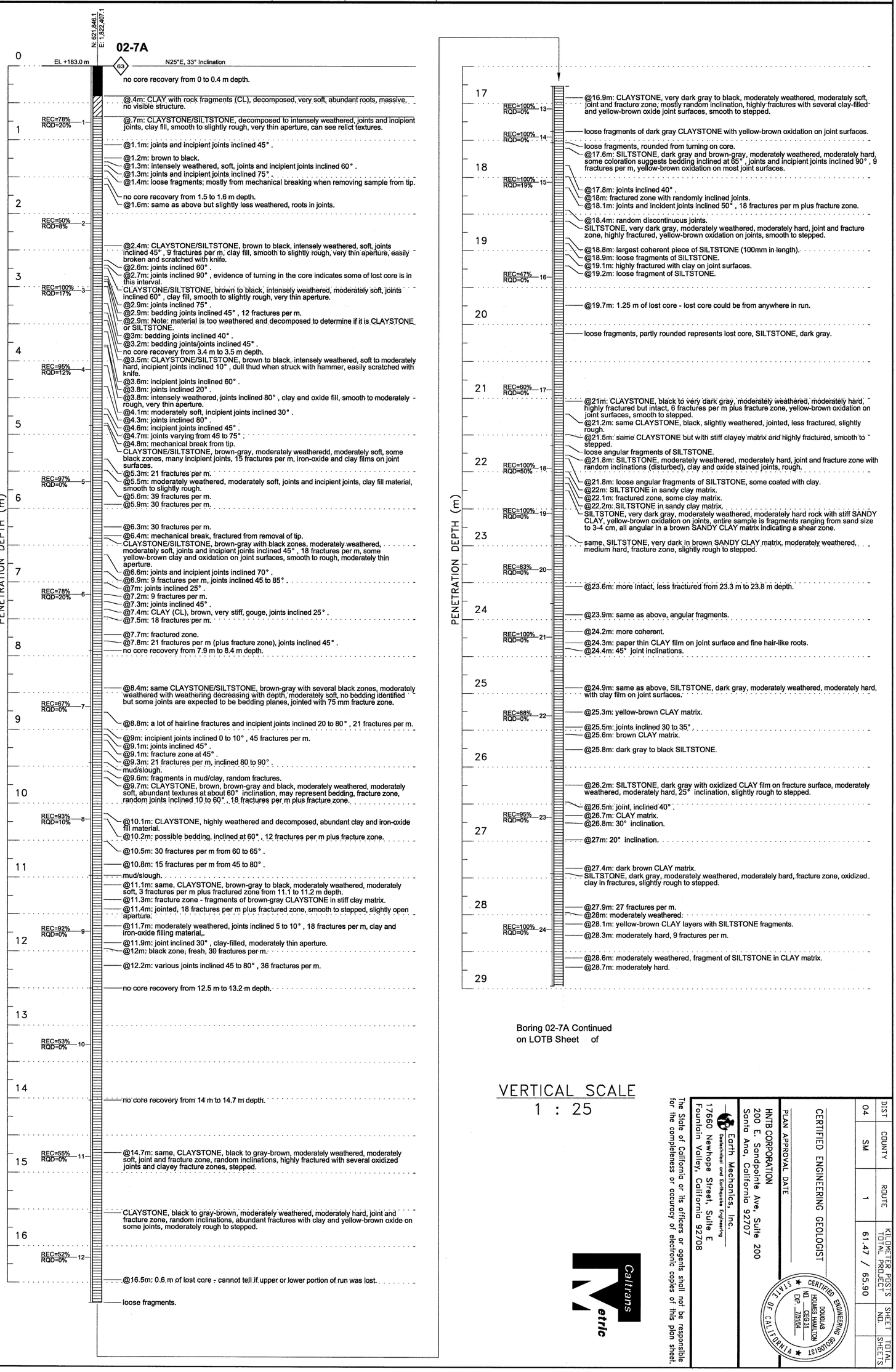
LEGEND OF BORING OPERATIONS





Boring 02-7A Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

DESIGN — BY E. BROWN — 11/20/02
CHECKED — BY S. SICILIANO — 2/10/03
DATE
B. SCHELLGEOLOGIST
S. VARATHARAJENGINEER
FIELD INVESTIGATION/TITLE
AS SHOWN
ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

Caltrans Metric

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Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HAMILTON NO. CEG 31 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
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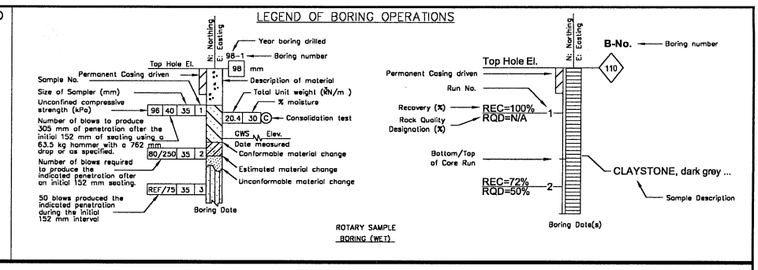
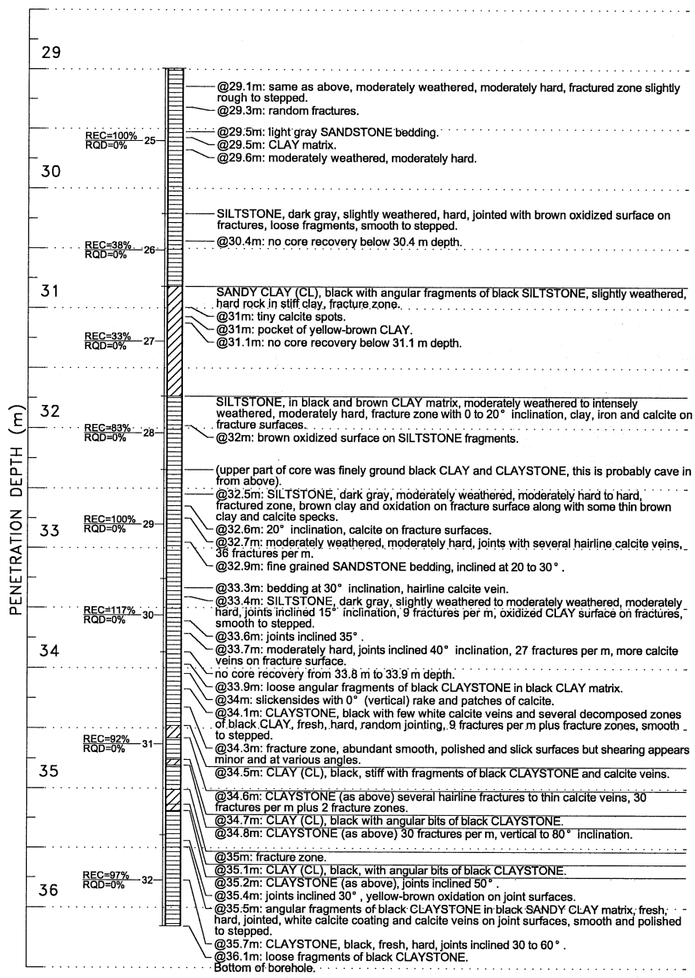
LEGEND OF BORING OPERATIONS



Boring 02-7A Continued
from LOTB Sheet of



8/20/02 and 8/21/02

VERTICAL SCALE
1 : 25

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/10/03
B. SCHELL/GEOLOGIST
S. VARATHARAJ/ENGINEER
FIELD INVESTIGATOR'S/TITLE
DATE AS SHOWN
M. KAPUSKAR
PROJECT ENGINEER

ORIGINAL SCALE IN mm
FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

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STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HOWARD ZUR No. EG 1314 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE:

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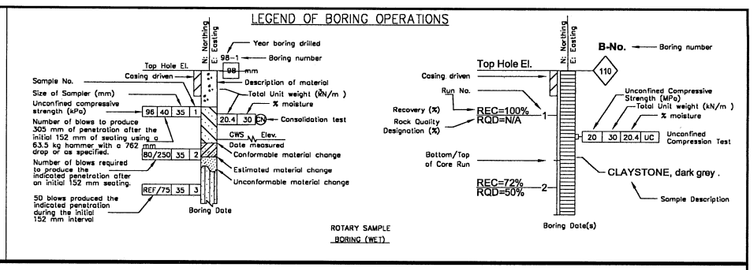

N: 621,916.8
E: 1,822,659.9

02-8A

El. +162.8 m — B3 — N29°W, 37° Inclination

SANDSTONE with interbedded SILTSTONE/CLAYSTONE, yellowish brown and black, decomposed to intensely weathered, intensely fractured, very soft to soft. Top 0.3 m consisting of (clayey silt) top soil with rootlets, dark brown, very soft.

@.3m: Rock structure is not well recognizable due to intense weathering: sandstone fragments up to 10 cm in clay matrix, light yellowish brown, soft (RQD is a good indicator of rock quality since rock fragments are held by soil matrix).

REC=100% RQD=57% (1)

moderately to intensely fractured, with black siltstone claystone interbeds.

@1.8m: with a contorted siltstone/claystone interbed, 2.5 cm thick, black. Fine grained interbeds are not clearly distinguishable but color change into black is indicative of their presence.

REC=100% RQD=22% (2)

intensely fractured to locally decomposed into soil, with rock fragments up to 0.5 cm in soft clay matrix. Rock fragments are light yellowish brown and in minor part black.

@2.7m: rock structure is barely recognizable due to intense weathering.

REC=88% RQD=0% (3)

@3.4m: no core recovery.

color change to dark gray (sandstone), rock fragments up to 0.5 cm in clay matrix, soft.

@4m: with a siltstone/claystone interbed inclined 25° with core axis, clay filled.

@4.3m: fracture zone: rock structure is lost, gouge-like material, soft.

REC=60% RQD=0% (4)

@4.6m: no core recovery.

@4.9m: no core recovery.

fracture zone: fragments of sandstone, light gray and siltstone/claystone, black, up to 5 cm, in clay matrix, soft.

REC=63% RQD=0% (5)

@6.1m: with light yellowish brown clay filling, 0.3 m wide, less rock fragments. Bottom 20 cm not recovered.

fracture zone: diffuse iron oxide on rock fragments, clay matrix (casing installed, 5 m).

REC=100% RQD=0% (6)

fracture zone: angular fragments of sandstone, light gray and siltstone/claystone, black, up to 4 cm, in yellowish brown clay matrix, soft, iron oxidation.

REC=100% RQD=0% (7)

moderately soft to very soft in shear zones: rock is brecciated along joints oriented 70°, clay filled, 1 to 2 mm aperture, slightly rough.

@7.6m: with a 20° and a 40° inclined joints, clay filled and iron oxidized, 5 mm aperture to open, slightly rough and a small fracture zone, 30 cm wide composed of angular rock fragments in soft clay matrix.

REC=100% RQD=0% (8)

@8.2m: with a 40° inclined joint, clay filled and iron oxidized, 5 mm aperture, stepped and a small fracture zone, 20 cm wide composed of angular rock fragments in clay matrix, light yellowish brown, soft.

fracture zone: angular fragments of sandstone, light gray and siltstone/claystone, black, up to 4 cm, in yellowish brown clay matrix, soft, iron oxidation.

REC=100% RQD=0% (9)

@9.1m: poorly indurated sandstone at 9.3 m depth, light yellowish brown, no clay, intensely fractured, soft (rock is reducible to sand with finger pressure).

shear zone: rock structure is lost. Rock is decomposed to clayey gouge, only color change suggests lithology change.

@10.1m: dark gray stiff clayey gouge.

@10.4m: dark gray stiff sandy clay matrix with small rock fragments and white concretion.

REC=63% RQD=N/A (10)

dark gray stiff clayey gouge.

@11.6m: SANDSTONE, yellowish brown, decomposed to intensely weathered, intensely fractured, very soft to moderately soft, with a 30° and a 25° bedding planes, oxidized, open, slightly rough.

REC=70% RQD=0% (11)

@11.9m: fracture zone, 0.3 m wide: angular fragments of sandstone, light gray and siltstone/claystone, black, up to 4 cm, in yellowish brown clay matrix, soft, iron oxidation.

@12.2m: no core recovery.

@12.5m: no core recovery.

fracture zone, 0.3 m wide: angular fragments of siltstone/claystone, black, up to 4 cm, in yellowish brown clay matrix, soft, iron oxidation.

REC=75% RQD=0% (12)

@13.1m: with dark gray soft clayey gouge, 10 cm wide. Bottom 15 cm of run not recovered.

yellowish brown clayey gouge, soft, with sand and small scattered rock fragments (poor recovery).

@13.7m: no core recovery.

REC=17% RQD=N/A (13)

@14m: no core recovery.

(PA) @14.3m: fracture zone, 0.3 m wide: subrounded rock fragments up to 1 cm (probable cave-in).

@14.6m: fracture zone, 0.4 m wide: sandstone fragments up to 5 cm, angular, in clayey matrix, yellowish brown, soft. Diffuse iron oxidation.

@14.9m: rock is decomposed to yellowish brown soft clay.

REC=57% RQD=0% (14)

@15.2m: no core recovery.

@15.5m: no core recovery.

fracture zone, 25 cm wide: subrounded rock fragments up to 1 cm (probable cave-in).

@16.2m: fracture zone, 40 cm wide: sandstone fragments up to 5 cm, angular, in clayey matrix, dark yellowish brown, soft. Diffuse iron oxidation.

REC=67% RQD=0% (15)

@16.5m: no core recovery.

yellowish brown clayey gouge (decomposed sandstone), soft, grading into black gouge (decomposed siltstone/claystone).

REC=100% RQD=N/A (16)

@17.1m: black clayey gouge, very soft, with white at 17.4 m depth.

black clayey gouge, with white concretions at 18.4 m depth, consistency of stiff clay.

REC=80% RQD=N/A (17)

rounded rock fragments, probable cave-in.

REC=75% RQD=0% (18)

@19.2m: black clayey gouge, consistency of stiff clay, with siltstone/claystone fragments, black, and yellowish brown sandstone fragments at 19.3 m.

yellowish brown sandstone fragments, with a 5 cm thick layer of clay at 19.7 m depth, yellowish brown, soft.

REC=92% RQD=0% (19)

@19.8m: siltstone/claystone fragments, black, and yellowish brown sandstone fragments.

yellowish brown clayey gouge (decomposed sandstone) with rock fragments up to 1 cm, soft.

@20.4m: interbedded siltstone/sandstone, intensely fractured with interstitial clay.

REC=89% RQD=0% (20)

@20.7m: black gouge (decomposed siltstone/claystone) with rock fragments up to 2.5 cm.

SANDSTONE, with SILTSTONE/CLAYSTONE interbeds, light gray and black, moderately weathered, intensely fractured, moderately hard.

@21.3m: with a bedding plane inclined 70°, clean, tight and a 25° joint, oxidized, open.

REC=75% RQD=0% (21)

@21.6m: no core recovery.

only gravel-size fragments of sandstone and siltstone recovered.

REC=25% RQD=0% (22)

@22.3m: no core recovery.

Yellowish brown clay with darker clay zones, very soft.

REC=75% RQD=0% (23)

@22.9m: no core recovery.

SANDSTONE, light gray, intensely weathered, intensely fractured, moderately hard, with a 65 and a 40° joint, clay filled, slightly rough, iron oxide.

@23.5m: with a small fracture zone, 10 cm wide grading into soft clay gouge, black at 23.7 m depth.

REC=92% RQD=0% (24)

no core recovery.

REC=0% RQD=N/A (25)

only 0.3 m of fragments of siltstone/claystone up to 5 cm recovered. One fragment contains polished joint surface with slickensides and re-crystallization minerals (chlorite, green and calcite, white).

REC=50% RQD=0% (26)

Fracture zone, at 27.5 m depth, 0.3 m wide: black rock fragments up to 1 cm in black clay matrix, soft.

@25.9m: SILTSTONE/CLAYSTONE, black, moderately weathered, intensely fractured, moderately hard, with two 70° joints, chlorite and calcite coated, open, rough and calcite veining, hairline to 1 cm thick.

REC=78% RQD=0% (27)

@26.2m: no core recovery.

black clayey gouge (decomposed siltstone/claystone) with rock fragments up to 1 cm, soft.

@26.8m: no core recovery.

REC=36% RQD=0% (28)

SILTSTONE/CLAYSTONE, black, moderately to slightly weathered, intensely fractured, moderately hard to locally soft, with sandstone interbeds up to 1 cm thick, yellowish brown, with two bedding planes inclined 65°, closed.

REC=100% RQD=21% (29)

@27.7m: fracture zone, 15 cm wide: rock is chipped in a yellowish brown clayey matrix, with two bedding planes inclined 60 and 55° at 27.9 m depth.

(PA) @28m: moderately fractured, moderately hard, with two sandstone interbeds 1 cm thick inclined 60° and a 40° inclined joint, oxidized, thin, slightly rough.

@28.4m: with two sandstone interbeds 1 cm thick inclined 60°, yellowish brown (moderately weathered) to light gray (slightly weathered to fresh).

@28.7m: slightly weathered, with two sandstone interbeds 1 cm thick inclined 60°.

REC=100% RQD=38% (30)

@29m: with a light gray sandstone interbed 1 cm thick inclined 60° and a 40° joint, clean, stepped.

@29.3m: with a light gray sandstone interbed 1 cm thick inclined 60°.

with two sandstone interbeds, 1 cm thick, inclined 60°.

Boring 02-8A Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

DESIGN: BY R. VARATHARAJ 11/20/02
CHECKED: BY S. SICILIANO 2/10/03
DATE: S. SICILIANO — FIELD INVESTIGATOR/TITLE — 8/2/02 to 8/8/02

ORIGINAL SCALE IN mm FOR REDUCED PLANS: 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

KILOMETER POST | BRIDGE NO.

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION	DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

Caltrans Metric

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★
DOUGLAS HAMILTON
No. CEG 31
EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
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11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2½" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST

LEGEND OF BORING OPERATIONS

Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified.; Number of blows required to produce the indicated penetration after an initial 152 mm seating.; 50 blows produced the indicated penetration during the initial 152 mm interval; Top Hole El.; Casing driven; Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; CWS; Elev.; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date

ROTARY SAMPLE BORING (WET): Top Hole El.; Casing driven; Run No.; Recovery (%); Rock Quality Designation (%); REC=100% RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; B-No.; Boring number; Unconfined Compressive Strength (MPa); Total Unit weight (kN/m³); % moisture; Unconfined Compression Test; CLAYSTONE, dark grey.; Sample Description; Boring Date(s)

Boring 02-8A Continued from LOTB Sheet of

30
- @29.9m: with two yellowish brown sandstone interbeds, 1 cm thick, inclined 60 and 65°.
- Run 31: REC=100% RQD=53%
- @30.2m: sandstone interbeds become light gray (fresh), consistently inclined 60°, fractures usually along bedding planes, closely spaced.
- @30.5m: sandstone interbeds, light gray (fresh), consistently inclined 60°, fractures usually along bedding planes, closely spaced.

31
- SILTSTONE/CLAYSTONE, black, slightly weathered to fresh, slightly fractured, hard, with sandstone interbeds up to 1 cm thick, light gray and yellowish brown (close to fractures where water percolates) inclined 60°; minor oxidation around fractures.
- @31.4m: with two light gray and yellowish brown sandstone interbeds, 1 cm thick, inclined 60°.
- @31.7m: with closely spaced light gray and yellowish brown sandstone interbeds, 1 cm thick, inclined 60 to 70°, fine grained.

32
- Run 32: REC=100% RQD=63%
- @32m: with closely spaced light gray and yellowish brown sandstone interbeds, 1 cm thick, inclined 55 to 60°, fine grained, and a 10° joint, minor oxidation, open, wavy.
- @32.3m: with closely spaced light gray and yellowish brown sandstone interbeds, 1 cm thick, inclined 60 to 65°, slightly rough.
- with closely spaced light gray and yellowish brown sandstone interbeds, 1 cm thick, inclined 60°, slightly rough and a 50 and a 40° joint.

33
- @32.9m: with closely spaced light gray and yellowish brown sandstone interbeds, 1 cm thick, inclined 60°, slightly rough and a 25° joint, calcite filled and minor iron oxide, stepped.
- Run 33: REC=80% RQD=28%
- @33.2m: with closely spaced light gray and yellowish brown sandstone interbeds, 1 cm thick, inclined 60 to 65°, slightly rough and a shear zone, 15 cm wide: rock is reduced to yellowish brown clay, soft (small fault gouge).
- @33.5m: SANDSTONE, light gray, massive, fresh, slightly fractured, hard, fine grained,.

34
- @33.8m: with closely spaced light gray sandstone interbeds, 1 cm thick, inclined 40 to 60°, slightly rough.
- SILTSTONE/CLAYSTONE, black, slightly weathered, intensely fractured, hard to locally soft in shear zone, with sandstone interbeds up to 5 cm thick, light gray and yellowish brown, inclined 60°; minor oxidation around fractures.
- @34.5m: fracture zone, 15 cm wide: rock is chipped into 1 cm angular fragments in clayey matrix.
- @34.8m: interbedded SILTSTONE/CLAYSTONE and SANDSTONE, black and yellowish brown to light gray, inclined 60°; minor oxidation around fractures.

35
- Run 34: REC=43% RQD=0%
- @35.1m: no core recovery.
- @35.4m: no core recovery.
- with closely spaced light gray sandstone interbeds, 1 cm thick, inclined 60°, typical alignment of siltstone grains into sandstone along bedding (60°).

36
- Run 35: REC=100% RQD=0%
- @36m: with a light gray sandstone interbed, 1 cm thick, inclined 60°, and a fracture zone 15cm wide: rock is chipped into small fragments in clayey matrix, yellowish brown.
- moderately fractured, with closely spaced light gray sandstone interbeds, 1 cm thick, inclined 60 and 65°, iron oxide, slightly rough.
- Run 36: REC=100% RQD=19%
- @36.6m: with a fracture zone, 15 cm wide, and a sandstone interbed, 4 cm thick, inclined 50°, yellowish brown, fine grained.

37
- @36.9m: with a typical alignment of claystone grains into siltstone matrix along bedding (50°) and a 40° inclined joint, oxidized, slightly rough.
- with a 20° joint, clean, stepped.
- @37.5m: slightly weathered, with closely spaced light gray sandstone interbeds, up to 0.6 cm thick, inclined 60°, fine grained interbedded in siltstone, light gray.

38
- Run 37: REC=81% RQD=16%
- @37.8m: with a fracture zone, 15 cm wide, with rock fragments and clay matrix, soft.
- @38.1m: sandstone, light gray, moderately hard, fine grained, with calcite veining up to 0.6 cm thick.
- moderately to intensely fractured, with a small fracture zone 5 cm wide in fine grained sandstone.
- Run 38: REC=100% RQD=0%
- @38.7m: with closely spaced siltstone interbeds, up to 1 cm thick, inclined 50 to 60°, interbedded in sandstone, light gray, and a 1 cm thick calcite bed, inclined 90°.

39
- with a 40° joint, iron oxide, open, stepped and a fracture zone, 15 cm wide centered at 39.3 m depth.
- @39.3m: with closely spaced sandstone interbeds, up to 1 cm thick, inclined 50 to 60°, interbedded in siltstone/claystone, light gray, and a small fracture zone (probably end of run mechanical breaks).
- Run 39: REC=60% RQD=0%
- (PA) @39.5m
- @39.6m: no core recovery.

40
- @39.9m: no core recovery.
- with closely spaced sandstone interbeds, up to 2.5 cm thick, inclined 50 to 60°, grading into fine grained sandstone.
- @40.5m: fine grained sandstone, light gray (fresh) and yellowish brown close to fractures.
- Run 40: REC=100% RQD=0%

41
- @40.9m: fracture zone, 20 cm wide: rock is chipped into 1 cm angular fragments in clayey matrix.
- fine grained sandstone, light gray (fresh) and yellowish brown (slightly weathered) 1 cm around fractures (weathering rind), with a fracture zone 13 cm wide at bottom of run.
- Run 41: REC=100% RQD=0%
- with a fracture zone 18 cm wide, clay filled, bounded by a 60 and a 40° joints, clay filled.

42
- Run 42: REC=56% RQD=0%
- @41.8m: fracture zone, 15 cm wide: rock is finely ground into black angular fragments in clayey matrix, yellowish brown, soft.
- @42.1m: no core recovery.
- fracture zone, 20 cm wide: angular and subrounded sandstone fragments, clean (probably cave-in).
- @42.7m: with closely spaced siltstone interbeds, hairline to 1 cm thick, inclined 50 to 60°, interbedded with sandstone, light gray, fresh, fine grained, and a fracture zone in sandstone, yellowish brown.

43
- Run 43: REC=67% RQD=0%
- @43m: no core recovery.
- SANDSTONE, light gray, fresh, intensely fractured, hard, with interbedded siltstone/claystone, black, and a calcite-filled bedding plane, 1 cm thick, inclined 60°, dividing fine grained sandstone from medium grained.
- @43.6m: with a small fracture zone, 8 cm wide and two 30° joints, Fe-oxidized, open, slightly rough, in sandstone.

44
- Run 44: REC=100% RQD=0%
- @43.9m: with a siltstone interbed, 3 cm thick inclined 60°, intensely fractured, and two calcite filled bedding planes, hairline to 1 cm thick, in sandstone.
- only sandstone fragments recovered, angular, fe-oxidized, fine grained, with pervasive calcite veining.
- Run 45: REC=100% RQD=0%
- Fracture zone: fragments of sandstone interbedded with siltstone/claystone recovered, angular, minor fe-oxidized (driller reports caving @ bottom 8 m of borehole).
- Run 46: REC=100% RQD=0%

45
- Fracture zone: fragments of sandstone (90%) interbedded with siltstone/claystone, angular, fe-oxidation on joints' surfaces.
- @45.1m: fragments of sandstone interbedded with siltstone/claystone, angular, fe-oxidation on joints' surfaces, uncertain bedding orientation due to intense fracturing.
- Run 47: REC=58% RQD=0%
- @45.4m: no core recovery.
- @45.7m: no core recovery.

46
- Fracture zone: angular fragments of sandstone interbedded with siltstone/claystone, fe-oxidation on joints' surfaces. Some fragments present striations.
- Run 48: REC=100% RQD=0%
- Fracture zone: angular fragments up to 5 cm of sandstone, light gray, interbedded with siltstone/claystone, black, fe-oxidation on joints' surfaces.

46
- Run 49: REC=54% RQD=0%
- @46.6m: no core recovery.

47
- Fracture zone: angular fragments up to 5 cm of sandstone (90%), light gray, interbedded with siltstone/claystone, black, fe-oxidation on joints' surfaces, pervasive calcite deposits and some black gouge @ bottom, soft. Poor recovery probably due to washing-out of soil-like portion.
- Run 50: REC=54% RQD=0%
- @47.3m: no core recovery.
- Fracture zone: angular fragments up to 5 cm of sandstone (90%), light gray, interbedded with siltstone/claystone, black, fe-oxidation on joints' surfaces, pervasive calcite deposits.

48
- Run 51: REC=69% RQD=0%
- @47.9m: Fracture zone: angular fragments up to 5 cm of sandstone, light gray, interbedded with siltstone/claystone, black, fe-oxidation on joints' surfaces, pervasive calcite deposits,
- @48.2m: no core recovery.
- no core recovery.
- @48.8m: no core recovery.

49
- Run 52: REC=0% RQD=N/A
- @49.1m: no core recovery.
- Fracture zone: angular fragments sandstone, light gray, minor clay filling, slickensides and polished fractures indicative of tectonic shear.
- Run 53: REC=100% RQD=0%
- Fracture zone: angular fragments of sandstone up to 8 cm in black clayey matrix (almost completely washed away), light gray, with slickensides and polished fractures indicative of tectonic shear (FAULTING).

50
- Run 54: REC=100% RQD=0%
- only 18 cm of sandstone fragments recovered, light gray, angular, fe-oxidized, fine grained, with pervasive calcite veining and clay filling.
- Run 55: REC=58% RQD=0%
- Fracture zone: angular fragments of sandstone up to 5 cm, light gray, minor interstitial clay, with slickensides and polished fractures indicative of tectonic shear on one fragment.
- Run 56: REC=100% RQD=0%
- Fracture zone: angular to subrounded fragments of sandstone up to 4 cm, light gray, minor interstitial clay (driller reports very difficult drilling conditions., extremely slow advancement because of cave-in).

51
- Run 57: REC=100% RQD=0%
- Fracture zone: angular to subrounded fragments of sandstone up to 5 cm, light gray, minor interstitial clay @ bottom of core barrel.
- Run 58: REC=100% RQD=0%
- Fracture zone: angular to subrounded fragments of sandstone up to 5 cm, light gray, unclear if caved-in (very slow coring).
- Run 59: REC=100% RQD=0%
- Fracture zone: angular to subrounded fragments of sandstone up to 5 cm, light gray, probable caved-in (hole abandoned after 3 days of trials).

52
- @51.8m: no core recovery.
- Run 60: REC=17% RQD=0%
- @52.1m: no core recovery.
- @52.4m: no core recovery.
- @52.4m: Bottom of borehole.

8/2/02 to 8/8/02

VERTICAL SCALE 1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY R. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/10/03

S. SICILIANO — FIELD INVESTIGATOR(S)/TITLE
DATE 8/2/02 TO 8/8/02

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
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		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

TYPE OF BORINGS

- 2¼" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING size
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (FA) CHEMICAL ANALYSIS
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- (C) CONSOLIDATION
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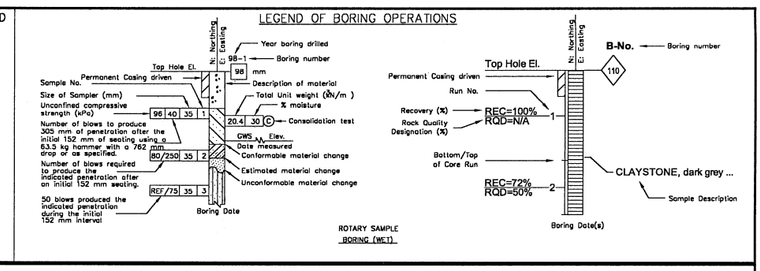
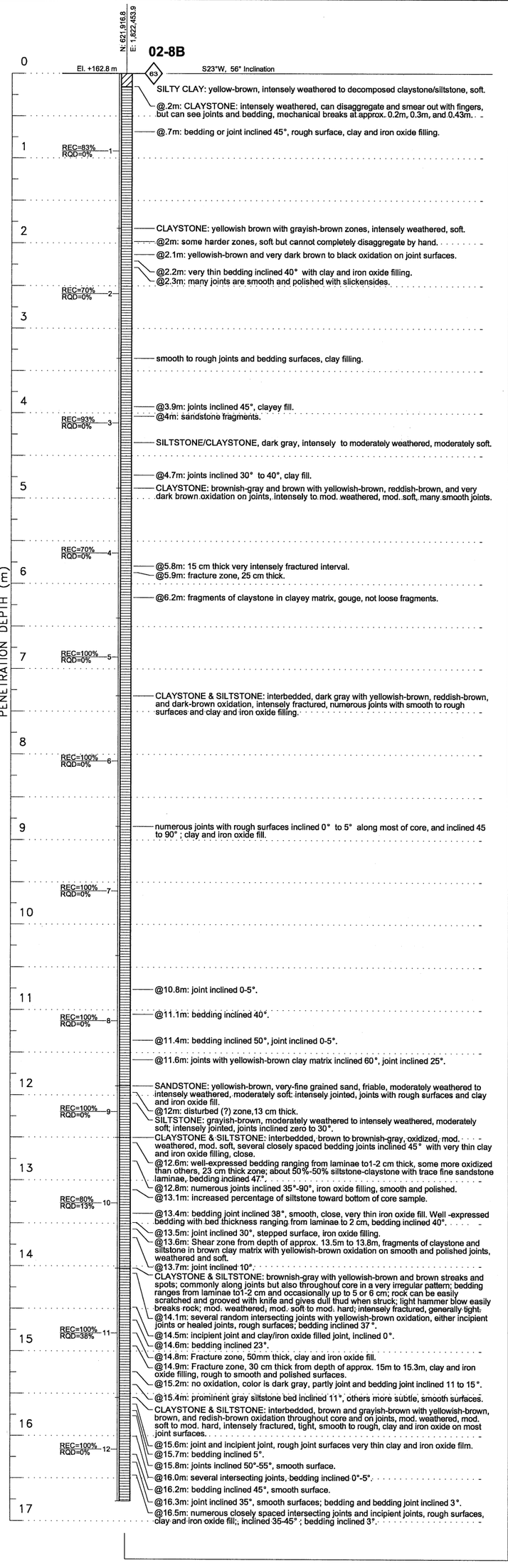
LEGEND OF BORING OPERATIONS





Boring 02-8B Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

Caltrans Metric

DESIGN BY E. BROWN 11/20/02
CHECKED BY S.SICILIANO 12/6/02
B. SCHELLGEOLOGIST
S. VARATHARAJENGINEER
DATE FIELD INVESTIGATOR/TITLE
AS SHOWN
ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100
M. KAPUSKAR PROJECT ENGINEER
PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION
DESIGN OVERSIGHT KEYHAN MOGHBEL
SIGNOFF DATE
CU 240
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BRIDGE No.
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DISREGARD PRINTS BEARING EARLIER REVISION DATES
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DEVIL'S SLIDE TUNNELS
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PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★
DOUGLAS HOWARD MANSON
No. EG2218
EXP. 7/30/04

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2½" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

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LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Top Hole El.; Permanent Casing driven; Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Description of material; Conformable material change; Total Unit weight (kN/m³); % moisture; Consolidation test; GWS Elev.; Date measured; Estimated material change; Unconformable material change; Boring Date

ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

Boring 02-8B Continued
from LOTB Sheet of

PENETRATION DEPTH (m)

31
loose fragments of siltstone and claystone with signs of rotating core at bottom, 150mm thick fracture, joints inclined 50 and 35°.
SILTSTONE & CLAYSTONE: black to very-dark-gray, moderately expressed bedding, inclined 65 to 75°; moderately fractured, rough to stepped surfaces, tight, most joints show yellowish-brown oxidation, several oxidized incipient joints (or heale
@31.1m: two oxidized faults inclined 25 and 15°, bedding inclined 65° offset 1cm.
REC=100% RQD=63% — 23
@31.2m: joints inclined 85°, clay and iron oxide fill.
@31.4m: bedding inclined 65°, joints inclined 60° -75° with iron oxide fill.
32
@31.6m: incipient joint inclined 45°.
@31.9m: joint inclined 75°-85°, clay fill, bedding joint inclined 58°.
@32.2m: bedding inclined 70°, joint inclined 45°.
SILTSTONE (50%) & CLAYSTONE (50%):interbedded, black, very few very-fine-grained sandstone laminations, slightly weathered, hard; faintly bedded with beds ranging from laminae to few cm thick: moderately fractured, slightly rough to stepped, tight, abundan
@32.6m: steep random oxidized incipient joints, fault inclined 15° with 1 cm separation of joints; bedding inclined 60° counter to joints.
@32.8m: joint inclined 80°, oxidized incipient joints.
33
REC=100% RQD=53% — 24
@33.2m: bedding inclined 35°, joint inclined 60°.
@33.4m: joint inclined 55°, clay and iron oxide filling.
@33.5m: random oxidized incipient joints.
34
SILTSTONE (50%) & CLAYSTONE (50%):interbedded, black, very few very-fine-grained sandstone laminations, slightly weathered, hard; faintly bedded with beds ranging from laminae to few cm thick: moderately to very intensely fractured, rough to stepped, tight
@33.9m: bedding inclined 35°, below joint with rough surface and iron oxide stain.
@34m: several intersecting joints inclined 45 to 85°, clay films and iron oxide stain on rough surfaces.
REC=100% RQD=8% — 25
@34.2m: joint inclined 65°.
@34.3m: very intensely fractured zone from depth 34.3m to 34.6m, random intersecting joints with clay fill and iron oxide stain, soft but held together by clay.
35
@34.7m: bedding inclined 20 to 25°, joint inclined 60°.
@34.8m: fault, tight, oxidized fault inclined 40° offsetting bedding by mm.
@34.9m: fracture zone inclined 20° from depth 34.8m to 35m, iron-stained.
@35.1m: joints inclined 30°-45°, clayey fracture zone 2-7 cm thick.
@35.2m: three intersecting joints inclined 85 and 40°, rough, iron oxide stain.
as above but very intensely fractured with lots of clay fill and brown oxidation, slightly weathered, hard.
@35.6m: joints inclined 70°.
36
REC=90% RQD=0% — 26
@35.7m: joints inclined 45°, near top of very intensely fractured zone.
@36m: very intensely fractured with clay alteration and brownish iron oxidation; soft from depth of 36m to 36.5m, in spite of clay content this fracture zone does not appear to be sheared.
@36.5m: NCR.
NCR from depth 36.58m to 36.74m.
@36.7m: very intensely fractured zone from depth 36.8m to 37m, hard fragments in clayey matrix somewhat intact with inclinations of 65-70°, several loose fragments, numerous joints and bedding joints, iron oxide on several joints.
37
CLAYSTONE (58%) & SILTSTONE (40%) with SANDSTONE (2%) interbedded as above, black, slightly weathered, hard; moderately expressed bedding; intensely fractured, mostly rough to stepped with some smooth surfaces, tight.
REC=91% RQD=6% — 27
@37.3m: closely spaced fractures inclined 45 to 80°, brown clay fill.
@37.4m: prominent 57mm thick sandstone bed, yellow-brown and medium-grained, bounded by bedding joints inclined 75°.
@37.7m: joints and bedding joints inclined 75°-85°, clay and iron oxide fill.
38
@38m: set of joints inclined 25°, iron oxide filling.
@38.1m: bedding joint inclined 75°, with clay and iron oxide filling.
@38.2m: bedding joint inclined 75°, joints inclined 25° and 60°, 1mm thick brown-gray sandstone bed.
NCR of top 0.4m of core.
SILTSTONE & CLAYSTONE as above: black, slightly weathered, hard, intensely fractured, clay film on top joint.
@38.7m: faint bedding inclined 75°, bedding joint inclined 75°, clay film.
39
REC=77% RQD=N/A — 28
@38.9m: fracture zone, 10 cm thick, clayey, fracture zone, 38 cm thick, intact, with abundant intersecting oxidized joints.
@39.1m: bedding dark gray lamination inclined 72°.
@39.4m: joint at botttom of fracture zone, inclined 65°.
@39.6m: fracture zone, 10 cm thick, with abundant random intersecting oxidized joints.
40
NCR of top 0.4m of core.
CLAYSTONE (80%) & SILTSTONE (20%) (as above), black with a few thin gray laminations of very-fine-grained sandstone: intensely fractured, most joints with clay fill and clay films, about half of joints are oxidized, several clayey fracture zones.
REC=55% RQD=0% — 29
@40.3m: bedding inclined 65°, joint inclined 80° with brown clay fill 1 cm thick.
41
@40.4m: zone of loose fragments inclined 55°, 5 cm thick, clay films, slightly rough.
@40.5m: numerous joints inclined between 40° and 75°, clay filling.
@40.6m: joints inclined 65° -75°, clay fill.
@40.8m: two joints inclined 55°, clay fill.
@40.9m: clayey fracture zone with brown oxidation (no shearing), several joints inclined 70°
@41.2m: NCR.
CLAYSTONE (50%) & SILTSTONE (50%) (as above): interbedded, black with a few gray laminae of fine-grained sandstone, slightly weathered, hard, moderately to intensely fractured, generally rough surfaces, tight.
42
@41.8m: incipient joints inclined 20°, joints inclined 60°, and bedding joint inclined 55°, clay and iron oxide filling.
REC=100% RQD=40% — 30
@42.1m: fractured between depth of 42m and 42.2m, with abundant random joints and major oxidized feature inclined 25° with 2-3 mm clay.
@42.3m: bedding inclined 45-50° from approx. depth 42.2m to 42.7m, two joints inclined 50° and 40° at depth 42.4m with 1 mm clay fill and oxidized.
@42.4m: moderately spaced fractures.
43
@42.8m: very intensely fractured zone from approx. depth 42.8m to 43m, brown clayey filling and iron oxidation, joints inclined from 40° -80°.
loose fragments with clay and iron oxide coating.
@43.1m: joint inclined 70° at bottom of fracture zone.
REC=100% RQD=N/A — 31
CLAYSTONE: black wtih few gray laminations of siltstone (?), fresh, hard; intensely fractured, most joints oxidized brown and yellowish-brown with clay films, couple of white hairline calcite veins,.
@43.4m: bedding inclined 40°, joint inclined 0-15°.
@43.5m: brown sandy clay (gouge), and joints inclined 30 and 60°.
@43.6m: two joints inclined 75° with slickensides at 40° rake.
44
CLAYSTONE & SILTSTONE: black, slightly to moderately weathered, hard; more intensely fractured and first good signs of shearing, slickensided to stepped surfaces, tight.
@43.8m: joint and incipient joint at depths of 43.7m and 43.9m, respectively; clay and iron oxide filling.
REC=93% RQD=7% — 32
@44m: possible bedding, very subtle, very intensely fractured and sheared zone from approx. depth 43.9m to 45m, clay matrix with calcite veins and blebs throughout, iron oxide stain.
@44.2m: intensely fractured with clay matrix and calcite veins and blebs.
@44.4m: slickensides with calcite streaks.
45
@44.5m: Crushed zone in black and brown clay matrix with white calcite, 80mm thick, soft.
@44.7m: abundant joints.
@44.9m: loose fragments.
NCR.
CLAYSTONE: black, slightly weathered, hard; bedding poorly expressed; intensely fractured with sheared zones, slightly rough to rough surfaces, tight, joint at top inclined 60°
REC=67% RQD=0% — 33
@45.4m: gray sandstone bed inclined 25° to 30°.
@45.5m: joint inclined 75°, clay and iron oxide filling.
46
@45.6m: Fractured zone, 130mm thick, joints inclined 30° and 60°.
@45.7m: Sheared zone, 230mm thick, dark gray sandy clay with hard black fragments, joint inclined 60°.
@45.9m: NCR of last 150mm of core run.
NCR of top 100mm of core run.
REC=87% RQD=0% — 34
CLAYSTONE & SILTSTONE: black with brown and yellow-brown oxidation on joints, a few hairline calcite veins, slightly weathered, hard, intensely fractured, loose fragments to depth of approx. 46.3m.
@46.3m: numerous joints, clay and calcite fill and iron oxide stain, slightly rough to rough, tight.
47
@46.6m: Sheared zone, 150mm thick, soft sandy clay.
@46.7m: Fractured claystone, loose fragments and some with clay coats.
@46.9m: NCR of last 100mm of core run.
48

PENETRATION DEPTH (m)

47
NCR of top 0.3m of core run.
@47.3m: CLAYSTONE & SILTSTONE (as above), fresh, hard; intensely fractured and sheared, few thin white calcite veins and fragments, little oxidation, generally rough, tight, several joint surfaces with slickensides and polished surfaces.
REC=69% RQD=0% — 35
@47.3m: joints inclined 50° to 70°, clay filling.
@47.6m: Sheared zone, 254mm thick, soft sandy clay with hard fragments, several white calcite fragments.
48
@47.8m: numerous joints with clay filling.
@48.1m: NCR of last 75mm of core run.
CLAYSTONE & SILTSTONE: black, fresh, hard intensely fractured with several hairline calcite veins inclined 80° to 90°, joints with clay and calcite filling, smooth and polished to rough surfaces.
REC=100% RQD=0% — 36
@48.5m: very intensely fractured and sheared zone, approx. 0.3m thick, clayey joint fill and matrix, calcite filling.
NCR of top 203mm of core.
49
@49m: CLAYSTONE: with some siltstone, black, fresh, hard; very intensely fractured with clayey shear zones and white calcite, no oxidation, random joint inclinations throughout, surfaces polished to stepped, tight.
@49.3m: highly fractured with clay filling.
REC=52% RQD=0% — 37
@49.4m: 200mm zone of black angular fragments of claystone cemented by 30-40 % white calcite, 2-3mm piece of white calcite.
@49.6m: very intensely fractured and sheared zone with clayey matrix, 50mm thick; black clay shear zone.
@49.7m: NCR of last 0.46m of core.
50
@50m: NCR.
NCR of top 100mm of core.
@50.3m: CLAYSTONE & SILTSTONE (as above):black with few dark gray laminae, fresh, hard; moderately expressed bedding: intensely fractured, abundant evidence of shearing represented by smooth, polished, and slickensided joint surfaces, slickensides on joint
REC=87% RQD=11% — 38
@50.6m: bedding inclined 40° and 35°, very thin calcite film.
51
@50.7m: joints inclined 45°, very thin calcite film.
@50.8m: Shear zone, 50mm thick, inclined 75°, clayey matrix with hard fragments; Change in bedding inclination across shear zone.
@50.9m: irregular gray sandstone bed inclined 25°, 2-5mm thick, above and below bed are joints inclined 15° and 80°.
@51.1m: bedding inclined 35°, siltstone/very fine sandstone laminae.
@51.1m: numerous joints inclined between 30° and 80° to bottom of core, slickensided, smooth, and polished.
REC=100% RQD=0% — 39
@51.2m: joint inclined 80°.
@51.4m: NCR of last 75mm of core.
52
CLAYSTONE & SILTSTONE: black, fresh, hard: poorly expressed bedding, at top and near bottom of core bedding inclined 26° and 25°, at bottom of core bedding joint inclined 30°; intensely fractured, patchy calcite coating on several joint faces.
REC=86% RQD=0% — 40
NCR of top 50mm of core.
@51.9m: CLAYSTONE & SILTSTONE as above: black, fresh, hard;l very intensely fractured, slightly rough to rough, one fragment has bed of shiny yellow grains that appear to be pyrite and of depositional origin and inclination of this bed is about 5°, small amounts of calcite coating.
53
@52.3m: joints inclined 60° and 40°.
@52.5m: joints inclined 80°.
REC=100% RQD=11% — 41
@52.6m: NCR - 75mm of sandy clay at bottom of core suggests lost core is clayey shear zone.
CLAYSTONE (70%), SILTSTONE (30%), AND RARE SANDSTONE, black, fresh, hard; moderately expressed bedding very fractured, no oxidation, fresh, hard, very thin clay filling, one thin (1mm) gray sandstone bed inclined 35°, joints inclined 35° to 78°, joint surfaces are smooth and polished with slicks,several hairline to mod. thin (1-2mm) calcite veins and joint lining.
54
@53.1m: bedding inclined 30°, calcite film.
@53.3m: several joints, 60°, rough, calcite 1-2 mm thick.
@53.4m: joints inclined 50°, rough.
@53.6m: stepped joint with calcite lining.
CLAYSTONE: black, very fractured, fresh, hard,; one fracture open about 1mm inclined 10°.
REC=59% RQD=0% — 42
@53.9m: joint inclined 50° above intensely fractured and sheared zone, approx. 0.5m thick, mostly smooth and polished joint surfaces, many joint surfaces with slicks and sandy clay coating.
@54.5m: NCR of last 0.56m of core.
@54.6m: NCR.
55
CLAYSTONE: black, very fractured, fresh, hard, loose fragments of black claystone and siltstone with calcite lining surfaces.
@55.3m: bedding inclined 50°, smooth and polished with some slicks.
@55.3m: sheared and very intensely fractured zone, 127mm thick, clayey matrix with hard fragments of claystone.
REC=40% RQD=0% — 43
@55.5m: NCR of last 0.635m of core.
@55.8m: NCR.
56
Recovered only few loose fragments of CLAYSTONE, black with portions of smooth, polished, and slickensided joint surfaces, calcite coatings and veins, fresh, hard. Lost water to formation.
REC=13% RQD=0% — 44
@56.4m: NCR.
NCR of top 150mm of core.
@56.9m: CLAYSTONE & SILTSTONE: black, very intensely fractured with loose angular fragments, fresh, hard fragments, random joint inclination, smooth and polished with slicks to rough and stepped joint surfaces, calcite coating.
57
REC=67% RQD=0% — 45
@57m: very intensely fractured but somewhat intact due to cohesion from clay joint filling.
@57.2m: white calcite veins 2-3mm thick and offset by minor faults in clayey sand matrix.
@57.3m: sandy clay zone, 50mm thick, inclined 80°, stiff, black.
@57.4m: joint inclined 50°, predominantly calcite filling with some clay.
REC=100% RQD=0% — 46
@57.4m: Fracture zone, 50mm thick, followed by rough joint inclined 70°.
@57.5m: NCR of last 150mm of core.
58
REC=100% RQD=0% — 47
CLAYSTONE: black, fresh, hard: intensely fractured and sheared, loose fragments with hairline calcite veins, most fragments have smooth and polished surfaces, many with calcite coating and slickensides, one dark grey sandstone bed inclined 30°, joints inclined 35 deg to 75 deg. Hole collapsed, had to redrill several times to get back to bottom of hole; added one sack bentonite pellets (Enviroplug) and one sack PelPlug and let set overnight; the Enviroplug should fill 3m of HQ hole but it only filled 1.2m, which indicates belled hole; losing water to hole, poor circulation.
drilled out bentonite plug, got 3 feet of bentonite and 30 cm of rock; CLAYSTONE, black.
REC=75% RQD=0% — 48
@58m: CLAYSTONE: black, fresh, hard; few hairline calcite veins, joints inclined 70° and 85°, thin smeared calcite linings: left short piece of bentonite attached to core.
@58.2m: faint bedding inclined 70°, highly polished joint surface (shearing).
59
NCR of top 75mm of core.
@58.4m: angular fragments embedded in bentonite.
@58.7m: CLAYSTONE AND SILTSTONE interbedded, black and gray, fresh, hard; well-expressed bedding in laminae to 2 cm thick beds, inclined 60-65°; intensely fractured, smooth, polished to rough.
@58.8m: bentonite matrix, 50mm thick, with fractured rock after bentonite, rough surfaces.
@59m: mostly siltstone well-expressed bedding, inclined 60-65°; inversely graded (I.e. beds stratigraphically overturned); slightly rough joints.
60
@59.1m: NCR of last 0.61m of core.

Boring 02-8B Continued
on LOTB Sheet of

VERTICAL SCALE
1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT	KEYHAN MOGHBEL
SIGNOFF DATE	

DESIGN	BY E. BROWN	11/20/02
CHECKED	BY S.SICILIANO	12/6/02

B. SCHELL/GEOLOGIST
S. VARATHARAJ/ENGINEER
FIELD INVESTIGATOR(S)/TITLE
DATE AS SHOWN

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Permanent Casing driven; Top Hole El.; Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; GWS Elev.; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date

ROTARY SAMPLE BORING (WET)

Permanent Casing driven; Run No.; Recovery (%); Rock Quality Designation (%); REC=100% RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ...; Sample Description; B-No. – Boring number; Boring Date(s)

Boring 02-8B

Boring 02-8B Continued from LOTB Sheet of

PENETRATION DEPTH (m): 59 – 76

- Run 49: REC=53% RQD=0%
- Run 50: REC=100% RQD=31%
- Run 51: REC=100% RQD=0%
- Run 52: REC=42% RQD=0%
- Run 53: REC=90% RQD=19%
- Run 54: REC=100% RQD=0%
- Run 55: REC=96% RQD=0%
- Run 56: REC=40% RQD=0%
- Run 57: REC=69% RQD=0%
- Run 58: REC=53% RQD=0%
- Run 59: REC=100% RQD=0%
- Run 60: REC=60% RQD=0%
- Run 61: REC=48% RQD=0%
- Run 62: REC=100% RQD=0%
- Run 63: REC=63% RQD=0%
- Run 64: REC=88% RQD=0%
- Run 65: REC=96% RQD=0%
- Run 66: REC=17% RQD=0%
- Run 67: REC=100% RQD=0%
- Run 68: REC=67% RQD=0%
- Run 69: REC=100% RQD=0%

NCR of top 75mm of core.
@59.8m: SILTSTONE & CLAYSTONE, interbedded, black and gray, faint bedding seen as coarser gray siltstone laminae, fresh, hard, highly fractured, loose fragments in upper 100mm of core.
@60m: bedding inclined 70°, large white calcite veins (0.5 to 1cm thick).
@60.2m: joint inclined 90°, smooth, numerous joints inclined 20° to 70°, rough to smooth and polished joint surfaces.
@60.5m: highly broken and disturbed, many joint surfaces are smooth and polished.
@60.5m: NCR of last 0.73m of core.

CLAYSTONE & SILTSTONE: interbedded, black, fresh, hard, top 200mm of sample is highly fractured, calcite filling and many polished and slickensided surfaces, below top 200mm of sample, rock shows faint bedding and several joints with down-dip slicks.
@61.6m: faint bedding inclined 45° and 55°, joint inclined 80°, smooth.
@61.8m: joints inclined 35° and 65°, with very thin calcite film, smooth to slightly rough with well developed slicks with smeared calcite and down-dip rake.
@62m: joints inclined zero to 60°, stepped with very thin calcite film, several hairline to 6mm thick calcite veins zero to 5° inclination.
@62.5m: faint bedding inclined 40°-55°, smooth surface, joints inclined 40°-80°, rough joint surface.
@62.6m: bedding joint inclined 35° with smooth surface.
SILTSTONE & CLAYSTONE: black, faintly bedded, bedding inclined 30° and 40°, closely spaced fractures, several slickensided joints inclined 25° to 60° with smeared calcite.
@63m: bedding inclined 40° ; closely spaced fractures, joints inclined zero to 70°, rough to smooth and polished surfaces, clay filling.
@63.1m: joints inclined 35-70°, smooth and polished with slickensides, 3mm thick calcite joint lining with 1mm clay.
@63.3m: bedding inclined 50° to 55° ; stepped joint inclined 85°, rough joint inclined 25° at bottom of core.
NCR of top 0.3m of core run; good circulation of drilling fluid.
@63.7m: SILTSTONE & CLAYSTONE: black, fresh, hard; loose fragments; poorly expressed bedding inclined 30° to 35° at top of sample between joints inclined 85° and 40° ; intensely fractured, slightly rough to rough with calcite filling.
@64.1m: NCR of last 0.23m of core.
SILTSTONE & CLAYSTONE: black, faintly bedded, bedding inclined 35° ; intensely fractured, joints inclined 60° and 50°, smooth to slightly rough, generally tight.
@64.5m: joint inclined 50°, slightly rough; small fold in bedding (soft-sediment deformation).
@64.6m: white calcite vein to 1.5mm thick inclined zero to 5° on rough joint surface.
@64.8m: joints inclined 50° and 67°, very thin calcite filling, smooth and slightly rough.
@64.9m: bedding inclined 35°, Fracture zone - very closely spaced joint fractures, calcite coating on many joints and commonly smeared by shearing, even rough joints are polished and slickensided.
@65.2m: Shear zone, 25mm thick, with clay and small fragments; joints inclined 35°-50°, rough to slightly rough.
@65.3m: NCR of last 100mm of core run.
SILTSTONE & CLAYSTONE: black, large fragments from first run after reaming out hole after overnight, some slough and fragments with oxidation that fell in hole from higher elevation, bedding inclined 60°.
SILTSTONE (50%) & CLAYSTONE (50%): interbedded, fresh, hard; prominent dark-gray siltstone beds; intensely fractured, joints inclined 35° and 40° with calcite filling, rough surfaces.
@65.6m: bedding inclined 35°, stepped joint inclined 35°, with calcite lining.
@65.9m: bedding inclined 50°, joint inclined 90°, rough surfaces.
@66m: joint inclined 70°, white calcite vein 1.5-2 cm thick, rough surfaces.
@66.1m: joints inclined 60°, white calcite vein 1.5-2cm thick, bedding inclined 50° and bedding joint inclined 50° near bottom of sample.
NCR of top 0.3m of core.
@66.5m: SILTSTONE & CLAYSTONE: very fractured, loose fragments.
@66.7m: thin white calcite veins 0.5-1mm thick, joint inclined 70°, polished and slickensided with down-dip rake.
@66.8m: NCR of bottom 150mm of core.
NCR of top 0.28m of core.
@67.2m: SILTSTONE (60%) & CLAYSTONE (30%) with SANDSTONE (10%): fresh, hard; well-expressed bedding; loose fragments at top, probably mostly from last run.
@67.4m: joints inclined 75° and 45°, calcite film, slightly rough but polished with slickensides, 500mm core loss (rotated core).
@67.5m: fine pyrite in a sandstone bed.
@67.6m: bedding and bedding joints inclined 60° to 70° from depth 67.5m to 67.8m, calcite film on surfaces.
@67.8m: 37mm thick fine sandstone bed, gray with 1mm thick calcite vein, loose fragments in last 150mm of sample.
NCR of top 178mm of core.
@68.2m: mostly loose fragments of rock, one fine sandstone bed 1cm thick but several sandstone laminae throughout sample, fresh, hard, thin smeared calcite filling, most joints are polished and slickensided.
@68.4m: 1cm thick sandstone bed, also bedding and bedding joint inclined 35°.
CLAYSTONE (55%), SILTSTONE (40%), and SANDSTONE (5%): fresh, hard; well-expressed bedding with graded bedding (suggests strata to be stratigraphically right side up), bedding inclined primarily at 50° with few beds at 55°, wavy to planar bedding, in
@69.5m: SILTSTONE (45-50%), CLAYSTONE (35%), and SANDSTONE (15-20%): interbedded, dark gray, black, grey, fresh, hard; well-bedded with beds ranging from laminae to 2 cm thick; graded bedding is inclined 45° to 50° and wavy; intensely fractured.

@70.3m: loose fragments of mostly siltstone and claystone.
@70.6m: SANDSTONE (50%), SILTSTONE (30%) and CLAYSTONE (10%): well-expressed bedding, graded bedding, laminae to 5-6 cm thick, numerous rough to stepped, tight joints with very little calcite filling.
@70.7m: graded bedding inclined 45° : joints inclined 60°, rough, very thin calcite fill, tight.
@70.8m: bedding inclined 45°.
CLAYSTONE (50%)& SILTSTONE (50%): black to very dark gray, fresh, hard; poorly expressed bedding with beds 2-5cm thick, only one lamination of fine sandstone; intensely fractured with loose angular fragments,mostly rough and stepped joint surfaces.
@71.3m: sandstone bed inclined 35°, few joints inclined 50° to 65°, rough to stepped, no fill.
@71.9m: SILTSTONE (60%), CLAYSTONE (20%) and SANDSTONE (20%), black to gray, fresh, hard; bedding inclined 30° to 45° ; intensely fractured, moderately rough to stepped joint surfaces.
@72m: bedding inclined 40°, black clay filling, 25mm thick, immediately below clay filling is 76mm thick fracture zone.
@72.1m: Fracture zone, 50mm thick, black clay on joint surfaces, above bedding inclined 45°.
loose rock fragments.
@72.5m: SILTSTONE (50%), CLAYSTONE (40%), and SANDSTONE (10%): fresh, hard, fine-grained sandstone; well-expressed bedding, planar to wavy; intensely fractured, moderately rough to stepped, commonly clean; joint inclined 55°, bedding joint inclined 45°.
@72.6m: Fracture zone inclined 45°, 75mm thick, clay filling, followed by bedding inclined 55°.
@72.7m: joint inclined 60°, at bottom of sample joint with calcite filling.
SANDSTONE (40%), SILTSTONE (40%), and CLAYSTONE (20%): interbedded; fresh, hard, very fine, fine, and medium sandstone; well-expressed bedding; intensely fractured, joints inclined 60° and 70°, slightly rough.
@73m: fold in siltstone and sandstone laminations (soft sediment deformation).
@73.1m: bedding joint inclined 50°, bedding inclined 50° to 55°, joint inclined 45°, slightly rough and polished.
@73.2m: bedding joint inclined 47°, joints inclined 40° to 75°, mostly rough joint surfaces.
@73.4m: few joints inclined 40°.
SILTSTONE & CLAYSTONE: recovered only a few loose fragments, stiff black clay adhering to some fragments. Cored with NQ size for pressure meter testing.
SILTSTONE (50%), CLAYSTONE (30%), SANDSTONE (20%):fresh, hard; interbedded, well-expressed bedding inclined 75° : intensely fractured, some joints open less than 1mm (perhaps washed out during drilling) bedding joints and incipient joints throughout cor
SILTSTONE (40%), CLAYSTONE (30%), AND SANDSTONE (30%), black to gray with white calcite veins 1-2 mm thick COLLAPSING HOLE, hole is taking water, added 3 bags of bentonite chips which filled 4.3 m of hole (it should have filled 9m of hole therefore hole must be enlarged about 2 X).
@74.7m: fragments of siltstone and claystone, bedding joint and bedding inclined 70°, smooth and polished.
@74.8m: gray sandstone fragments with abundant white calcite veins 1-2mm thick, some black clay adhering to a few fragments near top of interval. Rocks too fractured and sheared to run pressure meter tests, filled bottom of hole with bentonite chips.
Redrilled NQ borehole from 73.5 - 75 meters with HQ-size core barrel. CLAYSTONE, SILTSTONE, SANDSTONE interbedded, fresh, hard; fine-grained sandstone; poorly expressed bedding, laminae to 6 cm thick, inclined 70° ; intensely fractured, moderately rough
@75.1m: bedding joint inclined 70°, moderately rough, calcite fill, graded bedding finer at top.
@75.2m: SILTSTONE & CLAYSTONE: black, faintly bedded with beds 2-6cm thick, bedding inclined 70°, very fractured, bedding joint inclined 70°.
@75.4m: very intensely fractured zone, 150 mm thick, claystone and siltstone fragments several with clayey and calcite coating and smooth and polished surfaces, several joints at 0° ; also bedding joint inclined 70°.
@75.5m: SILTSTONE & SANDSTONE: fine sandstone, dark gray and gray, joint inclined 20°, smooth and polished surface.

PENETRATION DEPTH (m): 75 – 85

- Run 70: REC=69% RQD=28%
- Run 71: REC=58% RQD=0%
- Run 72: REC=58% RQD=0%
- Run 73: REC=63% RQD=0%
- Run 74: REC=100% RQD=0%
- Run 75: REC=55% RQD=0%
- Run 76: REC=83% RQD=67%
- Run 77: REC=83% RQD=14%
- Run 78: REC=81% RQD=31%
- Run 79: REC=100% RQD=0%
- Run 80: REC=100% RQD=25%
- Run 81: REC=100% RQD=0%
- Run 82: REC=100% RQD=15%

SILTSTONE (40%), CLAYSTONE (25%), and SANDSTONE (35%): very fine to fine-grained sandstone, black to gray, fresh, hard; well-expressed bedding ranging from laminae to 3-4 cm, graded bedding from finer at top to coarser at bottom. Joint inclined 45°, closely spaced fractures, rough to moderately rough.
@76.1m: bedding and bedding joint inclined 65°, joint inclined 0°, calcite filling, rough.
@76.4m: nicely graded depositional unit - claystone to fine sandstone.
@76.5m: bedding inclined 65°, 37mm thick claystone at bottom of sample.
@76.8m: CLAYSTONE (70%): with thin interbeds and laminae of SILTSTONE and very fine SANDSTONE, fresh, hard, closely spaced fractures, slightly to moderately rough surfaces, patchy calcite film.
@76.9m: bedding and bedding joint inclined 65°; joint inclined 80°.
@77.1m: laminated claystone, siltstone, and very fine sandstone, wavy bedding.
@77.4m: SILTSTONE (40%), CLAYSTONE (30%), AND SANDSTONE (30%): fresh, hard, very fine sandstone, well-expressed bedding ranging from laminae to 2 cm; intensely fracturee, slightly rough to stepped fracture surfaces, joint at top of sample inclined 75°.
@77.5m: joint inclined 75°, stepped joint surface, bedding inclined 70° to 75°.
@77.6m: bedding joint inclined 55°, moderately rough surface.
@77.7m: Shear zone inclined 30°, 37mm thick, black sandy clay; sandstone at bottom of sample.
@78m: loose rock fragments, calcite filling.
@78.1m: SANDSTONE (60%) & SILTSTONE (30%): dark gray to gray with few thin white calcite veins, fresh, hard; well-expressed bedding; intensely fractured, joints inclined from 30° to 70°, moderately rough to stepped.
SANDSTONE: gray, fine to medium with few black laminations, fresh, hard, very fractured, slightly rough surfaces, calcite coatings, joints inclined 30° and 50°.
@78.9m: SILTSTONE AND SANDSTONE, very fine to fine sandstone with a few thin beds and laminations of claystone, fresh, hard, bedding inclined 80° with calcite; intensely fractured. (Note: Circulation good. losing about 25% drilling fluid to formation).
@79m: Fracture zone, 100mm thick, some black clay and many polished surfaces, rotated core on claystone bed, joint inclined 25°.
@79.4m: joints inclined from 35° to 45°, calcite coating.
@79.5m: bedding inclined 55°, discontinuous black laminations, joints at bottom of core inclined 45°.
hole caving, added bentonite, resumed drilling after short wait; NCR in top 100mm of core.
@79.7m: joint inclined 20°, followed by 25mm lost core.
@79.7m: SILTSTONE & CLAYSTONE: loose fragment of siltstone and claystone, some smooth polished and slickensided surfaces, small amount of black clay on some fragments, bedding inclined 60°-65°.
@80m: SILTSTONE (80%): with interbedd fine sandstone (15%), fresh, hard, some discontinuous laminations, joint inclined 20°, smooth and polished, some calcite coating.
@80.1m: loose fragments of siltstone and sandstone, 1mm thick white calcite vein, inclined 5°.
@80.3m: SANDSTONE: gray, fine sandstone, fresh, hard, joints inclined 0° to 20°.
@80.5m: SANDSTONE: gray, fine- to medium-grained, several hairline calcite veins, a few black laminations indicate bedding inclined 60°, fresh, hard, intensely fractured, thin patchey calcite linings on surfaces.
@80.6m: joint inclined 55°, several intersecting calcite veins (2mm thick), bedding joints inclined 60°.
@80.8m: joint inclined 25° (Note: relatively little fracturing compared to material above; looks similar to central block material).
@80.9m: several joints inclined 40° to 45°, slightly rough to smooth, hairline calcite veins.
@81.2m: several discontinuous black laminations indicated bedding is inclined 60°.
@81.3m: joint inclined 25°, numerous closely spaced fractures, dark gray siltstone observed at bottom of interval.
@81.6m: SILTSTONE, CLAYSTONE, SANDSTONE; dark gray, fresh, hard, well-expressed bedding, graded bedding with finer at top and coarser at bottom, mostly loose fragments.
@81.9m: rough black claystone bed, underlain by stepped dark gray siltstone bed.
@82m: SANDSTONE: gray, with discontinuous black laminations, fresh, hard, bedding joint, white calcite veins 1-2mm thick.
@82.2m: black claystone bed, underlain by dark gray siltstone bed, moderately rough surfaces, bedding inclined 65°.
@82.4m: black siltstone bed, rough fracture surface, joints, slightly rough.
@82.5m: Fracture zone, 75mm thick, loose fragments of siltstone and sandstone, bedding joint inclined 65° in sandstone at bottom of sample, smooth and polished.
CLAYSTONE & SILTSTONE: black, fragments, bedding joint inclined 65°.
@82.7m: SANDSTONE: gray, fine to medium grained graywacke, with black laminae indicating bedding inclined 60° to 65°, and trace of pyrite, joints inclined 0° to 45°, very thin calcite coating, incipient joint inclined 65° and black clay on bedding plane.
CLAYSTONE & SILTSTONE: black to very dark gray, faintly bedded, bedding joint inclined 60°, fresh, hard, closely spaced fractures, tight joints.
@83.1m: joints inclined 80° and 60°, followed by gradational contact.
@83.2m: SILTSTONE & SANDSTONE: very dark gray and gray siltstone, gray fine sandstone, interbedded, inclined 60° to 65°, calcite veins inclined 35°, moderately spaced fractures.
@83.3m: bedding joint inclined 55°, calcite veins inclined 30°-40°.
@83.5m: SANDSTONE: fine- to medium-grained with black laminations, bedding joint, joint inclined 45°, closely spaced fractures, abundant intersecting calcite veins, minor fault with 18mm of bedding offset.
@83.6m: joint inclined 40°, white calcite veins 1-2mm thick.
@83.8m: sharp irregular contact between black claystone and siltstone, bedding joint inclined 65°, followed by joint inclined 40°.
CLAYSTONE: fresh, hard, closely spaced fractures, joints inclined 65° and 55°, polished to smooth to moderately rough surfaces, gradational lower contact.
@84.1m: SILTSTONE: fresh, hard, closely spaced fractures, bedding joints inclined 60°, moderately rough surfaces, gradational lower contact.
@84.2m: SANDSTONE: medium-grained, fresh, hard, small fault offset of 5mm, closely spaced fractures, moderately rough surfaces.
@84.3m: fragments of sandstone and siltstone, bedding joint, smooth and polished.
SANDSTONE: fine- to medium-grained, thinly bedded with lenses of siltstone (5-10%) and black laminations, fresh, hard, very closely spaced fractures, bedding joints inclined 70° to 75°, slightly rough to rough, tight joints.
@84.8m: joint inclined 0° to 10°, closely spaced fractures.
@84.9m: SANDSTONE, medium-grained, gray with white calcite veins and few discontinuous black laminations, bedding inclined 65°, rough joint surfaces.
@85.1m: joints inclined 25°-80°, slightly rough but polished.
@85.4m: decrease in bedding inclination to 65° ; joints near top of interval are inclined 70° and 30° and have rough surfaces, joints near bottom of interval are inclined 65° and have stepped surfaces, maybe 5-10% coarse grains in lower 150mm

Boring 02-8B Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST – DOUGLAS HOLMES HAMILTON – NO. CEG 31 – EXP. 7/31/04 – STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY E. BROWN 11/20/02
CHECKED BY S.SICILIANO 12/6/02

B. SCHELL/GEOLOGIST
S. VARATHARAJ/ENGINEER
FIELD INVESTIGATOR(S)/TITLE
DATE: AS SHOWN

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

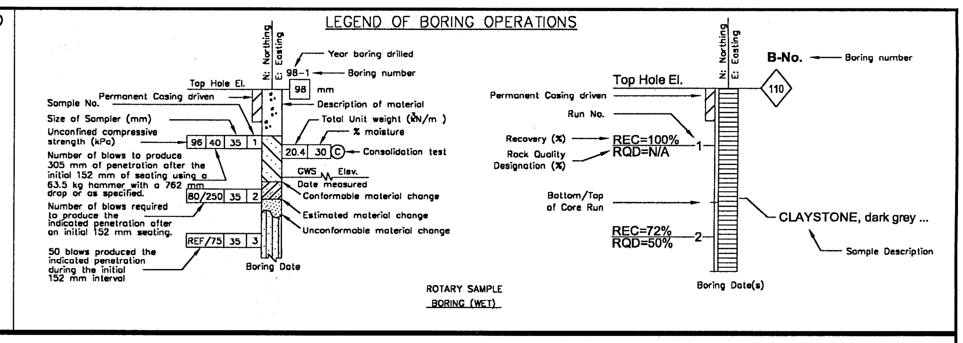
TYPE OF BORINGS

- 2¼" CONE PENETRATION
- ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- AUGER BORING (DRY)
- TEST PIT
- DIAMOND CORE BORING
- SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-8B Continued from LOTB Sheet of

PENETRATION DEPTH (m)

Depth (m)	Run	Description
85		SANDSTONE: gray, medium- to coarse-grained, numerous discontinuous white calcite veins; fresh; hard; possible bedding inclined 65°; no fractures.
		@86m: coarse grained with white "granitic" grains, moderately spaced fractures, joints inclined 40° to 70°, rough with slicks, calcite filling.
		@86.1m: joint inclined 50°, stepped joint with calcite filling.
		(UC) @86.2m: sandstone, coarse-O652grained with sevral calcite healed fractures.
	REC=100% RQD=77% 83	@86.4m: joint inclined 50°, softer zone with black clay, rough with slicks at 45° rake, calcite and clay filling, above coarse sandstone.
86		@86.5m: joint inclined 75°, altered clay fill 25 mm thick.
		@86.7m: joint inclined 50°, softer zone with black clay alteration (gouge), stepped, clay filling.
		@86.7m: joint inclined 90°, 1.5cm thick stiff black clay gouge with sandstone and unidentified black grains; top of conglomerate. CONGLOMERATE: clasts to 2 cm size composed of igneous, sedimentary (claystone, siltstone, and fine sandstone pebbles), most are rounded, abundant random calcite veins some within clasts.
		@86.9m: joint inclined 30°.
		CONGLOMERATE: sandy, white to gray, calcareous cement.
87		@87.3m: CLAYSTONE & SILTSTONE: appears to be a depositional unit (bed) within the conglomerate, the contact is inclined 40° to 45°.
	REC=100% RQD=28% 84	@87.4m: white calcite vein up to 7cm thick.
		@87.5m: SANDSTONE: medium- to coarse-grained, fresh, hard, moderately fractured, tight.
		@87.6m: bedding inclined 55°, rough surfaces.
		@87.7m: numerous calcite veins.
		@88m: black gouge, 37mm thick, contacts inclined 60° and 70°, smooth and polished.
88		@88m: intensely fractured and recemented sandstone with calcareous cement (ancient feature).
		@88.2m: gouge zone (young)100mm thick, contacts inclined 30°, rough surfaces.
		@88.3m: CONGLOMERATE: with sandstone matrix.
		@88.4m: cobbles ??.
		@88.5m: bedding inclined 60°, rough surfaces.
		@88.5m: joint inclined 55°, joints inclined 25° to 30° near bottom of interval.
89	REC=100% RQD=87% 85	CONGLOMERATE: well sorted from coarse sand matrix to at least 7cm (small cobbles), gray overall with wide range of colors of clasts from black claystone to white plutonic rocks, small percentage of yellowish-green rock that appears to be weathered/altered
		@89m: joint inclined 60°, rough joint surfaces, tight, moderately spaced fractures.
		@89.2m: joints inclined 55° and 45°, rough and rough with slicks, tight.
		@89.7m: Shear zone, 50mm thick, soft gouge zone, holds moisture, contacts inclined 50°.
90		@89.9m: joint inclined 0°.
		@90m: joint inclined 70°, rough with slicks.
		CONGLOMERATE: same as previous run, fresh, very hard, pebbles to cobble size.
	REC=100% RQD=87% 86	@90.5m: joints inclined 85° and 35°, stepped joints, tight, moderately spaced fractures.
		@90.6m: PEBBLE CONGLOMERATE, gradational contact: below contact pebbles predominantly 1cm size, poorly graded, about 5% black claystone, 30-40% gray siltstone, 30-40% plutonic rock, 20-30% sand matrix, abundant thin calcite veins in conglomerate and clasts
		@90.8m: joints inclined 60° and 25°, moderately rough with slicks, very thin calcite film.
91		@91.2m: joint inclined 60°, moderately rough with slicks, calcite fill.
		(UC) @91.4m: conglomerate with several calcite healed joints.
		@91.6m: healed fault (minor), joint inclined 50°, rough joint surface.
		@91.7m: joints inclined 50°, rough surface.
		PEBBLE CONGLOMERATE: as above, fresh, hard, one fracture.
		@91.8m: COBBLE-PEBBLE CONGLOMERATE: contact inclined 80°; below contact is more poorly sorted (well graded) conglomerate in coarse sand matrix.
92	REC=100% RQD=97% 87	@92m: joint inclined 35°, stepped joint, tight, patchy black clay lining.
		@92.9m: structural fabric, healed joints or faults.
		@93.1m: joints inclined 50° and 45°, stepped joint surfaces.
		CONGLOMERATE: as above, hammer ringing with good rebound, forced break goes both through and around pebbles.
		@93.5m: joint inclined 80°, rough with slickensides, tight.
93		@93.7m: joint (or mechanical break??) inclined 80°, rough surface.
		(UC) @93.8m: conglomerate with several calcite healed joints.
		@93.8m: healed joint.
	REC=100% RQD=80% 88	@94m: joints inclined 85°, rough with slicks, tight, also a healed joint and healed fault offset black clast about 1cm.
		@94.1m: joint inclined 55°, rough surface.
		@94.3m: bedding or structural texture inclined 55°.
		@94.4m: joints inclined 30, 35, and 50°, rough with slickensides, tight; black matrix.
94		@94.5m: moderately spaced fractures, joints inclined 0° to 30°, rough surfaces, tight.
		CONGLOMERATE: as above, well-graded pebble-cobble conglomerate in coarse sand matrix, generally clast supported, largest clasts are 6-8 cm, fresh, extremely hard; Composition: 45% plutonic rocks (granodiorite); 5% black claystone-siltstone; 25% fine sandstone-siltstone; 15% coarse sand matrix; 10% unidentifiable fine rocks; trace of yellowish-green fine-grained clast; many calcite veins both between clasts and within clasts; moderately to slightly fractured; joints moderately rough; tight.
95	REC=100% RQD=100% 89	@95m: depositional contact (bedding?) inclined 70°, tight.
		@95.1m: healed fault, minor but cannot match pebbles across fault, fault inclined 15°.
		@95.2m: joint inclined 85°, moderately rough with patchy calcite, tight.
		@95.4m: healed fault, 2.5cm right-lateral separation, fault inclined 50°.
		@95.6m: healed fault, minor but cannot match pebbles across fault, fault inclined 50°.
		@95.7m: healed joint inclined 10°, tight.
		@96m: joint inclined 70°, moderately rough with patchy calcite.
		(UC) @96m: conglomerate with several calcite healed fractures.
96		@96.3m: intersecting joints inclined 15° and 30°, some drilling mud on joint suggests small aperture, moderately rough.
		CONGLOMERATE: same as above, with up to boulder size rocks in coarse sand matrix, similar to last run in composition, clasts are mostly rounded with a small percentage of subrounded to subangular clasts, abundant calcite veins, calcareous cement, fresh, very hard, moderately fractured.
	REC=100% RQD=78% 90	@96.4m: joints inclined 80° and 65°, rough surfaces, tight.
		@96.7m: joint inclined 65°, rough surface, tight.
		@96.8m: joint inclined 50°, stepped with slickensides, calcite coating.
		@97m: joint inclined 60°, stepped, tight, clast with lime-green alteration.
97		@97.1m: incipient joint, large diorite clast.
		@97.4m: joint inclined 45°, moderately rough, black stain on surface, immediately below joint is 254mm thick clast of diorite/monzonite cobble-boulder.
		@97.5m: joint inclined 40°, rough surface, tight.
		@97.7m: contact and mechanical break, fracture inclined 60°, black claystone/siltstone, soft.
		@97.8m: rough joint inclined 25° with black surface with faint slicks, stepped joint inclined 75°, both joints have linear fabric/structure.
		CONGLOMERATE: as above, pebble-cobble conglomerate with very tightly packed clasts with minimal sand matrix, similar composition as above but less sand matrix, fresh, very hard, moderately to slightly fractured.
98	REC=100% RQD=73% 91	@98m: joint inclined 40°, stepped fracture, tight.
		@98.1m: Fracture zone, 50mm thick, inclined 90°; stepped surfaces.
		@98.2m: minor fault inclined 65°, 2-3mm offset of cobble, healed.
		@98.3m: Fault inclined 50°, black surface with mullions.
		@98.6m: 75mm gray siltstone cobble, immediately below cobble is slightly rough joint inclined 80° with dark gray clay film.
		@98.8m: joint inclined 80°, rough but polished black surface.
		@98.9m: joint inclined 65°, tight.
99		@99m: Fault inclined 20°, mullions/slickensides on fault face have 80° rake, surface is black and polished fairly smooth but surface is classified as moderately rough because of relief of mullions which is 2-3 mm.
		@99.2m: joint inclined 80°, tight.
		@99.2m: Fault inclined 50°, stepped and rough, black polished surface with down-dip mullions.
	REC=100% RQD=80% 92	@99.3m: two mechanical breaks near and at bottom of interval, breaks inclined 90°.
		same conglomerate, top 150mm white diorite boulder (?), thin slice of other pebbles against white rock, moderately fractured.
		@99.6m: joint inclined 70°, rough surface, tight.
100		@99.8m: joint inclined 60°, stepped joint surface, tight.
		@99.8m: joint inclined 70°, smooth, tight.
		@99.9m: joint inclined 60°, slightly rough and polished, tight.
		(UC) @99.9m: conglomerate with weak dark-gray claystone matrix.
		@100.1m: 127mm gray cobble/boulder.
		@100.3m: 25mm lime-green pebble.
		@100.3m: stepped joint inclined 70°.
		@100.5m: healed hairline fault, inclined 0°, from depth 100.3m to 100.6m, with 1cm separation.
101		@100.6m: joint inclined 70°, stepped surface, tight.
		@100.7m: healed faults, inclined 80°.
		@100.8m: joints inclined 15° and 70°, fault with black surface with 80° to 85° rake on slicks.
		@100.9m: Bottom of borehole.

9/16/02 to 9/26/02

VERTICAL SCALE 1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT	KEYHAN MOGHBEL
SIGNOFF DATE	

DESIGN	BY E. BROWN	11/20/02
CHECKED	BY S.SICILIANO	12/6/02

B. SCHELL/GEOLOGIST
S. VARATHARAJ/ENGINEER
FIELD INVESTIGATOR(S)/TITLE
DATE AS SHOWN

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

CONSISTENCY CLASSIFICATION FOR SOILS

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11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

TYPE OF BORINGS

- $2\frac{1}{4}$" CONE PENETRATION
- ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- AUGER BORING (DRY)
- TEST PIT
- DIAMOND CORE BORING
- SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Sample No.; Permanent Casing driven; Top Hole El.; N: Northing; E: Easting; 98-1 Year boring drilled; Boring number; mm; Size of Sampler (mm); Description of material; Unconfined compressive strength (kPa); Total Unit weight (kN/m³); % moisture; 96 | 40 | 35 | 1; 20.4 | 30 (C) Consolidation test; Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified.; CWS Elev. Date measured; 80/250 | 35 | 2; Conformable material change; Number of blows required to produce the indicated penetration after an initial 152 mm seating.; Estimated material change; Unconformable material change; 50 blows produced the indicated penetration during the initial 152 mm interval; REF/75 | 35 | 3; Boring Date

ROTARY SAMPLE BORING (WET)

B-No. Boring number (110); Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ...; Sample Description; Boring Date(s)

02-8C

N: 621,916.8 E: 1,822,453.9

El. +162.8 m — (63) — N8.5°E, 40° Inclination

PENETRATION DEPTH (m)

- 0
- Top soil: clay, orange brown, very soft to very stifff, wet, non plastic.
- @.3m: with some organics.
- 1 — REC=100% RQD=N/A — 1
- @.6m: with streaks of dark brown oxidation.
- @.9m: very stifff, silt-rich.
- more silt, very wet.
- 2 — REC=72% RQD=50% — 2
- @1.8m: very stifff, disaggregated silt with some organic material, no rock structure.
- @2.1m: NCR.
- SILTSTONE/CLAYSTONE, orange brown, intensely weathered to decomposed to clay, very soft.
- 3 — REC=56% RQD=0% — 3
- @3m: NCR.
- decomposed, with gray brown clay-rich intervals and organic material (<5%).
- @3.7m: no rock structure, soil-like.
- 4 — REC=42% RQD=N/A — 4
- @4m: NCR.
- @4.3m: NCR.
- @4.6m: NCR.
- 5
- with streaks of dark brown oxidation.
- @5.2m: with gray clay-rich intervals.
- REC=73% RQD=N/A — 5
- 6
- @5.8m: NCR.
- REC=133% RQD=0% — 6
- SILTSTONE/CLAYSTONE, orange brown, intensely weathered to decomposed to silt with clay, very soft, oxidation on surfaces (some recovery from previous run).
- intensely weathered to decomposed to stiff clay, with streaks of dark brown and orange oxidation and 5 joints inclined 85 to 90°.
- 7 — REC=68% RQD=25% — 7
- @6.7m: with two 75°, a 60° and a 90° joint.
- 8
- @7.6m: NCR.
- only remnants of rock structure: a 20 and a 60° inclined joints, clay filled, smooth.
- 9 — REC=58% RQD=0% — 8
- @8.5m: decomposed to soil.
- @9.1m: NCR.
- decomposed to silty soil, brown very wet.
- 10
- @9.8m: no rock structure identifiable.
- REC=100% RQD=65% — 9
- @10.1m: with two 60° decomposed joints, oxidized.
- @10.4m: with stifff clay.
- 11
- decomposed to clayey silt, orange brown with streaks of dark brown and orange oxidation, with a 85 and a 25° joint, clay filled, smooth.
- REC=100% RQD=28% — 10
- @11m: with a 40 and a 50° joint.
- @11.3m: with a 85° inclined joint.
- 12
- with a 85° inclined joint, clay filled, smooth.
- REC=100% RQD=17% — 11
- @11.9m: with a 60 and a 20° inclined joint.
- @12.2m: with a 40° inclined joint and stifff clay at bottom of run.
- 13
- intensely weathered to decomposed to stifff clay.
- REC=100% RQD=54% — 12
- @12.8m: decomposed.
- decomposed to intensely weathered.
- @13.4m: dark gray intensely weathered, with a 15° inclined joint, clay filled, orange and dark brown oxidation.
- 14 — REC=95% RQD=33% — 13
- @13.7m: with a 80 and a 75° inclined joints, clay filled, oxidized.
- @14m: with two 55° inclined joints.
- @14.3m: decomposed.
- 15
- with a 30° inclined joint, clay filled, oxidized.
- REC=61% RQD=0% — 14
- @14.9m: intensely weathered, with three 60° inclined joints, clay filled, orange and dark brown oxidation.
- decomposed.
- 16
- @15.9m: intensely weathered.
- REC=95% RQD=38% — 15
- @16.2m: with a 70, 60, 90 and 50° inclined joints, clay filled.
- @16.5m: with a 60 and a 45° inclined joints.
- 17
- @16.8m: with a 85° inclined joints.
- siltstone fragments in clay matrix.
- @17.4m: with black lenticular claystone grains aligned at 90° and a 65, 60 and 40° joints.
- 18 — REC=72% RQD=0% — 16
- @17.7m: with a 70° inclined joint and rock fragments in clay matrix.
- @18m: with two bedding planes inclined at 60°.
- @18.3m: NCR.
- with a 60° bedding plane and two 85° joints.
- 19
- @18.9m: with a 55° bedding plane, a 60° and two 70° joints.
- REC=48% RQD=0% — 17
- @19.2m: decomposed (driller reports loss of circulation).
- @19.5m: NCR.
- 20
- @19.8m: NCR.
- REC=100% RQD=0% — 18
- intensely weathered with a 20° inclined joint, clay filled, orange oxidation, smooth.
- 21
- with a 75° inclined joint, clay filled, smooth.
- @20.7m: with a 25, 20 and 45° inclined joint.
- REC=50% RQD=0% — 19
- @21m: NCR.
- @21.3m: NCR.
- 22
- with a 55, 85 and two 80° inclined joints, clay filled, smooth.
- @22m: with a 65, 85 and a 75° inclined joint, clay filled, smooth.
- REC=92% RQD=0% — 20
- @22.3m: siltstone/claystone fragments in clay matrix.
- 23
- @22.6m: decomposed to stifff clay.
- moderately weathered with localized fracture zone 8 cm wide composed of siltstone fragments in clay matrix.
- REC=64% RQD=0% — 21
- @23.5m: NCR.
- 24
- dark gray siltstone fragments in clay matrix, very soft.
- @24.1m: angular siltstone breccia up to 2.5 cm, with a 40, 30 and 35° joints, calcite and clay filled and calcite veining, moderately soft.
- REC=92% RQD=0% — 22
- @24.4m: with a 60 and a 85° joints, calcite and clay filled, very soft.
- 25 — REC=100% RQD=0% — 23
- with bedding apparently inclined at 70° and two 85° joints, clay filled, smooth.
- moderately weathered, with bedding at 90° rees and three joints dipping 80 to 85°, clay filled, dark brown to orange oxidation.
- REC=96% RQD=10% — 24
- @25.3m: with three joints dipping 80 to 90°, clay filled, dark brown to orange oxidation.
- 26
- @25.6m: with three joints dipping 60 to 70°, clay filled, dark brown to orange oxidation.
- @25.9m: with a 70° inclined joint.
- REC=167% RQD=0% — 25
- slough-in unconsolidated material.
- 27
- @26.5m: dark gray siltstone fragments in clay matrix, very soft, orange brown oxidation.
- REC=97% RQD=0% — 26
- with bedding inclined at 85 to 90°, oxidation, smooth.
- @27.1m: with a 85 and two 20° inclined joints, clay filled, smooth.
- @27.4m: with two 85° inclined joints.
- 28
- with bedding oriented at 80 to 85° and a small fracture zone cm wide composed of angular siltstone breccia up to 0.4 cm in dark gray clay matrix.
- @28m: with two 80° inclined bedding planes, calcite filled and clay coated.
- REC=100% RQD=33% — 27
- @28.4m: with a 85, 40, 65 and 10° inclined joint.
- @28.7m: with two 80° and a 10° inclined joints.
- 29
- @29m: with a 30° inclined joint, slightly rough.
- with bedding oriented at 85° and two 90° joints, calcite and clay filled, thin, smooth.
- 30
- @29.6m: with a 10, 30, 85 and 90° joints, slightly rough.
- REC=95% RQD=33% — 28
- @29.9m: with a 80, 85, 40 and 65° inclined joints, calcite and clay coated, thin.
- @30.2m: with jointing sub-perpendicular to the core axis, calcite coated.
- @30.5m: with a fracture zone, 0.3 m wide: siltstone fragments in clay matrix, calcite veining and remnants of sub-perpendicular jointing.
- 31
- bedding oriented at 65-70°, thin, oxidation on joints surfaces, with a 80 and a 40° joints, clean.
- @31.1m: with a 60° joint, calcite coated, striations on joint surface and a 10 cm wide fracture zone bounded by two 75° joints, composed of angular siltstone fragments up to 1 cm in brown clay matrix.
- REC=78% RQD=27% — 29
- 32
- @31.4m: with a 80° inclined joint, clay filled.
- @31.7m: with a 10 cm wide fracture zone bounded by two 80° joints, composed of angular siltstone fragments up to 0.5 cm in brown-orange clay matrix.
- @32m: NCR.
- SANDSTONE with SILTSTONE/CLAYSTONE interbeds, light gray and black, slightly weathered, very hard, thinly bedded with calcite veins up to a quarter of cm thick.
- 33 — REC=103% RQD=38% — 30
- @32.6m: with a small fracture zone, 2.5 cm thick, composed of angular fragments of siltstone/claystone up to 0.6 cm in clay matrix. Sandstone appear coarse to medium grained, upwardly fining, with four 75° inclined siltstone claystone interbeds up to 2.
- 34
- @32.9m: more fine grained rock section, moderately soft in fine grained interbeds, thinly bedded, bedding inclined at 75-80°.
- @33.2m: bedding up to 85°, slightly rough.
- @33.5m: with calcite vein up to 0.6 cm thick inclined 5° and two 75° joints, calcite coated, moderately rough.

PENETRATION DEPTH (m)

- 34
- siltstone-rich section, moderately soft in fine grained interbeds, thinly bedded, bedding inclined at 80°.
- REC=100% RQD=27% — 31
- @34.1m: sandstone, hard, with two 85° joints and a 5° inclined cross-joint.
- 35
- @34.5m: orange brown oxidation streaks in 15 cm-decomposed siltstone section inclined 85°.
- @34.8m: with two 85° joints, thick clay filling.
- @35.1m: with a 75° inclined joint.
- fine grained sandstone, moderately fractured, with siltstone interbeds inclined at 80°.
- 36 — REC=88% RQD=0% — 32
- @35.7m: with two siltstone interbeds up to 1 cm thick inclined 70 to 80°, clay filled, and two 20° joints.
- @36m: with two low angle fractures inclined 10 and 15°.
- @36.3m: incipient fractures along bedding.
- 37
- moderately to slightly fractured, with two siltstone interbeds inclined 80°, calcite and clay coated, smooth.
- REC=97% RQD=61% — 33
- @37.2m: with two siltstone interbeds inclined 80 and 85°, calcite coated with a 0.6 cm-thick clay filling, smooth.
- 38
- with dark gray siltstone interbeds weathering to orange brown, thin, oriented at 85° and a 3 cm-thick dark gray silty clay zone at 38 m depth.
- @38.1m: with two siltstone interbeds inclined 80 and 85° and a 30° cross joint.
- REC=97% RQD=27% — 34
- 39
- @38.4m: with two siltstone interbeds inclined 80°, a 10 and a 30° cross joint.
- @38.7m: with a 0.6 cm wide calcite and clay filled siltstone interbed and two 80° inclined bedding plane joints.
- intensely fractured, moderately hard to moderately soft locally, with three bedding planes inclined 80 to 85°, calcite coated, and a 10° cross-joint.
- 40 — REC=83% RQD=0% — 35
- interbedded, intensely fractured.
- @40.2m: with bedding inclined 65 to 90° and angular brecciated siltstone in clay matrix, 2.5 cm wide.
- REC=73% RQD=0% — 36
- 41
- @40.5m: fracture zone, 0.3 m wide: angular brecciated siltstone up to 2.5 cm in clay matrix.
- fracture zone: angular brecciated sandstone and siltstone up to 4 cm in clay matrix, very soft.
- REC=83% RQD=0% — 37
- 42
- bedding planes inclined 80° and a fracture zone composed of angular brecciated siltstone up to 1 cm in clay matrix.
- @41.8m: angular brecciated siltstone in clay matrix bounded by 80° bedding planes.
- REC=78% RQD=0% — 38
- @42.1m: angular brecciated siltstone in clay matrix bounded by 75 to 85° bedding planes in fine grained sandstone, relatively more intact.
- 43
- @42.4m: sandstone, light gray, medium to coarse grained, very hard, interbedded at 80° with siltstone, sheared into dark gray stifff clay, very soft.
- SANDSTONE, medium light gray (N6), fine to coarse grained, poorly graded (little coarse), angular to sub-rounded; silty.
- REC=64% RQD=0% — 39
- @43.3m: shear zone, 0.3 m wide: dark gray (N3); clayey sand.
- 44
- @43.6m: NCR.
- moderately fractured, with a 59° joint and a fracture zone 15 cm wide.
- REC=100% RQD=17% — 40
- @44.2m: with a 71° bedding joint and a fracture zone 15 cm wide.
- shear zone, 0.7 m wide: dark gray (N3); clayey sand, crushed, soft.
- 45
- REC=50% RQD=0% — 41
- @45.1m: with hairline calcite veining.
- 46
- @45.7m: NCR.
- SANDSTONE, medium dark gray (N4), intensely fractured, fine to medium grained, with thin calcite veins.
- REC=100% RQD=0% — 42
- REC=100% RQD=0% — 43
- with a shear zone, 0.3 m wide composed of clayey gravel, and a claystone bed, black, inclined 68°.
- 47
- with a claystone bed, black, inclined 88°.
- REC=100% RQD=0% — 44
- with a fracture zone, 0.3 m wide composed of sheared claystone.
- 48
- @47.9m: thinly bedded sandstone, medium gray (N5) to medium dark gray (N4); fine to medium grained, silty, with few inter beds of claystone less than 2.5 cm thick.
- REC=89% RQD=0% — 45
- @48.2m: with a bedding plane joint inclined at 82°, slightly to moderately rough, oxidized.
- 49 — REC=83% RQD=0% — 46
- with a bedding plane joint inclined at 74°, slightly rough, oxidized.
- with a fracture zone, 0.3 m wide composed of sheared claystone.
- REC=63% RQD=0% — 47
- @49.4m: partial recovery.
- 50
- with a fracture zone, 13 cm wide composed of black (N1) clayey sand, soft.
- REC=100% RQD=0% — 48
- @50.3m: sandstone, moderately hard.
- 51 — REC=100% RQD=0% — 49
- sandstone, moderately hard, brecciated and re-cemented.
- only sandstone fragments recovered.
- REC=52% RQD=0% — 50
- @51.5m: NCR.
- 52
- @51.8m: NCR.
- Shear zone: black (N1) clayey sand to clayey gravel [RQD may not be a good indicator of rock quality since is the clay in the shear zone holding the core together].
- 53 — REC=100% RQD=61% — 51
- @52.4m: with a 60° joint, slightly rough.
- @52.7m: with a 58° bedding joint.
- shear zone, with a 20° joint, slightly rough and a bedding plane joint inclined 70°.
- REC=100% RQD=0% — 52
- 54
- beds of sandy siltstone up to 8 cm thick in silty sandstone, medium light gray (N6) and dark gray (N3), fine to medium grained.
- @54m: with a 72 and a 6° joints, slightly rough.
- REC=72% RQD=0% — 53
- @54.3m: with a small fault inclined 75°, minor clay filling.
- @54.6m: with a bedding plane joint inclined 76°.
- 55
- @54.9m: NCR.
- with a sheared claystone section 5 cm thick, inclined 60°, soft.
- 56 — REC=100% RQD=0% — 54
- @55.8m: with a sheared claystone bed, 4 cm thick, inclined 68°, soft.
- with a shear zone, 6 cm wide: grayish black (N2) clayey sand to clayey gravel (sheared claystone with sandstone blocks).
- 57 — REC=67% RQD=0% — 55
- @56.7m: NCR.
- with a shear zone: grayish black (N2) clayey sand to clayey gravel (sheared claystone with sandstone blocks), soft [RQD not indicative of rock quality].
- 58 — REC=58% RQD=8% — 56
- @57.6m: NCR.
- @57.9m: NCR.
- with a shear zone: grayish black (N2) clayey sand to clayey gravel (sheared claystone with sandstone blocks), soft.
- REC=100% RQD=0% — 57
- 59
- @58.5m: with a 52° small fault, slightly rough.
- with a shear zone, 0.3 m wide: grayish black (N2) clayey sand to clayey gravel (sheared claystone with sandstone blocks), soft.
- @59.1m: with a fault contact inclined 73° dividing above shear zone from sandstone, medium dark gray (N4), fine to medium grained, silty; discontinuous laminations of siltstone, calcite veins common.
- REC=79% RQD=23% — 58
- 60
- @59.5m: with a 48°, 82° (bedding), 20° and 85° joints, calcite coated, slightly to moderately rough.
- REC=100% RQD=0% — 59
- @59.8m: with a shear zone (partial recovery).
- with a shear zone, 0.3 m wide: grayish black (N2) clayey sand to clayey gravel (sheared claystone with sandstone blocks), soft.
- 61
- with a 73° bedding joint, slightly rough.

Boring 02-8C Continued on LOTB Sheet of

VERTICAL SCALE
1 : 50

Caltrans Metric

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

The State of California or its officers or agents shall not be responsible for the completeness or accuracy of electronic copies of this plan sheet.

DESIGN OVERSIGHT — KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN — BY E. BROWN, S.VARATHARAJ — 11/20/02
CHECKED — BY S.SICILIANO — 12/6/02

J. CASTLE, P. FRAME, M. HACHEY/GEOLOGISTS
FIELD INVESTIGATOR(S)/TITLE
DATE — AS SHOWN

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS)

BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

TYPE OF BORINGS

- 2¼" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
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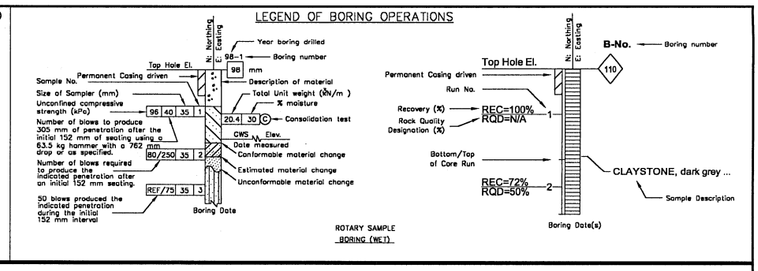
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-8C Continued from LOTB Sheet of

PENETRATION DEPTH (m)

61
- REC=86% RQD=0% — 60
- with a 73° bedding joint, slightly rough.
- @60.7m: with a shear zone bounded by a 72° fault and a 70° bedding joint, soft.
- @61m: with a shear zone (partial recovery).

62
- REC=100% RQD=46% — 61
- SANDSTONE, medium gray (N5) to dark gray (N3), fresh, moderately fractured, hard, fine to medium grained, silty, grades to siltstone locally. With a 56° incipient fracture.
- @61.6m: with a 70° joint, moderately rough and a 3 cm shear zone, soft.
- @61.9m: with a 64° small fault with 5 cm gouge zone associated, soft.
- @62.2m: with two small faults, 57 and 52° inclined, clay filled, slightly rough.

63
- REC=92% RQD=0% — 62
- with a 43 and a 57° joints, slightly rough.
- @62.8m: with a 57° fault with 5 cm clayey gouge associated.
- fracture zone, 0.6 m wide: moderately soft, sheared claystone consolidated to clayey sand.

64
- REC=100% RQD=33% — 63
- REC=100% RQD=25% — 64
- SILTSTONE, dark gray (N3), fresh, moderately to intensely fractured, moderately hard to soft, with laminations of silty sandstone inclined 63°.
- @64m: with two bedding plane joints inclined 66 and 86°, slightly rough.
- with a shear zone, 15 cm wide: grayish black (N2) clayey sand to clayey gravel, soft, bounded at lower end by a 52° fault.

65
- REC=86% RQD=0% — 65
- @64.6m: with a 66° smal fault and a 52° bedding joint, both slightly rough.
- @64.9m: with a shear zone, 0.3 m wide: grayish black (N2) clayey sand to clayey gravel, soft (partial recovery).

66
- REC=83% RQD=0% — 66
- SILTSTONE/CLAYSTONE, grayish black (N2), fresh, moderately to intensely fractured, moderately hard to soft, with hairline calcite veins, a 78 and a 62° joint, moderately to slightly rough.
- @65.5m: with a 62° fault, slightly rough associated with a shear zone 0.4 m wide composed of rock fragments, soft.

67
- REC=21% RQD=0% — 67
- @65.9m: partial recovery of rock fragments.
- shear zone: black (N1); sheared siltstone/claystone matrix with sandstone blocks, soft (partial recovery).

68
- REC=98% RQD=83% — 68
- @66.5m: NCR.
- with a 75° fault, smooth, with an associated shear zone, black, as above.

69
- REC=42% RQD=42% — 69
- @67.1m: with a 60° fault, smooth, with an associated shear zone, black, as above.
- shear zone: black (N1); sheared siltstone/claystone matrix with sandstone blocks, soft (partial recovery).

70
- REC=42% RQD=0% — 70
- @67.7m: NCR.

71
- REC=28% RQD=0% — 71
- moderately hard, possible slickensides, diffuse calcite veining (partial recovery).

72
- shear zone: black (N1); clay, lean to fat matrix (sheared siltstone/claystone) with siltstone fragments up to 5 cm, very soft, common calcite (partial recovery; well shut down for difficult advancement).
- @68.6m: NCR.
- @68.9m: Bottom of borehole.

8/12/02 to 8/16/02

VERTICAL SCALE
1 : 50

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE:

DESIGN: E. BROWN BY S.VARATHARAJ 11/20/02
CHECKED: BY S.SICILIANO 12/6/02

J. CASTLE, P. FRAME
M.I. HACHEY/GEOLOGISTS
DATE: FIELD INVESTIGATION/TITLE
AS SHOWN

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HOLMES HAMILTON NO. CEG 31 EXP. 7/31/04

HNTB CORPORATION
200 E. Sandpointe Ave. Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; POORLY-GRADED SAND (SP); CLAY (CL or CH); WELL-GRADED SAND (SW); SILT (ML or MH); SILTY SAND (SM) or SANDY SILT; PEAT and/or ORGANIC MATTER; CLAYEY SAND (SC) or SANDY CLAY; WELL-GRADED GRAVEL (GW); COBBLES/BOULDERS; POORLY-GRADED GRAVEL (GP); IGNEOUS ROCK; SILTY GRAVEL (GM); SEDIMENTARY ROCK; CLAYEY GRAVEL (GC); METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

02-11

N: 622,047.1 E: 1,822,510.1

El. +107.7 m — S22.5°E, 0 to 6.5° Dip

PENETRATION DEPTH (m)

Depth (m)	Run	Description
0		SANDSTONE, yellowish brown, intensely weathered, moderately soft to moderately hard; well-expressed bedding in thin (1cm) to 10 cm thick beds.
		@0m: fractured, primarily with joints, randomly oriented from 35 to 70°, slightly open with thin fill of manganese oxide and iron oxide, moderately rough surfaces..
1	1: REC=45% RQD=0%	@.3m: NCR.
		@1.2m: SANDY CLAY (decomposed sandstone) with sand and angular rock fragments, yellowish-brown, soft, plastic, can smear with finger pressure.
2	2: REC=72% RQD=0%	@2.1m: SANDSTONE, yellowish-brown, moderately weathered, moderately hard, massive, fine- to medium-grained; intensely fractured, inclined from 25 to 90°, slightly open,.
		@2.1m: manganese oxide stain, slightly rough to moderately rough surfaces, several joint sets, very closely spaced, some roots growing along joints..
3	3: REC=78% RQD=0%	
4		darker zones.
	4: REC=100% RQD=0%	@4.3m: dark grayish brown, joint lined with soft, brownish-yellow clay.
5	5: REC=95% RQD=0%	
6		@6.1m: CLAYSTONE bed 3 cm thick, brown, decomposed, soft.
	6: REC=71% RQD=0%	@6.4m: SANDSTONE, yellowish-brown, fine to medium grained.
		@6.7m: CLAYSTONE, dark grayish-brown, decomposed, soft.
7		loose fragments of sandstone.
		@7.3m: light-gray sandstone with oxidation.
	7: REC=78% RQD=0%	@7.5m: SANDSTONE, brown (10YR5/3), moderately weathered, hard to moderately hard, medium grained; intensely jointed, most joints with yellowish brown or black oxidation and light-yellowish-brown clay films. Poorly graded quartz and plagioclase grains.
8		@7.6m: random jointing.
		@7.9m: 30° joint.
		@8.2m: joints at 20 to 90°.
		CLAYSTONE AND SANDSTONE INTERBEDDED, gray and black, moderately weathered to intensely weathered, intensely fractured with joints and faults...
		@8.5m: NCR.
9	8: REC=58% RQD=0%	@9.1m: Sandstone, brownish-gray, fine grained, bedding from 1 mm to 1 cm thick, dipping 15°. Some roots in joints.
		@9.2m: Claystone and clayey zones, black, sheared and altered to soft clay with hard fragments, some bedding dipping 30°, few white calcite veins to 4 mm thick.
		NCR.
		@9.8m: loose washed sandstone fragments, several with white calcite veins.
10	9: REC=71% RQD=0%	@10.4m: Abundant calcite veins, 1 to 3 mm thich, various orientations.
		@10.5m: SANDSTONE: brownish-gray, fine-grained, moderately weathered, hard to moderately hard; bedding inclined 65° based on faint dark laminae; intensely jointed, joints inclined 30 to 70°, tight to slightly open, lined.
		@10.5m: with clay films and iron and manganese oxide stain, slightly rough to stepped.
11	10: REC=67% RQD=0%	@10.7m: manganese oxide stain, slightly rough to stepped.
		loose fragments of fine-grained sandstone.
		@11.1m: SANDSTONE, brown, fine-grained, moderately weathered, moderately hard, joints at 0 and 35°, intensely fractured, joints open 1 -2 mm with yellowish-brown clay filling, slightly rough surfaces.
		loose fragments except at tip where yellowish-brown clay holds small fragments of fine-grained Sandstone, gray and very-dark-gray, moderately weathered.
12	11: REC=67% RQD=0%	loose fragments of fine-grained sandstone with some clay matrix.
	12: REC=100% RQD=0%	@12.4m: clayey zone with small fragments of fine sandstone.
		@12.5m: SANDSTONE, dark-gray to bownish-gray, fine-grained, moderately weathered, moderately hard to soft, fracture zone, open 1 mm, clay fill with iron oxide stain, rough to stepped surfaces.
13		NCR.
		@13.1m: loose fragments of sandstone.
	13: REC=75% RQD=0%	@13.4m: SANDSTONE, brownish-gray to very dark gray, fine-grained, moderately weathered, hard to moderately hard, intensely jointed, oriented 0 to 60°, open 1 mm, iron oxide stain and clay fill, slightly rough surfaces.
14		SANDSTONE, brownish-gray, fine grained, moderately weathered, moderately hard to hard, intensely jointed, inclined 15 to 50°, tight to open 1mm, iron and manganese oxide stain with clay and calcite fill, moderately rough surfaces.
	14: REC=100% RQD=0%	
15		SILTSTONE, very-dark-gray with black claystone grains and sandstone, gray, fine-grained, moderately weathered, moderately hard to hard, moderately thick to thick.
	15: REC=100% RQD=0%	@14.9m: bedded, intensely jointed with joints inclined 0 to 70°, open to 1 mm, iron oxide stain, stepped to moderately rough.
		SANDSTONE, gray, fine-grained, slightly weathered to moderately weathered, hard, poorly bedded, 65-70° inclination, intensely jointed, some oxidation on joint surfaces, tight to slightly open.
16	16: REC=95% RQD=0%	@15.9m: clayey zone with small fragments of fine-grained sandstone.
		@16.2m: calcite veins inclined 20°.
		@16.3m: CLAYSTONE, black, slightly weathered to moderately weathered, hard, bedding inclined 65 to 70°, moderately spaced, intensely jointed, inclined 50 to 70°, tight to slightly open joints, clean, irregular upper contact.
		@16.4m: CLAYSTONE,SILTSTONE, AND SANDSTONE INTERBEDDED, Claystone is generally black, siltstone is black to dark gray, and sandstone is generally gray to light gray, moderately weathered to slightly weathered, moderately hard to hard, well-exressed.
17		@16.4m: moderately hard to hard, well-expressed bedding, laminated to thickly bedded:- very intensely fractured to moderately fractured, joints tight to slightly open (<1mm) with clay and calcite filling, iron and manganese oxide stain, thin calcite veins.
		loose fragments in upper 10 cm.
		@16.6m: 45° bedding, 1-cm-thick claystone bed between sandstone and siltstone beds.
	17: REC=87% RQD=0%	@16.8m: slightly rough to moderately rough.
		@17.1m: joint inclination 5 to 60°.
		@17.4m: random, random jointing.
18	18: REC=100% RQD=0%	@17.7m: bedding at moderate inclinations (40 - 60°).
		@18m: few thin/hairline calcite veins.
		intensely fractured silty sandstone, pale-yellowish-brown (10YR6/2), fine- to medium-grained.
	19: REC=54% RQD=0%	@18.3m: 0 to 10° joints.
		@18.6m: NCR.
19	20: REC=100% RQD=0%	@18.9m: intensely fractured sandstone, 20 to 65° joints.
		@19.2m: 26° joints.
		65 to 80° joints, bedding 1 to 4 cm thick.
	21: REC=100% RQD=22%	@19.5m: 65, 63, 64° bedding joints.
20		(DS) @19.8m: planar, rough joint.
		@19.8m: 66° clayey bedding joint.
		@20.1m: equipment malfunction, trouble coring, most core lost, only fragments recovered.
	22: REC=4% RQD=0%	@20.4m: NCR.
21		@20.7m: NCR.
		@21m: NCR.
	23: REC=75% RQD=0%	intensely fractured sandstone, angular gravel-size fragments in clayey sand matrix.
		silty sandstone, light olive-gray (5Y6/1), fine- to medium-grained, 22, 26, and 43° joints with vague slickensides (faulting ?).
22	24: REC=54% RQD=0%	@21.6m: intensely fractured.
		@22m: hole caving, only sand-sized fragments.
		intensely fractured, intensely weathered, clayey gravel with sandstone fragments, dark-yellowish-brown (10YR4/2).
	25: REC=78% RQD=0%	@22.3m: intensely fractured.
		intensely fractured, pale yellowish-brown (10YR6/2), fractures coated with iron and manganese stain, rare calcite vein.
23	26: REC=75% RQD=0%	@22.9m: intensely fractured, hole caving.
	27: REC=100% RQD=0%	olive black (5Y2/1).
		intensely fractured.
	28: REC=100% RQD=22%	@23.5m: 15, 44, 46, 48° joints.
24		14° joint with calcite fill, below fracture zone.
	29: REC=100% RQD=0%	@24.1m: olive black (5Y2/1), 66° bedding joint, 12° joint.
		@24.4m: 68° beding joint, 14° joints.
		71° bedding joint, beds 1 to 3 cm thick.
		@24.7m: 68° bedding joint.
25	30: REC=93% RQD=13%	@25m: 63° bedding joint above moderately weathered fractured zone..
		all materials below are slightly weathered, laminated to moderately thick bedding, 0 to 10° joints.
		@25.6m: 25 % sandstone beds to 5 cm thick, inclined 55 to 65°, 56° bedding joint,.
26	31: REC=100% RQD=21%	@25.9m: 65° bedding joint.
		@26.2m: 72° bedding joint, 0° joints.
		50 % claystone, light olive black and 50 % light olive gray sandstone, laminated to 15-cm-thick bedding, random jointing.
		@26.5m: 66° bedding joint.
27	32: REC=100% RQD=0%	@26.8m: 67° bedding joint.
		@27m: 64° bedding joint.
		@27.3m: 68° bedding joint between claystone and sandstone beds.
		@27.4m: 66° bedding joint between claystone and sandstone beds, 22° joint with calcite fill and iron oxide stain.
	33: REC=94% RQD=52%	(DS) @27.7m: slightly wavy clay-filled joint with oxide coating in slightly weathered, hard, brownish-gray sandstone.
28		(DS) @27.7m: 67, 64, 64° bedding joints between sandstone and claystone.
		@27.9m: thickly bedded sandstone, medium gray (N5) with thin white calcite veins, 64° beddding joint at top and 25° joint within.
		@28m: 61° joint.
		(UC)(E) @28.2m
		64 and 59° bedding joint.
		(DS) @28.5m: brecciated claystone within light brown sandstone.
		(DS) @28.5m: bedding contact inclined about 60°, in claystone.
		@28.7m: 65° bedding joint, 28° joint.
29	34: REC=82% RQD=27%	@29m: 63° bedding, joints at 5, 30, 35°.
		@29.3m: gravelly clay gouge, dark-yellowish-borwn (10YR4/2).
30		20° joint.

Boring 02-11 Continued on LOTB Sheet of

VERTICAL SCALE 1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY R. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/11/03

B. SCHELL/GEOLOGIST
P. FRAME/GEOLOGIST
FIELD INVESTIGATOR(S)/TITLE
DATE: AS SHOWN

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

LEGEND OF BORING OPERATIONS

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According to the Standard Penetration Test (ASTM D-1586)

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0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

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Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date; Sample No.; Permanent Casing driven; Top Hole El.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified.; Number of blows required to produce the indicated penetration after an initial 152 mm seating.; 50 blows produced the indicated penetration during the initial 152 mm interval; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

Boring 02-11 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

Depth (m)	Run	Description
30	35: REC=75% RQD=21%	@30.2m: gouge, dark-yellowish-borwn.
		66% black claystone and siltstone, 33 % olive sandstone, 63 and 68° joints.
		@30.8m: 67° bedding joint.
31	36: REC=100% RQD=43%	@31.1m: thin calcite veins in gray (N5) sandstone, 60° bedding joint.
		@31.3m: claystone, siltstone, and sandstone fragments in clayey matrix, 52° inclination.
		@31.4m: light-olive-gray sandstone with calcite veins; 49 and 50° joints. ran orientation probe: inclination 0, azimuth 203° (S23W) [average of two readings].
		@31.7m: joint contact at 82°.
32	37: REC=88% RQD=31%	@32m: joints at 48,73, 45°.
		@32.2m: 63° bedding joint.
		(DS) @32.2m: slightly wavy oxide-stained contact between claystone and light-brown sandstone.
		@32.3m: crushed claystone/siltstone/sandstone in clayey matrix, upper contact at 72°.
		light olive gray sandstone (50%) and black claystone, bedding 1 to 15 cm thick.
		@32.8m: 64° bedding joint.
33		@32.9m: 70° bedding joint, joints at 68, 32, 50°.
	38: REC=100% RQD=33%	@33.2m: joints at 16 and 65°.
		@33.4m: clayey gravel, dark-reddish- brown (5YR3/4), upper contact is bedding joint at 68°
		@33.5m: 10% black claystone in beds 5 cm thick.
34		@34m: 82° bedding joint with clay fill.
		(PT) @34.1m: fine-grained sandstone.
		(UC) @34.3m: light-brownish-gray fine- to medium-grained sandstone with few poorly healed fractures.
	39: REC=91% RQD=55%	@34.5m: 66° bedding joint.
		@34.8m: 79° bedding joint.
35		@34.9m: 78° joint.
		top of highly fractured sheared zone.
	40: REC=78% RQD=0%	
36		@36m: medium-dark-gray (N4) with grains and interbeds of gray sandstone.
	41: REC=100% RQD=70%	@36.3m: calcite vein.
		65° bedding joint, random jointing.
		@36.7m: 74° bedding, bottom of sheared zone.
37		@36.9m: 68° bedding joints, 18° joint.
		@37m: 68° bedding joint.
	42: REC=93% RQD=33%	@37.2m: with medium and light gray (N6), fine- top medium-grained sandstone interbeds to 5 cm thick, joint at 10°.
		@37.3m: CLAYSTONE/SILTSTONE, black claystone, gray and light gray siltstone, with gray fine-grained sandstone beds, slightly weathered to fresh, moderately hard to hard with few soft zones; well-expressed bedding, laminated to thinly bedded; very.
38		@37.4m: intensely jointed to widely spaced joints, tight, generally clean with some thin clay fill and iron oxide stain, slightly rough to moderately rough surfaces with some smooth and some rough surfaces.
		@37.4m: surfaces with some smooth and some rough surfaces.
		(PT) @37.7m: 72 and 66° bedding joints.
		(DS) @37.7m: partly healed, oxide-stained joint in claystone and sandstone.
		@37.8m: 0 and 80° jointing.
		@38.1m: 71° bedding joint.
	43: REC=100% RQD=75%	@38.4m: sandstone bed 6 to 9 cm thick, 80° bedding joint, 90° joints.
		(UC)(E) @38.8m: fresh to slightly weathered interbedded claystone, siltstone, and fine-grained sandstone.
39		@38.9m: 72° bedding joint, sandstone bed 2-3 cm thick.
		@39m: 71° bedding joint, 0 and 67° joints.
		@39.3m: 20° joint.
		@39.6m: 12, 38° joints.
40		@39.8m: 73° bedding joint.
		(UC) @39.9m: fresh to slightly weathered interbedded claystone, siltstone, sandstone.
	44: REC=100% RQD=62%	@40.1m: 67° bedding joint.
41		@40.9m: 0, 10, 70° joints.
		sandstone beds to 3 cm thick, 14° joint, slightly weathered to fresh.
		@41.3m: 70° bedding joint, 20° joint with iron oxide stain.
		@41.5m: 74, 62, 70° bedding joints.
	45: REC=100% RQD=35%	(UC)(E) @41.8m: 70, 72° bedding joint, predominantly claystone.
42		@41.9m: 70° bedding joint.
		@42.1m: 67° bedding joint.
		@42.2m: 68° bedding joint, 10° joint.
		@42.4m: 68° bedding joint.
		30, 20° joints.
		@42.7m: 0, 49° joints.
		@42.8m: 63° bedding joint.
43	46: REC=100% RQD=0%	@43m: locally crushed.
		71° beddding joint.
		@43.6m: 71, 75° bedding joints.
		@43.8m: 80° bedding joint.
44		@43.9m: 44° joint.
	47: REC=100% RQD=25%	@44m: 46° joint.
		@44.5m: 10° joint.
		85° bedding joint.
45		@44.9m: 63° bedding joint.
	48: REC=100% RQD=0%	@45m: 60° bedding joint, 16° joint.
		@45.1m: sandstone, mostly fragments.
		@45.6m: 72°, smooth, bedding joint on top of silty sandstone bed, light-gray (N7), fine- to medium-grained; 50° bedding joint at bottom of bed.
46	49: REC=87% RQD=20%	@45.9m: sandstone bed 5 cm thick; 0° joint with iron oxide stain.
		@46m: sandstone bed 5 cm thick 10° joint, slightly rough with iron oxide stain.
		78° joint.
47		

Depth (m)	Run	Description
47		@47.2m: Clayey gravel, sheared claystone, olive black (5YR2/1).
	51: REC=100% RQD=0%	@47.4m: 58° bedding in sandstone, 64° bedding joint at bottom contact with claystone.
48		@47.9m: sandstone bed 4 cm thick, 80° bedding joints top and bottom, slightly rough.
	52: REC=100% RQD=33%	@48.1m: 13° joint, moderately rough.
		@48.3m: 80° bedding joints, smooth.
		80° bedding joints, smooth.
		@48.7m: sandstone bed, 3 to 4 cm thick, with calcite veins.
		@48.8m: 68° bedding joint on top of sandstone bed 15 cm thick.
49	53: REC=100% RQD=58%	@49.1m: sandstone 5 cm thick.
		@49.4m: 78° bedding joint, 65 to 70 % claystone and siltstone with 30 % sandstone; bedding laminar to 1 cm thick.
		(UC) @49.5m: dark-gray highly fractured claystone/siltstone.
		68° bedding joint, slightly rough.
50		@49.8m: 72° bedding joint, slightly rough.
		@50m: 72° bedding joint, slightly rough.
	54: REC=39% RQD=39%	@50.3m: NCR.
		claystone with sandstone, very intensely fractured with random jointing.
	55: REC=100% RQD=50%	@50.8m: 70° bedding joint.
51		water from formation affecting drilling operations.
		@51.1m: bedding joints 71, 69, 74° between claystone, siltstone, and sandstone interbeds 3 to 4 cm thick.
		@51.2m: first measureable water from formation, estimated 20 liters/min (5 gal/min).
	56: REC=69% RQD=12%	@51.5m: bedding joint 74°, numerous steep (0-10°) joints.
52		increase in water flow from formation; siltstone laminations common, 81° bedding joint, 39° joint.
		@52.1m: 68° bedding joint, slightly rough.
	57: REC=97% RQD=0%	@52.3m: irregular contact with sandstone 15 cm thick.
		@52.4m: 55 and 74° smooth joints.
		@52.6m: sandstone bed 17 -18 cm thick, irregular upper contact.
		70° bedding joint, slightly rough.
53		@52.8m: 64 and 65° beds and bedding joints, slightly rough.
	58: REC=100% RQD=19%	@53m: silty sandstone bed, medium-light-gray (N6) to medium-dark-gray (N4), fine- to medium-grained, 20 cm thick, slightly weathered, calcite veins, 10° joint with calcite fill and iron oxide stain.
		@53.2m: 84° bedding; predominantly fresh unweathered material below.
		@53.4m: 46° joint, moderately rough.
		@53.5m: 48° joint, slightly rough.
		@53.7m: 62° bedding joint.
54		@54m: 75° bedding joint, slightly rough.
	59: REC=83% RQD=43%	@54.3m: 72° bedding joint, slightly rough.
		@54.4m: sandstone lens grading to claystone with depth.
		@54.6m: 63 and 52° bedding joints, fragments below, calcite veins.
55		@55m: 83 and 54° joints, slightly rough and moderately rough.
		(UC) @55.2m: siltstone and claystone with healed calcite fractures.
	60: REC=81% RQD=22%	@55.3m: sheared fragments witha abundant calcite veins, 60° upper contact, 62° lower contact.
		@55.5m: shear zone, 53° inclination.
56		sheared claystone, olive black (5Y2/1), with clasts of intact claystone to 5 cm size and with polished surfaces.
	61: REC=72% RQD=0%	
		fragments of claystone, 75° inclination.
		@56.4m: shear zone 1 cm thick, clayey on either side, 60° ree inclination, slightly rough.
	62: REC=100% RQD=39%	@56.6m: 30° contact, moderately rough; 42° joint.
		@56.7m: 86° bedding joint, 25° joint slightly rough.
57		Sheared Claystone with abundant lenses of sandstone, shear fabric consistant throughout; 43° joint, slightly rough, polished.
	63: REC=96% RQD=0%	@57m: 53° joint, slightly rough, polished.
		@57.2m: 35 and 34° joints, slightly rough.
		@57.3m: INTERBEDDED CLAYSTONE, SILTSTONE, AND SANDSTONE, claystone is black, siltstone is black to dark gray, sandstone is dark gray to light gray, fresh to slightly weathered, generally moderately hard but.
		@57.3m: ranging from soft to hard, well-expressed bedding in laminations to thin beds, generally intensely fractured to moderately fractured, joints tight to slightly open, occasionally with thin clay fill and commonly with iron.
58	64: REC=67% RQD=0%	@57.3m: oxide stain, smooth to moderately rough, commonly polished and slickensided.
		@57.6m: sand and gravel size fragments.
		@57.8m: crushed claystone in clay matrix grayish-black (N2).
59	65: REC=85% RQD=41%	
		Claystone (50%) and sandstone (50%). 53° dip on polished surface with slickensides.
60		

Boring 02-11 Continued on LOTB Sheet of

VERTICAL SCALE 1 : 25

Caltrans Metric

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST DOUGLAS HOLMES HAMILTON NO. CEG 31 EXP. 7/31/04 STATE OF CALIFORNIA

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

The State of California or its officers or agents shall not be responsible for the completeness or accuracy of electronic copies of this plan sheet.

DESIGN OVERSIGHT KEYHAN MOGHBEL

SIGNOFF DATE

DESIGN BY R. VARATHARAJ 11/20/02

CHECKED BY S. SICILIANO 2/11/03

B. SCHELL/GEOLOGIST
P. FRAME/GEOLOGIST
FIELD INVESTIGATOR(S)/TITLE
DATE AS SHOWN

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.

KILOMETER POST

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
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5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

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- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

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- 2½" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

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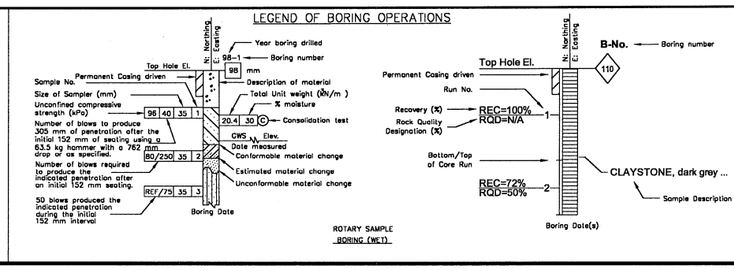
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-11 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

60 REC=100% RQD=25% 66
- Claystone (50%) and sandstone (50%), 53° dip on polished surface with slickensides.
- claystone (30%) and sandstone (80%), bedding to 2 cm thick at 46° inclination; joint at 70° with slightly rough surface.
- @60.7m: calcite vein at 51° inclination on slightly rough joint.

61 REC=72% RQD=22% 67
- @60.8m: bedding-plane joints inclined 46 and 48° with slightly rough and polished surfaces.
- @61.4m: clayey gouge about 2 cm thick.
- @61.6m: gouge and intensely fractured shale.
- @61.6m: interbedded claystone, siltstone, and sandstone, laminated and very thinly bedded, inclined 74°, with calcite veins: upper contact inclined 58°, joint inclined 37°.

62 REC=88% RQD=13% 68
- @61.8m: fractured zone.
- @62m: bedding inclined 72 and 65°, slightly rough surfaces.
- @62.2m: bedding inclined 78 and 73°, slightly rough surfaces.
- Ran orientation survey: borehole inclination -5°, azimuth 203.5 (S23.5W) (true). Predominantly claystone and sandstone in beds to 2 cm thick; bedding joints, smooth, inclined 80 to 85°; joints 0 to 10°.
- @62.7m: top of faulted and folded zone with lower angle bedding and sheared/fractured zones and abundant oxidation. Bottom of zone is at 69.36 meters.

63 REC=60% RQD=0% 69
- @62.8m: faulting highly fractured clayey zone, upper surface inclined 10°; polished, lower contact inclined 72°, slightly rough with iron oxide stain. Abrupt change in bedding orientation below.
- @63m: Folded zone, bedding and bedding joints inclined 22°, moderately rough; joints inclined 63°, moderately rough, iron oxide stain..
- @63.1m: 80° rough joint.
- claystone 70%, sandstone 30%; thin calcite veins common, slightly weathered.
- @63.7m: joints 76 and 10°, moderately rough, iron oxide stain.

64 REC=100% RQD=89% 70
- @64.2m: 78° joint, rough, iron oxide stain.
- @64.3m: 86° joint, rough.
- (VS) @64.4m: claystone with calcite veins.
- @64.6m: joints inclined 25 to 84°, slightly rough, iron oxide stain.

65 REC=100% RQD=83% 71
- highly fractured at top.
- @65.4m: well-bedded sequence, bedding joints inclined 76 and 77°, moderately rough, abundant oxidation.
- (VS)(E) @65.5m: interbedded claystone and sandstone with calcite-healed fractures.

66 REC=100% RQD=78% 72
- @65.9m: 78° bedding joints, slightly rough.
- @66m: oxidized zone, rough joints, open 2 mm, calcite veins.
- @66.2m: bedding joints 68, 77, 78°, slightly rough, calcite fill and iron oxide stain.
- @66.6m: sandstone bed 7-8 cm thick offset on calcite-filled fault and recemented.
- @66.8m: offset sandstone bed, bedding joint 36°, iron oxide stain.

67 REC=32% RQD=23% 73
- claystone/siltstone, grayish black (N2) with thin sandstone beds to 5-6 mm thick, highly fractured and sheared: slightly rough bedding joint inclined 39°.
- @68.2m: 43° fault, moderately rough.
- @68.4m: sheared claystone, locally abundant calcite inclined 49 and 64°.

68 REC=100% RQD=0% 74
- (VS) @68.6m: dark gray clayey gouge.
- @69.4m: lower contact of faulted/folded zone; rocks below are well-bedded, dark gray (N3) claystone/siltstone (70%) and medium-light-gray (N6) sandstone (30%), fresh; beds generally < 2 cm thick, bedding joint inclined 72°.
- @69.4m: slightly rough joint inclined 18°.
- (PT) @69.7m: 68° bedding joint, slightly rough;well-expressed bedding inclined 70 to 80° in claystone and siltstone.

69 REC=100% RQD=78% 75
- @69.8m: 66° bedding joint, slightly rough.
- @70.1m: 42 to 10° joints, moderately rough to slightly rough with iron oxide stain, slightly weathered.
- @70.4m: steep (0°) joint, moderately rough.
- @70.6m: 80° bedding joint, slightly rough; 37° rough joint.
- slightly weathered, several sheared and fractured zones;minor joints random, major joint 27° with iron oxide stained slightly rough surface.

70 REC=98% RQD=22% 76
- @70.9m: 76° bedding joint, moderately rough.
- @70.9m: contact with zone of sheared grayish black claystone (clayey gravel) with minor sandstone.
- (VS) @71.3m: contact between clayey gouge and claystone.
- @71.3m: 10° fault and abundant joints, rough to moderately rough with calcite and iron oxide stain.
- @71.8m: 51° rough joint and calcite vein.

71 REC=100% RQD=78% 77
- @72m: 74° bedding joint, slightly rough with iron oxide stain.
- @72.1m: 6° joint, slightly rough, iron oxide stain.
- @72.3m: clayey fractured zone inclined 72°; top of low-angle (0°) shear zone.
- @72.6m: 74° bedding joint.
- @72.9m: several joints inclined 40 to 60°, moderately rough.

72 REC=98% RQD=65% 78
- (VS) @72.9m: claystone/sandstone with horizontal calcite veins.
- @73.2m: 32° slightly rough joint.
- @73.3m: fragments with iron oxide stain.
- @73.5m: 44° joint.
- (VS)(E) @73.6m: claystone and fine-grained sandstone.
- well-bedded sequence, consistent bedding inclined about 70°.
- @74.1m: steep fault, moderately rough with iron oxide stain, wavy slickensides.
- @74.2m: fractured zone with iron oxide stain, 20° inclination.

73 REC=100% RQD=76% 79
- (VS) @74.6m: claystone,siltstone, sandstone sequence inclined about 70°.
- @74.8m: 70° joint/bedding joint.
- @74.9m: 68° bedding joint.
- (VS) @75.3m: 77° bedding joint, well-bedded claystone with siltstone and fine sandstone laminae with consistent dips from 70-80°.
- @75.7m: fractured zone with iron oxide stain, top contact is joint with 54° inclination, rough.

74 REC=96% RQD=69% 80
- @75.9m: bottom of fractured zone.
- @76.1m: 19° fault with polished surface.
- @76.3m: calcite lining on bedding joint dipping about 75°.
- @76.3m: joints, slightly rough, inclined 52 and 40°.
- @76.5m: 74° bedding joint, 30° joint.

PENETRATION DEPTH (m)

77 REC=88% RQD=10% 79
- @76.8m: 42 and 74° joints, slightly rough to moderately rough.
- @77m: 78° bedding joint, slightly rough.
- @77.1m: 35° joint moderately rough.
- @77.3m: joints inclined 45 and 8°, smooth and slightly rough.
- @77.4m: fractured zone 7-8 cm thick, moderately rough, iron oxide stain.
- @77.6m: 60° moderately rough bedding joint, 85° joint.

78 REC=83% RQD=0% 80
- 49° fault, slightly rough with clay fill.
- @78m: 18° joint.
- @78m: 46° joint, rough.
- @78.2m: 60° joint, rough, thick calcite vein.
- @78.3m: 70-75° bedding.
- @78.4m: top of highly fractured and sheared claystone with local clayey matrix.

79 REC=100% RQD=44% 81
- bedding inclined about 70°.
- @79m: 70° bedding joint, slightly rough.
- @79m: 15° joint, smooth, iron oxide stain; top of fracture zone.
- @79.3m: 52° moderately rough bedding joint.
- @79.3m: bottom of fracture zone.
- @79.4m: rough joint inclined 42°., slightly rough joint at 14°.
- @79.6m: oxidized zone with calcite veins 0.5 cm thick.

80 REC=100% RQD=93% 82
- (VS) @79.8m: PREDOMINANTLY SILTSTONE (50%) AND SANDSTONE (30%) with interbedded CLAYSTONE (20%), gray and dark gray with black laminations and thin zones of black, slightly weathered in upper part and fresh in lower, well-expressed bedding ranging from laminati
- @0m: to very thin beds with occasional thin beds (3-5 cm), intensely fractured to moderately fractured, generally tight joints with some slightly open joints, clean with occasional clay film and and calcite lining, ranging from smooth to rough but.
- @79.8m: generally slightly rough and moderately rough.
- @79.8m: 68° bedding joint.
- @80m: 66° bedding joint.
- @80.1m: 64° bedding joint.
- 66° bedding joint.

81 REC=100% RQD=83% 83
- @80.5m: 76° beddding joint.
- @80.9m: 74° bedding joint, moderately rough.
- @81m: 82° bedding joint, slightly rough.
- (VS)(E) @81m: well-expressed siltstone and sandstone interbeds inclined 75-85°..
- @81.3m: 80° bedding joint, slightly rough.
- @81.4m: 79° bedding joint, slightly rough.
- @81.6m: 68° joint, moderately rough.
- @81.6m: 5° joint, moderately rough, iron oxide stain.

82 REC=98% RQD=83% 84
- well-expressed bedding, steeply dipping 75 to 85°.
- @81.8m: 13° joint, rough, iron oxide stain.
- @82m: 79 and 83° bedding joints, slighty rough and moderately rough, with iron oxide stain.
- (VS) @82.1m: siltstone with fine sandstone interbeds, few hairline calcite veins, well-expressed bedding inclined 75-85°.
- @82.2m: 78° bedding joint, slightly rough, open 1 mm, clay fill with iron oxide stain.

83 REC=100% RQD=78% 85
- @82.3m: 20° joint, rough, iron oxide stain.
- @82.5m: 72° bedding joint, slighty rough.
- @82.8m: 76° bedding joint, slightly rough.
- well-expressed bedding, steeply dipping at 75 to 85°.
- @83.3m: 31° joint with iron oxide stain.
- (VS) @83.4m: claystone with siltstone and sandstone interbeds, well-expressed bedding inclined 75-85°.
- @83.7m: 74° bedding joint, slightly rough.

84 REC=100% RQD=37% 86
- @83.9m: 73° bedding joint, slightly rough, iron oxide stain.
- @84m: 74° joint intersecting 20° moderately rough joint.
- @84.3m: 83° bedding joint, slightly rough.
- @84.4m: 76° joint, iron oxide stain.
- @84.5m: 64° joint, calcite fill with iron oxide stain.
- (VS)(E) @84.6m: well-expressed claystone-siltstone bedding, steeply dipping at 70-85°; fresh unweathered.
- @84.9m: 42 and 47° joints, slightly rough with dip-slip slickensides and iron oxide stain at top of fracture zone.

85 REC=94% RQD=21% 87
- @85.2m: 82° bedding joint with clay fill.
- @85.4m: 67° bedding joint, slightly rough.
- @85.5m: 79° joint, smooth.
- @85.6m: calcite vein up to 4 cm thick, 20° inclination, moderately rough at top of fractured zone.
- @85.9m: 69° joint, slightly rough.
- @86m: 5° joint, slightly rough.
- well-expressed bedding at 65-70°.
- @86.4m: 63° bedding joint, moderately rough at top of fracture zone in medium gray (N5) sandstone bed, 58° slightly rough joint.

86 REC=100% RQD=31% 88
- @87m: 66° bedding joint, moderately rough; at bottom of fracture zone.
- 73° bedding joint, moderately rough.
- @87.7m: 68° bedding joint, slightly rough.
- @87.7m: 60° bedding joint.
- @87.8m: fracture zone in claystone/siltstone.
- @88.1m: 31° joint, modrately rough.
- @88.4m: 50° fracture zone in sandstone.
- very fractured in upper part of sample and well-expressed bedding in lower part.

Boring 02-11 Continued on LOTB Sheet xx of xx

VERTICAL SCALE
1 : 25

DESIGN OVERSIGHT: KEYHAN MOGHBEL
DATE: SIGNOFF

	BY	DATE
DESIGN	R. VARATHARAJ	11/20/02
CHECKED	S. SICILIANO	2/11/03
DRAWN	B. SCHELL/GEOLOGIST P. FRAME/GEOLOGIST	
DATE	FIELD INVESTIGATION/TITLE	
AS SHOWN		

ORIGINAL SCALE IN mm FOR REDUCED PLANS: 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

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CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HAMILTON NO. EG535 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
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- size TEST PIT
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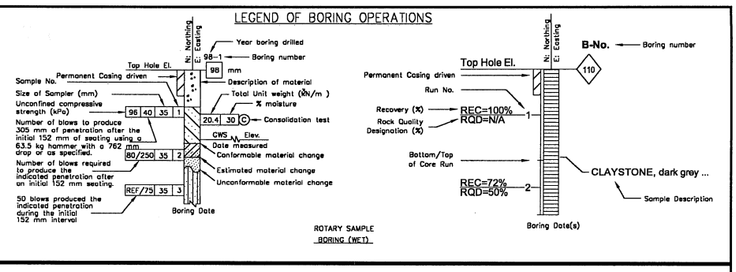

Boring 02-11 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

89
- @88.9m: 45° joint.
- @89m: joints at 39 to 0° with abundant calcite viens to 5mm thick, moderately rough.
- REC=100% RQD=45% 88
- @89.2m: 42° joint with calcite fill.
- @89.4m: 60° joint, slightly rough with clay fill.
- @89.5m: 70° bedding joint, slightly rough, well-expressed bedding below inclined 70-80° .

90
- @89.7m: 72° bedding joint, slightly rough.
- @89.8m: 78° bedding joint, slightly rough.
- @89.9m: 77° bedding joint, slightly rough.
- well-expressed bedding as above, inclined 70-80° , laminations to 2 cm thick, grayish-black (N2), increasing % of claystone.
- @90.2m: 16° joint, moderately rough.
- @90.6m: 72° bedding joint, slightly rough.

91
- REC=100% RQD=100% 89
- @91m: 80° bedding joint, slightly rough; 8° joint, moderately rough.
- @91.2m: 74° bedding joint, slightly rough.
- @91.5m: 74° bedding joint, slightly rough.
- CLAYSTONE (45%), SILTSTONE (35%), AND SANDSTONE (20%) INTERBEDDED, grayish-black (N2) to medium-light-gray (N6). Fresh, moderately hard; well-expressed bedding generally ranging from laminae to layers 1 cm thick but with occasional bed 5 cm thick..

92
- REC=92% RQD=39% 90
- @91.6m: to 10 cm thick, steeply dipping from about 70 to 85° . Moderately fractured, tight joints, generally clean with some clay films and calcite fill, generally slightly rough to moderately rough. (similar to above but with more claystone)..
- @91.7m: 15 and 23° joints, moderately rough, calcite fill.
- @92.2m: 72° clayey fault zone, soft.
- @92.2m: 75° bedding joint, slightly rough.
- @92.3m: 70° joint, rough.
- moderately expressed thicker bedding, some beds to 5-10 cm thick.

93
- @92.6m: 77° bedding joint, slightly rough.
- @92.7m: 8° joint, slightly rough.
- @92.8m: 73° bedding joint, slightly rough.
- REC=100% RQD=17% 91
- @92.8m: intensely fractured claystone/siltstone in clayey matrix , 2 to 5 cm thick, soft.
- @93m: several nearly horizontal joints, rough.
- @93.1m: 70° bedding joint, slightly rough.
- @93.4m: 65° bedding joint, slightly rough.
- @93.6m: nearly horizontal joint.

94
- @93.7m: sheared claystone with abundant fragments of claystone, sandstone, and calcite, slightly rough surfaces inclined 57 and 49° .
- moderately expressed bedding inclined 70 to 80° . 54° moderately rough joint.
- @94.3m: 70° joint, slightly rough.
- @94.3m: 57° bedding joint over zone of thick calcite veins.
- @94.5m: 36° joint , slightly rough.
- @94.6m: 58° joint slightly rough.
- REC=100% RQD=69% 92
- @94.7m: 76° bedding jint, slightly rough.
- @94.8m: well-expressed bedding inclined 70-80° .

95
- @94.9m: 30° joint, moderately rough with calcite fill in claystone-siltstone bedding inclined 70-80° .
- @95m: 77° bedding joint, slightly rough.
- @95.2m: 73° bedding joint, slightly rough.
- @95.3m: 75° bedding joint, slightly rough over 74° slightly rough joints.
- well-expressed bedding inclined 75 to 85° , laminated to very thinly bedded.

96
- @95.9m: 86° joint, moderately rough.
- @95.9m: 84° joints, moderately rough.
- REC=91% RQD=61% 93
- @96m: 84° bedding joint, slightly rough.
- @96.2m: 74° bedding joint, moderately rough.
- @96.3m: 88° bedding joint, slightly rough.
- @96.5m: 82° bedding joint, slightly rough.
- @96.5m: 80° joint, slightly rough.
- @96.6m: 83° bedding joint, moderately rough.

97
- CLAYSTONE (60%) AND SILTSTONE (30%) WITH INTERBEDDED SANDSTONE (10%), black to very- dark-gray, fresh, moderately hard; moderately well-expressed bedding generally ranging from laminae to 6 mm thick with occasional bed to 5-10 cm thick,..
- @96.8m: steeply dipping 70 to 80° . Joints closely spaced to moderately spaced, tight, with thin clay film on a few joints and calcite lining on some; generally slightly rough to moderately rough.
- @96.8m: claystone.
- REC=98% RQD=42% 94
- @97m: 73° bedding joint slightly rough.
- @97.1m: joints inclined 19 to 90° , moderately rough.
- @97.2m: clayey fractured zone, slightly rough.

98
- @97.3m: 77° bedding joint, slightly rough.
- @97.3m: 37° joint, slightly rough.
- @97.5m: top of fractured interval, 90° , 86° joint with clay fill.
- @97.7m: bottom of fractured interval, 72° inclination.
- @97.9m: several joints inclined 48, 37, 61° , clay fill on one; minor fault offsetting thin sandstone bed about 1 cm.
- @98m: 15° joints, moderately rough.
- @98.2m: 80° joint, slightly rough, with calcite fill.
- moderately expressed bedding, laminations to thin beds, steeply dipping 70-80° ; inversely graded; several hairline to thin (2mm) calcite veins, joints tight..

99
- REC=97% RQD=72% 95
- @98.5m: 71° bedding joint, slightly rough.
- @98.7m: 80° bedding joint, smooth.
- @98.8m: 74° bedding joint, slightly rough, calcite vein at top.
- @98.9m: fracture zone, steeply inclined.
- @99m: 61° joint, rough.
- @99.2m: 77 and 80° bedding joints.
- @99.4m: 80° bedding joints.

100
- @99.5m: bedding 75° , several small fault offsets (1 mm) with reverse and normal separation.
- @99.6m: 60° stepped joint.
- @99.7m: 85° bedding joint, moderately rough.
- @99.8m: MAJOR SHEAR ZONE; small bits of hard black claystone in black clayey matrix, soft, sheared, fragments range from sand size to small-gravel size; no obvious preferred orientation to foliation or sheared fabric; calcite vein at top inclined about 45 %
- REC=23% RQD=0% 96
- sheared and intensely fractured claystone and siltstone in black clayey matrix,..

101
- several bits of white calcite (sheared calcite veins).

102
- REC=73% RQD=0% 97
- @101.8m: three shear planes inclined 60° , smooth, polished surfaces with clay films and thin calcite fill.
- stiff sheared claystone, few white calcite fragments 1 to 3 mm size.

103
- REC=100% RQD=0% 98
- @102.7m: 70° joints.
- @102.9m: vague shear foliation.
- loose, flowing sand- and pebble-sized fragments of black claystone with several oxidized fine-grained sandstone fragments, many fragments with calcite coatings.

104
- REC=77% RQD=0% 99
- @103.4m: sheared claystone with small fragments of siltstone and fine-grained sandstone, predominantly (95%) claystone; hard fragments in soft clay matrix, few (<1%) white pieces of calcite (1-4mm), much of the.
- @103.4m: shearing appears to be along bedding with about 65° inclination.

105
- REC=71% RQD=0% 100
- @104.4m: joints ranging from 0 to 80° .
- @104.8m: abundant wite calcite to 10-15mm. Some with pyrite crystals.

106

PENETRATION DEPTH (m)

105
- REC=38% RQD=0% 101

106
- @105.8m: 70° bedding.
- REC=88% RQD=0% 102

107
- @106.7m: same shear zone but fine-grained sandstone now comprises significant percentage of sheared rock type, sandstone is gray with white calcite veins, joints are commonly polished and black with fine (0.5 mm) pyrite specks covering about 5 % of surfaces
- @106.7m: running borehole orientation tool; azimuth 201.5° (true), inclination 6.5° .
- REC=67% RQD=0% 103

108
- REC=67% RQD=0% 104
- larger fragments, several smooth polished joints and bedding joints inclined about 70° .

109
- REC=94% RQD=0% 105

110
- REC=100% RQD=0% 106
- SANDSTONE, gray, fresh, hard except in sheared zones, poorly expressed bedding inclined about 65° based on orientation of dark grains and textural changes, thickly bedded to massive, very intensely jointed and sheared with numerous black shear.
- @110.1m: zones, joints of all orientations from 0 to 80° ; samples commonly intact due to clay matrix, calcite common as joint lining and as fractured pieces, many joints clean and tight, smooth to stepped.
- REC=93% RQD=7% 107

111
- @110.5m: 65° bedding joint.
- @110.8m: 65° bedding joint, calcite coating.
- @111m: 65° bedding joint.
- @111.3m: sheared claystone, black, clayey matrix, 45° inclination.
- intensely fractured sandstone, joints of all orientations with most in 45 to 85° range, most joints clean, some with thin patchy calcite coating.
- @111.6m: joints inclined 45 to 80° .

112
- REC=88% RQD=0% 108
- @111.9m: joints inclined 55° .
- @112.2m: joints inclined 20 to 55° .
- Increased water flow from formation; sandstone, gray, fresh; hard to very hard except where sheared, intensely fractured eith joints ranging from 20 to 80° inclinations.

113
- REC=100% RQD=0% 109
- @112.8m: claystone and sheared claystone, black, soft to moderately stiff.
- @113m: sandstone, dark gray to black, medium-grained.
- joints ranging from 10 to 80° , calcite vein 6 mm thick at top of sample.

114
- REC=78% RQD=11% 110
- @113.7m: INTERBEDDED CLAYSTONE(30%), SILTSTONE(30%), AND SANDSTONE(40 %) with black clayey shear zones, black to gray, fresh, hard sandstone to moderately hard claystone; moderately thick units, poorly expressed bedding within units but unit.
- @113.7m: contacts indicate steeply inclined bedding inclined about 75° ; very intensely jointed with abundant clayey shear zones, individual joints generally tight and clean or with thin and patchy calcite, smooth to stepped, commonly polished and slick
- intensely jointed ranging from 0 to 75° .

115
- @114.2m: black clayey shear zone 5 cm thick.
- @114.5m: black clayey shear zone 10 cm thick.
- REC=94% RQD=0% 111
- @114.7m: pyrite on joint surfaces inclined 70-75° .
- @114.9m: black clayey shear zone 8 cm thick.
- @115.2m: black clayey shear zone 3 cm thick.
- water flow from formation about 114 liters/min (30 gal/min); most joints parallel to bedding.

116
- REC=93% RQD=11% 112
- @116m: black clayey shear zone 5 cm thick, inclined 75° .

117
- predominantly loose fragments and clayey zones with many white calcite chips, slightly weathered in upper 0.3 m.
- REC=100% RQD=0% 113

118

Boring 02-11 Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

Caltrans Metric

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Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

HNTB CORPORATION
200 E. Sandpointe Ave., Suite 200
Santa Ana, California 92707

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

STATE OF CALIFORNIA — CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — No. CEG 31 — Exp. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN OVERSIGHT: KEYHAN MOGHBEL
STGNDFF DATE:

	BY	DATE
DESIGN	R. VARATHARAJ	11/20/02
CHECKED	S. SICILIANO	2/11/03

B. SCHELLGEOLOGIST
P. FRAMEGEOLOGIST
FIELD INVESTIGATOR(S)/TITLE(S)

AS SHOWN

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

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> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

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- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
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- SOIL TUBE

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- (C) CONSOLIDATION
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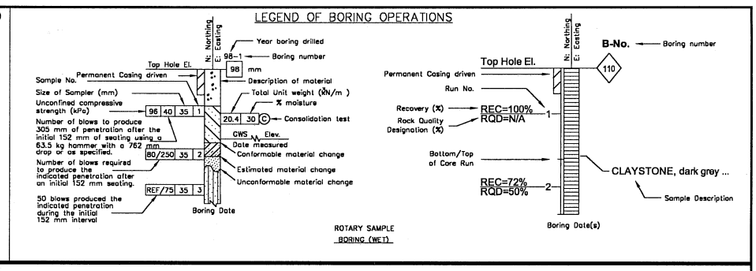
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-11 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

118	REC=100% RQD=24%	114	sheared claystone in black clayey matrix, rough joint surface, 90° inclination.
			@117.7m: 85° bedding joint, smooth; at top of fgractured zone consiting of 6 mm to 12 mm pieces.
			@117.8m: 75° bedding joint, bottom of fracture zone.
			@117.8m: bedding dipping 75° , faint laminations.
			@117.9m: 65° joint, smooth.
			@118m: several intersecting joints inclined 0 to 30° , and calcite veins, voids in calcite lining joint suggests dissolution.
			@118m: 75° bedding joints, thin calcite fill, slightly rough with slickensides indicating 30-60° slip relative to dip direction.
			@118.1m: 75° bedding joints slightly rough with slickensides and calcite coating.
119			@118.2m: 68° bedding joint with slickensides indicating 30-60° slip relative to dip direction.
	REC=81% RQD=0%	115	@118.4m: 77° bedding joint, slightly rough with thin calcite coating.
			@118.4m: 30° joint.
			SANDSTONE, gray to very dark gray, fresh, hard to very hard, poorly expressed bedding, apparently thick bedded to massive, very intensely fractured with several black clayey shear zones, joints tight, some with thin patchy calcite coating,.
			@118.6m: slightly rough to stepped , several intersecting hairline calcite veins at all orientations.
120			water flow from formation about 284 liters/min (75 gal/min).
			@120.1m: several intersecting calcite veins, hairline to 3 mm thick, joints random to 60° inlicnations, smooth to stepped surfaces with thin calcite and clay fill.
	REC=77% RQD=8%	116	@120.2m: calcite vein 4 mm thick over siltstone with 80° bedding.
			@120.4m: black clayey shear zone 8 cm thick, gray sandstone fragment showing bedding out of alignment.
			@120.5m: black clayey shear zone 1 cm thick inclined 55° .
			@120.6m: black clayey shear zone 5cm thick.
121			@120.7m: sheared sandstone, black to very dark gray, loose fragments.
	REC=50% RQD=0%	117	loose fragments of dark gray sandstone with black sheared surfaces in black sandy mud.
			@121.1m: black shiny surface inclined 75° on sandstone with abundant calcite veining, sample appears to be from sheared zone.
			claystone, siltstone and fine-grained sandstone, very dark gray to black, intensely jointed with joints inclined 20 to 55° , rough and stepped surfaces, some polished, with thin clay films.
			@121.8m: sandstone, grey, medium- to coarse-grained, several white calcite veins, fresh, very hard; intensely jointed, joints inclined 20 to 70° , slightly rough to stepped with slickensides, calcite fill.
122	REC=93% RQD=8%	118	@122m: black clay and sheared rock, primarily sandstone, 120 cm thick.
			@122.3m: several calcite veins, to 4 mm thick.
			medium-grained sandstone, with several thin horizontal calcite veings.
123			
	REC=100% RQD=24%	119	bedding joint 70° .
			thin horizontal calcite veins, hairline to 2 mm thick.
			abundant water flowing from formation; estimated 114 liters/min (30gpm); intensely jointed gray sandstone, medium-grained with white calcite veins 1.5 mm thick, joints inclined 15 to 60° , rough to stepped, tight, with calcite and clay films.
124	REC=100% RQD=0%	120	@124.1m: shear zone 7 cm thick, sandstone fragments in gray to black clay matrix.
			heavy water flow from formation, estimated up to 284 liters/min (75 gpm); intensely fractured and sheared, joints inclined 40° , smooth to stepped and polished.
			@124.5m: sheared sandstone, black and very dark gray, sand-size to 2-3 cm partcles in clayey matrix, many smooth and polished surfaces on fragments.
125	REC=100% RQD=0%	121	@125m: sandstone and siltstone with abundant random calcite veining, joints inclined 55 to 65° .
			@125.8m: Halted drilling to due to large water outflow from formation. Hole caved at 100 m depth; could not return to bottom of hole.
126			

7/25/02 to 8/13/02

VERTICAL SCALE
1 : 25

DESIGN BY R. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/11/03
DESIGN OVERSIGHT KEYHAN MOGHBEL
STANDARD DATE

B. SCHELL/GEOLOGIST
P. FRAME/GEOLOGIST
FIELD INVESTIGATOR(S)/TITLE
DATE
AS SHOWN
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PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE No.
KILOMETER POST

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DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

Caltrans Metric

CERTIFIED ENGINEERING GEOLOGIST
DOUGLAS HAMILTON
NO. CEG 31
EXP. 7/31/04
STATE OF CALIFORNIA
CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

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200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

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LEGEND OF BORING OPERATIONS

Sample No., Permanent Casing driven, Top Hole El., N: Northing, E: Easting, 98-1, Year boring drilled, Boring number, 98 mm, Size of Sampler (mm), Description of material, Unconfined compressive strength (kPa), Total Unit weight (kN/m³), % moisture, 96 40 35 1, 20.4 30 (C), Consolidation test, Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified., 80/250 35 2, CWS Elev., Date measured, Conformable material change, Number of blows required to produce the indicated penetration after an initial 152 mm seating., Estimated material change, REF/75 35 3, Unconformable material change, 50 blows produced the indicated penetration during the initial 152 mm interval, Boring Date

ROTARY SAMPLE BORING (WET)

B-No. — Boring number; 110; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A — 1; Bottom/Top of Core Run; REC=72% RQD=50% — 2; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

02-11A

N: 622,047.1 E: 1,822,510.1

El. +107.7 m — (63) — S21.5°E, 0 to 4° Dip

PENETRATION DEPTH (m)

Note: See boring 02-11 for rock condition from 0-11.9 m.

12 — SANDSTONE, grey, mostly weathered to orange-brown, core is thoroughly broken into angular pieces with clay filling and fracture surfaces are oxidized and weathered.

REC=38% RQD=0% — 11

13 — intensely weathered to decomposed core, thoroughly fractured.
@13.3m: completely disaggregated.

REC=120% RQD=0% — 12

14 — @13.8m: SANDSTONE, tan/grey, weathering to orange-brown, moderately hard, fractures filled with orange clay, surfaces oxidized.
SANDSTONE (same as above), intensely weathered, moderately soft to moderately hard, clay filling, core is thoroughly broken and weathered.

REC=75% RQD=0% — 13

SANDSTONE, light grey/tan, intensely weathered to decomposed to orange-brown, moderately hard, clay filling, slightly rough, fracture surfaces oxidized.

15 — REC=100% RQD=0% — 14
@14.8m: very soft, brecciated in orange-brown clay matrix.
@15m: SILTSTONE, dark grey weathering to orange.
@15.1m: disaggregated sand/siltstone.
SANDSTONE, brown-grey and brown, moderately weathered, moderately hard, clay filling, slightly rough to smooth, fine grained, no bedding evident, fracture surfaces oxidized dark brown.
@15.5m: predominate fractures subparallel to core axis (inclined at 0-5°), clay and calcite filling.

REC=92% RQD=11% — 15

16 — @15.8m: darker laminae of claystone and dark minerals, indicating bedding inclined 70°.
@15.9m: 20° joint.
@15.9m: brecciated sandstone in clay matrix.
@16m: clay-filled joints, 0°, 1-2mm of brown sandy clay fill.
SANDSTONE (same as above), intensely weathered, moderately hard, clay filling, slightly rough to smooth, loose angular fragments at top.
@16.4m: brecciated to disaggregated sandstone in clay matrix.
@16.5m: loose angular fragments, some mechanical breaks.

REC=100% RQD=0% — 16

17 — SANDSTONE, light grey/tan, intensely weathered, moderately soft to moderately hard, clay filling, ,smooth, weathering to orange-brown, fine grained, fracture surfaces oxidized from dark brown to orange.
@17.1m: SILTSTONE, dark grey, weathered orange, clay filled fractures.
@17.2m: SANDSTONE.

REC=50% RQD=0% — 17

18 — SANDSTONE/SILTSTONE, interbedded, moderately weathered, moderately hard, bedding inclined at 65°.
@17.9m: SANDSTONE, light grey with orange-brown weathering, fine grained.
@18m: SILTSTONE, tan/dark grey, weathering to orange-brown, highly fractured,.
@18.1m: joint inclined at 20°, clay filling, smooth, very thin.
@18.2m: clay/siltstone beds inclined at 65°, smooth.
@18.4m: calcite veins, very thin.
@18.4m: joint inclined at 20°, clay filling, moderately rough, moderately thin.

REC=100% RQD=19% — 18

19 — @18.5m: calcite veins, very thin, subparallel to 20° fracture.
@18.5m: bedding joint and bedding inclined at 65°, smooth.
@18.6m: bedding joint inclined 65°, smooth.
@18.7m: moderately healed fracture.
SANDSTONE (same as above), generally brown but with brown grey zones, intensely weathered, disaggregated in clay matrix.
@19.1m: moderately hard.
@19.2m: joint inclined at 35°, clay filling.
@19.2m: bedding inclined at 65°, moderately soft, smooth.
@19.3m: bedding inclined at 65°, moderately soft, smooth.
@19.5m: moderately hard.
@19.7m: completely decomposed sand/siltstone.
SANDSTONE/SILTSTONE in orange-brown clay matrix, intensely weathered to decomposed, very soft.

REC=92% RQD=14% — 19

20 — REC=50% RQD=0% — 20

21 — SANDSTONE/SILTSTONE, completely weathered to orange-brown, very poor recovery, broken completely.

22 — REC=28% RQD=0% — 21

loose angular fragments of yellowish-gray,sandstone, moderately westhered, brown clay in fractures.

REC=100% RQD=0% — 22

23 — @22.6m: joint inclined at 70°, rough, clay filling.
SANDSTONE with several thin beds of SILTSTONE greenish-brown , brown, to very dark brown, moderately weathered, moderately hard, fine- to medium-grained; well-expressed bedding ranging from laminations to beds several centimeters thick, inverse grading ind

REC=100% RQD=25% — 23

@23.1m: joint inclined at 40°, open.
@23.2m: siltstone beds, black-brown, inclined at 55-60°, brown clay filling.
@23.2m: joint parallel to core axis.
@23.3m: bedding joint inclined at 65°, moderately thin, rough, clay filling.
@23.4m: intensely weathered zone.
@23.5m: 60° joint.

24 — @23.6m: calcite vein, brown-grey zone, less weathering; 60° joint.
SANDSTONE, brown, moderately to intensely weathered, soft, fine to medium grained, local quartz veins and clay-filled joints.
@23.9m: moderately weathered, moderately hard, closely spaced joints inclined 30°, two at 60°.
@24.1m: sheared fracture zone, very soft, rough, moderately thin fractures.
@24.2m: joints inclined 10 and 75°, fragments with quartz veins.
SANDSTONE AND SILTSTONE INTERBEDDED, grey to greyish-brown, slightly to moderately weathered, hard, moderately to intensely fractured; well-expressed bedding inclined 60-70° ; joints mostly clay filled, rough.
@24.5m: intensely jointed zone.
@24.7m: bottom of intensely jointed zone.

REC=100% RQD=17% — 24

REC=107% RQD=52% — 25

25 — @25.2m: joint parallel to core axis, 4 mm aperture, rough, clay fill.
SANDSTONE AND SILTSTONE INTERBEDDED, grey and greyish brown, moderately weathered, moderately hard to hard; fine-grained with black streaks parallel to bedding; well-expressed bedding, laminated to thinly bedded, numerous joints inclined at 60°.

26 — @25.6m: bedding plane joints inclined 60°.
@25.9m: joint inclined at 30°.
@26.1m: two bedding joints inclined at 60°.
@26.2m: joint inclined 5°, clay filling.
@26.4m: two bedding joints inclined at 60°.
@26.4m: carbonaceous streaks defining bedding at 60°.
@26.5m: bedding joint inclined at 60°.
@26.6m: bedding joint inclined at 60°,; random joints with clay fill and 1-4 mm apertures.

REC=98% RQD=52% — 26

27 — SANDSTONE, grey to brownish-grey, slightly weathered to moderately weathered, moderately hard to hard,; well-expressed bedding inclined at 60°, thickness ranges from laminations to moderately thick, clay fill, slightly rough to rough, 1-2 mm apertures,.
@26.8m: joint inclined at 5°, rough, clay filling, thin, rough.
@26.9m: shale/carbonaceous joint inclined at 55°.
@27.1m: several bedding joints inclined at 55°, one at 65°.
@27.6m: closely spaced joints inclined at 5-30°, 10°, two at 65°, hard.

REC=100% RQD=48% — 27

28 — @28.1m: intersecting joints inclined at 10 and 70°, clay filling, thin.
SANDSTONE, grey-brown with a few brown Siltstone beds; moderately to intensely weathered, moderately hard with moderately soft zones (weathered siltstone); bedding joints inclined at 60°, rough, apertures range form 1 to 3 mm.

29 — @28.3m: joint inclined at 5°, rough, moderately open.
@28.5m: joints inclined at 5°, slightly open.
@28.7m: moderately soft.
@28.8m: fracture zone 2-3 cm thick, decomposed, soft.
@29m: moderately soft, mechanical break.
@29.2m: moderately hard.
@29.3m: joints inclined 10°, moderately weathered, rough, 2 mm aperture, soft.

REC=100% RQD=0% — 28

Boring 02-11A Continued on LOTB Sheet of

VERTICAL SCALE 1 : 25

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
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Caltrans Metric

DESIGN OVERSIGHT KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY R. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/11/03

B. SCHELL, J. CASTLE, L. PATZKOWSKI, M. HACHEY/GEOLOGISTS
FIELD INVESTIGATOR(S)/TITLE
DATE AS SHOWN

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Top Hole El.; Permanent Casing driven; Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified.; Number of blows required to produce the indicated penetration after an initial 152 mm seating.; 50 blows produced the indicated penetration during the initial 152 mm interval; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; GWS Elev.; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

Boring 02-11A Continued from LOTB Sheet of

PENETRATION DEPTH (m)

30
REC=92% RQD=8% — 29

- SANDSTONE WITH SILTSTONE INTERBEDS, dark grey to grey, moderately weathered with decomposed zones, moderately hard to hard; moderately well-expressed bedding ranging from laminations to several centimeters thick, inclined 65°. Several bedding joints inclined 60°-65°.
- @29.7m: joint parallel to core axis, bedding joint inclined at 65°.
- @29.9m: claystone bed; bedding joint inclined 65°.

31
REC=104% RQD=13% — 30

- @30.5m: 20-cm-thick shear zone.
- SANDSTONE AND SILTSTONE, interbedded, moderately weathered, moderately soft to moderately hard; bedding well expressed and inclined at 65°; intensely to moderately jointed, clay and calcite fill, smooth to rough, tight.
- @30.8m: stepped and moderately rough joints inclined at 65°, tight.
- @30.9m: stepped joint inclined at 65°, moderately rough, tight, incipient joints.
- @31.1m: 150mm thick fracture zone.
- @31.3m: joint inclined at 55°, clay and calcite filling, smooth, very thin.
- @31.4m: disaggregated sand/siltstone, 125mm thick fracture zone, clay and calcite filling.

32
REC=83% RQD=0% — 31

- @31.5m: 50mm thick decomposed sandy orange-brown, stiff clay.
- @31.6m: moderately weathered, joint inclined at 45°, clay and calcite filling, slightly rough,joint inclined at 85°, clay filling, moderately rough.
- SANDSTONE, light grey, moderately weathered to orange-brown, moderately hard, fine-grained, fracture surfaces oxidized.
- @31.9m: SILTSTONE, dark grey, intensely weathered to brown/orange, fractured in a clay matrix, small interbeds of fine grained sand less than 10mm thick.
- @32.2m: series of joints inclined from 45-70°.
- @32.4m: brecciated siltstone in clay matrix.
- @32.5m: decomposed, joints inclined from 60-70°, clay filling.
- @32.6m: NCR.

33
REC=83% RQD=0% — 32

- SANDSTONE/SILTSTONE interbedded, moderately to intensely weathered, moderately hard.
- @33.1m: randomly inclined joints, clay filling.
- @33.2m: 75mm fracture zone.
- @33.3m: joint inclined at 60°, calcite and clay filling, slightly rough, disaggregated in clay matrix to completely decomposed.
- SANDSTONE with SILTSTONE interbeds inclined at 65-70°.
- @33.6m: bedding joint inclined at 65°, 75°, smooth to mod. rough, moderately open.

34

- @33.7m: closley spaced joints inclined at 45°, 75°, 70°, smooth to rough.
- @34m: 50mm thick fracture zone, intensely weathered, inclined at 75°, clay filling.
- @34.1m: joint parallel to core axis, moderately rough, moderately thin.
- @34.3m: joint inclined at 40°, slightly weathered, clay filling, slightly rough.

35
REC=49% RQD=18% — 33

- @34.5m: healed fractures.
- @34.5m: slightly weathered joint inclined at 75°, clay filling, slightly rough, moderately thin.
- @34.6m: slightly weathered joint inclined at 70°, clay filling, slightly rough, moderately thin.
- @34.8m: NCR.
- @35.1m: SANDSTONE AND SILTSTONE WITH CLAYSTONE INTERBEDS, grey to black, intensely fractured and sheared, decomposed.
- @35.7m: silstone grading into very stiff clay.

36

- SANDSTONE AND SILTSTONE with Claystone interbeds, inclined at 65°, slightly weathered, moderately soft to moderately rough.
- @36m: brecciated siltstone in sandy clay matrix.
- @36.1m: thin interbeds of sand/siltstone, inclined at 65°, clay filling, moderately thin.
- @36.2m: joint inclined at 60°, weathered to orange-brown.
- @36.3m: joint inclined at 75°, smooth, moderately thin, randomly inclined joints.

37
REC=100% RQD=13% — 35

- @36.5m: bedding joints inclined from 65 to 85°, clay filling.
- @36.6m: mod. spaced joint inclined at 80°, 55°, 65°, tight, smooth.
- @36.9m: closely spaced joints inclined at 60°, 55°, calcite and clay filling, tight, sl. rough.
- @37m: fracture inclined at 50°, calcite filling, moderately healed.
- @37.2m: joints inclined at 80°, clay filling, smooth.
- @37.3m: joint perpendicular to core axis, clay filling, smooth.
- @37.4m: disaggregated silt/sandstone in dark grey clay matrix.
- SANDSTONE, light grey, slightly weathered to yellow-brown, moderately soft to moderately hard, fine grained, extremely fractured, random joints with clay filling.

38
REC=95% RQD=17% — 36

- @37.7m: SILTSTONE, dark grey, weathered to orange-brown, fractured to brecciated.
- @37.9m: clay with brecciated siltstone.
- @38m: closely spaced bedding joints inclined at 75°, joint at 70°, clay filling, smooth, tight.
- @38.1m: joint inclined at 85°, clay filling, smooth, tight.
- @38.3m: incipient fractures.
- @38.4m: bedding joint inclined at 85°, clay filling, smooth, tight.
- @38.6m: angular brecciated sandstone/siltstone in dark grey clay matrix.
- @38.8m: joint inclined at 60°, disaggregated sandstone/siltstone in clay matrix, clay and calcite filling.

39

- SILTSTONE (50%), SANDSTONE (30%), CLAYSTONE (20%) interbedded, slightly weathered, claystone is moderately hard, sandstone and siltstone is hard to very hard; well-expressed bedding ranging from laminations to 8 mm and inclined 65-70°, inverse grading s

40
REC=100% RQD=25% — 37

- @39.2m: joint inclined at 60°, clay fill, striations perpendicular to core axis.
- @39.3m: most bedding joints inclined at 65-70°, joints surfaces have calcite and thin clay, some yellow-brown oxidation on other joints (ones not along bedding).
- @39.4m: closely spaced joints inclined at 15°, 20°, bedding joints at 65°, 50°, 65°, clay filling, very rough to smooth, 1-2 mm aperture,.
- @40m: moderately healed fracture, clay and calcite on bedding joint surface about 1mm thick.
- @40.1m: incipient fractures, healed, slightly oxidized.
- @40.2m: bedding joint inclined at 65°, calcite filling, smooth, tight.
- @40.3m: joint inclined at 40°, clay filling, slightly rough, very thin, mechanical break.

41
REC=90% RQD=0% — 38

- SANDSTONE/SILTSTONE/CLAYSTONE (as above) interbedded, slightly weathered, moderately soft to moderately hard, intensely fractured, random inclinations throughout core, clay filling.
- @40.9m: random jointing 0 to 90°.
- @41.2m: joints inclined 25 to 65°, two bedding joints at 65°.

42

- SANDSTONE/SILTSTONE/CLAYSTONE interbedded (same as above), mechanical break.
- @41.7m: joint inclined at 15°, clay filling, slightly rough, tight.
- @41.7m: bedding joint inclined at 65°, clay filling, smooth, tight.
- @41.8m: closely spaced joints joint inclined at 75°, 85°, 65°, sl. to mod. rough, mod. thin, clay filling one joint.
- @42m: angular brecciated siltstone in dark grey clay matrix, joint inclined at 70°, smooth, tight.

REC=100% RQD=18% — 39

- @42.1m: bedding joint inclined at 60°, clay filling, smooth, tight, calcite veins at 40°.
- @42.2m: joint inclined at 85°, clay filling, smooth, tight.
- @42.3m: bedding joint inclined at 65°, clay filling, tight.
- @42.5m: random jointing, clay filling.

43

- @42.8m: 150mm thick, fracture zone, large angular brecciated sand/siltstone in clay matrix, defined by joints at top and bottom inclined at 70°.
- SANDSTONE/SILTSTONE/CLAYSTONE interbedded (same as above), slightly weathered, moderately soft to moderately hard.
- @43.2m: closely spaced joint inclined at 85°, 80°, clay, calcite filling, slightly rough, 1-2mm aperture.
- @43.4m: closely spaced joint inclined at 60°, four at 75°, clay and clcite fill, sl. rough to smooth, mod. thin aperture.

44
REC=105% RQD=40% — 40

- @43.9m: two joints inclined at 70°, moderately rough, tight.
- @44.1m: fully healed fracture, mod. spaced joints inclined at 45°, 80°, mod. rough to smooth, clay filling, tight.
- SANDSTONE/SILTSTONE/CLAYSTONE (same as above), slightly weathered to fresh, moderately hard.
- @44.3m: angular brecciated sand/siltstone in black clay matrix, very soft, random fractures.

45
REC=92% RQD=0% — 41

- @44.8m: SILTSTONE, dark grey, joint inclined at 70°.
- SANDSTONE/SILTSTONE/CLAYSTONE, interbedded, grey to dark grey with weathering to orange-brown, slightly weathered, moderately soft to moderately hard, bedding inclined 80°, not all fracture surfaces oxidized.
- @45.2m: joint inclined at 85°, clay filling, moderately thin.
- @45.3m: joint inclined at 85°, clay filling, tight.
- @45.4m: randomly oriented fractures, clay and calcite filling.
- @45.6m: joint inclined at 35°, large calcite vein with brecciated siltstone inclusions.

46
REC=103% RQD=0% — 42

- @45.7m: brecciated sandstone/siltstone in black clay matrix with random fractures, 10 cm thick.
- @45.8m: bedding joints two inclined at 80°, clay filling, tight, 75 mm thick fracture zone.

46

- SANDSTONE/SILTSTONE/CLAYSTONE, slightly weathered, moderately soft, bedding inclined from 65-70°, bedding ranges from laminae to 12 cm thick.
- @46.1m: fracture inclined at 60°, clay and calcite filling, joint inclined at 60°.
- @46.3m: rip-up clasts suggest overturned beds, random fracture.
- @46.4m: bedding joint inclined at 70°, clay filled, smooth to slightly rough, fracture surfaces weathered yellow-brown with thin brown clay films.

47
REC=100% RQD=0% — 43

- @46.6m: bedding joint inclined at 70°, smooth, 125 mm thick fracture zone.
- @46.8m: bedding joint inclined at 65°, clay filling, smooth, fully healed fracture, calcite filling, thin.
- @47m: joint inclined at 70°, clay filling, smooth, calcite veins inclined at 35°.
- @47.1m: angular brecciated siltstone in clay matrix, fracture inclined at 60°, clay and calcite filling.
- @47.3m: mod. spaced joints inclined at 10°, 65°, smooth to slightly rough.

48

- CLAYSTONE (20%), SILTSTONE (50%), SANDSTONE (30%) interbedded, black, very dark gray, and gray, slightly weathered to fresh, moderately soft to moderately hard; well-expressed bedding, laminated to thin bedded, inclined 75°; very intensely to intensely

REC=100% RQD=0% — 44

- @47.8m: fracture zone, angular fragments of siltstone and claystone.
- @48m: series of joints inclined at 75°.
- @48.3m: series of joints inclined at 75°.
- @48.5m: clay and brecciated siltstone bed inclined at 55°, 15mm thick.
- @48.6m: incipient joint.

49

- CLAYSTONE/SILTSTONE/SANDSTONE (same as above), fresh to slightly weathered, moderately soft to moderately hard, bedding inclined at 75 to 80°; gradational contacts and "inversely" graded bedding suggests beds are overturned.
- @49m: 175mm thick zone of broken core.
- @49.2m: SANDSTONE, light grey, very fine grained, thinly bedded at 80°, weathering to yellow-brown.
- @49.3m: bedding joints inclined at 70-85°.
- (TX) @49.4m: dark gray claystone with medium gray fine-grained sandstone interbeds.

50
REC=102% RQD=18% — 45

- @49.5m: SILTSTONE, dark grey, thinly bedded at 75°.
- @49.8m: joint inclined at 30°, clay filling,.
- @49.8m: joint inclined at 70°, with slickensides inclined at 85°, patchy calcite also slickensided.
- @49.9m: calcite veins, hairline to 1mm thick in sandstone, nearly terminated at contact with claystone.
- @49.9m: joints inclined at 50-55°, clay filling, slightly rough.

REC=100% RQD=0% — 46

- @50.2m: joint surfaces inclined at 80°, clay films less than 1mm thick.
- @50.3m: water trickling from borehole, < 5 liters/min.

51
REC=100% RQD=0% — 47

- SANDSTONE (50%) and SILTSTONE (50%) interbedded, fresh, very hard, joints and bedding joints inclined at 70°, intensely fractured, tight, thin discontinuous patchy clay and calcite fill, slightly rough to stepped, parting common along bedding planes an
- @50.7m: calcite vein inclined at 15°, 1/2mm thick, (extra piece came out on next attempt) 2 intersecting joints at 15-20°, calcite coating.
- no advancement, pulled drill rod and replaced bit, got half of 75mm piece in core barrel.

REC=100% RQD=0% — 48

- @50.9m: SANDSTONE/SILTSTONE, interbedded, black to dark grey, fresh, hard to very hard, bedding inclined at 75°, closely spaced fractures, calcite filling, slightly rough to stepped, clean, angular fragments.

52

- @51m: bedding joint inclined at 75°.
- CLAYSTONE/SILTSTONE/SANDSTONE interbedded, fresh, hard, bedding inclined at 70-80°, calcite and clay filling, slightly rough to stepped, very thin.

REC=100% RQD=0% — 49

- @51.3m: bedding joints inclined 80°, 10°, joint at 15°.
- @51.6m: bedding joints inclined 80°.
- @51.6m: white calcite vein 15 mm thick above fracture zone of ground-up claystone/siltstone, stiff sandy clay matrix, black; fragments range from sand size to 4 cm, no slicks to indicate shearing.
- 2-cm ball of black claystone in stiff clay matrix (as at bottom of last run).

53

- @51.9m: SILTSTONE, black and very dark grey SANDSTONE, grey, predominately siltstone above 52.3m depth, hard, joints inclined at 45°, closely spaced fractures, slightly rough to stepped, tight.
- @52.1m: sheared claystone and siltstone; bedding joints inclined at 65°.
- @52.2m: SANDSTONE with SILTSTONE interbeds, very fine- to fine-grained, bedding joints inclined at 75°, calcite filling, several steeply inclined hairline to 1mm thick calcite veins.

REC=100% RQD=19% — 50

- @52.5m: joint inclined at 10°, calcite and iron-oxide filling.
- @52.6m: several joint surfaced partly coated with yellowish-brown and reddish-brown oxide.

54

- SILTSTONE and SANDSTONE (30%) with CLAYSTONE (10-20%) interbedded, black to dark grey, fresh, hard to very hard, joints inclined at 50-65°, closely to moderately spaced fractures, calcite and clay filling, slightly rough to stepped, tight; well-expresse
- @52.9m: joints inclined 50-65°, at 30°, 25°.
- @53.4m: 30 cm of highly fractured core, some clay, joint inclined at 15°.
- @53.5m: calcite vein inclined at 25°, polished and slickensided with 80° rake.

55
REC=33% RQD=0% — 51

- @53.6m: ancient fault (3mm separation) healed with calcite.
- @53.7m: several thin claystone bedding lenses and laminae, inclined at 60°, sharp planar contact.
- @53.9m: grading from sandstone to claystone, bedding joint inclined at 60°, fragments in sandy clay matrix, bedding joint inclined at 70°.
- @54.1m: fragments in sandy clay matrix (shear zone).
- NCR (possible top of sheared zone).
- @54.9m: sheared claystone and siltstone in clay matrix, black, fresh, very soft, fragments are sand-sized to 10-20 mm, include fragments of white calcite.

56
REC=100% RQD=27% — 52

- @55.2m: sandy clay shear zone.
- sheared and intensely fractured claystone, siltstone, and sandstone, generally black to very dark grey with occasional grey and white (calcite) fragments, fresh, soft with hard fragments.
- @55.4m: joint inclined at 80°, bedding joint at 60°, calcite vein 10 mm thick.
- @55.7m: claystone and siltstone beds inclined 80°.
- @55.8m: highly fractured, fine-grained sandstone, abundant intersecting white calcite veins.

57
REC=81% RQD=0% — 53

- @56m: joint/shear zone inclined at 60°.
- @56m: sheared claystone, shear zone inclined at 45°.
- sheared siltstone, claystone, and sandstone, grey to dark grey, fresh, hard fragments in clay matrix, abundant white calcite veins, mostly intact plastic material the commonly disintegrates when handled.
- @56.3m: joint inclined at 60°.
- @56.4m: joint inclined at 70°, clay and calcite filling, smooth and polished with irregular surfaces, tight.

58
REC=63% RQD=0% — 54

- @56.5m: calcite vein 1-3mm thick.
- @56.7m: shear zone, fragments of fine sandstone and siltstone in sheared black clay, stiff.
- sheared and intensely fractured claystone, siltstone, and sandstone, hard fragments in clayey matrix, black except for occasional grey sandstone fragment and white calcite veings, bedding rotated to 15°, joints smooth to stepped and generally polished.
- @57.5m: bedding inclined 15° indicates folding and/or faulting, 35° rake on slickensides and grooves (mullions).
- sheared, intensely fractured dark gray siltstone. Water flowing from formation, about 5 liters/min.

59
REC=108% RQD=25% — 55

- @58.2m: bottom of shear zone. SANDSTONE, light grey fine-grained and grey very-fine-grained beds 5 to 15 mm thick, inclined 70-80°.
- @58.3m: 2mm thick calcite vein inclined at 55°, 4mm thick vein at 50°, mod. spaced joint inclined at 75°, 55°, 50°.

Boring 02-11A Continued on LOTB Sheet of

VERTICAL SCALE 1 : 25

Caltrans Metric

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
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CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY R. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/11/03

B. SCHELL, J. CASTLE, L. PATZKOWSKI, M. HACHEY/GEOLOGISTS
FIELD INVESTIGATOR(S)/TITLE
DATE: AS SHOWN

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

SECTION OVERSIGHT

KEYHAN MOGHBEL

SIGNOFF DATE

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31 – 50	Dense	9 – 15	Stiff
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		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

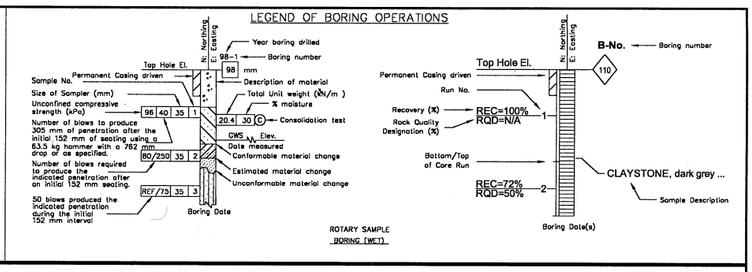
TYPE OF BORINGS

- 2½" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-11A Continued from LOTB Sheet of

PENETRATION DEPTH (m)

59
- SANDSTONE/SILTSTONE interbedded, fresh, moderately soft; bedding inclined 70-90 °.
- @59.1m: joints inclined at 50°, 70°, poorly developed striations with 50° rake, some calcite lining.
- @59.3m: arcuate joint with 75° rake to grooves, joint inclined at 45°.
- REC=67% RQD=0% — 56
- @59.5m: abundant calcite veins in light-gray fine-grained sandstone, joints inclined 45°.
- @59.6m: very intensely fractured siltstone in dark grey clay matrix inclined 70°.

60
- SILTSTONE, dark gray, moderately soft, fresh, thinly bedded, inclined 65°.
- REC=83% RQD=0% — 57
- @60.2m: joint inclined 60°, polished, with slickensides on irregular surface.
- REC=50% RQD=0% — 58
- @60.3m: joint inclined at 55°, clay filling, smooth, tight.
- @60.3m: bedding joint inclined at 70°, smooth, tight.
- REC=106% RQD=0% — 59
- dark grey lean stiff clay.
- @60.4m: SILTSTONE dark grey, very thin bedding inclined 80°.

61
- SANDSTONE, light grey, bedding inclined at 65°, fine grained.
- @60.6m: SILTSTONE, series of joints spaced about 50mm apart inclined at 50°.
- @60.7m: intensely fractured siltstone 8 cm thick.
- @60.8m: joint inclined at 30°, polished.
- @60.8m: SANDSTONE/SILTSTONE, brecciated in dark clay matrix.
- REC=97% RQD=0% — 60
- @60.9m: joint inclined at 60°, polished.
- @61m: fracture surface polished with well-developed slickensides at 85° rake.

62
- SANDSTONE/SILTSTONE, interbedded, dark grey, fresh, moderately soft to moderately hard, bedding inclined 65°.
- @61.1m: sheared intensely fractured siltstone in dark clay matrix, 23 cm thick zone.
- REC=100% RQD=17% — 61
- @61.4m: sandstone and siltstone laminae inclined 85°.

63
- SILTSTONE/SANDSTONE, interbedded, slightly weathered, moderately hard, bedding inclined at 65-70°, intensely jointed, smooth to slightly rough.
- @61.8m: some weathered siltstone layers resulting in grooved appearance along fracture surface.
- REC=107% RQD=0% — 62
- @61.8m: laminae of siltstone and very fine-grained sandstone inclined at 70°.
- @62.2m: platy brecciated siltstone and angular brecciated sandstone and calcite in clay matrix.
- SILTSTONE grading into very stiff clay.

64
- @62.5m: SANDSTONE, light grey with yellow-brown weathering, moderately weathered, very soft, bedding inclined 75°, intensely fractured; fine- to medium-grained.
- @62.7m: calcite veins 1-2mm thick.
- REC=104% RQD=0% — 63
- SANDSTONE/SILTSTONE, interbedded, slightly to moderately weathered, moderately soft, major change in bedding inclination to 20-25°, fractures tend to be parallel to bedding; fracture surfaces oxidized to orange-brown, smooth/polished surfaces.

65
- @63.3m: closely spaced joints inclined at 20°, several at 45° across bedding.
- @63.7m: sheared siltstone/sandstone in clay matrix.
- REC=108% RQD=79% — 64
- SANDSTONE/SILTSTONE, interbedded, light grey to dark grey with weathering to orange-brown, slightly weathered, moderately soft to moderately hard; laminated, abrupt change in bedding inclination back to 70-80°; very fine- to medium-grained sandstone.

66
- @63.9m: closely spaced bedding joints inclined at 70°, smooth, joint at 75° slightly rough, 3mm calcite veins at 0°, orange brown weathering outside of core, random fracture, very rough.
- @64.4m: fully healed fracture, calcite filling, thin.
- @64.5m: closely spaced bedding joints inclined at 75°, rough, orange-brown weathering surrounding healed fracture, joint at 75°, two bedding joint at 80°, sl. rough; inverse graded bedding indicates beds overturned.
- SANDSTONE/SILTSTONE, slightly weathered, moderately soft, bedding inclined at 75°.
- @65.2m: two fractures inclined at 55° and 75° with breccia and clay filling.
- REC=98% RQD=28% — 65
- @65.4m: fully healed fracture inclined at 23°, rough, core is weathered to orange-brown throughout.

67
- @65.6m: bedding joints two inclined at 80°,sl. rough to rough, joints at 75° - 90°, sl. rough.
- @65.9m: 100mm thick shear zone, slightly weathered.
- @65.9m: sheared and intensely fractured zone about 15 cm thick; bedding within zone inclined 55°, numerous calcite veins, moderately healed shear zone.
- @66.1m: bedding inclined at 80°.
- @66.2m: interbedded siltstone (75%) and very fibne-grained sandstone (25%).
- REC=86% RQD=24% — 66
- @66.3m: 10mm thick brecciated zone, bedding inclined at 40°.
- SANDSTONE AND SILTSTONE, slightly weathered, moderately soft to moderately hard; well-expressed bedding inclined 60°, laminae to 3 cm thick; intensely jointed, tight to moderately open, smooth with some slickensides and clay films.

68
- @66.6m: very intensely fractured siltstone with clay-filled fractures inclined at 45-60°, 5mm thick.
- @66.7m: fracture zone 30 cm long with randomly oriented fractures, orange-brown oxidation along fracture surfaces, fractures and veining throughout, deformed bedding inclined at 20-30° (probably ancient deformation).
- @67m: thin clay film with black clay and some small rock fragments.
- @67.1m: joint inclined at 10°, 45° with slickensides, 30°, clay filling, smooth, tight, bedding joint at 60°.
- REC=111% RQD=19% — 67
- SILTSTONE (80%) AND SANDSTONE (20%) interbedded, black and dark grey, fresh, moderately soft, bedding inclined at 50°. Sandstone is very fine grained.
- @67.6m: bedding joint inclined at 50°, clay filling, smooth, 1 mm aperture.
- @67.7m: hairline to 1mm thick white calcite vein, healed minor fault.
- @67.9m: bedding joint inclined at 60°, slightly rough.
- @68m: joint inclined at 45°, slighly rough.
- @68.1m: shear zone 25 mm thick.

69
- @68.2m: shear zone 20 cm thick, predominately sandstone, light grey, fine- to medium-grained.
- @68.2m: brecciated siltstone in dark clay matrix.
- REC=100% RQD=0% — 68
- SILTSTONE (75-80%) AND SANDSTONE (20%) interbedded, includes claystone locally (5 %), dark grey and black, fresh, hard, bedding inclined at 55-75° (lower angles where distorted by faulting), intensely to moderately fractured, smooth and polished surfaces

70
- @68.8m: bedding joints inclined at 75-85°, minor fault offsets inclined from 65-85°, 1-10mm thick, clay filling, smooth and polished but wavy.
- @68.9m: hairline, white calcite veins, 10mm thick calcite vein inclined at 30°.
- REC=81% RQD=0% — 69
- @69.2m: joints inclined from 20-35°, clay filling, core parted along two bedding joints with thin clay filling upon handling, mechanical breaks from sample handling.

71
- Ran orientation probe; Azimuth 185° magnetic and 4° downward inclination. 15 cm of Loose siltstone, claystone, and fine-grained sandstone fragments at top of run, many fragments with polished surfaces indicating shearing.
- @69.6m: SILTSTONE WITH CLAYSTONE (~5%) AND SANDSTONE (5-10%), few thin (less than 1mm) white calcite veins inclined opposite of bedding which dips 60°.
- @69.7m: shear zone 3 cm thick, smooth and polished surfaces with slickensides, clay fill, tight, healed fault with 4mm separation.
- @69.9m: bedding joints two inclined at 60°, joints at 20° - 30°, clay filling, smooth.
- REC=100% RQD=11% — 70
- @70m: shear zone 30 cm thick; claystone, siltstone, and sandstone fragments in black clayey matrix with white calcite fragments, bedding and structure still evident.

72
- @70.3m: 25 mm calcite fragment.
- SILTSTONE with SANDSTONE (10%) and CLAYSTONE (10%) interbeds, fresh, hard; well-expressed bedding ranges from laminae to 6 cm thick, inclined 75°; intensely fractured, rough to stepped, tight, clay films; irregular bedding due to soft-sediment erosion a
- @70.5m: loose fragments, mechanical breaks with calcite, bedding joints inclined at 75°, clay filling.
- @70.7m: low angle joints inclined at about 15°, clay filling, thin.
- REC=100% RQD=20% — 71
- @70.8m: several incipient joints counter to bedding, clay filling, thin.
- @70.9m: bedding joints inclined at 75°, joint at 75°, clay filling, rough, tight, abundant incipient joints in random intersecting orientations, 2 calcite veins.

73
- @71.2m: shear zone 75mm thick, black sandy clay zone, loose fragments, mechanical breaks.
- SILTSTONE with SANDSTONE and CLAYSTONE interbeds (same as above), fresh, hard, bedding inclined from 65-70°, alternating black, dark grey, and black beds with thickness ranging from laminae to 2 cm thick: intensely to moderately fractured, tight, with c
- @71.6m: three intersecting joints; two joints inclined at 80° and another 5°.

74
- @72.2m: bedding joint inclined at 65°.
- @72.3m: shear zone 150mm thick bounded by bedding joints at top and bottom inclined 70°, highly fractured and sheared rock fragments and calcite in sandy clay matrix.
- REC=102% RQD=94% — 72
- @72.6m: fractured rock core rotated about 180°, bedding joint inclined at 70°.
- @72.8m: three bedding joints inclined at 70° spaced 50mm apart.
- SILTSTONE with SANDSTONE and CLAYSTONE interbeds (same as above); fresh, hard, bedding inclined from 75-80°; beds range from laminae to 2-3 cm thick; intensely to slightly fractured, tight, clay films and calcite filling.

75
- @73.1m: intact bedding joint, dried clay and calcite filling, inclined at 75°.
- @73.2m: abundant calcite veins, hairline to 1 mm thick.
- @73.5m: joints inclined at 70 and 15°, incipient joint inclined at 15°.
- @74m: bedding joint inclined at 80°, moderately thin calcite vein.
- REC=98% RQD=18% — 73
- SILTSTONE (70%)with SANDSTONE (25%) and CLAYSTONE (5%), (same as above), fresh, hard, intensely to moderately fractured, slightly rough to moderately rough, tight, most joints have patches of hard dried clay fill.
- @74.2m: bedding joint inclined at 80°, 75°, hard dried clay on joint surface.

76
- @74.5m: hairline to 1/2mm thick calcite veins, series of bedding joints inclined at 80°, slightly rough to moderately rough, brown oxidation.
- @74.8m: small healed fault, offset of sandstone bed, closley spaced joint inclined at 15°, three at 20°, two at 30°, iron-oxide in few joints, bedding joint at 75°.

76
- SILTSTONE (65-75%) with SANDSTONE (5-10%) and CLAYSTONE (20-25%),(same as above), fresh to slightly weathered, hard, thin bedding inclined at 75°; close to moderately spaced fractures, slightly rough to stepped, tight, most joints have partially dried.
- REC=100% RQD=0% — 74
- @75.7m: bedding joints inclined at 35°, calcite coating.
- @75.9m: 25mm shear zone, joint inclined at 75°, dark grey clay filling.
- @76.2m: joints inclined at 25°-30°, clay filling, bedding joint inclined at 75°, very fractured zone with many incipient joints and small faults.
- @76.4m: shear zone, partially decomposed to clay, dark grey with brown oxidation, sheared material disturbed when handled.

77
- SILTSTONE with SANDSTONE and CLAYSTONE (same as above), fresh to slightly weathered, hard except in shear zones, bedding inclined at 75-80°, closely spaced tight fractures, clay filling, rough to stepped surfaces.
- @76.7m: 125mm long sheared clayey zone, approx half width of core.
- @76.8m: several bedding joints inclined at 75°, yellow-brown oxidization on joint surface.
- REC=96% RQD=0% — 75
- @77.1m: joints inclined 30°-35°, yellow-brown oxidization on joint surfaces.

78
- @77.2m: 25mm thick zone of clayey sheared material, half width of core.
- @77.3m: joint inclined at 40°, yellow-brown oxidation on joint surface.
- @77.4m: 300mm long zone of fractured core, some bedding joints inclined at 75-80°.
- @77.6m: intensely fractured and sheared zone 25 cm long, abundant calcite.
- @77.8m: joint inclined at 60°.
- same interbedded SILTSTONE/CLAYSTONE/SANDSTONE, dark grey grading to light grey with brown oxidized zones, fresh to slightly weathered, hard except clayey shear zones, intensely fractured, smooth to stepped tight joints with clay films and calcite lining a

79
- @78m: highly fractured siltstone altered to sandy clay, grey, stiff.
- REC=100% RQD=45% — 76
- @78m: calcite vein; highly fractured, most joints intact and lined with clay and calcite, most clay is oxidized yellowish- brown; bedding in this zone is generally inclined 30° and is faulted and deformed.
- @78.2m: fault with 10mm offset.
- @78.3m: 50mm calcite veins inclined with bedding.
- @78.4m: abundant jointing, bedding generally about 30°, faulted and distorted.

80
- @78.6m: bottom of fractured zone, bedding inclined at about 60-65°.
- @78.7m: joint inclined at 85°, oxidized.
- @78.9m: 20mm long segment with network of intersecting calcite veins, hairline to 4-5mm thick, beds are offset 1-2mm across veins, healed faults, oxidation on some joints.
- @79m: white opaline quartz, 10 mm thick oxidized above and below for 20-30 mm.
- @79.2m: bedding with two joints inclined 70°, network of hairline calcite veins, some of which are offset as are several of the beds.

81
- oxidized and fractured zone with abundant intersecting calcite veins.
- REC=100% RQD=45% — 77
- @79.5m: 175mm long fracture zone, oxidized quartz and siltstone, very fractured and folded.
- @79.6m: bedding inclined 70°, white quartz fractured and distorted.
- @79.8m: 3mm thick white calcite vein, joint inclined at 15°, oxidized, top of 450mm long oxidized zone with several low-angle calcite veins.
- @79.9m: joint inclined at 0-10°, joint inclined at 80°.
- @80.1m: two joints inclined at 70-80°, bedding joint inclined at 80°, clay filling and oxidation.

82
- @80.3m: bottom of fractured zone, top of well-bedded siltstone, claystone, sandstone sequence; with low-angle 0-5°) thin calcite veins, bedding inclined at 80°.
- @80.5m: bedding joint inclined at 80°, natural void opening 3-5mm, partially filled with hard clay, oxidation.
- @80.7m: bedding joints inclined at 80°, clay filling, oxidized within zone to 30 mm above and below.
- REC=100% RQD=75% — 78
- SILTSTONE WITH SANDSTONE (10%) AND OCCASIONAL CLAYSTONE LAMINAE interbedded, light grey to dark gray, slightly to intensely weathered, moderately hard to hard: well expressed bedding inclined 75°; moderately fractured.
- @81m: two bedding joints inclined at 75°, slightly rough, moderately open.
- @81.3m: bedding joint, clay and calcite filling, moderately open with several voids.

83
- @81.4m: 2-3mm by 25mm long void.
- @81.6m: moderately weathered to intensely weathered, oxidized on joint surface and 30mm on either side.
- @81.8m: 1mm by 20mm long void, oxidized on surface and oxidized clay films.
- @81.9m: bedding joints inclined at 60°, clay filling, very thin, rough.
- SILTSTONE WITH CLAYSTONE interbeds; grey, slightly weathered to moderately weathered, hard, bedding inclined at 65-70°, close to moderately spaced fractures, some very fine sandstone and black claystone rip-up clasts.
- REC=100% RQD=70% — 79
- @82.7m: bedding joints inclined at 65°, oxidized, rough, vertical calcite veins.
- @83.2m: bedding joint with clay filling, oxidized surfaces.
- @83.3m: fracture zone with oxidized coating and clay film on joint surfaces.

84
- @83.6m: CLAYSTONE, dark grey to black, slightly to moderately weathered, moderately hard to hard, bedding inclined at 70°, closely spaced fractures, clay and calcite filling, oxidized surfaces, rough to moderately rough, moderately thin.
- CLAYSTONE with SANDSTONE (<5%) and SILTSTONE (30%), interbedded, dark grey to black, slightly weathered, moderately hard to hard; well-expressed bedding inclined at 75-80°, beds range from laminae to 5mm thick, inverse grading indicates beds are overtur
- @84.5m: sandstone bed inclined at 75°, grey, fine-grained, 15mm thick.

85
- @84.7m: two bedding joints inclined at 75°, clay and calcite filling.
- REC=100% RQD=53% — 80
- @85.1m: 75mm thick shear zone, clay, slickensided.
- @85.2m: joint inclined at 80°, clay and calcite filling.
- @85.4m: bedding joint inclined at 55°, rough.

86
- CLAYSTONE, SILTSTONE (25%); AND SANDSTONE (5%) interbedded, black, dark gray and gray, fresh to slightly weathered, moderately hard to hard; well-expressed bedding inclined at 75°, intensely jointed, most joints are bedding plane separations.
- @85.7m: 75mm thick sandstone bed, vertical calcite veins.
- @85.8m: joint inclined at 75°, smooth, moderately thin.
- REC=87% RQD=46% — 81
- @86m: bedding joint, rough, tight.
- @86.1m: bedding joint, rough, tight.
- @86.2m: 2 joints inclined at 40 and 50°, clay and calcite filling, moderately thin.

87
- @86.3m: 2 mm thick calcite veins.
- @86.4m: 2 joints inclined at 40°.
- @86.5m: joint inclined at 70°.
- @86.5m: bedding joint inclined at 75°.
- SILTSTONE, light grey, slightly weathered, moderately soft to moderately hard, intensely fractured.
- @87.3m: joint inclined at 70°.
- REC=94% RQD=10% — 82
- @87.6m: calcite veins inclined at 65°.

88
- @87.8m: fractured zone.
- @87.9m: soft, calcite veins.

Boring 02-11A Continued on LOTB Sheet xx of xx

VERTICAL SCALE 1 : 25

DESIGN BY R. VARATHARAJ 11/20/02

CHECKED BY S. SICILIANO 2/11/03

DATE

B. SCHELL, J. CASTLE, M. HALPATZIGOWSKI FIELD INVESTIGATOR/TITLE

AS SHOWN

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR PROJECT ENGINEER

CU 240 EA 11237E

BRIDGE NO.

KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET OF

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

Caltrans Metric

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HOWARD MACLEOD EG 1538 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE:

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

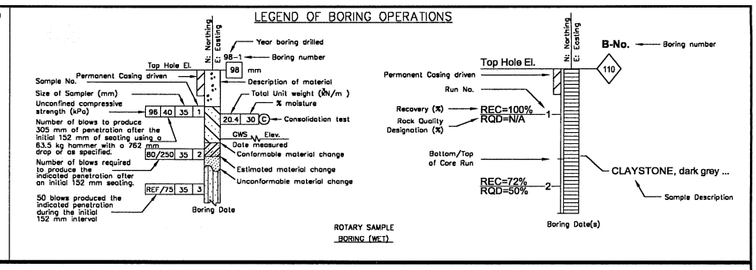
TYPE OF BORINGS

- 2½" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-11A Continued from LOTB Sheet of

PENETRATION DEPTH (m)

89
- SILTSTONE (same as above), slightly weathered, moderately soft to moderately hard, random fractures, closely spaced, rough, moderately thin to tight.
- @88.3m: fractures inclined 30-40°.
- REC=100% RQD=67% — 83
- (TX) @88.7m: dark gray claystone, bedding joint inclined 70°, clay and calcite filling.

90
- @89.1m: hard, fracture inclined at 75°, clay fill.
- SILTSTONE (same as above), light grey, slightly weathered, moderately soft to moderately hard, intensely to moderately fractured, fractures inclined 30 and 70°, 1-2 mm aperture, calcite and some oxidation.
- (TX) @89.9m: dark grey interbedded claystone and siltstone; fracture inclined at 80°.
- REC=100% RQD=58% — 84
- (UC) @90.1m: fracture inclined at 35°, 70°.

91
- @90.6m: bedding joint inclined at 75°.
- SILTSTONE (same as above), slightly weathered, moderately soft, closely spaced random fractures, clay and calcite filling, rough, very thin.
- REC=92% RQD=23% — 85
- @91.6m: fracture inclined at 80°, 30°, 75°, clay filling.

92
- (UC) @92.1m: SILTSTONE (same as above), slightly weathered, moderately hard, closely spaced fractures, calcite filling, rough, 1 mm aperture.
- (UC) @92.1m: bedding joint.
- @92.5m: fracture zone.
- @92.7m: mod. spaced bedding joint inclined at 50°, 60°.
- REC=100% RQD=32% — 86

93
- (UC) @93.6m: SILTSTONE (same as above), very intensely fractured; abundant calcite, 1-2 mm aperture.

94
- REC=100% RQD=7% — 87
- @94.5m: fracture inclined at 10°.

95
- @95m: fracture parallel to core axis, large calcite pocket.
- SILTSTONE (same as above), grey, fresh, moderately hard; bedding inclined at 80-85°; intensely fractured, calcite fill, rough to stepped, 1 mm aperture.
- @95.4m: 100m thick fracture zone.
- REC=100% RQD=19% — 88
- @95.6m: 50% calcite to 20mm thick, low-angle (0 inclination) veins.
- @95.7m: calcite veins inclined at 5-10°; joints with slickensides at 85° rake.

96
- @95.9m: 150mm thick shear zone, joints with slickensides inclined at 85°, very dark grey.
- SILTSTONE/CLAYSTONE, light grey, fresh, moderately soft to soft, bedding inclined at 80°, random fractures, clay and calcite fill, rough, 1-2 mm aperture.
- REC=67% RQD=0% — 89
- @96.1m: sheared claystone, fracture inclined at 45°.
- fragments of black sheared and calcite-rich claystone and siltstone, may indicate shear zone.
- REC=67% RQD=0% — 90
- @96.8m: SILTSTONE, grey with calcite veins to 10mm thick, low angle of inclination.

97
- SILTSTONE, dark grey, fresh, hard except in shear zones, bedding inclined 80°; intensely jointed and sheared, clay filling, smooth and polished with slickensides to rough, tight. Water flowing from formation at about 20 liters/min (no change from above).
- REC=100% RQD=0% — 91
- @97.1m: bedding joint inclined at 80°.
- @97.3m: 75mm thick sheared zone, sandy clay matrix.
- @97.3m: SILTSTONE/CLAYSTONE, closely spaced fractures, joints inclined 40-45°.

98
- @97.5m: bedding joint inclined at 80°.
- SANDSTONE, light grey, medium-grained, offset by healed faults, white calcite vein, 10mm thick.
- REC=100% RQD=0% — 92
- @97.7m: SILTSTONE and CLAYSTONE (30%), black to dark grey, fresh, hard, bedding inclined at 80°; intensely to very intensely fractured, thin clay filling in most joints, smooth and polished with slickensides.
- @97.9m: sandstone bed approx 10mm thick, bedding joints inclined 80°.
- @98.1m: joints inclined at 30-45°.
- @98.2m: bedding joints inclined at 80°.
- @98.4m: bedding joints inclined at 80°, joint inclined at 30°.

99
- SILTSTONE (70%) and CLAYSTONE (20%) with SANDSTONE (10%), black to very dark grey with grey beds, fresh, hard: bedding with joints inclined 85°; very intensely fractured, < 1 mm aperture, thin clay films on most joints, smooth and polished to rough.
- REC=100% RQD=22% — 93
- @98.9m: small patches of calcite on face, slickensides with 45° rake, several white calcite veins 10-20mm thick.
- @99.1m: joints inclined at 10-50°, two white calcite veins 2mm thick.
- sheared zone with hard siltstone and claystone fragments in black, soft to very soft, clay matrix.
- REC=43% RQD=0% — 94

100
- sheared claystone and siltstone in clayey matrix, shear fabric varies form 45 to 60°.
- REC=100% RQD=0% — 95

101
- NCR.

102
- @101.8m: sheared clyastone, siltstone, and sandstone in sandy clay matrix, black with gray sandstone fragments.
- REC=70% RQD=0% — 96
- @102.3m: sandstone, light grey, fine- to medium-grained, 13 cm thick.

103
- sheared rock in black clayey matrix.
- REC=96% RQD=0% — 97
- @103.2m: sandstone, light grey, fine grained, joints above and below inclined at 80° and 60°, respectively.
- @103.3m: shear zone, clay with black hard fragments.
- @103.5m: 25mm thick bands of siltstone and sandstone in clay matrix, black.
- SANDSTONE AND SILTSTONE, interbedded, light grey to dark grey, fresh, moderately soft to moderately hard, faint bedding inclined at 70-75°; very intensely fractured with several black clayey shear zones.

104
- REC=100% RQD=14% — 98
- @103.5m: bedding joints inclined 70-75°, calcite filling, slightly rough.
- @103.6m: two joints parallel to core axis inclined at 40°, slightly rough, tight.
- @103.7m: siltstone with interbeds of very fine grained sandstone, moderately soft.
- @103.9m: sheared clay, very soft, inclined at 75°, joint inclined at 80°, clay filling, slightly rough to smooth.
- @104m: sandstone with incipient fracture parallel to bedding, moderately hard.
- @104.1m: siltstone, very soft to moderately soft, sheared, clay matrix, fracture inclined 65°.
- @104.2m: sandstone, light grey to dark grey, moderately hard, bedding inclined at 70-75°, fine to medium grained, fracture inclined at 60°.
- @104.3m: siltstone, moderately soft.
- SANDSTONE, light grey, fresh, moderately hard, bedding inclined at 70-75°, medium grained.

Boring 02-11A Continued on LOTB Sheet of

PENETRATION DEPTH (m)

104
- joints inclined 20°, rough, 1-2 mm aperture, bedding joints inclined 70°-75°, rough, moderately open.
- @104.6m: joint perpendicular to core axis, clay filling, moderately rough, 3-5 mm aperture, moderately healed fracture with thin subparallel calcite veins.
- REC=103% RQD=0% — 99
- @104.7m: bedding joints inclined at 75°-80°, clay filling, slightly rough, 1 mm aperture.

105
- @105m: SILTSTONE, dark grey, fresh, hard, random fractures, black clay coating on surfaces, slightly rough.
- broken siltstone/sandstone - no clay matrix.
- REC=100% RQD=0% — 100
- @105.6m: SANDSTONE, light grey, fine-grained, joints above and below inclined at 80° and 60°, respectively.

106
- @105.7m: stepped joint inclined at 70°, moderately rough, calcite veins up to 2mm.
- @105.9m: grading into siltstone, joint inclined at 70°, slightly rough.
- loose sandstone fragments grey, fresh, very-fine-grained.
- REC=100% RQD=0% — 101
- @106.1m: sheared and intensely fractured siltstone and sandstone with abundant black clayey fractues and zones. Fragments rnge from sand size to 5 cm. Some zones of losse fragments and some zone intact and held together by clay.

107
- SILTSTONE/SANDSTONE, interbedded, light grey, fresh, moderately hard but very soft in shear zones, bedding inclined at 80°.
- @106.8m: sandstone, light grey, fine to medium grained, intensely fractured.
- @107m: brecciated siltstone and sandstone in black clay matrix, bedding joint inclined at 80°, moderately rough.
- REC=100% RQD=0% — 102
- @107.2m: joints and bedding joints inclined 0 to 80°, abundant calcite veins.

108
- @107.5m: 100mm zone of moderately healed fractures and calcite veins.
- REC=65% RQD=0% — 103
- @108.2m: sheared zone, black intact claystone/siltstone/sandstone fragments in clayey matrix, fragments range from sand size to 20-30mm, fresh, very soft.

109
- @109.2m: sandstone, light grey, fine grained, bedding inclined at 75-80°, bedding joints with clay films.
- @109.5m: bedding joints two inclined at 75°, moderately rough.
- @109.6m: two zones of 50mm thick platy siltstone breccia in clay matrix with joints at top and bottom inclined at 40°-45° and 60°-65°.
- REC=97% RQD=0% — 104
- @109.9m: sandstone, light grey, medium grained, joint inclined 75°, clay fill.

110
- @110m: two clay-filled joints about 50mm apart inclined at 60 and 50° with incipient fractures between.
- @110.2m: angular brecciated sandstone/siltstone in clay matrix.
- @110.3m: sandstone, light grey to dark grey, fine- to medium-grained, abundant calcite veining, clay fill.
- SANDSTONE, grey to dark grey, fresh, hard, fine to medium grained, thick bedding/massive, no obvious bedding. Water flowing from formation at estimated rate of 150 liters/min.
- @110.8m: black clay gouge coating fracture surfaces, bedding joint inclined at 80°, tight.
- REC=100% RQD=14% — 105
- @110.9m: joints inclined 15 and 65°, slightly rough, moderately thin to thin, calcite fill.

111
- @111.1m: 175mm thick zone of subparallel fractures oriented about 75-80°, sandy clay films in fractures, tight.
- @111.3m: several random hairline calcite veins, sandy clay matrix.
- SANDSTONE, light grey, fresh, hard with moderately soft fracture zones, bedding inclined at 60-65°; intensely to very intensely fractured, tight to 2-3 mm apertures, clay and calcite fill.
- REC=100% RQD=0% — 106
- @111.7m: joint inclined 65° with slickensides at 85° rake.
- @111.8m: joint inclined at 60°, 5°, 0°, clay and calcite filling in one joint, calcite veins up to 3mm thick.

112
- @112m: joint inclined at 25°, bedding inclined at 55°, calcite filling, small healed fault offset, rough, 2-3 mm aperture.
- @112.1m: joint inclined at 55°, rough, 2 mm aperture.
- @112.3m: sheared siltstone in black clay matrix, 20 cm thick.
- @112.6m: SANDSTONE, grey to dark-grey, fresh, hard, fine- to medium-grained, bedding inclined 70°, very intensely fractured.
- REC=90% RQD=0% — 107
- @112.9m: joint inclined at 15° and 70°, smooth to slightly rough, zone of incipient random joints, calcite veining.

113
- sheared and very intensely fractured SANDSTONE/SILTSTONE, grey to very dark grey, fresh, moderately hard to hard in soft clay matrix, random fractures, fracture zone with shears, calcite coatings on some pieces.
- REC=100% RQD=0% — 108
- @113.6m: black clay gouge inclined at 50°.

114
- @113.8m: siltstone with some interbeds of very fine sandstone, fractured and brecciated in clay matrix, sample crumbles into sand size to 30-40mm size fragments in sandy clay matrix when handled.
- @113.9m: shear zone, sand size to 3-4 cm size siltstone and sandstone fragments in clayey matrix, joints inclined at 45°.
- @114m: water flowing from formation at substantial rate, estimated at 100 to 150 liters/min.
- REC=100% RQD=0% — 109
- SANDSTONE/SILTSTONE, grey, fresh, hard, fine- to medium-grained, very intensely fractured, slightly rough to stepped surfaces.

115
- @114.5m: grading into siltstone, dark grey/black, brecciated, very little clay, moderately soft, 4mm calcite vein inclined 55°.
- @114.7m: bedding inclined at 45-50°, joints inclined from 35°-65°, calcite filling, rough.
- REC=92% RQD=0% — 110
- SILTSTONE/SANDSTONE, interbedded, very dark grey, fresh, moderately soft, very fine grained, fracture zone.
- @114.9m: sheared, joint and clay gouge inclined at 70°, lots of shears surfaces, few hairline calcite veins, smooth/polished surfaces.
- REC=50% RQD=0% — 111
- @115.1m: series of joints inclined at 45-70°, calcite striations inclined at 15°, slickensides predominately down dip..
- @115.3m: polished joint, slickensides with 25° rake.

116
- SILTSTONE and SANDSTONE, black to very dark grey, brecciated/sheared, fresh, hard rock fragments in very soft clay matrix, average size of 2-3mm, lots of polished and slickensided surfaces on 30-40-mm- size fragments.
- REC=100% RQD=0% — 112
- first run after hole shut in for 4 hours, water flowing from formation at about 75 to 115 liters/min. sample consists of very intensely fractured SANDSTONE and SILTSTONE, loose fragments with clayey coating and clayey shear zones common.

117
- SANDSTONE, grey, fresh, hard fragments in soft clay matrix, bedding joints inclined at 65-75°, sheared and polished irregular joint surfaces, fine to medium grained, several intersecting hairline calcite veins, calcite filling.

VERTICAL SCALE
1 : 25

Caltrans Metric

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Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HAMILTON NO. CEG 31 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN BY R. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/11/03

B. SCHELL, J. CASTLE, M. HACHEY/GEOLOGISTS
DATE: FIELD INVESTIGATOR/TITLE

ORIGINAL SCALE IN mm FOR REDUCED PLANS: 0 20 40 60 80 100
AS SHOWN

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

DESIGN OVERSIGHT
KEYHAN MOGHBEL
SIGNOFF DATE

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

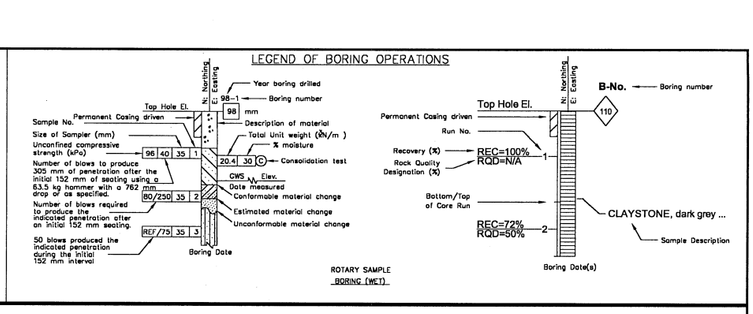
TYPE OF BORINGS

- 2¼" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-11A Continued from LOTB Sheet of

PENETRATION DEPTH (m)

116

REC=100% RQD=0% 113

117

REC=100% RQD=0% 114

REC=100% RQD=7% 115

118

REC=56% RQD=0% 116

119

REC=83% RQD=0% 117

120

REC=83% RQD=0% 118

121

REC=96% RQD=38% 119

122

REC=100% RQD=29% 120

123

REC=100% RQD=17% 121

124

REC=87% RQD=0% 122

125

REC=100% RQD=14% 123

126

REC=88% RQD=0% 124

127

REC=94% RQD=0% 125

128

REC=60% RQD=0% 126

129

REC=83% RQD=0% 127

130

REC=96% RQD=0% 128

131

REC=111% RQD=0% 129

132

REC=73% RQD=10% 130

133

SANDSTONE and SILTSTONE fragments in sandy clay wedge, very dark grey to black, fresh, 2-20mm size.
@116.3m: SANDSTONE grading to CLAYSTONE, grey grading to black, fresh, bedding joint inclined at 60°.
@116.4m: shear zone, small fragments in black sandy clay matrix.
@116.4m: SILTSTONE and SANDSTONE with claystone laminae, bedding inclined at 60-65°, clay filling, smooth/polished surfaces with slickensides.
@116.5m: CLAYSTONE, black, very fractured, 10mm thick black clay.
@116.6m: sheared zone, fragments of claystone and siltstone in clayey matrix, black, very stiff.
@116.7m: SANDSTONE, loose fragments, core rotated, bedding joints inclined at 85°.
@116.8m: black sandy clay, sheared.
@116.9m: sandstone, light grey, bedding joint inclined at 65°, medium grained grading down to fine grained, bedding joint inclined at 60°, three thin calcite veins.
@117m: large volumes of water flowing from formation, estimated up to 150 liters/min.
SANDSTONE, grey to dark grey, fresh, hard; joints inclined at 30°, clay and calcite filling, smooth to stepped, fine to medium grained. Still high volumes of water from formation, estimated at about 150 liters/min, temperature is 15° C.
SILTSTONE, black, fresh, very hard.
@117.3m: SANDSTONE, grey, fresh, fine- to medium-grained with hairline calcite veins, joint inclined at 70°, closely spaced fractures, smooth to stepped.
@117.6m: joint inclined at 25°, tight.
@117.7m: sheared and folded zone 3-cm thick, dark grey fragments with black clay fill, joints inclined at 70°.
@118m: joints inclined from 25-70°, calcite fill, tight.
@118.5m: joint inclined at 70°, 65°, 5°, black clay shear zones.
@118.7m: white calcite vein, 10 mm thick.
@119.1m: SANDSTONE, grey to dark grey, fresh, very hard with soft shear zones, very intensely fractured, all orientations, clay and calcite filling, rough to stepped, abundant calcite veins hairline to 20mm thick.
@119.4m: black clay shear zone.
SANDSTONE (same as above), grey to dark grey, fresh, very hard with soft shear zones, white calcite veins and black clay shear zones, rough to stepped.
@120.2m: clay shear zone inclined at 85°.
@120.4m: black clay shear zone inclined at 45°, rotated core.
SANDSTONE (same as above), grey to dark grey, fresh, very hard, closely spaced fractures, white calcite veins and black clayey sheared zones.
@120.7m: polished and blackened joint inclined at 45°.
@121m: black clay shear zone.
SANDSTONE (same as above), grey, fresh, very hard, subtle textures suggest steep bedding (70-80°), intensely to moderately fractured, stepped to slightly rough. One low-angle (0-5°) calcite vein 4-5 mm thick extends most of core. Water from formatio
@121.3m: sand grains include abundant black claystone grains (graywacke sandstone), medium- to coarse-sand-size, joint inclined at 70°.
@121.6m: two joints inclined at 35 and 80°, white calcite vein 4-5mm wide.
@121.8m: joint inclined at 25°, tight.
@121.9m: joint inclined at 65°, offset in calcite veins.
@122m: several hairline calcite veins.
@122.1m: joint inclined at 20°, calcite filling, tight.
@122.2m: two joints inclined at 55 and 75°, tight.
@122.3m: joint inclined at 60°, calcite filling, several mechanical breaks.
SANDSTONE (same as above), grey, fresh, hard to very hard, intensely fractured, tight, calcite fill, slightly rough: One long, low-angle, hairline, calcite vein.
@122.5m: 80° joint.
@122.6m: 45° joint.
@122.8m: joints inclined 45-80°.
@122.9m: 90° joint.
@123m: several joints inclined from 75-90°.
@123.1m: joints inclined 65°.
SANDSTONE (same as above), grey, fresh, very hard, intensely fractured, smooth, tight, grades from fine to medium.
@123.6m: several joints inclined from 45-75°, smooth, tight.
@123.8m: several random joints, smooth, tight, calcite lining.
@124m: two 25mm thick very dark grey sheared zone, joint inclined at 60°.
@124m: abundant white calcite veins to 10mm thick.
@124.2m: dark grey zone, several joints inclined from 45-80°, tight, stepped to rough, joint inclined at 5-10°.
SANDSTONE (same as above), intensely fractured, some fracture surfaces polished black and clay gouge filling.
@124.6m: mostly black sandy clay gouge, some gravel size sandstone.
@124.7m: joint inclined at 75°, clay filling, polished.
@124.8m: joint inclined at 65°, 20° very rough, clay filling with calcite veining on core, polished.
@124.9m: joint inclined at 85°, very rough, very thin.
@124.9m: sandy clay gouge up to 25 mm thick inclined at 80°, very rough, 1-2 mm aperture.
@125m: two joints inclined at 50°, calcite filling, slightly rough, 1-2 mm aperture.
@125.2m: clay gouge in very fractured sandstone, inclined at 50°.
@125.4m: joints inclined at 15°, 45°, calcite filling, sl. to mod. rough, 1-2 mm aperture.
@125.9m: SANDSTONE (same as above), light grey, fresh, hard, fine/medium-grained; bedding inclined 75° based on orientation of black laminae; intensely fractured, some surfaces coated with calcite, slightly rough to rough; upper contact is joint with po
@126.2m: top of very intensely fractured zone, very prominent calcite vein, 10 mm thick inclined at 25° with 60° rake to slickensides.
@126.5m: joint inclined at 50°, fracture surface polished black.
SANDSTONE, light grey, fresh, moderately hard to hard, fine grained grading to very fine grained sandstone/siltstone, bedding inclined at 80°, closely spaced fractures.
@126.9m: siltstone/very fine sandstone interbeds, joints inclined 65°-90°, calcite filling, polished, tight.
@127.1m: calcite veining and calcite coatings on fracture surfaces, some black clay gouge filling.
SANDSTONE, fresh, moderately hard to hard, medium grained, intensely fractured.
@127.4m: joints inclined at 60 and 70°, calcite filling, slightly rough, joint inclined at 35°, fracture surface striations inclined at 75° in calcite coating.
@127.5m: several polished joints 75 to 90°.
@127.6m: black sandy clay gouge with fine-gravel-sized sandstone clasts, joints inclined at 50° and 55°.
@127.7m: SILTSTONE, dark grey, fresh, moderately hard.
@127.9m: SANDSTONE, fine grained, bedding joint inclined at 75°.
@127.9m: sheared sandstone/siltstone in black clay matrix, random fracture inclined 40°.
fragments, loose, black, fresh, moderately hard to hard.
@128.3m: joint inclined at 55°, calcite coating on fracture surface, moderately rough.
@128.4m: SANDSTONE AND SILTSTONE INTERBEDDED, light grey and dark grey, fine-grained, bedding inclined at 70-75°. Joint inclined at 50°, rough, tight.
@128.5m: two joints inclined at 65 and 70°, clay filling, smooth.
@128.6m: sheared sandstone/siltstone in clay matrix, very soft, 10cm thick fracture zone.
SANDSTONE, light grey, fresh, hard to very hard, fine grained.
@129m: joint inclined at 35°; calcite coated surface with very thin clay filling, polished, tight, hairline calcite veins 0,5 mm thick oriented subparallel to core axis.
loose fragments of sandstone, some with polished surfaces.
SANDSTONE AND SILTSTONE INTERBEDDED, primarily dark grey with light gray zones, fresh, hard; moderately expressed bedding inclined about 80°; intensely fractured with abundant shear zones, primarily subparallel to bedding but with random fractures common, generally tight with thin clay and calcite fill.
@129.6m: joint inclined at 45°, slightly rough, moderately open, clay gouge.
@129.7m: joint inclined at 75°, smooth, tight and single incipient fracture.
@129.9m: fracture zone inclined at 75°, coherent calcite layer within gouge - 2mm thick.
@130.1m: healed fracture - offset calcite veins, fracture zone, bedding joint inclined at 80°, clay filling polished/platy, tight. Joints inclined 60° and 85°, calcite filling, slightly rough.
SANDSTONE with thin interbeds of siltstone, light grey with dark grey siltstone beds, fresh, hard, bedding 90°, intensely fractured.
@130.5m: joint inclined at 75°, 0°, 85°, 90°, two at 55°, 45°, sl. rough to polished, calcite fillings in some joints.
SANDSTONE, light grey, fresh, hard, bedding inclined at 75-80°; intensely fractured with several black sheared and very intensely fractured zones.
@131m: joints inclined 50°-55°, calcite filling, smooth/polished. 50mm thick fracture zone inclined 55°.
@131.3m: siltstone, dark grey, fresh, moderately hard, joints inclined 40°-70°, smooth to slightly rough.
@131.5m: 200mm fracture zone, brecciated sandstone in black sandy clay matrix, very soft.
@131.7m: incipient joint inclined at 75°, healed, calcite filling, very thin. Calcite veins up to 1mm thick.
@131.8m: joints inclined 55°-70°, 100m fracture zone, brecciated with coherent calcite veins up to 3mm, very soft.
@131.9m: thin fracture zone inclined at 65°, sandstone becoming coarser grained.

PENETRATION DEPTH (m)

133

REC=81% RQD=0% 131

134

REC=100% RQD=0% 132

135

REC=83% RQD=23% 133

136

REC=100% RQD=0% 134

137

REC=76% RQD=12% 135

138

REC=86% RQD=0% 136

139

REC=62% RQD=0% 137

140

REC=100% RQD=10% 138

141

REC=100% RQD=11% 139

142

REC=60% RQD=0% 140

143

REC=100% RQD=0% 141

144

REC=93% RQD=0% 142

145

REC=93% RQD=0% 143

SANDSTONE, SILTSTONE, CLAYSTONE INTERBEDDED, light grey to very dark gray; fresh, moderately hard with abundant very soft clay gouge and sheared zones, calcite veining up to 3mm; bedding inclined 70°, medium-grained sandstone.
@132.9m: intact fractured sandstone interval with bedding joints and bedding inclined 70°-85°; smooth and polished joints, tight.
@133m: sheared black sandy clay matrix, fresh, very soft, with bits of white calcite.
@133.3m: sheared zone with stiff clay gouge with shear fabric inclined 45°, abundant white calcite bits.
SANDSTONE, grey, fresh, moderately hard to hard, bedding inclined at 60-70°, very intensely fractured, some fracture surfaces polished to black, very little clay gouge.
@134.1m: joint inclined at 60°, smooth/polished, fracture surface striated with 85° rake.
@134.1m: joint inclined at 65°, surface partially calcite coated.
@134.2m: random fracture, moderately rough, joint inclined at 60°, smooth/polished.
SANDSTONE, light grey, fresh, hard, fine-grained; bedding inclined at 70°; intensely to moderately fractured, tight to 2 mm aperture; calcite and clay fill.
@134.4m: closely spaced joints inclined at 80°, 65°, 75°, sl. rough to polished, mod. open, calcite filling.
@134.6m: intact zone with thin interbeds of very-fine-grained grey sandstone and dark-grey siltstone inclined at 70°.
@134.7m: bedding joint inclined at 70°, calcite filling, smooth/polished, tight.
@134.9m: sheared sandstone in black sandy clay matrix zone inclined at 75°, 5 cm wide with calcite vein 5 mm wide. Joint inclined 40°, lean clay filling, smooth.
@135.2m: fractured zone of siltstone 15 cm thick, smooth to slightly rough joints, tight, clay filling with calcite veining.
SANDSTONE AND SILTSTONE, interbedded, grey to dark grey, fresh, moderately hard, very-fine-grained; moderately expressed bedding inclined 80°; intensely fractured, 1-2 mm apertures with clay and calcite fill.
@135.6m: 25mm zone of sandstone, lighter than rest of core, stepped joint, calcite filling.
@135.8m: thinly bedded, bedding joint inclined at 80°, clay fill, smooth. Random fracture. Joint parallel to core axis, clay and calcite filling, slightly rough, moderately thin.
@136m: shear zone 25 mm wide, inclined 65°, brecciated siltstone in black clay matrix. Joint inclined 45°, calcite filling, slightly rough, striations on fracture surface with 80° rake.
@136.1m: partially calcite filled joint continuing parallel to core axis.
@136.2m: bedding joint inclined at 80°, clay filling, slightly rough.
@136.3m: joints inclined 35° and 70°, moderately rough.
SILTSTONE AND SANDSTONE, interbedded (as above), grey, fresh, moderately hard to hard, very-fine- grained sandstone; moderately expressed thin bedding inclined 70-80°; intensely fractured; smooth and polished to rough, tight to 2 mm aperture; very thin
@136.6m: bedding joint inclined at 80°, clay filling, smooth.
@136.7m: joints inclined at 65°-70°, slightly open, stepped joint, rough, tight.
@136.8m: 75mm zone of brecciated sandstone/siltstone in clay matrix, joints at top and bottom inclined at 65 and 80°, moderately thin.
@137m: joint inclined at 65°, clay filling, moderately thin.
@137.1m: joint inclined at 5°, calcite filling up to 1mm thick, smooth/polished, tight.
predominantly SILTSTONE, dark gray interbedded with fine grey SANDSTONE, fresh, moderately hard; moderately expressed bedding inclined at 75°; intensely fractured.
@137.5m: very fractured, some fracture surfaces polished.
@137.6m: sheared siltstone in black clay matrix, joint inclined at 40°, polished.
@137.7m: joints inclined at 65 and 80°, calcite filling, polished.
@137.8m: several joints inclined at 45° and 70°, clay filling, polished.
@138.1m: sheared sandstone/siltstone in black sandy clay matrix.
SILTSTONE with SANDSTONE interbeds, dark grey with light interbeds; fresh; moderately hard to hard, bedding inclined at 55-60°.
@138.5m: Joint inclined at 25°, polished, tight, striations on fracture surface inclined at 60°.
Bedding joints inclined at 55°, clay filling, smooth, tight.
@138.7m: joints inclined at 35° and 40°, clay filling, polished, tight.
@138.8m: bedding joint inclined at 60°, clay filling, smooth but irregular, tight.
@138.9m: sheared siltstone10 cm thick in clay gouge matrix. Joint inclined at 80°, clay filling, slightly rough, tight.
SILTSTONE (as above), dark grey, fresh, moderately hard moderately expressed bedding with thin beds of fine-grained, light grey sandstone, inclined 70-85°; intensely fractured with sheared zones.
@139.6m: closely spaced joints inclined at 70°, two at 50°, polished, sl. open.
@139.8m: Sheared siltstone/sandstone, 75mm thick in black clay gouge matrix. Moderately spaced joints inclined at 70°-80°, clay filling, slightly to moderately rough, tight.
@140m: bedding joints inclined at 0°, 85°, clay filling, smooth, tight, joint at 45°.
@140.2m: sheared siltstone in black clay matrix, 10 cm thick, bedding attitude changes across zone to 70°.
@140.4m: mod. spaced joints inclined at 0°, three at 80°, 20°, 90°, 85°, clay and calcite filling, sl. to mod. rough.
CLAYSTONE AND SILTSTONE, black to very dark grey, fresh, hard, with fine SANDSTONE beds; moderately expressed, inclined at 75-85°, inversely graded; intensely fractured but much more intact than above; several white calcite veins hairline to 2mm thick,
@140.8m: closely spaced joints inclined at 80°, 0°, 90°.
@140.9m: closely spaced joints inclined at 90°, 40°, 80°, 15°, two at 85°.
@141.2m: closely spaced joints inclined at 70°, 55°, 70°, 40°, clay and calcite filling, polished, tight.
@141.9m: loose fragments of CLAYSTONE/SILTSTONE, black, fresh, hard, closely spaced fractures, one thick calcite vein 2 to 6 mm thick and several hairline veins.
@141.9m: joint, white calcite vein, 2-6mm thick.
@142.1m: bedding inclined 80°-85°, fracture zone, loose fragments.
SILTSTONE (60%), CLAYSTONE (30%) with fine-grained SANDSTONE (10%) interbedded, very dark grey to black, fresh, hard; moderately expressed bedding in laminae to 4 cm thick, inclined 80-90°; intensely fractured, joints are generally tight and clean.
@142.5m: joints inclined at 40°, 35°, tight, bedding joints at 90°, 88°, tight, clay, calcite filling.
@142.8m: 1mm thick calcite vein along healed fault, sandstone/siltstone beds offset 2mm.
@143m: bedding joint inclined 80°, tight, joints inclined at 50°, 45°, tight, calcite filling.
@143.1m: bedding joint inclined at 82°, calcite filling. Fine sandstone bed, grey, 8mm thick. Joint inclined 28°.
CLAYSTONE (60%) AND SILTSTONE (40%), interbedded, black to very dark grey, fresh, hard, bedding ranges from 30mm to laminae; few specks and streaks of white calcite; intensely fractured, slightly rough and slickensided, tight, generally clean, bedding join
@143.4m: 50mm fracture zone, joint.
@143.6m: 20mm fracture zone inclined 70°, joint inclined 85°.
@143.7m: joints inclined at 35° and 85°, calcite filling.
@143.8m: highly fractured into 2-20 mm fragments, clean, no clay, joint inclined at 85°.
CLAYSTONE (50%), SILTSTONE (45%), AND SANDSTONE (5%); black to very dark grey, fresh, hard; bedding inclined 80-85°; intensely fractured, smooth to slightly rough with few stepped surfaces, generally tight, generally clean, closely spaced bedding joints
@144.3m: very fractured, clay matrix. Joint inclined 60°, white calcite vein 1-2mm thick.
@144.4m: closely spaced bedding joints, offset 10-mm-thick fine sandstone bed along fault parallel to core axis, 15 mm offset, fault has calcite lining.
@144.8m: sheared zone of black claystone, bedding joint at top and fracture zone at bottom.

Boring 02-11A Continued on LOTB Sheet of

VERTICAL SCALE
1 : 25

DESIGN BY R. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/11/03
DATE
B. SCHELL, J. CASTLE, L. PATZKOWSKI
FIELD INVESTIGATOR(S)/TITLE
AS SHOWN

ORIGINAL SCALE IN mm
FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

Caltrans Metric

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

The State of California or its officers or agents shall not be responsible for the completeness or accuracy of electronic copies of this plan sheet.

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★
DOUGLAS HOLMES HAMILTON
NO. CEG 31
EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

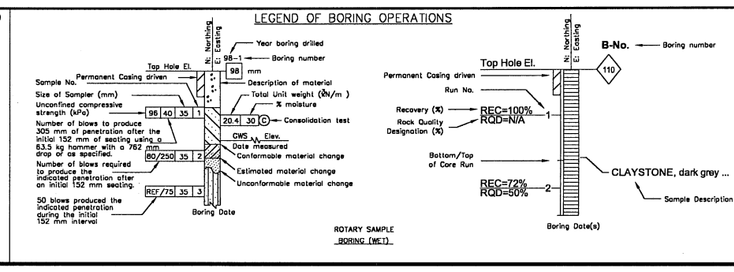
TYPE OF BORINGS

- 2½" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- HQ DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS



Boring 02-11A Continued from LOTB Sheet of

PENETRATION DEPTH (m)

145

SILTSTONE (65-70%), CLAYSTONE (25-30%), AND SANDSTONE (5-10%), black to very dark grey, fresh, hard; bedding ranges from laminae to 2 cm, siltstone beds commonly with small (coarse-sand-size) flat to arcuate claystone fragments; intensely to moderately fractured.

@145.3m: sandstone bed inclined at 85°, 8mm thick grading down into siltstone and claystone, joint inclined 65°.

146 REC=98% RQD=45% 144

@145.4m: bedding joints inclined at 85°.
@145.5m: fracture zone, loose fragments but very little lost core.
@145.7m: fine sandstone grading down into siltstone, grey to dark grey with thin white calcite veins, bedding joints and joints, joint inclined at 70°.
@145.8m: bedding joints inclined 80°-85°.
@146m: joint inclined at 50°.
@146.2m: joint inclined at 80°, single incipient joint.
(PA) @146.3m: dark gray interbedded claystone and medium-grey siltstone.
@146.4m: bedding joints inclined at 80°-85°, clay film.
(PA) @146.6m: dark gray siltstone.
@146.6m: bedding joint inclined at 80°.

147 REC=78% RQD=0% 145

CLAYSTONE (65%), SILTSTONE (30%) AND SANDSTONE (5%), (as above); black to dark grey, fresh, hard, well-expressed bedding inclined 85°.
@146.9m: fracture zone, random fractures.
@147.1m: sandy clay shear zone inclined at 45°, 80mm of lost core.
@147.2m: bedding joints inclined at 85°.
@147.3m: many layers and beds with tiny (sand sized) flat claystone particles within siltstone.
@147.4m: bedding inclined 60°, two joint inclined at 50° and 85°.

148 REC=87% RQD=13% 146

@147.5m: joint inclined at 45°, 1mm thick white calcite vein on joint surface.

CLAYSTONE with SILTSTONE (10-20%) beds, black, fresh, hard; bedding from laminae to 5 cm thick, inclined 90°, several thin (<1mm) white calcite veins; intensely fractured, rough to smooth with slickensides, tight, generally clean, some fragments with calcite filling.

@147.7m: joint inclined at 45°, joint perpendicular to core axis.
@147.9m: bedding joint perpendicular to core axis, joint inclined 50°.
@148.1m: loose fragments, calcite filling.

149 REC=67% RQD=8% 147

@148.8m: SILTSTONE (65%), CLAYSTONE (30%), black to very dark grey, fresh, very hard, bedding inclined at 85-90°, few fine sandstone beds (<5%); intensely fractured, moderately rough to rough, tight, primarily clean, closely spaced joints, bedding joint

@149.5m: fracture zone, with some clay filling (5 cm thick), random orientations, some calcite coating on fragments, joint inclined 80°.
@149.7m: bedding joints inclined at 75°, 80°.

150

SANDSTONE with claystone pebbles (5-15mm size) in fine- to medium-grained sandstone, numerous black laminae indicate bedding inclined at 80-90°.
@150m: joint inclined at 85°, calcite filling, rough, bedding joint.
@150.1m: CLAYSTONE (40%), SILTSTONE (40-45%), and SANSTONE (10-15%), interbedded, black and very dark grey with a few grey beds, fresh, hard: bedding inclined at 80-90°, inverse grading; intensely fractured, tight, mostly clean. Bedding joint inclined 80°.

REC=81% RQD=26% 148

(PA) @150.3m: dark grey highly fractured claystone, joint inclined at 45°, rough.

151

@150.5m: bedding joint inclined at 78°, slightly rough.
(PA) @150.5m: interbedded dark grey claystone and medium-grey siltstone, fractured.
@150.7m: fracture zone inclined at 87°, clayey fill with claystone fragments, bedding joint inclined 20°, slightly rough.
@150.8m: shear zone inclined at 88°, clayey fill with claystone fragments, joint inclined 30°, slightly rough.
@150.9m: bedding joint, slightly rough and single incipient joint.
@151.1m: fracture zone, probably mud from drilling, bedding joint inclined at 85°, slightly rough.
@151.2m: joint, calcite filling.

152 REC=100% RQD=41% 149

SILTSTONE (65-75%), CLAYSTONE (20-30%), interbedded, black to very dark grey with grey SANDSTONE (<5%) beds, few thin calcite veins, fresh, hard; well-expressed bedding inclined at 80-90°, numerous incipient joints.
@151.3m: bedding joints inclined at 85°, 0°, rough, joint inclined 70°.
@151.5m: bedding joints inclined at 75-90°, rough, joint inclined 45°, calcite filling, stepped.
@151.8m: bedding joint inclined at 85°, calcite filling, smooth, numerous low-angle (0-10°) incipient joints.
@152.3m: bedding joint inclined 90°, sandy clay sheare zone inclined 90°, white calcite vein 1-2mm thick, rough, joint inclined at 45°.

153

@152.5m: joints inclined at 55-70°, clay and calcite filling, rough to stepped.

REC=62% RQD=0% 150

@152.8m: SILTSTONE/CLAYSTONE, black to dark grey, fresh, hard with soft clayey zones, several white calcite specks and veins, sheared and highly fractured, clay and thin calcite fill.
@153.5m: sheared clayey gouge zone, black sandy clay with angular claystone/siltstone fragments, highly fractured, bedding inclined at 70-80°.
CLAYSTONE 980%) with SILTSTONE interbeds, black to very dark grey, fresh, hard; subtle bedding ranging from laminae to 1-2 cm thick inclined 85°; intensely fractured, smooth surfaces with slickensides, tight, clean with only patchy discontinuous calcite

154

REC=87% RQD=13% 151

@153.8m: bedding joint inclined at 80°, joint inclined 5°.
@154.1m: bedding joint inclined at 45, joint parallel to core axis.
@154.3m: bedding joints inclined 85° with calcite filling, smooth/polished with slickensides.
CLAYSTONE/SILTSTONE (same as above), fresh, hard; bedding joint inclined at 80°.
@154.6m: loose fragments of same, no clay coatings on fragments, evidence of rotating core.

155

REC=37% RQD=9% 152

156

NCR.

@156.1m: loose fragments of silstone and claystone, many with smooth surfaces and some with clay coating.

REC=45% RQD=0% 153

@156.3m: sheared zone, SANDY CLAY with fragments of siltstone and claystone, fresh, hard fragments in stiff clay matrix.

157

sheared zone of SANDY CLAY (same as above), angular siltstone and claystone fragments with polished and slickensided surfaces.

REC=53% RQD=0% 154

@157.3m: end shows lateral slickensides, i.e. 0° rake.
@157.3m: NCR.

CLAYSTONE, black with a few thin and hairline white calcite veins, fresh, hard, massive, no bedding; intensely fractured, smooth to stepped, tight, thin calcite film.

158

@157.8m: joint, calcite filling.
@157.9m: incipient joint inclined at 25°.
@158m: joint inclined at 60°, slightly rough.
@158.1m: two intersecting joints inclined at 50 and 35°, rough and stepped.

REC=90% RQD=32% 155

@158.4m: two joints inclined at 45 and 70°, calcite filling and stepped.
@158.5m: several healed calcite veins.
(PT) @158.5m: dark gray siltstone/claystone with parallel shear surfaces; joints inclined 60-70°.
@158.6m: joint inclined at 70°, calcite filling, slickensided.

159

(DS) @158.6m: dark gray claystone with a few joints.
@158.8m: joint inclined at 70°, calcite filling, slightly rough, moderately open.
@158.8m: joint inclined at 65°.
@158.9m: joint inclined at 65°, calcite filling, stepped.
@158.9m: joint inclined at 15°, calcite filling, slightly rough.
@159m: shear zone, black sandy/gravelly clay and sheared claystone.

REC=56% RQD=0% 156

@159.1m: claystone, as above shear zone except with smooth/polished surfaces with slickensides.

160

loose fragments.
@159.3m: CLAYSTONE, black with hairline calcite veins, fresh, hard.
@159.4m: fracture zone, loose fragments, many with polished surfaces and slickensides.
@159.5m: ball of sandy clay.
@159.6m: some fragments have clay coatings, abundant calcite veins.

REC=50% RQD=17% 157

@159.9m: CLAYSTONE, black with hairline calcite veins.
@160m: loose fragments,.
SILTSTONE/CLAYSTONE, fresh to slightly weathered, hard, intensely fractured, random calcite veins.

161

@160.2m: clayey zone.
SILTSTONE, fresh to slightly weathered, hard, some thin visible bedding inclined at 72°; thin calcite veins, moderately spaced fractures, rough.
(PT) @161.2m
@161.2m: shear zone, clayey.
@161.3m: visible bedding inclined 65°.

REC=83% RQD=58% 158

@161.4m: joint inclined at 50°.
@161.6m: random fracture inclined at 50°, bedding 70-75°.
@161.7m: random fracture.
@161.8m: random fracture, thin calcite veins parallel to core axis.

162

163 REC=83% RQD=0% 159

@162.8m: bedding inclined 70°.

SILTSTONE (same as above), fresh, moderately hard to hard; intensely fractured with calcite and clay filling; smooth to rough, 1 mm aperture.
@163.6m: joint inclined at 55°.
@163.7m: shear zone, clayey.

164 REC=71% RQD=14% 160

@163.9m: random fracture inclined at 35°.
@163.9m: random fracture inclined at 55°.
@164.1m: random fracture inclined at 35°, abundant calcite filling.

SILTSTONE, fresh, hard, intensely to moderately fractured, calcite filling, smooth to rough, 2 mm apertures.
@164.6m: random fracture inclined at 40°.
@164.6m: abundant hairline calcite veins inclined 90°.
@164.7m: abundant hairline calcite veins inclined 90°, random fracture inclined at 50°.

165

@164.9m: abundant hairline calcite veins inclined 90°.

REC=100% RQD=23% 161

@165.1m: calcite vein inclined 20° with strongly developed slickensides at a 80° rake.
@165.2m: bedding inclined 20-25°.
(PA) @165.5m: sheared dark gray siltstone with claystone and healed.
@165.5m: bedding inclined 20-25°.
@165.6m: fracture inclined at 45°.
@165.8m: fracture inclined at 55°.

166

REC=100% RQD=0% 162

substantial increase in water flow from formation; joint inclined 45°.
CLAYSTONE/SILTSTONE, fresh to slightly weathered, hard, clay filling, rough.
SILTSTONE, fresh to slightly weathered, hard; mod. expressed bedding inclined at 25°; intensely fractured, calcite fill, smooth to rough, 1-2 mm aperture.
@166.5m: fracture inclined at 40°, calcite fill.
@166.7m: fracture inclined at 50°, calcite fill.

167 REC=93% RQD=50% 163

@167m: fracture inclined at 30°, calcite fill.
@167m: calcite vein, 4 cm thick, inclined 30°.
@167.1m: clayey shear zone.

SILTSTONE, dark grey, fresh to slightly weathered, hard, intensely fractured, calcite and clay filling, rough, 1 mm aperture; water flow slowing.

REC=78% RQD=0% 164

168

SILTSTONE, fresh, hard, bedding inclined at 40-45°, moderately fractured, rough, tight to 2 mm aperture.
(PA) @168.3m: joint inclined at 50°; sheared dark gray siltstone and claystone.
@168.6m: joint inclined at 80°.

REC=97% RQD=62% 165

@168.9m: joints inclined 45 and 50° with slickensides, tight.

169

@169.4m: bedding inclined at 40-45°.
SILTSTONE, fresh, hard, bedding inclined at 60°; heavy water flow has returned.
@169.6m: random fracture, calcite filling, rough.

170

REC=100% RQD=81% 166

@170.2m: interbedded sandstone inclined at 55°, some calcite and quartz on fracture surfaces.
@170.4m: visible bedding inclined at 55-60°, calcite and slickensided fracture surfaces.
SILTSTONE, fresh, hard, bedding inclined at 50°.
@170.7m: several smooth to rough joints with calcite fill.

171

REC=100% RQD=93% 167

172

@172m: bedding inclined 50°.
(PA)(E) @172.1m: SILTSTONE, dark gray, fresh, hard, several medium-gray fine-grained sandstone beds inclined at 55°.

173 REC=87% RQD=73% 168

@173.3m: 50mm fracture zone.
@173.4m: 75mm fracture zone.
CLAYSTONE, fresh, moderately soft to soft.
@173.8m: shear zone, clay and calcite filling, 20 cm thick.

174

REC=100% RQD=0% 169

@174.2m: sheared claystone in clayey matrix.
@174.4m: Heavy water flow from formation, could not reenter core barrel due to water flow estimated at about 450 liters/min. Terminated borehole.

175

8/23/02 to 9/7/02

VERTICAL SCALE
1 : 25

Caltrans Metric

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Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

CERTIFIED ENGINEERING GEOLOGIST
200 E. Sandpointe Ave. Suite 200
Santa Ana, California 92707

PLAN APPROVAL DATE

HNTB CORPORATION

STATE OF CALIFORNIA — CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE:

DESIGN BY R. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/11/03
DATE
FIELD INVESTIGATORS/TITLE: B. SCHELL, J. CASTLE, L. PATZKOWSKI. / AS SHOWN

ORIGINAL SCALE IN mm FOR REDUCED PLANS: 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE No.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION	DATES (PRELIMINARY STAGE ONLY)	SHEET	OF

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
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> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

TYPE OF BORINGS

- 2½" CONE PENETRATION
- ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- AUGER BORING (DRY)
- TEST PIT
- DIAMOND CORE BORING
- SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (PR) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PT) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (Y) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

02-12

N: 622,022.9 E: 1,822,531

El. 123.3 m — N22°W, 40° Inclination — (63)

PENETRATION DEPTH (m)

Run	REC	RQD
1	79%	0%
2	175%	0%
3	100%	54%
4	96%	38%
5	100%	0%
6	81%	0%
7	92%	0%
8	78%	28%
9	69%	19%
10	70%	7%
11	50%	0%
12	73%	25%
13	46%	7%
14	75%	0%
15	79%	0%
16	46%	0%
17	53%	0%
18	83%	0%
19	0%	N/A
20	72%	11%
21	100%	0%
22	44%	0%
23	100%	0%
24	81%	21%
25	67%	0%
26	83%	17%
27	46%	0%
28	100%	0%
29	58%	0%
30	158%	0%
31	89%	0%
32	64%	11%
33	78%	0%
34	65%	29%
35	25%	0%
36	42%	0%
37	46%	0%
38	75%	17%
39	79%	0%
40	45%	7%
41	58%	0%
42	25%	0%
43	100%	0%
44	75%	0%
45	25%	0%
46	50%	0%
47	67%	0%
48	85%	43%
49	75%	0%
50	96%	42%
51	89%	28%
52	77%	42%
53	75%	38%
54	75%	45%
55	122%	39%
56	100%	71%
57	87%	33%
58	102%	24%
59	107%	29%
60	92%	0%

SANDSTONE, yellowish brown, intensely weathered, moderately to intensely fractured, very soft, with probable black shale interbeds. First 10 cm is decomposed to soil and rootlets are present. Iron oxidation.
@.2m: Joint, inclined at 30°, clay filled, slightly rough, thin aperture, located at 0.2 m depth.
Greater than 100% recovery belongs to previous run. Fractures, subparallel, inclined 60°, iron oxide and clay filling, stepped surface, unclear if bedding or mechanical break.
fine-grained, moderately to intensely weathered, soft to moderately soft, black shale interbeds, up to 1.3 cm thick. Bedding, very thin, inclined 60°.
@1m: Joint, inclined 40°, clay filling, stepped, thin aperture.
moderately hard to soft in fracture zones. Iron oxidation on all joint surfaces.
@1.5m: shale interbed, black, up to 1.3 cm thick, non-fissile, inclined 60-70°.
@1.9m: shear zone, 20 cm wide, clay filled, rock structure lost.
@2.3m: joint, inclined 50°, clay filled, slightly rough, moderately thin aperture, fracture zone below 2.3 m consists of end of run mechanical breaks.
actual RQD may be higher, as sample was dropped prior to logging.
@2.7m: joint, inclined 30°, clay filling, thin aperture, located at 2.7 m depth. Rock is broken into angular fragments up to 5 cm.
fracture zone, 25 cm wide, rock is broken into angular fragments up to 5 cm.
@3.4m: joint, inclined 60°, 20° to 30°, clay and iron oxide filling, slightly rough to stepped; thin aperture, shear zone, 5 cm wide.
@3.9m: shear zone, 8 cm wide, clay filled.
moderately weathered, bedding inclined 65-70°..
@4.6m: shear zone, 18 cm wide, clay filled.
@4.9m: joint, subparallel to core axis, clay and iron oxide filling, slightly rough, thin aperture.
@5.2m: fracture zone, up to 15 cm wide.
SANDSTONE, fine-grained, yellowish-brown, moderately weathered, moderately soft, with thin laminae of carbonaceous shale. Joint, inclined 30°, no filling, rough, tight aperture, located at 5.8 m depth. Post-logged, therefore actual RQD may be higher.
@6m: Bedding joint, inclined 30°, clay filling, very thin aperture.
core loss of approximately 30 cm between 6.3 and 6.9 m depth.
@6.6m: CLAY, brown, intensely weathered, very soft, lean to fat with sandstone core fragments.
@6.9m: moderately soft, possible shear zone, from 6.9 to 7 m depth.
@7m: Joints, inclined 40-50°, no filling, rough surface, moderately open aperture, located at 7 m depth.
SANDSTONE, fine-grained, gray to yellowish brown, moderately weathered, calcite seams up to 4 mm. Joints and bedding joints, inclined 20-25°, thin clay filling, rough surfaces, moderately thin apertures. Post-logged, therefore actual RQD may be higher
@7.6m: joint, inclined 50°, clay and iron oxide filling, rough surface, very thin aperture.
@8.1m: fracture zone, 6 cm wide, beginning at 8.1 m depth. Possible bedding joint, inclined 15° rees, no filling, tight aperture.
@8.2m: CLAY, brown, intensely weathered, lean to fat with sandstone core fragments, core loss zone.
SANDSTONE, fine-grained, gray-brown, moderately weathered, moderately hard, with highly broken, clay-filled zones. Post-logged, therefore actual RQD may be higher.
@8.9m: Bedding joint, inclined 20°, thin clay filling, rough surface, moderately thin aperture.
@9.7m: fracture zone, up to 23 cm wide, clay and gravel filled, beginning at 9.5 m depth.
@9.8m: joint, inclined 85°, clay filling, located at 9.7 m depth. Bedding joint, inclined 15°, no filling, smooth surface.
brecciated zone, angular siltstone fragments set in sandy clay matrix. Core loss possibly from upper portion of run. Post-logged, therefore actual RQD may be higher.
@10.5m: joints, inclined 40-50°, clay and iron oxide filling, rough surfaces, very thin apertures.
@10.8m: incipient joint, inclined 70°, located at 10.8 m depth. Intersecting joints, inclined 45°, clay filling, rough surfaces, very thin aperture.
four fragments of sandstone, approximately 8-10 cm long with bedding joints inclined 15-20°. Top and bottom of run is queried. Post-logged, therefore actual RQD may be higher.
CLAY, brown, with moderately weathered sandstone fragments. Possible shear zone. Post-logged.
SANDSTONE, fine-grained, brown, moderately to intensely weathered, moderately hard to soft, highly fractured. Joints, intersecting, inclined 40-70°, clay filled, rough surfaces, very thin to moderately thin apertures.
@13.1m: rock fragments in brown sandy clay matrix.
highly fractured, sandstone fragments, calcite and clay filling, no intact core.
upper portion of run is composed of loose fragments of sandstone and calcite vein fill.
@14.7m: fracture, inclined 60°, iron oxide filling.
shale laminae inclined 60°. Calcite stringers.
@15.1m: Joint, inclined 85°, bedding joint at 60°, clay and iron oxide filling, moderately thin to thin aperture.
highly fractured, no intact core..
@15.7m: possible bedding joint, inclined at 60°, clay filling, rough surface, moderately thin aperture.
slightly to intensely weathered. Bedding joints, inclined 20°, clay and iron oxide filling, rough surface, very thin apertures. Joints, inclined 60-70°, clay and iron oxide filling, rough surface, moderately thin apertures.
intensely fractured and intensely weathered, no intact core.
three intact core pieces, approximately 5 cm long with 15° bedding joints.
bedding joint, inclined 20°, clay filling, rough surface, moderately thin aperture.
@18.2m: Joint, inclined 60°, calcite filling, rough surface, very thin aperture, located at 18.2 m depth.
bedding joints, inclined 15-20°. Joints, inclined 60°, iron oxide filling, rough surfaces.
joints, inclined 60-70° and 15°, iron oxide filling, rough surfaces.
bedding joints, inclined, 20°, clay and iron oxide filling, rough surfaces.
@20.1m: intensely weathered below 20.1 m depth.
intensely fractured, fragments up to 8 cm long.
fine-grained, calcite cemented and veined. Angular fragments up to 5 cm.
joints, intersecting, inclined 40-50°, iron oxide coating.
greater than 100% recovery, belongs to previous run. Joints, intersecting, inclined 50-60°. Highly fractured, fragments up to 10 cm.
joints, intersecting, inclined 40-50°. Bedding joints inclined 30°. Mostly broken and fractured.
@22.6m: dark shale interbed in sandstone, inclined 55°.
SANDSTONE, fine grained, dark gray, moderately weathered, moderately hard, with interbedded shale laminae inclined 30°, mostly broken core.
@23.5m: bedding joints, inclined 30°, clay and iron oxide filling, rough surfaces, moderately thin apertures.
core intact in barrel, but mostly disaggregated upon transfer to corebox. Closely fractured to 8 cm maximum section, narrow calcite veins, fractures 40-60° to core axis.
calcite stringers, subparallel to core axis.
@25.2m: Bedding joint, inclined 20°, iron oxide filling, rough surface, very thin aperture.
@25.4m: joint, inclined 60°, iron oxide filling, rough surface, moderately thin aperture.
no intact core, fracture surfaces inclined 30, 60, and 70°, iron oxide coated with some thin clay coatings.
some intensely weathered zones. 15 cm of redrilled core fragments at top of run.
some intensely weathered zones. Fracture surfaces iron stained with some clay, rough.
joints, subparallel, inclined 45°, iron oxide filling, rough surfaces, very thin to moderately thin apertures.
@29.3m: joint, inclined 60°, iron oxide filling, rough surface, very thin aperture.
intersecting joints at 45 and 50°, iron oxide and thin clay coatings. Fragments up to 13 cm.
moderately to intensely weathered.
@30.3m: Bedding joint, inclined 30°, no filling, rough surface.
@30.4m: Joint, inclined 60°, iron oxide filling, rough surface, moderately thin aperture.
joint, subparallel to core axis, inclined 0°, iron oxide staining and clay filling, rough surface.
no intact core, highly fractured and disaggregated to soil-like or shaley consistency in some zones.
moderately soft. Shale laminae and interbeds. Some disaggregated and sheared zones.
highly fractured core, moderately to intensely weathered, with intersecting joints at 20, 30, 50, and 70°, iron oxide stained and some clay filling.
no intact core.
moderately soft to soft, highly weathered. Zones of possible clay gouge, possible shear or fault zone.
sheared sandstone, parts fat to lean black clay.
@36.6m: core is more competent below 36.6 m depth.
moderately weathered at joints, otherwise slightly weathered to fresh. Joints, inclined 20-40°, iron oxide staining and clay filling, rough surfaces.
highly fractured with some dark gray clay.
joints, subparallel, inclined 30°, clay filling, rough surfaces, moderately thin apertures, with broken zone between joints.
@39.2m: joint, inclined 50°, clay filling, rough surface, moderately thin aperture.
SANDSTONE, fine to medium grained, light gray, moderately weathered, very hard. Bedding joints, inclined 30°, iron oxide filling, rough, moderately thin aperture..
@39.6m: dark, carbonaceous partings, inclined 55°. Bedding joints, inclined 30°, no filling, moderately open aperture.
@40m: joint, inclined 20°, clay filling, rough surface, moderately thin aperture.
@40.3m: joint, inclined 60°, iron oxide and clay filling, rough surface.
@40.5m: joint, inclined 60°, iron oxide and clay filling, rough surface, thin aperture.
@41.2m: bedding joints, inclined 20°, clay filling, rough surfaces, moderately thin apertures. Joint, inclined 70°, no filling, rough surface, moderately open aperture.
highly weathered, shale interbeds in first 15 cm of run.
@42.5m: Bedding joint, inclined 30°, no filling, tight aperture.
@42.7m: bedding joints at 30° and steeper, rusty joints at 50°.
@43.4m: shaley laminae and zone of shale fragment conglomerate from 43.4 to 43.6 m depth.
greater than 100% recovery, belongs to previous run, shale fragment layers defining bedding inclined 35°. Intersecting fractures, inclined 45 and 70°.
@44.2m: irregular break along shale-breccia boundary.
@44.5m: fracture, yellow oxide clay lining. Shale layer, dark gray, 3 cm thick.
SHALE, dark gray, moderately hard, closely fractured, core is partly disaggregated.
@45m: Bedding joint, inclined 40°, calcite filled.
@45.1m: bedding laminae inclined 38°. Shale parting at end of run.
SANDSTONE, very fine grained, light gray, very hard, bedding defined by shale breccia layers inclined 30-38°.
@45.7m: bedding joint, iron oxide staining on fracture surface.
@46.6m: fracture zone, up to 8 cm wide, consisting of broken shale.
shale breccia layers inclined 45°.
@47.6m: fracture, inclined 18°, iron oxide and clay filling.
calcite veining throughout core.
fragmented interval.
@49.4m: medium grained interval, up to 3 cm wide, beginning at 49.4 m depth. Fragmented rock in fractured intersection.
@50m: brown aggregate of clay and rock fragments at end of run. Bottom of boring.

7/27/02 to 7/31/02

VERTICAL SCALE
1 : 50

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/11/03

D.Hamilton, M.Kapuskar
L.Patzkowski, S.Siciliano
FIELD INVESTIGATOR(S)/TITLE
DATE: As shown

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

02-13

N: 620,754.4 E: 1,821,938.6

El. +73.5 m — 63 — S53°E, horizontal

PENETRATION DEPTH (m)

Run	REC / RQD
1	REC=90% RQD=82%
2	REC=8% RQD=0%
3	REC=70% RQD=57%
4	REC=15% RQD=0%
5	REC=92% RQD=87%
6	REC=95% RQD=7%
7	REC=82% RQD=65%
8	REC=15% RQD=0%
9	REC=98% RQD=67%
10	REC=59% RQD=0%
11	REC=109% RQD=28%
12	REC=69% RQD=0%
13	REC=53% RQD=11%
14	REC=87% RQD=43%
15	REC=62% RQD=18%
16	REC=100% RQD=43%
17	REC=63% RQD=0%
18	REC=97% RQD=52%
19	REC=89% RQD=0%
20	REC=72% RQD=0%
21	REC=102% RQD=95%
22	REC=100% RQD=81%

DIORITE/QUARTZ DIORITE/GRANODIORITE, orange-brown, intensely weathered to decomposed, soft. Disaggregated to quartz granules and clay. Breaks under light manual pressure. RQD not a good indication of rock strength for this run..

@1.1m: joint, inclined 50° , possible mechanical break.

@1.4m: no core recovery.

DIORITE/QUARTZ DIORITE/GRANODIORITE, orange-brown, intensely weathered, rock is generally too weathered to identify positively, highly fractured. Almost no recovery on this run..

@1.6m: no core recovery.

some pieces of moderately weathered rock..

@2.8m: intensely weathered to decomposed, orange brown, clay and quartz granules.

@3.5m: joint, inclined 65° , iron oxide filling, smooth, thin aperture.

intensely fractured, very poor recovery.

@4.5m: no core recovery.

DIORITE/QUARTZ DIORITE, orange brown, locally oxidized to dark brown, intensely weathered to decomposed, soft.

@6m: joint, inclined 75°, no filling, slightly rough to smooth, tight aperture.

@6.2m: joint, inclined 55°, no filling, slightly rough to smooth, tight aperture.

@6.9m: joints, inclined 30° and 50°.

yellowish brown with few light gray zones, weathering to orange brown, yellowish brown and brown, intensely weathered, soft to moderately soft.

@7.5m: joint, inclined 25°, clay filling, smooth to polished, very thin aperture.

@7.8m: joint, inclined 35°, clay filling, smooth to polished, very thin aperture.

@7.9m: joint, inclined 30°, clay filling, smooth to polished, very thin aperture.

@8.2m: joint, inclined 75°, clay filling, smooth to polished, rock is completely decomposed below joint, clay matrix with quartz granules.

decomposed, very soft, breaks easily under light manual pressure, RQD is not a reliable indicator of rock strength for this run.

(S) @10.1m: no core recovery.

intensely weathered, moderately soft, highly fractured, fracture surfaces oxidized, poor recovery.

@10.6m: no core recovery.

joints, inclined 40° to 65°, no filling, smooth surfaces, dark brown-black oxidation.

@12.9m: completely broken, likely mechanical breaks, less oxidation, rough srufaces.

@13.3m: completely decomposed.

QUARTZ DIORITE, orange brown, intensely weathered, soft to very soft, pieces of chloritized quartz vein, white to light green, breaks under manual pressure. Joints, inclined 45°, rough to slightly rough, clay filling, very thin aperture..

@14m: joint, inclined 30°, no filling, smooth, tight aperture.

some recovery of previous run. Orange brown, moderately soft to moderately hard, requires heavy manual to light hammer pressure to break, more competent than previous runs. Open fractures, no filling, surfaces oxidized to dark brown-black.

@15.3m: joint, inclined 35°, no filling, slightly rough, moderately open to open aperture..

@15.5m: joint, inclined 60°, yellowish brown clay filling, smooth, very thin aperture.

@15.9m: intensely fractured, likely mechanical breaks due to drilling.

oxidized, friable core, breaks under light to moderate manual pressure.

@16.5m: joints, inclined 50° to 55°, clay filling, slightly to moderatley rough, very thin aperture.

@16.8m: no core recovery.

moderately hard, intensely fractured, breaks with light hammer blows.

@17.6m: no core recovery.

@18.3m: joints, inclined 40° to 70°, clay and quartz granule filling, slightly to moderately rough.

@18.9m: joint, inclined 55°, no filling, smooth.

@19m: joint, inclined 65°, clay filling, moderately rough, very thin aperture.

@19.8m: gray-white, weathering to orange brown, moderately weathered, moderately hard to hard, very fractured.

@20m: joint, inclined 35°, no filling, smooth.

@20m: green-gray, slightly weathered, hard, hydrothermally altered, possible chlorite, fracture surfaces oxidized red-brown.

@20m: joint, inclined 60°, no filling, rough.

highly fractured internally with yellowish-green hairline veins.

@21.3m: joints, inclined 75° to 85°, some clay filling, slightly to moderately rough, very thin apertures.

@21.6m: joint, inclined 80°, no filling, open aperture.

@22m: joint, inclined 70°, no filling, very rough, tight aperture.

@22.1m: zone of incipient and moderately healed fractures.

@22.2m: joint, inclined 60°, no filling.

gray, weathering to orange brown, moderately weathered, moderately hard to hard, intensely fractured, fracture surfaces oxidized to dark brown, very little clay filling present.

green gray, weathering to yellowish brown, moderately to slightly weathered, hard.

@23.7m: joint, inclined 85°, no filling, moderately rough.

@23.9m: fracture zone, 0.18m wide, some sand and clay filling.

@24.2m: joint, inclined 15°, iron oxide filling, smooth with poorly developed slickensides inclined 70°.

@24.7m: moderately hard, intensely fractured.

green gray, weathering to yellow brown, hard, moderately to slightly weathered, very fractured, joints inclined 30° to 35°, open fractures, surfaces oxidized to dark brown.

@25.5m: thin red brown clay layer.

@26m: joint, inclined 80°, no filling, slightly rough.

@26.1m: joint, inclined 15°, red brown clay filling, polished.

@26.4m: joint, inclined 30°, no filling, polished.

@26.6m: no core recovery.

all fracture surfaces slightly oxidized to orange brown and dark brown. Hairline random veins of yellow green material.

@27.1m: joint, inclined 75°, no filling, slightly rough.

(S) @27.1m

@28m: joint, inclined 50°, thin calcite coating, slightly rough, very thin aperture.

@28.1m: joint, inclined 50°, thin calcite coating, slightly rough, very thin aperture.

@28.3m: joints, inclined 45° to 50°, heavy iron oxidation, slightly rough, very thin aperture.

zone of larger crystals and some quartz--is probably a pegmatite dike.

@28.7m: stepped joint, inclined 90°, no filling, moderately rough.

@28.8m: joint, inclined 65°, no filling, moderately open aperture, numerous thin calcite veins subparallel to fracture, inclined 60° to 70°.

@29m: fully healed fracture, inclined 40°.

@29.1m: joint, inclined 75°, no filling, moderately open aperture.

@29.2m: joint, inclined 70°, no filling, moderately open aperture.

@29.3m: Bottom of boring.

10/2/02 to 10/4/02

VERTICAL SCALE
1 : 50

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Sample No.; Permanent Casing driven; Top Hole El.; Size of Sampler (mm); Unconfined compressive strength (kPa); Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified.; Number of blows required to produce the indicated penetration after an initial 152 mm seating.; 50 blows produced the indicated penetration during the initial 152 mm interval; GWS Elev.; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

Caltrans Metric

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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DESIGN OVERSIGHT — KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN — BY S. VARATHARAJ — 11/20/02
CHECKED — BY S. SICILIANO — 2/11/03

J. CASTLE/GEOLOGIST — FIELD INVESTIGATOR(S)/TITLE
DATE — AS SHOWN

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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- WELL-GRADED SAND (SW)
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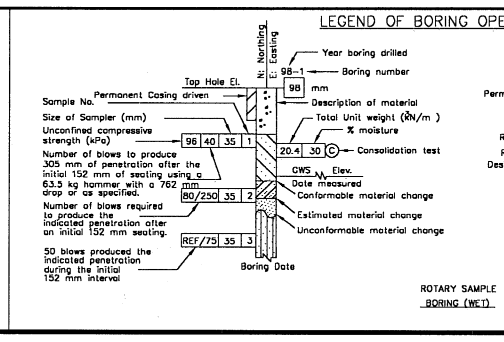
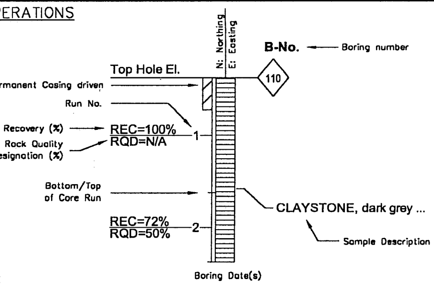
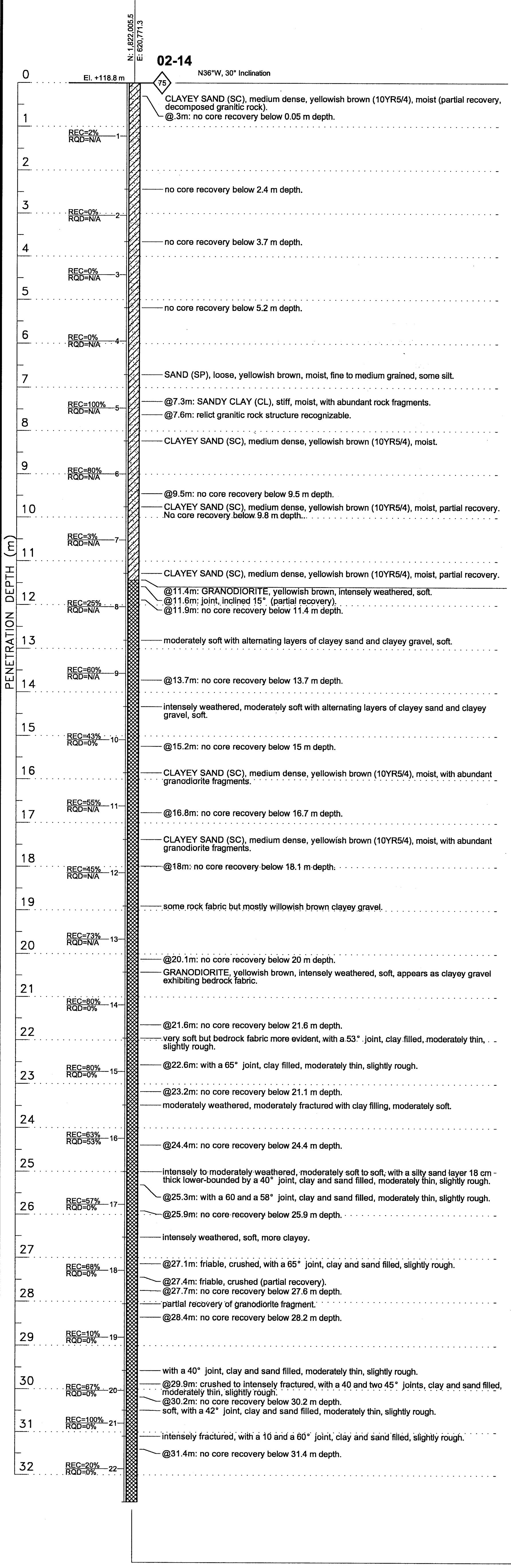
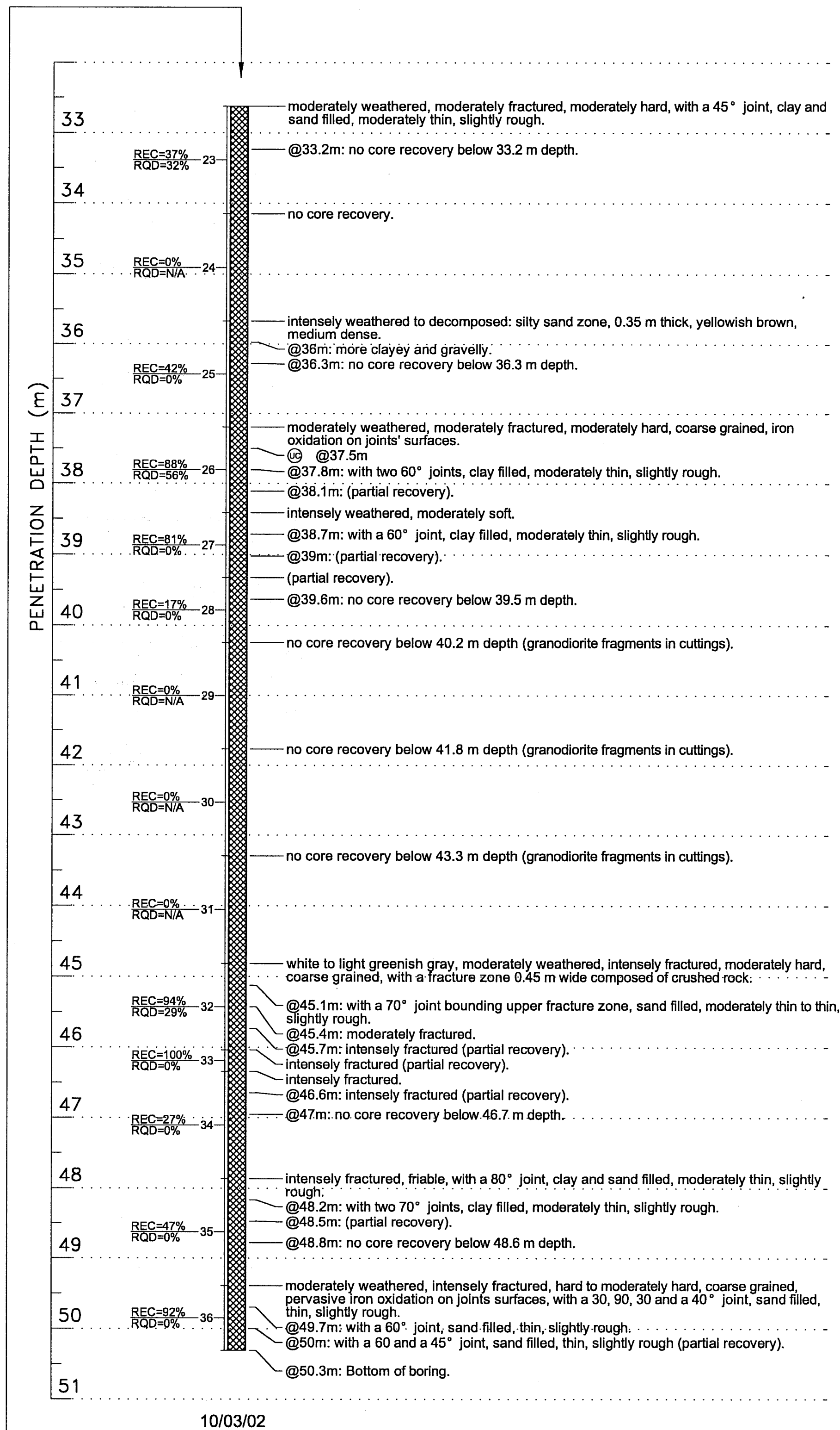
LEGEND OF BORING OPERATIONS





Boring 02-14





VERTICAL SCALE
1 : 50

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SIGNOFF DATE	
DESIGN	BY S. VARATHARAJ 11/20/02
CHECKED	BY S. SICILIANO 2/11/03
FIELD INVESTIGATOR(S)/TITLE	T.Bodkin
DATE	As shown
PROJECT ENGINEER	M. KAPUSKAR
BRIDGE No.	
KILOMETER POST	

PREPARED FOR THE
STATE OF CALIFORNIA
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DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

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		> 31	Hard

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- POORLY-GRADED GRAVEL (GP)
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- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

TYPE OF BORINGS

- 2¼" CONE PENETRATION
- size ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- size AUGER BORING (DRY)
- size TEST PIT
- DIAMOND CORE BORING
- size SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
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- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
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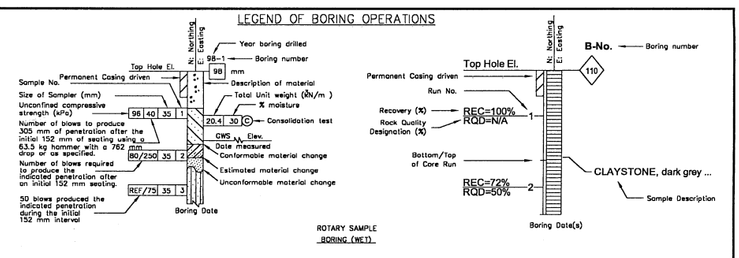
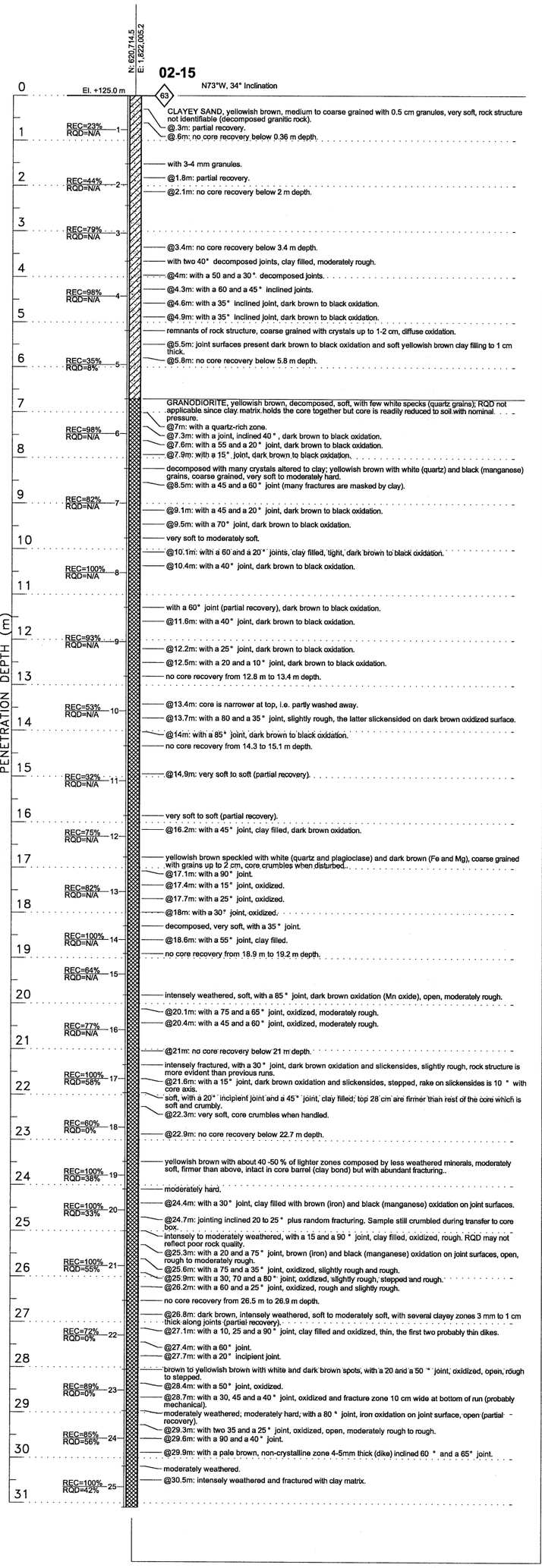
- (Y) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS





09/11/02 - 09/12/02

VERTICAL SCALE
1 : 50

DESIGN BY E.BROWN 11/20/02
CHECKED BY S. SICILIANO 2/11/03

DESIGN OVERSIGHT: SIDNEY DATE: KEYHAN MOGHBEL

B.Schell FIELD INVESTIGATOR(S)/TITLE
DATE: As shown

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR PROJECT ENGINEER

CU 240 EA 11237E

BRIDGE NO. KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET OF

Caltrans Metric

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Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

CERTIFIED ENGINEERING GEOLOGIST

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ DOUGLAS HAMILTON NO. EGG 31 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

DESIGN OVERSIGHT
KEYHAN MOGHBEL
SIGNOFF DATE

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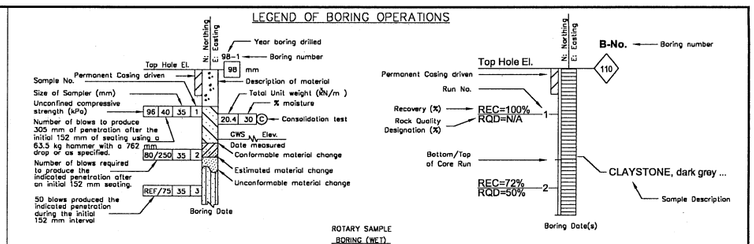

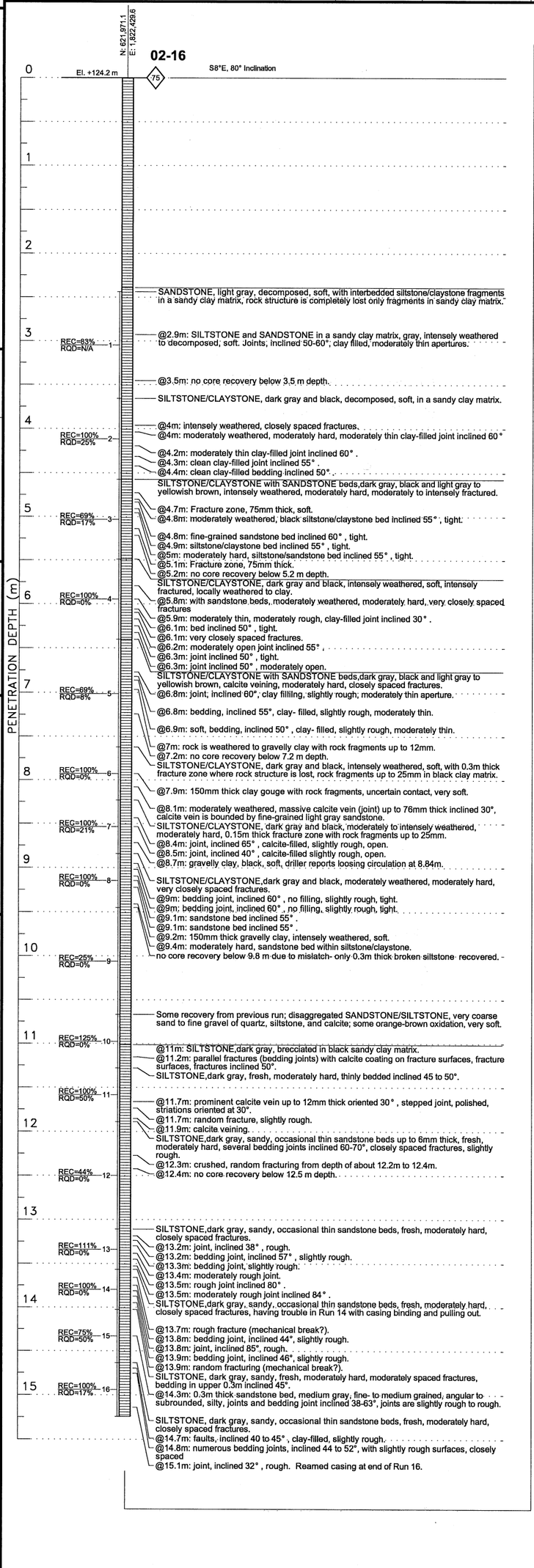

8/29/02 - 9/6/02

VERTICAL SCALE
1 : 25

DESIGN BY E.BROWN 11/20/02
CHECKED BY S. SICILIANO 2/1/03
DATE
J.Castle, P.Frame, S.Siciliano
FIELD INVESTIGATOR(S)/TITLE
As shown

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PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

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BRIDGE No.
KILOMETER POST

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DOUGLAS HOLMES HAMILTON
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LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Sample No.; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Permanent Casing driven; Top Hole El.; CWS Elev.; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

02-18A

N: 621,987 E: 1,822,509.3

El. +136.0 m — N46°W, 32° Inclination

PENETRATION DEPTH (m)

Depth (m)	Run / Recovery	Description
0–1	Run 1: REC=4% RQD=0%	Essentially no recovery in Run 1.
1–2	Run 2: REC=78% RQD=0%	SANDSTONE in clay matrix, light brown weathering to orange brown, intensely weathered, soft to very soft, clay and iron oxide filling, angular fragments less than 10mm.
2–3	Run 3: REC=47% RQD=0%	SANDSTONE, fine grained, brown weathering to orange, intensely weathered, soft, oxidized, joint inclined at 45° (50-75mm core section). @2.4m: SANDSTONE in clay matrix, light brown, angular fragments less than 10mm.
3–4	Run 4: REC=96% RQD=0%	SANDSTONE in sandy clay matrix, light brown, very fine grained, intensely weathered, soft to moderately soft, thinly bedded, bedding inclined at 52°, core held together by cohesive clay.
4–5	Run 5: REC=54% RQD=0%	SANDSTONE in sandy clay matrix (same as above), bedding inclined at 60°. @4.3m: broken oxidized rock and clay with light gray slick, soft clay in 75mm interval. @4.7m: SANDSTONE, decomposed, oxidized, relic bedding inclined at 60°. No core recovery below 4.62 m.
5–6	Run 6: REC=47% RQD=0%	SILTSTONE in clay matrix, brown and dark gray, intensely weathered, moderately soft, 25-50mm fragments. Joint, inclined 85°, clay filling, located at 5.41 m depth, suggestion of bedding inclined at 80°. @5.5m: no core recovery below 5.61m depth. SILTSTONE (same as above), dark gray-brown fragments in light brown clay matrix, weathering to orange brown, intensely weathered, moderately soft, intensely fractured. 1 fractured core section 20mm in length. No core recovery below 6.38 m depth.
7–8	Run 7: REC=31% RQD=0%; Run 8: REC=42% RQD=0%	CLAYSTONE, dark gray fragments in brown-orange clay matrix, intensely weathered, disaggregated, soft. @7.3m: SANDSTONE, fine to medium grained, light gray weathering to brown orange, moderately weathered, moderately hard, fracture surfaces heavily oxidized. No core recovery below 7.52 m depth.
8–9	Run 9: REC=83% RQD=0%; Run 10: REC=87% RQD=0%	angular rock fragments mostly smaller than 10mm in washed clay. SILTSTONE/CLAYSTONE, dark gray, intensely to moderately weathered, moderately soft to soft, partly oxidized, semi-fissile, bedding inclined at 65°, mostly intact 230 mm core section. @8.8m: rock fragments in clay. Joint, inclined 40°, smooth surface. @8.8m: SANDSTONE, brown, very fine grained, moderately weathered, moderately soft.
9–11	Run 11: REC=87% RQD=0%; Run 12: REC=70% RQD=0%	SANDSTONE, brown in fine sandy clay matrix, very fine grained, intensely weathered, moderately soft to very soft, shear zone composed of angular fragments less than 25mm. Within shear zone, most fractures inclined 20-50°. @9.5m: becomes fine to medium grained below 9.68 m depth. SILTSTONE/CLAYSTONE, gray-brown, intensely weathered, soft to moderately soft, core semi-intact but very fractured, bedding inclined at 40°.
11–12	Run 13: REC=117% RQD=0%; Run 14: REC=88% RQD=0%	SANDSTONE, very fine grained, drill-rounded fragments in clay, fragments display well developed slickensides. SILTSTONE/CLAYSTONE, dark gray with light gray very fine grained sandstone interlayers, moderately weathered, moderately soft to moderately hard, fractures, probable bedding joints, inclined at 45°, smooth. @11.1m: bedding inclined at 50°.
12–13	Run 15: REC=78% RQD=0%; Run 16: REC=70% RQD=0%	SILTSTONE/CLAYSTONE and SANDSTONE interlayered, dark and light gray, moderately weathered, moderately soft to moderately hard, moderately fissile with parallel fractures along bedding planes, fractures oxidized to dark brown-orange, bedding inclined at 50%. @11.9m: fracture across bedding inclined at 25°, calcite filled, up to 5mm width.
13–14	Run 17: REC=67% RQD=30%	SANDSTONE, light gray, decomposed, very fine grained, possible bedding inclined at about 48°, disaggregated in place. @12.5m: one coherent core section about 125mm, others are 50-75mm in length. @13m: broken fragments in clay.
14–15	Run 18: REC=75% RQD=0%; Run 19: REC=87% RQD=0%	SANDSTONE, medium grained, (280mm section), light gray, hard, slightly weathered, calcite veined, some thinly bedded sandstone and siltstone/claystone inclined at 52°. Joint, inclined 50°, clay and sand filled, rough. SILTSTONE/SANDSTONE, very fine grained, dark gray, moderately weathered, moderately soft, very fractured, largest piece 7.6 cm long, most pieces 1.3-2.5 cm. Some fracture surfaces planar, polished and oxidized to dark brown. @14.3m: no core recovery below 14.6 m depth. MUDSTONE, dark brown, intensely weathered to decomposed, very soft.
15–17	Run 20: REC=100% RQD=0%; Run 21: REC=100% RQD=0%	@14.9m: slightly more competent, intensely to moderately weathered, moderately soft, some relic bedding features inclined 45°. @15.2m: no core recovery below 15.3 m depth. although core holds together in barrel, it easily fractures in box, RQD is not a reliable indicator for this material. Fragments of rock, moderately weathered, calcite and clay filling.
17–18	Run 22: REC=100% RQD=0%	@15.7m: SANDSTONE with SILTSTONE/CLAYSTONE, gray to dark gray, fine grained. @16.1m: clayey zone with rock fragments, iron-oxide and clay filling. SANDSTONE, gray, intensely to moderately weathered, moderately soft to soft, with clay and siltstone layers, iron-oxide and clay staining. @16.4m: calcite.
18–19	Run 23: REC=76% RQD=0%; Run 24: REC=93% RQD=0%	SANDSTONE, moderately to intensely weathered. @16.9m: rock fragments. @17.3m: fragments in clay matrix. @18m: SHALEY SILTSTONE, dark gray, moderately to intensely weathered, clay and calcite filling. CLAYSTONE/SILTSTONE, dark gray weathering to orange brown, moderately to intensely weathered, moderately soft, intensely fractured.
19–21	Run 25: REC=75% RQD=0%	@19.9m: clay with rock fragments. no core recovery from 20.4 to 20.9 m depth.
21–22	Run 26: REC=40% RQD=0%	@20.9m: sandstone fragments, abundant calcite. @21.1m: sandstone bedding. no core recovery from 21.2 to 21.8 m depth.
22–23	Run 27: REC=40% RQD=0%; Run 28: REC=100% RQD=0%	@22m: rock fragments. @22.1m: rock fragments in clay matrix, yellow-brown to dark brown. @22.3m: rock fragments. @22.5m: SANDSTONE with clay, moderately to intensely weathered, moderately soft, clay and iron-oxide filling. no core recovery between 22.9 and 23.8 m depth.
23–24	Run 29: REC=14% RQD=0%	@23.8m: SANDSTONE, very fine grained, gray, moderately weathered, moderately hard to moderately soft, fragments of rock, largest piece 5.1 cm.
24–26	Run 30: REC=100% RQD=0%; Run 31: REC=100% RQD=0%; Run 32: REC=79% RQD=17%	@23.9m: SANDSTONE, fine grained, dark gray, moderately weathered, moderately soft, clay and iron oxide filling. @24.2m: SANDSTONE, dark gray with yellow-brown clay filling. SANDSTONE, fine grained, gray-brown, intensely weathered, moderately soft to soft, intensely fractured, very oxidized with dark gray clay siltstone, no coherent bedding recognized, some fabric inclined at 30°. SANDSTONE and SILTSTONE interbedded, light brown and dark gray, fine grained sandstone, moderately weathered, moderately soft to moderately hard, bedding inclined at 40°, no break on bedding planes.
26–27	Run 33: REC=86% RQD=22%	@25.3m: cross bedding fractures in sandstone, perpendicular to bedding. SILTSTONE, dark gray, bedding of thin lenses of light gray, very fine grained sandstone inclined at 30°. @25.9m: cross bed fracturing.
27–28	Run 34: REC=113% RQD=17%	@26.4m: planar fractures parallel to bedding. SILTSTONE, dark gray, moderately weathered, moderately soft to moderately hard, bedding of thin lenses of gray, very fine grained sandstone streaks. @26.8m: dip reversed or core twisted.
28–29	Run 35: REC=58% RQD=0%	SILTSTONE, dark gray, clayey. @27.5m: cross-fracturing. @27.6m: bedding. @27.9m: disaggregated small fragments.
29–30	Run 36: REC=113% RQD=0%; Run 37: REC=111% RQD=22%	SILTSTONE, dark gray, with light gray, moderately weathered, moderately hard to moderately soft, very fine grained sandstone layers interbedded at 45°. @28.6m: two planar breaks in bedding. SILTSTONE, dark gray, with light gray, very fine grained sandstone layers bedded at 40°, layers anywhere from 2mm to 125mm thick. @29.1m: most breaks are on bedding surfaces. @29.5m: wedge fracture above bedding plane break.
30–31	Run 38: REC=100% RQD=0%	core rotating or bedding reversal. @30.1m: bedding fracture. @30.2m: planar fracture inclined at 13°. @30.4m: fracture surface.
31–32	Run 39: REC=93% RQD=0%; Run 40: REC=100% RQD=0%	SANDSTONE, fine grained, light gray, moderately weathered, moderately hard, with dark siltstone/claystone interlayers. @30.9m: SILTSTONE/CLAYSTONE, dark gray, bedding not readily visible but core breaks in planes parallel to bedding in sandstone above. Bedding inclined 50°.
32–33	Run 41: REC=100% RQD=48%	slightly weathered to moderately weathered, clay and iron-oxide filling. @31.5m: dark gray. @31.6m: sandstone bedding. @31.8m: SILTSTONE/CLAYSTONE, dark gray. @32.3m: SANDSTONE with siltstone bedding, broken parallel to bedding planes.
33–34	Run 42: REC=100% RQD=0%	@33m: calcite vein approx. 10mm thick. fresh to moderately weathered, iron-oxide filling material.
34–35	Run 43: REC=100% RQD=0%; Run 44: REC=100% RQD=0%	@33.8m: SANDSTONE with siltstone bedding inclined at 30°.
36–37	Run 45: REC=24% RQD=0%; Run 46: REC=0% RQD=N/A	@36.2m: fragments of rock. @36.7m: bedding inclined at 30°, breaks parallel to bedding plane.
37–38	Run 47: REC=100% RQD=0%; Run 48: REC=100% RQD=0%	@37.1m: bedding inclined at 30°. @37.1m: 10mm fragments. @37.7m: fragments. @37.9m: shaly fragments.
38–39	Run 49: REC=100% RQD=0%; Run 50: REC=100% RQD=0%	@38.3m: fragments of sandstone/siltstone. @38.6m: shale fragments. @38.9m: rock fragments.
39–40	Run 51: REC=100% RQD=0%; Run 52: REC=200% RQD=0%	@39.2m: moderately weathered, siltstone bedding, calcite filling. @39.9m: SANDSTONE with siltstone bedding, moderately weathered to fresh, hard, calcite filling. @40.1m: Bottom of boring.

08/01/02 - 08/02/01

VERTICAL SCALE
1 : 50

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CERTIFIED ENGINEERING GEOLOGIST

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Caltrans Metric

DESIGN OVERSIGHT	KEYHAN MOGHBEL
SIGNOFF DATE	

DESIGN	BY S. VARATHARAJ	11/20/02	J.Castle, D.Hamilton, S.Varatharaj — FIELD INVESTIGATOR(S)/TITLE
CHECKED	BY S. SICILIANO	2/11/03	DATE: As shown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No. / KILOMETER POST

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LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

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REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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- (PM) PRESSUREMETER TEST
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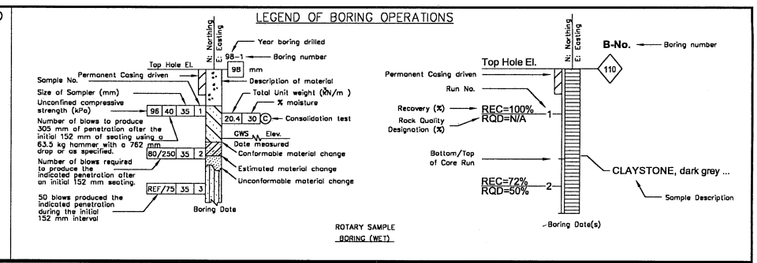
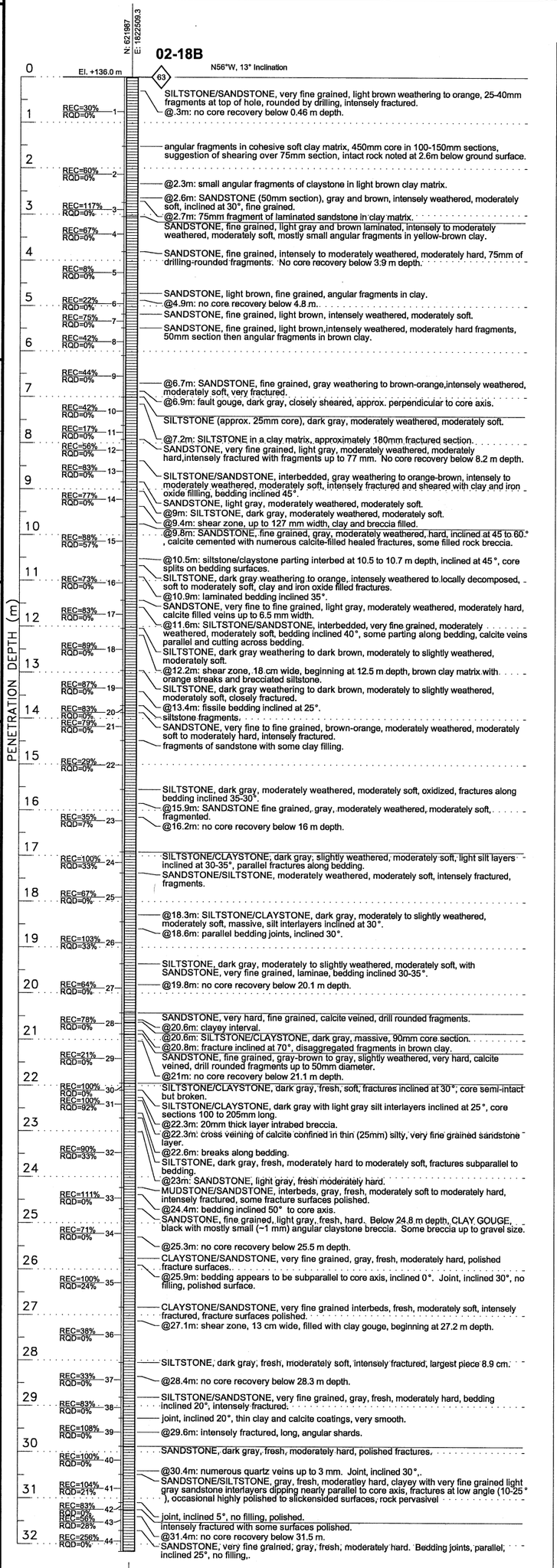
- (TX) TRIAXIAL TEST
- (Y) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS





Drilled 7/29/02 - 7/31/02
Groundwater at 14m depth on 8/1/02

VERTICAL SCALE
1 : 50

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY S. SICILIANO 2/11/03

DATE
J.Castle, D.Hamilton
FIELD INVESTIGATORS/TITLE
As shown

ORIGINAL SCALE IN inch FOR REDUCED PLANS 0 20 40 60 80 100

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

CU 240
EA 11237E

BRIDGE NO.
KILOMETER POST

DISREGARD PRINTS BEARING EARLIER REVISION DATES

DEVIL'S SLIDE TUNNELS

LOG OF TEST BORINGS OF

REVISION DATES (PRELIMINARY STAGE ONLY)	SHEET OF

Caltrans Metric

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Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

PLAN APPROVAL DATE

CERTIFIED ENGINEERING GEOLOGIST

STATE OF CALIFORNIA ★ CERTIFIED ENGINEERING GEOLOGIST ★ JOHN D. CASTLE No. EGS 1161 EXP. 7/31/04

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2½" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Sample No.; Permanent Casing driven; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; Top Hole El.; N: Northing; E: Easting; Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Elev.; Conformable material change; Estimated material change; Unconformable material change; Boring Date

ROTARY SAMPLE BORING (WET)

Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run REC=72% RQD=50%; B-No. Boring number; CLAYSTONE, dark gray ... Sample Description; Boring Date(s)

Boring 02-21

N: 621,056.6 E: 1,822,069.2 — El. 186.1 m — (63) — N25°E, 40° Inclination

PENETRATION DEPTH (m)

Depth (m)	Run	Description
0–1	REC=80% RQD=N/A —1—	residual soil, rootlets, orange to yellowish brown, soft to mod. Soft. @.6m: color change to dark yellowish brown. @.9m: GRANODIORITE, light yellowish brown, decomposed, moderately to intensely fractured, soft, rock structure is recognizable but decomposed to soil. @1.2m: NCR. moderately to intensely weathered, still soft but held together by residual clay (relatively unfractured but poor quality, RQD is not indicative). @1.8m: with reddish microcristalline segregation of granitic composition, harder and fresher than surrounding rock, 10 cm thick.
2	REC=100% RQD=73% —2—	@2.1m: moderately soft to moderately hard, with microcristalline to medium grained texture, up to 5 mm. @2.7m: poorly cemented, soft.
3	REC=100% RQD=63% —3—	@3.4m: with three closely spaced joints dipping 40° with core axis, rough, oxidized. with a 40° with core axis dipping joint, rough, oxidized, at 3.8m depth. @4m: with a 55 and 50° dipping joints, rough and slightly rough, oxidized, at 4m and 4.3m depth.
4	REC=100% RQD=62% —4—	@4.3m: larger quartz and plagioclase crystals up to 1cm, porfiric structure. @4.6m: with a 30 and 20° dipping joints, rough, oxidized, at 4.7m and 4.9m depth.
5–6	REC=0% RQD=N/A —5—	@5.5m: with a 30° dipping joint, slightly rough, oxidized, at 5.5m depth. @5.8m: fracture zone, 5 cm thick.
6–7	REC=100% RQD=47% —6—	@6.4m: with a 70 and 50° dipping joints, rough, oxidized. with two 30° dipping joints, rough, oxidized. Very fast coring. @7m: no minerals alignment evident. @7.3m: with a 40° dipping joint, rough, oxidized. @7.6m: with a 20° dipping joint, rough, oxidized.
8–9	REC=100% RQD=53% —7—	Rock is soft to moderately soft but held together by residual clay, readily penetrated by knife with little pressure. @8.5m: with a 60° dipping joint, rough, oxidized. @8.8m: with two 60° dipping joints, rough and slightly rough, oxidized. @9.1m: with a 50 and 60° dipping joints, rough and slightly rough, oxidized. @9.5m: fracture zone, 18 cm thick (extremely fast coring). with a 30° dipping joint, rough, oxidized.
10–11	REC=100% RQD=53% —8—	@10.4m: with two 50° dipping joints, rough and slightly rough, oxidized. @11m: very soft fracture zone, 46 cm thick. rock can still be reduce to soil by hand pressure, but moderately hard in sections.
11–12	REC=100% RQD=80% —9—	@11.6m: with a 50 and 35° dipping joints, rough, oxidized. @12.2m: fracture zone, 5 cm thick, with large quartz crystals. @12.5m: with a 80° dipping joint. harder than above, moderately soft to moderately hard. @13.1m: with a 80° dipping joint, oxidized on surface.
13–14	REC=77% RQD=23% —10—	@13.4m: intensely fractured, rock structure is hardly recognizable. @13.7m: fracture zone, 20 cm thick.
14–15	REC=100% RQD=44% —11—	fracture zone, soft, gravelly clayey sand. @14.6m: with a 40° dipping joint. @14.9m: fracture zone, loose clayey gravel. @15.2m: with a 40° dipping joint, oxidation on surface.
16	REC=65% RQD=20% —12—	@15.9m: fracture zone, with a 40° dipping joint, oxidation on surface. @16.2m: with a 40° dipping joint, oxidation on surface. @16.8m: fracture zone, 25 cm thick.
17–18	REC=100% RQD=78% —13—	@17.4m: with a 30° dipping joint, slightly rough, oxidation on surface. @17.7m: with a 25° dipping joint, slightly rough, black oxidation on surface. @18m: with a 20° dipping joint, slightly rough, black oxidation on surface. @18.3m: with a 30° dipping joint, slightly rough, black oxidation on surface.
19–20	REC=100% RQD=70% —14—	@19.2m: with a 25° dipping joint, rough, black oxidation on surface. @19.5m: with a 50° dipping joint, slightly rough, black oxidation on surface. @19.8m: with a 50° dipping joint, slightly rough, black oxidation on surface. @20.4m: with a 20° dipping joint, slightly rough, black oxidation on surface.
21–22	REC=50% RQD=39% —15—	@21.3m: with a 60 and 40° dipping joints, slightly rough, black oxidation on surface. @22m: quartz-rich coarse sand, very soft, with clayey matrix. @22.3m: with two 60° dipping joints, slightly rough, oxidized. @22.9m: small fracture zone, 5 cm thick.
23–25	REC=91% RQD=26% —17—	Granodiorite, light yellowish brown, intensely weathered, moderately fractured, soft to very soft, with a 80 and a 30° dipping joints, clay filled, slightly rough. @23.5m: with a 50 and a 40° dipping joints, clay filled, slightly rough. @23.8m: with a 50° dipping joint, clay filled, slightly rough. @24.1m: with a 60° dipping joint, clay filled, slightly rough. @24.4m: with a 50° dipping joint, clay filled, slightly rough. @24.7m: small fracture zone, probably end of run mechanical breaks. @25.3m: with a 20° dipping joint, clay filled, slightly rough.
26	REC=100% RQD=37% —18—	@25.9m: moderately soft, larger crystals, porfiric structure. @26.2m: with a 20 and 30° dipping joints, clay filled, slightly rough. moderately soft, with a 50° dipping joint. @26.8m: with a 30° dipping joint.
27–28	REC=100% RQD=87% —19—	@27.1m: with a 55° dipping joint. @27.4m: with a 40 and 50° dipping joints. @27.7m: with a 40° dipping joint. fracture zone, very soft. @28.4m: intensely weathered, soil-like consistency.
29	REC=0% RQD=N/A —20—	@29m: with a 50° dipping joint. @29.3m: with a 40° dipping joint. very soft to soft (RQD is not a good indicator of the rock quality which is very poor).
30–31	REC=100% RQD=53% —21—	@30.5m: with two 30° dipping joints. @30.8m: with a 40° dipping joint. white hardened filling material, probably gouge, sheared section 40 cm thick. @31.4m: with a 50° dipping joint, clay filled, slightly rough.
32–33	REC=100% RQD=35% —22—	@32m: with a 20° dipping joint, clay filled, slightly rough. moderately hard, with a 50° dipping joint.
33–34	REC=100% RQD=42% —23—	@33.5m: with a 40° dipping joint, clay filled, slightly rough, 1 cm aperture. @33.8m: with a 30 and 60° dipping joints, clay filled, slightly rough. poor recovery: driller reports difficult coring.
34–35	REC=50% RQD=0% —24—	@34.5m: fracture zone, 30 cm thick, rock is broken into clasts up to 7 cm. @34.8m: with a 40° dipping joint, clay filled, slightly rough, black oxidation on surface.
36	REC=100% RQD=46% —25—	@36m: with a 60° dipping joint. @36.3m: with a 40° dipping joint. @36.6m: with a 40 and 60° dipping joints, closed.
37–38	REC=83% RQD=0% —26—	fracture zone: rock fragments in clayey matrix. @37.2m: fracture zone with a 10 cm wide calcite deposit. @37.5m: fracture zone: rock fragments in clayey matrix. @37.8m: fracture zone: rock is reduced to loose sand and gravel. Granodiorite, light yellowish brown, moderately weathered, slightly fractured, moderately hard, porfiric structure with plagioclase and quartz crystals up to 2 cm.
39	REC=100% RQD=78% —27—	@38.4m: with a 30° dipping joint, closed. @39.3m: with a 40° dipping joint, closed. soft, brittle, with a 20° dipping joint, no filling.
40	REC=92% RQD=42% —28—	intensely fractured, soft, shear zone: coarse sand in clayey matrix (poor recovery-soil portion washed away.
41	REC=67% RQD=0% —29—	@41.2m: NCR. @41.5m: NCR.
42	REC=100% RQD=19% —30—	Granodiorite, yellowish brown to light gray, moderately to slightly weathered, moderately fractured, moderately hard to hard (color and hardness change at 42m depth). [Transition into harder fresher rock]. @42.4m: with a clean joint dipping 60°, minor oxidation around fractures.
43–44	REC=100% RQD=35% —31—	microcristalline section 0.5m thick, rock is light gray and uniform, no visible crystals, with a 40 and 50° dipping joints, slightly rough, no filling. @43.6m: with a 60° dipping joint, slightly rough, no filling. @43.9m: with 35 and 40° dipping joints, slightly rough, no filling.
45	REC=80% RQD=52% —32—	Granodiorite, light gray, slightly weathered, slightly fractured, hard. @44.5m: with 30 and 60° dipping joints, slightly rough, no filling. @44.8m: with a 30° dipping joint, slightly rough, no filling. @45.1m: with a 30° dipping joint, stepped, no filling, minor oxidation on surface.
46–47	REC=100% RQD=100% —33—	Granodiorite, light gray, fresh, slightly fractured, hard, microcristalline. @46m: with a 60° dipping joint, slightly rough, no filling. @46.3m: with a 70° dipping joint, slightly rough, no filling. @46.6m: with a 60° dipping joint, slightly rough, no filling, minor oxidation stain. @47m: with a 30° dipping joint, slightly rough, no filling. with a 20° dipping joint, stepped, calcite healed.
48	REC=94% RQD=64% —34—	@48.2m: with a 60° dipping joint, rough, no filling, minor oxidation stain.
49–50	REC=100% RQD=90% —35—	@48.8m: with a 40° dipping joint, rough, no filling. mostly microcristalline, no texture visible, with two 70° dipping joints. @49.4m: with a 60° dipping joint, rough, no filling. @50.3m: with a 20° dipping joint, stepped, open, no filling, minor oxidation stain.
51	REC=0% RQD=N/A —36—	fracture zone. @50.9m: with a 60° dipping joint, rough, no filling. @51.5m: with a 40° dipping joint, rough, open, no filling, minor oxidation stain. @51.8m: with 30 and 40° dipping joints, rough, no filling, minor oxidation stain.
52–53	REC=100% RQD=55% —37—	@52.4m: with a 50° dipping joint, clay filled. @52.7m: with 60 and 70° dipping joints, clay filled. @53.4m: with 70 and 60° dipping joints, clay filled, 1 cm aperture. with 30° dipping joint, healed. @54m: porfiric structure, crystals up to 3mm.
54–55	REC=100% RQD=58% —38—	@54.3m: with two 60° dipping joints, calcite healed. @54.6m: with a 50° dipping joint, no filling. @54.9m: with 60 and 50° dipping joints, no filling. fracture zone: rock is chipped with some interstitial clay. @55.5m: with a 40° dipping joint, slightly rough. @55.8m: calcite veining, up to 5cm thick.
56	REC=100% RQD=80% —39—	@56.1m: porfiric structure (salt and pepper), plagioclase and quartz crystals up to 1 cm, with a 40° dipping joint, slightly rough. @56.4m: with a 30° dipping joint, slightly rough, minor oxidation on joint surface. moderately fractured, with a 60° dipping joint, clean.
57–58	REC=100% RQD=53% —40—	@57m: with 70 and 30° dipping joints, slightly rough, 1mm aperture. @57.3m: with 70 and 20° dipping joints, slightly rough, closed. @57.6m: fracture zone: oxidation on joint surfaces. @57.9m: fracture zone: oxidation on joint surfaces. with 70° dipping joint, slightly rough, clean. @58.5m: with 40 and 50° dipping joints, slightly rough, clean.
59–60	REC=100% RQD=58% —41—	@58.8m: with 40° dipping joint, slightly rough, clean. @59.1m: fracture zone, probable mechanical breaks. @59.5m: with two 70° dipping joints, slightly rough, clean. with 30° dipping joint, slightly rough, clean (no filling).

Boring 02-21 Continued on LOTB Sheet xx of xx

VERTICAL SCALE 1 : 50

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON, NO. CEG 31, EXP. 7/31/04, STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT: KEYHAN MOGHBEL
SIGNOFF DATE

DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY M. KAPUSKAR 12/9/02
S.Siciliano — FIELD INVESTIGATOR(S)/TITLE
DATE: As shown

PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No. / KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

Boring 02-21 Continued fromLOTB Sheet of

PENETRATION DEPTH (m)

Depth (m)	Run	REC / RQD	Description
60–61	42	REC=100% RQD=33%	@60.1m: with 70 and 60° dipping joints, slightly rough, clean. @60.4m: with 30° dipping joint, slightly rough, clean. @60.7m: with 20° dipping joint, slightly rough, clean. @61m: with 20° dipping joint, slightly rough, clean.
62–63	43	REC=100% RQD=47%	@62.2m: with two 30° dipping joints, clean, minor oxidation on joint surfaces. @62.5m: with a 30° dipping joint, clean. @63.1m: with 30 and 50° dipping joints, slightly rough, minor clay filling and clean.
63–64	44	REC=0% RQD=N/A	@63.4m: with a 60° dipping joint, clean, 1 mm aperture. @63.7m: with a 60° dipping joint, clean, 1 mm aperture. @64m: with a 80° dipping joint, clean, 1 mm aperture.
64–66	45	REC=100% RQD=43%	@64.6m: clay filled soft zone, 5 cm thick, with 70 and 20° dipping joints, oxidized. @64.9m: fracture zone, 3cm thick, with a 20° dipping joint, slightly rough. microcristalline, fresh, hard, with a 60° dipping joint, clean, slightly rough, 1mm aperture.
66–68	46	REC=100% RQD=62%	@66.2m: porfiric structure, crystals up to 1 cm, with a 50° dipping joint, open, clean, slightly rough. @66.8m: with a 50° dipping joint, open, clean, slightly rough. @67.1m: fracture zone: rock fragments in clay matrix. Granodiorite, light gray, fresh to slightly weathered, intensely fractured, locally reduced to soil, hard to soft in shear zones (driller reports loss of circulation).
68–69	47	REC=40% RQD=0%	@67.7m: shear zone: rock fragments up to 5 cm in sandy matrix. @68m: shear zone: rock fragments up to 5 cm in sandy matrix. @68.3m: NCR. @68.6m: NCR. shear zone: rock fragments up to 5 cm in clayey sand matrix.
69–70	48	REC=40% RQD=0%	@69.2m: NCR. Granodiorite, light gray, fresh, slightly fractured, hard, porfiric (plagioclase crystals up to 1cm) to microcristalline.
70–71	49	REC=100% RQD=79%	@69.8m: with 60 and 50° dipping joints, slightly rough. @70.1m: with a 60° dipping joint, slightly rough. @70.4m: with 45 and 50° dipping joints, slightly rough and calcite veining up to 2.5 cm thick. locally intensely fractured and soft.
71–73	50	REC=85% RQD=55%	@71.3m: with a 30° dipping joint, calcite healed, slightly rough, minor oxidation on surface. @71.6m: with a 50° dipping joint, calcite healed, slightly rough. @72m: fracture zone: rock is reduced to sandy soil, soft, bottom 23 cm washed away (NCR). porfiric structure with grains up to 1 cm, calcite rich, milky matrix with black and green micaceous minerals.
73–74	51	REC=100% RQD=48%	@72.6m: with a 30° dipping joint, slightly rough, clean. @72.9m: with a 60° dipping joint, slightly rough, clean. @73.2m: shear zone: rock fragments up to 5 cm in dark brown clay matrix. Iron oxidation on all joint surfaces, microcristalline structure, occasional calcite deposits.
74–75	52	REC=100% RQD=58%	@74.1m: with 60 and 70° joints, slightly rough, oxidized. @74.4m: porfiric structure with grains up to 1 cm, with two 60° dipping joints, slightly rough. @74.7m: with 70 and 20° joints, slightly rough, oxidized. moderately fractured.
75–77	53	REC=100% RQD=32%	@75.3m: with two 30° joints, smooth, oxidized. @75.6m: with a 400° joint, smooth, oxidized. fracture zone: rock fragments, no clay.
77–78	54	REC=100% RQD=25%	@76.8m: microcristalline structure with hairline calcite veining. @77.1m: with a 25° dipping joint, minor clay coating, slightly rough. slightly fractured, with a 50° dipping joint, calcite healed, slightly rough. @78m: 0.3m porfiric section, with a 60° dipping joint, clean, slightly rough.
78–80	55	REC=100% RQD=70%	@78.4m: with a 25° dipping joint, wavy, minor oxidation. @78.7m: with a 25° dipping joint, wavy, minor oxidation. @79m: with a 60 and a 50° dipping joints, calcite filled and clean, slightly rough and smooth. intensely fractured, iron oxidation on all joints surfaces.
80	56	REC=100% RQD=0%	moderately fractured, with a 40° dipping joint, no filling, 1 mm aperture. @80.2m: with 50 and 60° dipping joints, clean, 1mm aperture.
80–82	57	REC=100% RQD=35%	@80.5m: small fracture zone 6 cm wide. @80.8m: 30° dipping joint, clay filled, open, slightly rough, rock fragments. @81.1m: 50° dipping joint, clay filled, open, slightly rough. color change to light greenish gray, slightly fractured.
82–83	58	REC=100% RQD=55%	@82m: lighter segregation planes up to 2 cm thick dipping 40°, 1 mm aperture. @82.3m: black laminae (probable biotite segregation), 0.5 cm thick dipping 70 to 80°, smooth surfaces, no oxidation. @82.6m: with 50 and 70° dipping joints, clean, slightly rough. @83.2m: with a 40° dipping joint, chlorite coating.
84–85	59	REC=100% RQD=48%	@83.8m: with a 70° dipping joint, chlorite coating. @84.1m: with a 40° dipping joint, chlorite coating and black lamina 0.5 cm thick (biotite foliation). hard to locally soft in fracture zone. @84.8m: fracture zone 30 cm wide: angular rock fragments up to 2 cm in clay matrix.
85–87	60	REC=100% RQD=63%	@85.1m: with 80 and 60° dipping joints with minor clay coating. @85.4m: black laminae (biotite foliation) up to 0.5 cm thick dipping 40 to 60° with clean smooth surface. @85.7m: black laminae (biotite foliation) up to 0.5 cm thick dipping 40 to 60° with clean smooth surface. black lamina (foliation) dipping 50°.
87–88	61	REC=100% RQD=57%	@86.9m: with a 30° dipping joint, clean. @87.2m: with 60 and 30° dipping joints, minor clay filling, fracture zone at bottom of run, some interstitial clay, soft. moderately fractured. Fracture zone: some clay and rock fragments. @87.8m: with two 50° dipping joints, clay and chlorite filling.
88–89	62	REC=100% RQD=29%	@88.1m: with a 50° dipping joint, clay and chlorite filling. @88.4m: with a 50 and a 40° dipping joint, clay and chlorite filling. @89m: small fault, 2cm off-set and a 50° dipping joint.
89–90	63	REC=100% RQD=40%	@89.3m: fracture zone 25 cm wide: rock fragments in clay matrix, soft. @89.6m: with a 45 and a 50° dipping joint, chlorite filling, smooth. intensely fractured: rock is chipped into fragments up to 2 cm. Laminae oriented 50° with the core axis, green and black (biotite and chlorite foliation).
90–91	64	REC=100% RQD=0%	@90.2m: fracture zone: diffuse chlorite mineralizationon all joints' surfaces. moderately fractured.
91–92	65	REC=86% RQD=43%	@90.9m: with a 40 and a 50° dipping joint, chlorite filling, slightly rough. @91.5m: small fracture zones, 5 cm wide, clay filled, abundant chlorite deposit. intensely fractured, locally soft in fracture zone, with a 70° dipping joint, chlorite and clay filled.
92–93	66	REC=0% RQD=N/A	@92.1m: fracture zone 30 cm wide: clay filled, soft, angular rock fragments. @92.4m: fracture zone 15 cm wide: clay and chlorite filled, soft, with a 30° dipping joint, slightly rough. fracture zone, 5 cm wide.
93–94	67	REC=100% RQD=40%	@93m: with a 30° dipping joint, chlorite coated, open, stepped. @93.3m: clay filling 5 cm thick, soft. @93.6m: small fracture zone, abundant quartz, with a 45° dipping joint, chlorite filled, open, stepped. small fracture zone 5 cm wide with abundant chlorite mineralization, with a 30 and a 60° dipping joints, chlorite coated, stepped and slightly rough.
94–95	68	REC=88% RQD=35%	@94.2m: with rock fragments up to 0.5 cm in finer matrix, re-lithified, grading into a fracture zone, 20 cm wide, composed of rock fragments up to 1 cm in greenish gray clay matrix, soft (signs of tectonic shear). @94.5m: small fracture zone, 10 cm wide, abundant quartz and chlorite mineralization. @94.8m: light greenish gray clay filling, 5 cm thick.
96–97	69	REC=100% RQD=38%	@95.7m: with two 60° dipping joints, clay filled and chlorite coated, slightly rough. @96m: shear zone, 38 cm wide: rock is decomposed to light greenish gray clay, no structure, stiff clay consistency, with abundant chlorite and decomposed joint dipping 70°. slightly fractured, hard, microcristalline.
97–99	70	REC=100% RQD=80%	@97.9m: with a 40 and a 70° dipping joints, clean and chlorite coated, open, smooth. small fracture zone, 7 cm wide: rock is chipped into coarse sand with clay, locally soft. @98.5m: with a 15° dipping joint, clay filled and chlorite coated, wavy.
99–100	71	REC=100% RQD=70%	@99.1m: with a 50 and a 70° dipping joints, clay and chlorite coated, rough and slightly rough. @99.4m: with a 80° dipping joint, chlorite coated, smooth. @100m: with a 60° dipping joint, chlorite coated.
100–102	72	REC=100% RQD=82%	@100.6m: small fracture zone, 5 cm wide. @100.9m: with a 70° dipping joint, chlorite coated. with a 40 and a 30° dipping joints, clay (minor) and chlorite coating, slightly rough. @101.5m: small clay rich zone, 5 cm wide, moderately soft.
102–103	73	REC=100% RQD=58%	@101.8m: with a 60° dipping joint, chlorite and clay coated, slightly rough. @102.1m: with a 25° dipping joint, chlorite and clay coated, slightly rough. @102.4m: with a 20° dipping joint, chlorite and clay coated, slightly rough. moderately to intensely fractured, hard to locally soft in fracture zone.
103–104	74	REC=100% RQD=20%	@103m: fracture zone, 35 cm wide: rock is chipped and partially re-lithified, clay and chlorite rich, moderately soft to soft. @103.7m: fracture zone, 30 cm wide: clay and chlorite rich, stiff clay consistency. slightly fractured, with a 70° dipping joint, chlorite coated.
104–106	75	REC=100% RQD=65%	@104.3m: with a 30° dipping joint, chlorite coated. @104.6m: with a 70° dipping joint, chlorite coated. @104.9m: with a 60° dipping joint, chlorite coated, stepped. @105.2m: with a 30° dipping joint, chlorite with minor clay coating, stepped. locally soft in fracture zone. @106.1m: with a 70° dipping joint, chlorite coated, stepped.
106–107	76	REC=98% RQD=50%	@106.7m: fracture zone, 18 cm wide: rock is crushed into coarse sand in stif clay matrix, moderately soft to soft, with a 60° dipping joint, clay and chlorite coated, rough. @107m: with a 50° dipping joint, chlorite coated, rough.
107–109	77	REC=100% RQD=25%	@107.6m: fracture zone, 30 cm wide: rock is crushed locally into coarse sand in stiff clay matrix with some bigger fragment of hard rock up to 4 cm. @108.2m: with a 50 and a 40° dipping joints, clay and chlorite coating, rough and slightly rough. Fracture zone at bottom 10 cm of run: rock fragments up to 3 cm in clay matrix.
109–110	78	REC=100% RQD=48%	moderately fractured, with a 50° dipping joint and a fracture zone15 cm wide composed of fine gravel size fragments (fine portion probably washed away). @108.8m: with a 30° dipping joint, minor clay and chlorite coating, slightly rough. @109.5m: with a 30 and a 40° dipping joints, calcite and chlorite coating, slightly rough. moderately to intensely fractured.
110–111	79	REC=100% RQD=20%	@110.1m: with a 60° dipping joint, chlorite coating, slightly rough. @110.4m: with a 40° dipping joint, minor clay and chlorite coating, slightly rough. @110.7m: with 40, 50 and 60° dipping joints, chlorite coating, slightly rough and rough (60° one) and a small fracture zone, 6 cm wide at 193 m depth.
111–113	80	REC=100% RQD=60%	slightly to moderately fractured, with a 60° dipping joint. @111.6m: small fractured zone, 8 cm wide, composed of crushed rock with clay, with a 60° joint. @111.9m: small fractured zone, 5 cm wide, composed of crushed rock with interstitial clay. @112.2m: quartz veins dipping 50°, hairline. @112.5m: with a 80° dipping joint, minor clay and chlorite coating, slightly rough.
113–114	81	REC=100% RQD=48%	slightly fractured, brittle, with a 50 and a 20° dipping joints, chlorite coated. @113.1m: with a small fracture zone, 2.5 cm wide and a 20° dipping joint, chlorite coated. hard to locally soft in fracture zone.
115–116	82	REC=100% RQD=48%	@114.6m: fracture zone, 20 cm wide, rock is crushed into fragments up to 2 cm in clay matrix, soft. @115.2m: with a 60 and a 20° dipping joints, calcite and chlorite coating, 1 and 2 mm aperture, slightly rough and rough. @115.5m: with a 30° dipping joint, calcite and chlorite coating, rough. (CS) @115.9m
116–117	83	REC=88% RQD=52%	@116.2m: fracture zone, 10 cm wide, rock is crushed into fragments up to 2 cm in clay matrix, soft, with a 40° dipping joint, clay and chlorite coating, slightly rough. @116.8m: fracture zone, 20 cm wide, rock is crushed into fragments up to 5 cm in clay matrix, soft, with a 40° dipping joint, clay and chlorite coating, slightly rough.
117–119	84	REC=100% RQD=50%	@117.1m: fracture zone, 10 cm wide: rock is crushed into stiff clay, greenish gray. Bottom 18 cm of core not recovered (probably washed away). moderately fractured. @117.7m: small fracture zone, 5 cm wide: rock is chipped into fine gravel with some interstitial clay, soft. @118m: with a 25° dipping joint, clay and chlorite coating, 1 mm aperture and a small fracture zone, 9 cm wide at bottom of run, rock is reduced into sandy clay gouge, soft.
119	85	REC=88% RQD=17%	intensely fractured, moderately hard with soft shear zones (poor recovery due to washing away of soil-like portion); with loose rock fragments up to 3 cm and stiff clay gouge from 118 m to 119 m depth. @118.6m: moderately hard, with a 20° dipping joint, chlorite and clay coating.
120	86	REC=100% RQD=17%	@118.9m: greenish gray stiff clay gouge at the bottom 5 cm of run. Fracture zone 35 cm wide: only 6 cm of intact core, rock is crushed into fine gravel with interstitial clay. @119.5m: with a joint sub-parallel to core-axis, 30 cm long, dividing the core into 2 parts: half soft clay gouge, half moderately hard rock. @119.8m: bottom 13 cm of run intact core.

Boring 02-21 Continued on LOTB Sheet xx of xx

VERTICAL SCALE 1 : 50

CONSISTENCY CLASSIFICATION FOR SOILS
According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488
FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS
2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS
(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS
Year boring drilled; Boring number; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date; Sample No.; Permanent Casing driven; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified; Number of blows required to produce the indicated penetration after an initial 152 mm seating; 50 blows produced the indicated penetration during the initial 152 mm interval; ROTARY SAMPLE BORING (WET); B-No. Boring number; Top Hole El.; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... Sample Description; Boring Date(s)

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST — PLAN APPROVAL DATE
(Seal: CERTIFIED ENGINEERING GEOLOGIST, DOUGLAS HOLMES HAMILTON, NO. CEG 31, EXP. 7/31/04, STATE OF CALIFORNIA)

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

The State of California or its officers or agents shall not be responsible for the completeness or accuracy of electronic copies of this plan sheet.

Caltrans Metric

DESIGN OVERSIGHT: KEYHAN MOGHBEL — SIGNOFF DATE
DESIGN BY S. VARATHARAJ 11/20/02
CHECKED BY M. KAPUSKAR 12/6/02
S.Siciliano — FIELD INVESTIGATOR(S)/TITLE — DATE 8/17/02 to 8/30/02
PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION
M. KAPUSKAR — PROJECT ENGINEER
BRIDGE No. — KILOMETER POST
ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100
CU 240 EA 11237E
DISREGARD PRINTS BEARING EARLIER REVISION DATES
REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 - 4	Very Loose	< 2	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 30	Medium Dense	5 - 8	Firm
31 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

FILL MATERIAL; CLAY (CL or CH); SILT (ML or MH); PEAT and/or ORGANIC MATTER; WELL-GRADED GRAVEL (GW); POORLY-GRADED GRAVEL (GP); SILTY GRAVEL (GM); CLAYEY GRAVEL (GC); POORLY-GRADED SAND (SP); WELL-GRADED SAND (SW); SILTY SAND (SM) or SANDY SILT; CLAYEY SAND (SC) or SANDY CLAY; COBBLES/BOULDERS; IGNEOUS ROCK; SEDIMENTARY ROCK; METAMORPHIC ROCK

TYPE OF BORINGS

2¼" CONE PENETRATION; ROTARY WASH; ELECTRONIC CONE PENETROMETER; AUGER BORING (DRY); TEST PIT; DIAMOND CORE BORING; SOIL TUBE

IN-SITU, LAB & FIELD TEST DESIGNATIONS

(AL) ATTERBERG LIMITS; (SA) SIEVE ANALYSIS; (W) WASH #200; (CA) CHEMICAL ANALYSIS; (MD) MAXIMUM DRY DENSITY; (C) CONSOLIDATION; (PR) POTENTIAL REACTIVITY; (R) R-VALUE; (DS) DIRECT SHEAR; (PA) PACKER TEST; (PT) PETROGRAPHICS TEST; (PM) PRESSUREMETER TEST; (UC) UNCONFINED COMPRESSION; (TX) TRIAXIAL TEST; (E) YOUNG'S MODULUS

LEGEND OF BORING OPERATIONS

Year boring drilled; Boring number; Top Hole El.; Sample No.; Permanent Casing driven; Size of Sampler (mm); Unconfined compressive strength (kPa); Number of blows to produce 305 mm of penetration after the initial 152 mm of seating using a 63.5 kg hammer with a 762 mm drop or as specified.; Number of blows required to produce the indicated penetration after an initial 152 mm seating.; 50 blows produced the indicated penetration during the initial 152 mm interval; Description of material; Total Unit weight (kN/m³); % moisture; Consolidation test; CWS Elev.; Date measured; Conformable material change; Estimated material change; Unconformable material change; Boring Date; ROTARY SAMPLE BORING (WET)

B-No. — Boring number; Top Hole El.; Permanent Casing driven; Run No.; Recovery (%) REC=100%; Rock Quality Designation (%) RQD=N/A; Bottom/Top of Core Run; REC=72% RQD=50%; CLAYSTONE, dark grey ... — Sample Description; Boring Date(s)

Boring 02-21 Continued from LOTB Sheet of

PENETRATION DEPTH (m)

Depth (m)	Run	Description
120–121	REC=100% RQD=58% — 87	GRANODIORITE, dark green and greenish gray, fresh, slightly to moderately fractured, hard to very hard, porfiric structure with quartz phenocrystals up to 1 cm. (lithology change).
122		@120.4m: with a 50° dipping joint, calcite and chlorite coating, 1 mm aperture, slightly rough.
	REC=100% RQD=53% — 88	@120.7m: with a 80 and a 75° dipping joints, calcite and chlorite coating, 1 mm aperture, slightly rough.
123		@121m: with a 30° dipping joint, calcite and chlorite coating, 1 mm aperture, stepped, quartz phenocrysts section.
		@121.3m: with a 20° dipping joint, calcite and chlorite coating, 1 mm aperture.
		locally soft in fracture zone, with a 90° dipping joint, chlorite and minor clay coating, 1mm aperture, slightly rough.
124	REC=100% RQD=63% — 89	@122m: with a 70° dipping joint, chlorite coated, stepped and diffuse calcite veining.
		@122.6m: with a 20° dipping joint, chlorite coated, 2 mm aperture, stepped.
		@122.9m: fracture zone, 23 cm wide: rock is crushed into soft clay gouge.
125	REC=100% RQD=95% — 90	fracture zone, 13 cm wide: rock is crushed into soft clay gouge.
		@123.8m: fracture zone, 13 cm wide: rock is crushed into soft clay gouge with large quartz phenocrysts and two 60° dipping joints, chlorite and clay coating.
126		@124.1m: light green re-healed section (cataclasite), signs of previous tectonic shear, joints dipping 65 to 80°, chlorite coated, closed.
		slightly fractured, hard to very hard, with a 80° dipping jointclay filled, closed, abundant quartz mineralization.
	REC=100% RQD=75% — 91	@124.7m: with two 65° oriented foliations dividing dark green rock with quartz phenocrysts up to 1 cm from light green with smaller crystals.
127		@125m: with a 70° dipping joint, closed.
		@125.3m: very hard section, almost unfractured with a 70° dipping joint, chlorite coated, 1 mm aperture, slightly rough.
		color varies from very light green to dark green, with a 80 and a 20° dipping joints, chlorite coated, 1mm aperture, slightly rough.
128	REC=100% RQD=100% — 92	@125.9m: with a 70° dipping joint, chlorite coated, 1mm aperture, slightly rough and pervasive quartz veining.
		@126.2m: with a small quartz dike dipping 60 to 70°, 8 cm thick.
		(UC) @127.1m: slightly fractured, very hard, with patchy quartz mineralization, phenocrystals up to 1 cm (very good quality run).
129		@127.4m: with two 40° joints, chlorite coated, 1 mm aperture, slightly rough.
		@127.7m: with a 70° joint, chlorite coated, 1 mm aperture, slightly rough.
	REC=100% RQD=93% — 93	@128m: with a 45° joint, chlorite coated, 1 mm aperture, slightly rough.
130		with a 50° joint, chlorite coated, open, slightly rough.
		@129m: pervasive calcite veining, hairline.
		@129.3m: with a 30° joint, chlorite coated, 1 mm aperture, slightly rough.
		@129.6m: pervasive calcite veining, hairline.
		@129.9m: with a 60 and a 40° joint, chlorite and minor clay coating on the latter, 1 mm aperture, slightly rough.
131	REC=100% RQD=83% — 94	locally soft in a small fracture zone at 131 m depth.
		@130.8m: pervasive calcite veining, hairline.
		@131.1m: small fracture zone, 20 cm wide: clay filling 2.5 cm thick bounded by two 60° dipping joints, clay filled.
132		@131.4m: with a 20° joint, chlorite coated, calcite healed.
		slightly to moderately fractured, hard to very hard, with a 60 and a 45° joint, chlorite and minor clay coating, slightly rough.
	REC=100% RQD=62% — 95	@132m: with a 15° joint, chlorite and clay coated, slightly rough.
133		@132.6m: with a 20° joint, chlorite and clay coated, slightly rough.
		@132.9m: with a small quartz dike, 5 cm thick.
		with a 60° joint, chlorite coated, open, rough,.
134	REC=100% RQD=70% — 96	@133.8m: with a 25° joint, chlorite and clay coated, and phenocrystals up to 0.5 cm.
		@134.1m: with a small fracture zone, 5 cm wide, brittle, some interstitial clay and a 20° dipping joint, chlorite and calcite coated.
135		various shades of green to purple, slightly fractured.
	REC=100% RQD=95% — 97	(PT) @135.1m: porfiric structure, quartz and micas crystals up to 0.5 cm and hairline calcite veins.
136		@135.4m: with two 40° dipping joints, chlorite and clay (for the latter) coated, slightly rough and rough.
		@135.7m: Fracture zone, 12 cm wide, with some interstitial clay and a 30° dipping joint, chlorite and clay coated, rough.
		@136m: hairline calcite veins.
		pervasive secondary calcite veining.
137	REC=100% RQD=87% — 98	@136.6m: patchy quartz mineralization, crystals up to 0.5 cm.
		@137.5m: with a 10° chlorite coated joint.
138		light green and black (breccia dike), with a 20° calcite healed joint, closed.
	REC=100% RQD=80% — 99	@138.1m: with a 30° calcite healed joint, stepped.
139		@138.4m: breccia dike 25 cm wide, black, hard, with 60° dipping joint, clay filled, 2 cm thick.
		@139m: breccia dike 22 cm wide, black, hard, with 20° dipping joint.
140	REC=100% RQD=87% — 100	CATACLASITE, light green, moderately hard to hard, re-lithified granodiorite fragments up to 1 cm in a finer, hard matrix, with small breccia dike injections.
		@139.6m: with a 90° dipping joint, clean, 2 mm aperture, rough.
		@139.9m: with a few small breccia dike injections, black, 5 cm wide at 139.8 m and 140.3 m depth.
141		with 70° dipping joint, clean, slightly rough.
142	REC=100% RQD=55% — 101	@141.5m: with 20° dipping joint, clean.
		@141.8m: with 40° dipping joint, clean.
143		cataclastic fragments up to 3 cm, mainly quartz.
		@142.7m: with a 70° dipping joint, chlorite coated.
	REC=100% RQD=90% — 102	(E) @143m
144		@144.2m: with two 20° dipping joints, clay coated, slightly rough.
145	REC=100% RQD=87% — 103	@144.8m: with a 30° joint, clay filled, 5 mm aperture, slihtly rough.
		@145.1m: quartz megacrystal up to 3 cm.
146		@145.7m: with a 70° joint, rough and calcite veining, hairline.
	REC=100% RQD=97% — 104	@146m: small calcite-healed fault, 5 cm off-set.
		@146.3m: with a 30° joint.
147		cataclastic fragments up to 4 cm, mainly quartz.
		@147.3m: with a calcite healed joint sub-parallele to core axis, 60 cm long.
148	REC=100% RQD=100% — 105	@148.2m: with a 50° joint, minor clay coating.
		with a 60 and a 70° joint, closed.
149		@148.8m: with a joint sub-parallele to core axis, 30 cm long, clay coated.
	REC=100% RQD=78% — 106	@149.1m: small fracture zone, 6 cm wide at 149 m depth, clay rich, stiff and dry, non expansive.
150		@149.7m: with a 60° dipping joint, clay, pyrite and chlorite coated.
151	REC=100% RQD=77% — 107	@150.9m: with a 80 and a 70° joint, chlorite and clay filling, smooth and slightly rough.
		@151.2m: with two 20° joints, clay, pyrite and chlorite coating, slightly rough.
152		moderately fractured, with a softer fracture zone at 152.5 m depth and a closed joint sub-parallel to core axis, clay filled.
	REC=100% RQD=58% — 108	@152.1m: with a small fracture zone, 3 cm wide and a 60° dipping joint, clean, closed.
153		@152.4m: fracture zone: rock fragments up to 3 cm in a soft clay matrix.
		@152.7m: with two 50° joints, chlorite and pyrite coated, open, smooth.
		harder (can be scratched with knife with heavy pressure).

Depth (m)	Run	Description
153–154		@153.4m: with a 60° joint, clean, closed, slightly rough.
154	REC=100% RQD=100% — 109	@154m: with a 80° joint, clean, closed, slightly rough.
		@154.3m: with a 80° joint, clean, closed, smooth.
155		@154.9m: joint sub-parallel to core axis, calcite filled, closed.
156	REC=100% RQD=100% — 110	@155.8m: patchy brecia dike injections, black, up to 5 cm, with a 70° joint, 0.5 mm aperture, smooth.
		light green and black (breccia dike) with yellowish brown shear zones, slightly to intensely fractured, hard to soft in shear zones (driller reports complete loss of circulation at bottom of run).
157	REC=100% RQD=47% — 111	@156.4m: with a 30° joint, calcite filled, open, stepped.
		@157m: black breccia dike, 0.5 m wide, hard,.
		@157.3m: intensely sheared and replaced by stiff clay, light gray, with a 30° joint, clay filled, 2 cm thick. Bottom foot of the run composed by soft clay with rock fragments (chiefly quartz) up to 1 cm. Diffuse iron oxide.
158		GRANODIORITE, greenish gray, fresh, intensely fractured, moderately hard to soft, porfiric texture (driller reports loss of circulation).
	REC=90% RQD=0% — 112	@157.9m: with a 20° decomposed joint, clay filled, dividing moderately hard rock (above) from clay filled soft fracture zone 0.3 m wide at 157.9 m depth.
159		@158.2m: minerals aligned at 80° with core axis, diffuse iron oxidation.
		moderately fractured, hard, porfiric texture with crystals up to 1 cm and a 60° dipping joint, clay coated and iron oxidized, rough and a small fracture zone, 2.5 cm wide.
160	REC=100% RQD=40% — 113	@159.5m: with a 50° dipping joint, clay coated and iron oxidized, slightly rough.
		@160.1m: with three 20° and one 30° dipping joints, clay and pyrite coating, slightly rough to rough.
		slightly to moderately fractured, with a 30° dipping joint, closed.
161	REC=100% RQD=67% — 114	@160.7m: quartz phenocrystals up to 2 cm, with a 40 and a 30° dipping joint, chlorite and pyrite coating, 1 mm aperture to open, slightly rough.
		@161m: light yellow pyrite mineralization, with a 70° dipping joint, chlorite and pyrite coating.
		moderately fractured, with a fracture zone 0.3 m wide at 161.4 m depth and with a 80° dipping joint, chlorite and pyrite coating.
162	REC=100% RQD=31% — 115	@161.6m: iron oxidation on joints' surfaces.
		@161.9m: with a 60° dipping joint, chlorite and pyrite coating, 1 mm aperture, slightly rough and minor pyrite concretion.
		@162.2m: Bottom of boring.

09/07/02 - 09/12/02

VERTICAL SCALE
1 : 50

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

CERTIFIED ENGINEERING GEOLOGIST

CERTIFIED ENGINEERING GEOLOGIST — DOUGLAS HOLMES HAMILTON — NO. CEG 31 — EXP. 7/31/04 — STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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Caltrans Metric

DESIGN OVERSIGHT	KEYHAN MOGHBEL		
SIGNOFF DATE			
DESIGN	BY S. VARATHARAJ	11/20/02	
CHECKED	BY M. KAPUSKAR	12/6/02	
S.Siciliano — FIELD INVESTIGATOR(S)/TITLE	DATE 8/17/02 to 8/30/02		

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR — PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

REGISTERED GEOTECHNICAL ENGINEER

REGISTERED PROFESSIONAL ENGINEER · MIKE KAPUSKAR · NO. GE 2364 · EXP. 12-31-04 · GEOTECHNICAL · STATE OF CALIFORNIA

PLAN APPROVAL DATE

HNTB CORPORATION
200 E. Sandpointe Ave, Suite 200
Santa Ana, California 92707

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
17660 Newhope Street, Suite E
Fountain Valley, California 92708

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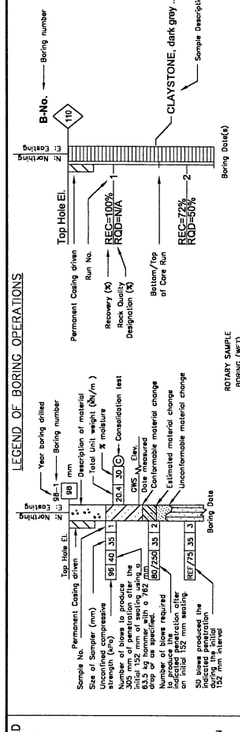
LEGEND OF BORING OPERATIONS



IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
- (C) CONSOLIDATION
- (R) POTENTIAL REACTIVITY
- (R) R-VALUE
- (DS) DIRECT SHEAR
- (PA) PACKER TEST
- (PE) PETROGRAPHICS TEST
- (PR) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (YM) YOUNG'S MODULUS

TYPE OF BORINGS

- 2½" CONE PENETRATION
- ROTARY WASH
- ELECTRONIC CONE PENETROMETER
- AUGER BORING (DRY)
- TEST PIT
- DIAMOND CORE BORING
- SOIL TUBE

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

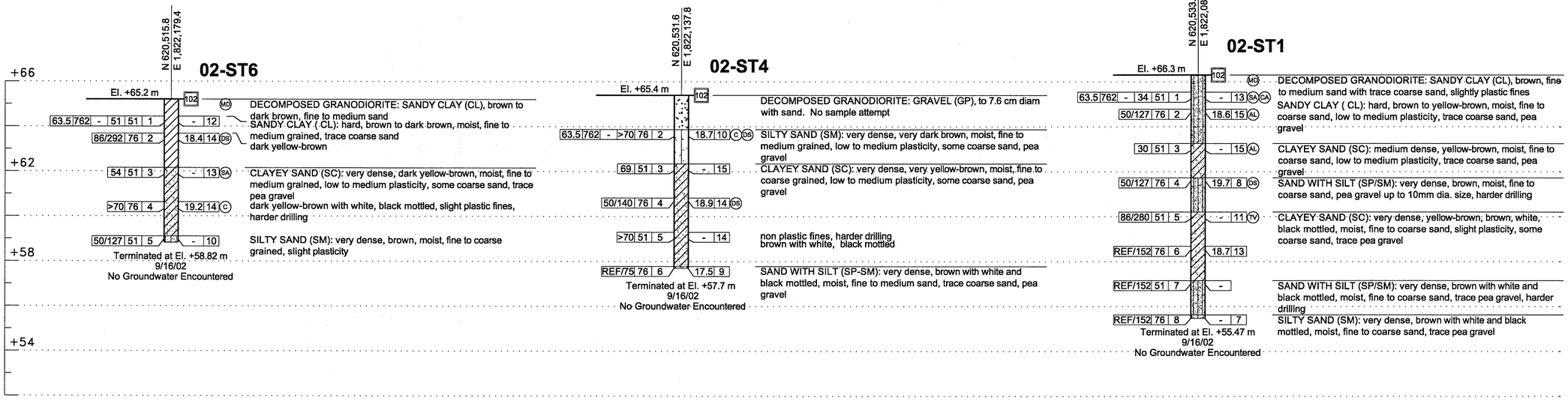
- TILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or HIGHLY ORGANIC MATTER
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- POORLY-GRADED GRAVEL (GP)
- WELL-GRADED GRAVEL (GW)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ft)	Granular	SPT N-value (blows/ft) 305 mm	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard



VERTICAL SCALE

1 : 100

DESIGN OVERSIGHT	KEYHAN MOGHBEL		
SIGNOFF DATE			
DESIGN	BY S. VARATHARAJ 11/20/02	R. JIE/FIELD TECHNICIAN FIELD INVESTIGATOR(S)/TITLE	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION
CHECKED	BY M. KAPUSKAR 12/6/02	DATE AS SHOWN	M. KAPUSKAR PROJECT ENGINEER

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

DIST	COUNTY	ROUTE	KILOMETER POSTS TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
04	SM	1	61.47 / 65.90		

Caltrans Metric

REGISTERED GEOTECHNICAL ENGINEER

PLAN APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER · MIKE KAPUSKAR · NO. GE 2364 · EXP. 12-31-04 · GEOTECHNICAL · STATE OF CALIFORNIA

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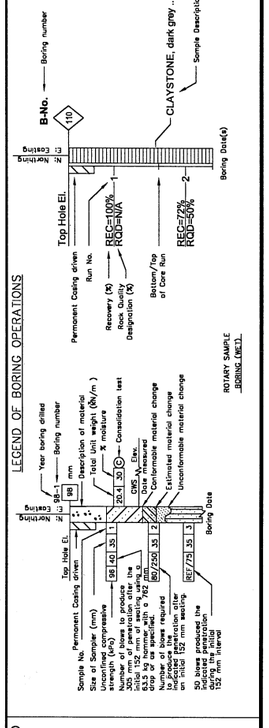
LEGEND OF BORING OPERATIONS



IN-SITU, LAB & FIELD TEST DESIGNATIONS

- (AL) ATTERBERG LIMITS
- (SA) SIEVE ANALYSIS
- (W) WASH #200
- (CA) CHEMICAL ANALYSIS
- (MD) MAXIMUM DRY DENSITY
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- (PR) POTENTIAL REACTIVITY
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- (DS) DIRECT SHEAR
- (E) PACKER TEST
- (PG) PETROGRAPHICS TEST
- (PM) PRESSUREMETER TEST
- (UC) UNCONFINED COMPRESSION
- (TX) TRIAXIAL TEST
- (LE) YOUNG'S MODULUS

TYPE OF BORINGS

- 2½" CONE PENETRATION
- ROTARY WASH (dia)
- ELECTRONIC CONE PENETROMETER
- AUGER BORING (DRT) (dia)
- TEST PIT (dia)
- DIAMOND CORE BORING (dia)
- SOIL TUBE (dia)

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

- FILL MATERIAL
- CLAY (CL or CH)
- SILT (ML or MH)
- PEAT and/or ORGANIC MATTER
- WELL-GRADED GRAVEL (GW)
- POORLY-GRADED GRAVEL (GP)
- SILTY GRAVEL (GM)
- CLAYEY GRAVEL (GC)
- POORLY-GRADED SAND (SP)
- WELL-GRADED SAND (SW)
- SILTY SAND (SM) or SANDY SILT
- CLAYEY SAND (SC) or SANDY CLAY
- COBBLES/BOULDERS
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/305 mm)	Granular	SPT N-value (blows/305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

02-ST3

N 620,622.8
E 1,822,195.1
El. +103.9 m

63.5	762	-	>70	1	-	9
REF	127	76	2	21.5	9	

DECOMPOSED GRANODIORITE: SANDY CLAY (CL), brown, yellow-brown, moist, fine to medium sand with trace coarse sand, low to medium plasticity

CLAYEY SAND (SC): very dense, dark yellow-brown with white dark brown, black mottled, moist, fine to coarse sand, low to medium plasticity, trace coarse sand, gravel/quartz up to 10 mm

Terminated at El. +102.31 m
9/19/02
No Groundwater Encountered

02-ST10

N 620,674.3
E 1,822,114.7
El. +104.0 m

63.5	762	-	29	51	1	- 14
60	76	2			17.7	17 (DS)
25	51	3			-	17 (SA)(AL)(CA)
57	76	4			19.2	13 (C)
47	51	5			-	13
50	76	6			18.9	12
26	51	7			-	16
40	76	8			18.6	15 (DS)
28	51	9			-	16 (M)
50/76	76	10				

DECOMPOSED GRANODIORITE: SANDY CLAY (CL), very dark brown, fine to medium sand with trace coarse sand, moderate plasticity, moist.

SANDY CLAY (CL): very stiff, very dark brown to yellow-brown, moist, fine to medium grained, low to medium plastic fines, trace coarse sand with depth

hard, yellow-brown with olive brown, white , black, trace quartz in coarse sand size, black stains

very stiff, dark yellow-brown with red -brown, black, white, yellow-brown mottled, medium to high plastic fines

CLAYEY SAND (SC): dense, very dark yellow-brown with pink, white, black mottled, moist, fine to medium grained, medium plasticity, trace pea gravel

trace small quartz

harder drilling

very dense, trace oxidation

medium dense, very moist, angular gravel up to 20mm dia

gravel up to 12 mm dia

Terminated at El. +90.03 m
9/18/02, 9/19/02
No Groundwater Encountered

02-19

N 620,844.0
E 1,821,946.1
El. +74.0 m

R						
63.5	76	-	21	76	1	18.7 16 (CA)(DS)
6	51	2			-	18 (SA)
21	76	3			19.7	11
12	51	4			-	18
26	76	5			19.6	13 (SA)
6	51	6				
34	76	7			19.0	14 (SA)
11	51	8			-	15
32	76	9			19.2	13 (DS)
18	51	10			-	18 (SA)
22	76	11			18.3	16 (DS)
15	51	12			-	19 (SA)
31	76	13			18.1	18
19	51	14			-	18
43	76	14A			17.8	18
41	76	15			17.1	20
50/114	51	16			-	17
REC=100%	1					
REC=100%	2					

SANDY CLAY: dark brown gray

CLAYEY SAND (SC): medium dense, dark yellow-brown with dark brown, white mottled, moist, fine to coarse grained, slight plasticity, trace pea gravel

SAND with SILT (SP-SM): loose, dark yellow-brown with dark brown, white mottled, very moist, fine to coarse grained, no plasticity, gravel up to 12 mm dia

medium dense, moist, gravel up to 25 mm dia

dark brown with yellow-brown, white, black mottled, gravel up to 12 mm dia

SILTY SAND (SM): medium dense, dark brown with dark yellow-brown, white, black mottled, fine to coarse grained, no plasticity, gravel up to 12 mm dia

no recovery

SAND with SILT (SP-SM): medium dense, dark yellow-brown with dark brown, white, black mottled, moist, fine to coarse grained, slight plasticity, gravel up to 12 mm dia

SILTY SAND (SM): medium dense, dark yellow-brown with dark brown, white, black mottled, moist, fine to coarse grained, slight plasticity, gravel up to 12 mm dia

very moist

CLAYEY SAND (SC): medium dense, dark yellow-brown with dark brown, white, black mottled, moist, fine to coarse grained, slight plasticity, gravel up to 12 mm dia

olive-green, olive-gray , olive brown mottled, pea gravel

gravel up to 12 mm dia, low plasticity, trace mica

green, greenish gray, olive gray, dark brown mottled, pieces of wood chips

SILTY SAND (SM): very dense, dark brown with yellow-brown, white, black mottled, moist, fine to coarse grained, no plasticity, trace pea gravel, mica, oxidation

QUARTZ GRANODIORITE

Terminated at El. +47.17 m
9/30/02
No Groundwater Encountered

ELEVATION (m)

+96 +92 +88 +82 +74 +70 +66 +62 +58 +54 +50 +46

VERTICAL SCALE
1 : 100

DESIGN	BY S. VARATHARAJ	11/20/02	
CHECKED	BY M. KAPUSKAR	2/12/03	

DESIGN OVERSIGHT KEYHAN MOGHBEL
SIGNOFF DATE

R. JIE/FIELD TECHNICIAN
FIELD INVESTIGATOR(S)/TITLE
DATE AS SHOWN

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

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Caltrans Metric

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REGISTERED PROFESSIONAL ENGINEER MIKE KAPUSKAR NO. GE 2364 EXP. 12-31-04 GEOTECHNICAL STATE OF CALIFORNIA

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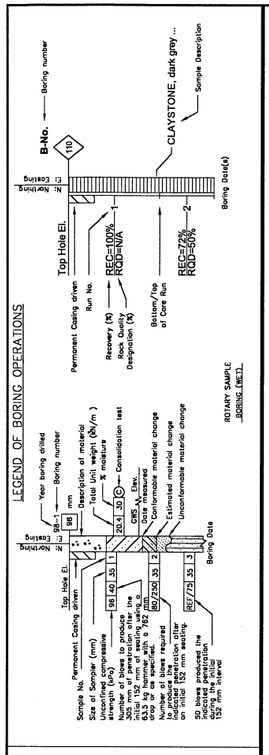
LEGEND OF BORING OPERATIONS



IN-SITU, LAB & FIELD TEST DESIGNATIONS

(A)	ATTERBERG LIMITS	(P)	MAXIMUM DRY DENSITY
(SA)	SIEVE ANALYSIS	(C)	CONSOLIDATION
(W)	WASH #200	(E)	POTENTIAL REACTIVITY
(CA)	CHEMICAL ANALYSIS	(R)	R-VALUE
(UC)	UNCONFINED COMPRESSION	(DS)	DIRECT SHEAR
(PI)	PERMEABILITY	(PA)	PACKER TEST
(PL)	POINT LOAD	(PET)	PETROGRAPHICS TEST
(M)	MOISTURE	(PM)	PRESSUREMETER TEST
(UU)	UNCONSOLIDATED UNDRAINED TRIAXIAL	(YM)	YOUNG'S MODULUS

TYPE OF BORINGS

●	2½" CONE PENETRATION		ELECTRONIC CONE PENETROMETER
RDB	ROTARY WASH	AUG	AUGER BORING (DRY)
		TP	TEST PIT
DCB	DIAMOND CORE BORING	SPT	SOIL TUBE

LEGEND OF EARTH MATERIALS (USCS) BASED ON ASTM D2487, D2488

	FILL MATERIAL		POORLY-GRADED SAND (SP)
	CLAY (CL or CH)		WELL-GRADED SAND (SW)
	SILT (ML or MH)		SILTY SAND (SM) or SANDY SILT
	PEAT and/or ORGANIC MATTER		CLAYEY SAND (SC) or SANDY CLAY
	WELL-GRADED GRAVEL (GW)		COBBLES/BOULDERS
	POORLY-GRADED GRAVEL (GP)		IGNEOUS ROCK
	SILTY GRAVEL (GM)		SEDIMENTARY ROCK
	CLAYEY GRAVEL (GC)		METAMORPHIC ROCK

CONSISTENCY CLASSIFICATION FOR SOILS
According to the Standard Penetration Test (ASTM D-1586)

SPT N-value (blows/ 305 mm)	Granular	SPT N-value (blows/ 305 mm)	Cohesive
0 – 4	Very Loose	< 2	Very Soft
5 – 10	Loose	2 – 4	Soft
11 – 30	Medium Dense	5 – 8	Firm
31 – 50	Dense	9 – 15	Stiff
> 50	Very Dense	16 – 30	Very Stiff
		> 31	Hard

Note: Visual classification of earth materials are based on field inspection and are confirmed or revised with laboratory test results as necessary.

ELEVATION (m)

02-ST8

N 620,611.6
E 1,822,109.3

El. +91.1 m

102						MD	DECOMPOSED GRANODIORITE: CLAYEY SAND (SC), dark brown, yellow brown, fine to medium sand with trace coarse sand, low plasticity, damp	+94
63.5/762	-	63	51	1	- 5	SA	SILTY SAND (SM): very dense, yellow-brown with white, black mottled, moist, fine to coarse grained, slight plasticity, trace gravel/quartz trace oxidation	+90
94/280	76	2			19.2 9	DS		
49	51	3			- 9		dense	
50/51	76	4			19.8 6	DS	very dense, 13 mm seam of yellow brown slightly plastic fines	+86

Terminated at El. +86.31 m
9/16/02
No Groundwater Encountered

02-ST9

N 620,589.3
E 1,822,175.2

El. +84.8 m

102						MD	DECOMPOSED GRANODIORITE: SANDY CLAY (CL), very dark brown, fine to medium sand with trace coarse sand, low to moderate plasticity, moist	
63.5/762	-	17	51	1	- 9		CLAYEY SAND (SC): medium dense, very dark brown trace pink, moist, fine to medium grained, low to medium plasticity, trace coarse sand	
20	76	2			18.9 14	SA AL		+82
35	51	3			- 14		SANDY CLAY (CL): stiff, very dark brown with trace pink, very moist, fine to medium grained, low to medium plastic fines, trace coarse sand hard, yellow-brown with trace white, black	
97/292	76	4			18.1 16	DS	CLAYEY SAND (SC): very dense, red, very dark red-brown, yellow-brown mottled, moist, fine to medium grained, medium plasticity, trace pea gravel	
45	51	5			- 20	SA	SANDY CLAY (CL): hard, very dark red-brown with red, yellow-brown mottled; moist; fine to medium grained, medium to high plastic fines, trace coarse sand	+78
>70	76	6			16.4	UU	very dark yellow-brown with lt. gray, trace gravel up to 25 mm	
57	51	7			- 16		very dark yellow-brown with red, yellow-brown black mottled, some pea gravel	
50/114	76	8			19.3 13		CLAYEY SAND (SC): very dense, very dark yellow-brown with red, yellow-brown black mottle, moist, fine to medium grained, medium plasticity, trace pea gravel	+74
53	51	9			- 16	SA AL	SANDY CLAY (CL): hard, very dark yellow-brown with red, yellow-brown, black mottled, moist, fine to medium grained, medium plastic fines	
50/114	76	10			18.3 16		pea gravel to 9 mm diameter	
68	51	11			- 15	SA	very dark yellow-brown with red, yellow-brown, black mottled, trace white, trace pea gravel	+70
50/152	76	12			18.3 16	DS		
50/51	76	13			17.8 15		harder drilling trace oxidation, clay balls, gravel up to 12 mm dia	+66
50/140	51	14					CLAYEY SAND (SC): very dense, very dark yellow-brown with red, yellow-brown black mottle, moist, fine to coarse grained, low plasticity, trace pea gravel	

Terminated at El. +65.98 m
9/18/02
No Groundwater Encountered

02-ST7

N 620,616.6
E 1,822,048.4

El. +94.4 m

102							DECOMPOSED GRANODIORITE: CLAYEY SAND (SC), very dark brown, fine to medium sand with some coarse sand, low to moderate plasticity, damp	
63.5/762	-	31	51	1	- 15	AL CA	CLAYEY SAND (SC): dense, very dark brown, moist, fine to medium grained, low to medium plasticity, some coarse sand, trace pea gravel	
70	76	2			18.0 16	SA DS	dark yellow-brown with black, white mottled	
43	51	3			- 17		low plasticity, trace oxidation	
REF/127	76	4			20.1 8		very dense, gravel up to 10 mm dia	
>70	51	5			- 12	SA CA	SILTY SAND (SM): very dense, dark brown with yellow-brown, pink, white, black mottled, moist, fine to coarse grained, no plasticity, gravel up to 10 mm dia trace oxidation	
REF/102	76	6			17.5 8			

Terminated at El. +86.68 m
9/19/02
No Groundwater Encountered

VERTICAL SCALE
1 : 100

DESIGN OVERSIGHT	KEYHAN MOGHBEL		
SIGNOFF DATE			
DESIGN	BY S. VARATHARAJ 11/20/02	R. JIE/FIELD TECHNICIAN FIELD INVESTIGATOR(S)/TITLE	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION
CHECKED	BY M. KAPUSKAR 2/12/03	DATE AS SHOWN	M. KAPUSKAR PROJECT ENGINEER

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

BRIDGE No.
KILOMETER POST

DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

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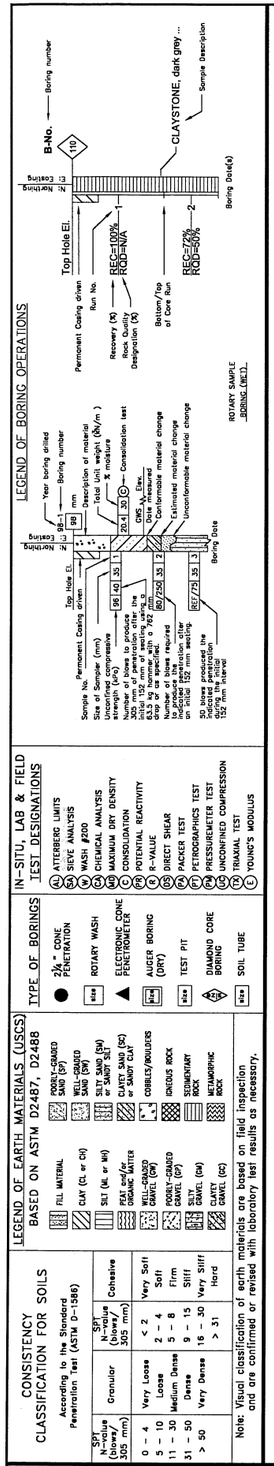
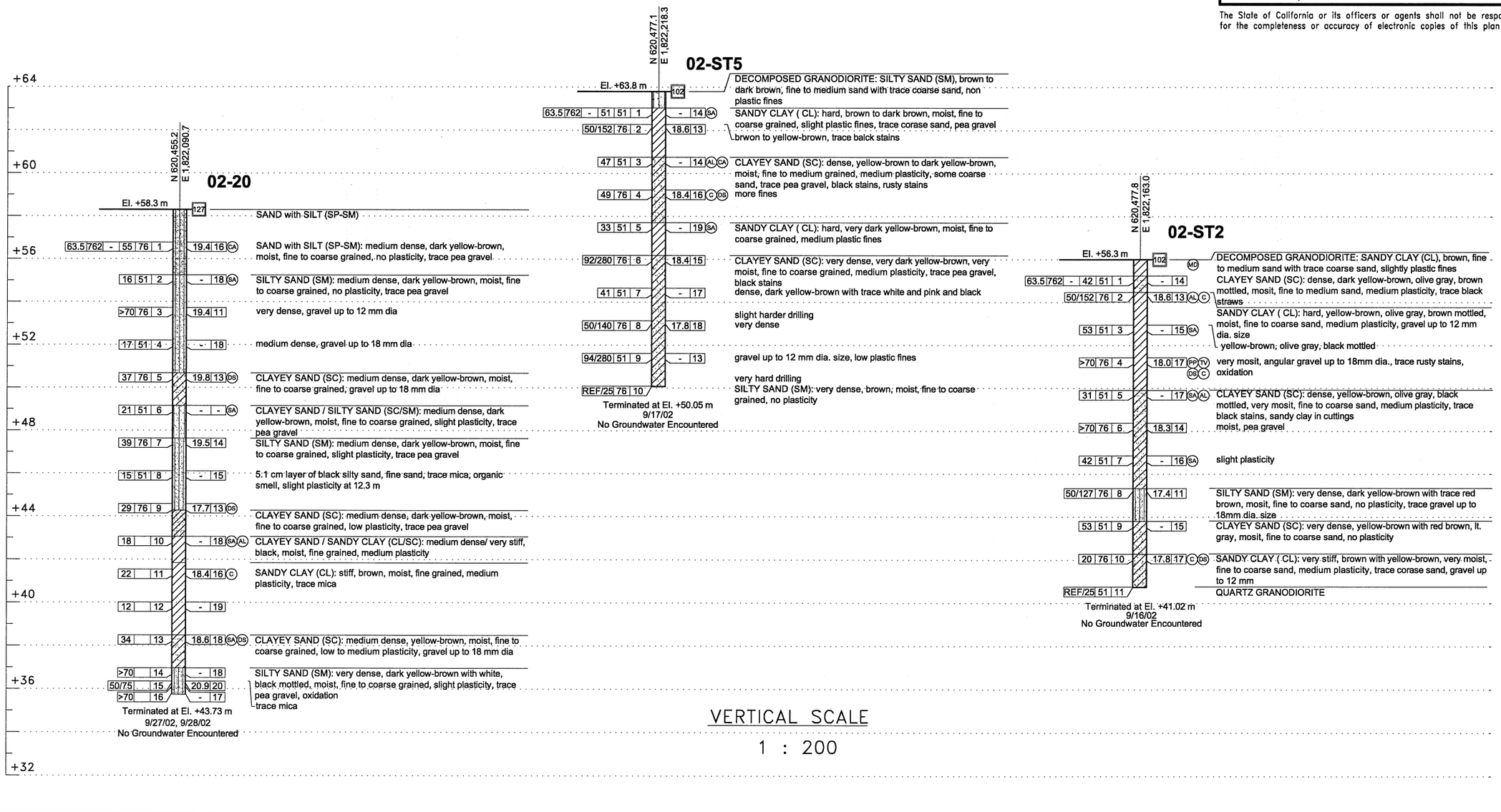
REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF





VERTICAL SCALE

1 : 200

Caltrans Metric

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DESIGN OVERSIGHT KEYHAN MOGHBEL

SIGNOFF DATE

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CHECKED BY M. KAPUSKAR 12/6/02

R. JIE/FIELD TECHNICIAN
FIELD INVESTIGATOR(S)/TITLE

DATE AS SHOWN

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

M. KAPUSKAR
PROJECT ENGINEER

ORIGINAL SCALE IN mm FOR REDUCED PLANS 0 20 40 60 80 100

CU 240
EA 11237E

BRIDGE No.

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DEVIL'S SLIDE TUNNELS
LOG OF TEST BORINGS OF

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APPENDIX C-1

FIELD LOGS
BY WOODWARD CLYDE CONSULTANTS
(REFERENCE)

FINAL

DEVIL'S SLIDE TUNNEL STUDY

APPENDIX II OF X

EXPLORATION DATA MEMORANDUM

VOLUME 2 OF 3 (Attachment II-C, Borehole Logs)

Prepared for:
California Department of Transportation

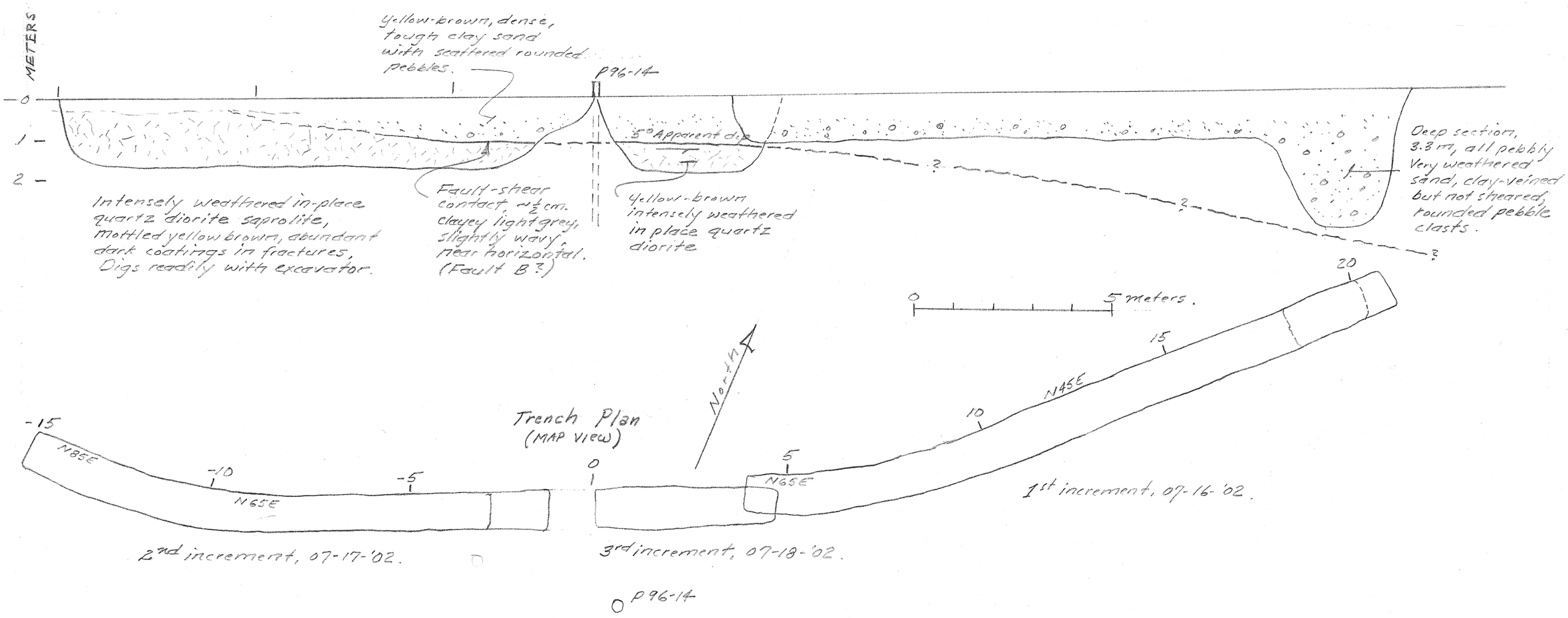
Prepared by:
Woodward-Clyde Consultants

AUGUST 1996

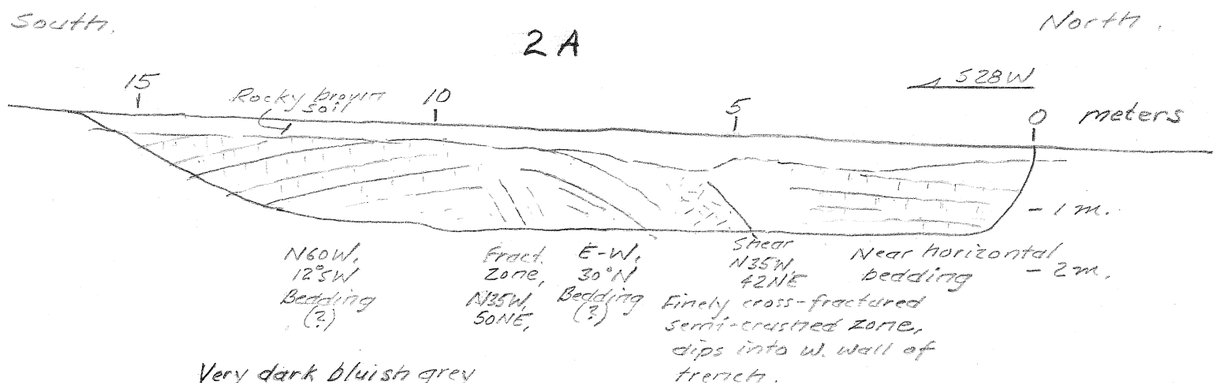
Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, California 94607-4014

APPENDIX D-1

LOGS OF TRENCHES
(2002 PHASE 2B EXPLORATION)



Log of Trench 02-T1



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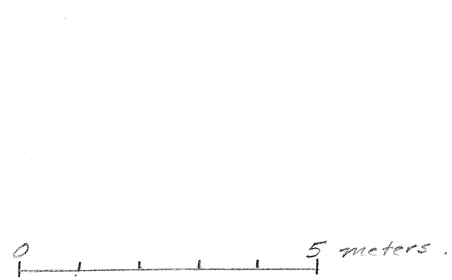

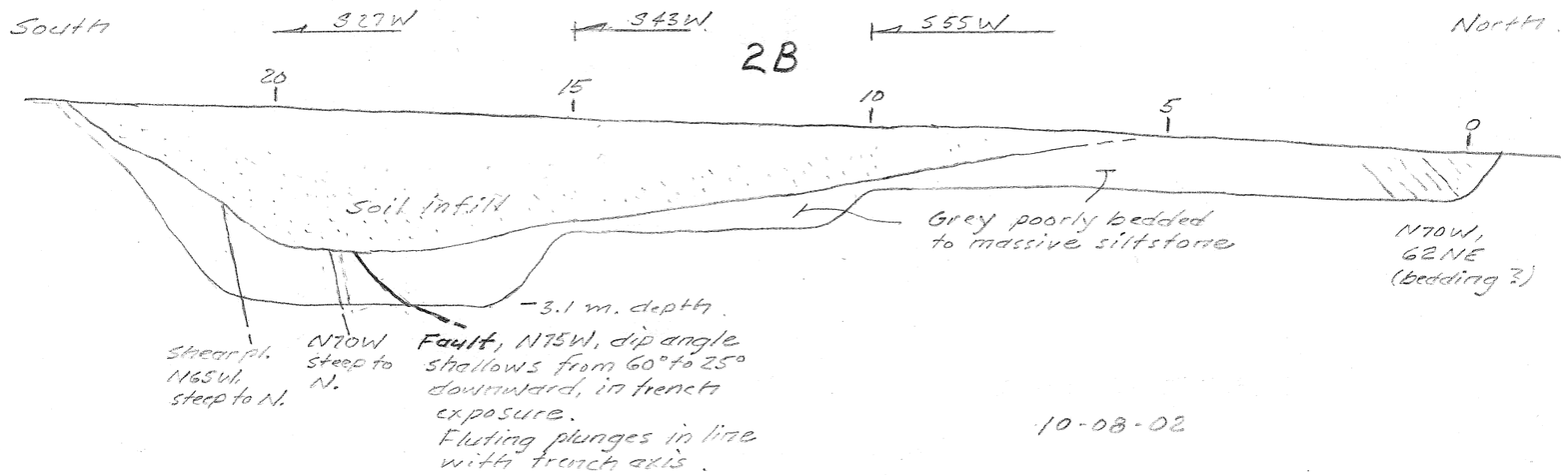

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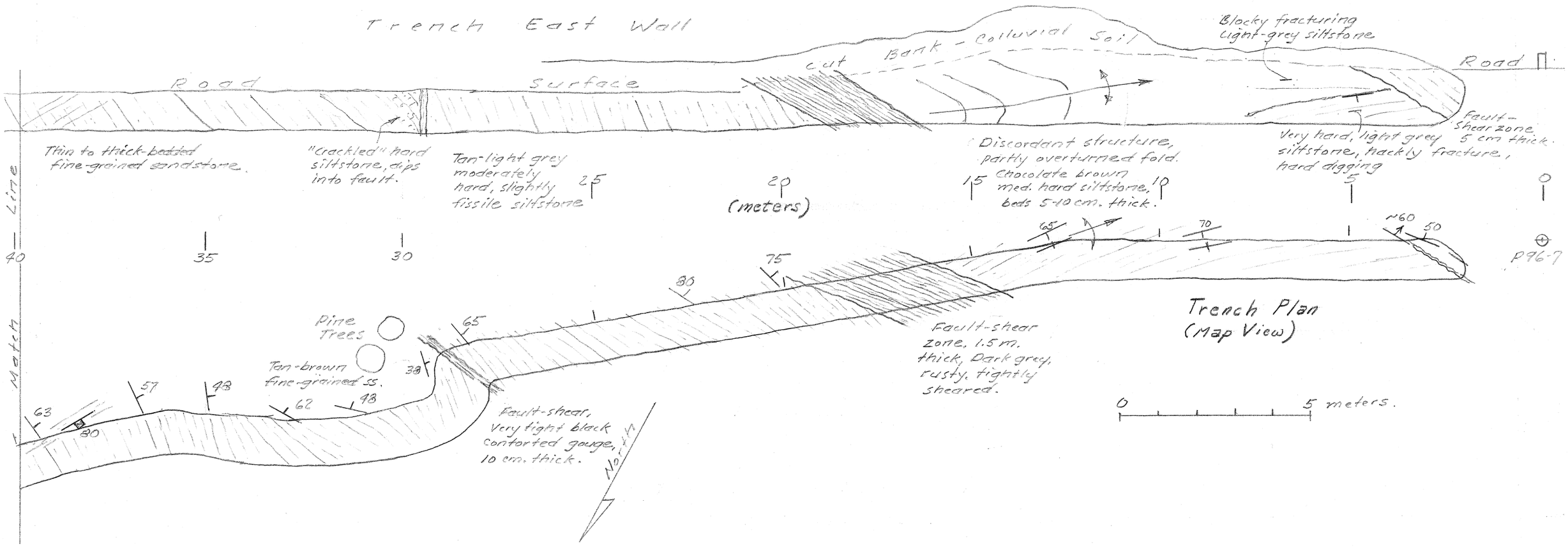

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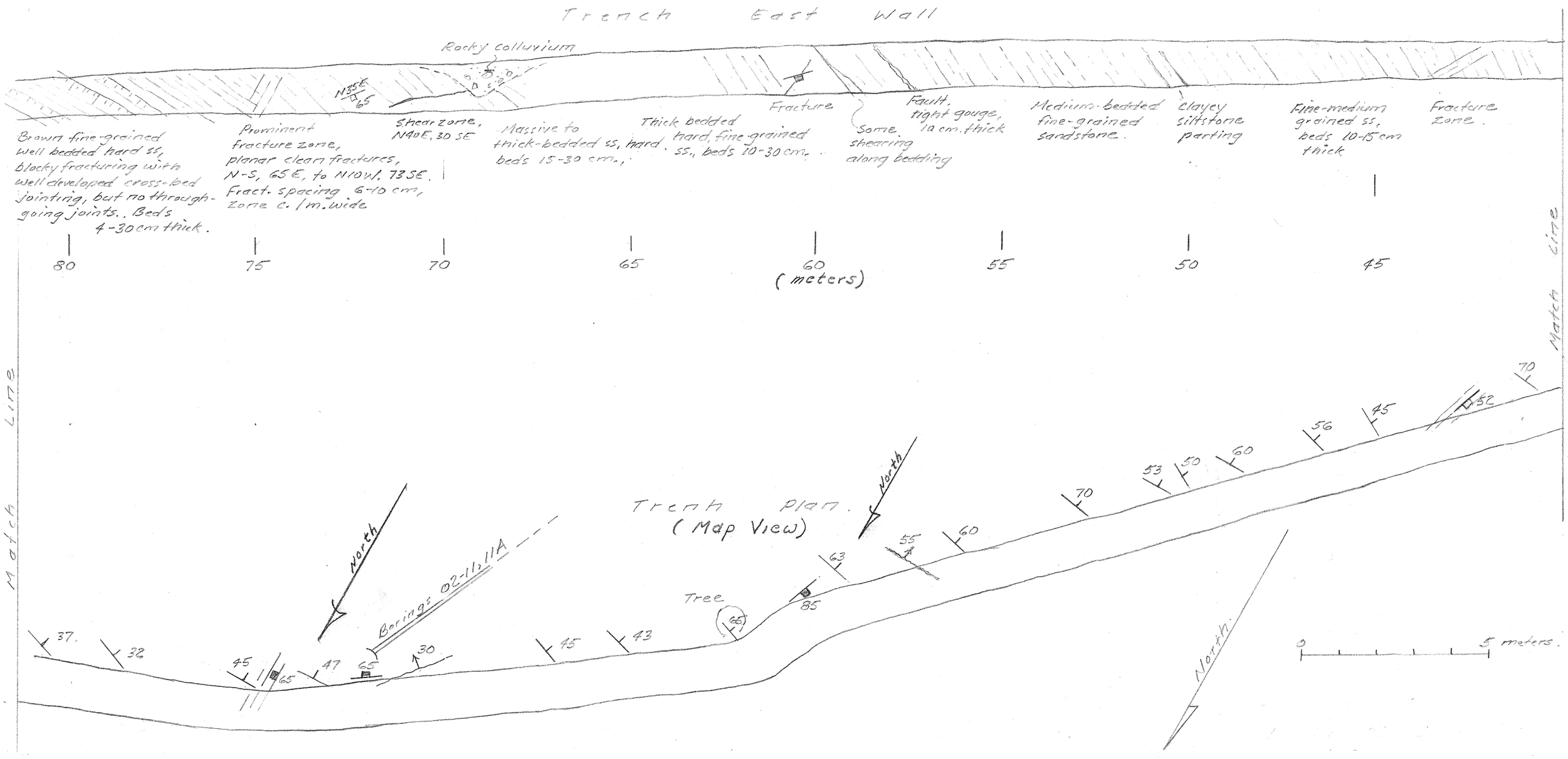

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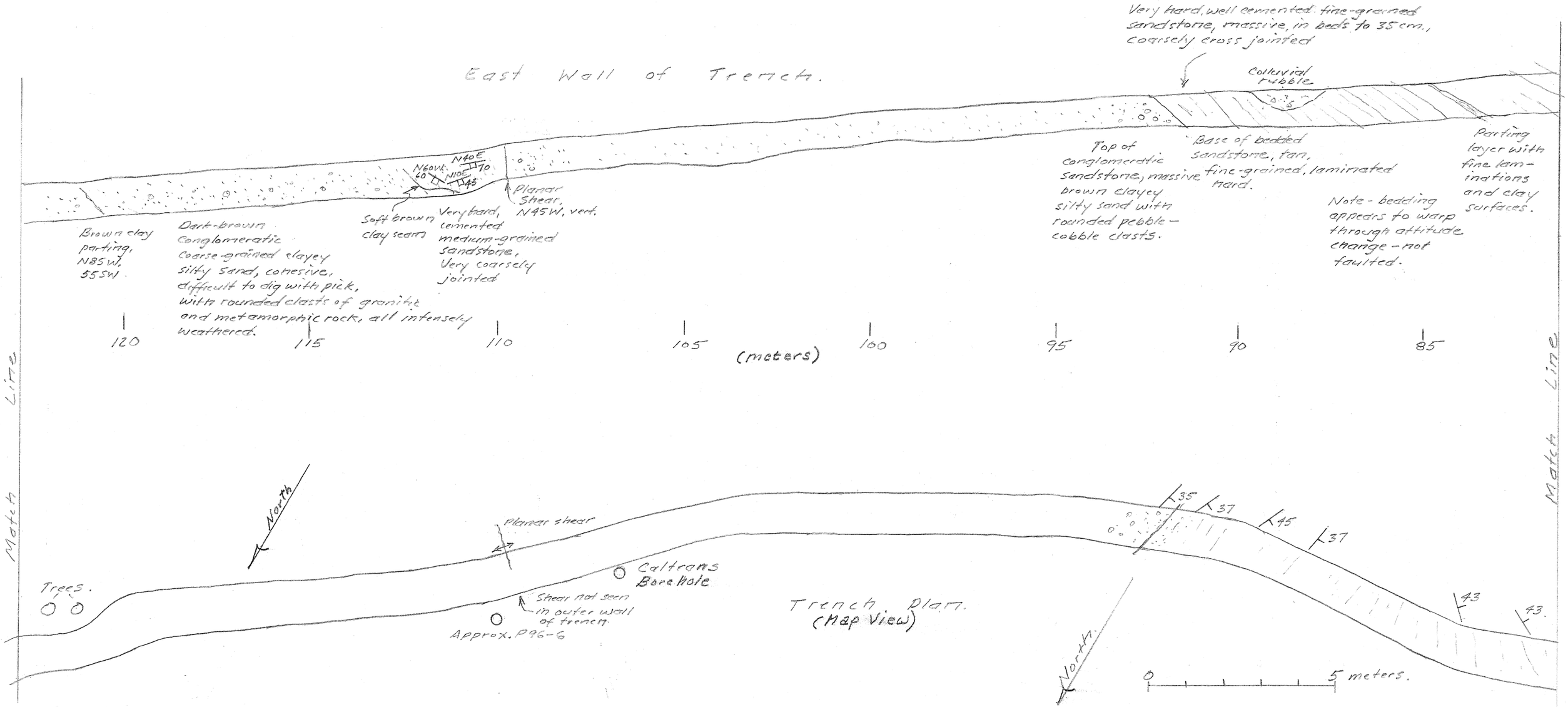
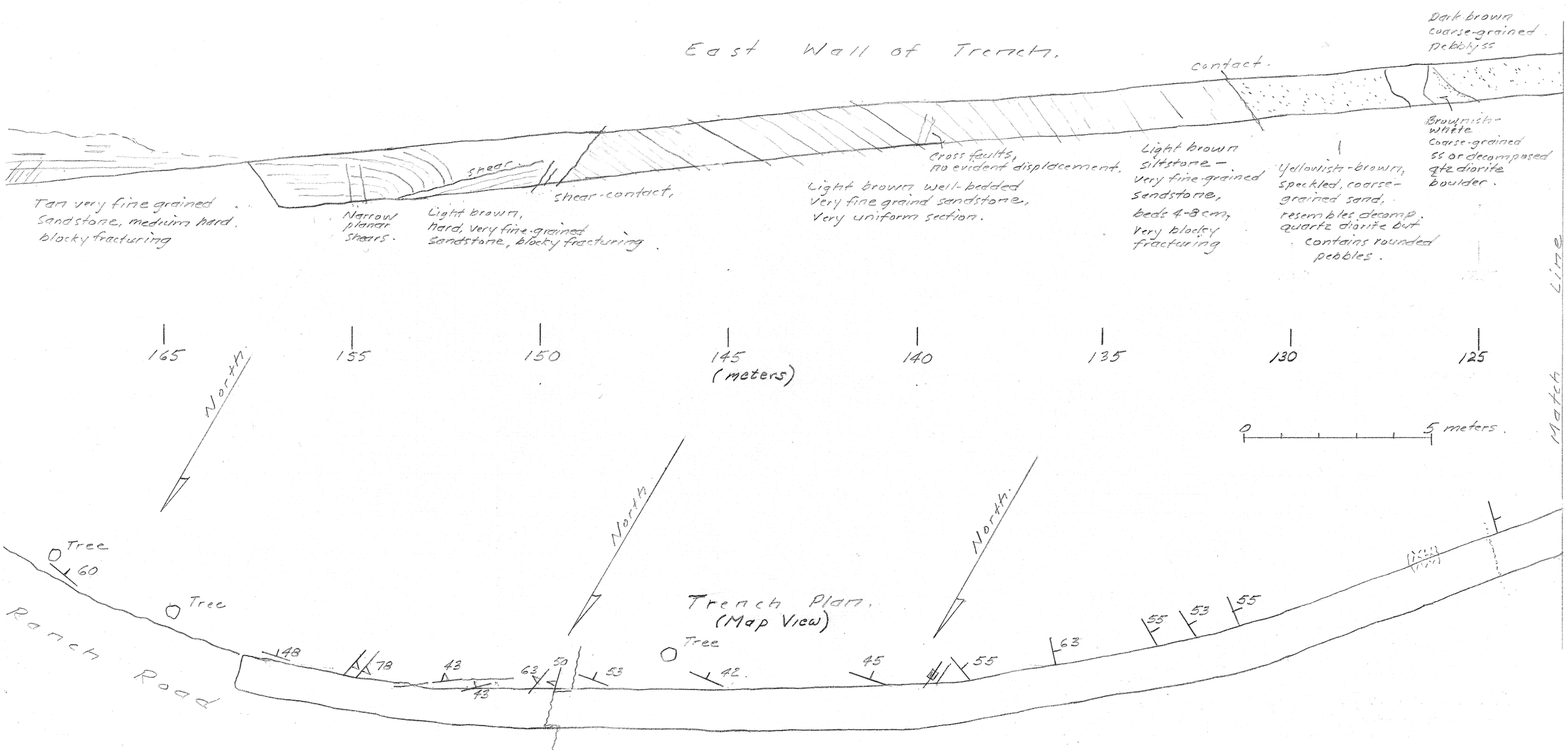


Log of Trench 02-T3 (Cont'd)



Log of Trench 02-T3 (Cont'd)

GEOLOGIC AND GEOTECHNICAL SITE CHARACTERIZATION

VOLUME 2 – IN-SITU TESTING

DEVIL'S SLIDE TUNNELS PROJECT

Prepared for
Caltrans
and
HNTB Corporation

December 9, 2002

By
Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, CA 92708

VOLUME 2 – IN-SITU TESTING

Appendix

A-2: Downhole Video Imaging ..... by Norcal

APPENDIX A-2

DOWNHOLE VIDEO IMAGING BY NORCAL

BOREHOLE GEOPHYSICAL LOGGING SURVEY
DEVIL'S SLIDE TUNNELS
SAN MATEO COUNTY, PACIFICA, CALIFORNIA

NORCAL Job Number 02-696.01B

A report prepared for

EARTH MECHANICS INCORPORATED
17600 Newhope St., Suite E
Fountain Valley, California 92708

Attention: Mike Kapuskar

by

William J. Henrich
California Registered Geophysicist GP-893

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1350 Industrial Avenue, Suite A
Petaluma, California
707-763-1312

November 25, 2002

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Appendix B: BOREHOLE 02-06 IMAGE LOG PLOTS, DISCONTINUITY AND DEVIATION TABLES

Appendix C: BOREHOLE 02-07 IMAGE LOG PLOTS, DISCONTINUITY AND DEVIATION TABLES

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NORCAL

Appendix I: CALIPER LOGS

I. INTRODUCTION

NORCAL Geophysical Consultants conducted a borehole geophysical logging survey in the Devil's Slide area which is on the east side of Highway 101 approximately one to two miles south of the city of Pacifica, California. The geophysical logging was in support of a geotechnical investigation being performed by Earth Mechanics Incorporated (EMI) along portions of a proposed 1200 meter long tunnel alignment. The geophysical logging was conducted in five phases spanning the time period August 8 through September 28, 2002 by NORCAL Geophysicist William J. Henrich. Field activities and logistical support was provided by Mr. Mike Kapuskar and Mr. Saverio Siciliano of EMI. The purpose of the survey was to identify and measure the orientation of bedding planes and fractures intercepted by a series of test borings. The data will be used to help make geologic structure maps and determine prominent fracture trends within the rock mass.

II. SCOPE OF WORK

The scope of work consisted of geophysically logging eight exploratory boreholes with optical televiewer (OPTV), acoustic televiewer (BHTV) and, when necessary, caliper tools. Depths of the exploratory boreholes ranged from 35 to194 meters.

III. SITE CONDITIONS

The study site lies within a portion of the California Coast Range. Topographic relief along the tunnel alignment varied by a much as 170 meters. The trend of the tunnel alignment is N24.7 °E. The underlying geology in the northern portion of the alignment consists of a thin (0.5 to 2 meters) layer of alluvium overlying Paleocene sandstone, shale and conglomerate. Granitic rock underlies the southern portion of the alignment. The bedrock below the tunnel alignment has been intersected by four major faults and thrusts. With the exception of one drive-up drill pad situated at the top of the highest ridge, the remaining drill pads were accessed by narrow dirt roads. As a result, it was necessary to transport the geophysical equipment by hand or with the aid of small all-terrain vehicles from a central staging area. Boreholes were drilled with a nominal100-millimeter diameter diamond core bit (HQ-size) which penetrated the underlying rock to depths ranging from 45 to 250 meters below existing grade. Most boreholes were slant boreholes with the inclination ranging from 13 to 45 degrees from vertical. Temporary conductor casing was installed at depths ranging from 1.5 to 9 meters below ground surface. Static water levels were observed ranging from the 30 to 67 meters. The wide range resulted from variations in equilibration time due to natural recharge or from dynamically falling water levels caused by recent flushing with fresh water.

IV. DATA ACQUISITION

We performed the geophysical logging using a Robertson Geologging, Ltd. Model Videologger II system. This system consisted of a control console with an in-board PC computer, portable DC winch, four-conductor logging cable, optical (OPTV) and acoustic televiewer (BHTV) probes plus a caliper logging tool.

The optical televiewer contains a "lookdown" CCD camera which records a reflected video image of the borehole wall via a precision hyperbolic mirror. The "unwrapped" sidewall borehole view (image) is created by compositing successive digitized lines of radial data referenced to magnetic North. We recorded data lines at 1 mm depth increments with a axial resolution of 720 pixels per data line. In addition, the optical tool contains a three-axis magnetometer and inclinometer that records the North reference plus bearing and inclination of the borehole axis as a function of depth.

The acoustic televiewer creates an "unwrapped" sidewall image by recording variations in two-way travel-time and amplitude attenuation from ultra sonic pulses emitted from a rotating sonic transducer mounted at the base of the tool. The center frequency of the BHTV transducer was 0.5 Mhz. The BHTV logging tool has the same orientation characteristics (reference to magnetic north) as the OPTV tool. We used two BHTV tools, one with a compass and one with compass and bearing/inclination sensors. The latter BHTV tool type was used to collect data in Borings 02-08B and 02-05. BHTV depth sampling was at 5 millimeters intervals. BHTV tool performance is generally unaffected by borehole fluid turbidity.

The sedimentary rocks in the Devils Slide area along the northern portion of the tunnel alignment have been subjected to successive episodes of tectonic activity that has resulted in extensive uplift, folding, shearing and faulting. This mechanical activity caused rock instability in localized portions of certain boreholes. In the cases where the drilling had encountered particularly unstable rock conditions (as reported by the rig geologist or driller) we conducted a caliper log in advance of logging the borehole with the more expensive image logging tools. For the survey in general, we experienced difficult logging conditions primarily because the boreholes had encountered faults or shear planes which precluded logging to total borehole depth. In some boreholes, loose rocks from crushed zones would fall on top of the probe, temporarily lodging it at depth. This made for very apprehensive recovery efforts.

Unless cautioned by the driller, we typically conducted the OPTV log first. Our log datum was taken as the existing ground surface. In general, OPTV image data was acquired both the down and up going directions at winch speeds of 1.3 meters per minute. On the initial (down going) OPTV log the viewing glass is typically free of smears and water marks. This presents the best opportunity to record a clear image in the dry section of the boring. This was important because in most cases the dry section comprised a significant percentage of each borehole. The logging would continue into the fluid-saturated portion of the borehole, assuming that the borehole fluid was clear for optical viewing. In cases where the borehole fluid became too cloudy or turbid to

view the sidewall, we terminated logging. Generally, a second OPTV log was recorded in the up going direction as check on the repeatability of the log in terms of image orientation.

In boreholes with cloudy fluid conditions with (determined by OPTV logging), we logged the fluid-filled portion of the borehole with an acoustic televiewer (BHTV). We recorded BHTV logs at a winch speed of 1.4 meters per minute.

We checked the OPTV and BHTV tool north references (magnetic north) with a Brunton compass and a specialized jig on the ground surface. The jig consists of a 75 millimeter diameter PVC casing (0.3 meters long), support stand and a non-magnetic rod (5 millimeters diameter) strapped vertically to the inside of the casing. We oriented the rod to the south with the Brunton compass, centered the logging tool in casing, then recorded a depth driven log file. The results of the checks showed throughout the survey that magnetic north/south as indicated by the logging tools was within plus or minus seven degrees of the magnetic north/south indicated with the jig.

As a field procedure, we distributed copies of the OPTV log to our client representative on a CD- ROM. These logs could be replayed on a Windows based computer through an attached program *VIEWOPTV* published by Robertson Geologging, Inc.

V. DATA PRESENTATION

The OPTV and BHTV logs are presented in Appendices A through H. Each letter Appendix corresponds to a single Borehole (02-05, 02-06 etc.) and can contain various runs of OPTV and BHTV plots conducted in the respective borehole.

Both OPTV and BHTV logs are represent as perspective core and continuous "unwrapped" images of the borehole wall as a function of depth. The OPTV logs are true 24-bit color video images. Distortions in the OPTV image occur as the result of borehole breakouts (diameter enlargements), fogging (air-filled borehole only), random smearing on the outside viewing glass or disruptions to logging speed caused by physical constrictions encountered in the borehole. The BHTV images are a false-color representations of the borehole wall with the changes in color intensity corresponding to variations in reflected amplitudes. Borehole discontinuities like fractures, thin shaly beds, and bedding contacts cause localized changes in borehole diameter which have the effect of scattering and reducing measured acoustic amplitudes. These borehole features are represented by low intensity colors approximating sinusoidal patterns on the BHTV plot.

The first image on the log plot is a core projection of the sidewall. The "eye"perspective is from north (front of the page) to south. The second image consists of a continuous two-dimensional "unwrapped" borehole section. The leftmost margin of this plot corresponds to north. Directionally, the borehole image "unwraps" left to right across the page, as east, south, west then finally to north represented by the far right margin on the plot. The major directions (east,

south, west) correspond to equi-spaced vertical grid lines superimposed on the plots. The orientation of these images has been corrected to true North by adding16 degrees to the raw north azimuth (0 degrees) recorded by both tool compasses.

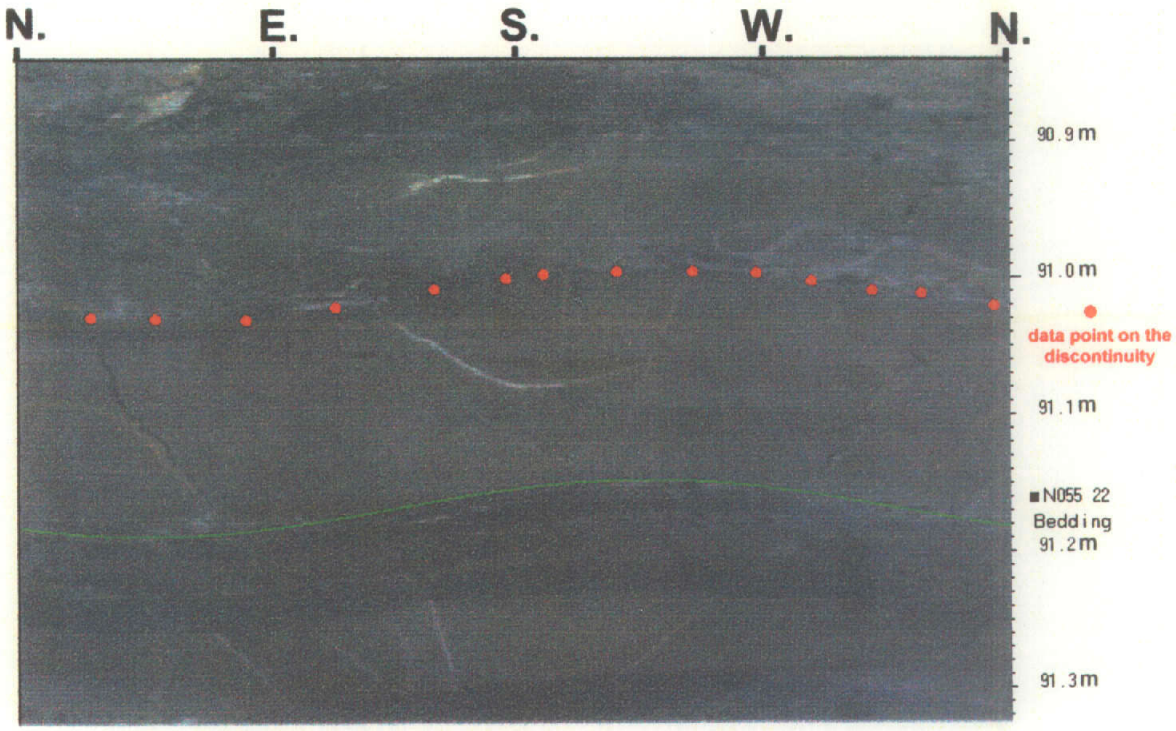
VI. DATA REDUCTION AND INTERPRETATION

Borehole Image Log Plots

The borehole Image logs were imported to the computer reduction and interpretation program *RGLDIP,* v. 6.1 (2002) published by Robertson Geologging, Ltd. Parameter input consisted of a magnetic correction (16 degrees) and a nominal borehole diameter. When caliper data was available, these data were input in lieu of a nominal borehole diameter. In instances where a compass-only BHTV tool was used to collect data, the average borehole deviation indicated by OPTV logging was extrapolated to the depth of the BHTV to create a borehole deviation record. This deviation record became part of the processed BHTV log and was subsequently accessed to convert interpreted discontinuities in borehole coordinates (dip direction, dip) to geographical coordinates.

In the interpretation stage, the computer program presents1to3 meter-long sections of correctly oriented " unwrapped" images (OPTV or BHTV) on a computer screen. For each discontinuity, we interactively nominate (mouse) points along the trace of the discontinuity (See Figure 1)

Figure 1 Unwrapped OPTV Image showing selected points Along a Discontinuity Trace



Typically, 5 to15 points were selected per trace. At the conclusion of point selection, the program calculates a best-fit ellipse that represents the discontinuity as a plane in terms of dip direction and dip magnitude. The apparent dip direction and magnitude (borehole axis coordinates) of the discontinuity are then corrected for borehole deviation into a geographically true dip direction and magnitude by the RGLDIP program. These corrected directional data can be found in text form next to the unwrapped image (see Appendix A through H) and under the "Comments" column. The computer program generated sinusoid associated with the text data can be found as either red or green color overlays on full or discontinuous borehole feature traces shown on the unwrapped image. BHTV image logs contain an additional plot, namely an "arrow" plot which is a graphic which depicts dip direction and dip angle of a discontinuity with an arrow like symbol. The arrow's plotted position on the horizontal axis represents dip magnitude. The direction of the arrow tip relates to the azimuth.

Discontinuity Tables

We classified discontinuities into two main types namely fractures or bedding. In general, we restricted our interpretation (selection) only to open fractures and not to cemented or mineralized fractures. Most discontinuities were continuous (360 degrees) across the "unwrapped" image plot, however, in complexly fractured zones or where discontinuities contain a apparent high dip angle (70 degrees or greater), only segments of the discontinuity were observed. We subdivided these discontinuities as either discontinuous or segmented. Due to the complexity and extreme segmentation of discontinuity traces in some fracture zones, not all possible fractures were subject to tabulation and interpretation. This is to say that the number of interpreted fractures in our analysis will not always correlate to the fracture frequency as determined from rock core analysis for reasons of significance, detection, cementation (in the case of BHTV logs) and undetected breakage of core at the surface. The results from of our discontinuity interpretation are presented as a series of tables and can be found in Appendix A through H. The tables contain column headers which identify various parameters and descriptions from the interpretation. A explanation of column headers is as follows:

COLUMN	CONTENTS
1	First column: discontinuity number (1....N)
2	*Depth*: center depth in meters of interpreted feature (fracture in the majority of cases)
3	*1-Po/100*: This parameter ranges from 0 thru 1.0 according to how well the calculated plane fits the digitized points on a discontinuity trace.
4	*Azimuth*: calculated true dip direction (0-360 degrees) of the plane contained in the discontinuity trace

5 *Dip*: calculated dip magnitude (0-90 degrees) of the plane contained in the discontinuity trace

6 n: number of digitized points selected along the discontinuity trace

7 *Q*: a quality parameter A, B, C, D with decreasing quality of fit

8 *K*: classification of interpreted feature (fracture or bedding)

9 *Upper Depth*: lowest position of the interpreted plane contained inside a discontinuity trace in meters

10 *Lower Depth*: highest position of the interpreted plane contained inside a discontinuity trace in meters

11 *Well Diam*: borehole diameter (in meters)

Well Deviation

12 *Azimuth*: bearing in degrees of the borehole axis

13 *Dev*: inclination in degrees of the borehole axis from vertical

14 *Thickness*: true thickness of fracture or bed. Not analyzed

15 Geologic classification of discontinuity with modifiers.

Bedding was obvious in our analysis of OPTV logs. This was because the sedimentary rock was very thinly bedded (a few centimeters in some cases) and visibly pronounced. With respect to the BHTV interpretation of bedding, we studied the overlap between the BHTV and OPTV logs where possible to learn how the BHTV pattern related to bedding, then extended this pattern recognition to other BHTV logs without complimentary OPTV coverage. As a generality, massive sandstone sections appeared to have retained a constant dip azimuth and dip magnitude throughout the logged borehole section. However, the weaker shaly interbeds or sheared, broken sub beds, showed bedding attitudes that changed significantly from the pattern of dip established by the more massive, competent sandstones. More severe changes in bedding appeared to be related to faulting.

Borehole Deviation Tables

As requested by EMI we have included the borehole deviation data in this report. Borehole deviation represents the trajectory of the borehole that is expressed in terms of true depth and the projection from true depth intervals to points on the surface in Northing and Easting coordinates. relative to the borehole collar (0,0). The deviation data is presented as a series of tables for all

boreholes in Appendix A through H, Borehole Deviation Tables. The six columns of these tables show the following:

Column	Contents
1	*Depth*: probe depth (in meters)
2	*North*: northing surface coordinate (in meters)
3	*East*: easting surface coordinate (in meters)
4	*down:* vertical depth (in meters)
5	*Devaz*: borehole bearing (in degrees from geographic North)
6	*Dev*: borehole inclination from vertical (in degrees)

Caliper Logs

Caliper logs conducted in Boreholes 02-05 and 02-08C are presented in Appendix I, Caliper Logs.

APPENDICES A THROUGH I

Appendix A

BOREHOLE 02-05
IMAGE LOG PLOTS
DISCONTINUITY AND DEVIATION TABLES

NORCAL GEOPHYSICAL CONSULTANTS, INC.

OPTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED OPTV DIPS LOG

26 Sep 2002

EARTH MECHANICS

Borehole: BH 02-05

DEVIL'S SLIDE

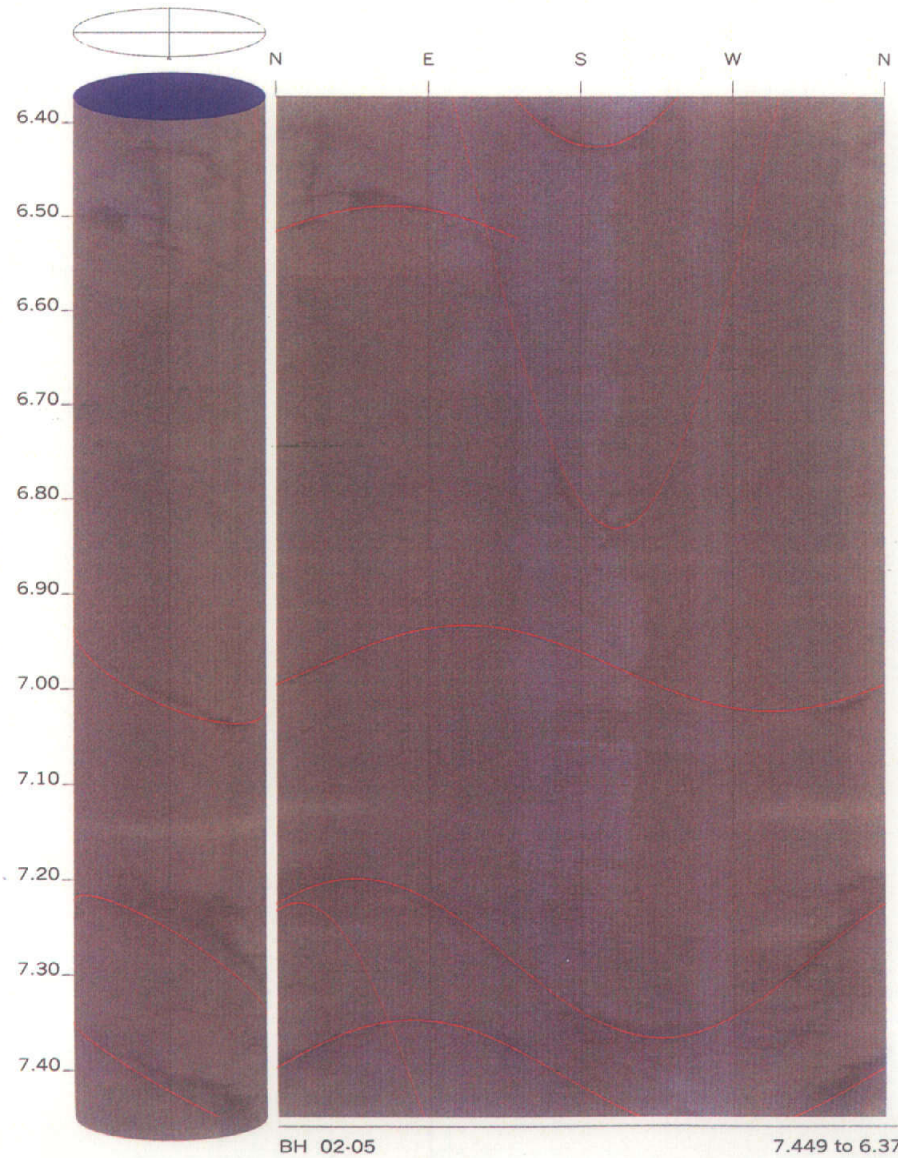
top of borehole.....
East:
North:
Alt:

North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = fixed format

Zone from 67.226 to 6.372m
Vertical = borehole-axis

Borehole diam: 11.130cm

BEDDING
FRACTURE
Identified units



COMMENTS

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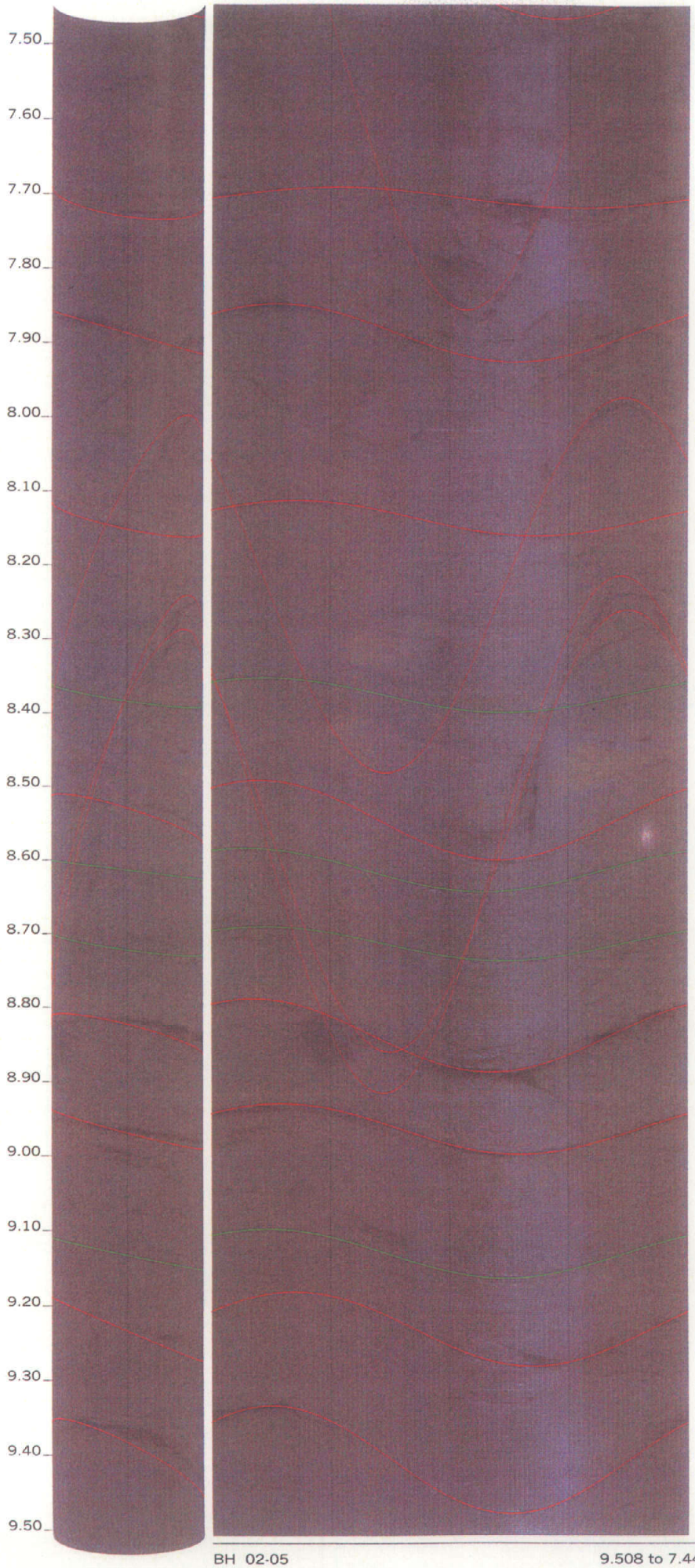
N246 40 Fracture Discontinuous

N291 39 Fracture

N226 57 Fracture

N259 47 Fracture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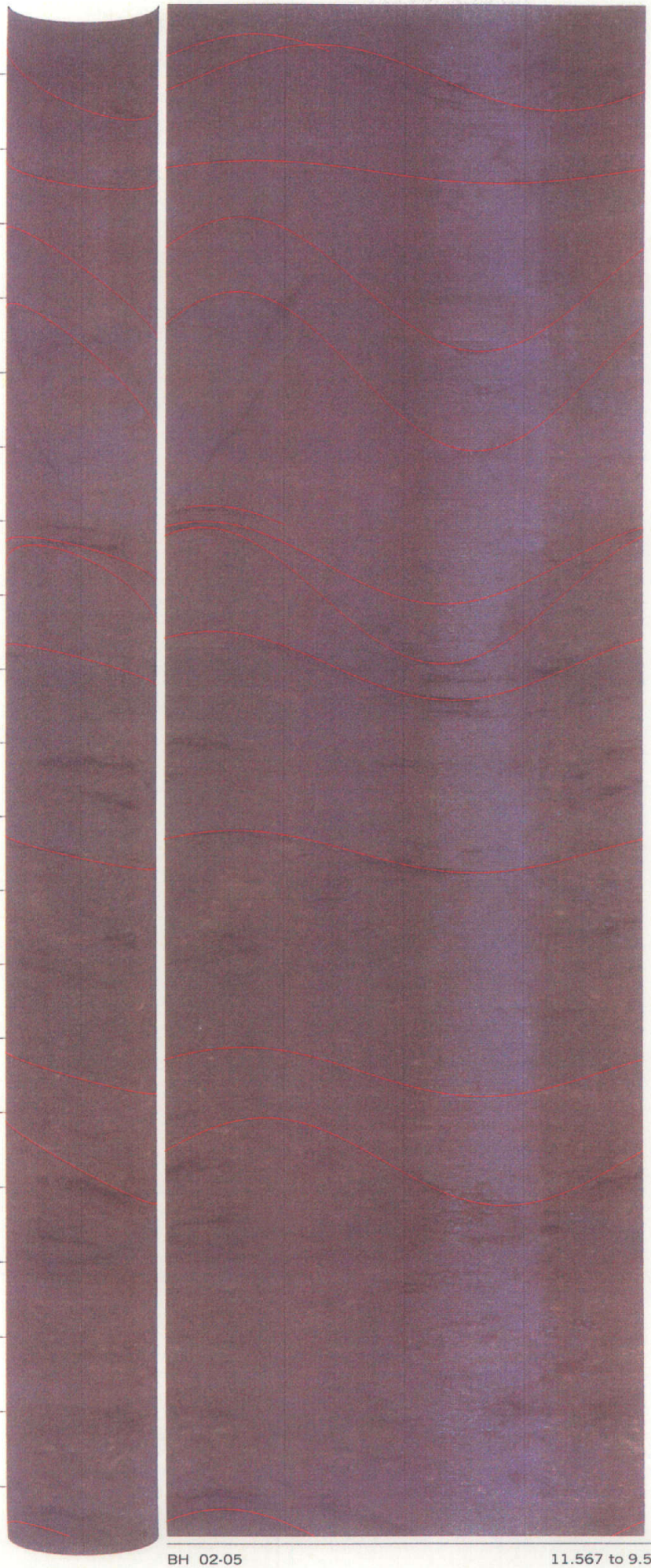
8.80
8.90
9.00
9.10
9.20
9.30
9.40
9.50
N193 81 Fracture Discontinuous
N273 13 Fracture
N229 35 Fracture Discontinuous
N243 23 Fracture
N132 78 Fracture
N220 23 Bedding
N216 45 Fracture
N206 29 Bedding
N219 23 Bedding
N211 42 Fracture
N232 32 Fracture
N222 31 Bedding
N242 42 Fracture
N225 53 Fracture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11.50
N245 42 Fracture Discontinuous
N293 37 Fracture
N247 15 Fracture
N236 58 Fracture Discontinuous
N234 63 Fracture
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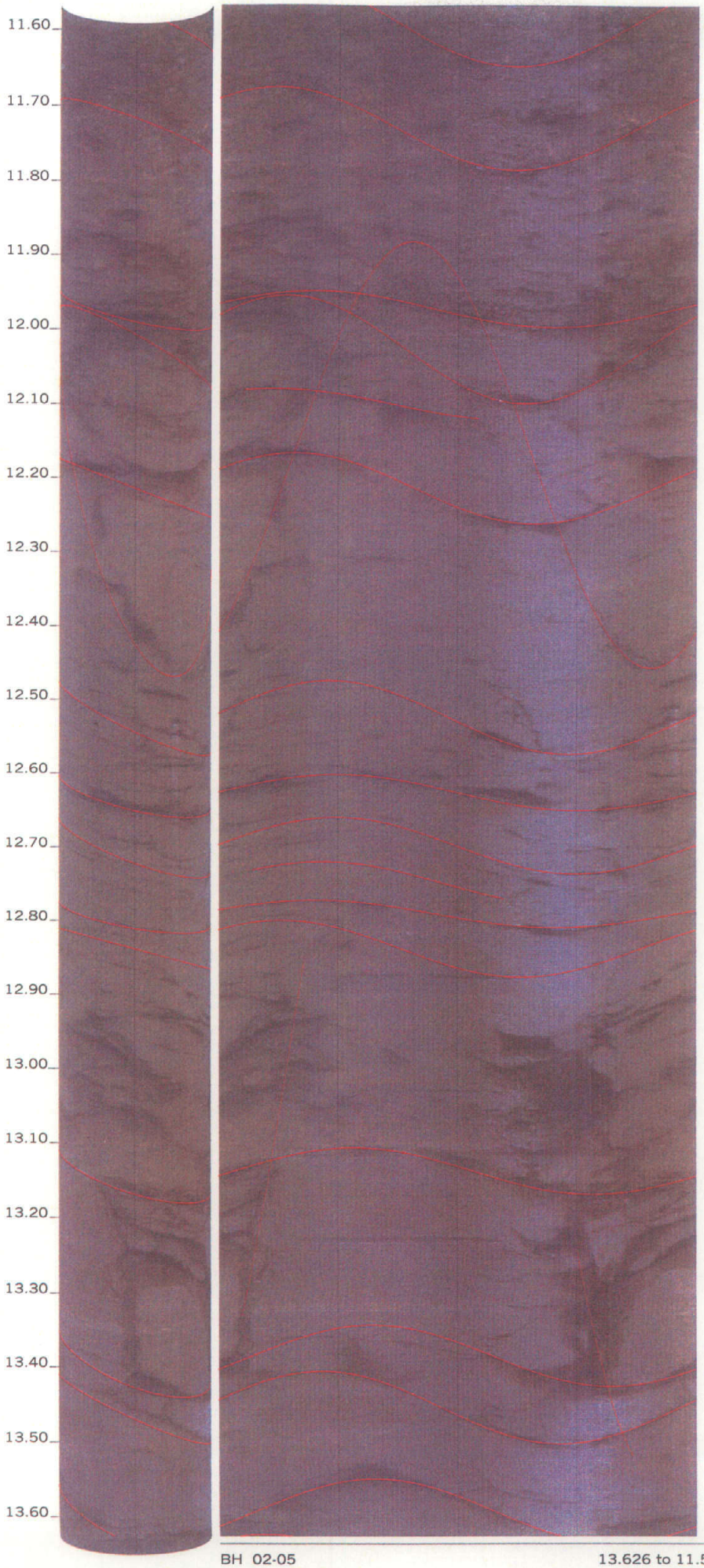
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N223 45 Fracture
N251 24 Fracture Weathered
N230 53 Fracture Discontinuous
N220 21 Fracture Discontinuous
N326 78 Fracture Discontinuous
N237 41 Fracture
N263 42 Fracture
N268 23 Fracture
N268 34 Fracture
N257 28 Fracture Discontinuous
N251 18 Fracture
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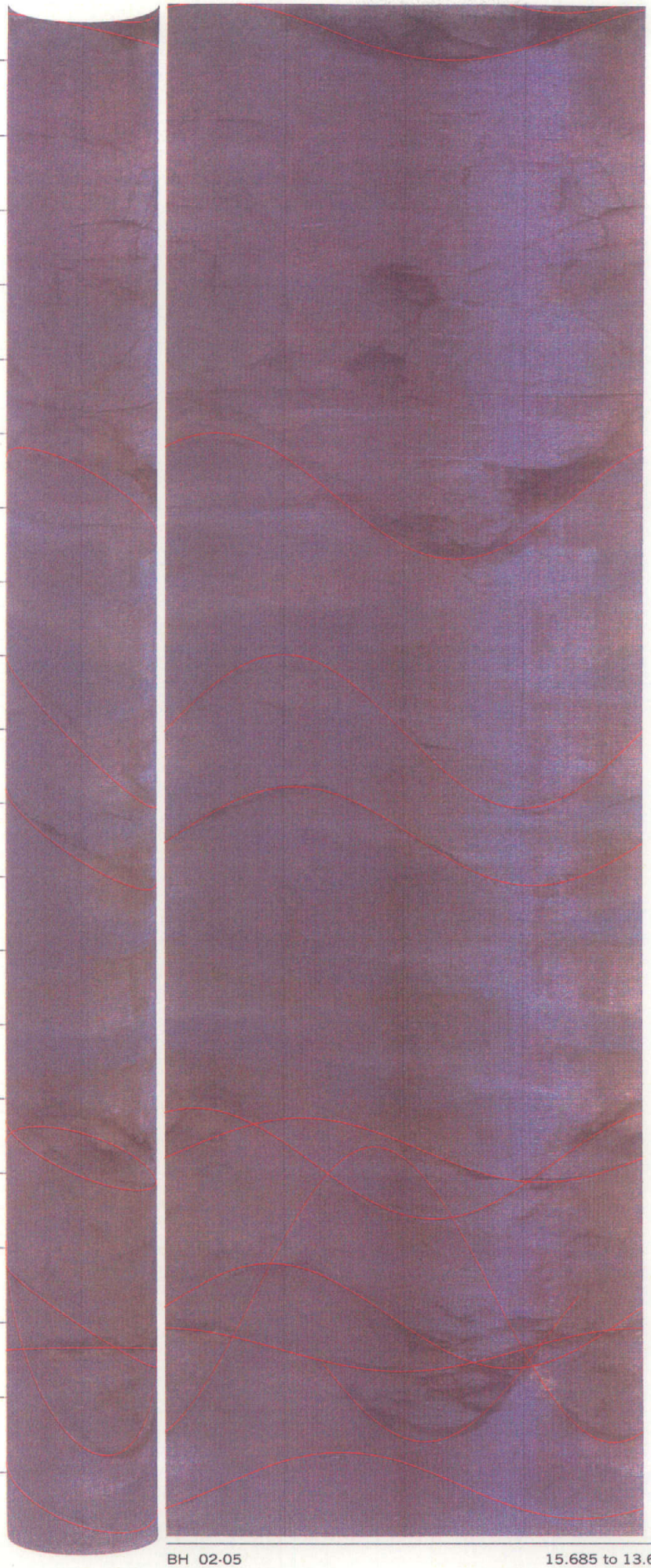
N295 36 Fracture
N257 41 Fracture
N298 37 Fracture Irregular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N218 57 Fracture Irregular
N270 61 Fracture
N277 50 Fracture
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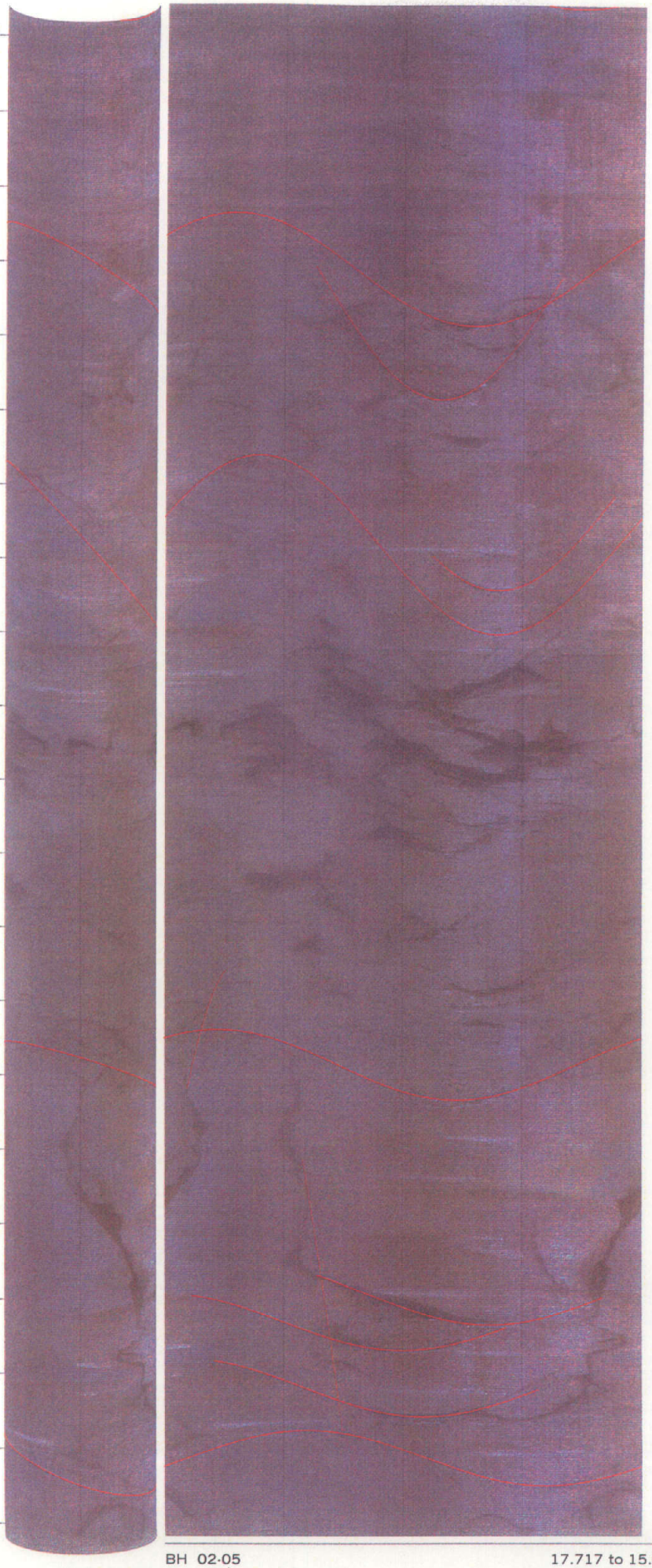
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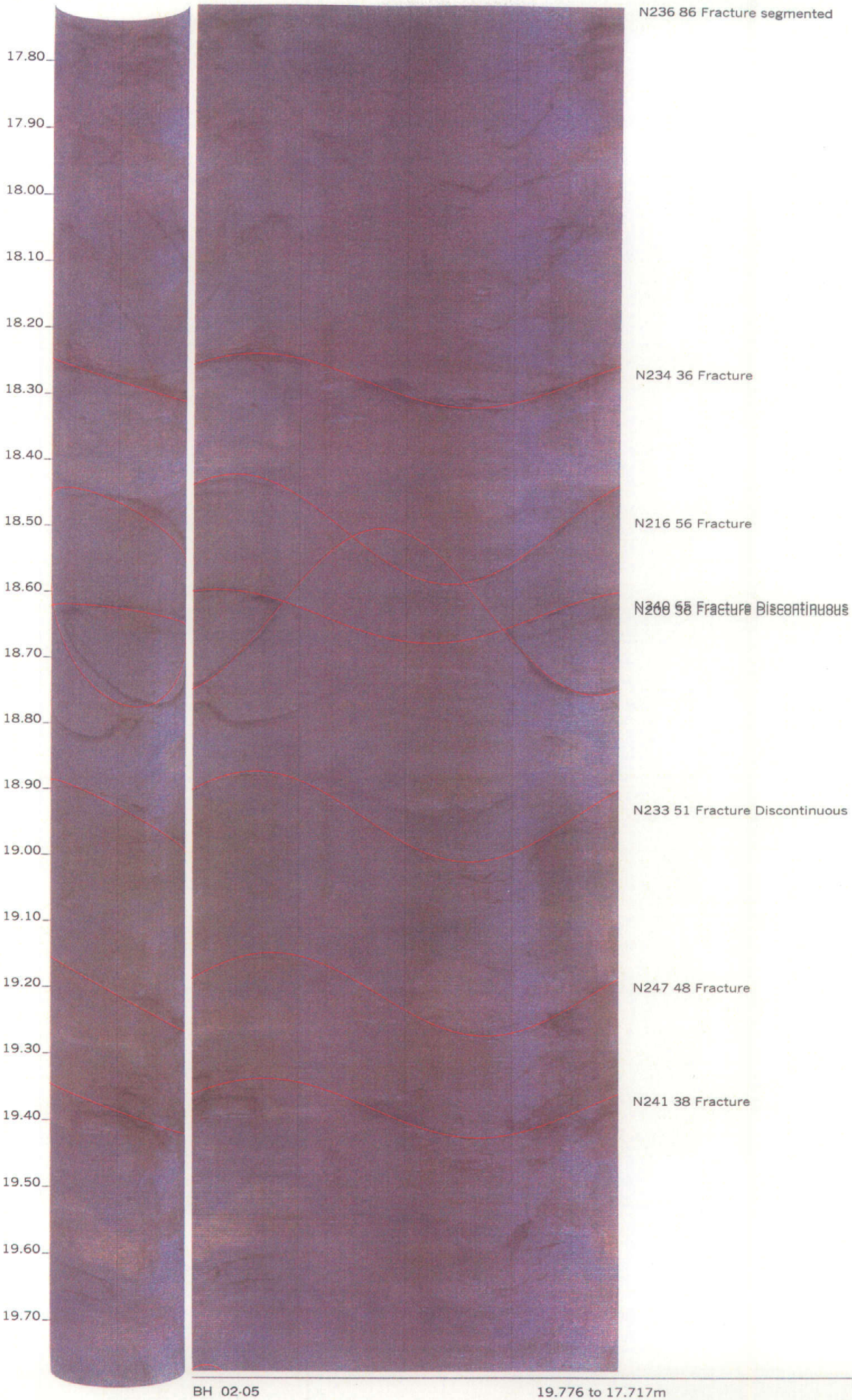
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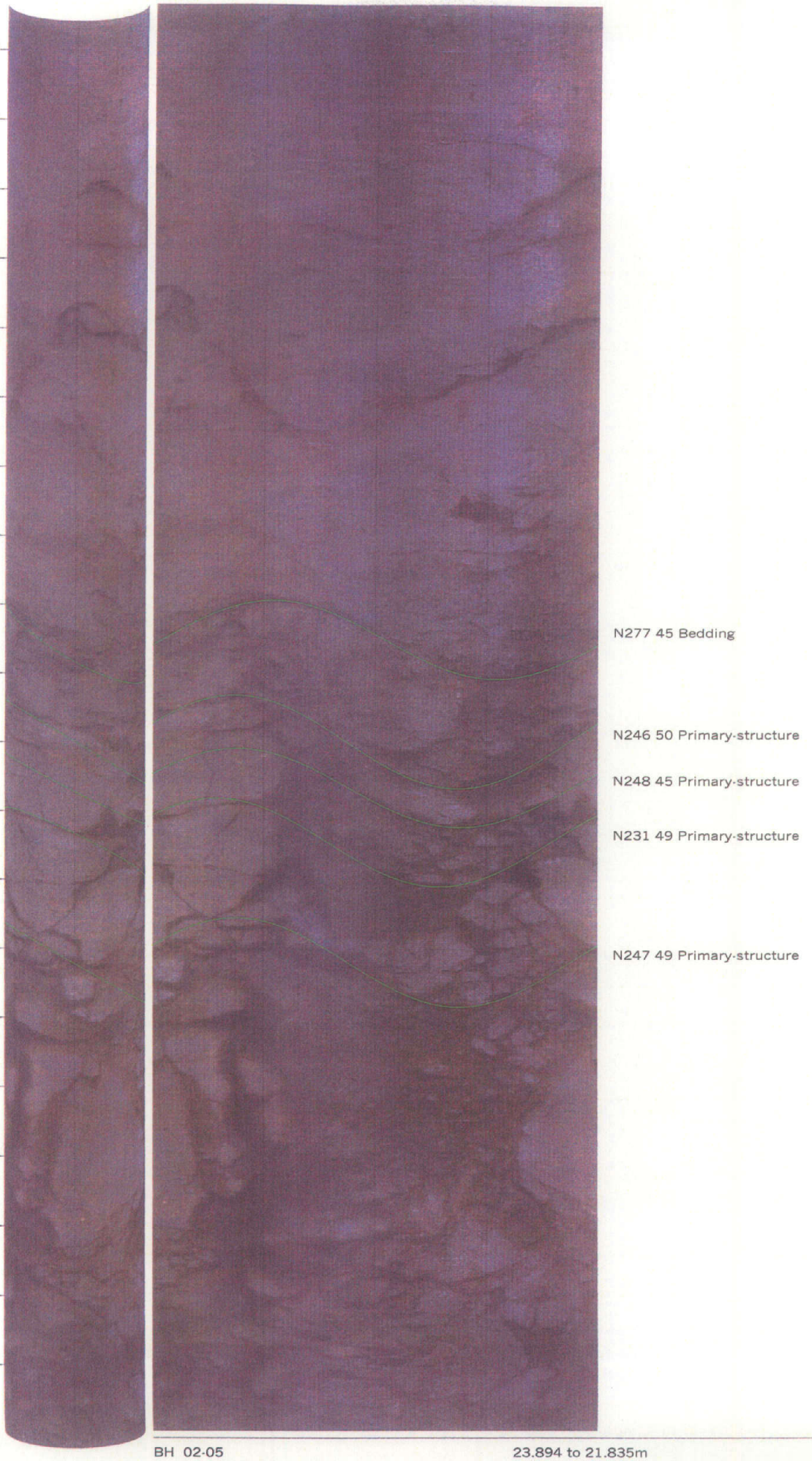
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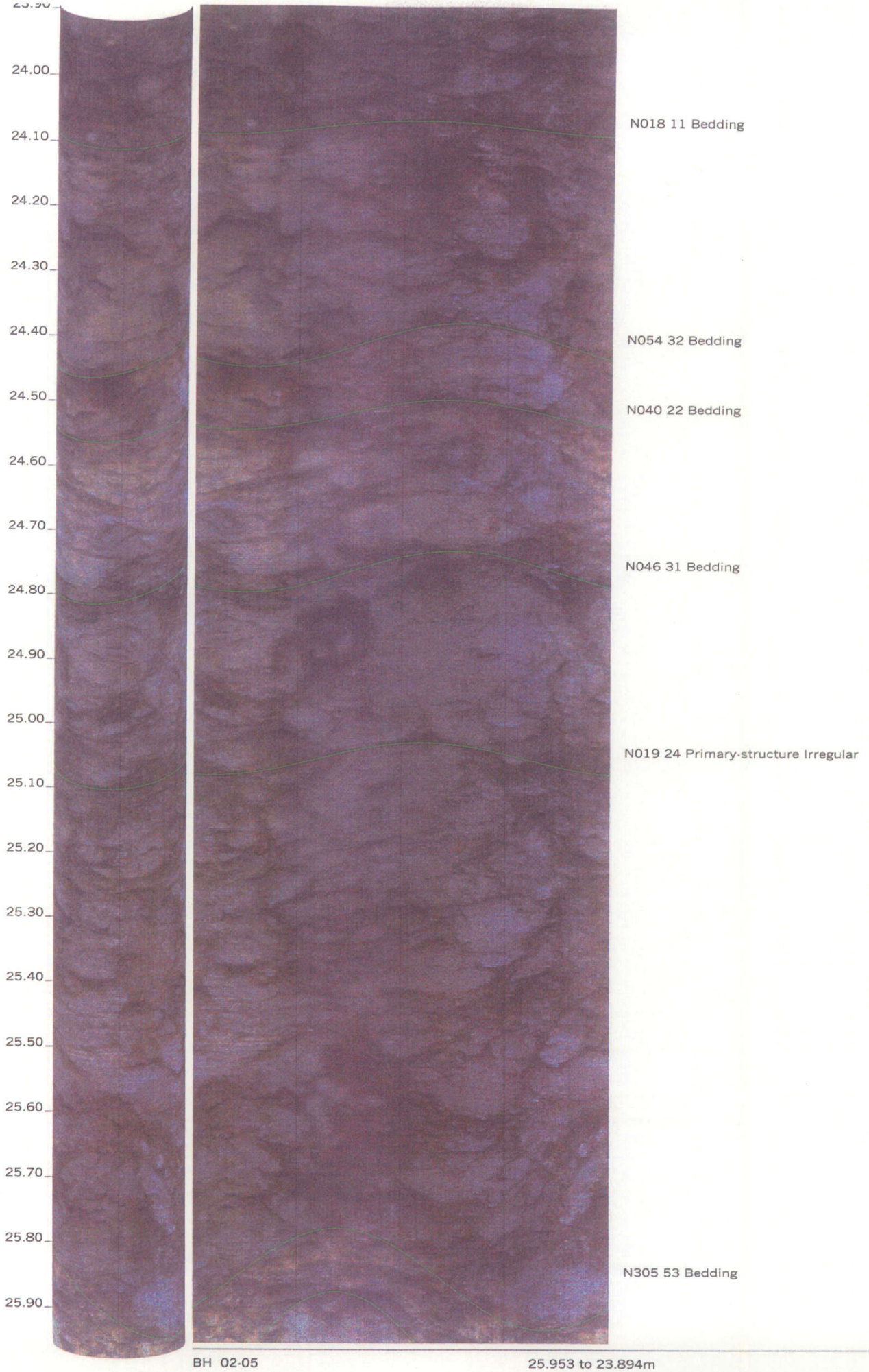
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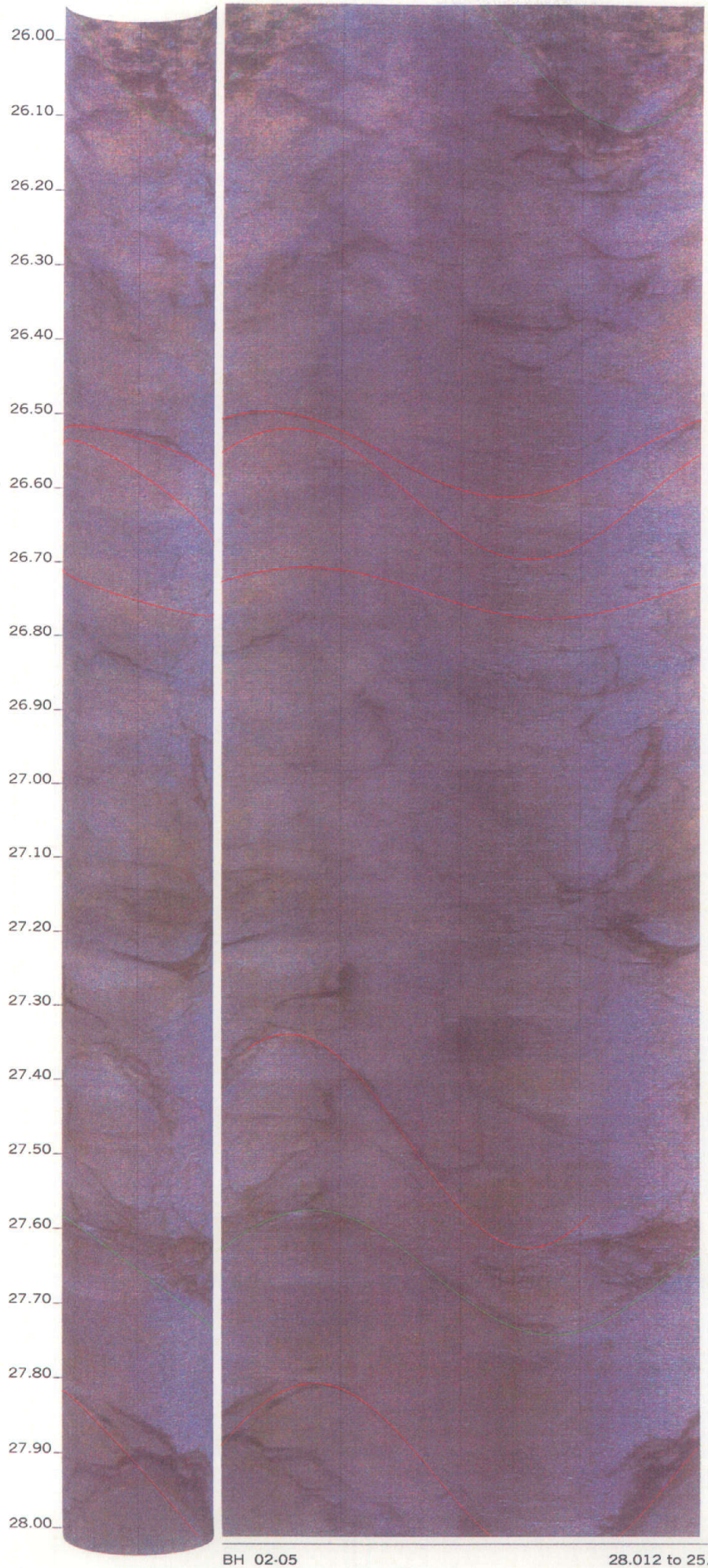
N305 53 Bedding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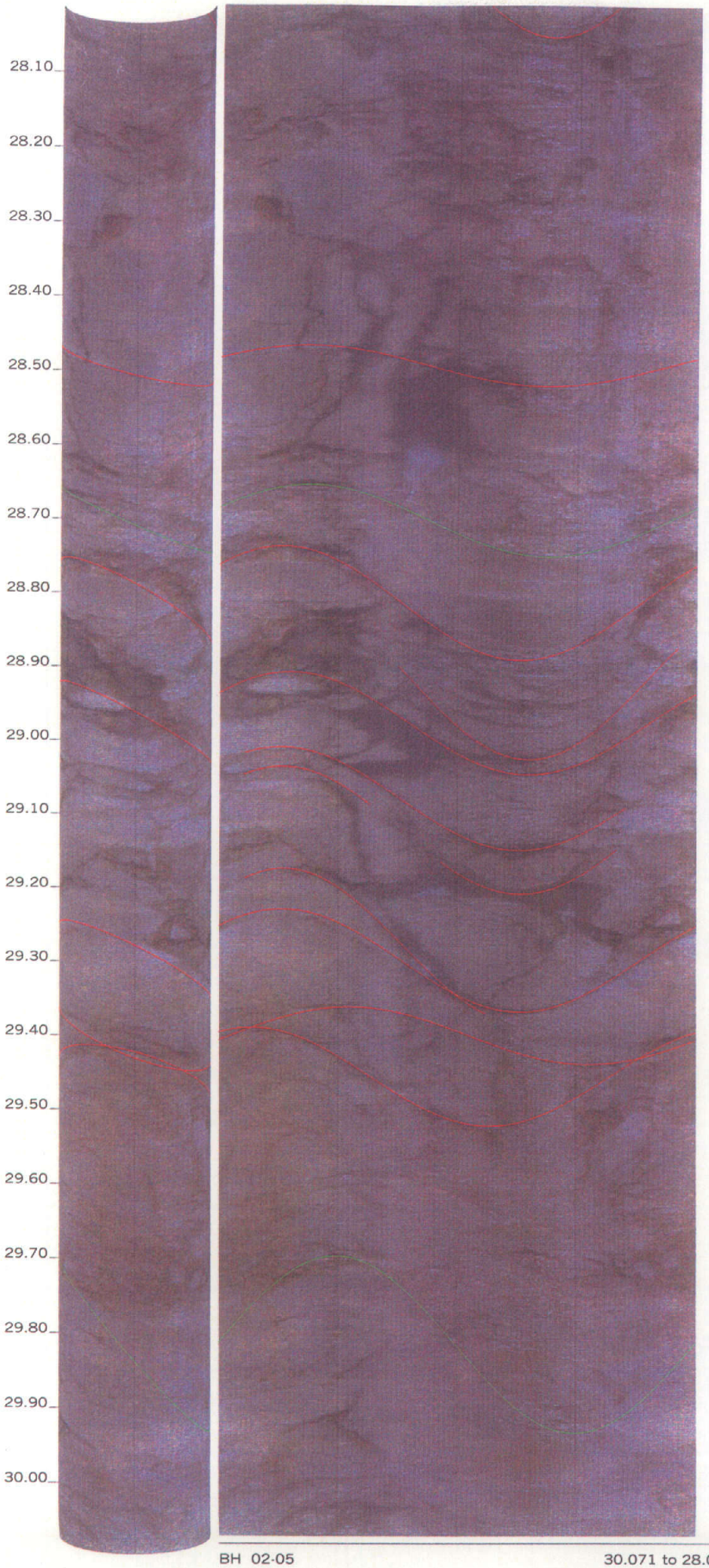
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N244 25 Fracture
N247 40 Bedding
N227 54 Fracture
N233 63 Fracture Discontinuous
N232 51 Fracture
N225 51 Fracture Discontinuous
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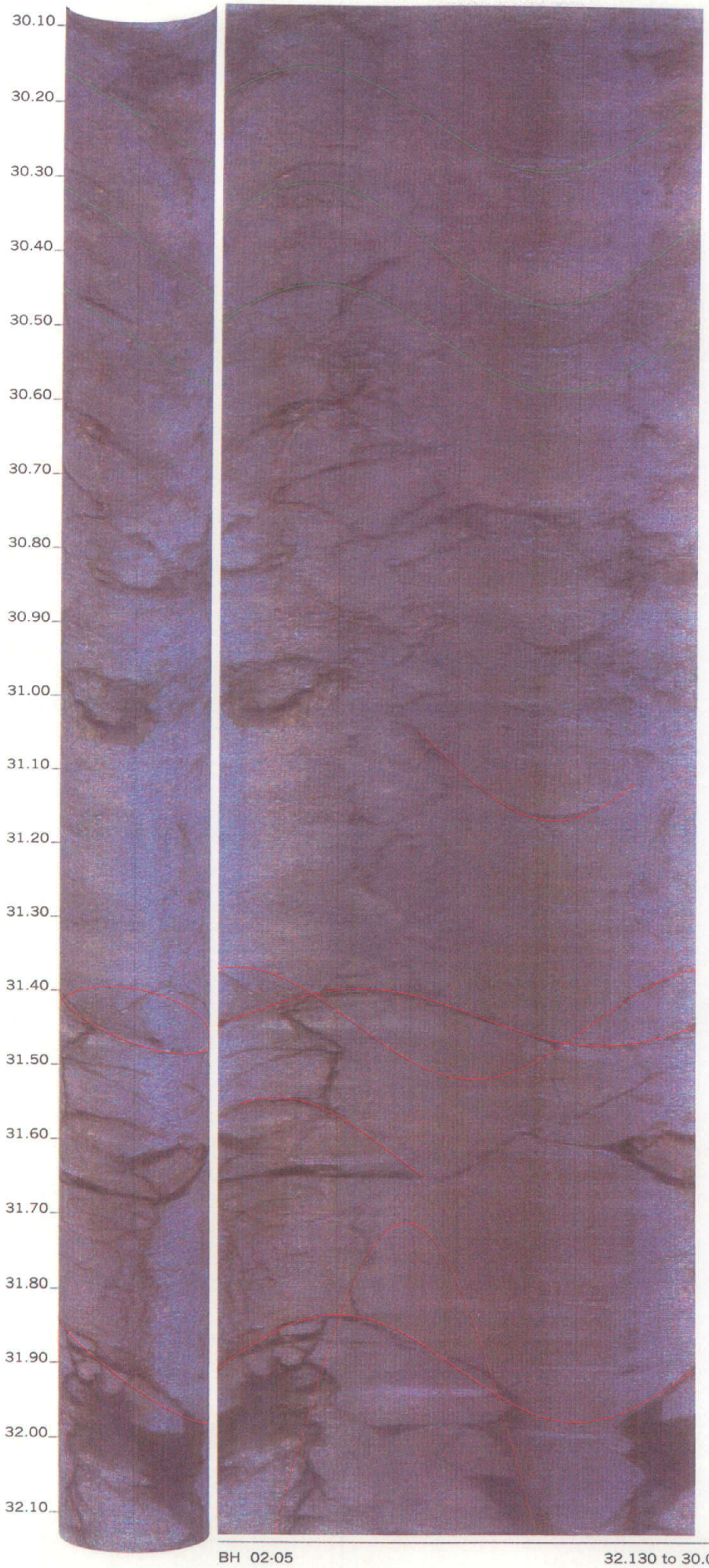
N203 51 Fracture
N268 64 Bedding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N247 54 Bedding
N253 51 Bedding
N252 59 Fracture Discontinuous
N287 33 Fracture
N192 54 Fracture Discontinuous
N223 54 Fracture Discontinuous
N270 51 Fracture Irregular
N322 79 Fracture segmented

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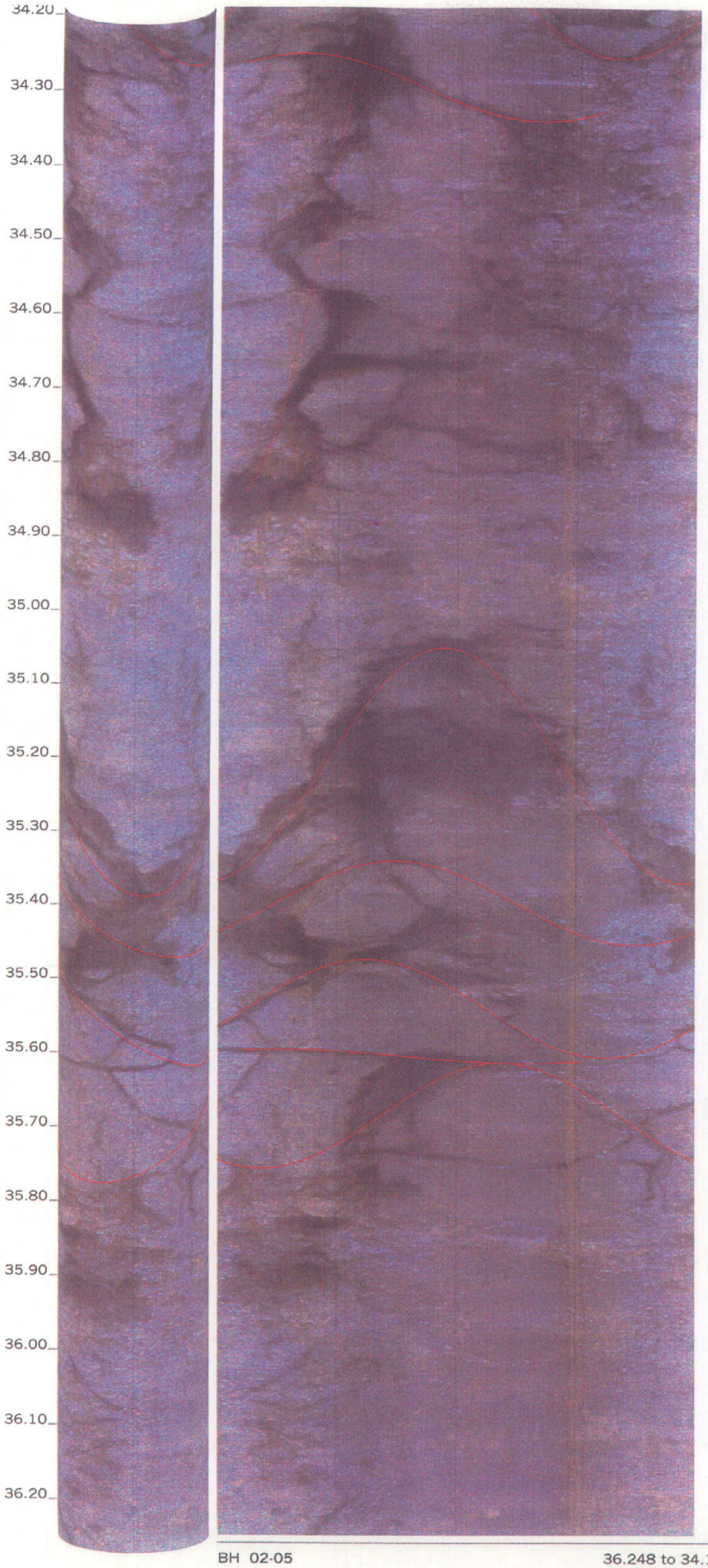
N300 60 Fracture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N241 37 Fracture Discontinuous
N351 70 Fracture
N314 44 Fracture Discontinuous
N292 48 Fracture Irregular
N219 9 Fracture Discontinuous
N035 52 Fracture Discontinuous

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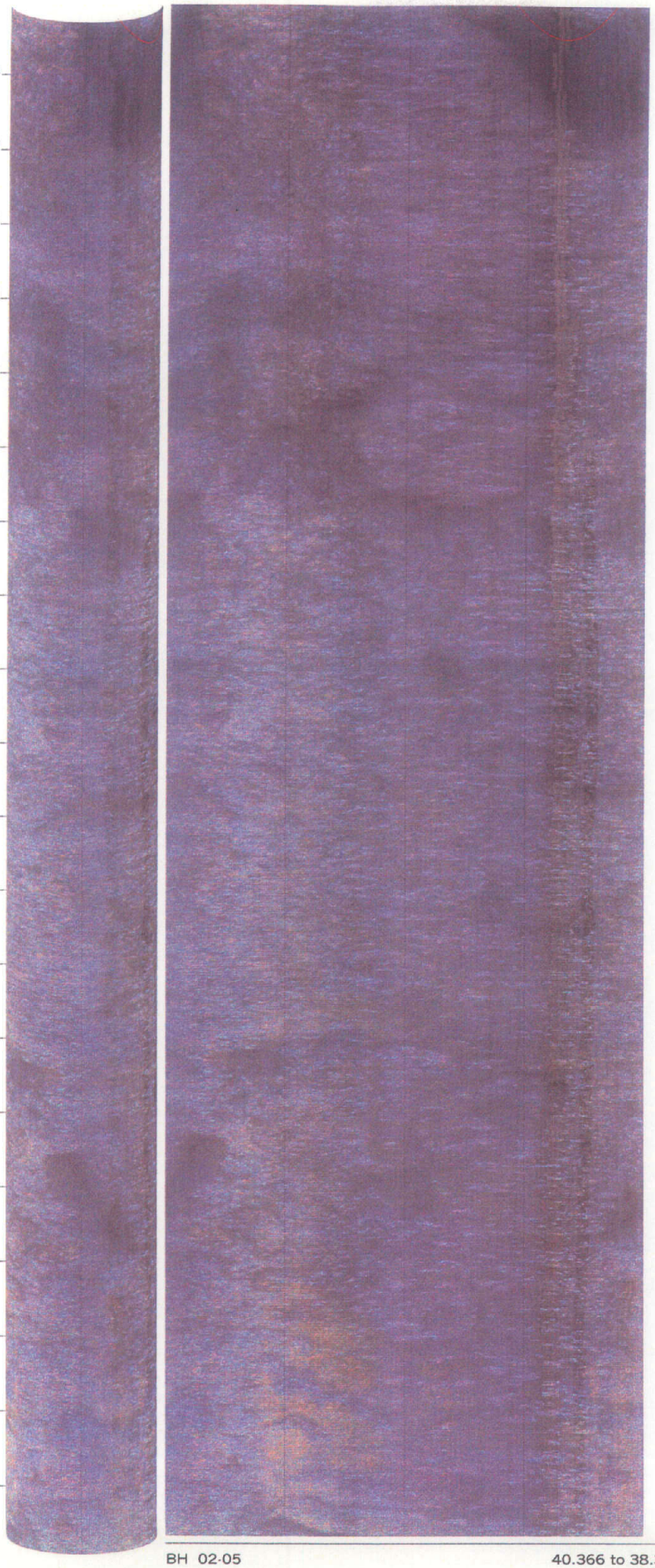
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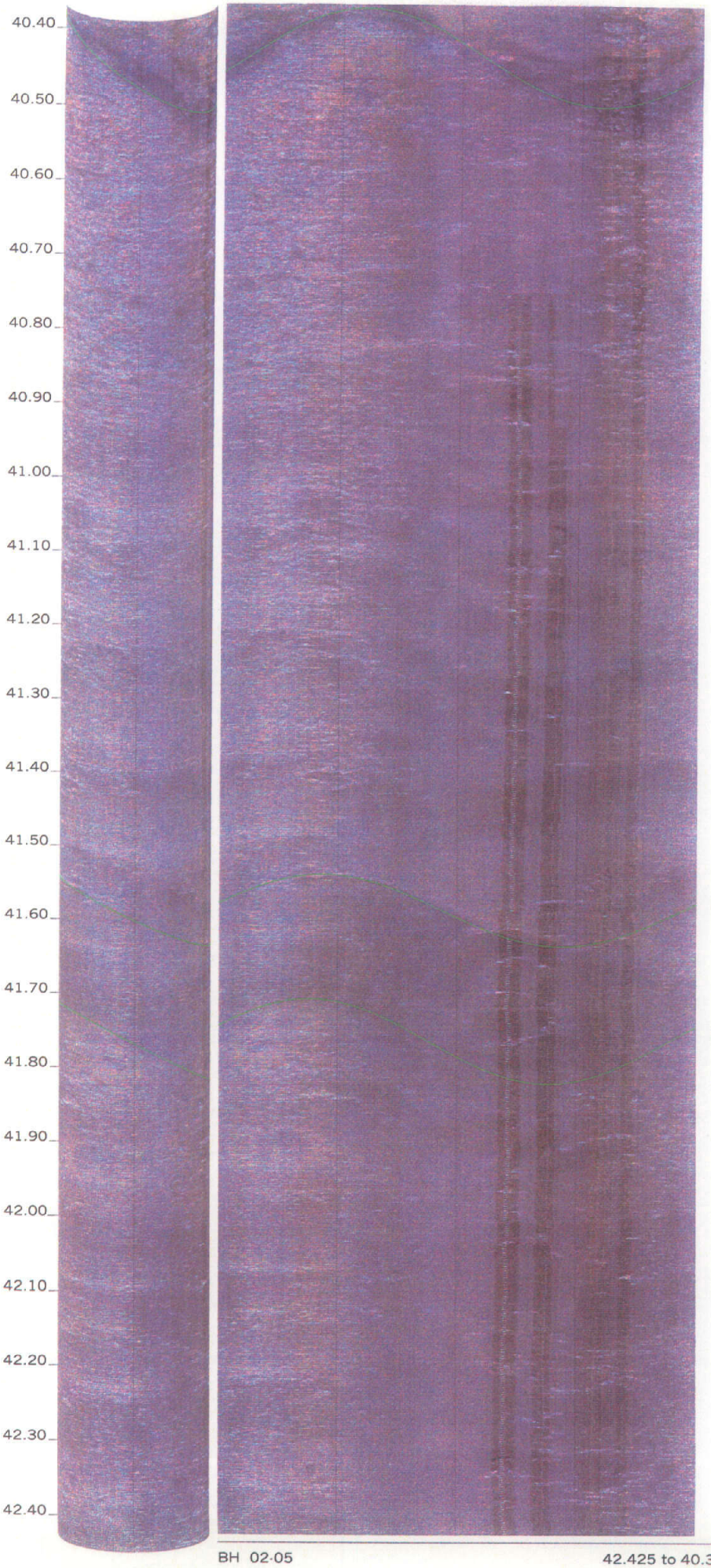
gouge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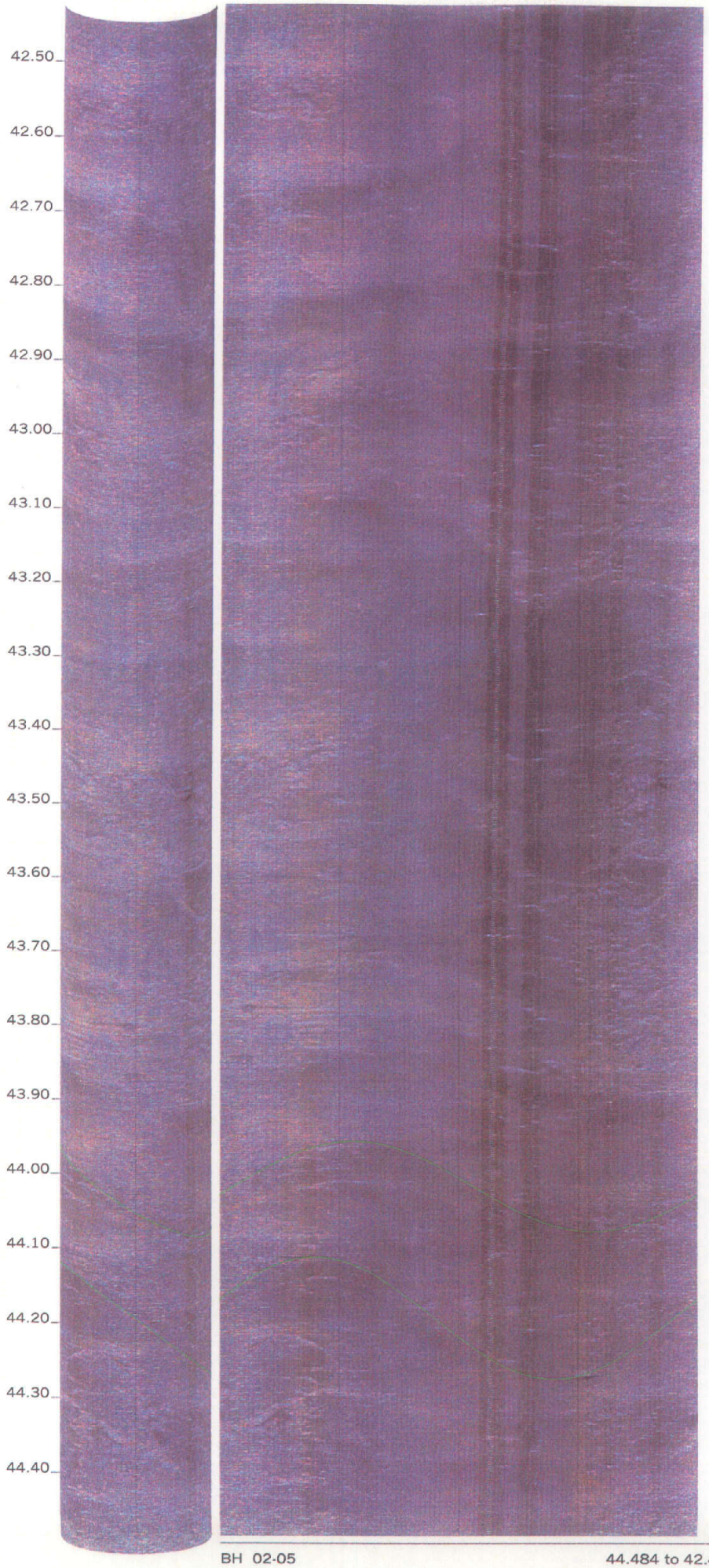
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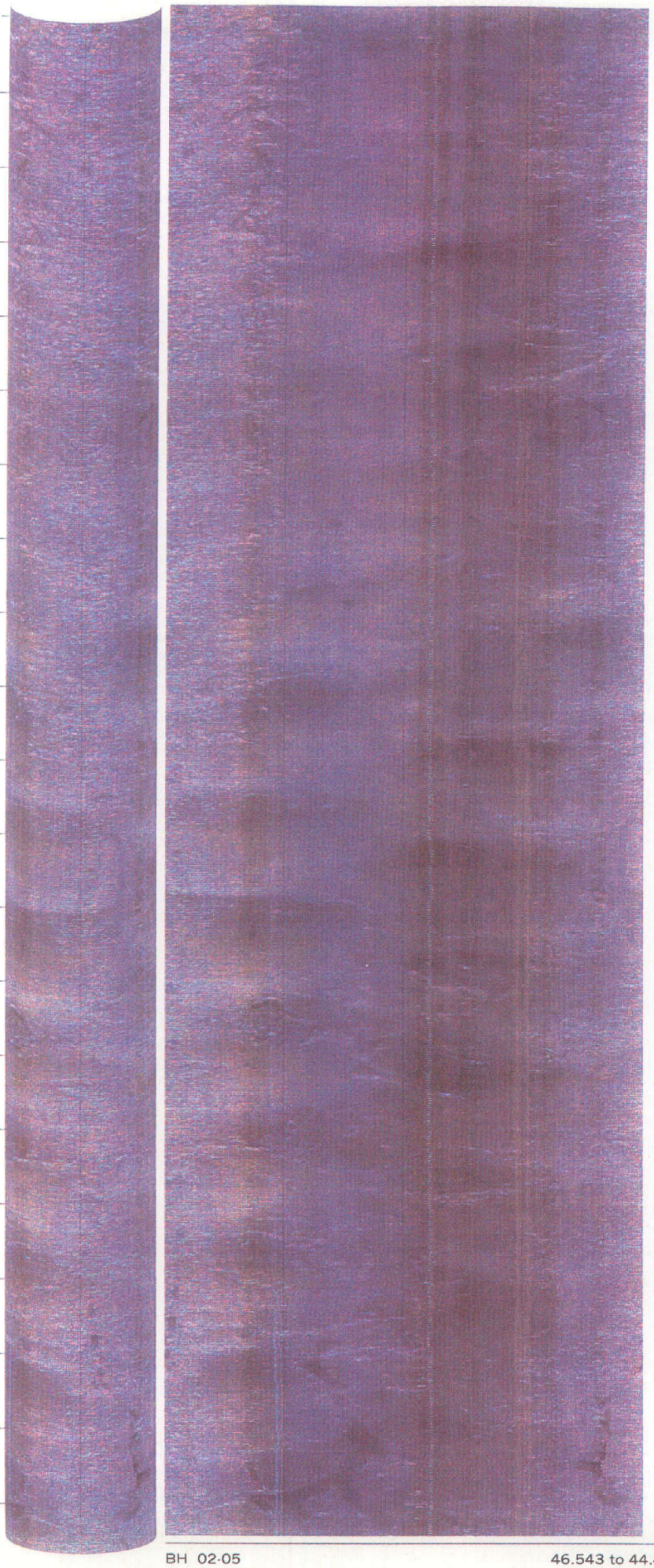
N251 55 Bedding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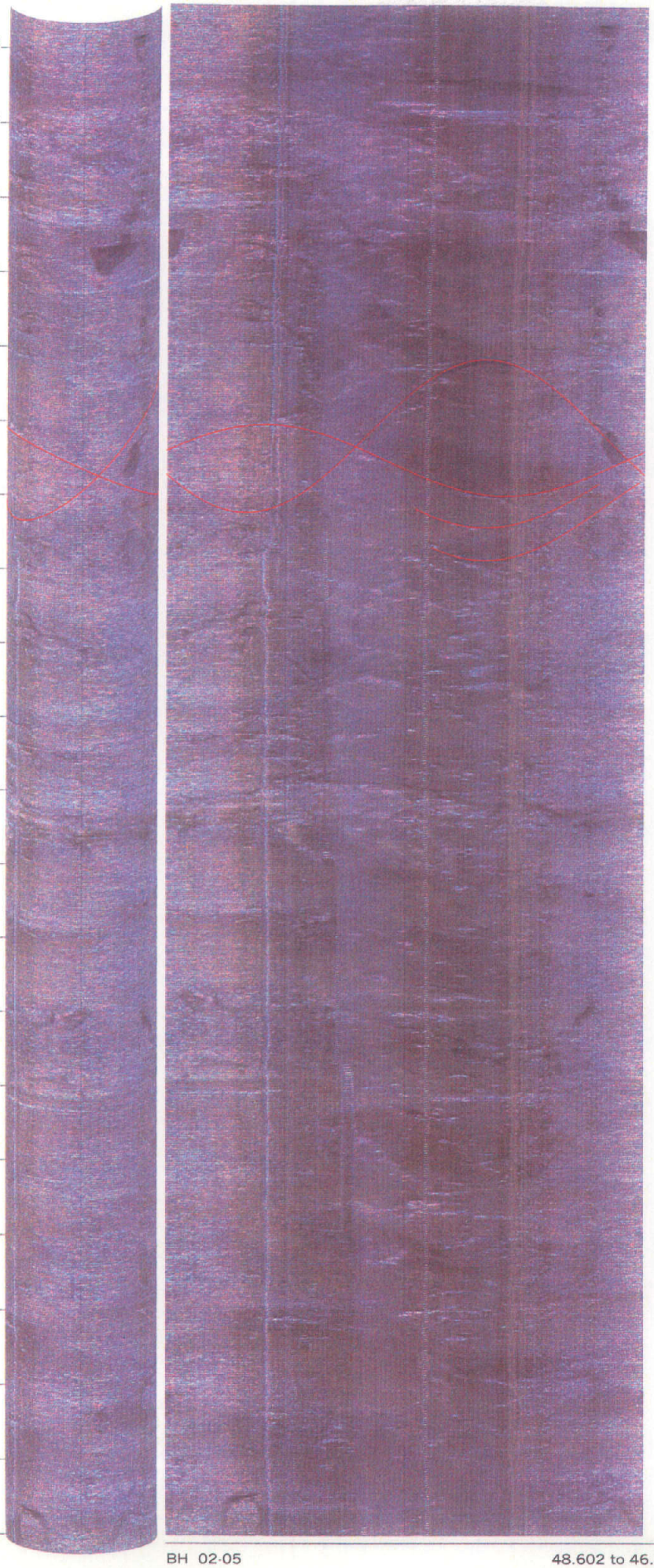
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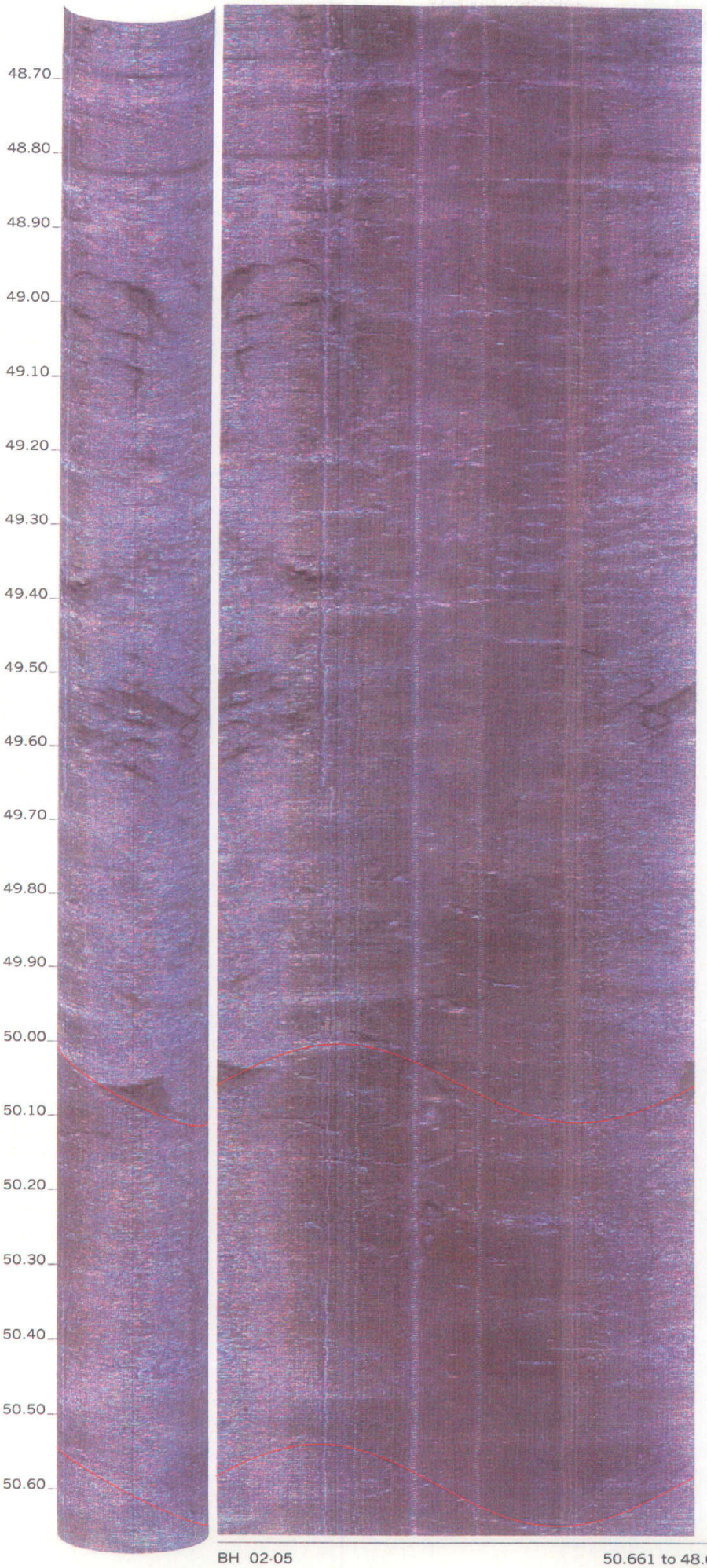
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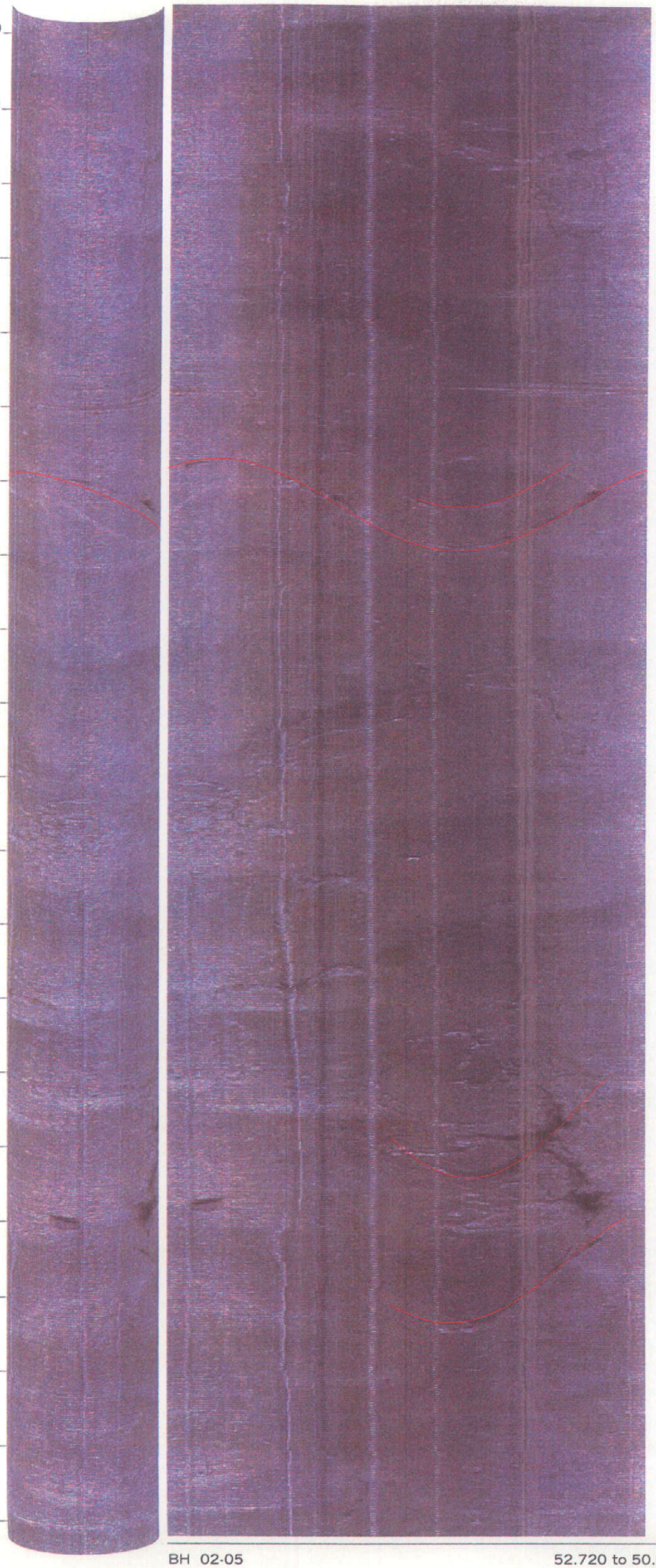
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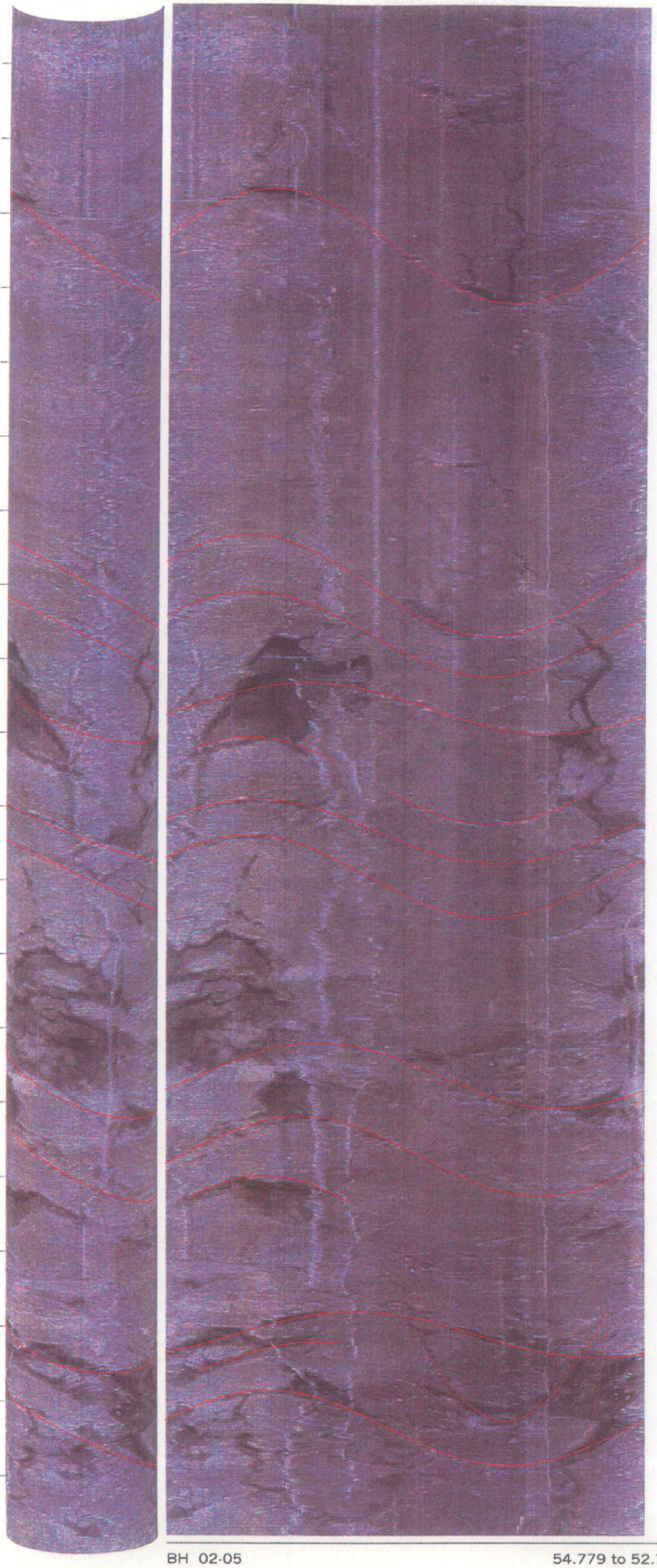
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N242 45 Fracture segmented
N246 36 Fracture segmented
N241 43 Fracture segmented
N296 35 Fracture
N281 41 Fracture
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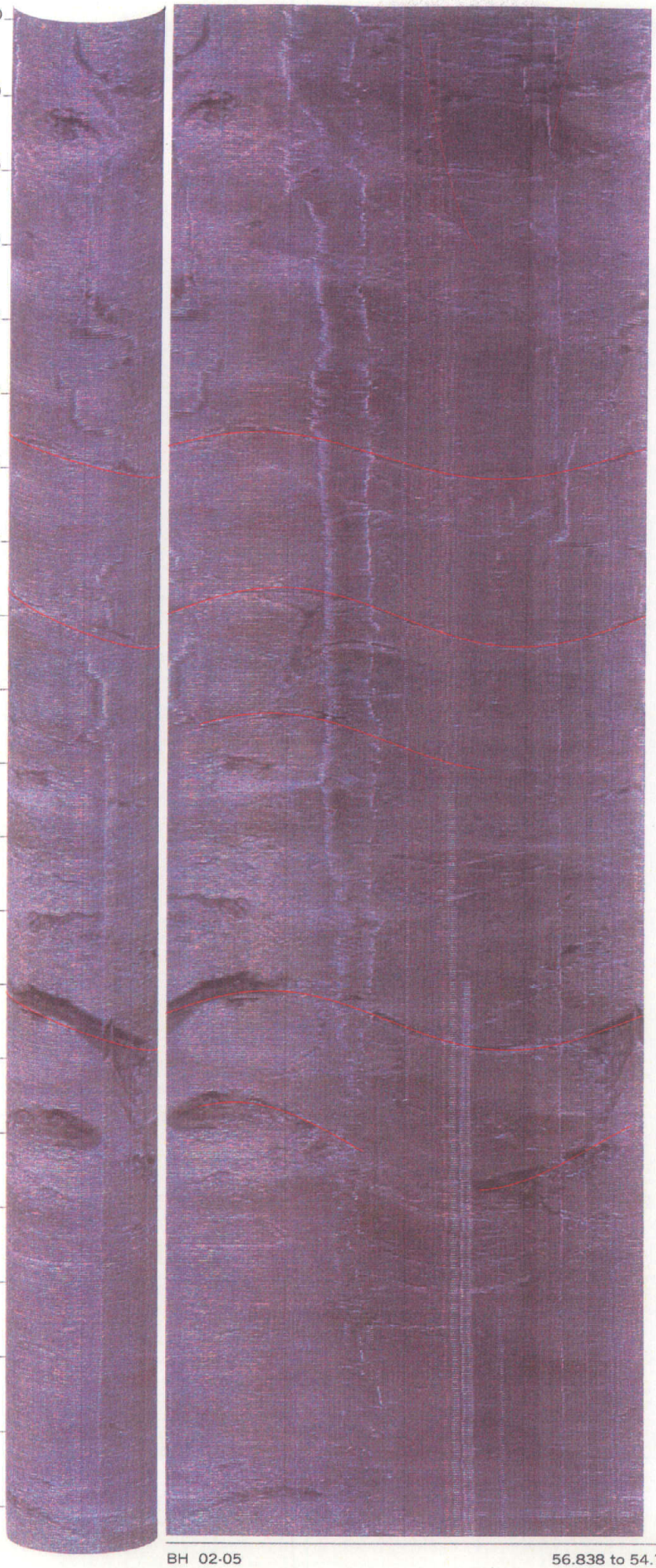
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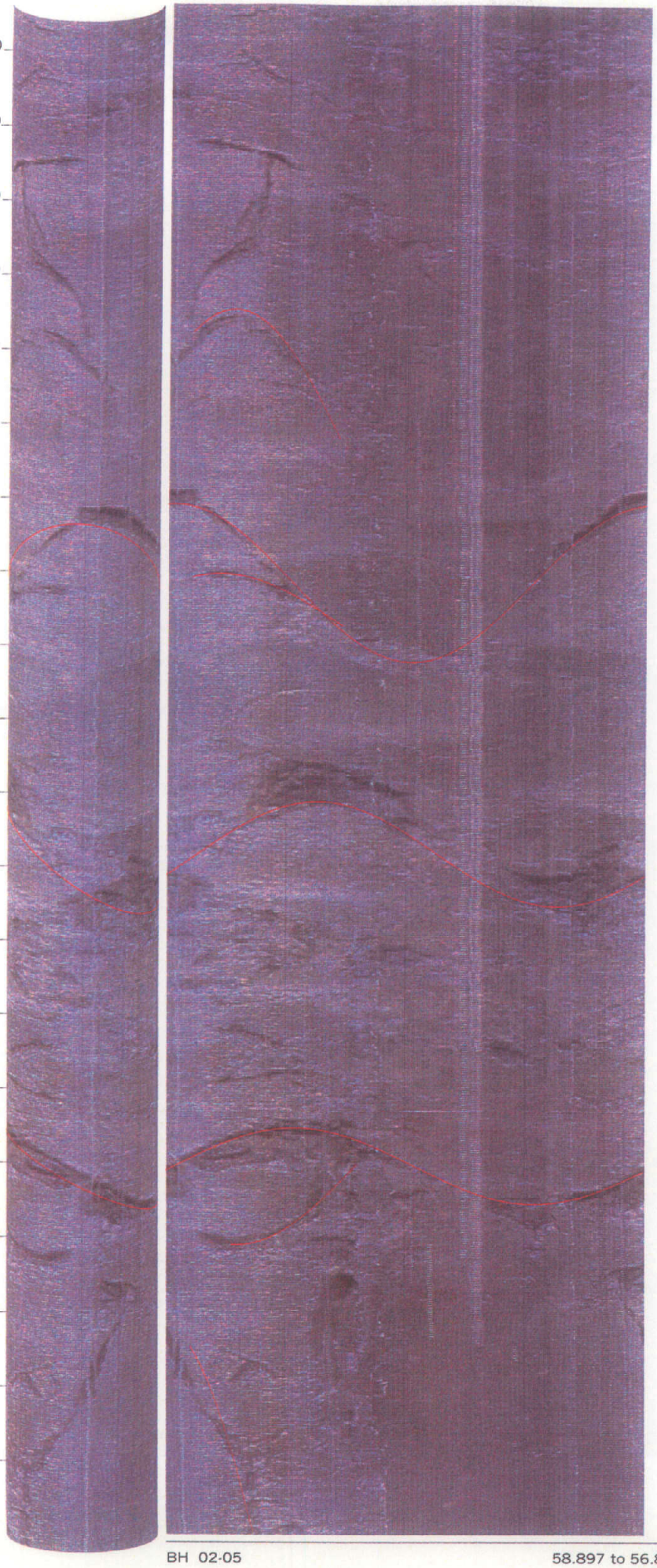
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N184 63 Fracture
N218 50 Fracture Discontinuous
gouge
N294 49 Fracture
N056 50 Fracture Discontinuous

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N243 57 Fracture
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N060 76 Fracture Discontinuous
N263 36 Fracture Discontinuous

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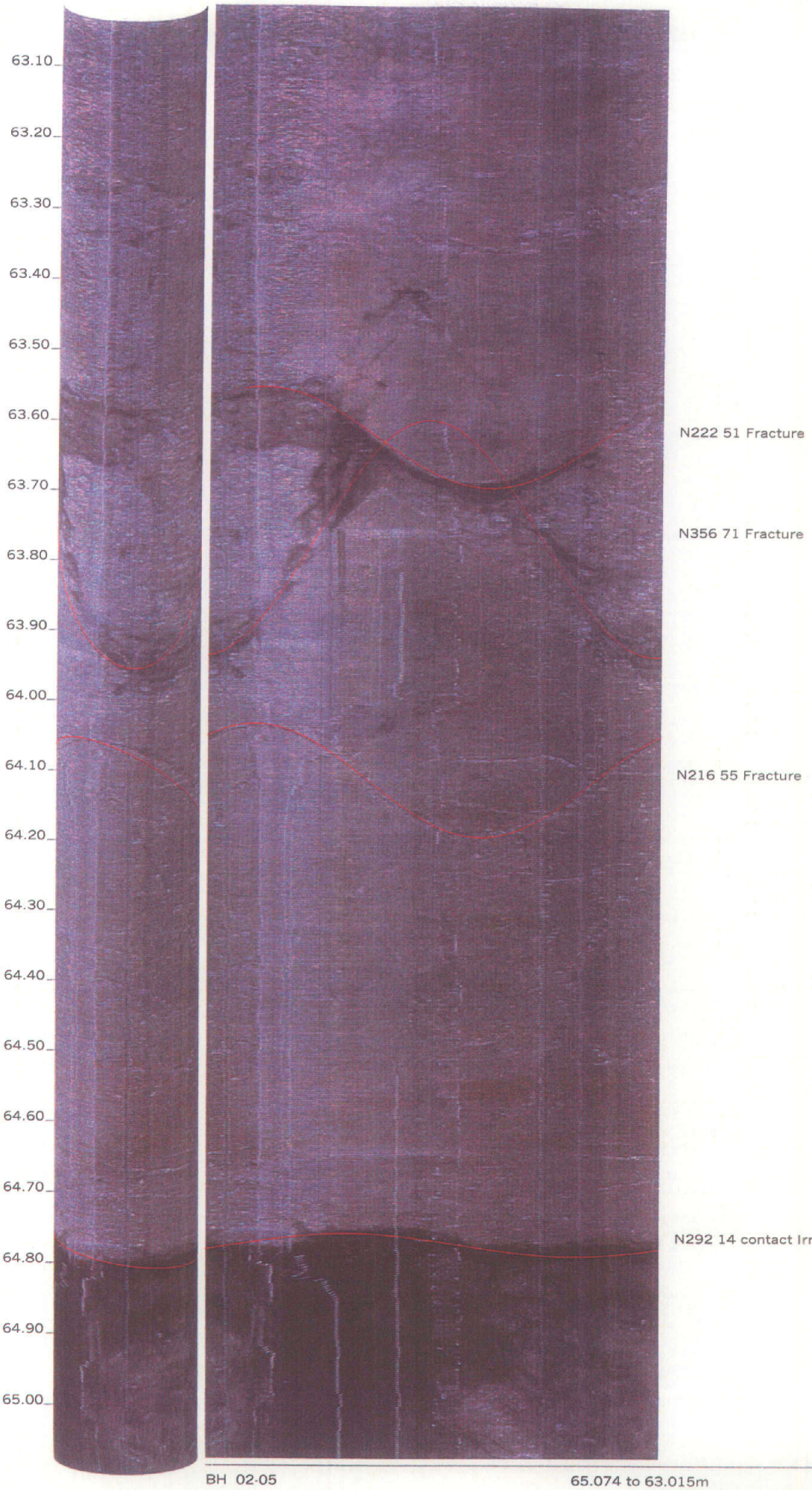

BH 02-05 65.074 to 63.015m

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66.90
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N060 28 Fresh Bedding
N055 27 Bedding

67.20_

NORCAL GEOPHYSICAL CONSULTANTS, INC.

BHTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED BHTV DIPS LOG

28 Sep 2002

EARTH MECHANICS

Borehole: BH 02-05

DEVILS SLIDE

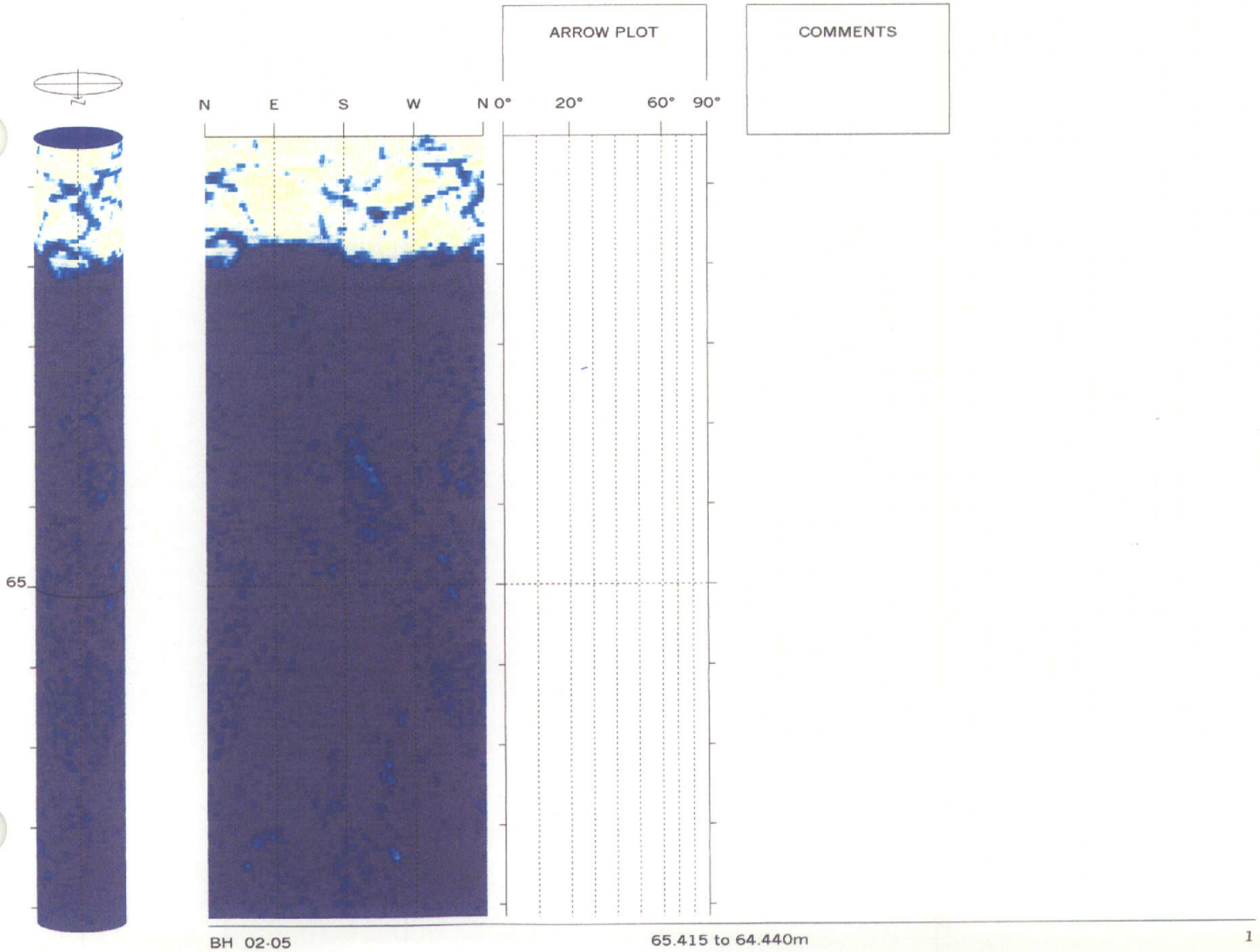
top of borehole.....
East: _
North: _
Alt: _

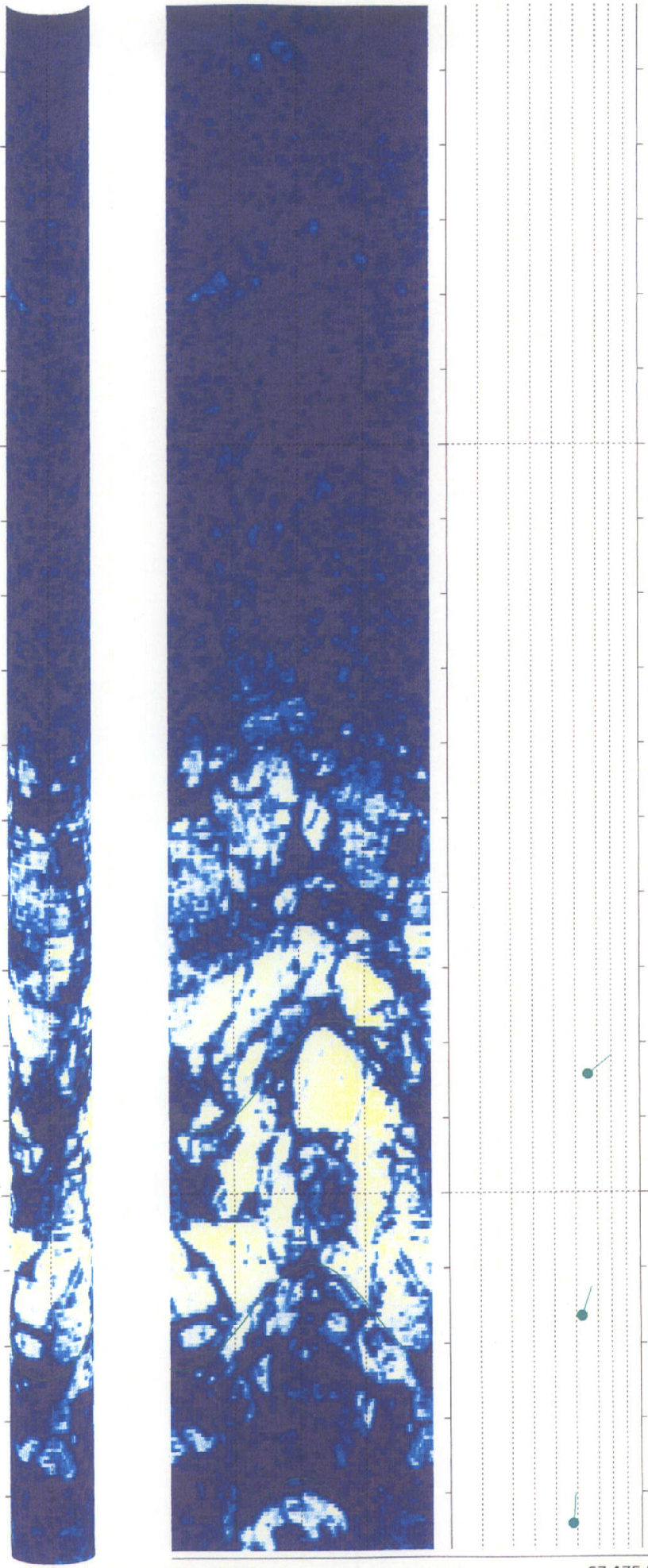
North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = vert scale

Zone from 167.500 to 64.440m

Borehole diam: 11.010cm
Vertical = borehole-axis
Amplitude

BEDDING
FRACTURE
Identified units

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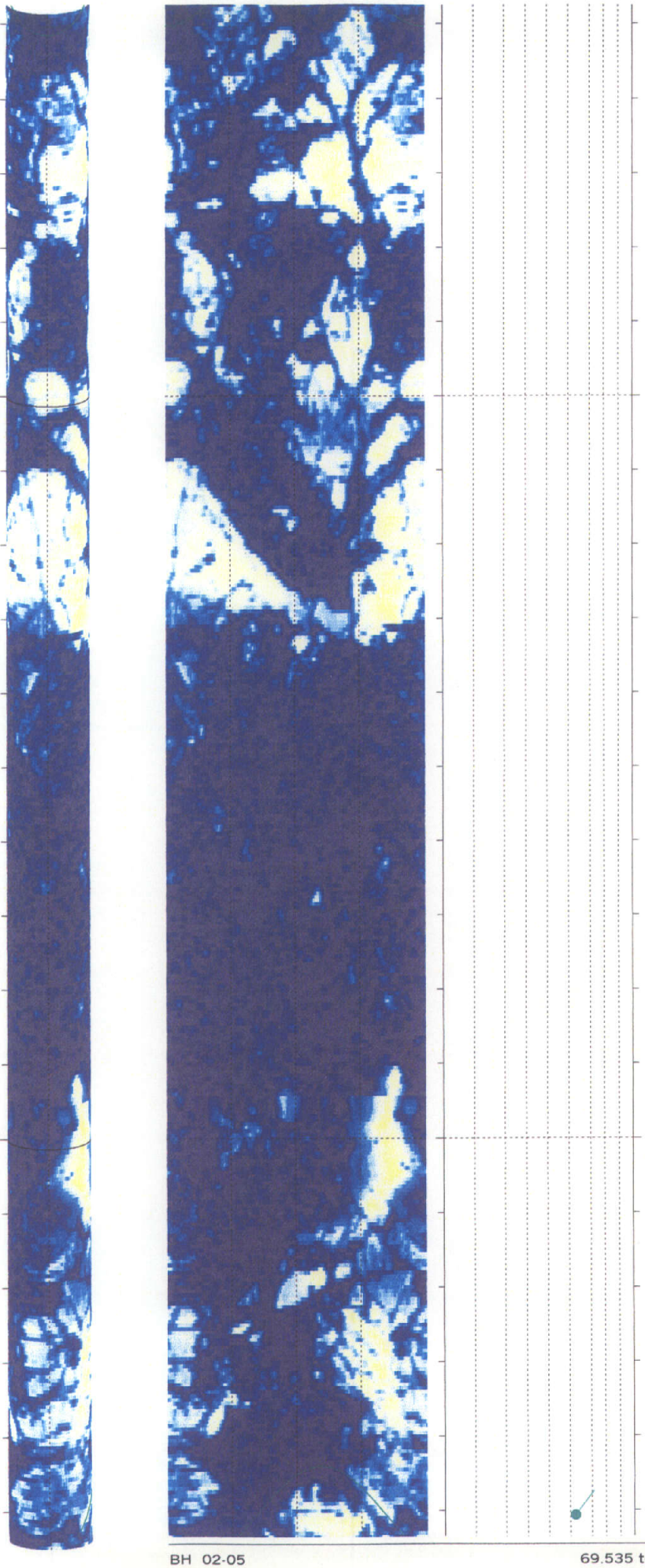
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gouge
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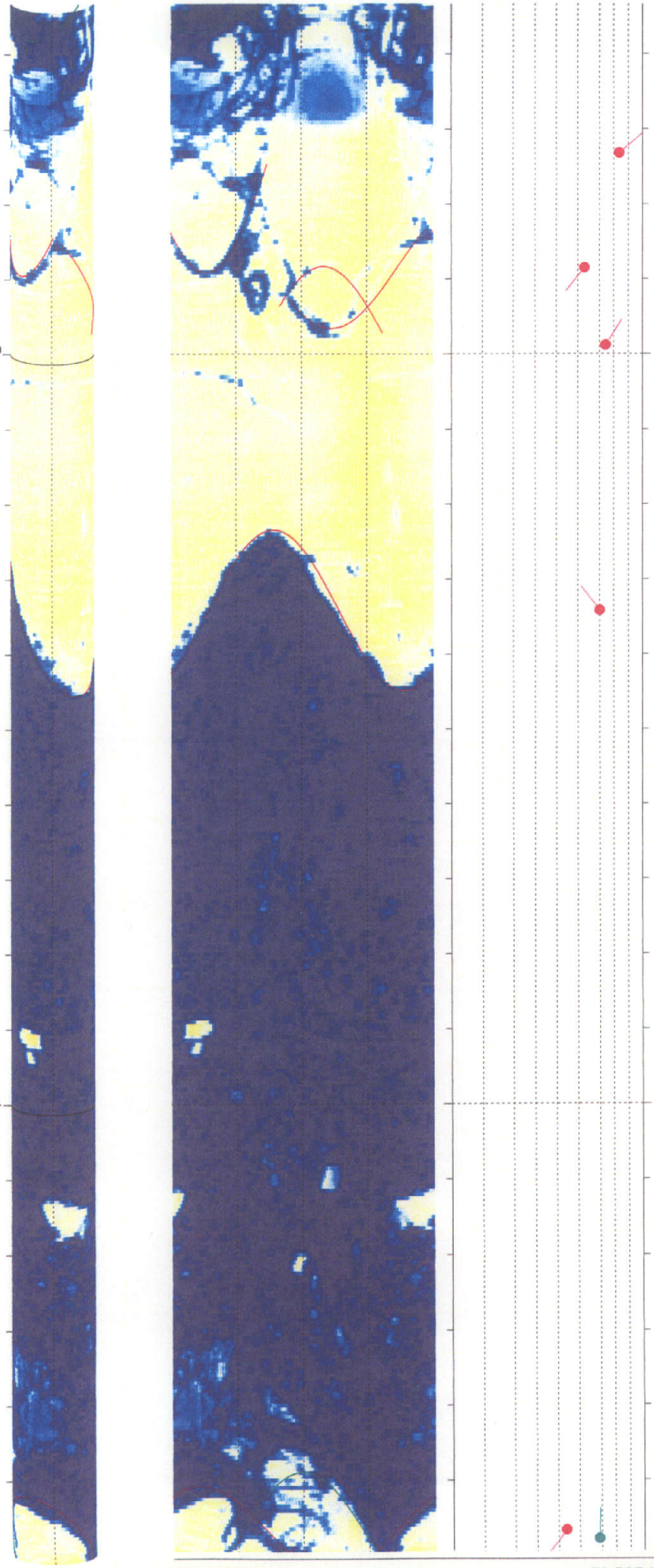
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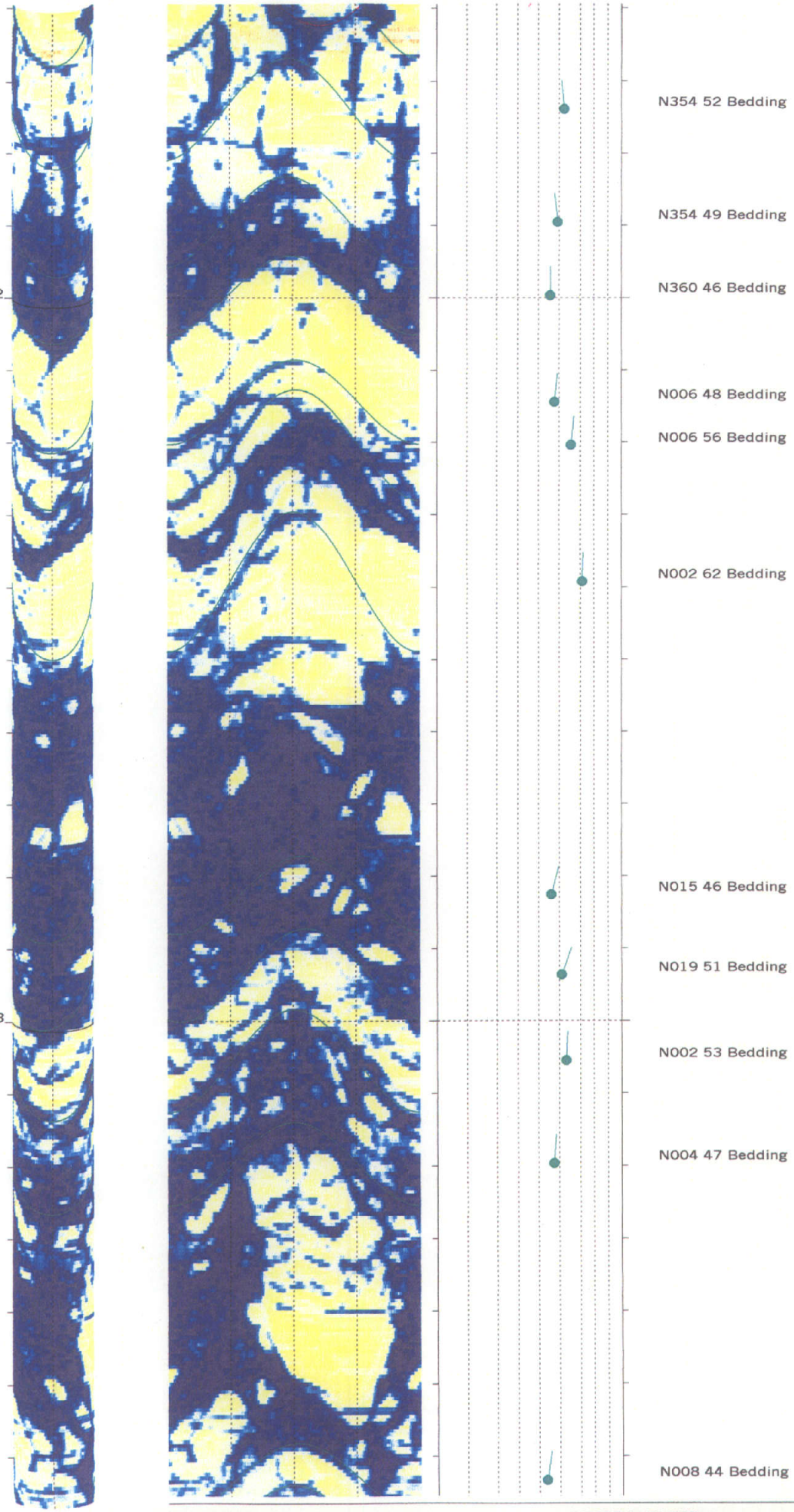
gouge
N217 44 Fracture
N001 59 Bedding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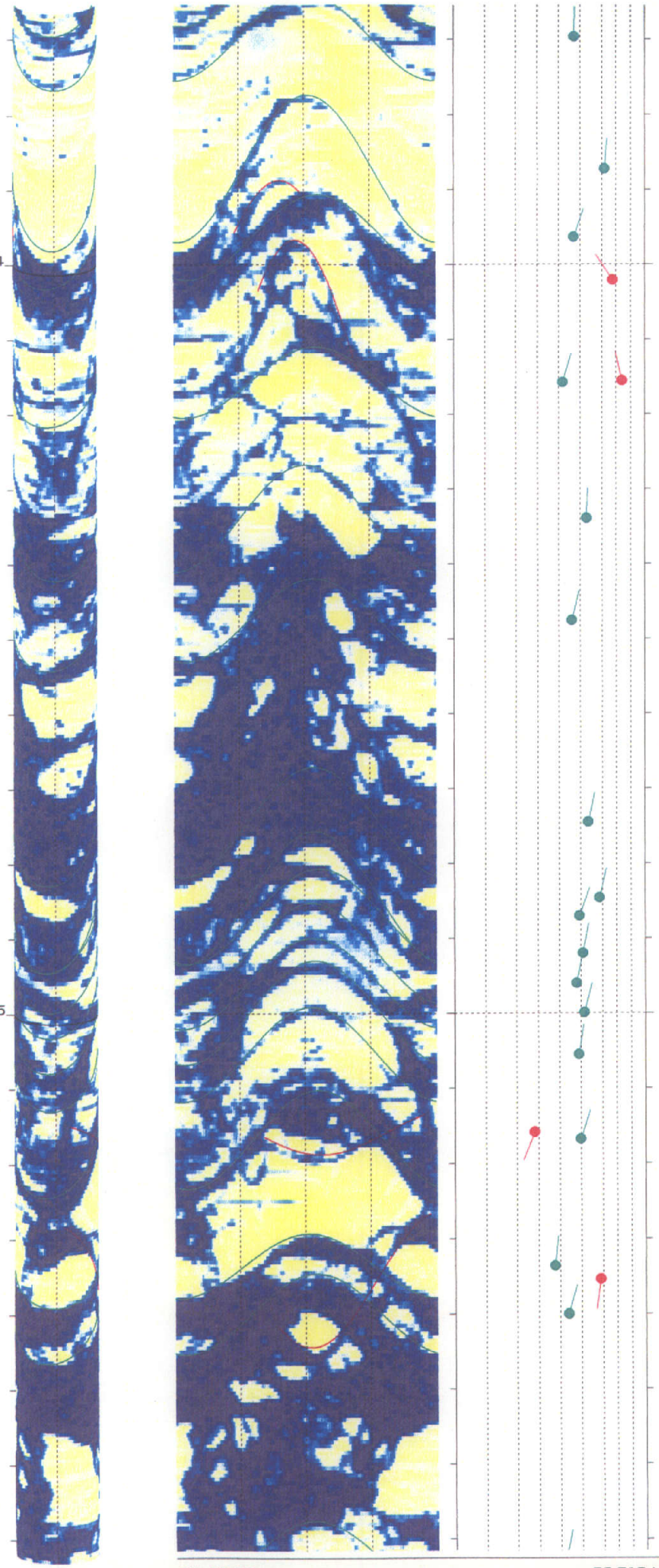
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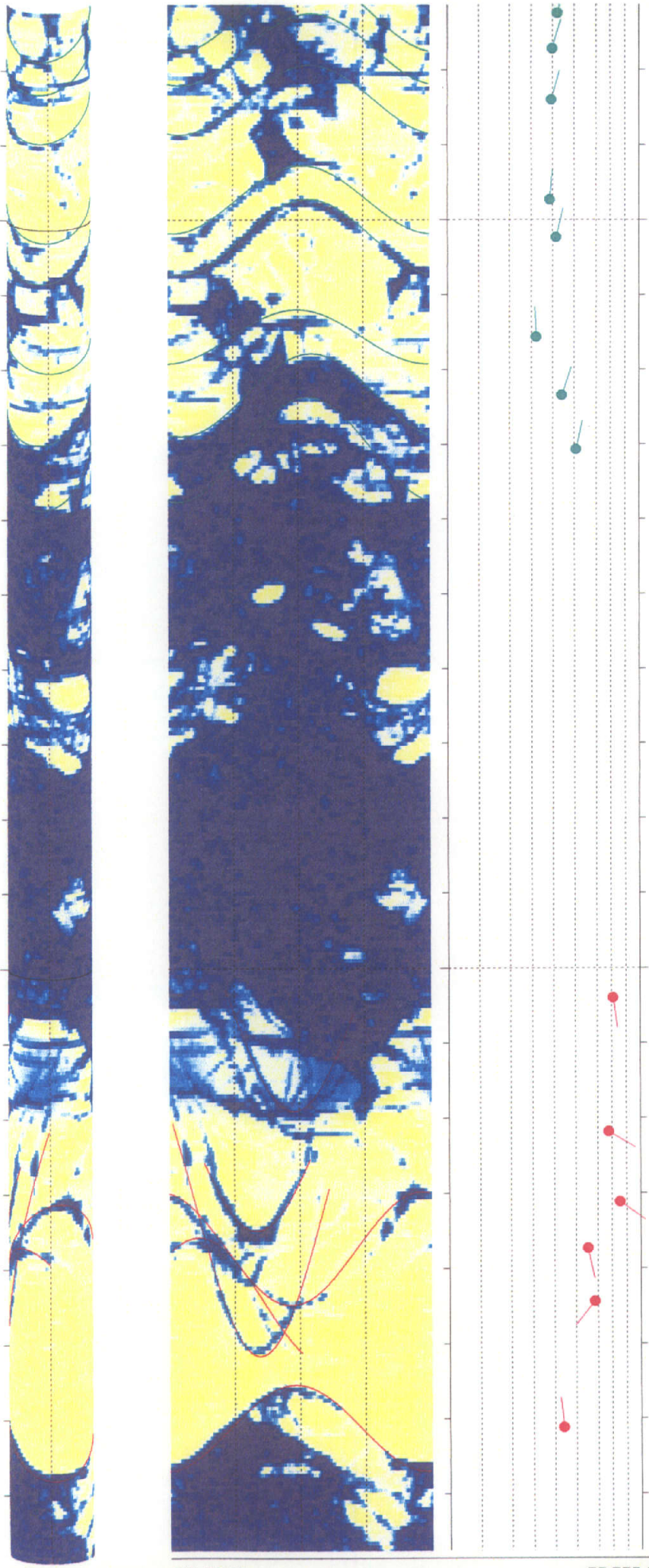
N015 44 Bedding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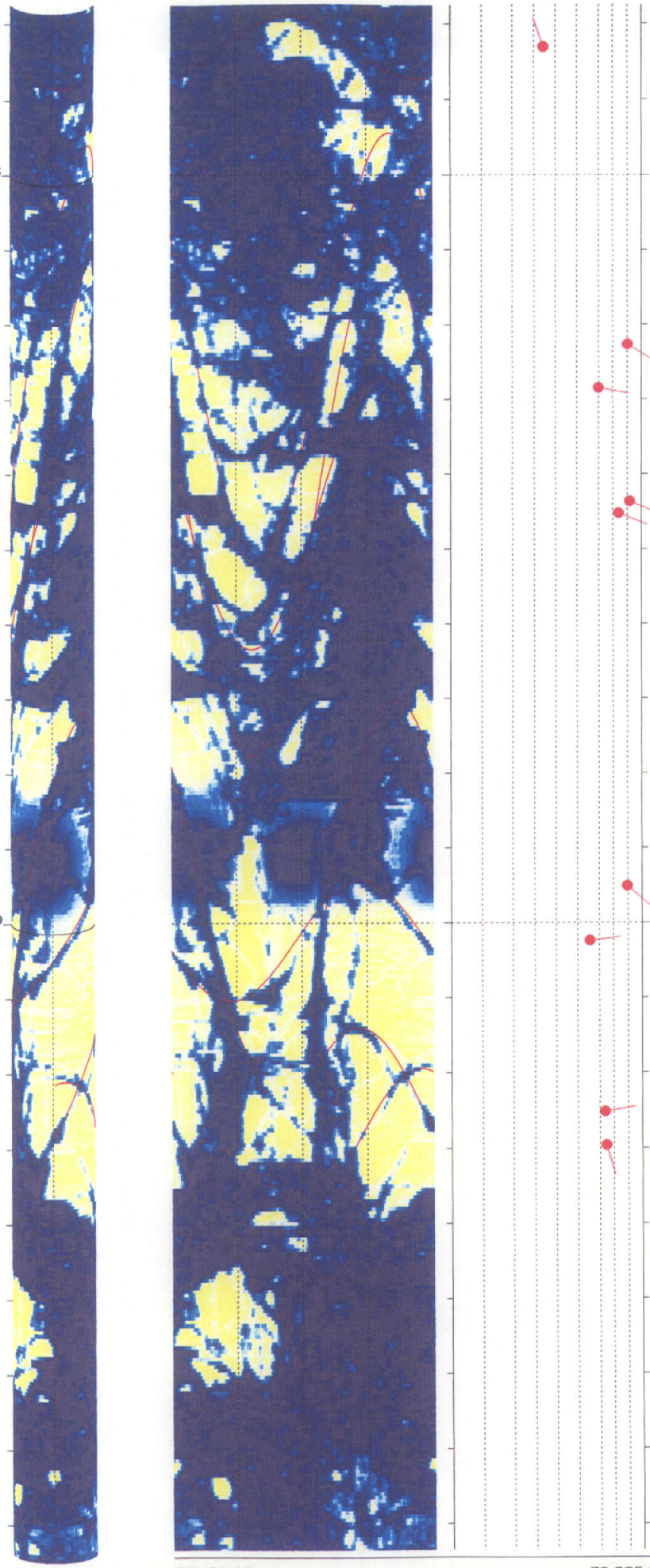
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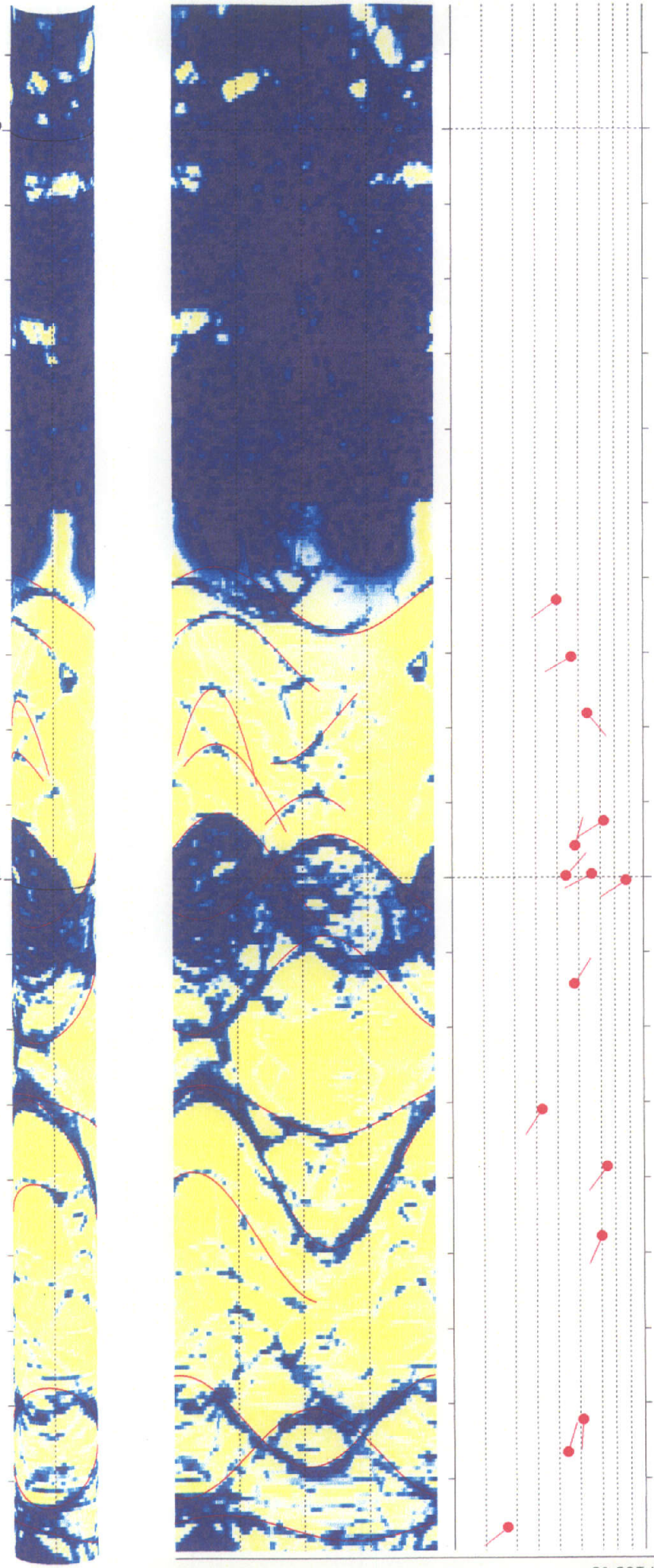
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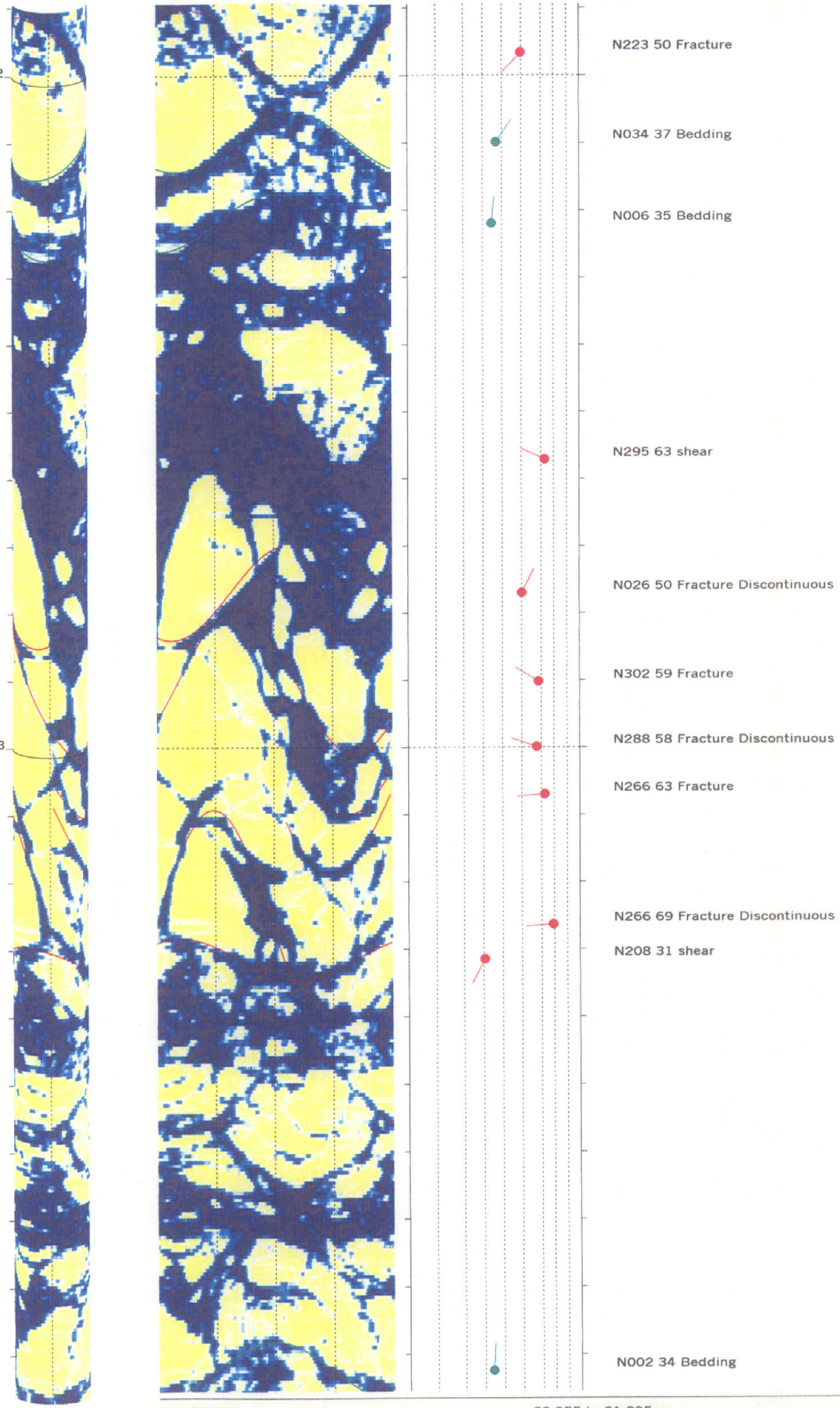
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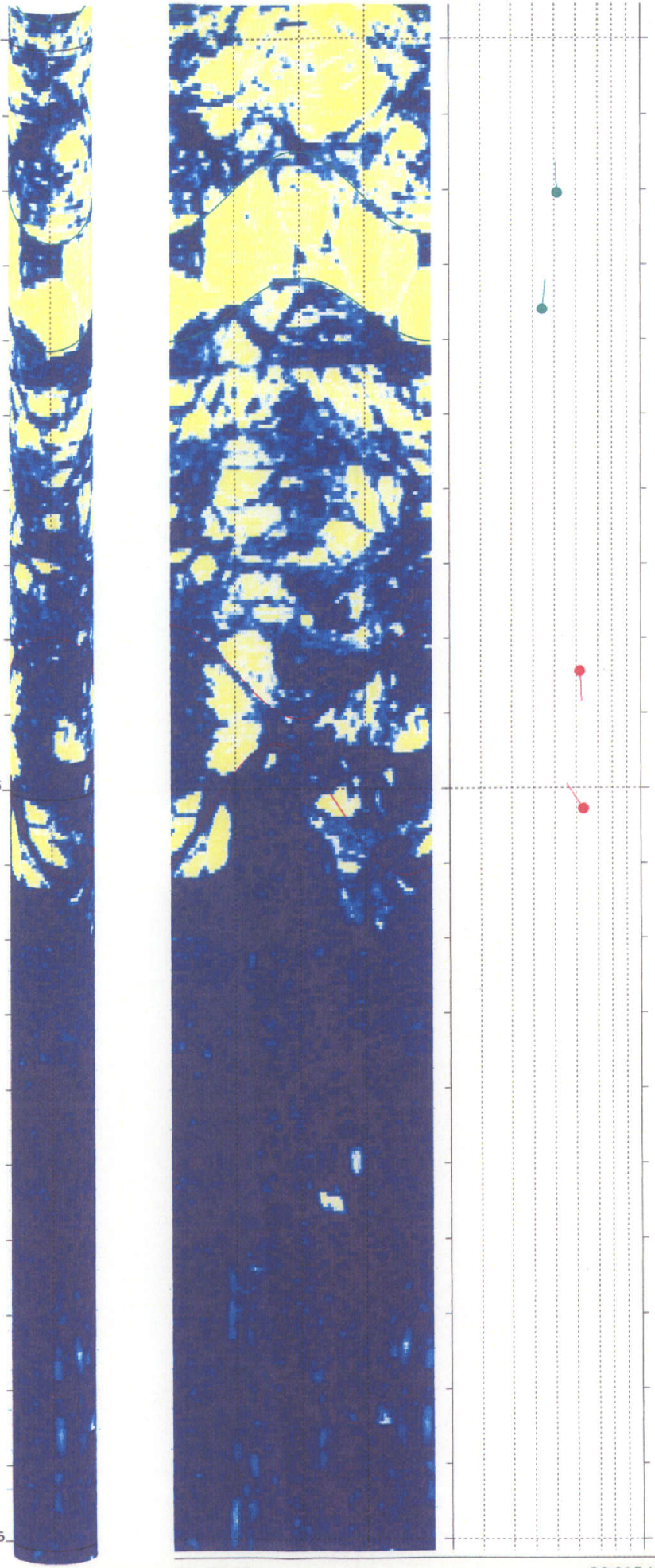
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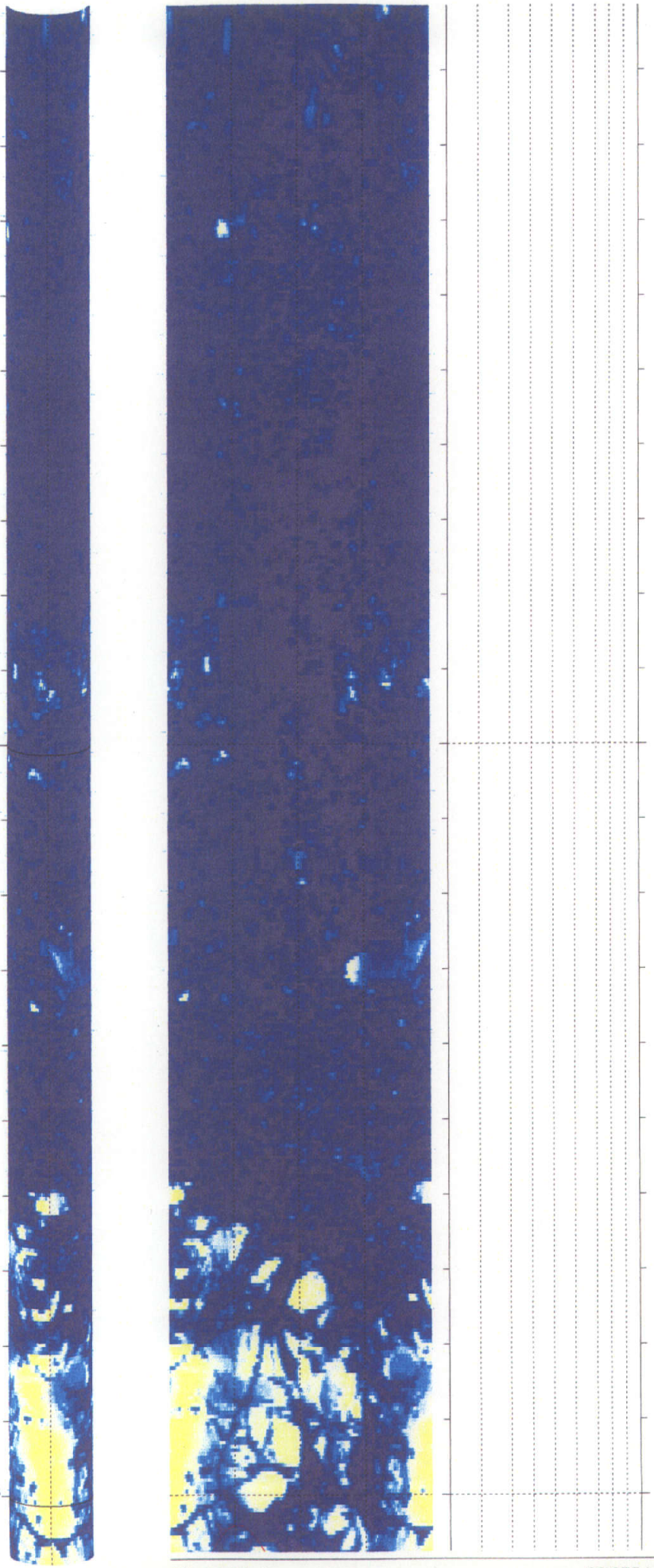
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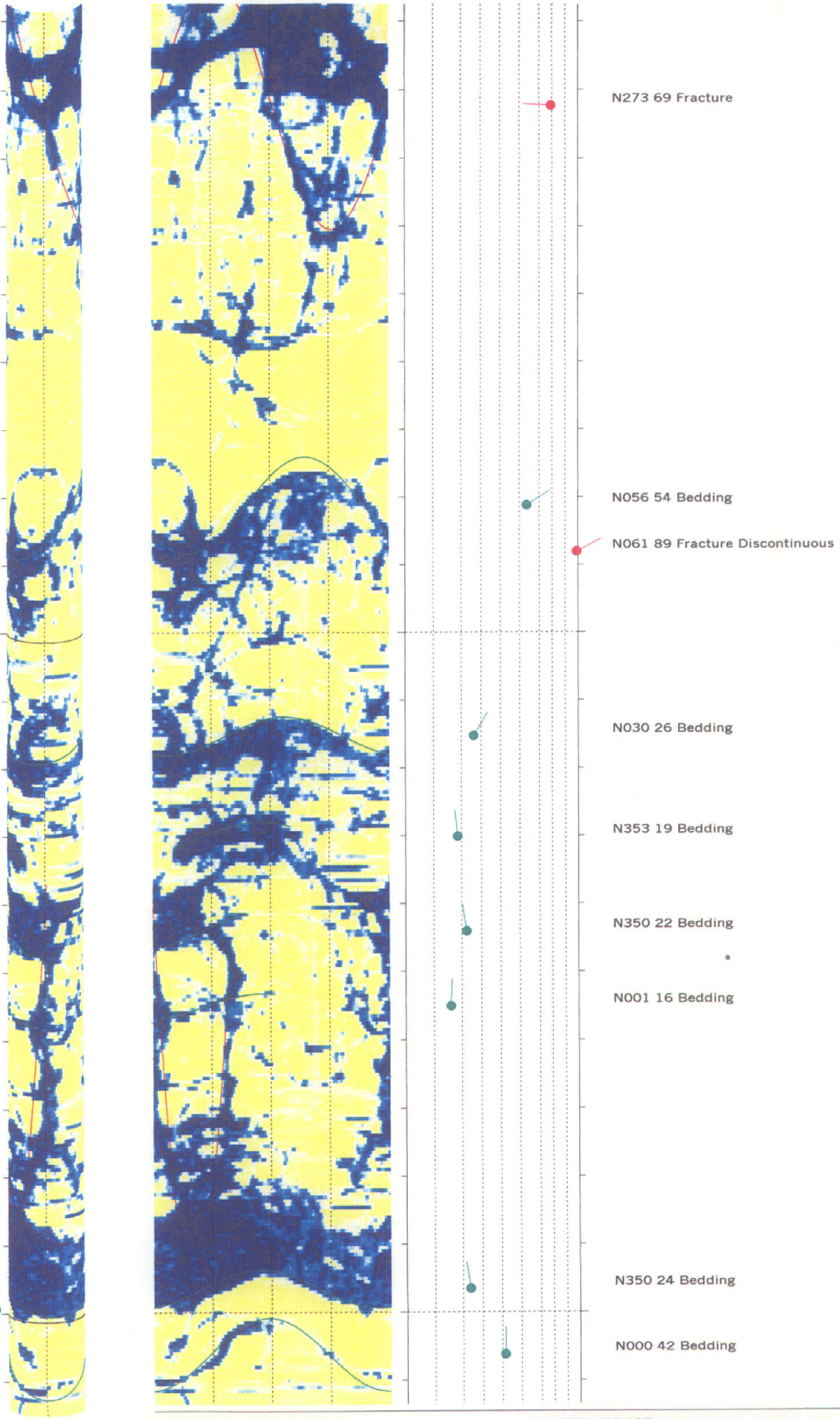
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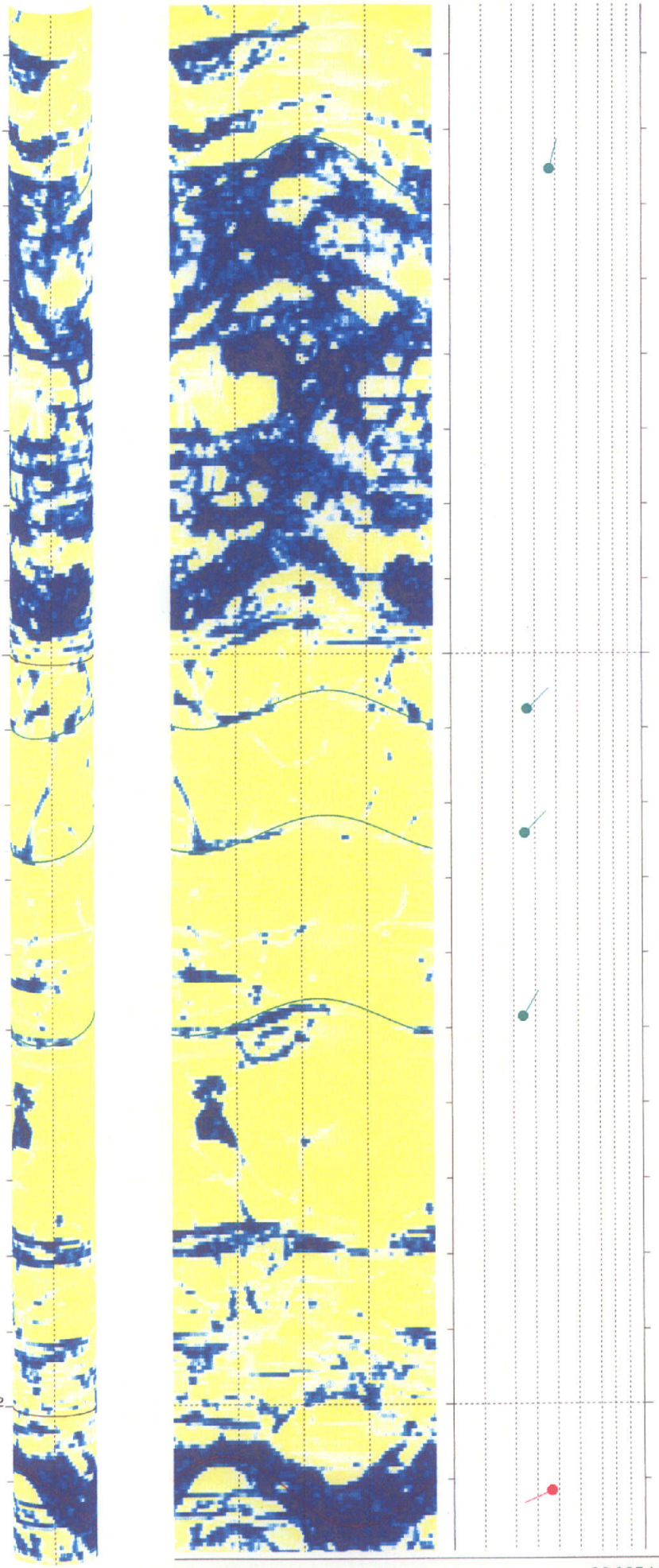
N000 42 Bedding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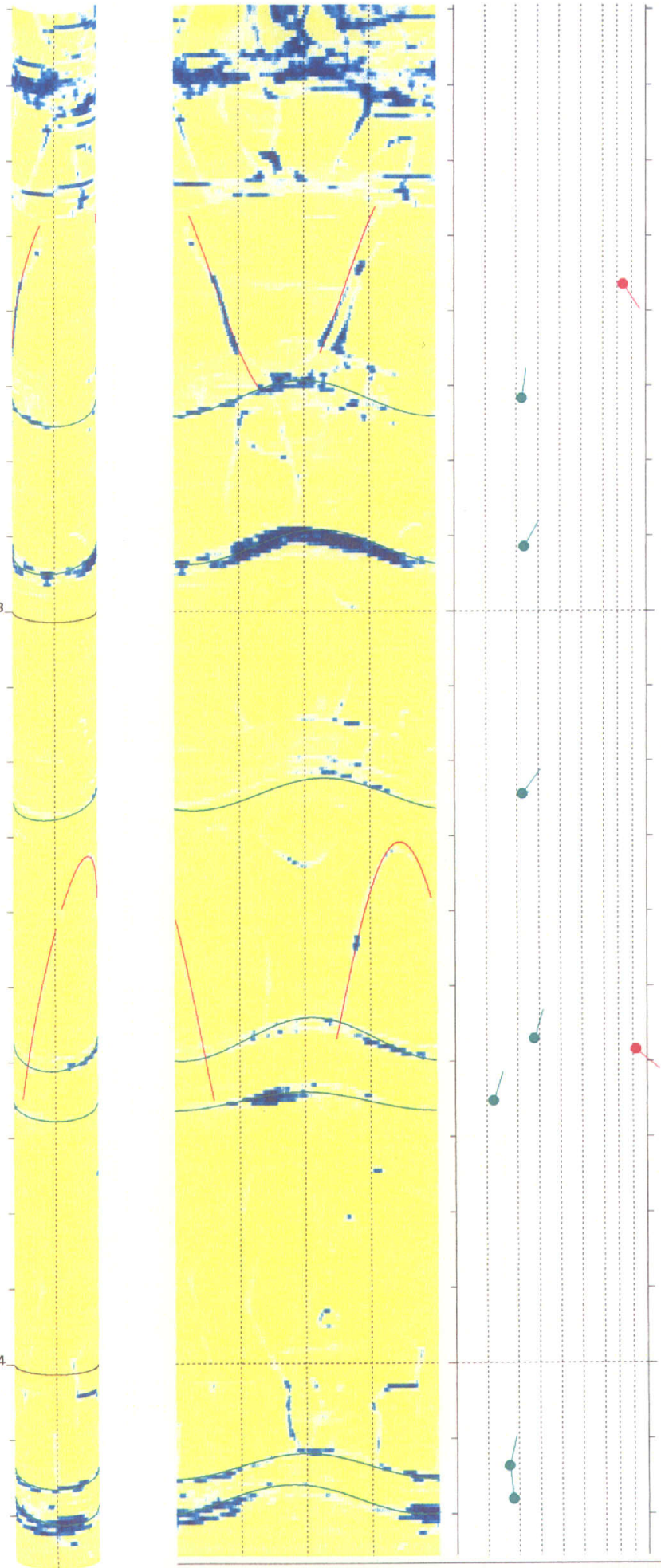
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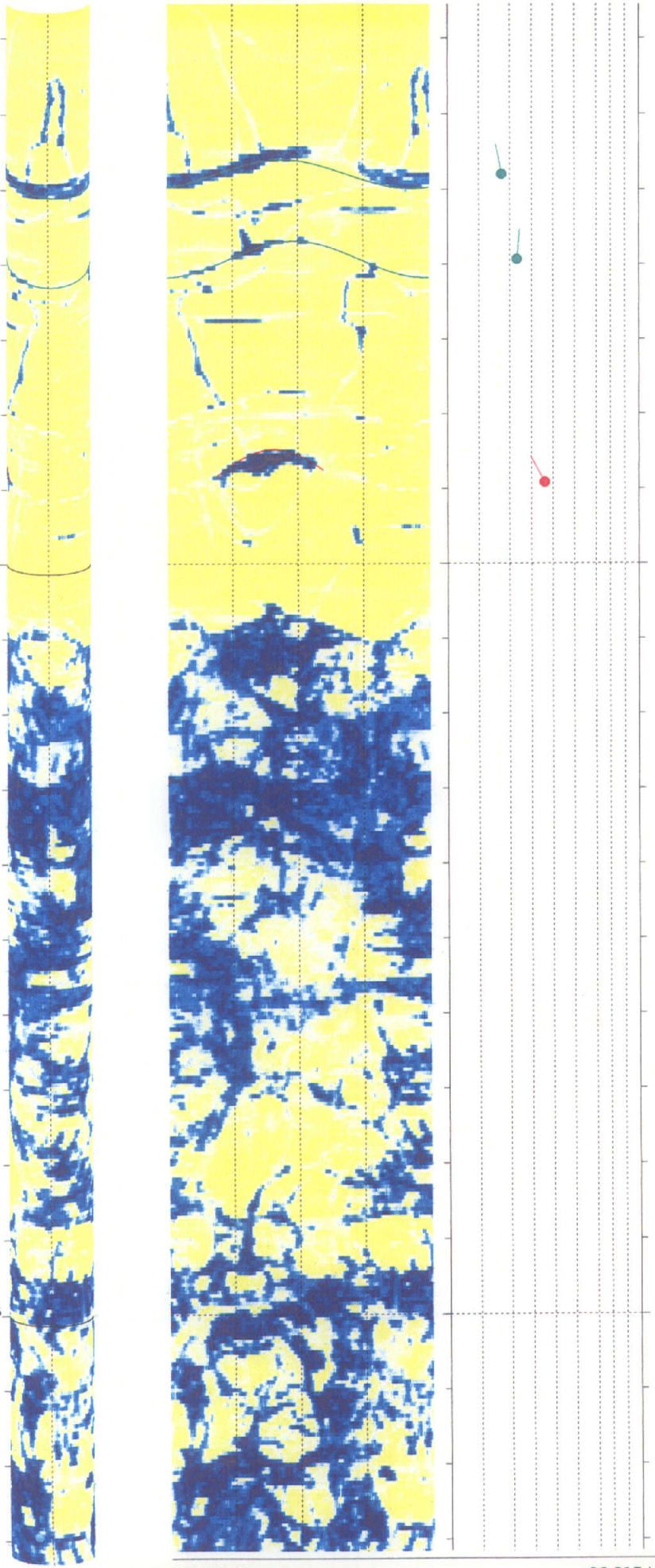
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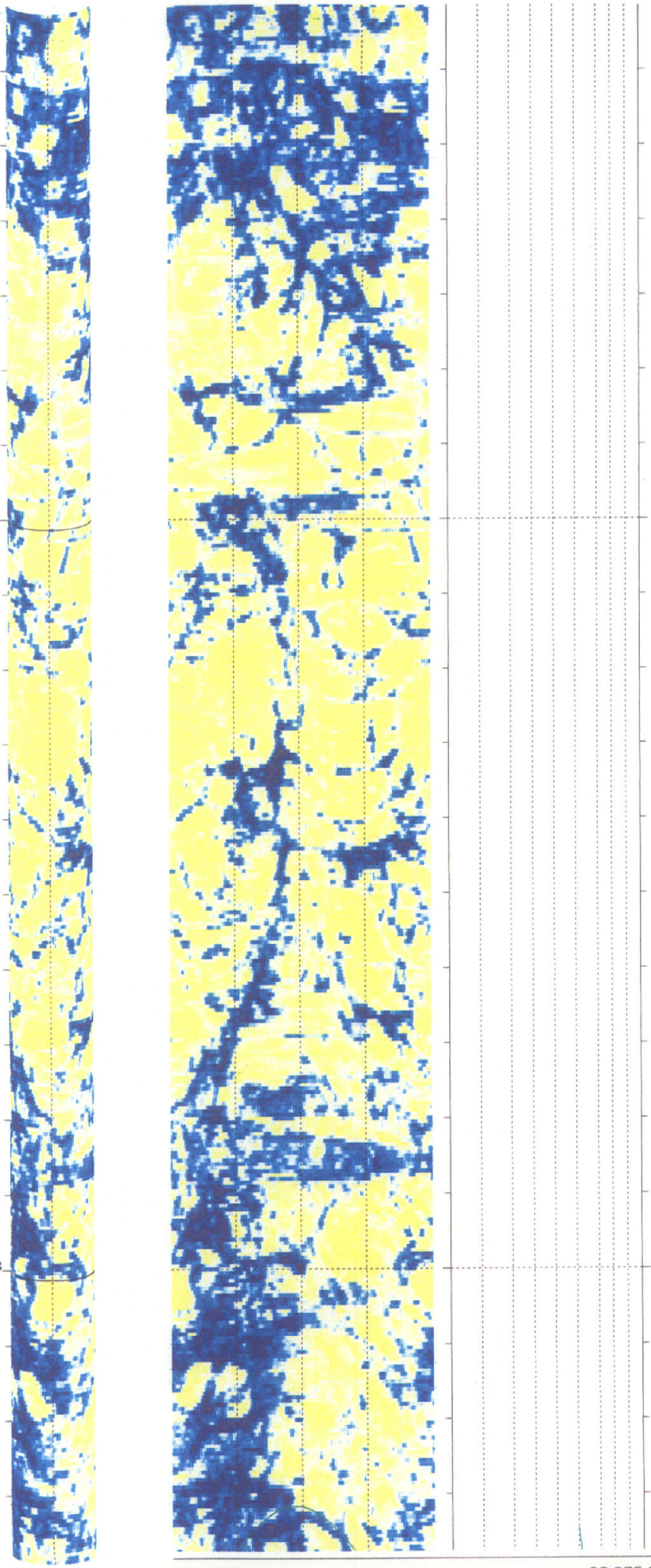
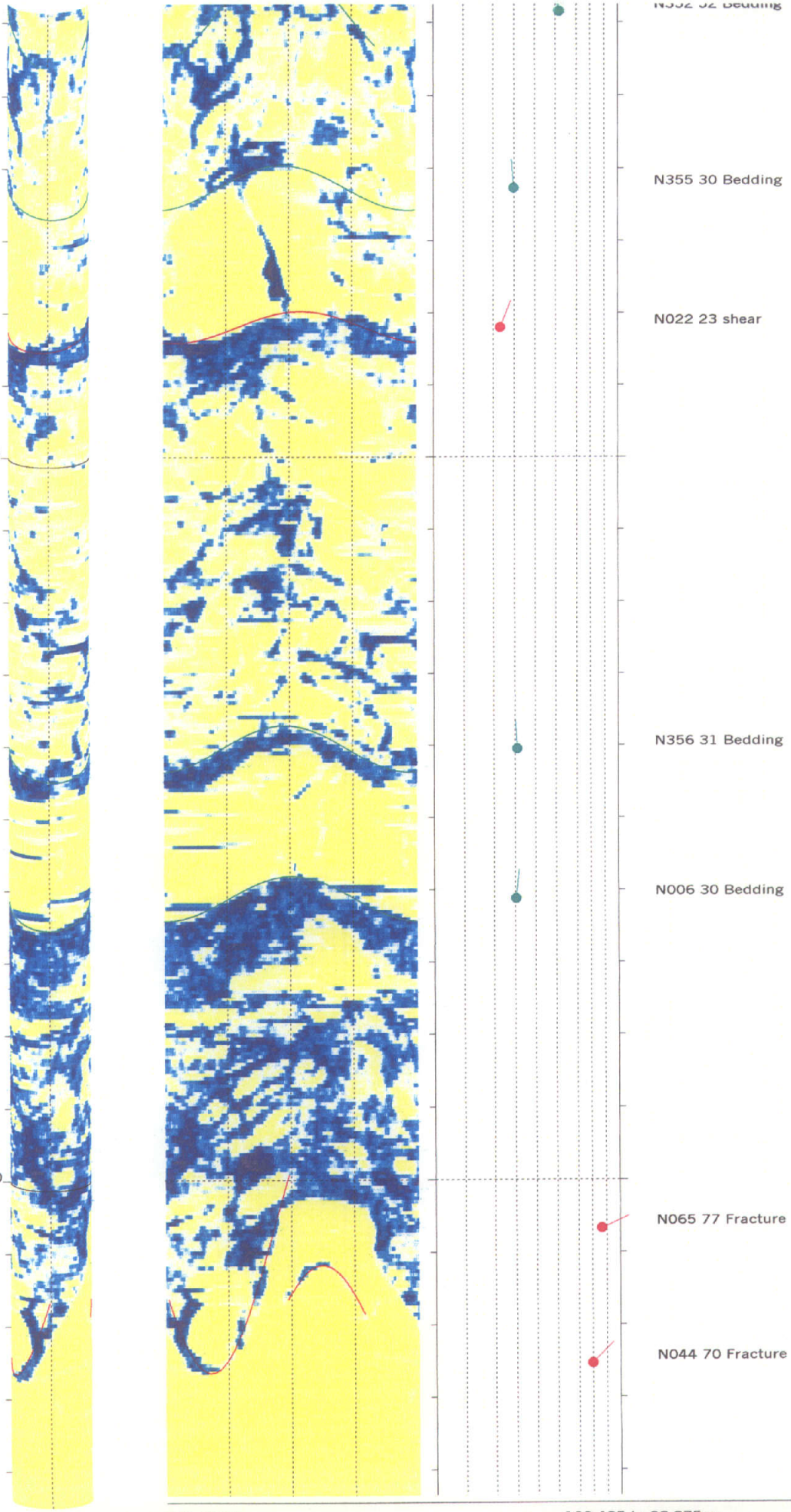
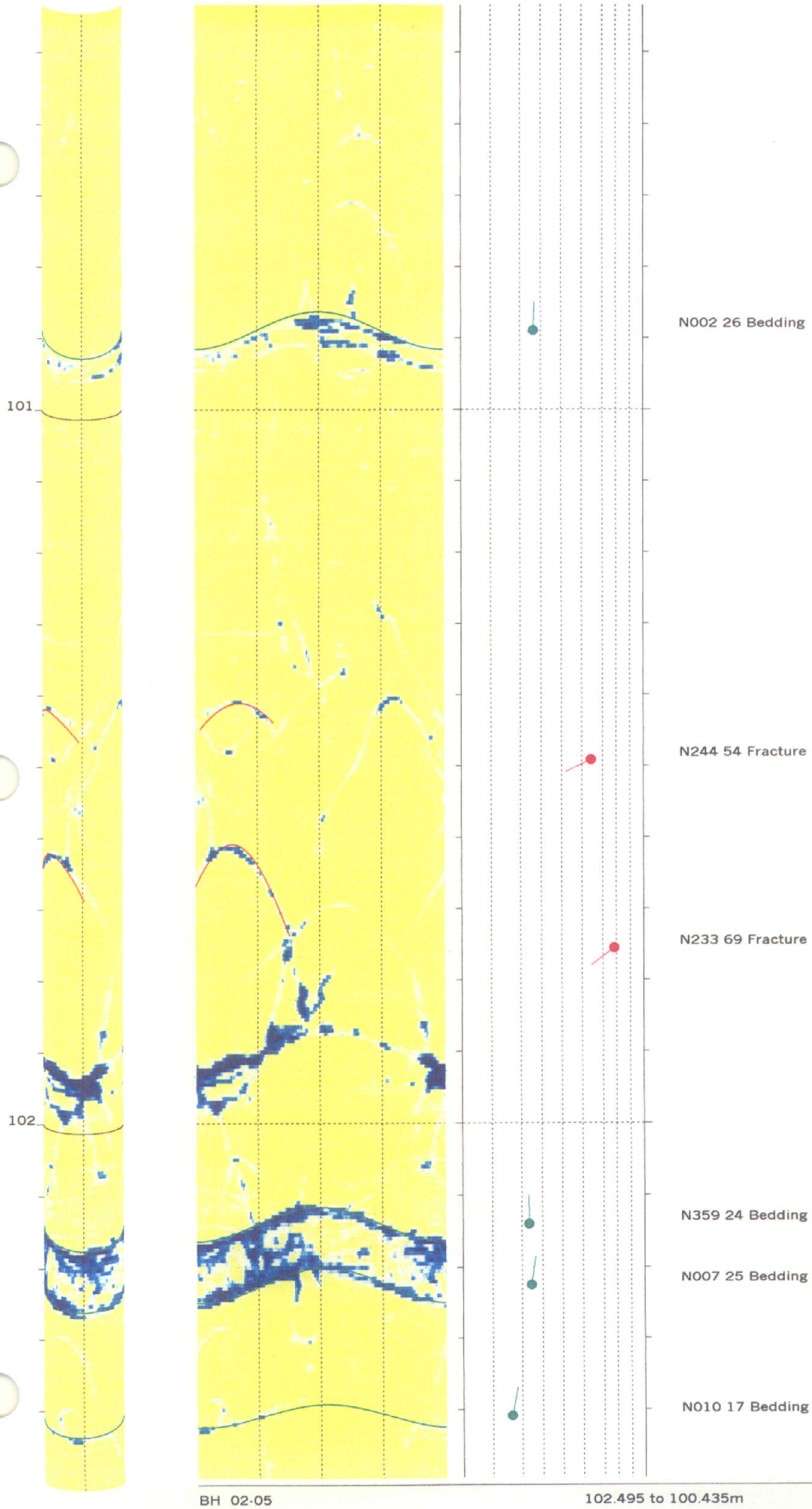
N004 23 Bedding
N331 36 Fracture
95
96


97
98
N352 52 Bedding


N352 32 Bedding
N355 30 Bedding
N022 23 shear
99
N356 31 Bedding
N006 30 Bedding
100
N065 77 Fracture
N044 70 Fracture


101
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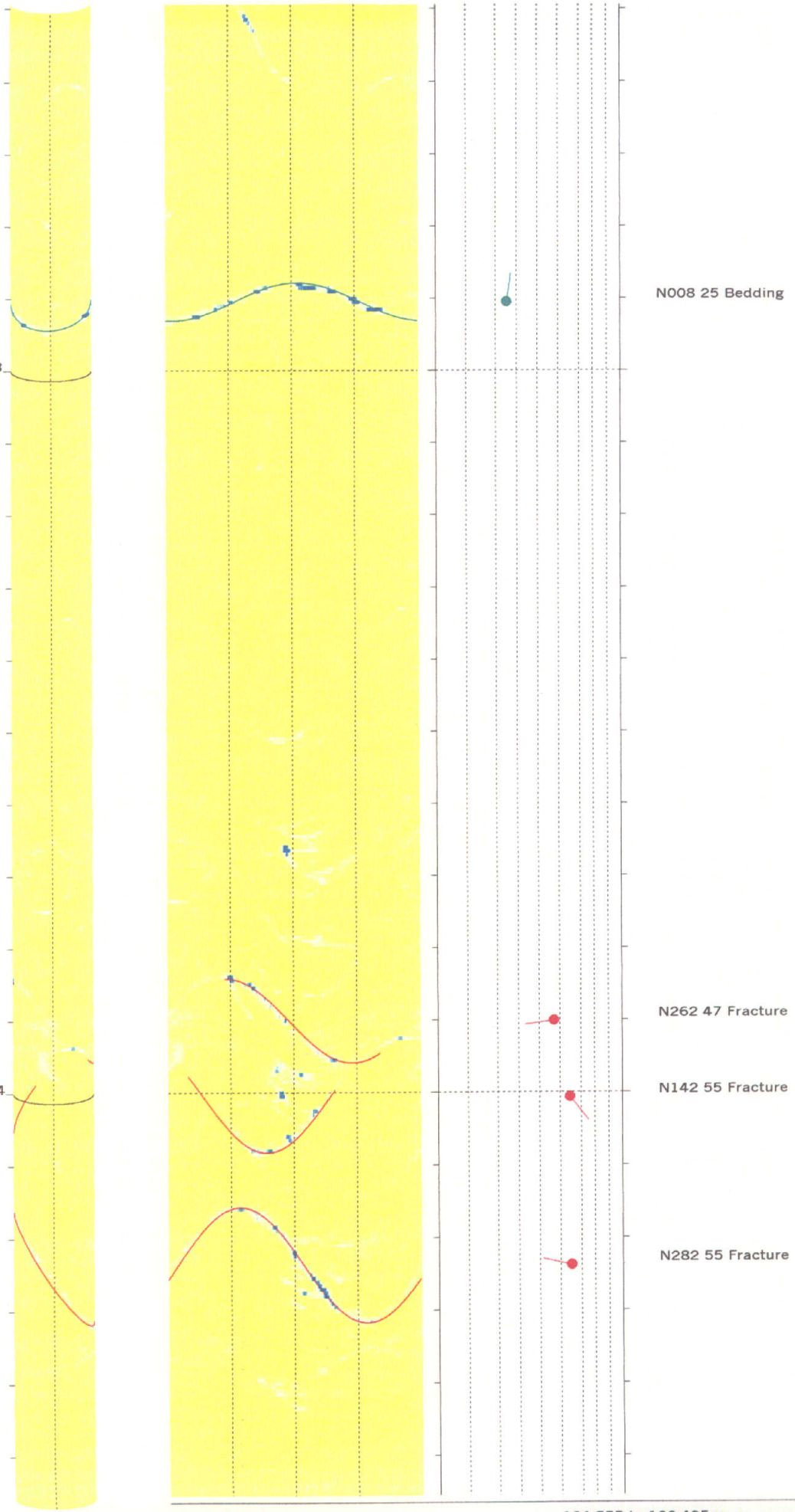
N244 54 Fracture
N233 69 Fracture
N359 24 Bedding
N007 25 Bedding
N010 17 Bedding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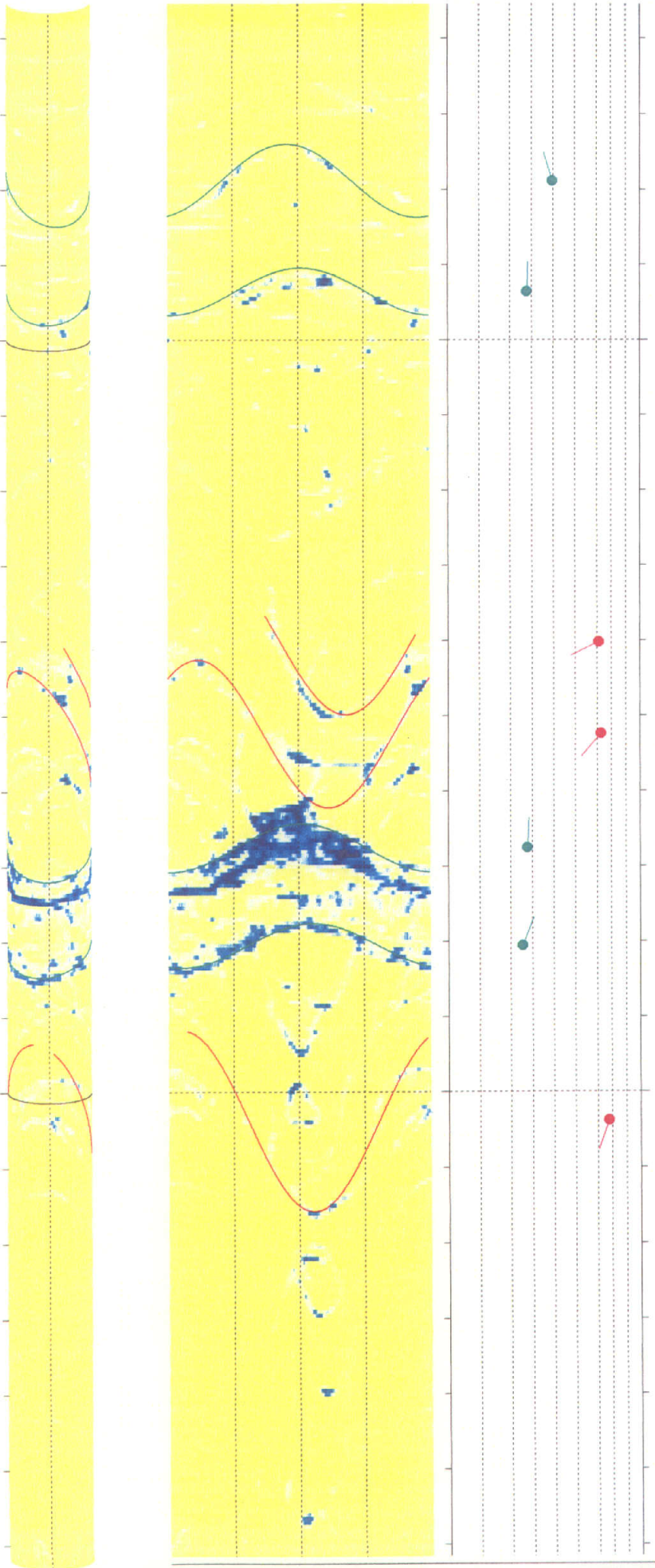
N142 55 Fracture
N282 55 Fracture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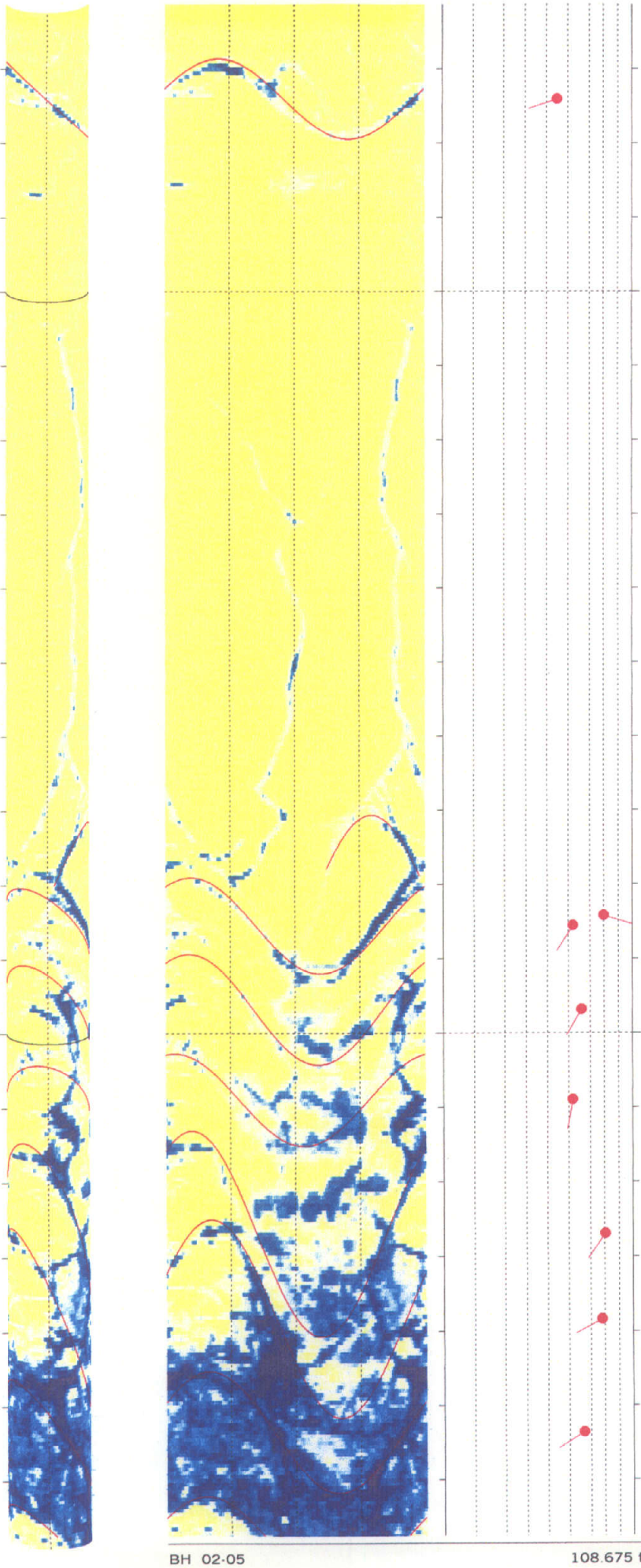
N021 25 Bedding
N200 68 Fracture


107
108
N252 45 Fracture
vertical_fracture
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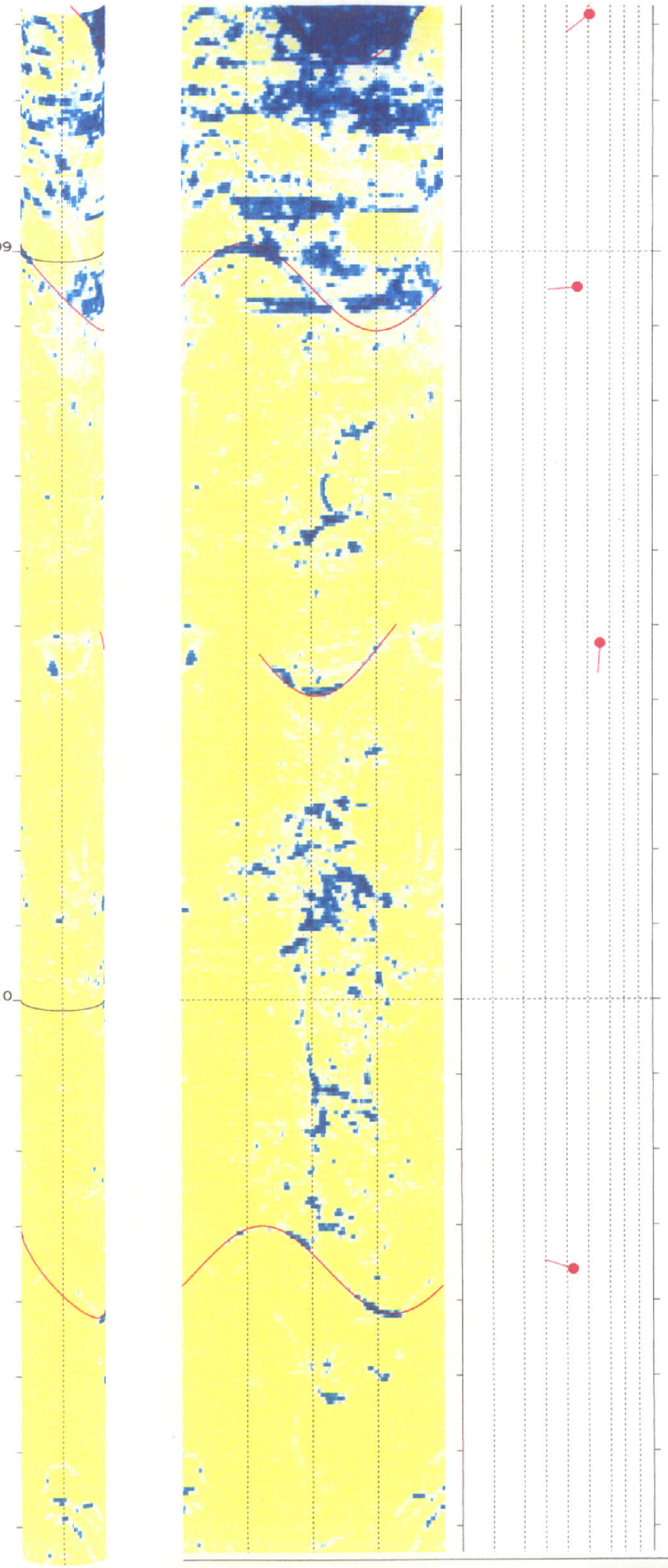
N213 52 Fracture
N210 56 Fracture
N190 52 Fracture
N215 70 Fracture
N241 68 Fracture
N237 57 shear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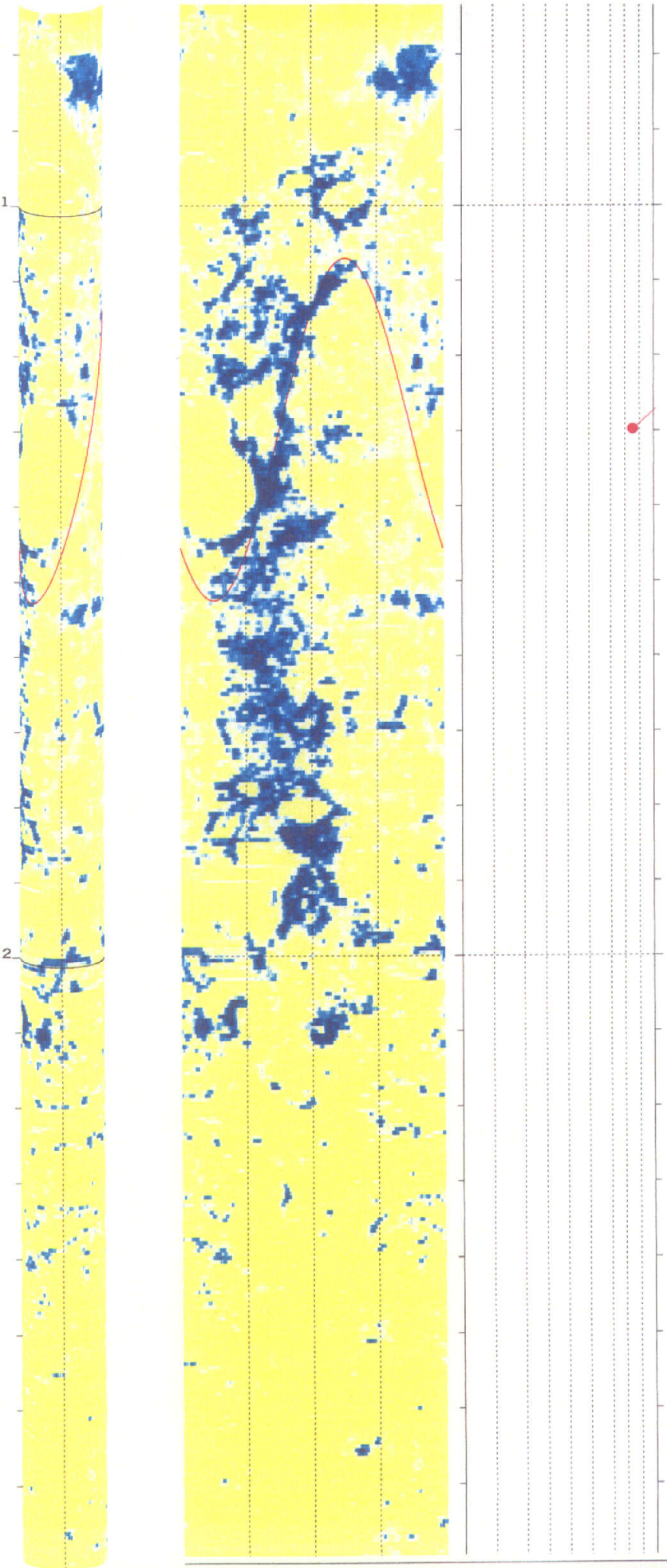
N288 43 Fracture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112
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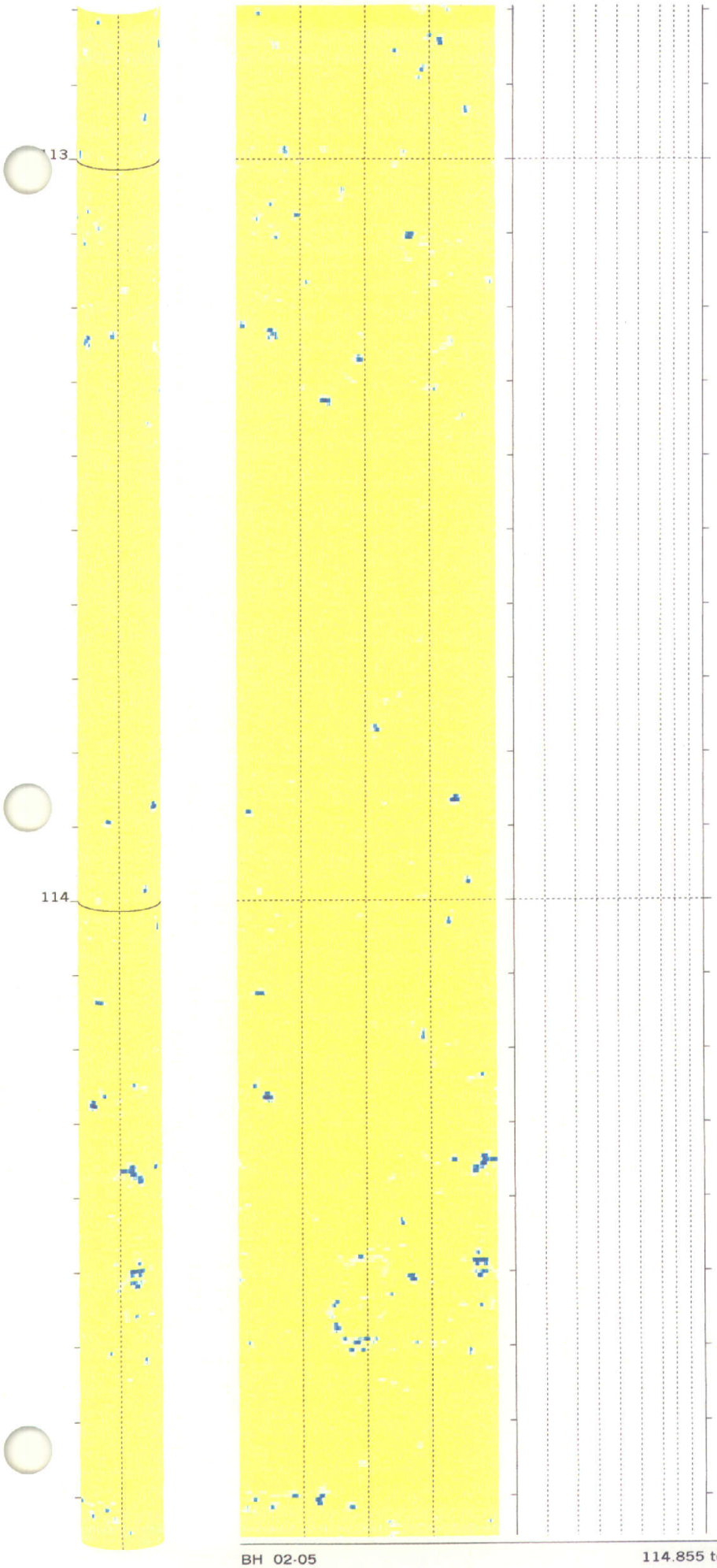
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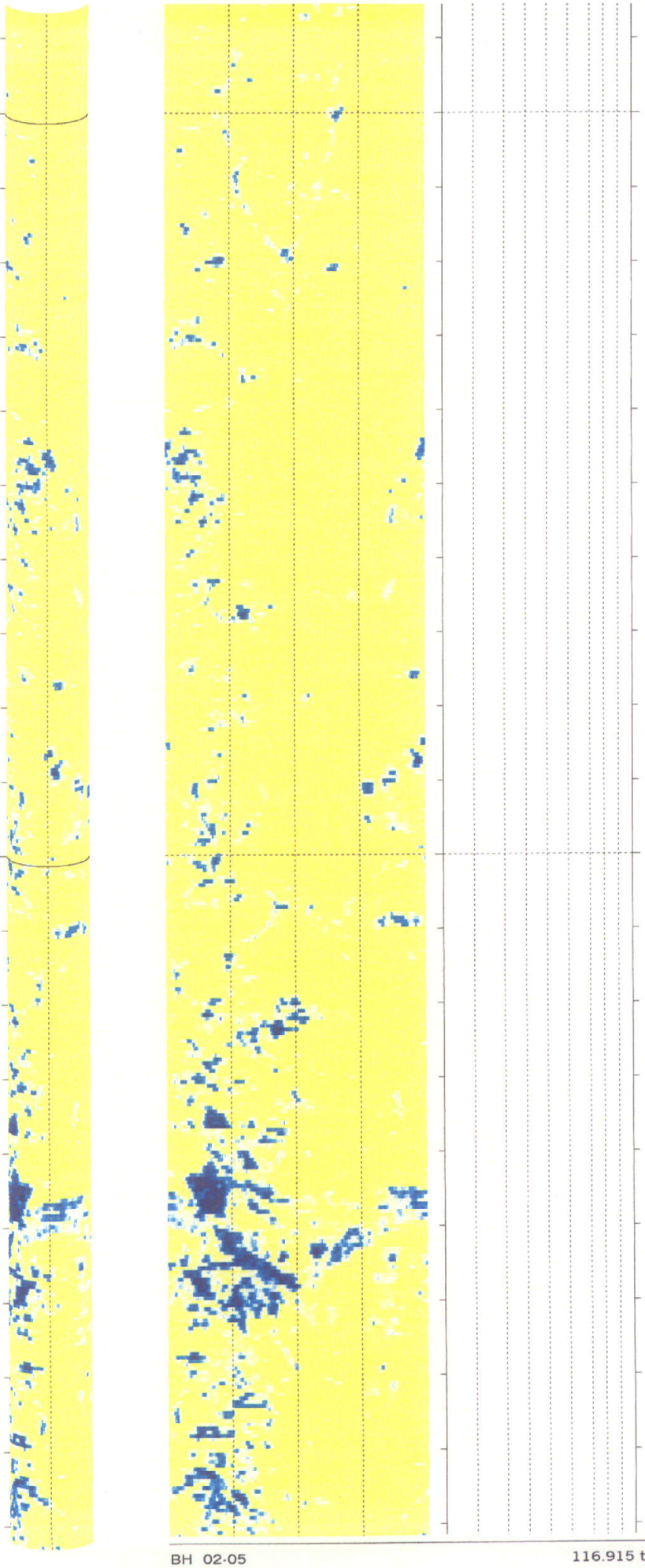
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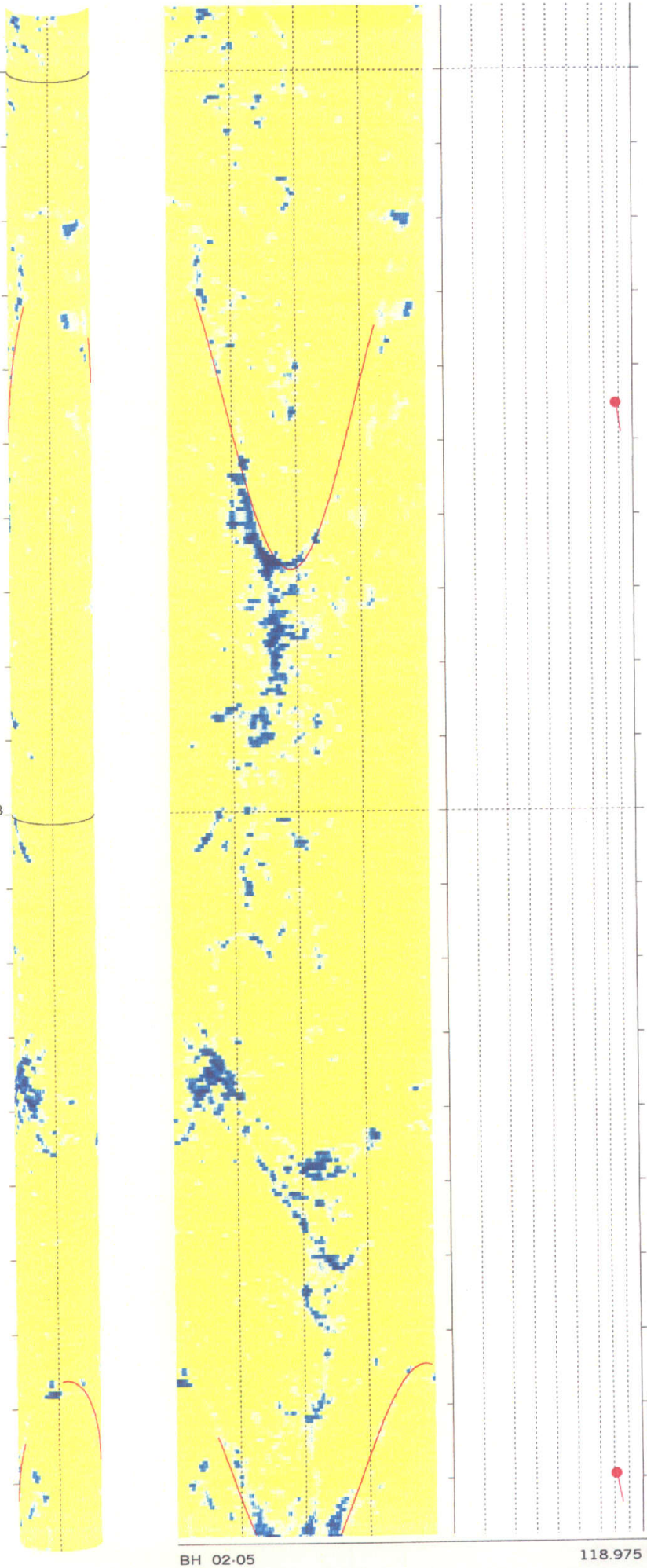
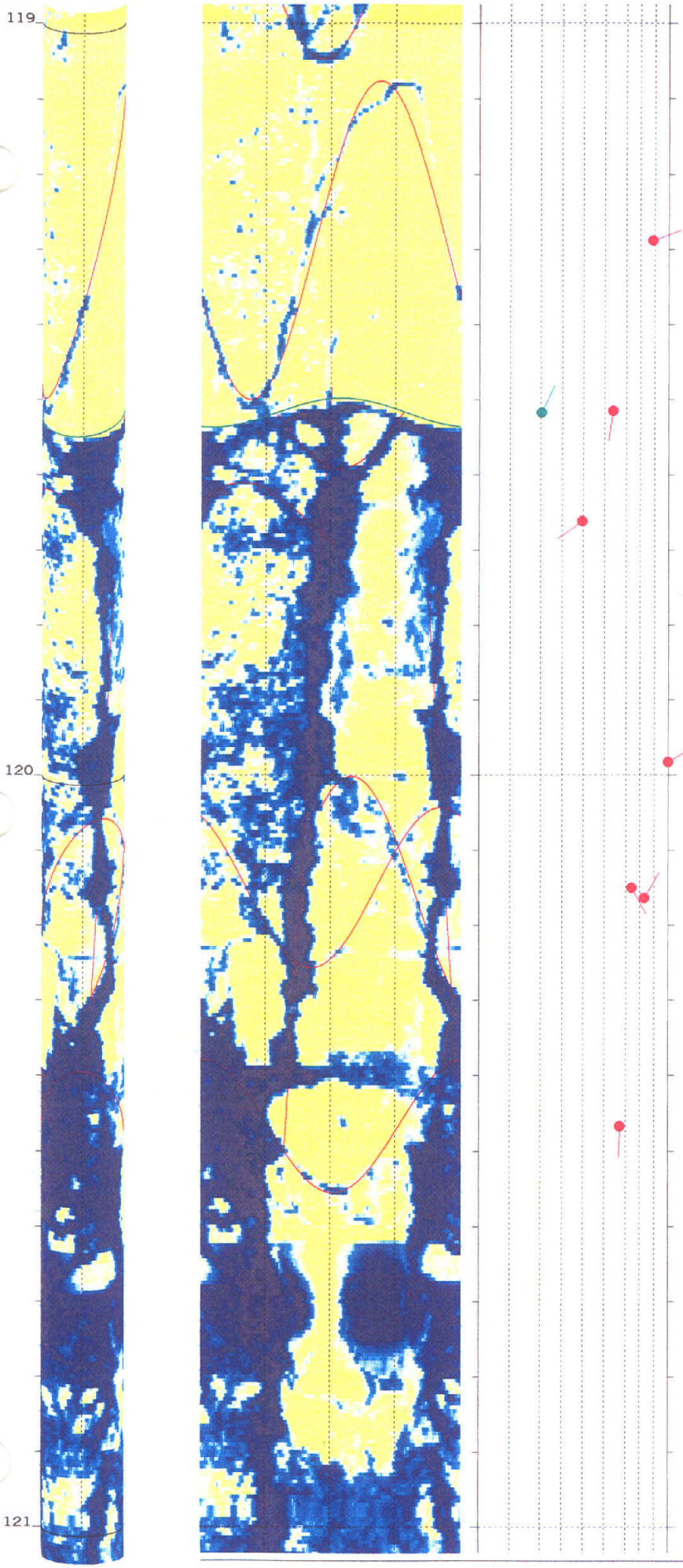
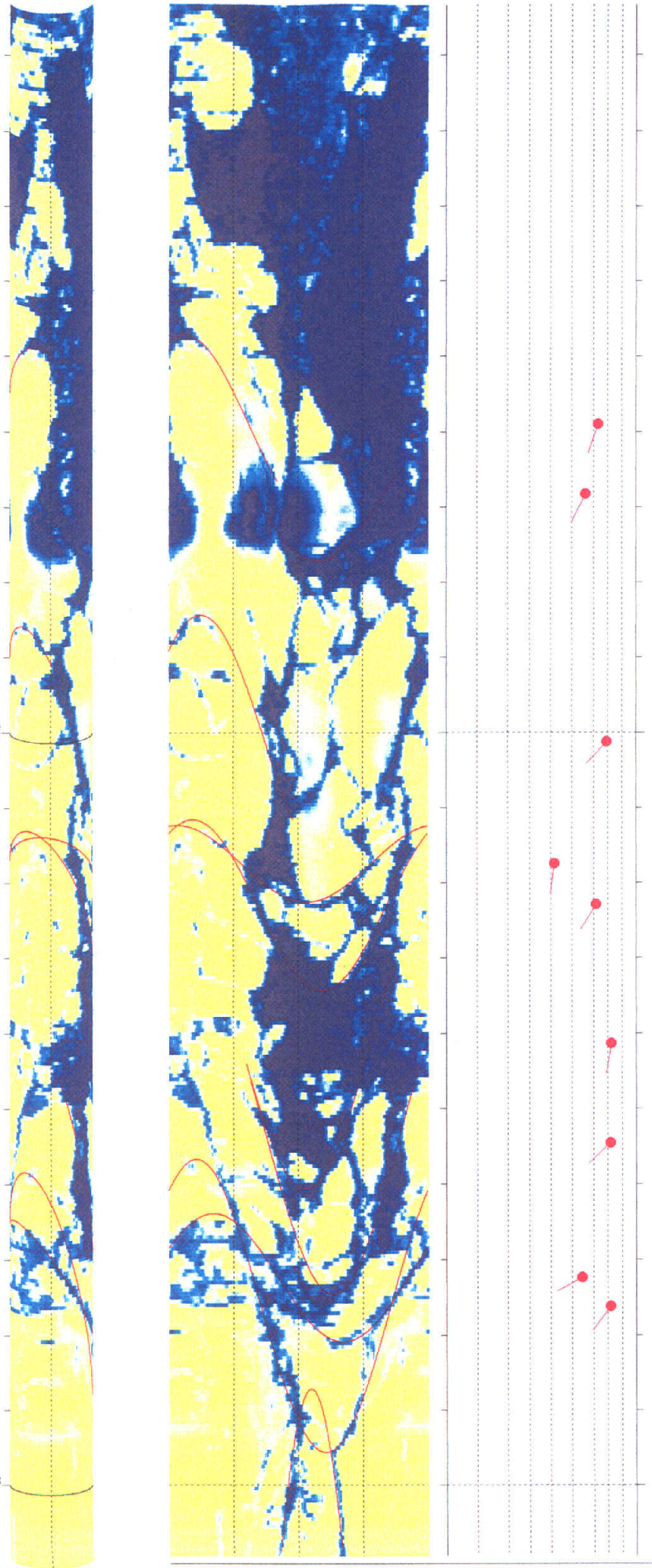


BH 02-05

118.975 to 116.915m


119
120
121
N069 79 Fracture Irregular
N029 20 Bedding
N235 40 Fracture Discontinuous
N059 90 Fracture Discontinuous
N151 64 Fracture Discontinuous
N030 73 Fracture Discontinuous
N182 57 Fracture


122
123
N200 63 Fracture Discontinuous
N206 56 Fracture
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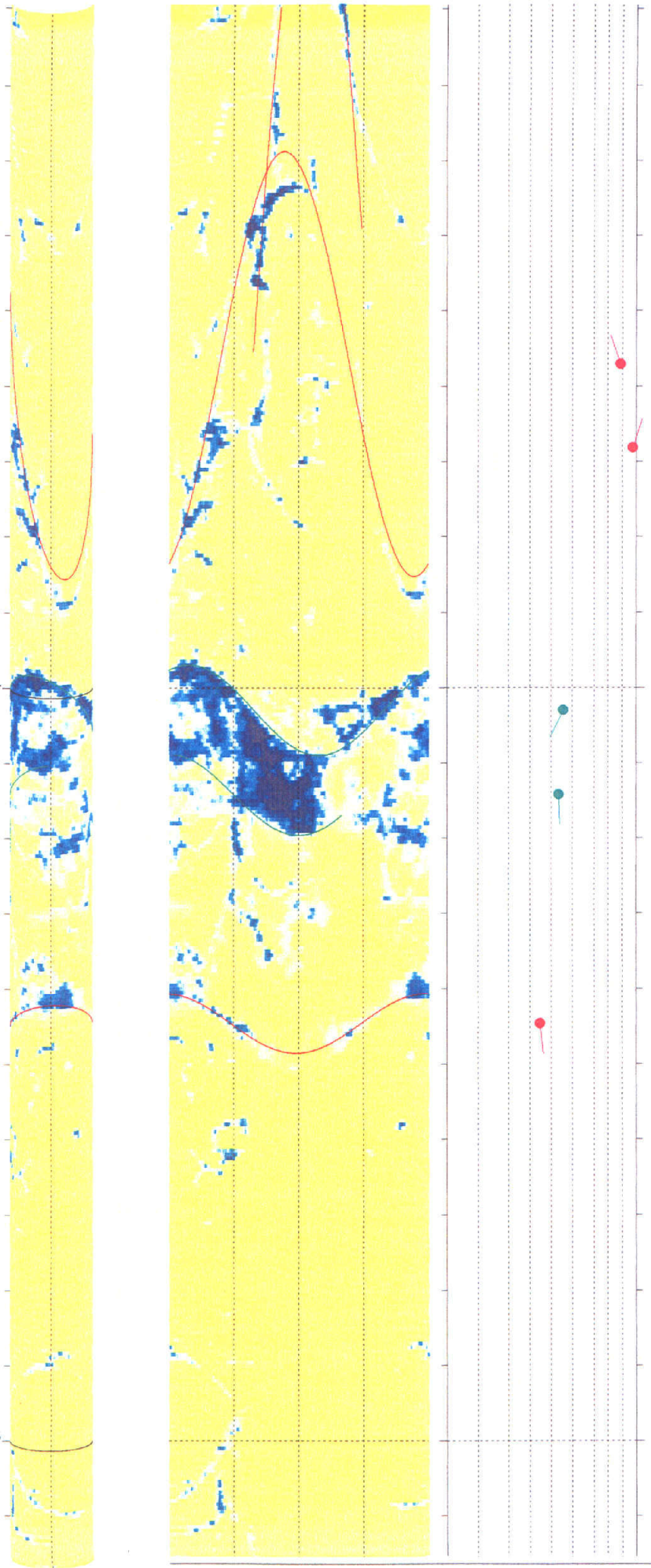
N212 62 Fracture
N189 73 Fracture Discontinuous
N228 72 Fracture Discontinuous
N242 55 Fracture
N218 72 Fracture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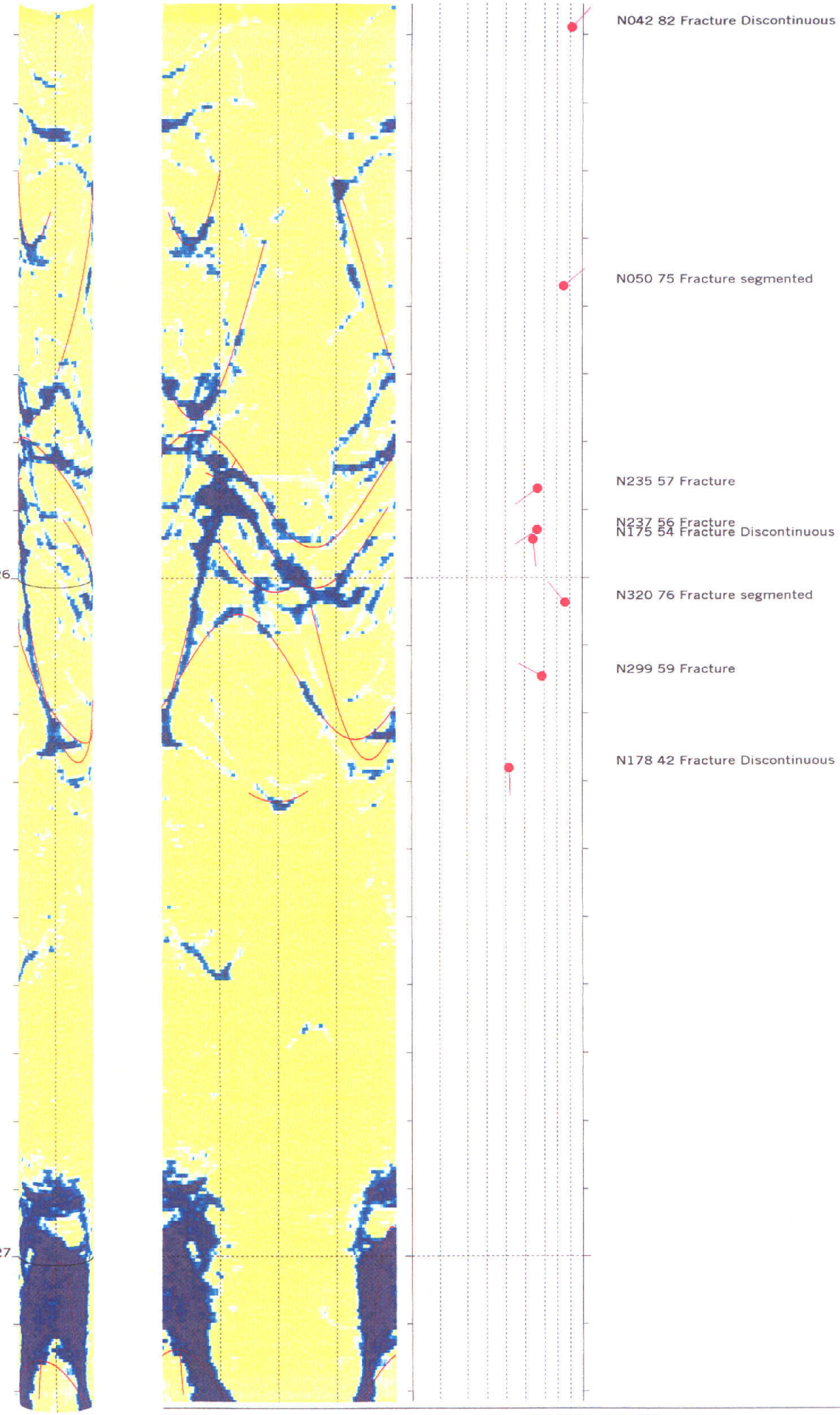
N018 88 Fracture Discontinuous
N207 46 Bedding
N178 44 Bedding
N174 35 Fracture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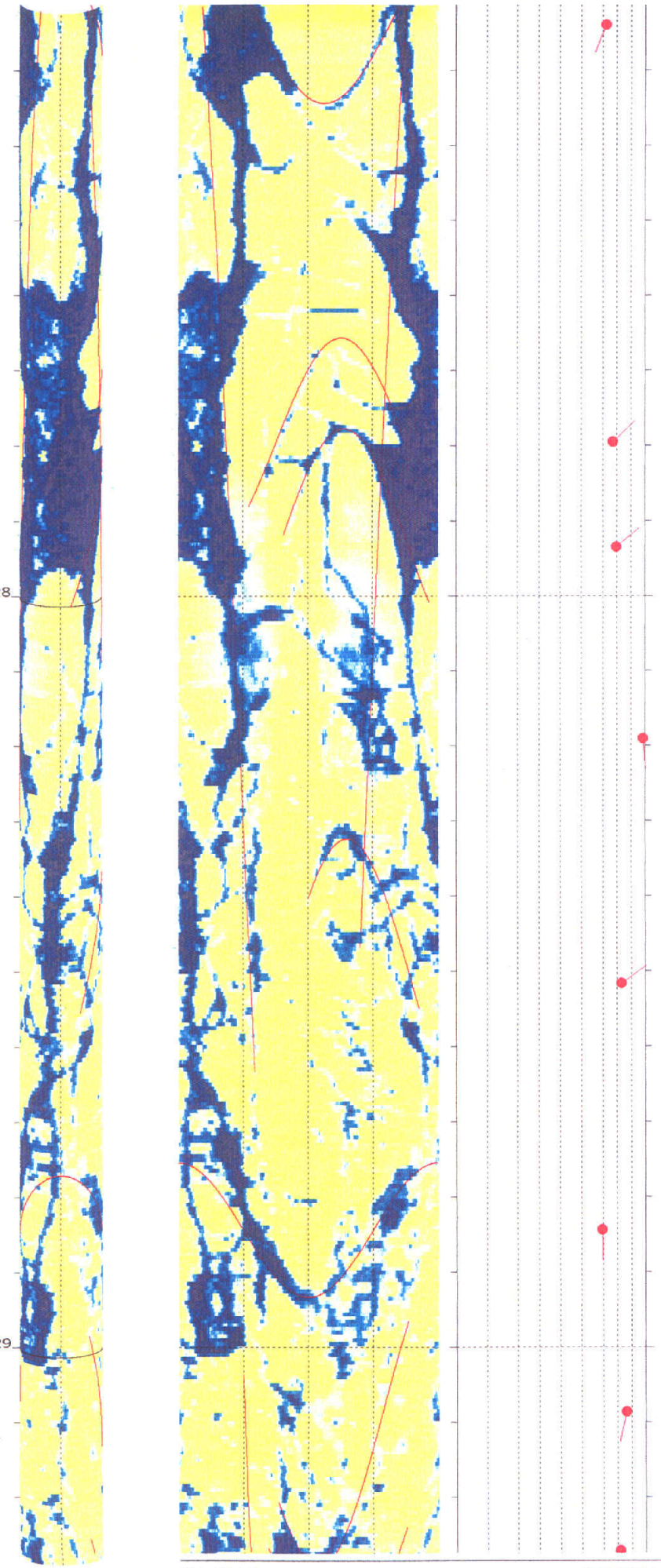
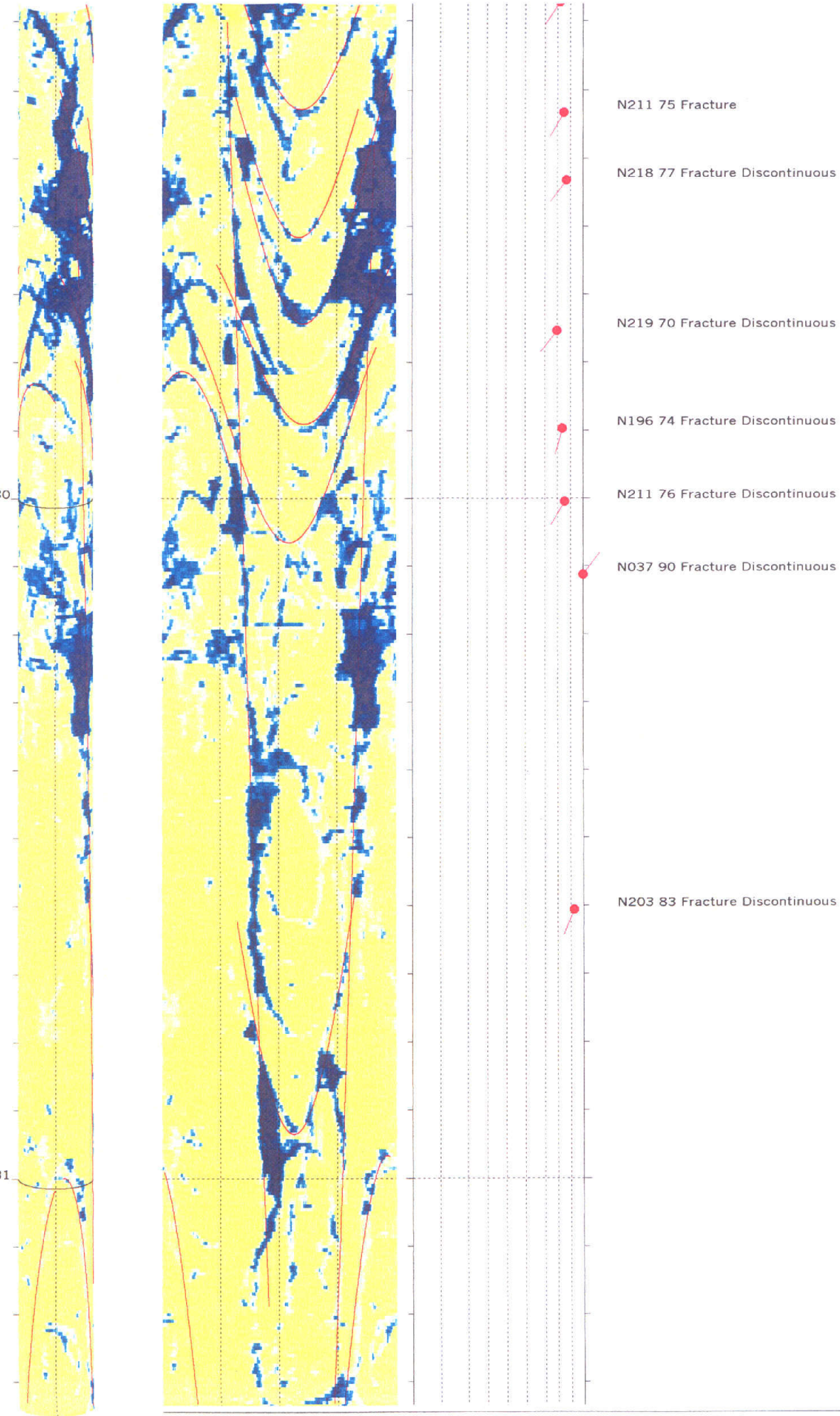
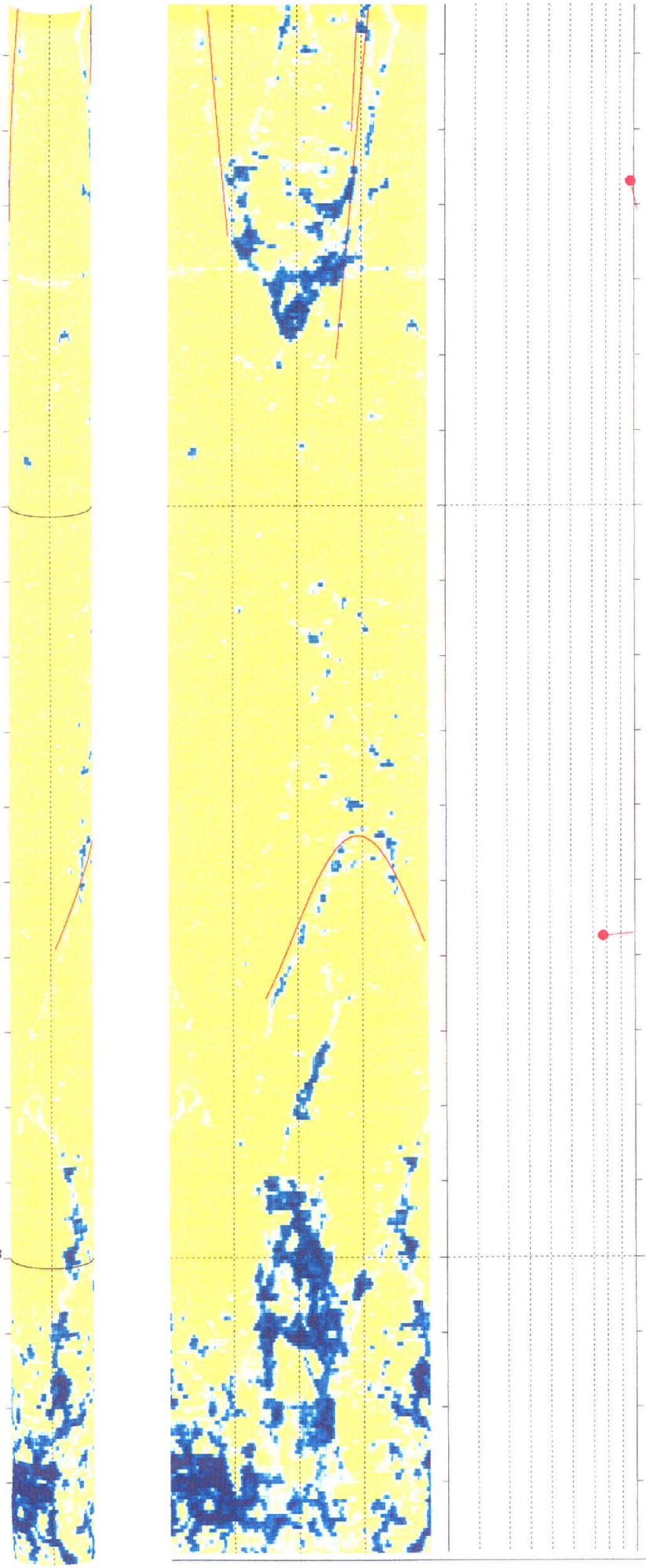
N050 75 Fracture segmented
N235 57 Fracture
N237 56 Fracture
N175 54 Fracture Discontinuous
126
N320 76 Fracture segmented
N299 59 Fracture
N178 42 Fracture Discontinuous
127


128
129
N203 63 Fracture
N046 67 Fracture Discontinuous
N050 70 Fracture Discontinuous
N175 88 Fracture Discontinuous
N054 73 Fracture Discontinuous
N180 60 Fracture
N193 77 Fracture
N215 72 Fracture Discontinuous


130
131
N211 75 Fracture
N218 77 Fracture Discontinuous
N219 70 Fracture Discontinuous
N196 74 Fracture Discontinuous
N211 76 Fracture Discontinuous
N037 90 Fracture Discontinuous
N203 83 Fracture Discontinuous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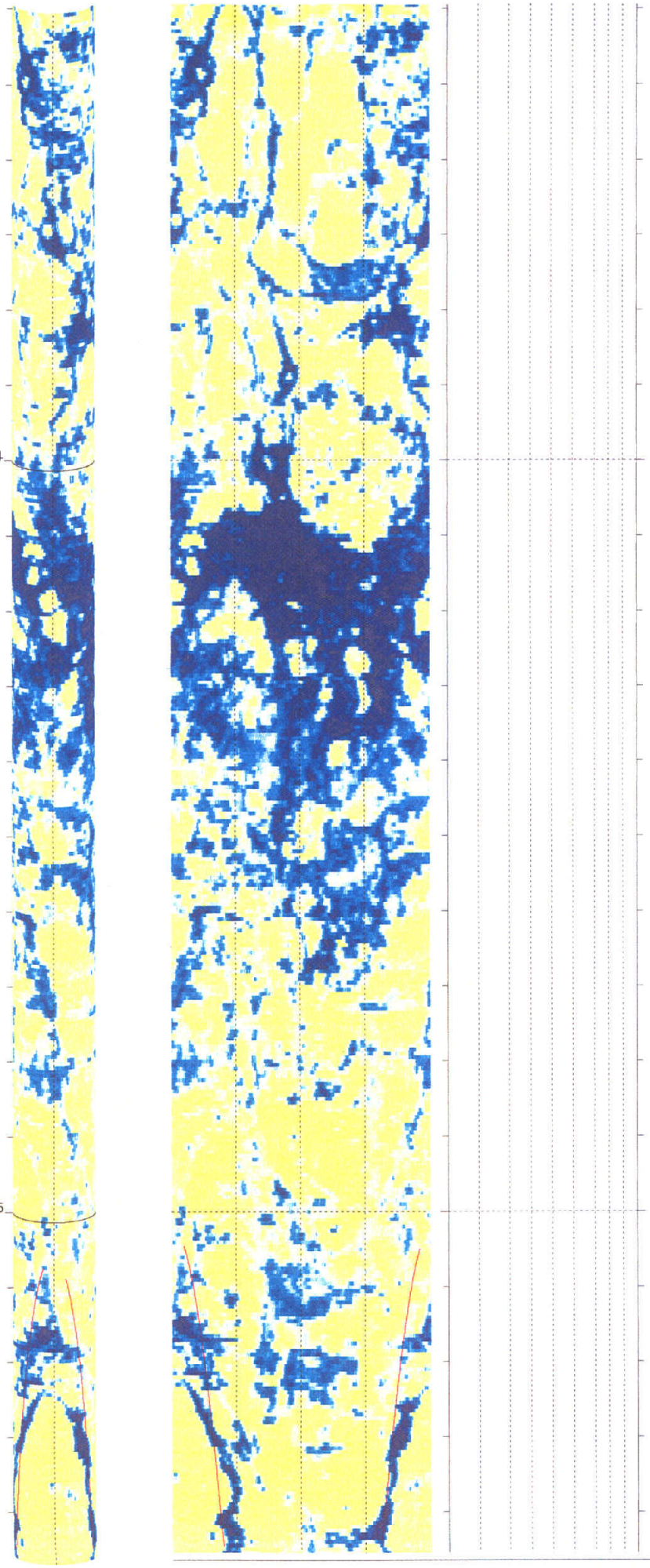
132
N084 67 Fracture Discontinuous
133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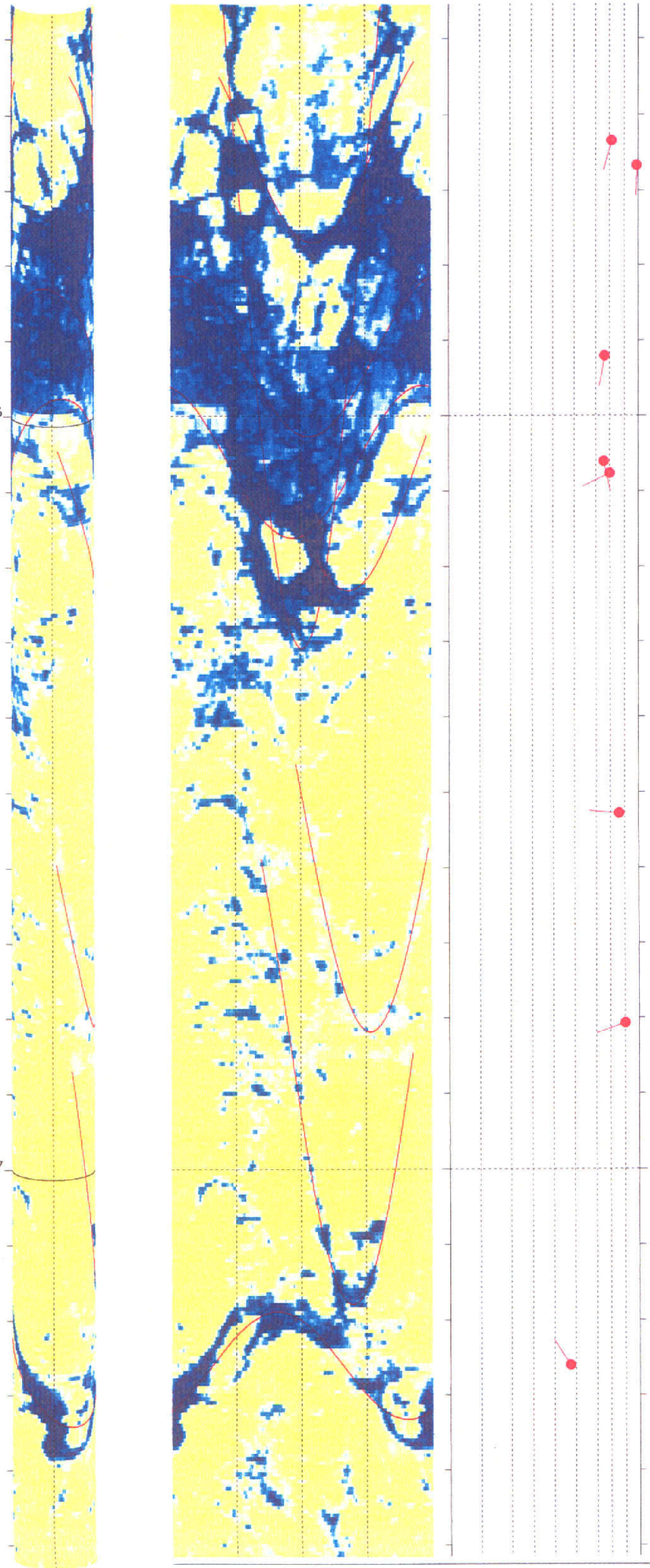
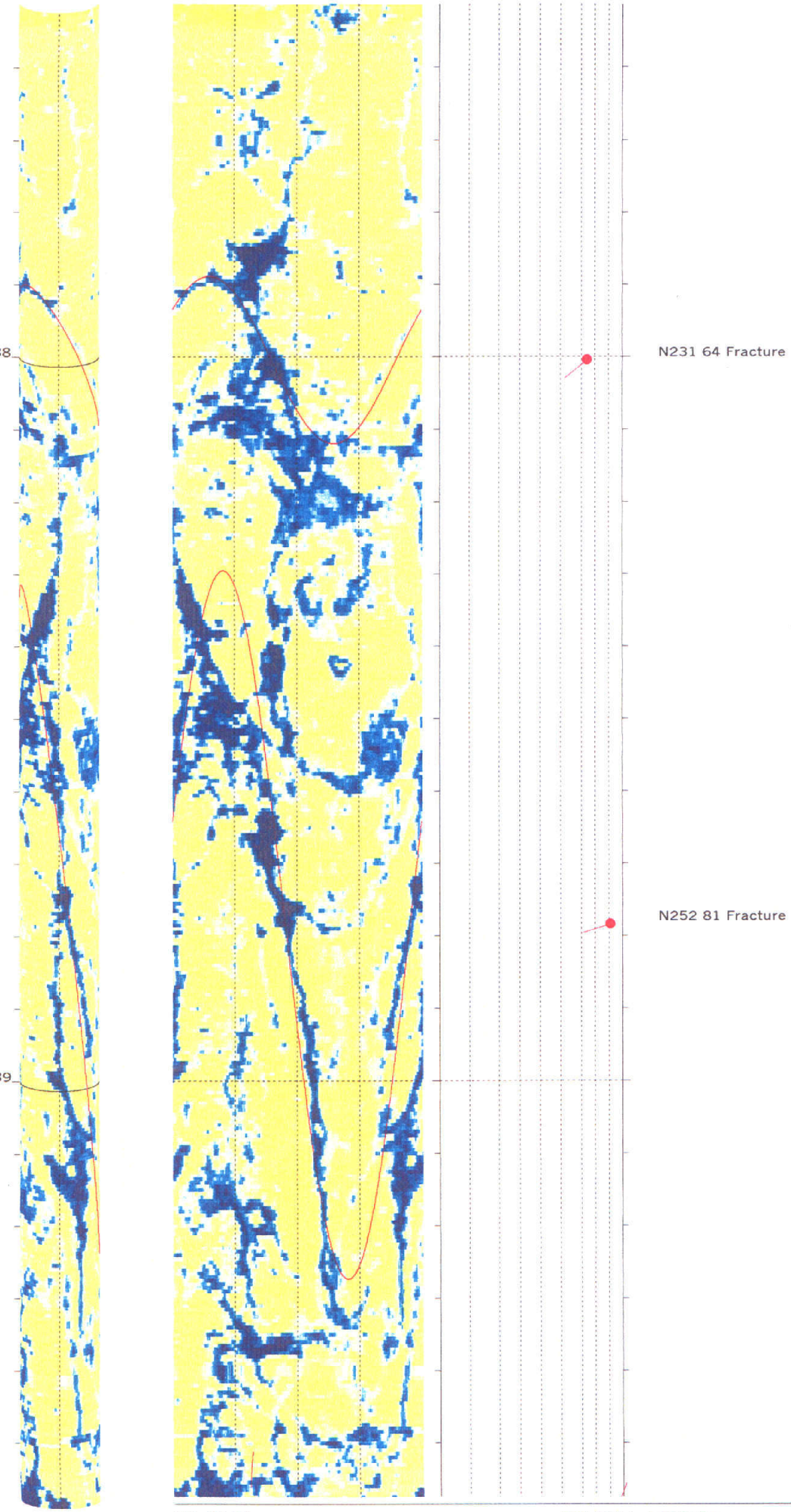

136
137
N196 71 Fracture Discontinuous
N182 89 Fracture Discontinuous
N191 66 Fracture
N168 66 Fracture
N244 70 Fracture
N275 76 Fracture Discontinuous
N250 80 Fracture Discontinuous
N327 48 Fracture Irregular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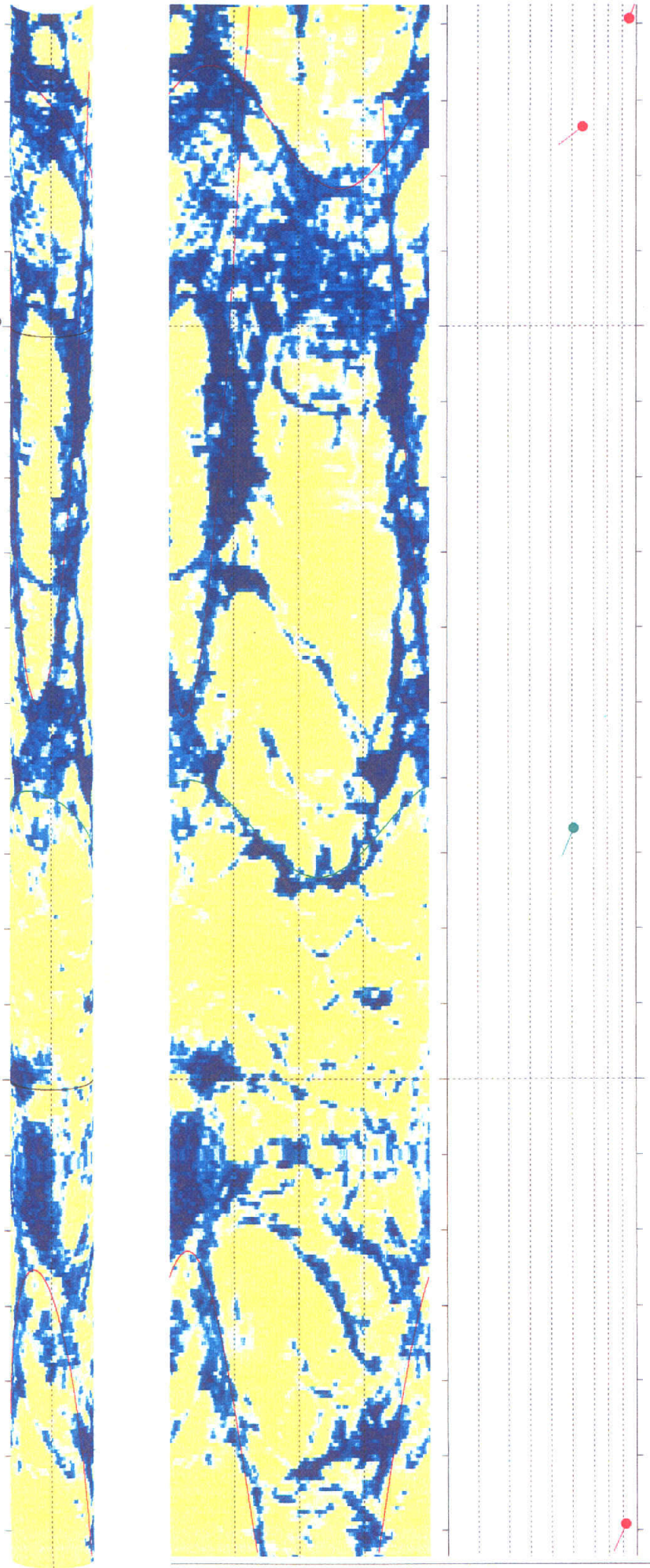
N252 81 Fracture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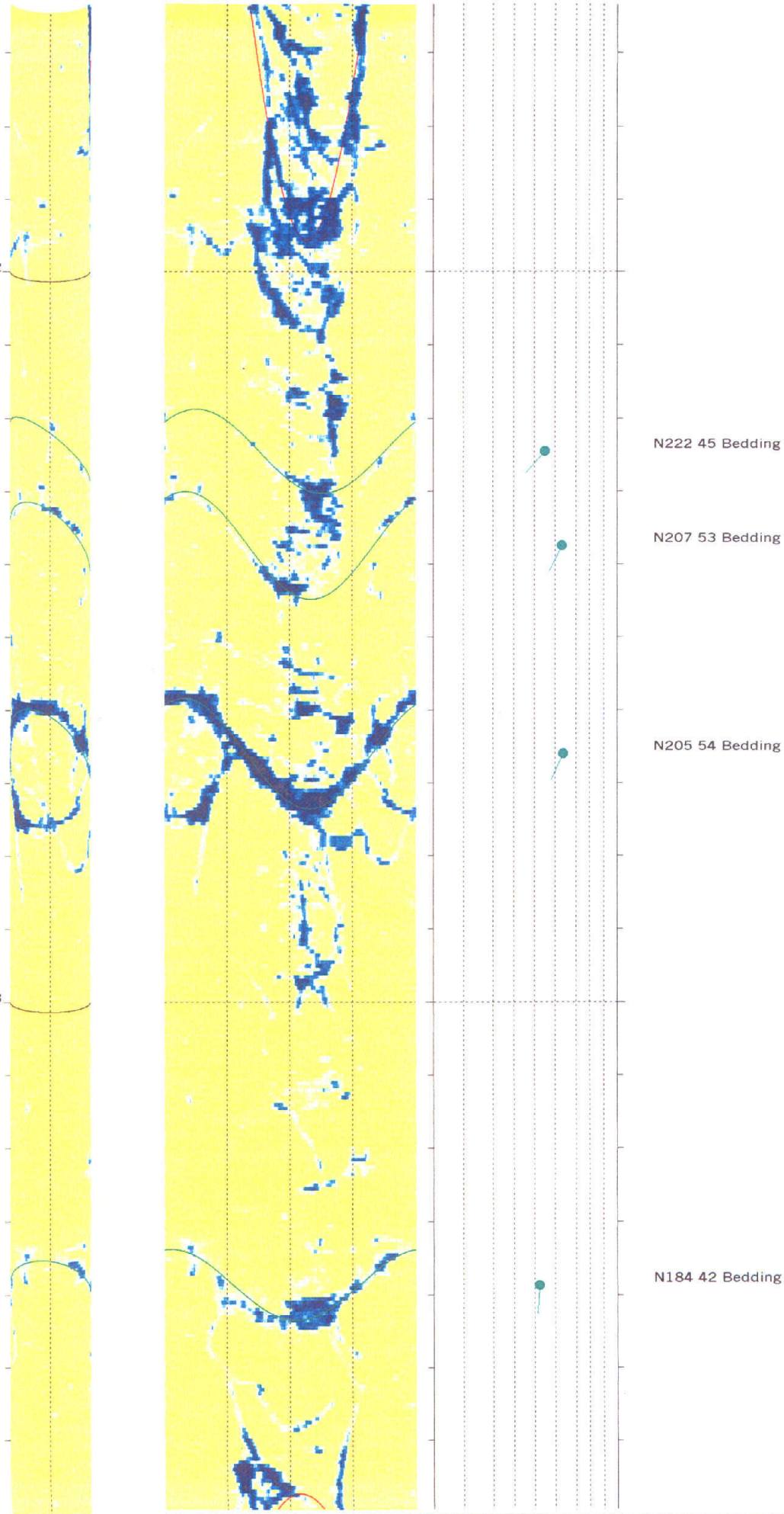
N204 82 Fracture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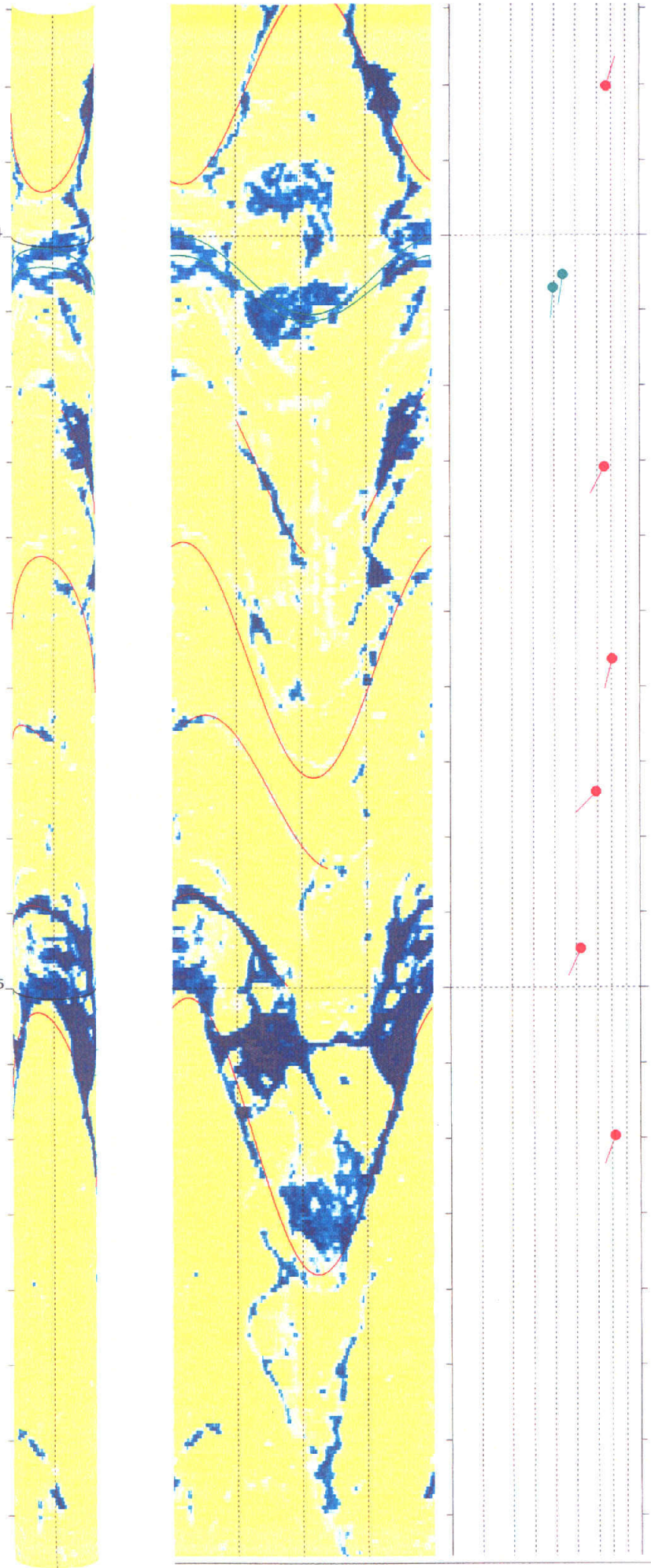
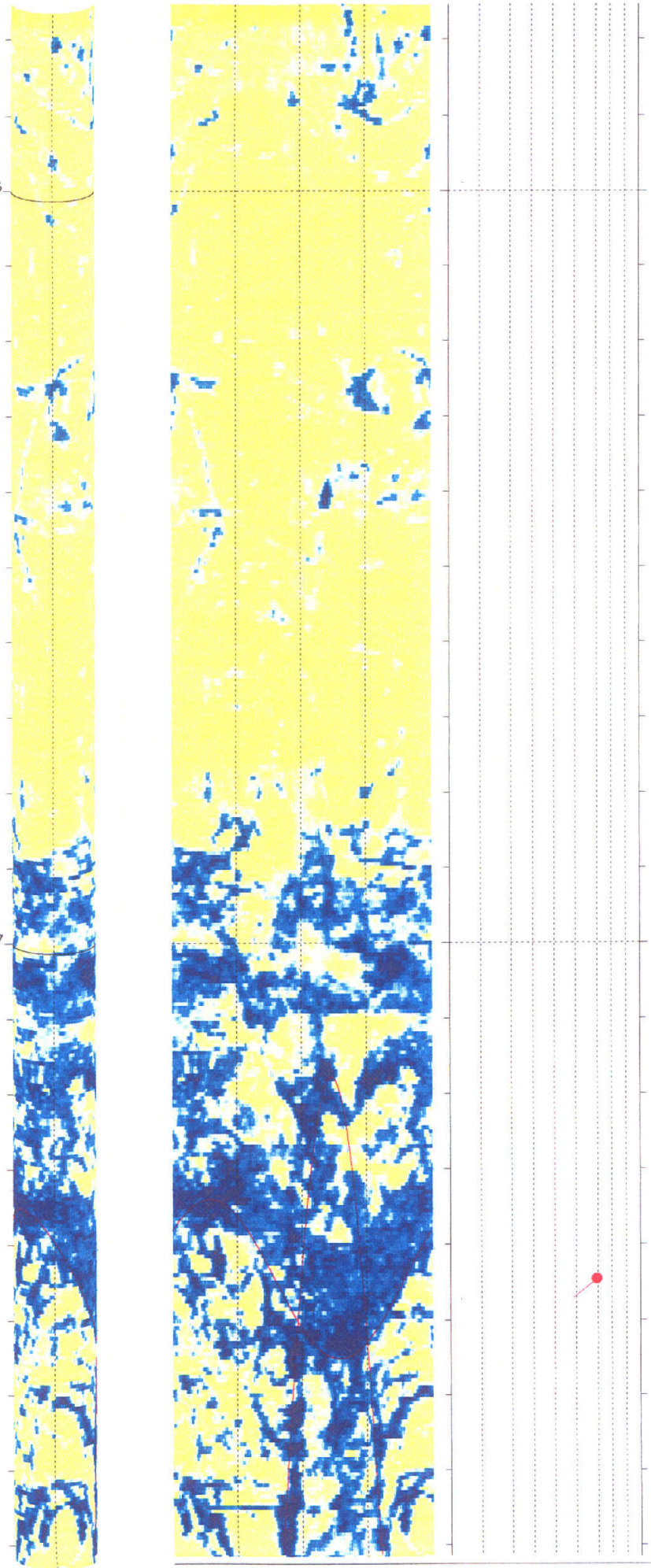
N207 53 Bedding
N205 54 Bedding
N184 42 Bedding


144
145
N017 67 Fracture
N188 44 Bedding
N185 40 Bedding
N208 65 Fracture Discontinuous
N194 70 Fracture
N224 59 Fracture
N205 52 Fracture Discontinuous
N201 72 Fracture Irregular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147
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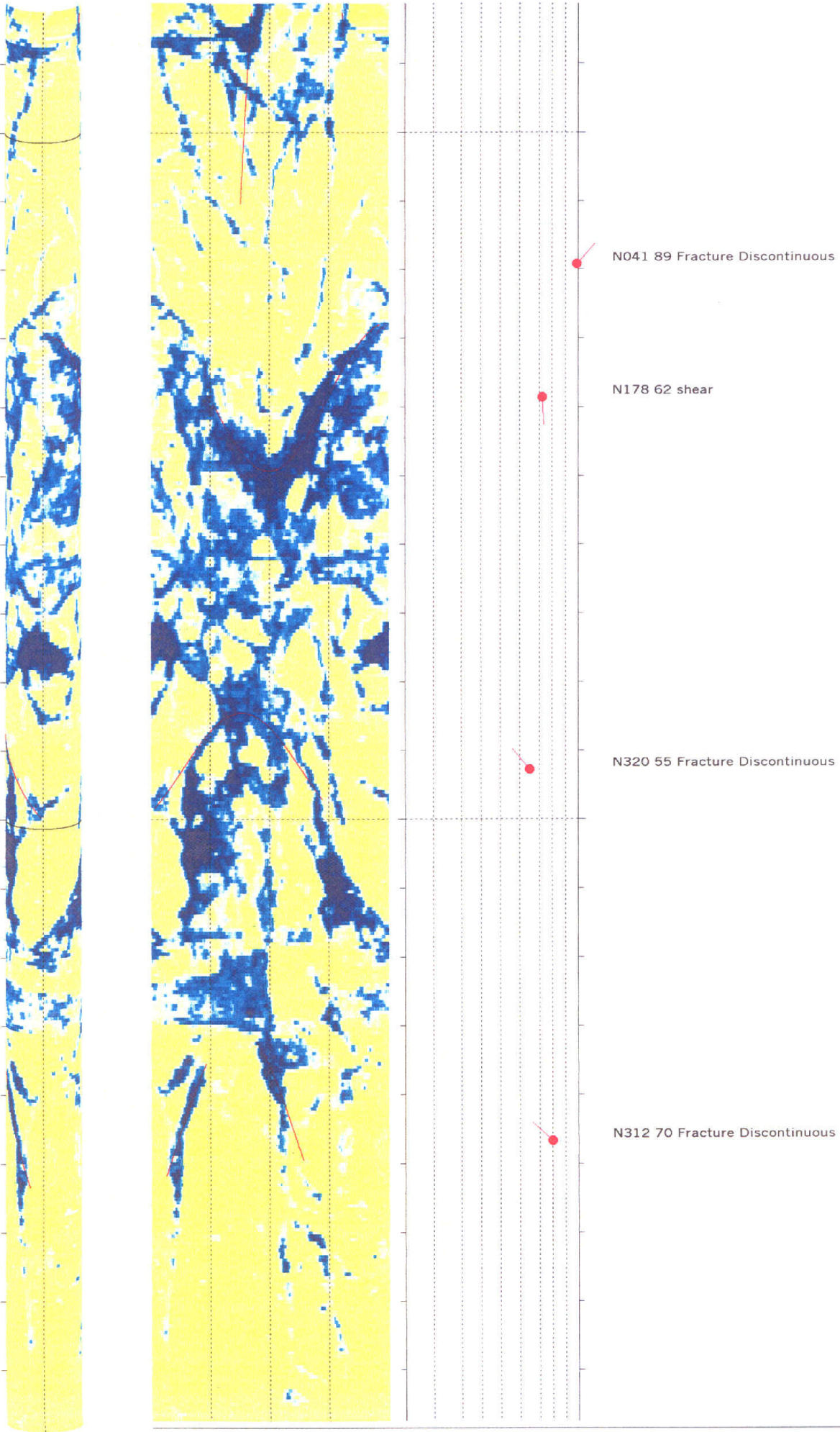
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N178 62 shear
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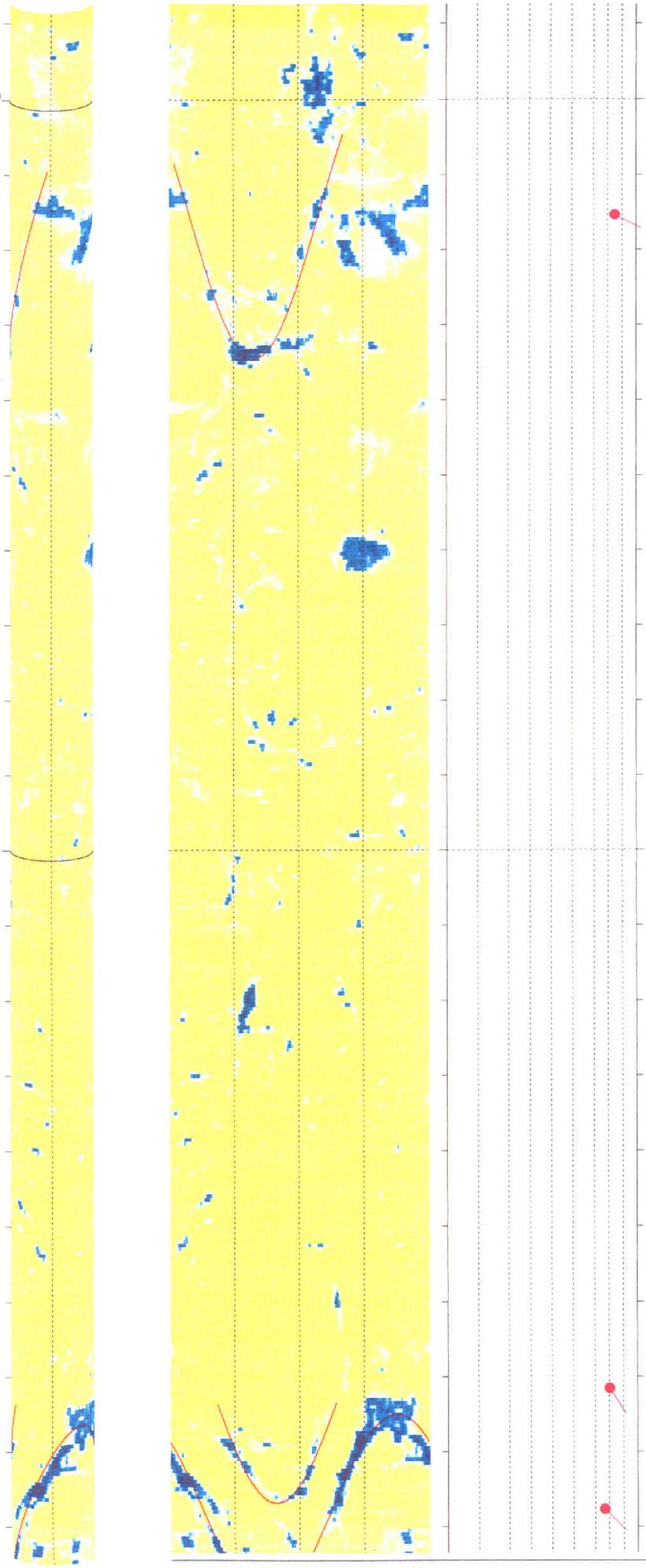
N312 70 Fracture Discontinuous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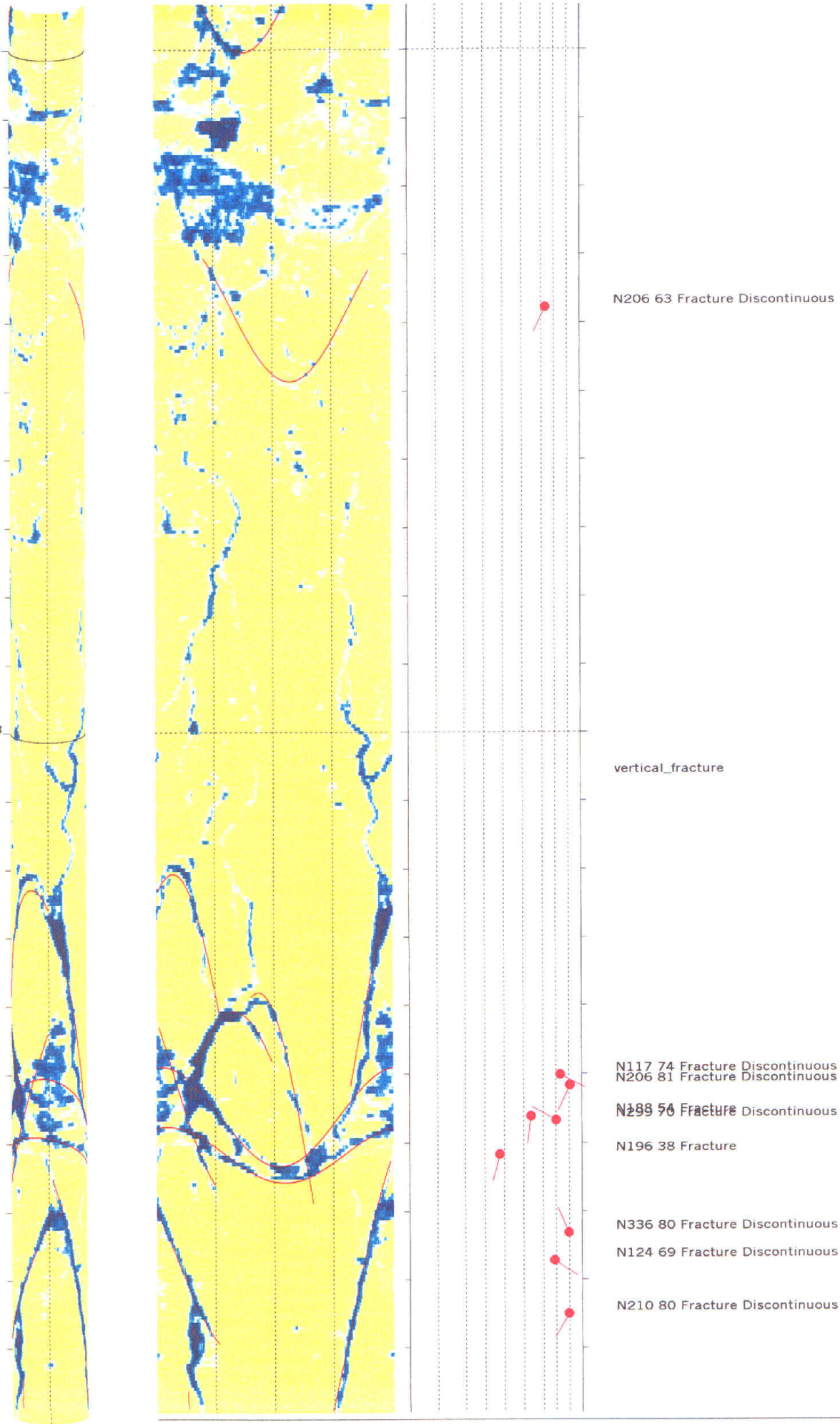
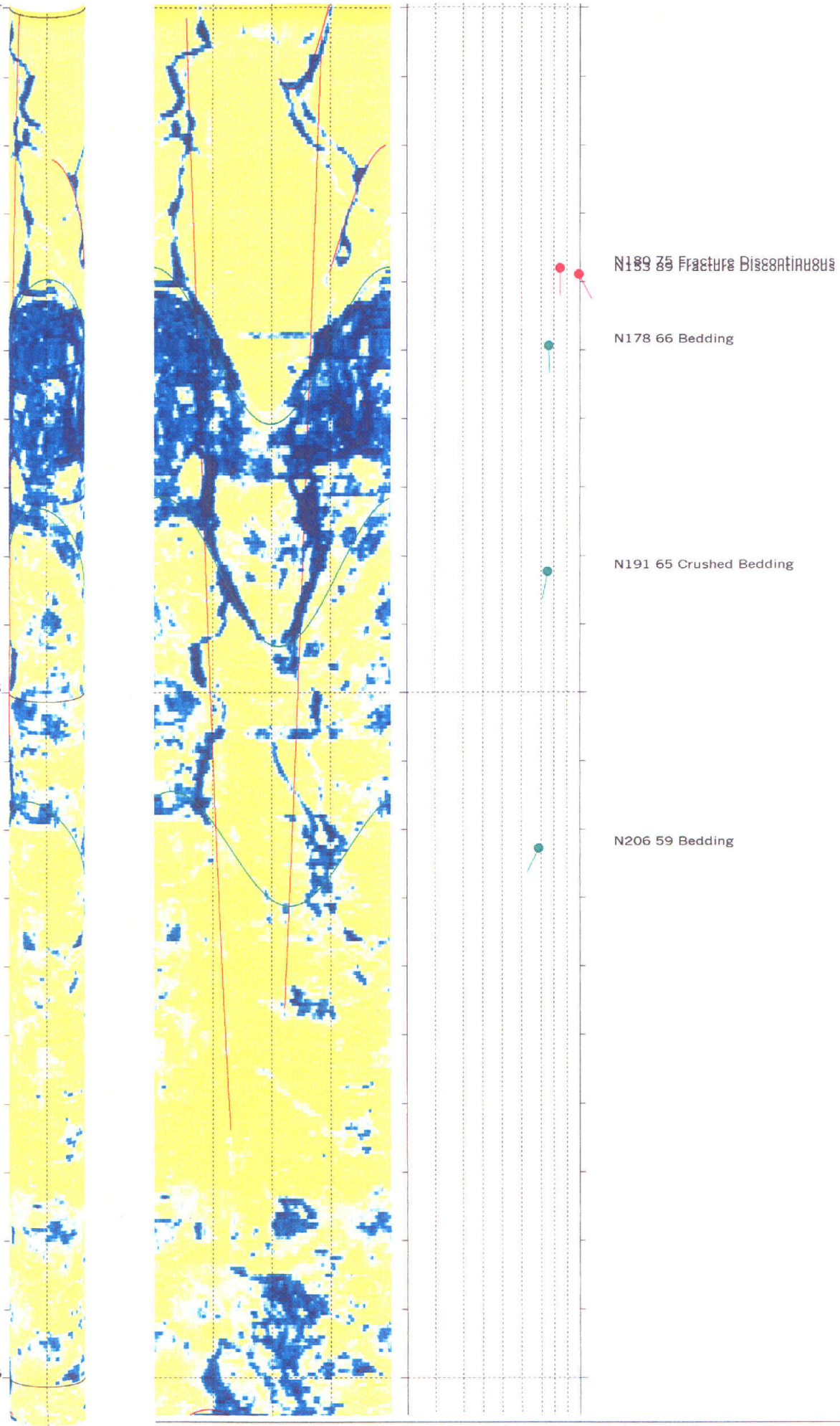

152
153
N206 63 Fracture Discontinuous
vertical_fracture
N117 74 Fracture Discontinuous
N206 81 Fracture Discontinuous
N196 38 Fracture
N336 80 Fracture Discontinuous
N124 69 Fracture Discontinuous
N210 80 Fracture Discontinuous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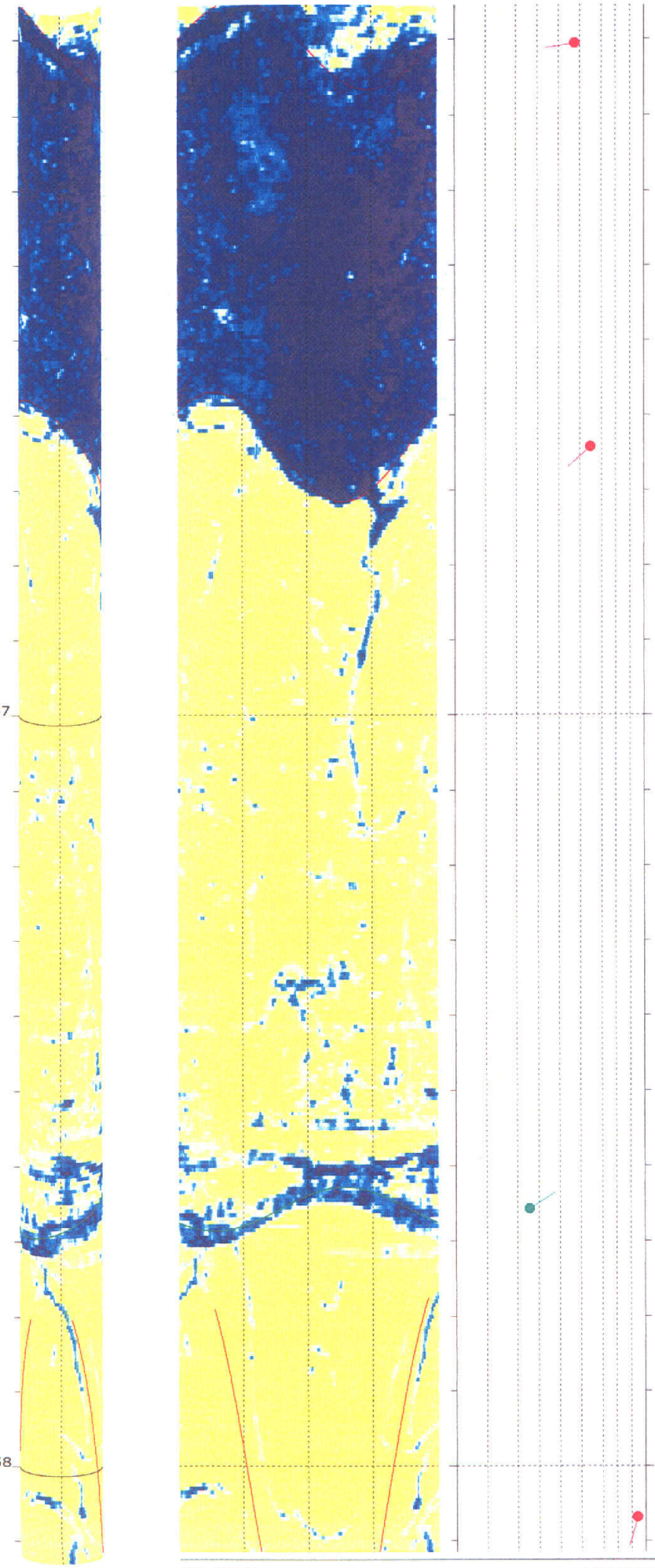
N178 66 Bedding
N191 65 Crushed Bedding
N206 59 Bedding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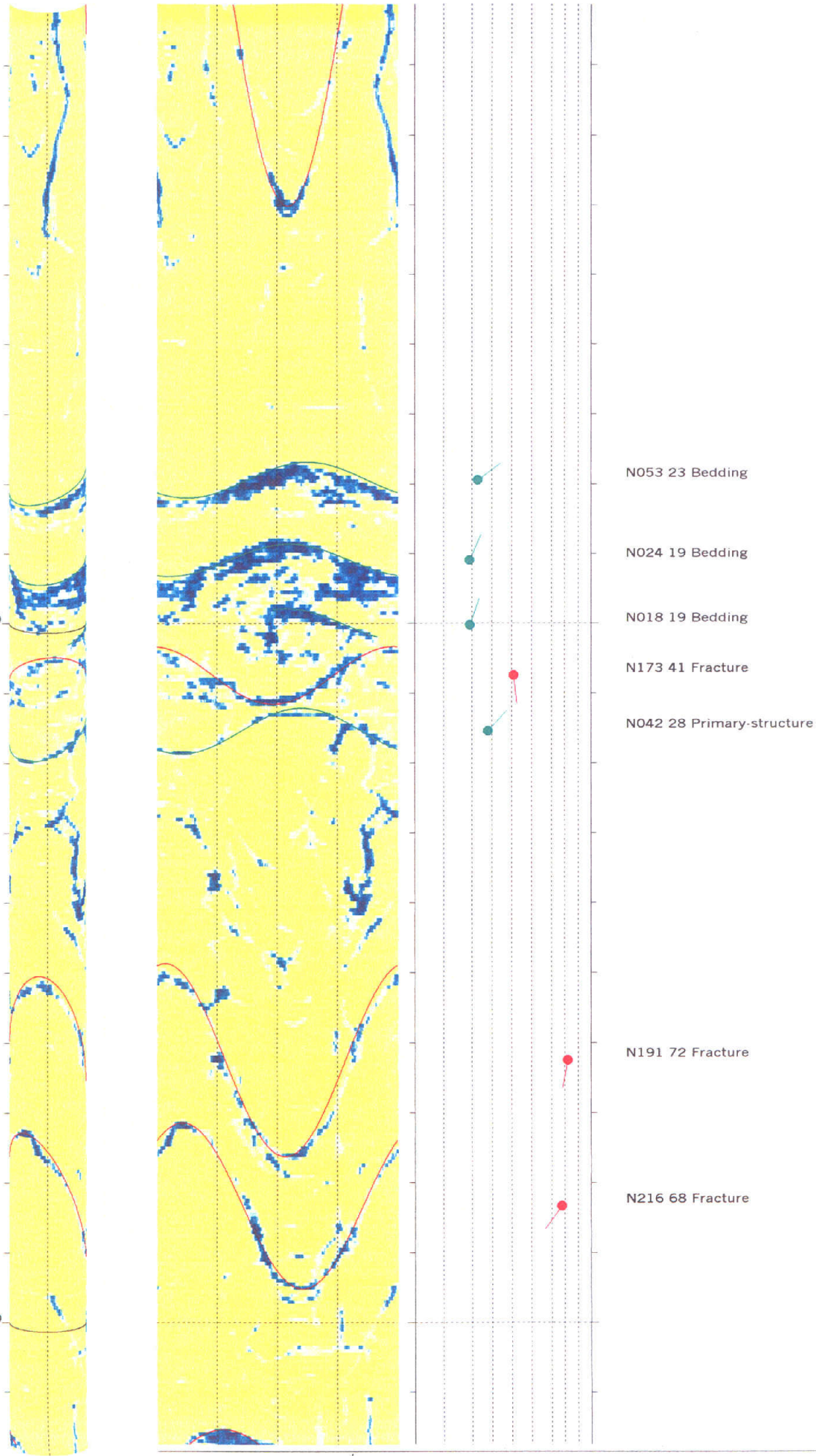
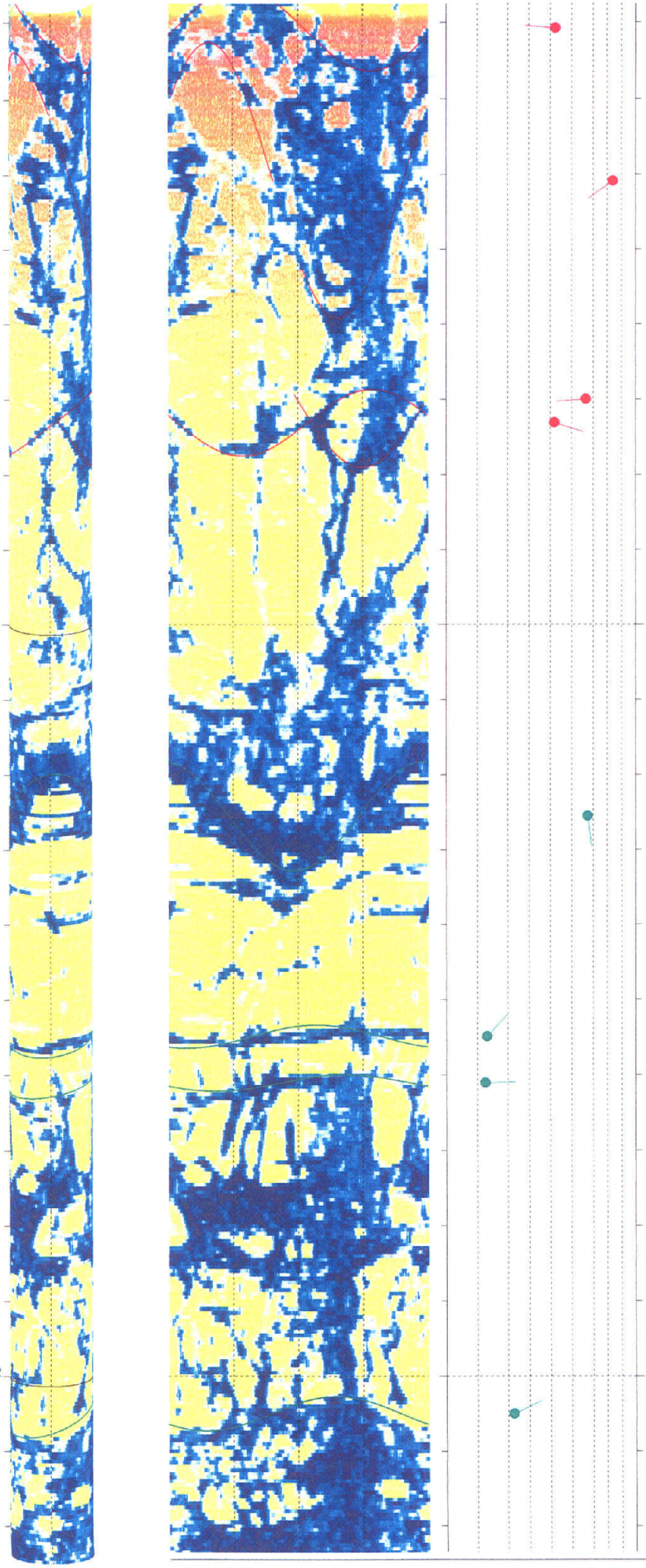
N228 55 shear
157
N057 26 Bedding
158
N196 84 Fracture Discontinuous


159
160
N053 23 Bedding
N024 19 Bedding
N018 19 Bedding
N173 41 Fracture
N042 28 Primary-structure
N191 72 Fracture
N216 68 Fracture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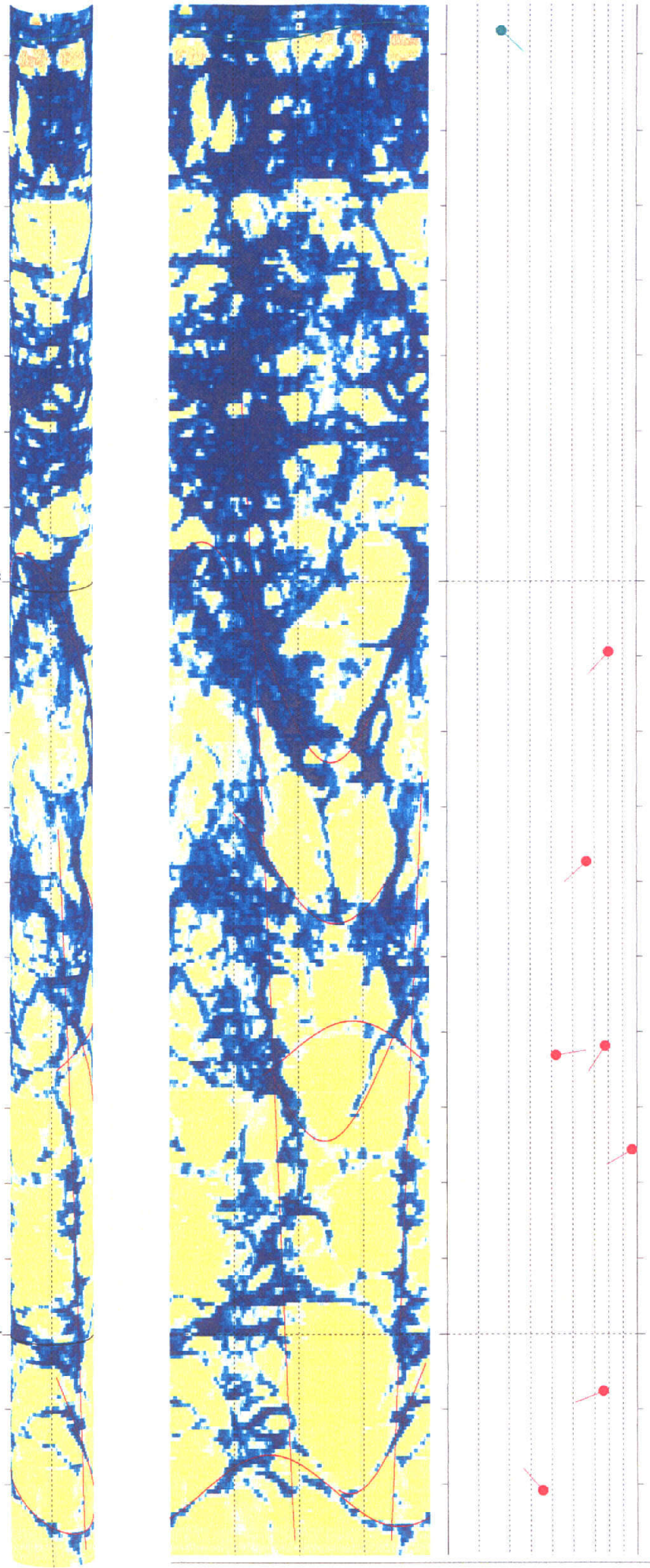
N235 74 Fracture segmented
N266 57 Fracture Discontinuous
N107 42 Fracture
161
N173 57 Bedding
N043 13 Bedding
N088 13 Bedding
162
N064 23 Bedding


163
164
N133 18 Bedding
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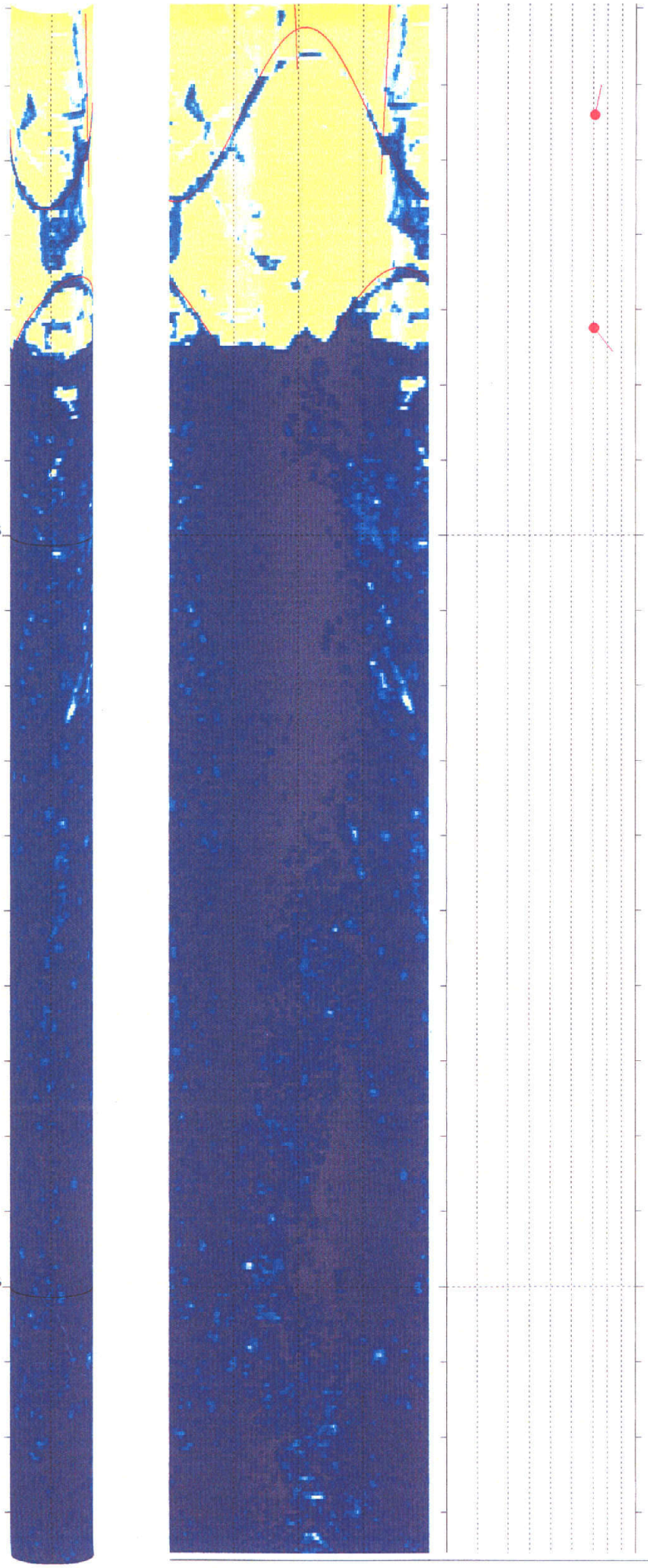
N080 42 Fracture Discontinuous
N240 87 Fracture Discontinuous
N248 66 Fracture Discontinuous
N319 36 Fracture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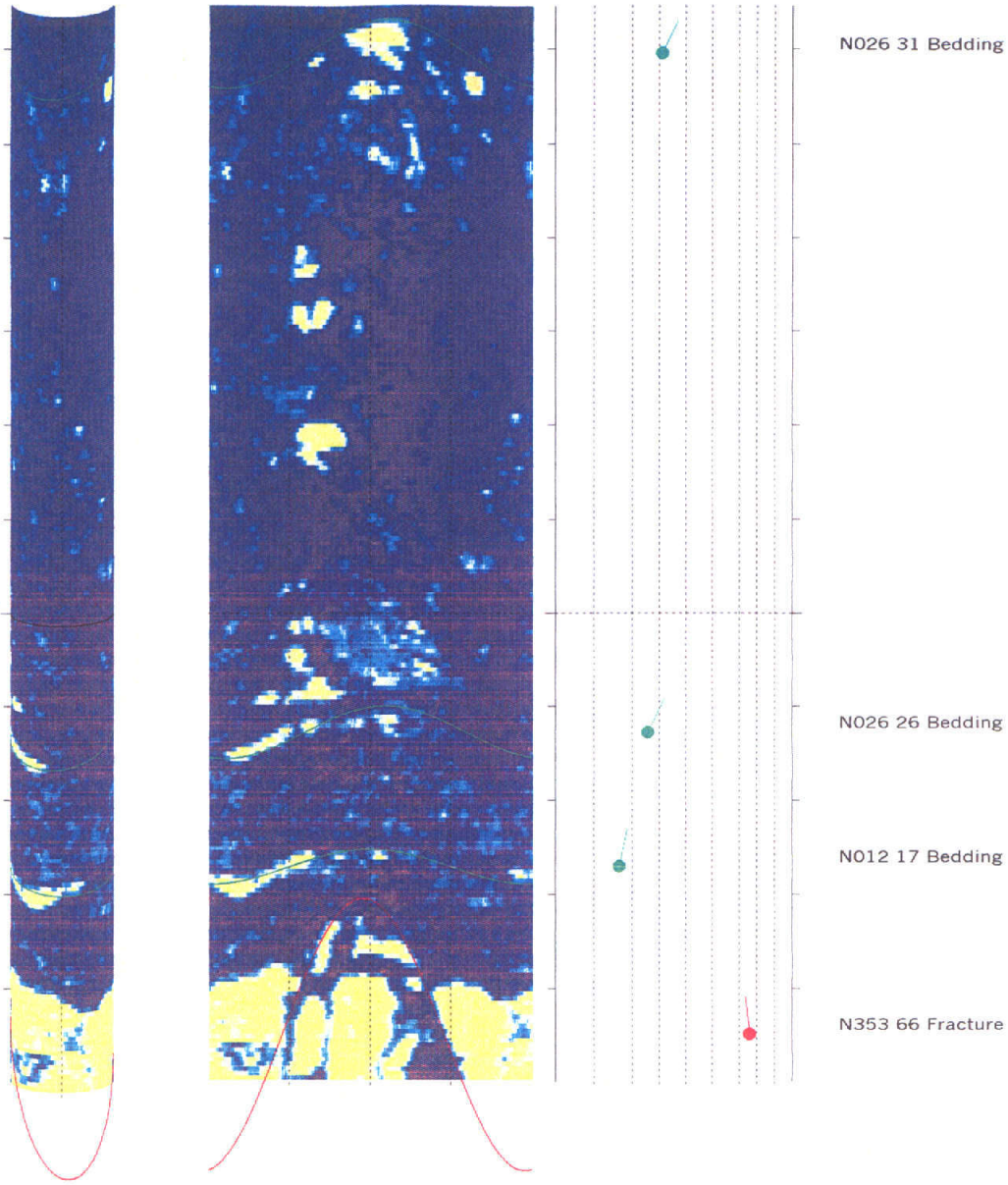
165
166


167
N026 31 Bedding
N026 26 Bedding
N012 17 Bedding
N353 66 Fracture

NORCAL GEOPHYSICAL CONSULTANTS, INC.

BHTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED BHTV DIPS LOG

28 Sep 2002

EARTH MECHANICS

Borehole: BH 02-05

SAN MATEO

top of borehole.....
East: _
North: _
Alt: _

North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = vert scale

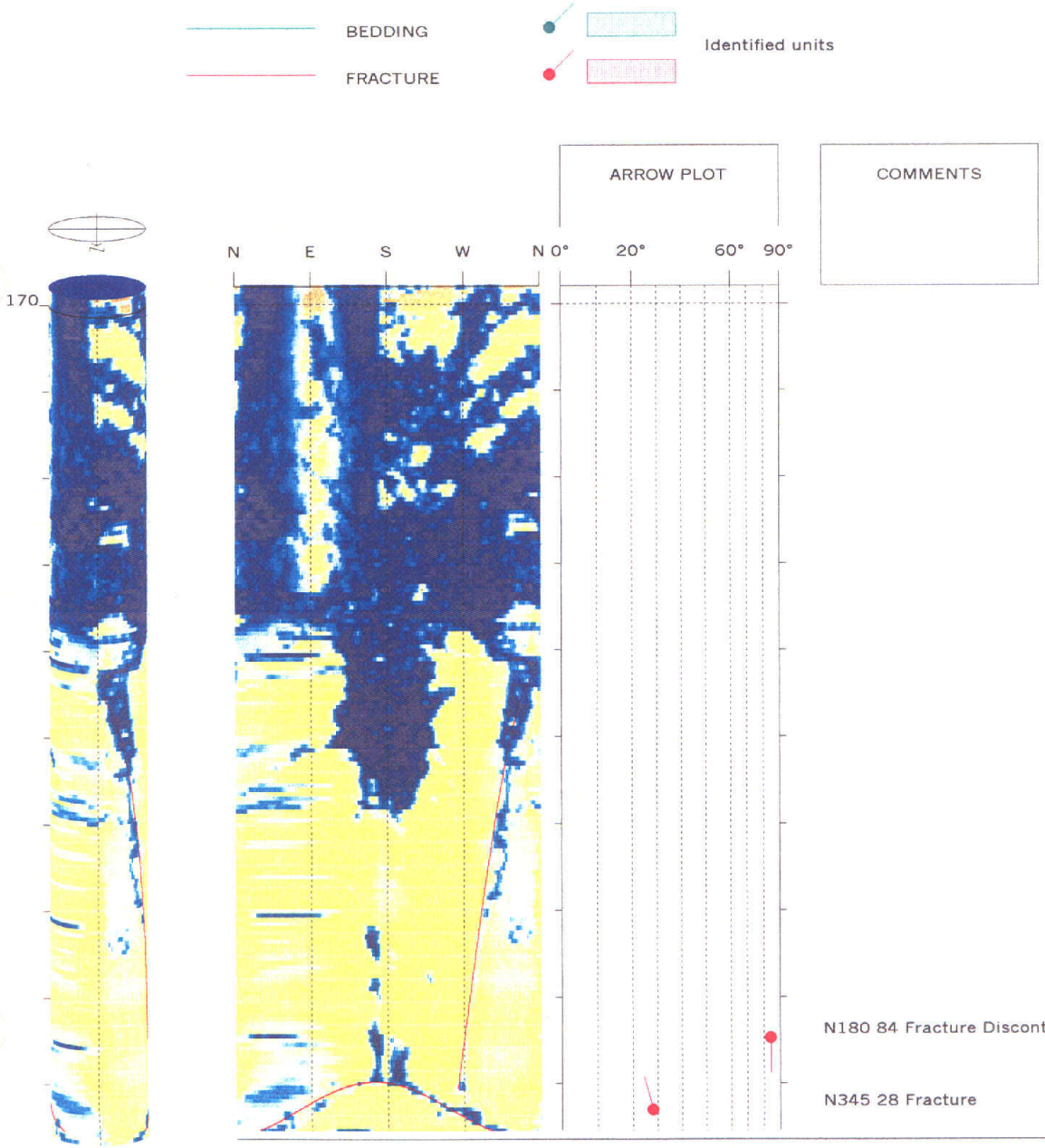
Zone from 170.955 to 169.980m

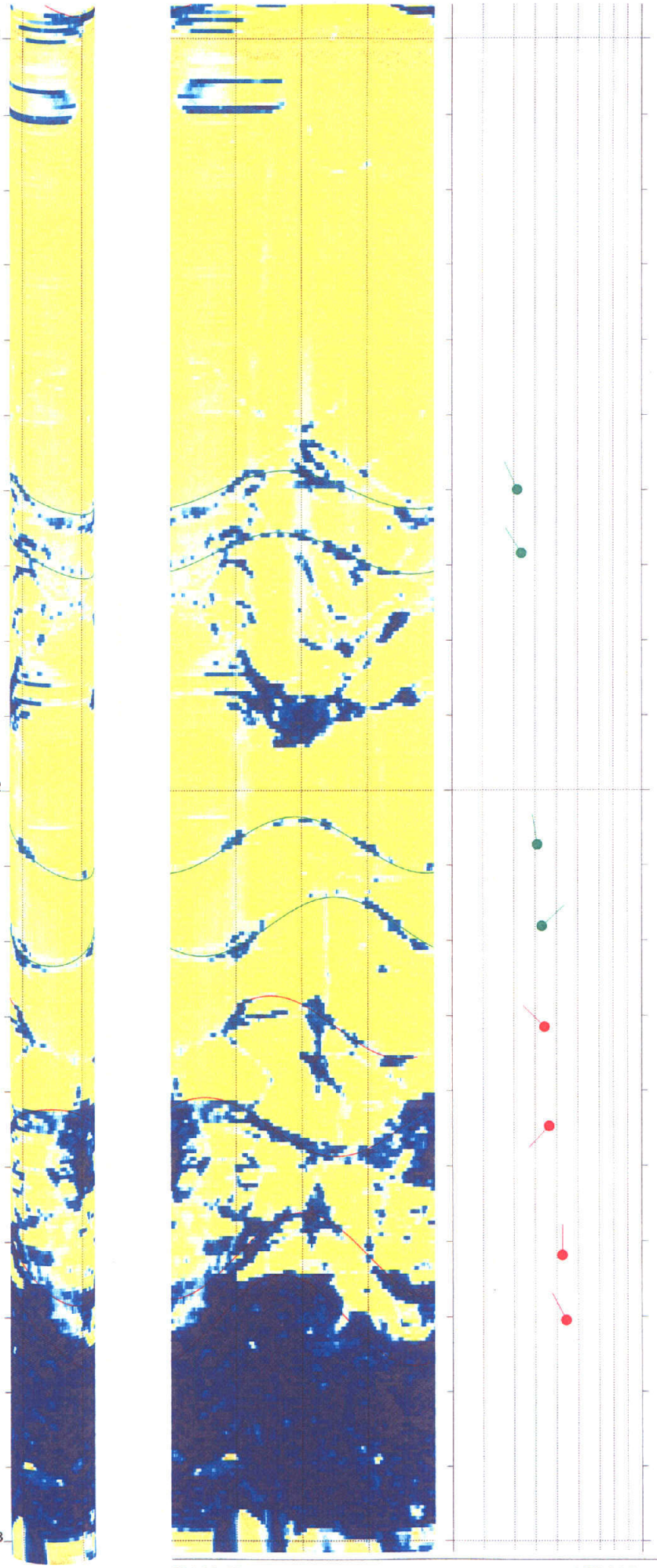
Borehole diam: 11.230cm
Vertical = borehole-axis
Amplitude

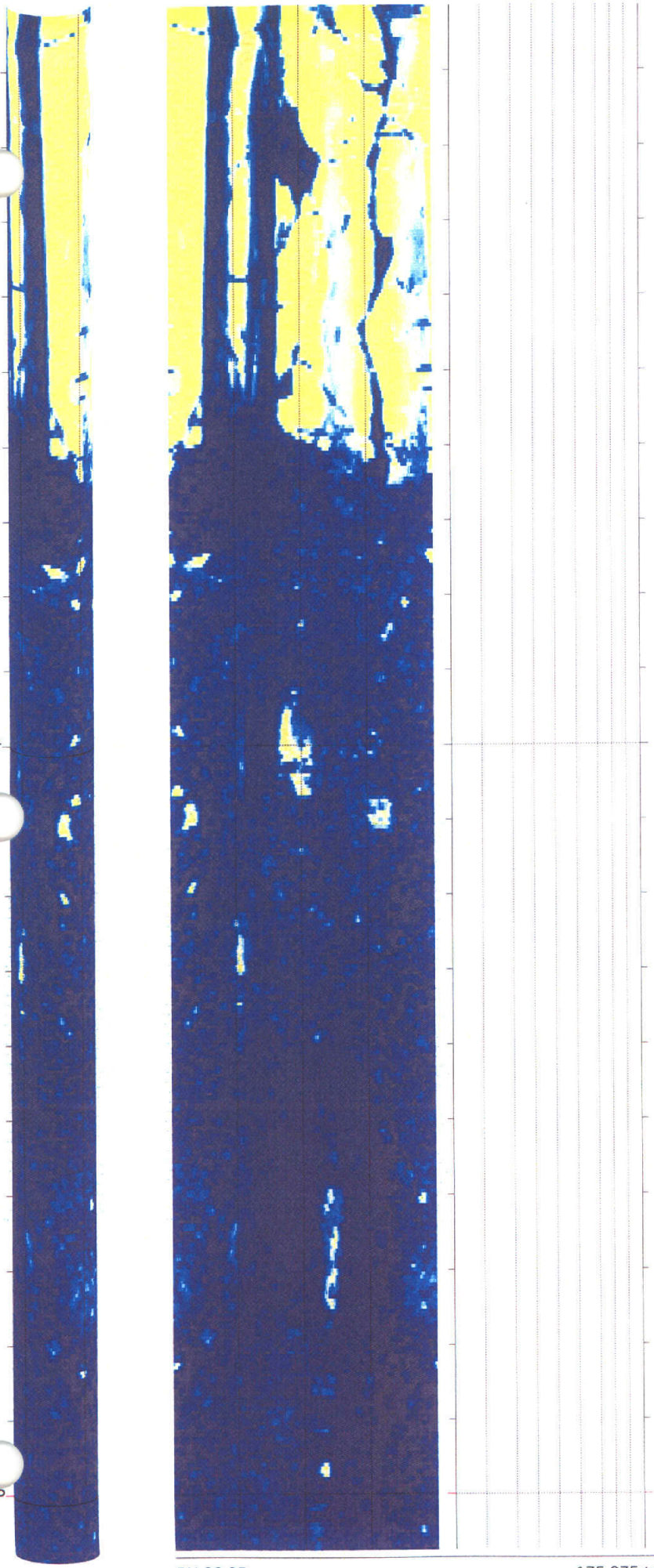
BEDDING

FRACTURE

Identified units




171
172
173
N335 22 Bedding
N328 24 Bedding
N351 31 Bedding
N047 33 Bedding
N315 34 Fracture
N224 37 shear
N000 43 shear
N332 44 shear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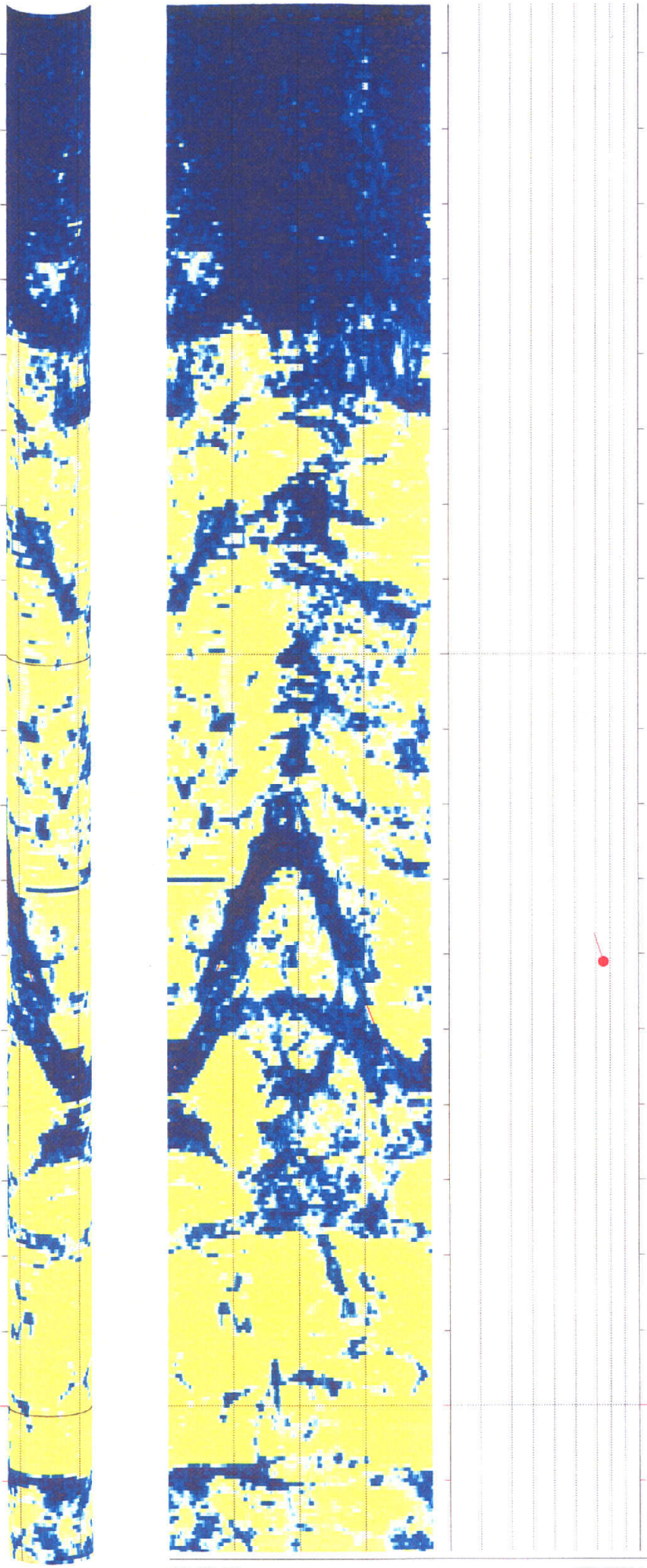
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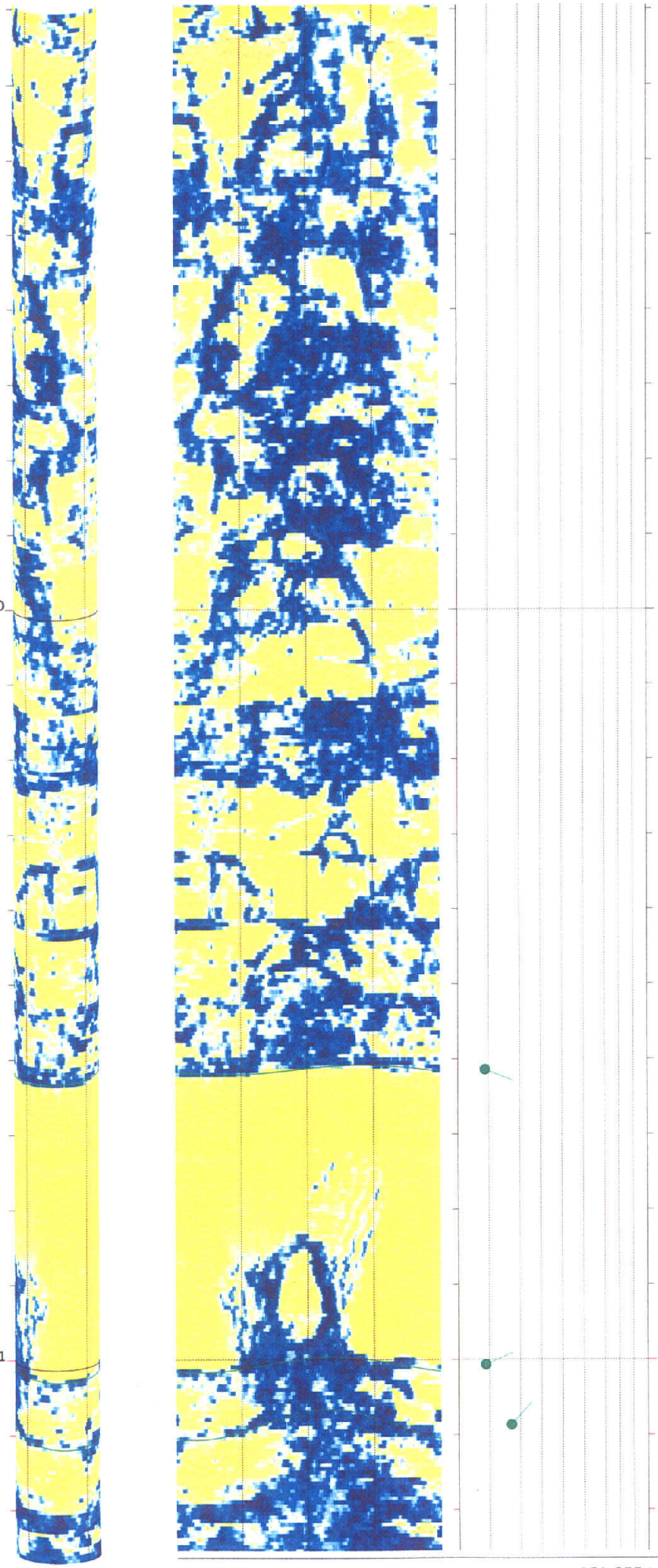
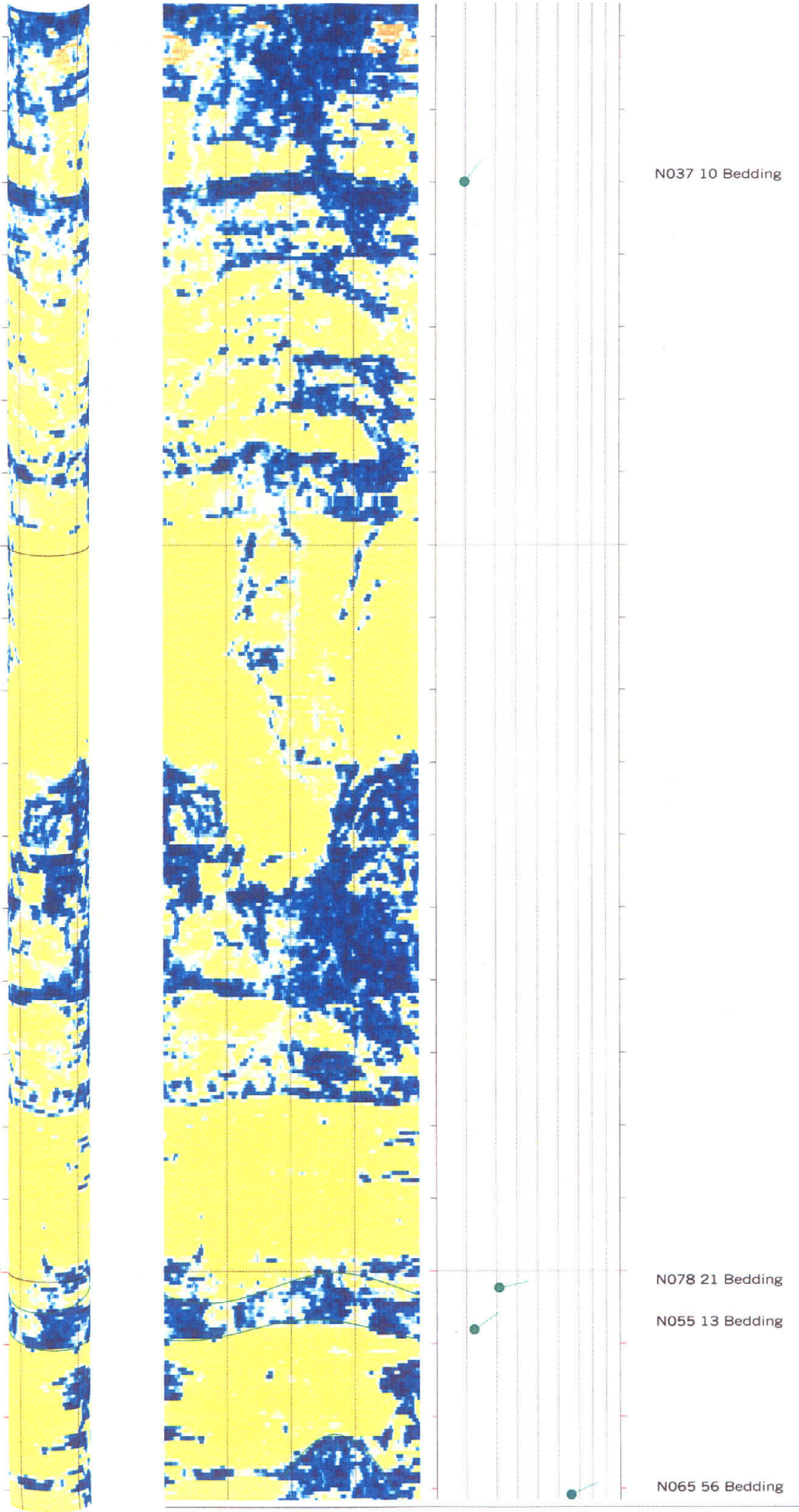
179
N342 65 shear



BH 02-05 181.255 to 179.195m


182
183
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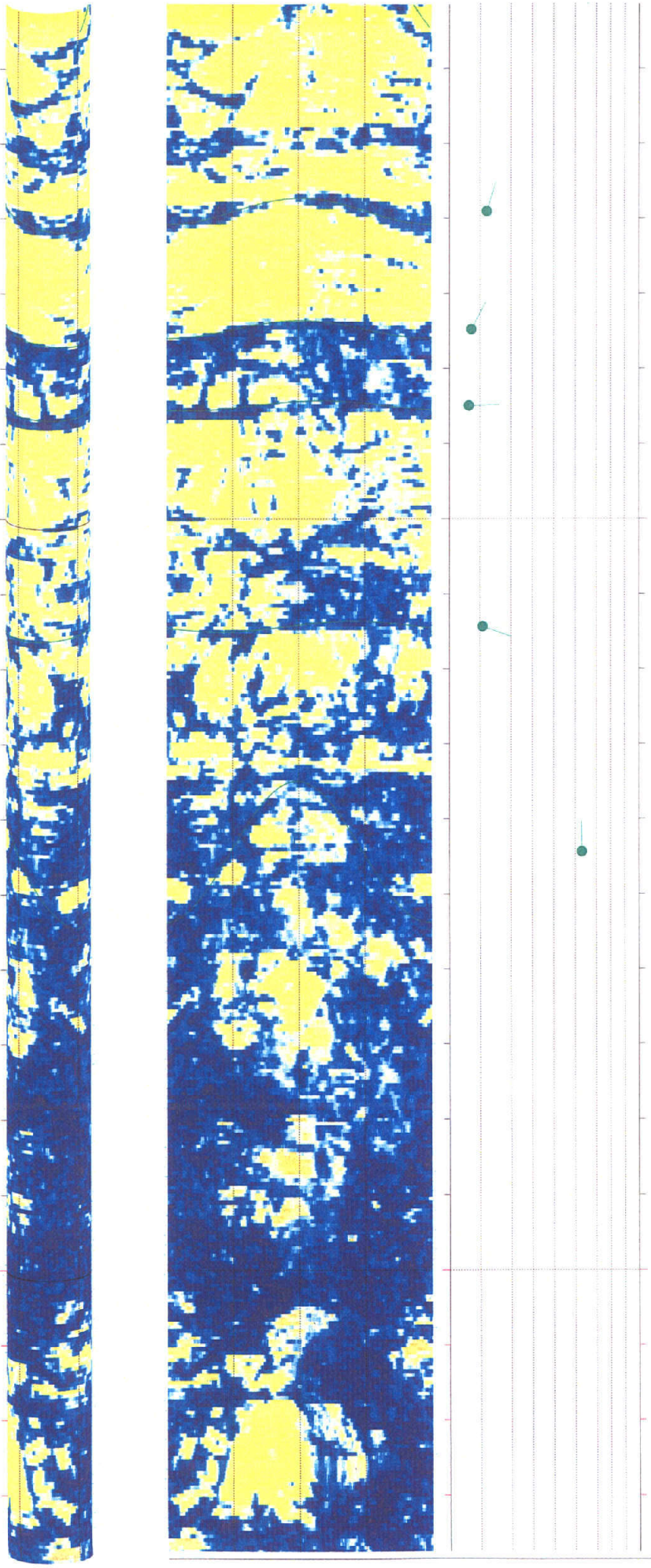
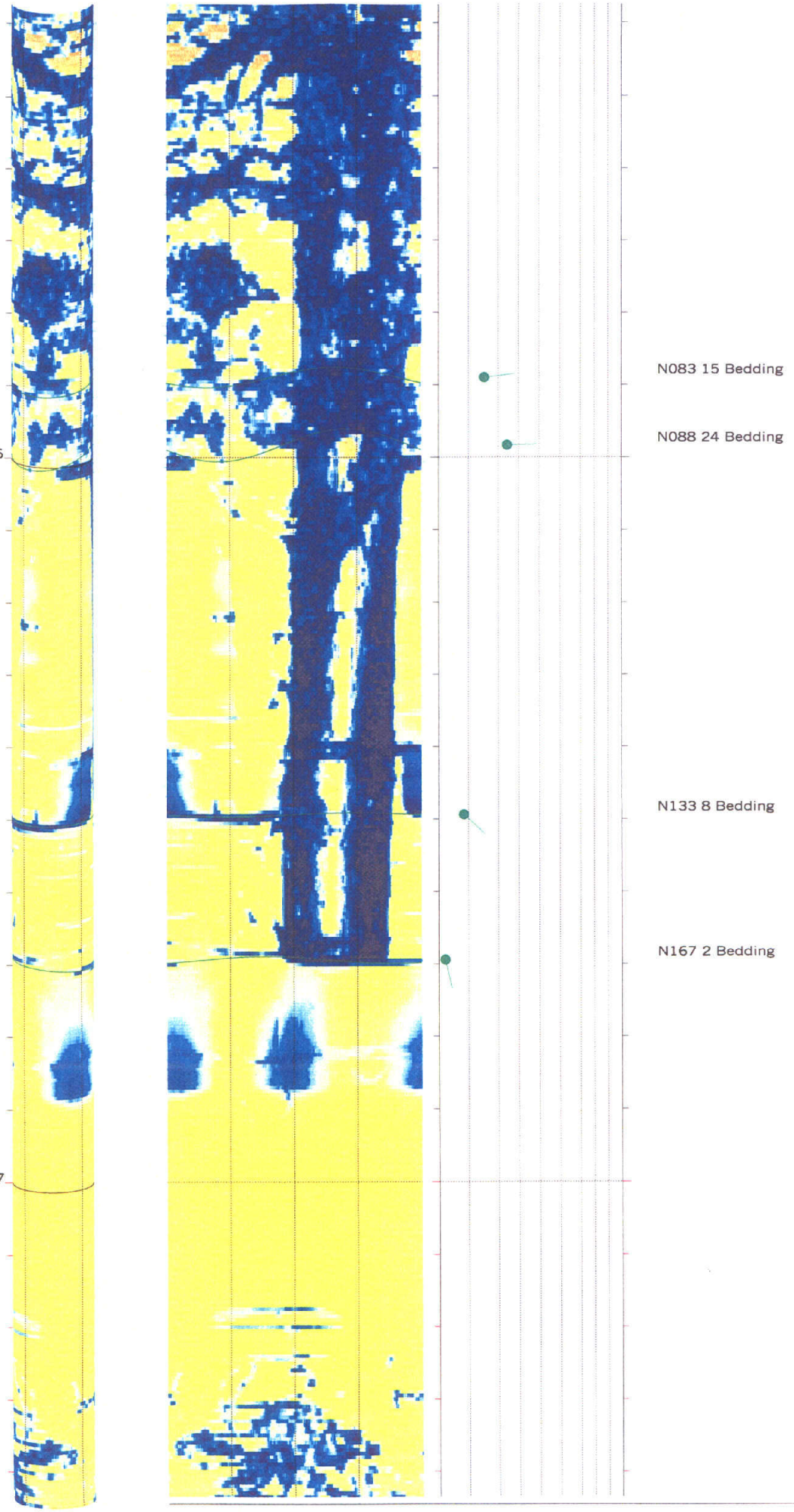
N078 21 Bedding
N055 13 Bedding
N065 56 Bedding


184
185
N017 12 Bedding
N027 7 Bedding
N088 6 Bedding
N110 11 Bedding
N359 53 Bedding
gouge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187
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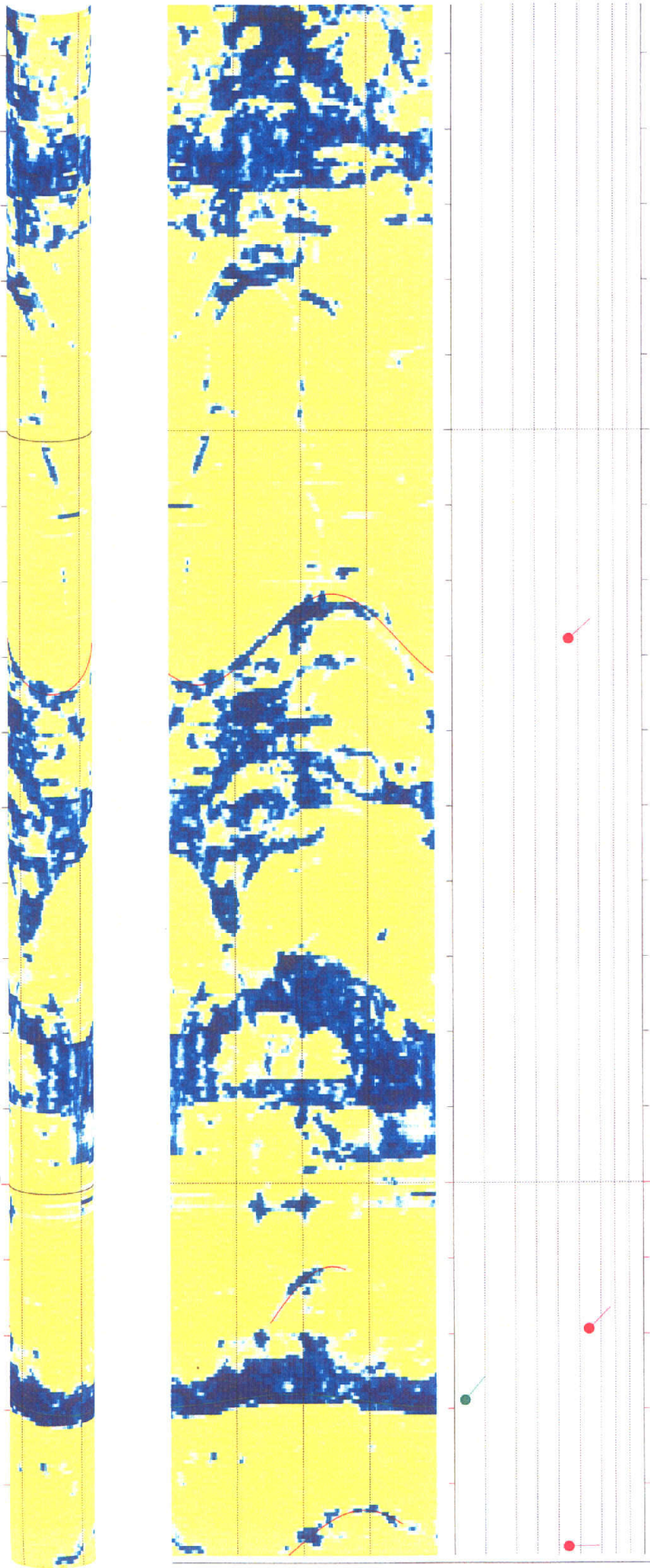
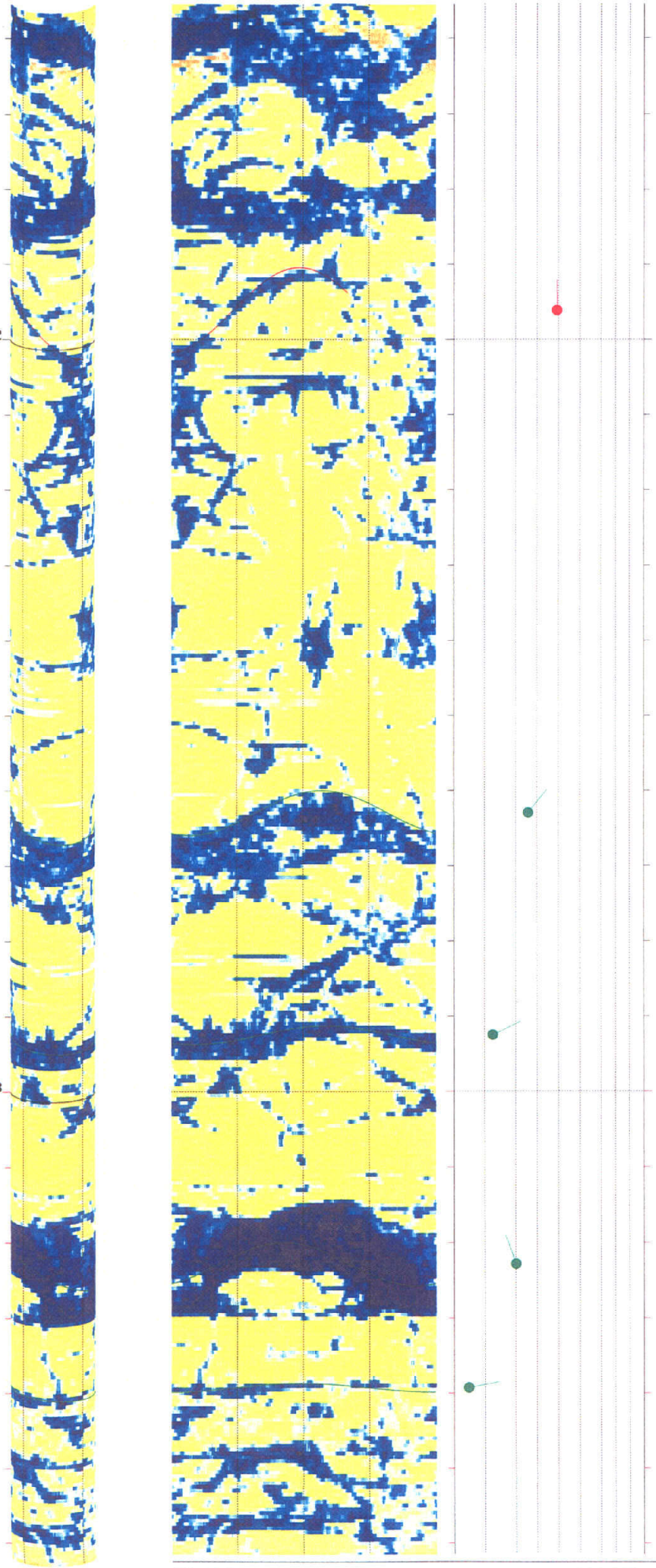
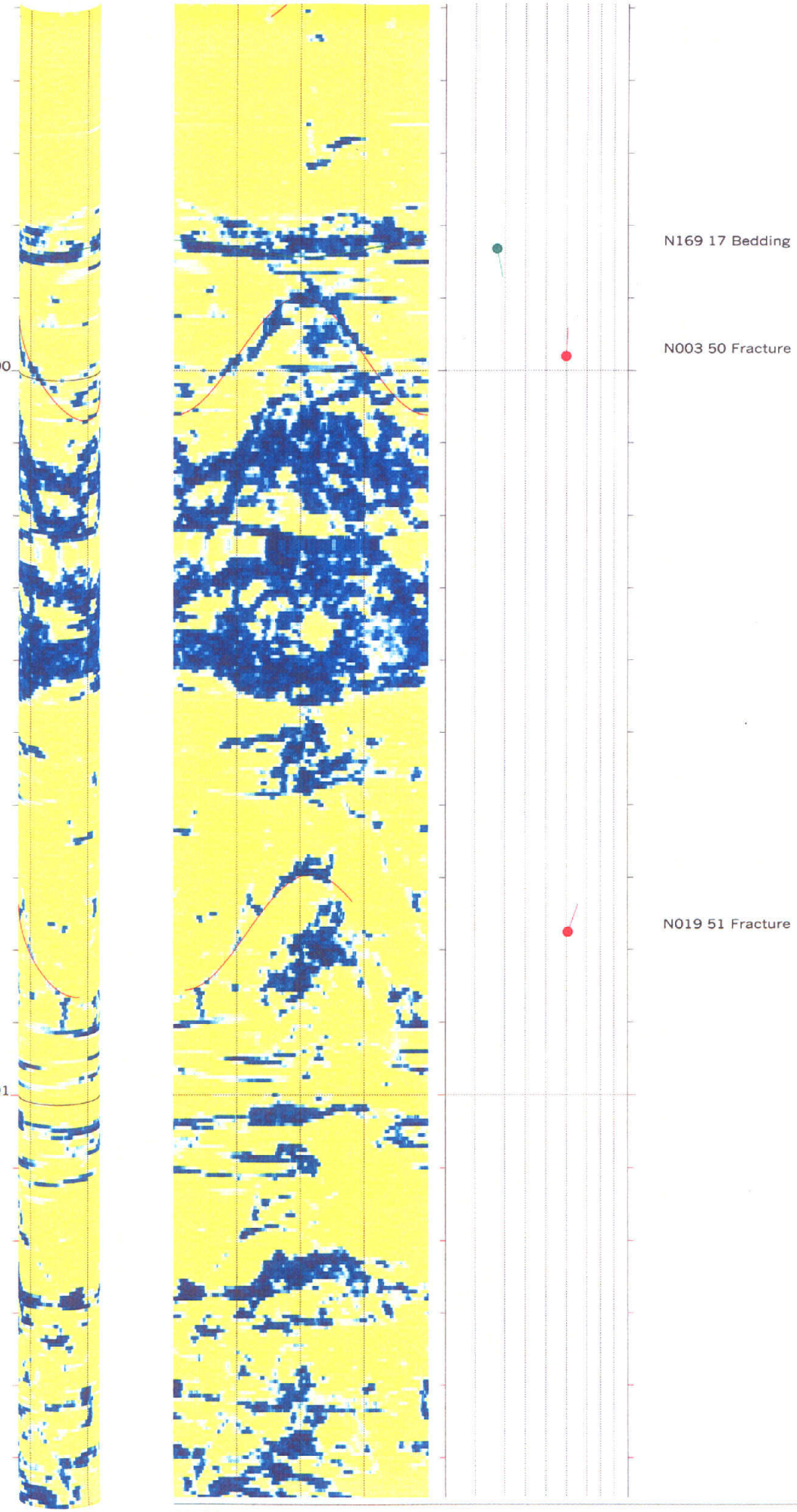
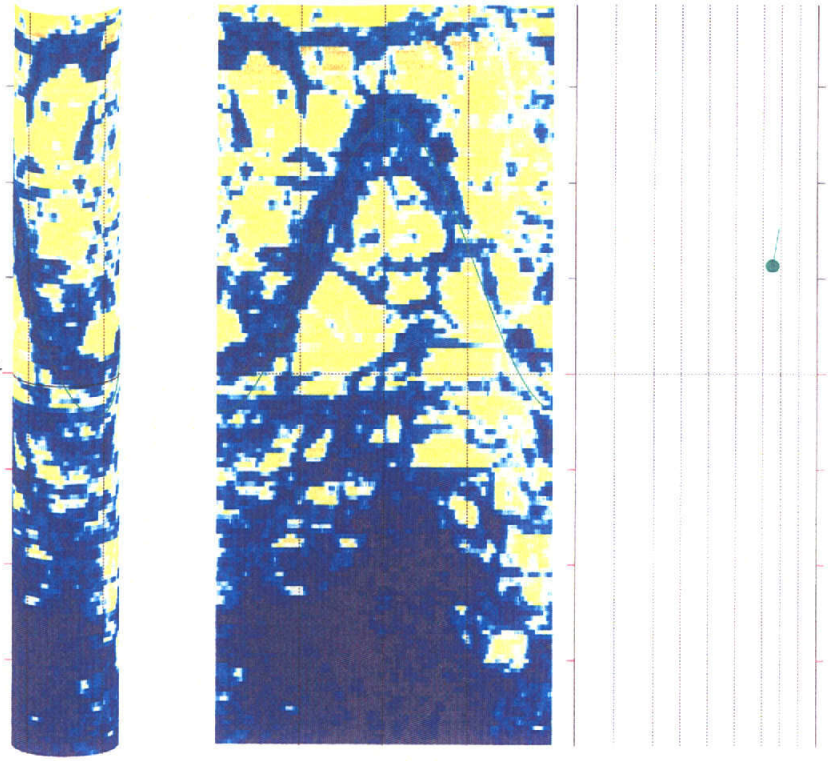
N088 24 Bedding
N133 8 Bedding
N167 2 Bedding


188
189
N047 46 Fracture
N045 54 Fracture Discontinuous
N040 4 Bedding
N088 45 Fracture Discontinuous


192
193
N360 39 Fracture Discontinuous
N039 26 Bedding
N064 13 Primary-structure Crushed
N340 20 Primary-structure Crushed
N079 5 Bedding


190
191
N169 17 Bedding
N003 50 Fracture
N019 51 Fracture


194
N009 65 Primary-structure Crushed

RGLDIPv6.1 OPTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole:02-05
zone from 6.372 to 68.226 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	66.762	55	27.3	0.976	6	A	0	66.736	66.789	0.111	273.57	2.32	0.0000	Bedding
2	66.579	60	28.1	0.965	7	B	0	66.548	66.610	0.122	289.98	2.00	0.0000	Fresh Bedding
3	64.774	292	14.2	0.925	5	C	2	64.758	64.789	0.106	294.45	2.55	0.0000	contact Irregular
4	64.113	216	55.0	0.960	6	B	2	64.035	64.192	0.107	293.30	2.35	0.0000	Fracture
5	63.767	356	71.0	0.965	15	B	2	63.602	63.932	0.109	283.48	2.42	0.0000	Fracture
6	63.623	222	50.7	0.947	7	B	2	63.551	63.695	0.111	285.38	3.00	0.0000	Fracture
7	62.183	229	40.5	0.995	6	A	2	62.156	62.232	0.111	295.78	2.00	0.0000	Fracture Discontinuous
8	60.694	263	36.5	0.973	11	A	2	60.651	60.737	0.106	292.71	2.95	0.0000	Fracture Discontinuous
9	60.407	60	76.4	0.987	7	A	2	60.447	60.608	0.111	291.43	3.00	0.0000	Fracture Discontinuous
10	60.363	53	74.7	0.992	5	A	2	60.468	60.559	0.111	306.05	2.35	0.0000	Fracture Discontinuous
11	60.350	243	57.4	0.934	12	C	2	60.265	60.436	0.106	311.94	2.09	0.0000	Fracture
12	60.013	209	59.1	0.946	14	C	2	59.923	60.103	0.106	292.86	3.00	0.0000	Fracture
13	59.599	265	69.6	0.936	11	C	2	59.442	59.756	0.106	292.68	2.00	0.0000	Fracture Discontinuous
14	59.154	245	37.7	0.969	7	B	2	59.110	59.198	0.106	299.84	3.00	0.0000	Fracture
15	59.072	179	84.2	0.962	8	B	2	58.648	59.273	0.111	293.60	3.00	0.0000	Fracture Discontinuous
16	58.404	276	39.9	0.966	11	B	2	58.355	58.453	0.107	296.84	2.84	0.0000	Fracture
17	58.404	54	63.6	0.980	6	A	2	58.403	58.510	0.111	296.84	2.84	0.0000	Fracture Discontinuous
18	57.982	294	48.9	0.970	10	B	2	57.914	58.050	0.106	298.72	3.00	0.0000	Fracture
19	57.670	218	50.0	0.985	7	A	2	57.602	57.675	0.111	297.89	3.00	0.0000	Fracture Discontinuous
20	57.615	184	63.5	0.955	11	B	2	57.513	57.717	0.106	293.49	3.00	0.0000	Fracture
21	57.457	229	74.1	0.995	8	A	2	57.245	57.422	0.111	293.23	2.77	0.0000	Fracture Discontinuous
22	56.317	230	45.3	0.958	8	B	2	56.258	56.375	0.111	293.09	2.58	0.0000	Fracture segmented
23	56.147	255	33.2	0.966	12	B	2	56.109	56.186	0.106	291.21	3.00	0.0000	Fracture
24	55.770	255	32.7	0.981	7	A	2	55.731	55.808	0.111	294.52	3.00	0.0000	Fracture Discontinuous
25	55.600	265	33.6	0.987	11	A	2	55.562	55.637	0.106	292.92	2.08	0.0000	Fracture
26	55.381	246	28.1	0.948	11	B	2	55.351	55.411	0.106	300.30	2.00	0.0000	Fracture
27	54.636	255	40.3	0.974	10	A	2	54.587	54.684	0.107	306.98	3.00	0.0000	Fracture
28	54.560	296	32.3	0.971	5	B	2	54.520	54.558	0.111	290.60	3.00	0.0000	Fracture Discontinuous
29	54.511	325	26.3	0.978	8	A	2	54.481	54.540	0.106	298.72	3.00	0.0000	Fracture Discontinuous
30	54.490	244	83.5	0.971	13	B	2	54.495	55.103	0.111	304.26	2.87	0.0000	Fracture segmented
31	54.437	255	72.3	0.966	7	B	2	54.474	54.626	0.111	306.94	2.19	0.0000	Fracture Discontinuous
32	54.359	253	45.6	0.975	6	A	2	54.299	54.334	0.111	307.32	3.00	0.0000	Fracture Discontinuous
33	54.272	281	41.0	0.972	7	B	2	54.220	54.324	0.109	301.55	3.00	0.0000	Fracture
34	54.164	296	35.5	0.957	10	B	2	54.121	54.206	0.107	295.12	3.00	0.0000	Fracture
35	53.894	241	43.1	0.990	6	A	2	53.840	53.948	0.107	286.18	3.00	0.0000	Fracture segmented
36	53.833	246	35.8	0.985	6	A	2	53.791	53.875	0.107	291.00	3.00	0.0000	Fracture segmented

37	53.765	242	44.5	0.976	6	A	2	53.706	53.823	0.111	289.74	3.00	0.0000 Fracture segmented
38	53.666	286	28.9	0.977	9	A	2	53.633	53.699	0.106	292.21	3.00	0.0000 Fracture segmented
39	53.565	241	44.1	0.949	8	B	2	53.511	53.620	0.106	299.56	3.00	0.0000 Fracture segmented
40	53.500	242	49.3	0.970	7	B	2	53.435	53.564	0.106	287.78	2.07	0.0000 Fracture segmented
41	53.042	259	52.6	0.970	6	B	2	52.968	53.115	0.107	304.58	2.08	0.0000 Fracture Discontinuous
42	52.350	211	56.7	0.970	7	B	2	52.291	52.435	0.111	302.77	2.91	0.0000 Fracture Discontinuous
43	52.132	226	62.1	0.989	7	A	2	52.103	52.241	0.111	299.13	3.00	0.0000 Fracture Discontinuous
44	51.331	215	48.2	0.989	6	A	2	51.272	51.390	0.106	308.47	3.00	0.0000 Fracture Discontinuous
45	51.262	218	51.7	0.999	5	A	2	51.270	51.333	0.111	304.33	3.00	0.0000 Fracture Discontinuous
46	50.594	256	42.1	0.972	5	B	2	50.542	50.647	0.107	293.10	3.00	0.0000 Fracture Discontinuous
47	50.056	272	41.9	0.959	10	B	2	50.005	50.107	0.107	301.81	2.00	0.0000 Fracture segmented
48	47.214	238	51.8	0.992	7	A	2	47.179	47.288	0.111	299.55	2.36	0.0000 Fracture Discontinuous
49	47.179	238	48.3	0.993	6	A	2	47.182	47.243	0.111	299.97	2.00	0.0000 Fracture Discontinuous
50	47.152	253	39.4	0.976	8	A	2	47.106	47.199	0.108	298.39	2.00	0.0000 Fracture Discontinuous
51	47.120	61	63.1	0.966	13	B	2	47.019	47.221	0.108	299.57	2.52	0.0000 Fracture Discontinuous
52	44.194	251	54.6	0.996	5	A	0	44.115	44.272	0.108	310.67	2.00	0.0000 Bedding
53	44.017	280	45.1	0.941	8	C	0	43.959	44.076	0.107	305.01	2.57	0.0000 Bedding
54	41.764	247	44.1	0.971	7	B	0	41.709	41.819	0.107	297.58	2.64	0.0000 Bedding
55	41.587	257	40.4	0.986	7	A	0	41.539	41.634	0.108	319.71	2.00	0.0000 Bedding
56	40.436	288	47.3	0.941	11	C	0	40.370	40.502	0.114	294.39	2.00	0.0000 Bedding
57	38.136	300	73.5	0.944	19	C	2	37.897	38.376	0.124	254.67	2.81	0.0000 Fracture Weathered
58	37.418	280	85.4	0.980	17	A	2	36.540	38.295	0.114	304.04	1.00	0.0000 Fracture Weathered
59	37.049	205	38.3	0.955	11	B	2	37.003	37.095	0.118	300.91	2.00	0.0000 Fracture
60	35.685	35	51.9	0.942	14	C	2	35.612	35.758	0.115	304.49	2.00	0.0000 Fracture Discontinuous
61	35.606	219	8.8	0.990	7	A	2	35.596	35.615	0.111	294.14	2.00	0.0000 Fracture Discontinuous
62	35.541	292	48.0	0.960	11	B	2	35.474	35.607	0.111	296.67	2.10	0.0000 Fracture Irregular
63	35.397	314	43.7	0.962	10	B	2	35.340	35.455	0.113	300.46	2.00	0.0000 Fracture Discontinuous
64	35.210	351	69.6	0.972	14	B	2	35.053	35.367	0.109	297.56	2.00	0.0000 Fracture
65	34.295	241	37.4	0.959	8	B	2	34.251	34.340	0.111	285.13	2.00	0.0000 Fracture Discontinuous
66	34.282	9	84.1	0.992	10	A	2	33.985	34.837	0.111	288.14	2.00	0.0000 Fracture Discontinuous
67	34.153	300	59.6	0.937	13	C	2	34.042	34.264	0.120	297.66	2.00	0.0000 Fracture
68	34.017	305	62.9	0.955	14	B	2	33.895	34.138	0.114	301.93	2.00	0.0000 Fracture
69	33.330	250	54.9	0.918	13	C	2	33.243	33.417	0.121	325.79	1.32	0.0000 Fracture
70	33.319	146	87.6	0.987	12	A	2	33.242	34.121	0.111	324.16	1.55	0.0000 Fracture Discontinuous
71	32.669	324	70.3	0.990	9	A	2	32.499	32.839	0.110	298.33	2.00	0.0000 Fracture Weathered
72	32.487	326	53.1	0.980	7	A	2	32.410	32.564	0.113	290.51	1.00	0.0000 Fracture Weathered
73	32.075	322	79.4	0.960	13	B	2	31.722	32.428	0.108	304.83	2.00	0.0000 Fracture segmented
74	31.907	270	50.9	0.921	12	C	2	31.838	31.977	0.108	316.41	2.00	0.0000 Fracture Irregular
75	31.623	223	54.2	0.986	6	A	2	31.545	31.652	0.111	305.50	2.00	0.0000 Fracture Discontinuous
76	31.444	192	54.4	0.993	6	A	2	31.370	31.517	0.109	309.38	2.00	0.0000 Fracture Discontinuous
77	31.435	287	32.7	0.981	7	A	2	31.398	31.473	0.109	307.05	2.00	0.0000 Fracture
78	31.069	252	59.4	0.981	6	A	2	31.048	31.168	0.111	299.00	2.00	0.0000 Fracture Discontinuous
79	30.514	253	50.8	0.988	7	A	0	30.445	30.583	0.108	302.26	2.00	0.0000 Bedding
80	30.389	247	54.4	0.989	5	A	0	30.310	30.468	0.108	292.29	2.00	0.0000 Bedding
81	30.221	245	50.4	0.981	6	A	0	30.154	30.288	0.108	302.53	1.50	0.0000 Bedding
82	29.815	268	63.6	0.942	6	C	0	29.700	29.930	0.108	310.62	1.62	0.0000 Bedding
83	29.456	203	50.8	0.988	8	A	2	29.389	29.523	0.112	316.41	2.00	0.0000 Fracture
84	29.400	278	33.0	0.976	7	A	2	29.361	29.439	0.112	302.45	2.00	0.0000 Fracture
85	29.299	226	51.3	0.986	12	A	2	29.230	29.367	0.110	315.41	1.94	0.0000 Fracture
86	29.278	228	61.5	0.958	8	B	2	29.174	29.372	0.111	308.29	2.00	0.0000 Fracture Discontinuous

87	29.122	227	57.0	0.978	11	A	2	29.035	29.209	0.111	309.05	2.00	0.0000	Fracture segmented
88	29.079	225	51.2	0.977	13	A	2	29.009	29.150	0.111	302.31	2.00	0.0000	Fracture Discontinuous
89	28.977	232	50.8	0.970	8	B	2	28.909	29.045	0.109	306.17	2.00	0.0000	Fracture
90	28.916	233	62.6	0.975	8	A	2	28.872	29.026	0.111	305.46	2.00	0.0000	Fracture Discontinuous
91	28.814	227	53.8	0.975	7	A	2	28.737	28.890	0.110	304.23	2.00	0.0000	Fracture
92	28.702	247	40.1	0.966	5	B	0	28.654	28.749	0.109	302.77	1.89	0.0000	Bedding
93	28.492	244	25.2	0.963	6	B	2	28.466	28.519	0.108	307.58	2.00	0.0000	Fracture
94	27.931	250	64.5	0.937	13	C	2	27.812	28.049	0.108	308.78	2.00	0.0000	Fracture Discontinuous
95	27.659	249	55.6	0.964	8	B	0	27.578	27.740	0.107	291.79	1.00	0.0000	Bedding
96	27.483	231	69.1	0.973	13	A	2	27.340	27.627	0.111	335.20	1.26	0.0000	Fracture
97	26.741	244	31.1	0.988	6	A	2	26.708	26.775	0.109	300.57	1.10	0.0000	Fracture
98	26.607	230	57.2	0.987	5	A	2	26.520	26.695	0.111	308.71	2.00	0.0000	Fracture
99	26.554	213	45.7	0.989	5	A	2	26.496	26.612	0.113	300.04	1.16	0.0000	Fracture
100	25.995	304	63.2	0.943	15	C	0	25.871	26.119	0.115	310.00	2.00	0.0000	Primary-structure
101	25.856	305	53.4	0.953	9	B	0	25.777	25.935	0.113	293.87	1.00	0.0000	Bedding
102	25.054	19	24.4	0.941	9	C	0	25.027	25.081	0.118	305.81	1.16	0.0000	Primary-structure Irregular
103	24.763	46	30.6	0.958	8	B	0	24.728	24.798	0.120	299.63	1.00	0.0000	Bedding
104	24.520	40	22.4	0.959	7	B	0	24.495	24.544	0.119	316.26	1.00	0.0000	Bedding
105	24.412	54	32.1	0.963	5	B	0	24.375	24.449	0.121	303.43	1.68	0.0000	Bedding
106	24.078	18	10.8	0.967	9	B	0	24.065	24.091	0.127	315.12	1.00	0.0000	Bedding
107	23.221	247	48.9	0.980	7	A	0	23.157	23.285	0.110	315.48	1.00	0.0000	Primary-structure
108	23.046	231	49.2	0.925	13	C	0	22.983	23.110	0.109	321.89	1.00	0.0000	Primary-structure
109	22.967	248	45.3	0.975	5	A	0	22.911	23.023	0.109	306.47	1.00	0.0000	Primary-structure
110	22.900	246	50.3	0.954	9	B	0	22.834	22.966	0.109	316.76	1.00	0.0000	Primary-structure
111	22.751	277	45.3	0.990	8	A	0	22.695	22.807	0.108	319.70	1.00	0.0000	Bedding
112	21.653	237	47.5	0.968	9	B	0	21.589	21.716	0.118	339.45	2.00	0.0000	Primary-structure
113	21.459	228	42.2	0.984	7	A	0	21.397	21.521	0.136	314.18	1.26	0.0000	Primary-structure
114	21.351	240	46.9	0.962	6	B	2	21.279	21.423	0.138	348.14	2.00	0.0000	Fracture
115	21.259	246	34.1	0.944	9	C	2	21.210	21.307	0.141	311.00	1.00	0.0000	Fracture
116	20.081	192	80.5	0.931	20	C	2	19.777	20.385	0.108	315.20	1.00	0.0000	Fracture Discontinuous
117	19.382	241	38.3	0.954	11	B	2	19.340	19.425	0.108	319.26	1.00	0.0000	Fracture
118	19.211	247	48.0	0.959	8	B	2	19.150	19.272	0.108	310.43	1.00	0.0000	Fracture
119	18.942	233	50.9	0.985	6	A	2	18.875	19.008	0.108	320.34	1.00	0.0000	Fracture Discontinuous
120	18.637	200	36.4	0.976	10	A	2	18.598	18.676	0.108	324.82	1.00	0.0000	Fracture Discontinuous
121	18.630	340	65.2	0.968	20	B	2	18.508	18.752	0.108	326.25	1.00	0.0000	Fracture Discontinuous
122	18.505	216	56.5	0.961	11	B	2	18.424	18.585	0.108	325.28	1.00	0.0000	Fracture
123	18.279	234	36.4	0.952	11	B	2	18.240	18.319	0.108	334.04	1.00	0.0000	Fracture
124	17.734	236	85.7	0.977	11	A	2	16.958	17.577	0.111	313.93	1.00	0.0000	Fracture segmented
125	17.613	287	32.7	0.975	6	A	2	17.577	17.649	0.109	311.78	1.00	0.0000	Fracture
126	17.519	195	35.1	0.976	9	A	2	17.484	17.558	0.111	309.79	1.00	0.0000	Fracture Discontinuous
127	17.431	179	35.3	0.990	6	A	2	17.395	17.469	0.111	323.89	1.00	0.0000	Fracture Discontinuous
128	17.395	245	35.7	0.949	7	B	2	17.369	17.435	0.111	318.86	1.00	0.0000	Fracture Discontinuous
129	17.086	220	40.3	0.965	9	B	2	17.040	17.133	0.109	301.90	1.00	0.0000	Fracture
130	16.381	252	65.1	0.961	9	B	2	16.264	16.499	0.107	322.50	1.00	0.0000	Fracture
131	16.309	252	66.9	0.985	5	A	2	16.315	16.443	0.111	311.04	1.00	0.0000	Fracture Discontinuous
132	16.021	209	71.7	0.978	8	A	2	16.007	16.185	0.111	326.91	1.00	0.0000	Fracture Discontinuous
133	16.010	233	53.9	0.966	11	B	2	15.935	16.084	0.109	330.10	1.00	0.0000	Fracture
134	15.618	313	37.6	0.959	14	B	2	15.575	15.661	0.108	328.60	1.00	0.0000	Fracture
135	15.437	178	28.2	0.954	9	B	2	15.409	15.464	0.107	319.44	1.00	0.0000	Fracture
136	15.424	196	68.2	0.973	8	A	2	15.363	15.559	0.111	318.67	1.00	0.0000	Fracture Discontinuous

137	15.391	259	51.1	0.936	14	C	2	15.324	15.459	0.107	317.19	1.00	0.0000	Fracture Discontinuous
138	15.363	338	73.4	0.986	8	A	2	15.172	15.554	0.107	318.33	1.00	0.0000	Fracture segmented
139	15.187	202	53.6	0.966	8	B	2	15.115	15.259	0.107	319.64	1.00	0.0000	Fracture
140	15.169	283	37.0	0.976	6	A	2	15.128	15.211	0.107	318.93	1.00	0.0000	Fracture
141	14.745	277	49.7	0.971	7	B	2	14.679	14.810	0.108	322.06	1.00	0.0000	Fracture
142	14.602	270	61.2	0.944	9	C	2	14.501	14.704	0.108	313.49	1.00	0.0000	Fracture
143	14.284	218	57.0	0.928	8	C	2	14.201	14.366	0.108	325.25	1.00	0.0000	Fracture Irregular
144	13.662	214	34.6	0.959	8	B	2	13.623	13.700	0.113	336.66	1.00	0.0000	Fracture Irregular
145	13.593	298	36.8	0.971	6	B	2	13.548	13.638	0.116	306.47	1.00	0.0000	Fracture Irregular
146	13.455	257	40.5	0.968	9	B	2	13.405	13.504	0.113	314.13	1.00	0.0000	Fracture
147	13.385	295	36.0	0.973	6	A	2	13.343	13.427	0.113	338.30	1.00	0.0000	Fracture
148	13.138	280	29.1	0.954	8	B	2	13.106	13.170	0.112	349.68	1.00	0.0000	Fracture
149	12.915	329	84.0	0.976	15	A	2	12.854	13.520	0.111	342.86	1.00	0.0000	Fracture segmented
150	12.838	227	35.1	0.978	8	A	2	12.800	12.877	0.112	343.20	1.00	0.0000	Fracture Discontinuous
151	12.791	251	18.3	0.964	8	B	2	12.772	12.810	0.111	330.04	1.00	0.0000	Fracture
152	12.749	257	27.5	1.000	0	*	2	12.720	12.771	0.111	346.80	1.00	0.0000	Fracture Discontinuous
153	12.698	268	34.2	1.000	0	*	2	12.659	12.737	0.112	334.56	1.00	0.0000	Fracture
154	12.626	268	23.3	0.978	8	A	2	12.602	12.651	0.111	338.74	1.00	0.0000	Fracture
155	12.524	263	41.8	0.947	8	B	2	12.473	12.576	0.114	340.73	1.00	0.0000	Fracture
156	12.214	237	41.1	0.949	8	B	2	12.166	12.261	0.110	353.30	1.00	0.0000	Fracture
157	12.169	326	78.1	0.960	28	B	2	11.885	12.454	0.110	344.77	1.00	0.0000	Fracture Discontinuous
158	12.100	220	21.5	0.961	6	B	2	12.079	12.120	0.111	350.76	1.00	0.0000	Fracture Discontinuous
159	12.026	230	52.9	0.986	8	A	2	11.954	12.099	0.111	339.48	1.00	0.0000	Fracture Discontinuous
160	11.972	251	24.0	0.955	7	B	2	11.948	11.997	0.110	350.37	1.00	0.0000	Fracture Weathered
161	11.730	223	45.1	0.962	6	B	2	11.676	11.784	0.109	331.75	1.00	0.0000	Fracture
162	11.589	223	47.2	0.976	6	A	2	11.532	11.647	0.109	349.87	1.00	0.0000	Fracture
163	11.067	255	46.4	0.945	9	C	2	11.009	11.124	0.108	335.57	1.00	0.0000	Fracture
164	10.946	238	31.2	0.969	5	B	2	10.914	10.979	0.108	337.02	1.00	0.0000	Fracture
165	10.648	232	27.7	0.972	5	B	2	10.620	10.676	0.107	342.11	1.00	0.0000	Fracture
166	10.395	216	40.4	0.980	8	A	2	10.350	10.440	0.108	340.98	1.00	0.0000	Fracture
167	10.301	209	59.4	0.964	15	B	2	10.212	10.389	0.108	339.09	1.00	0.0000	Fracture
168	10.256	209	45.5	0.992	6	A	2	10.202	10.309	0.108	337.39	1.00	0.0000	Fracture Discontinuous
169	10.234	212	45.1	0.986	5	A	2	10.179	10.206	0.111	337.24	1.00	0.0000	Fracture Discontinuous
170	9.998	234	62.9	0.955	11	B	2	9.895	10.101	0.108	348.03	1.00	0.0000	Fracture
171	9.881	236	58.4	0.995	5	A	2	9.794	9.967	0.108	341.40	1.00	0.0000	Fracture Discontinuous
172	9.730	247	15.3	0.977	8	A	2	9.715	9.744	0.108	344.30	1.00	0.0000	Fracture
173	9.604	293	37.4	0.986	7	A	2	9.562	9.646	0.108	349.02	1.00	0.0000	Fracture
174	9.597	245	42.1	0.971	6	B	2	9.547	9.576	0.111	349.87	1.00	0.0000	Fracture Discontinuous
175	9.407	225	53.0	0.976	11	A	2	9.337	9.477	0.108	352.15	1.00	0.0000	Fracture
176	9.232	242	42.5	0.984	8	A	2	9.183	9.280	0.108	347.74	1.00	0.0000	Fracture
177	9.131	222	31.0	0.968	5	B	0	9.099	9.163	0.108	353.10	1.00	0.0000	Bedding
178	8.964	232	32.0	0.963	6	B	2	8.931	8.997	0.108	349.83	1.00	0.0000	Fracture
179	8.838	211	42.2	0.980	10	A	2	8.790	8.886	0.108	347.68	1.00	0.0000	Fracture
180	8.714	219	23.1	0.978	7	A	0	8.692	8.736	0.108	353.28	1.00	0.0000	Bedding
181	8.614	206	28.7	0.998	5	A	0	8.585	8.643	0.108	346.92	1.00	0.0000	Bedding
182	8.565	130	81.7	0.958	18	B	2	8.225	8.906	0.108	351.09	1.00	0.0000	Fracture
183	8.560	135	80.3	0.958	13	B	2	8.269	8.852	0.108	351.56	1.00	0.0000	Fracture Discontinuous
184	8.546	216	44.9	0.963	9	B	2	8.494	8.599	0.108	352.99	1.00	0.0000	Fracture
185	8.376	220	23.4	0.986	7	A	0	8.353	8.399	0.109	348.22	1.00	0.0000	Bedding
186	8.227	132	78.4	0.991	10	A	2	7.979	8.476	0.109	356.13	1.00	0.0000	Fracture

187	8.136	243	23.3	0.974	6	A	2	8.113	8.160	0.109	339.79	1.00	0.0000	Fracture
188	7.887	229	35.3	0.983	5	A	2	7.848	7.925	0.110	343.38	1.00	0.0000	Fracture Discontinuous
189	7.704	273	13.5	0.963	8	B	2	7.691	7.718	0.110	336.22	1.00	0.0000	Fracture
190	7.541	193	80.9	0.990	15	A	2	7.225	7.856	0.111	354.04	1.00	0.0000	Fracture Discontinuous
191	7.407	259	47.0	0.947	14	B	2	7.349	7.466	0.110	346.54	1.00	0.0000	Fracture
192	7.283	226	56.8	0.959	18	B	2	7.200	7.365	0.110	338.17	1.00	0.0000	Fracture
193	6.979	291	38.6	0.961	8	B	2	6.934	7.024	0.110	342.85	1.00	0.0000	Fracture
194	6.535	246	39.9	0.990	6	A	2	6.489	6.524	0.111	352.51	1.00	0.0000	Fracture Discontinuous
195	6.420	291	38.6	0.966	11	B	2	6.011	6.830	0.111	342.85	1.00	0.0000	Fracture
196	6.269	291	38.6	0.990	9	A	2	6.115	6.423	0.110	342.85	1.00	0.0000	Fracture

RGLDIPv6.1 BHTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-05
zone from 167.500 to 64.440 meters
28 Sept. 2002

	Depth m	Azimuth deg	Dip deg	1-P0/100	n	Q	K	Upper Depth m	Lower Depth m	Well Diam m	Well deviation Azimuth deg	Dev deg	Thickness	
1	167.449	353	66.0	0.961	6	B	2	167.304	167.594	0.110	306.00	4.71	0.0000	Fracture
2	167.270	12	16.6	0.908	6	C	0	167.252	167.289	0.110	305.39	4.38	0.0000	Bedding
3	167.128	26	25.9	0.985	4	A	0	167.100	167.156	0.110	304.00	4.56	0.0000	Bedding
4	166.405	26	31.3	1.000	3	A	0	166.370	166.441	0.110	308.99	5.14	0.0000	Bedding
5	164.724	142	60.7	0.916	7	C	2	164.644	164.764	0.110	315.11	4.97	0.0000	Fracture
6	164.441	11	61.3	0.940	7	C	2	164.326	164.555	0.110	318.00	5.00	0.0000	Fracture
7	164.209	319	35.8	0.944	6	C	2	164.162	164.257	0.110	318.59	5.00	0.0000	Fracture
8	164.076	248	66.3	0.971	4	B	2	164.036	164.213	0.110	318.86	5.06	0.0000	Fracture Discontinuous
9	163.756	240	86.7	0.931	12	C	2	162.756	164.516	0.110	319.48	5.13	0.0000	Fracture Discontinuous
10	163.631	80	42.2	0.946	6	C	2	163.585	163.661	0.110	320.00	5.26	0.0000	Fracture Discontinuous
11	163.619	214	67.7	0.906	5	C	2	163.560	163.744	0.110	320.00	5.20	0.0000	Fracture Discontinuous
12	163.374	228	56.5	0.949	5	B	2	163.311	163.456	0.110	322.00	5.04	0.0000	Fracture
13	163.095	223	70.2	0.880	7	D	2	162.948	163.241	0.110	322.59	5.13	0.0000	shear
14	162.270	133	17.7	0.955	5	B	0	162.258	162.283	0.110	325.20	5.14	0.0000	Bedding
15	162.050	64	22.7	0.901	5	C	0	162.027	162.073	0.110	327.00	5.12	0.0000	Bedding
16	161.611	88	12.7	0.948	6	B	0	161.600	161.621	0.110	330.39	5.12	0.0000	Bedding
17	161.549	43	13.2	0.981	5	A	0	161.533	161.564	0.110	331.00	5.08	0.0000	Bedding
18	161.255	173	57.4	0.908	7	C	0	161.183	161.327	0.110	332.50	5.02	0.0000	Bedding
19	160.731	107	41.9	0.979	5	A	2	160.687	160.775	0.110	335.02	4.99	0.0000	Fracture
20	160.700	266	56.7	0.942	5	C	2	160.698	160.790	0.110	335.60	4.94	0.0000	Fracture Discontinuous
21	160.409	235	74.3	0.940	6	C	2	160.226	160.592	0.110	337.43	4.86	0.0000	Fracture segmented
22	160.208	274	42.3	0.948	7	B	2	160.154	160.263	0.110	338.86	4.78	0.0000	shear
23	159.834	216	67.8	0.936	8	C	2	159.715	159.952	0.110	342.93	4.63	0.0000	Fracture
24	159.625	191	72.2	0.941	4	C	2	159.488	159.763	0.110	344.90	4.50	0.0000	Fracture
25	159.154	42	28.0	0.956	7	B	0	159.122	159.187	0.110	346.00	4.39	0.0000	Primary-structure
26	159.075	173	40.9	0.911	7	C	2	159.034	159.116	0.110	346.11	4.35	0.0000	Fracture
27	159.003	18	19.2	0.952	6	B	0	158.979	159.018	0.110	347.00	4.32	0.0000	Bedding
28	158.909	24	19.2	0.937	5	C	0	158.886	158.932	0.110	348.00	4.28	0.0000	Bedding
29	158.794	53	22.9	0.939	8	C	0	158.769	158.820	0.110	348.71	4.19	0.0000	Bedding
30	158.068	196	84.2	0.973	7	A	2	157.779	158.402	0.110	354.24	3.81	0.0000	Fracture Discontinuous
31	157.658	57	25.6	0.968	6	B	0	157.629	157.687	0.110	356.89	3.86	0.0000	Bedding
32	156.642	228	54.9	0.904	8	C	2	156.569	156.715	0.110	357.24	3.15	0.0000	shear
33	156.106	261	47.5	0.875	13	D	2	156.047	156.165	0.110	1.47	3.04	0.0000	shear
34	155.228	206	58.9	0.951	8	B	0	155.144	155.312	0.110	3.96	2.40	0.0000	Bedding

35	154.823	191	65.3	0.940	10	C	0	154.714	154.932	0.110	6.00	2.08	0.0000	Crushed Bedding
36	154.493	178	66.2	0.797	6	D	0	154.379	154.608	0.110	5.53	1.91	0.0000	Bedding
37	154.389	153	89.5	0.944	13	C	2	153.964	155.620	0.110	6.64	1.82	0.0000	Fracture Discontinuous
38	154.380	180	74.9	0.972	5	B	2	154.201	154.386	0.110	6.99	1.80	0.0000	Fracture Discontinuous
39	153.850	210	79.7	0.980	8	A	2	153.629	154.117	0.110	4.41	1.51	0.0000	Fracture Discontinuous
40	153.772	124	68.8	0.971	7	B	2	153.700	153.892	0.110	2.85	1.49	0.0000	Fracture Discontinuous
41	153.732	336	79.8	0.997	6	A	2	153.382	153.683	0.110	2.04	1.40	0.0000	Fracture Discontinuous
42	153.617	196	37.8	0.949	7	B	2	153.576	153.658	0.110	0.52	1.30	0.0000	Fracture
43	153.568	299	70.2	0.969	6	B	2	153.410	153.489	0.110	1.50	1.26	0.0000	Fracture Discontinuous
44	153.562	188	53.9	0.924	4	C	2	153.490	153.634	0.110	1.28	1.26	0.0000	Fracture
45	153.517	206	81.0	0.971	8	B	2	153.208	153.517	0.110	0.27	1.24	0.0000	Fracture Discontinuous
46	153.502	117	73.5	0.954	6	B	2	153.432	153.660	0.110	0.57	1.23	0.0000	Fracture Discontinuous
47	152.378	206	63.5	0.971	7	B	2	152.307	152.486	0.110	337.05	0.66	0.0000	Fracture Discontinuous
48	151.877	135	67.0	0.965	8	B	2	151.751	152.003	0.110	299.69	0.59	0.0000	Fracture
49	151.716	148	70.6	0.966	6	B	2	151.737	151.868	0.110	281.57	0.67	0.0000	Fracture Discontinuous
50	150.154	118	75.1	0.988	7	A	2	150.050	150.345	0.110	251.52	1.69	0.0000	Fracture Discontinuous
51	149.467	312	70.4	0.958	9	B	2	149.323	149.521	0.110	248.25	2.23	0.0000	Fracture Discontinuous
52	148.928	320	55.2	0.969	5	B	2	148.845	148.986	0.110	254.04	2.44	0.0000	Fracture Discontinuous
53	148.386	178	62.4	0.938	7	C	2	148.281	148.493	0.110	259.00	2.73	0.0000	shear
54	148.193	41	89.1	0.940	16	C	2	147.180	148.105	0.110	261.00	2.86	0.0000	Fracture Discontinuous
55	147.446	231	59.6	0.945	6	C	2	147.341	147.552	0.110	264.00	3.36	0.0000	shear
56	145.197	201	72.5	0.853	10	D	2	145.014	145.381	0.110	279.65	4.11	0.0000	Fracture Irregular
57	144.949	205	52.0	0.966	7	B	2	144.876	145.000	0.110	280.61	4.23	0.0000	Fracture Discontinuous
58	144.740	224	59.5	0.971	6	B	2	144.637	144.842	0.110	281.21	4.26	0.0000	Fracture
59	144.564	194	70.4	0.945	5	C	2	144.407	144.721	0.110	282.00	4.28	0.0000	Fracture
60	144.308	208	65.1	0.939	9	C	2	144.210	144.423	0.110	283.00	4.30	0.0000	Fracture Discontinuous
61	144.070	185	39.6	0.910	6	C	0	144.026	144.115	0.110	286.19	4.35	0.0000	Bedding
62	144.053	188	44.1	0.898	7	D	0	144.001	144.106	0.110	286.54	4.36	0.0000	Bedding
63	143.802	17	66.6	0.929	7	C	2	143.674	143.931	0.110	287.55	4.40	0.0000	Fracture
64	143.387	184	42.5	0.945	8	C	0	143.338	143.435	0.110	290.00	4.38	0.0000	Bedding
65	142.660	205	53.9	0.943	7	C	0	142.584	142.735	0.110	296.00	4.58	0.0000	Bedding
66	142.375	207	53.3	0.983	4	A	0	142.301	142.449	0.110	298.89	4.52	0.0000	Bedding
67	142.246	222	45.2	0.962	7	B	0	142.188	142.303	0.110	299.69	4.58	0.0000	Bedding
68	141.592	204	82.2	0.925	16	C	2	141.229	141.956	0.110	304.75	4.65	0.0000	Fracture
69	140.668	203	50.7	0.956	7	B	0	140.603	140.732	0.110	308.00	4.70	0.0000	Bedding
70	139.735	234	54.8	0.925	8	C	2	139.653	139.817	0.110	310.09	4.86	0.0000	Fracture
71	139.593	20	84.8	0.987	17	A	2	139.529	140.516	0.110	311.00	4.89	0.0000	Fracture Discontinuous
72	138.784	252	81.2	0.919	10	C	2	138.296	139.272	0.110	314.00	4.88	0.0000	Fracture
73	138.004	231	64.3	0.954	6	B	2	137.889	138.119	0.110	320.51	4.84	0.0000	Fracture
74	137.261	327	47.6	0.868	6	D	2	137.189	137.333	0.110	324.00	4.90	0.0000	Fracture Irregular
75	136.807	250	80.3	0.969	7	B	2	136.594	137.179	0.110	325.45	4.81	0.0000	Fracture Discontinuous
76	136.528	275	76.3	0.971	6	B	2	136.468	136.818	0.110	327.04	4.78	0.0000	Fracture Discontinuous
77	136.077	244	70.1	0.948	8	B	2	136.024	136.232	0.110	331.07	4.66	0.0000	Fracture
78	136.061	168	65.8	0.788	11	D	2	135.960	136.162	0.110	331.38	4.66	0.0000	Fracture
79	135.921	191	66.4	0.888	12	D	2	135.814	136.027	0.110	333.82	4.65	0.0000	Fracture
80	135.667	182	89.2	0.914	15	C	2	135.048	136.308	0.110	334.26	4.62	0.0000	Fracture Discontinuous
81	135.634	196	71.3	0.939	8	C	2	135.529	135.770	0.110	334.91	4.62	0.0000	Fracture Discontinuous
82	132.574	84	67.5	0.960	7	B	2	132.440	132.658	0.110	355.00	3.38	0.0000	Fracture Discontinuous
83	131.569	167	87.5	0.953	14	B	2	130.968	131.803	0.110	2.77	2.87	0.0000	Fracture Discontinuous
84	130.606	203	82.8	0.987	5	A	2	130.566	130.935	0.110	7.52	2.36	0.0000	Fracture Discontinuous

85	130.113	37	90.0	0.940	17	C	2	128.727	131.186	0.110	9.00	2.06	0.0000	Fracture Discontinuous
86	130.005	211	75.8	0.991	5	A	2	129.814	130.038	0.110	9.00	2.01	0.0000	Fracture Discontinuous
87	129.897	196	73.8	0.966	7	B	2	129.764	130.066	0.110	10.00	1.95	0.0000	Fracture Discontinuous
88	129.754	219	69.8	0.983	7	A	2	129.653	129.891	0.110	10.47	1.87	0.0000	Fracture Discontinuous
89	129.532	218	77.1	0.947	7	B	2	129.377	129.744	0.110	10.96	1.85	0.0000	Fracture Discontinuous
90	129.432	211	75.0	0.995	4	A	2	129.410	129.616	0.110	9.92	1.78	0.0000	Fracture
91	129.272	215	72.0	0.972	6	B	2	129.242	129.427	0.110	10.68	1.60	0.0000	Fracture Discontinuous
92	129.086	193	76.6	0.965	7	B	2	128.968	129.292	0.110	11.37	1.51	0.0000	Fracture
93	128.844	180	59.7	0.973	7	B	2	128.755	128.933	0.110	15.71	1.46	0.0000	Fracture
94	128.517	54	73.2	0.991	5	A	2	128.324	128.548	0.110	17.51	1.14	0.0000	Fracture Discontinuous
95	128.191	175	88.5	0.904	14	C	2	126.958	128.612	0.110	23.06	1.20	0.0000	Fracture Discontinuous
96	127.935	50	69.5	0.972	5	B	2	127.778	128.006	0.110	22.00	1.26	0.0000	Fracture Discontinuous
97	127.795	46	67.3	0.965	7	B	2	127.657	127.880	0.110	19.31	1.10	0.0000	Fracture Discontinuous
98	127.242	203	62.6	0.970	6	B	2	127.139	127.344	0.110	6.54	0.75	0.0000	Fracture
99	126.281	178	41.9	0.956	5	B	2	126.315	126.331	0.110	258.02	0.42	0.0000	Fracture Discontinuous
100	126.146	299	58.8	0.974	6	A	2	126.054	126.238	0.110	251.32	0.51	0.0000	Fracture
101	126.037	320	76.5	0.988	5	A	2	125.827	126.268	0.110	245.87	0.57	0.0000	Fracture segmented
102	125.943	175	54.3	0.988	4	A	2	125.945	126.020	0.110	244.06	0.63	0.0000	Fracture Discontinuous
103	125.929	237	56.5	0.951	8	B	2	125.846	126.014	0.110	242.97	0.64	0.0000	Fracture
104	125.869	235	56.7	0.953	4	B	2	125.783	125.955	0.110	241.00	0.69	0.0000	Fracture
105	125.570	50	75.2	0.979	6	A	2	125.410	125.766	0.110	238.19	0.99	0.0000	Fracture segmented
106	125.190	42	81.5	0.986	5	A	2	125.404	125.510	0.110	239.80	1.38	0.0000	Fracture Discontinuous
107	124.446	174	34.9	0.982	6	A	2	124.407	124.486	0.110	241.67	1.86	0.0000	Fracture
108	124.142	178	43.5	0.986	5	A	0	124.089	124.197	0.110	242.00	2.17	0.0000	Bedding
109	124.030	207	45.7	0.922	7	C	0	123.970	124.090	0.110	244.00	2.27	0.0000	Bedding
110	123.681	18	87.7	0.978	8	A	2	122.874	123.555	0.110	248.97	2.54	0.0000	Fracture Discontinuous
111	123.570	341	79.0	0.929	8	C	2	123.288	123.852	0.110	249.80	2.58	0.0000	Fracture
112	122.762	218	72.2	0.992	5	A	2	122.568	122.957	0.110	245.72	2.31	0.0000	Fracture
113	122.724	242	54.6	0.972	5	B	2	122.639	122.809	0.110	247.37	2.37	0.0000	Fracture
114	122.545	228	72.0	0.937	8	C	2	122.449	122.745	0.110	254.24	2.90	0.0000	Fracture Discontinuous
115	122.413	189	72.7	0.966	4	B	2	122.306	122.606	0.110	252.67	2.84	0.0000	Fracture Discontinuous
116	122.229	212	61.9	0.937	7	C	2	122.116	122.343	0.110	256.04	3.04	0.0000	Fracture
117	122.175	188	41.8	1.000	3	A	2	122.124	122.226	0.110	258.79	3.10	0.0000	Fracture
118	122.012	223	69.3	1.000	4	A	2	121.845	122.116	0.110	258.35	3.07	0.0000	Fracture Discontinuous
119	121.682	206	56.2	0.968	6	B	2	121.646	121.772	0.110	260.85	3.61	0.0000	Fracture
120	121.590	200	63.5	0.973	6	A	2	121.472	121.666	0.110	261.39	3.20	0.0000	Fracture Discontinuous
121	120.467	182	57.3	0.969	5	B	2	120.380	120.555	0.110	264.00	3.53	0.0000	Fracture
122	120.164	30	73.2	0.982	8	A	2	120.002	120.294	0.110	268.00	3.81	0.0000	Fracture Discontinuous
123	120.150	151	64.4	0.948	5	B	2	120.043	120.257	0.110	268.00	3.80	0.0000	Fracture Discontinuous
124	119.983	59	90.0	0.937	15	C	2	119.499	120.494	0.110	270.00	3.90	0.0000	Fracture Discontinuous
125	119.662	235	39.6	0.946	5	C	2	119.611	119.694	0.110	273.64	3.80	0.0000	Fracture Discontinuous
126	119.518	25	20.4	0.962	8	B	0	119.499	119.537	0.110	275.00	3.92	0.0000	Bedding
127	119.515	189	53.9	0.931	7	C	2	119.514	119.592	0.110	275.00	3.92	0.0000	Fracture Discontinuous
128	119.288	69	78.9	0.929	15	C	2	119.077	119.500	0.110	275.83	3.95	0.0000	Fracture Irregular
129	118.896	168	71.4	0.969	7	B	2	118.745	119.046	0.110	279.00	4.05	0.0000	Fracture Discontinuous
130	117.451	170	78.0	0.943	6	C	2	117.309	117.672	0.110	288.00	4.28	0.0000	Fracture Discontinuous
131	111.299	47	75.7	0.935	10	C	2	111.071	111.526	0.110	324.37	4.72	0.0000	Fracture Lenticular
132	110.360	288	43.0	0.948	8	B	2	110.302	110.418	0.110	328.82	4.49	0.0000	Fracture
133	109.524	184	55.7	0.983	6	A	2	109.498	109.595	0.110	335.11	4.35	0.0000	Fracture Discontinuous
134	109.048	265	45.2	0.989	4	A	2	108.990	109.106	0.110	337.00	4.28	0.0000	Fracture

135	108.687	233	50.5	0.945	11	C	2	108.622	108.751	0.110	339.00	4.06	0.0000	shear
136	108.536	237	56.8	0.896	9	D	2	108.454	108.618	0.110	339.00	4.05	0.0000	shear
137	108.384	241	68.1	0.952	9	B	2	108.251	108.517	0.110	339.93	4.01	0.0000	Fracture
138	108.269	215	70.5	0.986	4	A	2	108.132	108.407	0.110	340.21	3.96	0.0000	Fracture
139	108.090	190	51.9	0.951	7	B	2	108.028	108.152	0.110	341.80	3.92	0.0000	Fracture
140	107.969	210	56.0	0.930	5	C	2	107.894	108.043	0.110	342.00	3.86	0.0000	Fracture
141	107.856	213	52.1	0.965	5	B	2	107.791	107.921	0.110	343.00	3.83	0.0000	Fracture
142	107.842	107	69.9	0.968	5	B	2	107.707	107.785	0.110	343.00	3.81	0.0000	Fracture Discontinuous
143	106.741	252	44.9	0.951	8	B	2	106.687	106.795	0.110	351.78	3.27	0.0000	Fracture
144	106.039	200	67.9	0.898	7	D	2	105.920	106.158	0.110	358.00	2.88	0.0000	Fracture
145	105.806	21	25.5	0.936	6	C	0	105.777	105.835	0.110	0.00	2.66	0.0000	Bedding
146	105.676	3	27.6	0.952	9	B	0	105.644	105.708	0.110	0.09	2.57	0.0000	Bedding
147	105.524	220	62.7	0.953	7	B	2	105.426	105.622	0.110	2.12	2.48	0.0000	Fracture
148	105.402	244	61.4	0.952	6	B	2	105.369	105.498	0.110	3.00	2.39	0.0000	Fracture
149	104.936	3	27.7	0.996	4	A	0	104.905	104.967	0.110	7.00	1.97	0.0000	Bedding
150	104.789	343	39.7	0.932	5	C	0	104.741	104.837	0.110	9.00	1.88	0.0000	Bedding
151	104.238	282	55.3	0.980	6	A	2	104.158	104.317	0.110	14.15	1.42	0.0000	Fracture
152	104.007	142	54.8	0.952	9	B	2	103.977	104.083	0.110	16.47	1.25	0.0000	Fracture
153	103.901	262	47.1	0.956	5	B	2	103.843	103.960	0.110	16.85	1.14	0.0000	Fracture
154	102.905	8	25.2	0.977	6	A	0	102.879	102.931	0.110	349.52	0.24	0.0000	Bedding
155	102.409	10	16.5	0.999	4	A	0	102.393	102.425	0.110	259.11	0.34	0.0000	Bedding
156	102.226	7	24.7	0.980	6	A	0	102.201	102.251	0.110	256.82	0.47	0.0000	Bedding
157	102.141	359	23.6	0.951	7	B	0	102.117	102.165	0.110	250.30	0.52	0.0000	Bedding
158	101.756	233	68.5	0.991	5	A	2	101.610	101.735	0.110	243.03	0.77	0.0000	Fracture
159	101.492	244	54.4	0.983	4	A	2	101.412	101.449	0.110	238.24	1.00	0.0000	Fracture
160	100.890	2	26.4	0.923	7	C	0	100.863	100.916	0.110	236.00	1.50	0.0000	Bedding
161	100.254	44	69.9	0.987	5	A	2	100.118	100.184	0.110	238.52	1.97	0.0000	Fracture
162	100.067	65	76.7	0.976	6	A	2	99.996	100.266	0.110	240.51	2.18	0.0000	Fracture
163	99.612	6	30.4	0.942	6	C	0	99.581	99.643	0.110	245.00	2.41	0.0000	Bedding
164	99.405	356	31.2	0.951	5	B	0	99.373	99.438	0.110	246.99	2.51	0.0000	Bedding
165	98.820	22	23.4	0.942	6	C	2	98.799	98.842	0.110	253.00	2.85	0.0000	shear
166	98.627	355	29.8	0.983	5	A	0	98.596	98.658	0.110	254.06	3.02	0.0000	Bedding
167	98.385	352	51.7	0.918	7	C	0	98.316	98.449	0.110	255.90	3.13	0.0000	Bedding
168	94.892	331	36.1	0.987	5	A	2	94.848	94.886	0.110	274.00	4.09	0.0000	Fracture
169	94.594	4	23.3	0.974	5	A	0	94.570	94.618	0.110	275.73	4.14	0.0000	Bedding
170	94.480	349	17.4	1.000	0	*	0	94.461	94.499	0.110	276.00	4.25	0.0000	Bedding
171	94.181	354	18.2	0.955	5	B	0	94.161	94.200	0.110	276.02	4.26	0.0000	Bedding
172	94.137	13	17.0	0.945	6	C	0	94.120	94.154	0.110	276.86	4.21	0.0000	Bedding
173	93.653	17	12.3	0.956	4	B	0	93.641	93.665	0.110	280.46	4.27	0.0000	Bedding
174	93.585	130	82.4	0.964	7	B	2	93.309	93.647	0.110	280.00	4.21	0.0000	Fracture
175	93.571	17	27.7	0.980	6	A	0	93.542	93.599	0.110	280.37	4.21	0.0000	Bedding
176	93.245	36	22.5	0.964	6	B	0	93.223	93.266	0.110	282.00	4.14	0.0000	Bedding
177	92.915	29	23.5	0.966	7	B	0	92.892	92.938	0.110	283.30	4.20	0.0000	Bedding
178	92.717	8	22.5	0.972	9	B	0	92.693	92.741	0.110	284.74	4.30	0.0000	Bedding
179	92.565	146	74.0	0.971	8	B	2	92.461	92.705	0.110	285.40	4.31	0.0000	Fracture
180	92.116	247	36.7	0.842	6	D	2	92.070	92.163	0.110	286.28	4.43	0.0000	shear
181	91.485	31	24.3	0.939	8	C	0	91.461	91.510	0.110	290.89	4.54	0.0000	Bedding
182	91.241	44	25.3	0.924	9	C	0	91.216	91.265	0.110	292.78	4.62	0.0000	Bedding
183	91.075	45	26.5	0.944	7	C	0	91.049	91.101	0.110	295.00	4.66	0.0000	Bedding
184	90.352	15	37.2	0.985	5	A	0	90.309	90.396	0.110	297.55	4.78	0.0000	Bedding

185	90.063	0	41.6	0.896	6	D	0	90.009	90.116	0.110	299.00	4.76	0.0000	Bedding
186	89.966	350	23.8	0.893	10	D	0	89.938	89.994	0.110	298.28	4.75	0.0000	Bedding
187	89.551	1	16.1	0.998	4	A	0	89.532	89.570	0.110	300.58	4.76	0.0000	Bedding
188	89.441	350	22.5	0.990	5	A	0	89.417	89.466	0.110	302.00	4.76	0.0000	Bedding
189	89.301	353	18.5	0.949	6	B	0	89.279	89.319	0.110	302.57	4.75	0.0000	Bedding
190	89.153	30	26.3	0.958	5	B	0	89.125	89.181	0.110	304.54	4.76	0.0000	Bedding
191	88.881	61	89.1	0.965	9	B	2	89.405	89.963	0.110	306.98	4.96	0.0000	Fracture Discontinuous
192	88.813	56	53.8	0.882	7	D	0	88.742	88.884	0.110	307.00	4.88	0.0000	Bedding
193	88.223	273	69.4	0.944	6	C	2	88.041	88.405	0.110	307.42	4.60	0.0000	Fracture
194	85.029	326	53.3	0.935	8	C	2	84.941	85.116	0.110	308.03	4.69	0.0000	Fracture
195	84.844	177	51.7	0.931	4	C	2	84.782	84.907	0.110	309.29	4.66	0.0000	Fracture
196	84.360	6	34.4	0.965	7	B	0	84.318	84.402	0.110	313.00	4.58	0.0000	Bedding
197	84.205	357	41.3	0.963	7	B	0	84.150	84.259	0.110	314.00	4.58	0.0000	Bedding
198	83.925	2	34.4	0.965	8	B	0	83.882	83.967	0.110	316.11	4.59	0.0000	Bedding
199	83.315	208	30.7	0.929	5	C	2	83.284	83.346	0.110	320.00	4.56	0.0000	shear
200	83.264	266	69.4	0.937	11	C	2	83.093	83.344	0.110	320.33	4.56	0.0000	Fracture Discontinuous
201	83.070	266	62.7	0.967	5	B	2	83.068	83.190	0.110	321.00	4.53	0.0000	Fracture
202	83.000	288	57.7	0.955	6	B	2	83.003	83.101	0.110	321.61	4.51	0.0000	Fracture Discontinuous
203	82.902	302	58.7	0.961	5	B	2	82.795	83.010	0.110	322.00	4.48	0.0000	Fracture
204	82.770	26	50.1	0.944	7	C	2	82.701	82.841	0.110	321.81	4.41	0.0000	Fracture Discontinuous
205	82.571	295	63.1	0.927	8	C	2	82.442	82.701	0.110	323.00	4.33	0.0000	shear
206	82.220	6	34.7	0.964	6	B	0	82.177	82.263	0.110	325.00	4.26	0.0000	Bedding
207	82.099	34	37.0	0.955	8	B	0	82.055	82.143	0.110	326.00	4.23	0.0000	Bedding
208	81.966	223	49.7	0.970	7	B	2	81.904	82.029	0.110	327.27	4.22	0.0000	Fracture
209	81.865	232	17.1	0.960	7	B	2	81.848	81.882	0.110	327.29	4.24	0.0000	Fracture
210	81.765	16	44.2	0.960	6	B	2	81.706	81.825	0.110	327.00	4.40	0.0000	Fracture
211	81.723	185	51.4	0.949	6	B	2	81.662	81.784	0.110	327.72	4.41	0.0000	Fracture
212	81.478	204	60.4	0.980	4	A	2	81.392	81.564	0.110	331.94	4.60	0.0000	Fracture Discontinuous
213	81.386	217	64.3	0.943	10	C	2	81.279	81.492	0.110	330.89	4.39	0.0000	Fracture
214	81.309	214	32.9	0.970	7	B	2	81.276	81.343	0.110	329.41	4.29	0.0000	Fracture
215	81.143	32	48.0	0.970	7	B	2	81.077	81.209	0.110	330.26	4.24	0.0000	Fracture
216	81.004	236	78.2	0.993	6	A	2	80.747	80.876	0.110	330.00	4.14	0.0000	Fracture Discontinuous
217	80.998	41	44.1	0.953	8	B	2	80.942	81.054	0.110	330.00	4.14	0.0000	shear
218	80.996	242	56.1	0.980	6	A	2	80.913	81.067	0.110	330.00	4.14	0.0000	Fracture Discontinuous
219	80.958	15	48.3	0.990	4	A	2	80.889	80.930	0.110	330.87	4.13	0.0000	Fracture Discontinuous
220	80.925	238	62.4	0.980	4	A	2	80.821	80.940	0.110	331.91	4.12	0.0000	Fracture Discontinuous
221	80.782	141	54.1	0.958	5	B	2	80.755	80.847	0.110	331.00	4.16	0.0000	Fracture
222	80.706	240	46.8	0.965	6	B	2	80.647	80.753	0.110	331.51	4.00	0.0000	Fracture Discontinuous
223	80.630	234	39.9	0.944	6	C	2	80.584	80.675	0.110	331.99	3.94	0.0000	Fracture
224	79.297	164	65.0	0.979	5	A	2	79.195	79.309	0.110	345.66	3.28	0.0000	Fracture Discontinuous
225	79.252	80	64.0	0.978	5	A	2	79.140	79.269	0.110	346.00	3.30	0.0000	Fracture Discontinuous
226	79.024	83	55.8	0.943	10	C	2	78.944	79.104	0.110	347.76	3.12	0.0000	Fracture
227	78.951	130	80.0	1.000	3	A	2	78.703	79.199	0.110	347.73	3.13	0.0000	Fracture Discontinuous
228	78.453	112	74.2	0.949	7	B	2	78.271	78.634	0.110	356.55	2.53	0.0000	Fracture
229	78.437	112	81.9	0.984	6	A	2	78.097	78.777	0.110	356.86	2.50	0.0000	Fracture
230	78.286	100	60.2	0.988	5	A	2	78.324	78.379	0.110	356.11	2.60	0.0000	Fracture Discontinuous
231	78.227	121	80.6	0.947	8	C	2	77.945	78.510	0.110	355.21	2.72	0.0000	Fracture
232	77.832	341	34.5	0.985	4	A	2	77.791	77.873	0.110	1.93	2.32	0.0000	
233	77.613	354	44.1	0.954	7	B	2	77.555	77.670	0.110	359.70	2.07	0.0000	Fracture
234	77.444	219	58.6	0.962	5	B	2	77.359	77.512	0.110	3.44	1.87	0.0000	Fracture Discontinuous

235	77.373	168	55.4	0.928	11	C	2	77.298	77.449	0.110	3.87	1.73	0.0000	Fracture Discontinuous
236	77.312	125	75.8	0.962	6	B	2	77.207	77.516	0.110	3.36	1.70	0.0000	Fracture
237	77.219	121	67.9	0.988	6	A	2	77.257	77.349	0.110	2.68	1.53	0.0000	Fracture Discontinuous
238	77.040	172	71.2	0.963	6	B	2	77.030	77.191	0.110	8.62	1.29	0.0000	Fracture Discontinuous
239	76.307	12	50.7	0.971	7	B	0	76.238	76.377	0.110	9.45	0.97	0.0000	Bedding
240	76.235	18	44.1	0.956	6	B	0	76.180	76.290	0.110	8.19	0.89	0.0000	Bedding
241	76.156	358	32.2	0.993	4	A	0	76.120	76.192	0.110	4.77	0.93	0.0000	Bedding
242	76.024	13	41.5	0.972	9	B	0	75.973	76.074	0.110	3.76	1.01	0.0000	Bedding
243	75.974	5	38.7	0.986	4	A	0	75.928	76.019	0.110	9.12	0.83	0.0000	Bedding
244	75.840	15	39.3	0.957	5	B	0	75.794	75.886	0.110	4.02	0.65	0.0000	Bedding
245	75.774	16	39.8	0.985	6	A	0	75.727	75.821	0.110	355.09	0.51	0.0000	Bedding
246	75.727	12	42.1	0.953	8	B	0	75.676	75.777	0.110	2.50	0.47	0.0000	Bedding
247	75.400	15	43.9	0.965	5	B	0	75.347	75.454	0.110	337.77	0.27	0.0000	Bedding
248	75.354	188	58.9	0.940	7	C	2	75.267	75.444	0.110	331.69	0.24	0.0000	Fracture Discontinuous
249	75.337	5	37.7	0.948	6	B	0	75.294	75.380	0.110	326.93	0.24	0.0000	Bedding
250	75.168	18	49.8	0.928	10	C	0	75.103	75.233	0.110	300.18	0.16	0.0000	Bedding
251	75.159	202	28.3	0.967	5	B	2	75.136	75.188	0.110	301.14	0.17	0.0000	Fracture Discontinuous
252	75.056	9	49.0	0.930	6	C	0	74.992	75.119	0.110	256.92	0.19	0.0000	Bedding
253	75.000	14	51.6	0.954	8	B	0	74.931	75.069	0.110	244.24	0.23	0.0000	Bedding
254	74.961	11	47.8	0.968	7	B	0	74.900	75.021	0.110	238.53	0.33	0.0000	Bedding
255	74.920	10	50.9	0.979	6	A	0	74.853	74.987	0.110	225.00	0.44	0.0000	Bedding
256	74.871	19	49.4	0.961	7	B	0	74.808	74.934	0.110	224.82	0.53	0.0000	Bedding
257	74.847	13	58.8	0.982	5	A	0	74.758	74.936	0.110	224.33	0.58	0.0000	Bedding
258	74.745	12	53.5	0.949	7	B	0	74.672	74.819	0.110	234.08	0.66	0.0000	Bedding
259	74.475	13	46.0	0.954	7	B	0	74.420	74.531	0.110	222.55	0.86	0.0000	Bedding
260	74.339	2	53.0	0.989	5	A	0	74.268	74.411	0.110	228.19	1.03	0.0000	Bedding
261	74.157	16	41.7	0.956	7	B	0	74.110	74.205	0.110	229.55	1.27	0.0000	Bedding
262	74.156	347	74.2	0.990	6	A	2	73.969	74.139	0.110	229.51	1.27	0.0000	Fracture
263	74.021	327	67.6	0.999	4	A	2	73.888	73.961	0.110	230.00	1.27	0.0000	Fracture
264	73.964	19	47.0	0.951	9	B	0	73.907	74.021	0.110	228.72	1.31	0.0000	Bedding
265	73.873	4	61.8	0.956	8	B	0	73.774	73.971	0.110	225.30	1.36	0.0000	Bedding
266	73.697	1	47.1	0.959	7	B	0	73.640	73.754	0.110	226.69	1.44	0.0000	Bedding
267	73.634	8	43.8	0.972	7	B	0	73.583	73.684	0.110	225.07	1.46	0.0000	Bedding
268	73.197	4	47.4	0.937	8	C	0	73.140	73.254	0.110	233.66	2.15	0.0000	Bedding
269	73.055	2	53.3	0.928	7	C	0	72.985	73.126	0.110	234.51	2.14	0.0000	Bedding
270	72.937	19	51.2	0.921	9	C	0	72.873	73.001	0.110	235.74	2.32	0.0000	Bedding
271	72.826	15	46.1	0.956	7	B	0	72.772	72.880	0.110	236.15	2.44	0.0000	Bedding
272	72.393	2	61.5	0.894	6	D	0	72.297	72.489	0.110	244.74	2.94	0.0000	Bedding
273	72.204	6	55.7	0.986	7	A	0	72.127	72.281	0.110	249.07	3.03	0.0000	Bedding
274	72.144	6	47.7	0.955	6	B	0	72.086	72.202	0.110	252.00	2.93	0.0000	Bedding
275	71.997	360	45.7	0.890	10	D	0	71.943	72.051	0.110	247.64	3.10	0.0000	Bedding
276	71.896	354	49.4	0.978	5	A	0	71.833	71.960	0.110	257.09	3.16	0.0000	Bedding
277	71.740	354	52.4	0.989	4	A	0	71.669	71.810	0.110	258.57	3.18	0.0000	Bedding
278	71.579	1	59.1	0.966	4	B	0	71.490	71.667	0.110	253.97	3.33	0.0000	Bedding
279	71.567	217	43.8	0.926	7	C	2	71.509	71.625	0.110	253.73	3.33	0.0000	Fracture
280	70.342	323	60.2	0.965	6	B	2	70.235	70.449	0.110	270.00	4.17	0.0000	shear
281	69.988	31	64.4	0.993	4	A	2	69.884	69.968	0.110	263.83	3.51	0.0000	Fracture Discontinuous
282	69.885	219	53.2	0.988	5	A	2	69.833	69.966	0.110	268.21	3.89	0.0000	Fracture Discontinuous
283	69.732	49	73.9	0.987	5	A	2	69.751	69.890	0.110	265.00	3.81	0.0000	Fracture
284	69.507	36	52.5	0.953	8	B	0	69.441	69.573	0.110	266.00	3.92	0.0000	Bedding

285	67.441	4	48.1	0.972	5	B	0	67.379	67.503	0.110	275.00	4.27	0.0000 Bedding
286	67.164	18	52.6	0.964	7	B	0	67.094	67.234	0.110	277.36	4.07	0.0000 Bedding
287	66.843	50	55.9	0.916	5	C	0	66.770	66.916	0.110	273.74	4.27	0.0000 Bedding

RGLDIPv6.1 BHTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-05
zone from 194.390 to 169.980 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Dev (deg)	Thickness	
1	193.887	9	65.3	0.857	9	D	0	193.734	194.039	0.112	316.00	7.32	0.0000	Primary-structure Crushed
2	193.393	79	4.8	0.967	5	B	0	193.387	193.399	0.112	315.54	7.35	0.0000	Bedding
3	193.228	340	20.1	0.968	5	B	0	193.200	193.257	0.112	315.83	7.34	0.0000	Primary-structure Crushed
4	192.925	64	12.6	0.947	5	C	0	192.913	192.938	0.112	316.00	7.32	0.0000	Primary-structure Crushed
5	192.630	39	25.8	0.939	7	C	0	192.600	192.659	0.112	316.80	7.37	0.0000	Bedding
6	191.961	360	39.4	0.922	6	C	2	191.905	192.018	0.112	319.00	7.33	0.0000	Fracture Discontinuous
7	190.776	19	50.8	0.960	7	B	2	190.696	190.856	0.112	321.00	7.35	0.0000	Fracture
8	189.981	3	49.9	0.917	5	C	2	189.899	190.062	0.112	321.00	7.17	0.0000	Fracture
9	189.832	169	17.3	0.967	6	B	0	189.821	189.844	0.112	322.00	7.15	0.0000	Bedding
10	189.484	88	44.7	0.990	5	A	2	189.435	189.516	0.112	322.72	7.16	0.0000	Fracture Discontinuous
11	189.289	40	3.6	0.951	9	B	0	189.280	189.297	0.112	323.00	7.14	0.0000	Bedding
12	189.194	45	54.4	0.975	4	A	2	189.111	189.192	0.112	323.52	7.08	0.0000	Fracture Discontinuous
13	188.278	47	45.6	0.945	8	C	2	188.218	188.338	0.112	325.00	7.08	0.0000	Fracture
14	186.695	167	2.1	0.947	6	B	0	186.690	186.699	0.112	330.02	6.96	0.0000	Bedding
15	186.494	133	8.5	0.980	7	A	0	186.491	186.497	0.112	330.48	6.90	0.0000	Bedding
16	185.983	88	24.4	0.939	4	C	0	185.961	186.006	0.112	329.00	6.71	0.0000	Bedding
17	185.890	83	15.3	0.968	8	B	0	185.876	185.904	0.112	329.39	6.65	0.0000	Bedding
18	184.444	359	53.2	0.875	8	D	0	184.350	184.538	0.112	329.52	6.70	0.0000	Bedding
19	184.143	110	10.8	0.970	8	B	0	184.136	184.150	0.112	330.00	6.56	0.0000	Bedding
20	183.850	88	6.3	0.961	13	B	0	183.843	183.856	0.112	331.00	6.43	0.0000	Bedding
21	183.748	27	7.1	0.942	6	C	0	183.736	183.760	0.112	330.44	6.40	0.0000	Bedding
22	183.591	17	12.2	0.912	6	C	0	183.573	183.608	0.112	331.00	6.34	0.0000	Bedding
23	183.309	65	56.1	0.980	5	A	0	183.225	183.340	0.112	331.77	6.21	0.0000	Bedding
24	183.081	55	12.6	0.940	7	C	0	183.067	183.096	0.112	332.00	6.11	0.0000	Bedding
25	183.023	78	21.4	0.982	5	A	0	183.002	183.044	0.112	332.00	6.08	0.0000	Bedding
26	181.500	37	9.7	0.919	6	C	0	181.487	181.513	0.112	335.00	5.53	0.0000	Bedding
27	181.087	42	17.1	0.920	6	C	0	181.067	181.108	0.112	336.34	5.52	0.0000	Bedding
28	181.007	66	8.8	0.932	7	C	0	180.997	181.017	0.112	337.26	5.51	0.0000	Bedding
29	180.614	112	8.8	0.956	6	B	0	180.608	180.621	0.112	340.89	5.63	0.0000	Bedding
30	178.411	342	65.3	0.952	8	B	2	178.252	178.570	0.112	340.82	5.26	0.0000	shear
31	172.705	332	44.5	0.954	6	B	2	172.644	172.765	0.112	351.31	2.84	0.0000	shear
32	172.619	0	42.7	0.908	6	C	2	172.562	172.676	0.112	352.00	2.79	0.0000	shear
33	172.448	224	36.5	0.949	8	B	2	172.409	172.487	0.112	351.44	2.81	0.0000	shear
34	172.315	315	34.5	0.981	5	A	2	172.273	172.357	0.112	352.00	2.81	0.0000	Fracture
35	172.181	47	33.1	0.962	4	B	0	172.142	172.220	0.112	352.77	2.80	0.0000	Bedding
36	172.073	351	31.1	0.983	5	A	0	172.035	172.111	0.112	352.00	2.75	0.0000	Bedding

37	171.685	328	23.6	0.953	5	B	0	171.657	171.712	0.112	349.59	2.85	0.0000	Bedding
38	171.600	335	21.8	0.974	5	A	0	171.574	171.625	0.112	350.00	2.79	0.0000	Bedding
39	170.931	345	28.4	0.969	6	B	2	170.898	170.964	0.112	350.22	1.87	0.0000	Fracture
40	170.848	180	84.2	0.974	5	A	2	170.431	170.907	0.112	351.88	1.82	0.0000	Fracture Discontinuous

Borehole: BH_02-05
Depth range: 0.000 - 97.196m

Depth m	Deviation components North m	East m	Down m	Devaz deg	Dev deg
1.046	0.018	-0.003	1.046	351.00	1.00
2.046	0.035	-0.006	2.046	351.00	1.00
3.046	0.053	-0.008	3.046	351.00	1.00
4.046	0.070	-0.011	4.045	351.00	1.00
5.046	0.087	-0.014	5.045	351.00	1.00
6.046	0.104	-0.017	6.045	351.00	1.00
7.046	0.121	-0.021	7.045	331.00	1.00
8.046	0.138	-0.026	8.045	339.00	1.00
9.046	0.155	-0.029	9.045	1.00	1.00
10.046	0.172	-0.033	10.044	349.00	1.00
11.046	0.188	-0.038	11.044	345.00	1.00
12.046	0.204	-0.044	12.044	334.00	1.00
13.046	0.221	-0.048	13.044	330.00	1.00
14.046	0.235	-0.058	14.044	321.00	1.00
15.046	0.249	-0.069	15.044	318.00	1.00
16.046	0.262	-0.079	16.044	320.00	1.00
17.046	0.275	-0.091	17.043	318.00	1.00
18.046	0.287	-0.103	18.043	334.00	1.00
19.046	0.301	-0.114	19.043	319.00	1.00
20.046	0.313	-0.126	20.043	318.00	1.00
21.046	0.327	-0.142	21.043	306.00	2.00
22.046	0.349	-0.157	22.042	312.00	1.00
23.046	0.361	-0.170	23.042	322.00	1.00
24.046	0.367	-0.184	24.042	301.00	1.00
25.046	0.378	-0.201	25.042	305.00	1.00
26.046	0.393	-0.222	26.041	303.00	1.00
27.046	0.409	-0.244	27.041	309.00	1.00
28.046	0.426	-0.265	28.040	310.00	1.00
29.046	0.444	-0.293	29.040	291.00	2.00
30.046	0.463	-0.317	30.039	301.00	2.00
31.046	0.478	-0.345	31.039	299.00	2.00
32.046	0.498	-0.372	32.038	306.00	2.00
33.046	0.514	-0.398	33.038	303.00	2.00
34.046	0.537	-0.423	34.037	299.00	2.00
35.046	0.552	-0.454	35.037	296.00	2.00
36.046	0.567	-0.486	36.036	292.00	2.00
37.046	0.587	-0.515	37.035	300.00	2.00
38.046	0.612	-0.534	38.035	335.00	2.00
39.046	0.618	-0.575	39.033	299.00	3.00
40.046	0.634	-0.606	40.033	304.00	2.00
41.046	0.650	-0.637	41.032	299.00	2.00
42.046	0.669	-0.668	42.032	295.00	2.00
43.046	0.686	-0.700	43.031	298.00	2.00
44.046	0.706	-0.731	44.030	301.00	2.00
45.046	0.727	-0.764	45.029	304.00	2.00
46.046	0.746	-0.797	46.029	310.00	2.00
47.046	0.770	-0.836	47.027	301.00	3.00
48.046	0.791	-0.869	48.027	311.00	3.00
49.046	0.812	-0.902	49.026	320.00	3.00
50.046	0.833	-0.940	50.025	301.00	2.00
51.046	0.858	-0.978	51.024	308.00	2.00
52.046	0.884	-1.017	52.023	304.00	3.00

53.046	0.904	-1.054	53.022	305.00	2.00
54.046	0.925	-1.099	54.020	296.00	3.00
55.046	0.951	-1.140	55.019	299.00	3.00
56.046	0.973	-1.183	56.018	281.00	3.00
57.046	0.993	-1.222	57.017	296.00	2.00
58.046	1.014	-1.268	58.016	290.00	3.00
59.046	1.032	-1.309	59.015	290.00	3.00
60.046	1.050	-1.347	60.014	285.00	3.00
61.046	1.069	-1.389	61.013	282.00	3.00
62.046	1.085	-1.431	62.012	290.00	3.00
63.046	1.103	-1.472	63.011	292.00	3.00
64.046	1.119	-1.517	64.009	296.00	3.00
65.046	1.137	-1.556	65.008	297.00	3.00
66.046	1.149	-1.594	66.007	286.00	4.00
67.046	1.167	-1.641	67.006	294.00	2.00
68.046	1.180	-1.691	68.005	284.00	3.00
69.046	1.194	-1.742	69.003	286.00	3.00
70.046	1.207	-1.792	70.002	282.00	3.00
71.046	1.218	-1.840	71.001	265.00	2.00
72.046	1.235	-1.888	71.999	287.00	3.00
73.046	1.252	-1.939	72.998	285.00	3.00
74.046	1.268	-1.990	73.996	287.00	3.00
75.046	1.281	-2.041	74.995	283.00	3.00
76.046	1.294	-2.091	75.994	281.00	3.00
77.046	1.310	-2.141	76.992	283.00	3.00
78.046	1.325	-2.191	77.991	291.00	3.00
79.046	1.342	-2.243	78.989	293.00	4.00
80.046	1.360	-2.293	79.988	289.00	3.00
81.046	1.373	-2.344	80.986	291.00	3.00
82.046	1.395	-2.393	81.985	285.00	3.00
83.046	1.410	-2.443	82.984	291.00	3.00
84.046	1.430	-2.492	83.982	289.00	3.00
85.046	1.446	-2.542	84.981	288.00	3.00
86.046	1.459	-2.592	85.979	292.00	3.00
87.046	1.487	-2.644	86.977	286.00	4.00
88.046	1.509	-2.704	87.975	305.00	3.00
89.046	1.534	-2.757	88.974	292.00	3.00
90.046	1.553	-2.806	89.972	291.00	3.00
91.046	1.573	-2.854	90.971	295.00	3.00
92.046	1.594	-2.902	91.969	293.00	3.00
93.046	1.615	-2.950	92.968	295.00	3.00
94.046	1.635	-2.998	93.967	291.00	3.00
95.046	1.657	-3.047	94.965	297.00	3.00
96.046	1.680	-3.094	95.964	294.00	3.00
97.046	1.702	-3.141	96.963	295.00	3.00

Borehole: 02-05_ Logged section 65 to 167 meters
Depth range: 0.000 - 167.480m extrapolated from 65m to 0 meters

	Deviation components				
Depth	North	East	Down	Devaz	Dev
m	m	m	m	deg	deg
1.030	0.024	-0.075	1.027	288.00	4.40
2.030	0.048	-0.148	2.024	288.00	4.40
3.030	0.072	-0.221	3.021	288.00	4.40
4.030	0.096	-0.294	4.018	288.00	4.40
5.030	0.119	-0.367	5.015	288.00	4.40
6.030	0.143	-0.440	6.012	288.00	4.40
7.030	0.167	-0.513	7.009	288.00	4.40
8.030	0.190	-0.586	8.006	288.00	4.40
9.030	0.214	-0.659	9.003	288.00	4.40
10.030	0.238	-0.732	10.000	288.00	4.40
11.030	0.261	-0.805	10.997	288.00	4.40
12.030	0.285	-0.878	11.995	288.00	4.40
13.030	0.309	-0.951	12.992	288.00	4.40
14.030	0.333	-1.024	13.989	288.00	4.40
15.030	0.356	-1.097	14.986	288.00	4.40
16.030	0.380	-1.170	15.983	288.00	4.40
17.030	0.404	-1.243	16.980	288.00	4.40
18.030	0.427	-1.316	17.977	288.00	4.40
19.030	0.451	-1.389	18.974	288.00	4.40
20.030	0.475	-1.461	19.971	288.00	4.40
21.030	0.499	-1.534	20.968	288.00	4.40
22.030	0.522	-1.607	21.965	288.00	4.40
23.030	0.546	-1.680	22.962	288.00	4.40
24.030	0.570	-1.753	23.959	288.00	4.40
25.030	0.593	-1.826	24.956	288.00	4.40
26.030	0.617	-1.899	25.953	288.00	4.40
27.030	0.641	-1.972	26.950	288.00	4.40
28.030	0.665	-2.045	27.947	288.00	4.40
29.030	0.688	-2.118	28.944	288.00	4.40
30.030	0.712	-2.191	29.941	288.00	4.40
31.030	0.736	-2.264	30.939	288.00	4.40
32.030	0.759	-2.337	31.936	288.00	4.40
33.030	0.783	-2.410	32.933	288.00	4.40
34.030	0.807	-2.483	33.930	288.00	4.40
35.030	0.830	-2.556	34.927	288.00	4.40
36.030	0.854	-2.629	35.924	288.00	4.40
37.030	0.878	-2.702	36.921	288.00	4.40
38.030	0.902	-2.775	37.918	288.00	4.40
39.030	0.925	-2.848	38.915	288.00	4.40
40.030	0.949	-2.921	39.912	288.00	4.40
41.030	0.973	-2.994	40.909	288.00	4.40
42.030	0.996	-3.067	41.906	288.00	4.40
43.030	1.020	-3.140	42.903	288.00	4.40
44.030	1.044	-3.213	43.900	288.00	4.40
45.030	1.068	-3.286	44.897	288.00	4.40
46.030	1.091	-3.359	45.894	288.00	4.40
47.030	1.115	-3.432	46.891	288.00	4.40
48.030	1.139	-3.504	47.888	288.00	4.40
49.030	1.162	-3.577	48.885	288.00	4.40
50.030	1.186	-3.650	49.883	288.00	4.40
51.030	1.210	-3.723	50.880	288.00	4.40
52.030	1.234	-3.796	51.877	288.00	4.40
53.030	1.257	-3.869	52.874	288.00	4.40

54.030	1.281	-3.942	53.871	288.00	4.40
55.030	1.305	-4.015	54.868	288.00	4.40
56.030	1.328	-4.088	55.865	288.00	4.40
57.030	1.352	-4.161	56.862	288.00	4.40
58.030	1.376	-4.234	57.859	288.00	4.40
59.030	1.399	-4.307	58.856	288.00	4.40
60.030	1.423	-4.380	59.853	288.00	4.40
61.030	1.447	-4.453	60.850	288.00	4.40
62.030	1.471	-4.526	61.847	288.00	4.40
63.030	1.494	-4.599	62.844	288.00	4.40
64.030	1.518	-4.672	63.841	288.00	4.40
65.030	1.541	-4.746	64.838	285.00	4.31
66.030	1.553	-4.821	65.835	281.00	4.96
67.030	1.564	-4.899	66.832	277.00	4.40
68.030	1.572	-4.972	67.829	274.00	4.17
69.030	1.573	-5.044	68.827	265.00	3.79
70.030	1.569	-5.111	69.825	263.00	3.63
71.030	1.564	-5.181	70.822	262.00	3.88
72.030	1.551	-5.237	71.820	245.00	2.87
73.030	1.529	-5.279	72.819	234.00	2.16
74.030	1.510	-5.301	73.819	230.00	1.27
75.030	1.501	-5.312	74.819	240.00	0.17
76.030	1.508	-5.313	75.819	3.00	1.03
77.030	1.527	-5.310	76.819	7.00	1.30
78.030	1.561	-5.309	77.818	2.00	2.37
79.030	1.609	-5.314	78.817	348.00	3.13
80.030	1.666	-5.331	79.815	341.00	3.26
81.030	1.725	-5.362	80.813	330.00	4.14
82.030	1.791	-5.400	81.810	326.00	4.20
83.030	1.852	-5.445	82.807	321.00	4.53
84.030	1.912	-5.498	83.804	316.00	4.58
85.030	1.965	-5.559	84.800	308.00	4.69
86.030	2.014	-5.622	85.797	306.00	4.56
87.030	2.069	-5.690	86.793	302.00	5.25
88.030	2.117	-5.765	87.789	296.00	4.61
89.030	2.167	-5.832	88.786	306.00	4.79
90.030	2.210	-5.903	89.782	299.00	4.75
91.030	2.247	-5.976	90.779	295.00	4.73
92.030	2.275	-6.051	91.776	287.00	4.45
93.030	2.295	-6.123	92.773	283.00	4.12
94.030	2.308	-6.195	93.770	276.00	4.25
95.030	2.315	-6.268	94.768	274.00	4.07
96.030	2.318	-6.336	95.765	270.00	3.80
97.030	2.315	-6.399	96.763	265.00	3.52
98.030	2.306	-6.458	97.762	260.00	3.25
99.030	2.292	-6.509	98.760	251.00	2.72
100.030	2.275	-6.548	99.759	242.00	2.19
101.030	2.258	-6.574	100.759	234.00	1.36
102.030	2.250	-6.588	101.759	251.00	0.60
103.030	2.250	-6.592	102.759	4.00	0.31
104.030	2.264	-6.588	103.759	16.00	1.27
105.030	2.293	-6.582	104.758	7.00	2.08
106.030	2.336	-6.581	105.757	358.00	2.87
107.030	2.391	-6.587	106.756	349.00	3.47
108.030	2.454	-6.604	107.753	342.00	3.88
109.030	2.520	-6.629	108.751	337.00	4.27
110.030	2.589	-6.662	109.748	332.00	4.44
111.030	2.656	-6.704	110.745	325.00	4.60
112.030	2.721	-6.754	111.742	321.00	4.72

113.030	2.781	-6.810	112.738	315.00	4.69
114.030	2.836	-6.871	113.735	310.00	4.71
115.030	2.885	-6.937	114.731	304.00	4.74
116.030	2.927	-7.007	115.728	298.00	4.66
117.030	2.959	-7.079	116.725	290.00	4.41
118.030	2.981	-7.150	117.722	285.00	4.13
119.030	2.995	-7.220	118.720	278.00	4.05
120.030	3.000	-7.287	119.717	270.00	3.83
121.030	2.996	-7.347	120.715	259.00	3.12
122.030	2.986	-7.402	121.714	258.00	3.10
123.030	2.972	-7.449	122.713	253.00	2.88
124.030	2.956	-7.491	123.712	244.00	2.27
125.030	2.941	-7.519	124.711	239.00	1.50
126.030	2.932	-7.534	125.711	246.00	0.58
127.030	2.933	-7.540	126.711	339.00	0.46
128.030	2.949	-7.535	127.711	24.00	1.24
129.030	2.969	-7.529	128.711	16.00	1.44
130.030	3.000	-7.523	129.710	9.00	2.06
131.030	3.040	-7.518	130.709	6.00	2.58
132.030	3.090	-7.516	131.708	359.00	3.03
133.030	3.148	-7.521	132.706	352.00	3.63
134.030	3.213	-7.535	133.704	344.00	4.01
135.030	3.283	-7.561	134.701	336.00	4.51
136.030	3.357	-7.596	135.698	332.00	4.66
137.030	3.427	-7.641	136.695	324.00	4.87
138.030	3.495	-7.692	137.691	320.00	4.82
139.030	3.556	-7.750	138.687	314.00	4.90
140.030	3.612	-7.813	139.684	310.00	4.82
141.030	3.664	-7.878	140.680	308.00	4.71
142.030	3.710	-7.944	141.677	301.00	4.54
143.030	3.746	-8.015	142.674	294.00	4.54
144.030	3.771	-8.087	143.671	287.00	4.38
145.030	3.788	-8.160	144.668	279.00	4.20
146.030	3.796	-8.230	145.666	274.00	3.81
147.030	3.798	-8.293	146.664	268.00	3.53
148.030	3.792	-8.351	147.662	263.00	3.00
149.030	3.782	-8.395	148.661	253.00	2.36
150.030	3.769	-8.430	149.660	251.00	1.77
151.030	3.763	-8.454	150.660	260.00	1.09
152.030	3.764	-8.467	151.660	313.00	0.57
153.030	3.776	-8.471	152.660	353.00	0.93
154.030	3.798	-8.471	153.659	5.00	1.68
155.030	3.832	-8.468	154.659	5.00	2.26
156.030	3.879	-8.465	155.658	2.00	3.02
157.030	3.934	-8.466	156.656	357.00	3.45
158.030	3.999	-8.470	157.654	355.00	3.79
159.030	4.069	-8.482	158.652	347.00	4.35
160.030	4.144	-8.504	159.649	340.00	4.71
161.030	4.222	-8.538	160.645	334.00	5.01
162.030	4.300	-8.581	161.641	327.00	5.10
163.030	4.372	-8.632	162.637	324.00	5.10
164.030	4.440	-8.688	163.633	317.00	5.01
165.030	4.503	-8.749	164.629	311.00	4.82
166.030	4.546	-8.817	165.626	302.00	4.65
167.030	4.599	-8.888	166.622	304.00	5.03

Borehole: 02-05 Logged section 196-169m
Depth range: 0.000 - 194.370m Extrapolated from 169 to 0 meters

	Deviation components				
Depth	North	East	Down	Devaz	Dev
m	m	m	m	deg	deg
1.020	0.024	-0.004	1.020	351.00	1.36
2.020	0.047	-0.007	2.019	351.00	1.36
3.020	0.071	-0.011	3.019	351.00	1.36
4.020	0.094	-0.015	4.019	351.00	1.36
5.020	0.118	-0.019	5.019	351.00	1.36
6.020	0.141	-0.022	6.018	351.00	1.36
7.020	0.165	-0.026	7.018	351.00	1.36
8.020	0.188	-0.030	8.018	351.00	1.36
9.020	0.211	-0.033	9.017	351.00	1.36
10.020	0.235	-0.037	10.017	351.00	1.36
11.020	0.258	-0.041	11.017	351.00	1.36
12.020	0.282	-0.045	12.017	351.00	1.36
13.020	0.305	-0.048	13.016	351.00	1.36
14.020	0.329	-0.052	14.016	351.00	1.36
15.020	0.352	-0.056	15.016	351.00	1.36
16.020	0.376	-0.059	16.015	351.00	1.36
17.020	0.399	-0.063	17.015	351.00	1.36
18.020	0.422	-0.067	18.015	351.00	1.36
19.020	0.446	-0.071	19.015	351.00	1.36
20.020	0.469	-0.074	20.014	351.00	1.36
21.020	0.493	-0.078	21.014	351.00	1.36
22.020	0.516	-0.082	22.014	351.00	1.36
23.020	0.540	-0.085	23.014	351.00	1.36
24.020	0.563	-0.089	24.013	351.00	1.36
25.020	0.587	-0.093	25.013	351.00	1.36
26.020	0.610	-0.097	26.013	351.00	1.36
27.020	0.633	-0.100	27.012	351.00	1.36
28.020	0.657	-0.104	28.012	351.00	1.36
29.020	0.680	-0.108	29.012	351.00	1.36
30.020	0.704	-0.111	30.012	351.00	1.36
31.020	0.727	-0.115	31.011	351.00	1.36
32.020	0.751	-0.119	32.011	351.00	1.36
33.020	0.774	-0.123	33.011	351.00	1.36
34.020	0.797	-0.126	34.010	351.00	1.36
35.020	0.821	-0.130	35.010	351.00	1.36
36.020	0.844	-0.134	36.010	351.00	1.36
37.020	0.868	-0.137	37.010	351.00	1.36
38.020	0.891	-0.141	38.009	351.00	1.36
39.020	0.915	-0.145	39.009	351.00	1.36
40.020	0.938	-0.149	40.009	351.00	1.36
41.020	0.962	-0.152	41.008	351.00	1.36
42.020	0.985	-0.156	42.008	351.00	1.36
43.020	1.008	-0.160	43.008	351.00	1.36
44.020	1.032	-0.163	44.008	351.00	1.36
45.020	1.055	-0.167	45.007	351.00	1.36
46.020	1.079	-0.171	46.007	351.00	1.36
47.020	1.102	-0.175	47.007	351.00	1.36
48.020	1.126	-0.178	48.006	351.00	1.36
49.020	1.149	-0.182	49.006	351.00	1.36
50.020	1.173	-0.186	50.006	351.00	1.36
51.020	1.196	-0.189	51.006	351.00	1.36
52.020	1.219	-0.193	52.005	351.00	1.36

53.020	1.243	-0.197	53.005	351.00	1.36
54.020	1.266	-0.201	54.005	351.00	1.36
55.020	1.290	-0.204	55.005	351.00	1.36
56.020	1.313	-0.208	56.004	351.00	1.36
57.020	1.337	-0.212	57.004	351.00	1.36
58.020	1.360	-0.215	58.004	351.00	1.36
59.020	1.384	-0.219	59.003	351.00	1.36
60.020	1.407	-0.223	60.003	351.00	1.36
61.020	1.430	-0.227	61.003	351.00	1.36
62.020	1.454	-0.230	62.003	351.00	1.36
63.020	1.477	-0.234	63.002	351.00	1.36
64.020	1.501	-0.238	64.002	351.00	1.36
65.020	1.524	-0.241	65.002	351.00	1.36
66.020	1.548	-0.245	66.001	351.00	1.36
67.020	1.571	-0.249	67.001	351.00	1.36
68.020	1.595	-0.253	68.001	351.00	1.36
69.020	1.618	-0.256	69.001	351.00	1.36
70.020	1.641	-0.260	70.000	351.00	1.36
71.020	1.665	-0.264	71.000	351.00	1.36
72.020	1.688	-0.267	72.000	351.00	1.36
73.020	1.712	-0.271	72.999	351.00	1.36
74.020	1.735	-0.275	73.999	351.00	1.36
75.020	1.759	-0.279	74.999	351.00	1.36
76.020	1.782	-0.282	75.999	351.00	1.36
77.020	1.806	-0.286	76.998	351.00	1.36
78.020	1.829	-0.290	77.998	351.00	1.36
79.020	1.852	-0.293	78.998	351.00	1.36
80.020	1.876	-0.297	79.997	351.00	1.36
81.020	1.899	-0.301	80.997	351.00	1.36
82.020	1.923	-0.305	81.997	351.00	1.36
83.020	1.946	-0.308	82.997	351.00	1.36
84.020	1.970	-0.312	83.996	351.00	1.36
85.020	1.993	-0.316	84.996	351.00	1.36
86.020	2.016	-0.319	85.996	351.00	1.36
87.020	2.040	-0.323	86.995	351.00	1.36
88.020	2.063	-0.327	87.995	351.00	1.36
89.020	2.087	-0.331	88.995	351.00	1.36
90.020	2.110	-0.334	89.995	351.00	1.36
91.020	2.134	-0.338	90.994	351.00	1.36
92.020	2.157	-0.342	91.994	351.00	1.36
93.020	2.181	-0.345	92.994	351.00	1.36
94.020	2.204	-0.349	93.994	351.00	1.36
95.020	2.227	-0.353	94.993	351.00	1.36
96.020	2.251	-0.357	95.993	351.00	1.36
97.020	2.274	-0.360	96.993	351.00	1.36
98.020	2.298	-0.364	97.992	351.00	1.36
99.020	2.321	-0.368	98.992	351.00	1.36
100.020	2.345	-0.371	99.992	351.00	1.36
101.020	2.368	-0.375	100.992	351.00	1.36
102.020	2.392	-0.379	101.991	351.00	1.36
103.020	2.415	-0.382	102.991	351.00	1.36
104.020	2.438	-0.386	103.991	351.00	1.36
105.020	2.462	-0.390	104.990	351.00	1.36
106.020	2.485	-0.394	105.990	351.00	1.36
107.020	2.509	-0.397	106.990	351.00	1.36
108.020	2.532	-0.401	107.990	351.00	1.36
109.020	2.556	-0.405	108.989	351.00	1.36
110.020	2.579	-0.408	109.989	351.00	1.36
111.020	2.603	-0.412	110.989	351.00	1.36

112.020	2.626	-0.416	111.988	351.00	1.36
113.020	2.649	-0.420	112.988	351.00	1.36
114.020	2.673	-0.423	113.988	351.00	1.36
115.020	2.696	-0.427	114.988	351.00	1.36
116.020	2.720	-0.431	115.987	351.00	1.36
117.020	2.743	-0.434	116.987	351.00	1.36
118.020	2.767	-0.438	117.987	351.00	1.36
119.020	2.790	-0.442	118.986	351.00	1.36
120.020	2.814	-0.446	119.986	351.00	1.36
121.020	2.837	-0.449	120.986	351.00	1.36
122.020	2.860	-0.453	121.986	351.00	1.36
123.020	2.884	-0.457	122.985	351.00	1.36
124.020	2.907	-0.460	123.985	351.00	1.36
125.020	2.931	-0.464	124.985	351.00	1.36
126.020	2.954	-0.468	125.985	351.00	1.36
127.020	2.978	-0.472	126.984	351.00	1.36
128.020	3.001	-0.475	127.984	351.00	1.36
129.020	3.024	-0.479	128.984	351.00	1.36
130.020	3.048	-0.483	129.983	351.00	1.36
131.020	3.071	-0.486	130.983	351.00	1.36
132.020	3.095	-0.490	131.983	351.00	1.36
133.020	3.118	-0.494	132.983	351.00	1.36
134.020	3.142	-0.498	133.982	351.00	1.36
135.020	3.165	-0.501	134.982	351.00	1.36
136.020	3.189	-0.505	135.982	351.00	1.36
137.020	3.212	-0.509	136.981	351.00	1.36
138.020	3.235	-0.512	137.981	351.00	1.36
139.020	3.259	-0.516	138.981	351.00	1.36
140.020	3.282	-0.520	139.981	351.00	1.36
141.020	3.306	-0.524	140.980	351.00	1.36
142.020	3.329	-0.527	141.980	351.00	1.36
143.020	3.353	-0.531	142.980	351.00	1.36
144.020	3.376	-0.535	143.979	351.00	1.36
145.020	3.400	-0.538	144.979	351.00	1.36
146.020	3.423	-0.542	145.979	351.00	1.36
147.020	3.446	-0.546	146.979	351.00	1.36
148.020	3.470	-0.550	147.978	351.00	1.36
149.020	3.493	-0.553	148.978	351.00	1.36
150.020	3.517	-0.557	149.978	351.00	1.36
151.020	3.540	-0.561	150.977	351.00	1.36
152.020	3.564	-0.564	151.977	351.00	1.36
153.020	3.587	-0.568	152.977	351.00	1.36
154.020	3.611	-0.572	153.977	351.00	1.36
155.020	3.634	-0.576	154.976	351.00	1.36
156.020	3.657	-0.579	155.976	351.00	1.36
157.020	3.681	-0.583	156.976	351.00	1.36
158.020	3.704	-0.587	157.975	351.00	1.36
159.020	3.728	-0.590	158.975	351.00	1.36
160.020	3.751	-0.594	159.975	351.00	1.36
161.020	3.775	-0.598	160.975	351.00	1.36
162.020	3.798	-0.602	161.974	351.00	1.36
163.020	3.822	-0.605	162.974	351.00	1.36
164.020	3.845	-0.609	163.974	351.00	1.36
165.020	3.868	-0.613	164.974	351.00	1.36
166.020	3.892	-0.616	165.973	351.00	1.36
167.020	3.915	-0.620	166.973	351.00	1.36
168.020	3.939	-0.624	167.973	351.00	1.36
169.020	3.962	-0.628	168.972	351.00	1.36
170.020	3.986	-0.631	169.972	351.00	1.36

171.020	4.013	-0.635	170.972	350.00	1.94
172.020	4.056	-0.642	171.971	352.00	2.75
173.020	4.105	-0.649	172.970	354.00	3.04
174.020	4.151	-0.656	173.968	349.00	2.66
175.020	4.196	-0.665	174.967	347.00	3.12
176.020	4.270	-0.679	175.965	354.00	5.03
177.020	4.353	-0.696	176.961	348.00	4.78
178.020	4.439	-0.717	177.957	343.00	5.25
179.020	4.527	-0.748	178.953	339.00	5.12
180.020	4.613	-0.780	179.948	340.00	5.42
181.020	4.703	-0.813	180.944	337.00	5.49
182.020	4.791	-0.854	181.939	335.00	5.59
183.020	4.882	-0.900	182.934	332.00	6.08
184.020	4.978	-0.953	183.928	330.00	6.49
185.020	5.079	-1.012	184.921	329.00	6.72
186.020	5.178	-1.072	185.914	329.00	6.66
187.020	5.281	-1.131	186.907	329.00	6.77
188.020	5.383	-1.193	187.900	326.00	6.99
189.020	5.484	-1.265	188.892	324.00	7.14
190.020	5.582	-1.341	189.884	321.00	7.18
191.020	5.681	-1.421	190.876	320.00	7.35
192.020	5.778	-1.505	191.868	318.00	7.28
193.020	5.871	-1.592	192.860	316.00	7.33
194.020	5.962	-1.682	193.852	315.00	7.43

Appendix B

BOREHOLE 02-06
IMAGE LOG PLOTS
DISCONTINUITY AND DEVIATION TABLES

NORCAL GEOPHYSICAL CONSULTANTS, INC.

OPTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED OPTV DIPS LOG

13 Aug 2002

EARTH MECHANICS

Borehole: BH 02-06

DEVIL'S SLIDE

top of borehole.....
East:
North:
Alt: 0

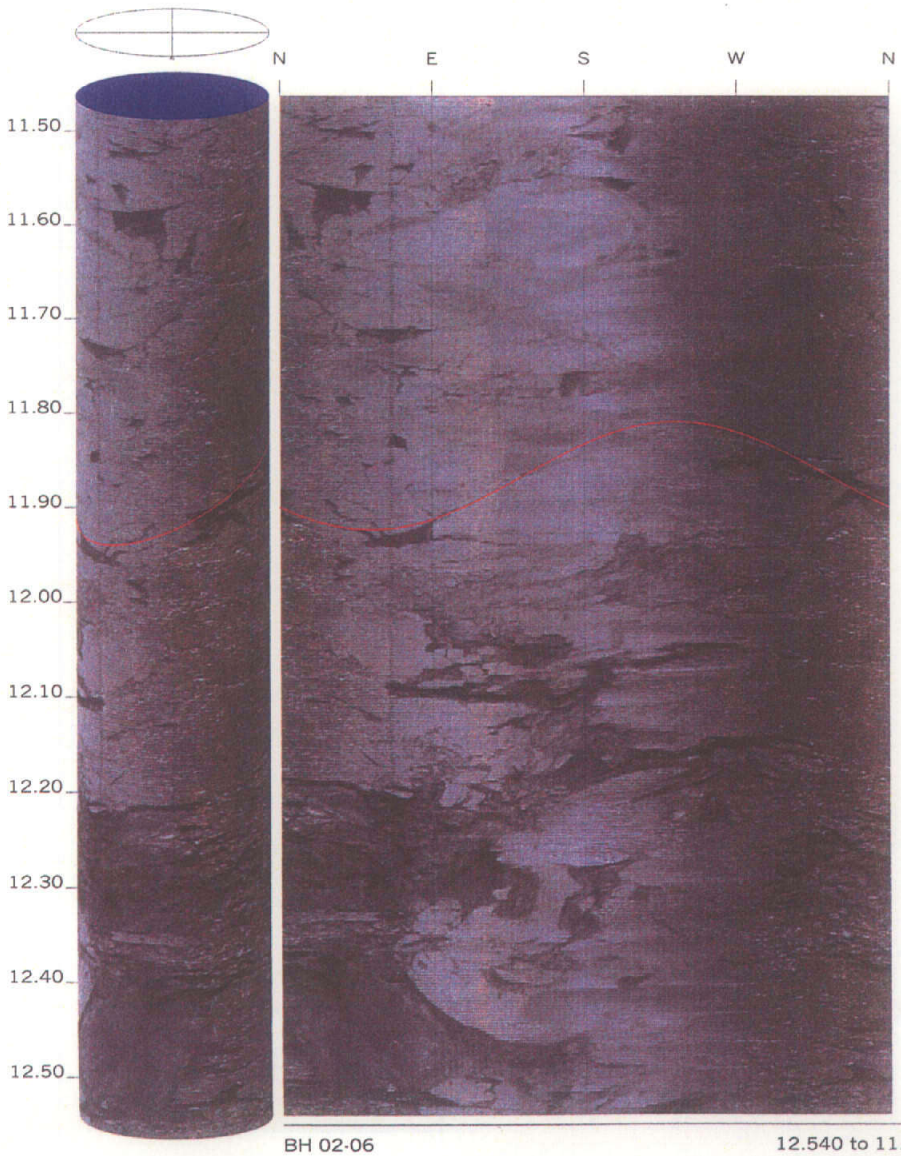
North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = fixed format

Zone from 67.294 to 11.463m
Vertical = borehole-axis

Borehole diam: 11.000cm

BEDDING
FRACTURE
Identified units

COMMENTS



N038 47 Fracture

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13.70
13.80
13.90
14.00
14.10
14.20
14.30
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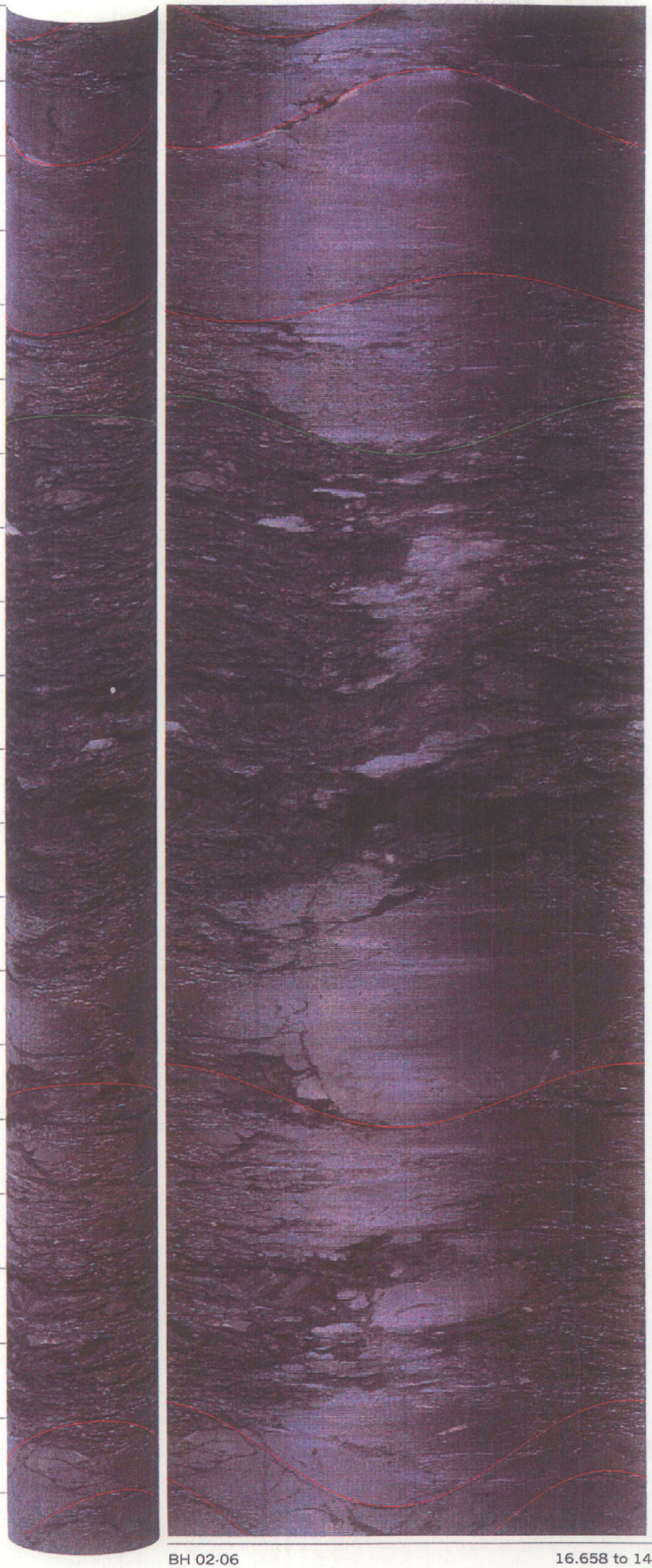
N011 55 Fracture
N211 40 Fracture Discontinuous
N030 57 Fracture
N045 53 Fracture
N068 34 Fracture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16.30
16.40
16.50
16.60
N010 52 Fracture Mineralized
N028 32 Fracture
N200 26 Primary-structure Sheared
vertical_fracture
N190 26 Fracture
N176 38 Fracture
N154 43 Fracture

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16.80
16.90
17.00
17.10
17.20
17.30
17.40
17.50
17.60
17.70
17.80
17.90
18.00
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18.20
18.30
18.40
18.50
18.60
18.70
N148 18 Bedding
N094 14 Bedding
N355 27 Bedding
N028 20 Fracture Discontinuous Sheared
N058 62 Fracture Discontinuous
N095 65 Fracture

18.80
18.90
19.00
19.10
19.20
19.30
19.40
19.50
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19.80
19.90
20.00
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20.40
20.50
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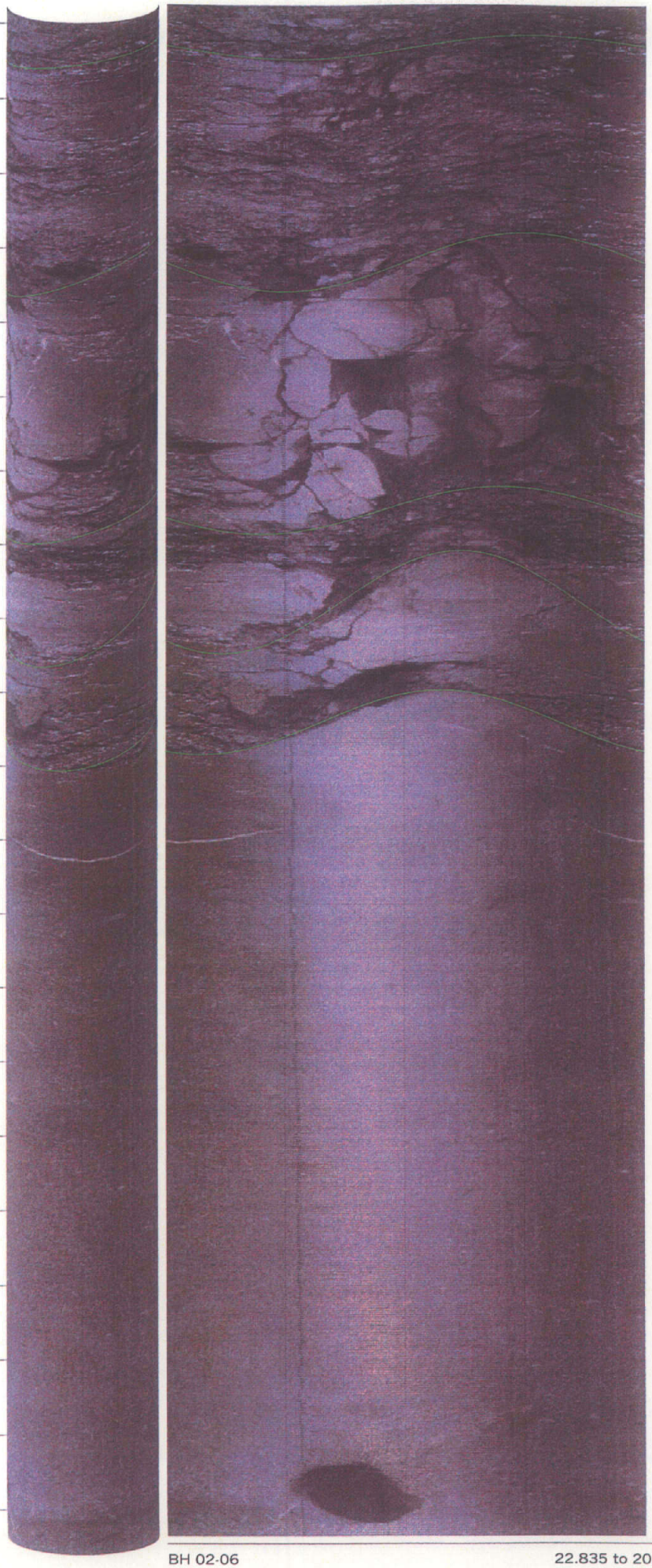
N159 29 Primary-structure
N063 65 Fracture
N001 51 Fracture
N239 84 Fracture
N229 38 Primary-structure Sheared
N015 28 Bedding
N241 27 Fracture Discontinuous
N156 49 Fracture Discontinuous
N024 28 Fracture Discontinuous
N087 24 Fracture Discontinuous
N355 17 Bedding
N019 20 Bedding
N023 19 Bedding
N019 13 Bedding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22.10
22.20
22.30
22.40
22.50
22.60
22.70
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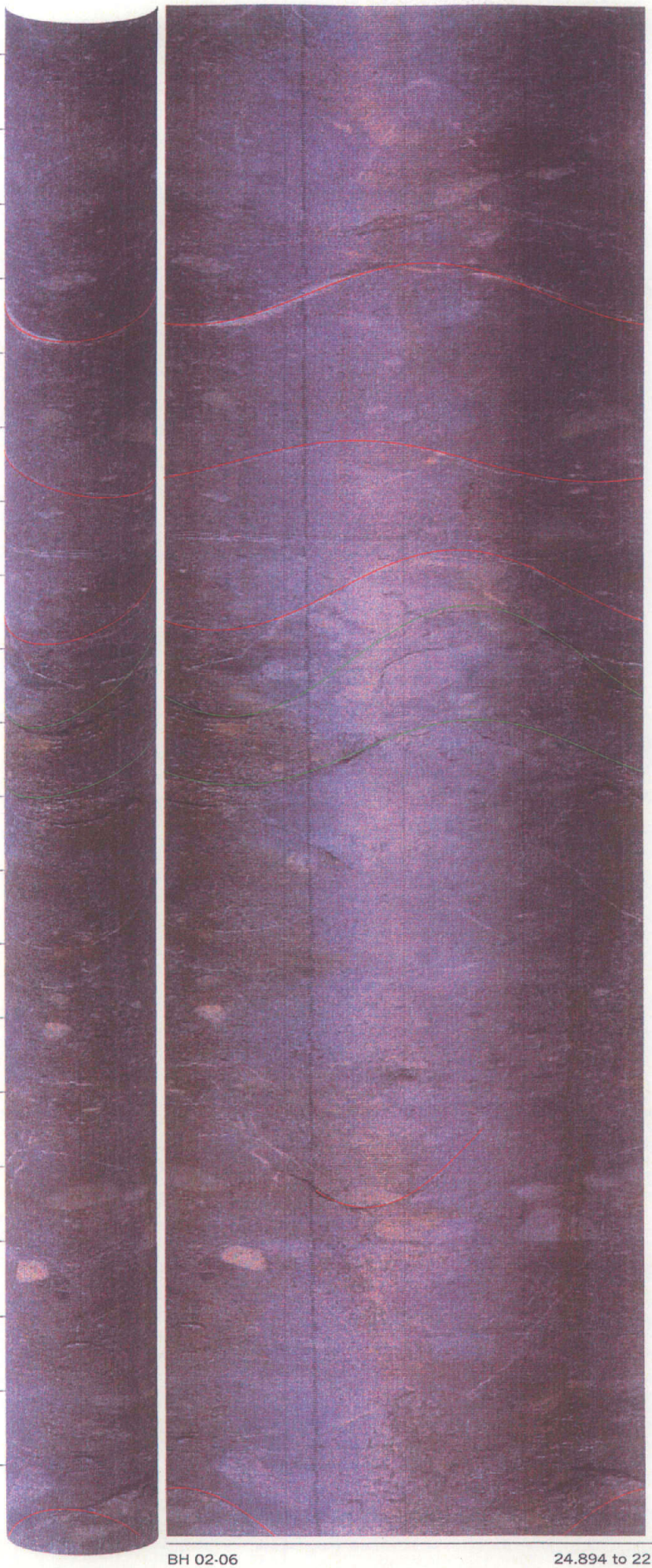
N067 28 Primary-structure Sheared
N044 28 Crushed Bedding
N030 55 Primary-structure Sheared
N012 46 Primary-structure Sheared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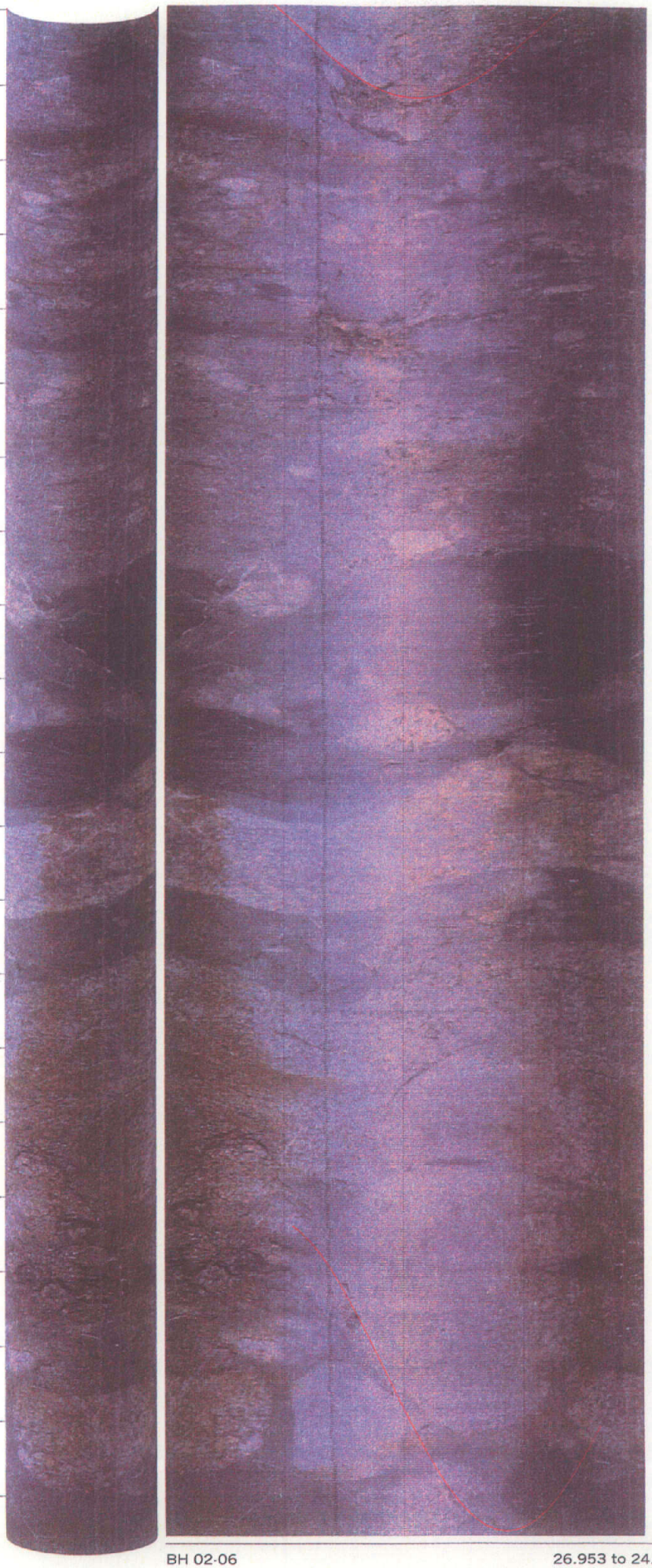
24.10
24.20
24.30
24.40
24.50
24.60
24.70
24.80
N004 46 Fracture Mineralized
N322 42 Fracture Mineralized
N026 49 Fracture Mineralized
N038 55 Primary-structure
N035 40 Primary-structure
N152 48 Fracture Discontinuous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25.80
25.90
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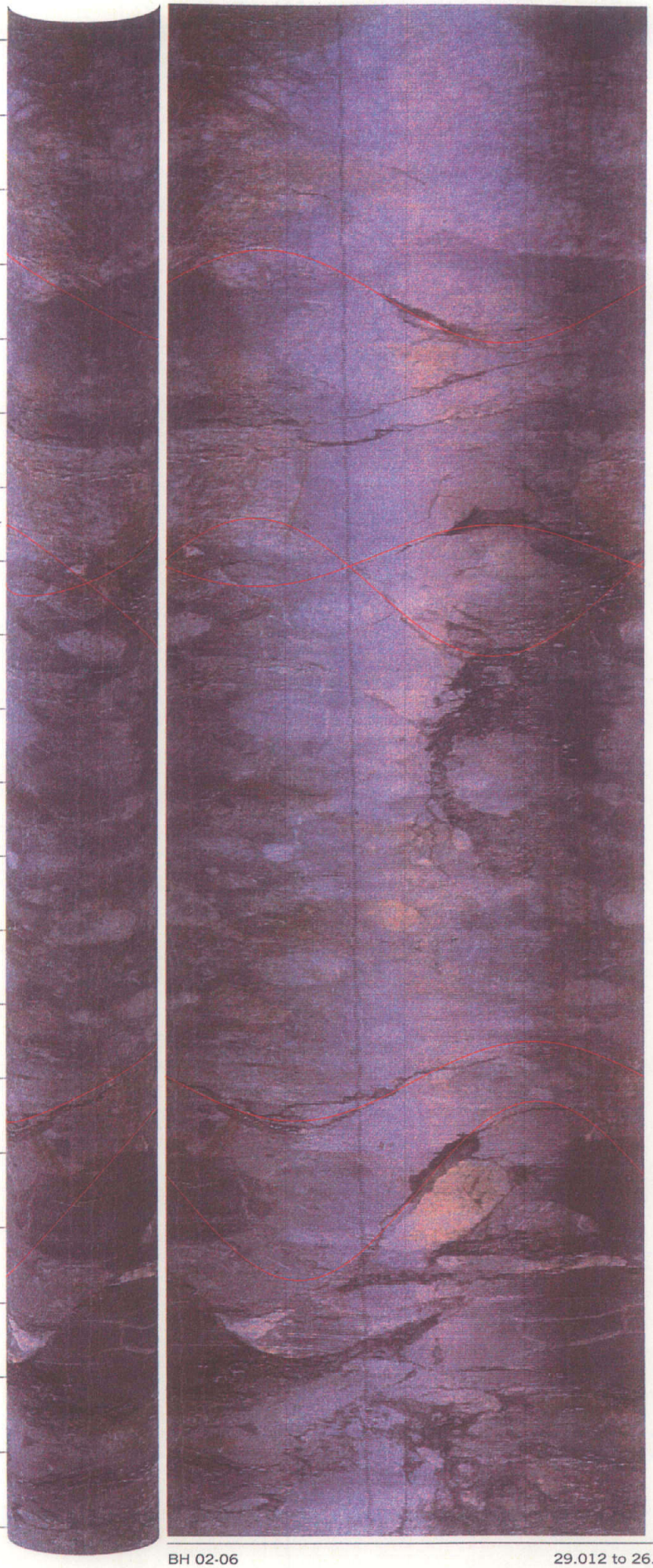
26.50
26.60
26.70
26.80
26.90
N198 51 Fracture Sheared
N259 83 Fracture Weathered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28.30
28.40
28.50
28.60
28.70
28.80
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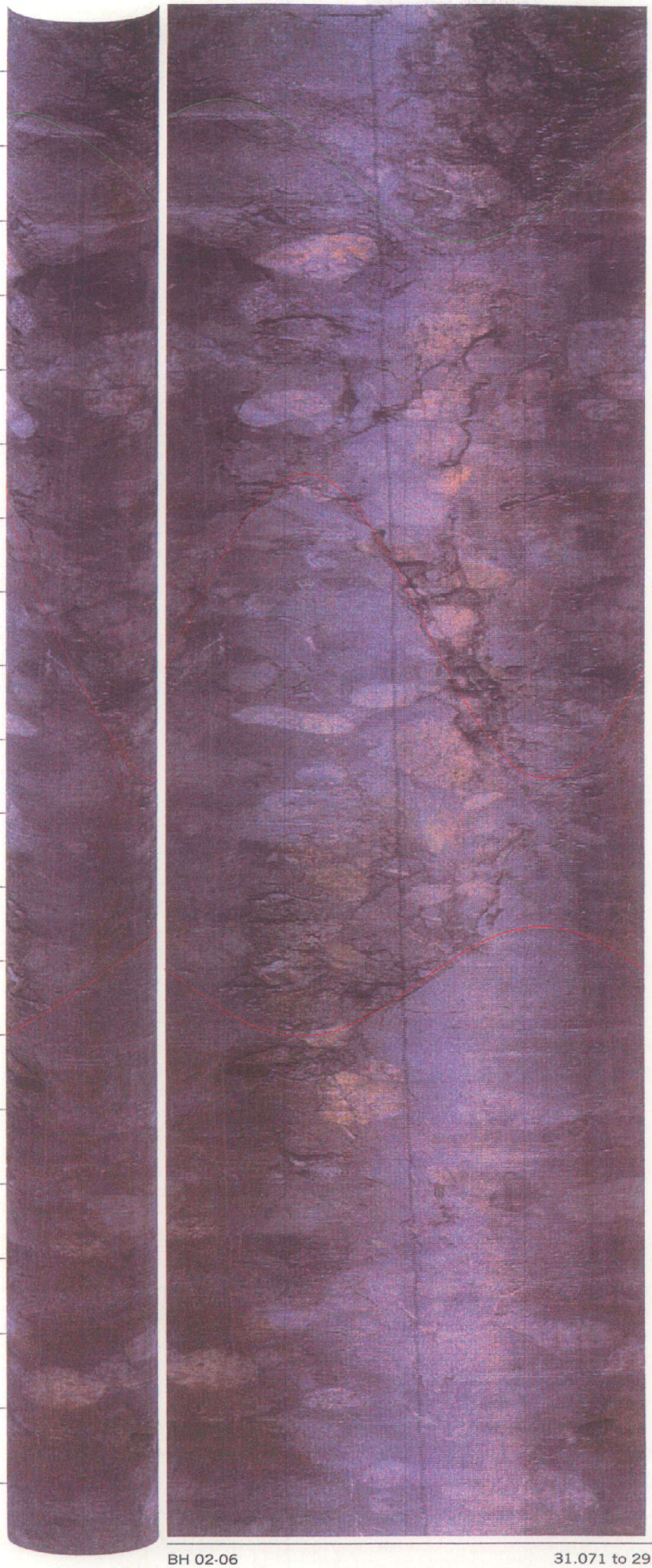
N047 35 Fracture Discontinuous
N253 64 Fracture Discontinuous
N083 35 Fracture Discontinuous
N093 55 Fracture Discontinuous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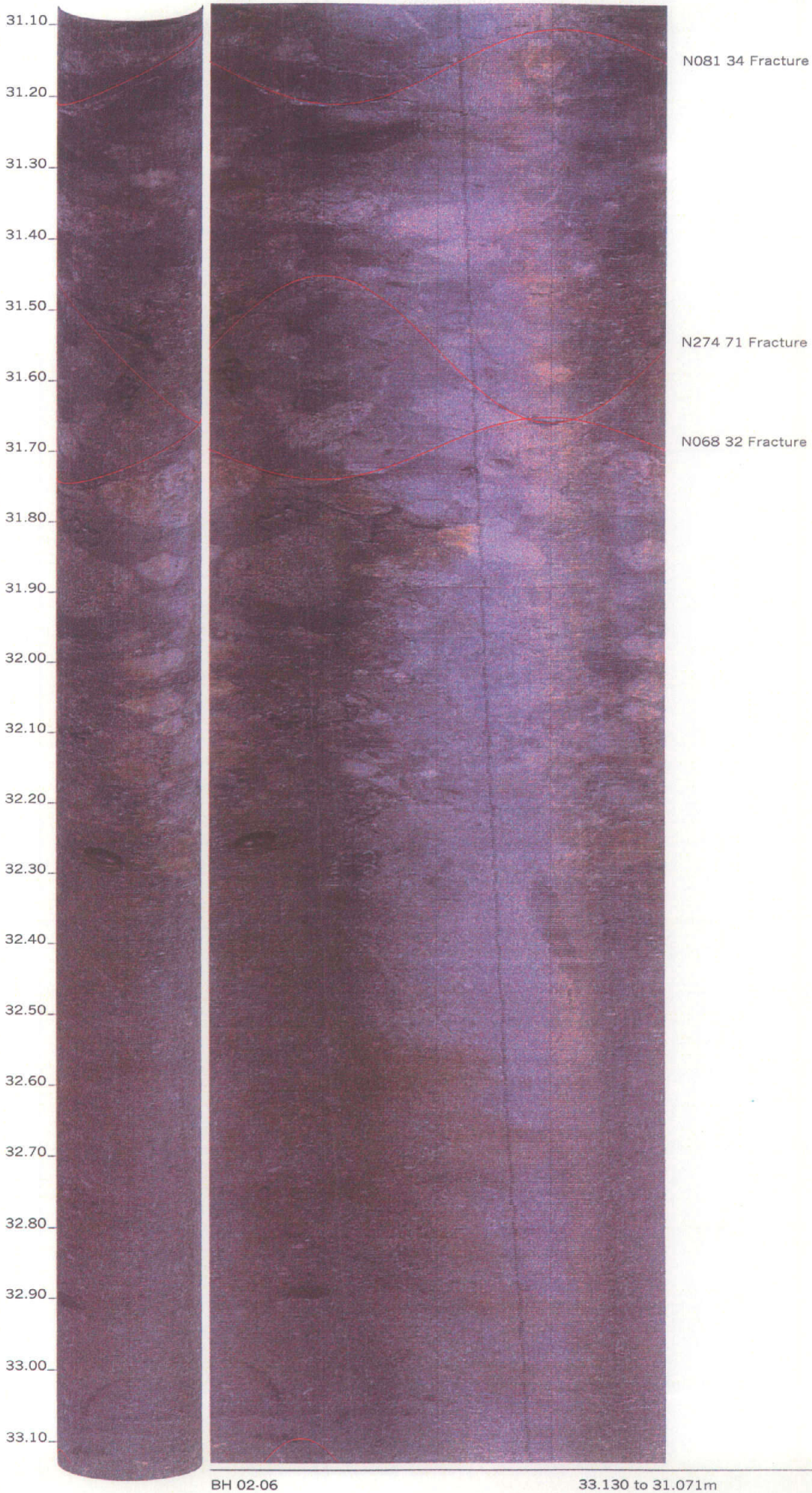
N286 87 Fracture Irregular
N092 43 Fracture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32.50
32.60
32.70
32.80
32.90
33.00
33.10
N081 34 Fracture
N274 71 Fracture
N068 32 Fracture

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34.50
34.60
34.70
34.80
34.90
35.00
35.10
N253 84 Fracture Discontinuous
vertical_fracture
N269 57 Fracture
N060 30 Fracture Discontinuous

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36.90
37.00
37.10
37.20
N218 52 Fracture

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37.60
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37.80
37.90
38.00
38.10
38.20
38.30
38.40
38.50
38.60
38.70
38.80
38.90
39.00
39.10
39.20
39.30
N080 39 Fracture
N076 39 Fracture
N051 88 Fracture Irregular
N040 36 Fracture
N021 49 Fracture
N010 48 Fracture
N026 38 Fracture

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39.60
39.70
39.80
39.90
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40.30
40.40
40.50
40.60
40.70
40.80
40.90
41.00
41.10
41.20
41.30
N066 44 Fracture
N050 26 Fracture Irregular
N049 62 Fracture Irregular
N139 36 Fracture

41.40
41.50
41.60
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41.80
41.90
42.00
42.10
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42.30
42.40
42.50
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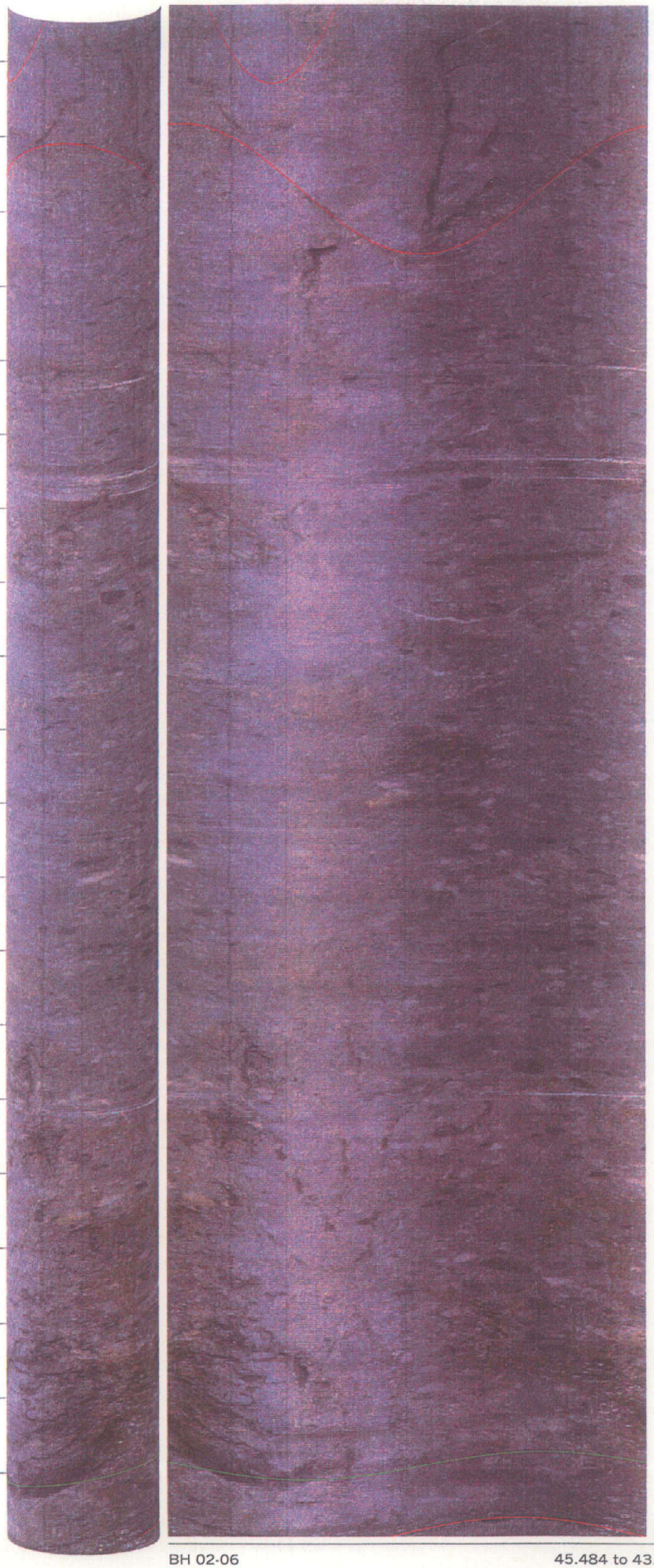
N241 82 Fracture
N074 73 Fracture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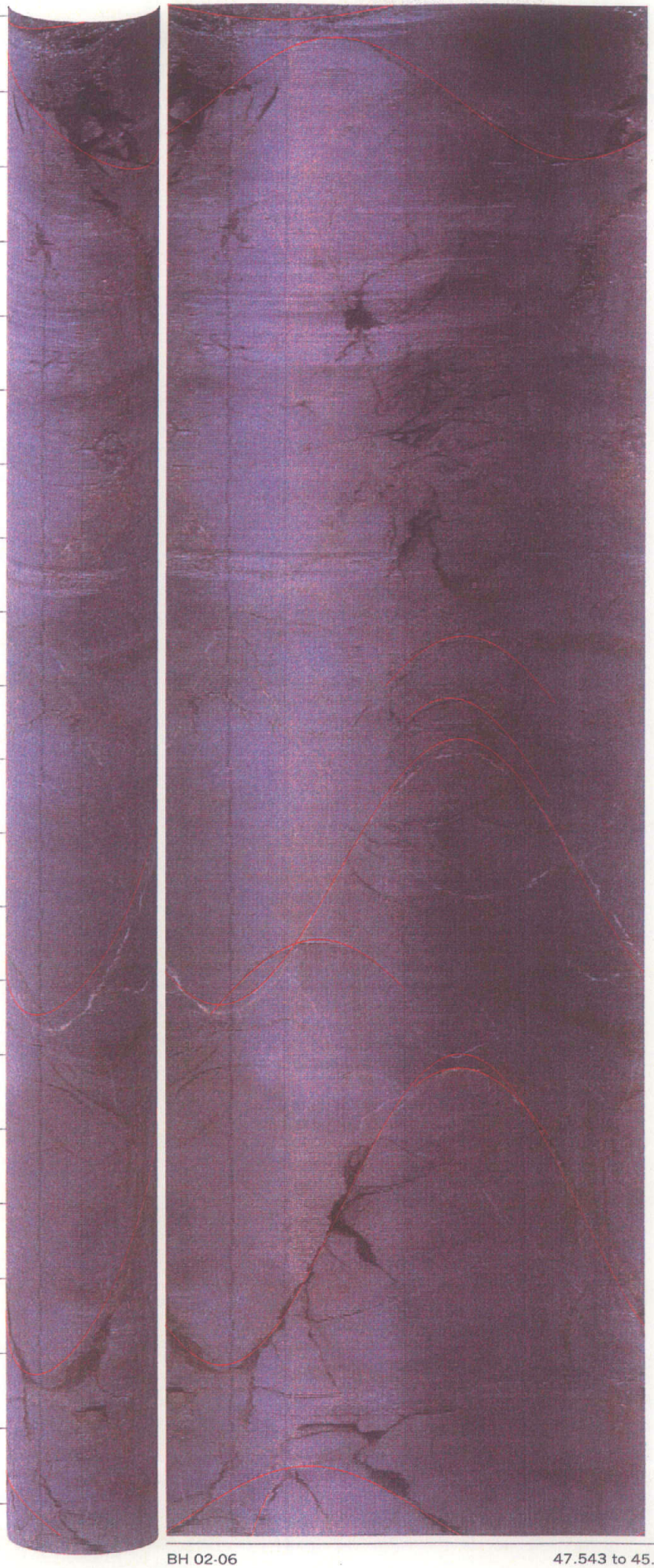
N043 19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47.00
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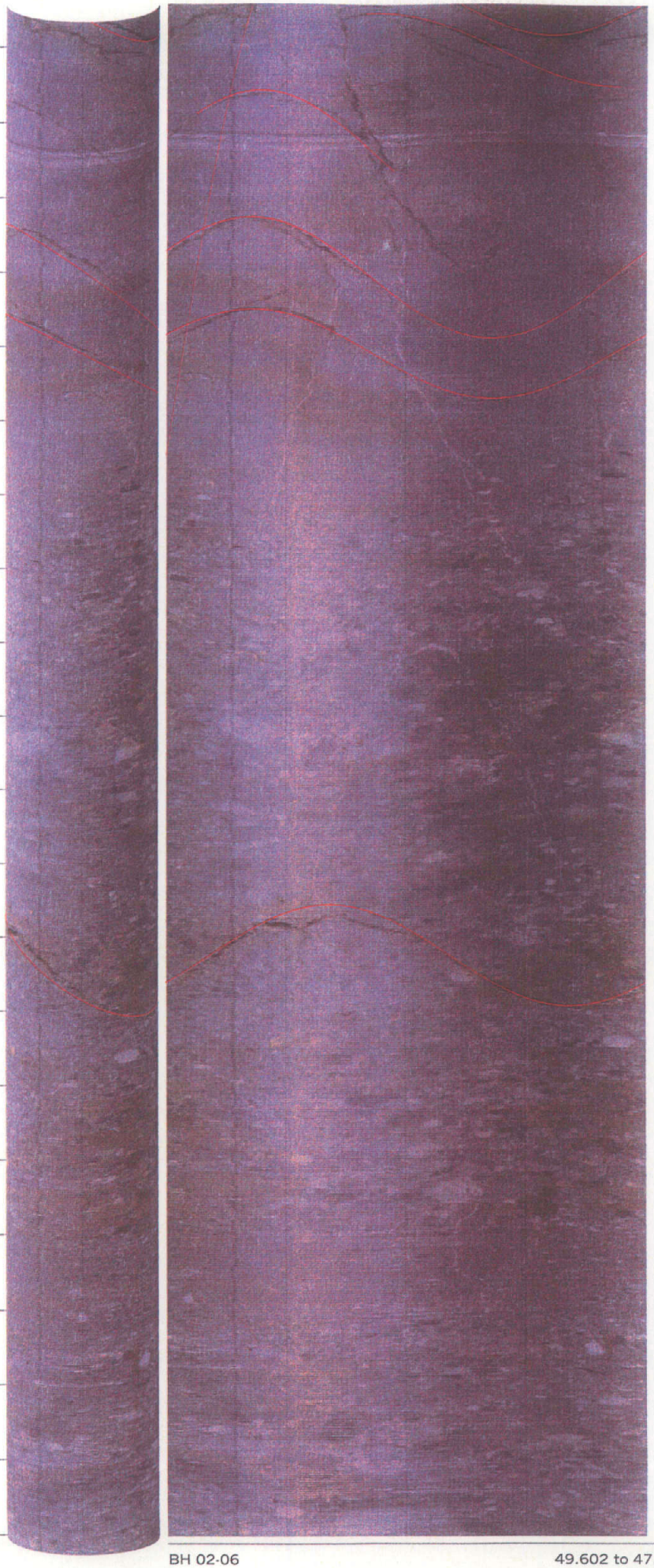
N308 71 Fracture Irregular
N037 71 Fracture Discontinuous
N029 78 Fracture Discontinuous
N036 76 Fracture Mineralized
N297 79 Fracture Discontinuous
N035 73 Fracture Discontinuous
N038 78 Fracture
N292 63 Fracture Discontinuous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48.90
49.00
49.10
49.20
49.30
49.40
49.50
49.60
N334 56 Fracture Discontinuous
N257 65 Fracture Discontinuous
N252 61 Fracture
N256 53 Fracture
N093 84 Fracture Discontinuous
N305 65 Fracture

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50.80
50.90
51.00
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51.50
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N289 82 Fracture Discontinuous
N280 78 Fracture Discontinuous
N264 75 Fracture Discontinuous
N260 59 Fracture Discontinuous
N284 88 Fracture Discontinuous
N258 54 Fracture Discontinuous

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52.70
52.80
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53.00
53.10
53.20
53.30
53.40
53.50
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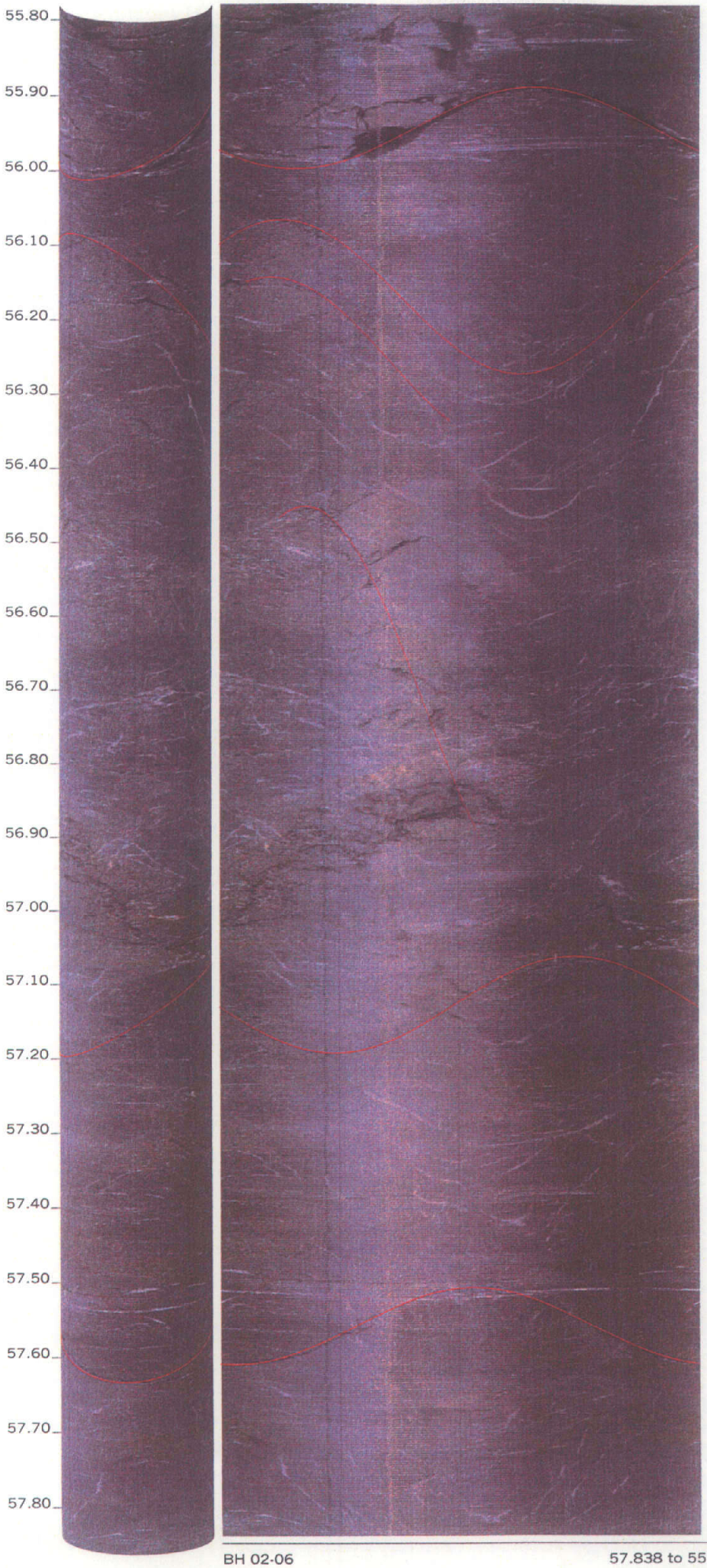
53.70
vertical_fracture
N040 69 Fracture Discontinuous
N338 71 Fracture Discontinuous
N263 58 Fracture Discontinuous

BH 02-06 55.779 to 53.720m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57.00
57.10
57.20
57.30
57.40
57.50
57.60
57.70
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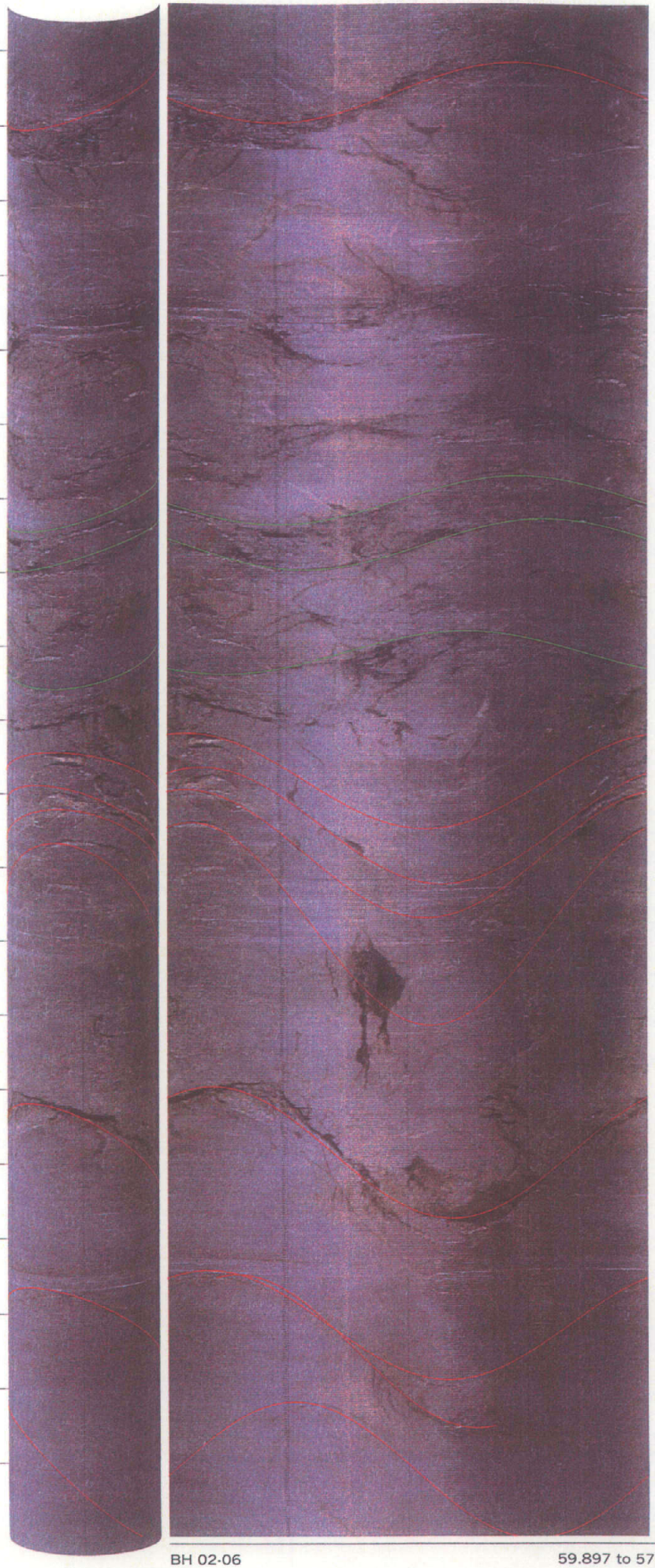
N234 62 Fracture Discontinuous
N226 62 Fracture Discontinuous
N246 82 Fracture Discontinuous
N073 42 Fracture
N000 54 Fracture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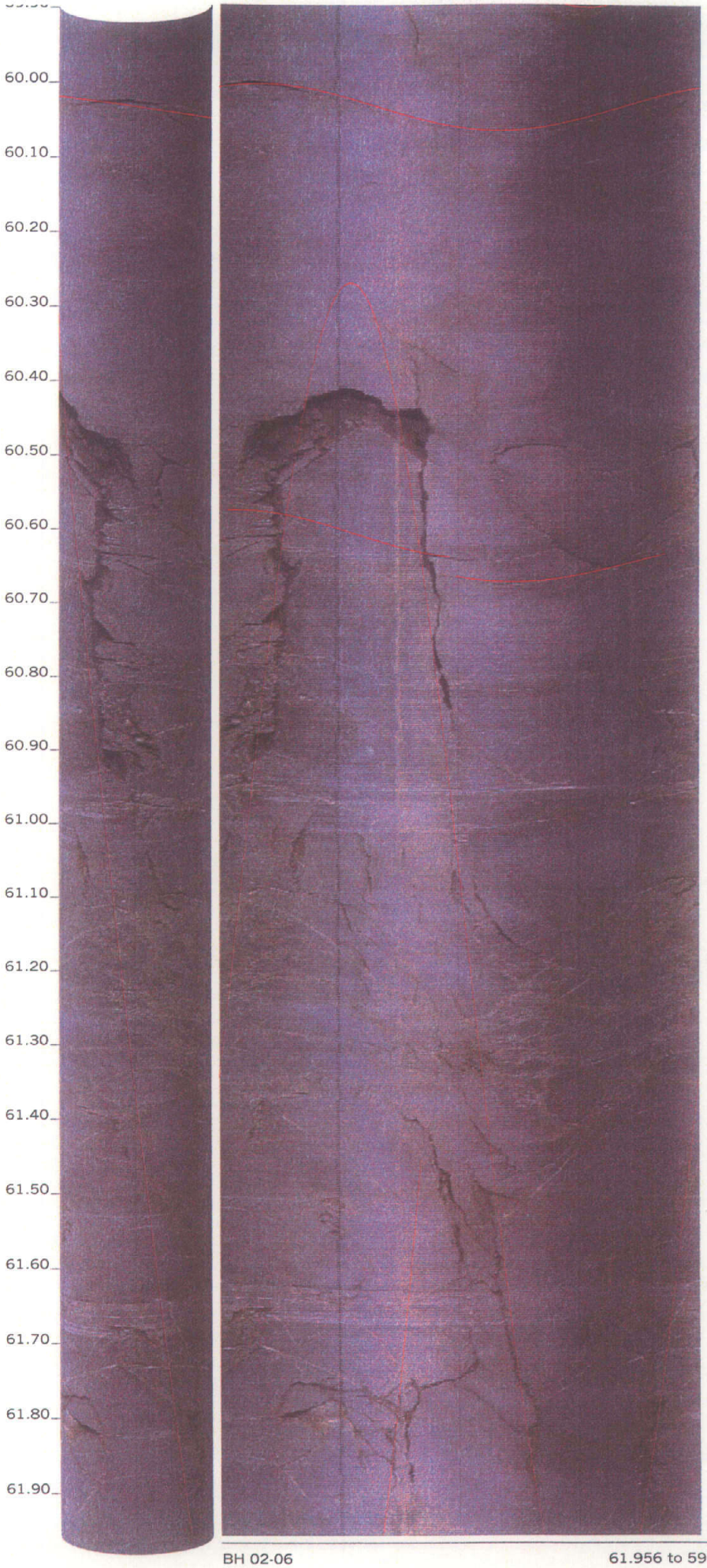
59.30
59.40
59.50
59.60
59.70
59.80
N058 31 Sheared
N056 26 Bedding
N080 22 Bedding
N019 33 Bedding
N206 42 Hairline-fracture
N216 50 Hairline-fracture
N202 50 Hairline-fracture
N203 61 Discontinuous Hairline-fracture
N223 55 Fracture open
N222 50 Fracture Discontinuous
N239 63 Fracture Discontinuous
N279 69 Fracture Discontinuous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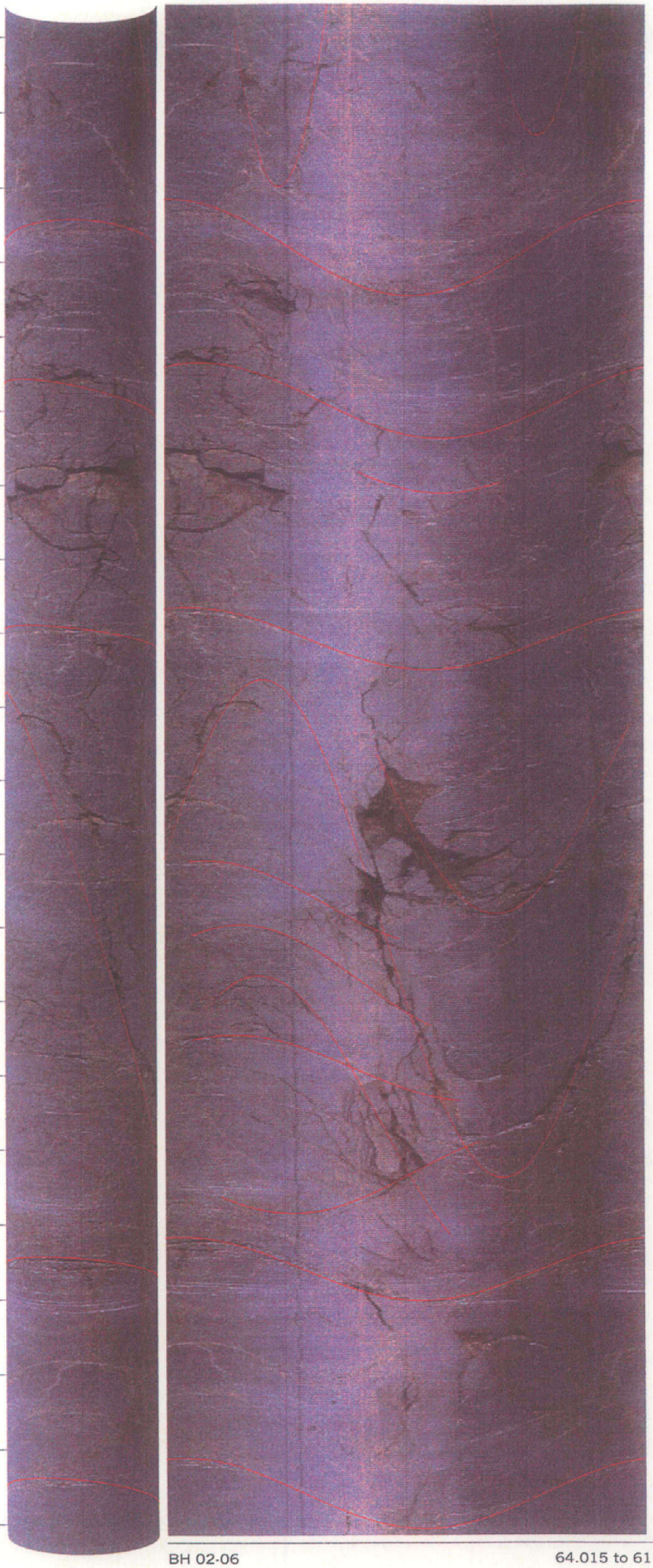
N218 24 Fracture Discontinuous
N250 27 Fracture Discontinuous
N084 80 Fracture Discontinuous
N098 82 Fracture Irregular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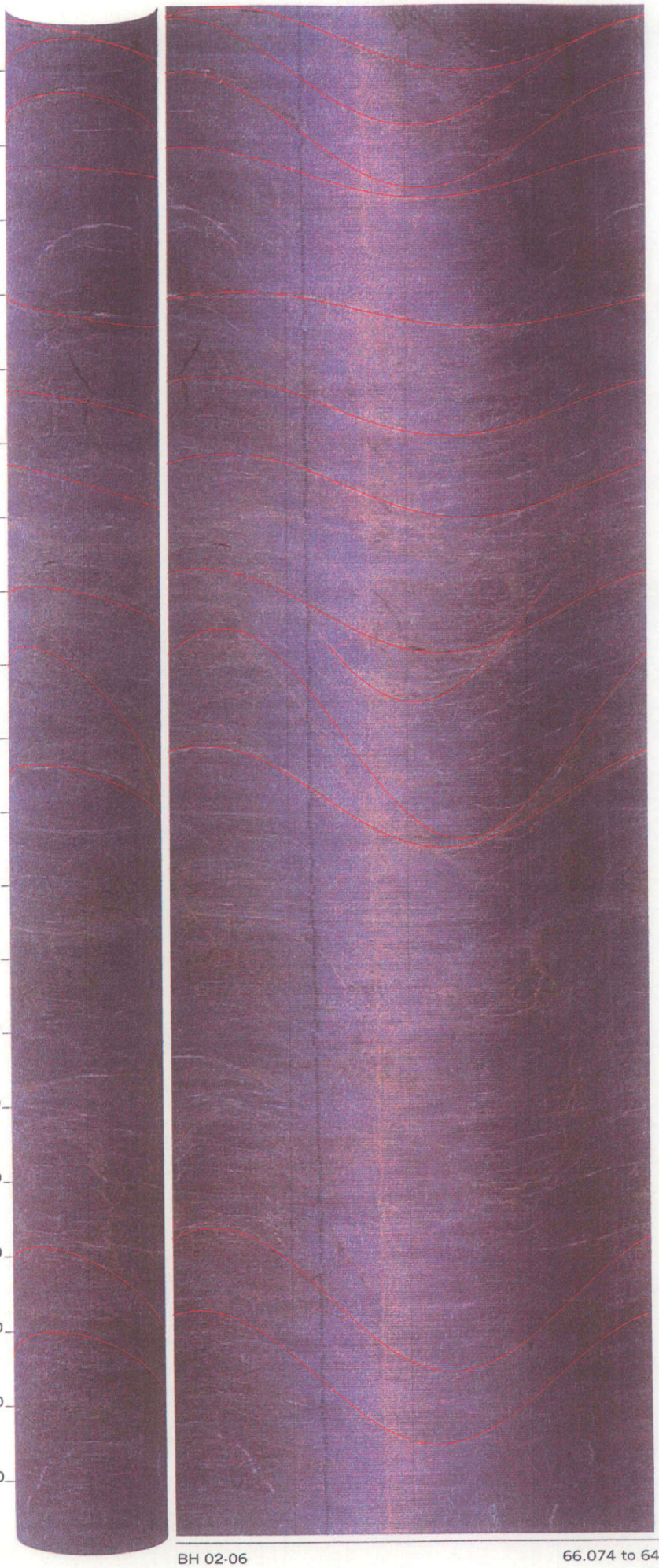
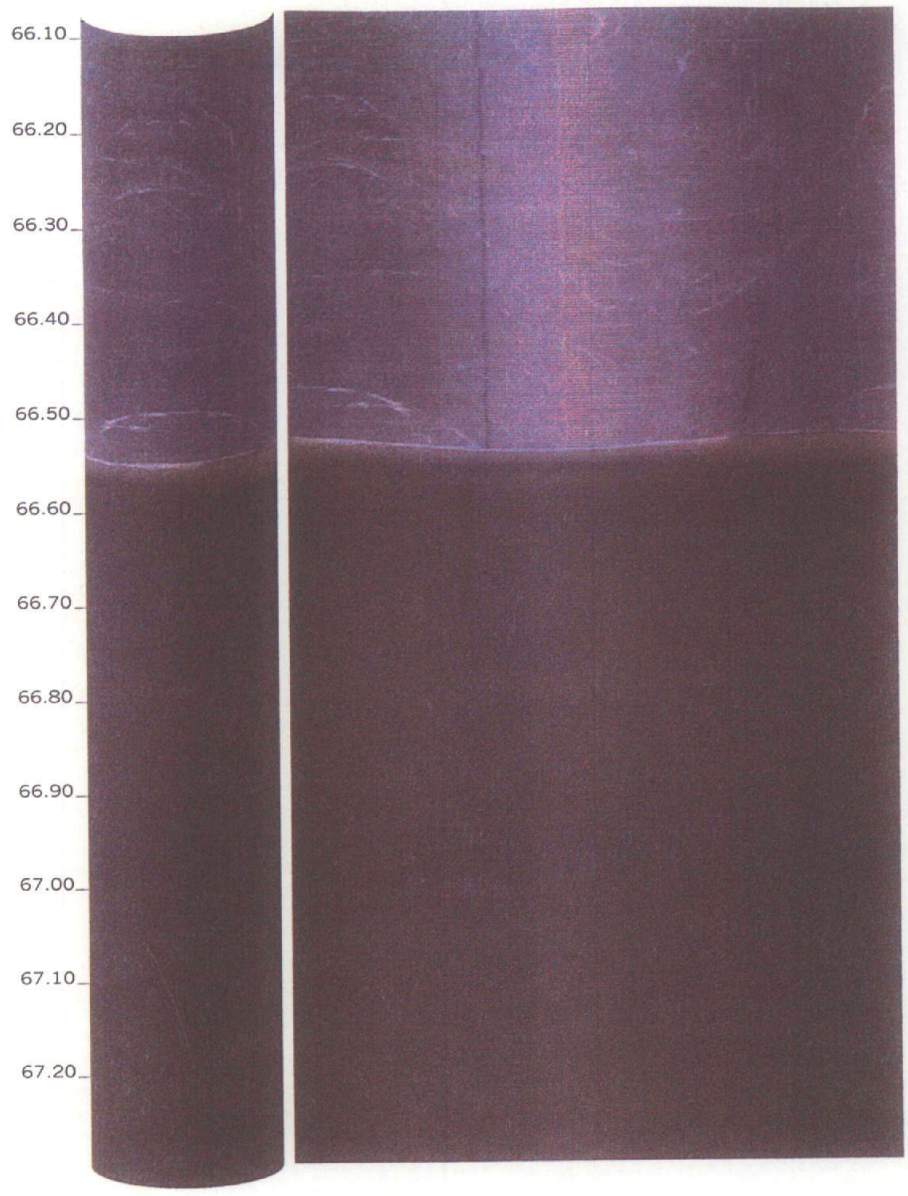
63.30
63.40
63.50
63.60
63.70
63.80
63.90
64.00
N195 40 Fracture
N222 39 Hairline-fracture
N223 40 Hairline-fracture
N217 31 Fracture
N251 81 Fracture Discontinuous
N224 43 Fracture OFFSET
N254 87 Fracture Irregular
N246 57 Fracture Discontinuous
N248 41 Fracture Discontinuous
N253 79 Fracture Discontinuous
N082 36 Fracture Discontinuous
N210 31 Fracture
N210 33 Hairline-fracture



BH 02-06

66.074 to 64.015m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67.10
67.20

NORCAL GEOPHYSICAL CONSULTANTS, INC.

BHTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED BHTV DIPS LOG

13 Aug 2002

EARTH MECHANICS

Borehole: BH 02-06

DEVILS SLIDE

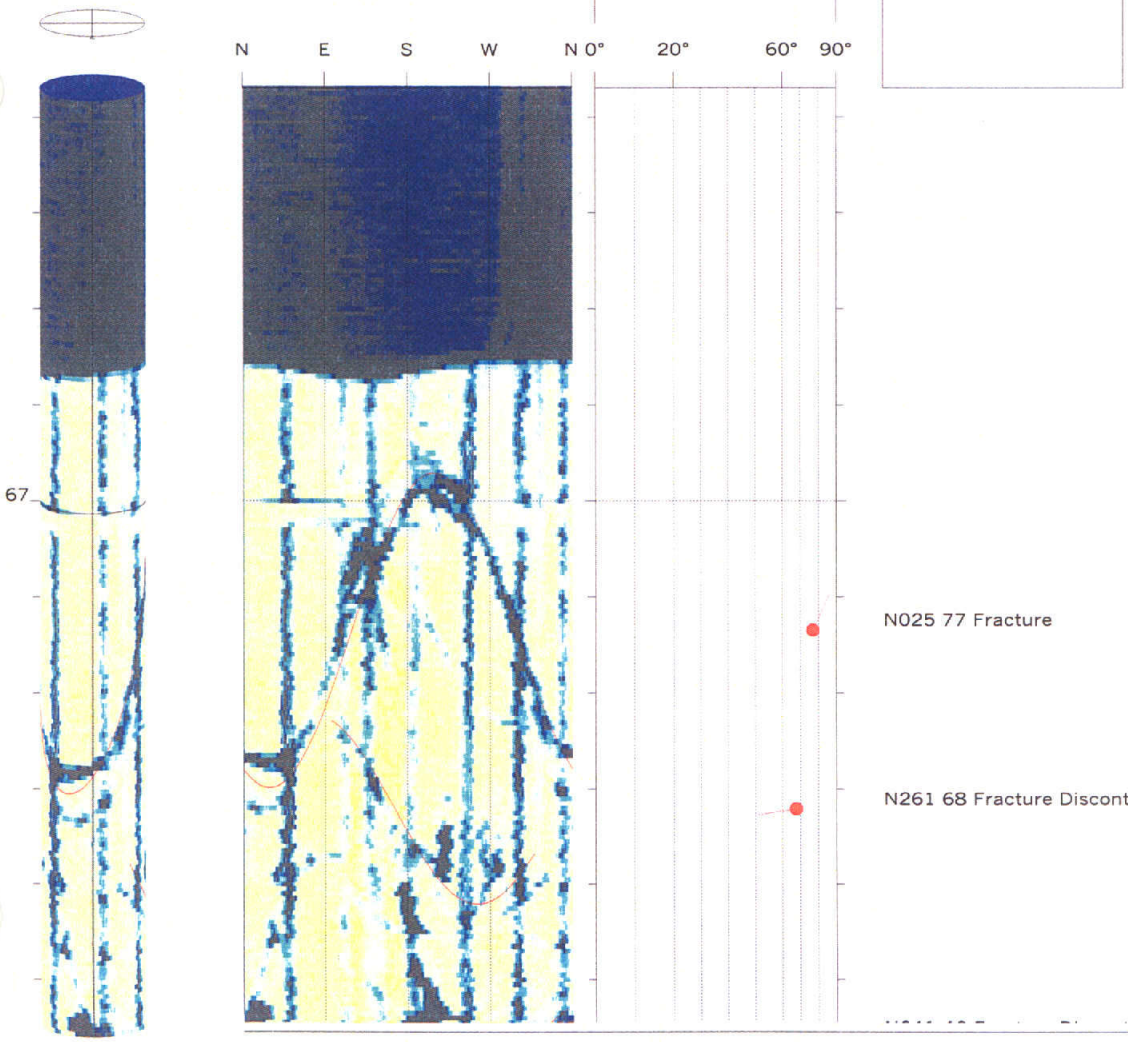
top of borehole.....
East:
North:
Alt:

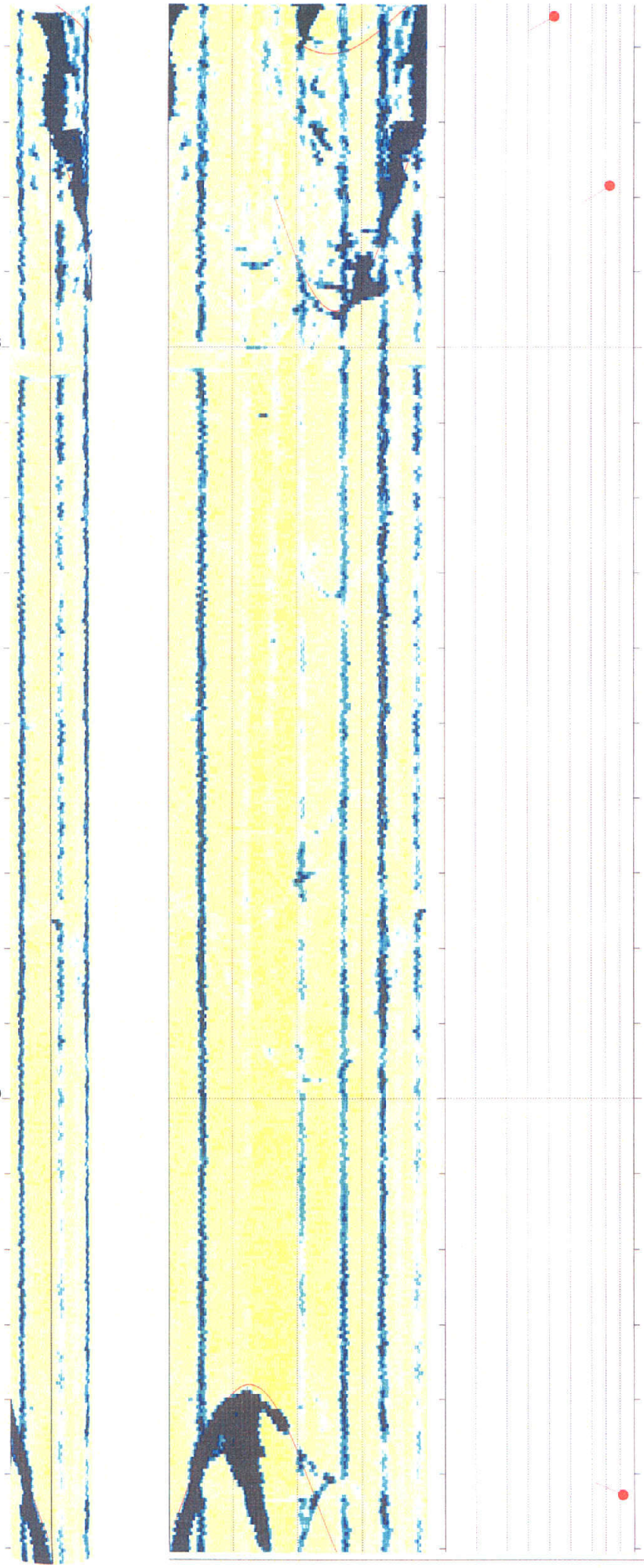
North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = vert scale

Zone from 139.210 to 66.570m

Borehole diam: 11.000cm
Vertical = borehole-axis
Amplitude

BEDDING
FRACTURE
Identified units

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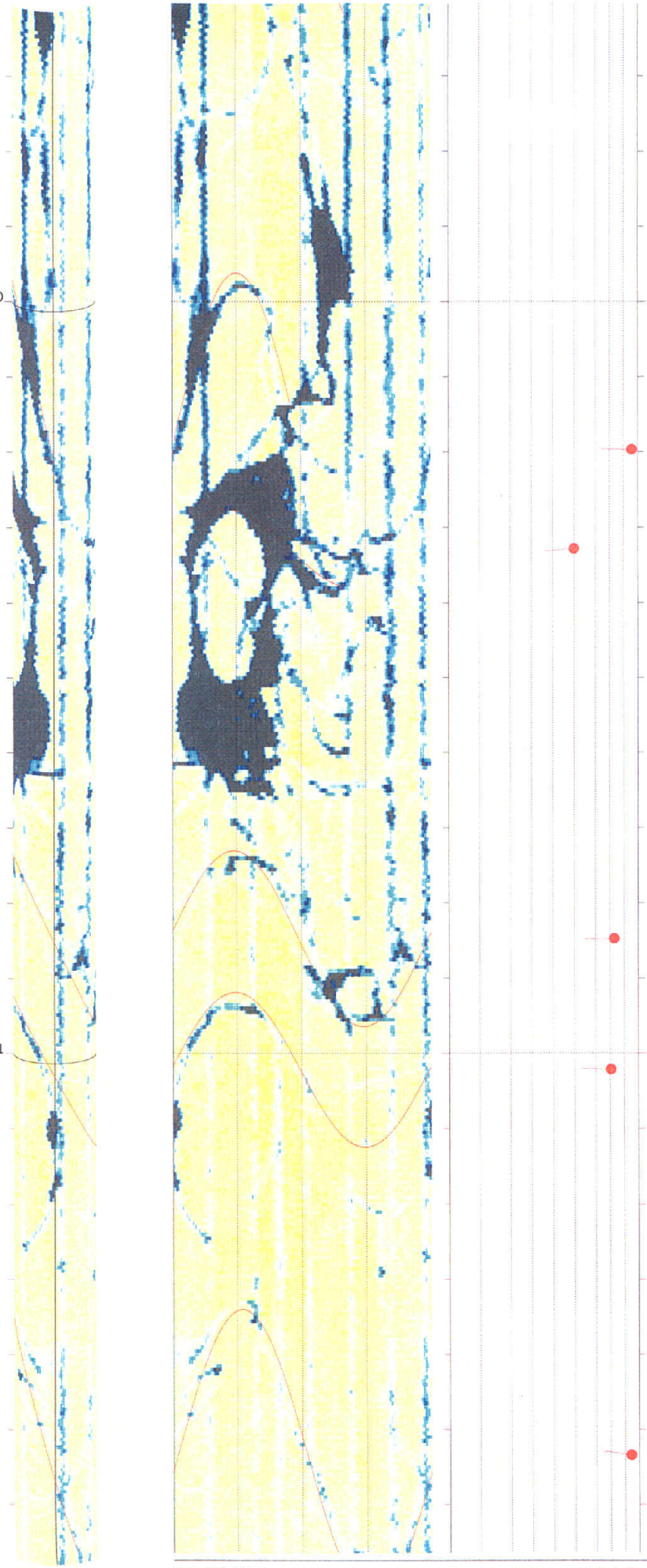
N238 73 Fracture Discontinuous
68
69
N294 82 Fracture Discontinuous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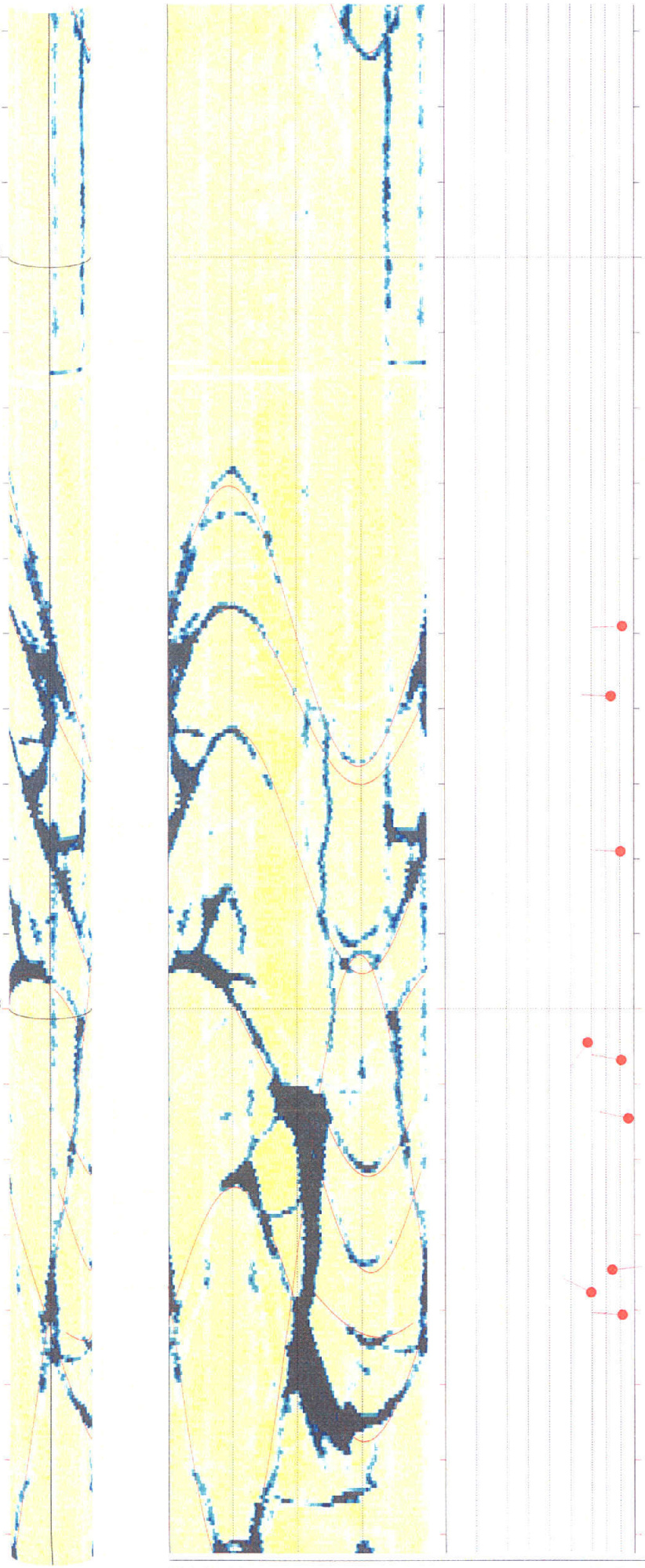
N265 50 Fracture Discontinuous
N269 73 Fracture
N272 71 Fracture
N278 84 Fracture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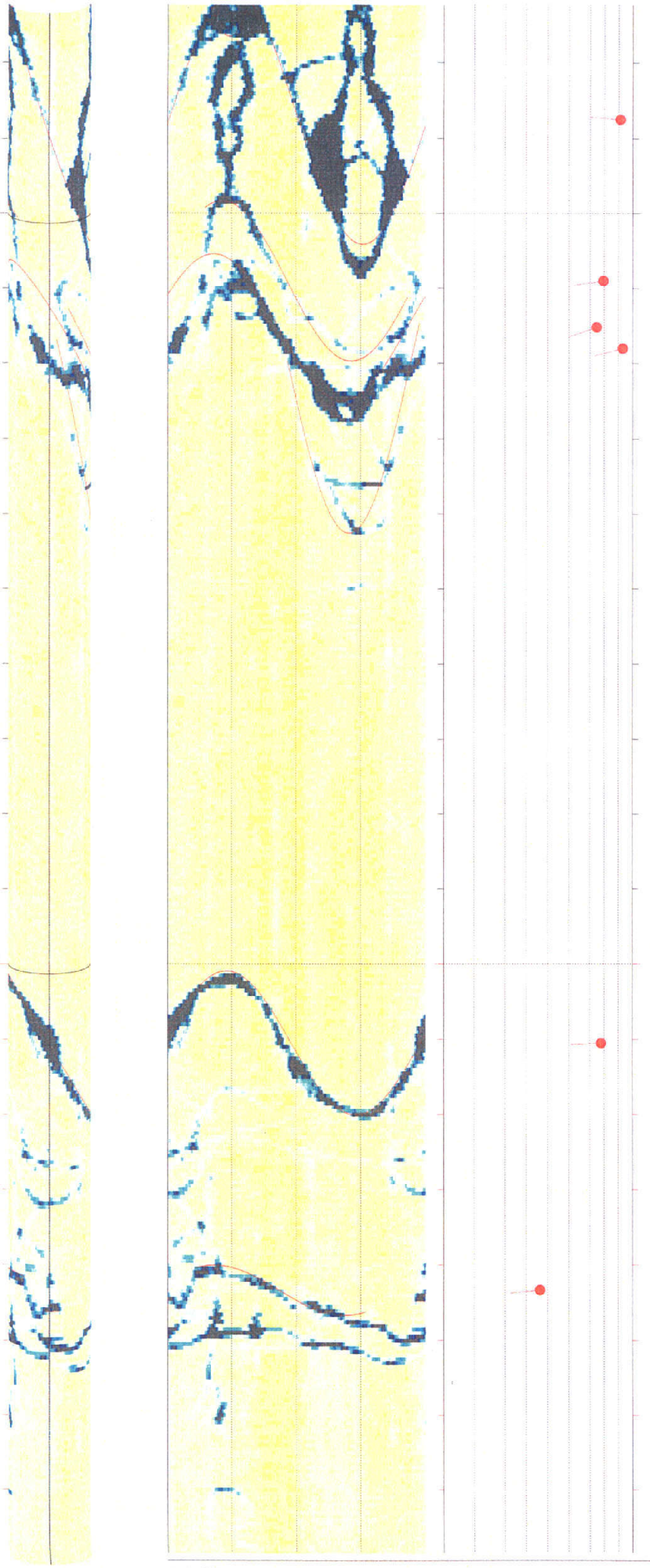
N268 82 Fracture
N272 74 Fracture
N273 81 Fracture
N216 58 Fracture segmented
N280 81 Fracture Discontinuous
N283 86 Fracture
N084 74 Fracture
N297 60 Fracture
N275 82 Fracture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N262 70 Fracture Discontinuous
N251 65 Fracture
N255 83 Fracture Discontinuous
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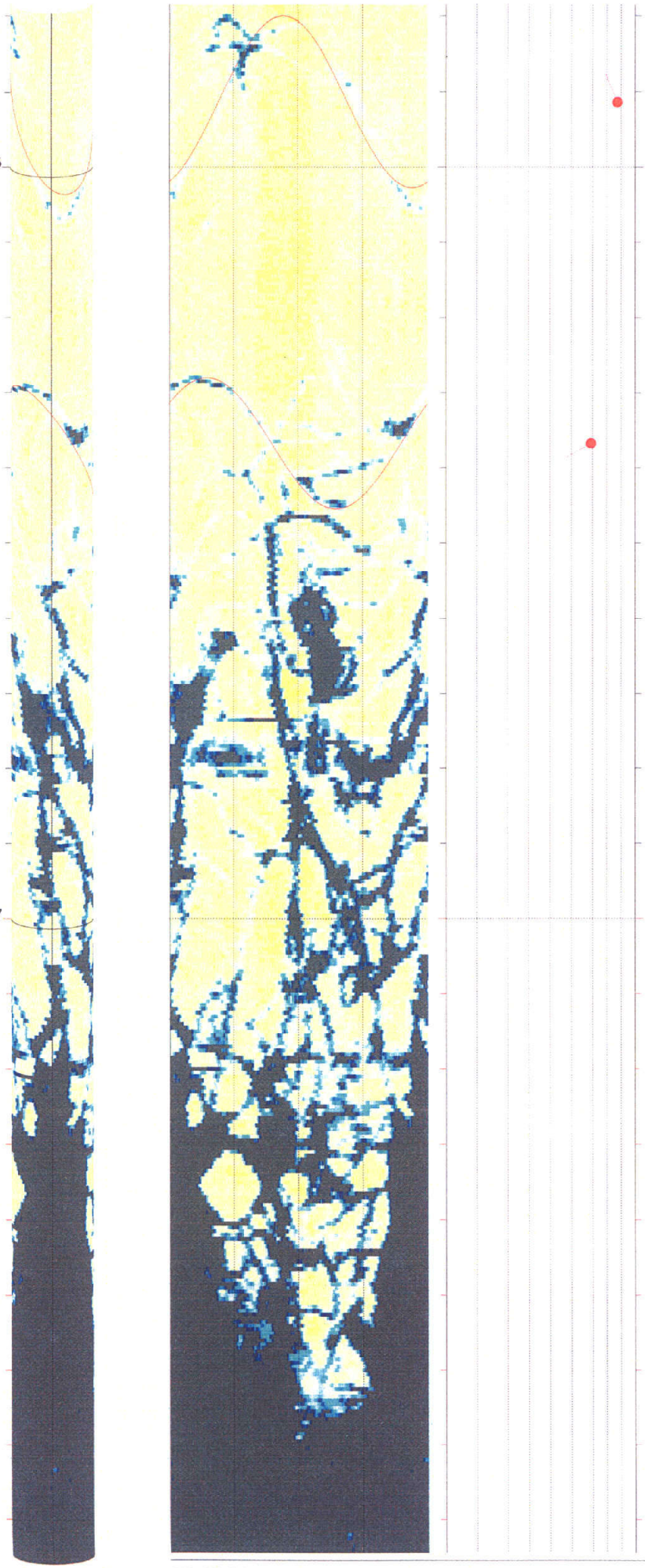
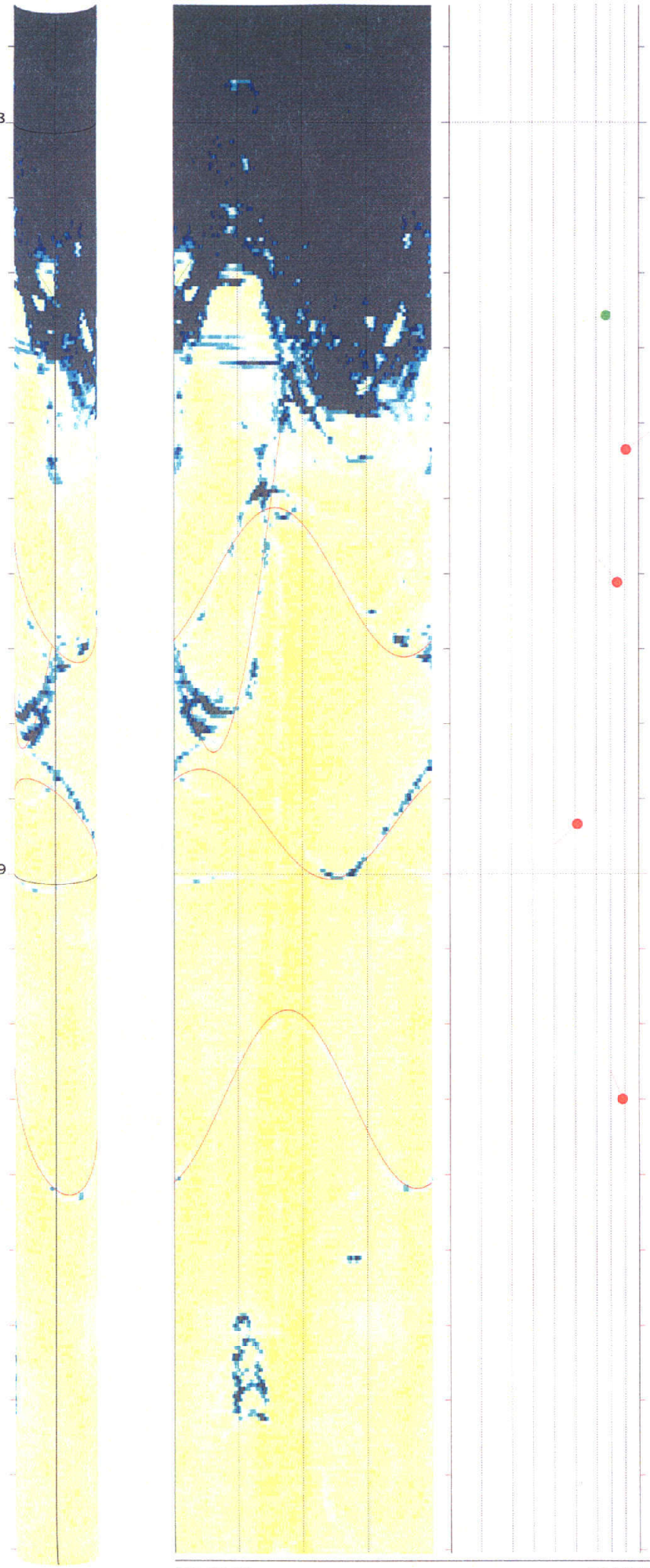
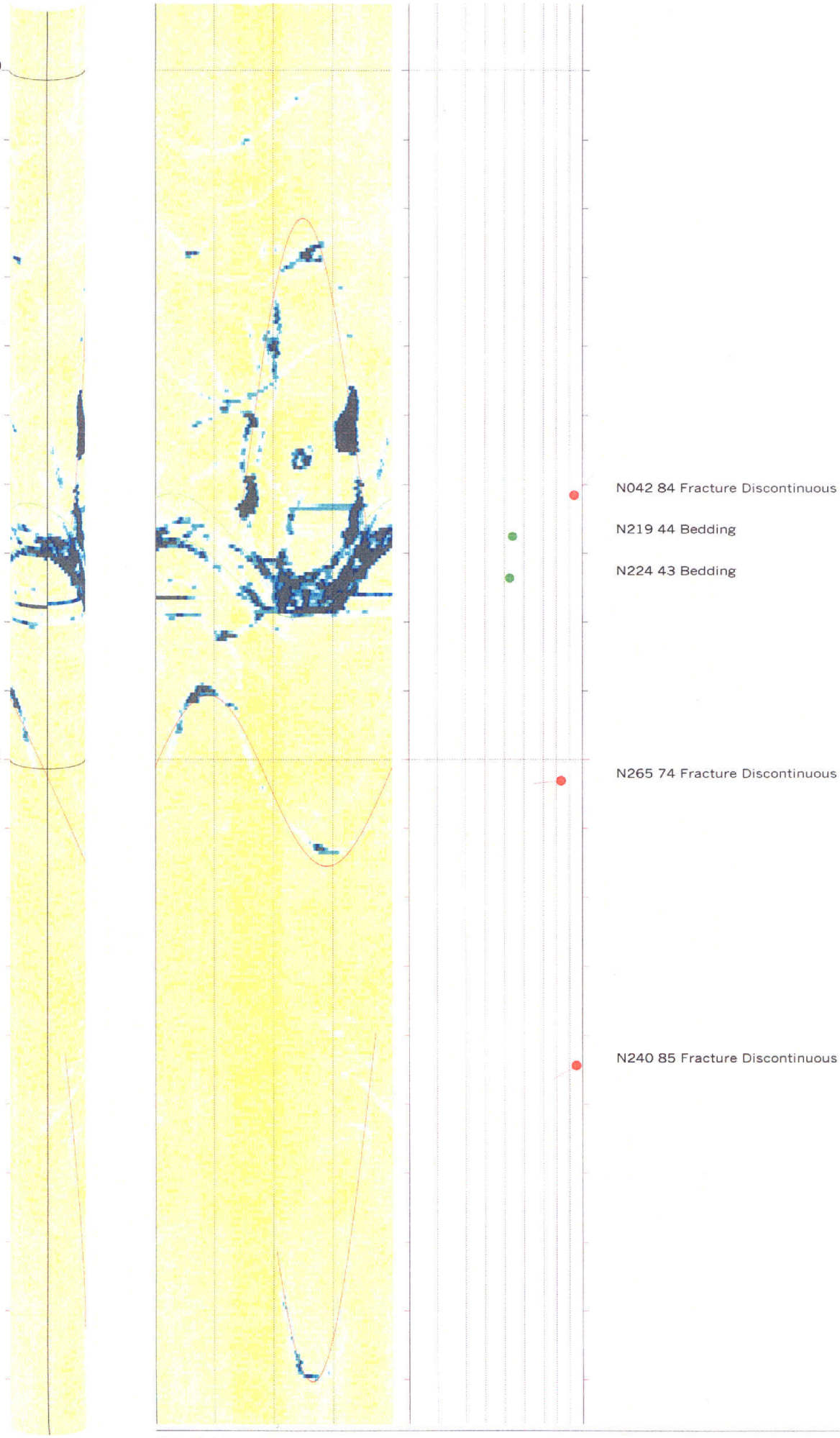
N264 37 Fracture


76
77
N337 78 Fracture
N241 59 Fracture


78
79
N255 67 Bedding
N053 81 Fracture Discontinuous
N321 75 Fracture
N228 51 Fracture
N337 78 Fracture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N219 44 Bedding
N224 43 Bedding
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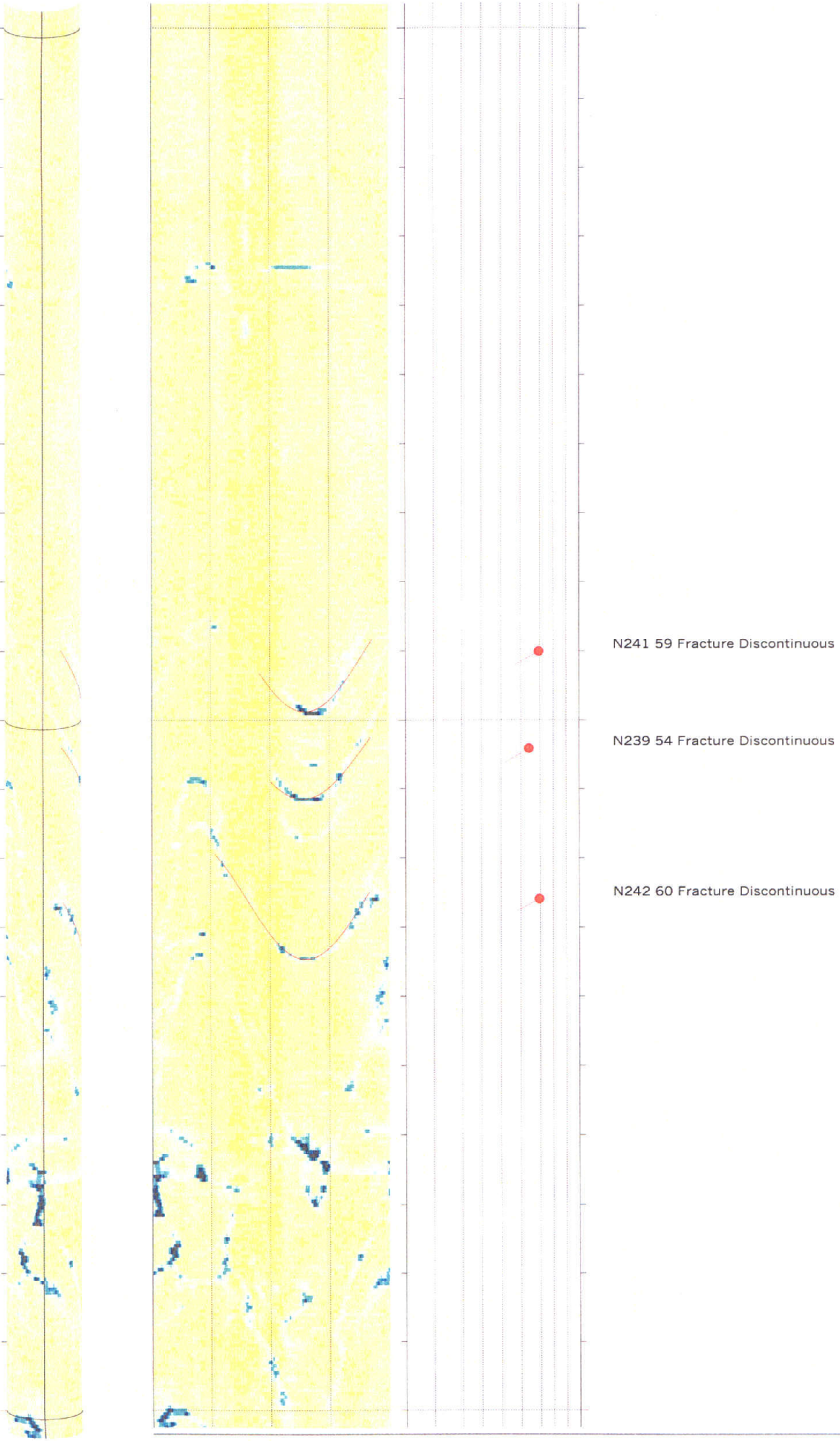
82
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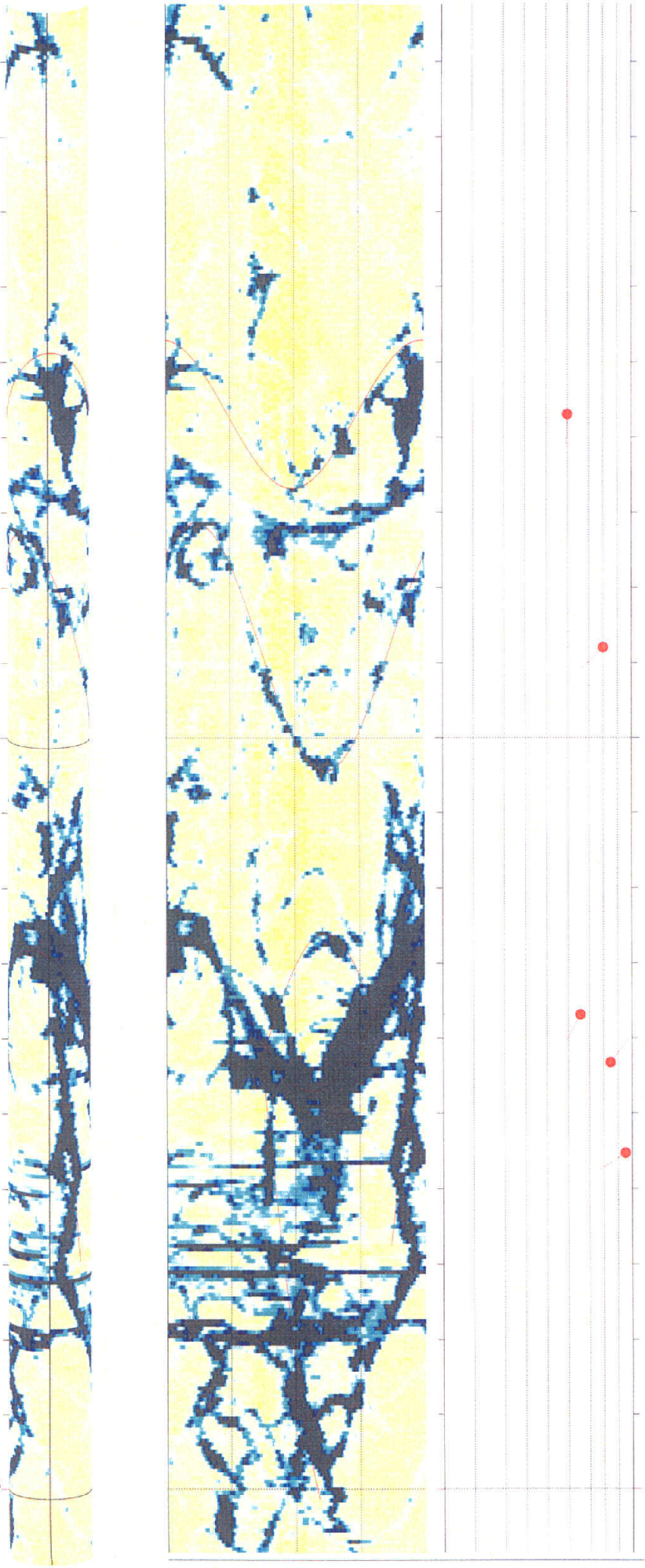
84
N241 59 Fracture Discontinuous
N239 54 Fracture Discontinuous
N242 60 Fracture Discontinuous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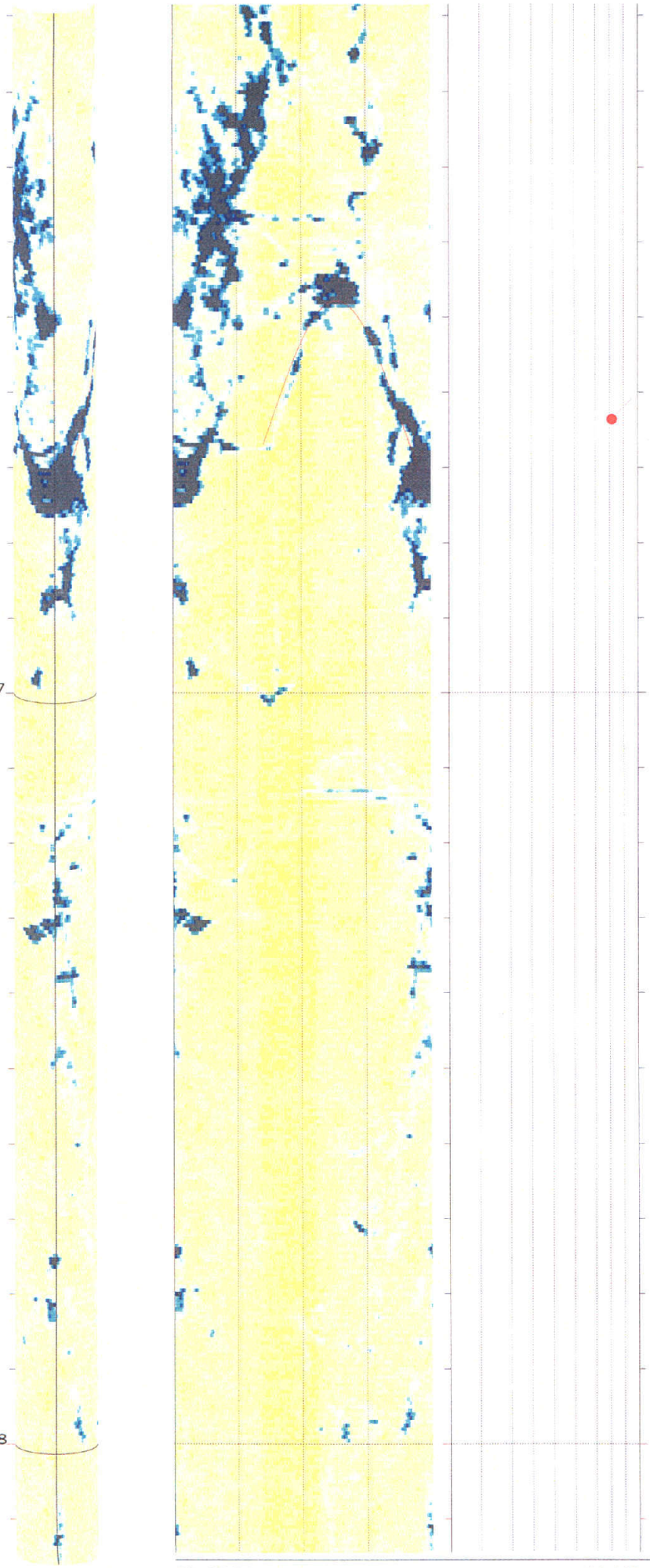
N226 70 Fracture
N209 56 Fracture
N037 75 Fracture Discontinuous
N237 85 Fracture segmented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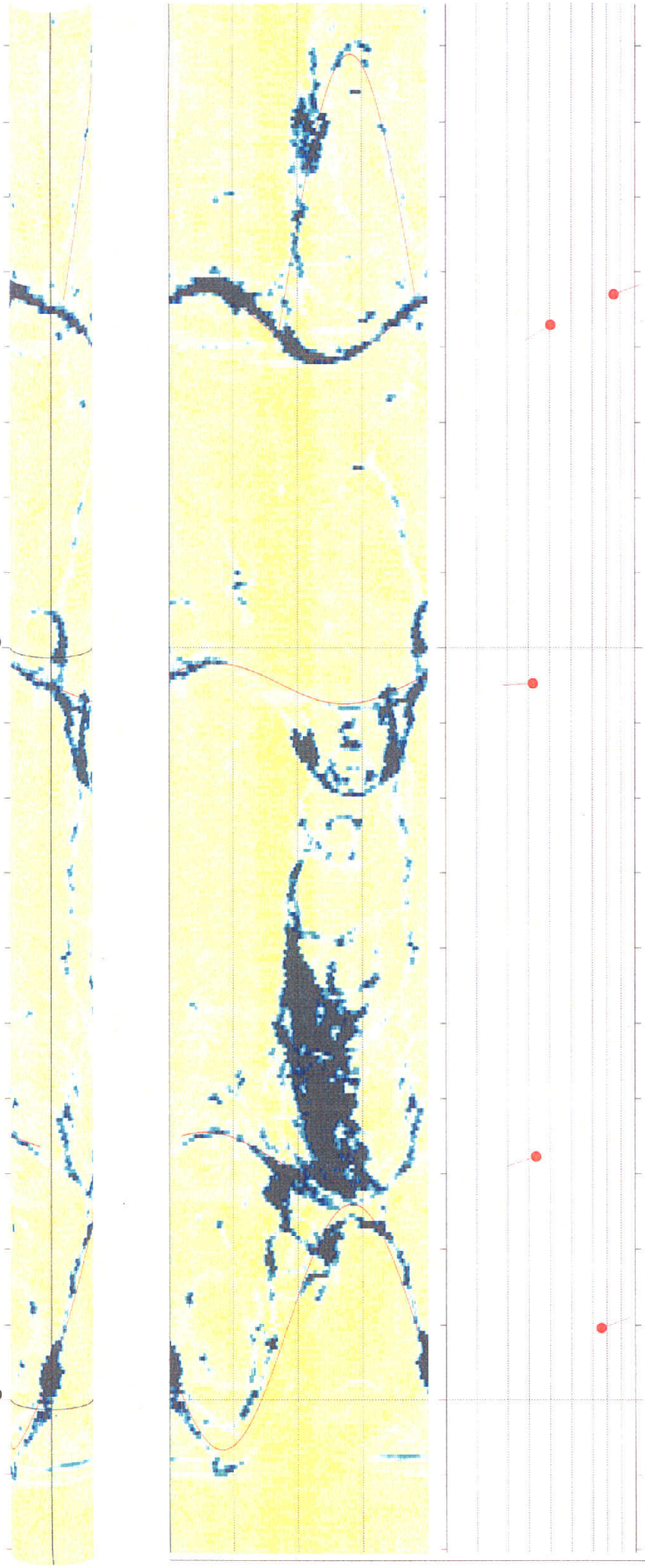
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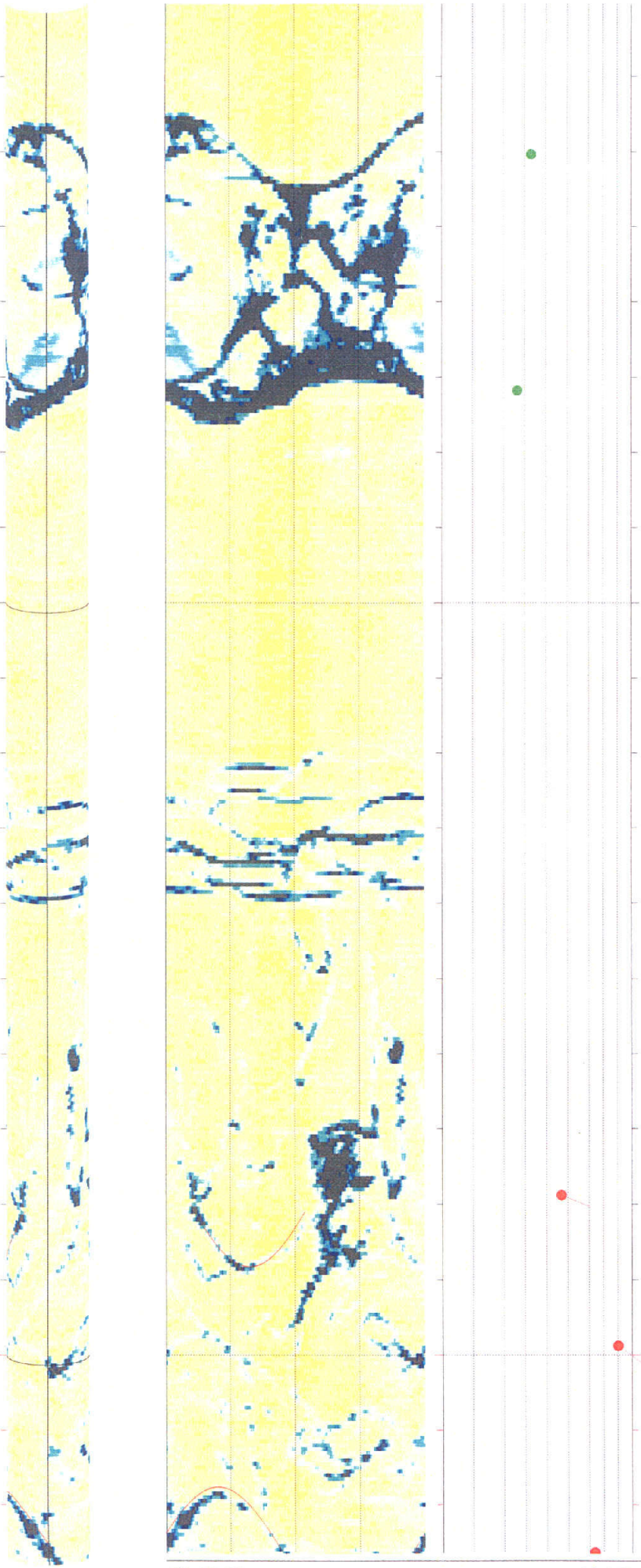
N069 66 Fracture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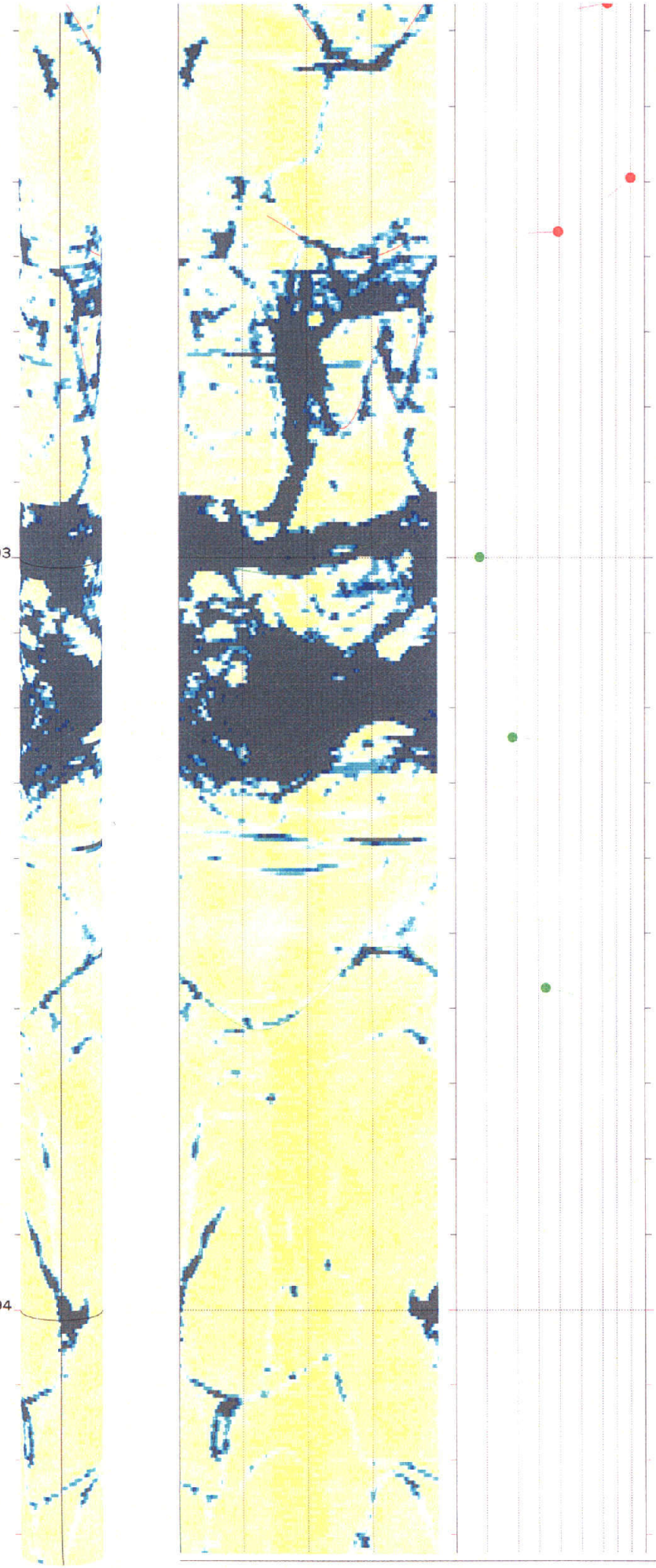
N259 64 Fracture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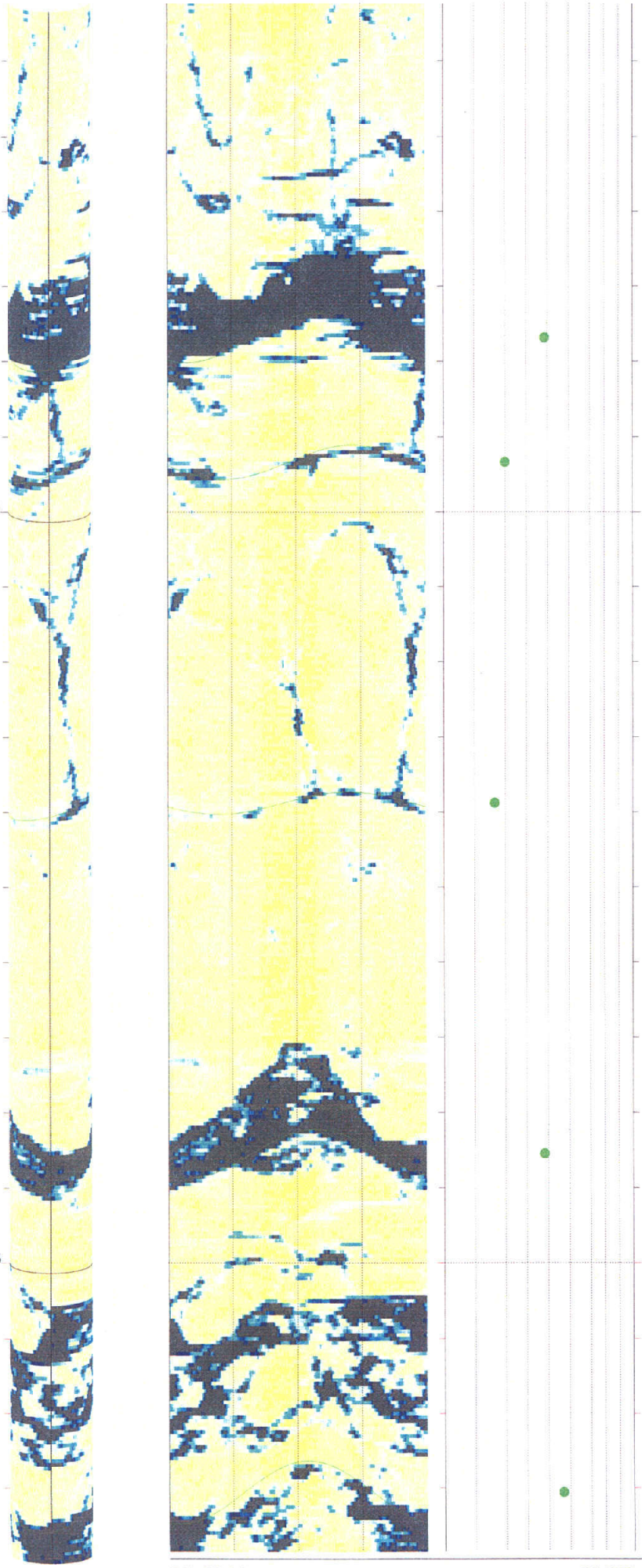
N095 19 Bedding
N103 33 Bedding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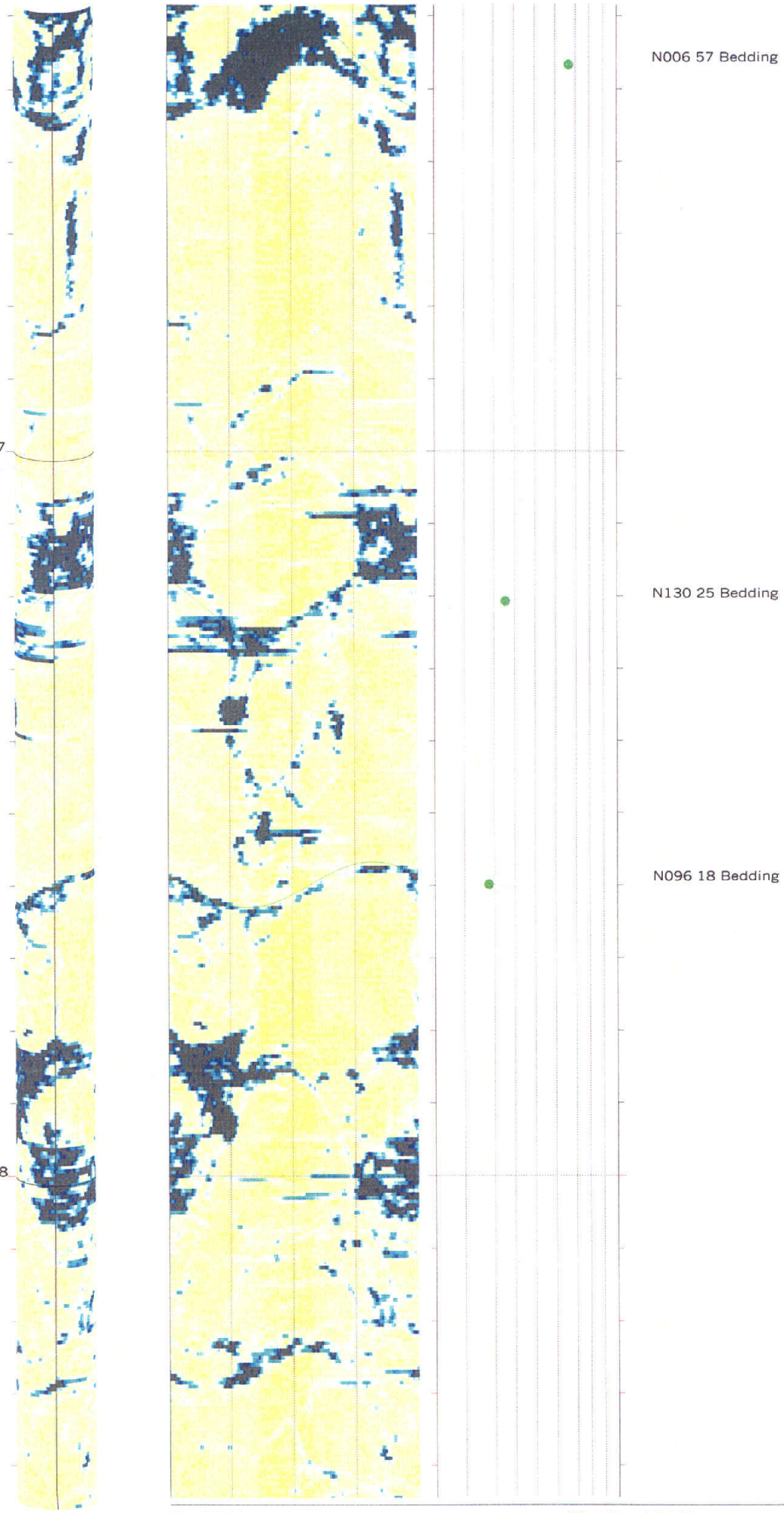
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N096 18 Bedding
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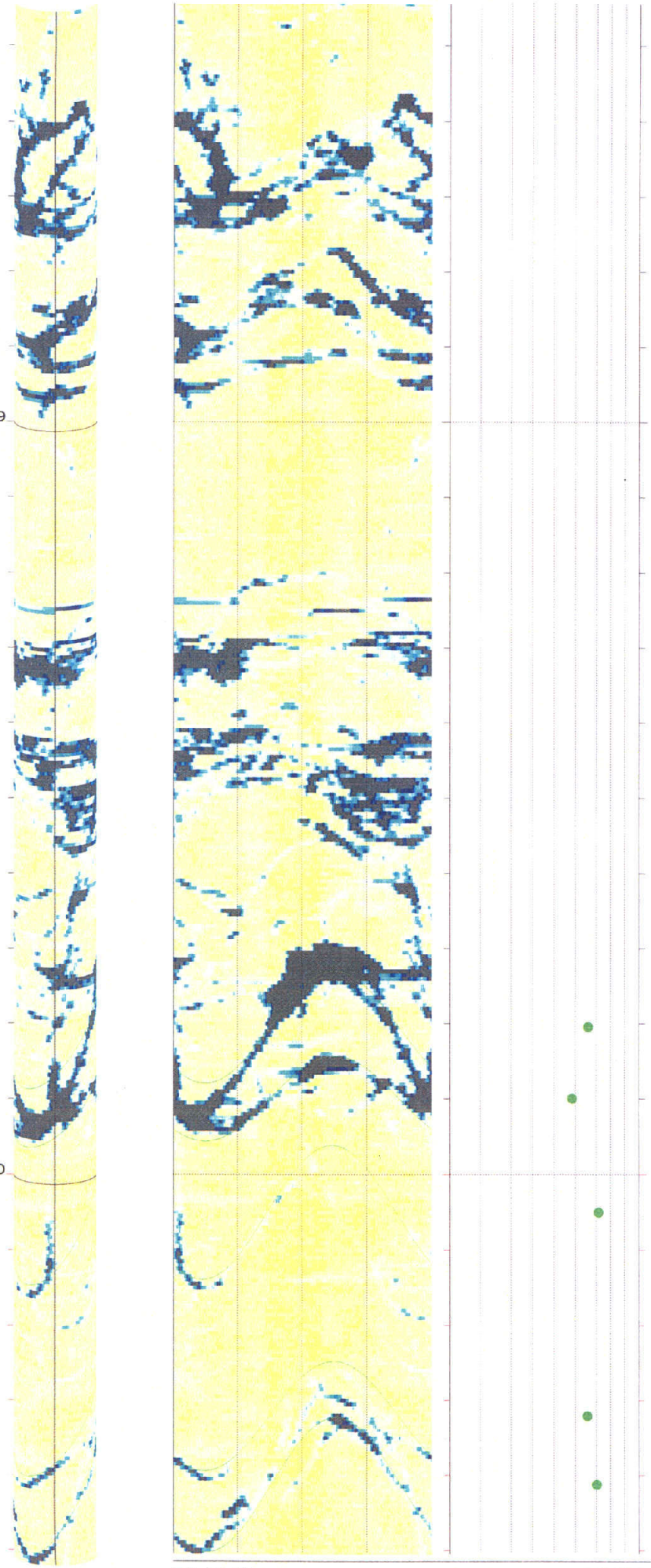
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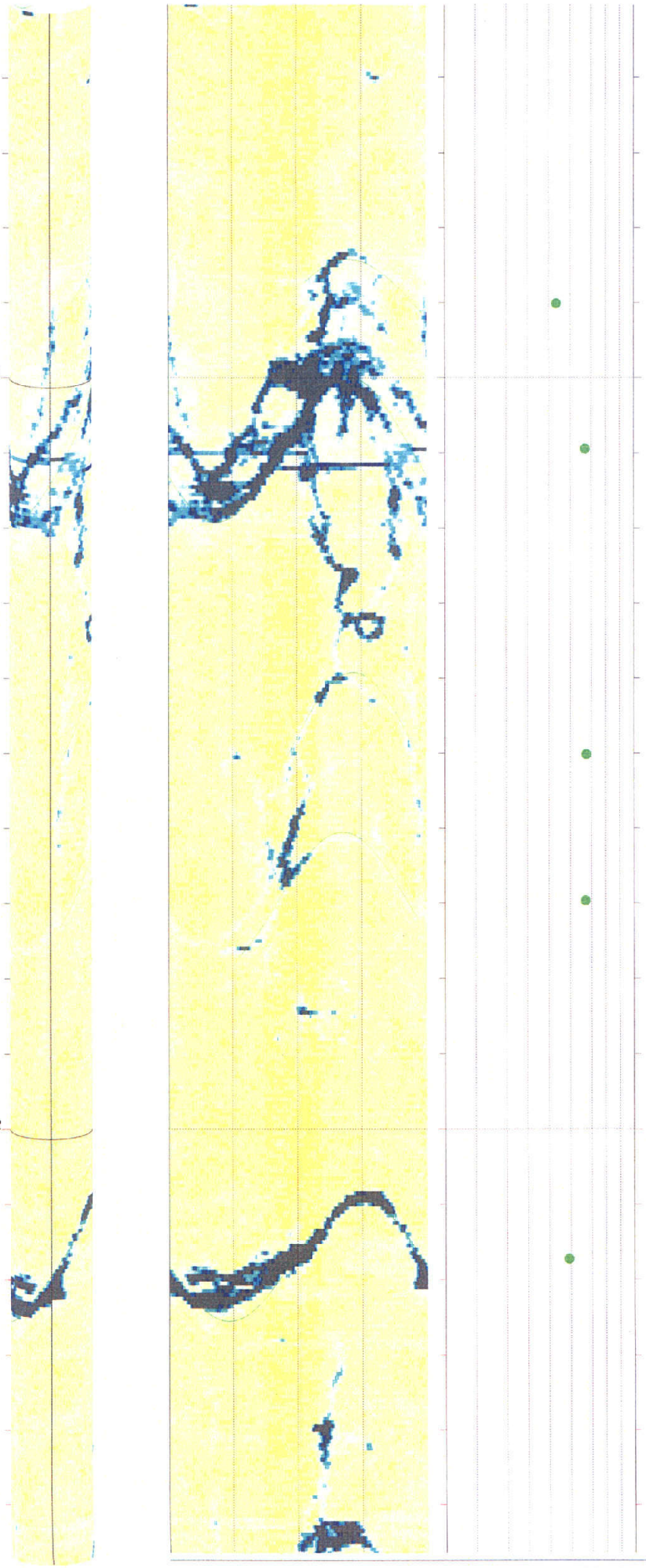
N033 56 Bedding
N038 60 Bedding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N053 57 Bedding
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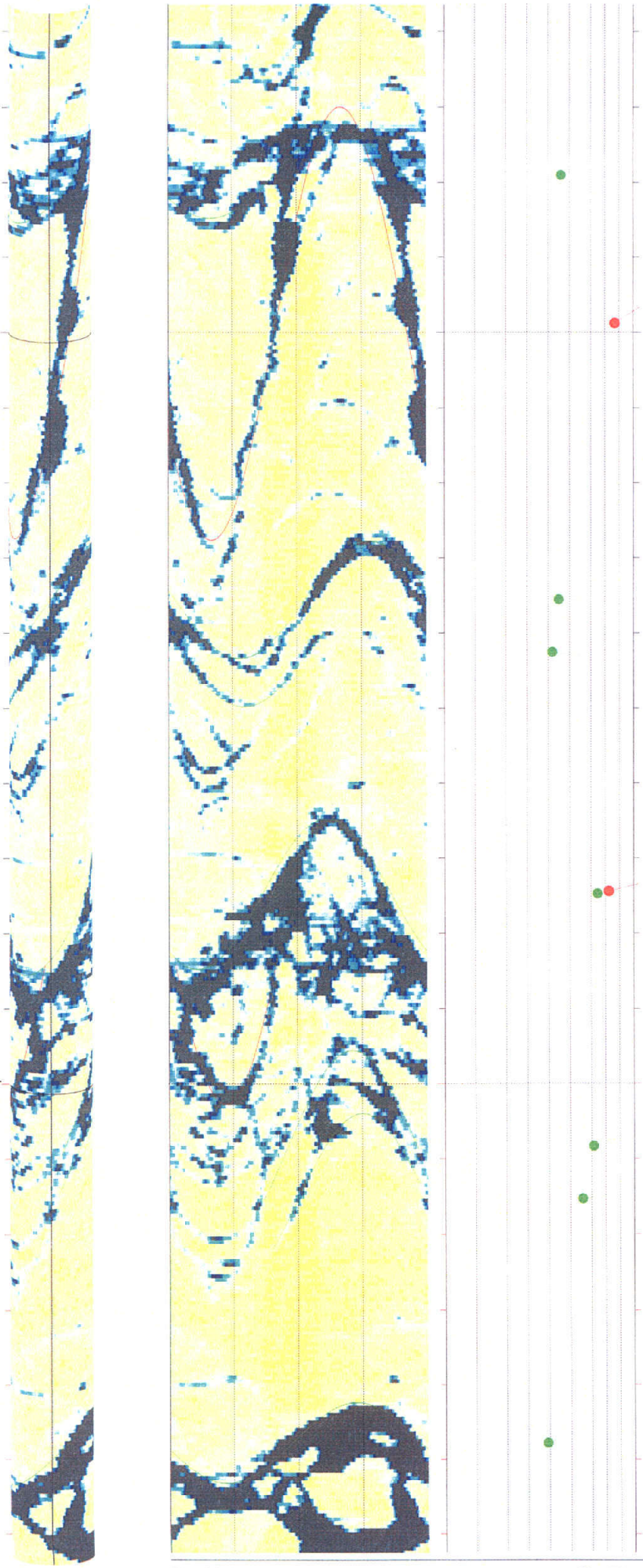
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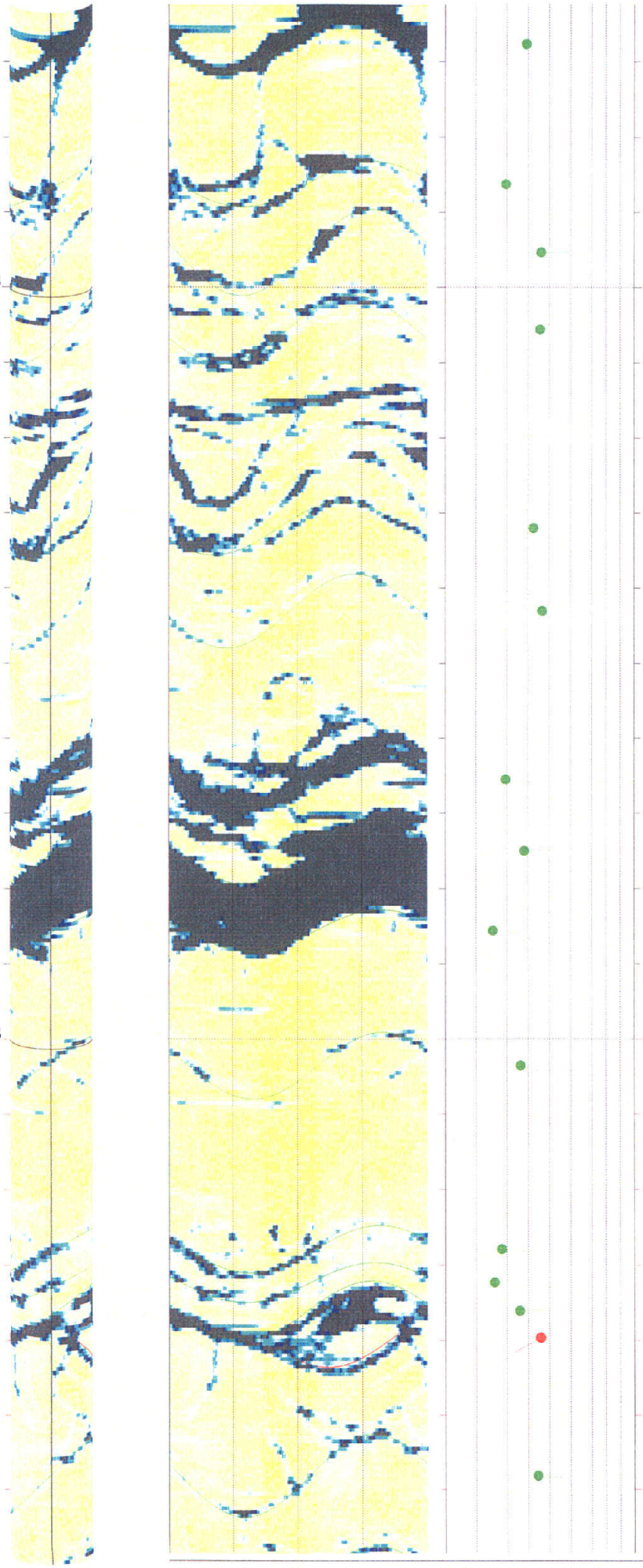
N066 39 Bedding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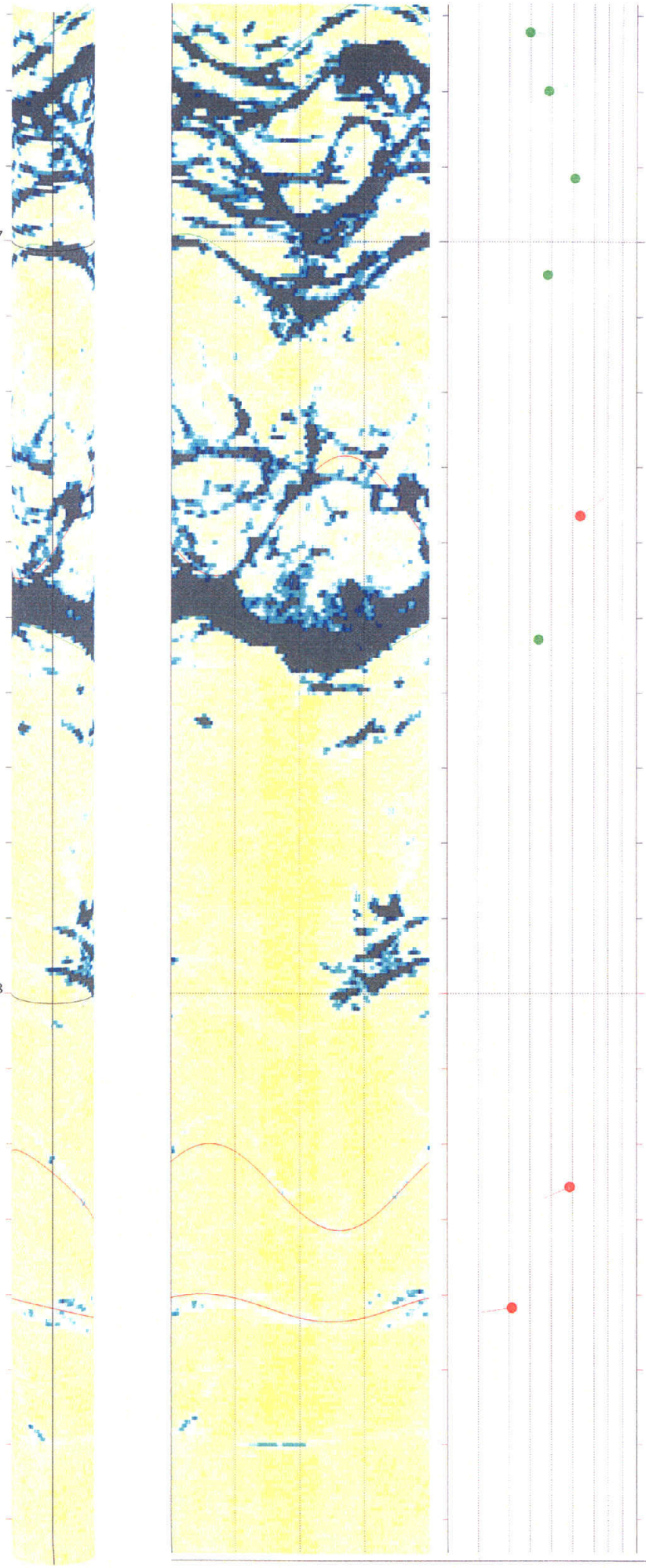
N094 35 Bedding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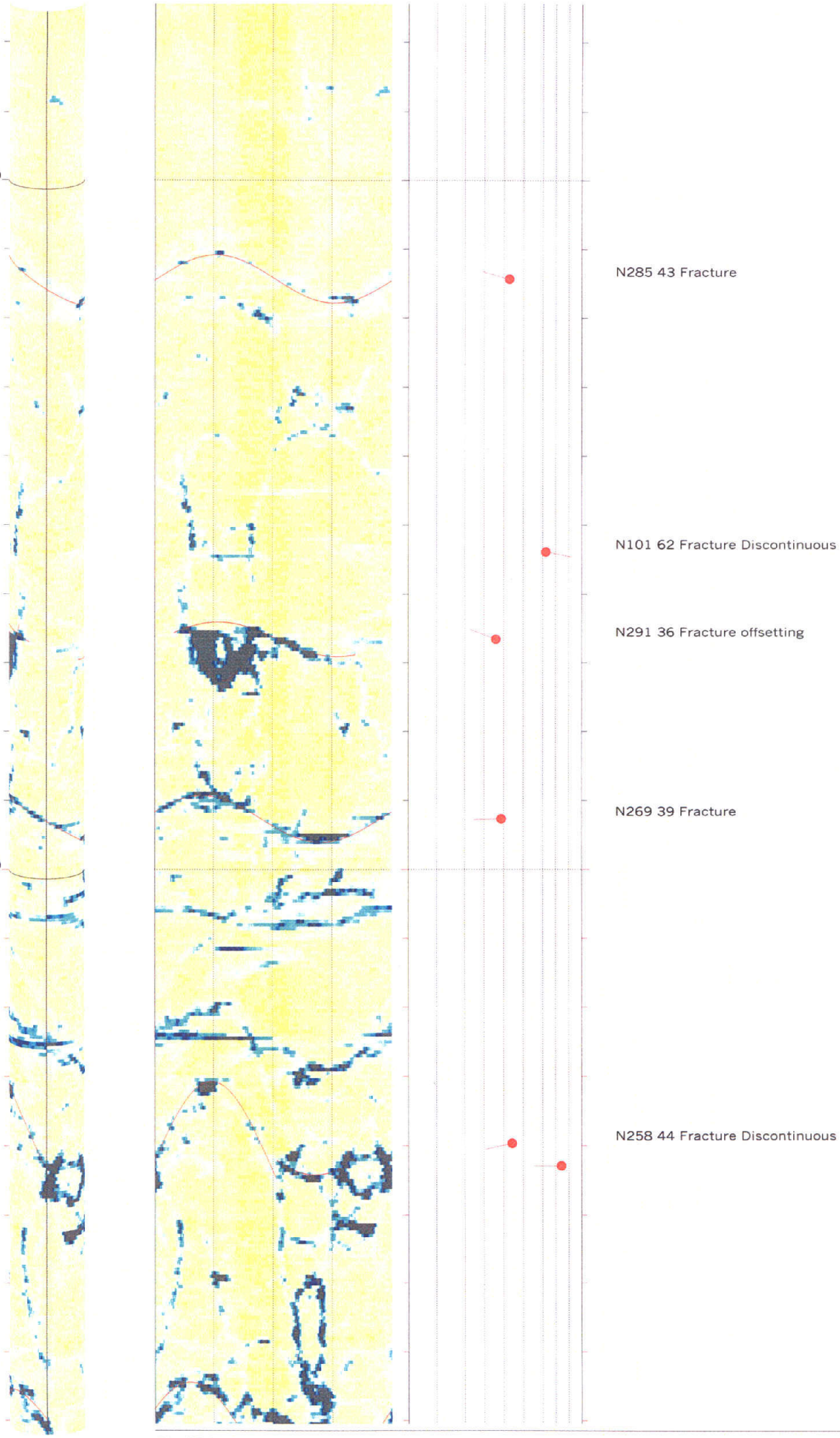
N052 54 Fracture
N254 34 Bedding
N247 49 Fracture Discontinuous
N262 21 Fracture Discontinuous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N101 62 Fracture Discontinuous
N291 36 Fracture offsetting
N269 39 Fracture
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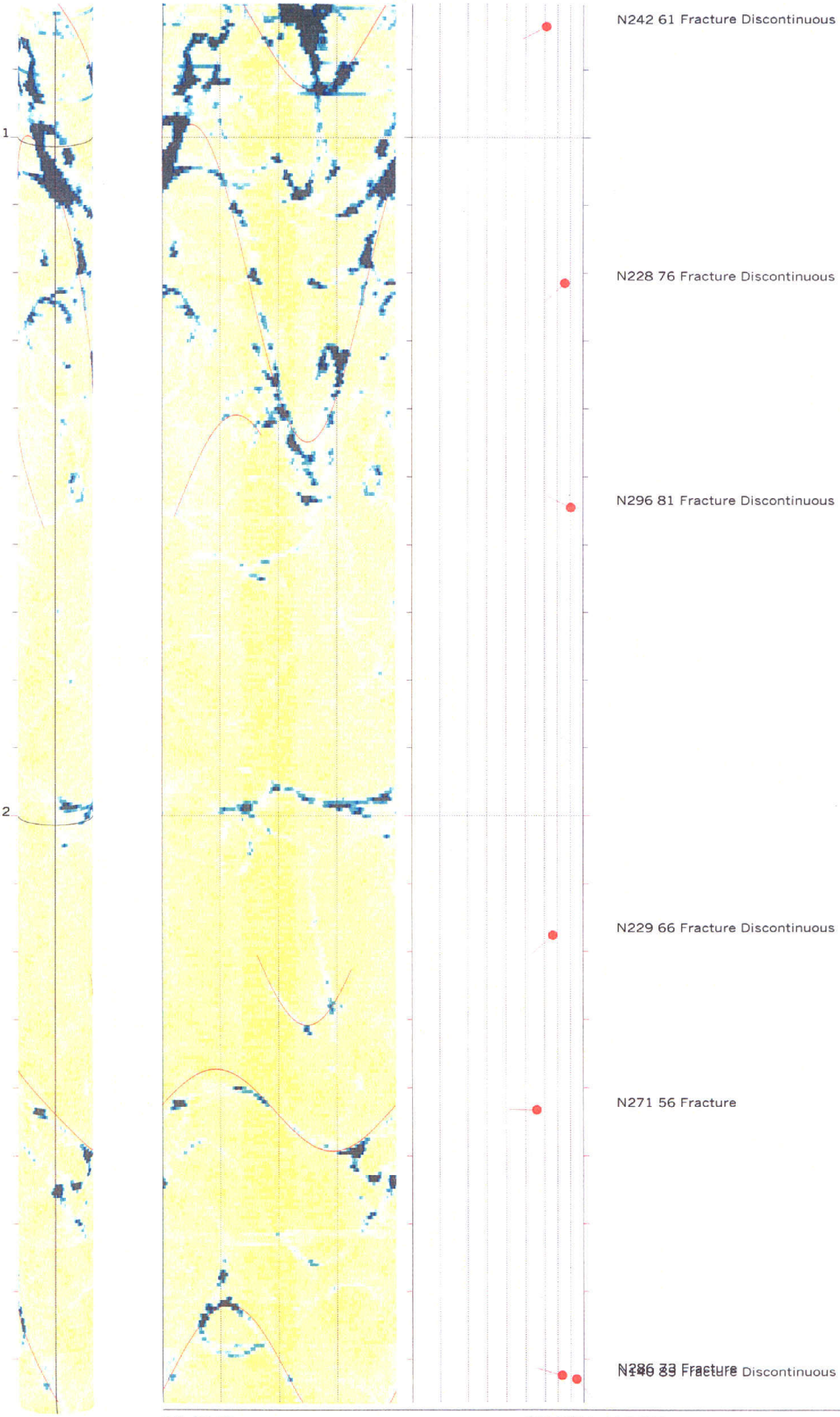
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N242 61 Fracture Discontinuous
N228 76 Fracture Discontinuous
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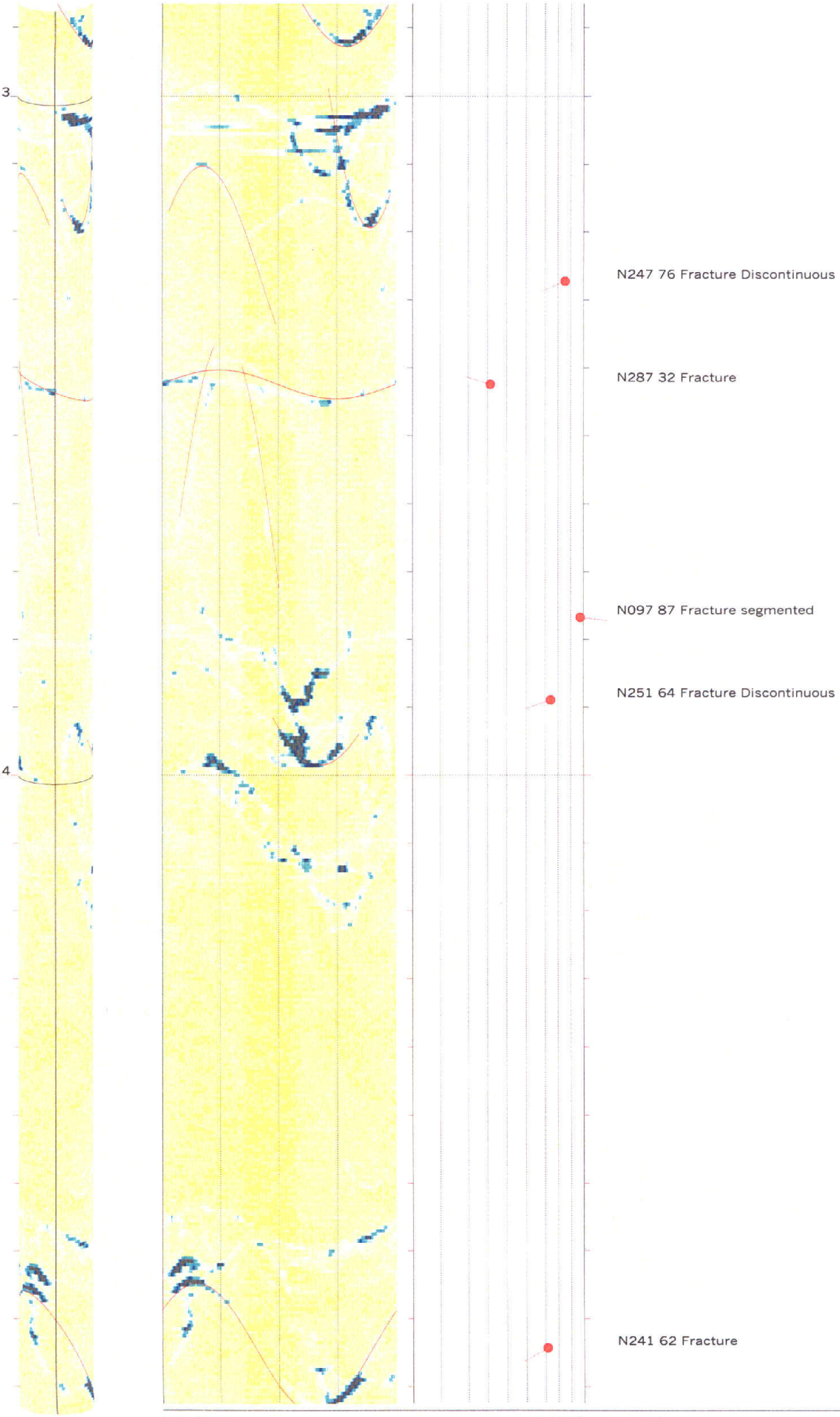
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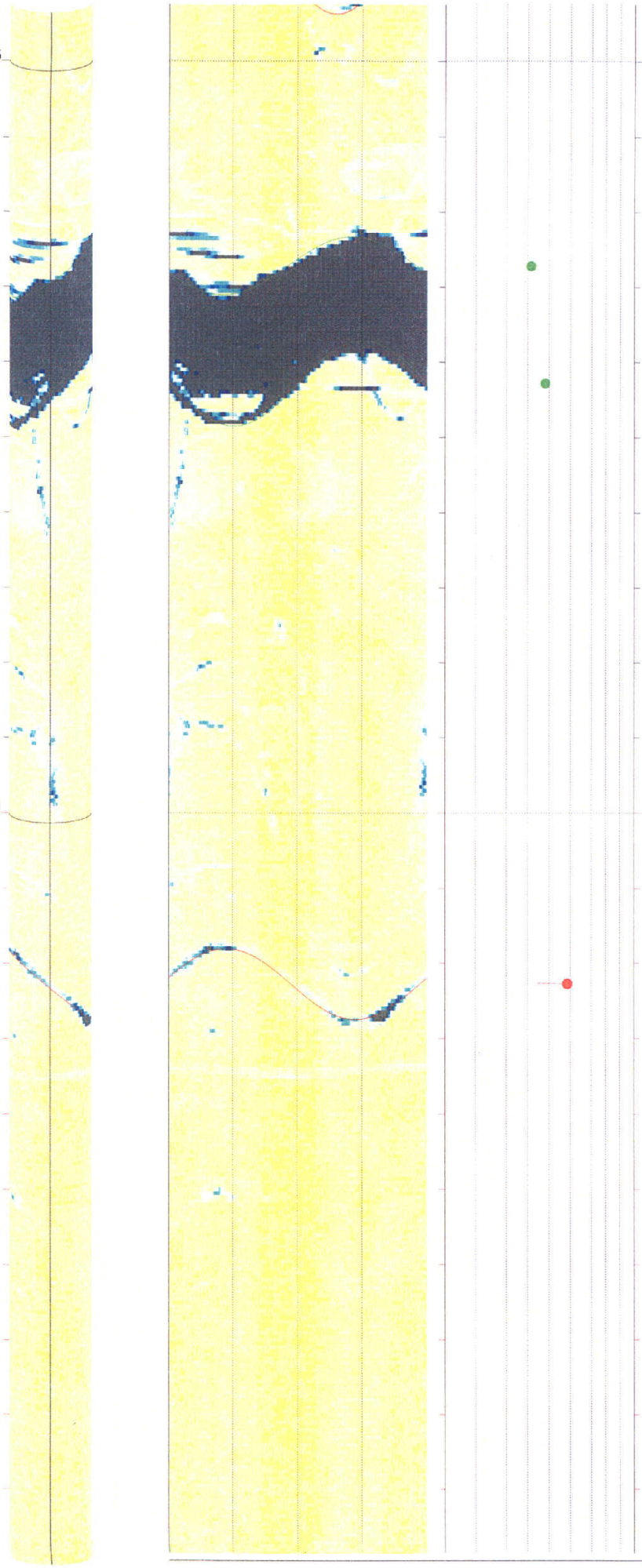
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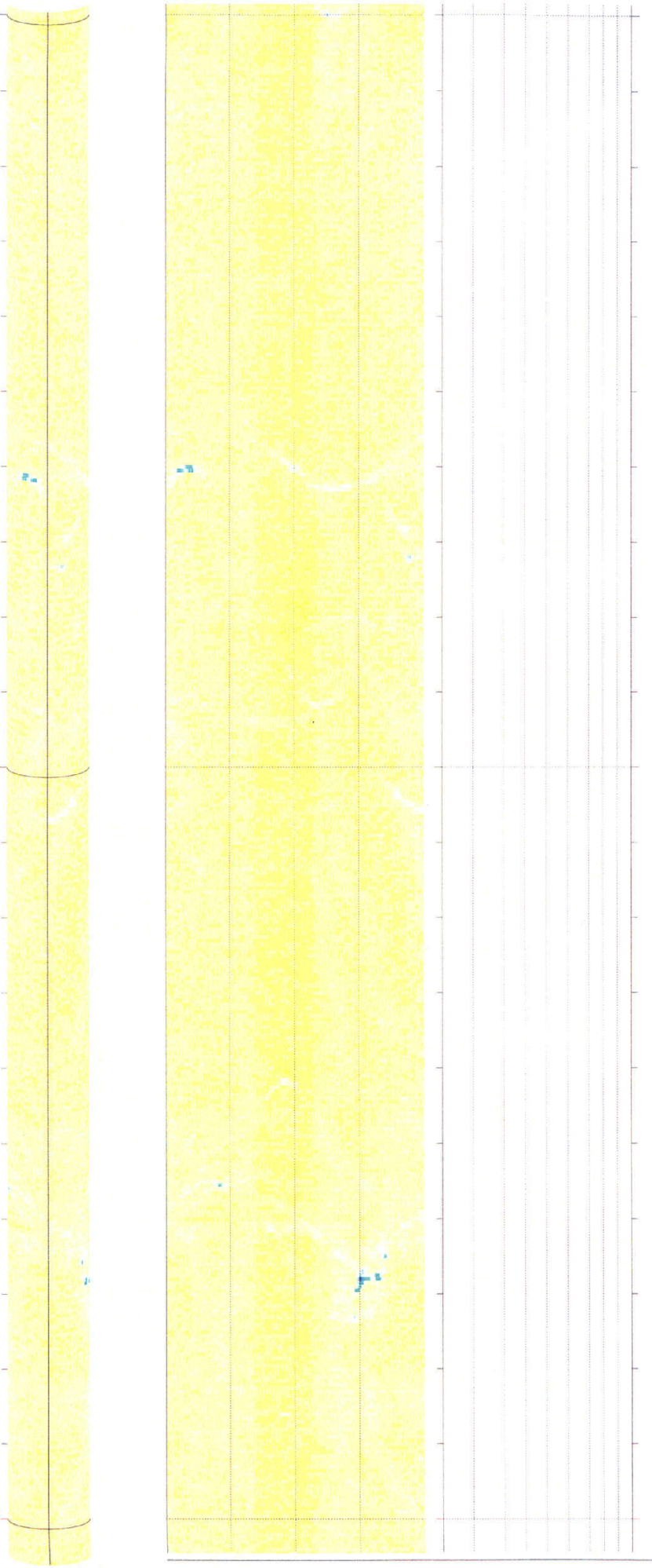
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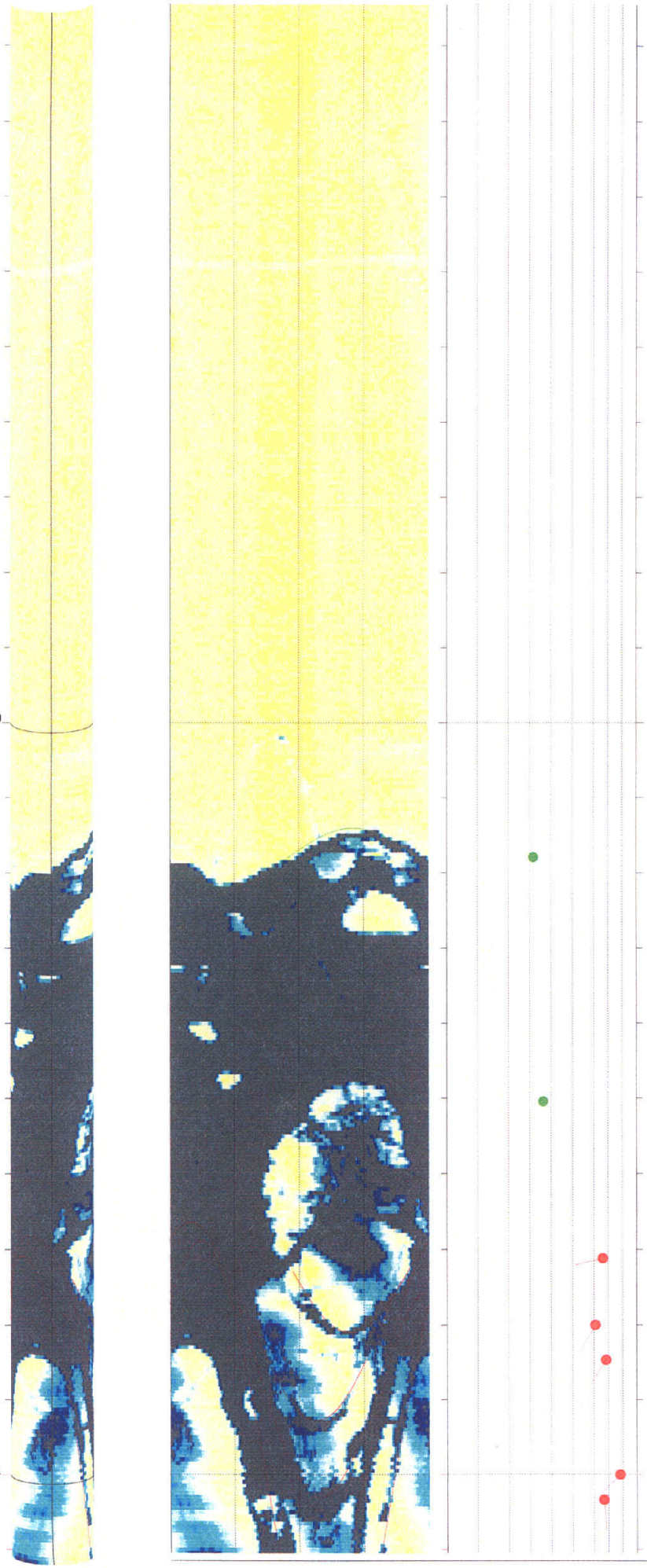
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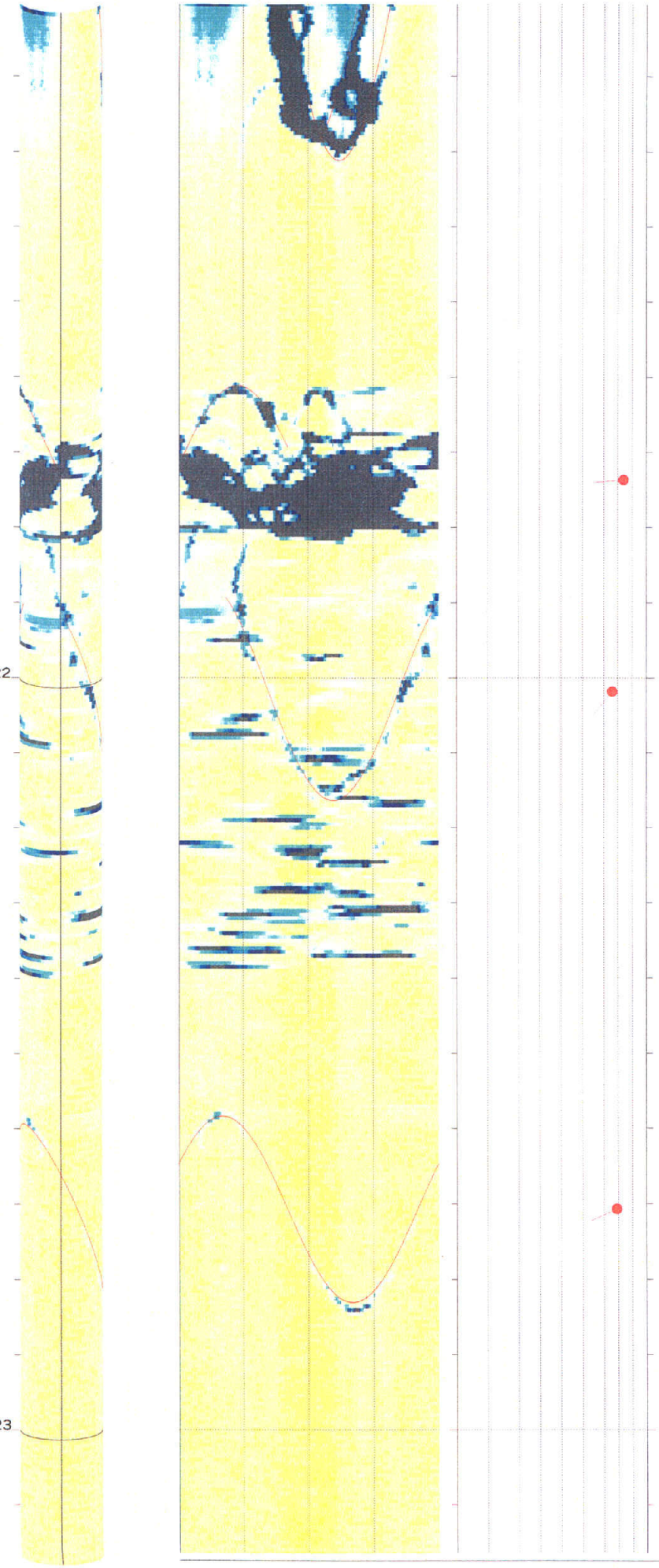
N176 67 Fracture Discontinuous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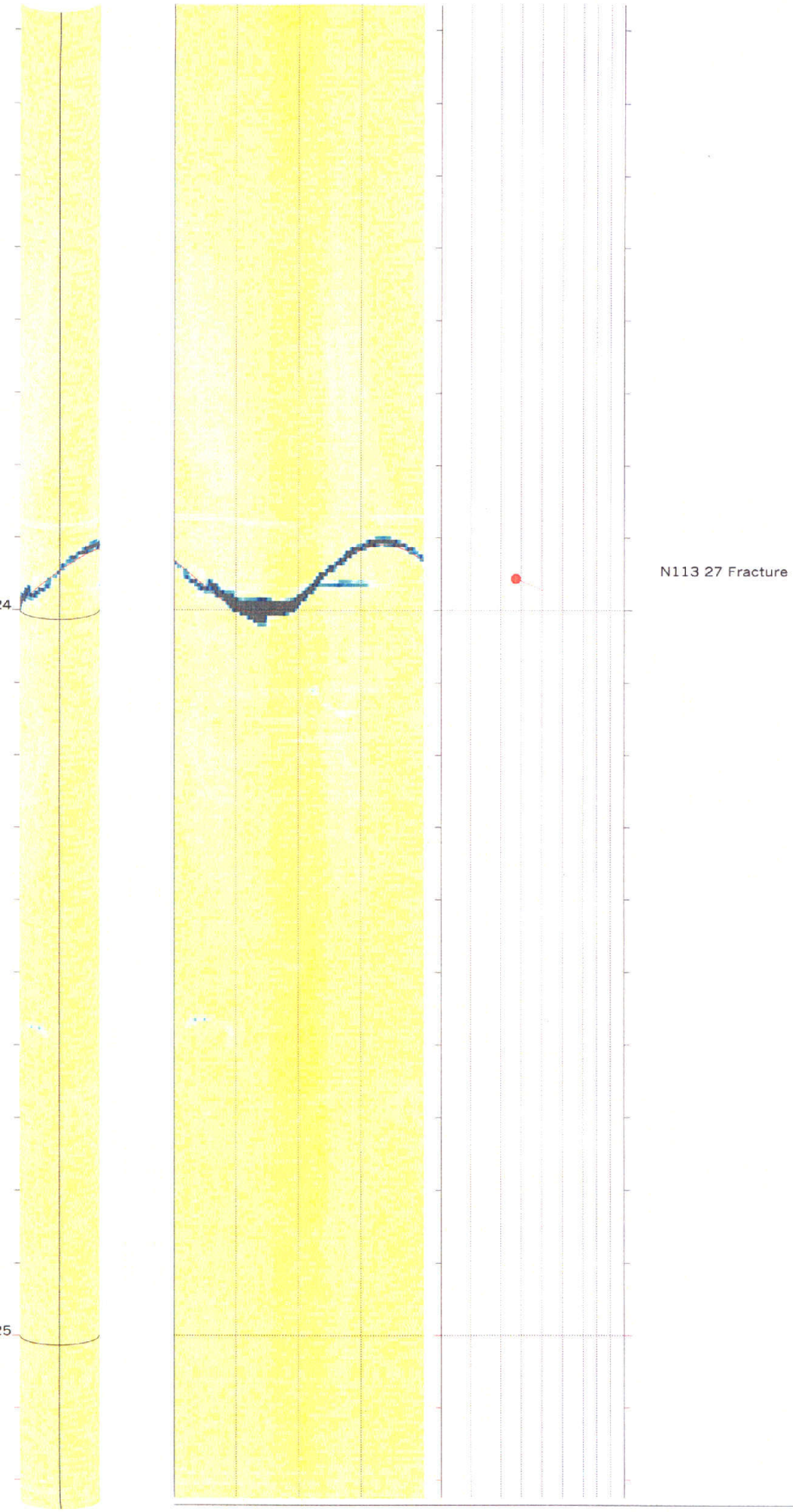
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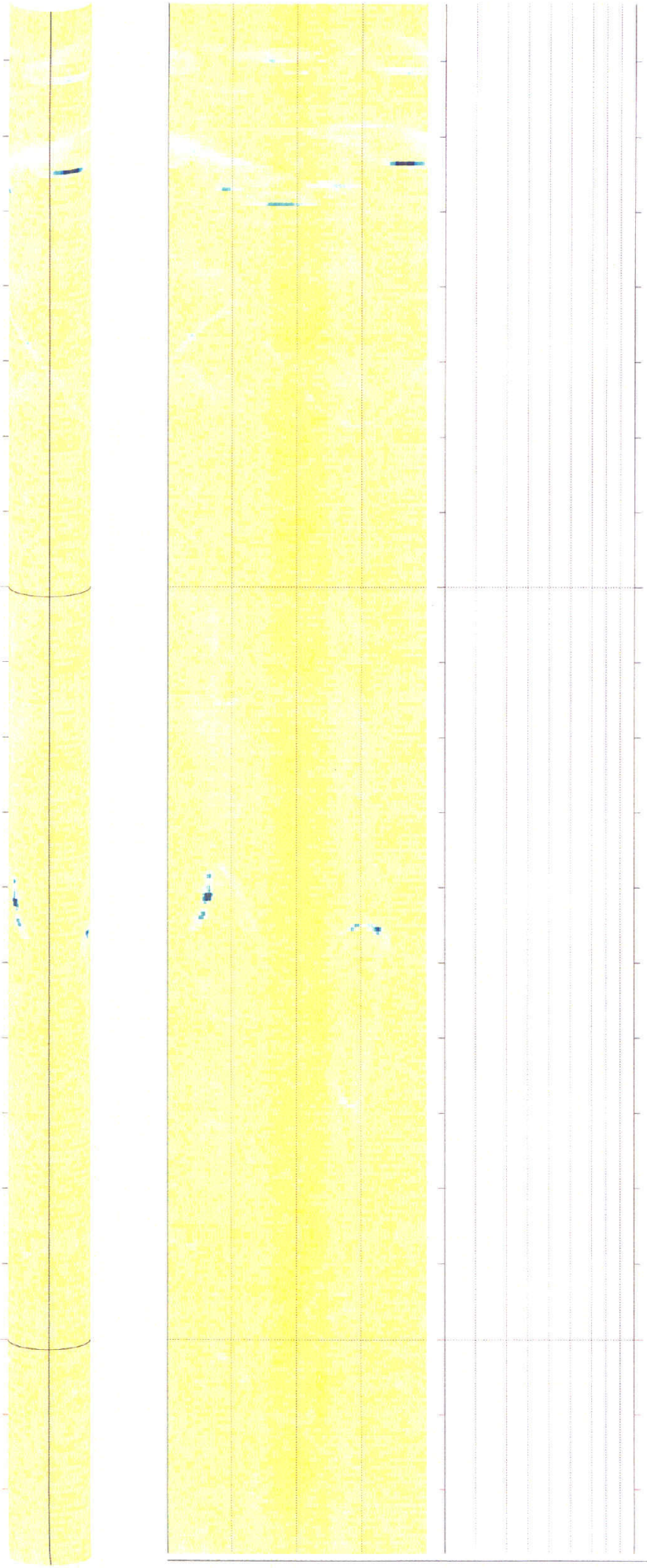
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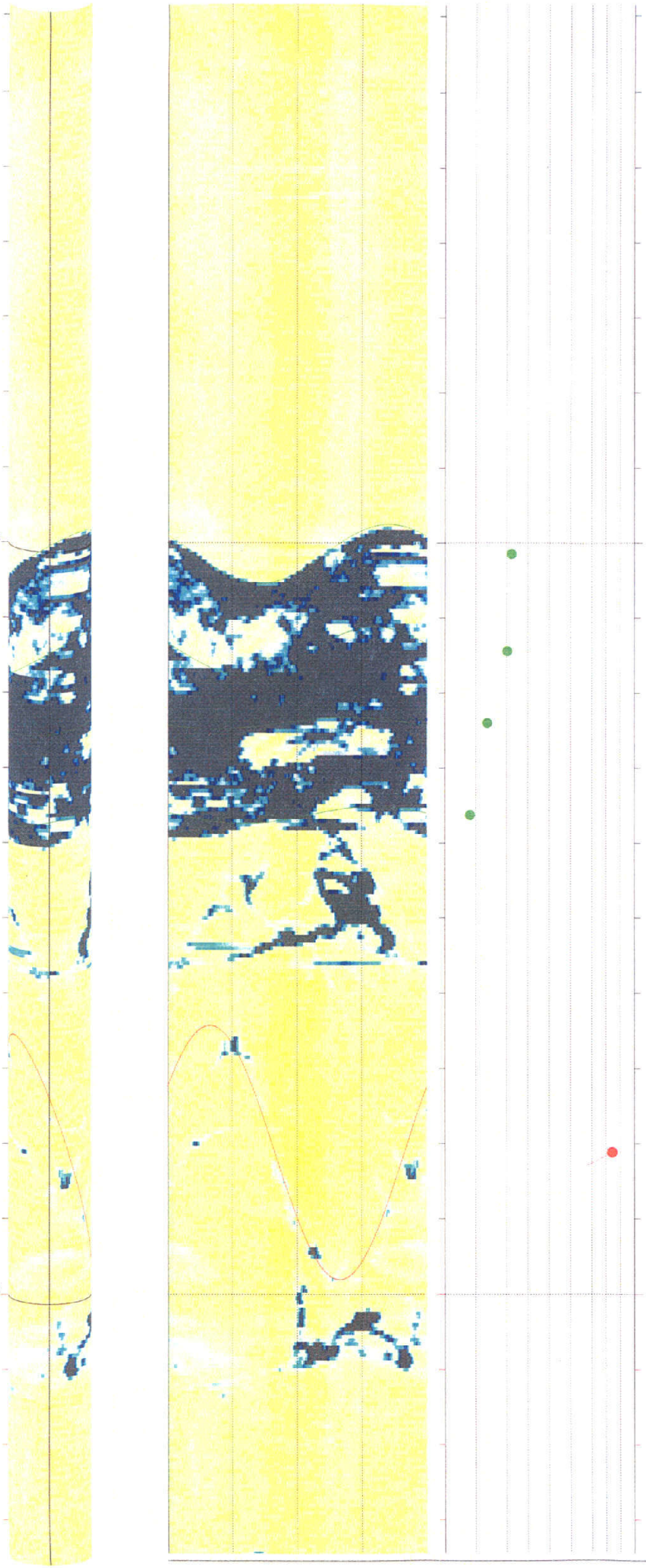
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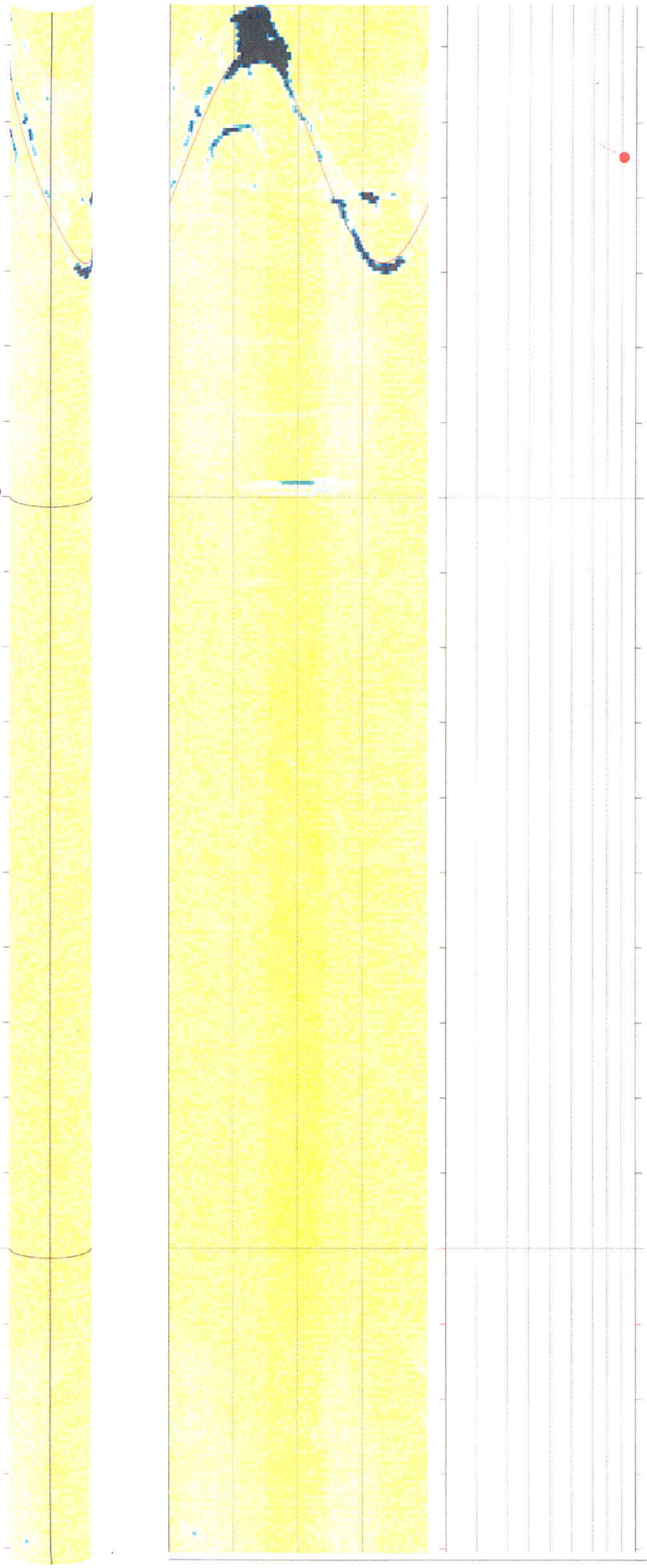
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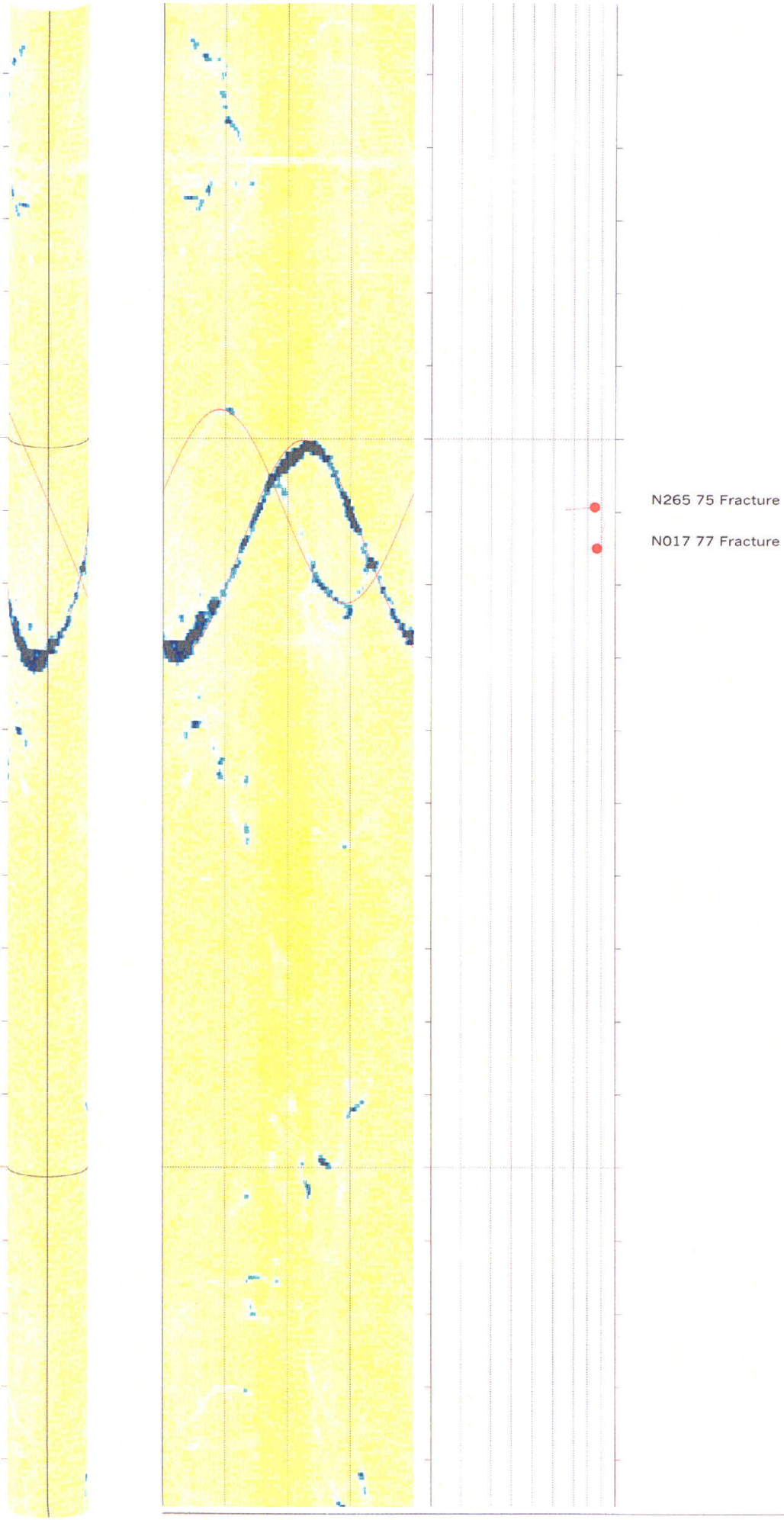
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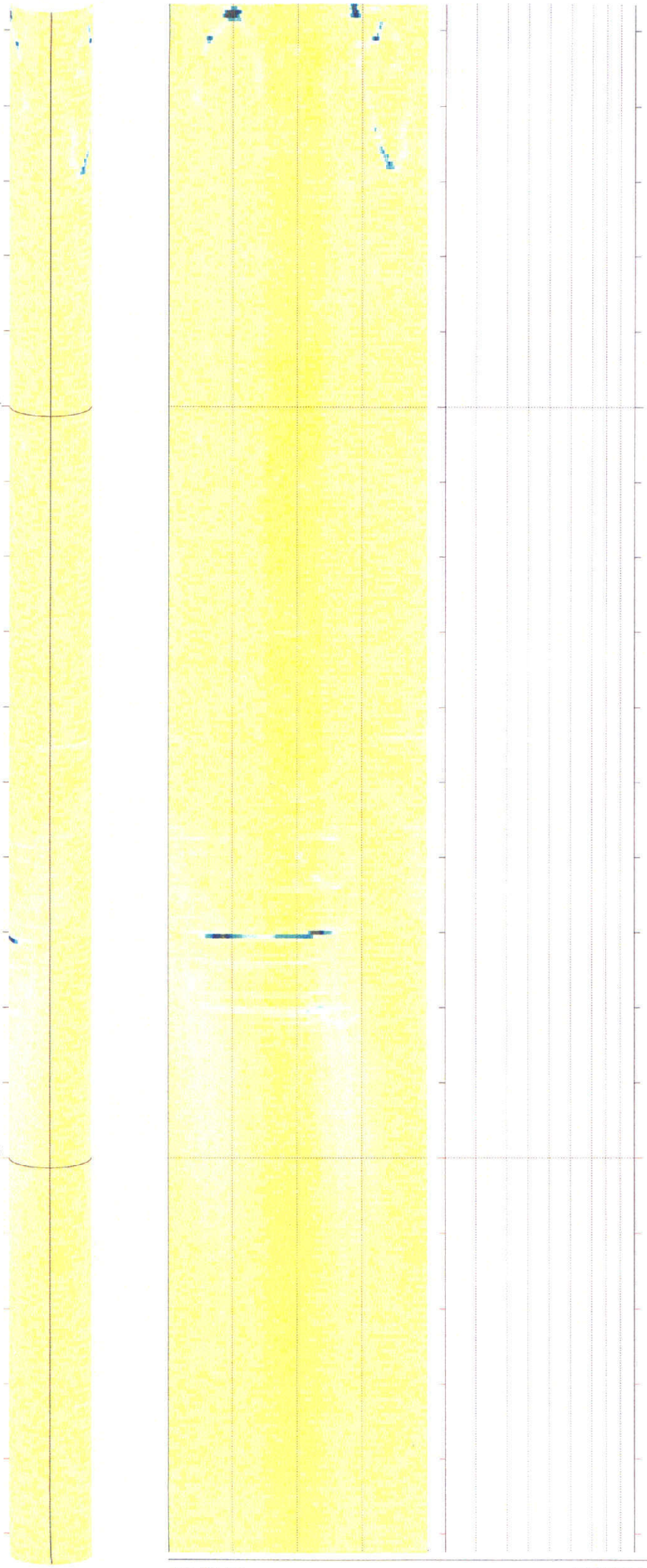
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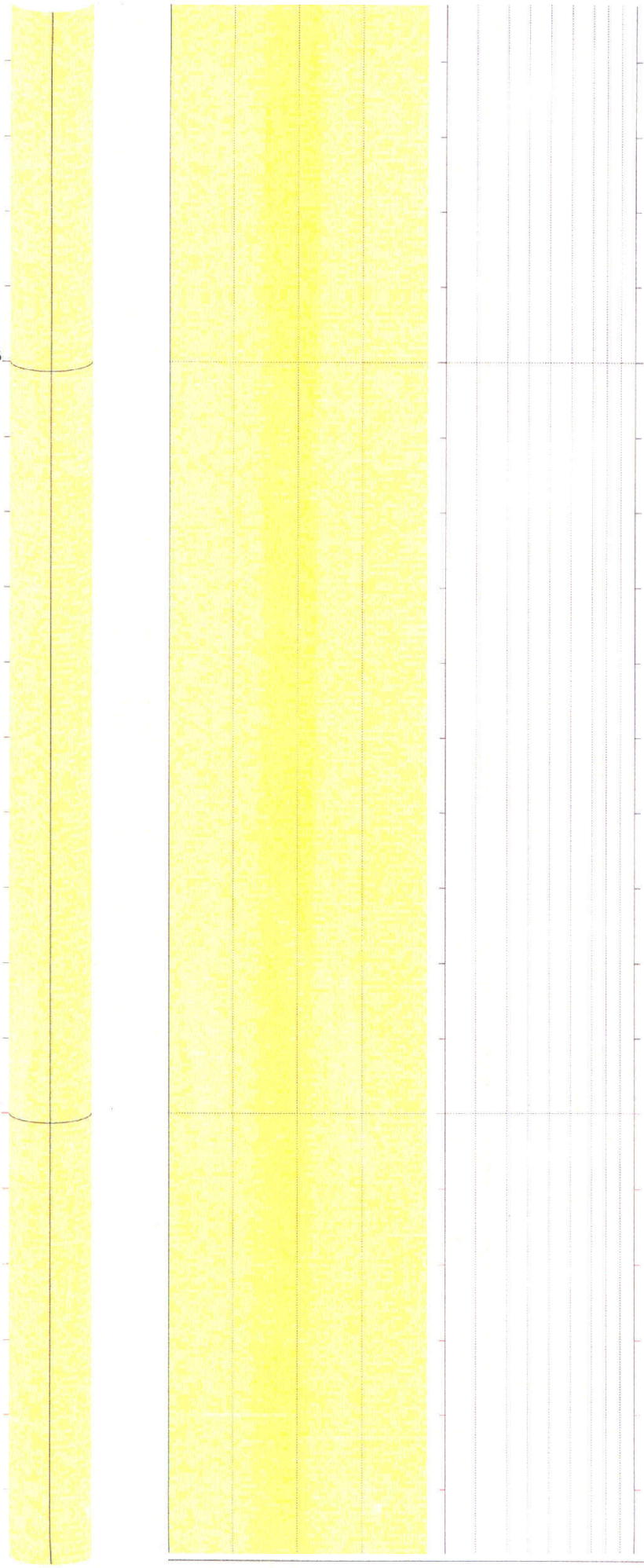
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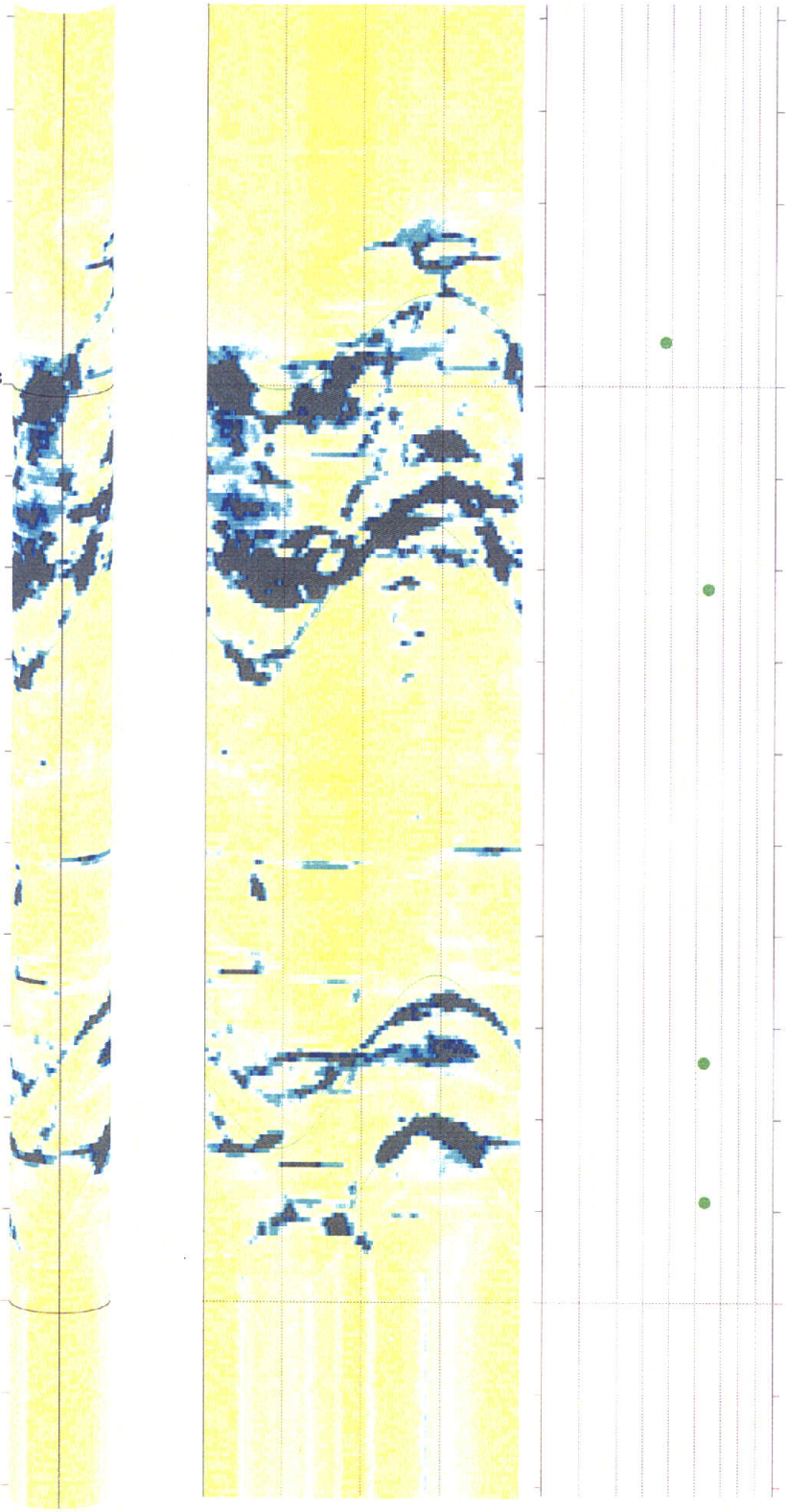
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N067 38 Bedding
N048 54 Bedding
N074 53 Bedding
N072 54 Bedding

RGLDIPv6.1 OPTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-06
zone from 11.463 to 67.295 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	65.865	208	51.7	0.992	4	A	2	65.774	65.955	0.110	141.00	15.00	0.0000	Hairline-fracture
2	65.761	218	56.2	1.000	3	A	2	65.664	65.858	0.110	142.00	14.00	0.0000	Hairline-fracture
3	65.082	218	47.1	0.989	7	A	2	65.012	65.151	0.110	140.29	14.71	0.0000	Hairline-fracture
4	64.996	226	67.0	0.983	6	A	2	64.852	65.139	0.110	141.00	15.00	0.0000	Hairline-fracture
5	64.829	218	41.3	0.980	7	A	2	64.771	64.886	0.110	141.66	14.00	0.0000	Hairline-fracture
6	64.818	190	58.2	0.975	6	A	2	64.802	64.953	0.110	141.43	14.00	0.0000	Discontinuous Hairline-fracture
7	64.660	242	39.4	0.986	6	A	2	64.615	64.704	0.110	140.73	14.27	0.0000	Mineralized Hairline-fracture
8	64.552	231	34.2	0.990	4	A	2	64.511	64.593	0.110	140.88	14.12	0.0000	Hairline-fracture
9	64.421	261	28.6	0.995	5	A	2	64.397	64.446	0.110	139.50	15.00	0.0000	Mineralized Hairline-fracture
10	64.238	215	25.5	1.000	3	A	2	64.204	64.272	0.110	140.00	14.00	0.0000	Hairline-fracture
11	64.181	199	46.2	0.971	5	B	2	64.103	64.259	0.110	140.00	14.30	0.0000	Hairline-fracture
12	64.103	195	42.9	0.993	5	A	2	64.031	64.175	0.110	139.14	15.00	0.0000	Hairline-fracture
13	64.060	239	38.2	0.967	10	B	2	64.017	64.103	0.110	139.72	14.28	0.0000	Hairline-fracture
14	63.960	210	33.4	0.962	7	B	2	63.913	64.007	0.110	140.28	14.28	0.0000	Hairline-fracture
15	63.660	210	30.8	0.984	4	A	2	63.618	63.703	0.110	140.00	14.00	0.0000	Fracture
16	63.532	82	35.8	0.972	4	B	2	63.484	63.586	0.110	141.00	14.00	0.0000	Fracture Discontinuous
17	63.460	253	79.1	0.980	7	A	2	63.266	63.611	0.110	141.00	14.00	0.0000	Fracture Discontinuous
18	63.391	248	41.2	0.985	5	A	2	63.346	63.431	0.110	140.90	14.00	0.0000	Fracture Discontinuous
19	63.273	246	56.7	0.987	6	A	2	63.197	63.326	0.110	141.00	14.46	0.0000	Fracture Discontinuous
20	63.201	254	87.0	0.899	21	D	2	62.863	63.538	0.110	139.19	15.00	0.0000	Fracture Irregular
21	63.168	224	43.4	0.983	5	A	2	63.110	63.208	0.110	140.11	14.45	0.0000	Fracture OFFSET
22	62.963	251	80.5	0.950	16	B	2	62.931	63.182	0.110	140.34	14.00	0.0000	Fracture Discontinuous
23	62.808	217	31.4	0.971	4	B	2	62.766	62.850	0.110	141.00	14.76	0.0000	Fracture
24	62.557	223	40.4	0.967	5	B	2	62.569	62.611	0.110	141.00	15.00	0.0000	Hairline-fracture
25	62.486	222	38.9	0.972	4	B	2	62.435	62.537	0.110	140.00	14.20	0.0000	Hairline-fracture
26	62.280	195	39.6	0.952	8	B	2	62.216	62.345	0.110	140.00	15.00	0.0000	Fracture
27	61.199	98	82.5	0.929	21	C	2	60.269	62.130	0.110	141.00	14.93	0.0000	Fracture Irregular
28	60.928	84	79.7	0.990	13	A	2	61.414	62.199	0.110	141.64	14.36	0.0000	Fracture Discontinuous
29	60.645	250	27.2	0.984	6	A	2	60.647	60.672	0.110	141.00	15.00	0.0000	Fracture Discontinuous
30	60.607	218	24.1	0.990	6	A	2	60.575	60.631	0.110	141.00	15.00	0.0000	Fracture Discontinuous
31	60.034	236	27.7	0.974	5	A	2	60.003	60.065	0.110	139.24	14.76	0.0000	Fracture
32	59.810	279	68.9	0.937	15	C	2	59.719	59.900	0.110	140.27	14.00	0.0000	Fracture Discontinuous
33	59.651	239	63.4	0.954	12	B	2	59.549	59.754	0.110	138.90	15.00	0.0000	Fracture Discontinuous
34	59.616	222	49.8	0.973	11	A	2	59.543	59.689	0.110	138.40	15.00	0.0000	Fracture Discontinuous
35	59.385	223	54.7	0.929	19	C	2	59.297	59.474	0.110	140.58	15.00	0.0000	Fracture open

36	59.077	203	60.7	0.993	5	A	2	58.940	59.215	0.110	140.25	15.00	0.0000 Discontinuous Hairline-fracture
37	58.982	202	49.8	0.999	4	A	2	58.895	59.069	0.110	141.00	14.28	0.0000 Hairline-fracture
38	58.944	216	49.9	0.996	4	A	2	58.865	59.023	0.110	140.95	15.00	0.0000 Hairline-fracture
39	58.883	206	41.9	0.943	7	C	2	58.818	58.948	0.110	140.00	15.00	0.0000 Hairline-fracture
40	58.709	19	33.4	0.978	5	A	0	58.679	58.738	0.110	140.25	14.75	0.0000 Bedding
41	58.562	80	22.3	0.982	7	A	0	58.527	58.597	0.110	140.00	15.00	0.0000 Bedding
42	58.502	56	26.0	0.970	7	B	0	58.469	58.536	0.110	139.13	15.00	0.0000 Bedding
43	57.956	58	31.1	0.959	6	B	2	57.916	57.996	0.110	139.00	15.00	0.0000 Sheared
44	57.559	0	53.7	0.989	9	A	2	57.508	57.611	0.110	139.74	15.00	0.0000 Fracture
45	57.128	73	41.9	0.945	7	C	2	57.063	57.193	0.110	138.64	15.00	0.0000 Fracture
46	56.722	246	82.5	0.989	5	A	2	56.451	56.887	0.110	140.00	15.00	0.0000 Fracture Discontinuous
47	56.257	226	62.3	0.969	5	B	2	56.143	56.327	0.110	139.00	15.00	0.0000 Fracture Discontinuous
48	56.170	234	62.2	0.968	7	B	2	56.066	56.273	0.110	139.53	15.00	0.0000 Fracture Discontinuous
49	55.943	41	44.6	0.971	7	B	2	55.889	55.997	0.110	139.05	14.95	0.0000 Fracture open
50	55.718	46	37.7	0.979	6	A	2	55.673	55.762	0.110	139.43	14.57	0.0000 Sheared
51	55.413	208	38.7	0.975	13	A	2	55.355	55.470	0.110	138.68	15.66	0.0000 Fracture
52	55.340	27	42.6	0.990	5	A	2	55.296	55.364	0.110	140.11	15.00	0.0000 Fracture
53	55.295	18	42.8	0.956	8	B	2	55.254	55.336	0.110	141.00	14.98	0.0000 Fracture
54	55.266	56	27.9	0.982	7	A	2	55.232	55.301	0.110	141.00	14.41	0.0000 Fracture
55	55.237	68	33.2	0.976	7	A	2	55.192	55.282	0.110	140.82	14.18	0.0000 Sheared
56	54.790	356	78.7	0.970	8	B	0	54.661	54.919	0.110	139.00	15.00	0.0000 Primary-structure
57	54.468	29	53.0	0.949	9	B	0	54.403	54.532	0.110	138.44	15.00	0.0000 Primary-structure Sheared
58	54.233	243	63.6	0.956	9	B	2	54.134	54.332	0.110	139.00	15.00	0.0000 Fracture Irregular
59	54.040	240	40.2	0.986	4	A	2	54.019	54.086	0.110	139.11	15.00	0.0000 Fracture Discontinuous
60	53.789	3	68.9	0.974	8	A	0	53.698	53.879	0.110	138.00	15.00	0.0000 Primary-structure
61	53.605	263	58.4	0.960	8	B	2	53.542	53.672	0.110	138.35	15.00	0.0000 Fracture Discontinuous
62	53.105	338	71.1	0.991	6	A	2	53.020	53.189	0.110	139.17	15.00	0.0000 Fracture Discontinuous
63	52.996	40	69.0	0.968	13	B	2	52.865	53.127	0.110	140.00	16.00	0.0000 Fracture Discontinuous
64	50.665	258	53.8	0.970	6	B	2	50.604	50.727	0.110	140.39	15.00	0.0000 Fracture Discontinuous
65	50.543	284	88.3	0.974	7	A	2	50.322	50.476	0.110	138.94	15.00	0.0000 Fracture Discontinuous
66	50.522	260	58.7	0.979	5	A	2	50.452	50.592	0.110	138.52	15.00	0.0000 Fracture Discontinuous
67	50.510	264	74.5	0.975	8	A	2	50.386	50.571	0.110	138.29	15.00	0.0000 Fracture Discontinuous
68	50.239	280	78.4	0.987	8	A	2	50.111	50.209	0.110	138.13	14.87	0.0000 Fracture Discontinuous
69	50.188	289	82.4	0.992	11	A	2	50.035	50.102	0.110	138.69	14.15	0.0000 Fracture Discontinuous
70	48.824	305	65.0	0.967	15	B	2	48.756	48.893	0.110	139.14	14.43	0.0000 Fracture
71	48.102	93	83.5	0.989	17	A	2	48.068	48.720	0.110	137.23	15.89	0.0000 Fracture Discontinuous
72	48.009	256	53.3	0.946	8	C	2	47.949	48.069	0.110	138.00	15.26	0.0000 Fracture
73	47.907	252	60.9	0.965	15	B	2	47.826	47.988	0.110	138.22	15.00	0.0000 Fracture
74	47.749	257	65.5	0.957	10	B	2	47.657	47.756	0.110	138.89	15.05	0.0000 Fracture Discontinuous
75	47.602	334	56.4	0.977	6	A	2	47.555	47.650	0.110	138.87	16.00	0.0000 Fracture Discontinuous
76	47.517	292	62.9	0.987	11	A	2	47.450	47.583	0.110	140.42	14.58	0.0000 Fracture Discontinuous
77	47.107	38	78.0	0.947	9	B	2	46.899	47.316	0.110	141.00	14.00	0.0000 Fracture
78	47.066	35	73.0	0.993	5	A	2	46.918	47.024	0.110	141.00	14.60	0.0000 Fracture Discontinuous
79	46.863	297	78.8	0.975	6	A	2	46.744	46.846	0.110	140.00	15.00	0.0000 Fracture Discontinuous
80	46.652	36	76.2	0.938	5	C	2	46.471	46.833	0.110	140.12	15.00	0.0000 Fracture Mineralized
81	46.599	29	78.2	0.990	6	A	2	46.416	46.566	0.110	139.06	15.94	0.0000 Fracture Discontinuous
82	46.475	37	71.0	0.994	6	A	2	46.332	46.439	0.110	137.42	15.58	0.0000 Fracture Discontinuous
83	45.608	308	70.8	0.979	4	A	2	45.528	45.688	0.110	138.48	15.76	0.0000 Fracture Irregular
84	45.482	43	19.1	0.962	8	B	2	45.459	45.505	0.110	139.72	15.28	0.0000
85	45.390	50	11.2	0.902	6	C	0	45.371	45.409	0.110	139.00	15.12	0.0000 Bedding

86	43.669	198	48.9	0.971	7	B	2	43.582	43.756	0.110	139.00	15.00	0.0000	Fracture
87	43.231	74	72.7	0.904	9	C	2	42.934	43.529	0.110	138.42	15.00	0.0000	Fracture
88	42.840	241	81.8	0.917	11	C	2	42.556	43.124	0.110	138.88	15.00	0.0000	Fracture
89	41.028	139	35.7	0.960	7	B	2	40.958	41.097	0.110	137.64	16.00	0.0000	Fracture
90	40.536	49	61.6	0.897	10	D	2	40.431	40.641	0.110	140.00	15.00	0.0000	Fracture Irregular
91	39.954	50	26.5	0.950	9	B	2	39.922	39.986	0.110	139.00	15.00	0.0000	Fracture Irregular
92	39.680	66	44.0	0.953	5	B	2	39.614	39.747	0.110	138.32	15.68	0.0000	Fracture
93	39.161	26	37.7	0.924	11	C	2	39.124	39.198	0.110	139.60	15.70	0.0000	Fracture
94	39.147	10	47.8	0.966	4	B	2	39.102	39.192	0.110	139.04	15.98	0.0000	Fracture
95	39.122	21	48.9	0.976	9	A	2	39.070	39.173	0.110	139.98	15.51	0.0000	Fracture
96	39.065	40	36.3	0.971	8	B	2	39.024	39.106	0.110	140.38	15.00	0.0000	Fracture
97	39.039	51	87.5	0.853	19	D	2	37.495	40.583	0.110	140.00	15.00	0.0000	Fracture Irregular
98	39.004	76	39.4	0.965	8	B	2	38.944	39.064	0.110	140.00	15.00	0.0000	Fracture
99	38.055	80	39.2	0.985	5	A	2	37.993	38.117	0.110	138.18	15.00	0.0000	Fracture
100	35.536	218	52.0	0.960	5	B	2	35.454	35.618	0.110	138.00	15.00	0.0000	Fracture
101	35.124	60	30.2	0.985	7	A	2	35.084	35.136	0.110	139.13	15.44	0.0000	Fracture Discontinuous
102	34.896	269	57.2	0.950	6	B	2	34.836	34.957	0.110	137.00	16.00	0.0000	Fracture
103	33.360	253	84.4	0.984	9	A	2	33.096	33.625	0.110	139.29	15.71	0.0000	Fracture Discontinuous
104	31.695	68	31.8	0.962	9	B	2	31.651	31.739	0.110	141.04	15.00	0.0000	Fracture
105	31.555	274	71.5	0.944	8	C	2	31.451	31.659	0.110	143.18	15.00	0.0000	Fracture
106	31.159	81	34.0	0.972	5	B	2	31.107	31.211	0.110	143.00	15.74	0.0000	Fracture
107	30.328	92	42.6	0.985	6	A	2	30.254	30.402	0.110	142.00	15.00	0.0000	Fracture
108	29.847	286	87.3	0.956	15	B	2	29.640	30.053	0.110	141.00	15.00	0.0000	Fracture Irregular
109	29.232	232	58.8	0.969	6	B	0	29.137	29.327	0.110	141.72	14.72	0.0000	Primary-structure
110	28.551	93	54.5	0.947	7	B	2	28.431	28.671	0.110	140.00	15.00	0.0000	Fracture Discontinuous
111	28.404	83	35.5	0.920	10	C	2	28.351	28.458	0.110	141.84	14.00	0.0000	Fracture Discontinuous
112	27.735	253	64.4	0.936	6	C	2	27.642	27.828	0.110	139.78	15.00	0.0000	Fracture Discontinuous
113	27.692	47	35.4	0.987	10	A	2	27.650	27.734	0.110	139.08	14.92	0.0000	Fracture Discontinuous
114	27.342	263	55.3	0.961	9	B	2	27.280	27.404	0.110	140.00	15.00	0.0000	Fracture Discontinuous
115	26.737	259	82.7	0.955	14	B	2	26.537	26.946	0.110	139.37	15.82	0.0000	Fracture Weathered
116	24.923	198	50.5	0.925	6	C	2	24.830	25.016	0.110	139.54	15.00	0.0000	Fracture Sheared
117	24.347	152	48.4	0.988	6	A	2	24.351	24.455	0.110	140.01	14.99	0.0000	Fracture Discontinuous
118	23.841	35	40.5	0.963	7	B	0	23.796	23.885	0.110	140.00	15.00	0.0000	Primary-structure
119	23.716	38	55.3	0.996	4	A	0	23.641	23.791	0.110	139.40	15.00	0.0000	Primary-structure
120	23.620	26	49.4	0.937	7	C	2	23.566	23.675	0.110	140.00	15.00	0.0000	Fracture Mineralized
121	23.445	322	41.7	0.966	7	B	2	23.418	23.473	0.110	139.01	15.00	0.0000	Fracture Mineralized
122	23.220	4	46.5	0.951	6	B	2	23.179	23.262	0.110	139.51	14.49	0.0000	Fracture Mineralized
123	21.741	12	46.4	0.942	6	C	0	21.696	21.785	0.110	138.89	15.11	0.0000	Primary-structure Sheared
124	21.577	30	55.2	0.937	6	C	0	21.507	21.648	0.110	137.75	15.00	0.0000	Primary-structure Sheared
125	21.453	44	28.3	0.964	6	B	0	21.420	21.486	0.110	139.00	15.00	0.0000	Crushed Bedding
126	21.119	67	28.4	0.888	12	D	0	21.079	21.159	0.110	138.08	15.00	0.0000	Primary-structure Sheared
127	20.832	33	11.2	0.959	8	B	0	20.816	20.848	0.110	138.72	15.00	0.0000	Crushed Bedding
128	20.758	19	13.3	0.978	7	A	0	20.744	20.772	0.110	138.76	15.00	0.0000	Bedding
129	20.734	23	19.2	0.977	6	A	0	20.715	20.752	0.110	139.25	15.00	0.0000	Bedding
130	20.687	19	19.6	0.982	7	A	0	20.670	20.704	0.110	139.82	15.00	0.0000	Bedding
131	20.615	355	16.8	0.982	6	A	0	20.606	20.625	0.110	139.61	15.00	0.0000	Bedding
132	20.378	193	35.1	0.967	9	B	2	20.322	20.434	0.110	139.63	15.00	0.0000	Fracture Discontinuous
133	20.375	342	48.3	0.935	6	C	0	20.337	20.414	0.110	139.59	15.00	0.0000	Primary-structure Sheared
134	20.250	87	24.4	0.994	5	A	2	20.211	20.289	0.110	139.00	15.00	0.0000	Fracture Discontinuous
135	20.218	24	28.3	0.981	5	A	2	20.194	20.244	0.110	139.00	15.00	0.0000	Fracture Discontinuous

136	20.207	156	48.9	0.976	8	A	2	20.176	20.317	0.110	139.00	15.00	0.0000	Fracture Discontinuous
137	20.185	241	27.1	0.966	6	B	2	20.156	20.214	0.110	138.78	15.22	0.0000	Fracture Discontinuous
138	20.020	15	28.2	0.952	5	B	0	19.996	20.044	0.110	137.07	15.48	0.0000	Bedding
139	19.881	229	38.5	0.936	7	C	0	19.833	19.929	0.110	141.10	14.30	0.0000	Primary-structure Sheared
140	19.441	239	84.1	0.950	13	B	2	19.062	19.819	0.110	139.00	15.00	0.0000	Fracture
141	19.009	1	51.4	0.947	4	B	2	18.961	19.056	0.110	138.27	15.00	0.0000	Fracture
142	18.970	63	65.3	0.985	9	A	2	18.819	19.121	0.110	138.00	15.00	0.0000	Fracture
143	18.848	159	28.5	0.957	6	B	0	18.796	18.901	0.110	137.10	16.00	0.0000	Primary-structure
144	18.107	95	65.0	0.987	5	A	2	17.934	18.331	0.110	139.00	15.00	0.0000	Fracture
145	18.090	58	62.0	0.987	6	A	2	17.989	18.194	0.110	138.87	15.13	0.0000	Fracture Discontinuous
146	17.985	38	56.3	0.975	6	A	2	17.965	18.062	0.110	139.77	15.00	0.0000	Fracture Discontinuous
147	17.984	228	19.8	0.976	5	A	0	17.959	18.010	0.110	139.77	15.00	0.0000	Primary-structure Sheared
148	17.307	355	26.8	0.961	4	B	0	17.290	17.323	0.110	138.00	16.00	0.0000	Bedding
149	16.896	94	14.2	0.952	10	B	0	16.868	16.924	0.110	138.00	15.00	0.0000	Bedding
150	16.772	148	17.7	0.974	6	A	0	16.737	16.808	0.110	139.00	15.00	0.0000	Bedding
151	16.658	154	42.7	0.956	10	B	2	16.572	16.744	0.110	137.76	15.24	0.0000	Fracture
152	16.548	176	38.5	1.000	4	A	2	16.478	16.619	0.110	139.90	16.00	0.0000	Fracture
153	16.069	190	26.1	0.989	6	A	2	16.026	16.111	0.110	138.36	15.55	0.0000	Fracture
154	15.161	200	25.9	0.963	8	B	0	15.122	15.201	0.110	137.31	16.00	0.0000	Primary-structure Sheared
155	14.990	28	32.3	0.967	6	B	2	14.958	15.022	0.110	137.12	15.88	0.0000	Fracture
156	14.737	10	52.4	0.959	9	B	2	14.684	14.791	0.110	138.00	15.17	0.0000	Fracture Mineralized
157	14.592	68	34.1	0.937	11	C	2	14.542	14.642	0.110	136.09	15.91	0.0000	Fracture
158	14.317	45	53.3	0.978	5	A	2	14.241	14.393	0.110	137.42	15.42	0.0000	Fracture
159	14.263	30	56.6	0.949	10	B	2	14.189	14.336	0.110	137.67	15.00	0.0000	Fracture
160	14.062	211	40.1	1.000	3	A	2	14.042	14.120	0.110	137.32	15.68	0.0000	Fracture Discontinuous
161	13.976	11	55.3	0.949	7	B	2	13.917	14.036	0.110	137.60	15.40	0.0000	Fracture
162	13.523	23	21.4	0.968	6	B	0	13.503	13.544	0.110	137.45	15.00	0.0000	Primary-structure Sheared
163	11.867	38	46.5	0.918	7	C	2	11.810	11.924	0.110	137.43	15.43	0.0000	Fracture

RGLDIPv6.1 BHTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-06
zone from 139.210 to 66.570 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	138.890	72	53.6	0.959	5	B	0	138.796	138.890	0.110	140.00	14.00	0.0000	Bedding
2	138.738	74	53.2	0.833	6	D	0	138.643	138.832	0.110	140.00	14.00	0.0000	Bedding
3	138.222	48	54.4	0.937	5	C	0	138.142	138.301	0.110	140.00	14.00	0.0000	Bedding
4	137.952	67	37.7	0.975	5	A	0	137.900	138.005	0.110	140.00	14.00	0.0000	Bedding
5	132.150	17	76.7	0.979	7	A	2	132.002	132.298	0.110	140.00	14.00	0.0000	Fracture
6	132.093	265	75.1	0.955	5	B	2	131.961	132.226	0.110	140.00	14.00	0.0000	Fracture
7	129.546	298	81.6	0.971	4	B	2	129.404	129.687	0.110	140.00	14.00	0.0000	Fracture
8	128.812	242	74.4	0.932	6	C	2	128.643	128.980	0.110	140.00	14.00	0.0000	Fracture
9	128.363	16	8.1	0.988	4	A	0	128.351	128.374	0.110	140.00	14.00	0.0000	Bedding
10	128.240	354	13.8	0.967	4	B	0	128.232	128.248	0.110	140.00	14.00	0.0000	Bedding
11	128.145	87	20.3	0.918	5	C	0	128.112	128.177	0.110	140.00	14.00	0.0000	Bedding
12	128.015	120	22.3	0.962	7	B	0	127.975	128.054	0.110	140.00	14.00	0.0000	Bedding
13	123.957	113	27.5	0.891	5	D	2	123.910	124.004	0.110	140.00	14.00	0.0000	Fracture
14	122.707	246	69.1	0.980	4	A	2	122.584	122.830	0.110	140.00	14.00	0.0000	Fracture
15	122.018	220	66.1	0.925	5	C	2	121.888	122.164	0.110	140.00	14.00	0.0000	Fracture Discontinuous
16	121.737	265	74.0	0.943	4	C	2	121.612	121.713	0.110	140.00	14.00	0.0000	Fracture Discontinuous
17	121.034	176	67.0	0.959	8	B	2	120.762	121.288	0.110	140.00	14.00	0.0000	Fracture Discontinuous
18	121.000	225	78.4	0.935	10	C	2	120.690	121.311	0.110	140.00	14.00	0.0000	Fracture
19	120.847	213	68.5	0.954	8	B	2	120.665	121.030	0.110	140.00	14.00	0.0000	Fracture Discontinuous
20	120.800	209	61.0	0.969	5	B	2	120.747	120.928	0.110	140.00	14.00	0.0000	Fracture Discontinuous
21	120.712	257	66.4	1.000	3	A	2	120.712	120.810	0.110	140.00	14.00	0.0000	Fracture Discontinuous
22	120.504	56	36.3	0.952	6	B	0	120.459	120.550	0.110	140.00	14.00	0.0000	Bedding
23	120.179	53	31.7	0.924	6	C	0	120.141	120.218	0.110	140.00	14.00	0.0000	Bedding
24	116.228	272	48.8	0.890	9	D	2	116.181	116.275	0.110	140.00	14.00	0.0000	Fracture Discontinuous
25	115.428	77	38.2	0.965	6	B	0	115.371	115.485	0.110	140.00	14.00	0.0000	Bedding
26	115.272	54	31.6	0.933	9	C	0	115.233	115.311	0.110	140.00	14.00	0.0000	Bedding
27	114.843	241	61.7	0.978	5	A	2	114.748	114.938	0.110	140.00	14.00	0.0000	Fracture
28	113.890	251	64.2	0.960	4	B	2	113.906	113.985	0.110	140.00	14.00	0.0000	Fracture Discontinuous
29	113.768	97	87.4	0.994	4	A	2	113.818	114.163	0.110	140.00	14.00	0.0000	Fracture
30	113.425	287	31.6	0.937	6	C	2	113.404	113.446	0.110	140.00	14.00	0.0000	Fracture
31	113.273	247	75.6	0.981	4	A	2	113.104	113.325	0.110	140.00	14.00	0.0000	Fracture Discontinuous
32	112.829	140	84.6	0.968	8	B	2	112.466	112.664	0.110	140.00	14.00	0.0000	Fracture Discontinuous
33	112.824	286	73.4	0.964	5	B	2	112.720	112.928	0.110	140.00	14.00	0.0000	Fracture
34	112.433	271	55.9	0.987	5	A	2	112.373	112.493	0.110	140.00	14.00	0.0000	Fracture
35	112.176	229	66.5	0.980	5	A	2	112.194	112.308	0.110	140.00	14.00	0.0000	Fracture Discontinuous

36	111.546	296	80.6	1.000	3	A	2	111.410	111.562	0.110	140.00	14.00	0.0000	Fracture Discontinuous
37	111.215	228	75.7	0.906	10	C	2	110.982	111.449	0.110	140.00	14.00	0.0000	Fracture Discontinuous
38	110.838	242	61.3	0.914	9	C	2	110.745	110.930	0.110	140.00	14.00	0.0000	Fracture Discontinuous
39	110.430	270	74.4	0.974	4	A	2	110.308	110.438	0.110	140.00	14.00	0.0000	Fracture Discontinuous
40	110.397	258	44.4	0.970	5	B	2	110.411	110.442	0.110	140.00	14.00	0.0000	Fracture Discontinuous
41	109.927	269	38.8	0.934	5	C	2	109.893	109.961	0.110	140.00	14.00	0.0000	Fracture
42	109.666	291	36.0	0.901	7	C	2	109.641	109.691	0.110	140.00	14.00	0.0000	Fracture OFFSET
43	109.539	101	62.5	0.967	5	B	2	109.654	109.726	0.110	140.00	14.00	0.0000	Fracture Discontinuous
44	109.143	285	42.9	0.890	7	D	2	109.109	109.178	0.110	140.00	14.00	0.0000	Fracture
45	108.417	262	21.5	0.911	5	C	2	108.399	108.435	0.110	140.00	14.00	0.0000	Fracture Discontinuous
46	108.257	247	48.8	0.981	5	A	2	108.200	108.314	0.110	140.00	14.00	0.0000	Fracture Discontinuous
47	107.529	254	34.0	0.846	5	D	0	107.496	107.561	0.110	140.00	14.00	0.0000	Bedding
48	107.365	52	53.6	0.872	7	D	2	107.285	107.444	0.110	140.00	14.00	0.0000	Fracture
49	107.044	213	38.3	0.907	5	C	0	106.991	107.097	0.110	140.00	14.00	0.0000	Bedding
50	106.915	219	50.9	0.930	8	C	0	106.837	106.993	0.110	140.00	14.00	0.0000	Bedding
51	106.800	74	38.6	0.945	6	C	0	106.743	106.856	0.110	140.00	14.00	0.0000	Bedding
52	106.723	95	29.8	0.975	6	A	0	106.676	106.770	0.110	140.00	14.00	0.0000	Bedding
53	106.581	94	34.5	0.955	5	B	0	106.526	106.637	0.110	140.00	14.00	0.0000	Bedding
54	106.397	241	36.0	0.994	5	A	2	106.395	106.436	0.110	140.00	14.00	0.0000	Fracture
55	106.360	85	26.0	0.924	8	C	0	106.321	106.400	0.110	140.00	14.00	0.0000	Bedding
56	106.323	79	15.9	0.971	4	B	0	106.297	106.349	0.110	140.00	14.00	0.0000	Bedding
57	106.279	94	18.3	0.946	5	C	0	106.248	106.310	0.110	140.00	14.00	0.0000	Bedding
58	106.036	107	26.5	0.939	5	C	0	105.991	106.080	0.110	140.00	14.00	0.0000	Bedding
59	105.856	92	15.5	0.948	6	B	0	105.828	105.884	0.110	140.00	14.00	0.0000	Bedding
60	105.750	88	28.3	0.943	8	C	0	105.707	105.794	0.110	140.00	14.00	0.0000	Bedding
61	105.655	98	19.6	0.919	8	C	0	105.622	105.689	0.110	140.00	14.00	0.0000	Bedding
62	105.430	63	36.7	0.961	7	B	0	105.381	105.480	0.110	140.00	14.00	0.0000	Bedding
63	105.320	40	32.7	0.903	6	C	0	105.285	105.356	0.110	140.00	14.00	0.0000	Bedding
64	105.056	58	35.8	0.953	10	B	0	105.010	105.102	0.110	140.00	14.00	0.0000	Bedding
65	104.954	90	36.2	0.906	8	C	0	104.896	105.011	0.110	140.00	14.00	0.0000	Bedding
66	104.862	80	19.8	0.960	4	B	0	104.831	104.893	0.110	140.00	14.00	0.0000	Bedding
67	104.678	55	29.3	0.968	7	B	0	104.642	104.714	0.110	140.00	14.00	0.0000	Bedding
68	104.478	66	39.1	0.920	10	C	0	104.424	104.532	0.110	140.00	14.00	0.0000	Bedding
69	104.153	83	55.8	0.905	6	C	0	104.040	104.210	0.110	140.00	14.00	0.0000	Bedding
70	104.084	69	61.4	0.971	5	B	0	103.956	104.141	0.110	140.00	14.00	0.0000	Bedding
71	103.748	33	64.4	0.913	7	C	0	103.648	103.848	0.110	140.00	14.00	0.0000	Bedding
72	103.745	76	72.5	0.950	10	B	2	103.798	104.027	0.110	140.00	14.00	0.0000	Fracture
73	103.426	97	41.8	0.946	4	C	0	103.391	103.498	0.110	140.00	14.00	0.0000	Bedding
74	103.356	91	44.9	0.900	9	C	0	103.278	103.434	0.110	140.00	14.00	0.0000	Bedding
75	102.988	57	77.1	0.920	15	C	2	102.701	103.276	0.110	140.00	14.00	0.0000	Fracture
76	102.790	45	46.1	0.910	7	C	0	102.732	102.848	0.110	140.00	14.00	0.0000	Bedding
77	102.173	74	49.1	0.876	8	D	0	102.092	102.254	0.110	140.00	14.00	0.0000	Bedding
78	101.697	53	57.1	0.925	6	C	0	101.605	101.763	0.110	140.00	14.00	0.0000	Bedding
79	101.502	70	57.6	0.945	5	C	0	101.393	101.505	0.110	140.00	14.00	0.0000	Bedding
80	101.094	60	57.0	0.950	5	B	0	100.998	101.191	0.110	140.00	14.00	0.0000	Bedding
81	100.902	58	43.5	0.975	4	A	0	100.843	100.926	0.110	140.00	14.00	0.0000	Bedding
82	100.413	38	60.4	0.934	8	C	0	100.323	100.502	0.110	140.00	14.00	0.0000	Bedding
83	100.321	33	55.9	0.980	4	A	0	100.248	100.394	0.110	140.00	14.00	0.0000	Bedding
84	100.050	32	61.6	0.940	7	C	0	99.961	100.139	0.110	140.00	14.00	0.0000	Bedding
85	99.900	31	48.7	0.965	9	B	0	99.843	99.956	0.110	140.00	14.00	0.0000	Bedding

86	99.805	34	56.2	0.908	7	C	0	99.730	99.879	0.110	140.00	14.00	0.0000 Bedding
87	97.599	96	18.1	0.953	5	B	0	97.567	97.630	0.110	140.00	14.00	0.0000 Bedding
88	97.208	130	25.5	0.945	7	C	0	97.163	97.253	0.110	140.00	14.00	0.0000 Bedding
89	96.467	6	56.7	0.906	8	C	0	96.407	96.527	0.110	140.00	14.00	0.0000 Bedding
90	96.306	3	46.9	0.968	6	B	0	96.264	96.348	0.110	140.00	14.00	0.0000 Bedding
91	95.855	8	38.3	0.955	7	B	0	95.822	95.887	0.110	140.00	14.00	0.0000 Bedding
92	95.388	19	16.6	0.980	5	A	0	95.373	95.403	0.110	140.00	14.00	0.0000 Bedding
93	94.934	42	20.0	0.948	6	B	0	94.911	94.957	0.110	140.00	14.00	0.0000 Bedding
94	94.769	9	38.6	0.897	10	D	0	94.736	94.802	0.110	140.00	14.00	0.0000 Bedding
95	93.573	103	33.4	0.983	5	A	0	93.518	93.629	0.110	140.00	14.00	0.0000 Bedding
96	93.240	95	18.5	0.898	11	D	0	93.208	93.272	0.110	140.00	14.00	0.0000 Bedding
97	92.999	99	7.9	0.990	6	A	0	92.979	93.020	0.110	140.00	14.00	0.0000 Bedding
98	92.567	267	39.5	1.000	3	A	2	92.539	92.602	0.110	140.00	14.00	0.0000 Fracture Discontinuous
99	92.495	230	80.2	0.985	6	A	2	92.635	92.828	0.110	140.00	14.00	0.0000 Fracture Discontinuous
100	92.264	259	63.8	0.940	5	C	2	92.177	92.351	0.110	140.00	14.00	0.0000 Fracture
101	91.988	126	80.3	0.996	6	A	2	91.184	91.354	0.110	140.00	14.00	0.0000 Fracture Discontinuous
102	91.788	112	47.1	0.995	4	A	2	91.803	91.882	0.110	140.00	14.00	0.0000 Fracture
103	90.718	63	26.5	0.892	7	D	0	90.683	90.753	0.110	140.00	14.00	0.0000 Bedding
104	90.404	214	33.1	0.996	6	A	0	90.359	90.448	0.110	140.00	14.00	0.0000 Bedding
105	89.904	69	66.2	0.944	10	C	2	89.741	90.067	0.110	140.00	14.00	0.0000 Fracture
106	89.677	252	33.4	1.000	4	A	2	89.645	89.709	0.110	140.00	14.00	0.0000 Fracture
107	89.048	267	32.1	0.945	5	C	2	89.021	89.075	0.110	140.00	14.00	0.0000 Fracture
108	88.571	239	40.4	0.969	6	B	2	88.525	88.618	0.110	140.00	14.00	0.0000 Fracture
109	88.530	69	75.2	0.965	6	B	2	88.212	88.569	0.110	140.00	14.00	0.0000 Fracture Discontinuous
110	86.636	43	71.8	0.976	6	A	2	86.479	86.717	0.110	140.00	14.00	0.0000 Fracture Irregular
111	85.553	237	85.4	0.909	14	C	2	85.348	86.009	0.110	140.00	14.00	0.0000 Fracture
112	85.433	37	74.9	0.962	5	B	2	85.261	85.418	0.110	140.00	14.00	0.0000 Fracture Discontinuous
113	85.369	209	55.7	0.883	8	D	2	85.267	85.471	0.110	140.00	14.00	0.0000 Fracture
114	84.880	226	70.0	0.922	9	C	2	84.715	85.044	0.110	140.00	14.00	0.0000 Fracture
115	84.570	182	49.9	0.882	7	D	2	84.471	84.668	0.110	140.00	14.00	0.0000 Fracture Irregular
116	83.260	242	59.5	0.980	6	A	2	83.188	83.347	0.110	140.00	14.00	0.0000 Fracture Discontinuous
117	83.042	239	54.3	1.000	4	A	2	83.038	83.115	0.110	140.00	14.00	0.0000 Fracture Discontinuous
118	82.901	241	59.3	0.966	5	B	2	82.896	82.988	0.110	140.00	14.00	0.0000 Fracture Discontinuous
119	81.444	240	85.3	0.992	5	A	2	81.412	81.902	0.110	140.00	14.00	0.0000 Fracture Discontinuous
120	81.031	265	73.6	0.874	9	D	2	80.907	81.155	0.110	140.00	14.00	0.0000 Fracture Discontinuous
121	80.737	224	42.6	0.886	6	D	0	80.680	80.793	0.110	140.00	14.00	0.0000 Bedding
122	80.676	219	44.2	0.978	6	A	0	80.614	80.738	0.110	140.00	14.00	0.0000 Bedding
123	80.616	42	83.8	0.938	11	C	2	80.216	80.678	0.110	140.00	14.00	0.0000 Fracture Discontinuous
124	79.300	337	78.4	0.866	5	D	2	79.182	79.418	0.110	140.00	14.00	0.0000 Fracture
125	78.934	228	51.1	0.972	5	B	2	78.861	79.007	0.110	140.00	14.00	0.0000 Fracture
126	78.612	321	75.0	0.920	6	C	2	78.513	78.711	0.110	140.00	14.00	0.0000 Fracture
127	78.435	53	81.2	0.941	5	C	2	78.379	78.838	0.110	140.00	14.00	0.0000 Fracture Discontinuous
128	78.257	255	66.8	0.846	12	D	0	78.156	78.358	0.110	140.00	14.00	0.0000 Bedding
129	76.368	241	59.3	0.941	5	C	2	76.281	76.455	0.110	140.00	14.00	0.0000 Fracture
130	75.914	337	77.5	0.910	5	C	2	75.800	76.027	0.110	140.00	14.00	0.0000 Fracture
131	75.433	264	36.6	0.983	4	A	2	75.401	75.466	0.110	140.00	14.00	0.0000 Fracture
132	75.105	268	68.0	0.916	5	C	2	75.010	75.200	0.110	140.00	14.00	0.0000 Fracture
133	74.181	255	83.1	0.933	8	C	2	74.155	74.425	0.110	140.00	14.00	0.0000 Fracture Discontinuous
134	74.152	251	64.8	0.991	4	A	2	74.055	74.249	0.110	140.00	14.00	0.0000 Fracture
135	74.090	262	69.5	0.911	7	C	2	73.984	74.197	0.110	140.00	14.00	0.0000 Fracture Discontinuous

136	73.875	275	81.3	0.932	13	C	2	73.709	74.041	0.110	140.00	14.00	0.0000	Fracture
137	73.407	275	81.6	0.917	10	C	2	73.238	73.575	0.110	140.00	14.00	0.0000	Fracture
138	73.377	297	59.7	0.933	5	C	2	73.369	73.437	0.110	140.00	14.00	0.0000	Fracture
139	73.347	84	74.5	0.953	14	B	2	72.929	73.765	0.110	140.00	14.00	0.0000	Fracture
140	73.146	283	86.0	0.948	4	B	2	73.171	73.350	0.110	140.00	14.00	0.0000	Fracture
141	73.068	280	81.0	0.968	4	B	2	73.123	73.222	0.110	140.00	14.00	0.0000	Fracture Discontinuous
142	73.045	216	58.2	0.972	5	B	2	72.939	73.147	0.110	140.00	14.00	0.0000	Fracture
143	72.790	273	80.6	0.965	6	B	2	72.627	72.953	0.110	140.00	14.00	0.0000	Fracture
144	72.584	272	73.8	0.965	6	B	2	72.467	72.701	0.110	140.00	14.00	0.0000	Fracture
145	72.490	268	81.9	0.937	10	C	2	72.304	72.676	0.110	140.00	14.00	0.0000	Fracture
146	71.534	278	84.5	0.938	8	C	2	71.340	71.729	0.110	140.00	14.00	0.0000	Fracture
147	71.022	272	70.7	0.984	5	A	2	70.919	71.124	0.110	140.00	14.00	0.0000	Fracture
148	70.848	269	73.3	0.955	8	B	2	70.731	70.964	0.110	140.00	14.00	0.0000	Fracture
149	70.328	265	50.1	0.843	14	D	2	70.277	70.375	0.110	140.00	14.00	0.0000	Fracture Discontinuous
150	70.197	271	85.8	0.989	5	A	2	69.963	70.189	0.110	140.00	14.00	0.0000	Fracture Discontinuous
151	69.528	294	82.1	0.955	6	B	2	69.380	69.629	0.110	140.00	14.00	0.0000	Fracture Discontinuous
152	67.784	238	73.1	0.958	5	B	2	67.730	67.951	0.110	140.00	14.00	0.0000	Fracture Discontinuous
153	67.561	241	42.3	1.000	4	A	2	67.542	67.610	0.110	140.00	14.00	0.0000	Fracture Discontinuous
154	67.321	261	67.7	0.853	6	D	2	67.226	67.421	0.110	140.00	14.00	0.0000	Fracture Discontinuous
155	67.135	25	77.1	0.917	8	C	2	66.972	67.299	0.110	140.00	14.00	0.0000	Fracture

RGLDIPv6.1 OPTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-07
zone from 115.467 to 16.606 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	115.411	0	0.0	1.000	0	*	2	115.399	115.424	0.110	0.00	0.00	0.0000	Fracture
2	114.777	342	83.2	0.965	8	B	2	114.702	114.851	0.110	201.00	40.45	0.0000	Fracture Discontinuous
3	114.717	23	70.3	0.980	8	A	2	114.685	114.748	0.110	201.00	40.75	0.0000	Fracture
4	114.165	48	81.8	0.964	5	B	2	114.108	114.221	0.110	203.37	41.00	0.0000	Fracture
5	114.063	40	76.0	0.981	5	A	2	114.020	114.106	0.110	202.00	41.00	0.0000	Fracture
6	113.925	211	88.8	0.970	6	B	2	113.857	113.992	0.110	201.59	41.00	0.0000	Fracture
7	113.825	22	83.7	0.958	7	B	2	113.774	113.875	0.110	202.59	41.00	0.0000	Fracture
8	112.554	238	81.2	0.951	9	B	2	112.480	112.681	0.110	201.01	41.00	0.0000	Fracture Discontinuous
9	112.384	64	90.0	0.973	5	A	2	112.286	112.355	0.110	202.00	41.00	0.0000	Fracture Discontinuous
10	110.420	56	88.3	0.972	6	B	2	110.339	110.500	0.110	202.00	41.00	0.0000	Fracture
11	110.268	52	74.7	0.986	9	A	2	110.219	110.316	0.110	202.00	41.00	0.0000	Fracture Discontinuous
12	107.440	12	70.2	0.977	6	A	2	107.410	107.471	0.110	202.00	42.00	0.0000	Fracture Irregular
13	107.402	15	67.7	0.970	8	B	2	107.374	107.421	0.110	202.00	41.95	0.0000	Fracture Discontinuous
14	107.359	20	56.2	0.969	10	B	2	107.344	107.371	0.110	202.00	41.10	0.0000	Fracture Discontinuous
15	104.573	35	76.8	0.975	7	A	2	104.532	104.614	0.110	202.00	41.62	0.0000	Hairline-fracture
16	103.995	17	85.5	0.988	10	A	2	103.943	104.048	0.110	202.00	42.00	0.0000	Hairline-fracture
17	102.670	224	76.7	0.983	9	A	2	102.557	102.783	0.110	202.67	42.00	0.0000	Hairline-fracture
18	102.351	87	86.8	0.944	12	C	2	102.220	102.513	0.110	202.00	41.94	0.0000	Fracture
19	102.064	81	87.3	0.877	20	D	2	101.929	102.199	0.110	202.00	41.19	0.0000	Fracture Irregular
20	101.958	67	68.3	0.908	8	C	2	101.903	102.012	0.110	202.00	42.00	0.0000	Fracture Irregular
21	101.811	360	62.3	0.974	6	A	2	101.782	101.837	0.110	202.00	41.13	0.0000	Fracture Discontinuous
22	101.590	64	62.2	0.982	7	A	2	101.547	101.634	0.110	202.00	41.73	0.0000	Fracture Discontinuous fracture
23	101.528	18	68.6	0.997	4	A	2	101.500	101.549	0.110	202.00	41.52	0.0000	Discontinuous Hairline-fracture
24	101.054	234	86.2	0.961	11	B	2	100.963	101.146	0.110	202.00	42.00	0.0000	Fracture Mineralized
25	100.483	107	84.1	0.945	12	C	2	100.222	100.892	0.110	202.00	42.00	0.0000	Fracture Discontinuous
26	100.439	50	78.0	0.972	13	B	2	100.388	100.490	0.110	202.00	42.00	0.0000	Fracture
27	100.225	92	79.7	0.963	10	B	2	100.079	100.371	0.110	202.00	42.00	0.0000	Fracture
28	99.834	358	70.9	0.974	7	A	2	99.795	99.868	0.110	202.00	42.00	0.0000	Fracture Discontinuous
29	99.815	104	76.4	0.978	15	A	2	99.617	100.014	0.110	202.00	42.00	0.0000	Fracture Discontinuous
30	99.749	95	83.8	0.930	13	C	2	99.563	99.941	0.110	202.00	41.91	0.0000	Fracture Discontinuous
31	99.700	18	68.3	0.978	10	A	2	99.672	99.729	0.110	202.00	41.08	0.0128	Vein Mineralized
32	99.659	17	75.1	0.954	8	B	2	99.623	99.696	0.110	202.00	41.89	0.0000	Vein
33	99.596	92	84.0	0.940	23	C	2	99.421	99.771	0.110	202.00	42.00	0.0000	Fracture Irregular
34	99.495	82	79.1	0.979	7	A	2	99.392	99.557	0.110	202.00	42.17	0.0000	Fracture Discontinuous
35	99.324	163	82.7	0.912	17	C	2	99.205	99.443	0.110	202.00	42.00	0.0000	Fracture Mineralized

36	99.224	335	77.7	0.926	9	C	2	99.151	99.298	0.110	202.59	42.00	0.0000 Fracture
37	99.167	346	75.4	0.939	12	C	2	99.113	99.221	0.110	202.26	42.00	0.0000 Fracture Mineralized
38	98.946	337	77.7	0.937	13	C	2	98.877	99.016	0.110	202.15	42.00	0.0000 Fracture
39	98.519	325	65.2	0.954	8	B	2	98.451	98.587	0.110	203.00	42.00	0.0000 Fracture
40	98.508	231	67.7	0.979	7	A	2	98.310	98.585	0.110	203.00	42.00	0.0000 Fracture Discontinuous
41	98.426	13	70.2	0.952	7	B	2	98.395	98.456	0.110	202.43	42.00	0.0000 Fracture
42	97.577	227	66.6	0.925	13	C	2	97.376	97.778	0.110	202.00	42.00	0.0000 Fracture Mineralized
43	97.279	297	79.5	0.949	10	B	2	97.023	97.336	0.110	202.51	42.00	0.0000 Fracture Discontinuous
44	97.253	343	69.4	0.988	7	A	2	97.204	97.302	0.110	202.00	42.00	0.0000 Fracture
45	97.025	244	69.6	0.984	10	A	2	96.761	96.860	0.110	202.00	42.00	0.0000 Fracture Discontinuous
46	97.007	31	82.7	0.953	8	B	2	96.958	97.056	0.110	202.00	42.00	0.0000 Fracture
47	96.943	33	65.8	0.961	9	B	2	96.917	96.968	0.110	202.00	42.00	0.0000 Fracture
48	96.401	356	86.4	0.991	12	A	2	96.335	96.467	0.110	202.95	42.00	0.0000 contract
49	96.323	359	86.4	0.943	8	C	2	96.260	96.385	0.110	202.00	42.00	0.0000 Fracture
50	96.035	177	89.2	0.936	9	C	2	95.961	96.109	0.110	202.38	42.00	0.0000 Fracture Irregular
51	95.849	191	79.1	0.956	5	B	2	95.754	95.943	0.110	202.89	42.00	0.0000 Fracture Mineralized
52	95.699	41	66.0	0.985	5	A	2	95.669	95.729	0.110	202.00	42.00	0.0000 Fracture
53	95.435	50	72.0	0.959	17	B	2	95.393	95.478	0.110	202.00	42.00	0.0000 Fracture
54	94.954	163	88.6	0.960	10	B	2	94.859	95.049	0.110	202.00	42.00	0.0000 Fracture Mineralized
55	94.814	164	80.2	0.977	9	A	2	94.684	94.944	0.110	202.00	42.00	0.0000 Hairline-fracture
56	94.676	31	79.1	0.991	8	A	2	94.633	94.719	0.110	202.00	42.00	0.0000 Hairline-fracture
57	94.617	41	84.8	0.913	10	C	2	94.560	94.673	0.110	202.00	42.00	0.0000 Fracture
58	94.006	216	88.8	0.960	13	B	2	93.940	94.073	0.110	203.00	42.00	0.0000 Fracture
59	92.911	106	22.5	0.988	8	A	2	92.857	92.965	0.110	202.14	42.00	0.0000 Fracture
60	92.813	65	17.1	0.975	6	A	2	92.779	92.846	0.110	202.00	42.00	0.0000 Fracture
61	92.564	227	86.0	0.941	7	C	2	92.481	92.646	0.110	202.00	42.00	0.0000 Fracture Mineralized
62	92.462	233	63.8	0.947	12	B	2	92.177	92.747	0.110	202.84	42.00	0.0000 Fracture Mineralized
63	91.600	204	80.1	0.951	7	B	2	91.509	91.691	0.110	202.00	41.07	0.0000 Fracture Mineralized
64	91.265	24	84.3	0.968	6	B	2	91.215	91.315	0.110	202.57	42.00	0.0000 Fracture
65	91.063	224	72.6	0.935	16	C	2	90.928	91.198	0.110	203.00	42.18	0.0000 Fracture Sheared
66	90.967	227	67.7	0.974	10	A	2	90.780	91.154	0.110	203.00	42.00	0.0000 Fracture Sheared
67	90.938	223	56.7	0.961	16	B	2	90.750	91.401	0.110	203.00	42.00	0.0000 Fracture Discontinuous
68	90.924	227	74.6	0.970	7	B	2	90.794	90.911	0.110	203.00	42.00	0.0000 Fracture Discontinuous
69	90.872	233	77.6	0.985	6	A	2	90.749	90.882	0.110	203.00	42.00	0.0000 Fracture Discontinuous
70	90.826	227	79.9	0.987	7	A	2	90.724	90.829	0.110	203.00	42.00	0.0000 Fracture Discontinuous
71	90.682	256	89.1	0.986	6	A	2	90.551	90.672	0.110	203.00	42.00	0.0000 Fracture Discontinuous
72	90.343	200	84.5	0.978	7	A	2	90.271	90.416	0.110	203.00	42.78	0.0000 Fracture
73	90.267	211	81.6	0.965	9	B	2	90.185	90.350	0.110	202.27	42.73	0.0000 Fracture
74	89.625	243	43.4	0.925	13	C	2	89.325	89.926	0.110	203.00	42.43	0.0000 Fracture
75	89.443	213	80.4	0.948	7	B	2	89.400	89.532	0.110	203.00	42.00	0.0000 Fracture Discontinuous
76	88.164	27	85.5	0.988	5	A	2	88.113	88.215	0.110	203.00	42.81	0.0000 Hairline-fracture
77	88.118	26	77.9	0.982	4	A	2	88.079	88.158	0.110	203.00	42.28	0.0000 Hairline-fracture
78	87.893	25	78.4	0.972	7	B	2	87.853	87.932	0.110	202.23	43.00	0.0000 Hairline-fracture
79	87.762	213	87.2	0.991	8	A	2	87.692	87.831	0.110	202.00	42.16	0.0000 Hairline-fracture
80	87.707	25	82.8	0.977	6	A	2	87.660	87.755	0.110	202.00	42.00	0.0000 Hairline-fracture
81	87.669	215	68.8	0.973	10	A	2	87.589	87.822	0.110	202.00	42.00	0.0000 Fracture Weathered
82	87.258	25	81.5	0.974	5	A	2	87.212	87.271	0.110	203.00	42.00	0.0000 Fracture
83	87.229	19	85.0	0.985	5	A	2	87.178	87.243	0.110	202.51	42.00	0.0000 Fracture
84	87.156	201	71.4	0.972	9	B	2	87.034	87.277	0.110	202.97	42.97	0.0000 Fracture
85	86.804	211	61.4	0.988	6	A	2	86.689	87.022	0.110	203.99	42.99	0.0000 Fracture

86	86.322	207	74.3	0.916	9	C	2	86.249	86.429	0.110	203.63	43.00	0.0000	
87	85.560	30	79.3	0.958	6	B	2	85.518	85.602	0.110	203.00	42.12	0.0000	Fracture
88	85.265	322	24.3	0.983	7	A	2	85.224	85.307	0.110	203.77	43.00	0.0000	Hairline-fracture
89	85.130	295	30.0	0.990	7	A	2	85.065	85.196	0.110	203.00	43.00	0.0000	Hairline-fracture
90	84.889	295	29.0	0.972	6	B	2	84.825	84.953	0.110	203.00	43.00	0.0000	Mineralized Hairline-fracture
91	84.442	328	22.4	0.955	7	B	2	84.405	84.479	0.110	203.00	42.76	0.0000	Hairline-fracture
92	84.299	55	83.7	0.945	8	C	2	84.236	84.362	0.110	203.00	43.00	0.0000	Fracture
93	84.142	133	31.2	0.953	7	B	2	84.123	84.237	0.110	203.00	43.00	0.0000	Fracture Discontinuous
94	84.097	151	89.7	0.979	6	A	2	84.080	84.218	0.110	203.00	43.00	0.0000	Fracture Discontinuous
95	84.086	144	88.6	0.985	8	A	2	84.169	84.241	0.110	203.00	43.00	0.0000	Fracture Discontinuous
96	83.570	57	69.7	0.905	10	C	2	83.527	83.604	0.110	203.00	42.33	0.0000	Fracture Discontinuous
97	83.054	47	89.3	0.998	4	A	2	82.986	83.122	0.110	203.00	43.00	0.0000	Fracture
98	83.033	316	87.5	0.947	12	C	2	82.858	83.207	0.110	203.00	43.00	0.0000	Fracture
99	82.825	353	28.8	0.995	4	A	2	82.803	82.848	0.110	203.00	42.43	0.0000	Fracture
100	82.669	273	27.3	0.944	10	C	2	82.584	82.754	0.110	203.00	43.00	0.0000	Fracture
101	81.583	213	89.0	0.911	7	C	2	81.520	81.646	0.110	203.00	43.00	0.0000	Fracture
102	81.452	234	67.5	0.930	8	C	2	81.247	81.658	0.110	203.00	43.00	0.0000	Fracture
103	81.368	45	89.6	0.971	10	B	2	81.301	81.434	0.110	203.00	43.00	0.0000	Fracture
104	79.968	232	77.9	0.991	5	A	2	79.849	80.087	0.110	203.00	42.28	0.0000	Fracture
105	79.918	210	71.5	0.995	6	A	2	79.794	80.042	0.110	203.00	42.72	0.0000	Fracture
106	79.844	221	71.4	0.953	14	B	2	79.705	79.982	0.110	203.00	42.20	0.0000	Fracture
107	79.398	70	70.3	0.929	9	C	2	79.339	79.457	0.110	203.00	42.88	0.0000	Fracture
108	79.230	85	71.4	0.976	8	A	2	79.163	79.317	0.110	203.00	43.00	0.0000	Fracture Discontinuous
109	79.151	295	59.4	0.957	25	B	2	79.023	79.279	0.110	203.00	42.06	0.0000	Fracture
110	78.334	23	47.4	0.984	6	A	2	78.330	78.338	0.110	203.00	43.00	0.0000	Fracture Irregular
111	78.097	12	46.2	0.985	4	A	2	78.089	78.106	0.110	203.00	43.00	0.0000	Fracture
112	78.058	230	71.7	0.975	12	A	2	77.908	78.208	0.110	203.00	43.00	0.0000	Fracture
113	78.057	26	57.3	0.989	8	A	2	78.043	78.072	0.110	203.00	43.00	0.0000	Fracture
114	77.912	236	77.3	0.881	9	D	2	77.784	78.040	0.110	203.00	43.00	0.0000	Fracture
115	77.672	43	44.3	0.979	6	A	2	77.659	77.686	0.110	203.00	43.00	0.0000	Fracture
116	77.426	54	67.4	0.881	13	D	2	77.388	77.465	0.110	203.00	42.44	0.0000	Fracture
117	77.164	94	33.3	0.843	12	D	2	77.114	77.215	0.110	203.79	43.00	0.0000	Fracture Irregular
118	76.991	34	77.9	0.966	9	B	2	76.951	77.031	0.110	203.00	43.00	0.0000	Fracture Irregular
119	73.410	40	72.1	0.947	10	B	2	73.375	73.444	0.110	203.00	43.00	0.0000	Fracture Irregular
120	71.583	337	43.9	0.954	8	B	2	71.548	71.618	0.110	204.00	43.42	0.0000	Fracture Irregular
121	71.540	230	81.8	0.932	15	C	2	71.449	71.631	0.110	204.00	44.00	0.0000	Fracture Irregular
122	71.394	47	85.3	0.981	8	A	2	71.336	71.452	0.110	203.80	43.00	0.0000	Fracture Discontinuous
123	71.302	68	6.2	0.952	9	B	2	71.256	71.347	0.110	204.00	43.95	0.0000	Fracture Irregular
124	71.143	271	35.0	0.882	11	D	2	71.032	71.254	0.110	204.00	43.00	0.0000	Fracture Irregular
125	70.758	210	88.2	0.944	13	C	2	70.695	70.821	0.110	204.00	43.08	0.0000	Fracture Irregular
126	70.433	206	85.5	0.949	16	B	2	70.364	70.501	0.110	204.00	43.43	0.0000	Fracture Irregular
127	68.364	54	25.3	0.940	9	C	2	68.339	68.389	0.110	203.80	43.00	0.0000	Fracture Irregular
128	68.193	81	47.0	0.972	7	B	2	68.146	68.240	0.110	203.00	43.21	0.0000	contract Hairline-fracture
129	68.084	87	37.6	0.972	7	B	0	68.037	68.131	0.110	204.00	44.60	0.0000	Bedding
130	68.035	77	40.4	0.987	5	A	0	67.997	68.073	0.110	204.00	43.62	0.0000	Bedding
131	67.861	71	45.0	0.968	13	B	0	67.826	67.895	0.110	204.00	43.00	0.0000	Bedding
132	67.737	76	53.7	0.992	5	A	0	67.691	67.783	0.110	204.00	43.00	0.0000	Bedding
133	67.586	75	52.2	0.975	6	A	0	67.542	67.629	0.110	203.63	43.00	0.0000	Bedding
134	67.382	83	56.2	0.982	5	A	0	67.326	67.439	0.110	204.00	44.00	0.0000	Bedding
135	67.317	76	56.6	0.965	14	B	0	67.269	67.364	0.110	204.00	43.26	0.0000	Bedding

136	67.132	66	54.5	0.987	5	A	0	67.098	67.168	0.110	204.00	43.56	0.0000	Discontinuous Bedding
137	67.025	62	31.0	0.966	8	B	0	66.999	67.051	0.110	204.00	43.58	0.0000	Bedding
138	66.829	65	42.2	0.976	5	A	0	66.801	66.857	0.110	204.00	43.00	0.0000	Bedding
139	66.744	75	52.5	0.987	6	A	0	66.700	66.787	0.110	204.00	43.21	0.0000	Bedding
140	66.636	67	59.4	0.967	5	B	0	66.595	66.677	0.110	204.00	43.00	0.0000	Bedding
141	66.519	58	34.7	0.978	6	A	0	66.496	66.542	0.110	204.00	43.00	0.0000	Bedding
142	66.342	45	59.0	0.969	9	B	0	66.319	66.364	0.110	204.00	43.00	0.0000	Bedding
143	66.292	51	55.6	0.957	5	B	0	66.268	66.316	0.110	204.00	43.25	0.0000	Bedding
144	66.209	63	44.0	0.967	8	B	0	66.181	66.237	0.110	204.00	44.00	0.0000	Bedding
145	66.041	65	42.7	0.937	8	C	0	66.012	66.070	0.110	204.00	43.74	0.0000	Bedding
146	65.922	49	58.2	0.948	6	B	0	65.897	65.947	0.110	204.00	43.64	0.0000	Bedding
147	65.838	46	48.3	0.948	5	B	2	65.822	65.854	0.110	204.00	43.32	0.0000	Fracture
148	65.276	69	47.8	0.972	7	B	2	65.241	65.311	0.110	203.57	43.57	0.0000	Fracture
149	65.203	67	51.7	0.982	7	A	0	65.168	65.237	0.110	204.00	43.02	0.0000	Bedding
150	65.129	69	48.2	0.949	6	B	2	65.095	65.164	0.110	204.00	43.50	0.0000	Fracture
151	65.007	62	49.1	0.973	9	A	0	64.978	65.036	0.110	204.00	43.00	0.0000	Bedding
152	64.957	66	49.6	0.957	8	B	2	64.925	64.989	0.110	204.00	43.00	0.0000	Fracture
153	64.895	67	45.8	0.976	8	A	0	64.864	64.927	0.110	204.00	44.00	0.0000	Bedding
154	63.968	314	39.1	0.978	5	A	2	63.915	64.022	0.110	204.00	43.00	0.0000	Fracture
155	63.699	298	29.8	0.989	5	A	2	63.645	63.762	0.110	204.00	43.10	0.0000	Fracture Discontinuous
156	63.616	263	22.8	0.993	6	A	2	63.533	63.703	0.110	204.00	43.24	0.0000	Fracture Discontinuous
157	62.082	208	66.6	0.953	17	B	2	61.931	62.233	0.110	204.00	43.44	0.0000	Fracture Irregular
158	61.329	214	75.9	0.992	9	A	2	61.268	61.427	0.110	204.00	44.00	0.0000	Fracture Irregular
159	61.266	210	87.8	0.994	6	A	2	61.204	61.328	0.110	204.00	44.00	0.0000	Fracture
160	60.609	186	89.5	0.994	5	A	2	60.546	60.673	0.110	204.00	43.89	0.0000	Fracture
161	60.393	189	86.0	0.947	8	B	2	60.321	60.466	0.110	204.00	43.00	0.0000	Hairline-fracture
162	60.299	194	84.6	0.980	6	A	0	60.229	60.370	0.110	204.00	44.00	0.0000	Bedding
163	60.144	3	86.4	0.964	7	B	0	60.086	60.203	0.110	204.00	43.19	0.0000	Bedding
164	57.388	207	86.0	0.950	8	B	2	57.322	57.454	0.110	205.00	44.00	0.0000	Fracture open
165	56.417	320	32.5	0.903	11	C	2	56.372	56.463	0.110	204.00	44.00	0.0000	Fracture Irregular
166	55.345	249	34.5	0.954	9	B	2	55.193	55.514	0.110	205.00	44.00	0.0000	Fracture
167	51.994	70	60.5	0.989	4	A	2	51.953	52.035	0.110	208.00	44.00	0.0000	Fracture
168	51.928	41	69.1	0.991	5	A	2	51.899	51.956	0.110	208.00	44.00	0.0000	Fracture
169	50.325	352	84.6	0.941	7	C	0	50.256	50.395	0.110	207.58	43.00	0.0000	Bedding
170	48.905	352	44.1	0.988	6	A	0	48.880	48.931	0.110	207.97	44.00	0.0000	Bedding
171	48.000	37	53.7	0.988	4	A	2	47.989	48.008	0.110	208.00	43.93	0.0000	Fracture
172	47.157	21	66.1	0.977	7	A	0	47.134	47.180	0.110	207.06	44.00	0.0000	Bedding
173	46.723	12	57.6	0.991	5	A	0	46.703	46.742	0.110	207.37	42.37	0.0000	Bedding
174	46.347	21	68.4	0.989	4	A	0	46.321	46.373	0.110	208.00	43.85	0.0000	Bedding
175	46.011	2	57.9	0.981	8	A	0	45.986	46.036	0.110	208.00	44.00	0.0000	Bedding
176	45.908	8	64.5	0.988	5	A	0	45.881	45.936	0.110	208.00	43.91	0.0000	Bedding
177	45.857	2	66.9	0.985	9	A	0	45.824	45.890	0.110	208.00	44.00	0.0000	Bedding
178	45.794	4	63.7	0.979	6	A	0	45.765	45.824	0.110	207.81	43.00	0.0000	Bedding
179	45.727	4	62.6	0.986	5	A	0	45.699	45.755	0.110	207.00	43.00	0.0000	Bedding
180	45.288	2	56.1	0.990	5	A	0	45.265	45.312	0.110	208.00	43.31	0.0000	Bedding
181	45.085	11	70.8	0.973	6	B	0	45.052	45.118	0.110	207.63	43.00	0.0000	Bedding
182	44.981	9	81.1	0.986	6	A	0	44.933	45.030	0.110	208.00	43.00	0.0000	Bedding
183	44.497	358	83.9	0.938	13	C	0	44.436	44.559	0.110	208.00	43.00	0.0000	Bedding
184	43.773	30	78.2	0.963	8	B	0	43.736	43.810	0.110	208.00	44.00	0.0000	Bedding
185	43.003	61	79.4	0.963	10	B	2	42.946	43.007	0.110	208.00	43.00	0.0000	Fracture Discontinuous

186	38.819	236	88.1	0.977	6	A	2	38.742	38.896	0.110	208.00	43.30	0.0000	Fracture
187	38.662	328	30.8	0.936	8	C	2	38.621	38.704	0.110	208.00	44.00	0.0000	Fracture
188	38.585	333	5.9	0.985	5	A	0	38.539	38.632	0.110	207.37	43.37	0.0000	Bedding
189	38.370	315	7.0	0.990	5	A	0	38.320	38.419	0.110	208.00	43.69	0.0000	Bedding
190	38.177	343	14.3	0.970	6	B	0	38.139	38.215	0.110	208.00	43.54	0.0000	Bedding
191	37.756	68	81.4	0.954	9	B	2	37.689	37.823	0.110	208.00	43.96	0.0000	Fracture
192	37.670	74	65.5	0.977	8	A	2	37.619	37.720	0.110	208.00	44.31	0.0000	Fracture
193	37.612	91	85.5	0.985	11	A	2	37.468	37.756	0.110	207.16	43.16	0.0000	Fracture
194	37.490	223	77.3	0.985	6	A	2	37.391	37.578	0.110	208.00	43.29	0.0000	Fracture
195	36.626	17	71.9	0.976	6	A	2	36.596	36.657	0.110	208.00	44.10	0.0000	Fracture Irregular
196	33.974	349	56.4	0.996	5	A	0	33.940	34.008	0.110	207.60	44.00	0.0000	Bedding
197	31.173	352	78.2	0.974	7	A	2	31.117	31.229	0.110	208.00	44.00	0.0000	Fracture
198	31.083	327	78.4	0.988	5	A	2	30.980	31.059	0.110	208.00	44.00	0.0000	Fracture Discontinuous
199	31.008	246	89.7	0.976	6	A	2	30.923	31.092	0.110	208.00	44.00	0.0000	Fracture
200	30.974	326	60.1	0.989	5	A	2	30.909	30.960	0.110	208.00	44.00	0.0000	Fracture Discontinuous
201	30.212	74	7.0	0.938	5	C	2	30.167	30.257	0.110	208.00	44.00	0.0000	Fracture Discontinuous
202	30.040	33	22.0	0.985	10	A	0	30.018	30.062	0.110	208.00	44.00	0.0000	Bedding
203	29.897	19	26.1	0.943	13	C	0	29.879	29.915	0.110	208.00	44.00	0.0000	Bedding
204	28.911	11	47.9	0.982	5	A	0	28.898	28.923	0.110	208.00	43.13	0.0000	Bedding
205	26.849	235	63.8	0.950	12	B	2	26.624	27.073	0.110	208.80	43.90	0.0000	Fracture Discontinuous
206	25.380	327	24.5	0.975	7	A	0	25.337	25.422	0.110	208.00	44.49	0.0000	Bedding
207	24.855	343	50.2	0.932	6	C	0	24.820	24.890	0.110	207.00	44.00	0.0000	Bedding
208	24.650	353	55.0	0.959	17	B	0	24.621	24.679	0.110	207.08	44.00	0.0000	Bedding
209	24.169	356	59.2	0.972	6	B	0	24.138	24.199	0.110	207.71	45.00	0.0000	Bedding
210	20.442	335	53.0	0.926	7	C	0	20.397	20.488	0.110	207.23	46.77	0.0000	Bedding

RGLDIPv6.1 BHTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-08B
zone from 67.970 to 43.140 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness		
1	67.892	103	31.4	0.911	7	C	0	67.832	67.952	0.110	207.15	46.74	0.0000	Bedding	
2	67.787	77	35.6	0.961	5	B	0	67.751	67.823	0.110	208.00	46.70	0.0000	Bedding	
3	67.649	40	45.2	0.964	6	B	0	67.641	67.657	0.110	208.00	46.80	0.0000	Bedding	
4	67.442	65	46.5	0.950	5	B	0	67.414	67.470	0.110	207.00	46.84	0.0000	Bedding	
5	67.239	55	44.3	0.979	4	A	0	67.218	67.260	0.110	206.22	46.95	0.0000	Bedding	
6	67.052	69	31.8	0.912	6	C	0	67.020	67.084	0.110	206.96	46.69	0.0000	Bedding	
7	66.619	53	69.9	0.958	5	B	0	66.585	66.653	0.110	207.38	46.60	0.0000	Bedding	
8	66.100	75	50.5	0.926	9	C	0	66.059	66.141	0.110	206.00	46.86	0.0000	Bedding	
9	65.814	191	89.0	0.949	9	B	2	65.757	65.871	0.110	206.00	46.92	0.0000	Fracture	
10	65.731	101	31.4	0.968	9	B	2	65.672	65.790	0.110	206.00	46.98	0.0000	Fracture	
11	65.385	34	69.0	0.927	8	C	0	65.362	65.409	0.110	205.00	46.96	0.0000	Bedding	
12	65.182	90	48.7	0.974	6	A	2	65.136	65.240	0.110	205.36	46.93	0.0000	Fracture	Discontinuous
13	64.977	290	52.4	0.955	6	B	2	64.982	65.121	0.110	206.00	46.91	0.0000	Fracture	Discontinuous
14	63.526	130	23.3	0.977	6	A	2	63.445	63.607	0.110	206.48	46.96	0.0000	Fracture	
15	63.507	117	18.9	0.988	5	A	2	63.442	63.572	0.110	206.87	46.92	0.0000	Fracture	
16	63.441	161	15.0	0.993	4	A	2	63.388	63.530	0.110	206.00	46.90	0.0000	Fracture	Discontinuous
17	63.264	251	25.6	0.970	6	B	2	63.190	63.392	0.110	206.28	46.86	0.0000	Fracture	Discontinuous
18	63.049	158	23.9	0.973	8	A	2	62.931	63.166	0.110	206.00	47.03	0.0000	Fracture	
19	62.302	293	62.5	0.918	13	C	2	62.106	62.498	0.110	206.96	46.83	0.0000	Fracture	segmented
20	62.185	76	85.5	0.985	5	A	2	62.097	62.274	0.110	207.00	46.86	0.0000	Fracture	Discontinuous
21	62.138	140	32.7	0.988	4	A	2	62.019	62.046	0.110	207.00	46.86	0.0000	Fracture	Discontinuous
22	61.963	295	75.5	1.000	3	A	2	62.145	62.338	0.110	206.74	46.85	0.0000	Fracture	Discontinuous
23	61.925	68	53.7	0.944	6	C	2	61.890	61.960	0.110	206.49	46.73	0.0000	Fracture	
24	61.540	27	57.3	0.932	5	C	2	61.529	61.550	0.110	206.00	46.92	0.0000	Fracture	
25	61.462	265	26.4	0.973	6	A	2	61.351	61.574	0.110	206.75	46.87	0.0000	Fracture	Discontinuous
26	61.246	100	26.9	0.951	6	B	2	61.190	61.302	0.110	206.00	46.94	0.0000	Fracture	
27	60.380	25	49.1	0.904	9	C	0	60.377	60.382	0.110	207.59	46.85	0.0000	Bedding	
28	59.704	17	46.4	0.981	5	A	0	59.696	59.711	0.110	207.08	46.90	0.0000	Bedding	
29	59.150	38	78.5	0.946	5	C	0	59.114	59.186	0.110	207.00	47.00	0.0000	Bedding	
30	58.999	35	85.7	0.921	10	C	0	58.954	59.044	0.110	206.98	47.31	0.0000	Bedding	
31	58.796	30	65.7	0.957	7	B	0	58.778	58.815	0.110	205.93	47.22	0.0000	Bedding	
32	58.616	28	56.0	0.932	6	C	0	58.607	58.625	0.110	205.00	47.11	0.0000	Bedding	
33	58.290	15	62.6	0.959	9	B	0	58.272	58.309	0.110	206.81	46.94	0.0000	Bedding	
34	55.136	284	54.2	0.986	7	A	2	54.944	55.319	0.110	206.00	46.83	0.0000	Fracture	Discontinuous
35	53.948	103	16.9	0.966	5	B	0	53.892	54.004	0.110	206.00	46.82	0.0000	Bedding	

36	53.340	226	85.2	0.958	7	B	2	53.320	53.408	0.110	207.00	46.73	0.0000	Fracture Discontinuous
37	53.334	136	24.4	0.965	7	B	0	53.245	53.423	0.110	207.00	46.73	0.0000	Bedding
38	53.095	229	82.5	0.946	7	C	2	53.017	53.174	0.110	206.09	46.78	0.0000	Fracture
39	52.905	352	72.3	0.991	5	A	2	52.861	52.949	0.110	206.00	46.83	0.0000	Fracture
40	52.760	131	13.1	0.976	7	A	2	52.691	52.829	0.110	205.80	46.83	0.0000	Fracture
41	52.577	181	23.3	0.932	8	C	0	52.437	52.716	0.110	205.53	46.78	0.0000	Bedding
42	51.743	153	17.6	0.957	7	B	0	51.652	51.833	0.110	205.85	46.89	0.0000	Bedding
43	51.427	232	80.8	0.971	6	B	2	51.422	51.515	0.110	204.46	46.87	0.0000	Fracture Discontinuous
44	51.371	207	8.3	0.946	9	C	0	51.292	51.450	0.110	205.00	46.89	0.0000	Bedding
45	50.692	38	2.1	0.951	6	B	0	50.637	50.746	0.110	205.00	46.89	0.0000	Bedding
46	49.282	1	82.9	0.969	5	B	0	49.234	49.330	0.110	204.36	46.89	0.0000	Bedding
47	49.078	180	82.2	0.946	6	C	0	48.997	49.160	0.110	206.00	47.07	0.0000	Bedding
48	48.282	25	82.3	0.962	5	B	0	48.243	48.321	0.110	205.00	46.89	0.0000	Bedding
49	47.545	28	7.5	0.931	7	C	0	47.500	47.590	0.110	205.89	46.76	0.0000	Irregular Bedding
50	47.002	239	19.6	0.940	5	C	0	46.889	47.115	0.110	206.00	46.91	0.0000	Bedding
51	46.913	260	17.5	0.938	5	C	0	46.823	47.003	0.110	206.00	46.88	0.0000	Bedding
52	45.319	214	13.7	0.925	5	C	0	45.222	45.417	0.110	205.00	46.96	0.0000	Bedding
53	43.569	345	7.9	0.945	6	C	2	43.522	43.617	0.110	205.62	46.71	0.0000	Fracture

Borehole: BH_02-06 Logged from 11 to 67 meters
Depth range: 0.000 - 67.246m extrapolated from 11 to 0 meters

	Deviation components				
Depth	North	East	Down	Devaz	Dev
m	m	m	m	deg	deg
1.046	-0.211	0.197	1.005	137.00	16.00
2.046	-0.412	0.385	1.967	137.00	16.00
3.046	-0.614	0.573	2.928	137.00	16.00
4.046	-0.816	0.761	3.889	137.00	16.00
5.046	-1.017	0.949	4.851	137.00	16.00
6.046	-1.219	1.137	5.812	137.00	16.00
7.046	-1.420	1.325	6.773	137.00	16.00
8.046	-1.622	1.513	7.734	137.00	16.00
9.046	-1.824	1.701	8.696	137.00	16.00
10.046	-2.025	1.888	9.657	137.00	16.00
11.046	-2.227	2.076	10.618	137.00	16.00
12.046	-2.427	2.261	11.580	138.00	16.00
13.046	-2.623	2.443	12.544	139.00	15.00
14.046	-2.819	2.623	13.508	137.00	16.00
15.046	-3.015	2.802	14.472	137.00	16.00
16.046	-3.213	2.981	15.435	137.00	16.00
17.046	-3.411	3.156	16.400	138.00	16.00
18.046	-3.610	3.334	17.363	138.00	16.00
19.046	-3.807	3.510	18.328	139.00	15.00
20.046	-4.002	3.682	19.293	135.00	16.00
21.046	-4.199	3.854	20.259	139.00	15.00
22.046	-4.395	4.028	21.224	140.00	15.00
23.046	-4.590	4.199	22.189	139.00	15.00
24.046	-4.788	4.369	23.155	140.00	15.00
25.046	-4.985	4.537	24.120	138.00	15.00
26.046	-5.182	4.705	25.087	140.00	15.00
27.046	-5.380	4.869	26.053	140.00	14.00
28.046	-5.576	5.033	27.020	140.00	15.00
29.046	-5.773	5.194	27.987	142.00	15.00
30.046	-5.975	5.352	28.953	143.00	15.00
31.046	-6.182	5.508	29.919	144.00	15.00
32.046	-6.392	5.667	30.884	142.00	15.00
33.046	-6.597	5.834	31.848	139.00	16.00
34.046	-6.799	6.009	32.812	139.00	15.00
35.046	-6.996	6.193	33.774	138.00	15.00
36.046	-7.193	6.373	34.738	138.00	15.00
37.046	-7.391	6.552	35.702	138.00	16.00
38.046	-7.589	6.726	36.667	138.00	15.00
39.046	-7.787	6.900	37.631	140.00	15.00
40.046	-7.984	7.072	38.596	139.00	15.00
41.046	-8.183	7.246	39.561	138.00	16.00
42.046	-8.383	7.417	40.525	139.00	16.00
43.046	-8.576	7.588	41.491	138.00	15.00
44.046	-8.770	7.755	42.458	139.00	16.00
45.046	-8.970	7.927	43.423	140.00	15.00
46.046	-9.169	8.100	44.387	139.00	16.00
47.046	-9.364	8.267	45.354	141.00	15.00
48.046	-9.559	8.434	46.320	138.00	16.00
49.046	-9.756	8.605	47.285	140.00	14.00
50.046	-9.951	8.773	48.251	138.00	15.00
51.046	-10.146	8.942	49.218	139.00	15.00
52.046	-10.344	9.116	50.182	139.00	16.00
53.046	-10.544	9.282	51.148	139.00	16.00

54.046	-10.740	9.452	52.113	139.00	15.00
55.046	-10.934	9.620	53.080	139.00	15.00
56.046	-11.130	9.788	54.046	140.00	15.00
57.046	-11.327	9.957	55.012	137.00	15.00
58.046	-11.520	10.125	55.978	140.00	14.00
59.046	-11.715	10.287	56.946	139.00	15.00
60.046	-11.908	10.449	57.914	139.00	15.00
61.046	-12.103	10.610	58.881	141.00	14.00
62.046	-12.296	10.773	59.848	140.00	15.00
63.046	-12.490	10.933	60.816	141.00	14.00
64.046	-12.679	11.089	61.786	140.00	14.00
65.046	-12.871	11.248	62.754	141.00	14.00
66.046	-13.064	11.401	63.723	142.00	14.00
67.046	-13.255	11.553	64.693	141.00	14.00

Appendix C

BOREHOLE 02-07
IMAGE LOG PLOTS
DISCONTINUITY AND DEVIATION TABLES

NORCAL GEOPHYSICAL CONSULTANTS, INC.

OPTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED OPTV DIPS LOG

10 Aug 2002

EARTH MECHANICS

Borehole: BH 02-07

DEVIL'S SLIDE

top of borehole.....
East:
North:
Alt:

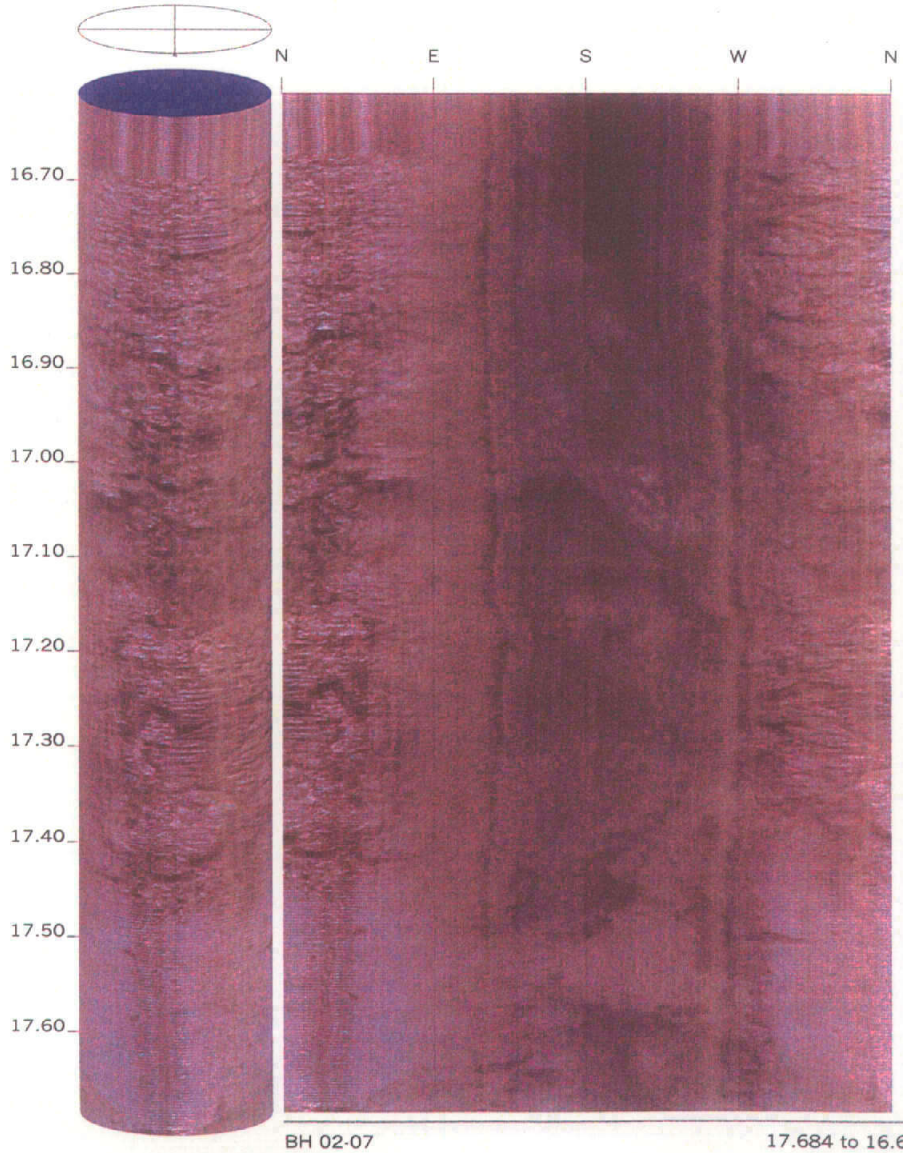
North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = fixed format

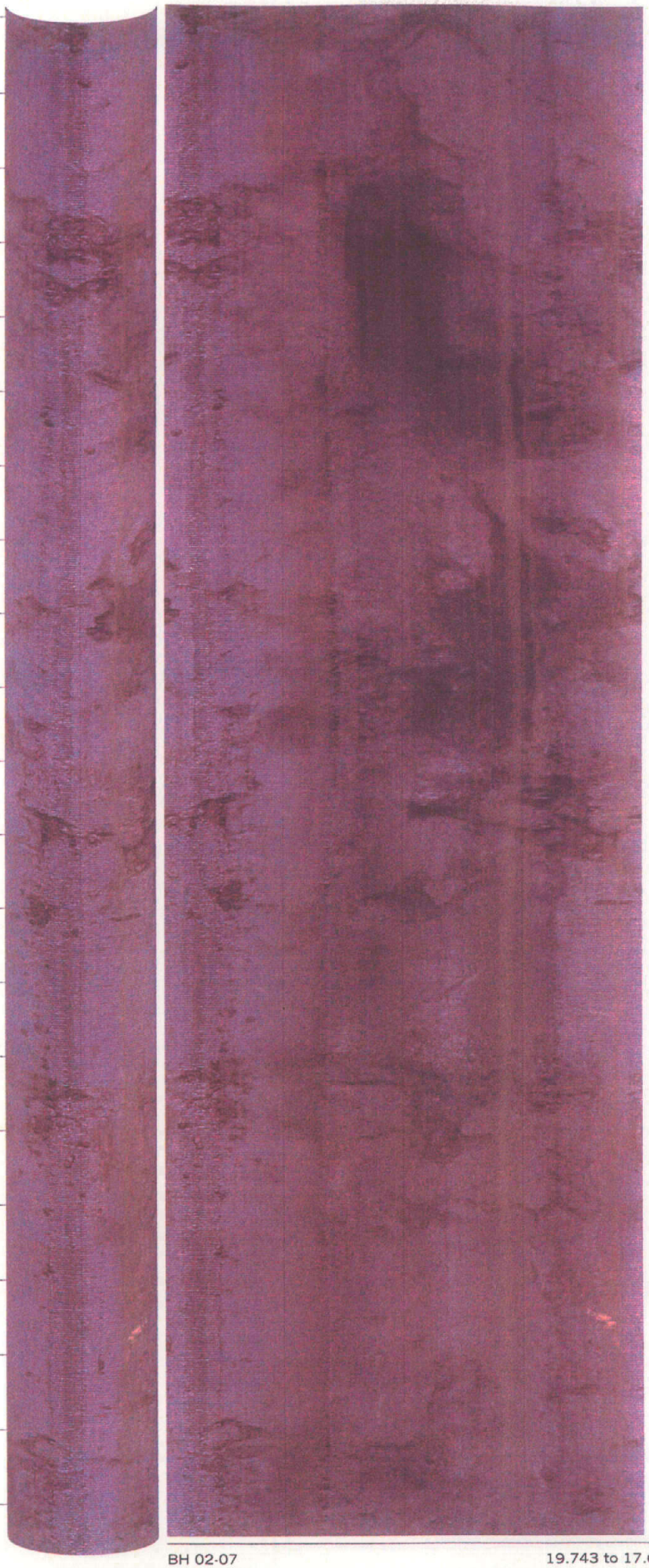
Zone from 115.467 to 16.607m
Vertical = borehole-axis

Borehole diam: 11.000cm

BEDDING
FRACTURE
Identified units

COMMENTS

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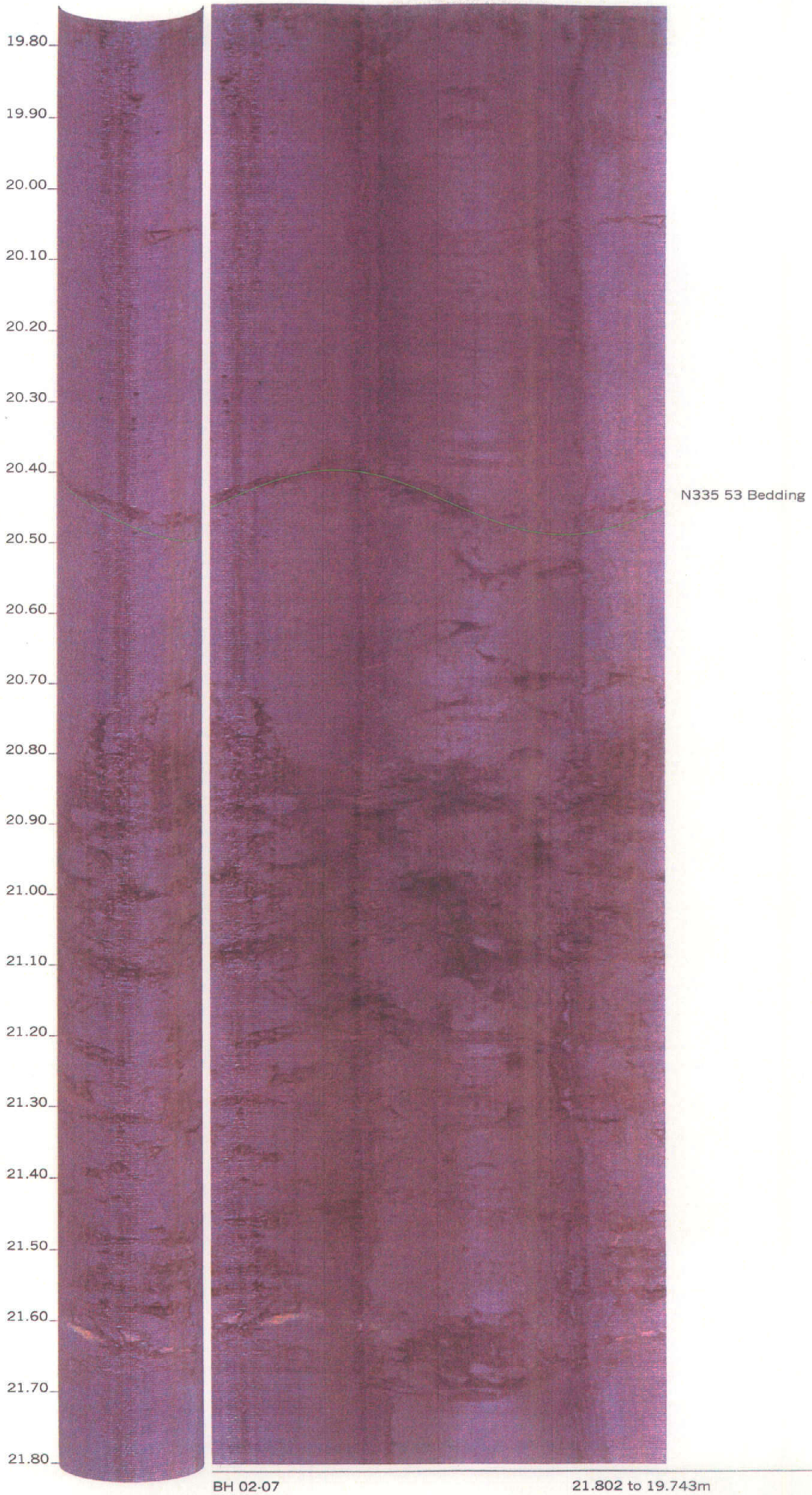
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21.30
21.40
21.50
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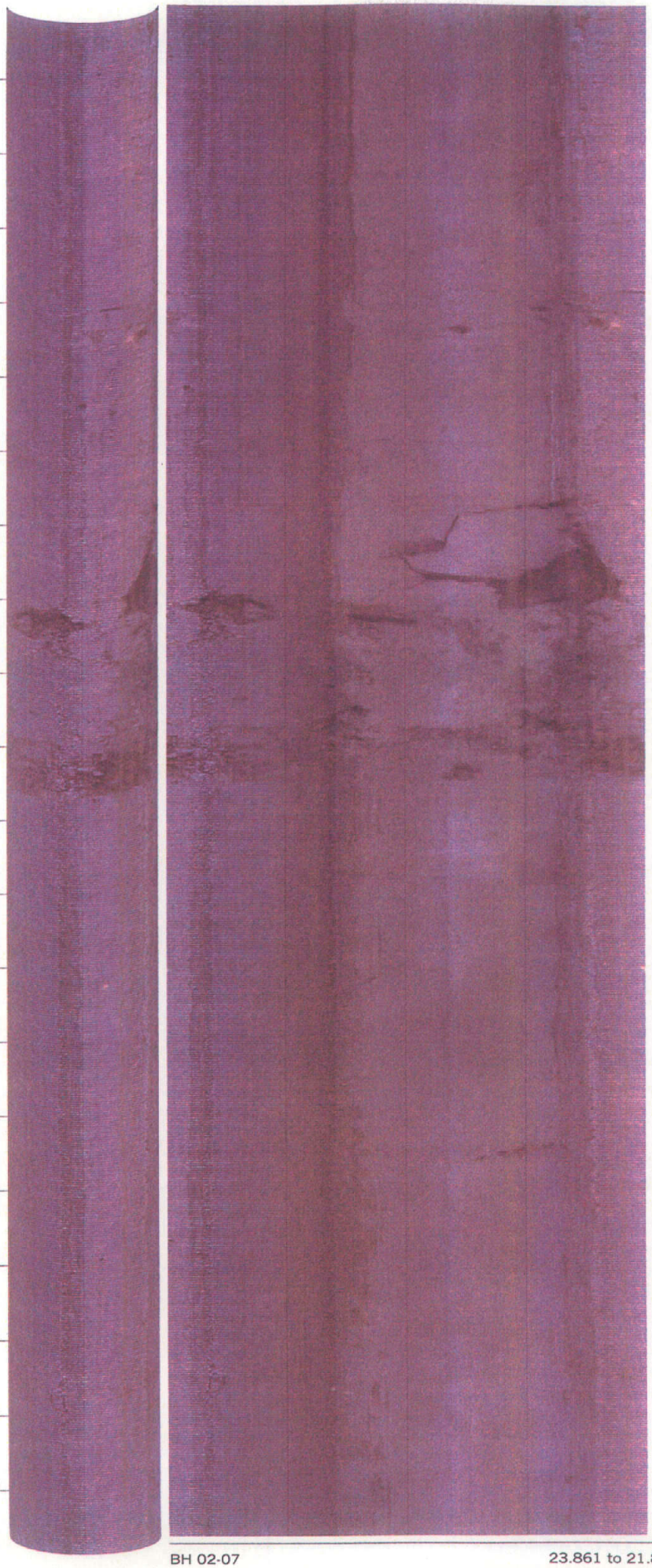
21.70
21.80
N335 53 Bedding



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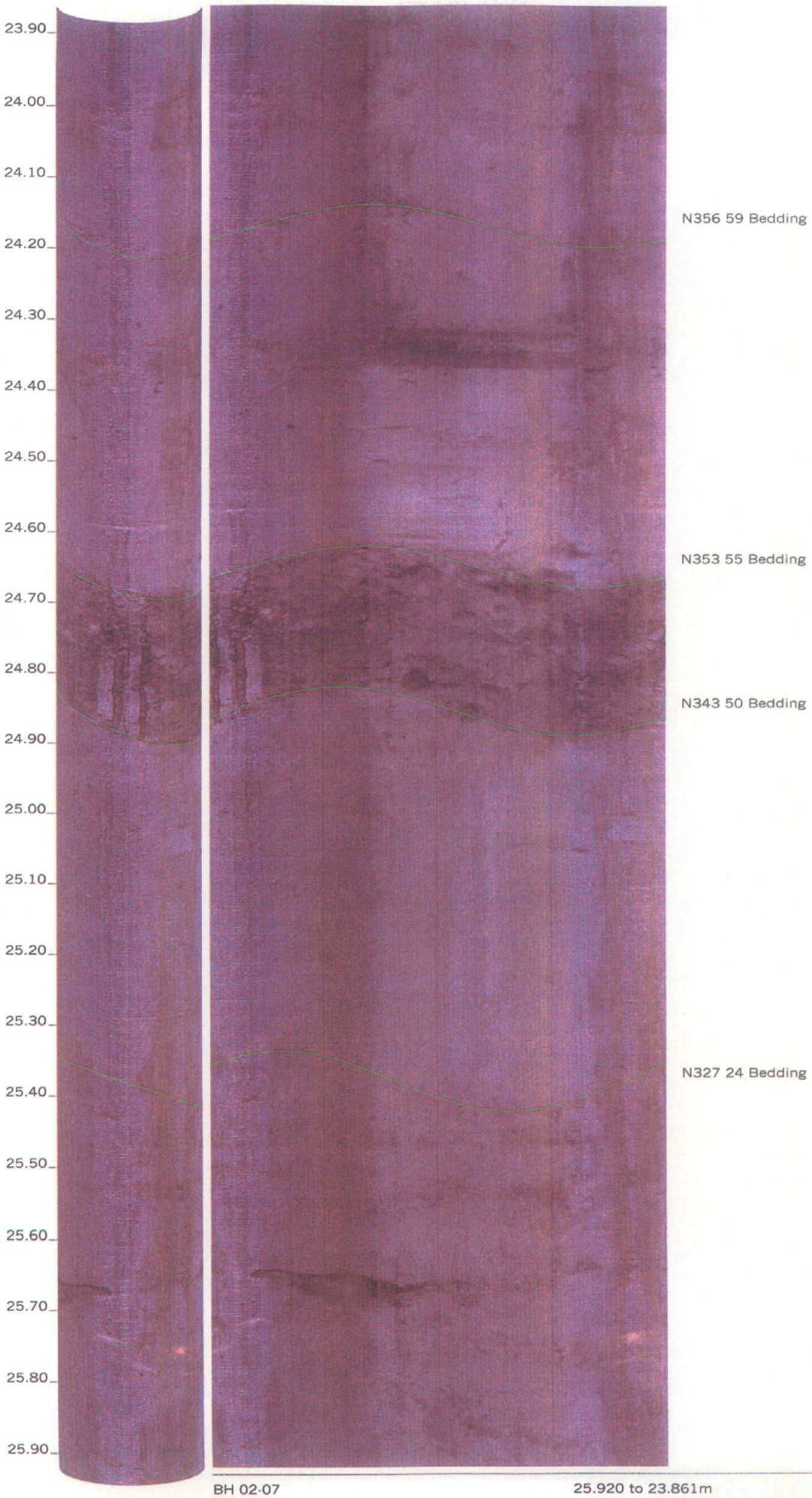
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25.20
25.30
25.40
25.50
25.60
25.70
25.80
25.90
N356 59 Bedding
N353 55 Bedding
N343 50 Bedding
N327 24 Bedding

N235 64 Fracture Discontinuous

28.00
28.10
28.20
28.30
28.40
28.50
28.60
28.70
28.80
28.90
29.00
29.10
29.20
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30.00
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N019 26 Bedding
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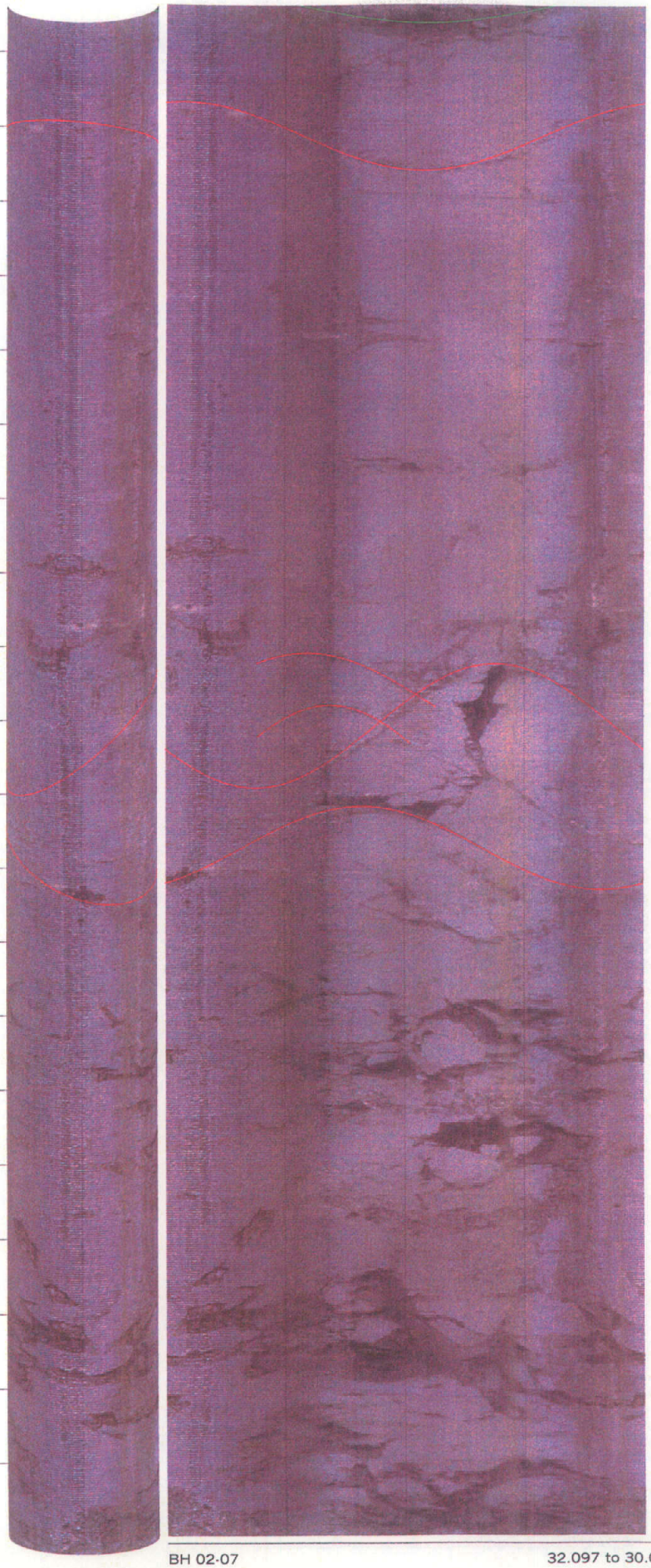
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31.50
31.60
31.70
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31.90
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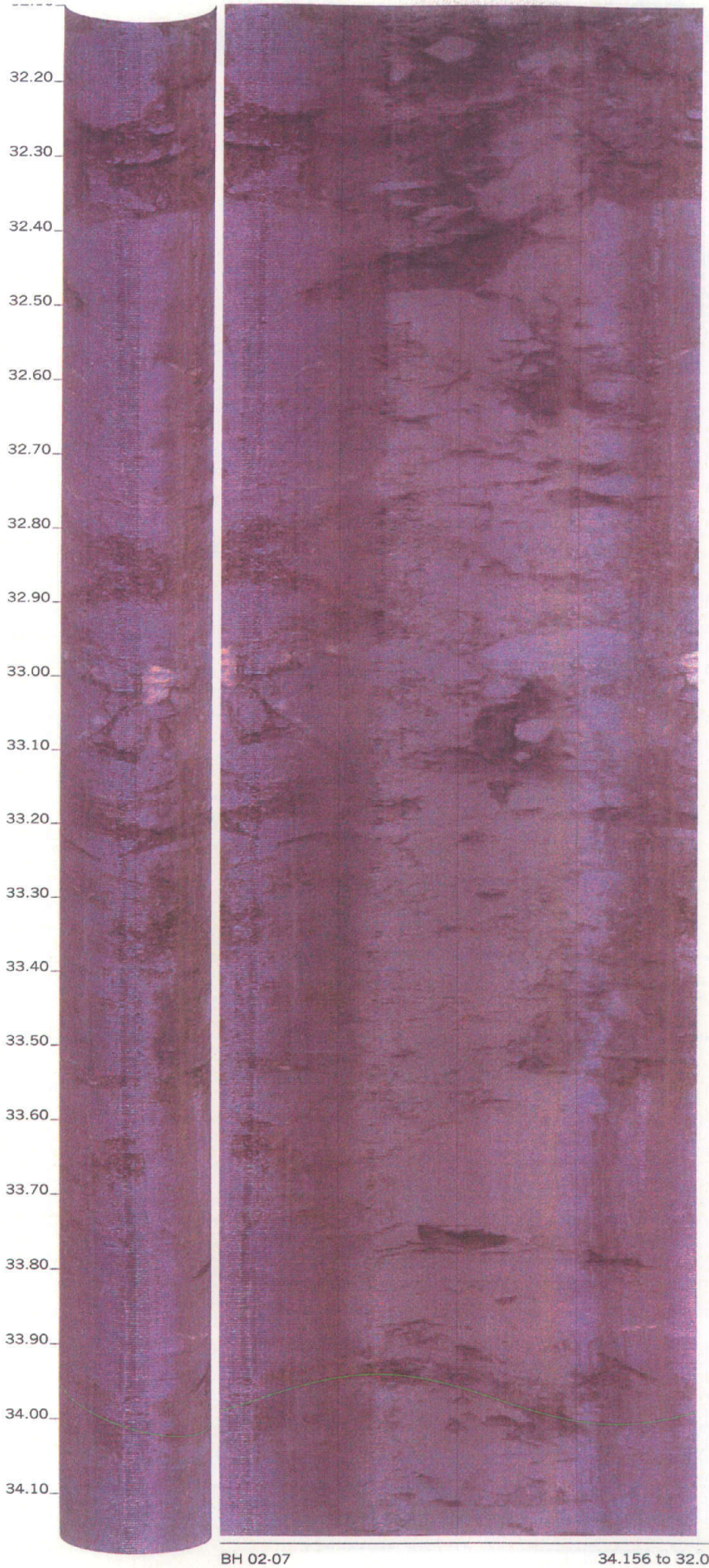
N326 60 Fracture Discontinuous
N246 90 Fracture
N327 78 Fracture Discontinuous
N352 78 Fracture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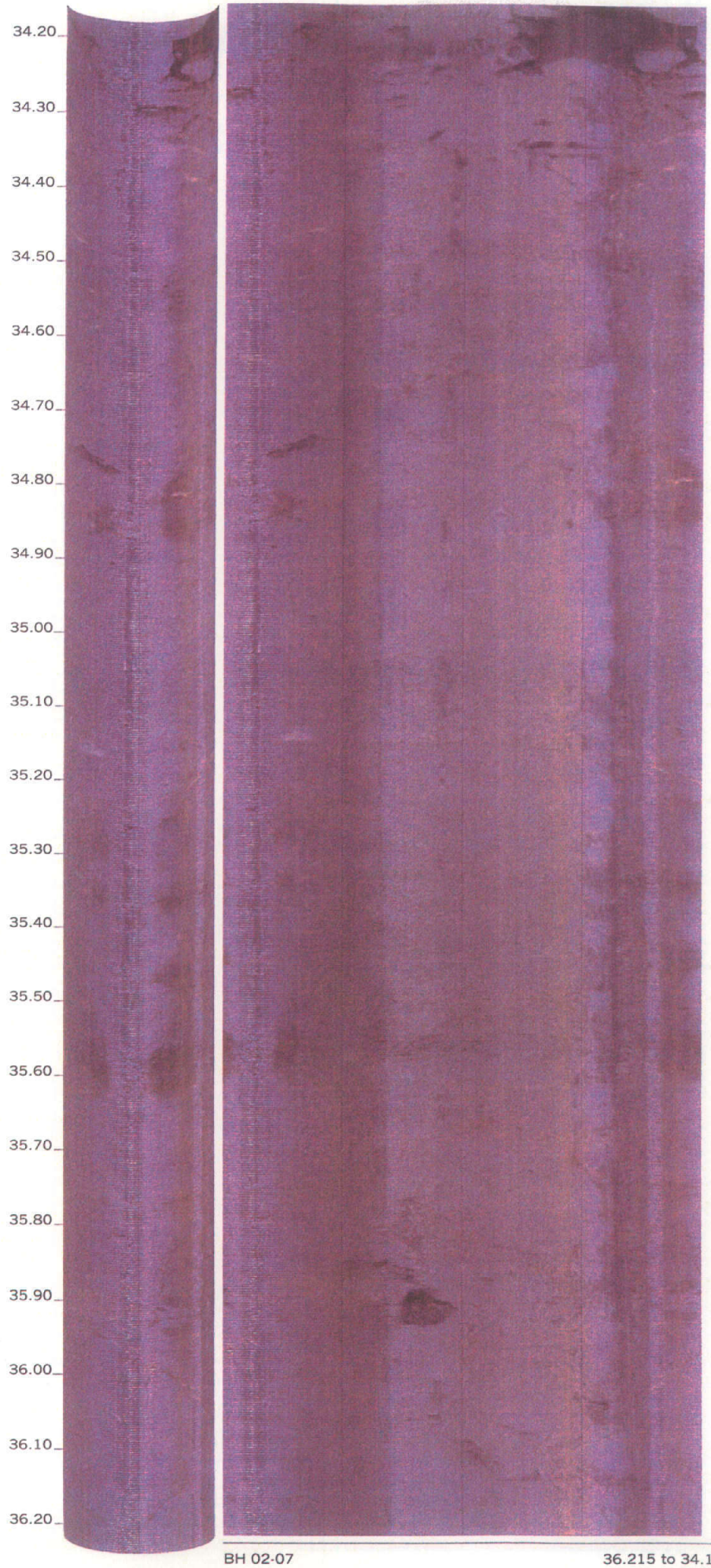
N349 56 Bedding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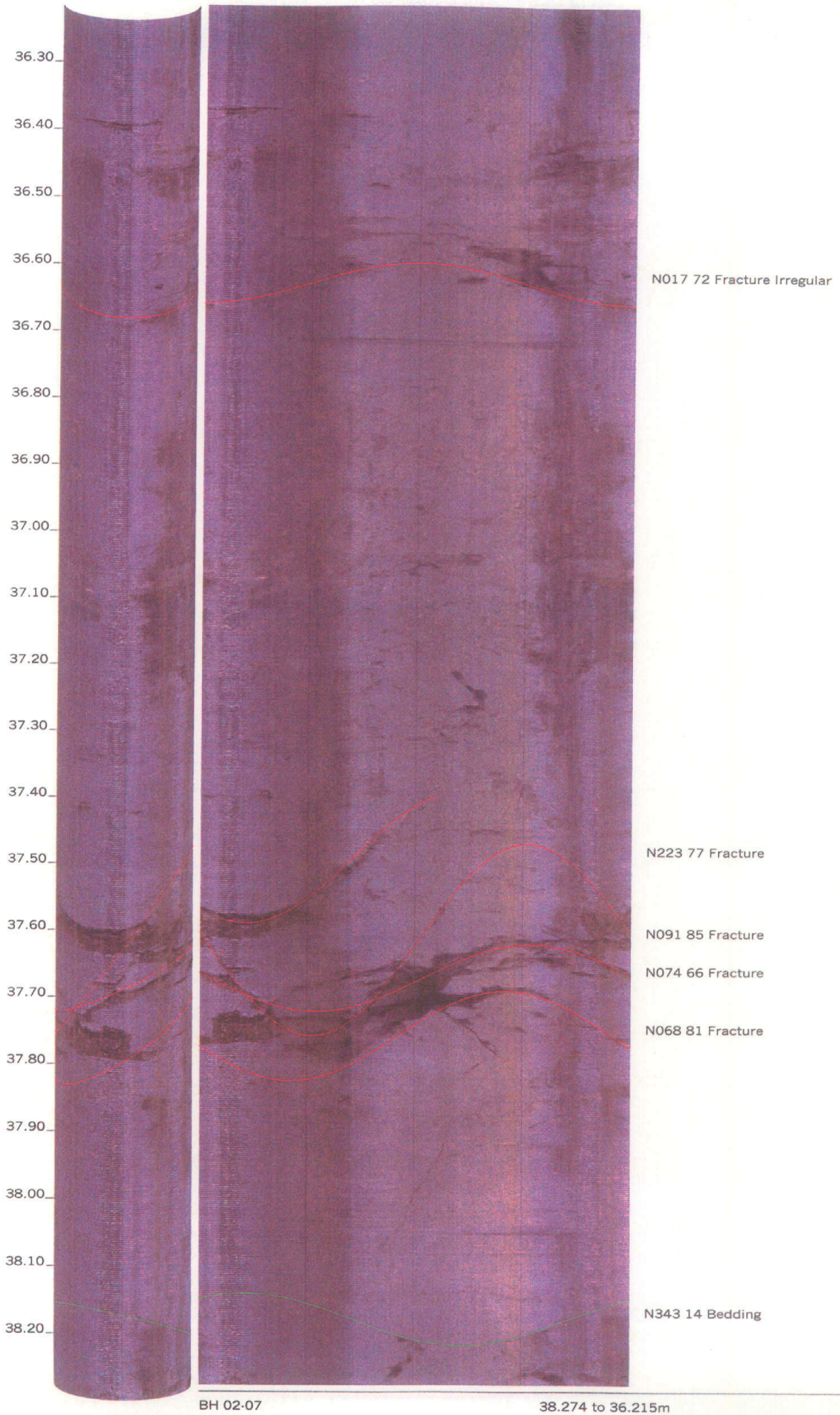
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37.60
37.70
37.80
37.90
38.00
38.10
38.20
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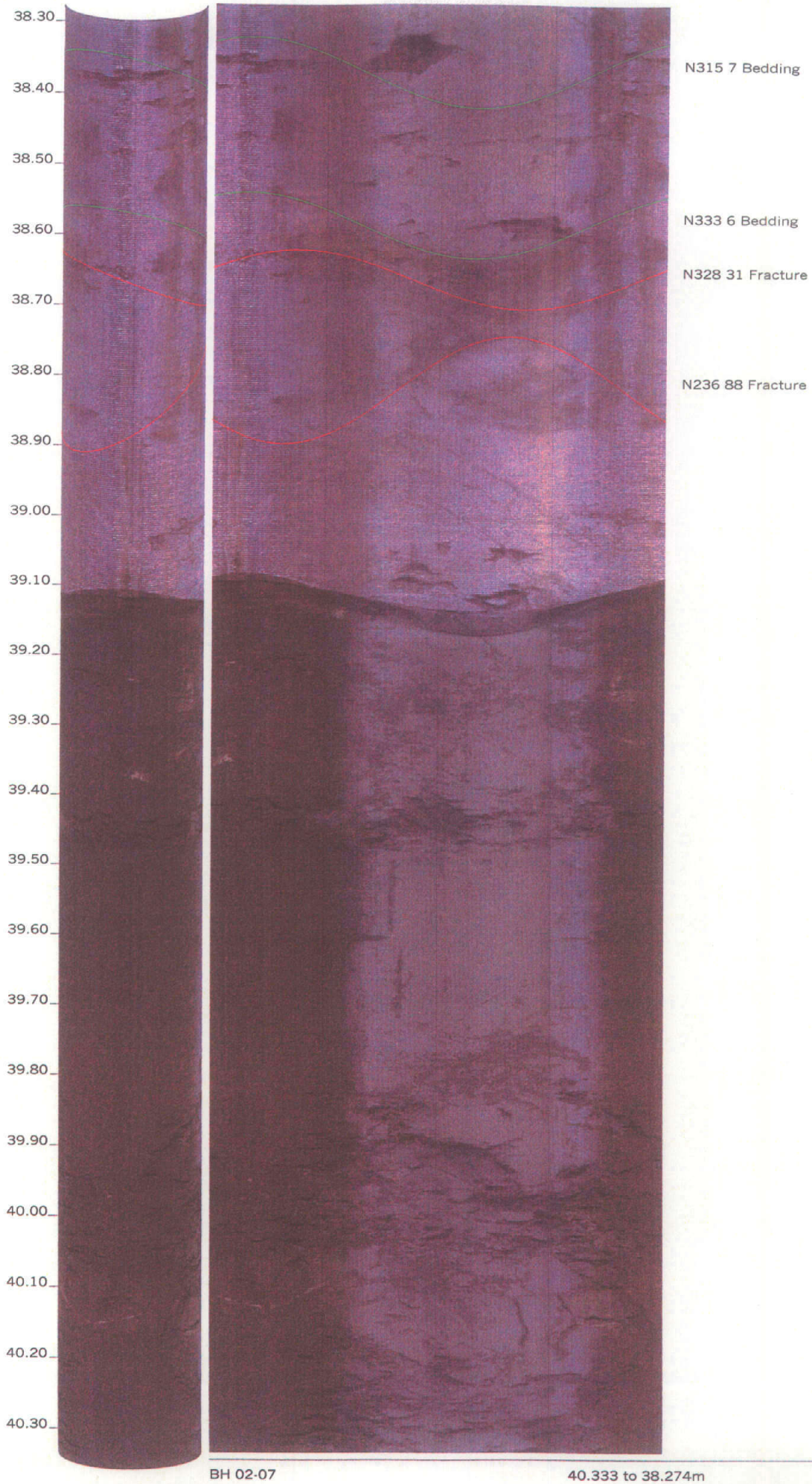
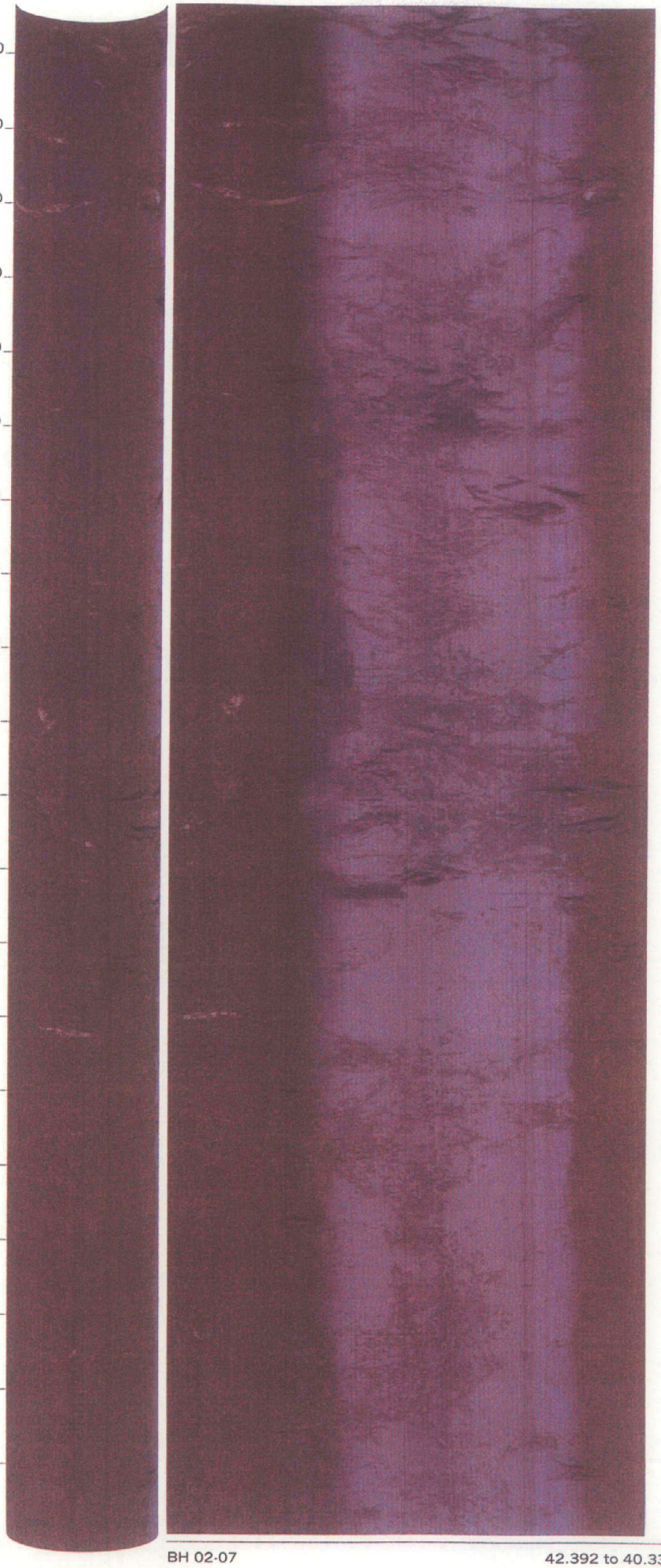
N223 77 Fracture
N091 85 Fracture
N074 66 Fracture
N068 81 Fracture
N343 14 Bedding



BH 02-07 40.333 to 38.274m 12



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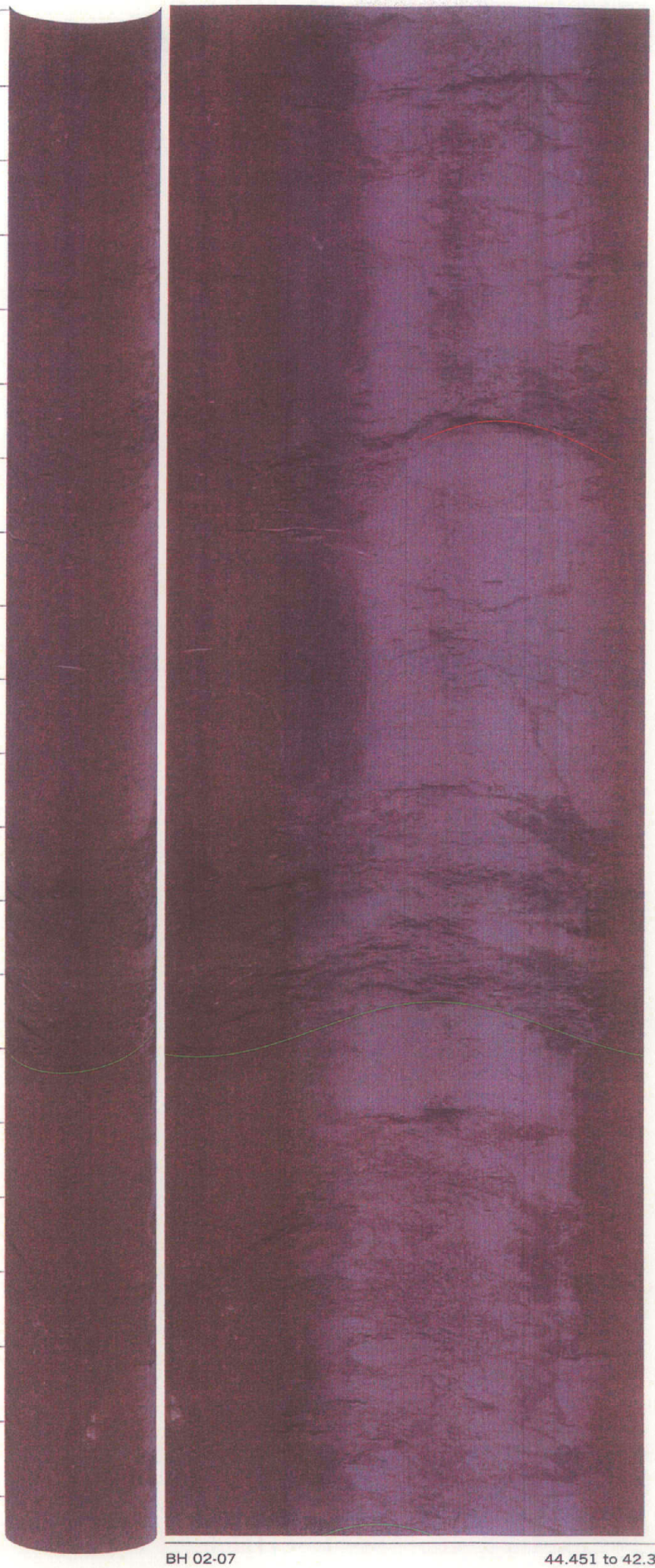
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44.00
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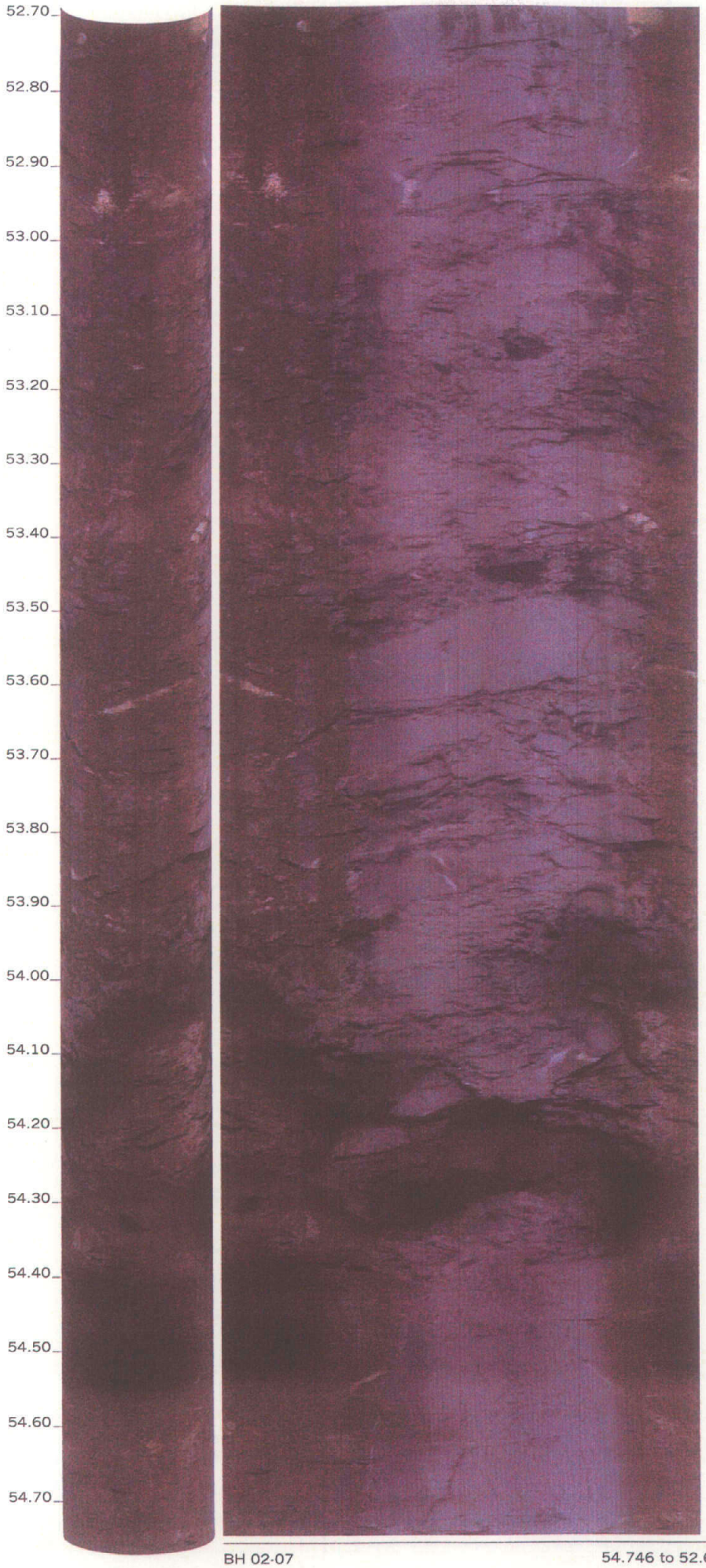
N061 79 Fracture Discontinuous
N030 78 Bedding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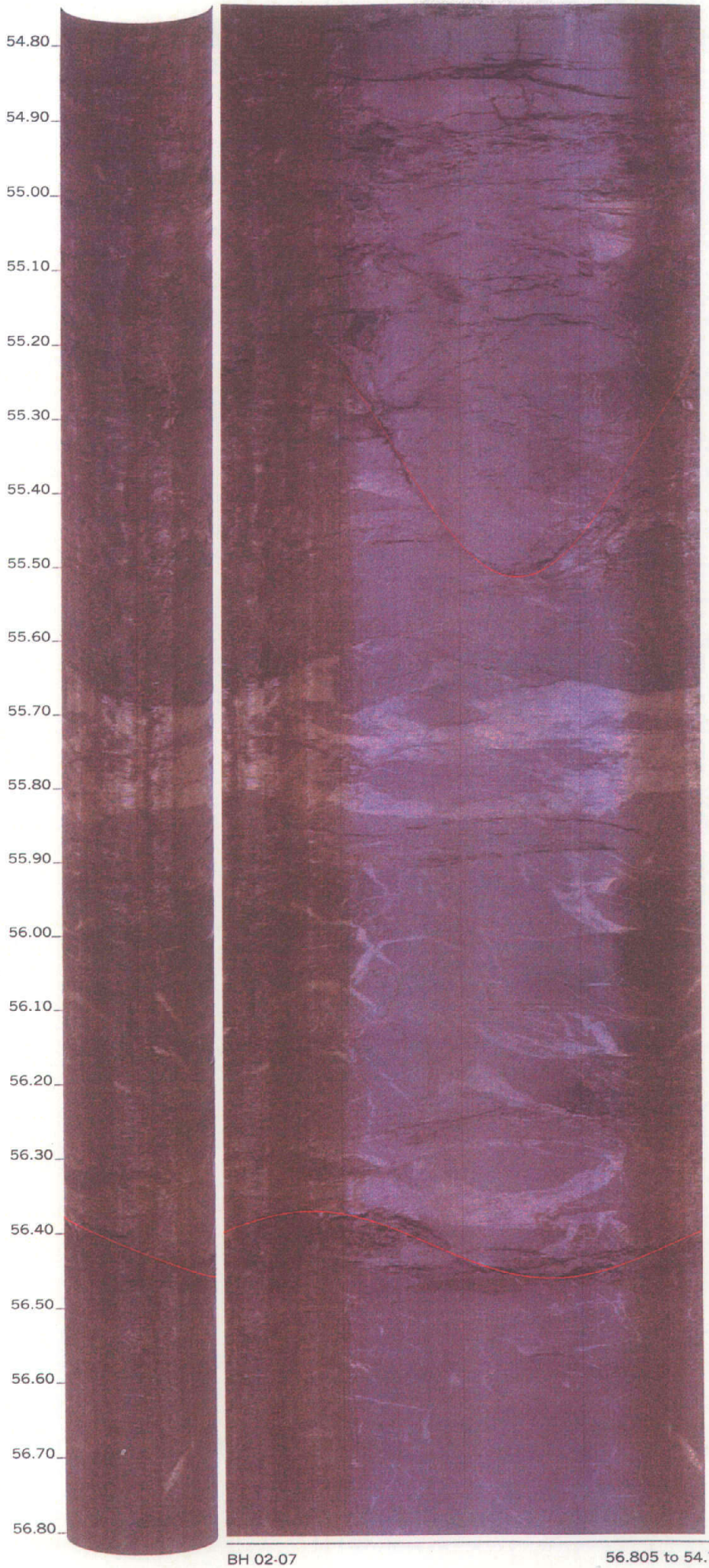
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N249 35 Fracture
N320 33 Fracture Irregular

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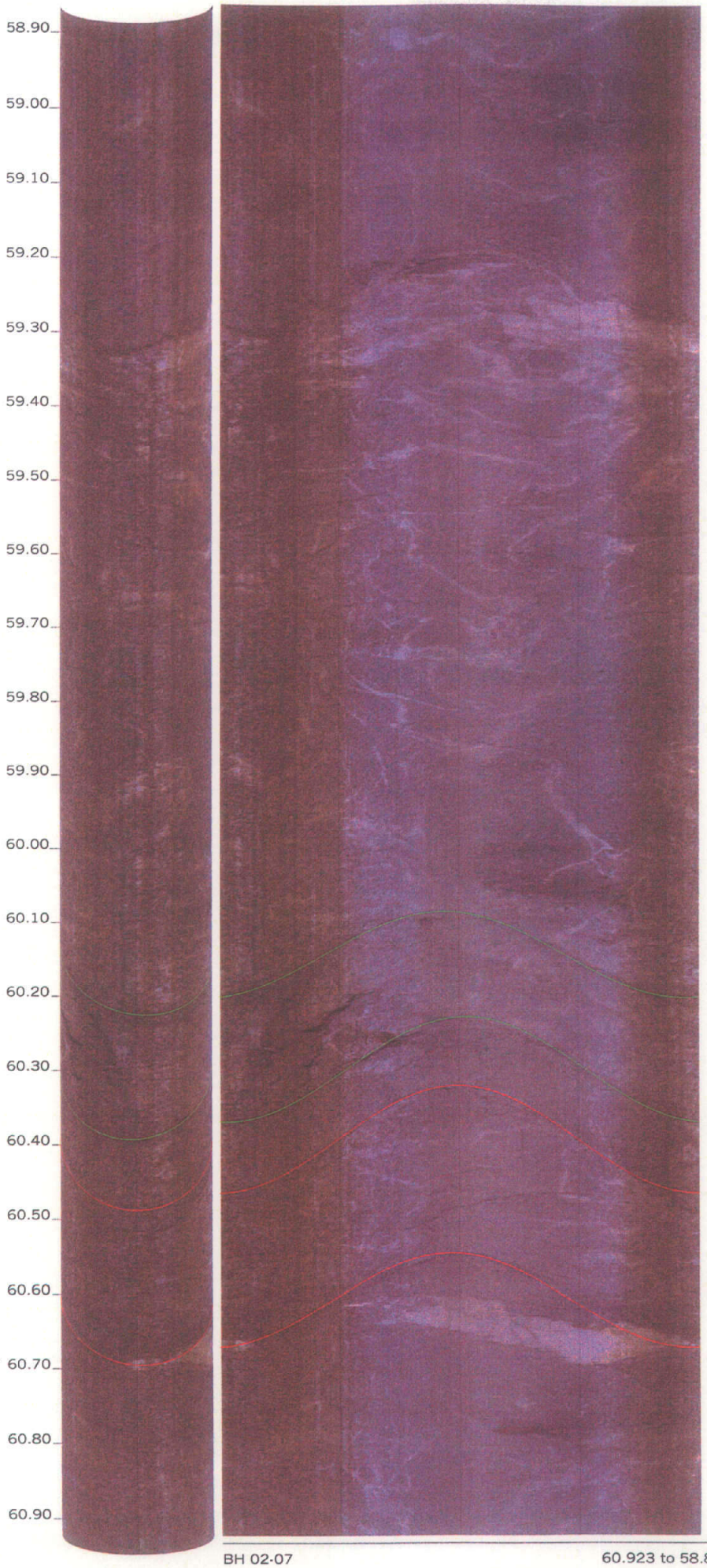
N207 86 Fracture open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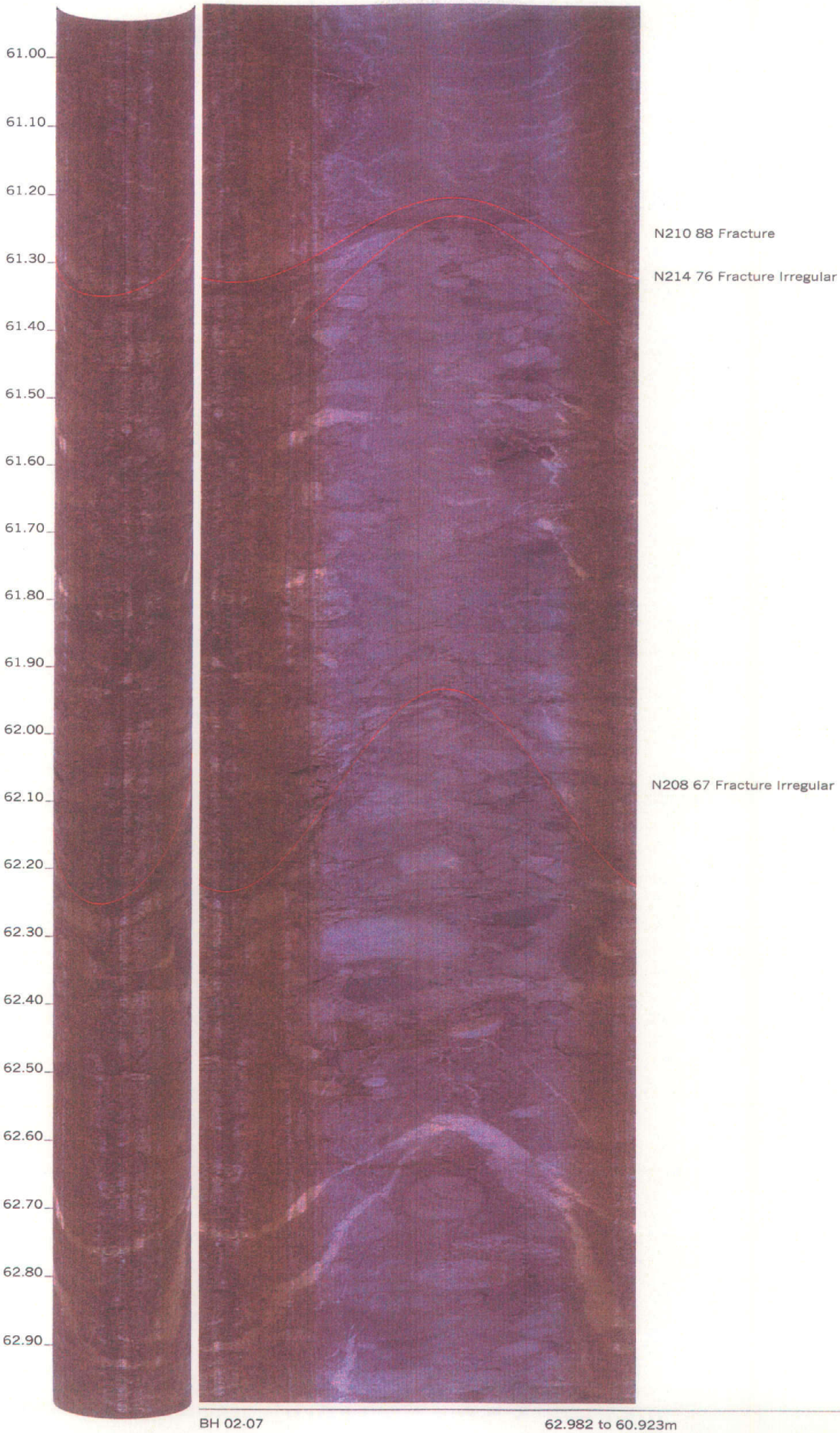
N003 86 Bedding
N194 85 Bedding
offset_fracture_lower_half
N189 86 Hairline-fracture
N186 90 Fracture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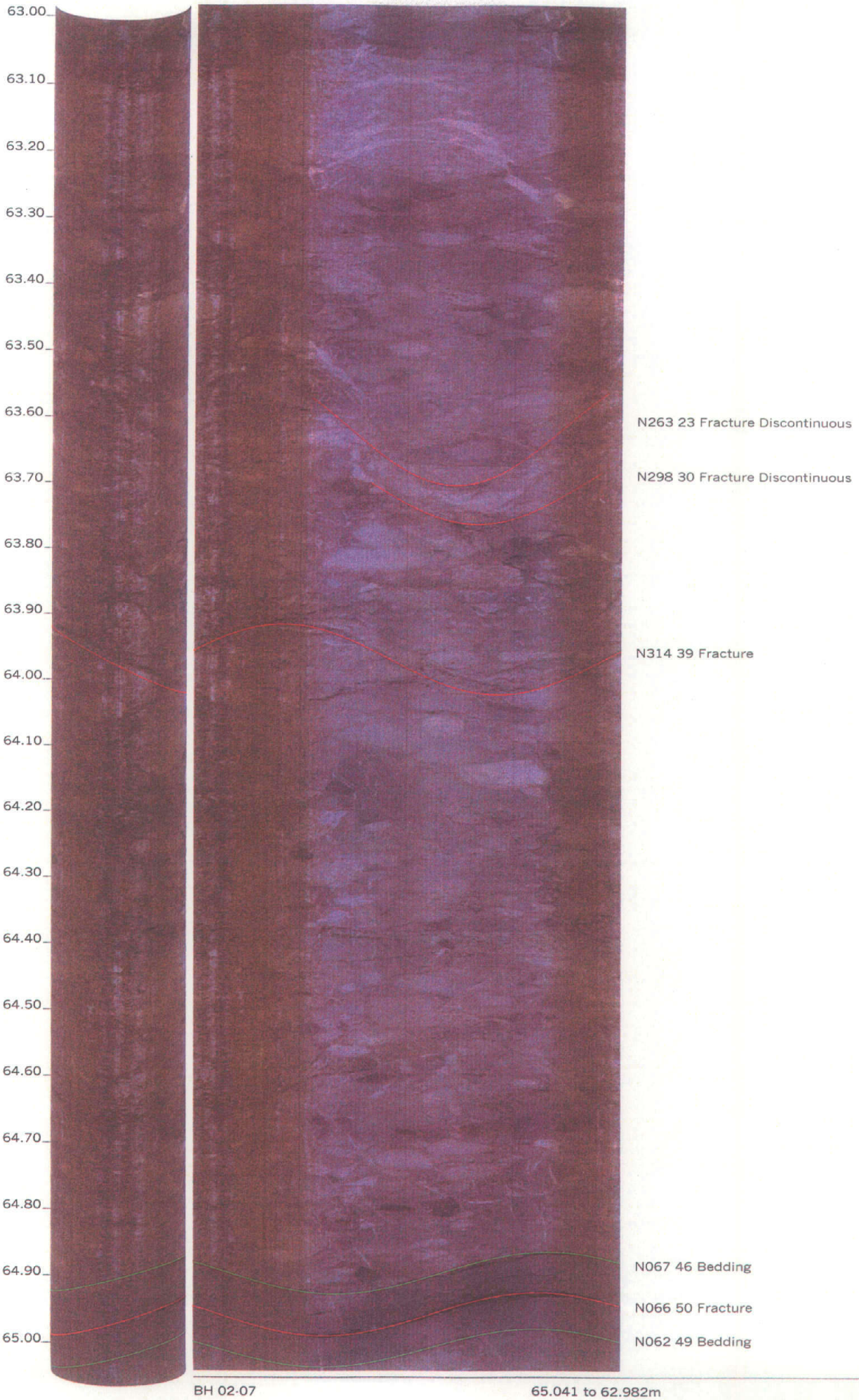
N210 88 Fracture
N214 76 Fracture Irregular
N208 67 Fracture Irregular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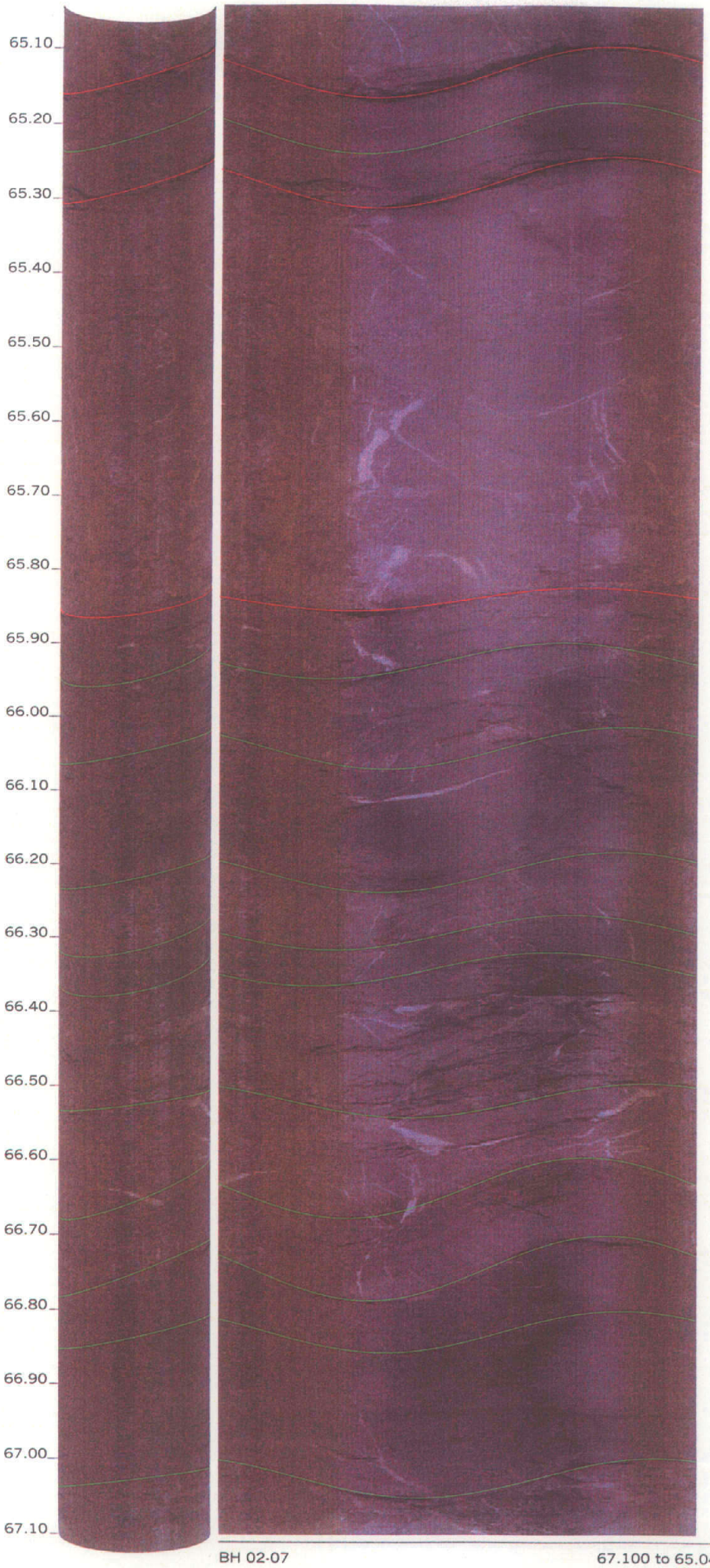
N263 23 Fracture Discontinuous
N298 30 Fracture Discontinuous
N314 39 Fracture
N067 46 Bedding
N066 50 Fracture
N062 49 Bedding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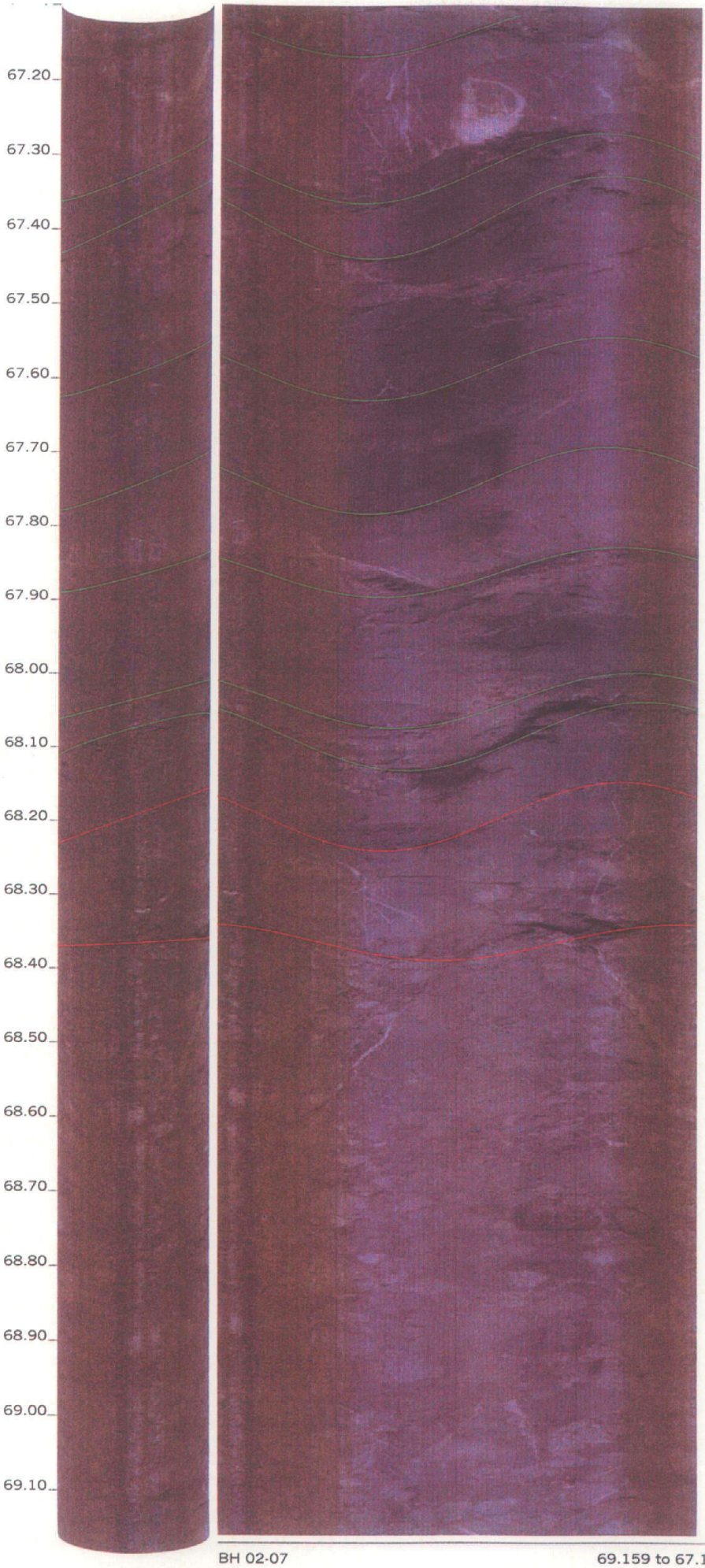
67.10
N069 48 Fracture
N067 52 Bedding
N069 48 Fracture
N046 48 Fracture
N049 58 Bedding
N065 43 Bedding
N063 44 Bedding
N051 56 Bedding
N045 59 Bedding
N058 35 Bedding
N067 59 Bedding
N075 53 Bedding
N065 42 Bedding
N062 31 Bedding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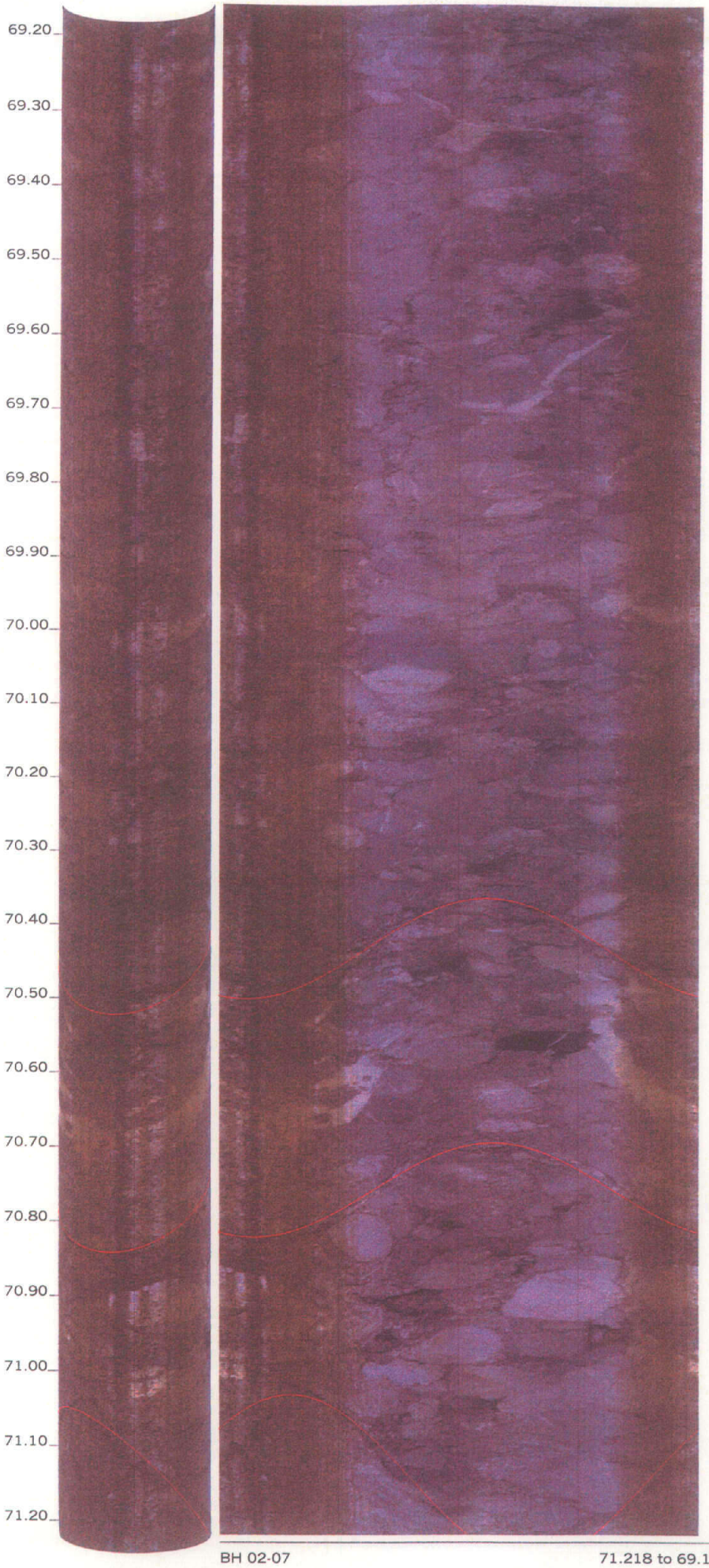
N066 55 Discontinuous Bedding
N076 57 Bedding
N083 56 Bedding
N075 52 Bedding
N076 54 Bedding
N071 45 Bedding
N077 40 Bedding
N087 38 Bedding
N081 47 contract Hairline-fracture
N054 25 Fracture Irregular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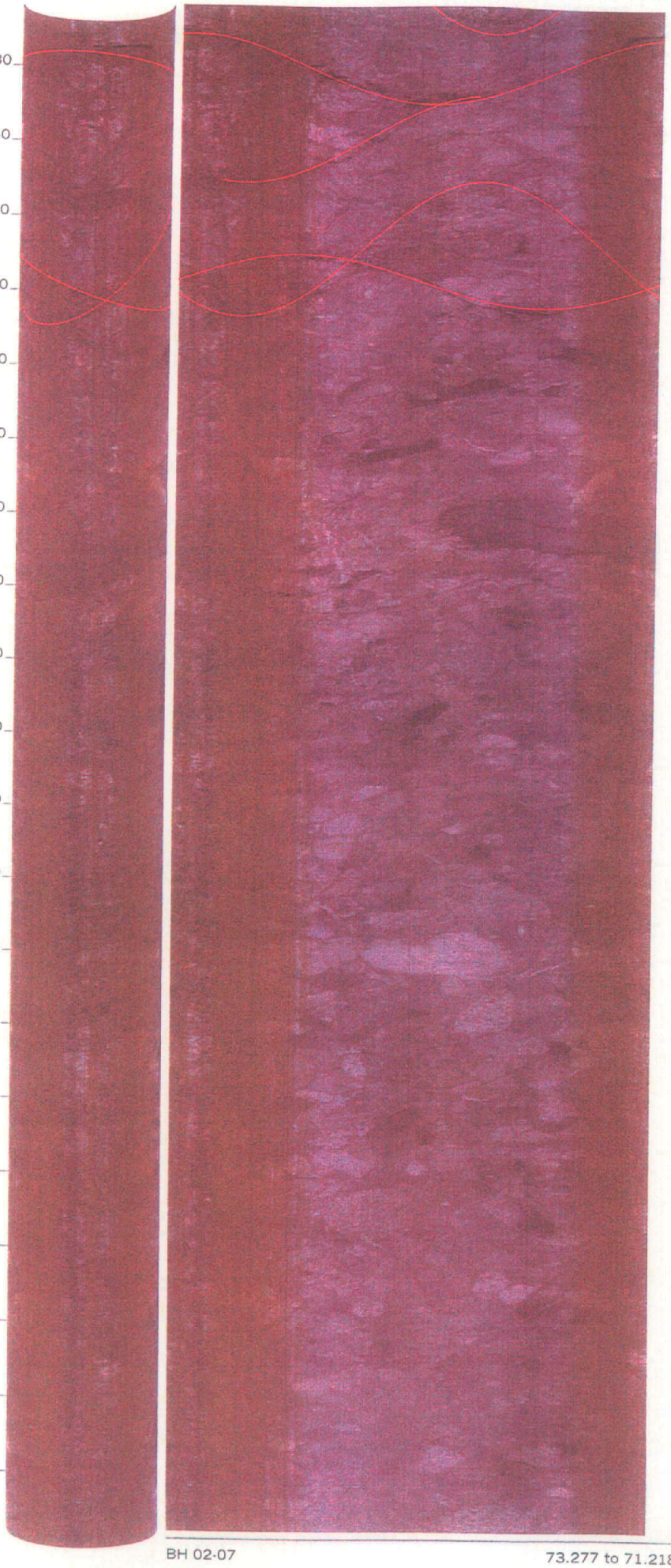
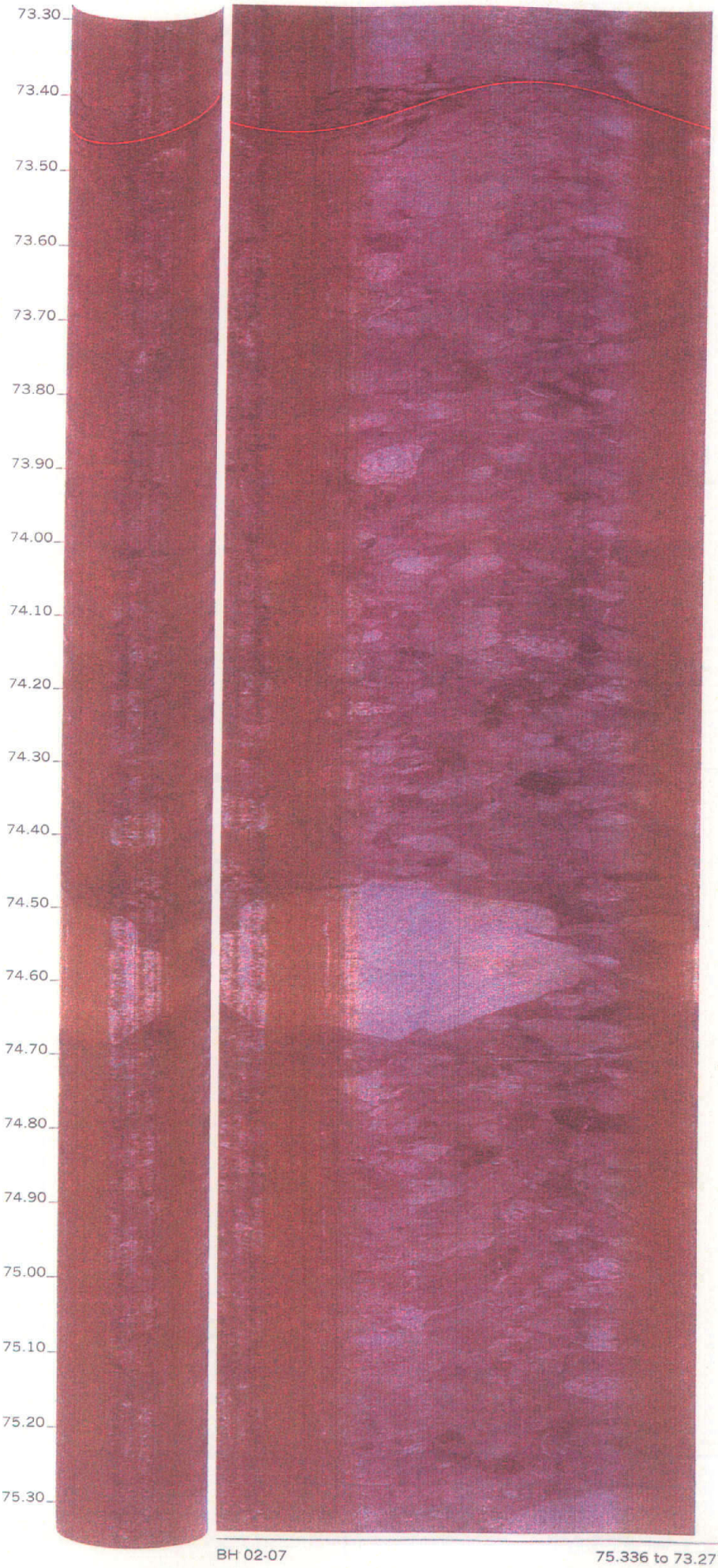
71.20
N206 85 Fracture Irregular
N210 88 Fracture Irregular
N271 35 Fracture Irregular



BH 02-07 73.277 to 71.218m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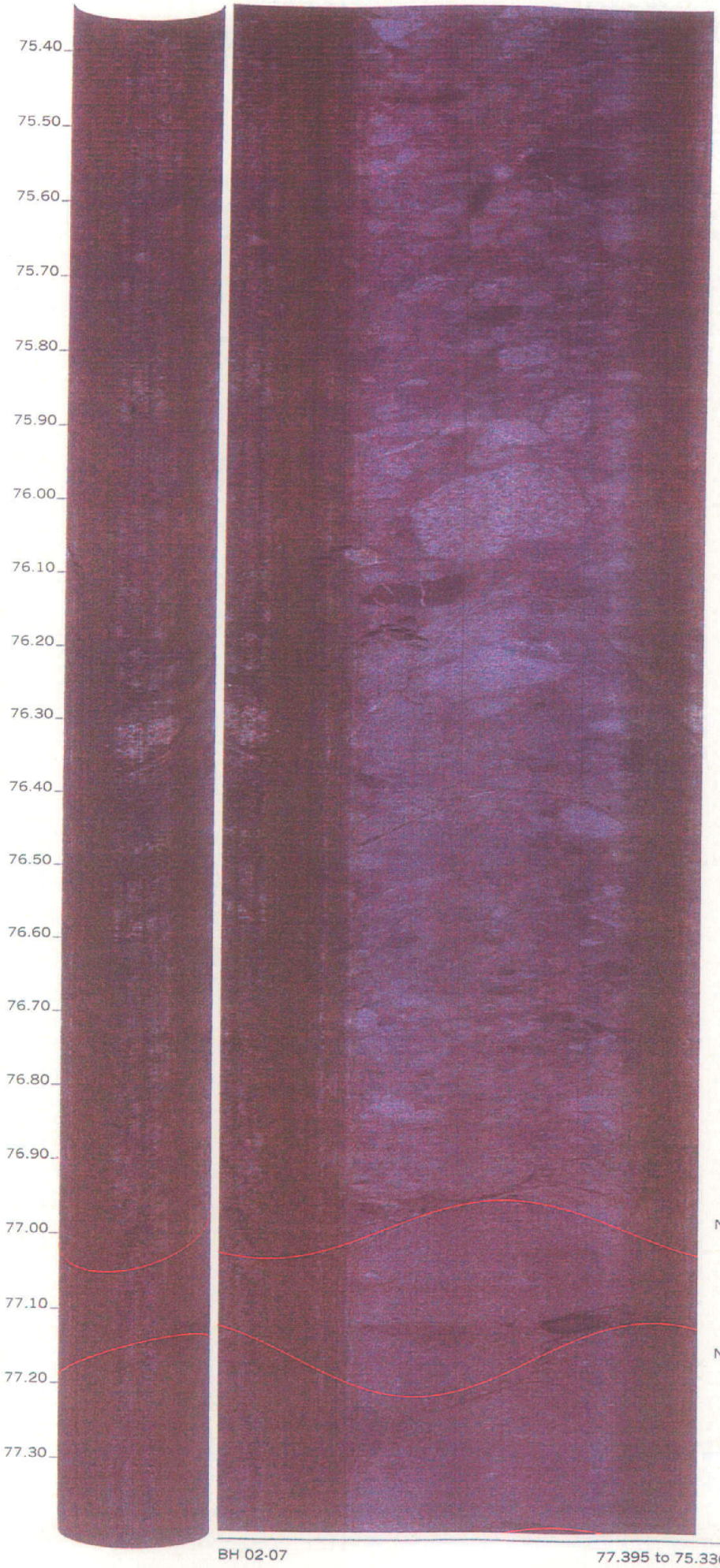
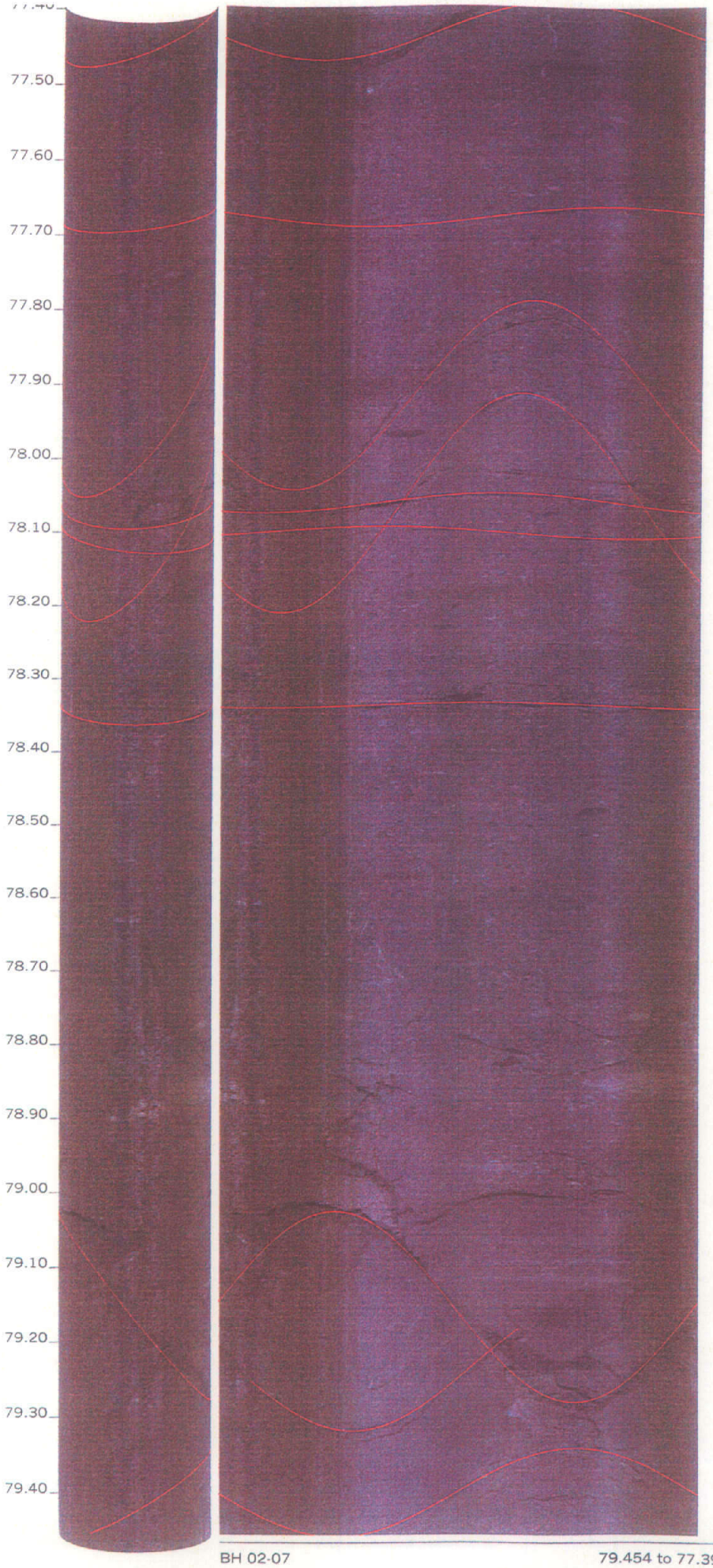
N040 72 Fracture Irregular



BH 02-07 77.395 to 75.336m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79.10
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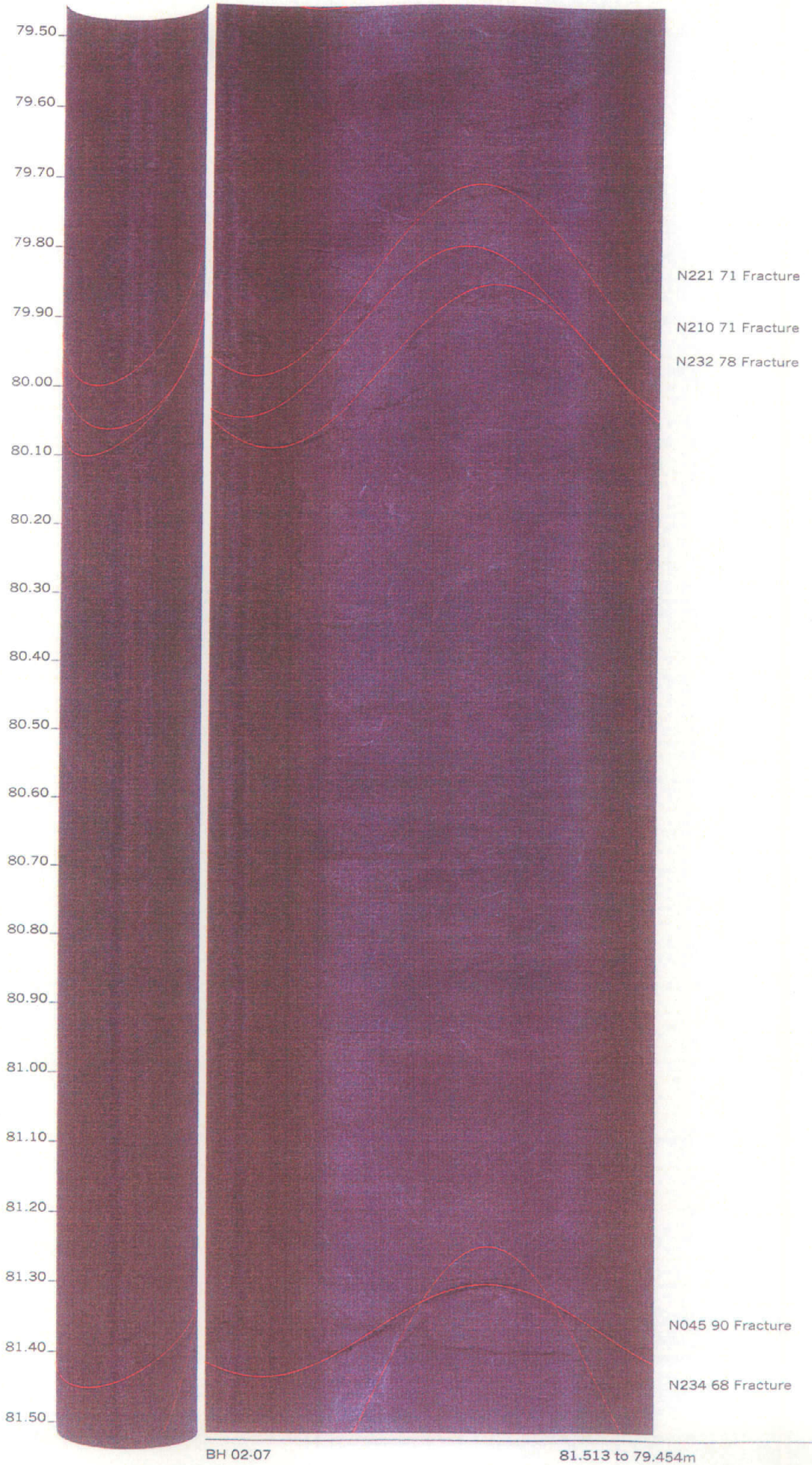
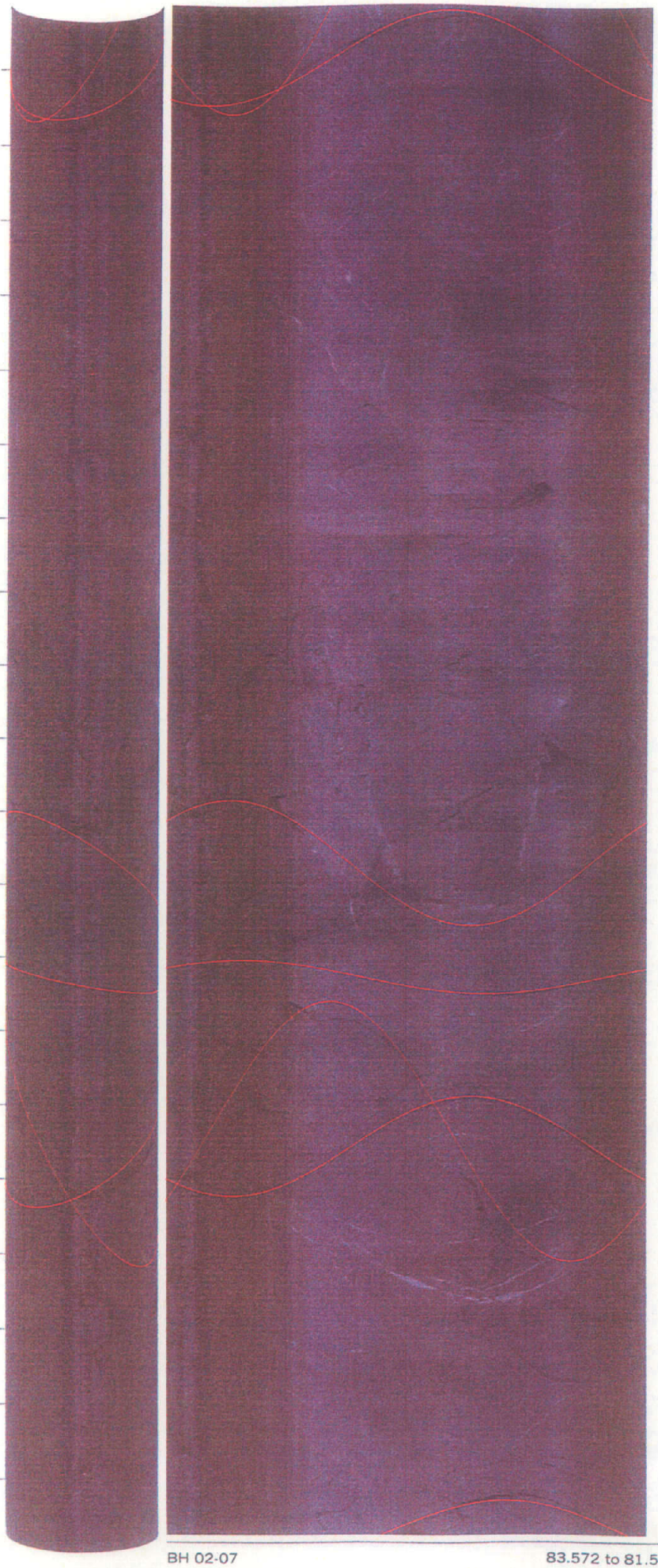
79.30
79.40
N054 67 Fracture
N043 44 Fracture
N236 77 Fracture
N012 46 Fracture
N023 47 Fracture Irregular
offset_fracture_lower_half
N295 59 Fracture
N085 71 Fracture Discontinuous
N070 70 Fracture



BH 02-07 81.513 to 79.454m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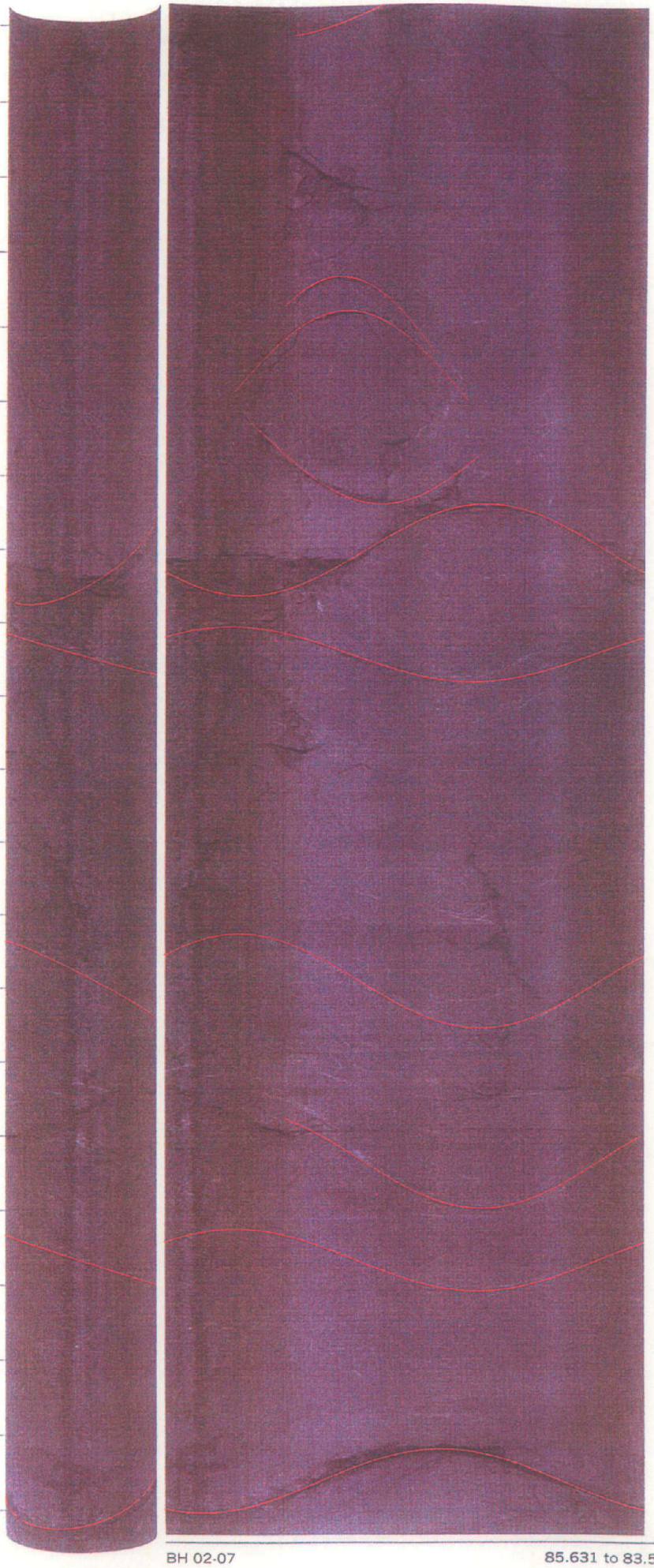
N213 89 Fracture
N273 27 Fracture
N353 29 Fracture
N316 88 Fracture
N047 89 Fracture
N057 70 Fracture Discontinuous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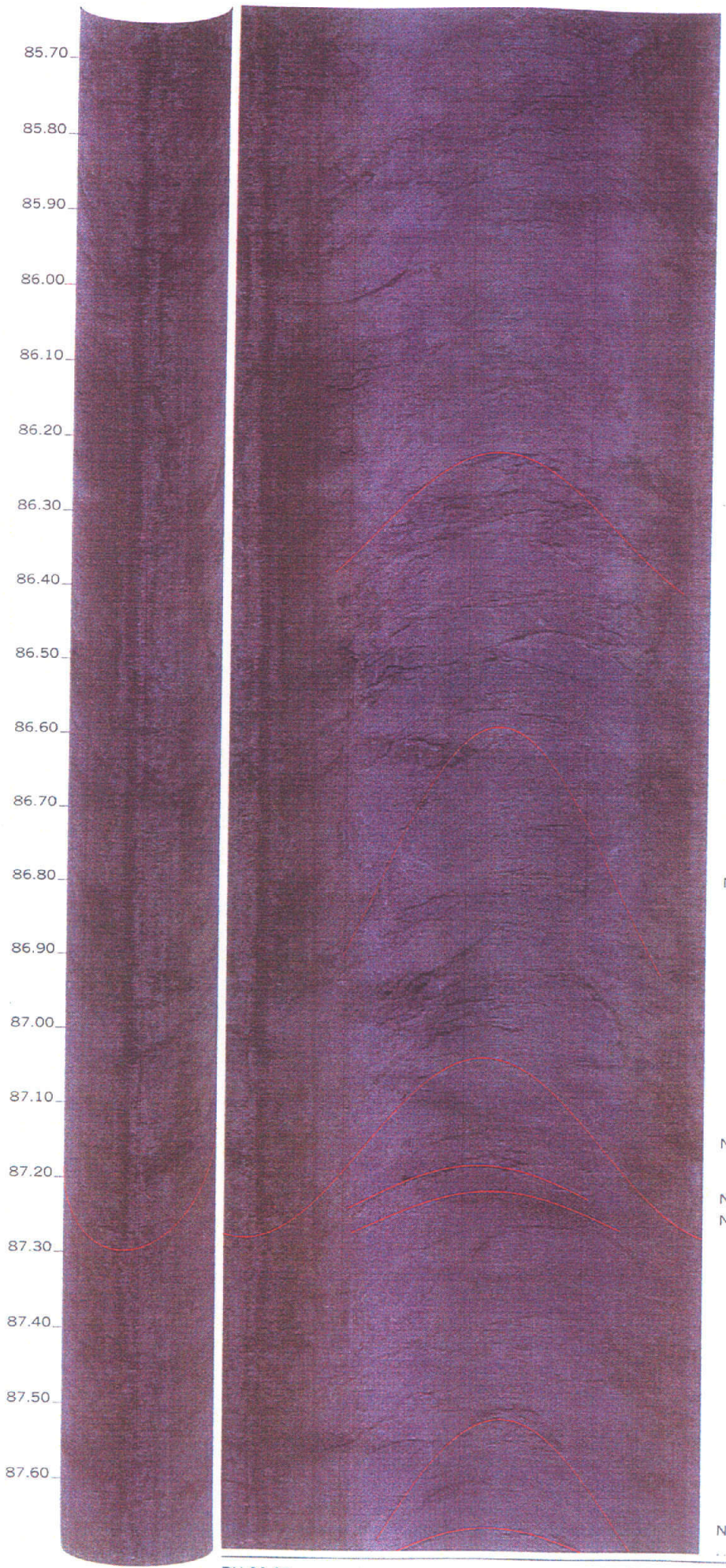
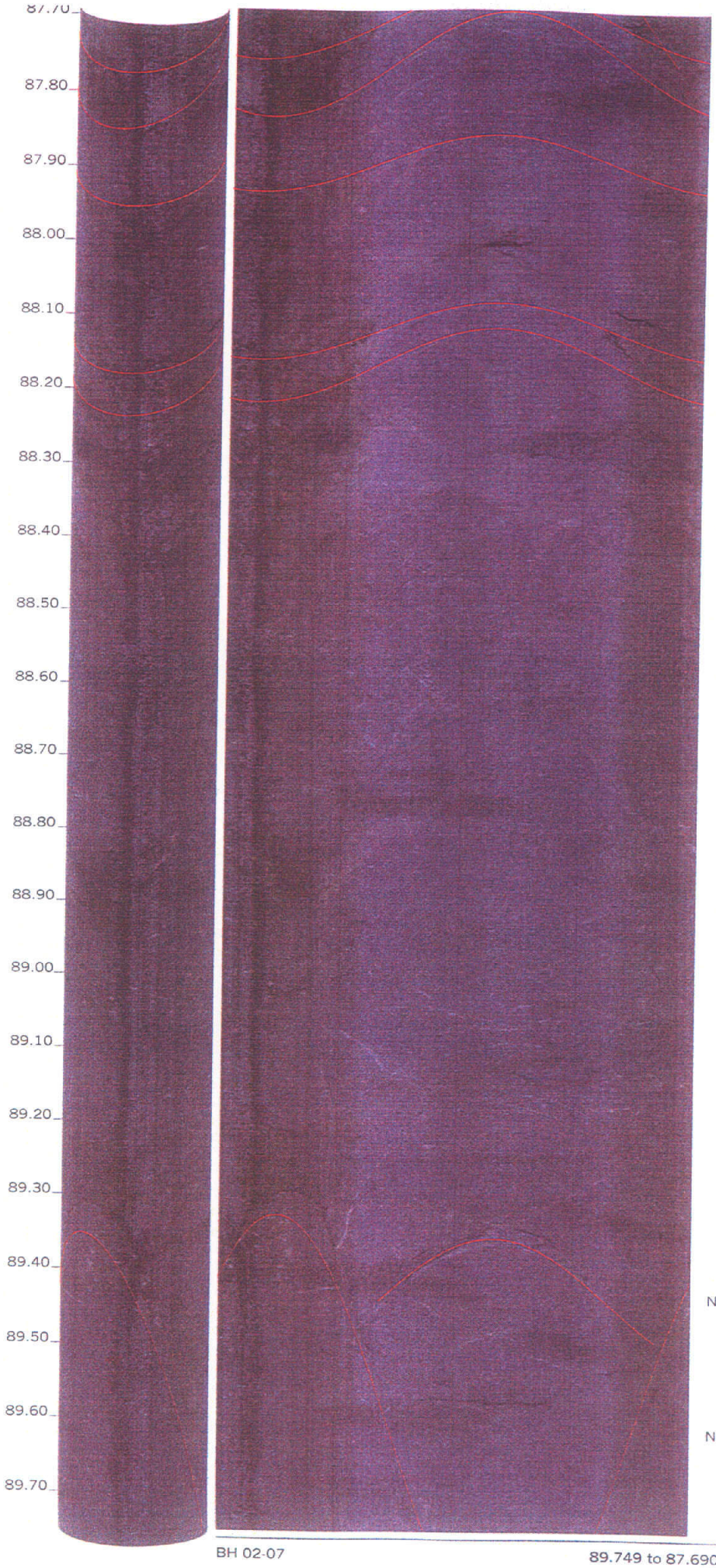
N144 89 Fracture Discontinuous
N151 90 Fracture Discontinuous
N133 31 Fracture Discontinuous
N055 84 Fracture
N328 22 Hairline-fracture
N295 29 Mineralized Hairline-fracture
N295 30 Hairline-fracture
N322 24 Hairline-fracture
N030 79 Fracture



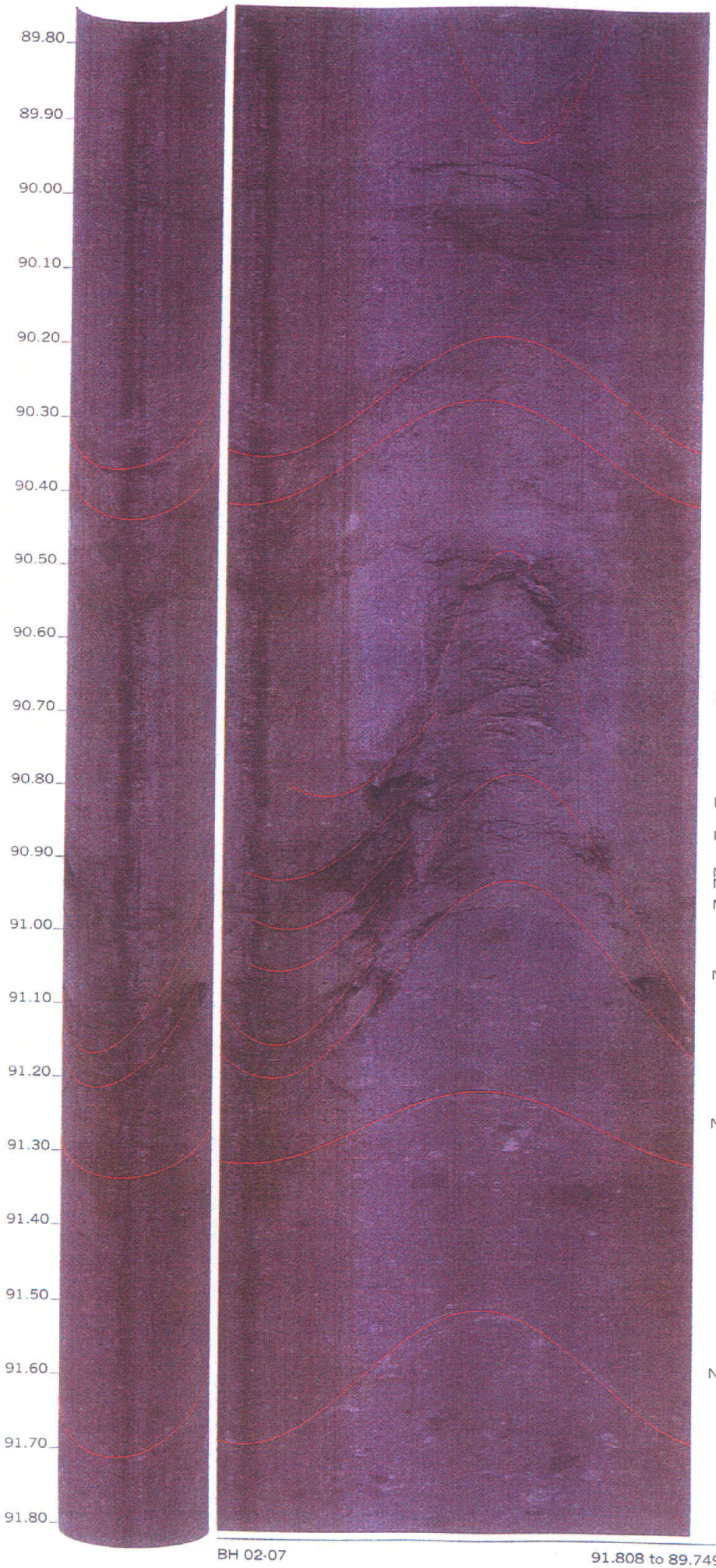
BH 02-07

87.690 to 85.631m



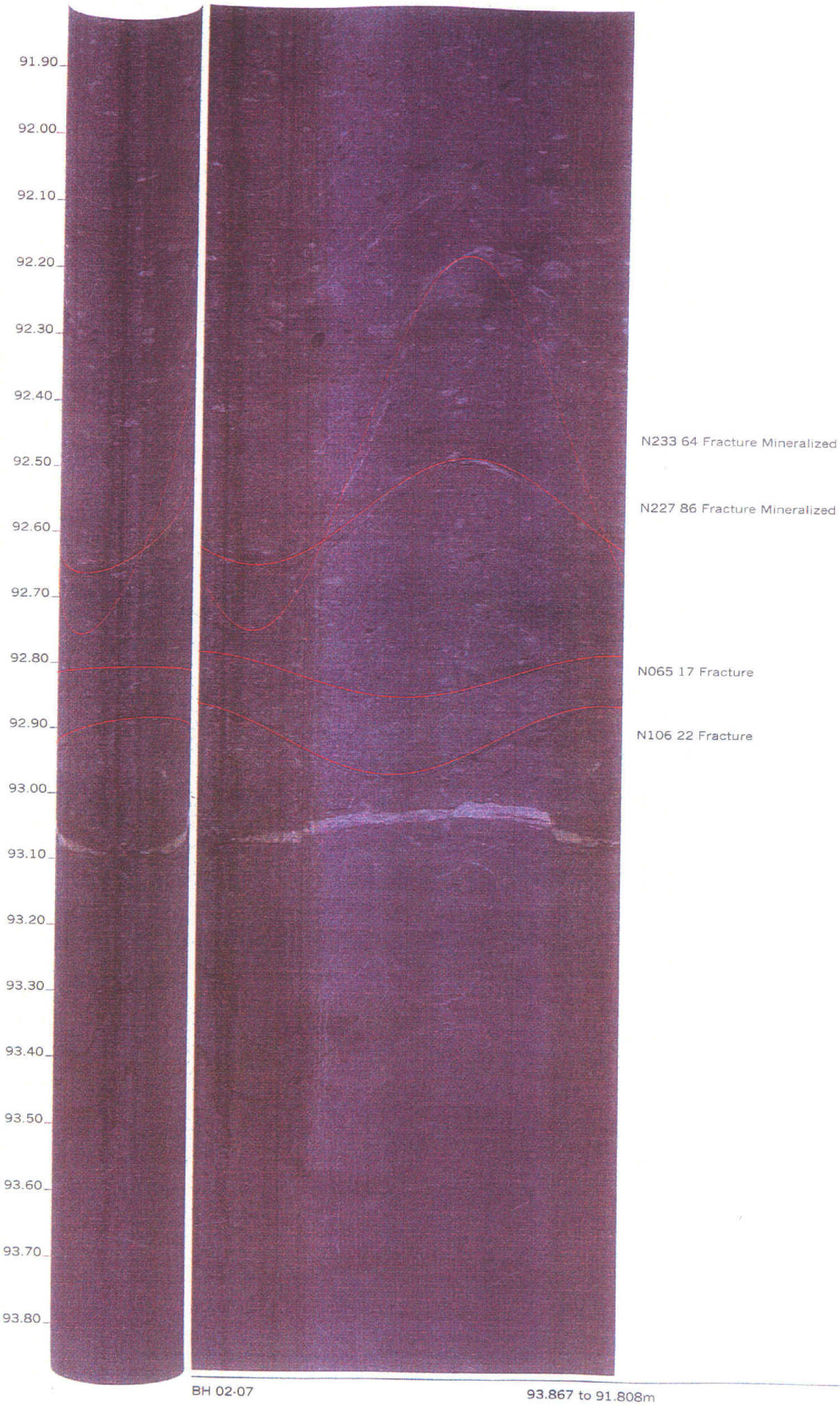
BH 02-07

89.749 to 87.690m



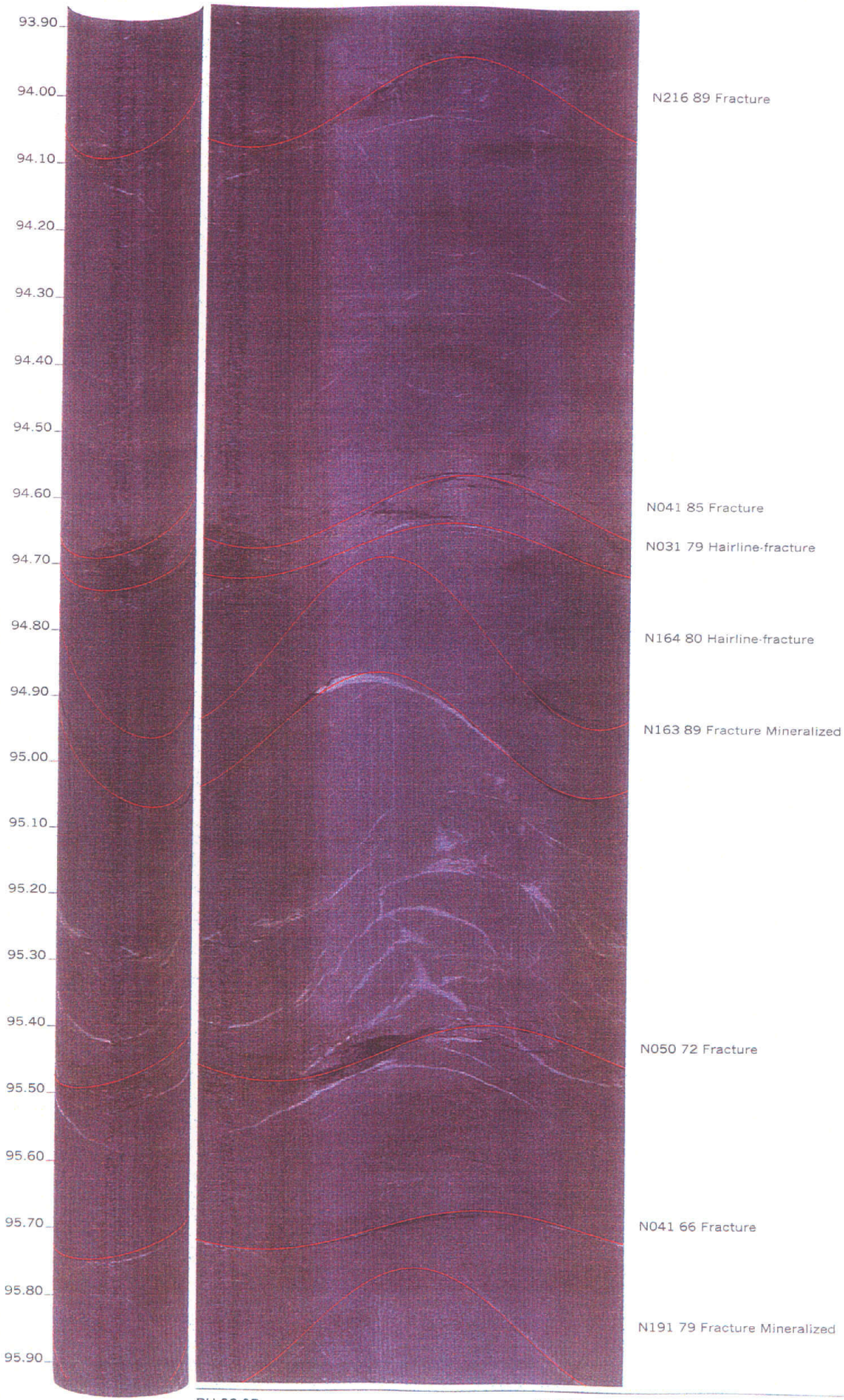
BH 02-07

91.808 to 89.749m



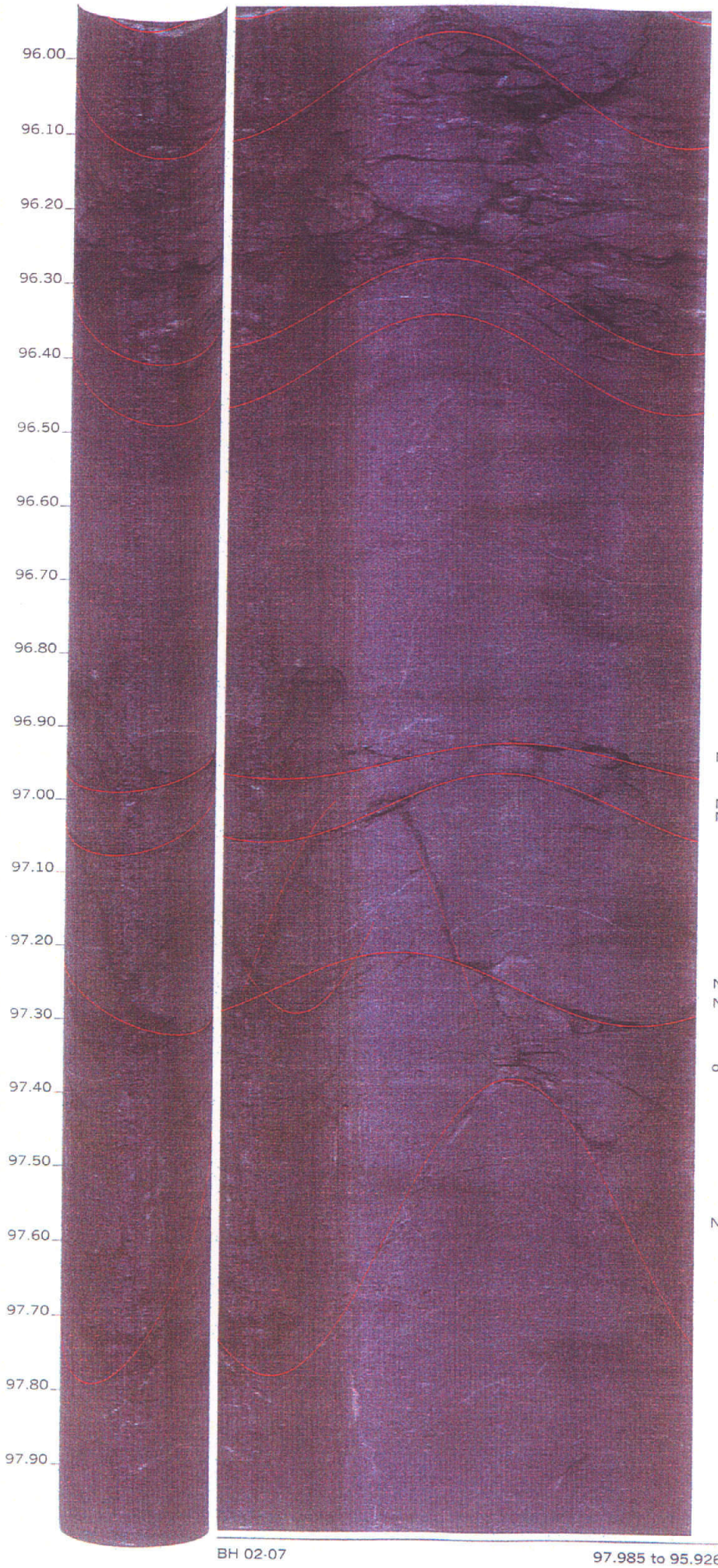
BH 02-07

93.867 to 91.808m



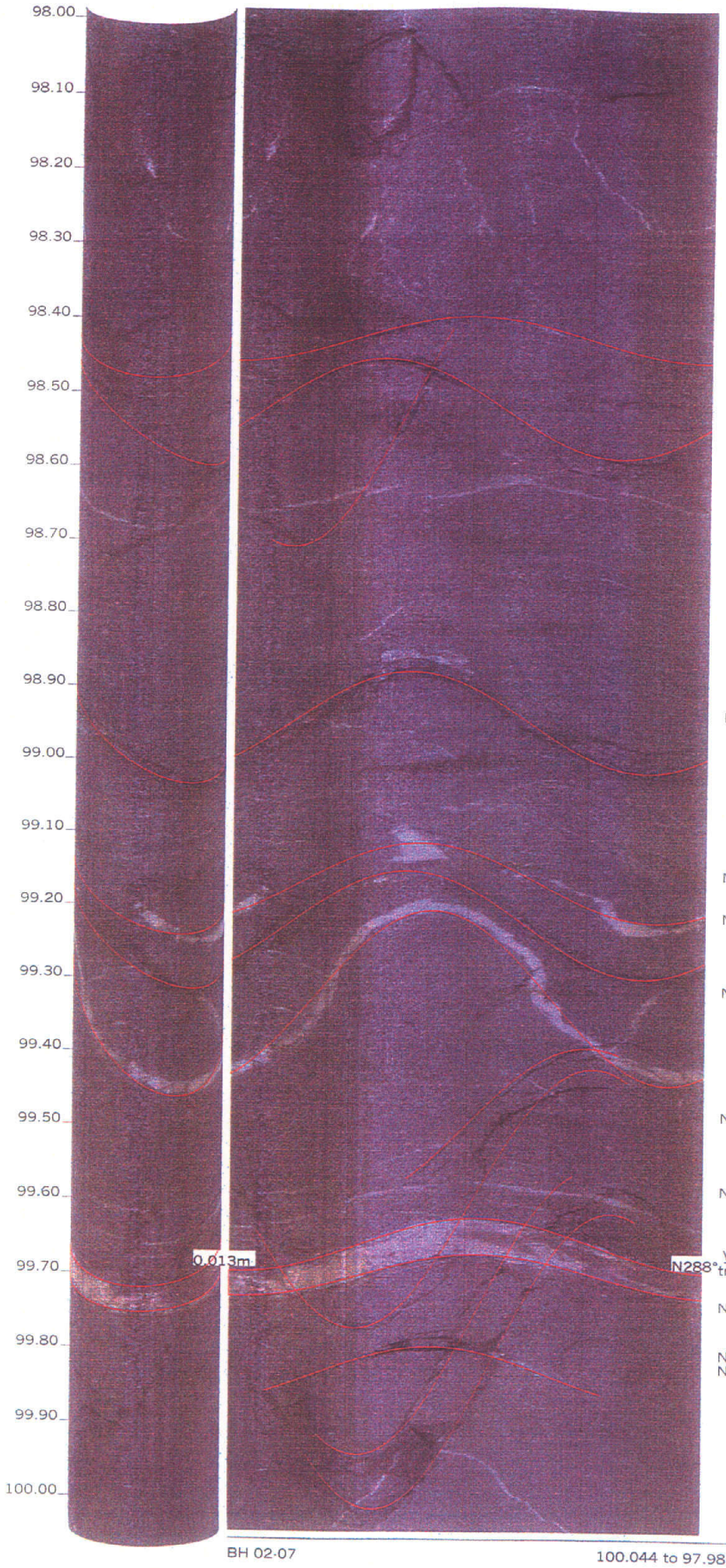
BH 02-07

95.926 to 93.867m



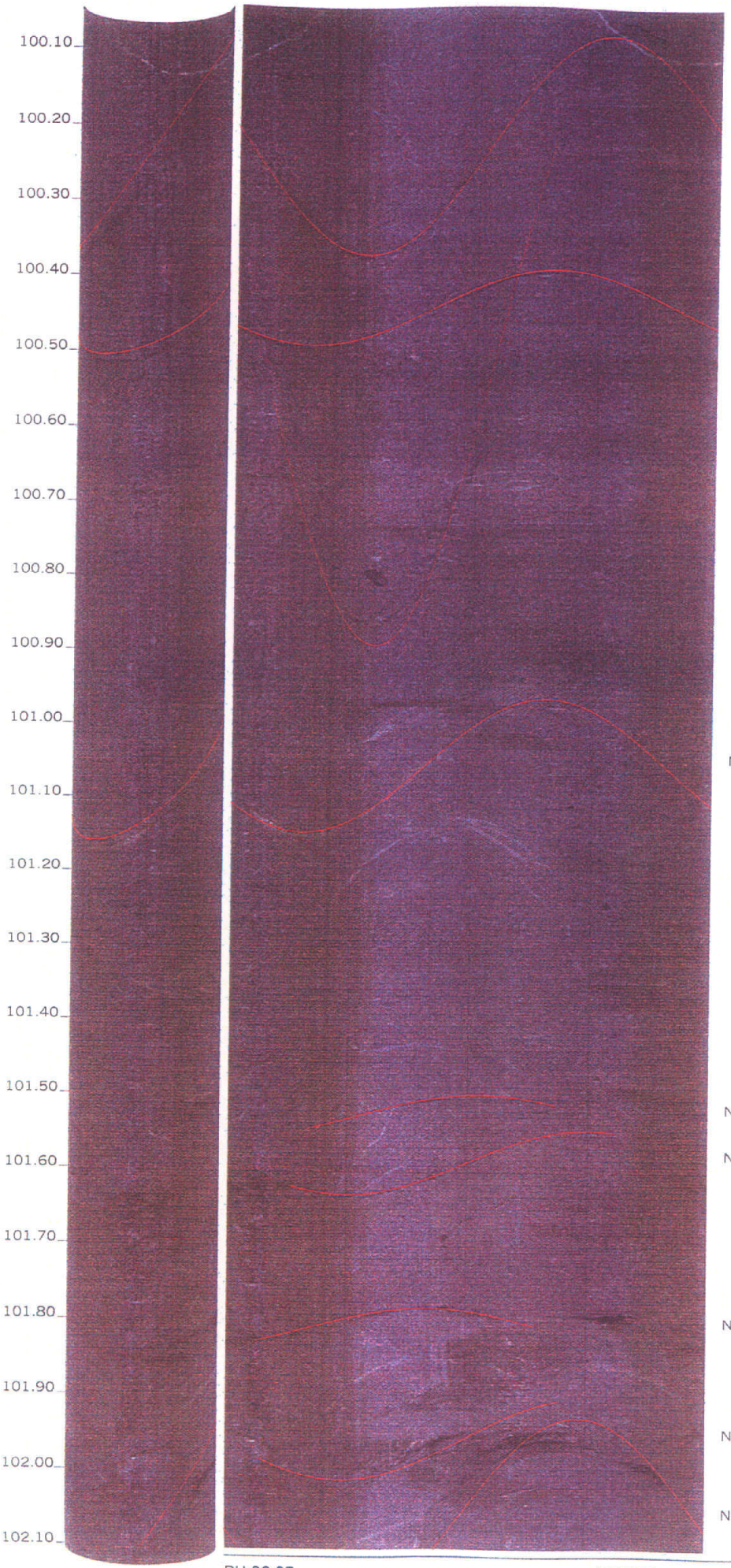
BH 02-07

97.985 to 95.926m



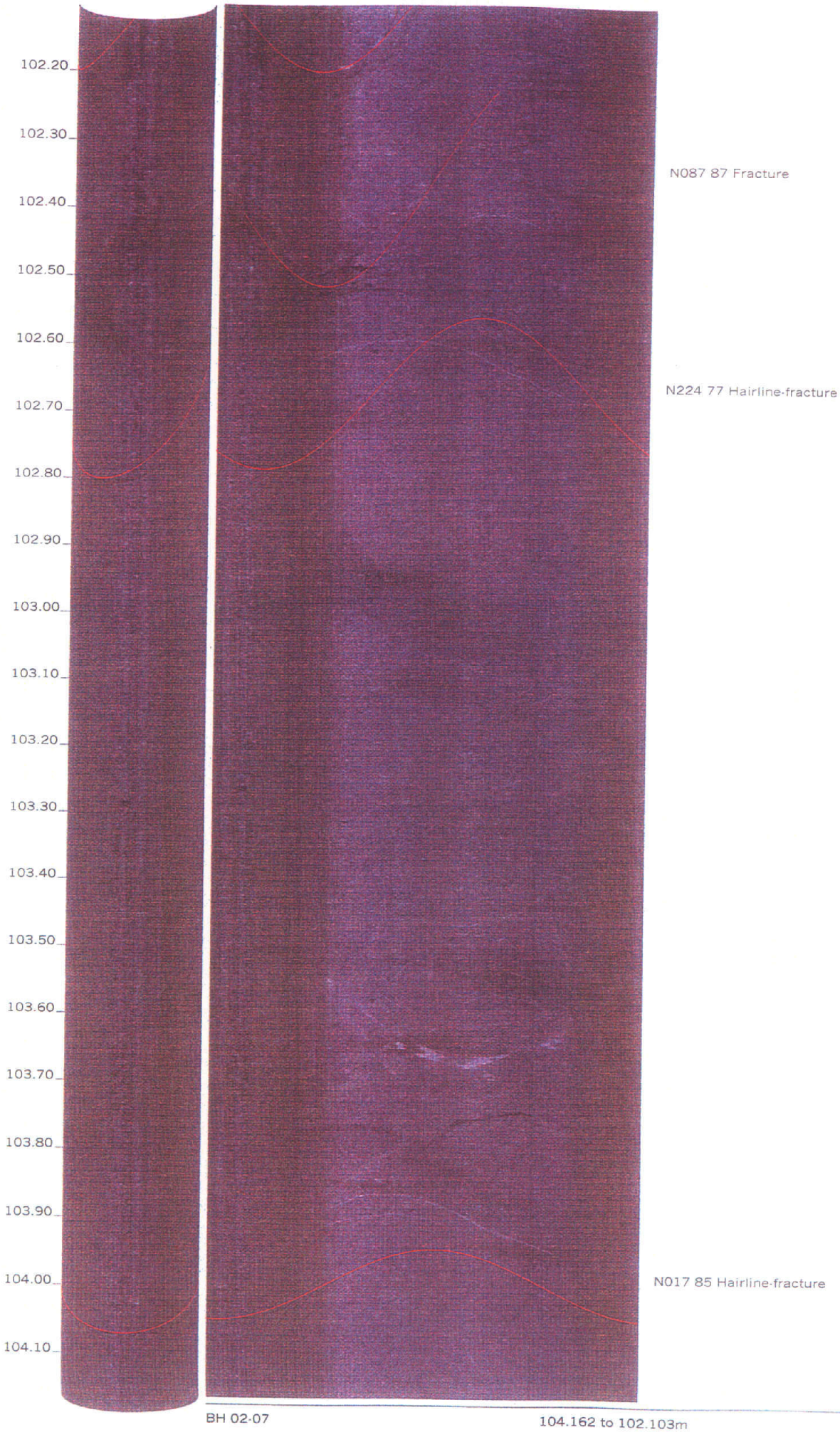
BH 02-07

100.044 to 97.985m



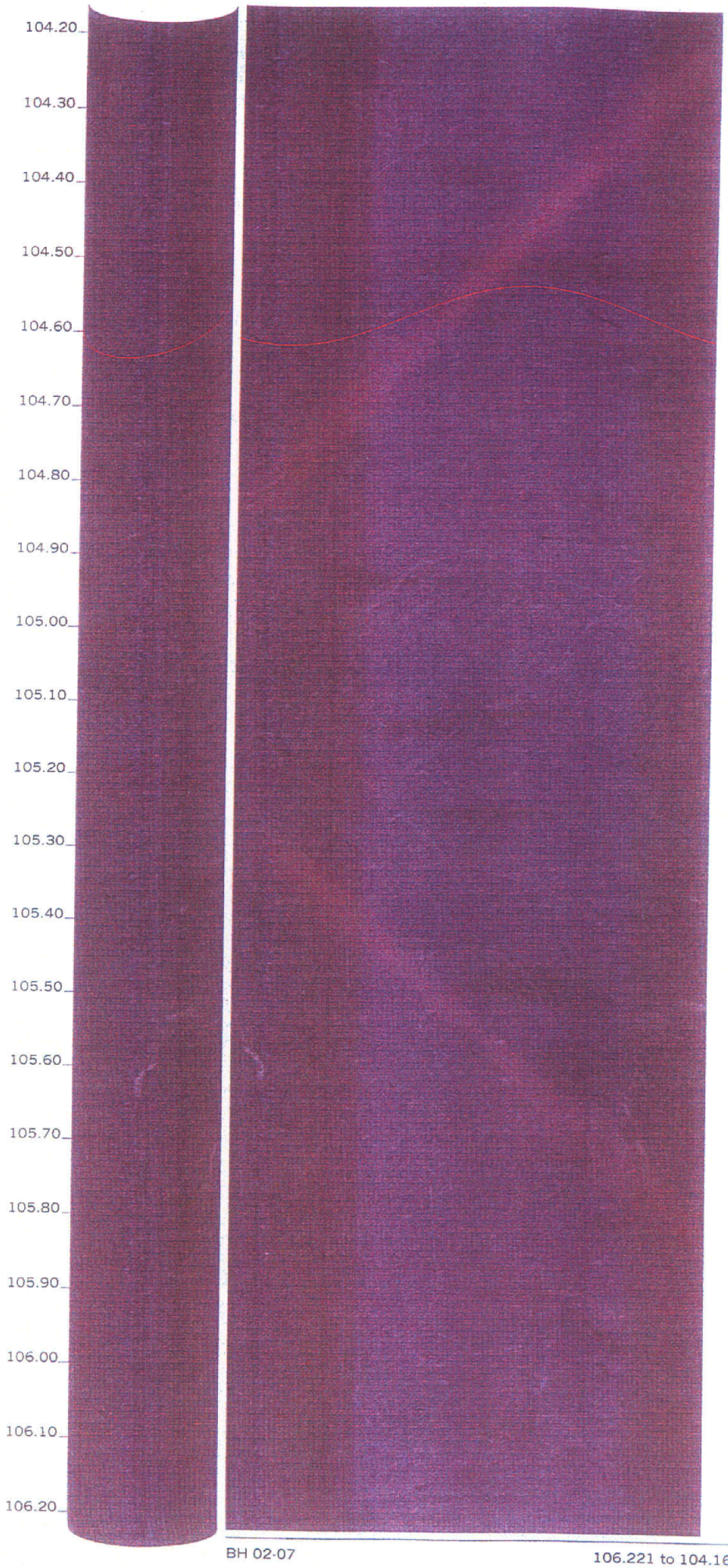
BH 02-07

102.103 to 100.044m



BH 02-07

104.162 to 102.103m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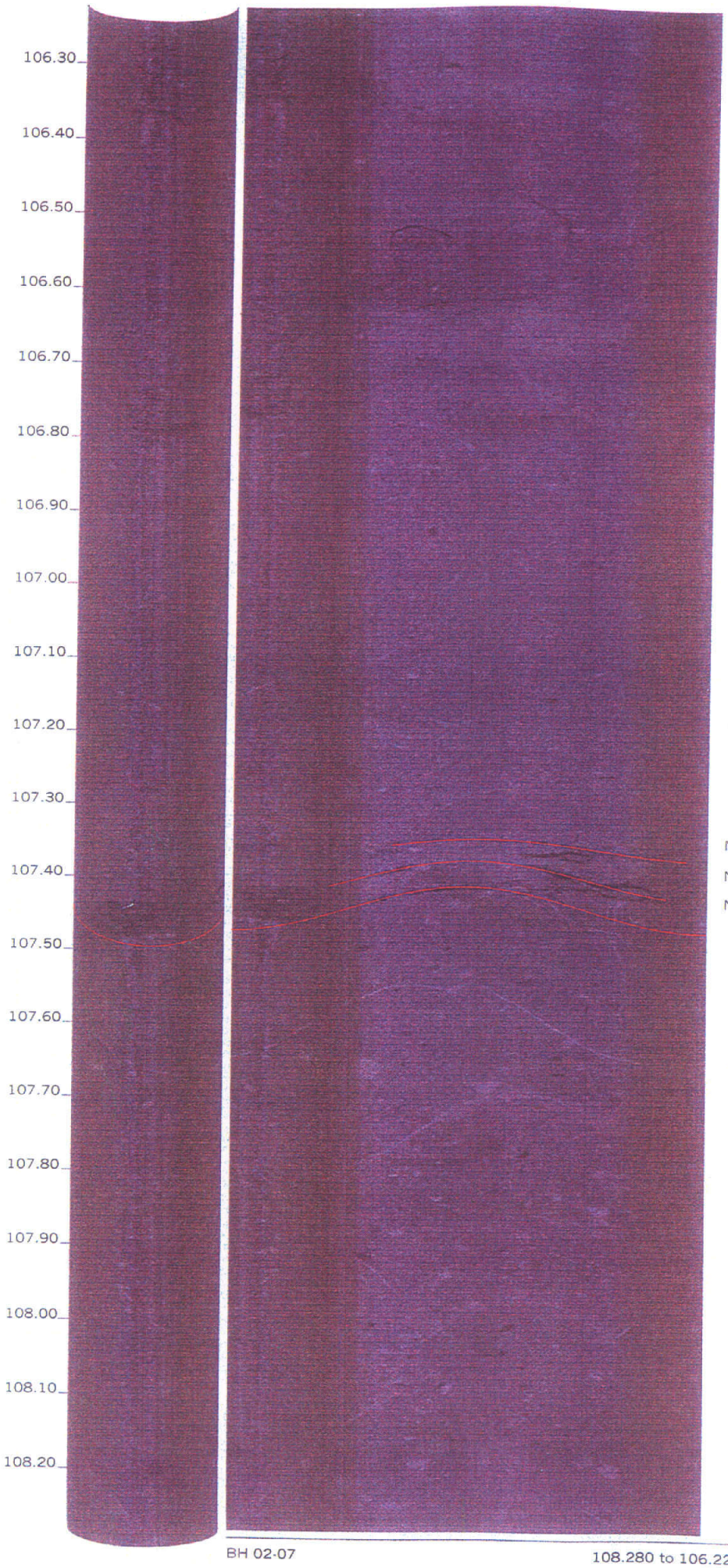
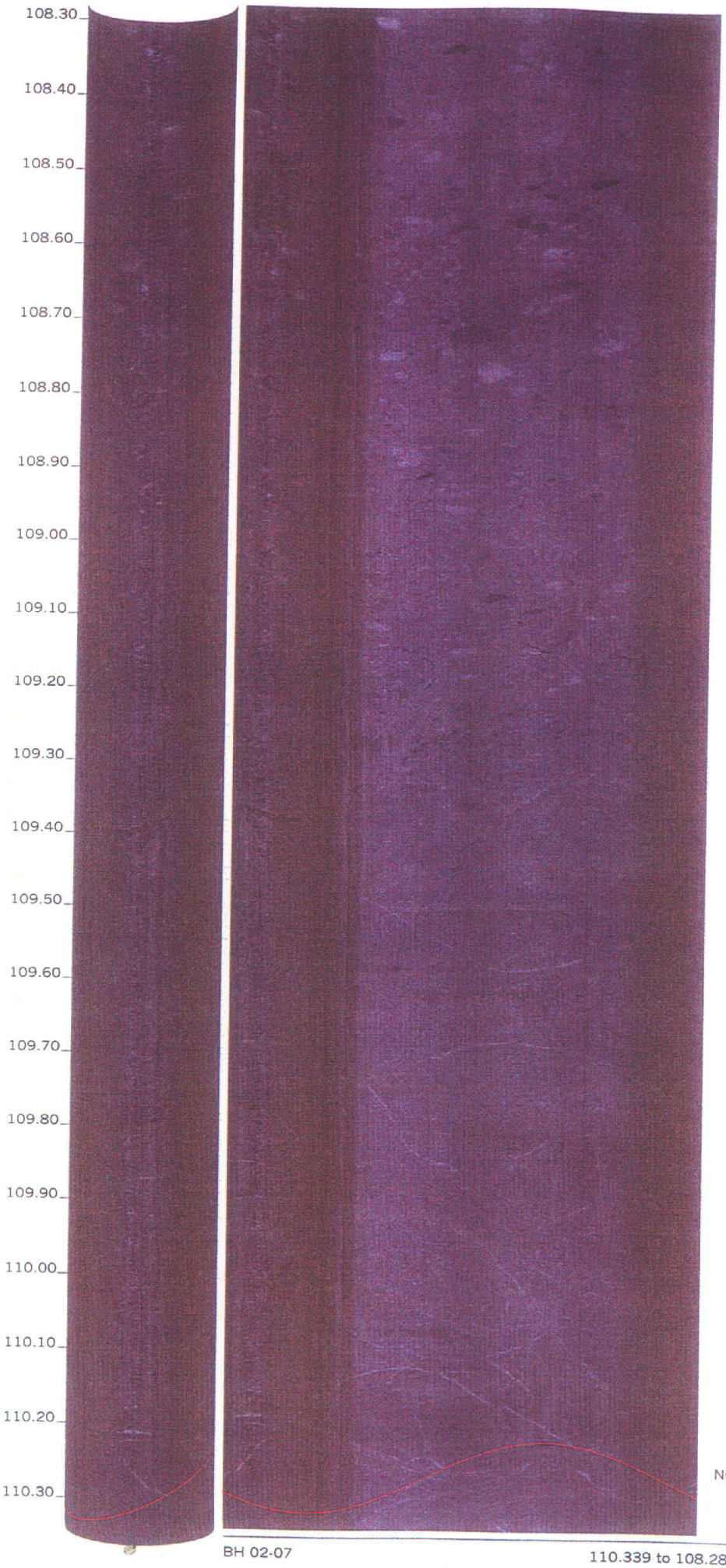
106.00
106.10
106.20
N035 77 Hairline-fracture



BH 02-07

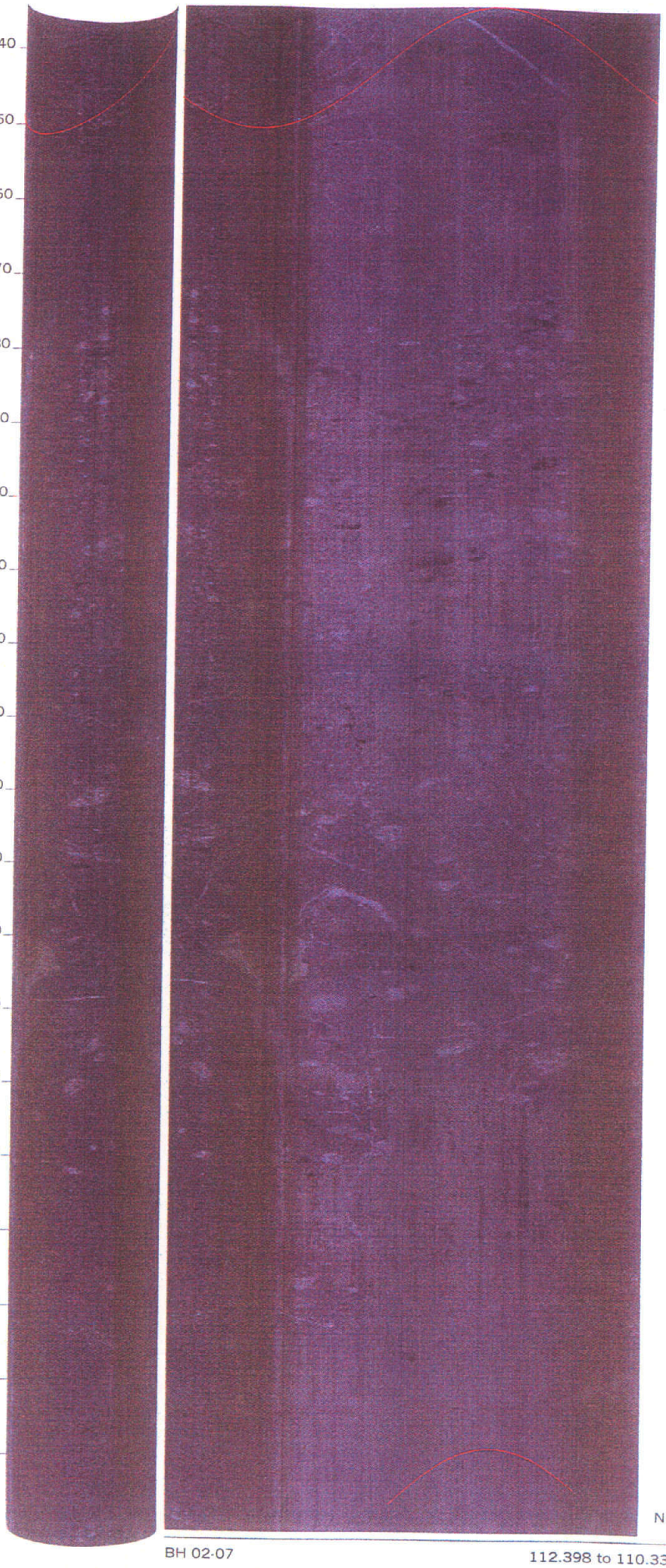
108.280 to 106.221m



N052 75 Fracture Discontinuous

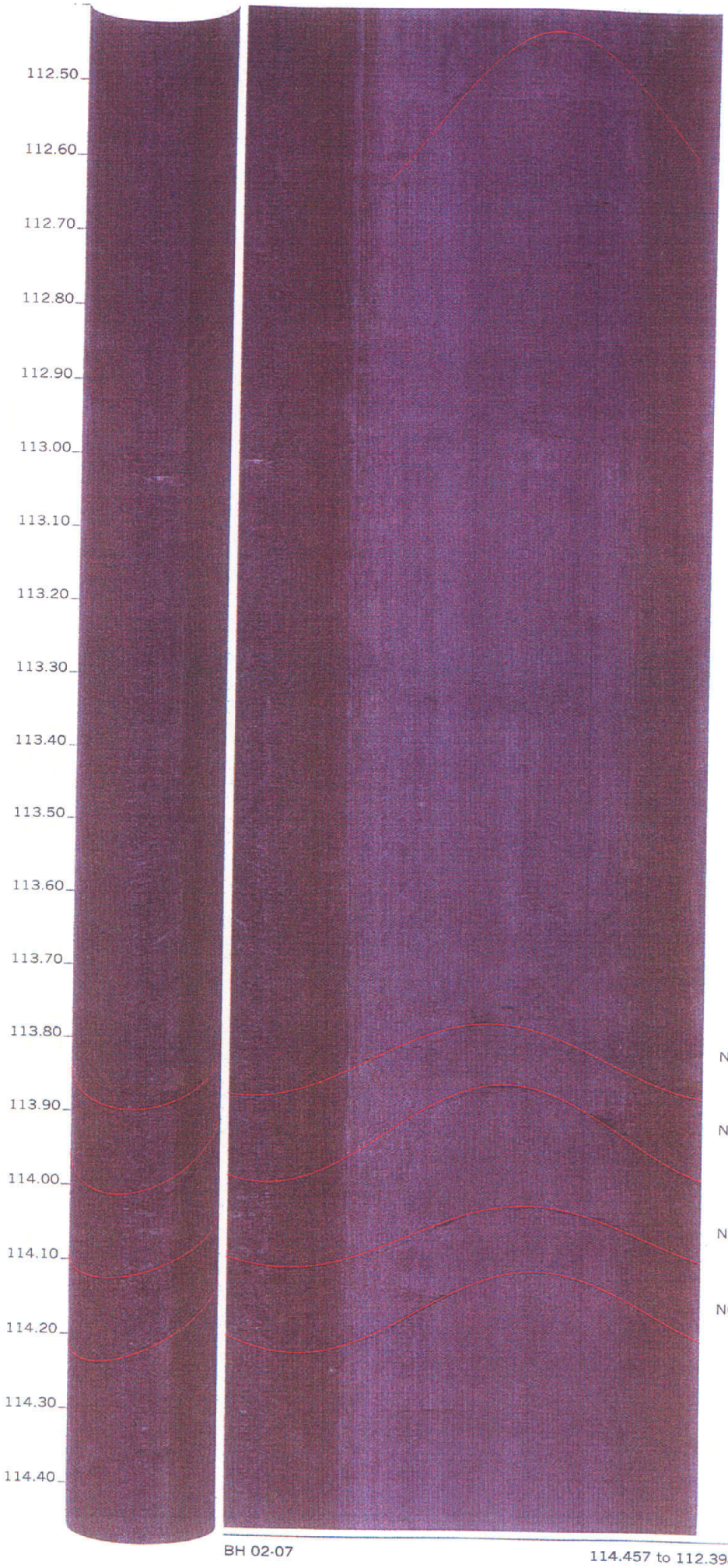
BH 02-07

110.339 to 108.280m



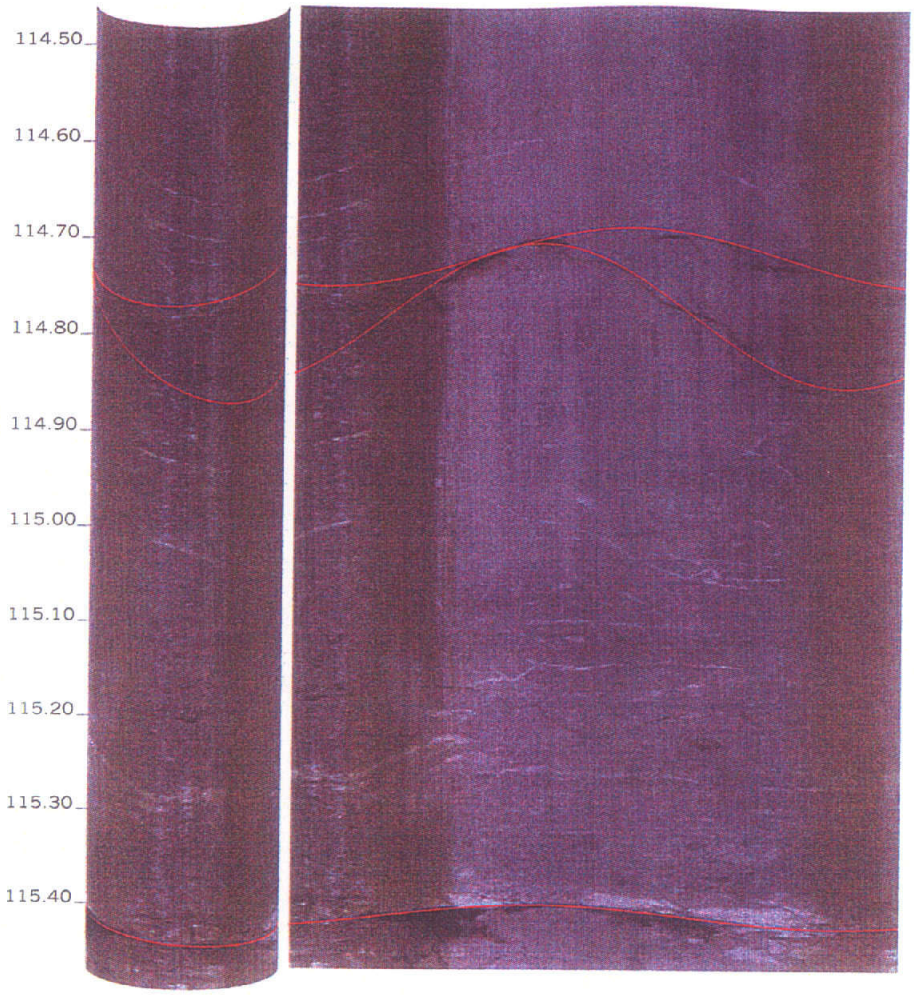
BH 02-07

112.398 to 110.339m



BH 02-07

114.457 to 112.398m



offset_fracture_lower_half

RGLDIPv6.1 OPTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-8B
zone from 36.234 to 1.252 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	35.220	302	38.0	0.938	11	C	2	35.155	35.285	0.110	199.67	45.65	0.0000	Fracture Discontinuous
2	34.939	35	72.2	0.925	13	C	2	34.909	34.962	0.110	199.69	46.76	0.0000	Fracture Discontinuous
3	34.491	284	20.6	0.990	7	A	2	34.421	34.561	0.110	199.27	46.66	0.0000	Fracture
4	34.416	345	67.3	0.983	6	A	2	34.376	34.457	0.110	200.00	45.26	0.0000	Fracture
5	33.224	335	72.6	0.913	13	C	2	33.168	33.280	0.110	199.40	46.00	0.0000	Fracture
6	32.685	61	21.2	0.957	10	B	2	32.650	32.720	0.110	200.00	46.00	0.0000	Fracture
7	32.250	174	12.7	0.956	7	B	2	32.207	32.351	0.110	200.00	49.77	0.0000	Fracture Discontinuous
8	32.184	179	20.2	0.987	5	A	2	32.197	32.311	0.110	200.00	47.39	0.0000	Fracture Discontinuous
9	31.882	16	76.2	0.954	8	B	0	31.852	31.912	0.110	200.00	47.69	0.0000	Bedding
10	31.746	13	62.9	0.970	8	B	0	31.728	31.763	0.110	200.00	46.00	0.0000	Bedding
11	31.697	121	66.9	0.970	13	B	2	31.740	32.070	0.110	200.00	46.53	0.0000	Fracture Discontinuous
12	30.817	10	69.1	0.981	11	A	0	30.795	30.840	0.110	200.00	48.53	0.0000	Bedding
13	30.083	179	70.4	0.979	7	A	2	30.097	30.204	0.110	199.59	46.95	0.0000	Fracture Discontinuous
14	29.773	24	51.7	0.985	7	A	0	29.766	29.779	0.110	199.37	45.75	0.0000	Bedding
15	29.469	334	79.1	0.970	5	B	2	29.400	29.538	0.110	199.70	45.20	0.0000	Fracture
16	29.093	349	87.5	0.904	14	C	2	29.027	29.159	0.110	199.00	45.00	0.0000	Fracture
17	28.644	350	65.2	0.969	6	B	2	28.612	28.658	0.110	199.00	47.00	0.0000	Fracture Discontinuous
18	26.838	33	88.8	0.970	5	B	0	26.783	26.893	0.110	199.68	45.36	0.0000	Bedding
19	26.655	18	88.4	0.928	12	C	0	26.601	26.708	0.110	199.01	44.05	0.0000	Irregular Bedding
20	26.168	11	66.0	0.934	10	C	0	26.148	26.188	0.110	200.00	47.56	0.0000	Bedding
21	26.052	19	69.4	0.977	9	A	0	26.031	26.072	0.110	199.95	48.77	0.0000	Bedding
22	24.983	193	65.3	0.892	13	D	2	24.853	25.114	0.110	200.00	47.83	0.0000	Fracture
23	24.835	22	72.2	0.958	9	B	0	24.808	24.862	0.110	199.37	46.12	0.0000	Bedding
24	24.695	29	78.2	0.985	6	A	0	24.660	24.730	0.110	200.00	46.36	0.0000	Bedding
25	24.646	28	82.3	0.992	6	A	0	24.607	24.686	0.110	200.00	47.37	0.0000	Bedding
26	24.118	31	81.0	0.970	9	B	0	24.081	24.156	0.110	200.43	48.01	0.0000	Bedding
27	23.986	35	75.8	0.953	12	B	0	23.951	24.022	0.110	200.35	45.76	0.0000	Bedding
28	23.682	39	88.8	0.962	9	B	0	23.624	23.739	0.110	199.00	46.34	0.0000	Bedding
29	23.118	214	83.9	0.952	7	B	0	23.043	23.194	0.110	199.00	44.00	0.0000	Bedding
30	22.679	219	80.0	0.975	10	A	0	22.597	22.762	0.110	199.51	46.53	0.0000	Bedding
31	21.283	242	11.0	0.904	10	C	0	21.207	21.359	0.110	199.41	45.65	0.0000	Bedding
32	18.250	70	85.1	0.943	16	C	2	18.164	18.335	0.110	200.91	48.00	0.0000	Fracture Irregular

Borehole: 02-06 Logged section from 66.6 to 139.1 meters
Depth range: 0.000 - 139.210m extrapolated from 0 to 66.6m

Depth	Deviation components North	East	Down	Devaz	Dev
m	m	m	m	deg	deg
1.010	-0.187	0.157	0.980	140.00	14.00
2.010	-0.372	0.313	1.950	140.00	14.00
3.010	-0.558	0.468	2.921	140.00	14.00
4.010	-0.743	0.624	3.891	140.00	14.00
5.010	-0.928	0.779	4.861	140.00	14.00
6.010	-1.114	0.935	5.831	140.00	14.00
7.010	-1.299	1.090	6.802	140.00	14.00
8.010	-1.484	1.246	7.772	140.00	14.00
9.010	-1.670	1.401	8.742	140.00	14.00
10.010	-1.855	1.557	9.713	140.00	14.00
11.010	-2.040	1.712	10.683	140.00	14.00
12.010	-2.226	1.868	11.653	140.00	14.00
13.010	-2.411	2.023	12.624	140.00	14.00
14.010	-2.596	2.179	13.594	140.00	14.00
15.010	-2.782	2.334	14.564	140.00	14.00
16.010	-2.967	2.490	15.534	140.00	14.00
17.010	-3.152	2.645	16.505	140.00	14.00
18.010	-3.338	2.801	17.475	140.00	14.00
19.010	-3.523	2.956	18.445	140.00	14.00
20.010	-3.708	3.112	19.416	140.00	14.00
21.010	-3.894	3.267	20.386	140.00	14.00
22.010	-4.079	3.423	21.356	140.00	14.00
23.010	-4.264	3.578	22.327	140.00	14.00
24.010	-4.450	3.734	23.297	140.00	14.00
25.010	-4.635	3.889	24.267	140.00	14.00
26.010	-4.820	4.045	25.237	140.00	14.00
27.010	-5.006	4.200	26.208	140.00	14.00
28.010	-5.191	4.356	27.178	140.00	14.00
29.010	-5.376	4.511	28.148	140.00	14.00
30.010	-5.562	4.667	29.119	140.00	14.00
31.010	-5.747	4.822	30.089	140.00	14.00
32.010	-5.932	4.978	31.059	140.00	14.00
33.010	-6.118	5.133	32.029	140.00	14.00
34.010	-6.303	5.289	33.000	140.00	14.00
35.010	-6.488	5.444	33.970	140.00	14.00
36.010	-6.673	5.600	34.940	140.00	14.00
37.010	-6.859	5.755	35.911	140.00	14.00
38.010	-7.044	5.911	36.881	140.00	14.00
39.010	-7.229	6.066	37.851	140.00	14.00
40.010	-7.415	6.222	38.822	140.00	14.00
41.010	-7.600	6.377	39.792	140.00	14.00
42.010	-7.785	6.533	40.762	140.00	14.00
43.010	-7.971	6.688	41.732	140.00	14.00
44.010	-8.156	6.844	42.703	140.00	14.00
45.010	-8.341	6.999	43.673	140.00	14.00
46.010	-8.527	7.155	44.643	140.00	14.00
47.010	-8.712	7.310	45.614	140.00	14.00
48.010	-8.897	7.466	46.584	140.00	14.00
49.010	-9.083	7.621	47.554	140.00	14.00
50.010	-9.268	7.777	48.524	140.00	14.00
51.010	-9.453	7.932	49.495	140.00	14.00
52.010	-9.639	8.088	50.465	140.00	14.00

53.010	-9.824	8.243	51.435	140.00	14.00
54.010	-10.009	8.399	52.406	140.00	14.00
55.010	-10.195	8.554	53.376	140.00	14.00
56.010	-10.380	8.710	54.346	140.00	14.00
57.010	-10.565	8.865	55.317	140.00	14.00
58.010	-10.751	9.021	56.287	140.00	14.00
59.010	-10.936	9.176	57.257	140.00	14.00
60.010	-11.121	9.332	58.227	140.00	14.00
61.010	-11.307	9.487	59.198	140.00	14.00
62.010	-11.492	9.643	60.168	140.00	14.00
63.010	-11.677	9.798	61.138	140.00	14.00
64.010	-11.863	9.954	62.109	140.00	14.00
65.010	-12.048	10.109	63.079	140.00	14.00
66.010	-12.233	10.265	64.049	140.00	14.00
67.010	-12.418	10.420	65.020	140.00	14.00
68.010	-12.604	10.576	65.990	140.00	14.00
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84.010	-15.569	13.064	81.515	140.00	14.00
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88.010	-16.310	13.686	85.396	140.00	14.00
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90.010	-16.681	13.997	87.336	140.00	14.00
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94.010	-17.422	14.619	91.218	140.00	14.00
95.010	-17.608	14.774	92.188	140.00	14.00
96.010	-17.793	14.930	93.158	140.00	14.00
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103.010	-19.090	16.019	99.950	140.00	14.00
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106.010	-19.646	16.485	102.861	140.00	14.00
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108.010	-20.017	16.796	104.802	140.00	14.00
109.010	-20.202	16.952	105.772	140.00	14.00
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123.010	-22.797	19.129	119.356	140.00	14.00
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132.010	-24.464	20.528	128.089	140.00	14.00
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134.010	-24.835	20.839	130.029	140.00	14.00
135.010	-25.020	20.995	131.000	140.00	14.00
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137.010	-25.391	21.306	132.940	140.00	14.00
138.010	-25.576	21.461	133.911	140.00	14.00
139.010	-25.762	21.617	134.881	140.00	14.00

112.004	-69.213	-33.348	81.374	202.00	41.00
113.004	-69.819	-33.594	82.130	202.00	41.00
114.004	-70.428	-33.836	82.885	202.00	41.00
115.004	-71.036	-34.078	83.642	202.00	41.00

Appendix D

BOREHOLE 02-08B
IMAGE LOG PLOTS
DISCONTINUITY AND DEVIATION TABLES

NORCAL GEOPHYSICAL CONSULTANTS, INC.

OPTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED OPTV DIPS LOG

25 Sep 2002

EARTH MECHANICS

Borehole: BH 08-8B

DEVILS SLIDE

top of borehole.....
East:
North:
Alt:

North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = fixed format

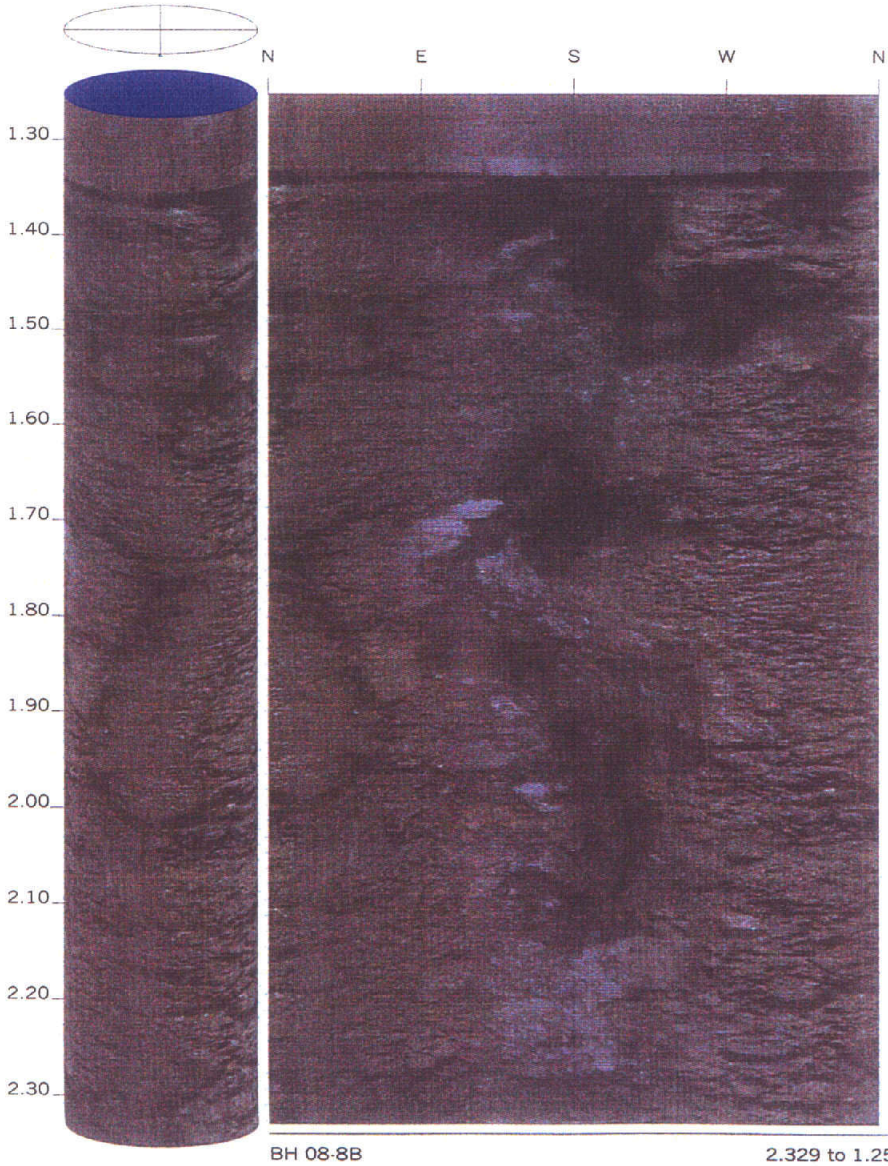
Zone from 36.234 to 1.252m
Vertical = borehole-axis

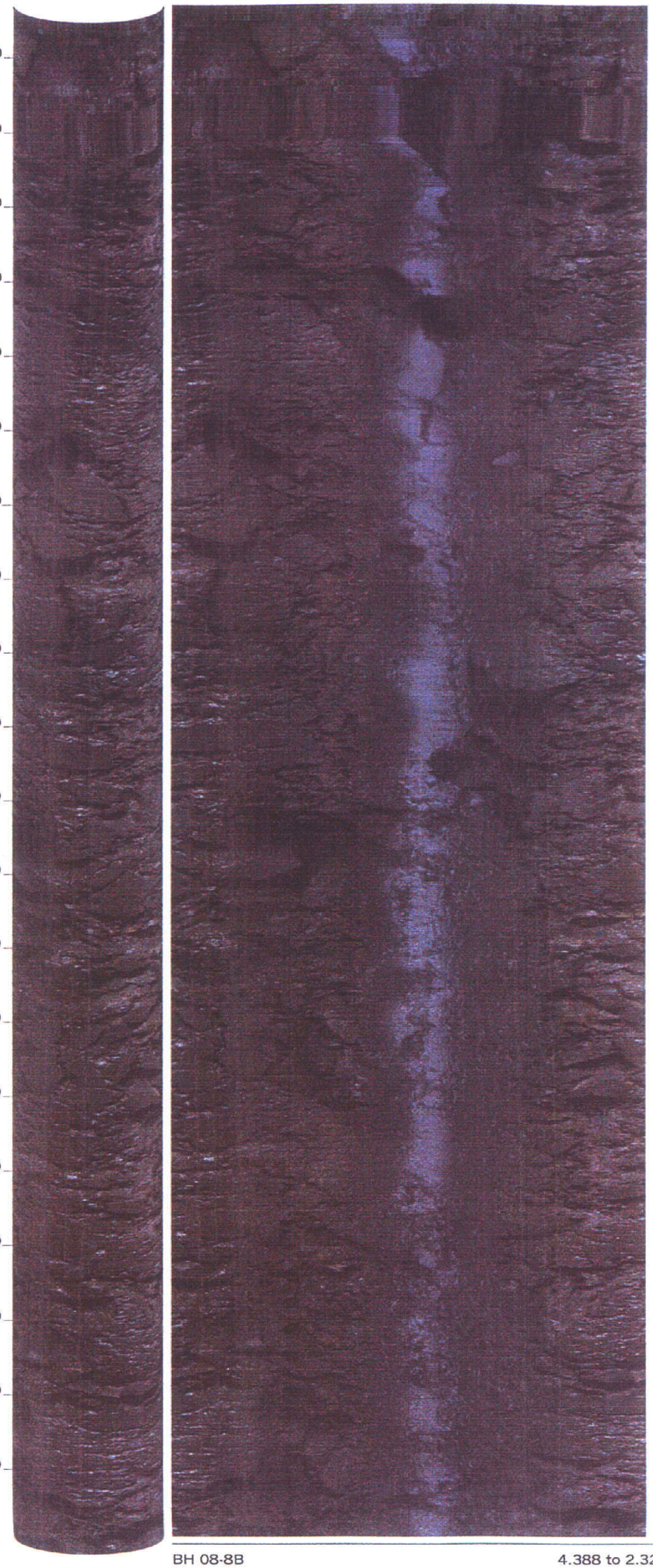
Borehole diam: 11.000cm

BEDDING
FRACTURE

Identified units

COMMENTS

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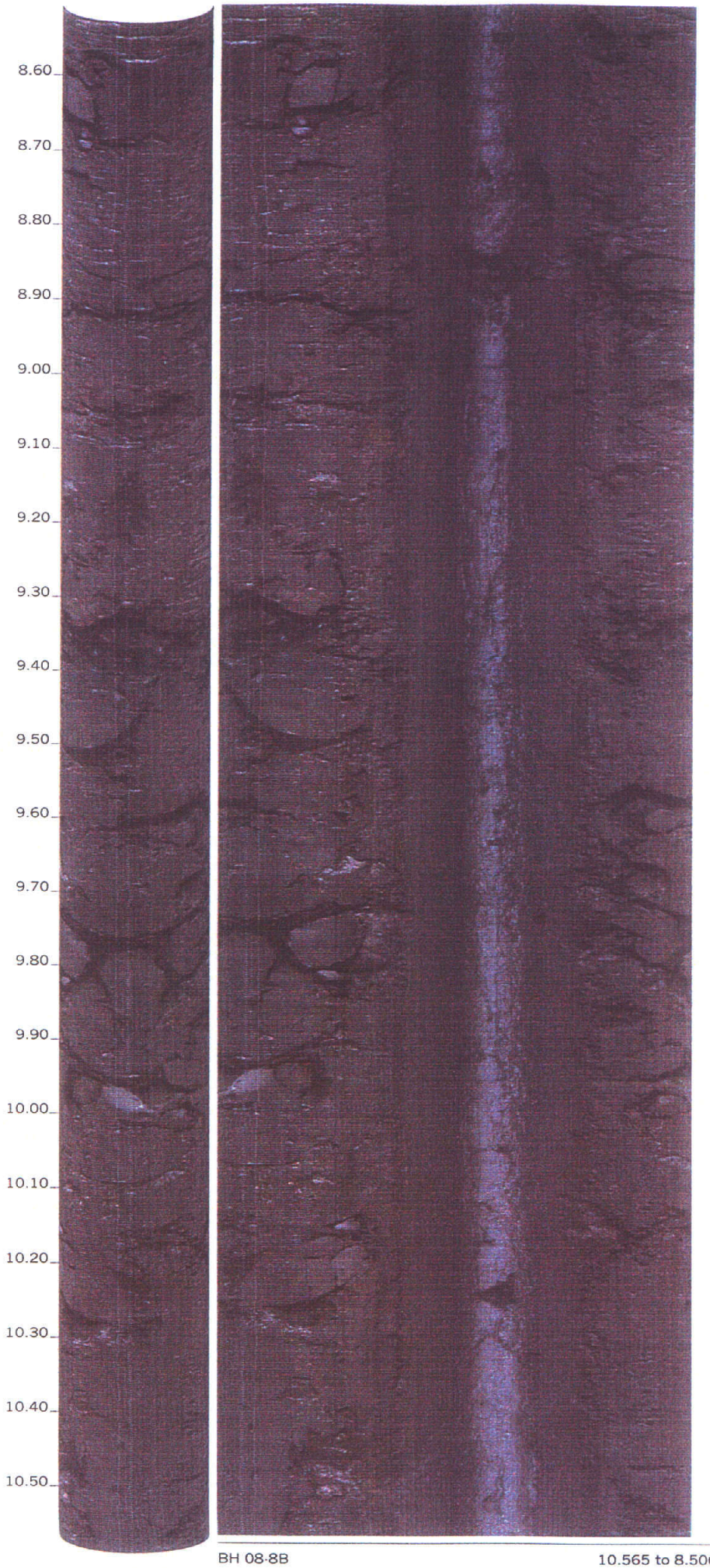
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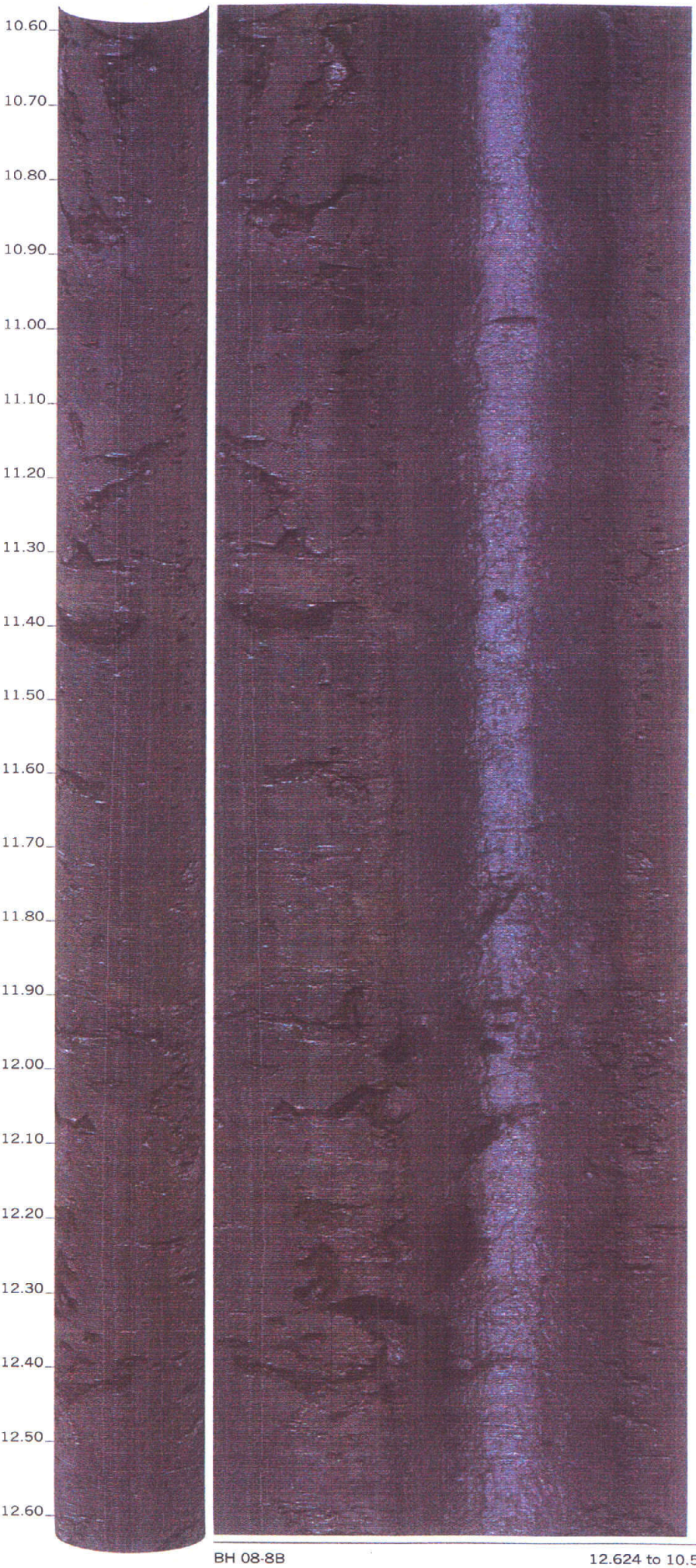
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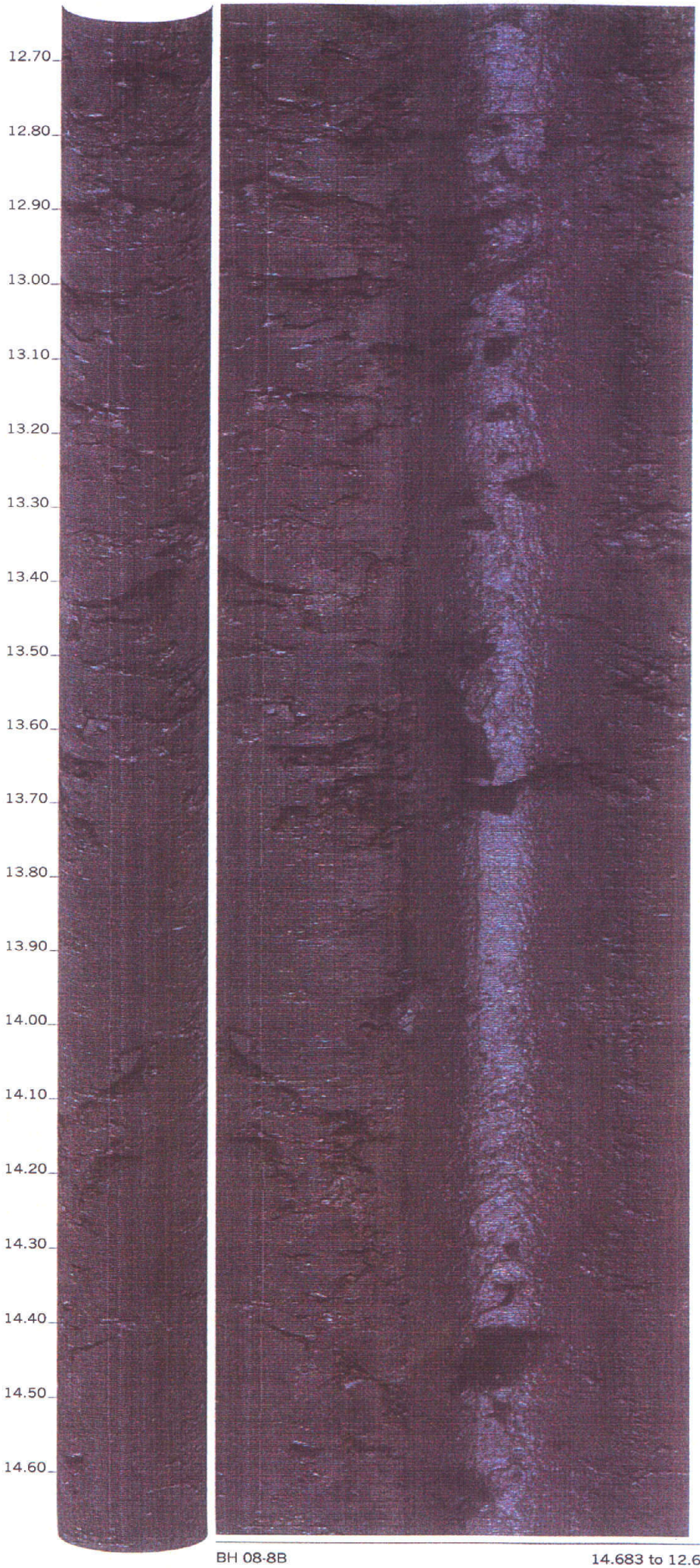
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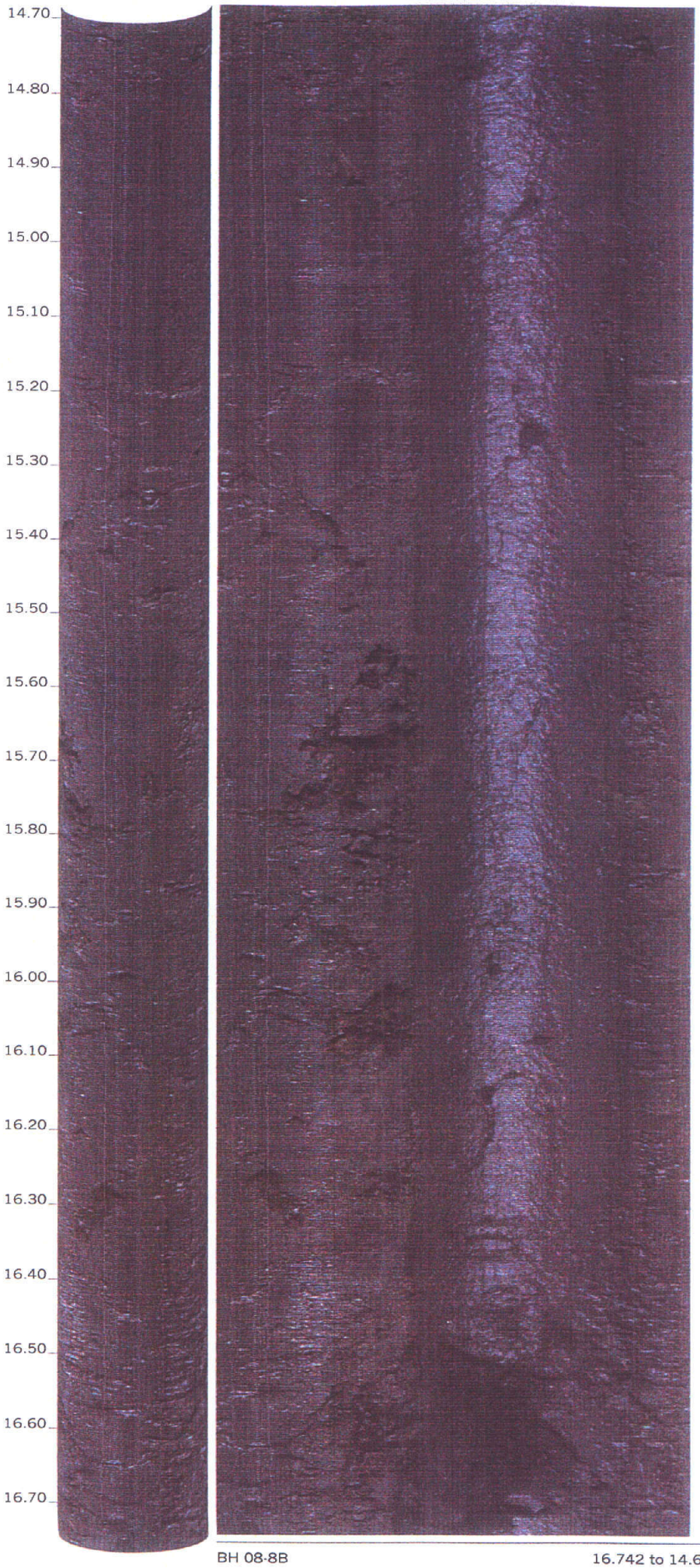
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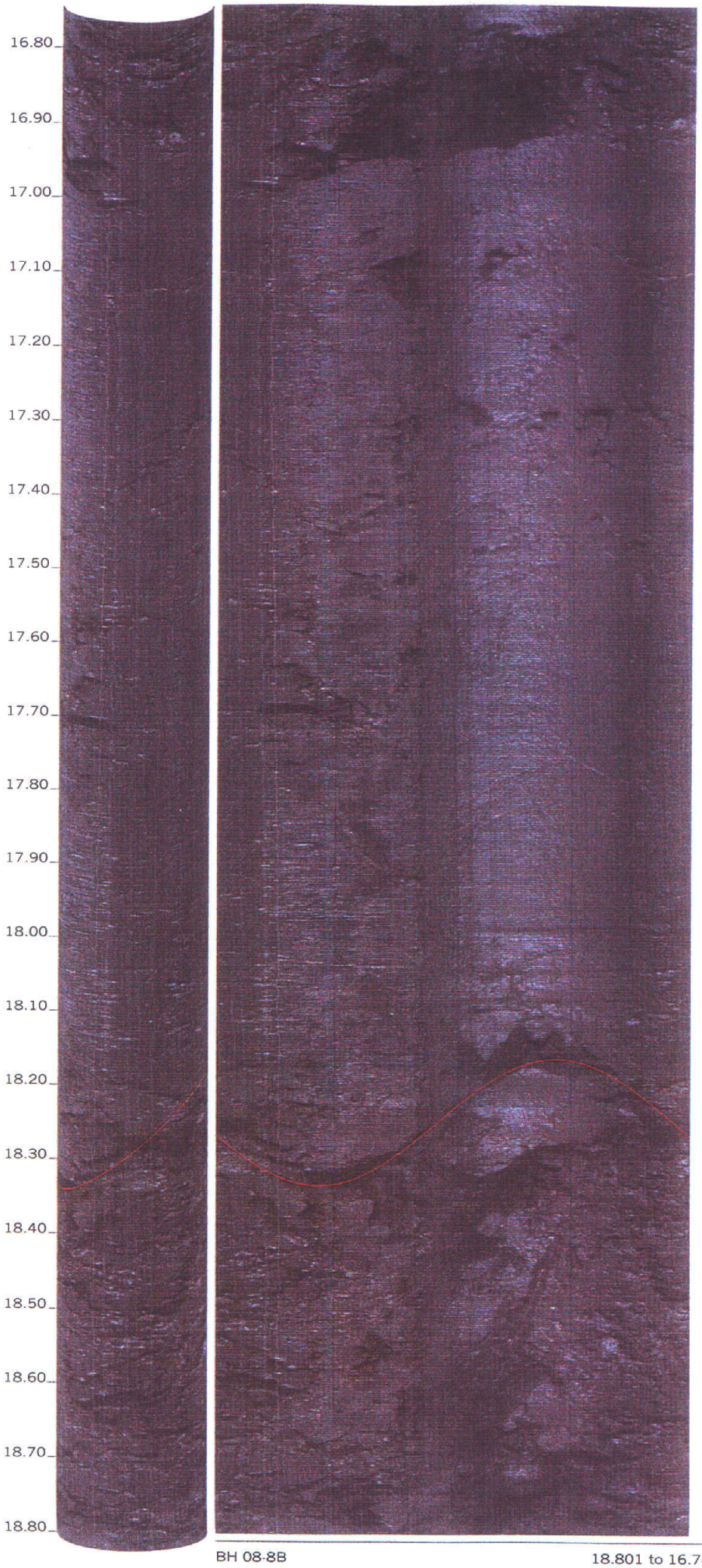

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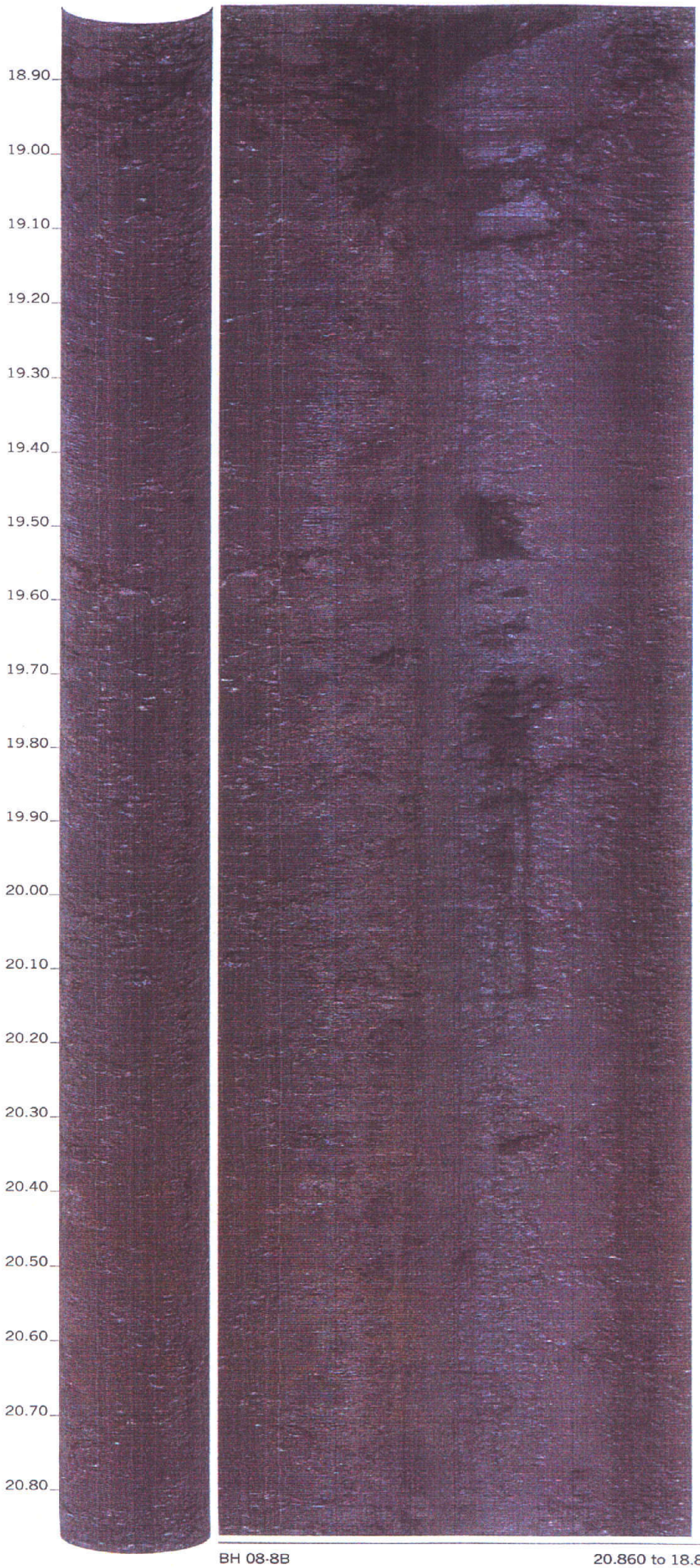
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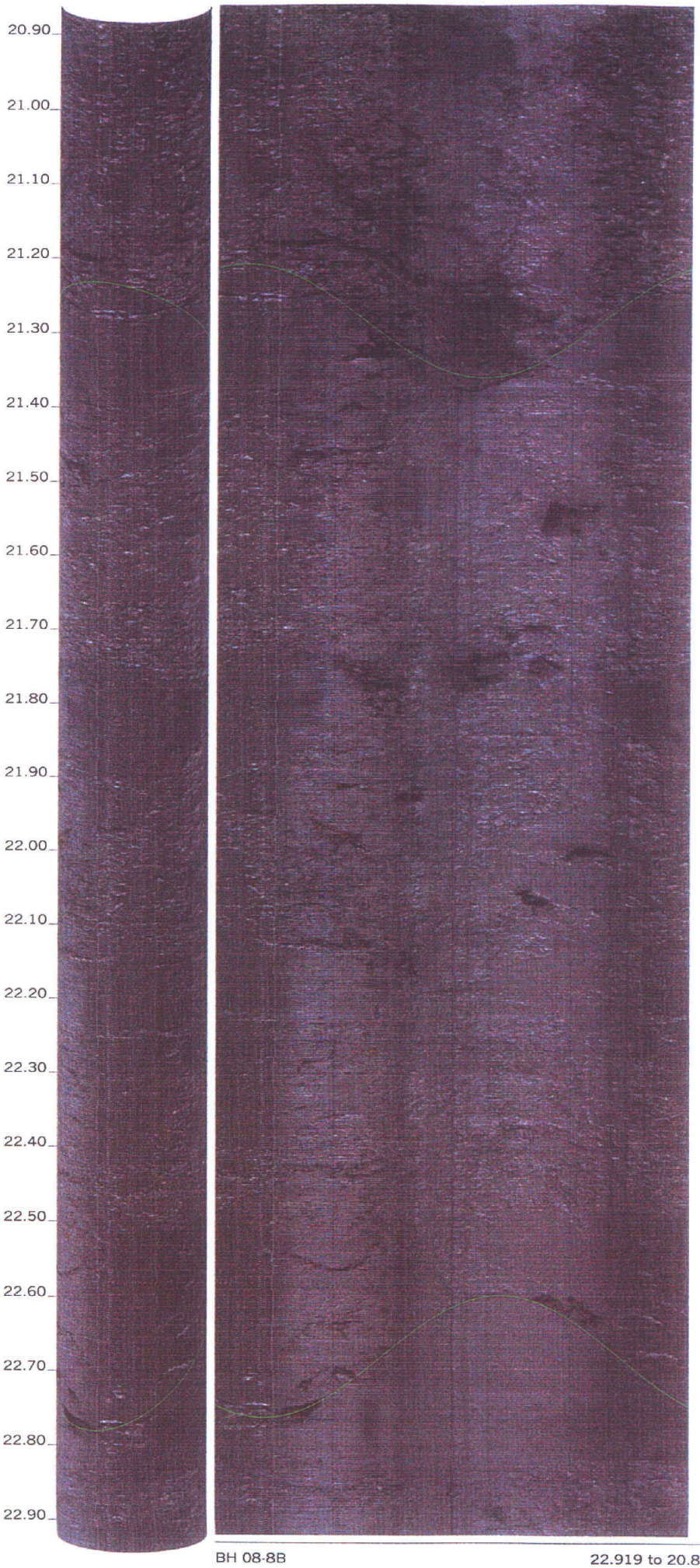
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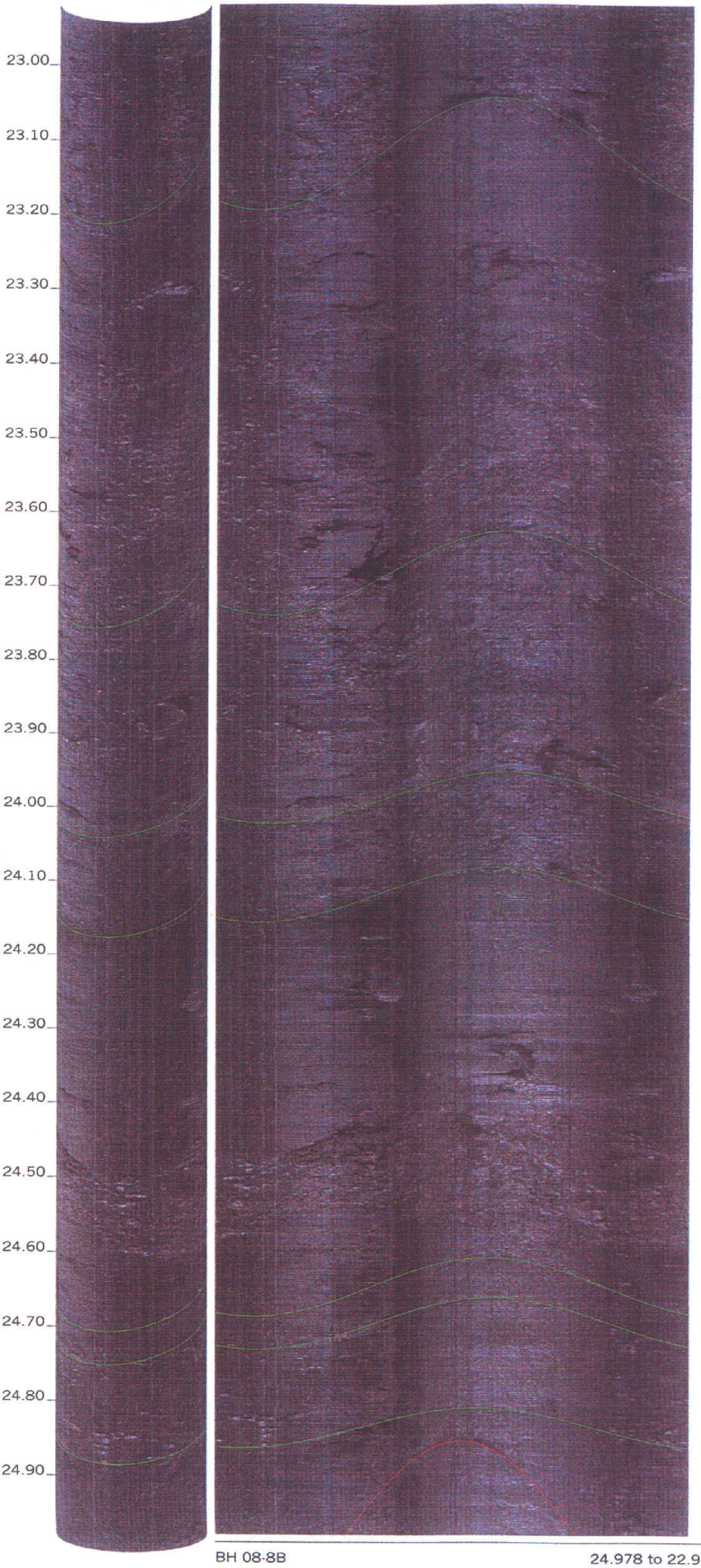
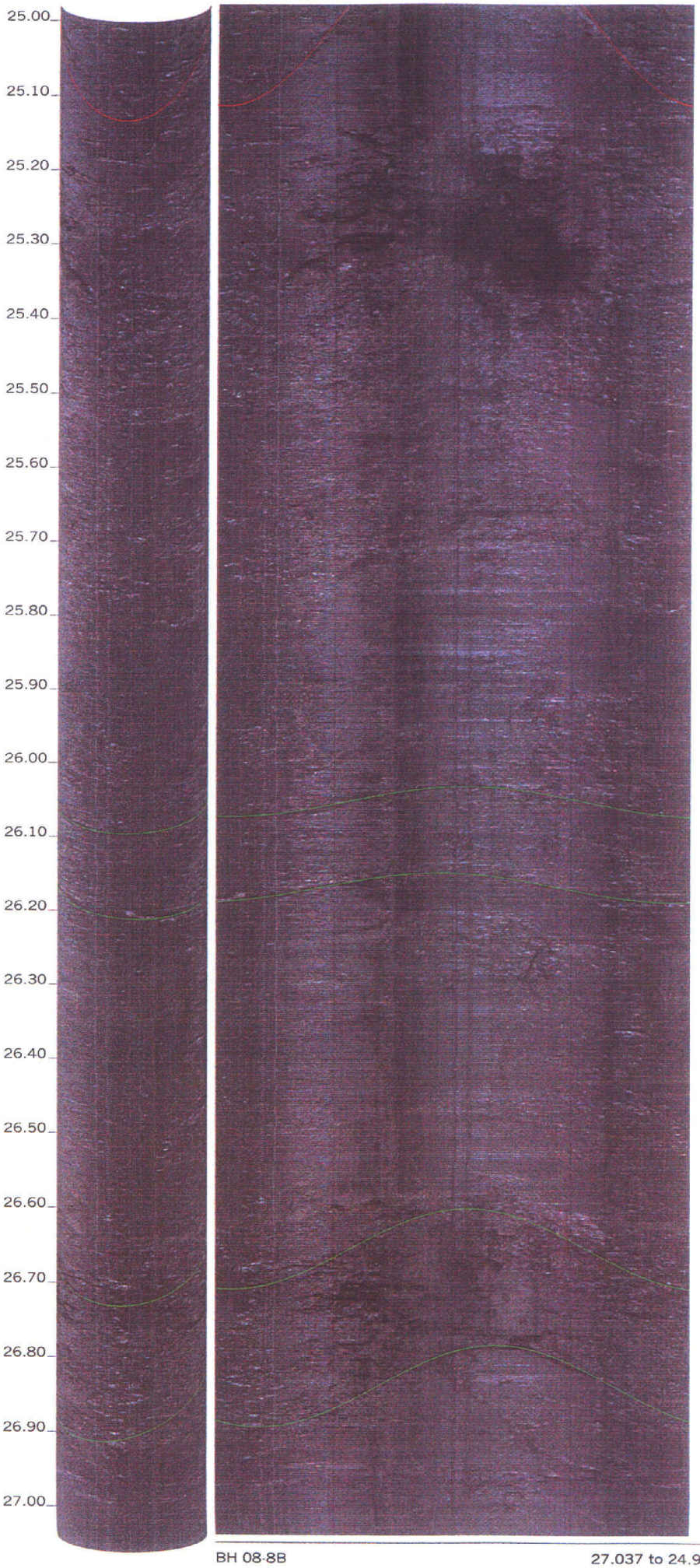
N219 80 Bedding



BH 08-8B

24.978 to 22.919m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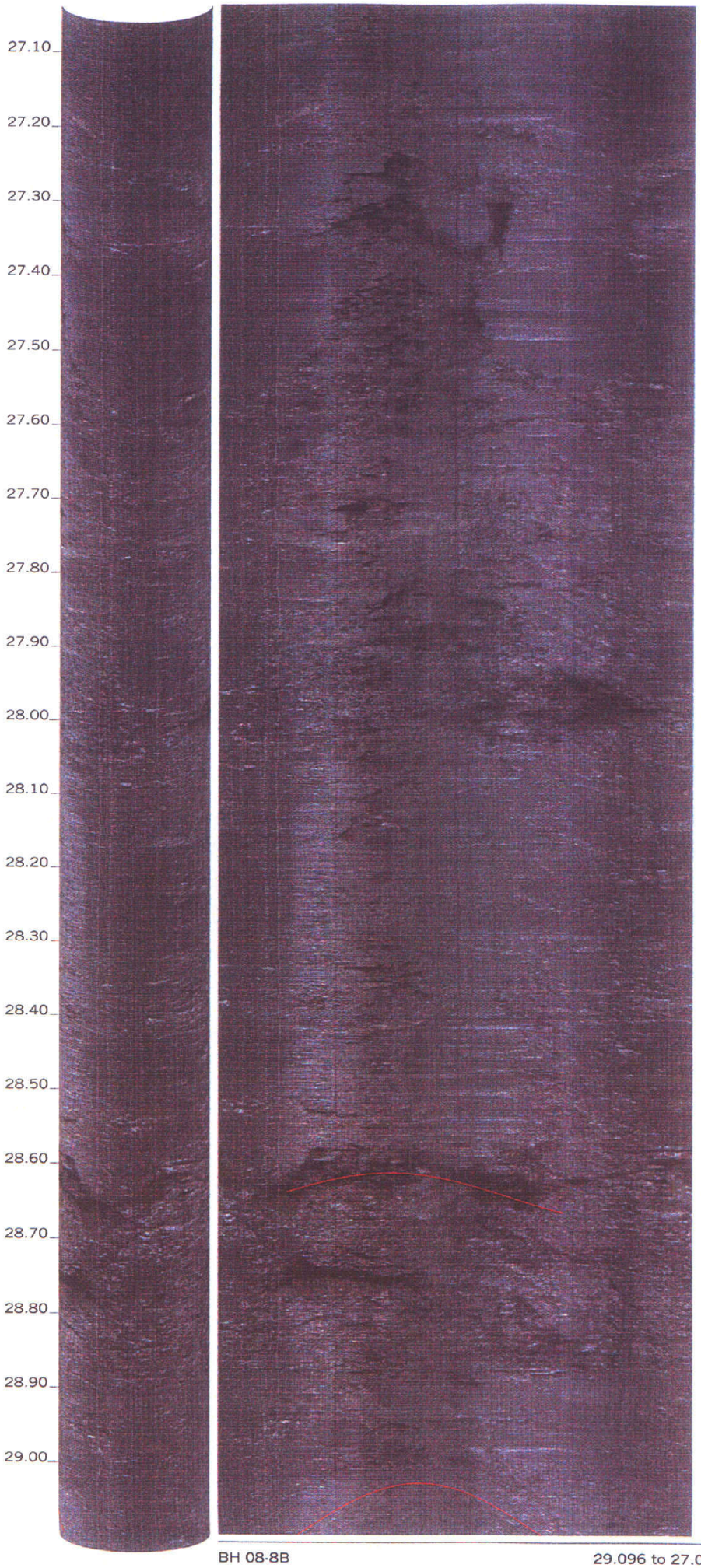
N011 66 Bedding
N018 88 Irregular Bedding
N033 89 Bedding



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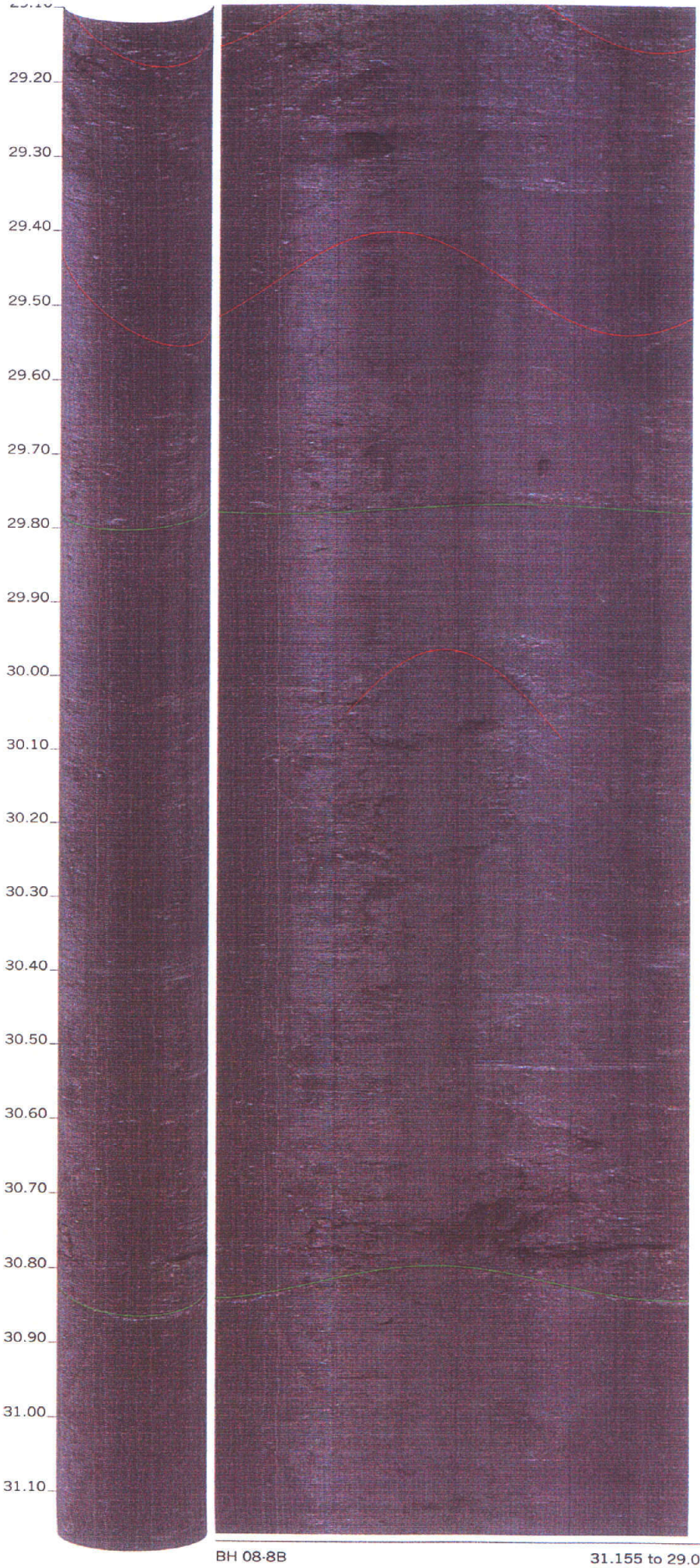
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N024 52 Bedding
N179 70 Fracture Discontinuous
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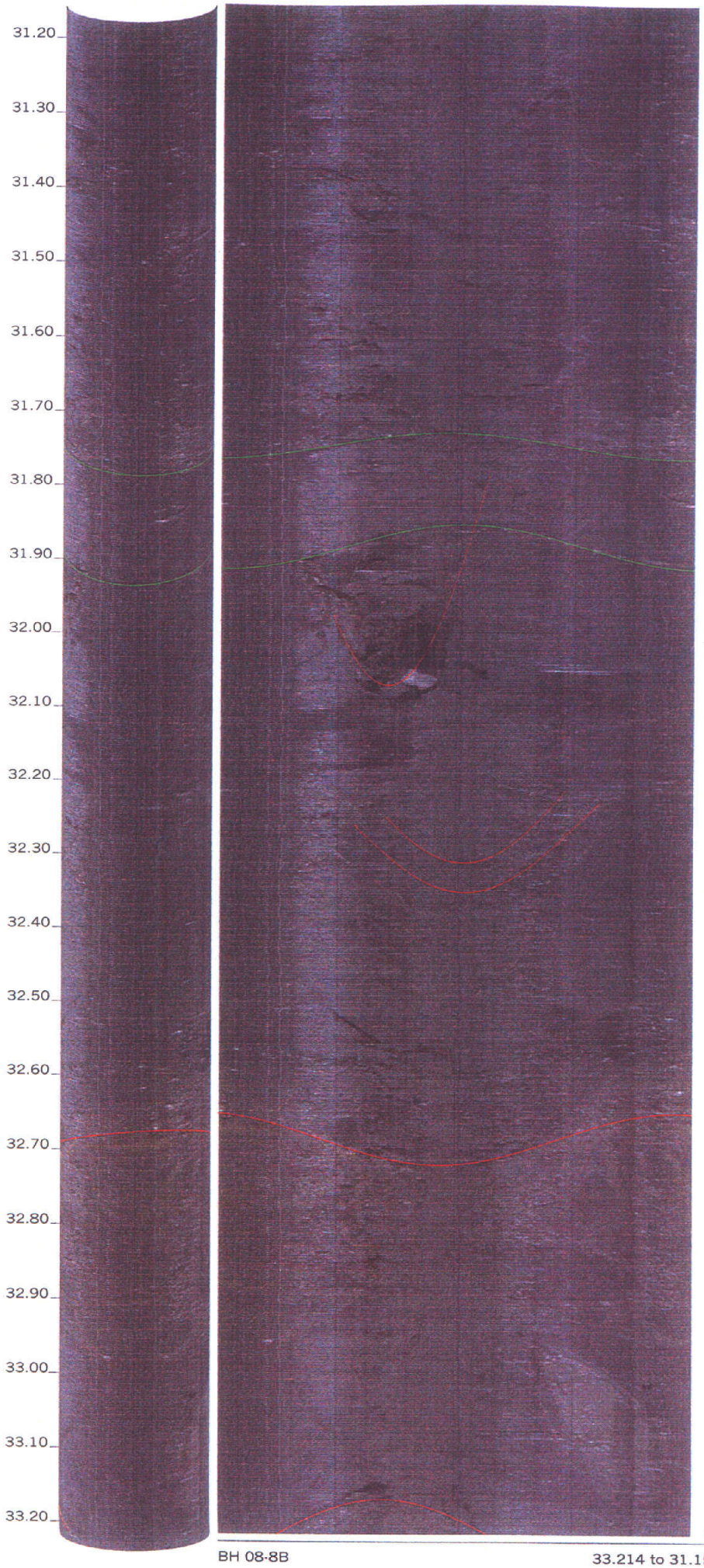

BH 08-8B

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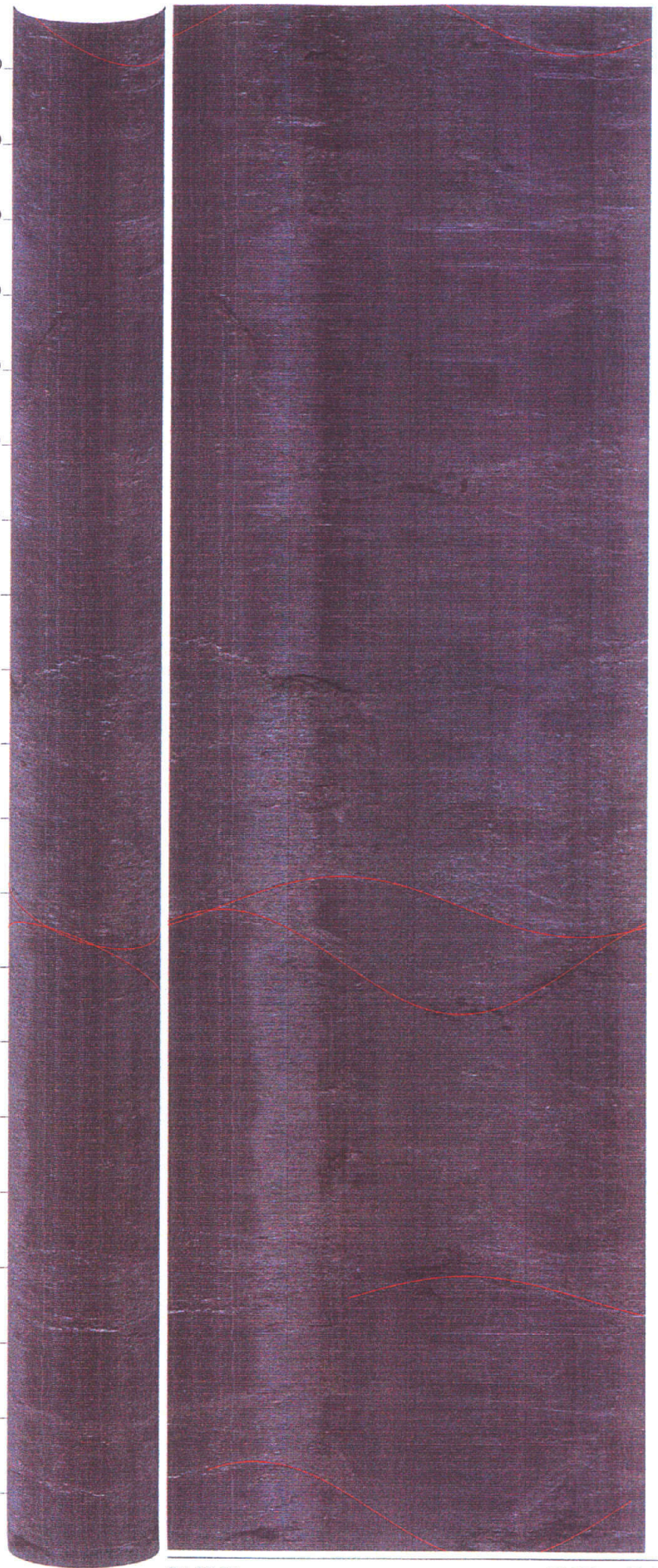
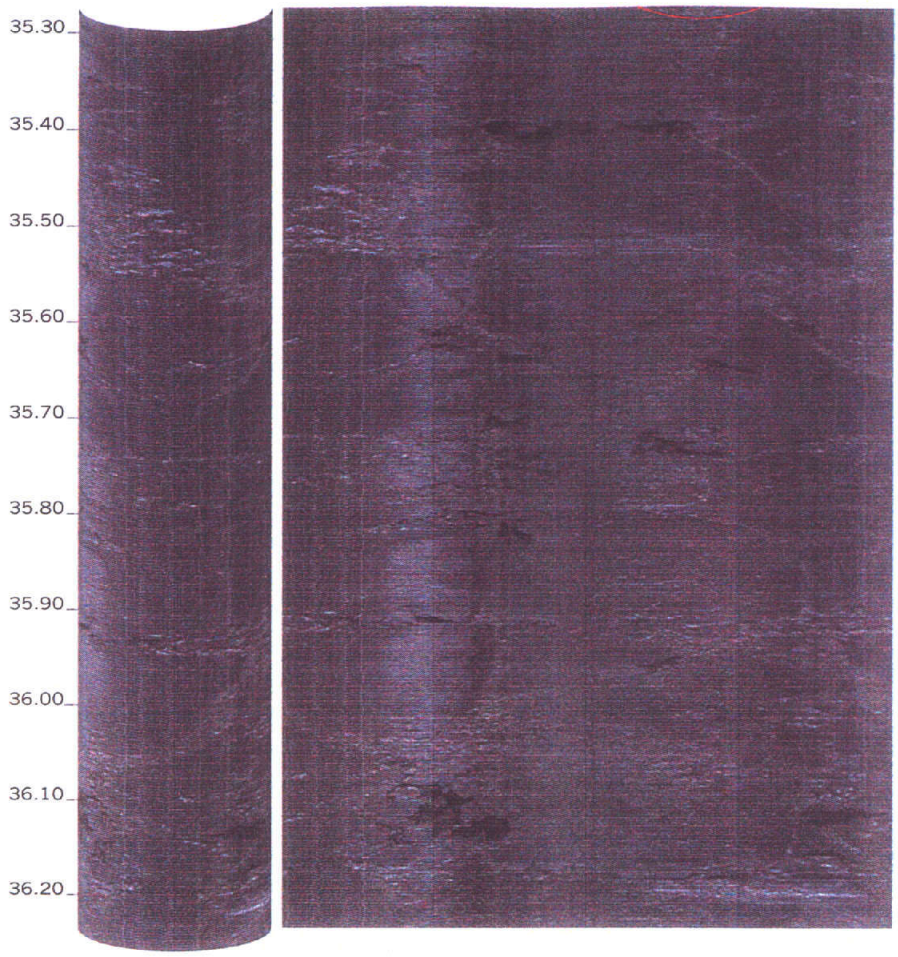


BH 08-8B 35.273 to 33.214m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36.20

NORCAL GEOPHYSICAL CONSULTANTS, INC.

BHTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED BHTV DIPS LOG

25 Sep 2002

EARTH MECHANICS

Borehole: 02-08B

DEVILS SLIDE

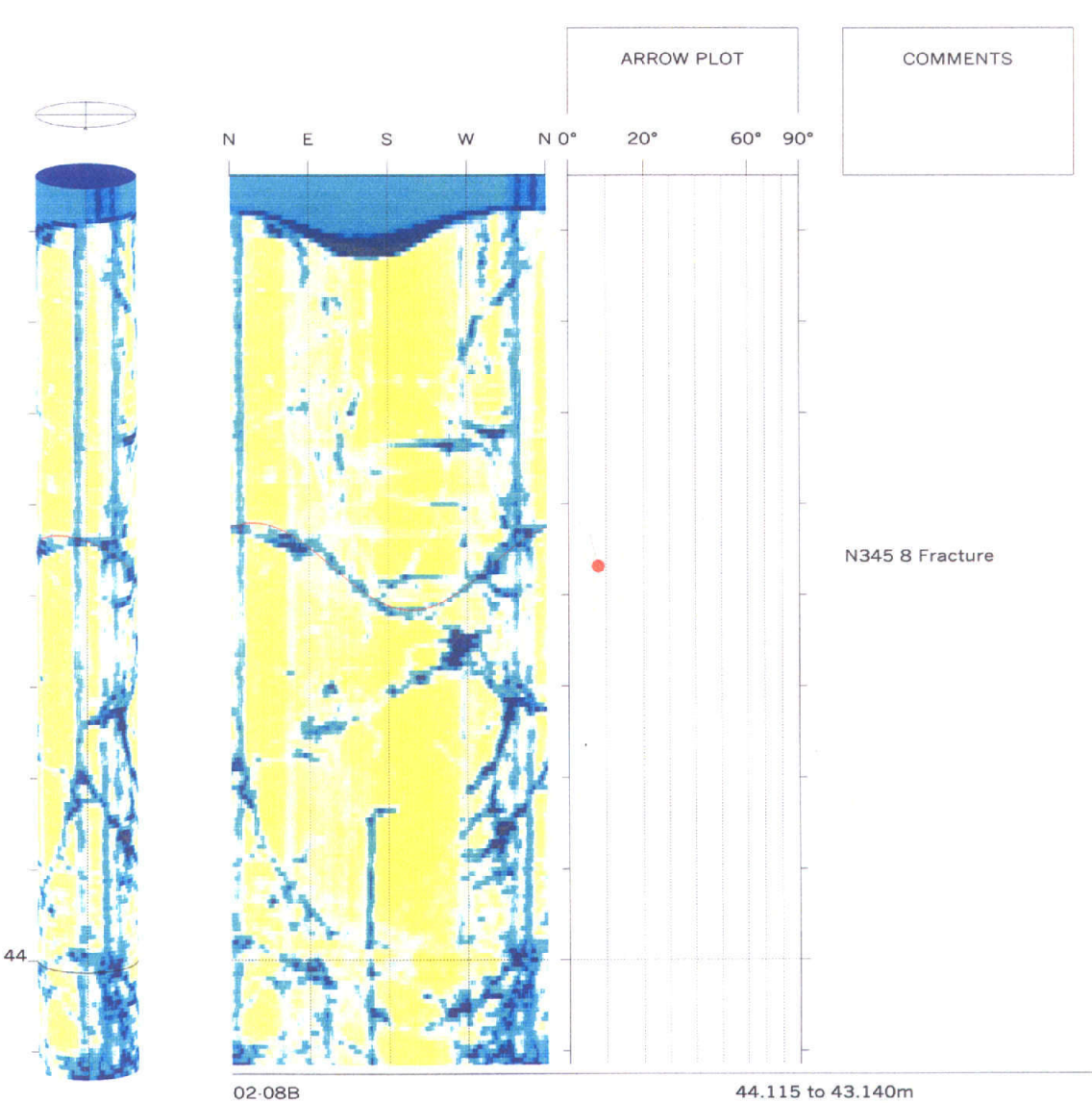
top of borehole.....
East:
North:
Alt:

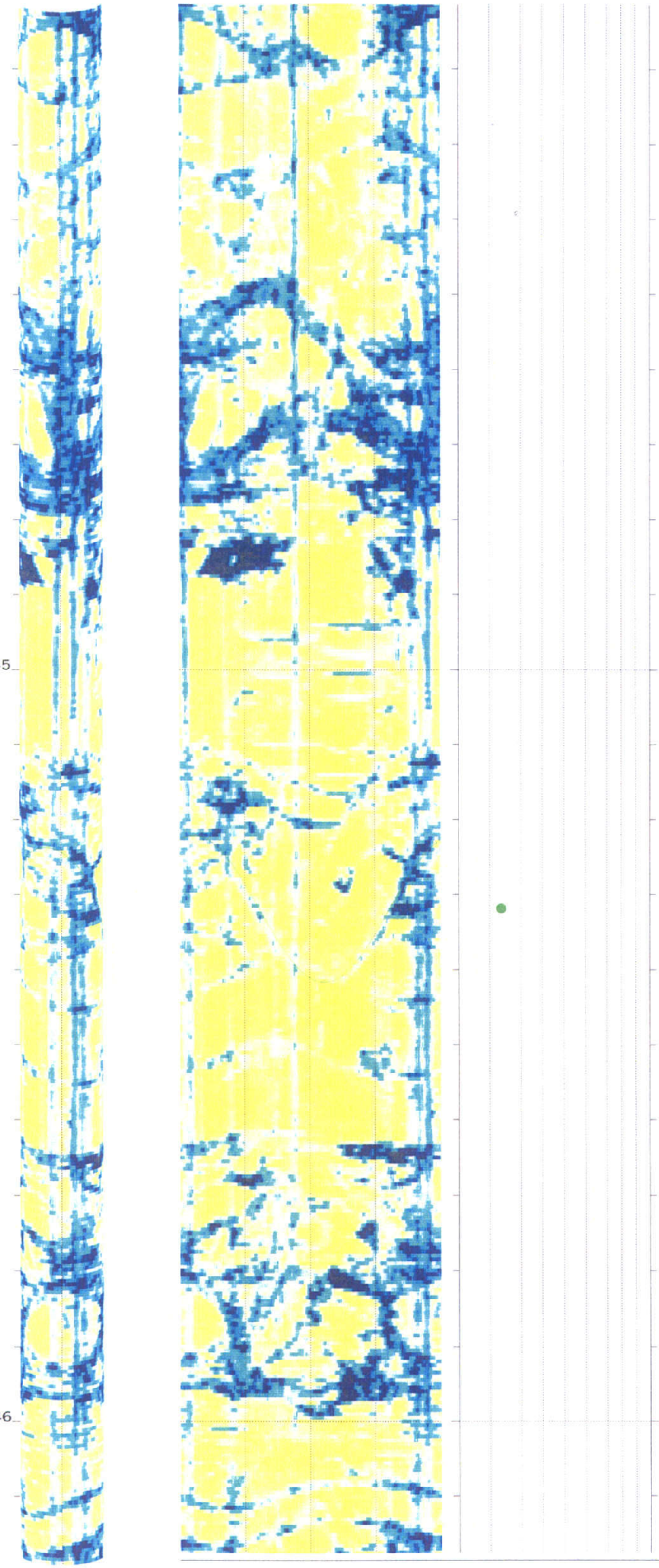
North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = vert scale

Zone from 67.970 to 43.140m

Borehole diam: 11.000cm
Vertical = borehole-axis
Amplitude

BEDDING
FRACTURE
Identified units

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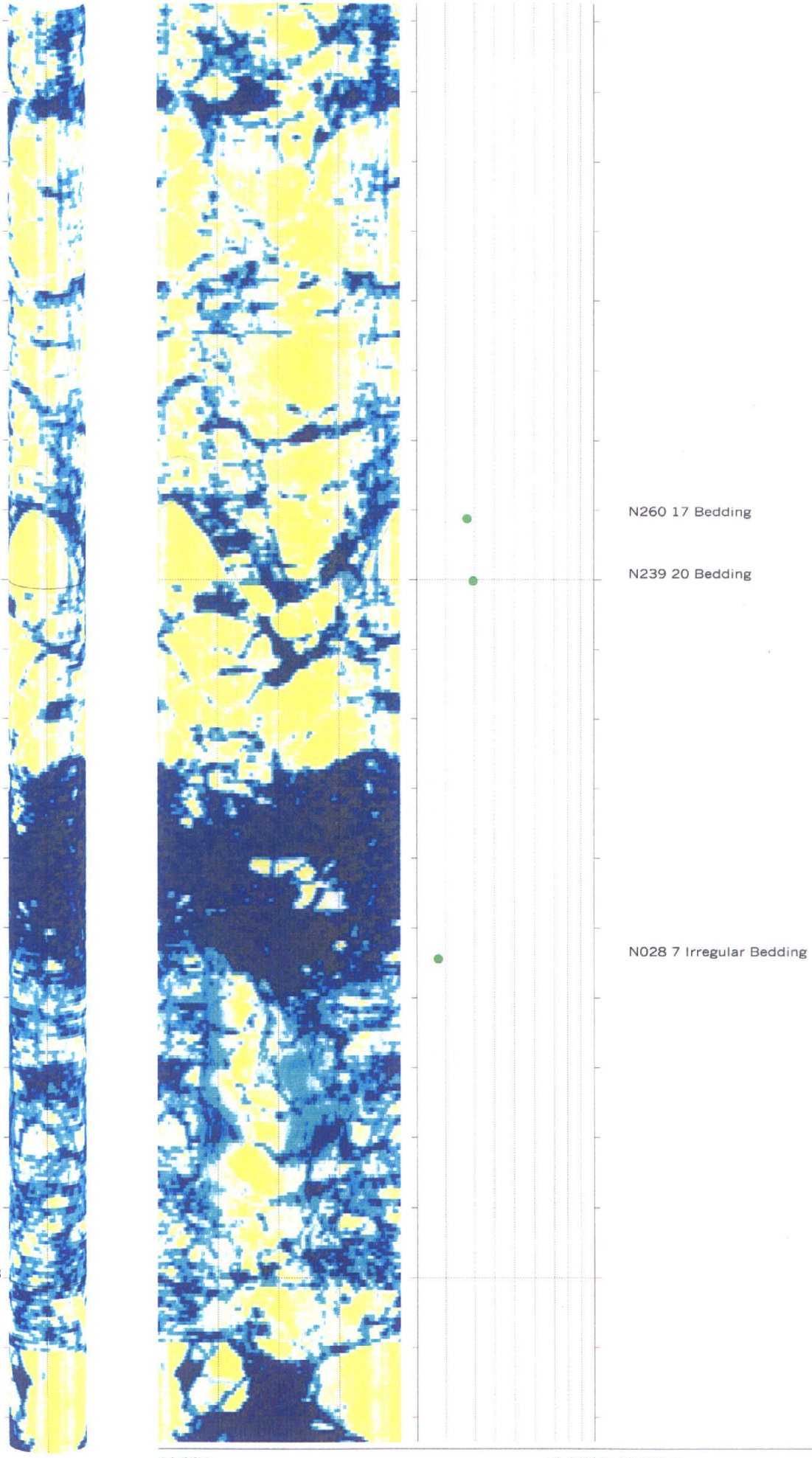
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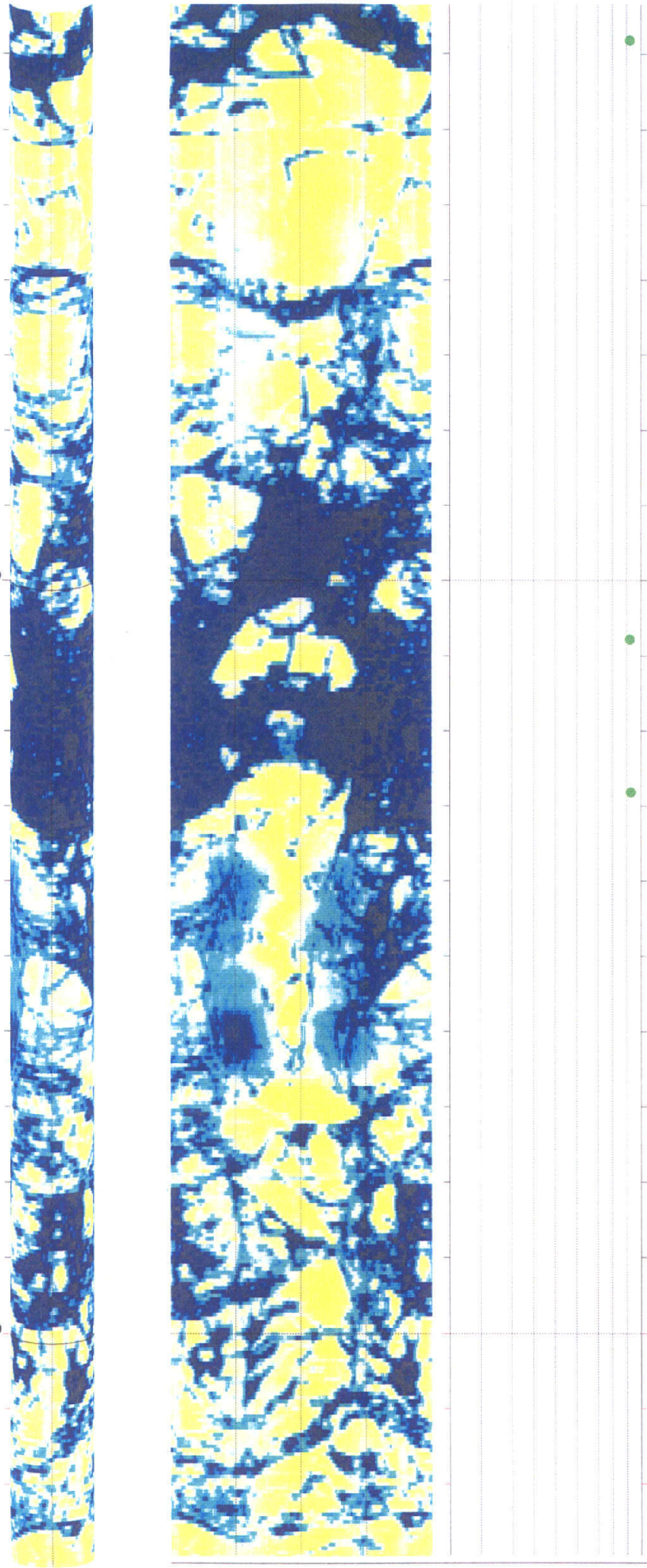
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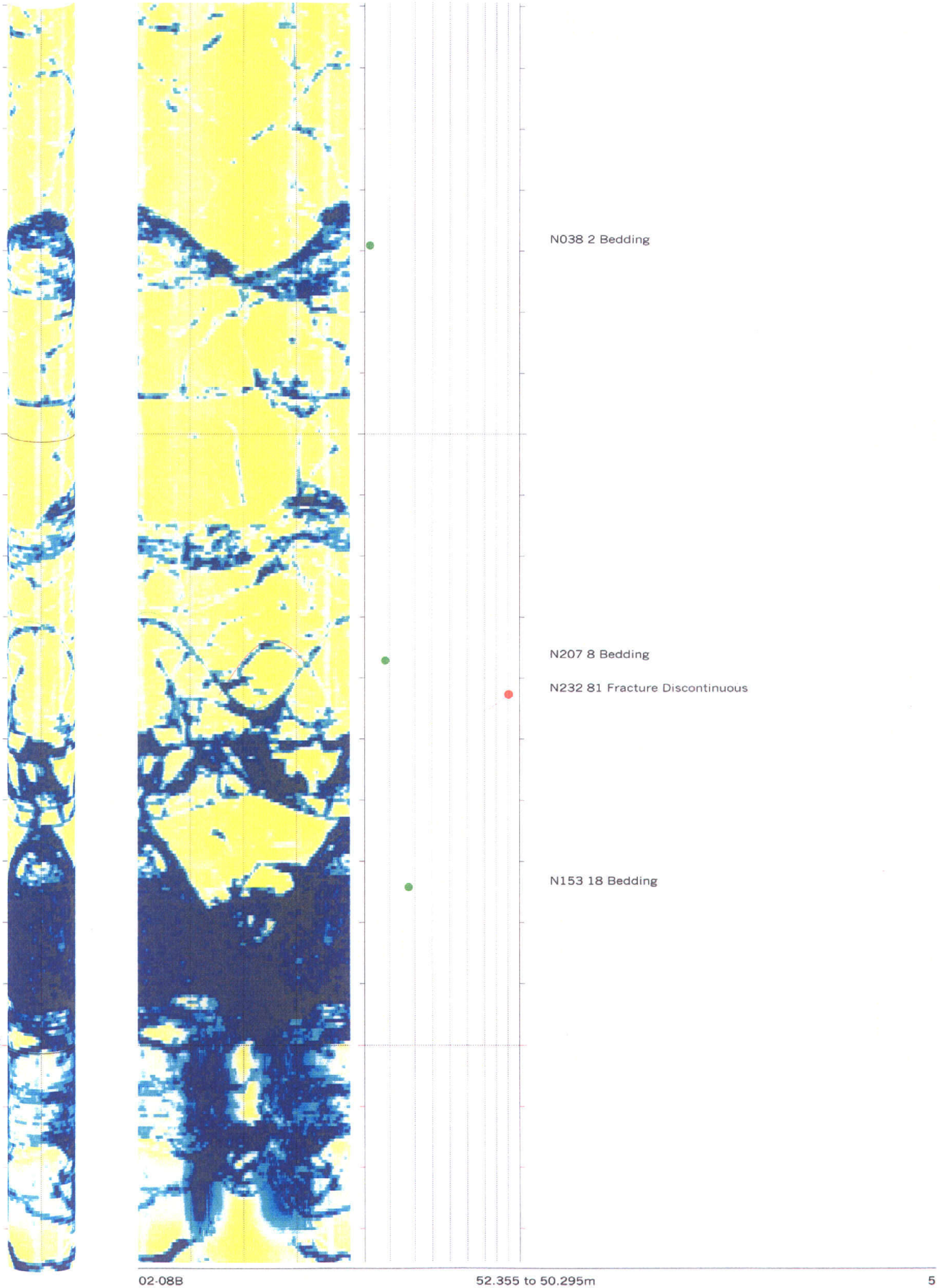
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N207 8 Bedding
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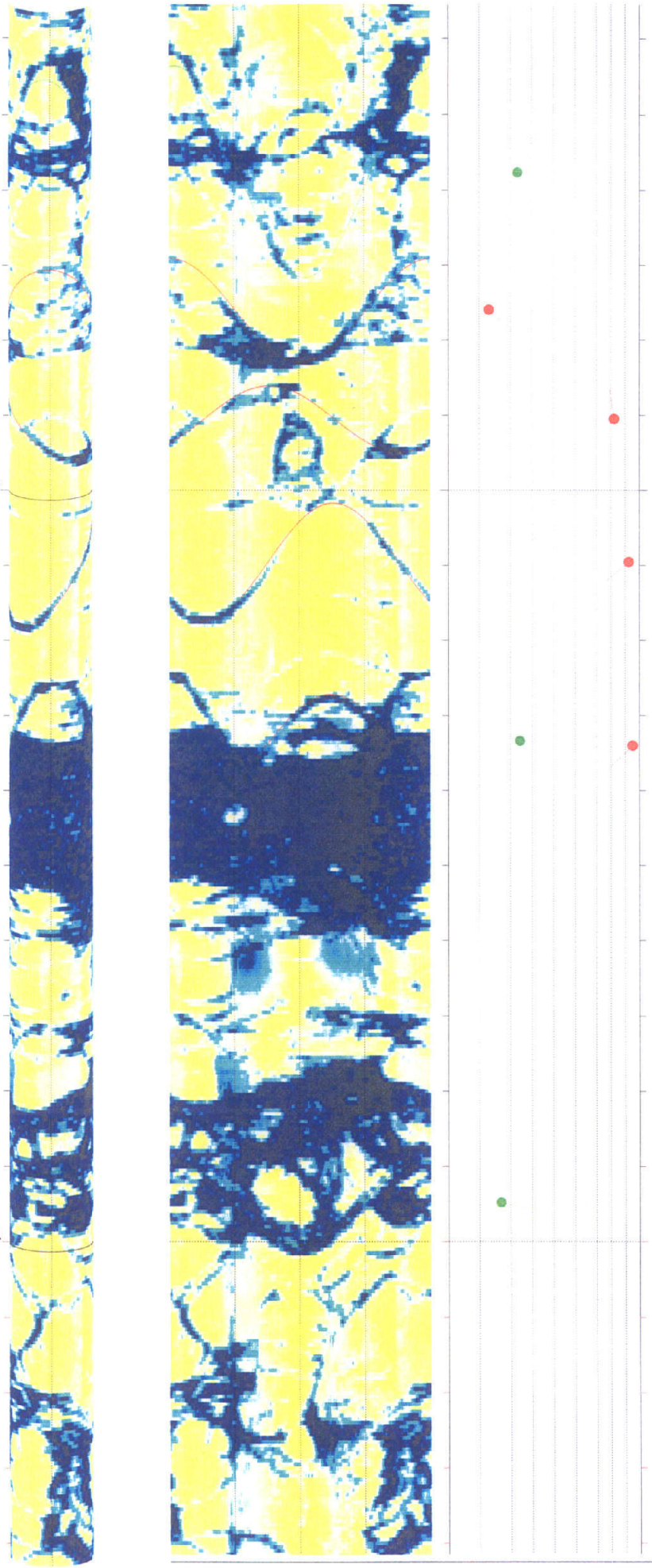
N153 18 Bedding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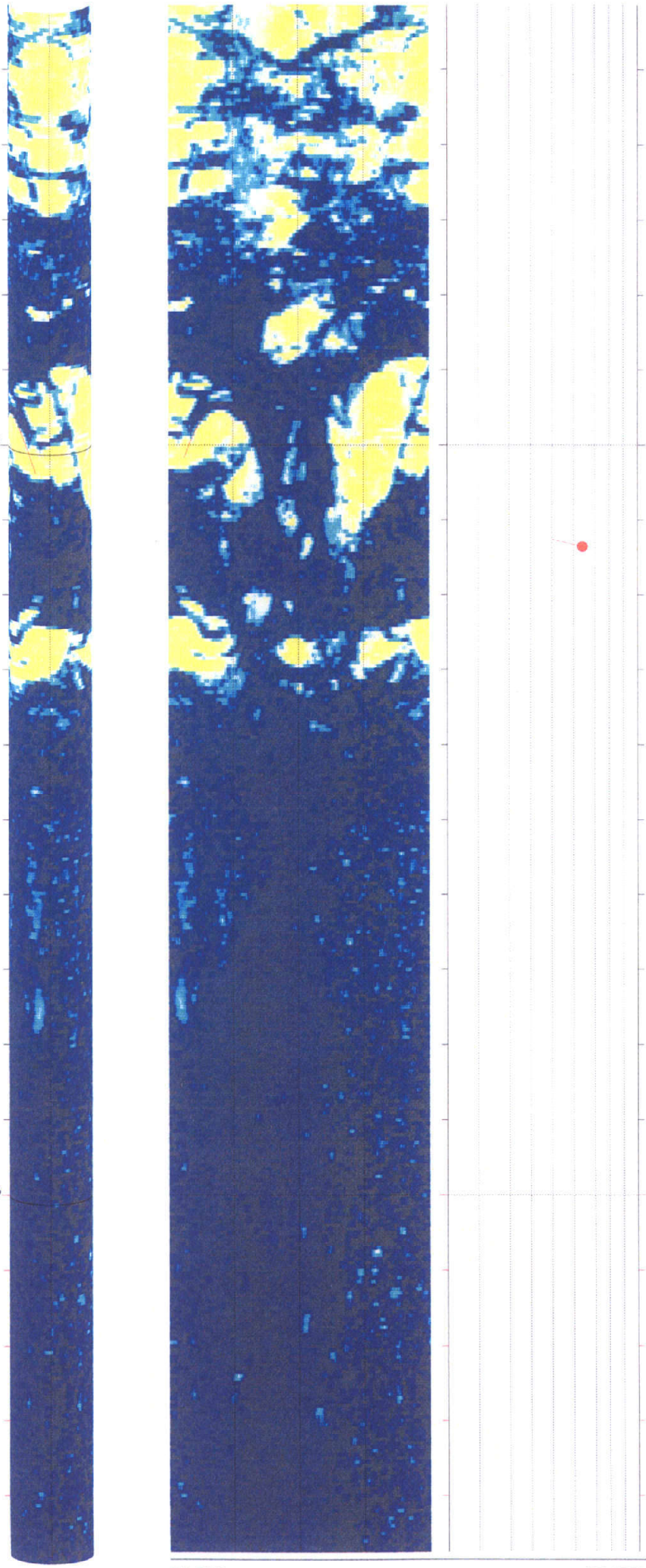

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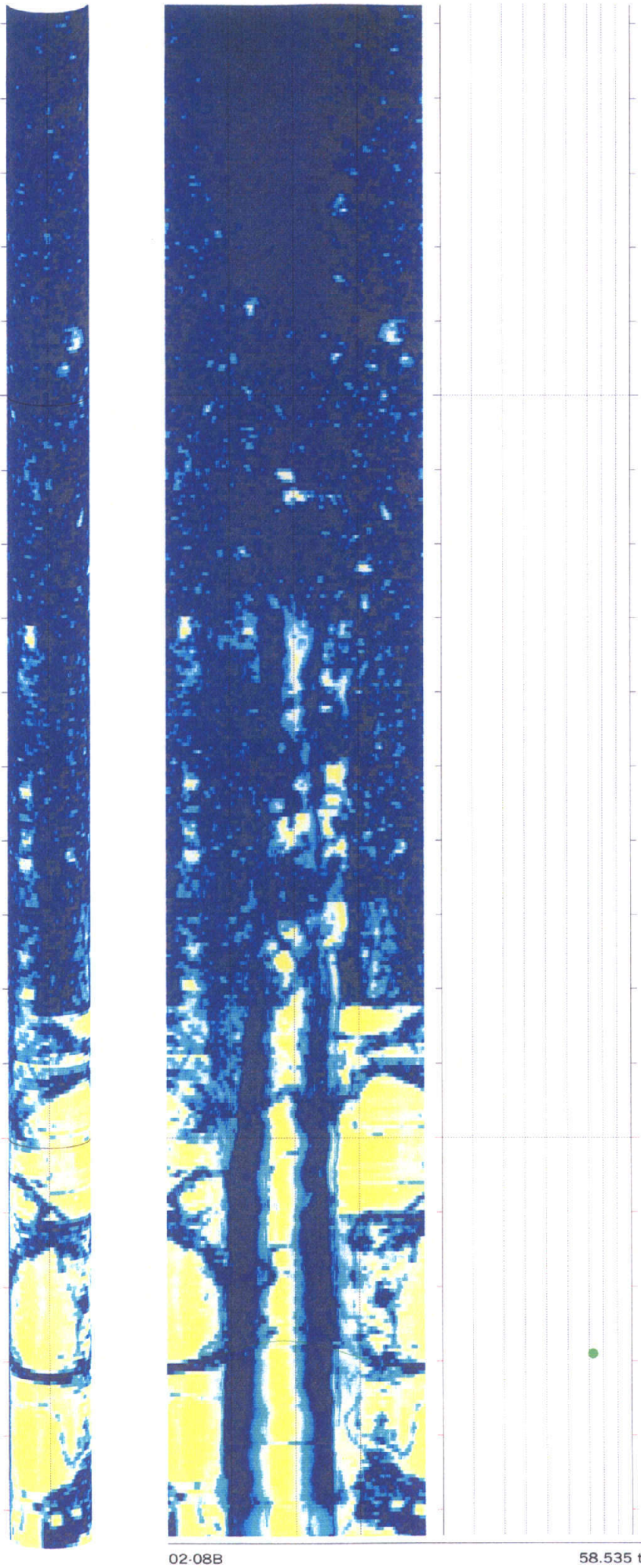
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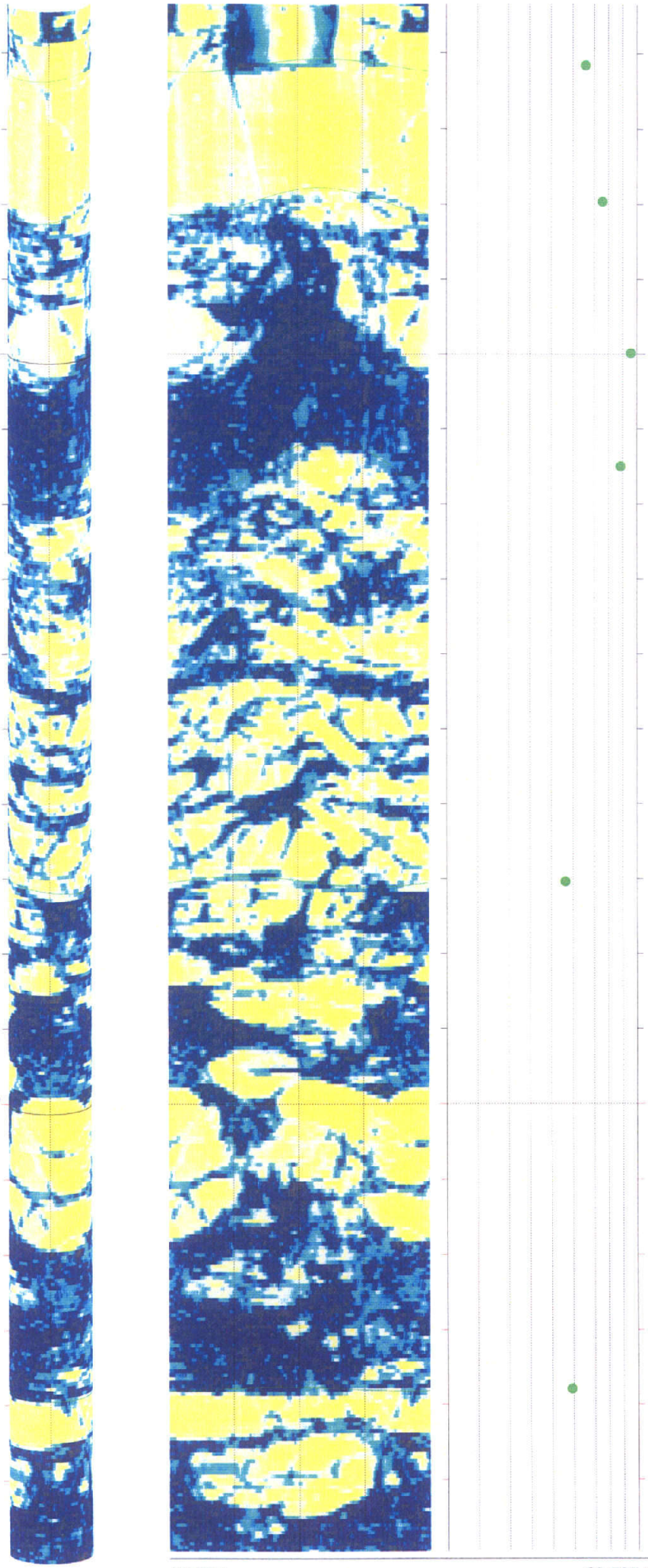
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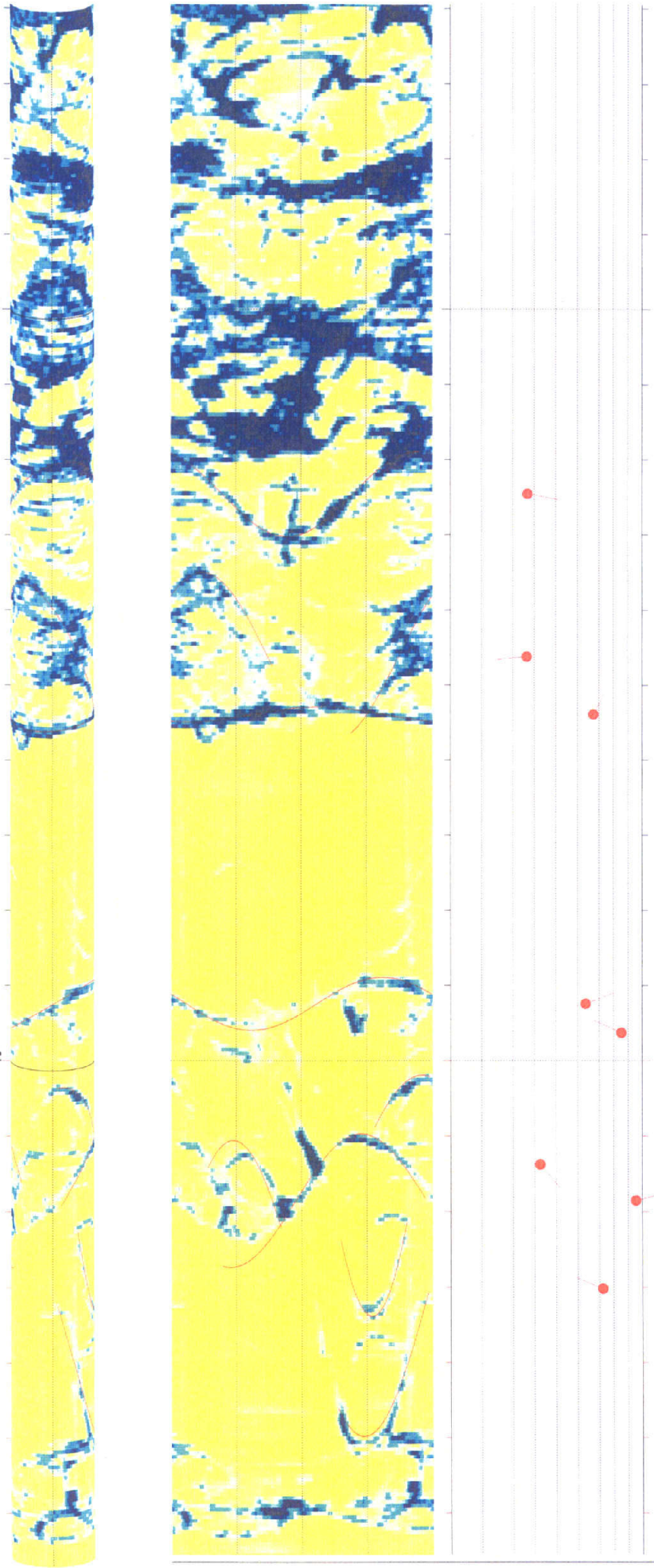
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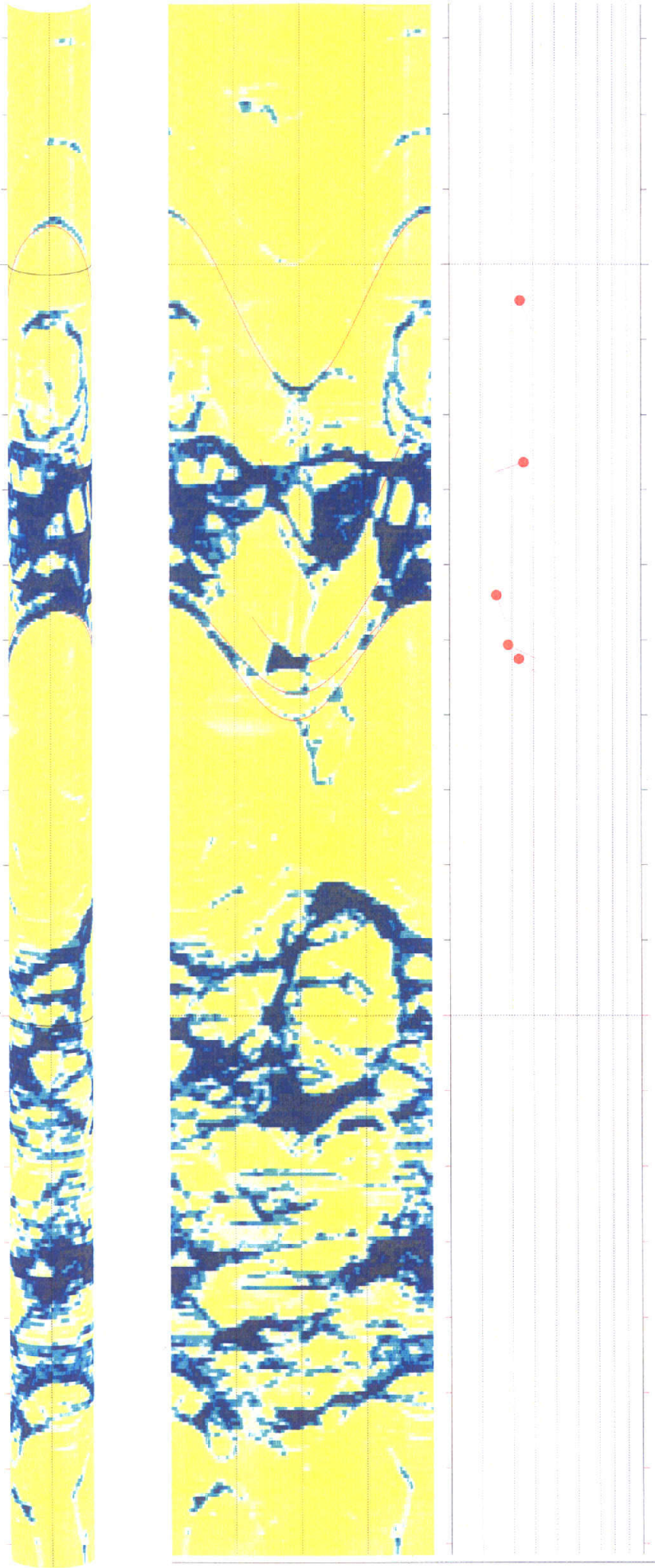
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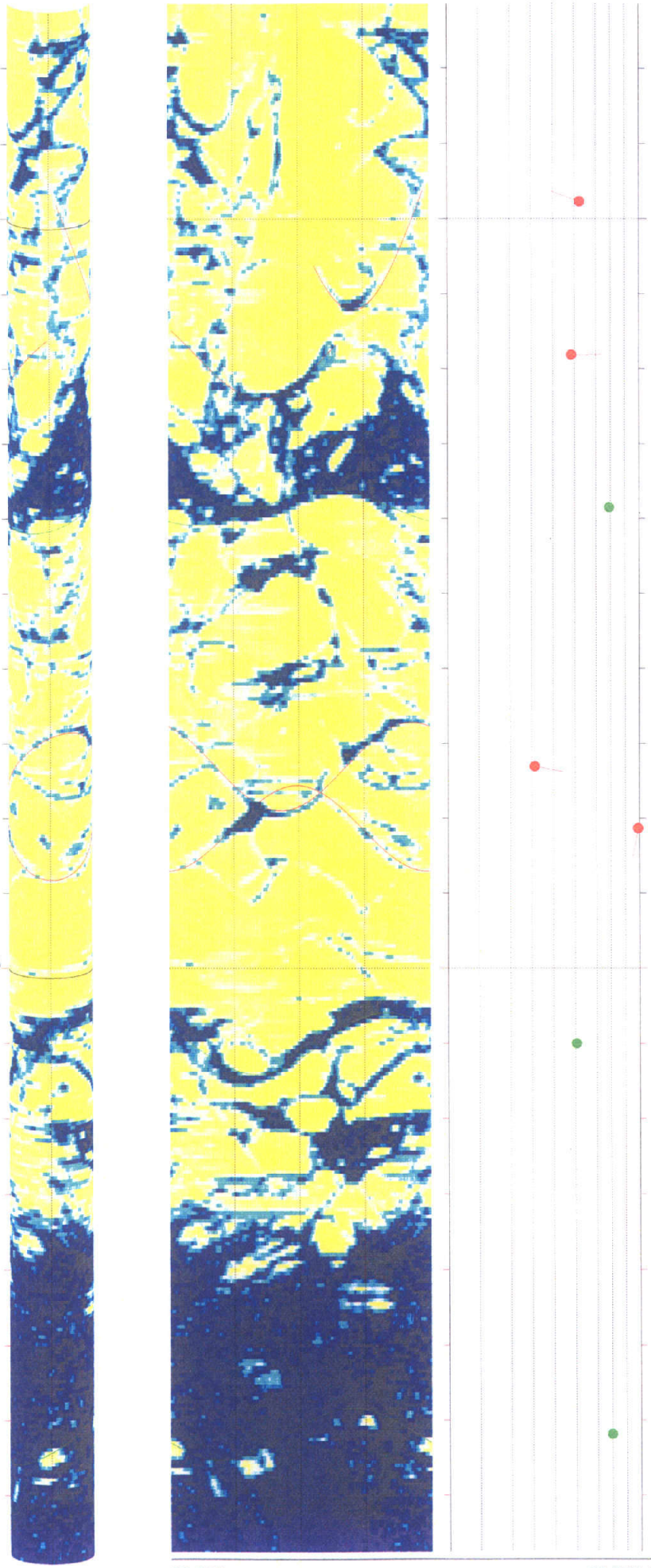
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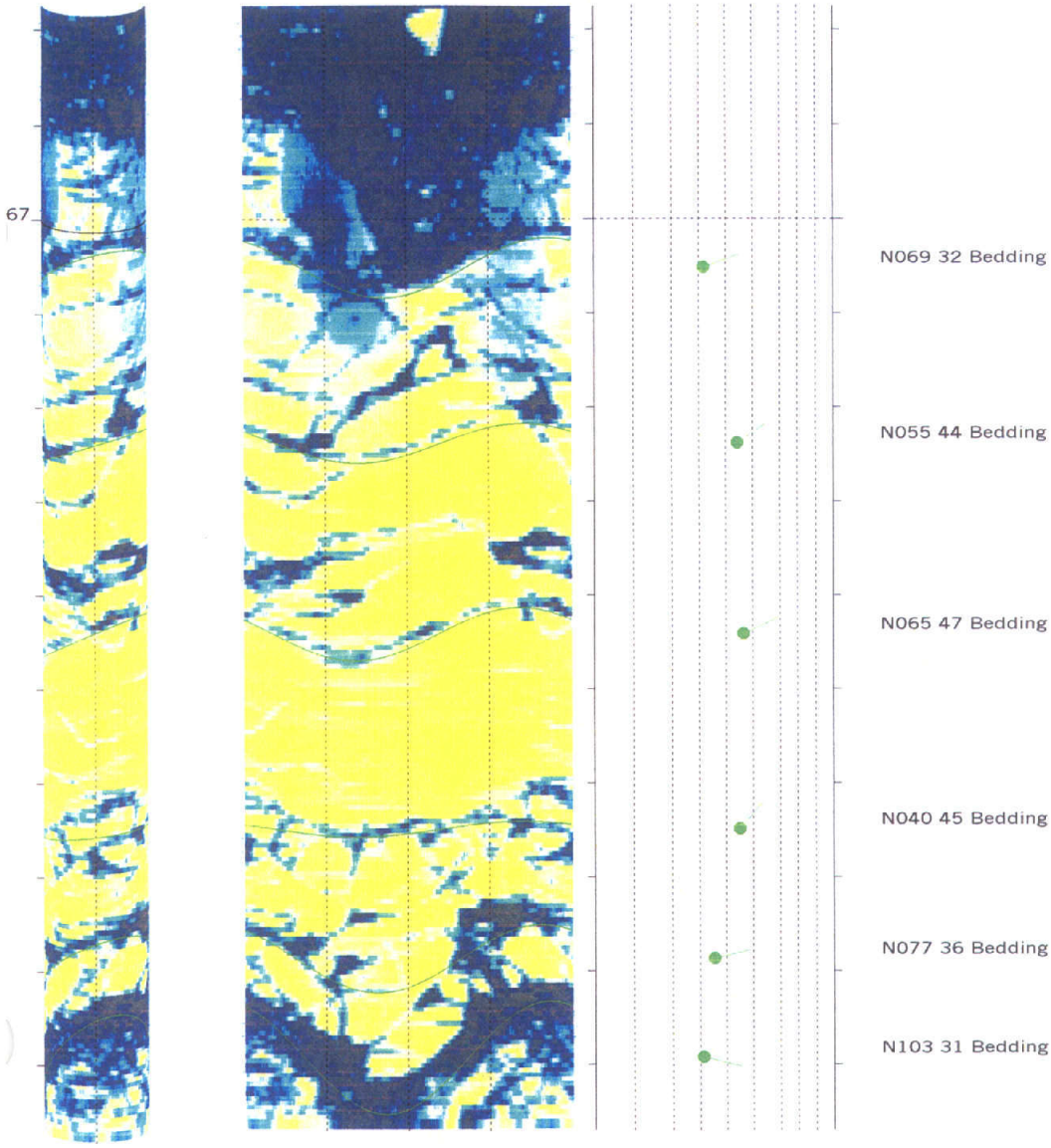
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N055 44 Bedding
N065 47 Bedding
N040 45 Bedding
N077 36 Bedding
N103 31 Bedding

Borehole: BH_08-8B
Depth range: 0.000 - 36.204m

Depth m	Deviation components North m	East m	Down m	Devaz deg	Dev deg
1.004	-0.649	-0.317	0.697	206.00	46.00
2.004	-1.318	-0.502	1.399	197.00	45.00
3.004	-1.974	-0.785	2.096	209.00	45.00
4.004	-2.595	-1.134	2.798	208.00	46.00
5.004	-3.224	-1.468	3.500	208.00	45.00
6.004	-3.860	-1.773	4.208	204.00	45.00
7.004	-4.521	-2.037	4.902	200.00	46.00
8.004	-5.194	-2.292	5.597	200.00	46.00
9.004	-5.878	-2.547	6.279	200.00	47.00
10.004	-6.562	-2.797	6.963	200.00	47.00
11.004	-7.248	-3.045	7.648	200.00	47.00
12.004	-7.928	-3.294	8.337	201.00	48.00
13.004	-8.609	-3.543	9.026	200.00	44.00
14.004	-9.287	-3.789	9.718	200.00	45.00
15.004	-9.973	-4.040	10.400	200.00	46.00
16.004	-10.651	-4.291	11.091	200.00	45.00
17.004	-11.335	-4.546	11.773	200.00	45.00
18.004	-12.018	-4.801	12.457	201.00	48.00
19.004	-12.703	-5.054	13.140	200.00	47.00
20.004	-13.388	-5.302	13.824	200.00	48.00
21.004	-14.069	-5.546	14.514	200.00	46.00
22.004	-14.749	-5.789	15.205	200.00	48.00
23.004	-15.430	-6.029	15.895	199.00	45.00
24.004	-16.112	-6.272	16.585	200.00	44.00
25.004	-16.794	-6.519	17.273	200.00	47.00
26.004	-17.472	-6.762	17.965	199.00	44.00
27.004	-18.154	-7.002	18.656	200.00	48.00
28.004	-18.833	-7.245	19.347	200.00	47.00
29.004	-19.518	-7.488	20.034	200.00	44.00
30.004	-20.201	-7.730	20.722	200.00	48.00
31.004	-20.892	-7.978	21.400	199.00	44.00
32.004	-21.572	-8.220	22.091	200.00	47.00
33.004	-22.256	-8.467	22.776	200.00	49.00
34.004	-22.932	-8.706	23.473	199.00	49.00
35.004	-23.607	-8.946	24.169	201.00	50.00
36.004	-24.291	-9.188	24.857	200.00	47.00

Borehole: 02-08B Logged from 43 to 67 meters
Depth range: 0.000 - 67.950m Extrapolated from 0 to 43 meters

Depth	Deviation components North	East	Down	Devaz	Dev
m	m	m	m	deg	deg
1.000	-0.656	-0.320	0.684	206.00	46.84
2.000	-1.311	-0.640	1.368	206.00	46.84
3.000	-1.967	-0.959	2.052	206.00	46.84
4.000	-2.622	-1.279	2.736	206.00	46.84
5.000	-3.278	-1.599	3.420	206.00	46.84
6.000	-3.934	-1.919	4.104	206.00	46.84
7.000	-4.589	-2.238	4.788	206.00	46.84
8.000	-5.245	-2.558	5.472	206.00	46.84
9.000	-5.901	-2.878	6.156	206.00	46.84
10.000	-6.556	-3.198	6.840	206.00	46.84
11.000	-7.212	-3.517	7.524	206.00	46.84
12.000	-7.867	-3.837	8.208	206.00	46.84
13.000	-8.523	-4.157	8.892	206.00	46.84
14.000	-9.179	-4.477	9.577	206.00	46.84
15.000	-9.834	-4.797	10.261	206.00	46.84
16.000	-10.490	-5.116	10.945	206.00	46.84
17.000	-11.146	-5.436	11.629	206.00	46.84
18.000	-11.801	-5.756	12.313	206.00	46.84
19.000	-12.457	-6.076	12.997	206.00	46.84
20.000	-13.112	-6.395	13.681	206.00	46.84
21.000	-13.768	-6.715	14.365	206.00	46.84
22.000	-14.424	-7.035	15.049	206.00	46.84
23.000	-15.079	-7.355	15.733	206.00	46.84
24.000	-15.735	-7.674	16.417	206.00	46.84
25.000	-16.391	-7.994	17.101	206.00	46.84
26.000	-17.046	-8.314	17.785	206.00	46.84
27.000	-17.702	-8.634	18.469	206.00	46.84
28.000	-18.357	-8.954	19.153	206.00	46.84
29.000	-19.013	-9.273	19.837	206.00	46.84
30.000	-19.669	-9.593	20.521	206.00	46.84
31.000	-20.324	-9.913	21.205	206.00	46.84
32.000	-20.980	-10.233	21.889	206.00	46.84
33.000	-21.636	-10.552	22.573	206.00	46.84
34.000	-22.291	-10.872	23.257	206.00	46.84
35.000	-22.947	-11.192	23.941	206.00	46.84
36.000	-23.602	-11.512	24.625	206.00	46.84
37.000	-24.258	-11.831	25.309	206.00	46.84
38.000	-24.914	-12.151	25.993	206.00	46.84
39.000	-25.569	-12.471	26.677	206.00	46.84
40.000	-26.225	-12.791	27.362	206.00	46.84
41.000	-26.881	-13.110	28.046	206.00	46.84
42.000	-27.536	-13.430	28.730	206.00	46.84
43.000	-28.192	-13.750	29.414	206.00	46.84
44.000	-28.848	-14.070	30.097	205.00	47.02
45.000	-29.515	-14.373	30.777	204.00	47.14
46.000	-30.176	-14.684	31.461	206.00	46.83
47.000	-30.831	-15.004	32.144	206.00	46.91
48.000	-31.488	-15.322	32.828	205.00	46.90
49.000	-32.147	-15.636	33.512	206.00	46.83
50.000	-32.808	-15.945	34.196	205.00	46.83
51.000	-33.469	-16.254	34.879	204.00	46.92
52.000	-34.131	-16.561	35.562	206.00	46.80

53.000	-34.788	-16.878	36.247	206.00	46.80
54.000	-35.440	-17.201	36.933	206.00	46.76
55.000	-36.097	-17.519	37.616	206.00	46.85
56.000	-36.749	-17.843	38.302	206.00	46.82
57.000	-37.405	-18.159	38.987	207.00	46.52
58.000	-38.056	-18.483	39.674	206.00	46.82
59.000	-38.713	-18.805	40.355	207.00	47.32
60.000	-39.363	-19.137	41.039	208.00	46.49
61.000	-40.011	-19.468	41.724	206.00	46.88
62.000	-40.666	-19.790	42.407	206.00	46.87
63.000	-41.319	-20.116	43.091	206.00	46.86
64.000	-41.973	-20.440	43.775	206.00	46.88
65.000	-42.629	-20.761	44.458	206.00	46.93
66.000	-43.286	-21.080	45.141	207.00	47.03
67.000	-43.934	-21.412	45.827	207.00	46.04

Appendix E

BOREHOLE 02-08C
IMAGE LOG PLOTS
DISCONTINUITY AND DEVIATION TABLES

NORCAL GEOPHYSICAL CONSULTANTS, INC.

OPTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED OPTV DIPS LOG

23 Aug 2002

EARTH MECHANICS

Borehole: BH 02-08C

DEVIL'S SLIDE

top of borehole.....
East:
North:
Alt: 0

North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = fixed format

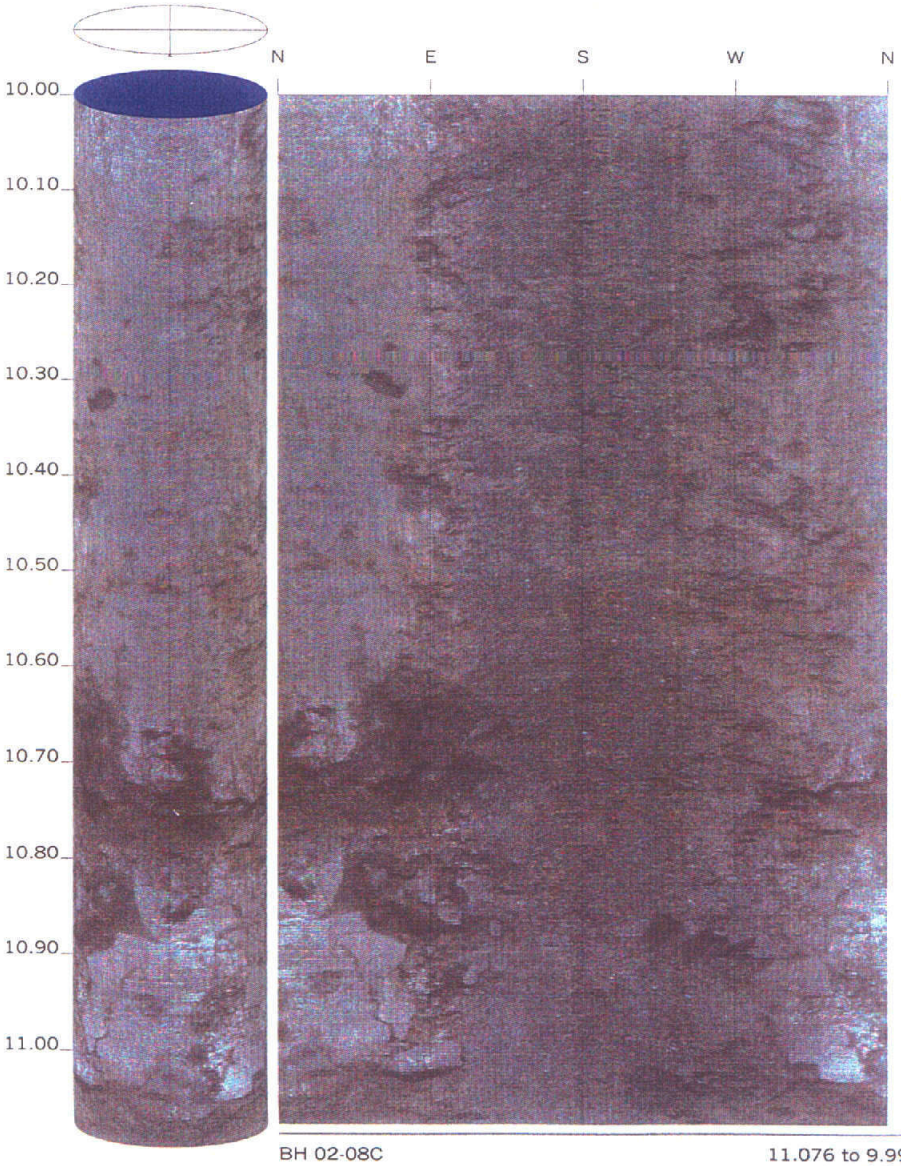
Zone from 45.604 to 9.999m
Vertical = borehole-axis

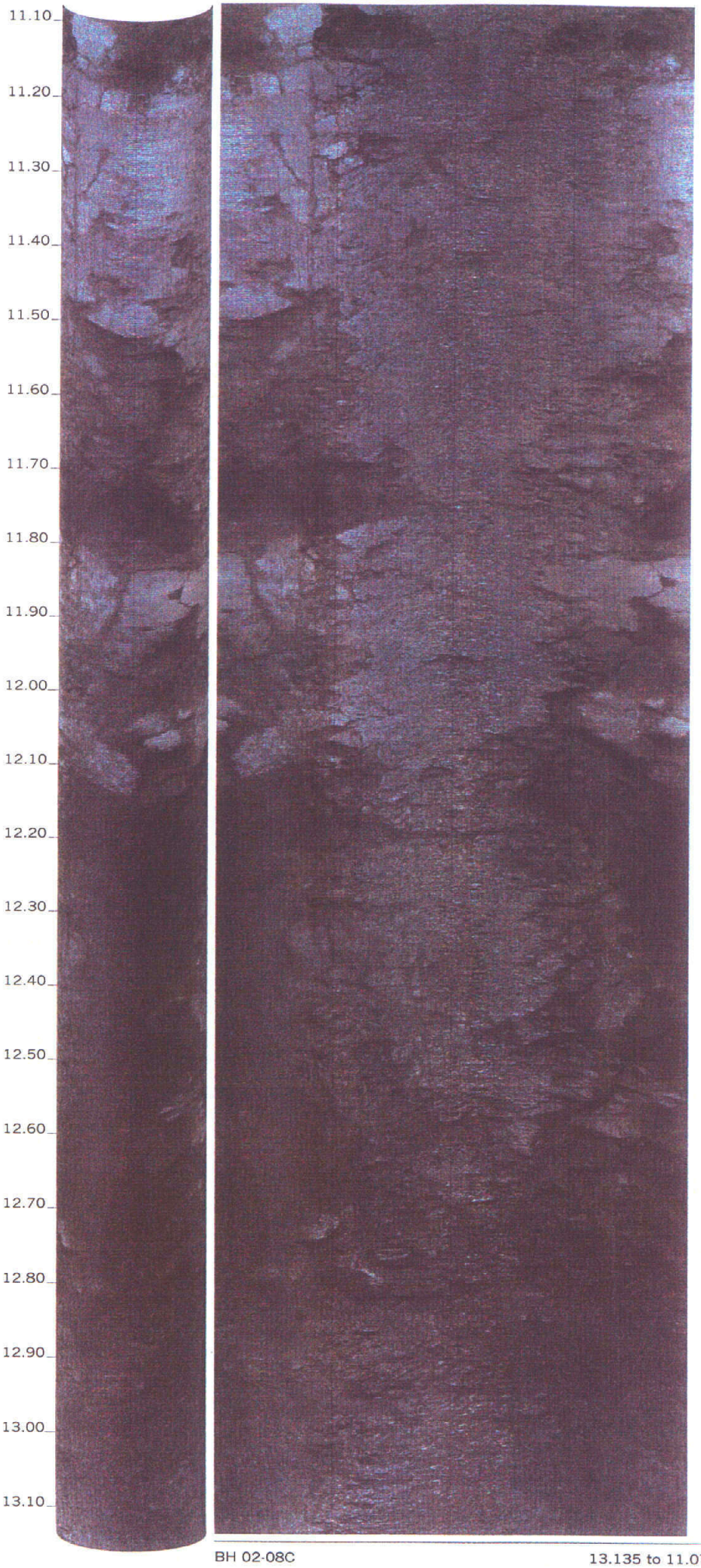
Borehole diam: 10.750cm

BEDDING
FRACTURE

Identified units

COMMENTS

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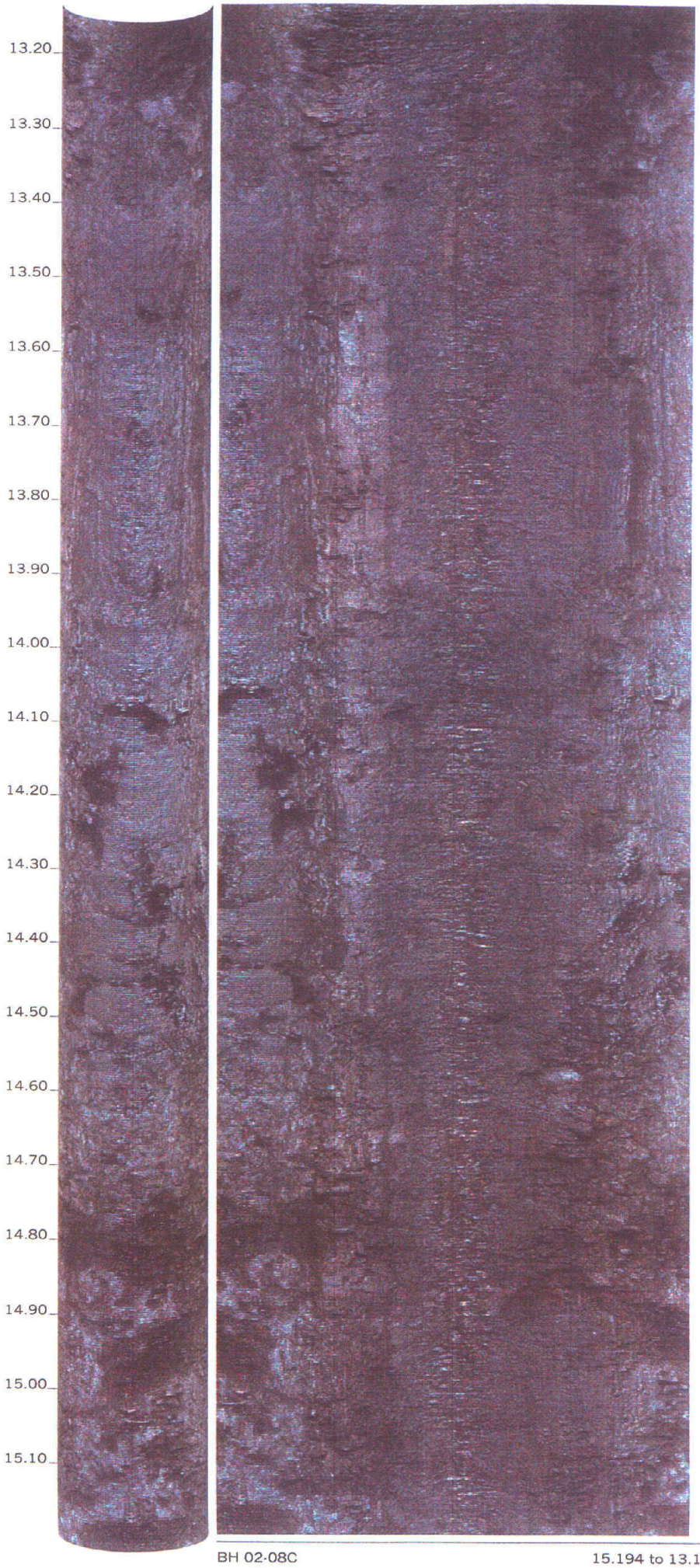
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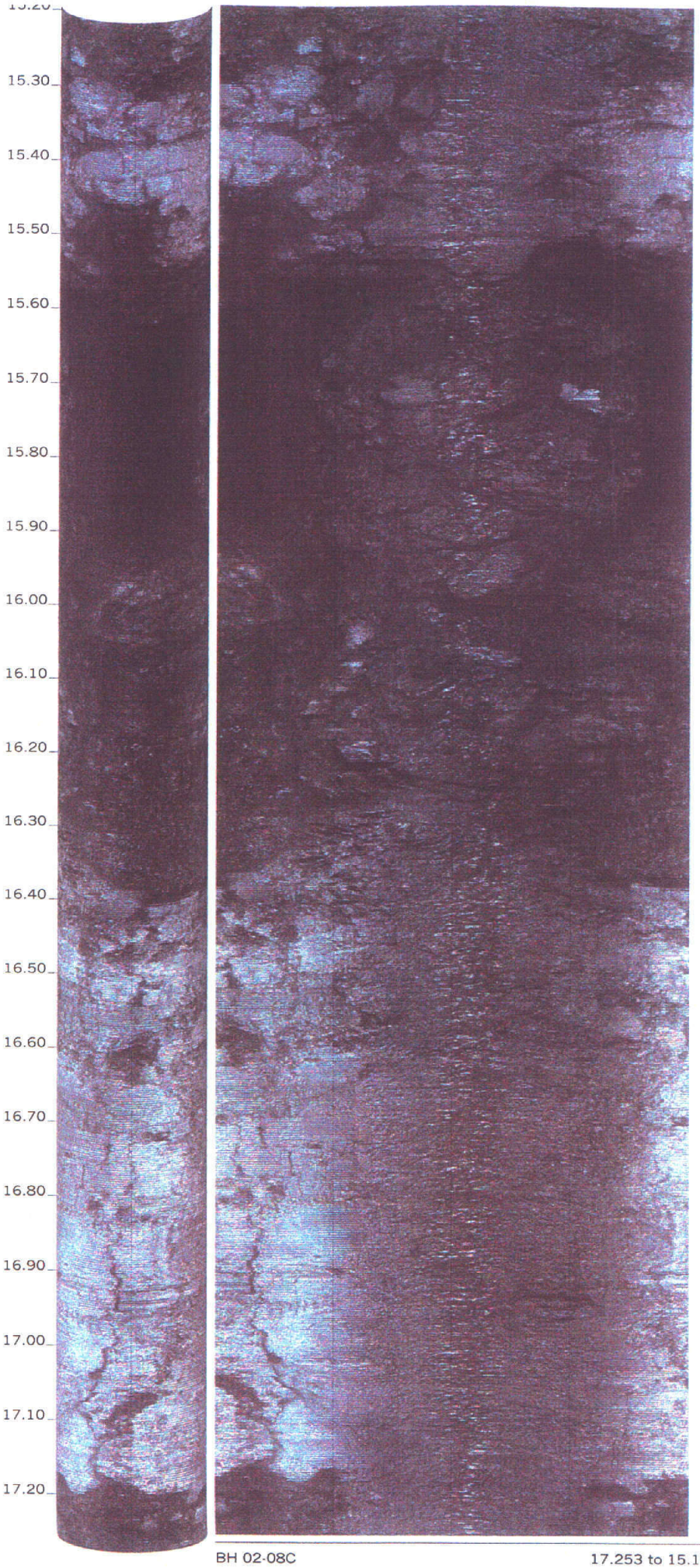
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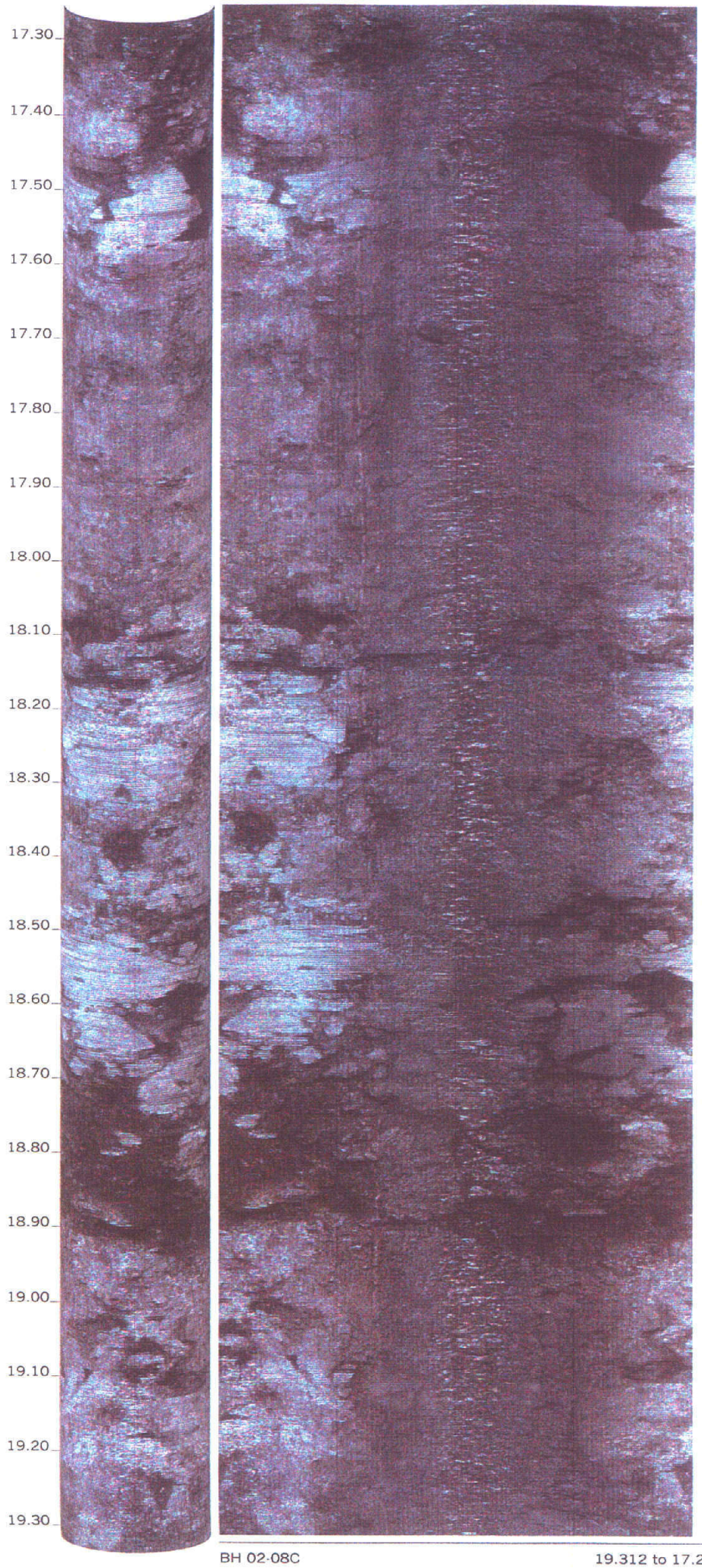
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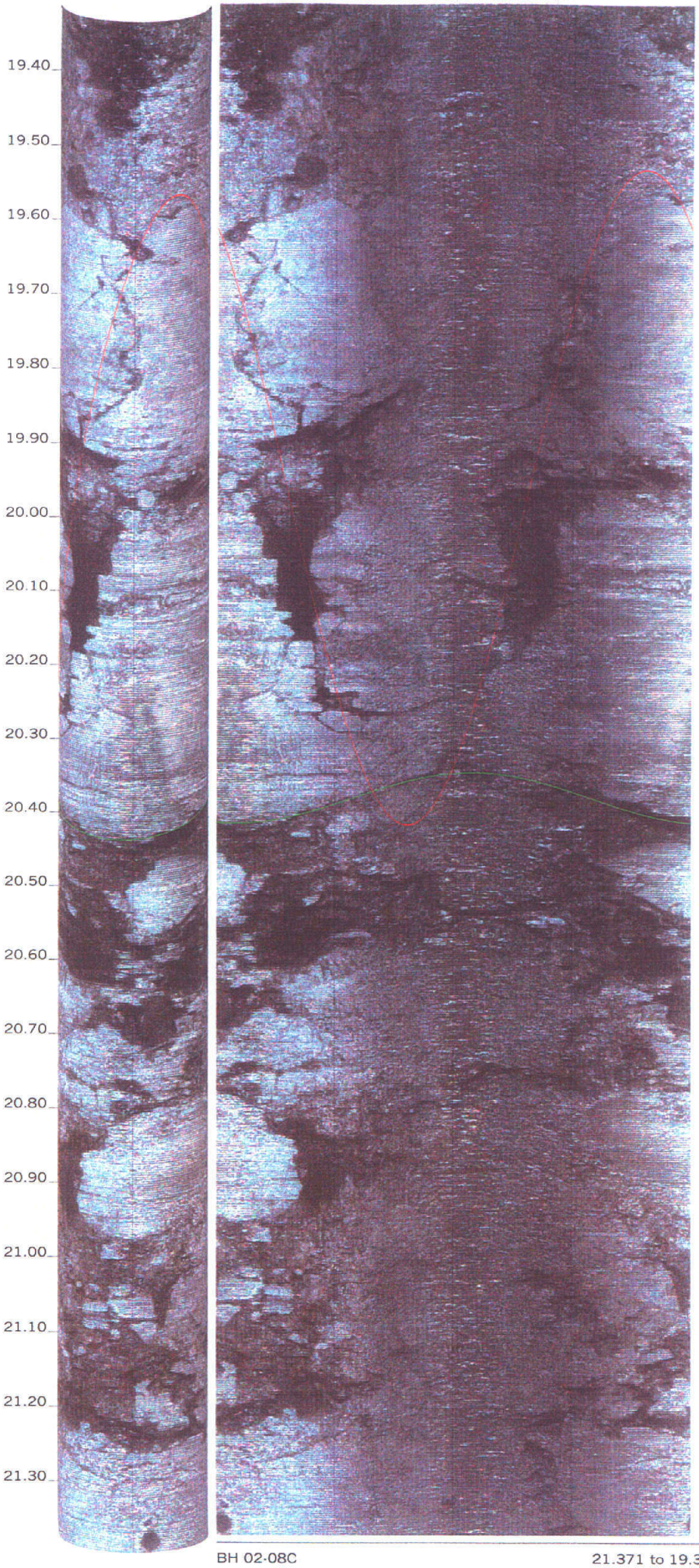
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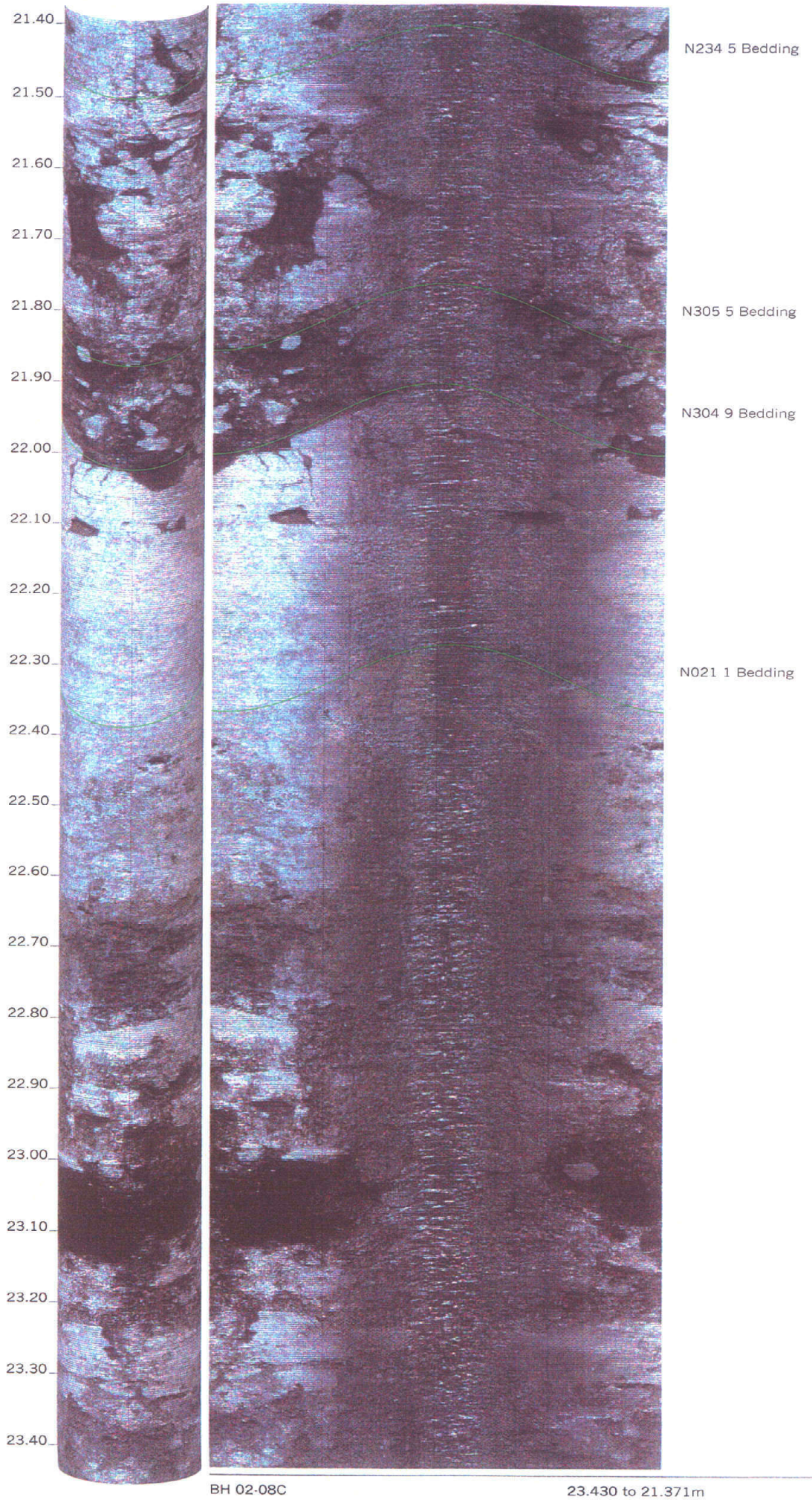
N181 8 Bedding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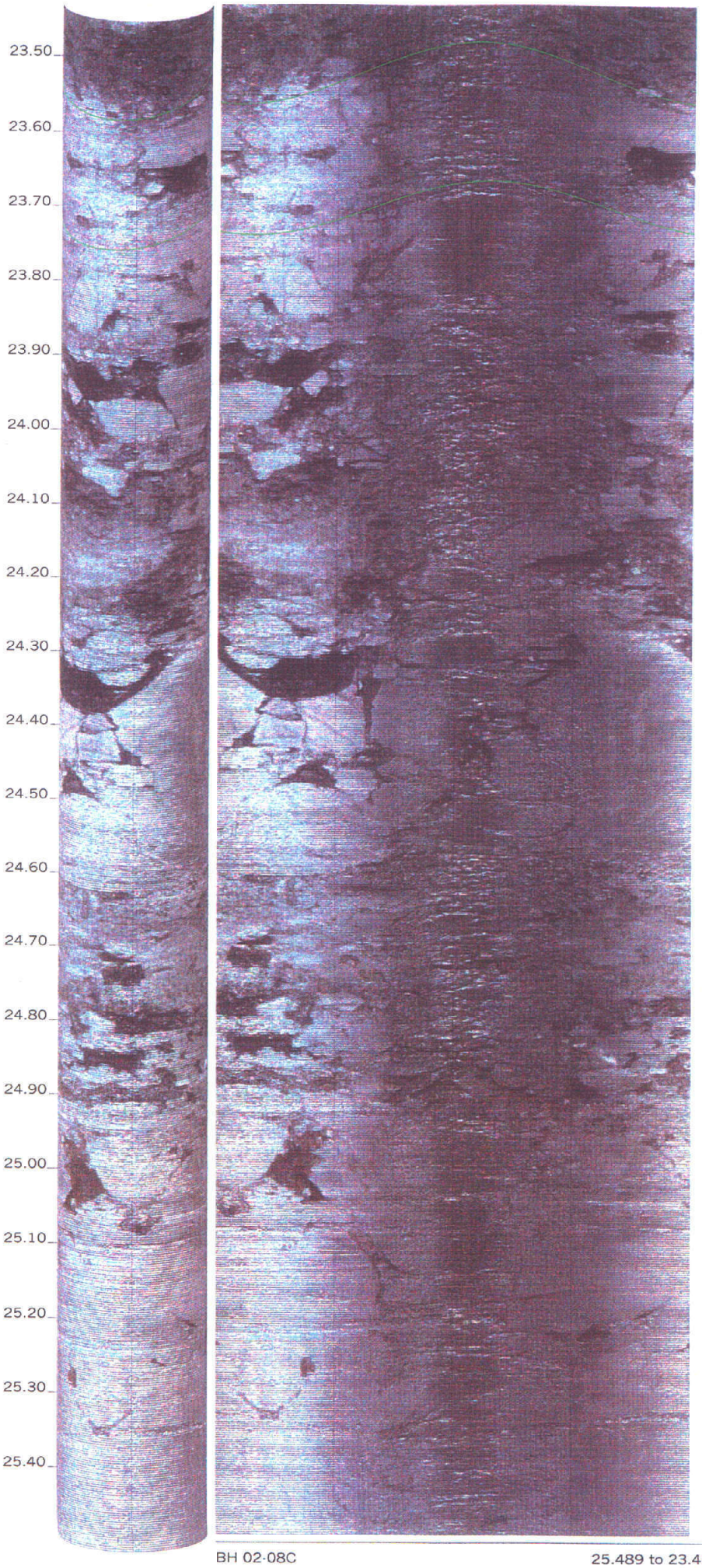
N021 1 Bedding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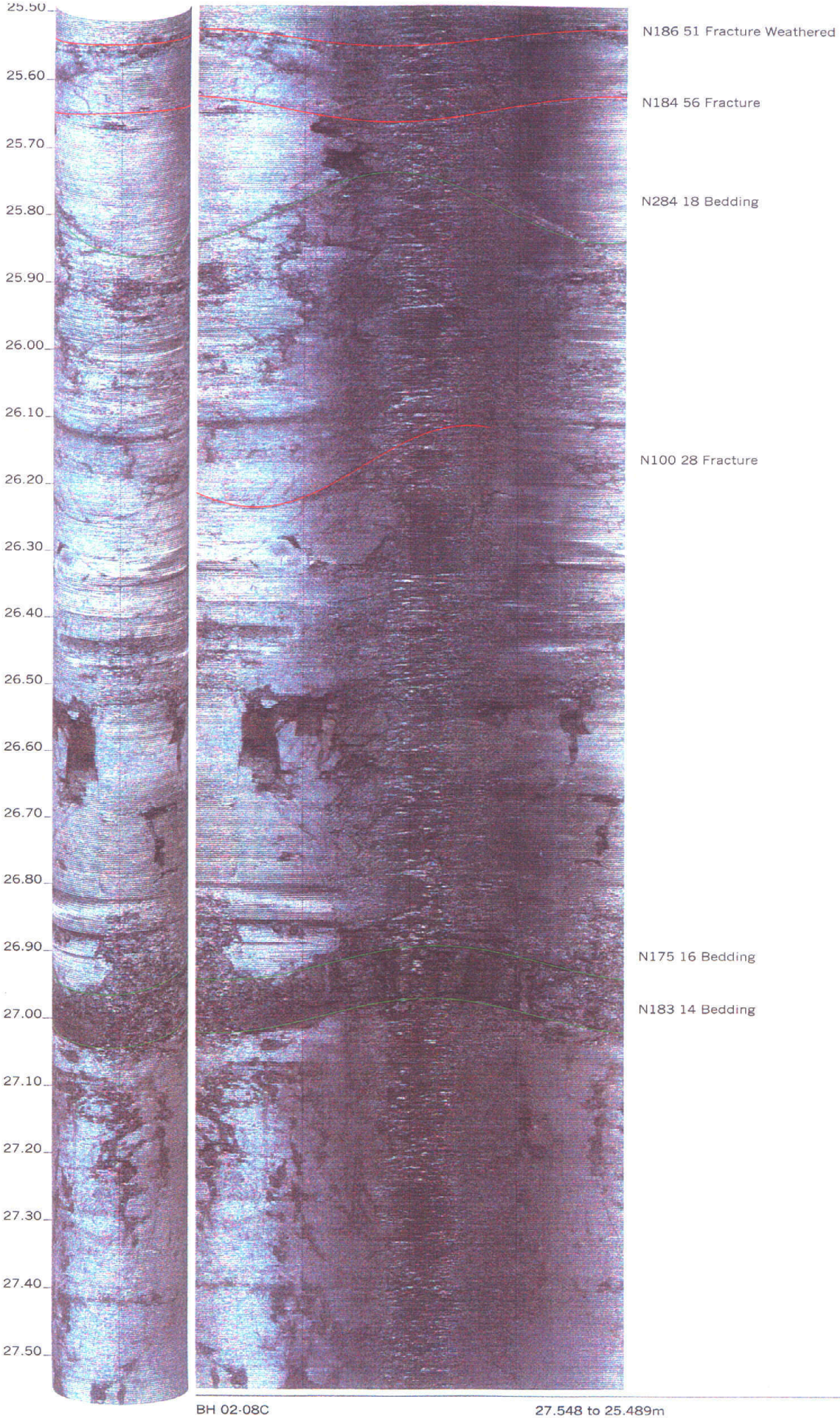
N142 11 Bedding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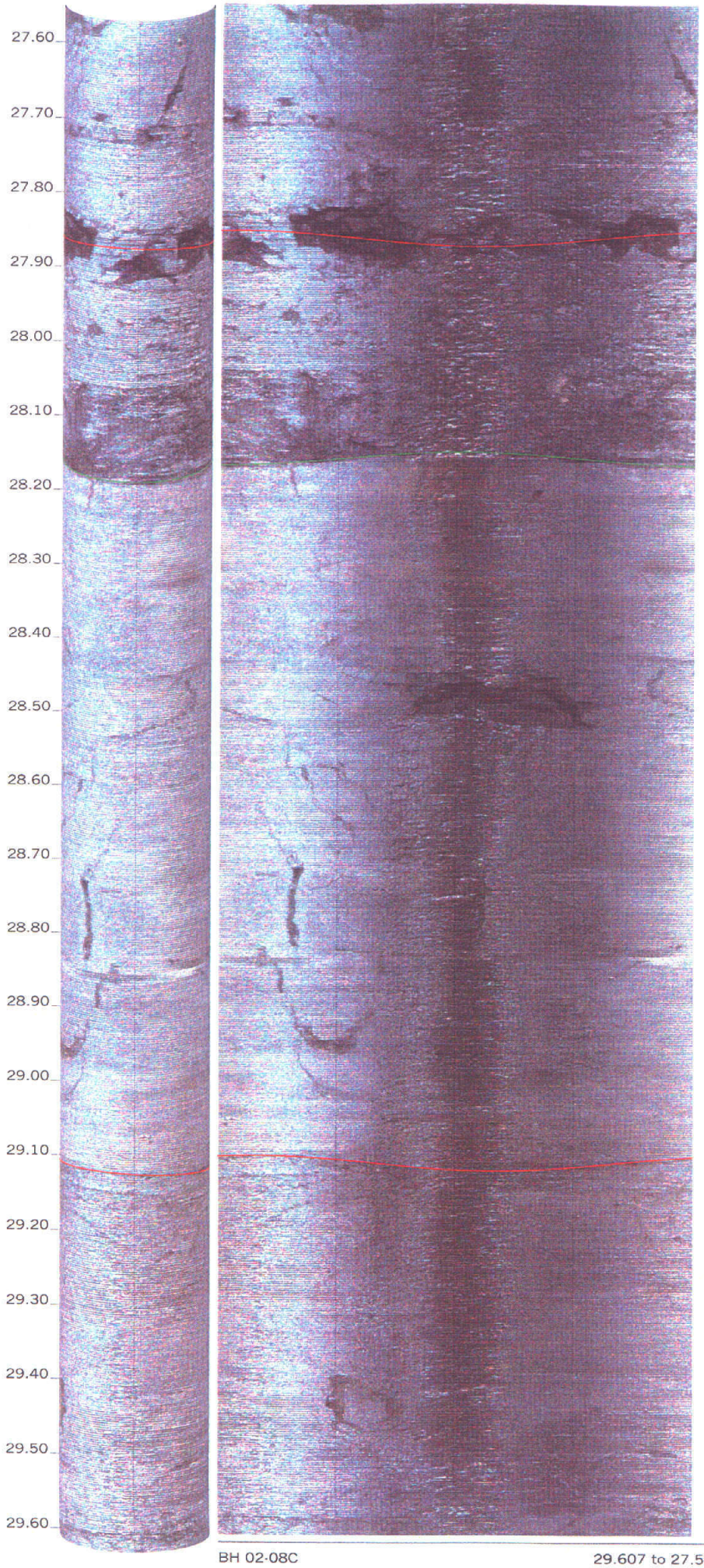
N183 14 Bedding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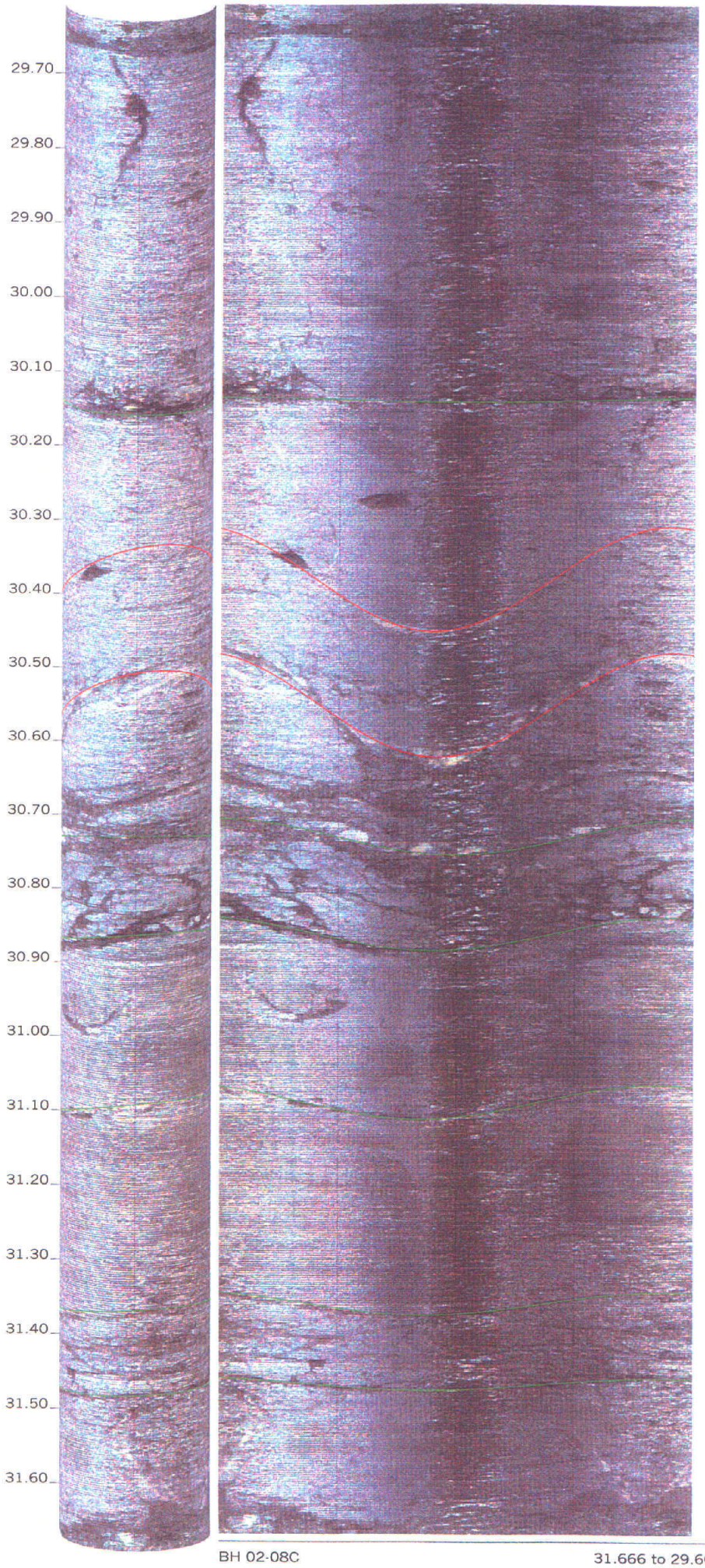
N199 51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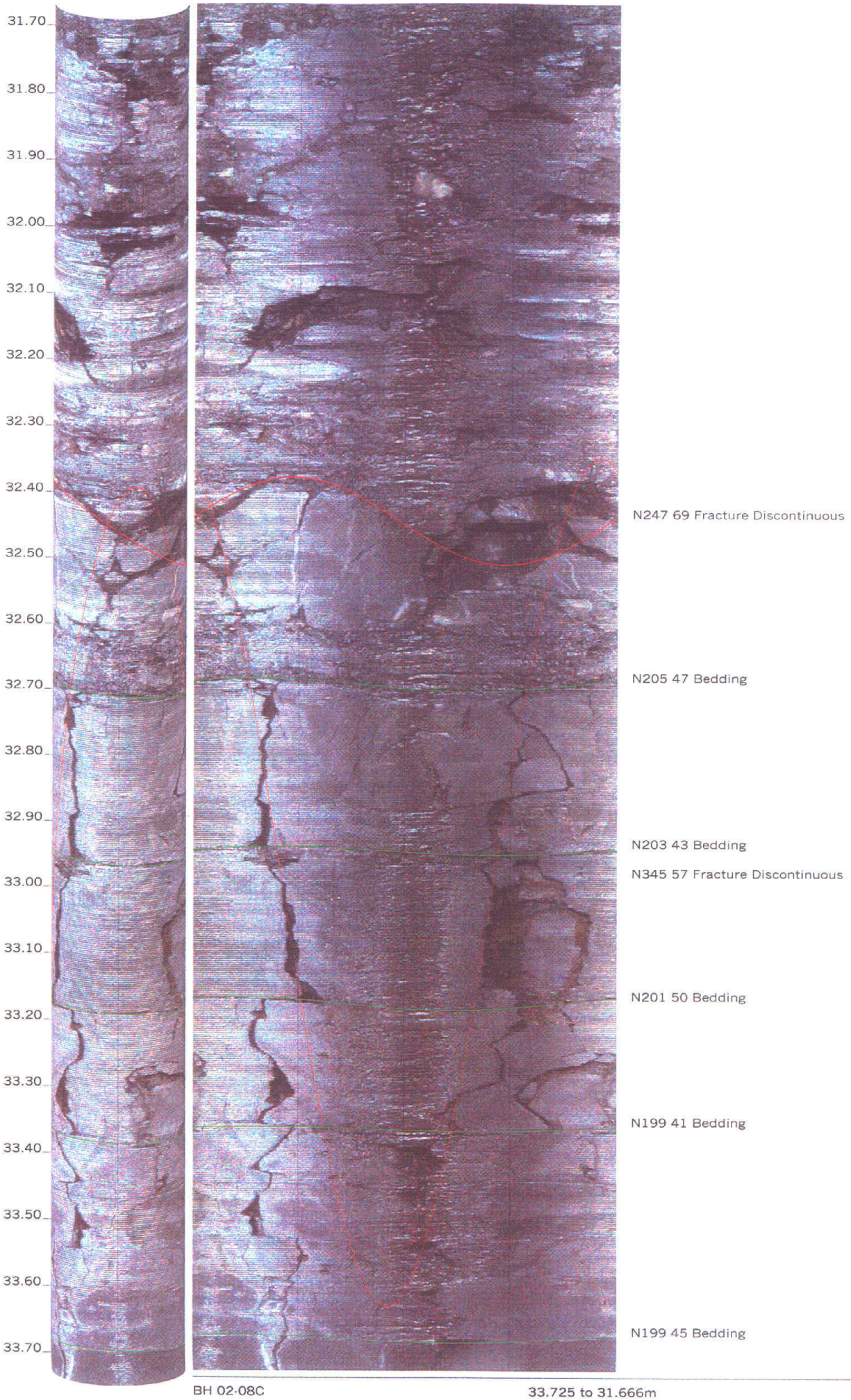
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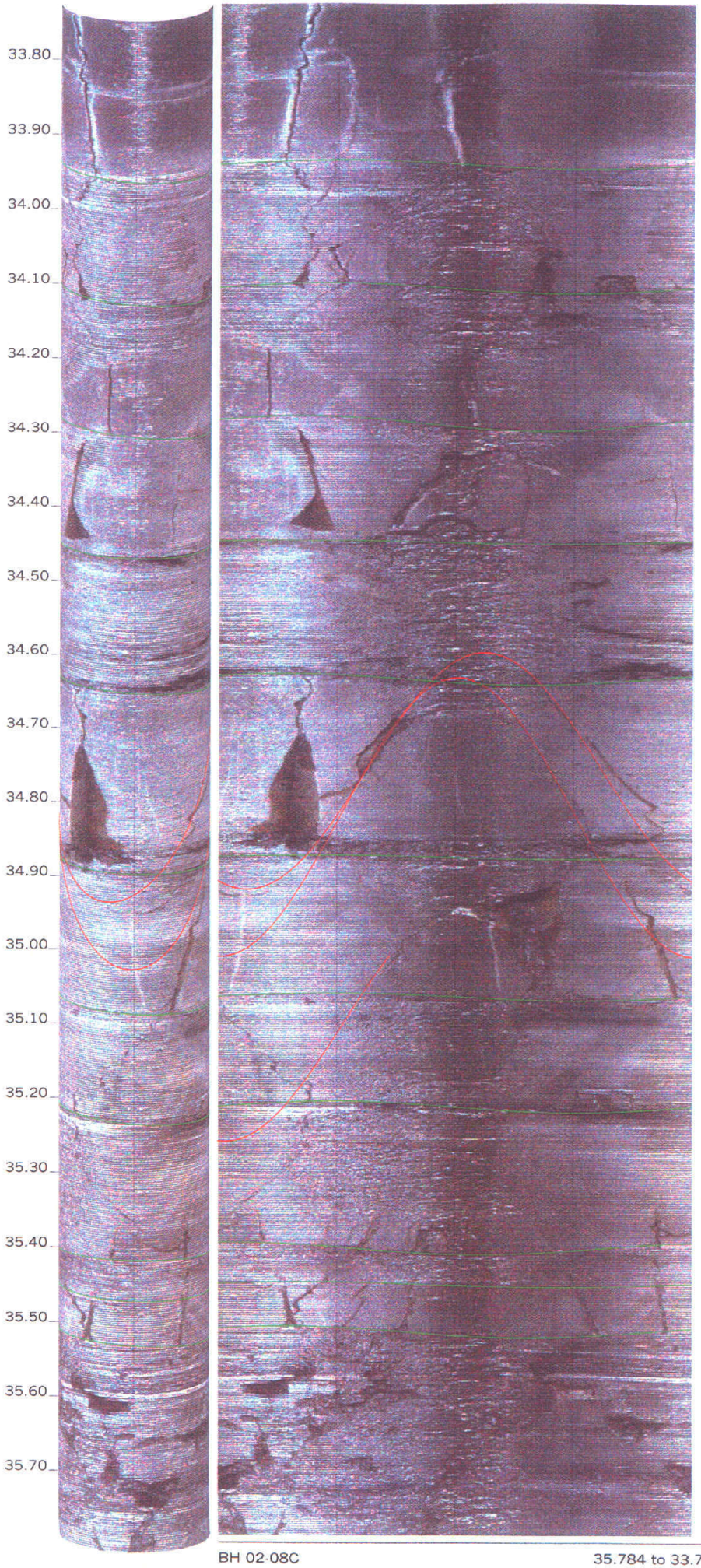
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N198 40 Bedding
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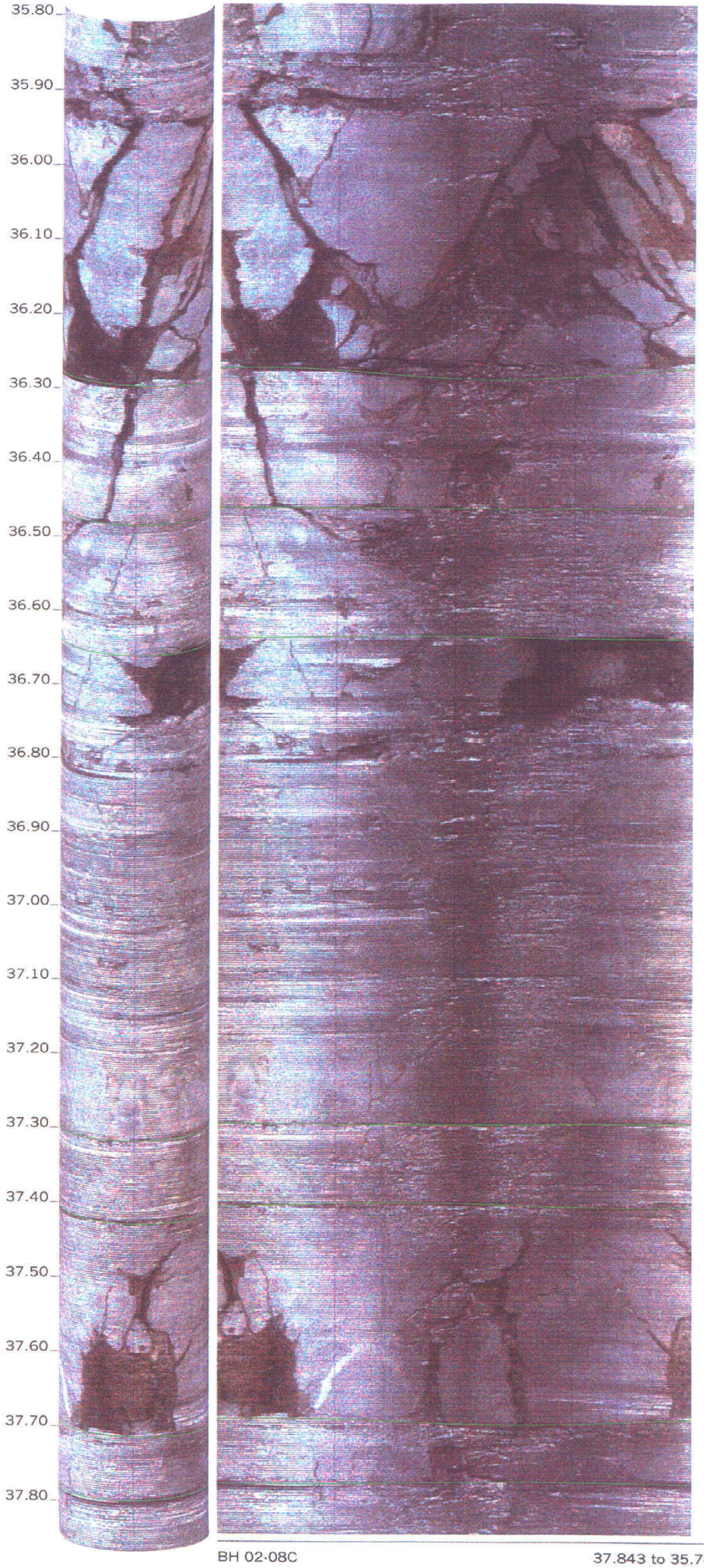
N202 46 Bedding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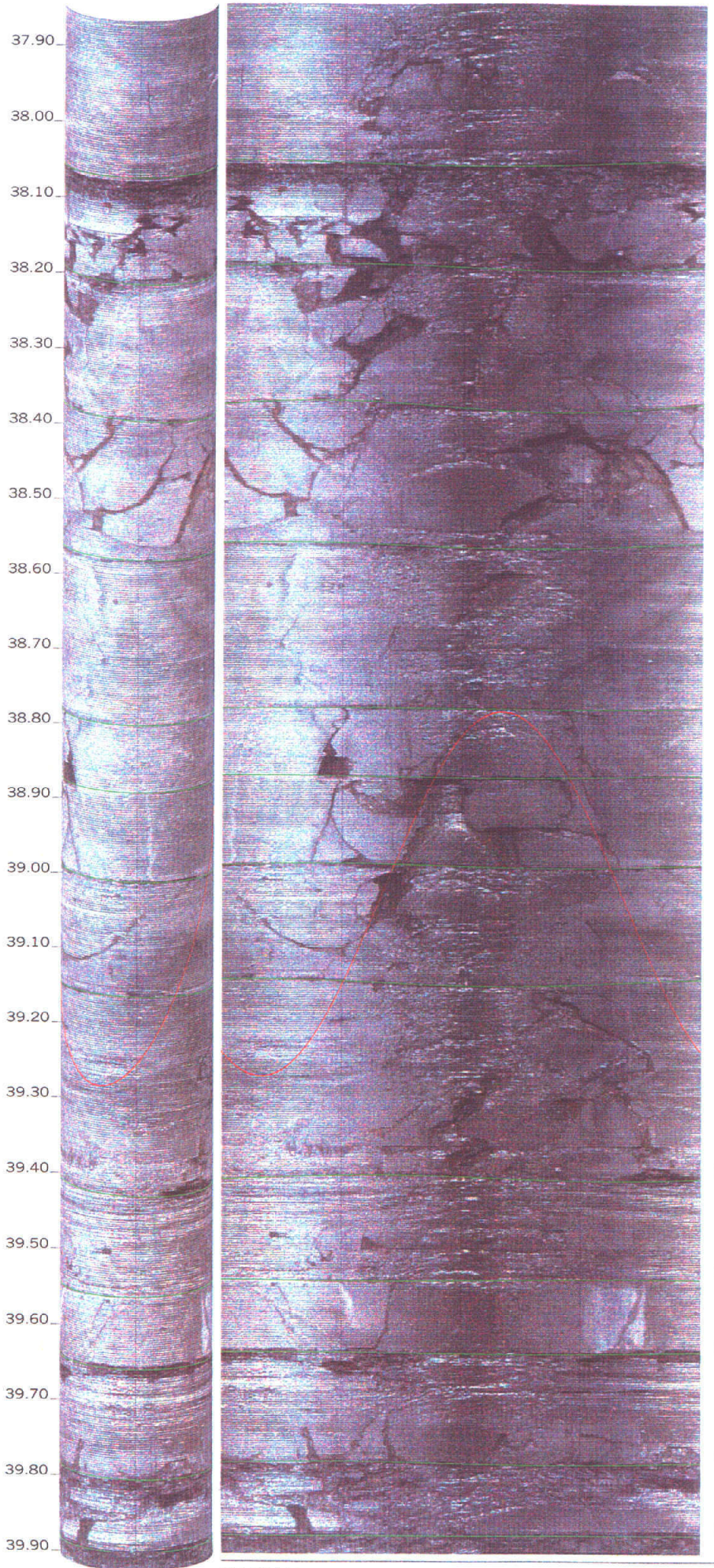
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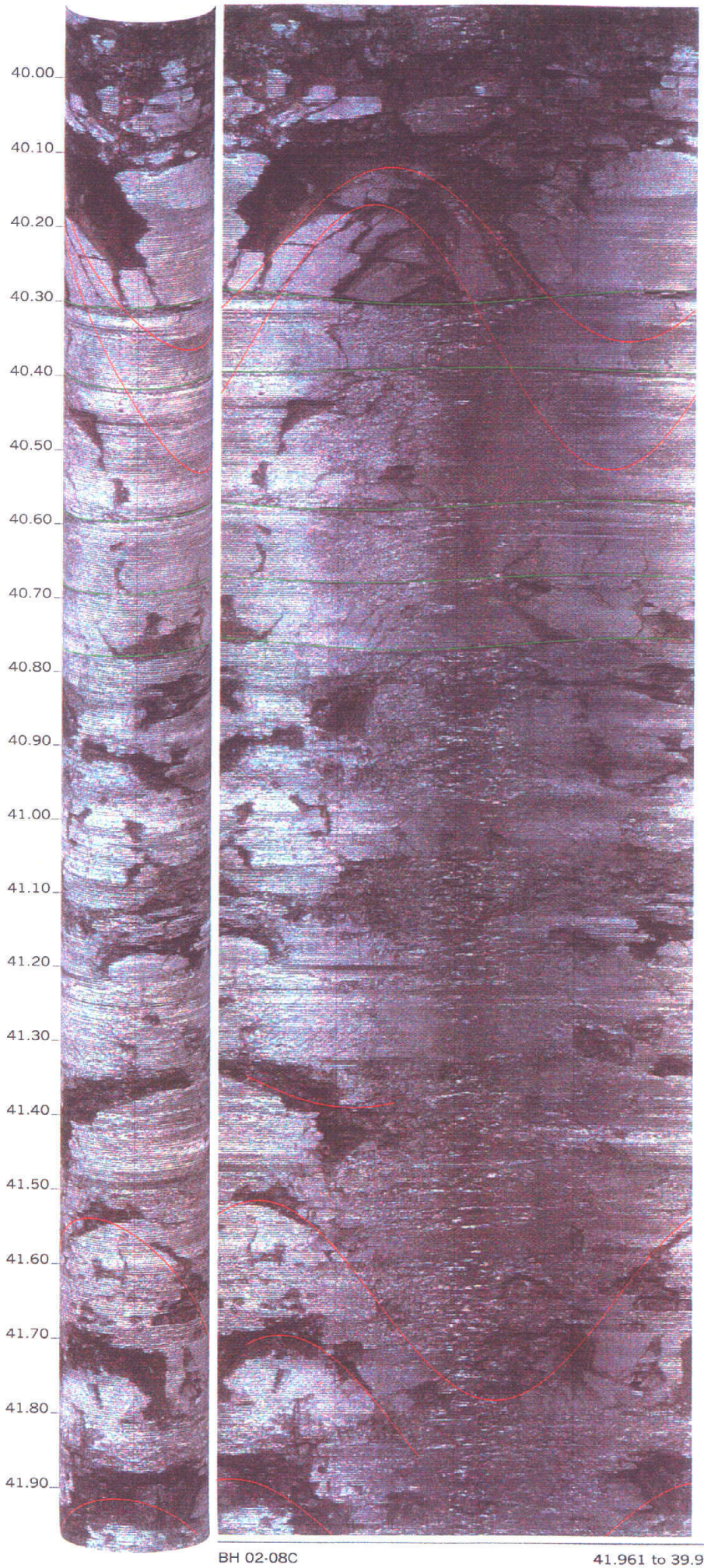
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N186 48 Irregular Bedding
N285 68 Fracture Discontinuous
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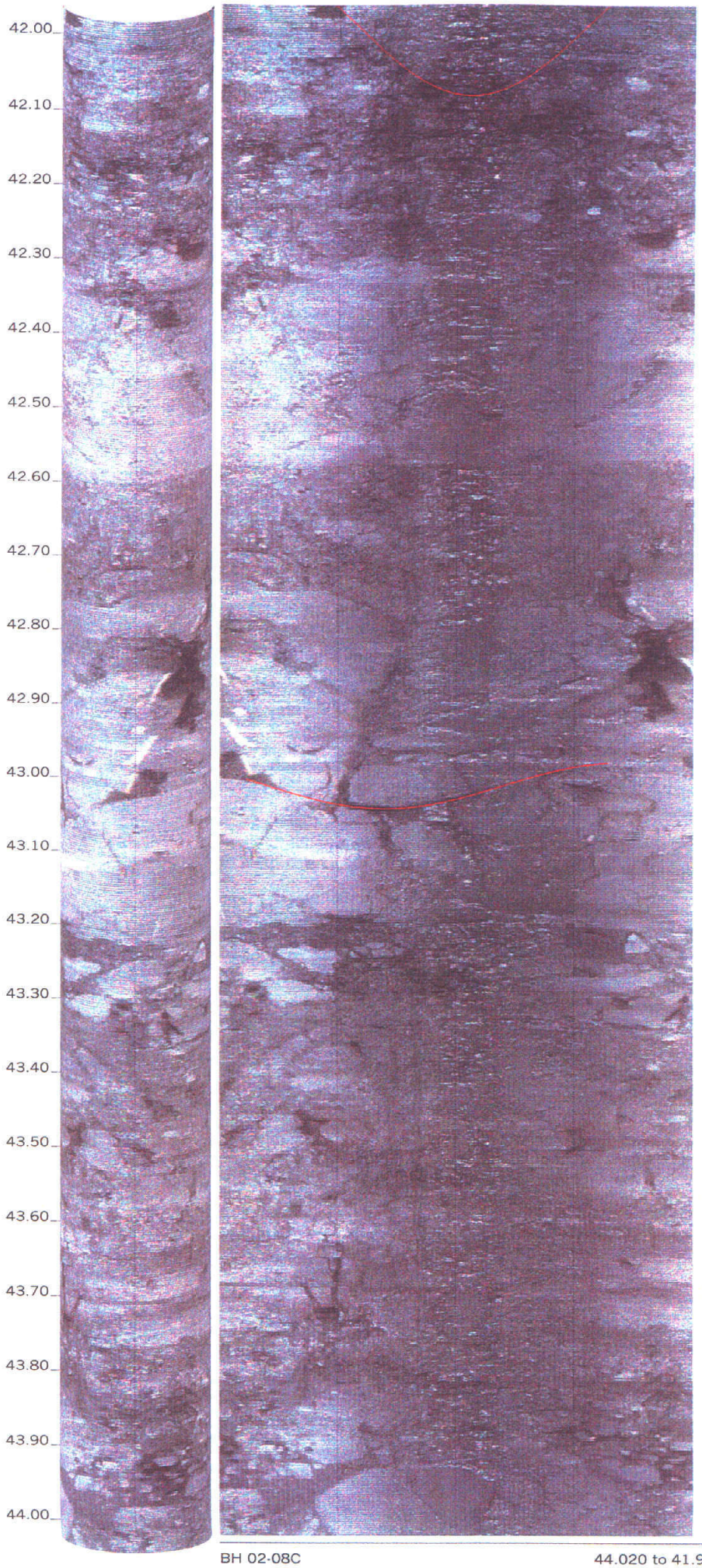
N033 77 Fracture Discontinuous
N048 80 Fracture Discontinuous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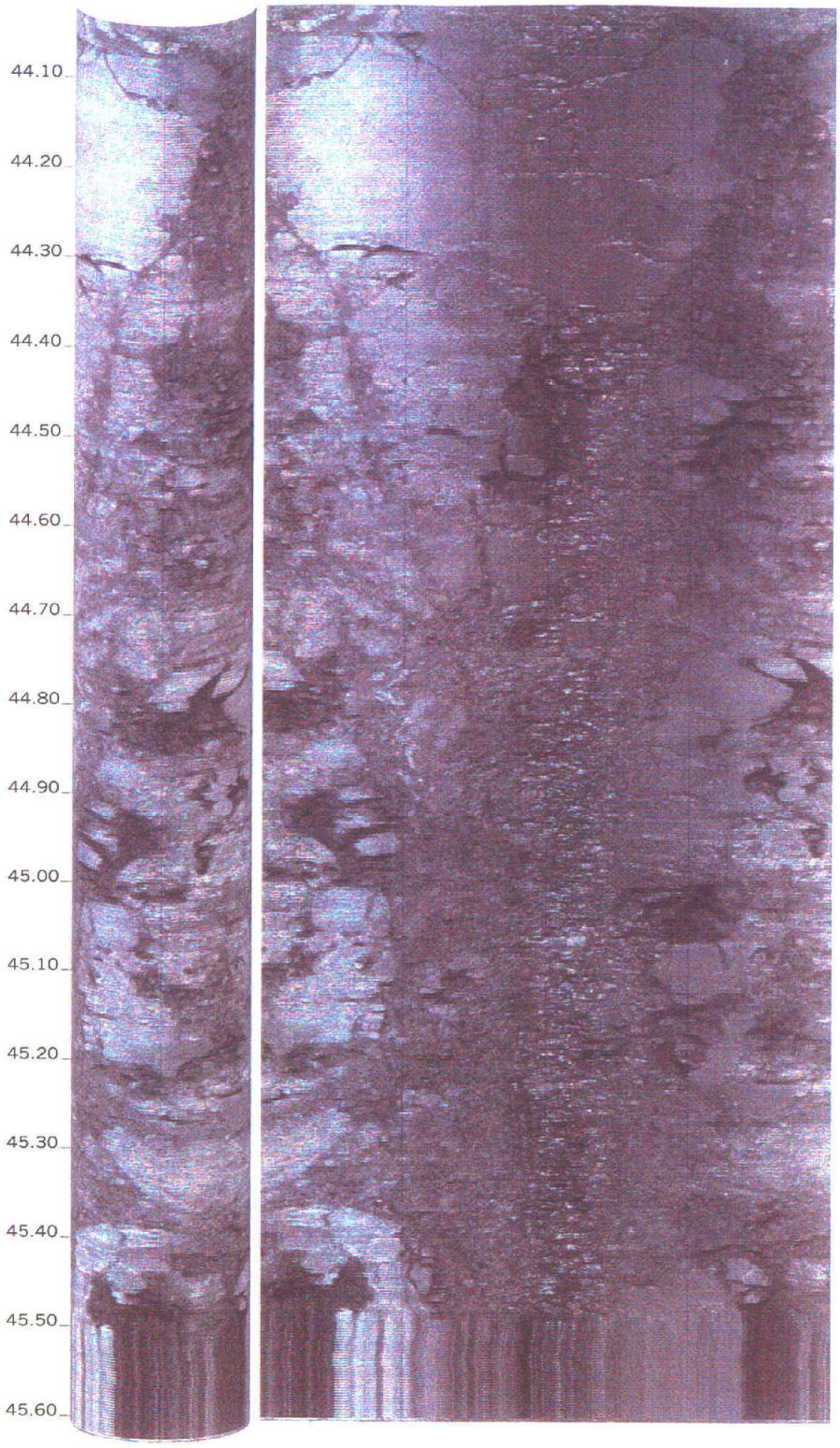
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45.40
45.50
45.60

NORCAL GEOPHYSICAL CONSULTANTS, INC.

BHTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED BHTV DIPS LOG

23 Aug 2002

EARTH MECHANICS

Borehole: BH 02-8C

DEVILS SLIDE

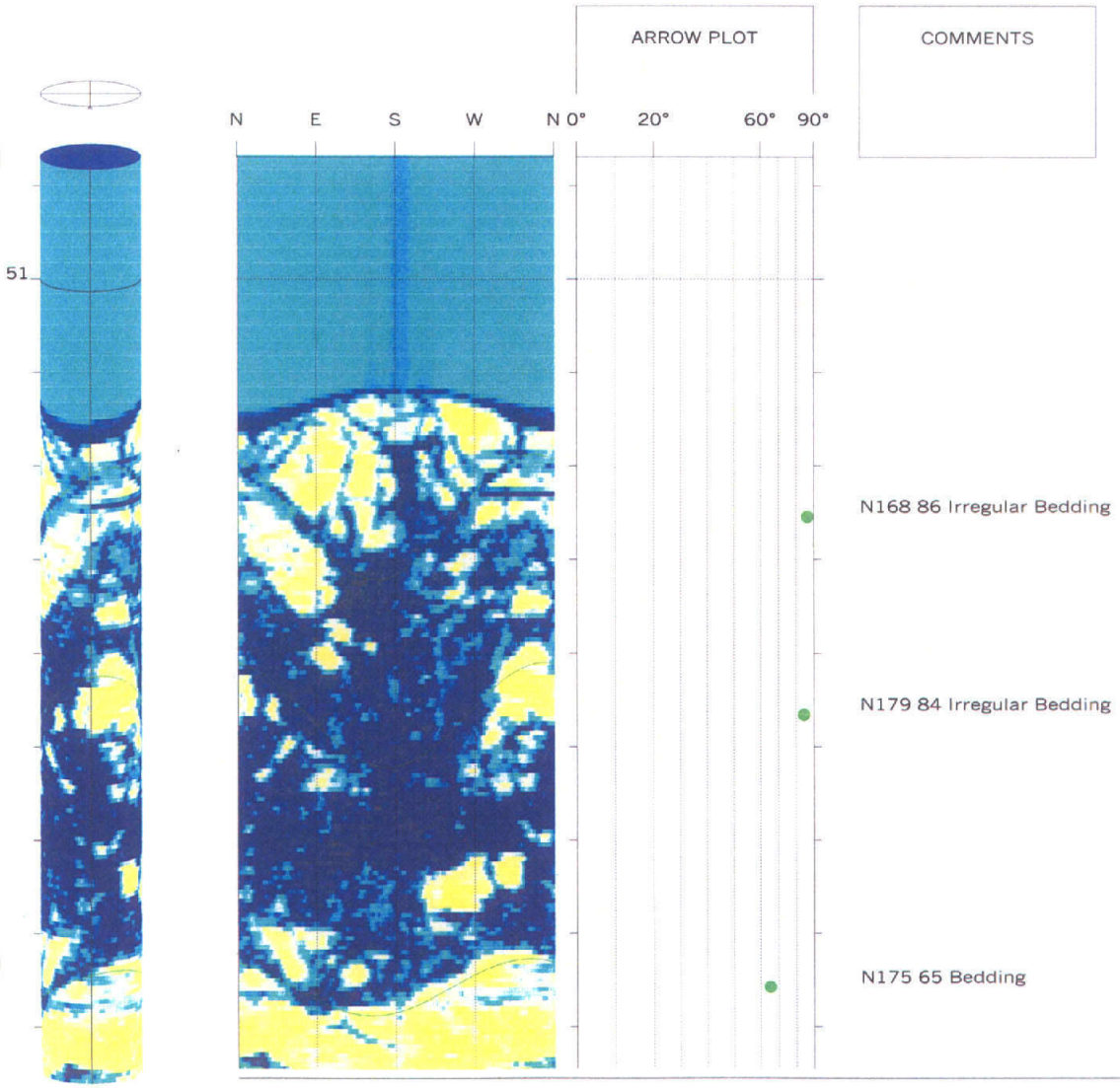
top of borehole.....
East:
North:
Alt:

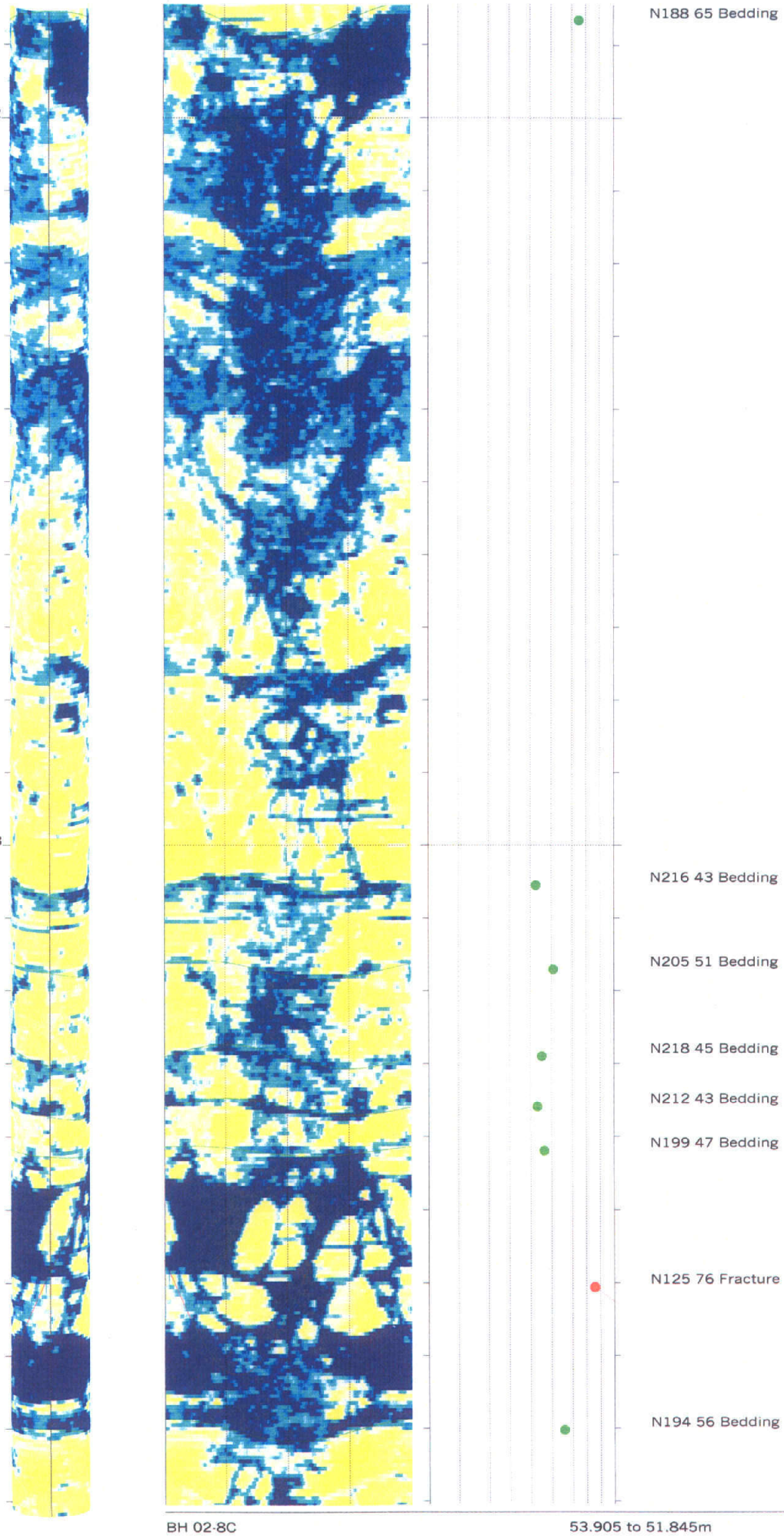
North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = vert scale

Zone from 66.520 to 50.870m

Borehole diam: 10.750cm
Vertical = borehole-axis
Amplitude

BEDDING
FRACTURE
Identified units

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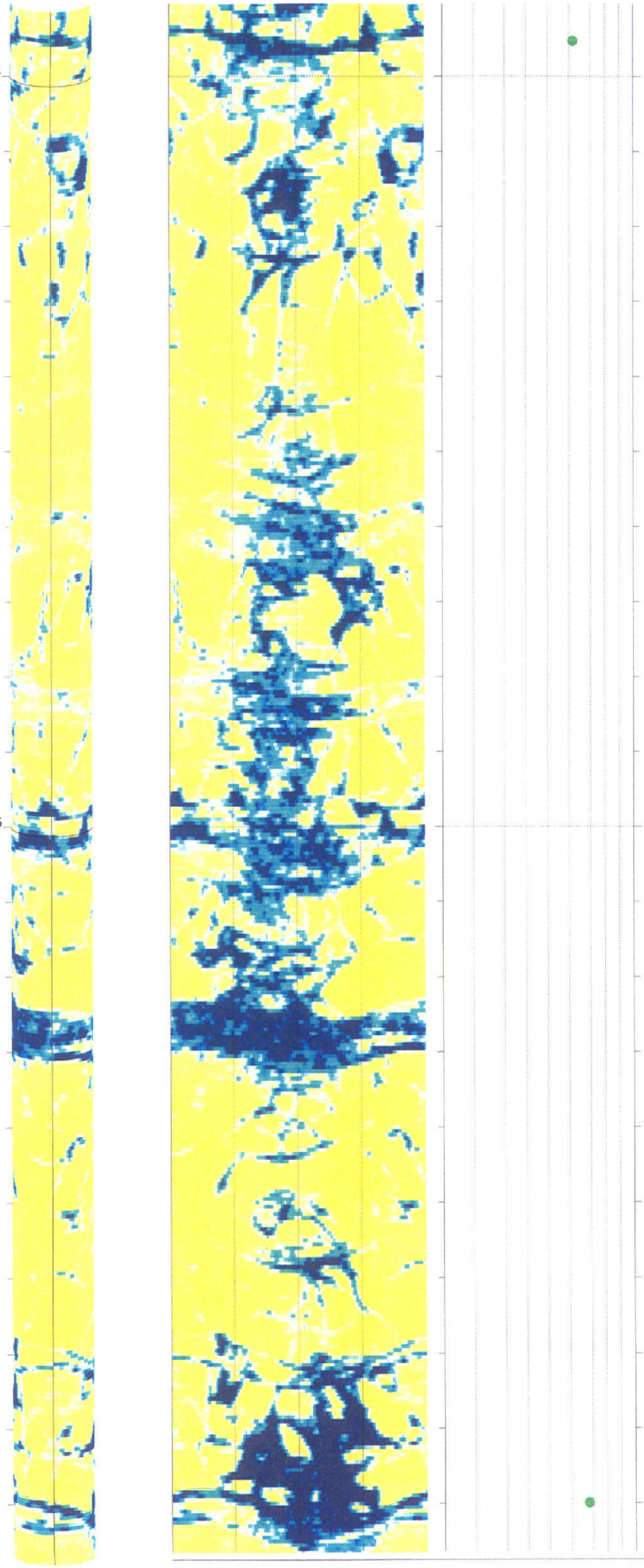
N194 56 Bedding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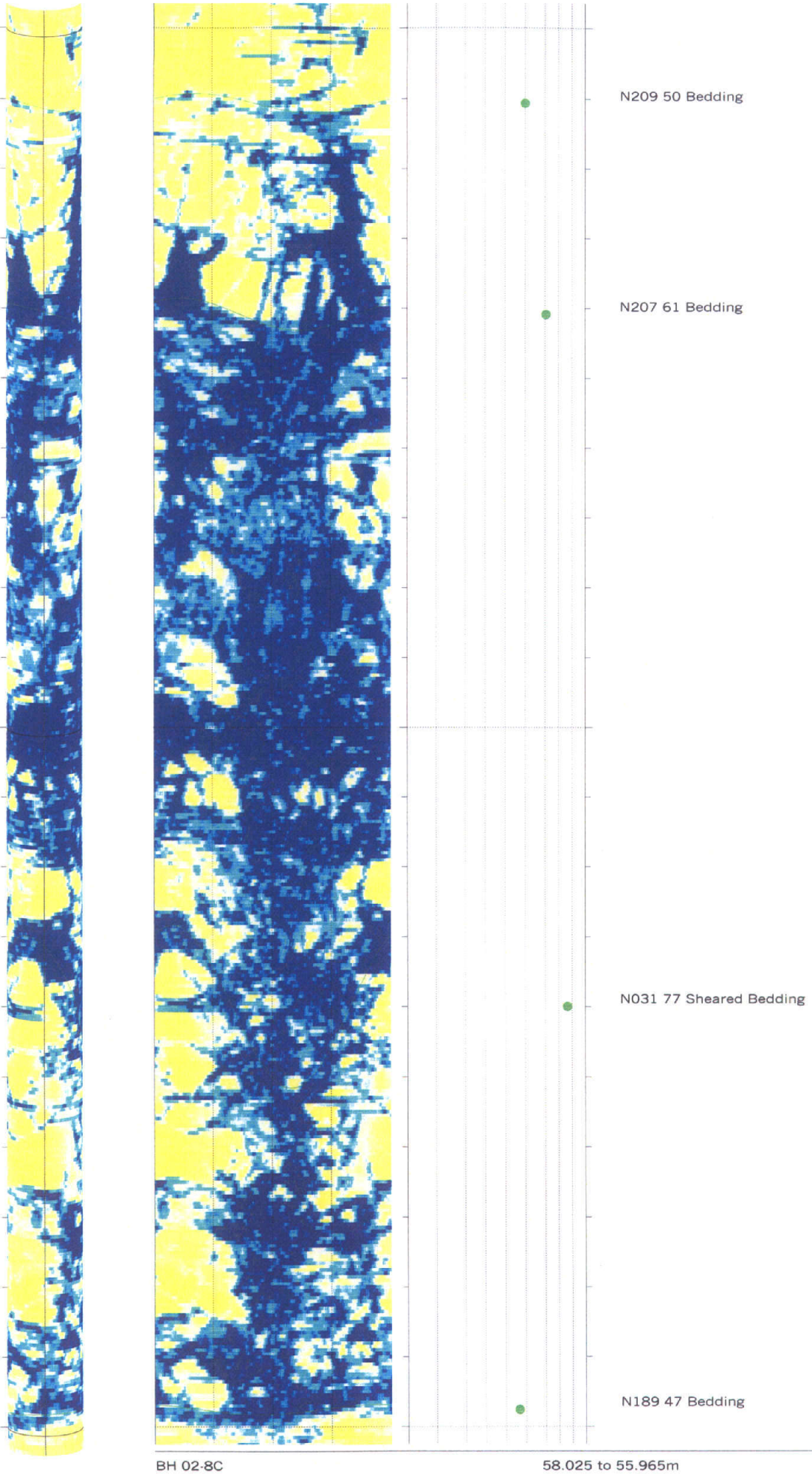
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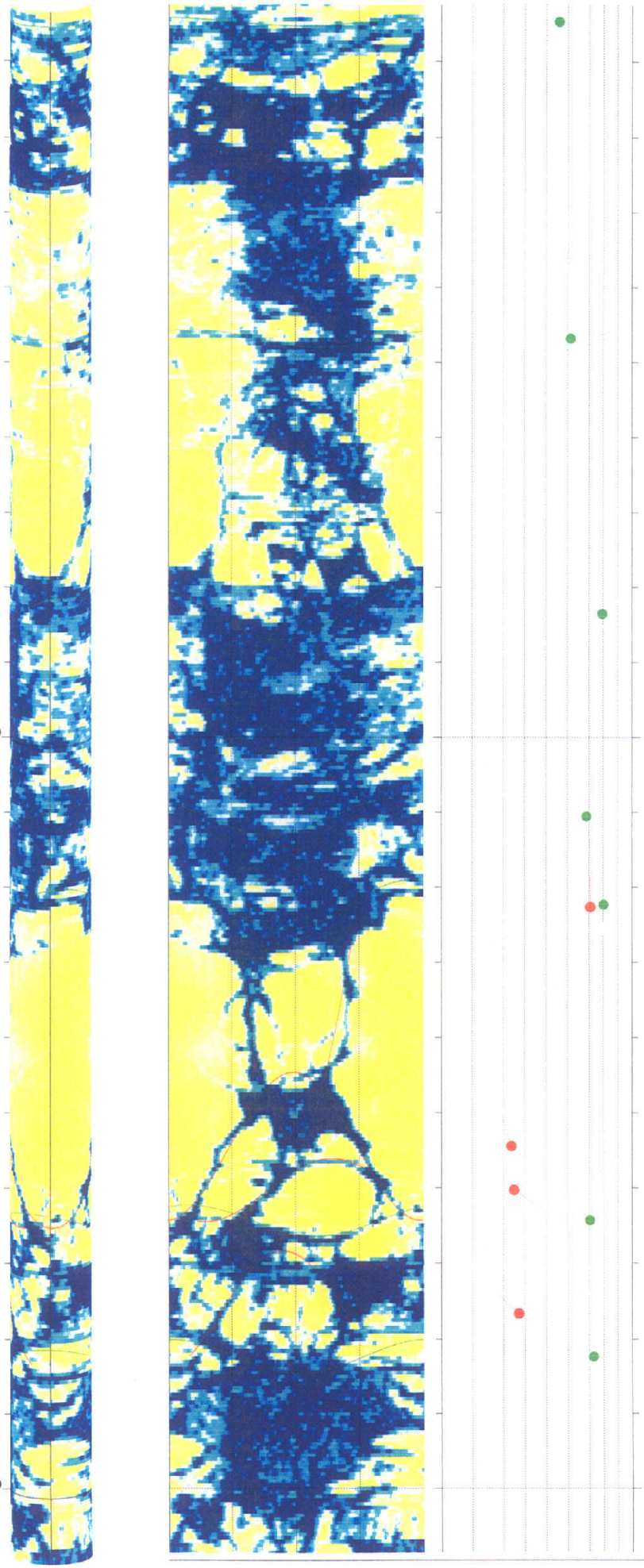

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N175 69 Bedding

N173 59 Bedding

N180 70 Bedding
N360 61 Fracture Discontinuous

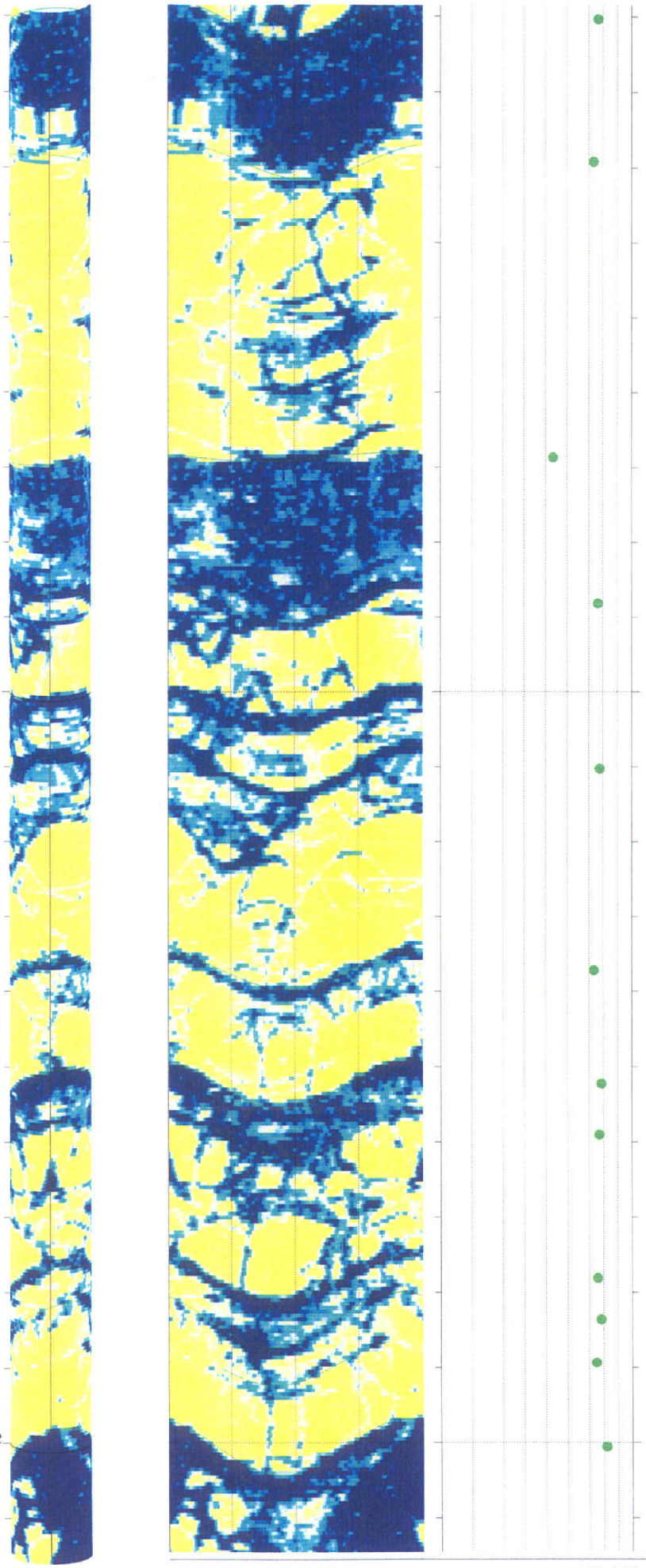
N343 24 Fracture

N124 25 Fracture

N201 60 Fracture Bedding

N312 27 Fracture

N191 63 Bedding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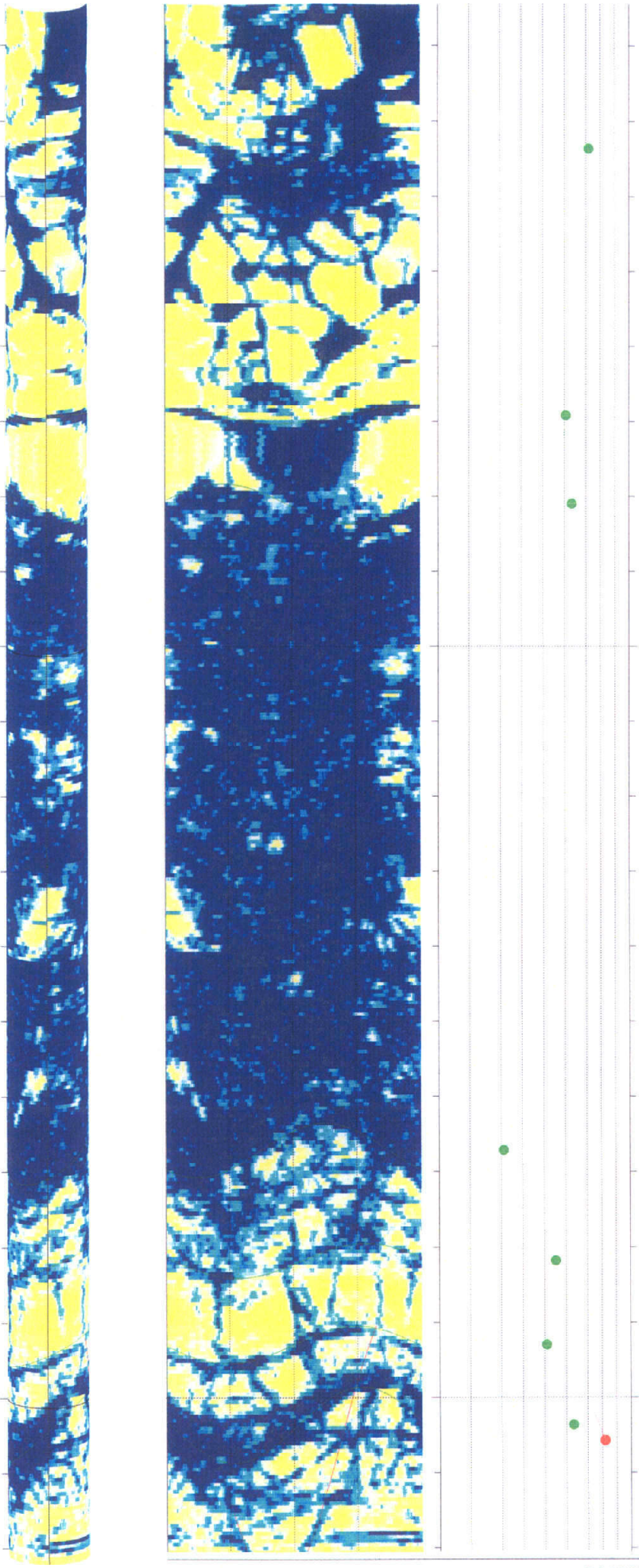
62
N176 72 Bedding


63
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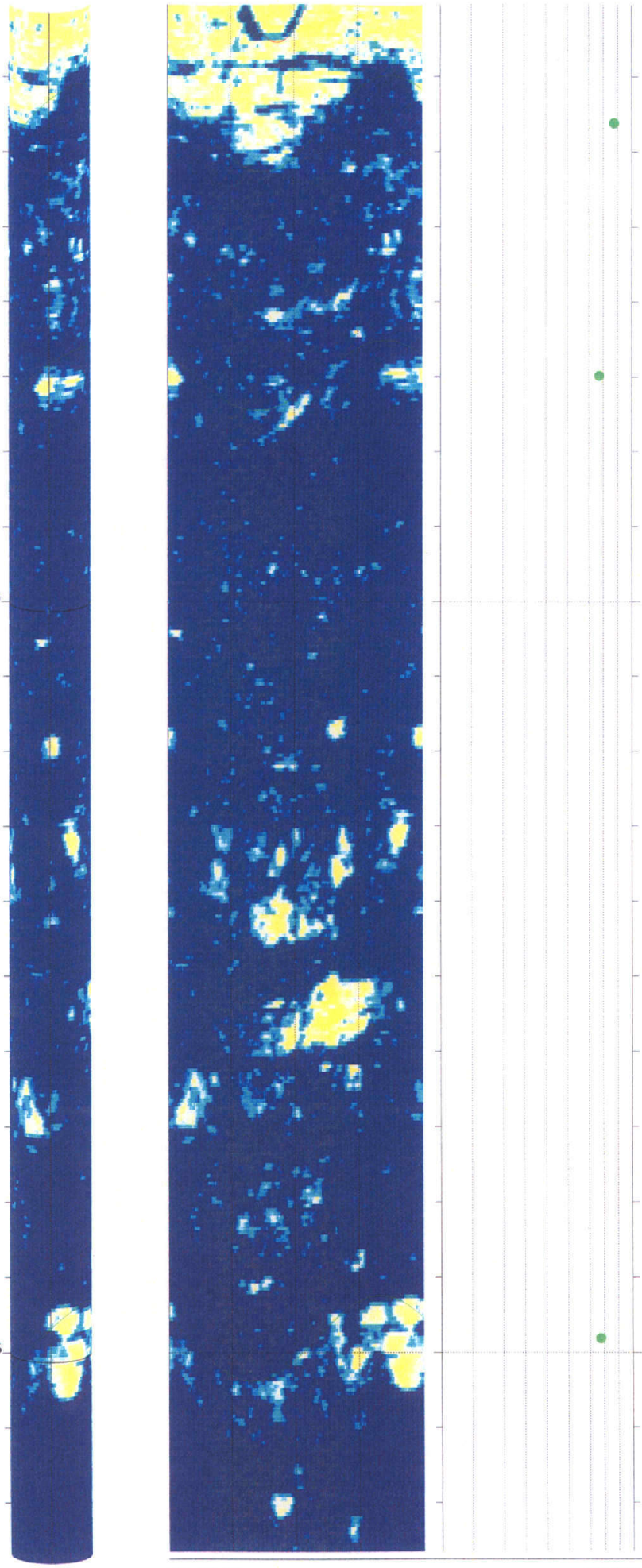
N339 72 Fracture Discontinuous



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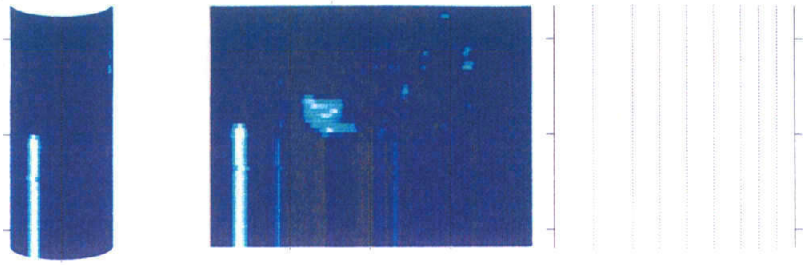
N155 67 Bedding

N146 68 Bedding



RGLDIPv6.1 OPTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-8C
zone from 45.663 to 55.136 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	51.288	257	77.0	0.974	5	A	2	51.174	51.401	0.110	13.00	38.00	0.0000	Fracture
2	50.472	333	61.1	0.939	13	C	2	49.611	51.333	0.110	13.00	40.00	0.0000	Fracture
3	49.426	192	38.1	1.000	0	*	0	49.426	49.427	0.110	12.60	37.60	0.0000	Bedding
4	49.359	190	37.7	1.000	0	*	0	49.357	49.361	0.110	12.00	38.48	0.0000	Bedding
5	48.810	195	41.8	0.995	5	A	0	48.807	48.813	0.110	13.00	39.00	0.0000	Bedding
6	48.216	231	58.8	0.964	9	B	2	48.179	48.254	0.110	12.60	38.79	0.0000	Fracture
7	48.144	100	52.9	0.957	12	B	2	48.033	48.255	0.110	13.00	39.04	0.0000	Fracture Discontinuous
8	47.447	168	88.9	0.944	7	C	2	47.371	47.523	0.110	13.00	39.01	0.0000	Fracture Mineralized
9	47.364	161	86.0	1.000	3	A	2	47.349	47.424	0.110	13.00	39.00	0.0000	Fracture Discontinuous Mineralized
10	45.923	33	47.2	0.875	15	D	2	45.338	46.508	0.110	13.00	39.07	0.0000	Fracture

36	35.401	195	47.0	0.987	7	A	0	35.392	35.409	0.107	14.00	38.28	0.0000	Bedding
37	35.211	206	41.2	0.967	8	B	0	35.203	35.219	0.107	14.00	38.70	0.0000	Bedding
38	35.099	3	30.6	0.975	11	A	2	35.002	35.258	0.108	14.00	41.00	0.0000	Fracture Discontinuous
39	35.063	202	40.4	0.964	6	B	0	35.058	35.068	0.106	14.00	39.01	0.0000	Bedding
40	34.874	198	41.7	0.983	6	A	0	34.871	34.877	0.107	14.00	40.55	0.0000	Bedding
41	34.820	359	34.4	0.900	27	C	2	34.630	35.009	0.108	14.00	40.53	0.0000	Fracture Discontinuous
42	34.757	35	31.2	0.955	13	B	2	34.597	34.917	0.107	14.00	41.78	0.0000	Fracture Discontinuous
43	34.632	202	46.7	0.962	8	B	0	34.625	34.640	0.107	14.00	40.46	0.0000	Bedding
44	34.447	198	39.6	0.978	10	A	0	34.444	34.449	0.107	14.00	38.04	0.0000	Bedding
45	34.286	206	48.0	0.971	10	B	0	34.276	34.297	0.107	14.00	41.00	0.0000	Bedding
46	34.105	205	41.7	0.983	7	A	0	34.098	34.112	0.107	14.00	39.36	0.0000	Bedding
47	33.939	204	39.3	0.973	8	A	0	33.933	33.945	0.107	14.00	38.27	0.0000	Bedding
48	33.677	199	44.7	0.982	11	A	0	33.671	33.683	0.107	14.00	39.00	0.0000	Bedding
49	33.363	199	41.4	0.939	6	C	0	33.359	33.367	0.108	14.00	38.68	0.0000	Bedding
50	33.175	201	50.5	0.989	7	A	0	33.164	33.185	0.108	14.00	40.72	0.0000	Bedding
51	32.989	345	57.4	0.941	19	C	2	32.346	33.632	0.108	14.00	41.58	0.0000	Fracture Discontinuous
52	32.944	203	42.7	0.984	25	A	0	32.938	32.951	0.107	14.00	39.10	0.0000	Bedding
53	32.692	205	47.5	0.964	11	B	0	32.682	32.703	0.108	14.00	39.07	0.0000	Bedding
54	32.443	247	69.4	0.939	11	C	2	32.376	32.510	0.108	14.00	39.11	0.0000	Fracture Discontinuous
55	31.465	187	46.1	0.978	8	A	0	31.457	31.473	0.107	14.00	38.76	0.0000	Bedding
56	31.357	182	52.4	0.976	8	A	0	31.341	31.372	0.107	14.00	38.64	0.0000	Bedding
57	31.087	177	59.5	0.965	9	B	0	31.064	31.110	0.106	14.00	40.00	0.0000	Bedding
58	30.860	182	61.7	0.960	9	B	0	30.837	30.882	0.108	14.00	40.91	0.0000	Bedding
59	30.728	188	63.5	0.986	9	A	0	30.704	30.752	0.107	14.00	39.64	0.0000	Bedding
60	30.549	354	89.1	0.924	16	C	2	30.479	30.620	0.107	14.00	41.00	0.0000	Fracture Mineralized
61	30.378	171	88.8	0.982	6	A	2	30.308	30.449	0.107	14.00	39.65	0.0000	Fracture Mineralized
62	30.137	194	43.8	0.985	10	A	0	30.134	30.139	0.107	14.00	41.00	0.0000	Bedding
63	29.110	199	50.7	0.943	6	C	2	29.099	29.120	0.108	14.00	40.46	0.0000	
64	28.157	196	30.8	0.982	12	A	0	28.148	28.166	0.107	14.00	40.21	0.0000	Bedding
65	27.861	195	50.6	0.975	11	A	2	27.851	27.871	0.107	14.00	40.00	0.0000	Fracture Irregular
66	26.995	183	13.6	0.940	12	C	0	26.969	27.021	0.108	14.00	39.00	0.0000	Bedding
67	26.917	175	16.0	0.967	8	B	0	26.891	26.942	0.107	14.00	40.17	0.0000	Bedding
68	26.172	100	27.8	0.981	7	A	2	26.120	26.233	0.108	14.00	40.00	0.0000	Fracture
69	25.787	284	17.5	0.955	7	B	0	25.735	25.839	0.108	14.00	41.36	0.0000	Bedding
70	25.641	184	55.8	0.959	9	B	2	25.622	25.660	0.107	14.00	38.10	0.0000	Fracture
71	25.536	186	51.5	0.990	6	A	2	25.524	25.549	0.107	14.00	39.39	0.0000	Fracture Weathered
72	23.701	142	10.8	0.990	10	A	0	23.665	23.737	0.105	14.00	40.00	0.0000	Bedding
73	23.521	140	4.6	0.924	11	C	0	23.479	23.563	0.108	14.00	40.00	0.0000	Irregular Bedding
74	22.318	21	1.3	0.935	7	C	0	22.271	22.366	0.107	14.00	40.33	0.0000	Bedding
75	21.951	304	8.6	0.941	9	C	0	21.901	22.001	0.107	14.00	39.30	0.0000	Bedding
76	21.808	305	4.9	0.943	19	C	0	21.760	21.857	0.110	14.00	39.49	0.0000	Bedding
77	21.440	234	5.3	0.954	8	B	0	21.400	21.480	0.110	14.00	40.00	0.0000	Bedding
78	20.380	181	7.9	0.914	9	C	0	20.344	20.415	0.110	14.00	40.34	0.0000	Bedding
79	19.974	324	69.0	0.850	21	D	2	19.525	20.423	0.109	14.00	40.56	0.0000	Fracture Discontinuous

Borehole: 02-08C Logged from 51 to 66 meters
Depth range: 0.000 - 66.519m Extrapolated from 50 to 0 meters

	Deviation components				
Depth	North	East	Down	Devaz	Dev
m	m	m	m	deg	deg
1.019	0.636	0.158	0.781	14.00	40.00
2.019	1.259	0.314	1.547	14.00	40.00
3.019	1.883	0.469	2.313	14.00	40.00
4.019	2.507	0.625	3.079	14.00	40.00
5.019	3.130	0.780	3.845	14.00	40.00
6.019	3.754	0.936	4.611	14.00	40.00
7.019	4.378	1.091	5.377	14.00	40.00
8.019	5.001	1.247	6.143	14.00	40.00
9.019	5.625	1.402	6.909	14.00	40.00
10.019	6.249	1.558	7.675	14.00	40.00
11.019	6.872	1.714	8.441	14.00	40.00
12.019	7.496	1.869	9.207	14.00	40.00
13.019	8.120	2.025	9.973	14.00	40.00
14.019	8.744	2.180	10.739	14.00	40.00
15.019	9.367	2.336	11.505	14.00	40.00
16.019	9.991	2.491	12.271	14.00	40.00
17.019	10.615	2.647	13.037	14.00	40.00
18.019	11.238	2.802	13.803	14.00	40.00
19.019	11.862	2.958	14.569	14.00	40.00
20.019	12.486	3.113	15.335	14.00	40.00
21.019	13.109	3.269	16.101	14.00	40.00
22.019	13.733	3.424	16.868	14.00	40.00
23.019	14.357	3.580	17.634	14.00	40.00
24.019	14.981	3.735	18.400	14.00	40.00
25.019	15.604	3.891	19.166	14.00	40.00
26.019	16.228	4.046	19.932	14.00	40.00
27.019	16.852	4.202	20.698	14.00	40.00
28.019	17.475	4.357	21.464	14.00	40.00
29.019	18.099	4.513	22.230	14.00	40.00
30.019	18.723	4.668	22.996	14.00	40.00
31.019	19.346	4.824	23.762	14.00	40.00
32.019	19.970	4.979	24.528	14.00	40.00
33.019	20.594	5.135	25.294	14.00	40.00
34.019	21.217	5.290	26.060	14.00	40.00
35.019	21.841	5.446	26.826	14.00	40.00
36.019	22.465	5.601	27.592	14.00	40.00
37.019	23.089	5.757	28.358	14.00	40.00
38.019	23.712	5.912	29.124	14.00	40.00
39.019	24.336	6.068	29.890	14.00	40.00
40.019	24.960	6.223	30.656	14.00	40.00
41.019	25.583	6.379	31.422	14.00	40.00
42.019	26.207	6.534	32.188	14.00	40.00
43.019	26.831	6.690	32.954	14.00	40.00
44.019	27.454	6.845	33.721	14.00	40.00
45.019	28.078	7.001	34.487	14.00	40.00
46.019	28.702	7.156	35.253	14.00	40.00
47.019	29.325	7.312	36.019	14.00	40.00
48.019	29.949	7.467	36.785	14.00	40.00
49.019	30.573	7.623	37.551	14.00	40.00
50.019	31.197	7.778	38.317	14.00	40.00
51.019	31.820	7.934	39.083	14.00	40.00
52.019	32.444	8.089	39.849	14.00	40.00

53.019	33.068	8.245	40.615	14.00	40.00
54.019	33.691	8.400	41.381	14.00	40.00
55.019	34.315	8.556	42.147	14.00	40.00
56.019	34.939	8.711	42.913	14.00	40.00
57.019	35.562	8.867	43.679	14.00	40.00
58.019	36.186	9.022	44.445	14.00	40.00
59.019	36.810	9.178	45.211	14.00	40.00
60.019	37.433	9.333	45.977	14.00	40.00
61.019	38.057	9.489	46.743	14.00	40.00
62.019	38.681	9.644	47.509	14.00	40.00
63.019	39.305	9.800	48.275	14.00	40.00
64.019	39.928	9.955	49.041	14.00	40.00
65.019	40.552	10.111	49.807	14.00	40.00
66.019	41.176	10.266	50.573	14.00	40.00

RGLDIPv6.1 OPTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-8C
Zone from 9.999 to 45.605 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	43.011	161	56.7	0.965	7	B	2	42.987	43.042	0.108	13.70	38.00	0.0000	Fracture Discontinuous
2	41.984	14	78.7	0.924	11	C	2	41.888	42.080	0.106	14.00	40.29	0.0000	Fracture Discontinuous
3	41.822	48	80.0	0.979	6	A	2	41.785	41.949	0.108	14.00	39.98	0.0000	Fracture Discontinuous
4	41.647	33	76.9	0.964	20	B	2	41.515	41.778	0.106	14.00	37.07	0.0000	Fracture Discontinuous
5	41.339	139	56.2	0.989	4	A	2	41.316	41.388	0.108	14.00	38.85	0.0000	Fracture Discontinuous
6	40.759	183	44.5	0.979	7	A	0	40.751	40.768	0.107	13.27	38.08	0.0000	Bedding
7	40.671	183	40.2	0.975	7	A	0	40.665	40.677	0.107	13.50	38.99	0.0000	Bedding
8	40.572	181	39.1	0.979	9	A	0	40.564	40.579	0.107	13.00	38.00	0.0000	Bedding
9	40.390	191	35.3	0.985	6	A	0	40.386	40.394	0.107	14.00	38.76	0.0000	Bedding
10	40.346	285	67.8	0.944	9	C	2	40.169	40.522	0.107	14.00	37.02	0.0000	Fracture Discontinuous
11	40.292	186	48.0	0.979	7	A	0	40.282	40.302	0.108	14.00	39.16	0.0000	Irregular Bedding
12	40.234	288	53.3	0.937	13	C	2	40.117	40.352	0.109	14.00	40.31	0.0000	Fracture Discontinuous
13	39.878	194	40.3	0.991	11	A	0	39.878	39.879	0.109	14.00	40.00	0.0000	Bedding
14	39.782	199	40.0	0.950	11	B	0	39.780	39.785	0.107	14.73	38.73	0.0000	Irregular Bedding
15	39.637	196	41.7	0.989	7	A	0	39.635	39.638	0.107	14.00	40.45	0.0000	Bedding
16	39.540	192	39.0	0.985	8	A	0	39.539	39.541	0.107	14.00	38.47	0.0000	Irregular Bedding
17	39.405	201	40.0	0.979	14	A	0	39.401	39.409	0.108	14.00	40.63	0.0000	Irregular Bedding
18	39.146	197	43.1	0.981	6	A	0	39.141	39.151	0.107	14.00	38.00	0.0000	Irregular Bedding
19	39.027	43	41.4	0.972	12	B	2	38.785	39.269	0.107	14.00	39.24	0.0000	Fracture Discontinuous
20	38.989	199	40.0	0.985	9	A	0	38.986	38.993	0.107	14.00	38.14	0.0000	Bedding
21	38.870	195	42.4	0.997	7	A	0	38.868	38.872	0.108	14.00	40.48	0.0000	Bedding
22	38.779	196	40.1	0.976	7	A	0	38.777	38.780	0.107	14.00	39.69	0.0000	Bedding
23	38.560	198	43.9	0.978	8	A	0	38.556	38.565	0.107	14.00	40.00	0.0000	Bedding
24	38.375	205	42.5	0.981	8	A	0	38.367	38.383	0.107	14.00	38.00	0.0000	Bedding
25	38.191	201	39.5	0.989	8	A	0	38.187	38.196	0.108	14.00	38.10	0.0000	Bedding
26	38.053	195	44.3	0.991	6	A	0	38.049	38.057	0.108	14.00	40.15	0.0000	Bedding
27	37.774	193	37.8	0.983	6	A	0	37.773	37.776	0.108	14.00	39.00	0.0000	Bedding
28	37.692	198	41.7	0.973	9	B	0	37.688	37.697	0.108	14.00	38.00	0.0000	Bedding
29	37.402	199	39.8	0.997	5	A	0	37.399	37.406	0.107	14.00	41.61	0.0000	Bedding
30	37.294	194	40.9	0.976	10	A	0	37.293	37.295	0.107	14.00	39.96	0.0000	Bedding
31	36.635	196	36.6	0.970	10	B	0	36.633	36.637	0.107	14.00	38.00	0.0000	Bedding
32	36.460	194	38.8	0.966	8	B	0	36.460	36.461	0.106	14.00	38.29	0.0000	Bedding
33	36.279	198	47.5	0.972	9	B	0	36.270	36.287	0.110	14.00	39.35	0.0000	Bedding
34	35.513	202	45.6	0.982	7	A	0	35.505	35.521	0.107	14.00	39.00	0.0000	Bedding
35	35.449	199	43.0	0.969	5	B	0	35.445	35.452	0.107	14.00	40.90	0.0000	Bedding

Appendix F

BOREHOLE 02-15
IMAGE LOG PLOTS
DISCONTINUITY AND DEVIATION TABLES

NORCAL GEOPHYSICAL CONSULTANTS, INC.

OPTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED OPTV DIPS LOG

25 Sep 2002

EARTH MECHANICS

Borehole: BH 02_15

DEVILS SLIDE

top of borehole.....
East:
North:
Alt:

North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = fixed format

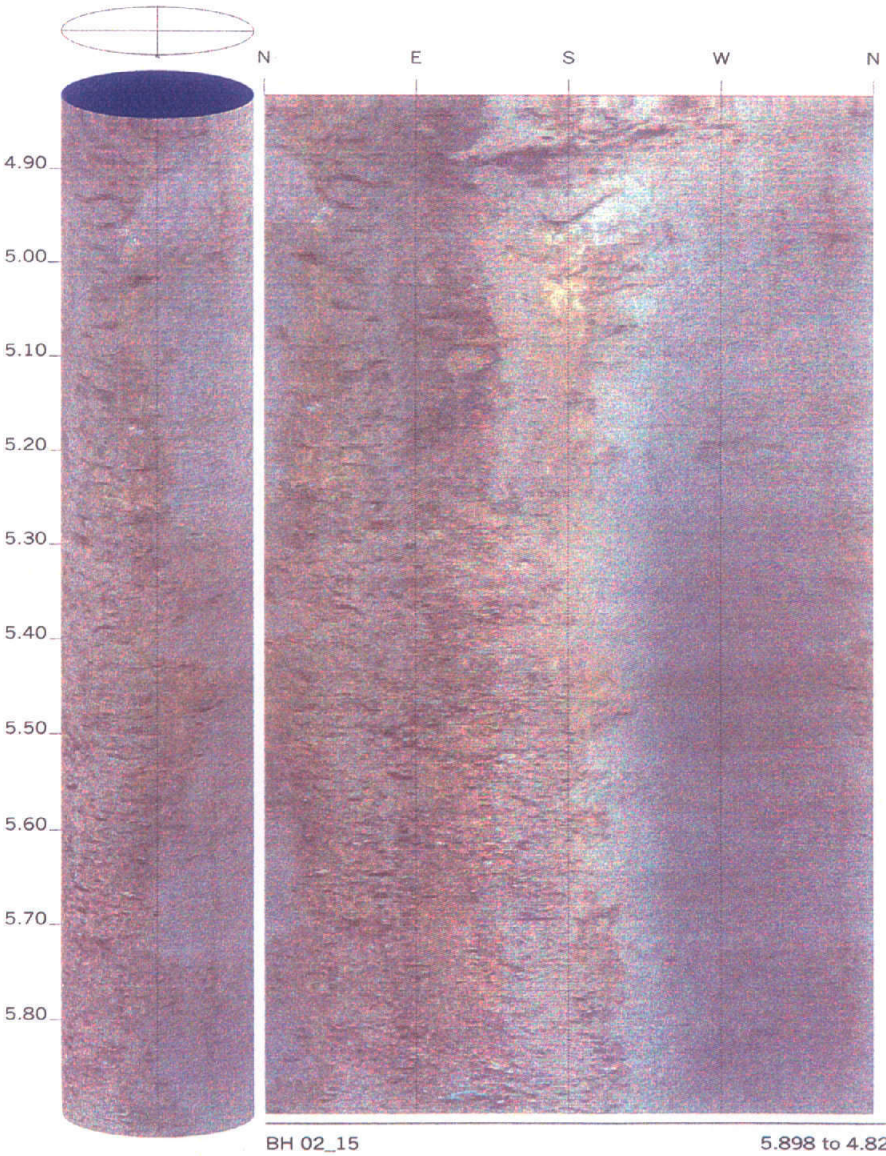
Zone from 52.277 to 4.821m
Vertical = borehole-axis

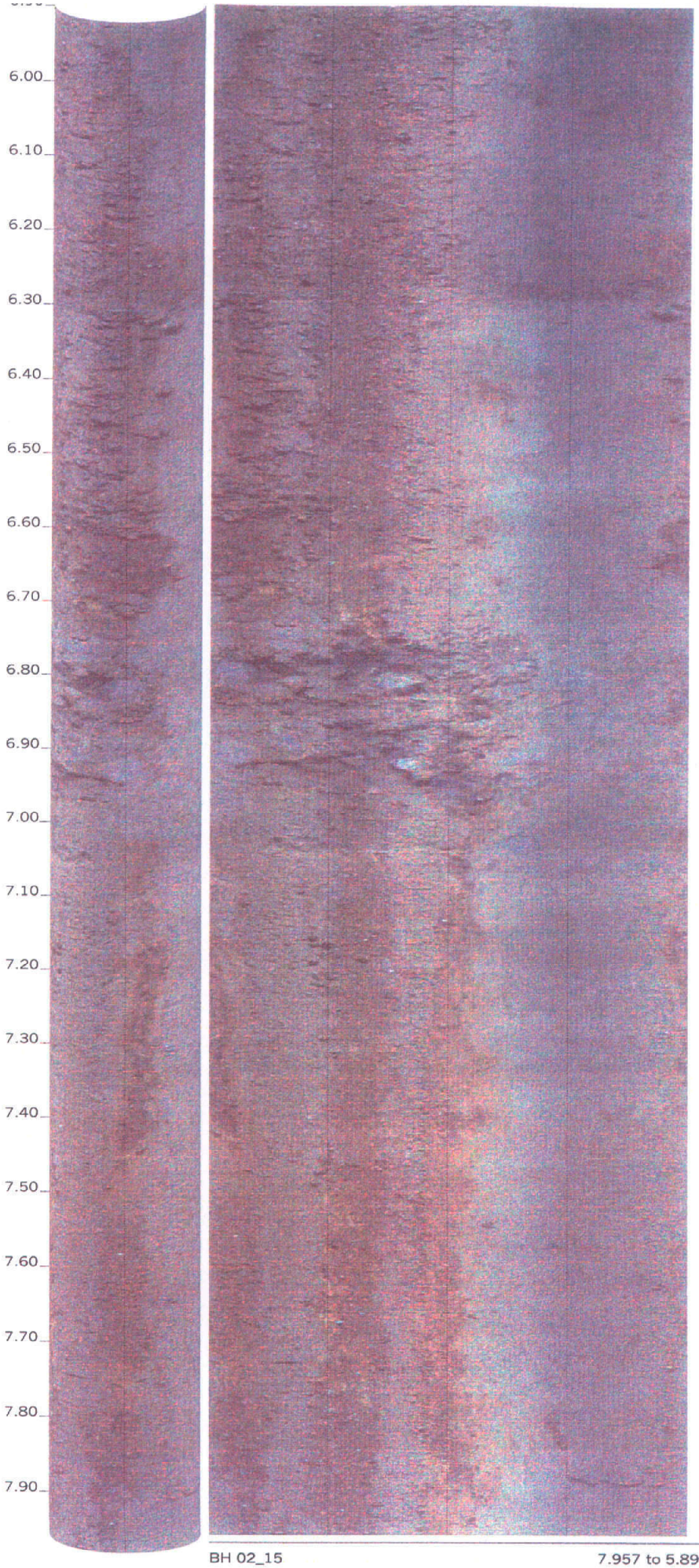
Borehole diam: 11.000cm

BEDDING
FRACTURE

Identified units

COMMENTS





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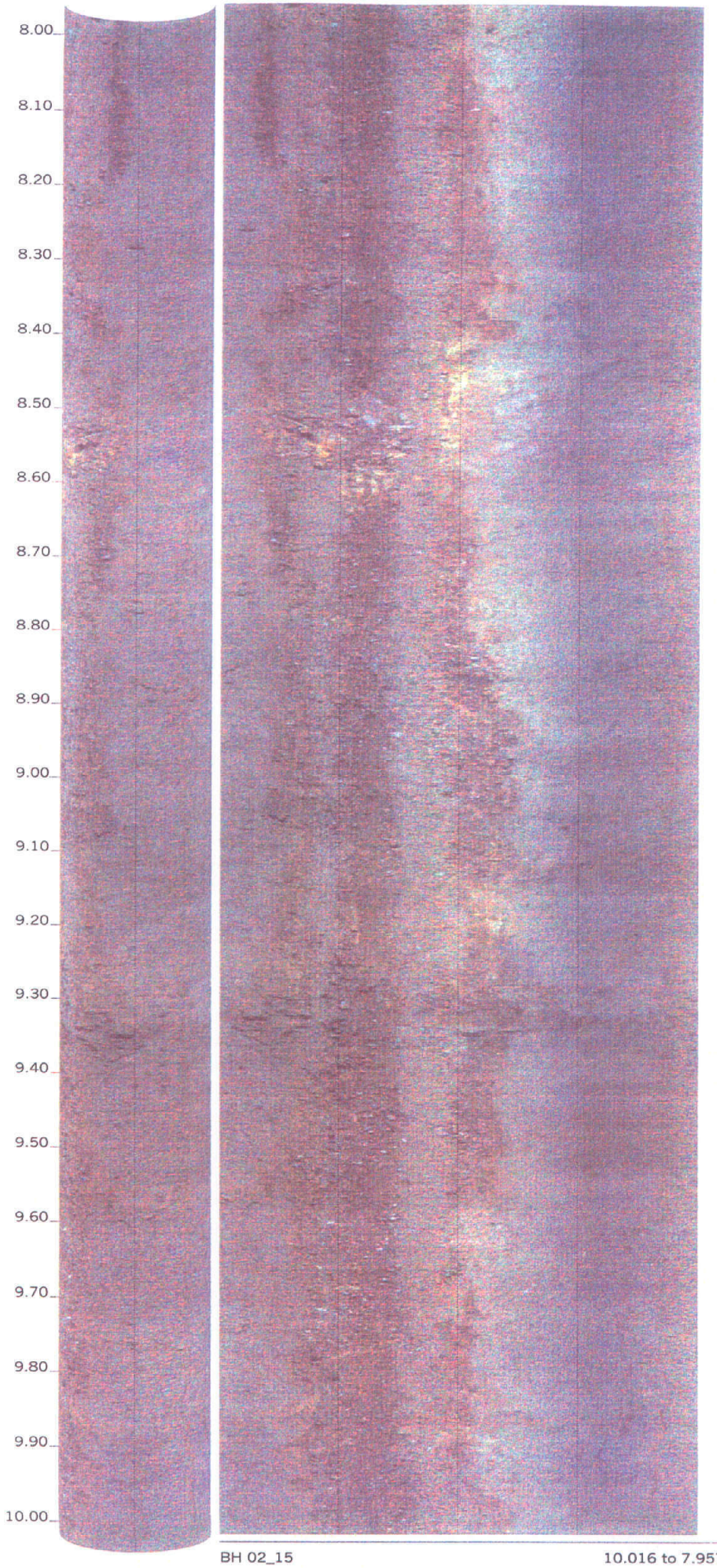

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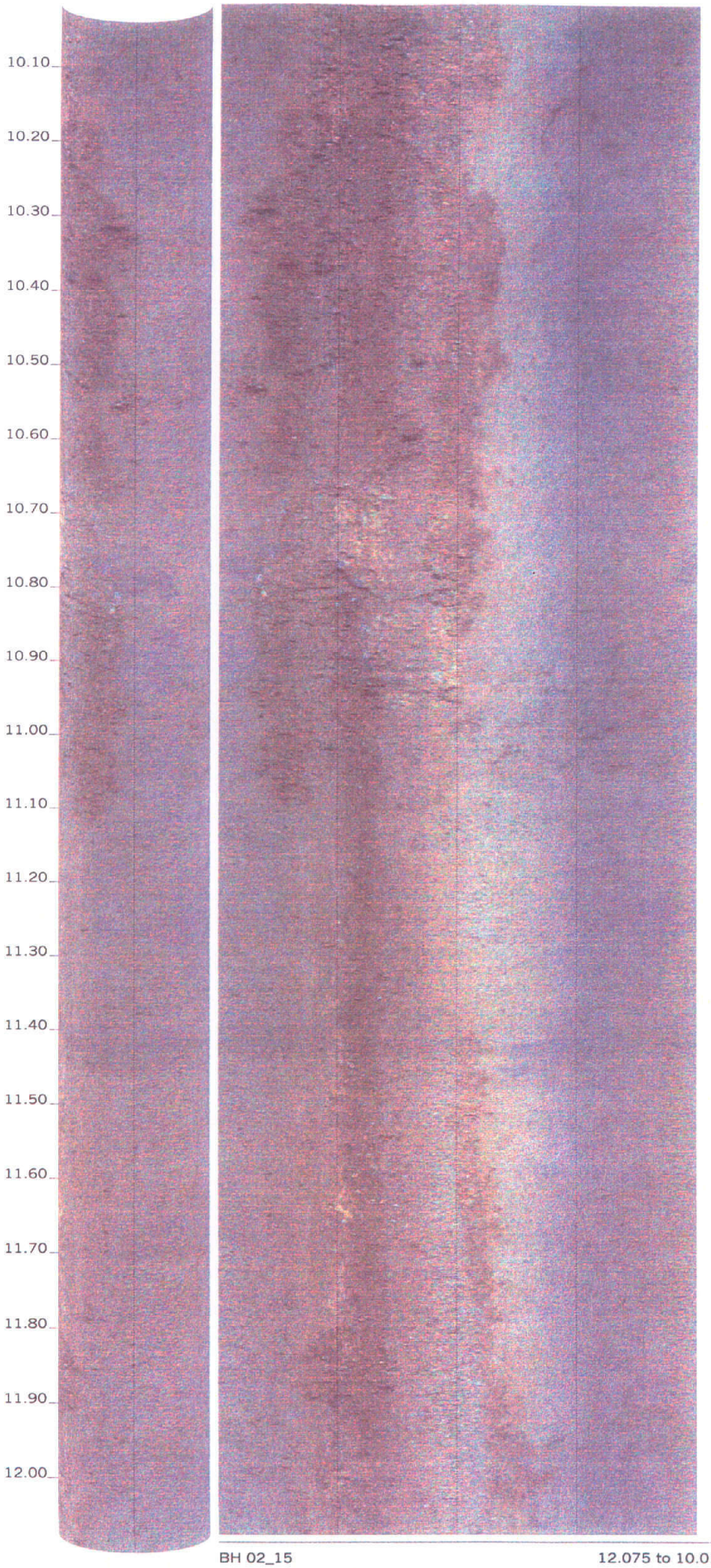
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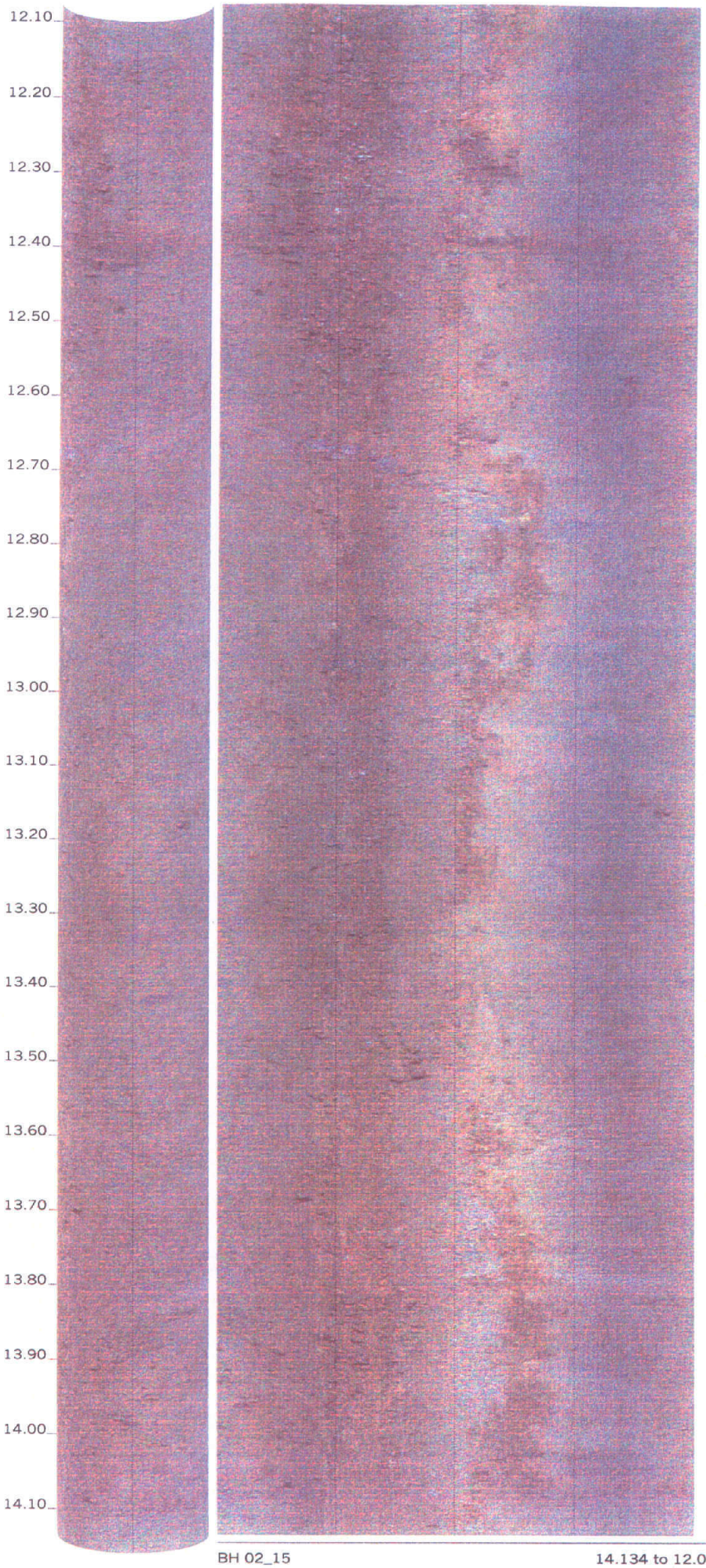

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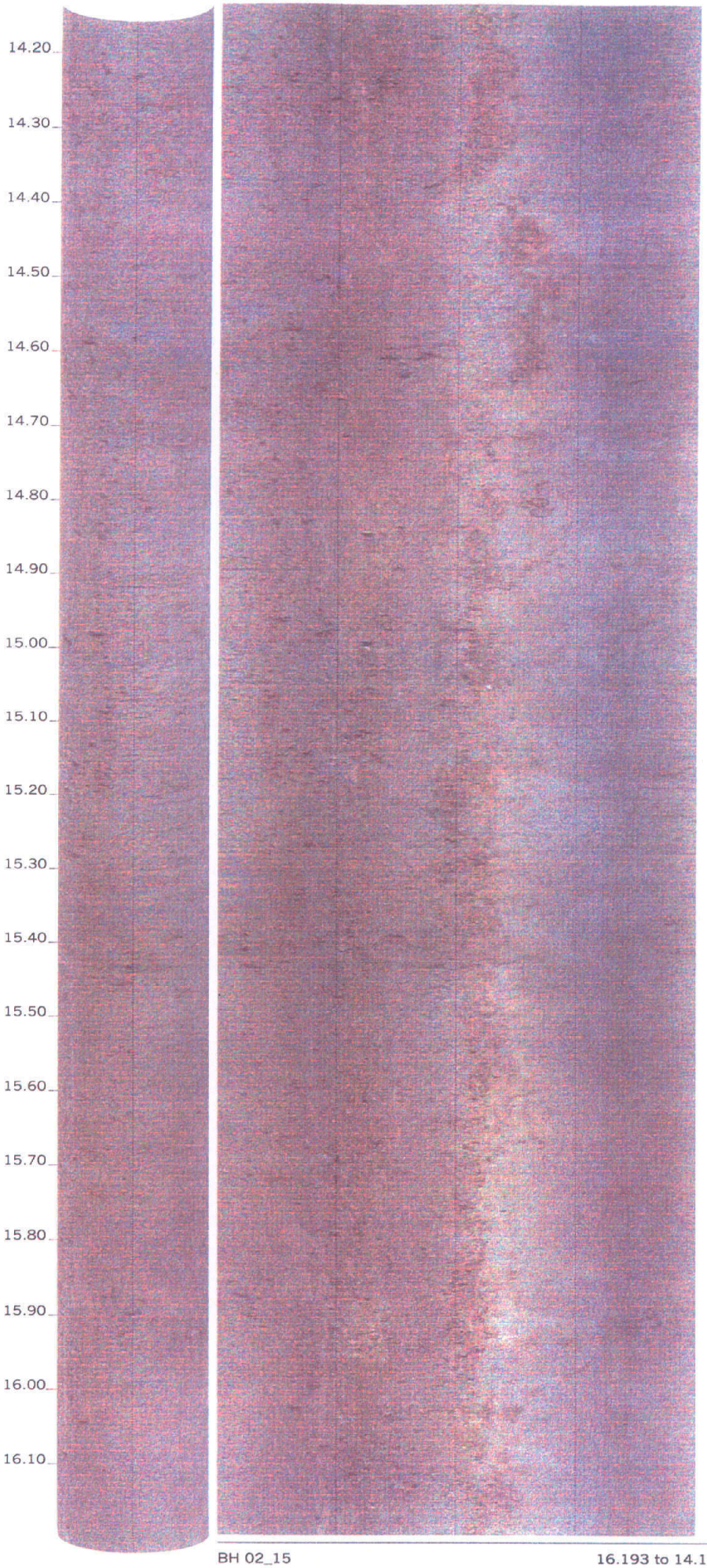

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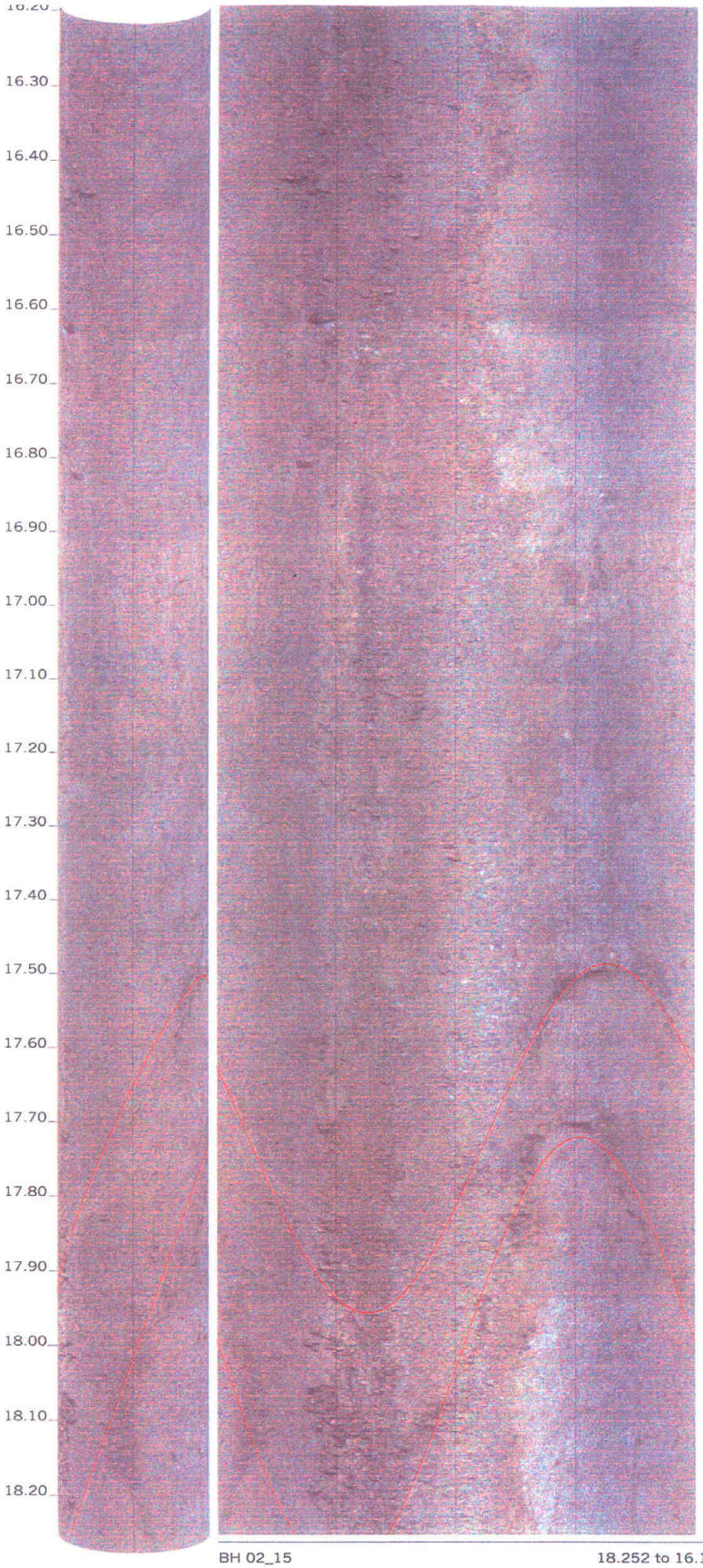
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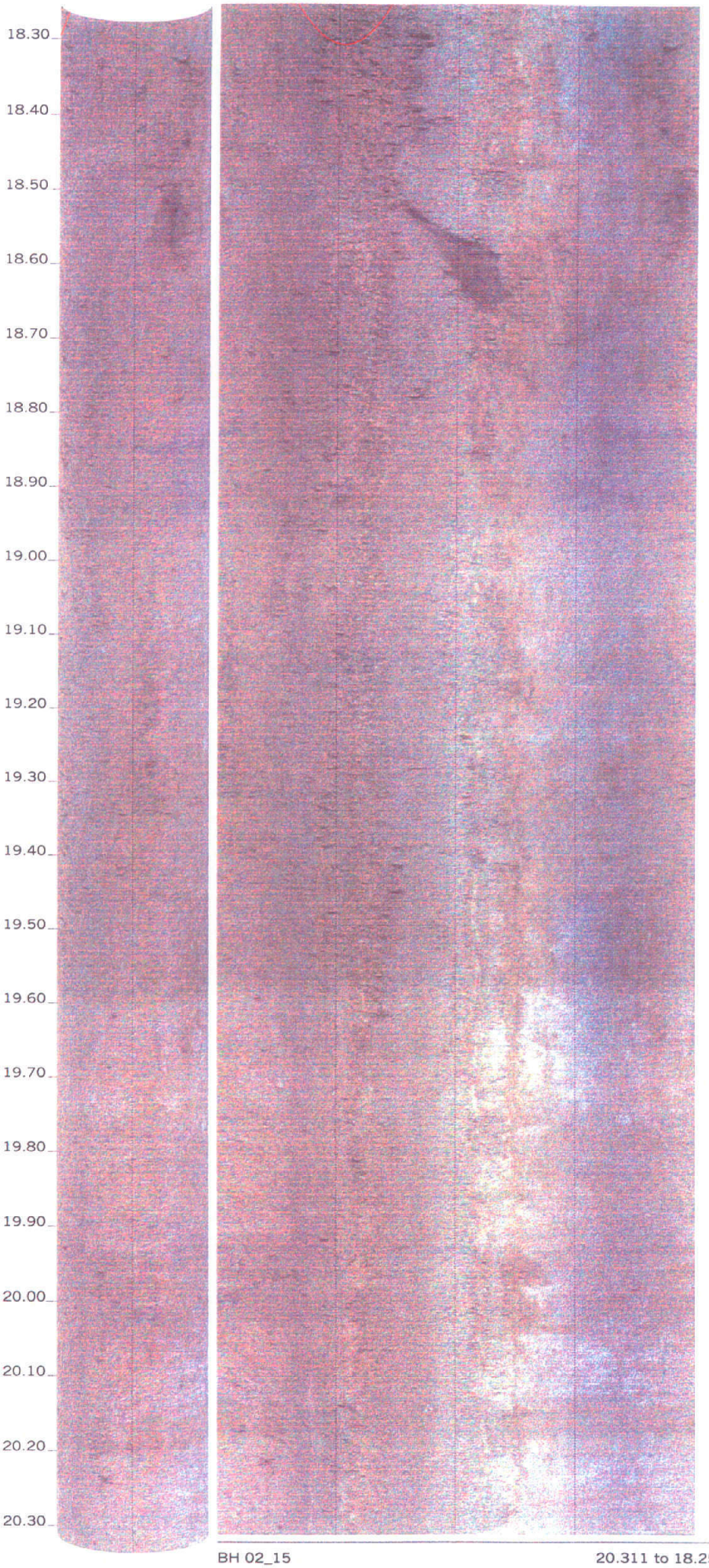
N290 69 Fracture Discontinuous
N270 69 Fracture Discontinuous



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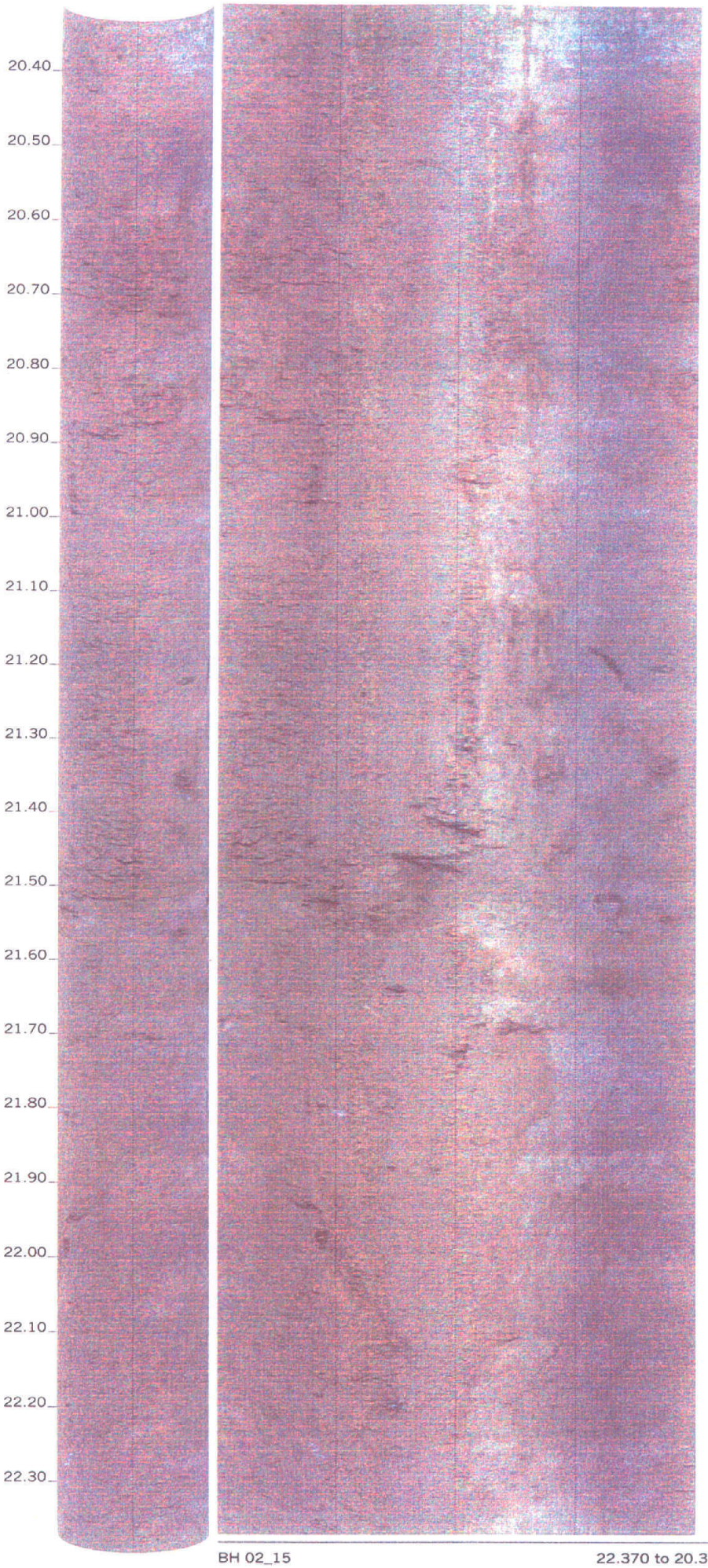
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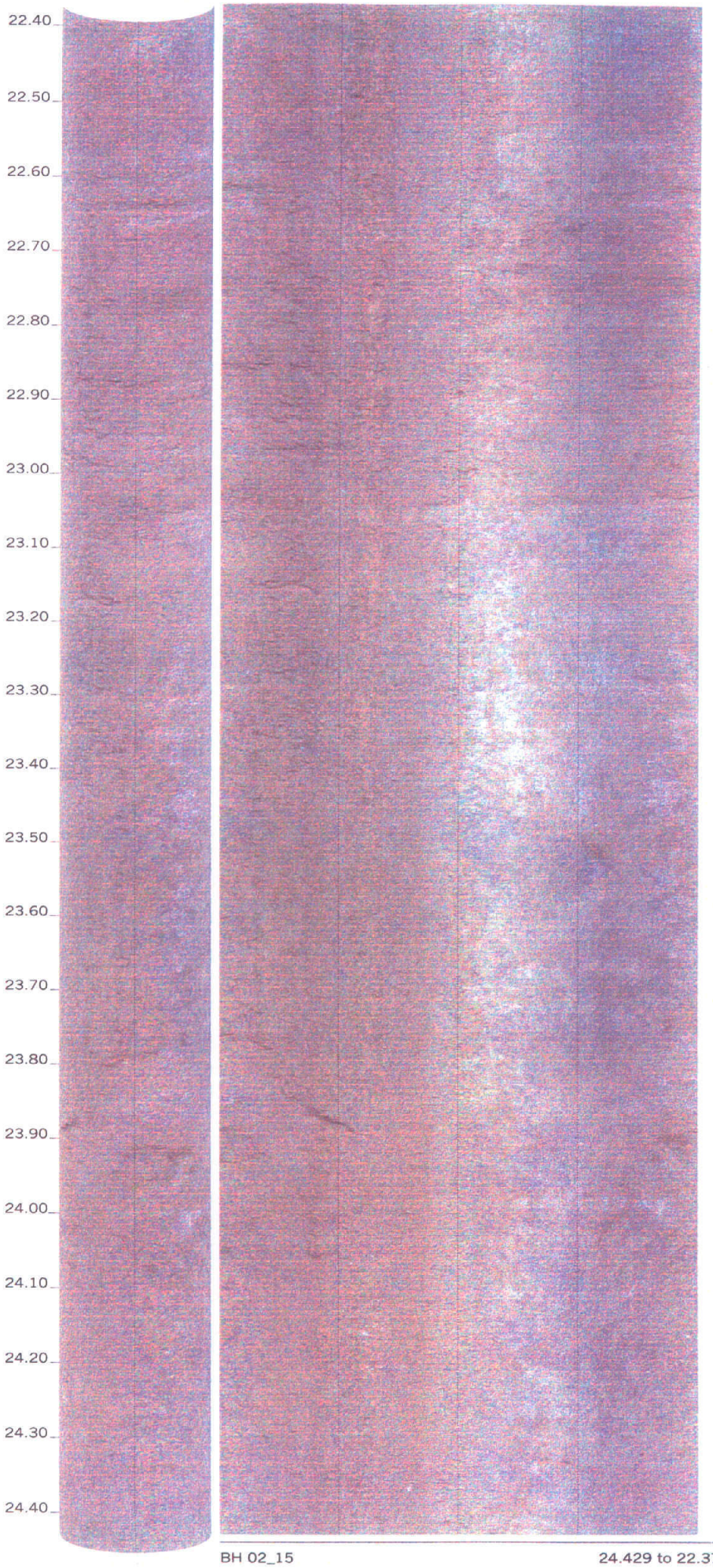
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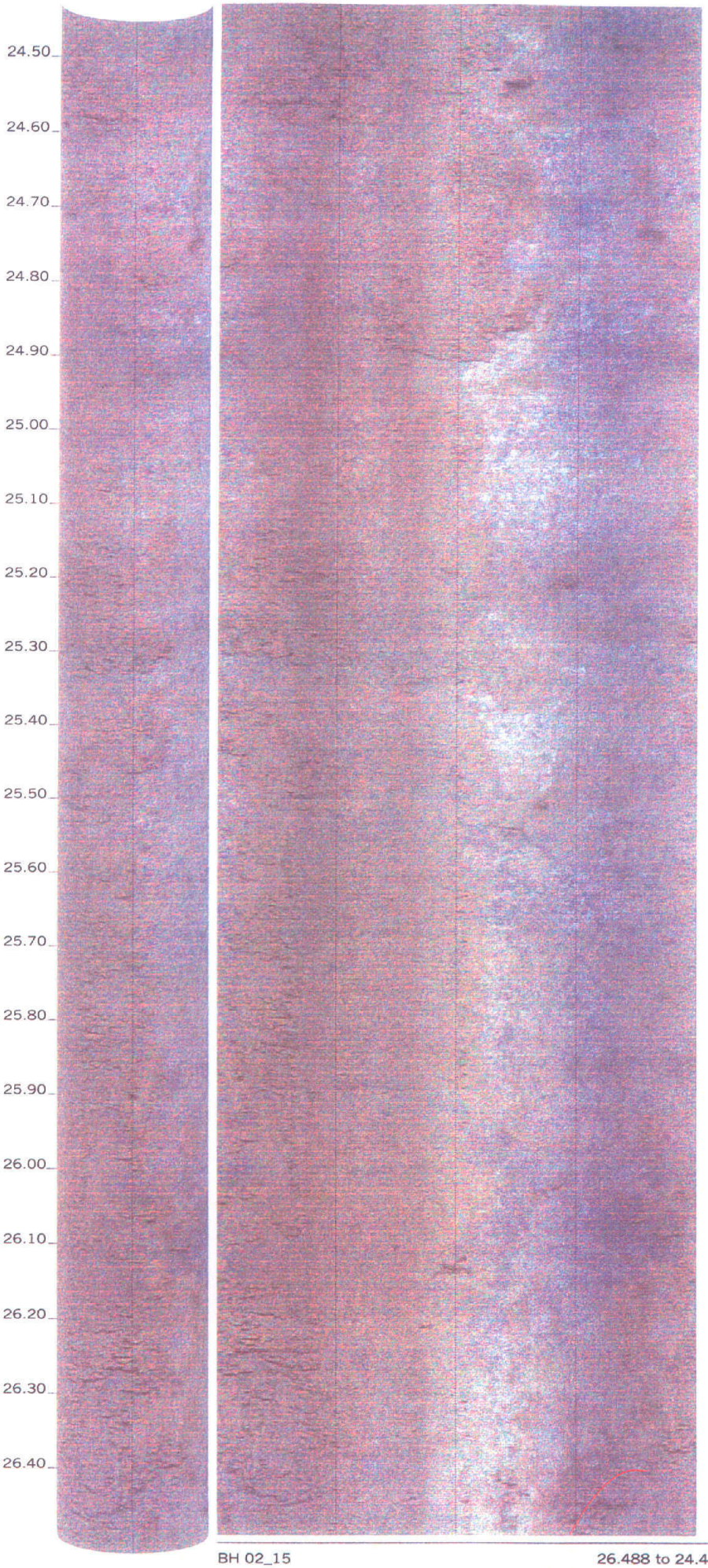
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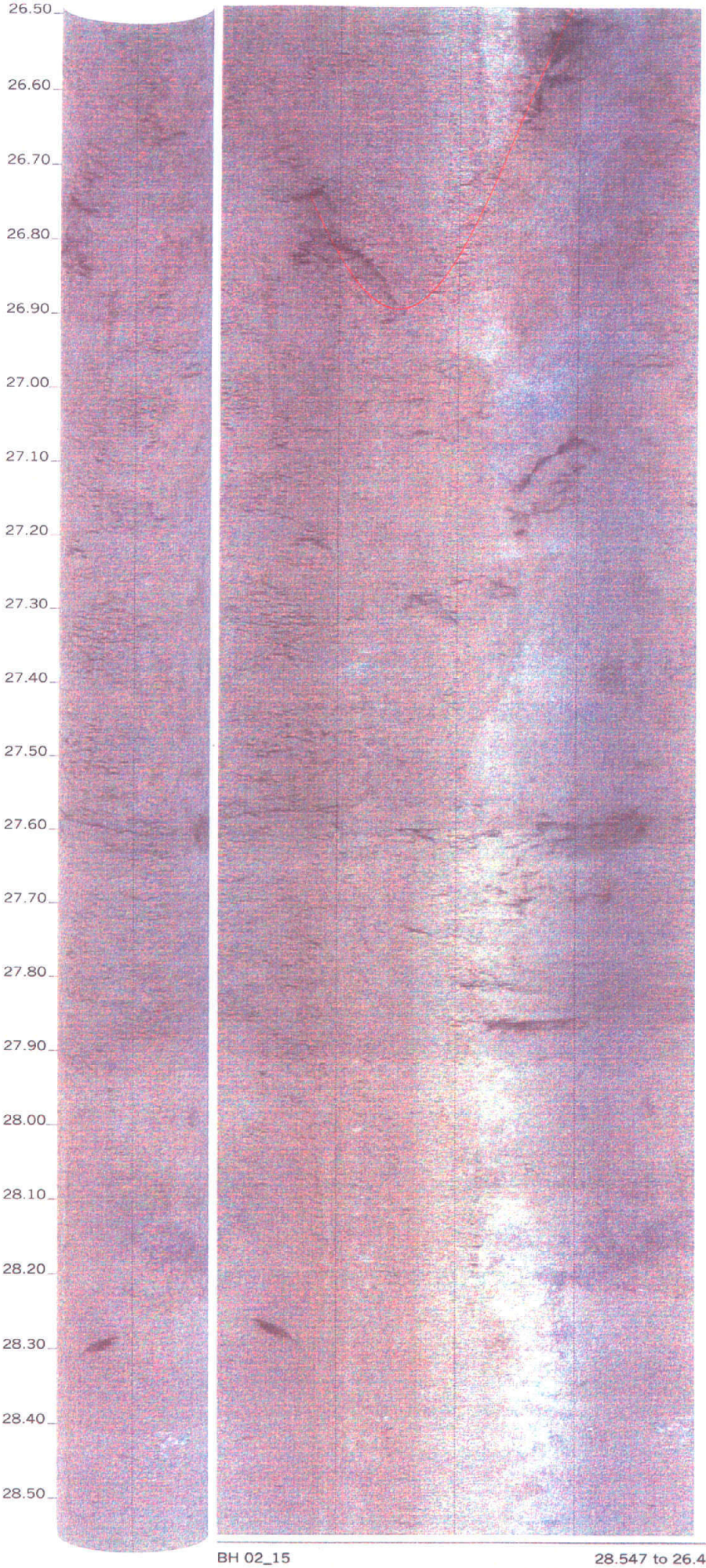
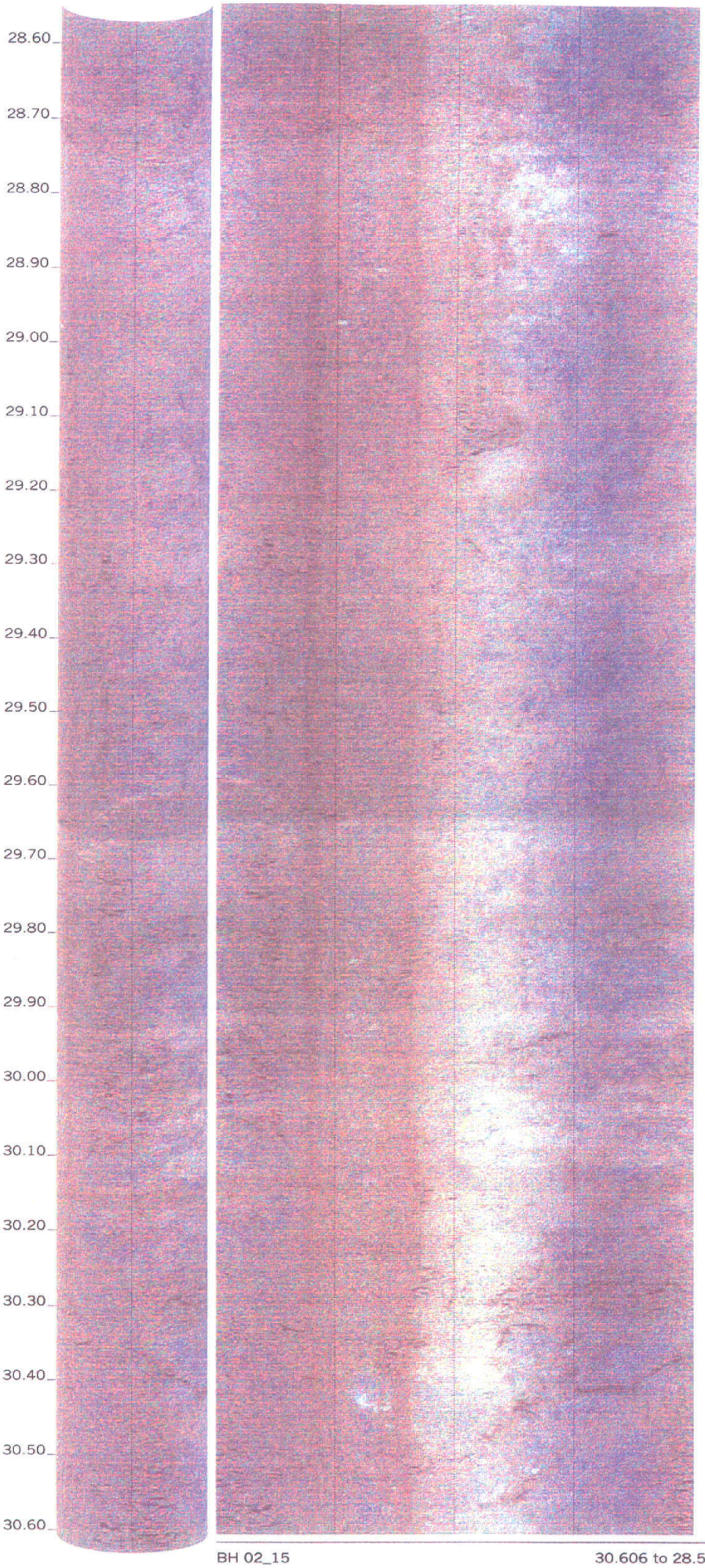


N312 72 Fracture Discontinuous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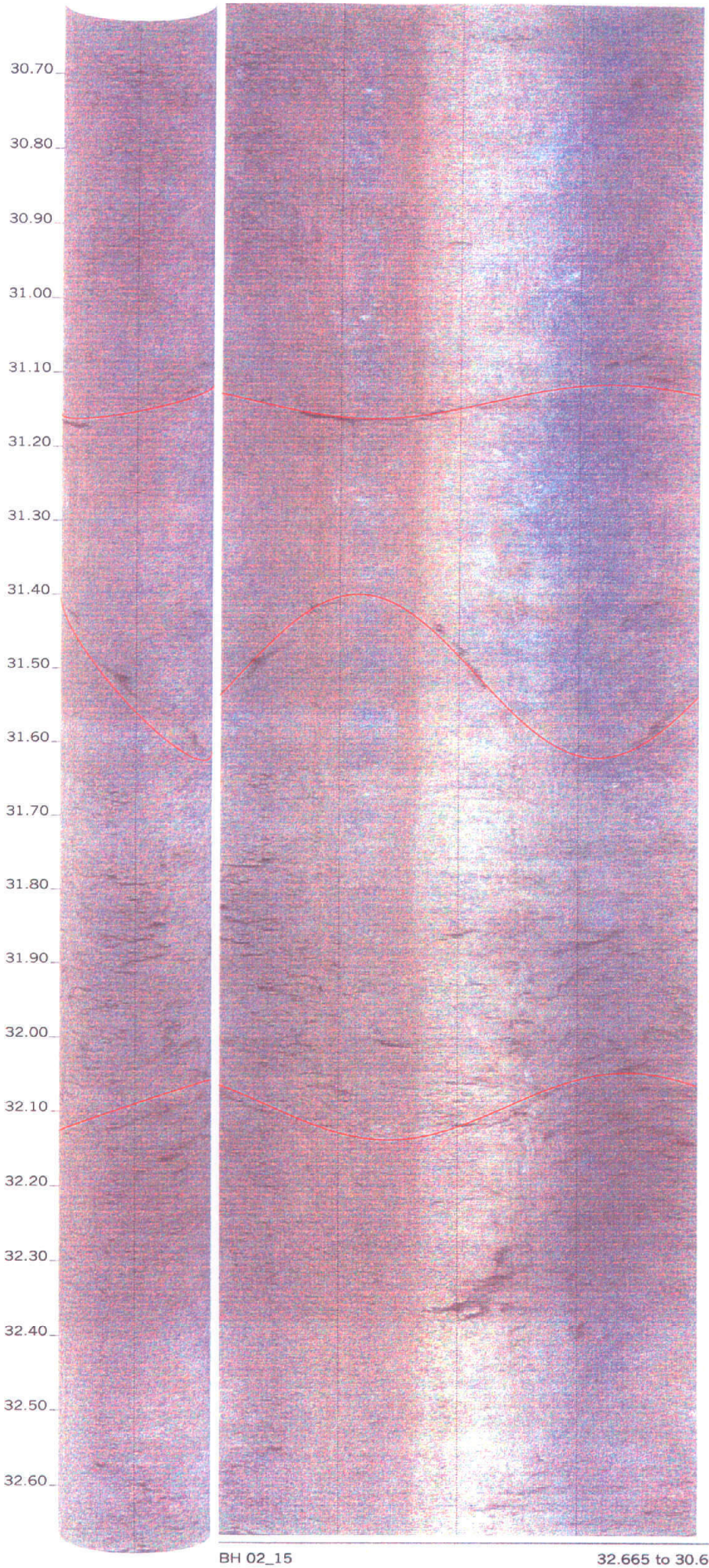
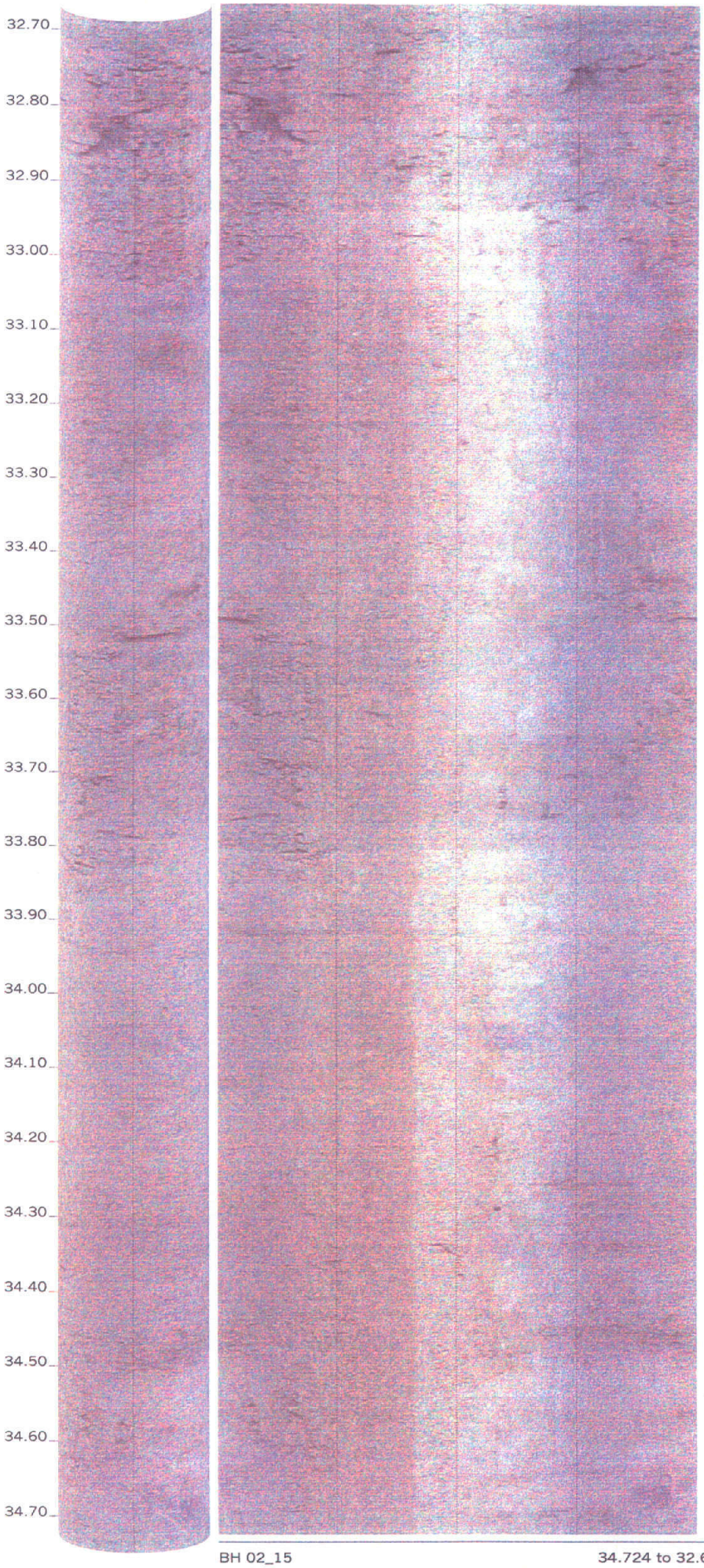


BH 02_15 32.665 to 30.606m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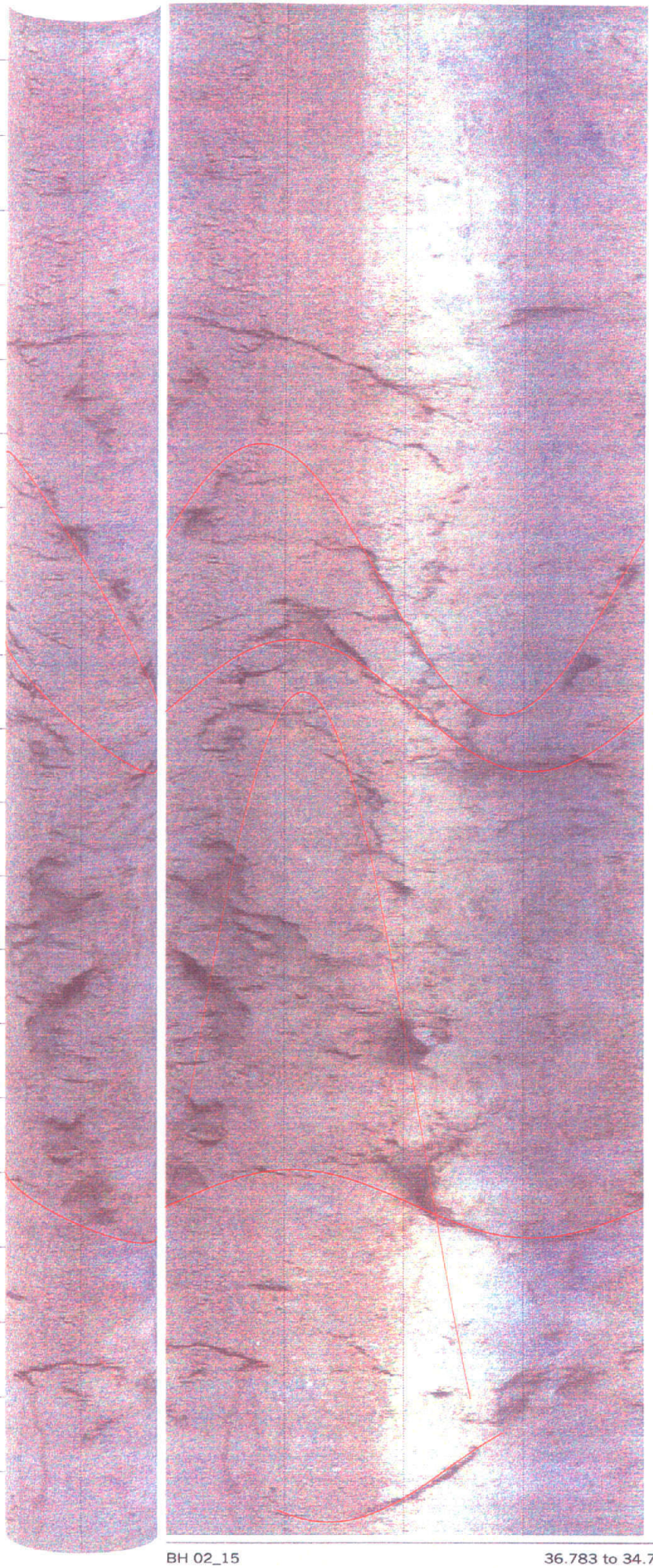
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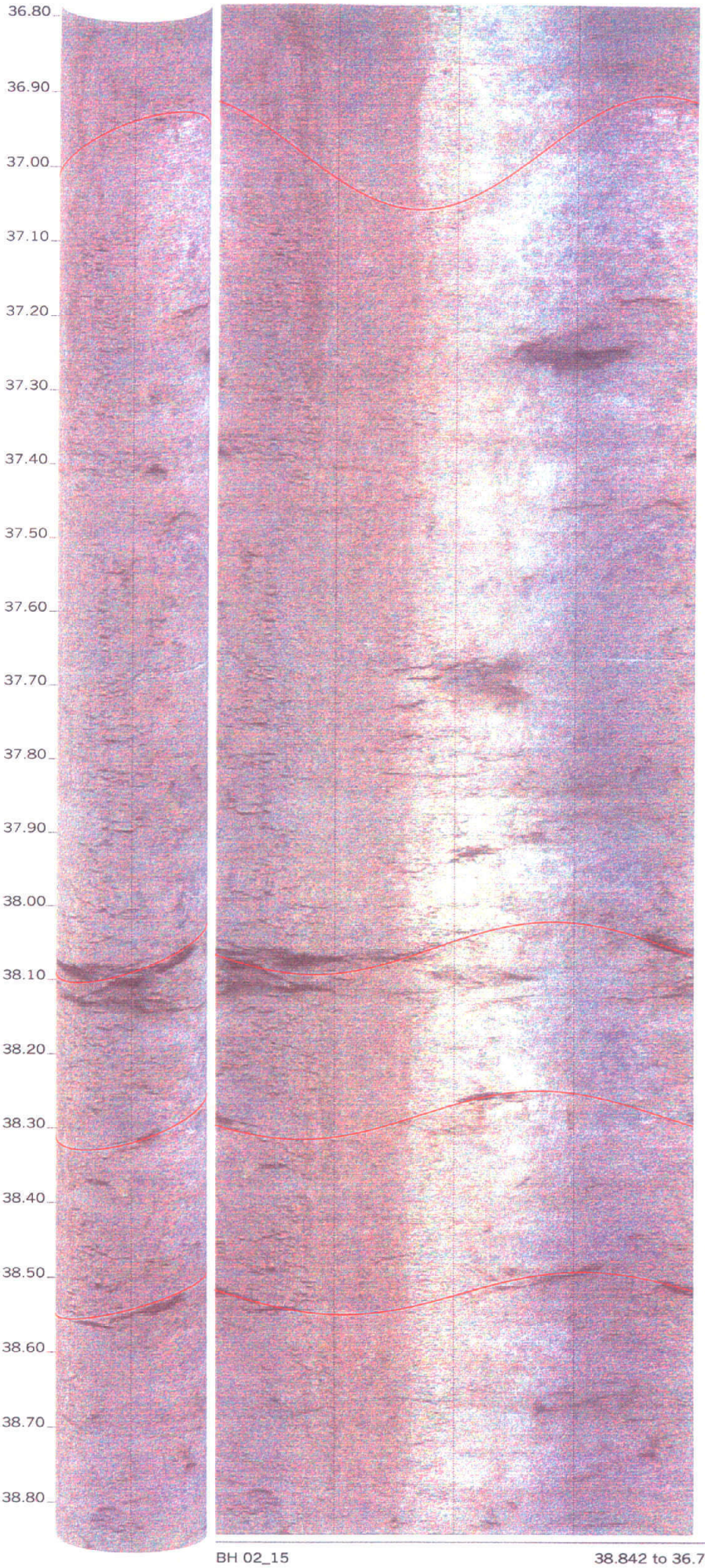
N257 28 Fracture Discontinuous
N279 53 Fracture Discontinuous Clayey
N222 12 Fracture
N118 85 Fracture Discontinuous Clayey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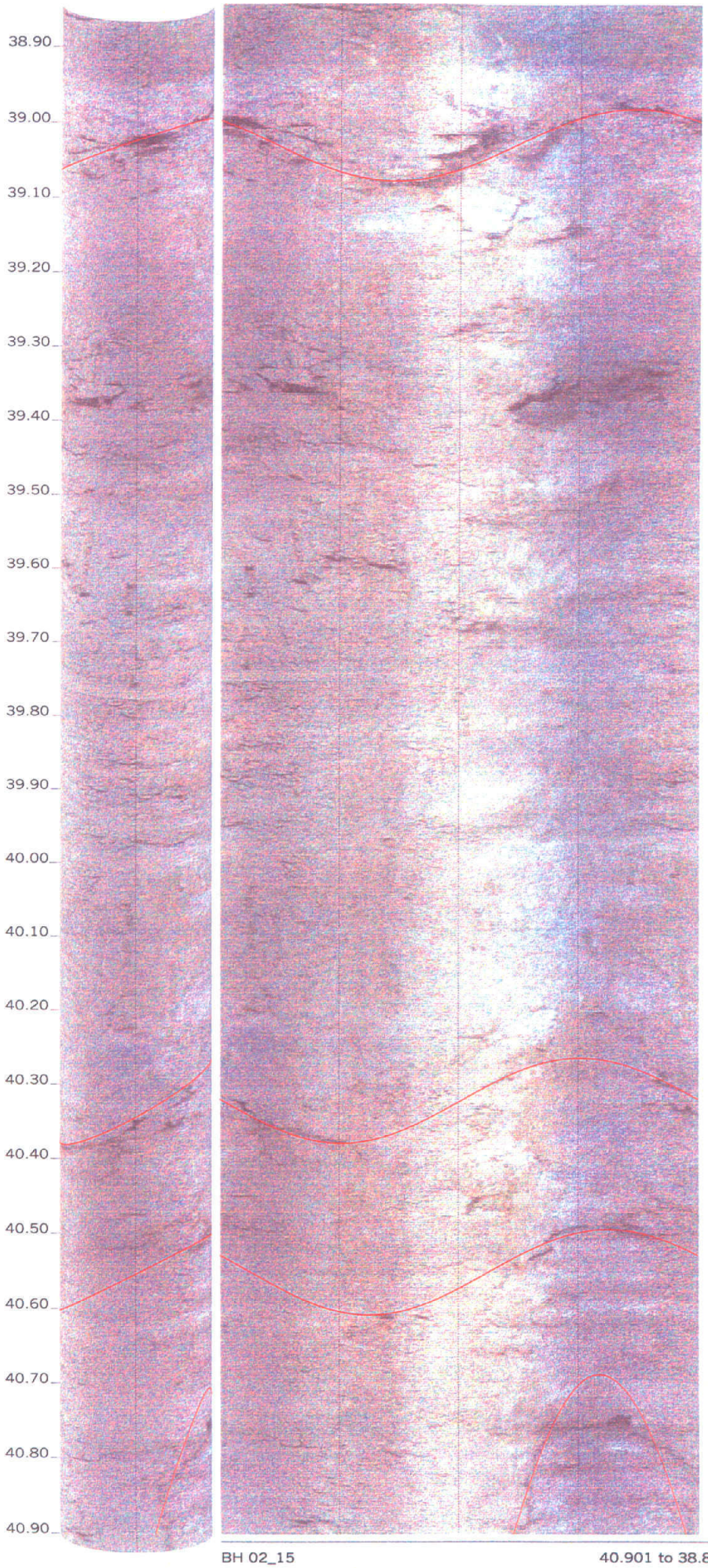
N141 82 Fracture Clayey
N087 62 Fracture Irregular
N083 57 Fracture Irregular
N102 59 Fracture Irregular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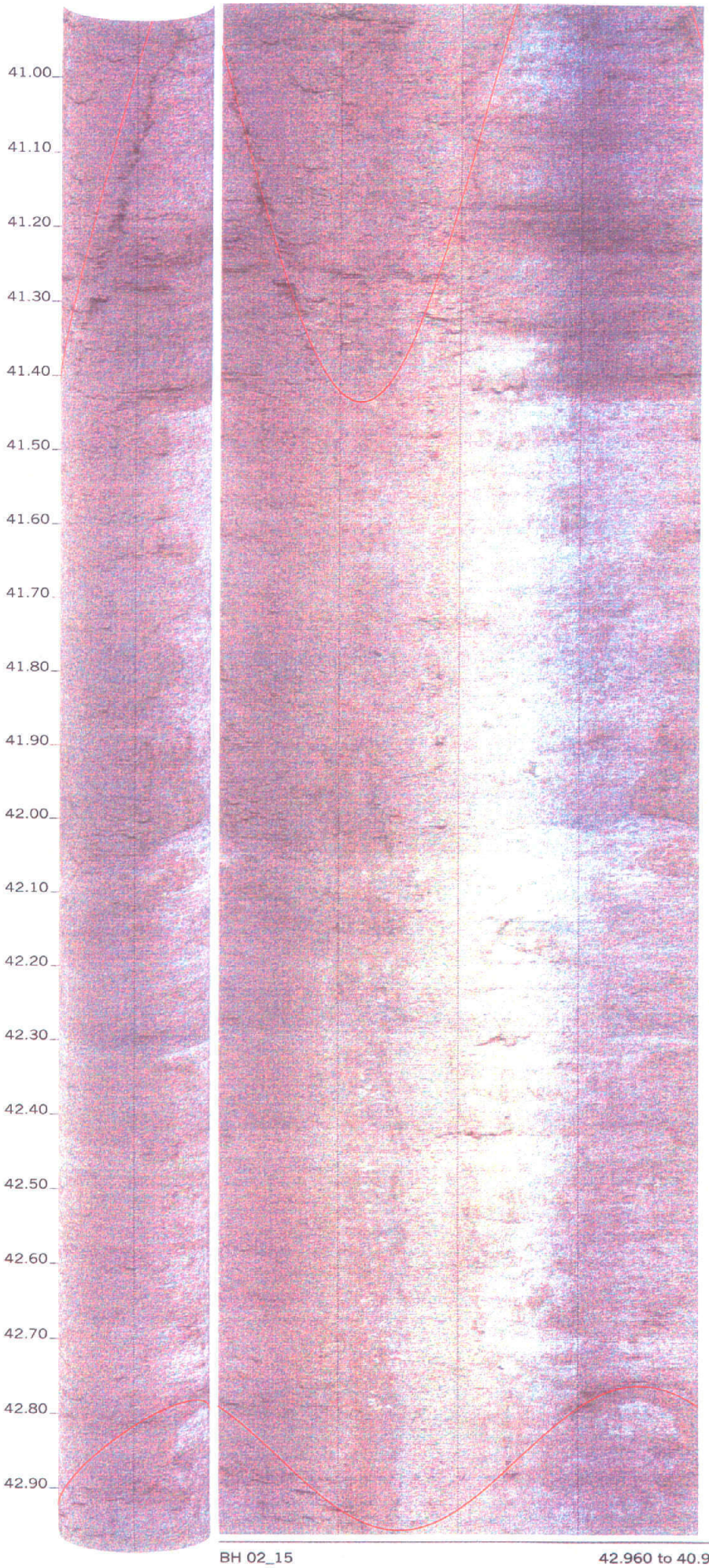
N094 77 Fracture Discontinuous
N110 78 Fracture Discontinuous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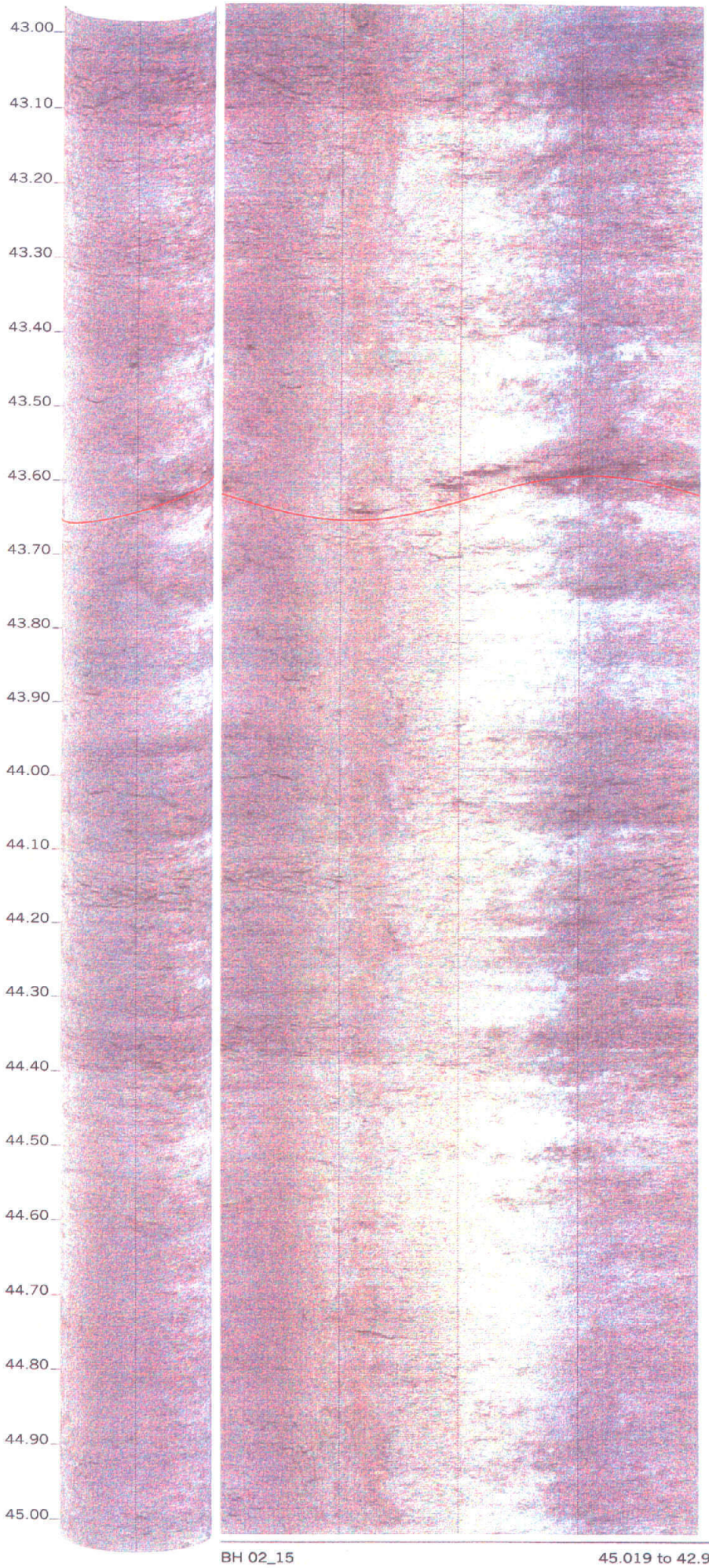
N282 66 Fracture Irregular
N309 89 Fracture Discontinuous Weathered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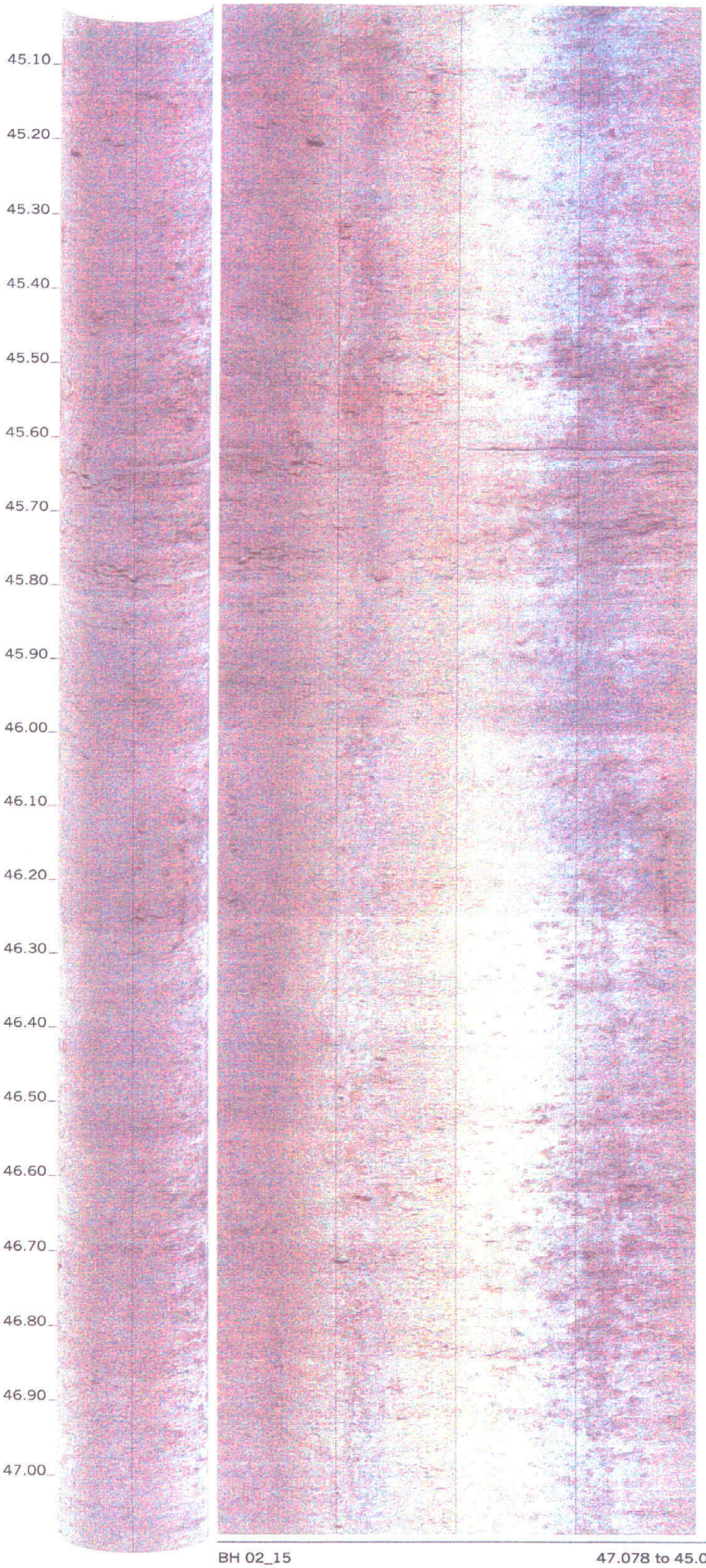
N102 61 Fracture Weathered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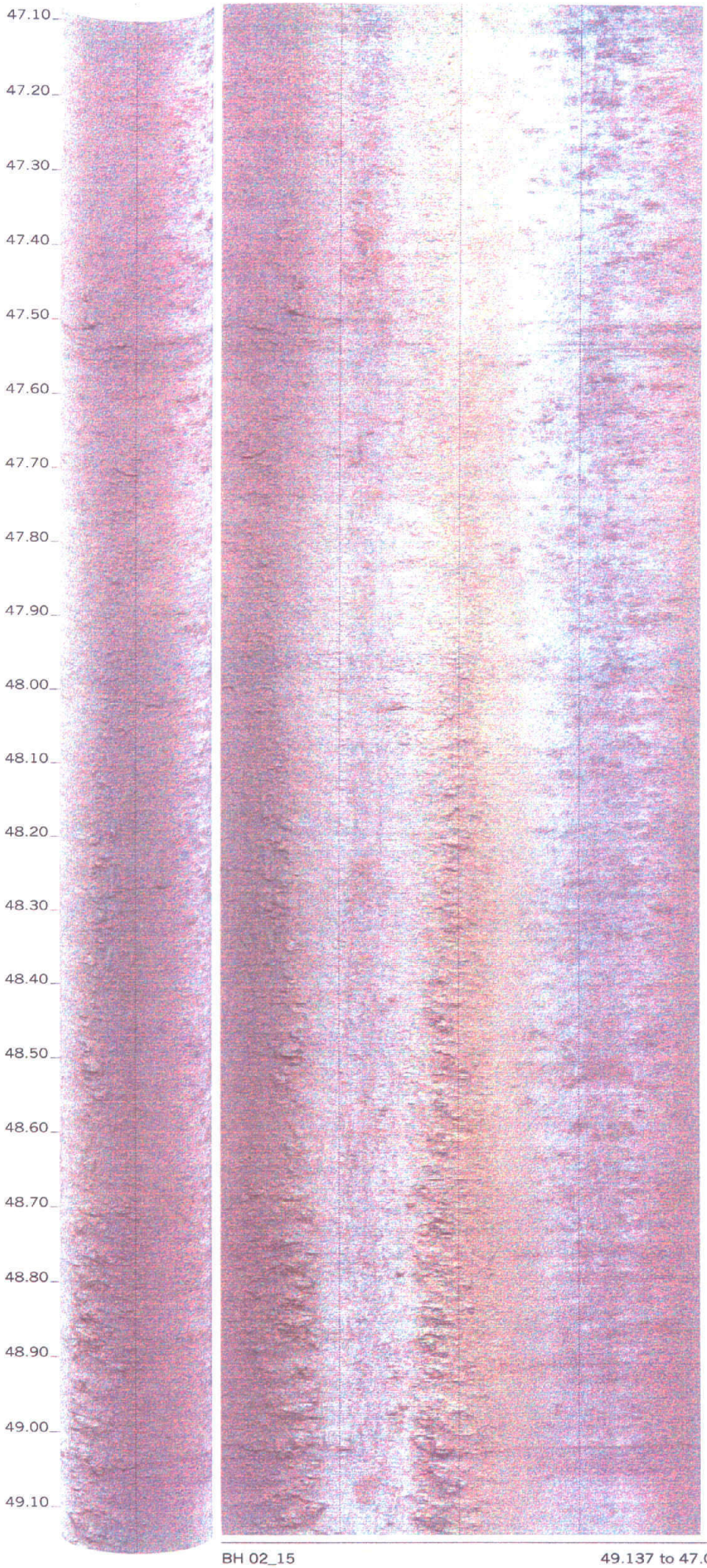
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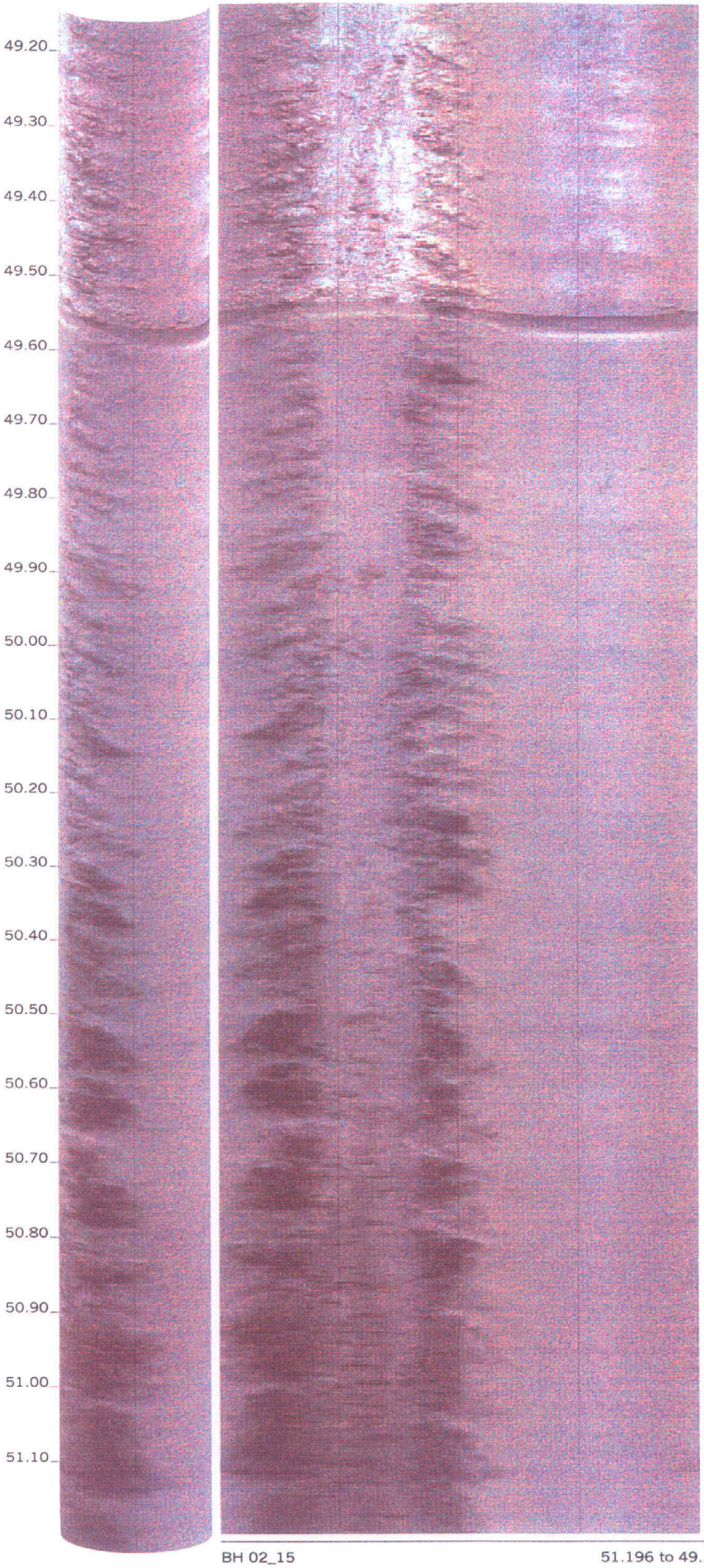
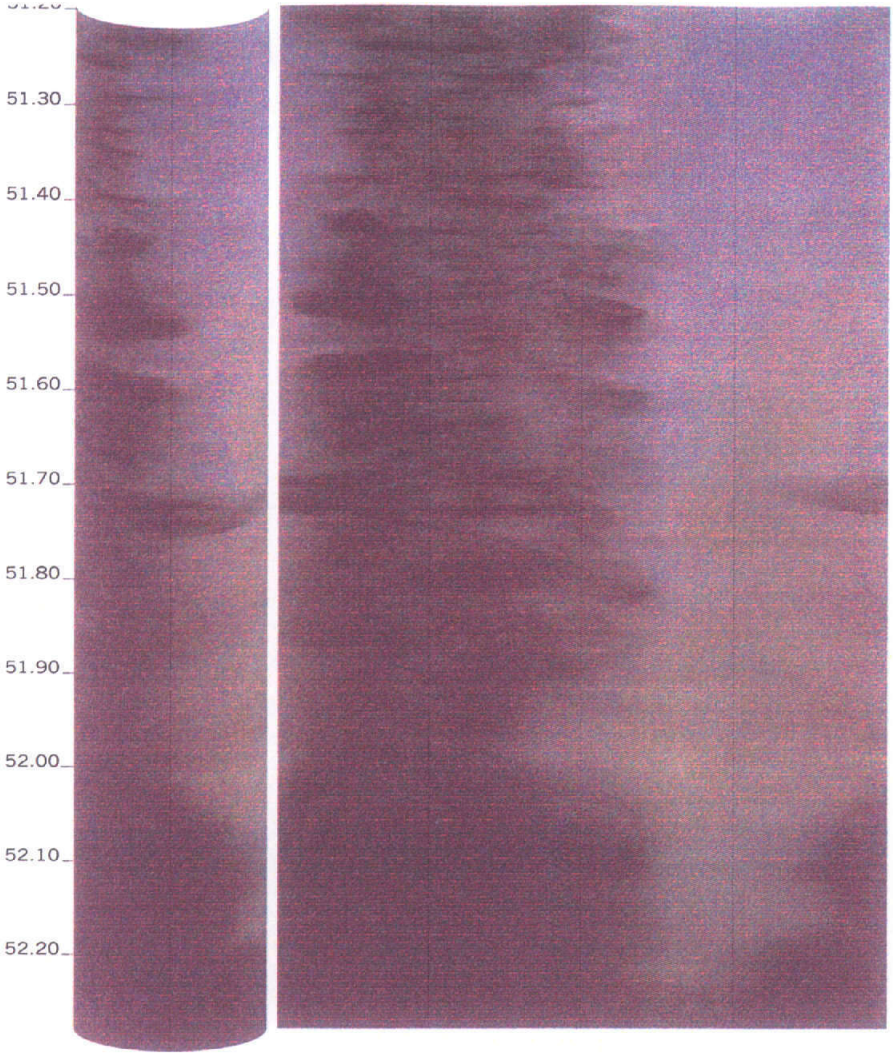


BH 02_15 51.196 to 49.137m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RGLDIPv6.1 OPTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole: 02-15
zone from 4.821 to 52.277 meters

no.	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	Comment
1	43.622	102	61.0	1.000	0	*	2	43.592	43.652	0.110	288.48	32.48	0.0000	Fracture Weathered
2	42.859	309	89.0	0.984	11	A	2	42.763	42.955	0.110	290.50	32.75	0.0000	Fracture Discontinuous Weathered
3	41.061	282	65.7	0.936	15	C	2	40.689	41.434	0.110	290.31	33.00	0.0000	Fracture Irregular
4	40.551	110	78.0	0.934	9	C	2	40.494	40.608	0.110	289.00	32.00	0.0000	Fracture Discontinuous
5	40.321	94	77.2	0.959	8	B	2	40.264	40.379	0.110	289.00	32.49	0.0000	Fracture Discontinuous
6	39.029	123	72.5	0.956	10	B	2	38.982	39.077	0.110	290.00	32.67	0.0000	Fracture Irregular
7	38.520	102	59.4	0.972	9	B	2	38.492	38.548	0.110	290.52	33.00	0.0000	Fracture Irregular
8	38.281	83	57.4	0.967	7	B	2	38.249	38.314	0.110	290.71	33.00	0.0000	Fracture Irregular
9	38.056	87	61.9	0.974	8	A	2	38.020	38.092	0.110	288.61	32.41	0.0000	Fracture Irregular
10	36.979	141	81.9	0.949	8	B	2	36.903	37.056	0.110	290.67	33.00	0.0000	Fracture Clayey
11	36.694	118	85.2	0.956	8	B	2	36.642	36.766	0.110	290.04	33.04	0.0000	Fracture Discontinuous Clayey
12	36.341	222	12.0	0.960	9	B	2	36.295	36.387	0.110	289.90	33.80	0.0000	Fracture
13	36.246	279	53.0	0.915	26	C	2	35.649	36.642	0.110	288.00	32.00	0.0000	Fracture Discontinuous Clayey
14	35.667	257	28.1	0.950	8	B	2	35.578	35.756	0.110	290.16	33.00	0.0000	Fracture Discontinuous
15	35.496	237	50.4	0.970	18	B	2	35.312	35.680	0.110	288.00	32.00	0.0000	Fracture Discontinuous
16	32.091	119	70.8	0.941	8	C	2	32.046	32.137	0.110	288.18	32.09	0.0000	Fracture
17	31.509	273	31.6	0.919	9	C	2	31.398	31.619	0.110	290.49	32.75	0.0000	Fracture
18	31.137	111	57.0	0.974	9	A	2	31.113	31.160	0.110	291.00	34.00	0.0000	Fracture
19	26.647	312	71.9	0.959	16	B	2	26.401	26.892	0.110	289.98	32.99	0.0000	Fracture Discontinuous
20	18.013	270	68.9	0.925	23	C	2	17.720	18.306	0.110	288.68	33.34	0.0000	Fracture Discontinuous
21	17.721	290	69.2	0.983	11	A	2	17.486	17.955	0.110	290.51	34.00	0.0000	Fracture Discontinuous

Borehole: BH_02_15
Depth range: 0.000 - 52.246m

Depth m	Deviation components North m	East m	Down m	Devaz deg	Dev deg
1.046	0.195	-0.567	0.857	289.00	35.00
2.046	0.382	-1.110	1.676	289.00	35.00
3.046	0.569	-1.652	2.495	289.00	35.00
4.046	0.756	-2.194	3.314	289.00	35.00
5.046	0.942	-2.734	4.135	290.00	34.00
6.046	1.125	-3.250	4.972	289.00	33.00
7.046	1.317	-3.778	5.799	291.00	34.00
8.046	1.515	-4.306	6.625	289.00	34.00
9.046	1.704	-4.830	7.455	289.00	33.00
10.046	1.891	-5.351	8.288	290.00	34.00
11.046	2.081	-5.875	9.118	290.00	34.00
12.046	2.274	-6.400	9.946	291.00	34.00
13.046	2.461	-6.921	10.779	289.00	33.00
14.046	2.646	-7.442	11.612	292.00	34.00
15.046	2.835	-7.960	12.446	291.00	34.00
16.046	3.021	-8.481	13.279	289.00	33.00
17.046	3.209	-9.000	14.113	291.00	34.00
18.046	3.395	-9.519	14.947	290.00	34.00
19.046	3.586	-10.041	15.778	288.00	33.00
20.046	3.769	-10.559	16.614	289.00	33.00
21.046	3.960	-11.078	17.447	291.00	34.00
22.046	4.142	-11.595	18.283	289.00	33.00
23.046	4.327	-12.112	19.119	289.00	33.00
24.046	4.513	-12.628	19.954	290.00	33.00
25.046	4.702	-13.143	20.790	289.00	33.00
26.046	4.884	-13.657	21.629	291.00	34.00
27.046	5.067	-14.169	22.467	289.00	32.00
28.046	5.252	-14.683	23.305	289.00	33.00
29.046	5.434	-15.193	24.145	290.00	33.00
30.046	5.615	-15.705	24.985	292.00	34.00
31.046	5.797	-16.218	25.824	289.00	33.00
32.046	5.982	-16.727	26.664	290.00	33.00
33.046	6.162	-17.239	27.504	290.00	33.00
34.046	6.340	-17.746	28.347	288.00	32.00
35.046	6.519	-18.255	29.189	289.00	33.00
36.046	6.699	-18.766	30.029	288.00	32.00
37.046	6.882	-19.277	30.869	291.00	33.00
38.046	7.063	-19.784	31.711	288.00	32.00
39.046	7.244	-20.293	32.553	291.00	33.00
40.046	7.423	-20.801	33.395	288.00	32.00
41.046	7.598	-21.307	34.239	290.00	33.00
42.046	7.772	-21.815	35.083	289.00	33.00
43.046	7.951	-22.320	35.927	290.00	32.00
44.046	8.136	-22.831	36.767	291.00	33.00
45.046	8.307	-23.333	37.614	292.00	34.00
46.046	8.485	-23.838	38.459	290.00	33.00
47.046	8.662	-24.341	39.304	290.00	32.00
48.046	8.835	-24.841	40.152	286.00	30.00
49.046	9.012	-25.345	40.997	290.00	33.00
50.046	9.191	-25.848	41.843	287.00	31.00
51.046	9.364	-26.348	42.691	288.00	32.00
52.046	9.552	-26.856	43.532	291.00	33.00

Appendix G

BOREHOLE 02-18A
IMAGE LOG PLOTS
DISCONTINUITY AND DEVIATION TABLES

NORCAL GEOPHYSICAL CONSULTANTS, INC.

OPTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED OPTV DIPS LOG

09 Aug 2002

EARTH MECHANICS

Borehole: BH 02-18A

DEVIL'S SLIDE

top of borehole.....
East:
North:
Alt: 0

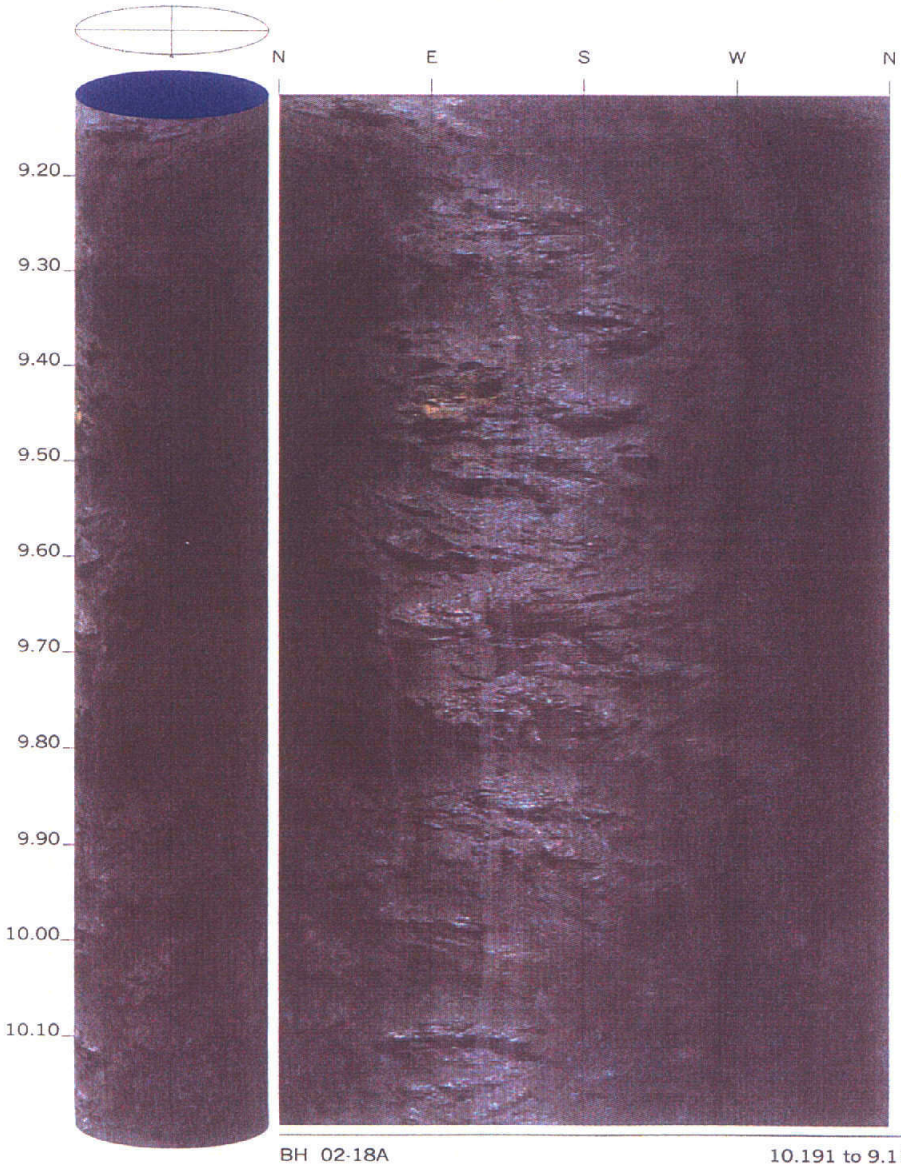
North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = fixed format

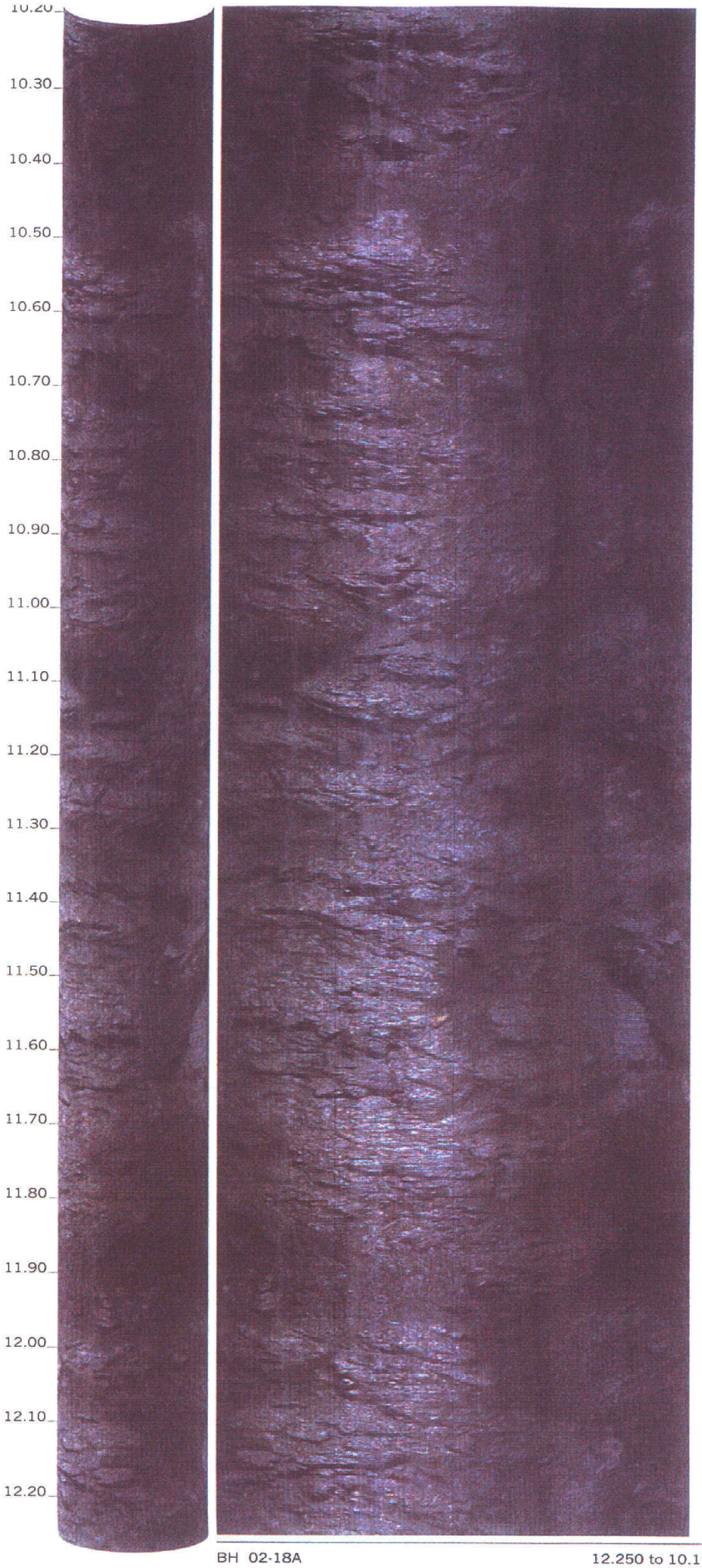
Zone from 24.871 to 9.114m
Vertical = borehole-axis

Borehole diam: 11.000cm

BEDDING
FRACTURE
Identified units

COMMENTS

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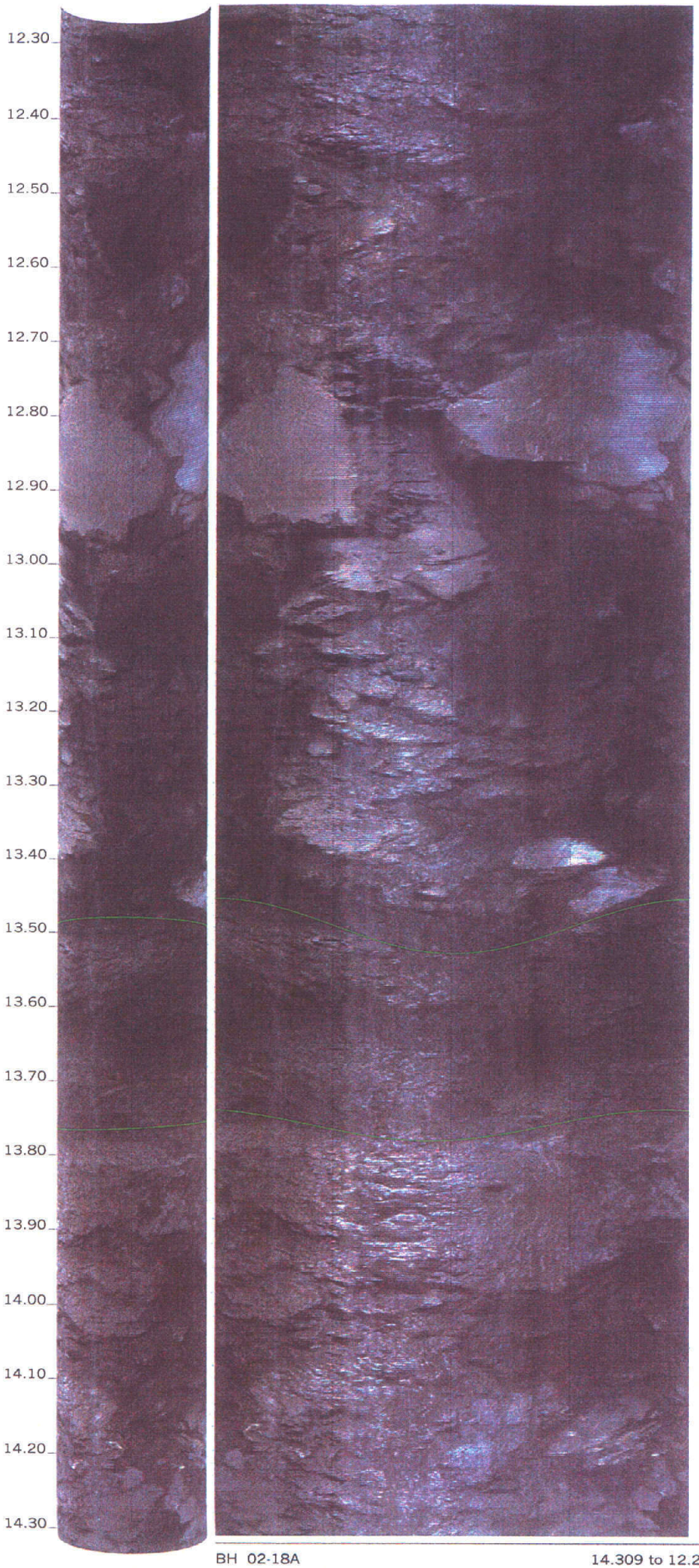
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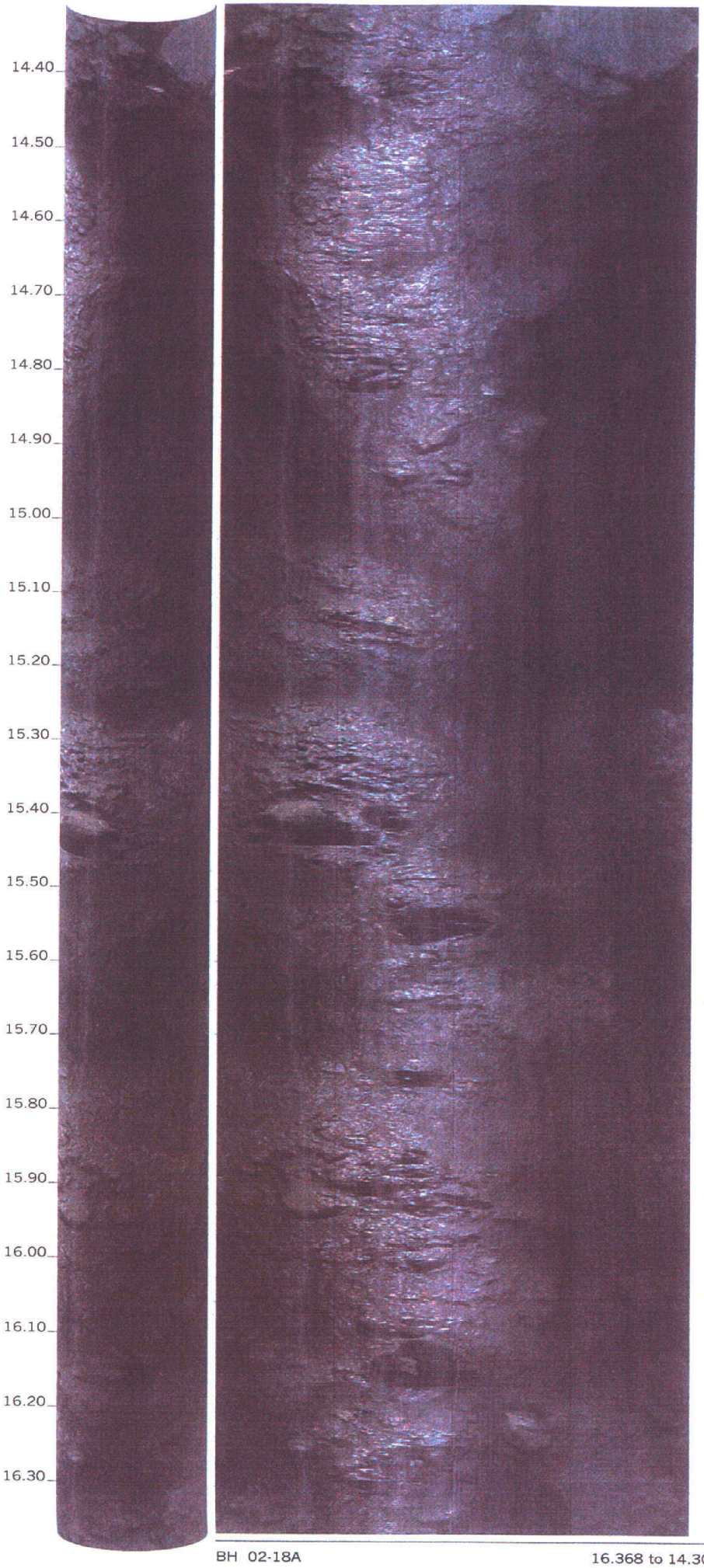
N144 52 Irregular Bedding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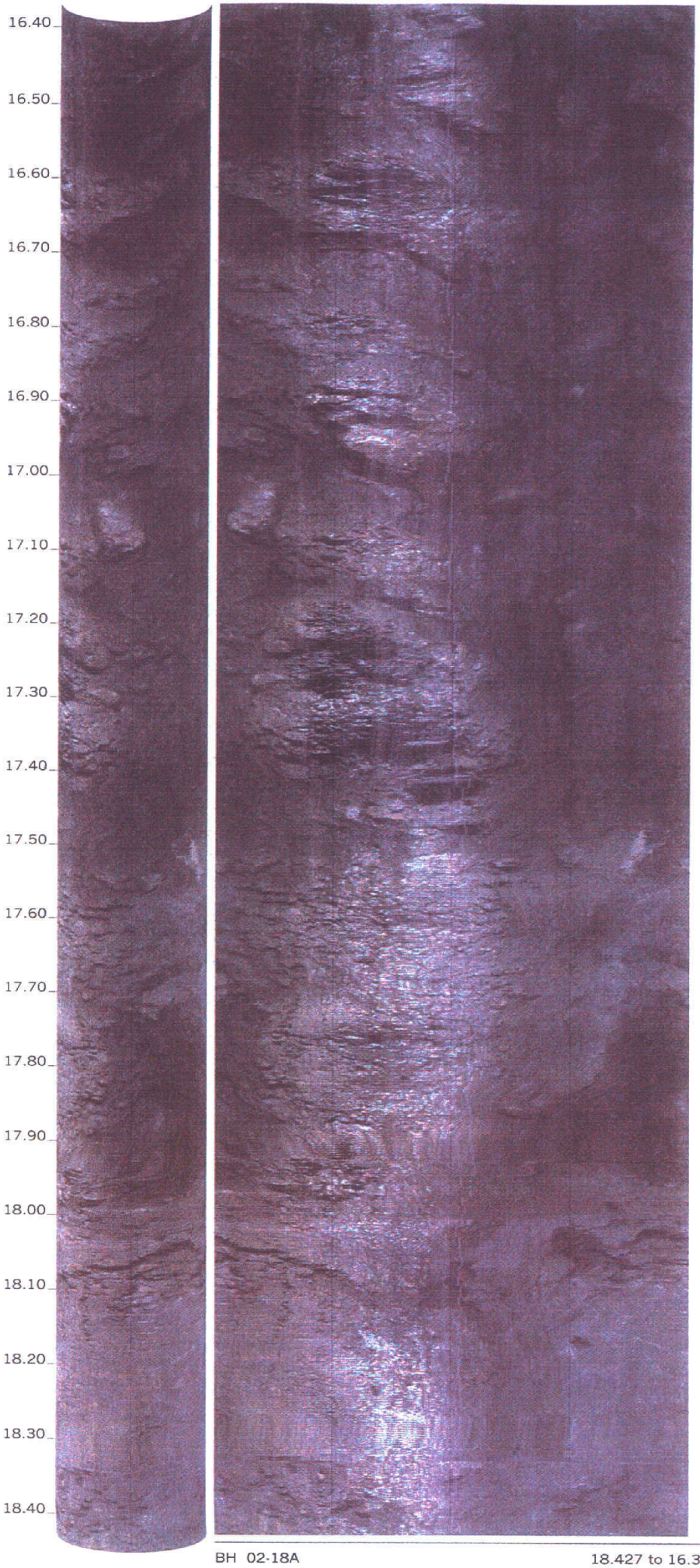
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18.40
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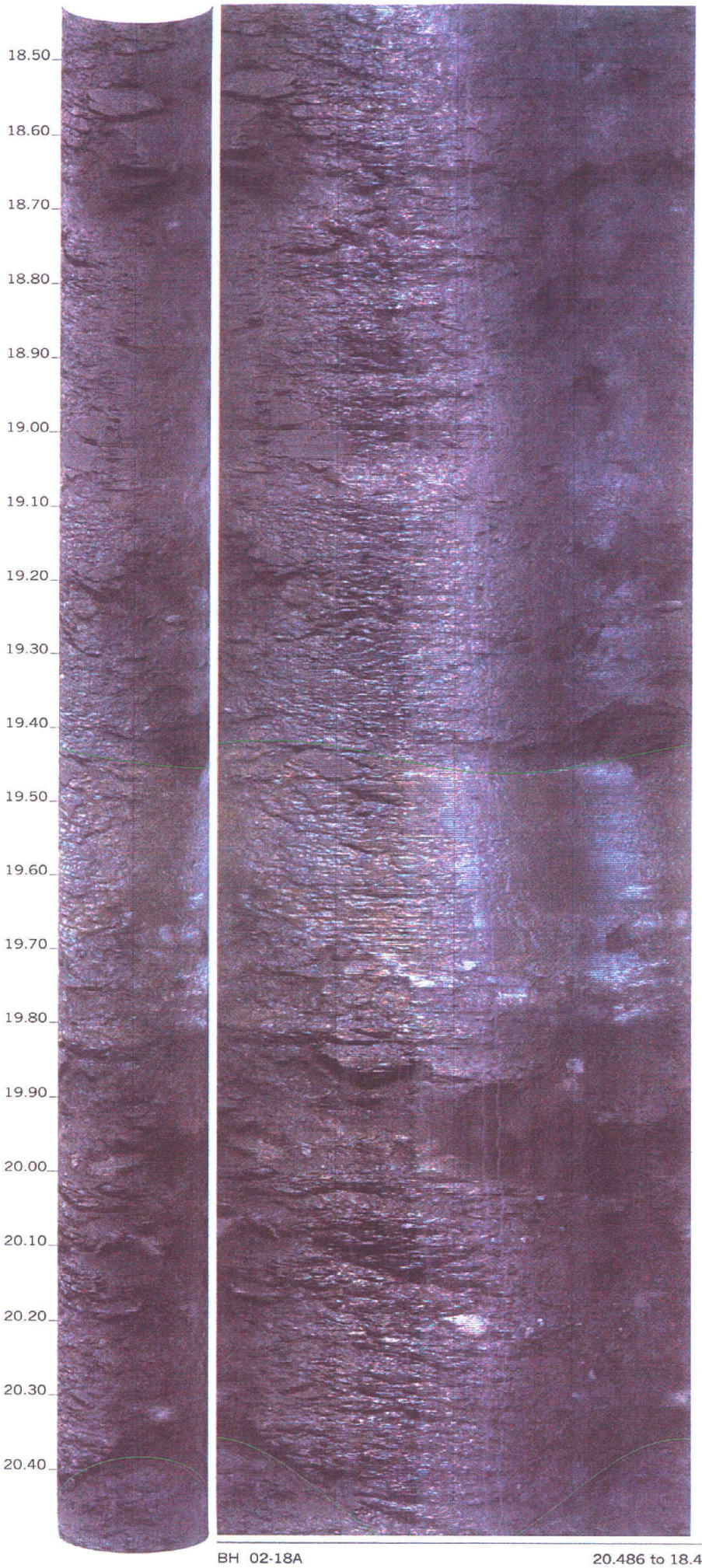
tool_hang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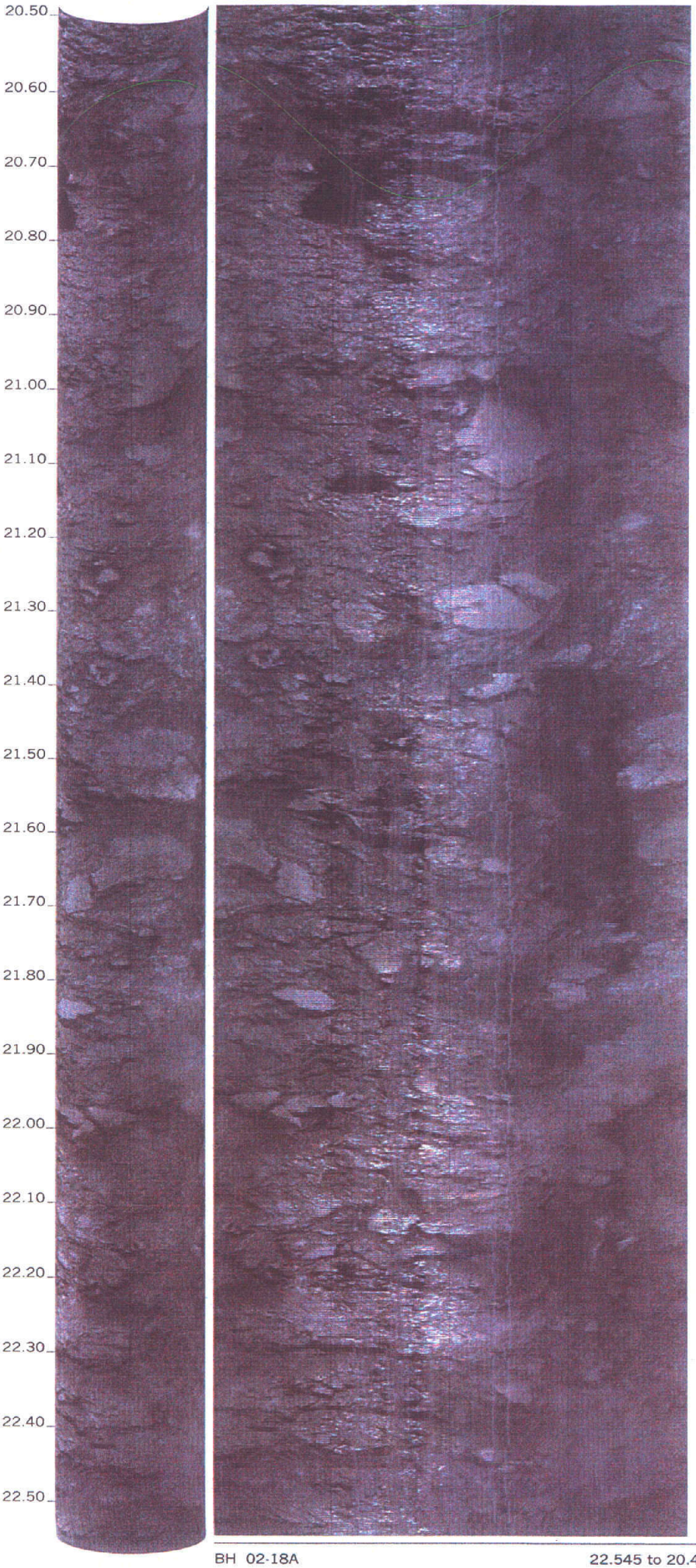
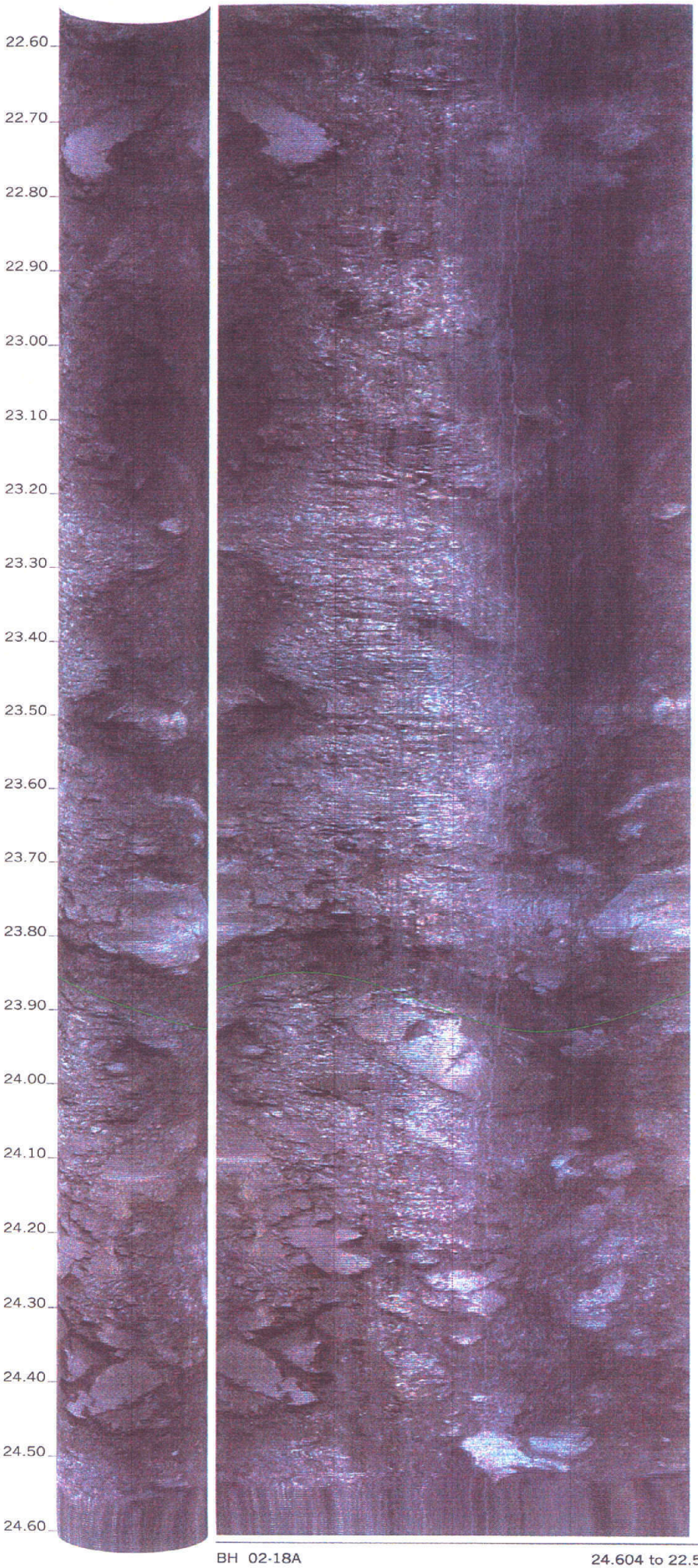
N166 40 Bedding
N163 82 Irregular Bedding



N151 88 Irregular Bedding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24.30
24.40
24.50
24.60
N198 37 Crushed Bedding

RGLDIPv6.1 OPTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole: 02-18A
zone from 9.114 to 24.872 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	23.888	198	36.8	0.918	7	C	0	23.848	23.928	0.110	311.84	31.16	0.0000	Crushed Bedding
2	20.651	151	88.4	0.821	9	D	0	20.558	20.744	0.110	311.89	31.00	0.0000	Irregular Bedding
3	20.436	163	82.2	0.923	10	C	0	20.355	20.518	0.110	311.81	31.81	0.0000	Irregular Bedding
4	19.439	166	39.8	0.981	10	A	0	19.417	19.461	0.110	311.15	31.15	0.0000	Bedding
5	13.758	144	52.5	0.936	9	C	0	13.737	13.779	0.110	312.00	33.00	0.0000	Irregular Bedding
6	13.490	159	60.4	0.901	10	C	0	13.453	13.528	0.110	311.12	32.12	0.0000	Irregular Bedding

Borehole Deviation Table

Borehole: BH 02-18A Deviation Table
Depth range: 0.000 - 24.846 meters

Depth	Deviation components North	East	Down	Devaz	Dev
m	m	m	m	deg	deg
1.046	0.193	-0.503	0.897	291.00	31.00
2.046	0.378	-0.984	1.754	291.00	31.00
3.046	0.562	-1.465	2.611	291.00	31.00
4.046	0.747	-1.945	3.468	291.00	31.00
5.046	0.931	-2.426	4.325	291.00	31.00
6.046	1.116	-2.907	5.182	291.00	31.00
7.046	1.301	-3.388	6.040	291.00	31.00
8.046	1.485	-3.869	6.897	291.00	31.00
9.046	1.670	-4.350	7.754	291.00	31.00
10.046	2.062	-4.683	8.606	318.00	33.00
11.046	2.442	-5.066	9.447	315.00	33.00
12.046	2.812	-5.461	10.288	314.00	34.00
13.046	3.173	-5.856	11.133	310.00	31.00
14.046	3.531	-6.256	11.976	311.00	31.00
15.046	3.888	-6.652	12.822	313.00	33.00
16.046	4.229	-7.049	13.674	308.00	31.00
17.046	4.581	-7.446	14.521	312.00	32.00
18.046	4.929	-7.848	15.367	311.00	33.00
19.046	5.282	-8.238	16.218	311.00	31.00
20.046	5.630	-8.629	17.069	314.00	33.00
21.046	5.980	-9.020	17.920	312.00	33.00
22.046	6.334	-9.417	18.767	314.00	32.00
23.046	6.693	-9.813	19.613	314.00	33.00
24.046	7.051	-10.208	20.458	313.00	32.00

Appendix H

BOREHOLE 02-18B
IMAGE LOG PLOTS
DISCONTINUITY AND DEVIATION TABLES

NORCAL GEOPHYSICAL CONSULTANTS, INC.

OPTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED OPTV DIPS LOG

09 Aug 2002

EARTH MECHANICS

Borehole: BH 02-18B

DEVILS SLIDE

top of borehole.....
East:
North:
Alt: 135 METERS

North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = fixed format

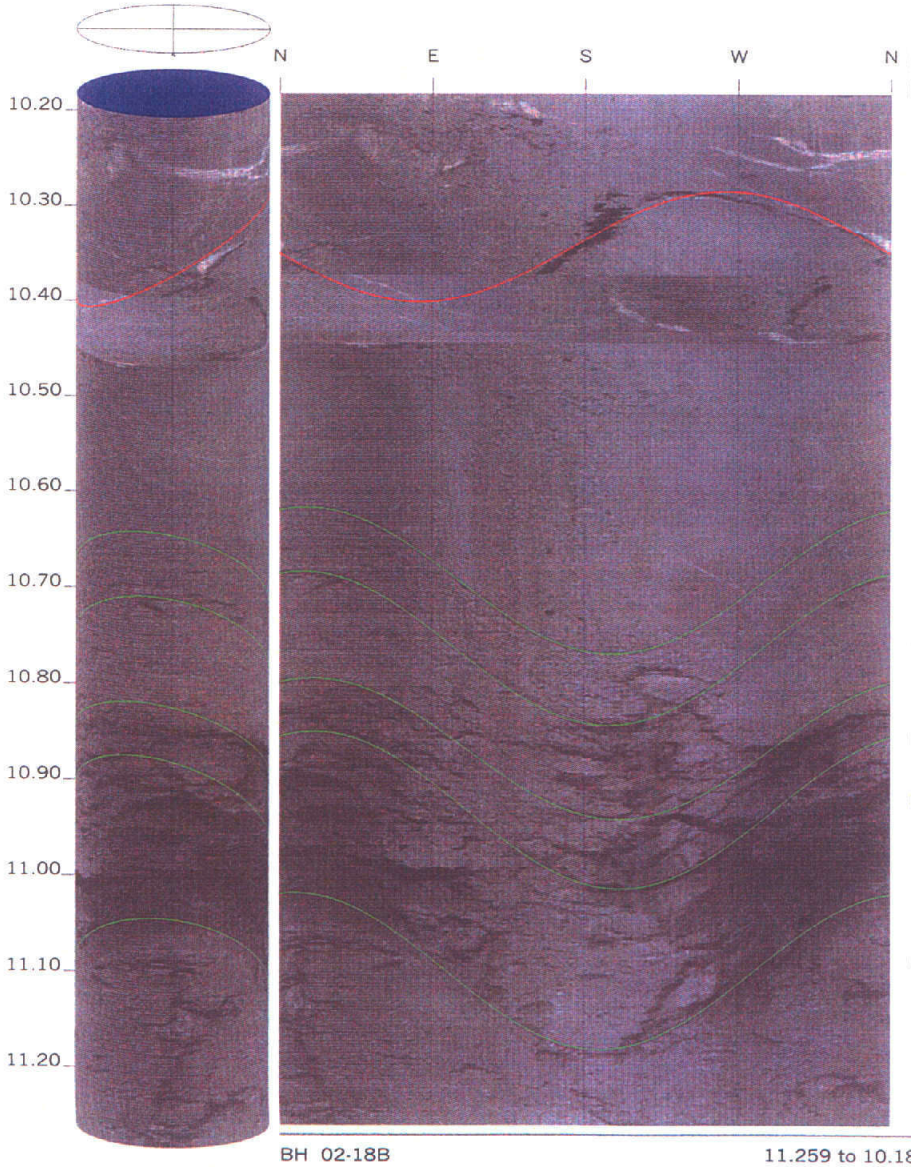
Zone from 28.000 to 10.182m
Vertical = borehole-axis

Borehole diam: 11.000cm

BEDDING
FRACTURE

Identified units

COMMENTS



N091 54 Fracture Irregular

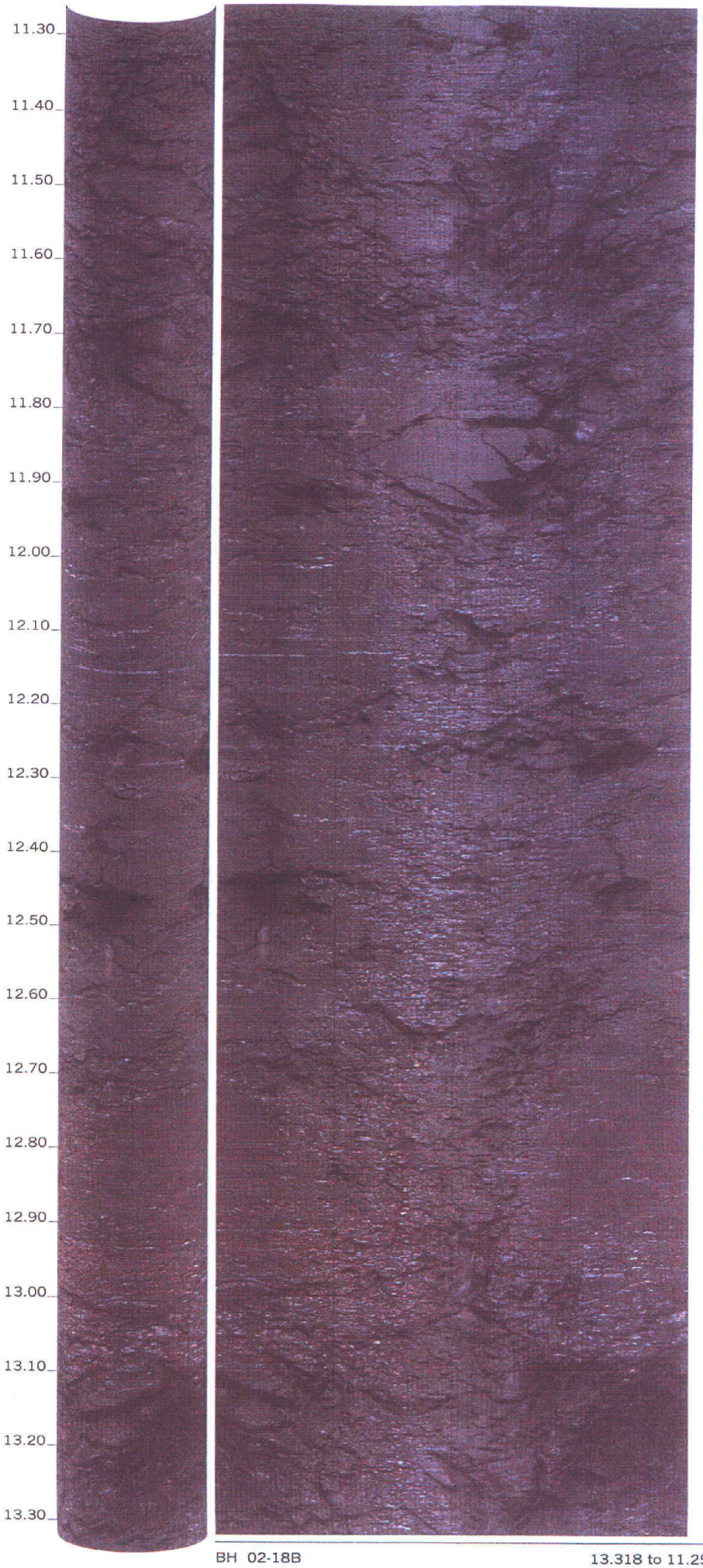
N188 61 Bedding

N187 63 Bedding

N191 59 Bedding

N193 61 Bedding

N182 63 Bedding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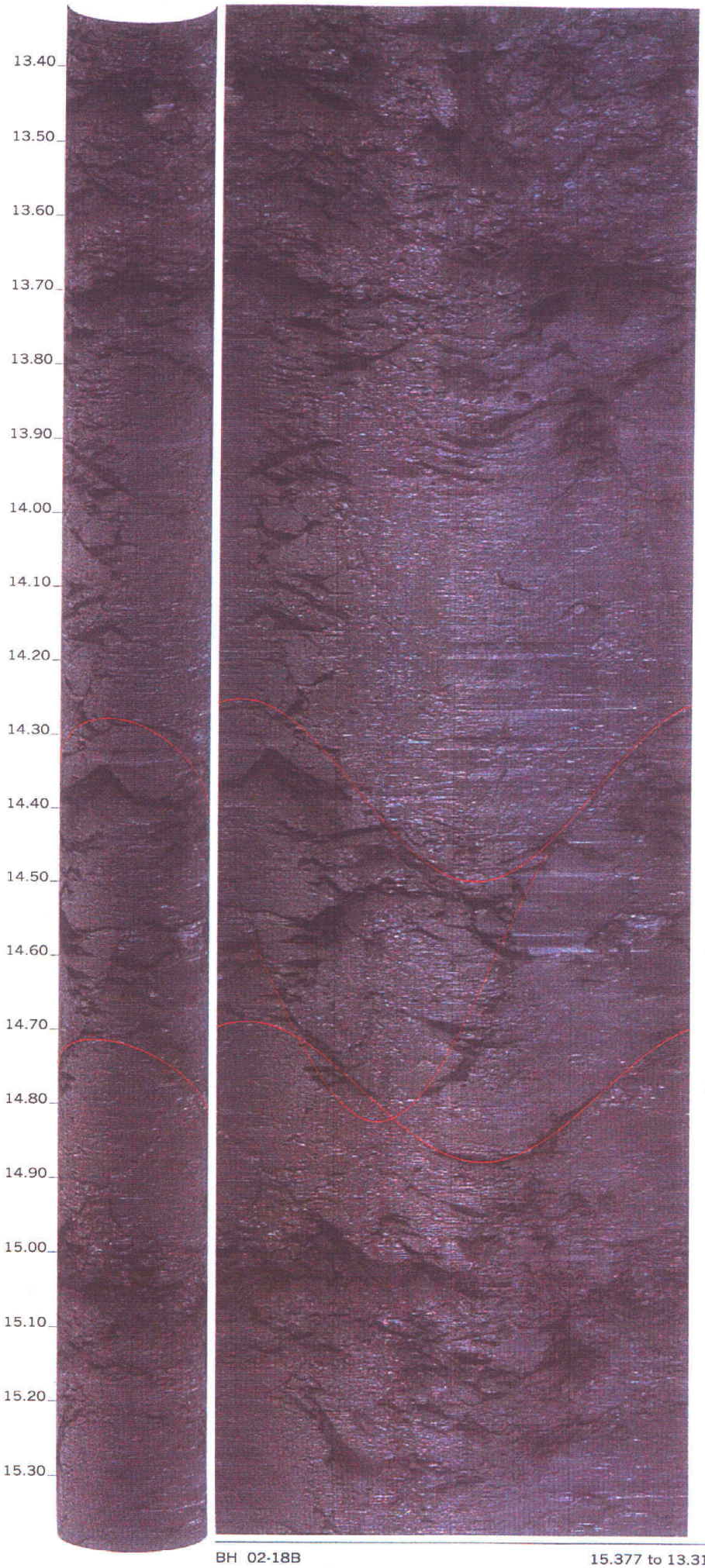
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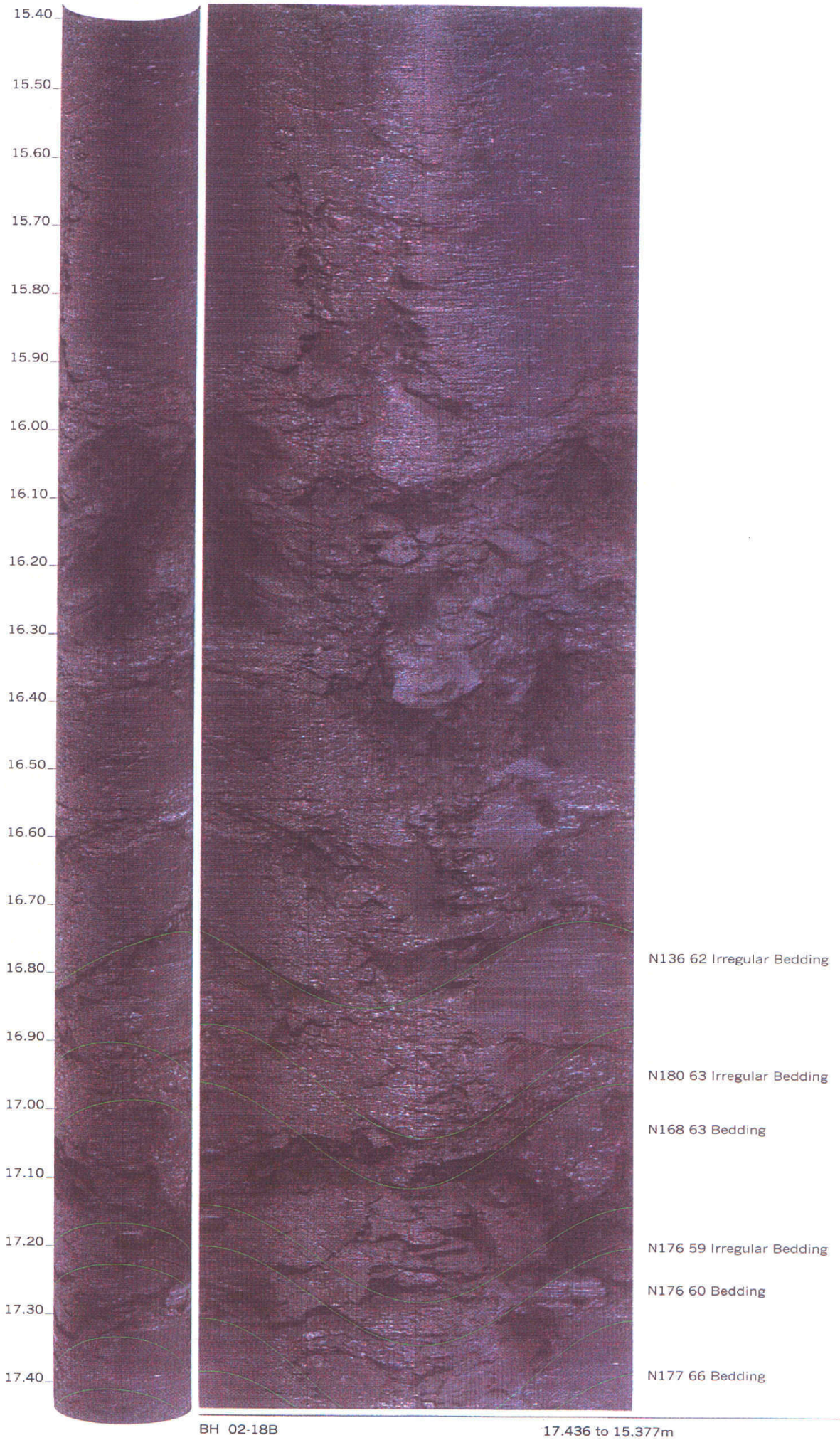
N192 70 Fracture Irregular
N122 89 Fracture Discontinuous
N196 63 Fracture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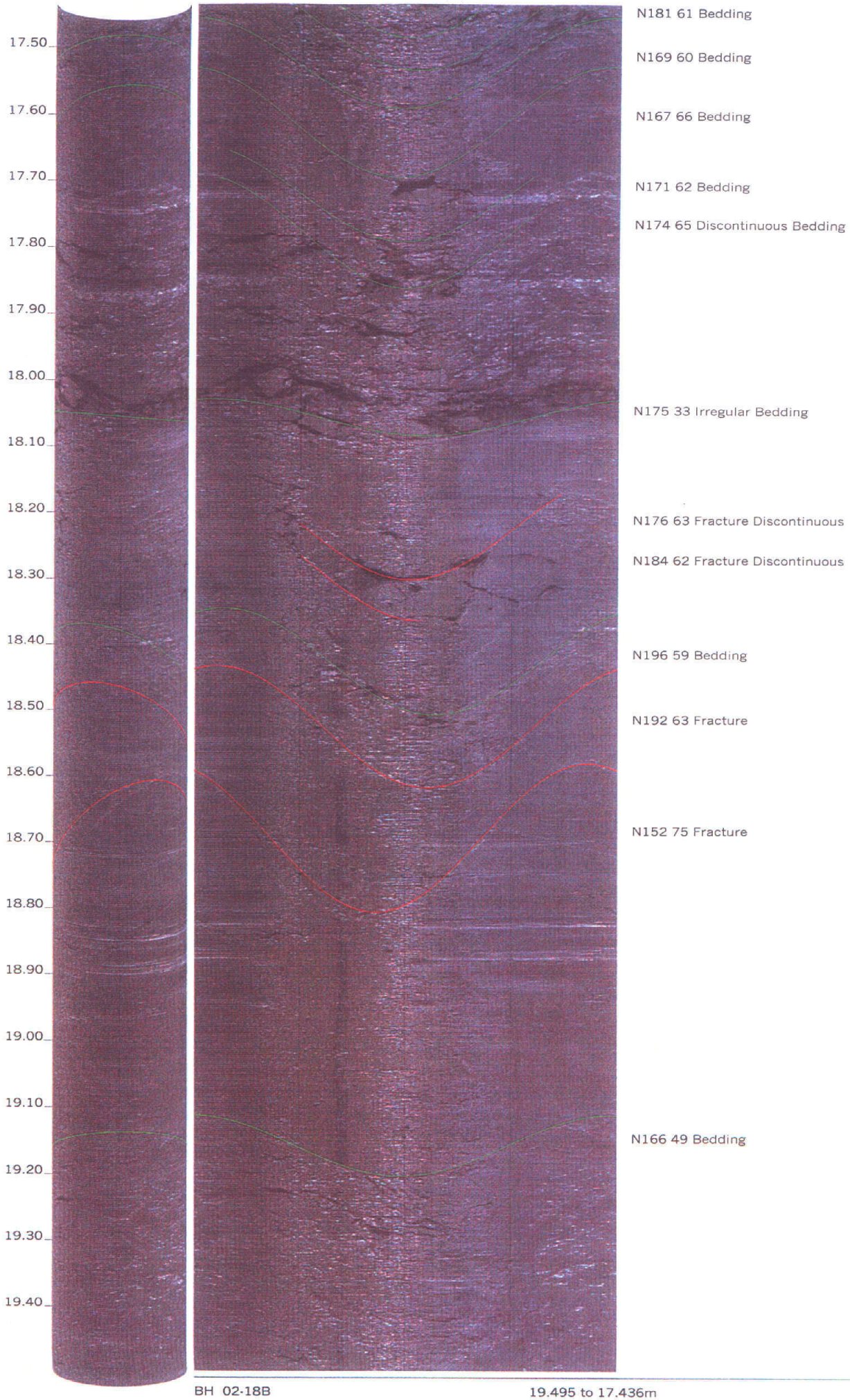
N168 63 Bedding
N176 59 Irregular Bedding
N176 60 Bedding
N177 66 Bedding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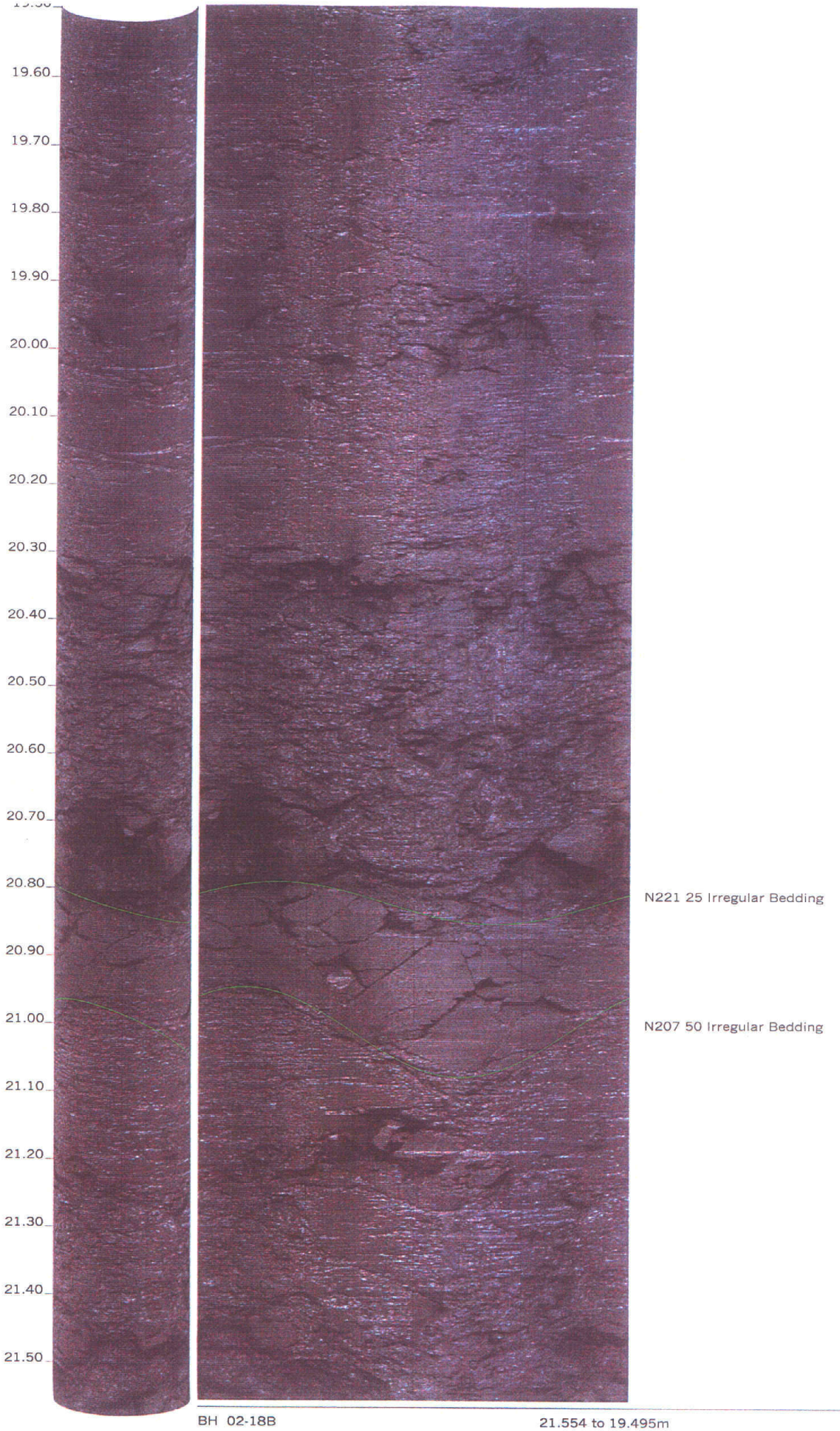
19.00
19.10
19.20
19.30
19.40
N181 61 Bedding
N169 60 Bedding
N167 66 Bedding
N171 62 Bedding
N174 65 Discontinuous Bedding
N175 33 Irregular Bedding
N176 63 Fracture Discontinuous
N184 62 Fracture Discontinuous
N196 59 Bedding
N192 63 Fracture
N152 75 Fracture
N166 49 Bedding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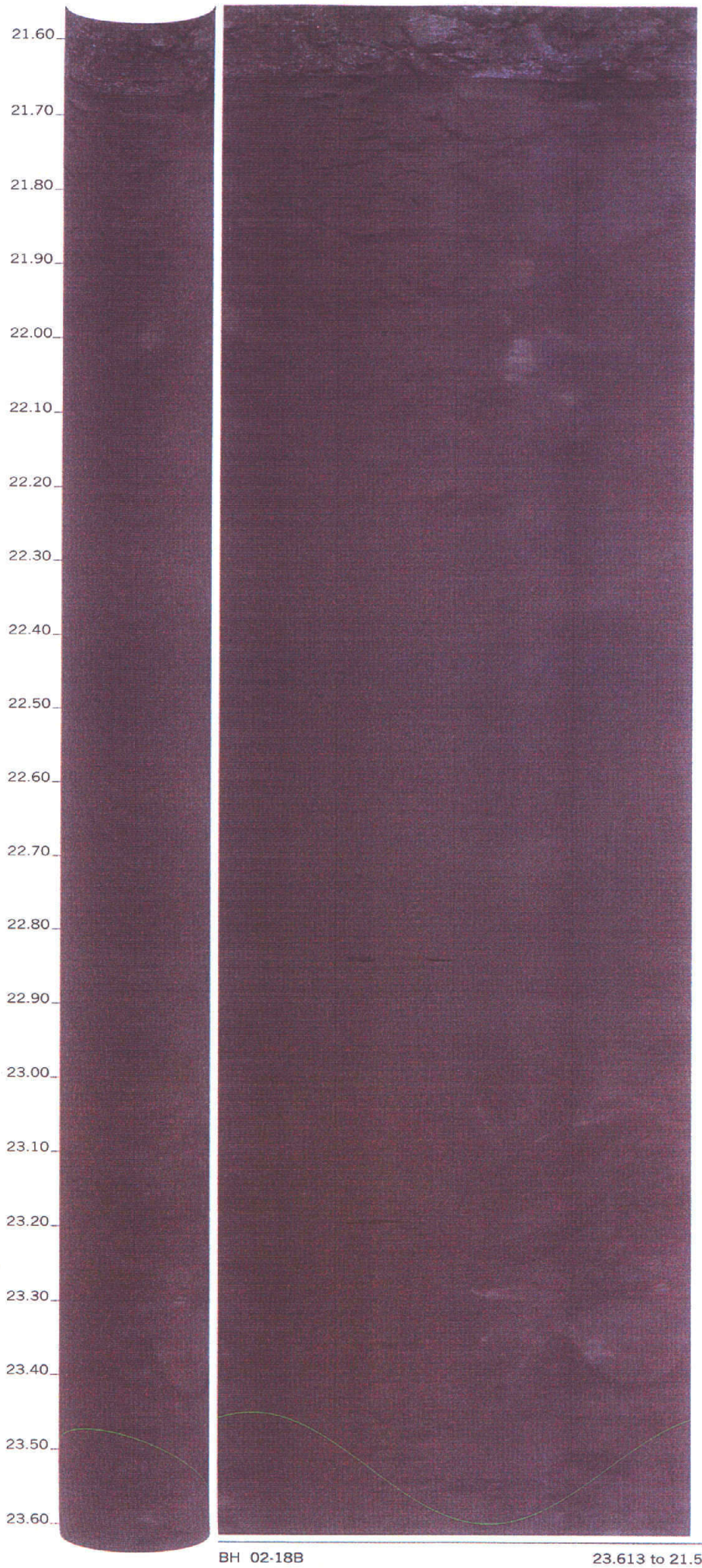
21.50
N221 25 Irregular Bedding
N207 50 Irregular Bedding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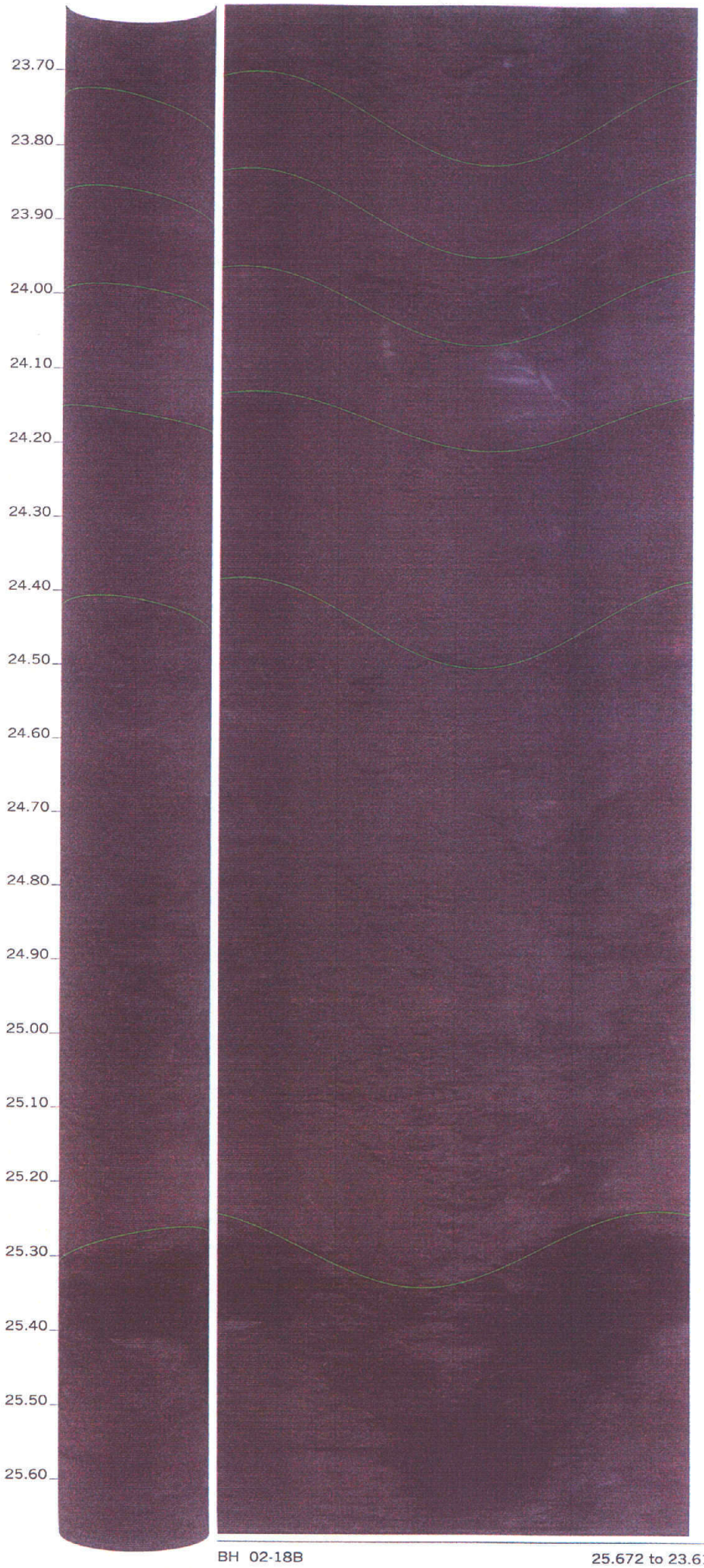
23.40
23.50
23.60
N197 56 Bedding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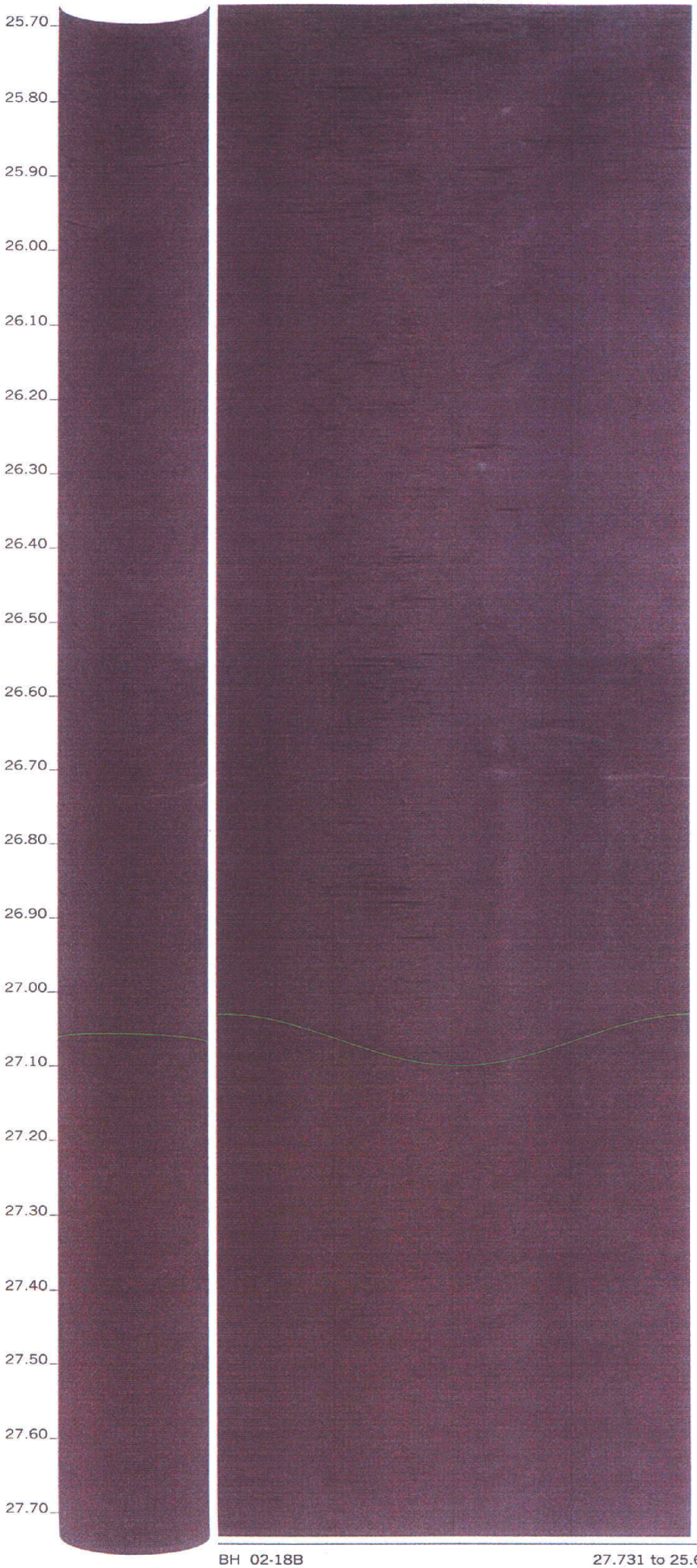
N186 53 Bedding
N150 55 Irregular Bedding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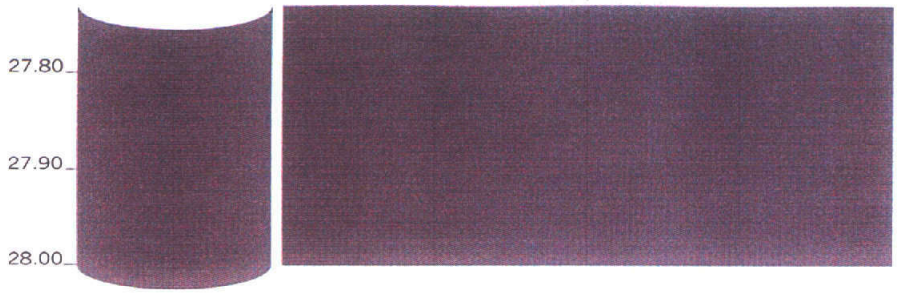
N170 40 Bedding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NORCAL GEOPHYSICAL CONSULTANTS, INC.

BHTV DATA PROCESSING
RGLDIP vsn 6.1
INTERPRETED BHTV DIPS LOG

09 Aug 2002

EARTH MECHANICS

Borehole: BH 02-18B

DEVILS SLIDE

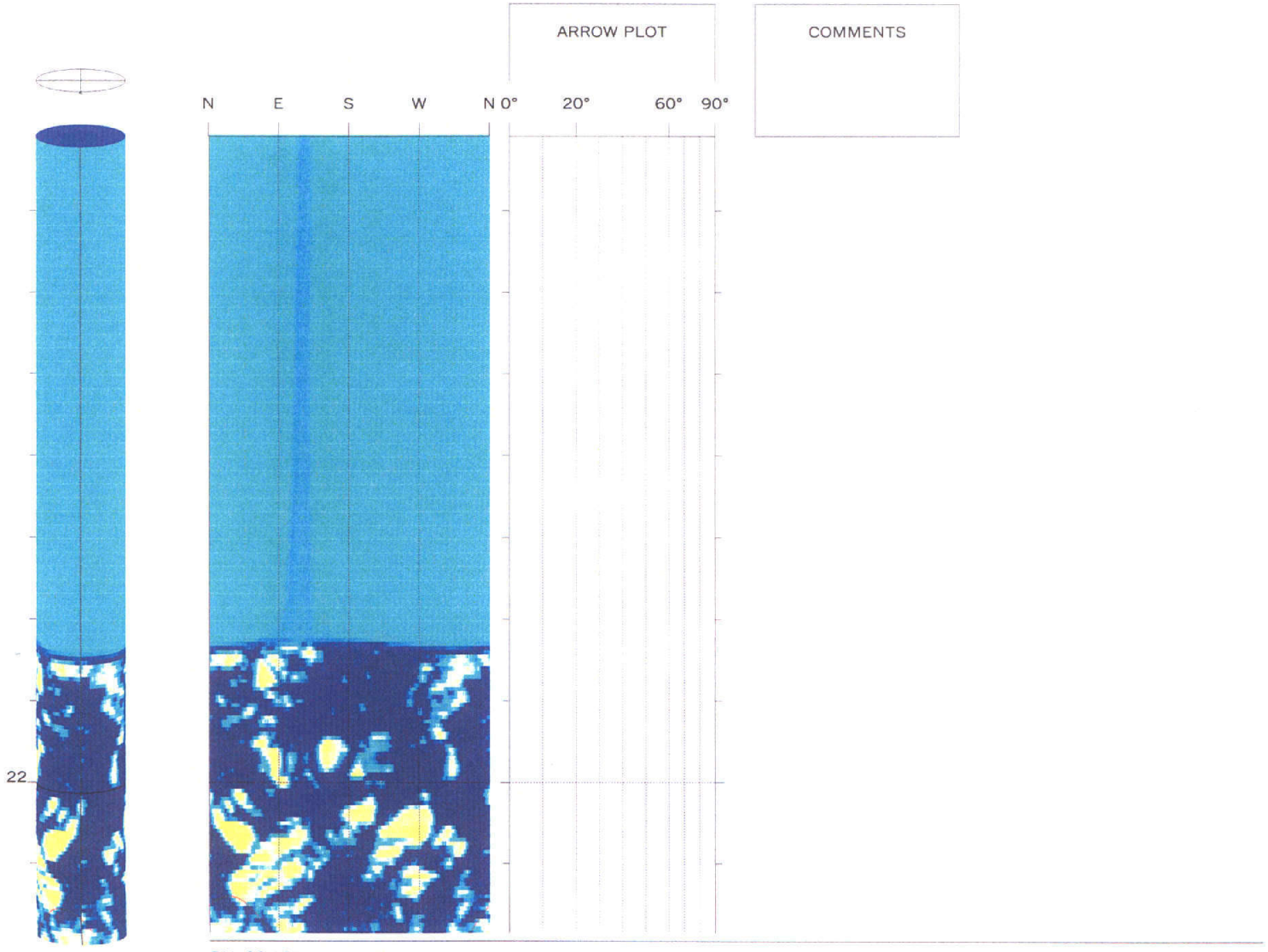
top of borehole.....
East:
North:
Alt:

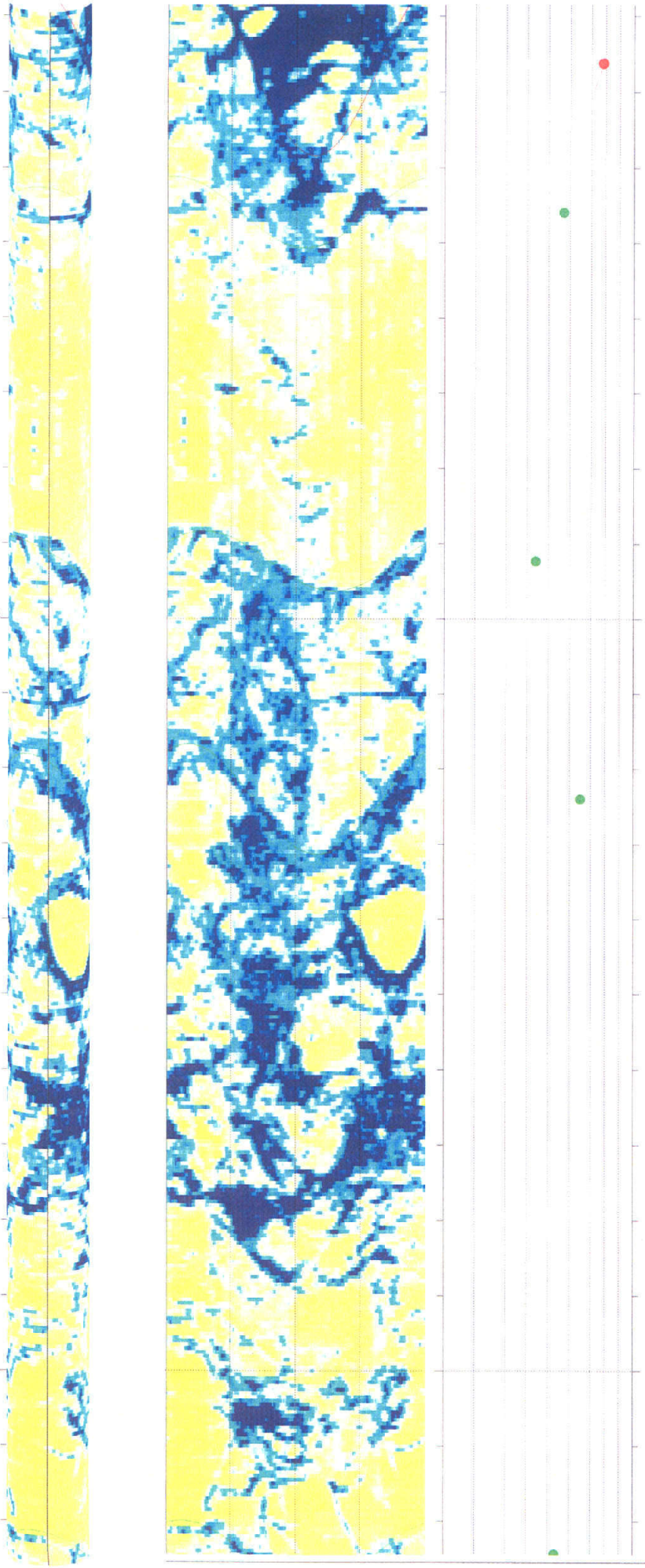
North ref. is true
Depth units are metres
Vertical scale: 1/8
Horiz scale = vert scale

Zone from 44.500 to 21.210m

Borehole diam: 11.000cm
Vertical = borehole-axis
Amplitude

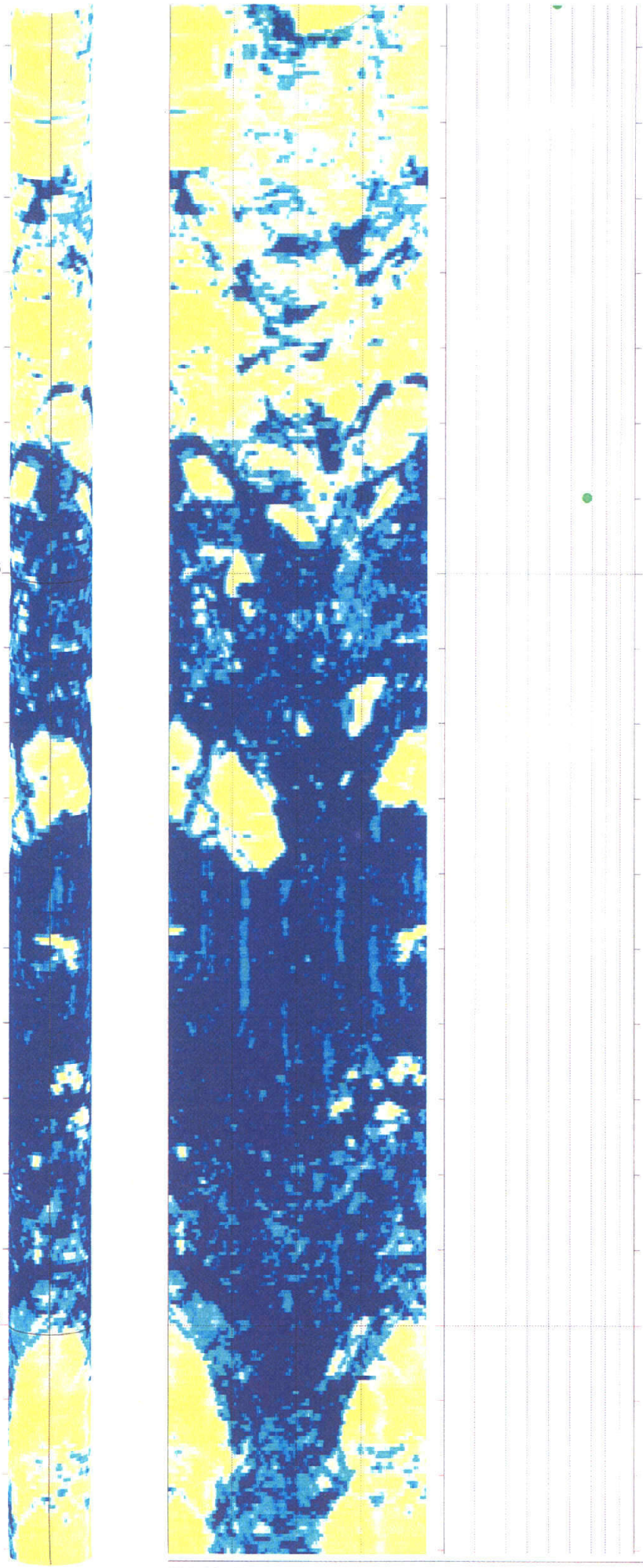
BEDDING
FRACTURE
Identified units





BH 02-18B

24.245 to 22.185m



BH 02-18B

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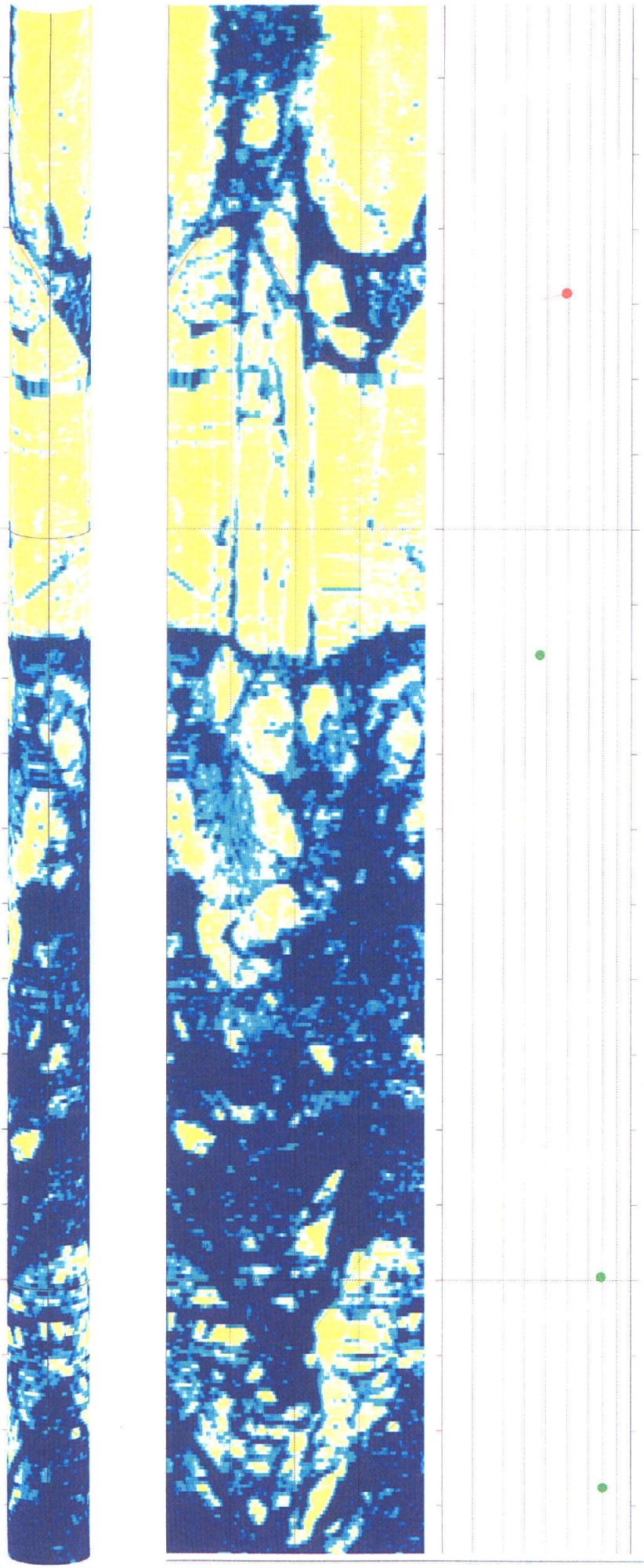
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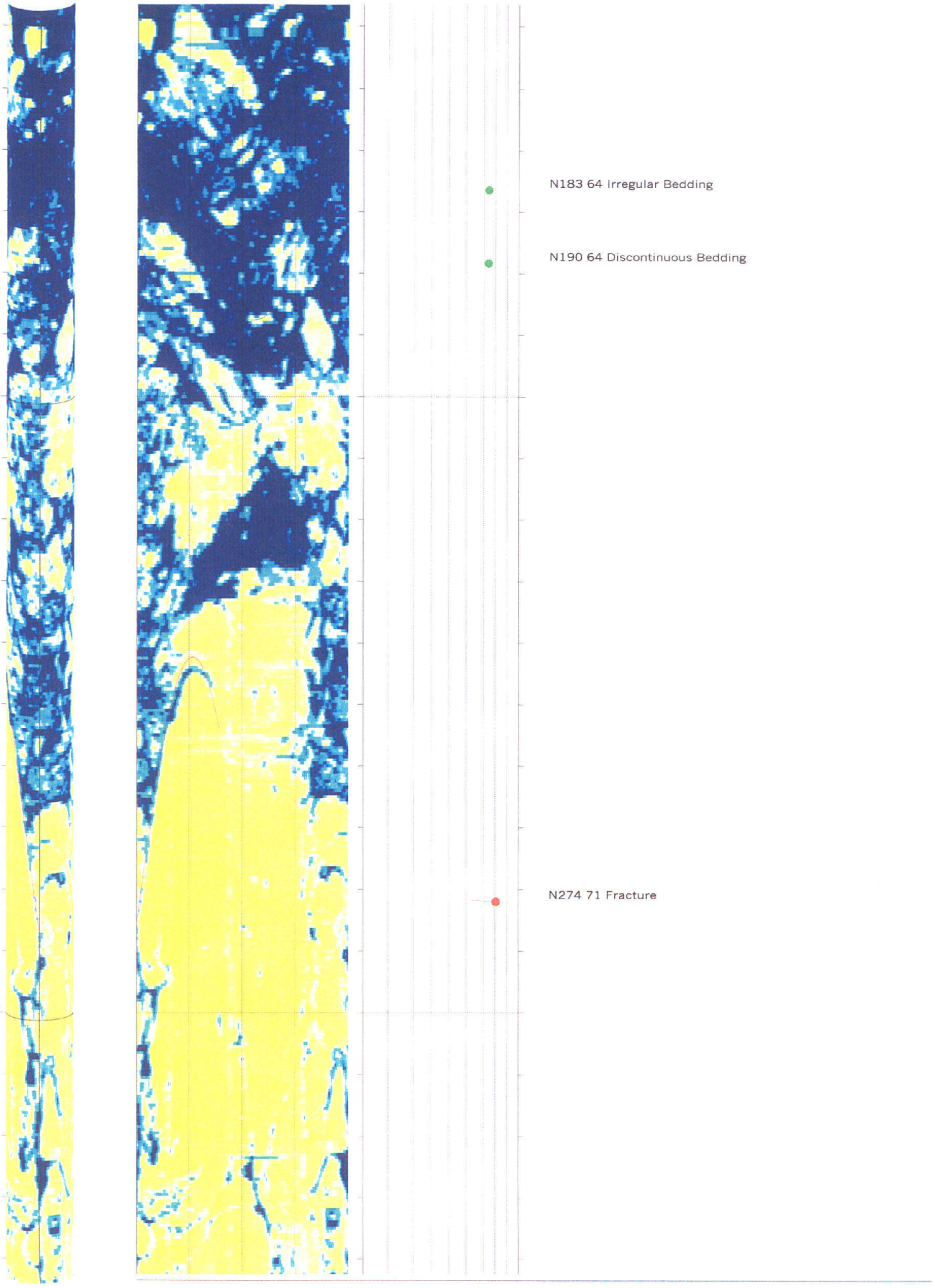
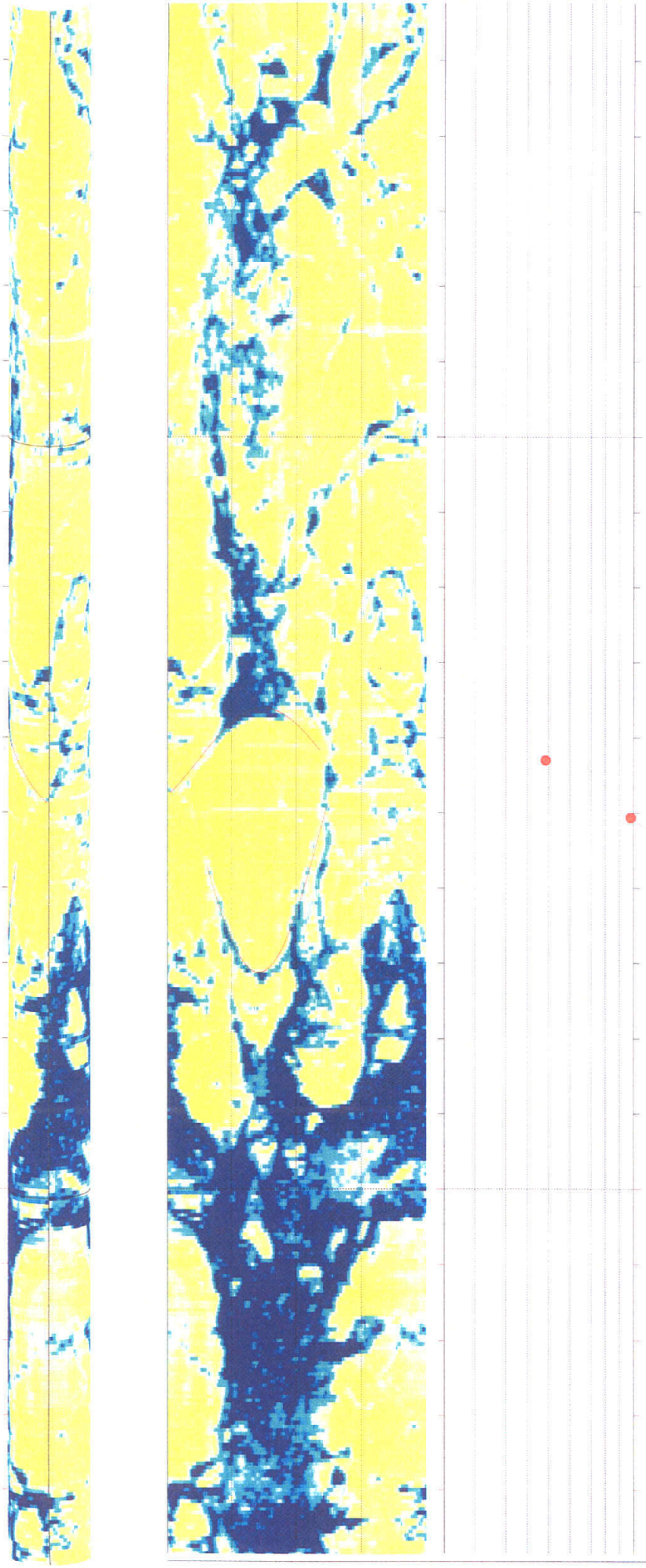
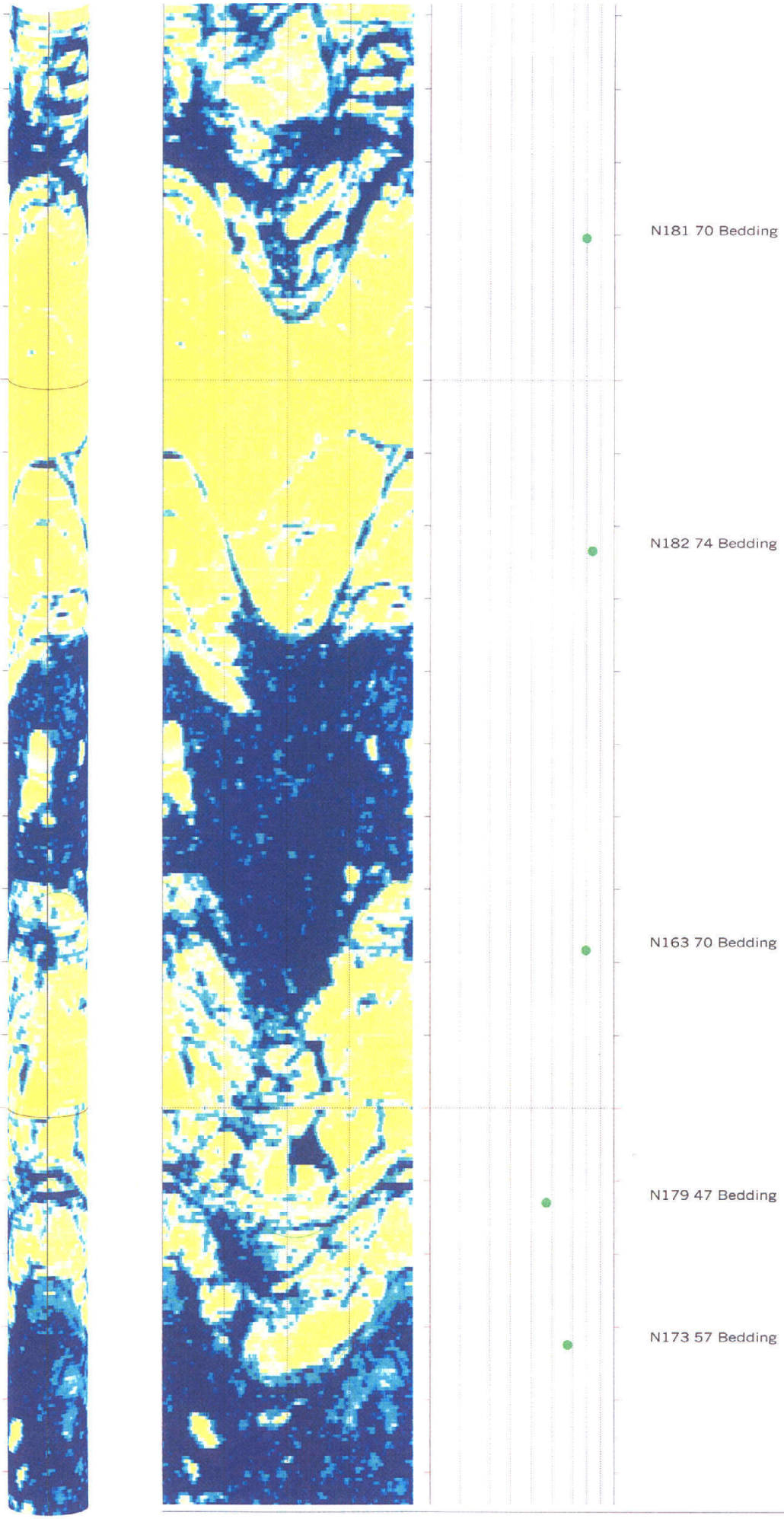
N257 49 Fracture
N185 37 Crushed Bedding
N161 69 Irregular Bedding
N162 70 Bedding


N183 64 Irregular Bedding
N190 64 Discontinuous Bedding
N274 71 Fracture
29
30



BH 02-18B

32.485 to 30.425m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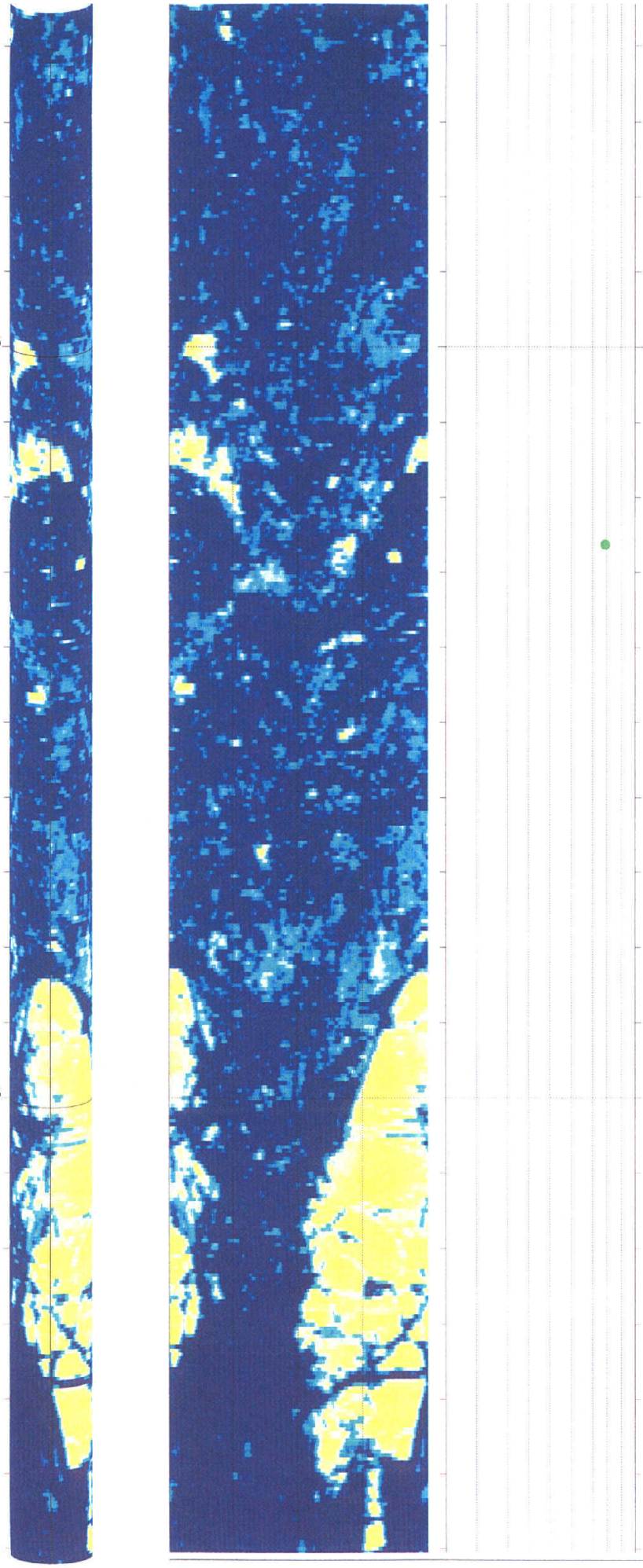
N181 70 Bedding
N182 74 Bedding
N163 70 Bedding
N179 47 Bedding
N173 57 Bedding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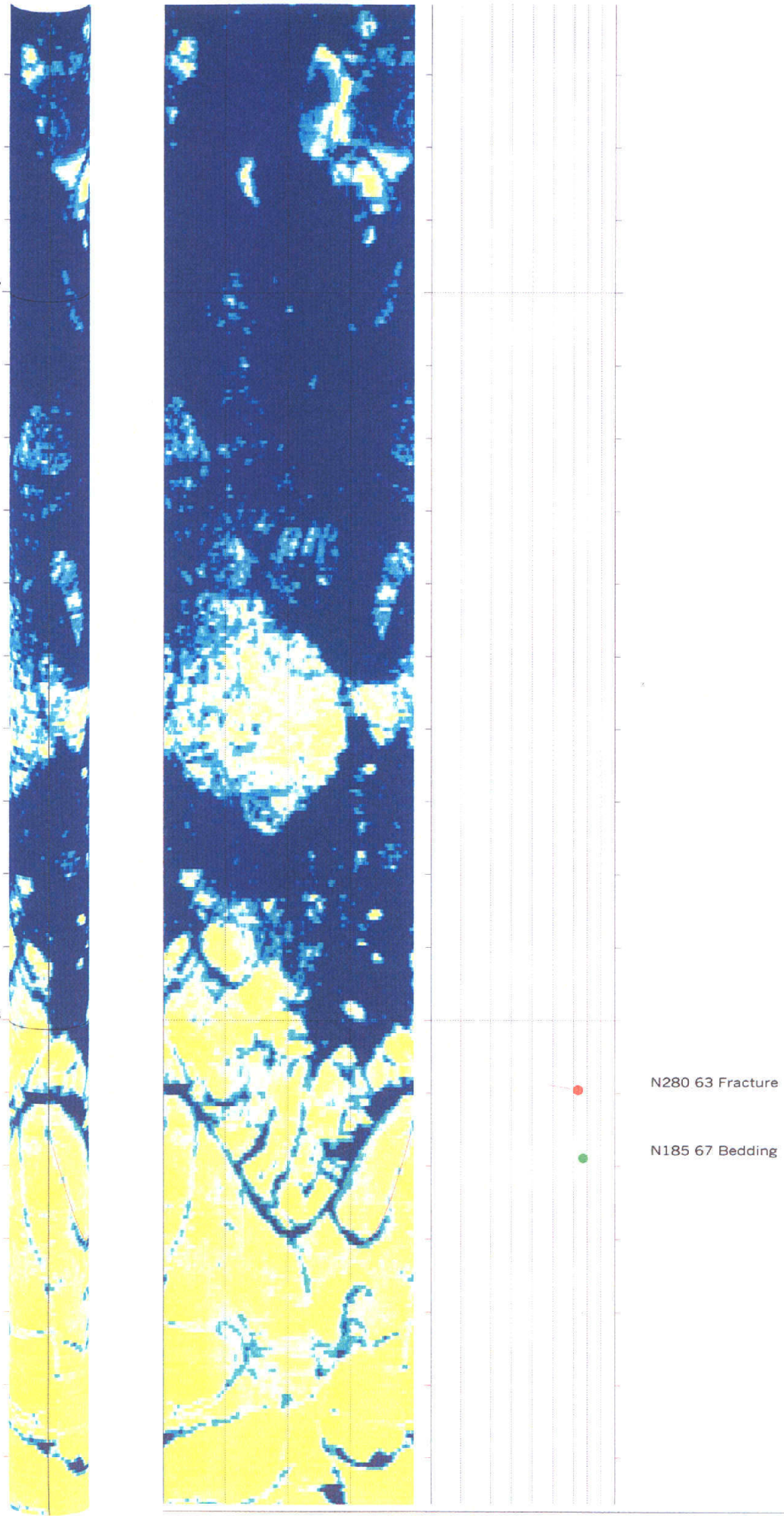
36
N182 69 Bedding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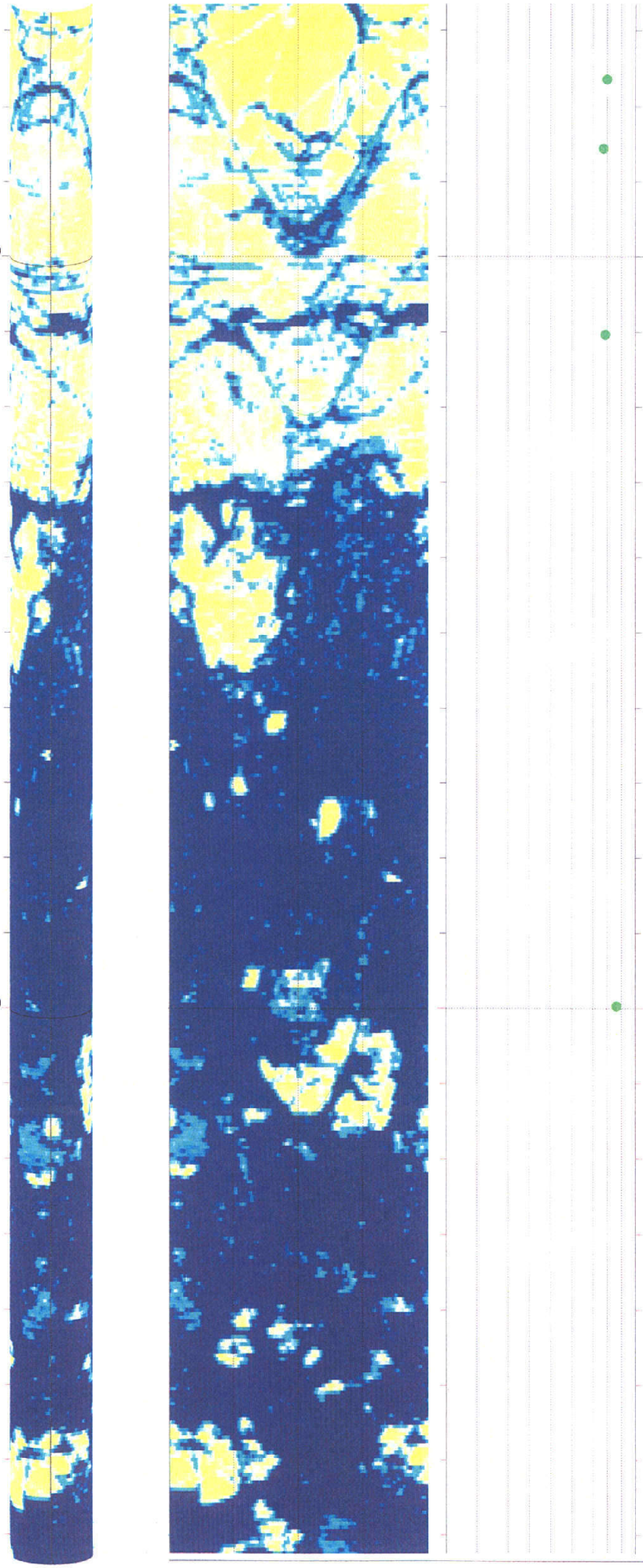
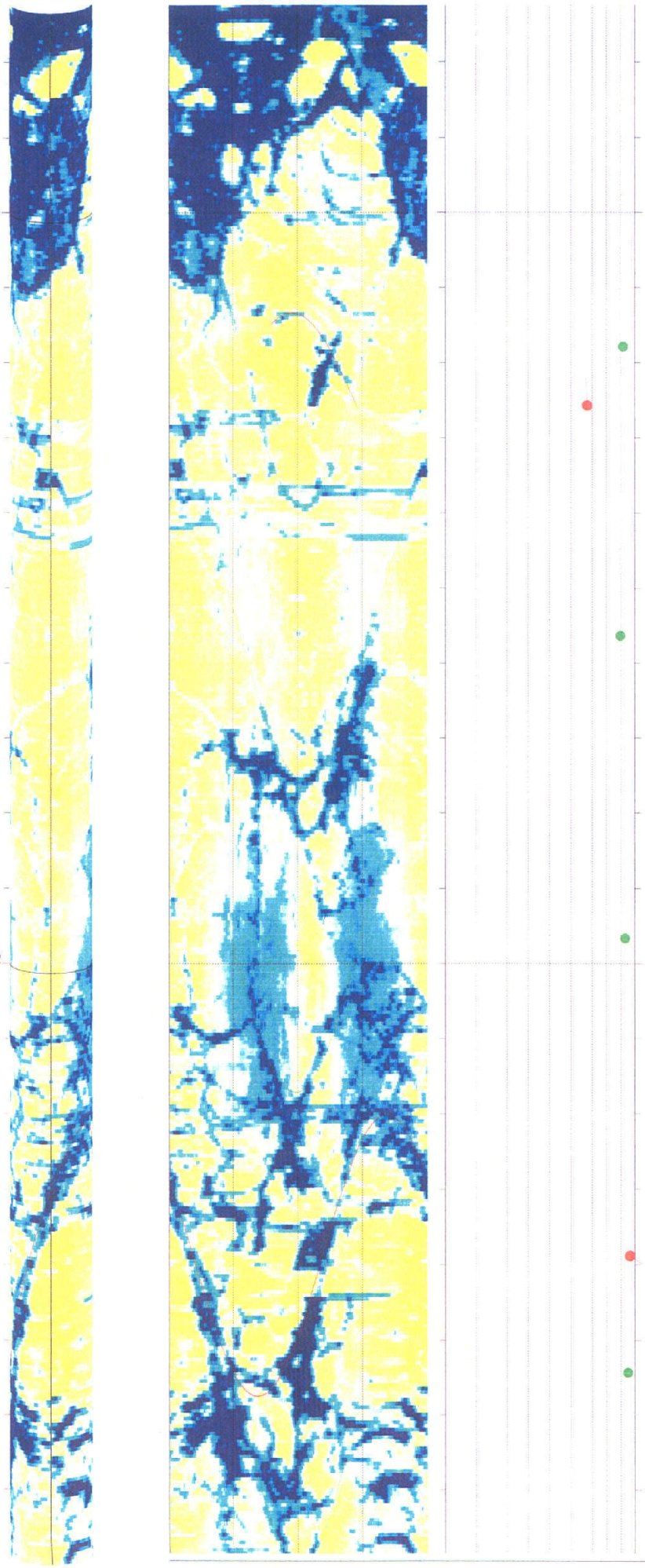
N280 63 Fracture
N185 67 Bedding



BH 02-18B

40.725 to 38.665m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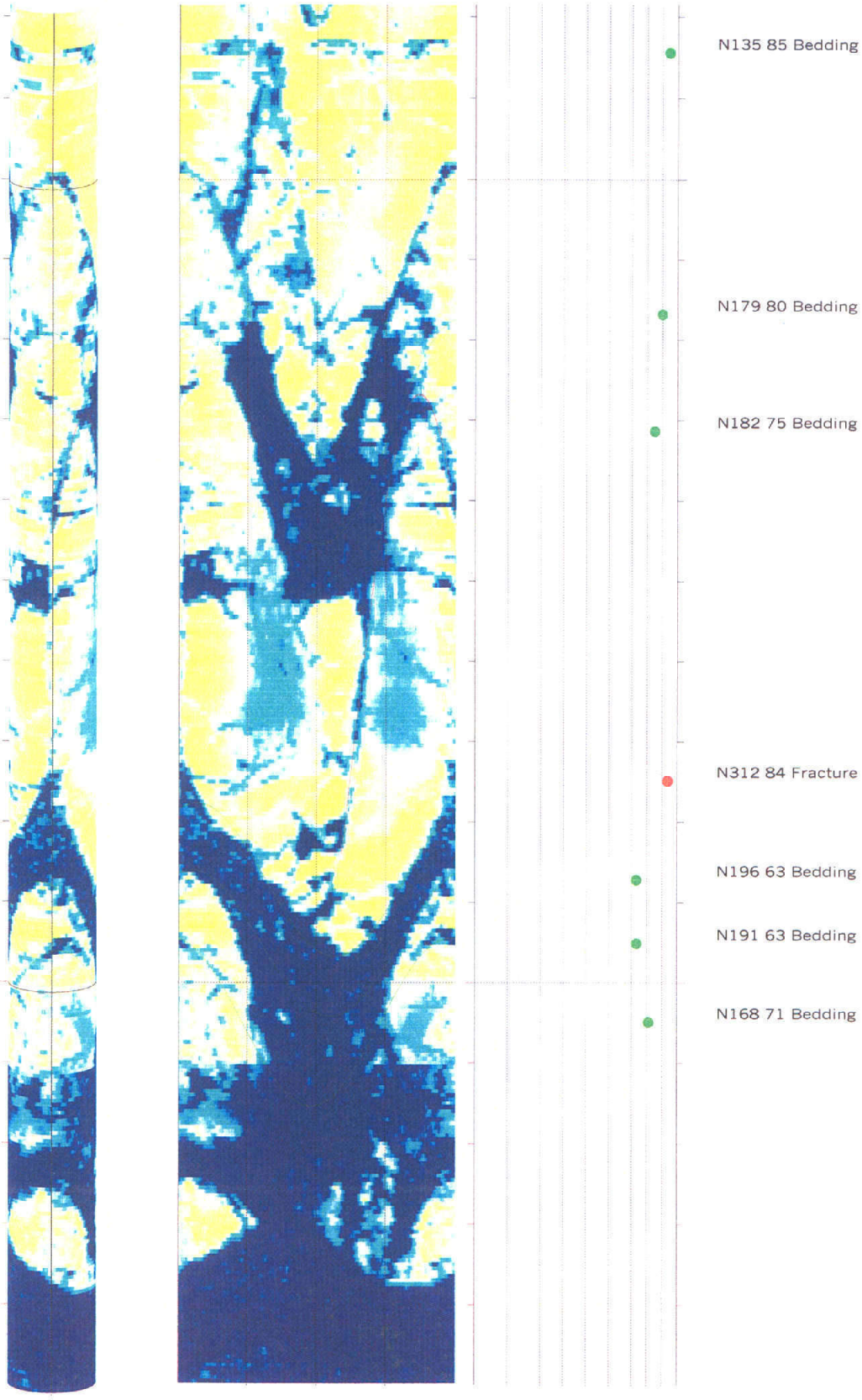
N184 82 Bedding
N357 58 Fracture Discontinuous
N187 80 Bedding
N174 83 Bedding
N123 87 Fracture
N180 85 Bedding


43
44
N135 85 Bedding
N179 80 Bedding
N182 75 Bedding
N312 84 Fracture
N196 63 Bedding
N191 63 Bedding
N168 71 Bedding

RGLDIPv6.1 OPTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole 02-18B
zone from 10.182 to 34.397 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	27.065	170	40.1	0.942	6	C	0	27.030	27.100	0.110	302.00	13.00	0.0000	Bedding
2	25.288	150	54.6	0.913	9	C	0	25.237	25.340	0.110	304.00	13.15	0.0000	Irregular Bedding
3	24.442	186	52.8	0.986	6	A	0	24.381	24.503	0.110	303.08	13.00	0.0000	Bedding
4	24.169	189	39.8	0.957	9	B	0	24.129	24.209	0.110	303.54	13.00	0.0000	Bedding
5	24.015	185	49.0	0.956	17	B	0	23.962	24.067	0.110	303.63	13.00	0.0000	Bedding
6	23.890	190	51.8	0.976	11	A	0	23.830	23.950	0.110	304.12	13.00	0.0000	Bedding
7	23.763	195	51.7	0.981	15	A	0	23.700	23.826	0.110	303.32	13.00	0.0000	Bedding
8	23.524	197	56.5	0.956	11	B	0	23.449	23.598	0.110	304.55	13.00	0.0000	Bedding
9	21.012	207	50.2	0.900	7	C	0	20.946	21.078	0.110	302.32	13.00	0.0000	Irregular Bedding
10	20.821	221	25.3	0.957	7	B	0	20.790	20.852	0.110	304.00	13.00	0.0000	Irregular Bedding
11	19.156	166	48.7	0.976	8	A	0	19.110	19.202	0.110	304.00	13.00	0.0000	Bedding
12	18.693	152	75.2	0.996	6	A	2	18.581	18.806	0.110	303.00	13.00	0.0000	Fracture
13	18.524	192	63.4	0.955	8	B	2	18.432	18.617	0.110	303.00	13.00	0.0000	Fracture
14	18.425	196	58.8	0.964	10	B	0	18.344	18.507	0.110	303.00	13.00	0.0000	Bedding
15	18.282	184	61.5	0.969	6	B	2	18.277	18.363	0.110	302.29	13.00	0.0000	Fracture Discontinuous
16	18.221	176	62.9	0.977	9	A	2	18.164	18.301	0.110	303.51	13.00	0.0000	Fracture Discontinuous
17	18.055	175	32.8	0.949	9	B	0	18.028	18.083	0.110	303.18	13.00	0.0000	Irregular Bedding
18	17.775	174	65.2	0.972	8	B	0	17.699	17.861	0.110	304.00	13.00	0.0000	Discontinuous Bedding
19	17.718	171	61.5	0.984	5	A	0	17.659	17.791	0.110	304.00	13.00	0.0000	Bedding
20	17.611	167	65.5	0.952	18	B	0	17.529	17.694	0.110	304.00	13.00	0.0000	Bedding
21	17.523	169	59.6	0.964	12	B	0	17.456	17.591	0.110	304.00	13.00	0.0000	Bedding
22	17.458	181	60.5	0.968	10	B	0	17.382	17.534	0.110	304.00	13.00	0.0000	Bedding
23	17.396	177	66.3	0.921	8	C	0	17.305	17.486	0.110	304.99	13.00	0.0000	Bedding
24	17.271	176	59.9	0.966	10	B	0	17.199	17.343	0.110	303.00	13.00	0.0000	Bedding
25	17.209	176	59.1	0.894	10	D	0	17.138	17.280	0.110	301.26	13.00	0.0000	Irregular Bedding
26	17.036	168	63.3	0.911	12	C	0	16.959	17.113	0.110	303.00	13.00	0.0000	Bedding
27	16.957	180	63.1	0.967	10	B	0	16.874	17.040	0.110	303.77	13.00	0.0000	Irregular Bedding
28	16.785	136	62.3	0.965	11	B	0	16.721	16.850	0.110	302.79	13.00	0.0000	Irregular Bedding
29	14.782	196	62.9	0.972	7	B	2	14.688	14.877	0.110	304.28	12.00	0.0000	Fracture
30	14.598	122	89.2	0.952	13	B	2	14.456	14.822	0.110	304.96	13.00	0.0000	Fracture Discontinuous
31	14.374	192	70.1	0.950	13	B	2	14.250	14.497	0.110	304.00	12.00	0.0000	Fracture Irregular
32	11.099	182	63.0	0.947	20	B	0	11.018	11.181	0.110	308.06	13.00	0.0000	Bedding
33	10.932	193	61.3	0.970	10	B	0	10.849	11.014	0.110	309.58	13.00	0.0000	Bedding
34	10.867	191	58.8	0.914	10	C	0	10.794	10.941	0.110	311.00	13.00	0.0000	Bedding
35	10.763	187	62.5	0.981	9	A	0	10.683	10.843	0.110	312.32	13.00	0.0000	Bedding

36	10.692	188	61.0	0.978	7	A	0	10.616	10.769	0.110	313.00	13.00	0.0000	Bedding
37	10.342	91	54.2	0.949	9	B	2	10.284	10.400	0.110	321.19	13.00	0.0000	Fracture Irregular

RGLDIPv6.1 BHTV Discontinuity Table

K = 0: BEDDING
K = 2: FRACTURE

Borehole: 02-18B
zone from 44.500 to 21.210 meters

	Depth (m)	Azimuth (deg)	Dip (deg)	1-P0/100	n	Q	K	Upper Depth (m)	Lower Depth (m)	Well Diam (m)	Well deviation Azimuth (deg)	Well deviation Dev (deg)	Thickness	
1	44.049	168	71.2	0.960	5	B	0	43.945	44.154	0.110	304.00	13.00	0.0000	Bedding
2	43.951	191	63.3	0.871	14	D	0	43.860	44.042	0.110	304.00	13.00	0.0000	Bedding
3	43.872	196	63.1	0.930	11	C	0	43.777	43.967	0.110	304.00	13.00	0.0000	Bedding
4	43.749	312	83.7	0.977	8	A	2	43.666	44.229	0.110	304.00	13.00	0.0000	Fracture
5	43.314	182	75.1	0.918	11	C	0	43.174	43.453	0.110	304.00	13.00	0.0000	Bedding
6	43.169	179	79.9	0.966	10	B	0	42.992	43.345	0.110	304.00	13.00	0.0000	Bedding
7	42.845	135	84.8	0.995	5	A	0	42.675	42.740	0.110	304.00	13.00	0.0000	Bedding
8	42.544	180	85.1	0.950	8	B	0	42.548	42.801	0.110	304.00	13.00	0.0000	Bedding
9	42.388	123	86.6	0.920	7	C	2	42.202	42.575	0.110	304.00	13.00	0.0000	Fracture
10	41.966	174	83.1	0.923	8	C	0	41.849	42.171	0.110	304.00	13.00	0.0000	Bedding
11	41.563	187	79.8	0.976	7	A	0	41.374	41.756	0.110	304.00	13.00	0.0000	Bedding
12	41.257	357	57.6	0.996	4	A	2	41.134	41.249	0.110	304.00	13.00	0.0000	Fracture Discontinuous
13	41.179	184	81.7	0.977	8	A	0	41.016	41.391	0.110	304.00	13.00	0.0000	Bedding
14	39.997	180	76.5	0.982	6	A	0	39.879	40.145	0.110	304.00	13.00	0.0000	Bedding
15	39.103	185	68.6	0.913	6	C	0	38.996	39.210	0.110	304.00	13.00	0.0000	Bedding
16	38.856	181	67.4	0.977	7	A	0	38.757	38.954	0.110	304.00	13.00	0.0000	Bedding
17	38.764	180	70.0	0.992	5	A	0	38.775	38.872	0.110	304.00	13.00	0.0000	Bedding
18	38.189	185	67.0	0.951	8	B	0	38.089	38.289	0.110	304.00	13.00	0.0000	Bedding
19	38.096	280	63.3	0.974	5	A	2	38.150	38.305	0.110	304.00	13.00	0.0000	Fracture
20	35.263	182	68.9	0.944	7	C	0	35.157	35.369	0.110	304.00	13.00	0.0000	Bedding
21	34.325	173	57.5	0.924	7	C	0	34.260	34.389	0.110	304.00	13.00	0.0000	Bedding
22	34.130	179	47.2	0.940	8	C	0	34.082	34.177	0.110	304.00	13.00	0.0000	Bedding
23	33.784	163	69.6	0.913	7	C	0	33.689	33.878	0.110	304.00	13.00	0.0000	Bedding
24	33.235	182	74.1	0.951	9	B	0	33.101	33.368	0.110	304.00	13.00	0.0000	Bedding
25	32.805	181	69.9	0.971	6	B	0	32.695	32.914	0.110	304.00	13.00	0.0000	Bedding
26	31.506	127	88.0	0.968	5	B	2	31.492	31.712	0.110	304.00	13.00	0.0000	Fracture
27	31.430	316	38.8	0.972	4	B	2	31.361	31.476	0.110	304.00	13.00	0.0000	Fracture Discontinuous
28	29.820	274	70.8	0.964	11	B	2	29.424	29.840	0.110	304.00	13.00	0.0000	Fracture
29	28.783	190	63.9	0.958	7	B	0	28.691	28.876	0.110	304.00	13.00	0.0000	Discontinuous Bedding
30	28.664	183	64.3	0.968	8	B	0	28.576	28.753	0.110	304.00	13.00	0.0000	Irregular Bedding
31	28.276	162	70.0	0.957	6	B	0	28.181	28.372	0.110	304.00	13.00	0.0000	Bedding
32	27.996	161	68.7	0.948	5	B	0	27.905	28.086	0.110	304.00	13.00	0.0000	Irregular Bedding
33	27.168	185	36.8	0.845	7	D	0	27.133	27.203	0.110	304.00	13.00	0.0000	Crushed Bedding
34	26.686	257	49.1	0.973	7	A	2	26.596	26.776	0.110	304.00	13.00	0.0000	Fracture
35	24.899	199	57.5	0.926	9	C	0	24.820	24.978	0.110	304.00	13.00	0.0000	Bedding

36	24.244	187	43.0	0.924	7	C	0	24.200	24.288	0.110	304.00	13.00	0.0000	Bedding
37	23.240	200	55.1	0.911	7	C	0	23.167	23.313	0.110	304.00	13.00	0.0000	Bedding
38	22.923	213	34.0	0.962	5	B	0	22.883	22.963	0.110	304.00	13.00	0.0000	Bedding
39	22.459	179	47.1	0.955	5	B	0	22.412	22.507	0.110	304.00	13.00	0.0000	Irregular Bedding
40	22.262	200	68.3	0.883	14	D	2	22.141	22.384	0.110	304.00	13.00	0.0000	Fracture Irregular

Borehole: BH__02-18B Logged from 10 to 28 meters
Depth range: 0.000 - 34.396m extrapolated from 0 to 10 m

Depth m	Deviation components North m	East m	Down m	Devaz deg	Dev deg
1.046	0.084	-0.220	1.019	291.00	13.00
2.046	0.165	-0.430	1.994	291.00	13.00
3.046	0.246	-0.640	2.968	291.00	13.00
4.046	0.326	-0.850	3.942	291.00	13.00
5.046	0.407	-1.060	4.917	291.00	13.00
6.046	0.487	-1.270	5.891	291.00	13.00
7.046	0.568	-1.480	6.865	291.00	13.00
8.046	0.649	-1.690	7.840	291.00	13.00
9.046	0.729	-1.900	8.814	291.00	13.00
10.046	0.810	-2.110	9.789	291.00	13.00
11.046	0.926	-2.272	10.763	309.00	13.00
12.046	1.056	-2.452	11.738	305.00	13.00
13.046	1.187	-2.636	12.712	304.00	13.00
14.046	1.311	-2.818	13.688	305.00	13.00
15.046	1.435	-2.998	14.663	305.00	12.00
16.046	1.558	-3.179	15.639	304.00	13.00
17.046	1.683	-3.363	16.614	303.00	13.00
18.046	1.807	-3.550	17.588	303.00	13.00
19.046	1.931	-3.738	18.563	303.00	13.00
20.046	2.056	-3.925	19.537	305.00	13.00
21.046	2.180	-4.112	20.512	303.00	13.00
22.046	2.307	-4.300	21.485	303.00	13.00
23.046	2.434	-4.487	22.460	305.00	13.00
24.046	2.558	-4.673	23.434	303.00	13.00
25.046	2.683	-4.861	24.409	304.00	13.00
26.046	2.808	-5.048	25.383	303.00	13.00
27.046	2.932	-5.237	26.357	302.00	13.00
28.046	3.055	-5.425	27.331	304.00	13.00
29.046	3.180	-5.614	28.305	304.00	13.00
30.046	3.304	-5.804	29.279	304.00	13.00
31.046	3.432	-5.992	30.253	304.00	13.00
32.046	3.558	-6.178	31.227	305.00	13.00
33.046	3.682	-6.365	32.202	304.00	13.00
34.046	3.807	-6.555	33.176	303.00	14.00

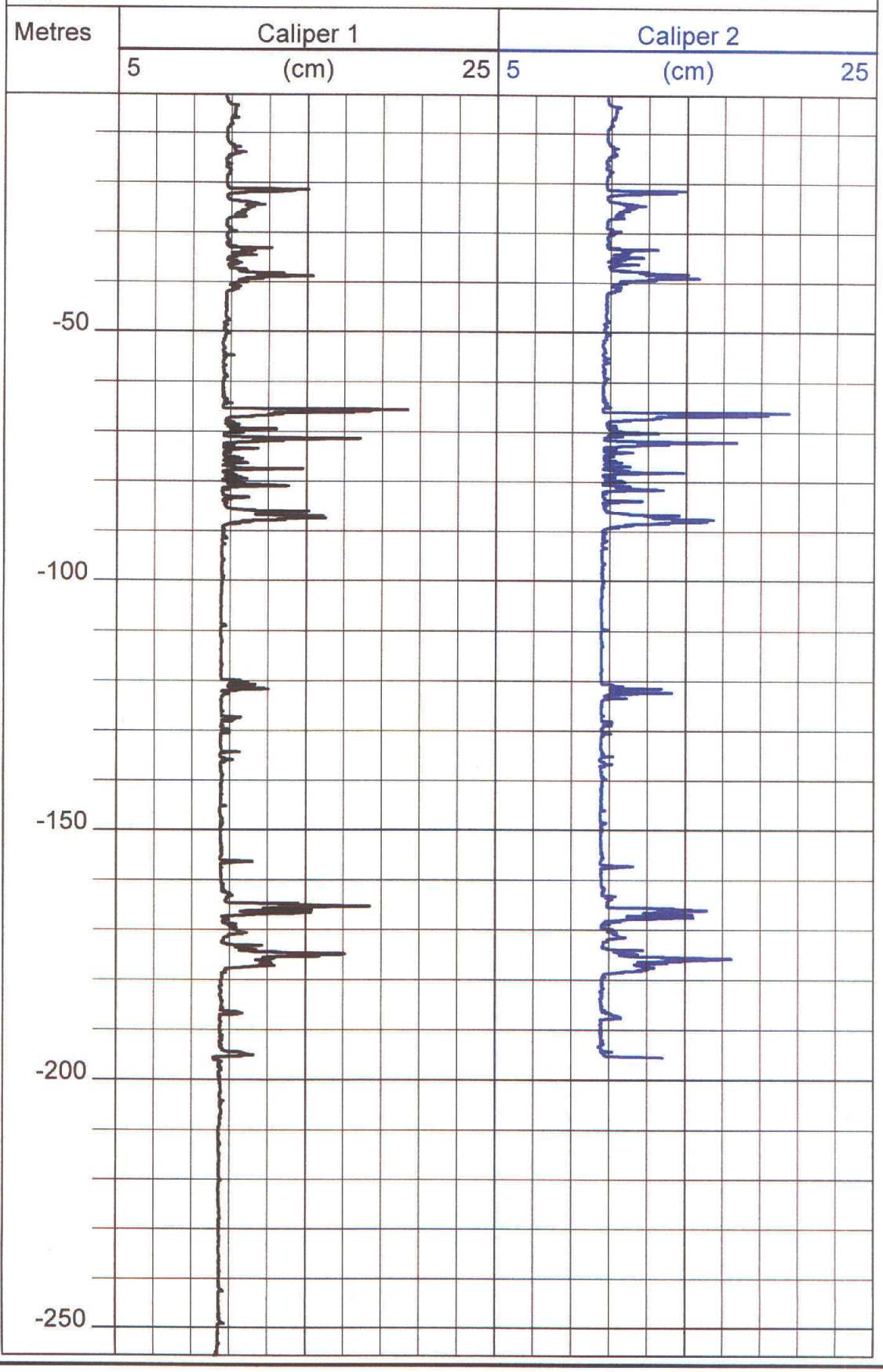
Borehole: BH__02-18B logged from 21 to 44.5 meters
Depth range: 0.000 - 44.500m extrapolated from 0 to 21 meters

Depth	Deviation components North	East	Down	Devaz	Dev
m	m	m	m	deg	deg
1.000	0.126	-0.186	0.974	304.00	13.00
2.000	0.252	-0.373	1.949	304.00	13.00
3.000	0.377	-0.559	2.923	304.00	13.00
4.000	0.503	-0.746	3.897	304.00	13.00
5.000	0.629	-0.932	4.872	304.00	13.00
6.000	0.755	-1.119	5.846	304.00	13.00
7.000	0.881	-1.305	6.821	304.00	13.00
8.000	1.006	-1.492	7.795	304.00	13.00
9.000	1.132	-1.678	8.769	304.00	13.00
10.000	1.258	-1.865	9.744	304.00	13.00
11.000	1.384	-2.051	10.718	304.00	13.00
12.000	1.509	-2.238	11.692	304.00	13.00
13.000	1.635	-2.424	12.667	304.00	13.00
14.000	1.761	-2.611	13.641	304.00	13.00
15.000	1.887	-2.797	14.616	304.00	13.00
16.000	2.013	-2.984	15.590	304.00	13.00
17.000	2.138	-3.170	16.564	304.00	13.00
18.000	2.264	-3.357	17.539	304.00	13.00
19.000	2.390	-3.543	18.513	304.00	13.00
20.000	2.516	-3.730	19.487	304.00	13.00
21.000	2.642	-3.916	20.462	304.00	13.00
22.000	2.767	-4.103	21.436	304.00	13.00
23.000	2.893	-4.289	22.411	304.00	13.00
24.000	3.019	-4.476	23.385	304.00	13.00
25.000	3.145	-4.662	24.359	304.00	13.00
26.000	3.271	-4.849	25.334	304.00	13.00
27.000	3.396	-5.035	26.308	304.00	13.00
28.000	3.522	-5.222	27.282	304.00	13.00
29.000	3.648	-5.408	28.257	304.00	13.00
30.000	3.774	-5.595	29.231	304.00	13.00
31.000	3.900	-5.781	30.205	304.00	13.00
32.000	4.025	-5.968	31.180	304.00	13.00
33.000	4.151	-6.154	32.154	304.00	13.00
34.000	4.277	-6.341	33.129	304.00	13.00
35.000	4.403	-6.527	34.103	304.00	13.00
36.000	4.528	-6.714	35.077	304.00	13.00
37.000	4.654	-6.900	36.052	304.00	13.00
38.000	4.780	-7.087	37.026	304.00	13.00
39.000	4.906	-7.273	38.000	304.00	13.00
40.000	5.032	-7.460	38.975	304.00	13.00
41.000	5.157	-7.646	39.949	304.00	13.00
42.000	5.283	-7.833	40.924	304.00	13.00
43.000	5.409	-8.019	41.898	304.00	13.00
44.000	5.535	-8.206	42.872	304.00	13.00

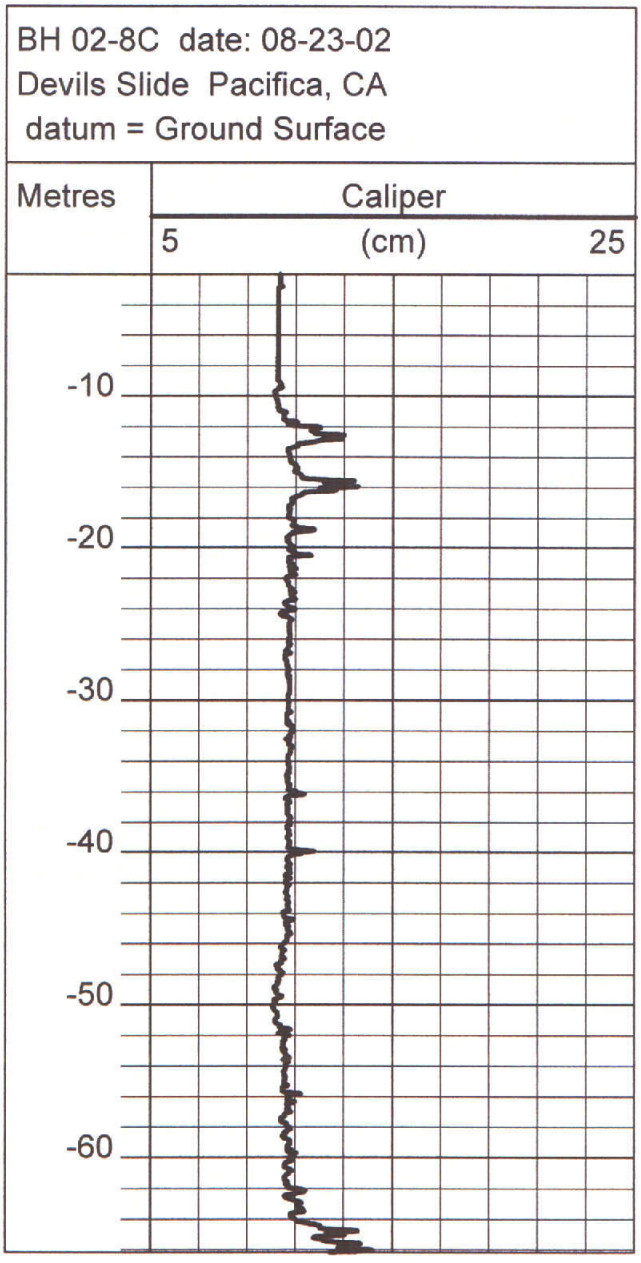
Appendix I

CALIPER LOGS

BH 02-05 dates: 09-26-02 & 09-28-02
Devil's Slide, Pacifica, CA
Datum =Ground Surface



BH 02-8C date: 08-23-02
Devils Slide Pacifica, CA
datum = Ground Surface



NORCAL

GEOLOGIC AND GEOTECHNICAL SITE CHARACTERIZATION

VOLUME 3 – IN-SITU TESTING

DEVIL'S SLIDE TUNNELS PROJECT

Prepared for
Caltrans
and
HNTB Corporation

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VOLUME 3 – IN-SITU TESTING

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Pressuremeter Testing

for

Devil's Slide Tunnels Project
Geotechnical Site Exploration
Task order 2B

submitted to

Earth Mechanics, Inc.
17660 Newhope Street, Suite E
Fountain Valley, CA 92708

October 30 2002
EMI Project No. 02-134
Hughes Insitu Engineering Report No. C-259

HUGHES INSITU ENGINEERING INC.
Suite 804, 938 Howe Street, Vancouver B.C. Canada V6Z-1N9
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View South near Hole 02-5 at the summit of the alignment of Devil's Slide Tunnels

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1.0 INTRODUCTION

This report outlines the results of a pressuremeter study conducted September 15-22, 2002 in holes 02-2 and 02-5 along the alignment of the Devil's Slide Tunnel South of Pacifica, CA.

The pressuremeter testing was performed by Hughes Insitu Engineering Inc., of Vancouver, B.C., Canada, for Earth Mechanics Inc., Fountain Valley, CA. The field work at these locations and the testing was under the direction of Mr. M. Kapuskar, G.E. of Earth Mechanics, Inc. This work is covered under the CALTRANS contract number 59A0234, Task Order 2B.

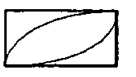
2.0 PRESSUREMETER

The pressuremeter used for this study, shown in Photograph 1, is a monocell pressuremeter. At the center of the pressuremeter are three electronic radial displacement sensors, spaced 120 degrees apart. Over these sensors is the flexible membrane, clamped at each end, which is pressurized to deform the adjacent rock. The membrane is covered by a protective sheet of stainless steel strips pre-bent to the initial shape of the borehole wall. The essential details of the instrument are shown in Fig. 1.

The displacements are measured by a sensor, which follows the movement at the center of the 100 mm long rigid plates over the sensors. These plates are free to rotate as they follow the expanding membrane. The measured displacement is a "minimum average" measurement of the membrane over the length of the plates, as shown on the left of Fig. 1. The signals from these sensors are transmitted by cable to the surface. During the test, the average expansion against pressure curve is displayed on a laptop computer screen.

The pressuremeter can be expanded either by manually pumping hydraulic oil to the instrument or controlling the flow of compressed nitrogen. With oil, the pressure that can be applied to the membrane can be up to 20 MPa. With air, the pressure is limited to the pressure in the gas tank of about 14 MPa.

In deep holes in which the mud pressure in the hole is low, oil cannot be used, as the pressuremeter will expand as it is lowered into the hole. This is as a result of the hydraulic pressure head in the lines acting on the membrane, which is not balanced by the mud pressure in the hole. Hence, in these holes, which were over 50 m in depth, with a low mud pressure in the holes, compressed air had to be used to inflate the membrane. With the pressure loss in the 200 m air lines, it was only possible to conduct two tests to 10 MPa before the supply of compressed gas available at the site was used up.



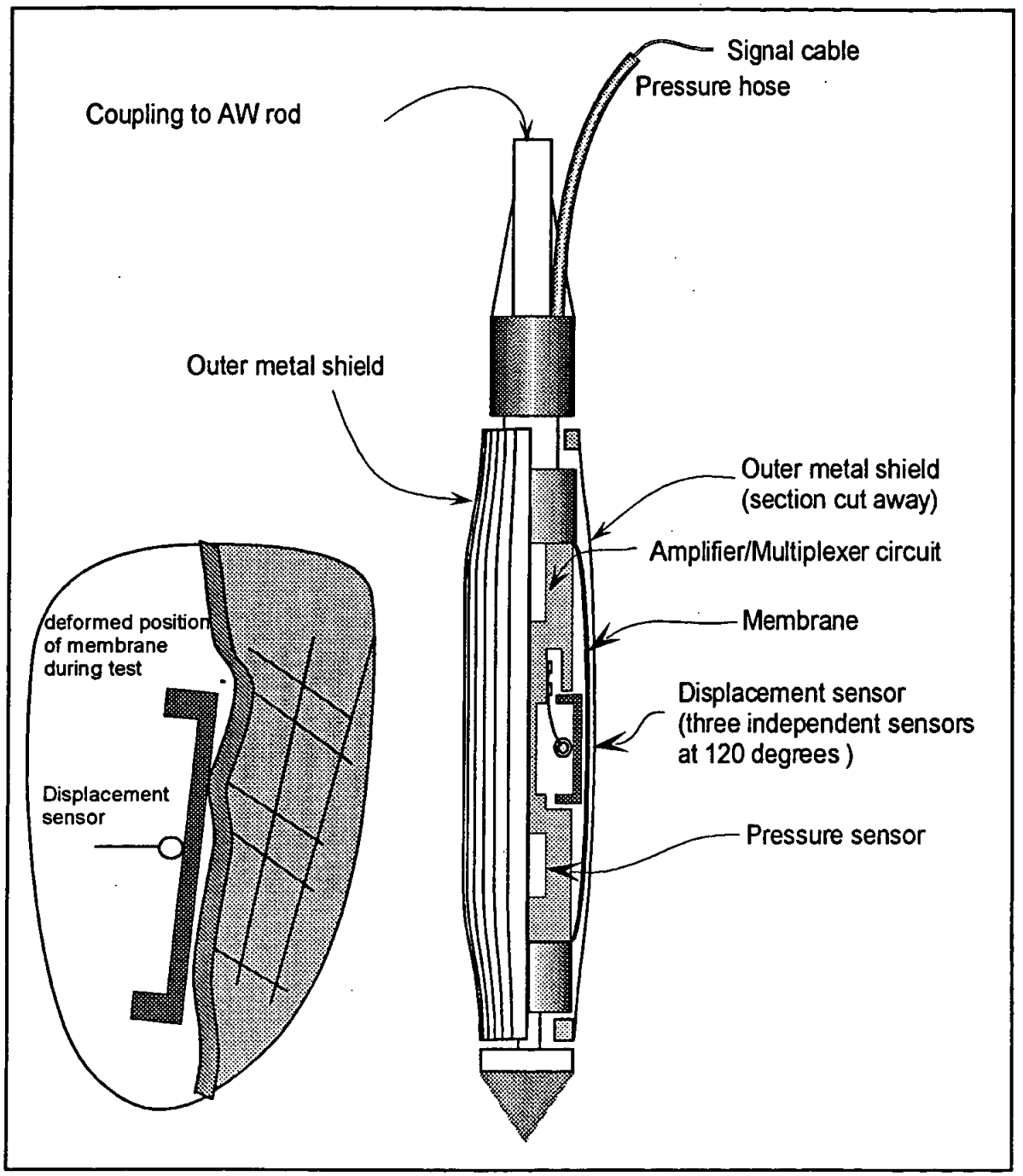


Figure 1

Schematic Outline of Pressuremeter

Photograph 1. Pressuremeter after Test 2 at Hole 02-5
(Note creases in the membrane from fractures in the rock)

3.0 HOLE FORMATION

The pressuremeter used for this study was designed to be deployed down a 76 mm diameter N-size hole. However, as the desired rock core size was H-diameter, all of the drill rigs were set up to take H cores. To accommodate the pressuremeter at the specified locations, a pocket was drilled with an N-size core barrel. Although this returned a smaller core than desired in all cases, the hole was well suited for pressuremeter testing. The pressuremeter was lowered into these pockets of freshly cored rock on BW rods.

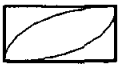
The locations of the pressuremeter tests were decided on site from inspection of the core by the geologist. The test depths and basic data are given in Table I. Two sets of two tests were performed in boreholes 02-2 and 02-5, for a total of 8 tests. Photographs 2-7 show the cores obtained at the locations of tests 3 to 8.

With the exception of Tests 7 and 8, the test pocket was approximately 1.5 m long. In this pocket two tests were performed. The pocket was intentionally kept short, to try and reduce the danger of fractured material falling behind the pressuremeter and making it difficult to withdraw the instrument through the H casing after the test.

Pressuremeter Testing, Devil's Slide Tunnels

Table I. Summary of basic rock properties

Test	Date	Hole	Depth (m)	Rock type	% Recovery	% RQD of sampling over Complete core run	% RQD over pressuremeter test interval (0.4m)
1	9-17-02	02-5	103.2	Sandstone, fresh, hard	100	55	61
2	9-17-02	02-5	102.7	Sandstone, fresh, hard	100	55	77
3	9-18-02	02-2	46.6	Quartz diorite, fractured	100	32	0
4	9-18-02	02-2	46.2	Quartz diorite, massive	100	100	100
5	9-18-02	02-2	53.0	Diorite joint	100	90	80
6	9-18-02	02-2	52.6	Diorite massive	100	100	100
7	9-19-02	02-5	169.2	Jointed claystone/clay filling	100	61	20
8	9-19-02	02-5	168.7	Jointed claystone/clay filling	100	61	40



During the drilling for the N-size test pocket for the final zone in Hole 02-5 at 166 m, the rock was very fractured, and the recovery was poor. Rather withdraw the N string, and advance the H casing, which at this stage was close to the proposed tunnel level, an attempt was made to continue coring with the N core until less fractured core was obtained. This was not achieved until the N hole was advanced approximately 5 m below the H casing. The final two tests were then conducted, at depths of 169.2 m and 168.7 m. Unfortunately, material fell in behind the pressuremeter, and prevented it being withdrawn through the H casing. Although the instrument was successfully recovered by retracting the H casing with the pressuremeter jammed inside the cutting shoe, considerable time was lost.

4.0 TEST PROCEDURE AND EVALUATION

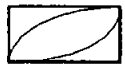
The general description of the test is best illustrated with reference to Test 7, at 169.2 m, in Hole 02-5 (Fig. 2). The rock at this location was a jointed claystone with some clay filling in the joints. Although there was 100% recovery, the RQD value, over the pressuremeter test section, was only 20%. Hence, this material is essentially an assemblage of closely fitting rock fragments, each fragment with a crushing strength probably in excess of 20 MPa. The core taken at the location of Test 7 is shown in Photograph 6.

After the pressuremeter was inserted to the bottom of the N size cored hole, the membrane was expanded by controlling the flow of compressed nitrogen from a tank at the surface, down through the 200 m long umbilical cable leading to the instrument. As pressure was applied to force the membrane against the borehole wall, the fractured blocks of rock moved or slid against each other and distorted in some elastic manner. The general stiffness of this mass behavior is given by the slope of the line A-B (Fig. 2.)

If the material is assumed to behave in an idealized manner, as an elastic homogeneous material, which does not fail under shear or tension, then the shear modulus of the mass of the material can be calculated from the general slope of this line (Mair and Wood, 1988).

For Test 7, the shear modulus G is given by:
$G = 0.5 \times \Delta(\text{Pressure})/\Delta(\text{radial displacement/radius})$
G = 224Mpa as shown in Fig. 2.

The Young's modulus E can be determined from the shear modulus G. However, a Poisson's ratio, μ, must be assumed as $E=2G(1+\mu)$.



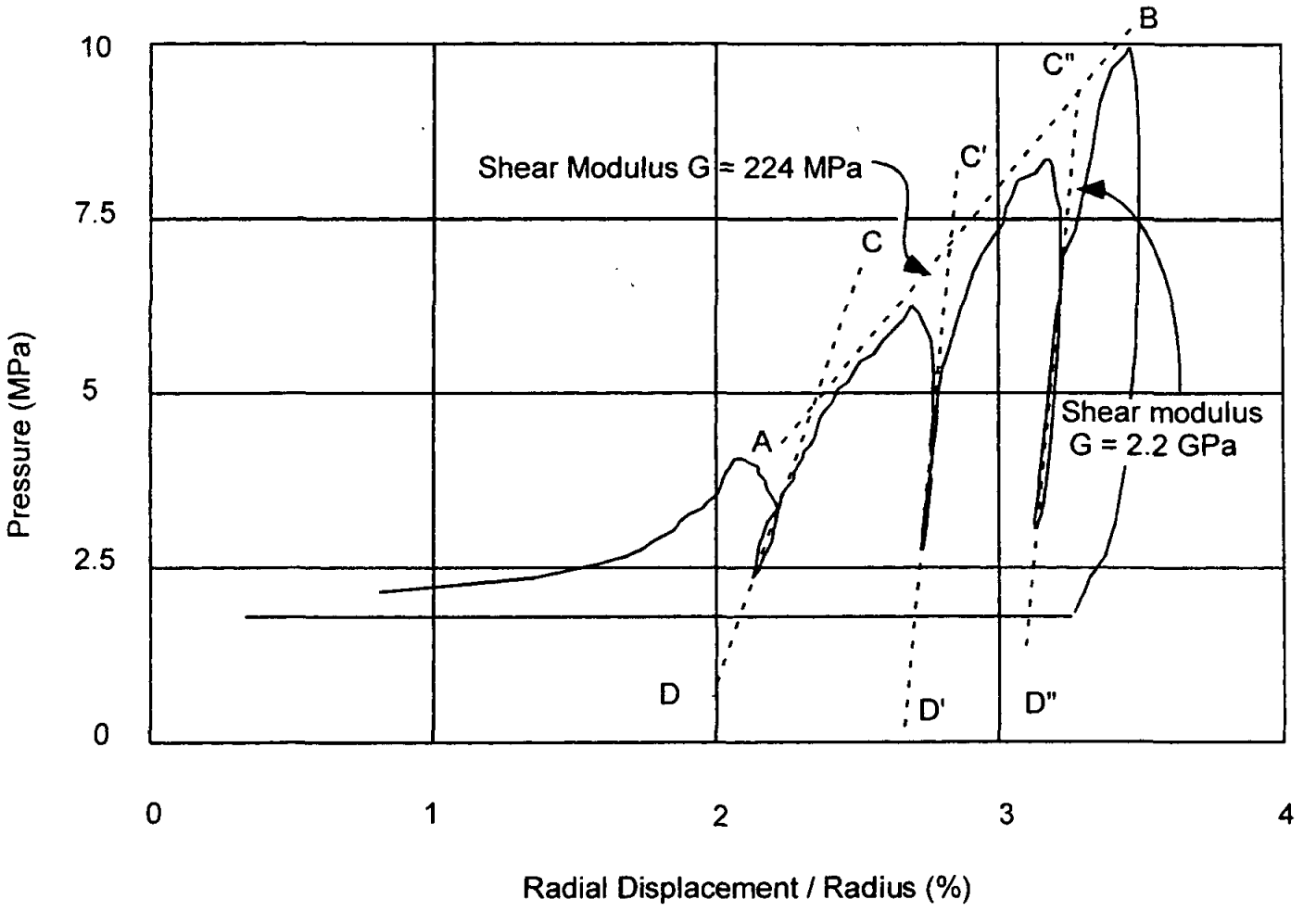


Fig. 2. Pressure-expansion curve for Test 7 at 169.2 m depth in Hole 02-5

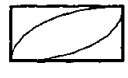
At three stages during this general loading the pressure was reduced, then increased again (CD, C'D' and C''D''). The general stiffness measured during this unloading/loading phase is usually well above the initial loading stiffness. During this stage, the fractured rock blocks are not sliding or moving relative to each other. The rock mass is probably responding more in an elastic manner, somewhat indicative of the intact rock. In general, the slopes of these unload-reload curves tend to become parallel. The slope of the initial unload curves are often flatter than the latter curves. This is probably a result of the disturbance and stress relief as a result of the formation of the hole. If the material is assumed to behave in an ideal elastic homogeneous manner, then the shear modulus of the intact material is in the order of 2.2 GPa (C''D''), as shown in Fig. 2.

If the material were much weaker, with a compressive strength less that 10 MPa, then the general shape of the initial loading curve would show significant curvature as the material shears under the pressure applied by the pressuremeter. However, there is no indication of mass shearing under the pressures that could be applied in this test. Hence, the shear strength of this material is likely to be in excess of 10 MPa.

Pressuremeter Testing at the Devil's Slide Tunnels

Table II. Summary of shear modulus determined from the pressuremeter

Test	Date	Hole	Depth (m)	Rock type	"Intact" Shear Modulus G (MPa)	"Mass" Shear Modulus G (MPa)
1	9-17-02	02-5	103.2	Sandstone, fresh, hard	>20,000	650
2	9-17-02	02-5	102.7	Sandstone, fresh, hard	3,500	450
3	9-18-02	02-2	46.6	Quartz diorite, fractured	2,000	120
4	9-18-02	02-2	46.2	Quartz diorite, massive	3,700	1,400
5	9-18-02	02-2	53.0	Diorite (one joint in pm section)	>20,000	2,600
6	9-18-02	02-2	52.6	Diorite massive (one crack)	>20,000	1,400
7	9-19-02	02-5	169.2	Jointed claystone/clay filling	2,200	250
8	9-19-02	02-5	168.7	Jointed claystone/clay filling	3,700	400



5.0 TEST RESULTS

Table II gives the average shear moduli, G, determined by the approach described in Section 4.0. The pressure-displacement curves for all of the tests are given in Appendix A.

Although the pressuremeter can be used to stress the rock to a stress greater than expected under design load, it does so in a horizontal direction. Because of the complex fracture pattern and spacing of the joints, the relationship between the vertical behavior and the horizontal behavior, as determined from the pressuremeter, is not readily apparent. Hence, the pressuremeter test in fractured rock is essentially an index test.

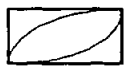
Based on the extensive testing of Franciscan rock obtained at the 2000 San Francisco-Oakland Bay Bridge investigation (Fugro-Earth Mechanics 2001), a tentative correlation between the Young's Modulus obtained from unload-reload loops from unconfined laboratory testing, and the Young's Modulus calculated from the pressuremeter data unload-reload loops, was found in that type of rock. However, in comparison to laboratory tests, the pressuremeter test stresses a larger block of rock. Therefore, as the pressuremeter tests a large block of rock, the material properties are such that the mass modulus and the load-unload modulus probably reflect the in-situ material behavior, at least in the horizontal direction.

The testing intervals were, in general, selected to test representative rock types. However at each test location the tests were conducted in pairs, between 0.4 m and 0.5 m apart. The purpose of conducting two tests so close together was to determine whether, in the same rock type, the tests were consistent with each other in the same rock type. In general that was the case. Therefore, the tests are probably representative of the zones of rock tested.

The pressuremeter tests 5 and 6 in the diorite at Hole 02-2 at 52-53 m depth are in massive material. However, in the vicinity of the tests, there is either an old joint (Test 6) or a fresh crack (Test 5). During these tests, particularly in Test 6, there is a very large step in the strain during the initial loading part of the test (Appendix A). At 8 MPa, the strain steps 0.5 %, after which little movement occurs. A similar step occurs, but at a lower stress level, in Test 6 (Appendix A). After reaching the maximum pressure, a final unload-reload cycle was conducted in Test 6 over an 8 MPa stress range. The slope of this final unload-reload loop indicated the material to be very stiff, having a shear modulus in excess of 20 GPa. Hence, during the test, there probably has been a sudden movement along the joint or the crack, after which the movement in the rock has stabilized. Therefore the cracking is probably very localized.

In contrast, the cracking in Test 7 is probably much more extensive, as the unload-reload loops, which are parallel, have a much lower slope, indicating a shear modulus of 2.2 GPa.

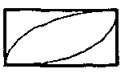
At the completion of the testing, the pressuremeter was expanded in a steel tube to check on the compressibility of the membrane and measuring system. The results of this test shown in Appendix B indicate the membrane and measuring system have a very low compressibility. However, the accuracy of the pressure and displacement sensors is not sufficient to measure a modulus above 20 GPa.



6.0 REFERENCES

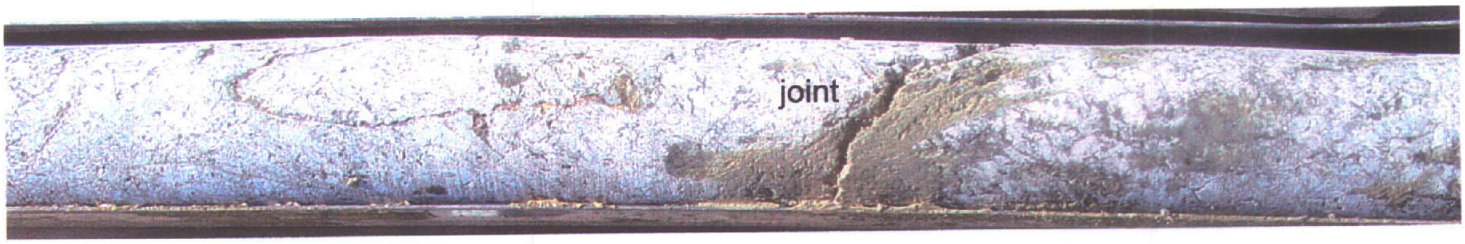
Fugro-Earth Mechanics. 2001. Final Yerba Buena Island Geotechnical Site Characterization Report, San Francisco Seismic Safety Project, Vol. 4.

Mair, R.J. and Wood, D.M. 1987. Pressuremeter testing: methods and interpretation. CIRIA Ground Engineering Report. Butterworths, London.



Photograph 2. Test 3 at 46.6 m in Hole 02-2 Fractured quartz diorite
RQD over pressuremeter testing area 0% G unload-reload = 2,000 MPa

Photograph 3. Test 4 at 46.2 m in Hole 02-2 Massive quartz diorite
RQD over pressuremeter testing area 100% G unload-reload =3,700MPa



Photograph 4. Test 5 at 53.0 m in hole 02-2 Massive diorite
RQD over pressuremeter testing area 80% G unload reload = 20,000 MPa

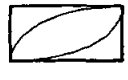
Photograph 5. Test 6 at 52.6 m in hole 02-2 Massive diorite
RQD over pressuremeter testing area 100% G unload-reload = 20,000 MPa

Photograph 6. Test 7 at 169.2 m in Hole 02-5. Jointed claystone/clay filling RQD over pressuremeter testing area 20% G unload-reload = 3,000 MPa

Photograph 7. Test 8 at 168.7 m in Hole 02-5 Jointed claystone/clay filling RQD over pressuremeter testing area 40% G unload-reload = 3,500 MPa

Appendix A

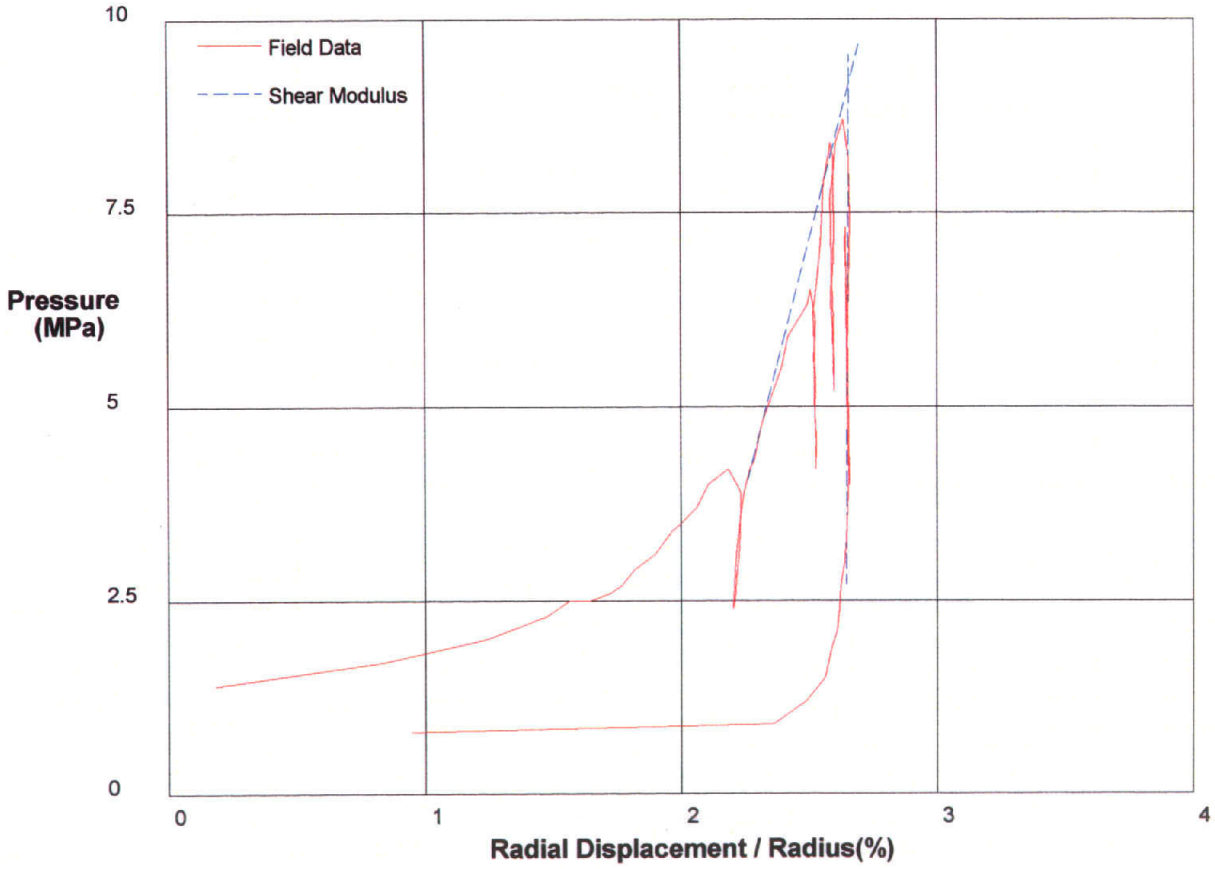
Basic data
Pressure-expansion curves for all of the tests



PRESSUREMETER DATA **Earth Mechanics, Inc.**

Devil's Slide Tunnel Project (02-134) **September 17, 2002**

Hole No. 02-5 **Depth 103.2 m** **File C:\DATA\C-259\DEV1AS.P**



Shear Modulus 32833 MPa

Shear Modulus 642 MPa

shift 1

HUGHES

PRESSUREMETER DATA **Earth Mechanics, Inc.**

Devil's Slide Tunnel Project (02-134) **September 17, 2002**

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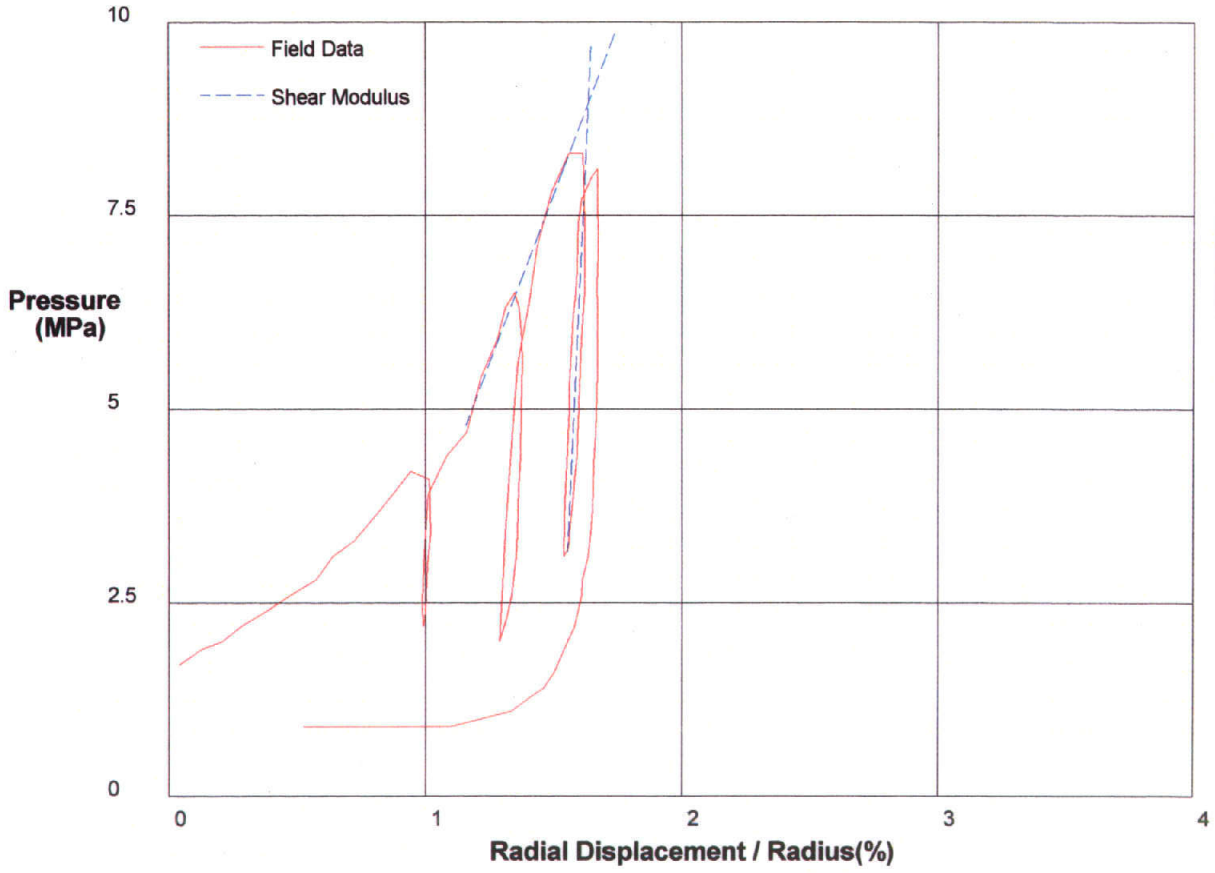

Shear Modulus 3500 MPa

Shear Modulus 435 MPa

shift 1

HUGHES

PRESSUREMETER DATA **Earth Mechanics, Inc.**

Devil's Slide Tunnel Project (02-134) **September 18, 2002**

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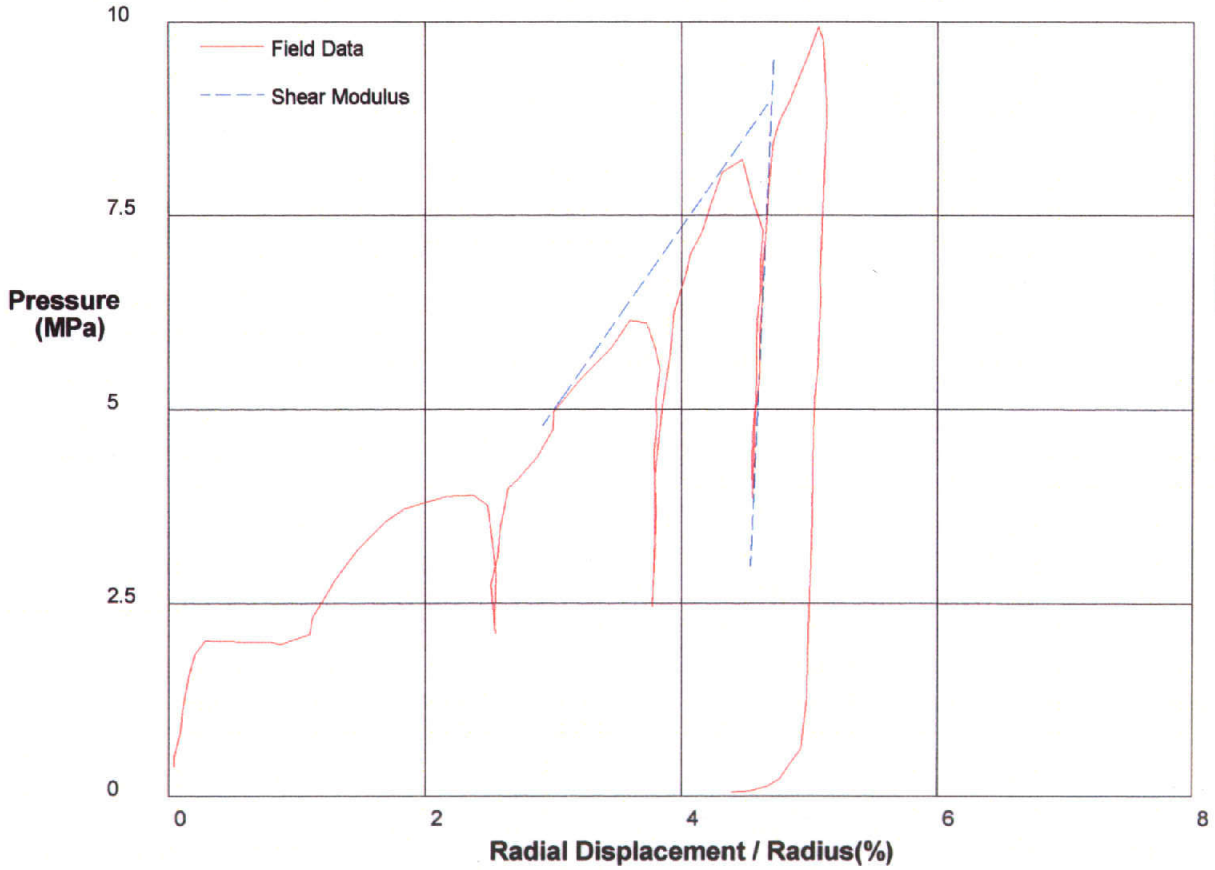


Shear Modulus 1857 MPa

Shear Modulus 117 MPa

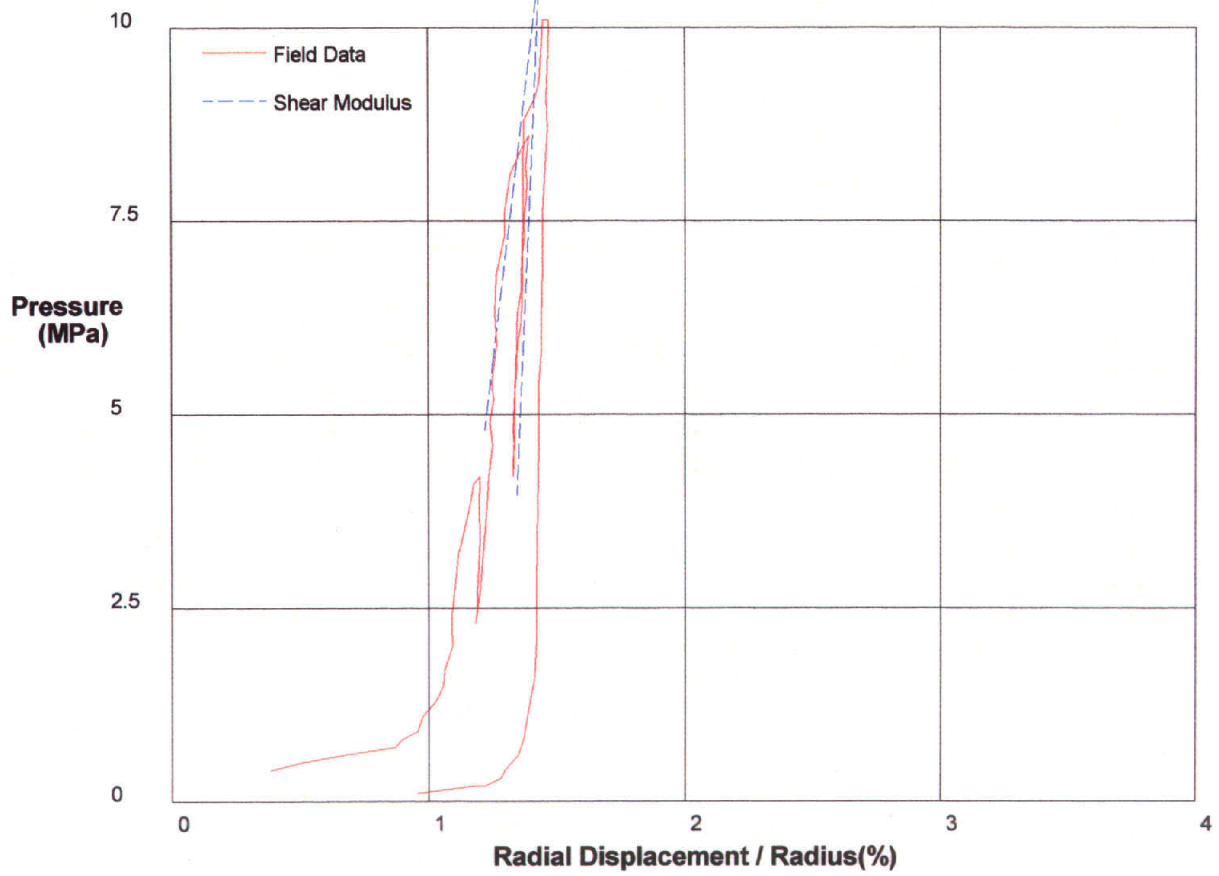
shift 0

HUGHES

PRESSUREMETER DATA **Earth Mechanics, Inc.**

Devil's Slide Tunnel Project (02-134) **September 18, 2002**

Hole No. 02-2 **Depth 46.2 m** **File C:\DATA\C-259\DEV4AS.P**

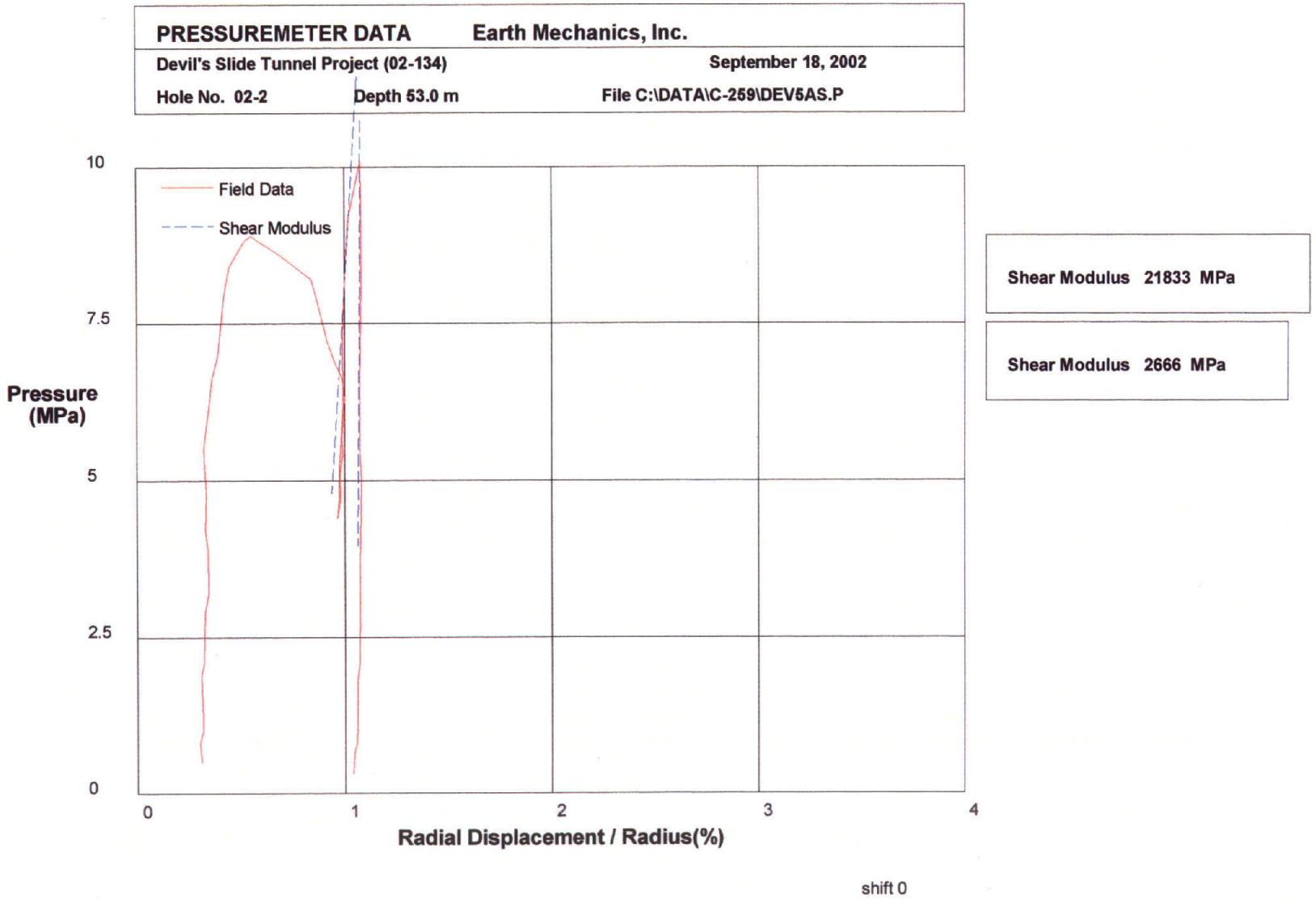


Shear Modulus 3715 MPa

Shear Modulus 1378 MPa

shift 3

HUGHES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Earth Mechanics, Inc.
Devil's Slide Tunnel Project (02-134)
September 18, 2002
Hole No. 02-2
Depth 53.0 m
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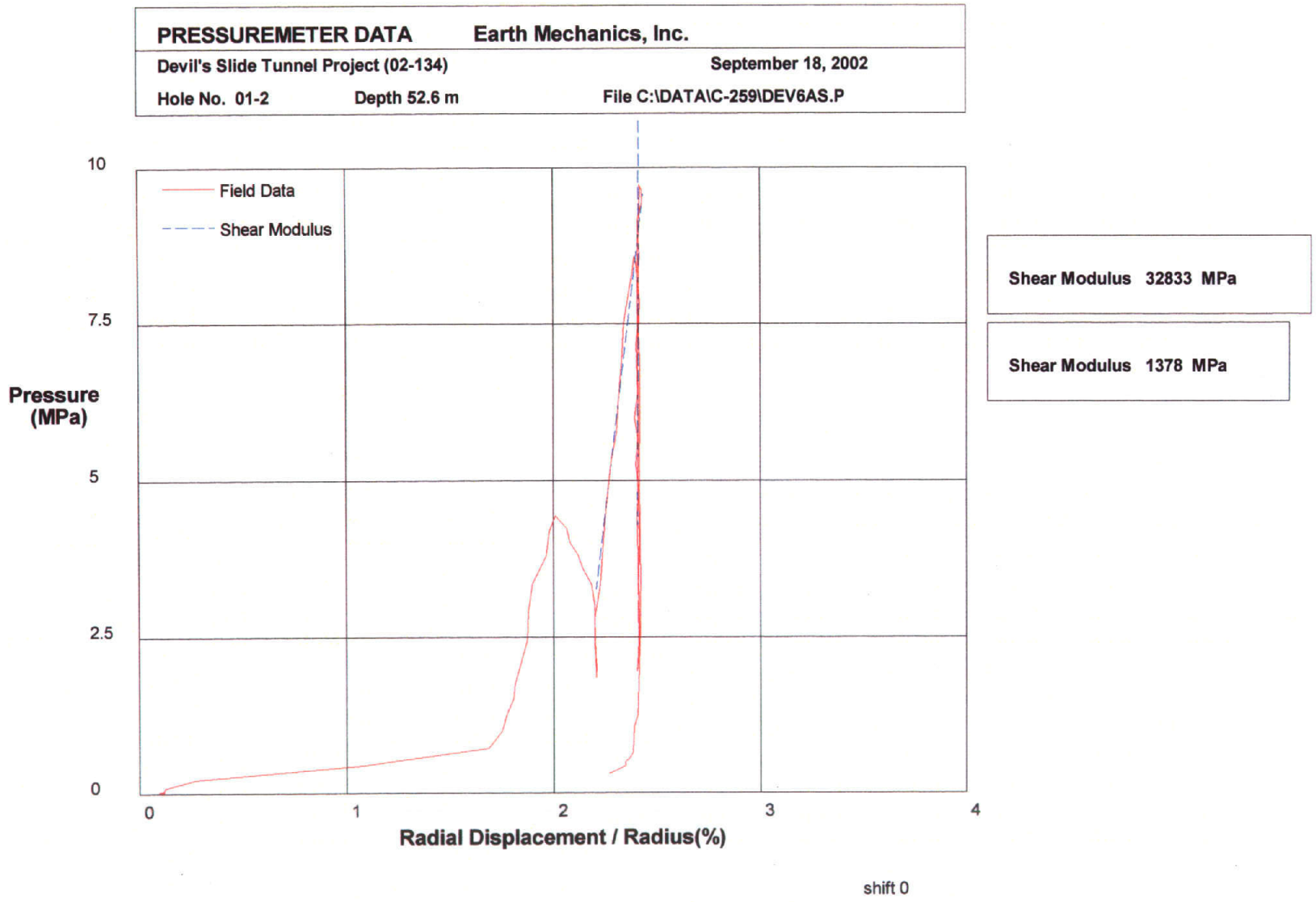
Field Data
Shear Modulus
Pressure (MPa)
10
7.5
5
2.5
0
0
1
2
3
4
Radial Displacement / Radius(%)
Shear Modulus 21833 MPa
Shear Modulus 2666 MPa
shift 0
HUGHES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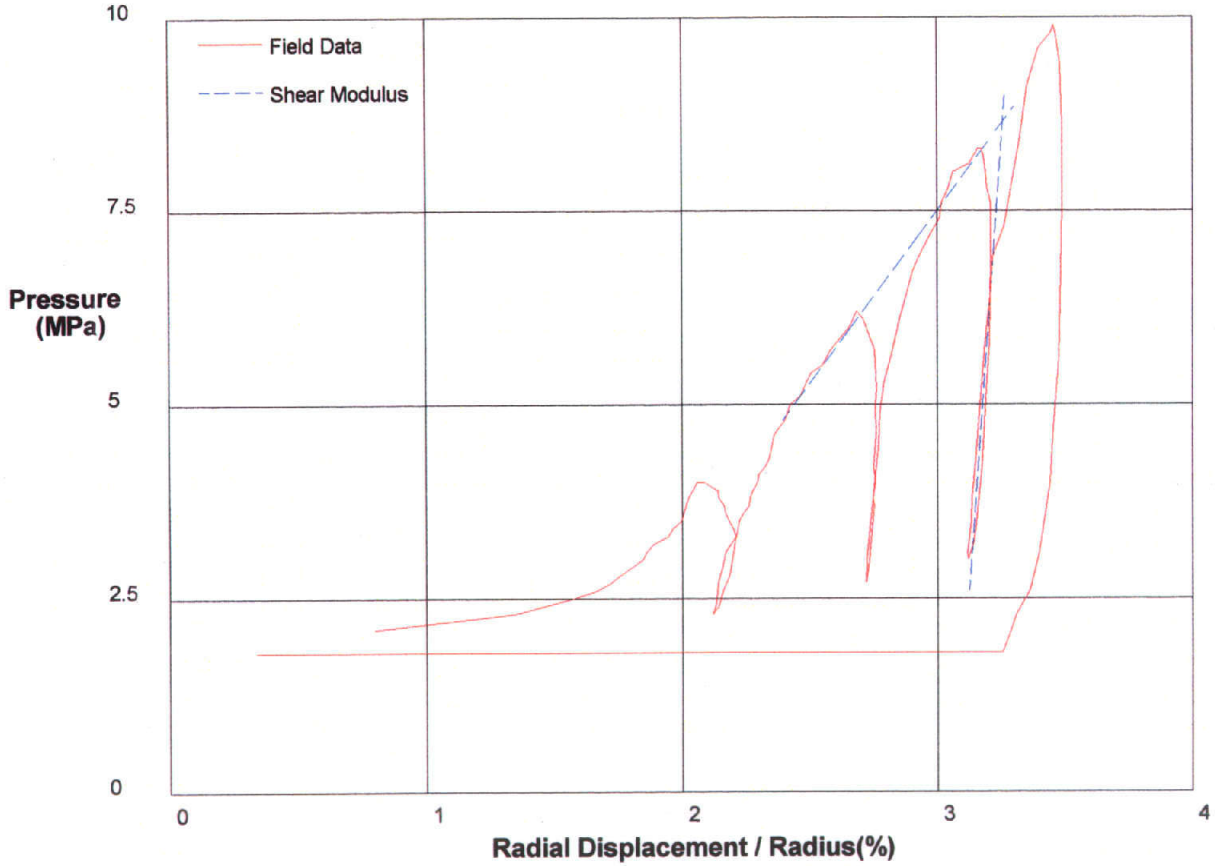
Earth Mechanics, Inc.
Devil's Slide Tunnel Project (02-134)
September 18, 2002
Hole No. 01-2
Depth 52.6 m
File C:\DATA\C-259\DEV6AS.P
Field Data
Shear Modulus
Shear Modulus 32833 MPa
Shear Modulus 1378 MPa
Pressure (MPa)
10
7.5
5
2.5
0
0
1
2
3
4
Radial Displacement / Radius(%)
shift 0
HUGHES

PRESSUREMETER DATA **Earth Mechanics, Inc.**

Devil's Slide Tunnel Project (02-134) **September 18, 2002**

Hole No. 02-5 **Depth 169.2 m** **File C:\DATA\C-259\DEV7AS.P**



Shear Modulus 2277 MPa

Shear Modulus 224 MPa

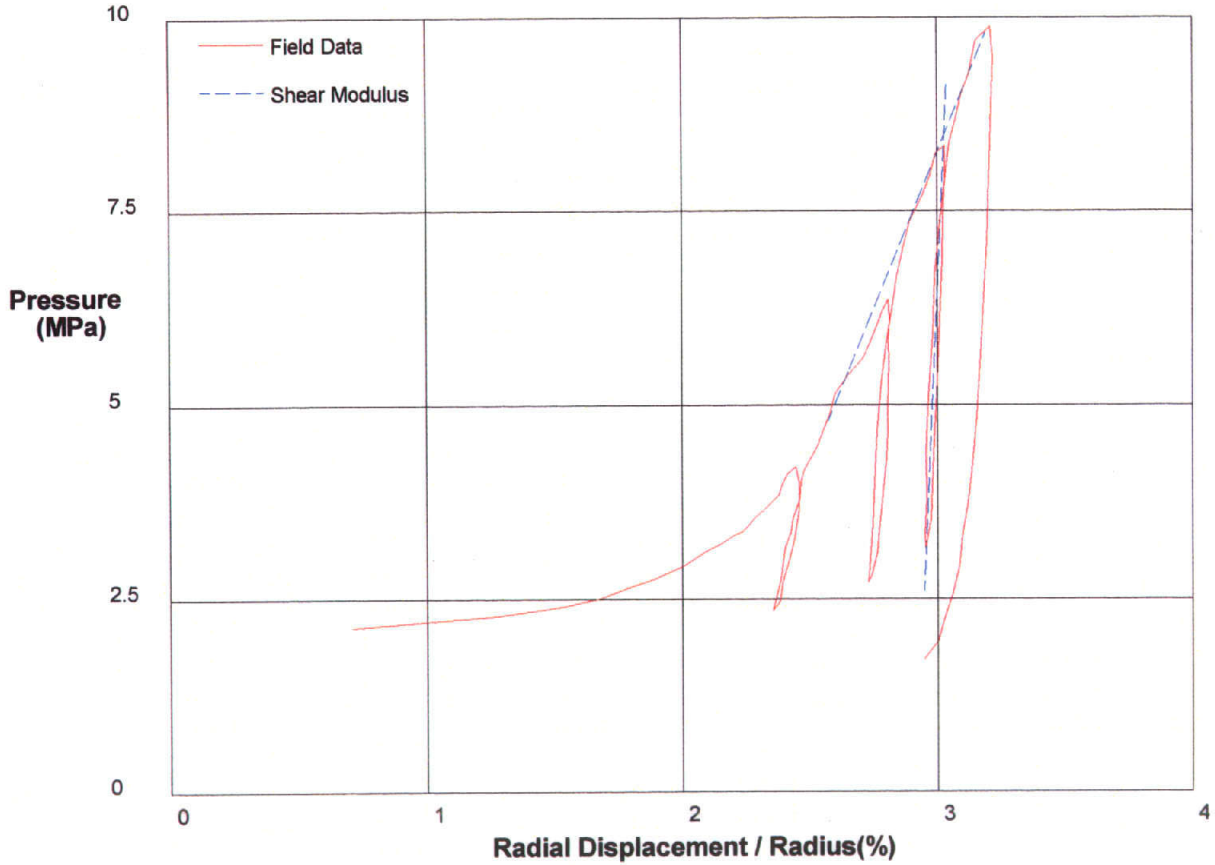
shift 5

HUGHES

PRESSUREMETER DATA **Earth Mechanics, Inc.**

Devil's Slide Tunnel Project (02-134) **September 19, 2002**

Hole No. 02-2 **Depth 168.7 m** **File C:\DATA\C-259\DEV8AS.P**



Shear Modulus 3715 MPa

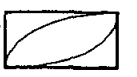
Shear Modulus 404 MPa

shift 5

HUGHES

Appendix B

Calibration for compression in membrane

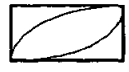


MEMBRANE COMPRESSION

After completion of Test 8, the pressuremeter was inflated inside a steel tube. This test was to measure the combined effect of the compression in the membrane and the response of the displacement gauges to pressure.

The measured movement with pressure is presented in Fig. B1 (the same scale as used on most of the pressure-expansion plots shown in Appendix A) and to a larger scale in Fig. B2.

The combined effect of the compression in the membrane and the response of the displacement gauges to pressure (line AB in Fig. B2) is small – in the same range as that of the elastic expansion of the steel tube (line CD in Fig. B2). In view of the accuracy of the pressure and displacement measurements, a shear modulus above 20 GPa cannot be reliably measured.



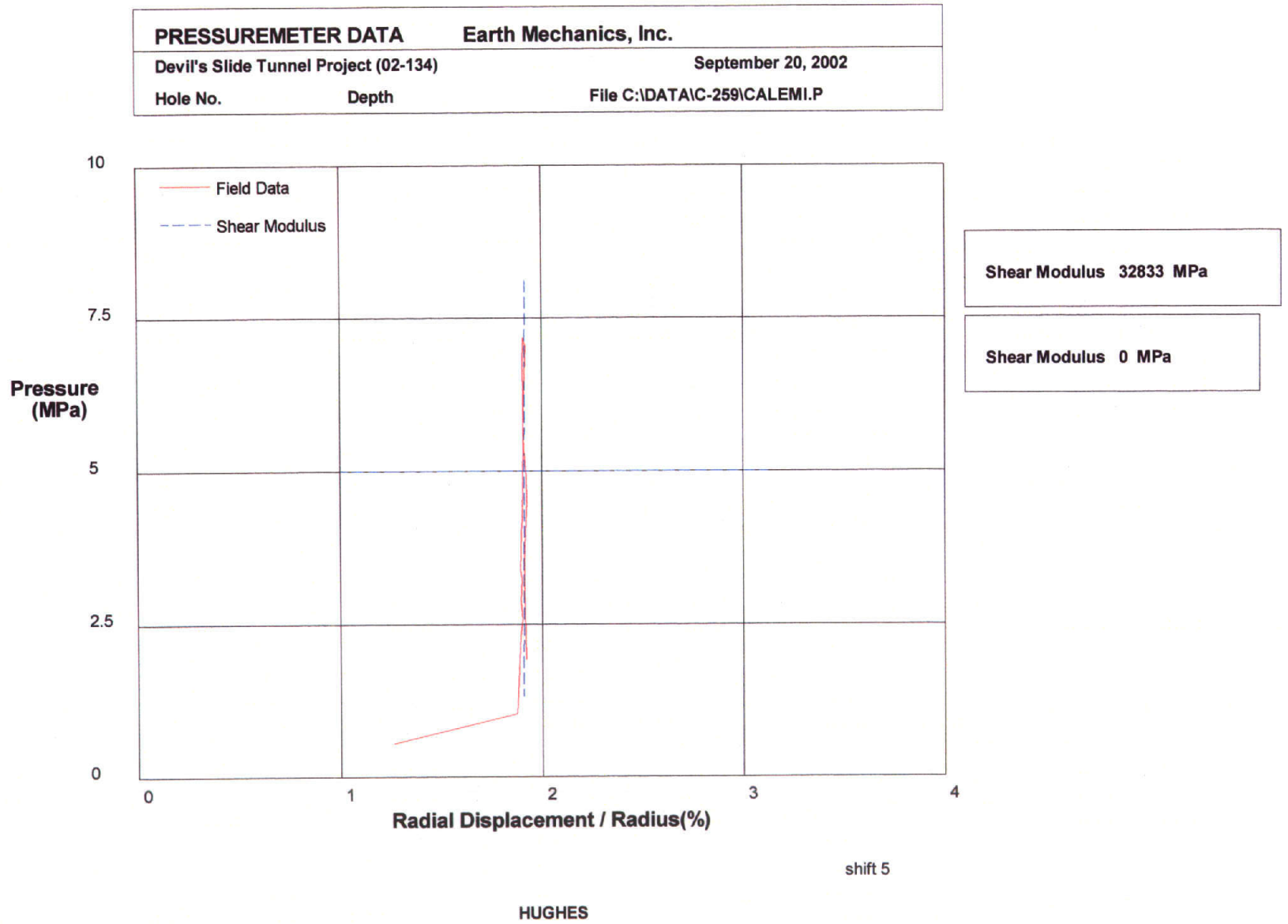


Fig. B1. Pressure/strain for test in steel tube

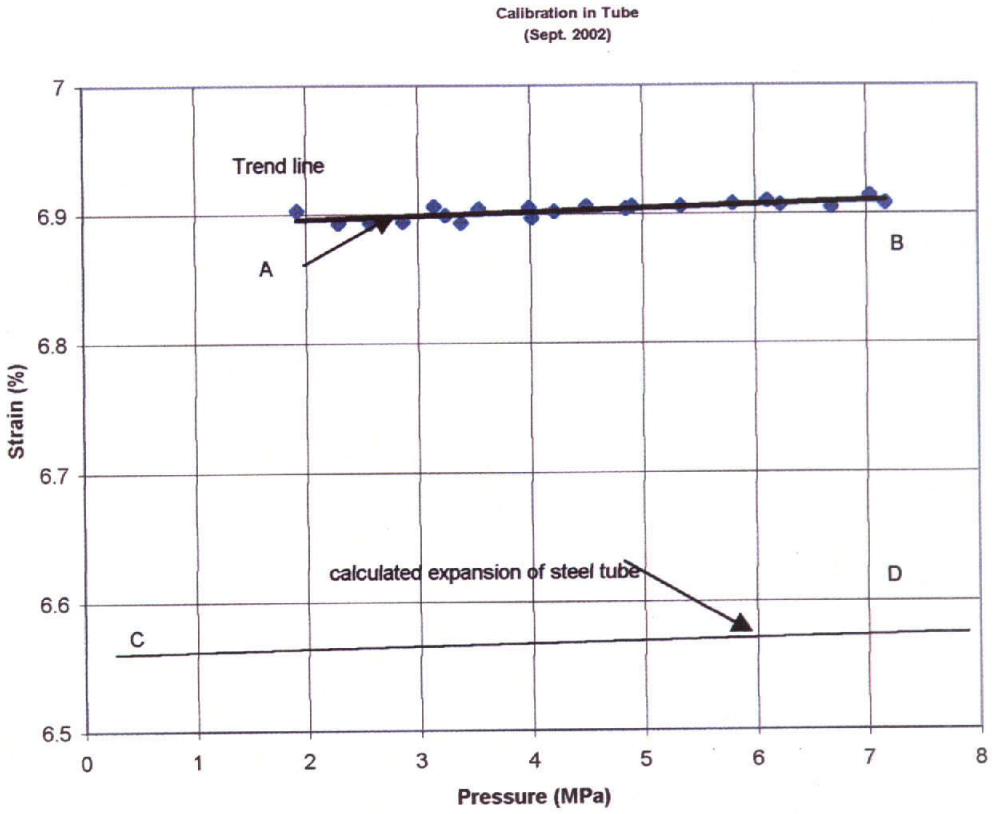


Fig. B2. Expanded view of Fig. B1

APPENDIX B-3

DOWNHOLE SEISMIC VELOCITY LOGGING BY GEOVISION

GEOVision

geophysical services
a division of Blackhawk Geometrics

SITE EXPLORATION

BOREHOLE VELOCITIES

DEVIL'S SLIDE

TUNNELS PROJECT

December 3, 2002

SITE EXPLORATION
BOREHOLE VELOCITIES
DEVIL'S SLIDE
TUNNELS PROJECT

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December 3, 2002
Report 2611-02

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INTRODUCTION

OYO suspension velocity measurements were performed in six land boreholes above the Devil's Slide section of Highway 1, south of Pacifica, California, as an element of the site exploration program for the Devil's Slide Tunnels Project. Suspension logging data acquisition was performed between August 14 and September 26, 2002 by Rob Steller of Geovision. The work was performed under subcontract with Earth Mechanics, with Mike Kapuskar as the field liaison for Earth Mechanics.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of suspension velocity measurements collected from August 14, to September 26, 2002, in the uncased boreholes located above Devil's Slide, as designated below. The purpose of these studies was to supplement stratigraphic information obtained from Earth Mechanics' soil and rock sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth, which, in turn, can be used to characterize ground response to earthquake motion.

BOREHOLE DESIGNATION	DATE LOGGED	DIP/ INCLINATION	COORDINATES (M)	
			NORTHING	EASTING
02-2	9/21/02	90° / 0°	1,821,997.4	620,930.2
02-5	9/26/02	90~86° / 0~4°	1,822,201.7	621,357.2
02-6	8/14/02, 8/15/02	75° / 15°	1,822,293.7	621,719.8
02-15	9/20/02	56° / 34°	1,822,005.2	620,714.5
02-18A	8/20/02	58° / 32°	1,822,509.3	NA
02-18B	8/20/02	77° / 13°	1,822,509.3	NA

Table 1. Borehole locations and logging dates

The OYO Model 170 Suspension Logging Recorder and Suspension Logging Probe were used to obtain in-situ horizontal shear and compressional wave velocity measurements at 0.5 m or 1.0 m intervals. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

> Guidelines for Determining Design Basis Ground Motions, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

SUSPENSION INSTRUMENTATION

Suspension soil velocity measurements were performed using the Model 170 Suspension Logging system, manufactured by OYO Corporation. This system directly determines the average velocity of a 1.0 m high segment of the soil column surrounding the borehole of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the borehole producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 1.0 m, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in this survey is 5.8 m, with the center point of the receiver pair 3.7 m above the bottom end of the probe. The probe receives control signals from, and sends the amplified receiver signals to, instrumentation on the surface via an armored 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data.

The entire probe is suspended by the cable and centered in the borehole by nylon "whiskers", therefore, source motion is not coupled directly to the borehole walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the borehole and surrounding the source. This pressure wave is converted to P and S_H-waves in the surrounding soil and rock as it impinges upon the borehole wall. These waves propagate through the soil and rock surrounding the borehole, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and S_H-waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H-wave signals.
2. At each depth, S_H-wave signals are recorded with the source actuated in opposite directions, producing S_H-wave signals of opposite polarity, providing a characteristic S_H-wave signature distinct from the P-wave signal.
3. The 2.14 m separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H-wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder is extended to allow greater separation of the P- and S_H-wave signals.
4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S_H-wave signal, permitting additional separation of the two signals by low pass filtering.
5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe (meter versus centimeter scale), preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H-wave arrivals; reversal of the source changes the polarity of the S_H-wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Model 170 has six channels (two simultaneous recording channels), each with a 12 bit 1024 sample record. The recorded data is displayed on a CRT display and on paper tape output as six channels with a common time scale. Data is stored on 3.5 inch floppy diskettes for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the CRT or paper tape allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Model 170 digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

SUSPENSION MEASUREMENT PROCEDURES

All land boreholes were logged as uncased boreholes filled with bentonite based drilling fluid or clear water. Prior to entering the borehole, the mechanical and electronic depth counters were set to zero. The probe was lowered to the bottom of the borehole, then returned to the bottom of the conductor casing, stopping at 0.5 m or 1.0 intervals to collect data, as summarized on the following page.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth was printed on paper tape, checked, and recorded on diskette before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at grade was verified prior to removal from the borehole.

BOREHOLE NUMBER	RUN NUMBER	DEPTH RANGE (METERS)	DEPTH AS DRILLED (METERS)	LOST TO SLOUGH/COLLAPSE (METERS)	SAMPLE INTERVAL (METERS)	DATE LOGGED
02-2	1	42.7 - 56.3	60.7	0.7/SLOUGH	0.5	9/21/02
02-2	2	NA	60.7	HOLE DRY ABOVE 43.0 M	NA	9/21/02
02-5	1	166.5 – 250.0	255.6	1.9/SLOUGH	0.5	9/26/02
02-5	2	163.0 – 168.0	255.6	STEEL ROD TO 163 M	0.5	9/26/02
02-5	2	72.0 – 163.0	255.6	HOLE DRY ABOVE 72.0 M	1.0	9/26/02
02-6	1	67.0 - 116.5	139.6	OBSTRUCTED AT 120.2 M WATER AT 67.2 M	0.5	8/14/02
02-6	2	NO DATA COLLECTED	139.6	TOOL FAILURE	NA	8/14/02
02-6	3	123.0 - 136.0	139.6	STEEL ROD TO 123 M	0.5	8/15/02
02-8A	1	NO DATA COLLECTED	52.4	OBSTRUCTED AT 23.3 M, HOLE DRY	NA	8/21/02
02-15	1	6.5 – 50.0	55.0	1.3/SLOUGH	0.5	9/20/02
02-18A	1	8.0 - 40.5	44.5	0.3/SLOUGH	0.5	8/20/02
02-18B	1	6.5 – 21.0	45.4	OBSTRUCTED AT 24.7 M	0.5	8/20/02

Table 2. Logging dates and depth ranges

SUSPENSION DATA ANALYSIS

The recorded digital records were analyzed to locate the first minima on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 1.0 m segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data.

The P-wave velocity calculated from the travel time over the 2.14 m interval from source to receiver 1 (S-R1) was calculated and plotted for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 1.57 m to correspond to the mid-point of the 2.14 m S-R1 interval, as illustrated in Figure 1. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 3.9 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

The recorded digital records were studied to establish the presence of clear S_H-wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H-wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering was used to remove the higher frequency P-wave signal from the S_H-wave signal. Different filter cutoffs were used to separate P- and S_H-waves at different depths, ranging from 500 Hz in the slowest zones to 5000 Hz in the regions of highest velocity. At each depth, the filter frequency was selected to be at least twice the fundamental frequency of the S_H-wave signal being filtered.

Generally, the first maxima was picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by borehole inclination. This variation does not affect the R1-R2 velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H-wave velocity calculated from the travel time over the 2.14 m interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 1.57 m to correspond to the mid-point of the 2.14 m S-R1 interval. Travel times were obtained by picking the first break of the S_H-wave signal at the near receiver and subtracting 3.9 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

Figure 2 shows an example of R1 - R2 measurements on the filtered record for a depth of 30.5 m in Borehole 02-18B. In Figure 2, the time difference over the 1.0 m interval of 0.57 milliseconds for the horizontal normal (H_N) signal is equivalent to an S_H-wave velocity of 1770 m/sec. Whenever possible, time differences were determined from several phase points on the S_H-waveform records to verify the data obtained from the first arrival of the S_H-wave pulse. Figure 3 displays the same record before filtering of the S_H-waveform record with an 1500 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H-wave by residual P-wave signal.

SUSPENSION RESULTS

Suspension R1-R2 P- and S_H-wave velocities are plotted in Figures 4 – 9. The suspension velocity data presented in these Figures are presented in Tables 3 – 8. P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A1 – A6 to aid in visual comparison. It must be noted that R1-R2 data is an average velocity over a 1.0 m segment of the soil column; S-R1 data is an average over 2.14 m, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in tabular format in Tables A1 – A6. Fair correspondence between the shape of the P- and S_H-wave velocity curves is observed for all these data sets. The velocities derived from S-R1 and R1-R2 data are in fair agreement, providing verification of the higher resolution R1-R2 data.

Calibration procedures and records for the suspension measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Both P- and S_H-wave velocities were measured using the Suspension Method in six land borings at depths up to 250.0 m below grade at Devil's Slide. All boreholes were in a rural area and no significant signal contamination from cultural vibration was observed, however, in several boreholes the addition of water to maintain water level in the borehole during measurements created noticeable disturbance due to the splashing of water on the water surface. In these instances, water was added periodically, and measurements were acquired in the quiet periods between addition of water. Several of the boreholes were inclined at angles up to 34 degrees from vertical, causing significant shifting of the source reversals relative to each other. In addition, the highly fractured rock found in many of the boreholes provided poor quality signals with broad arrivals and very low energy. Both of these factors combine to reduce the estimated precision of these measurements to +/- 10%.

Quality Assurance

These velocity measurements at Devil's Slide were performed using industry-standard or better methods for both measurements and analyses. All work was performed under Geovision quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 1.0 m interval of depth. This high resolution results in the scatter of values shown in the graphs. Individual measurements are very reliable with estimated precision of +/- 10%. Standardized field procedures and quality assurance checks add to the reliability of these data.

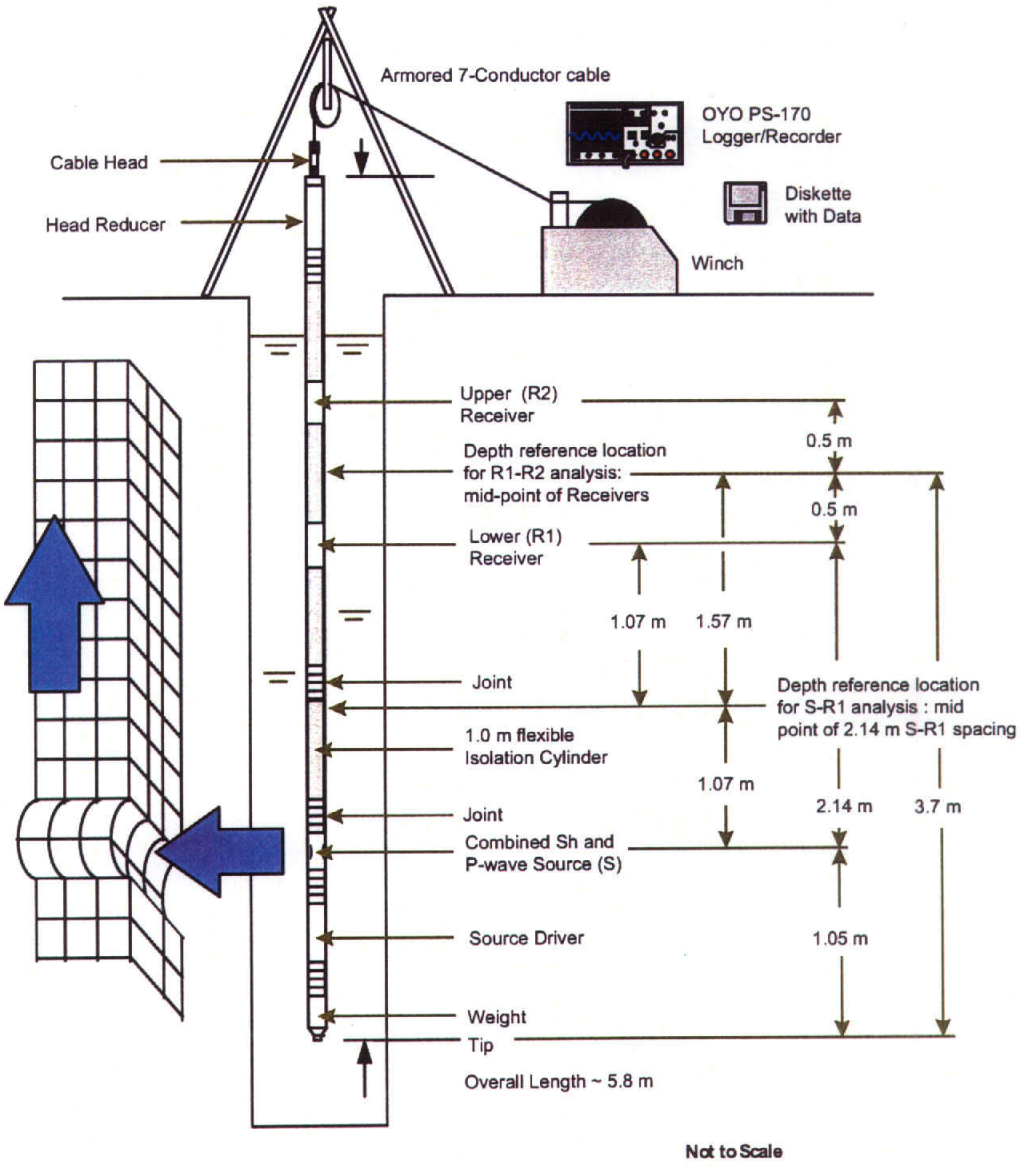

Figure 1. Concept illustration of P-S logging system

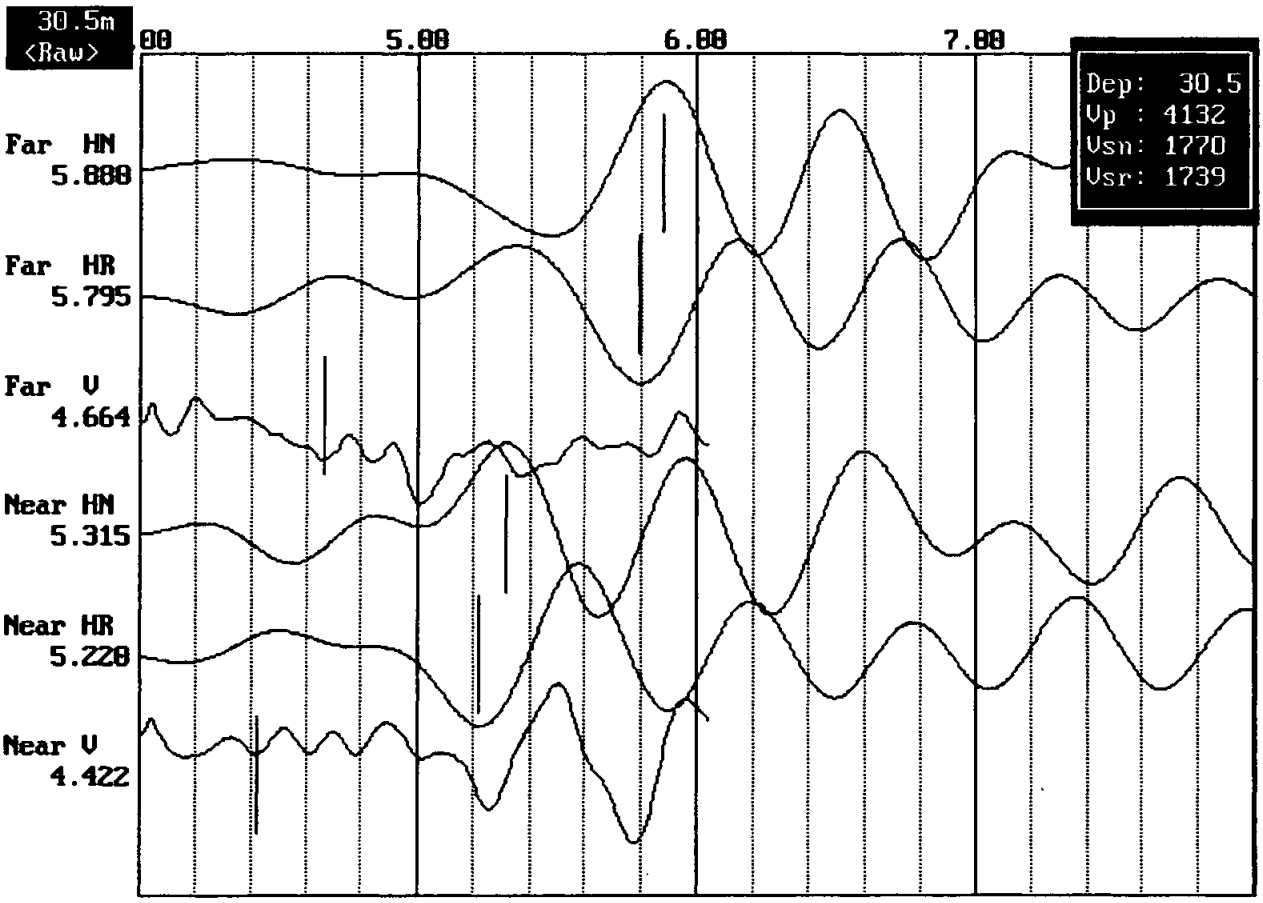

Figure 2. Filtered (1500 Hz lowpass) 30.5 m record from Borehole 02-18B

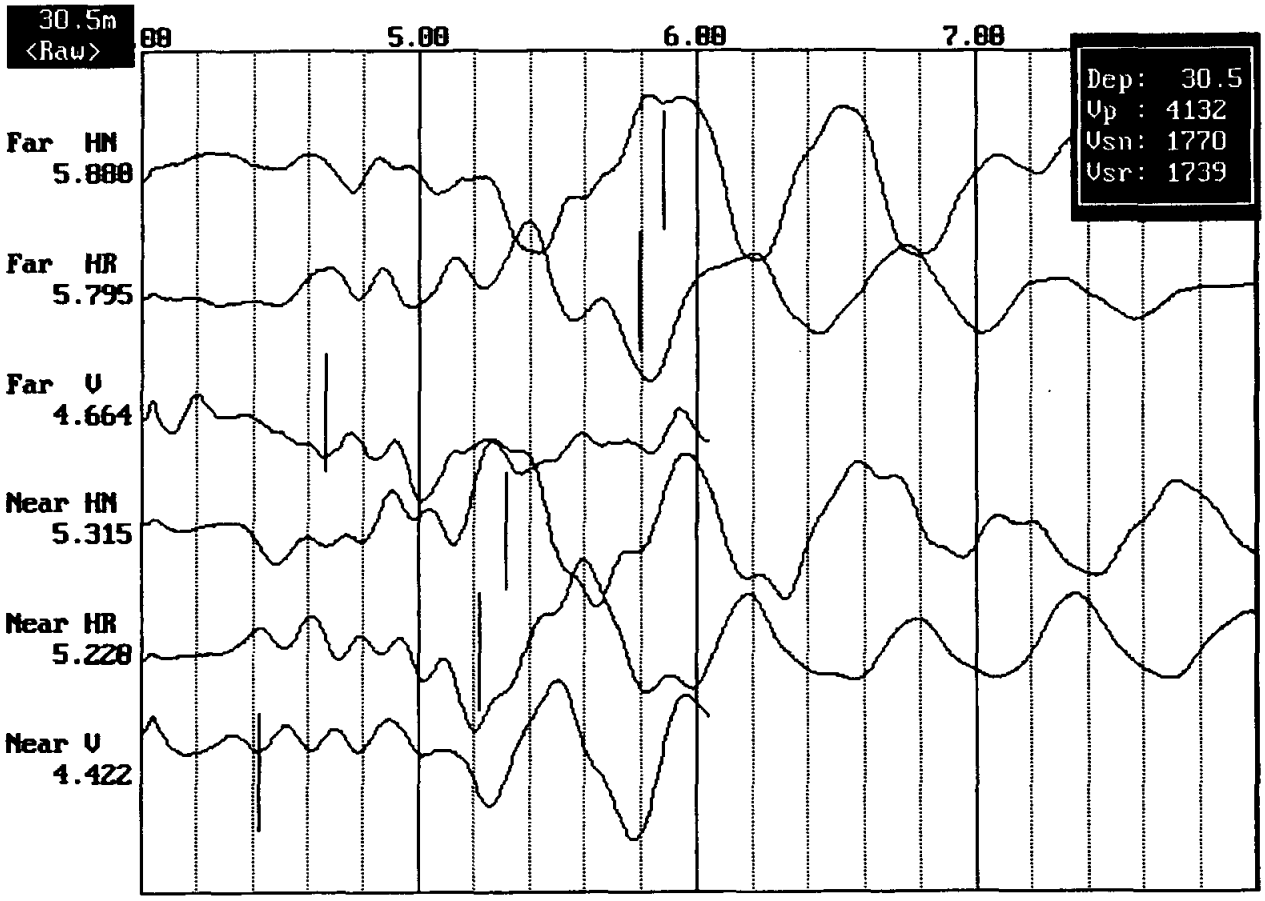

Figure 3. Unfiltered 30.5 m record from Borehole 02-18B

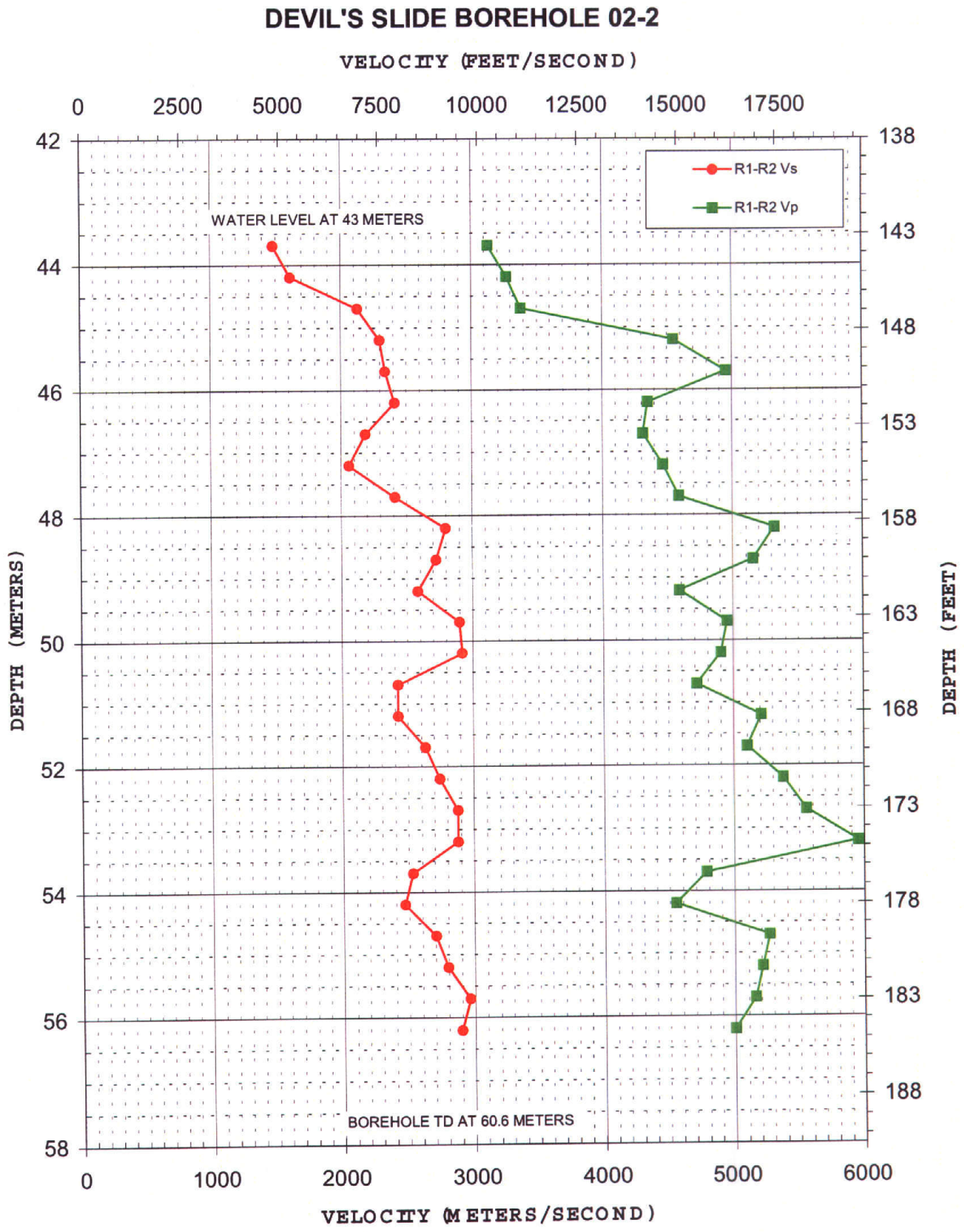

Figure 4. Borehole 02-2, Suspension P- and S_H-wave velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	$V\text{-}S_H$ (m/sec)	V-P (m/sec)	$V\text{-}S_H$ (ft/sec)	V-P (ft/sec)
42.7	144.0										
43.2	145.7										
43.7	147.3	4.76		3.88	4.08		3.56	1481	3125	4861	10253
44.2	149.0	4.71		3.87	4.09		3.57	1613	3268	5292	10722
44.7	150.6	4.54	4.84	4.28	4.05	4.39	3.99	2128	3378	6981	11084
45.2	152.2	4.49	4.64	3.72	4.06	4.19	3.50	2299	4545	7542	14913
45.7	153.9	4.43	4.63	3.70	4.02	4.18	3.50	2339	4950	7674	16242
46.2	155.5	4.73	4.56	3.74	4.32	4.13	3.51	2410	4348	7906	14265
46.7	157.2	4.37	4.54	3.67	3.92	4.07	3.44	2186	4310	7171	14142
47.2	158.8	4.38	4.56	3.76	3.89	4.08	3.54	2062	4464	6765	14647
47.7	160.4	4.30	4.47	3.67	3.88	4.06	3.45	2410	4587	7906	15050
48.2	162.1	4.24	4.38	3.63	3.89	4.02	3.44	2797	5319	9177	17451
48.7	163.7	4.31	4.48	3.64	3.93	4.13	3.45	2721	5155	8927	16912
49.2	165.4	4.28	4.46	3.75	3.89	4.07	3.54	2581	4587	8467	15050
49.7	167.0	4.27	4.47	3.69	3.91	4.14	3.49	2899	4950	9510	16242
50.2	168.6	4.24	4.47	3.69	3.87	4.16	3.49	2920	4902	9579	16083
50.7	170.3	4.29	4.53	3.67	3.85	4.14	3.46	2424	4717	7954	15476
51.2	171.9	4.26	4.39	3.67	3.84	3.98	3.48	2424	5208	7954	17088
51.7	173.6	4.29	4.45	3.67	3.90	4.08	3.47	2632	5102	8634	16739
52.2	175.2	4.27	4.48	3.64	3.90	4.12	3.46	2740	5376	8989	17639
52.7	176.8	4.26	4.44	3.65	3.91	4.10	3.47	2878	5556	9441	18227
53.2	178.5	4.26	4.51	3.69	3.91	4.17	3.52	2878	5952	9441	19529
53.7	180.1	4.26	4.49	3.70	3.87	4.08	3.49	2532	4785	8306	15698
54.2	181.8	4.26	4.43	3.67	3.85	4.04	3.45	2469	4545	8101	14913
54.7	183.4	4.16	4.33	3.63	3.79	3.96	3.44	2703	5263	8867	17268
55.2	185.0	4.18	4.33	3.68	3.82	3.97	3.49	2797	5208	9177	17088
55.7	186.7	4.39	4.62	3.70	4.05	4.28	3.51	2963	5155	9721	16912
56.2	188.3	4.51	4.70	3.63	4.17	4.35	3.43	2899	5000	9510	16404

Table 3. Borehole 02-2, Suspension R1-R2 depth, pick times, and velocities

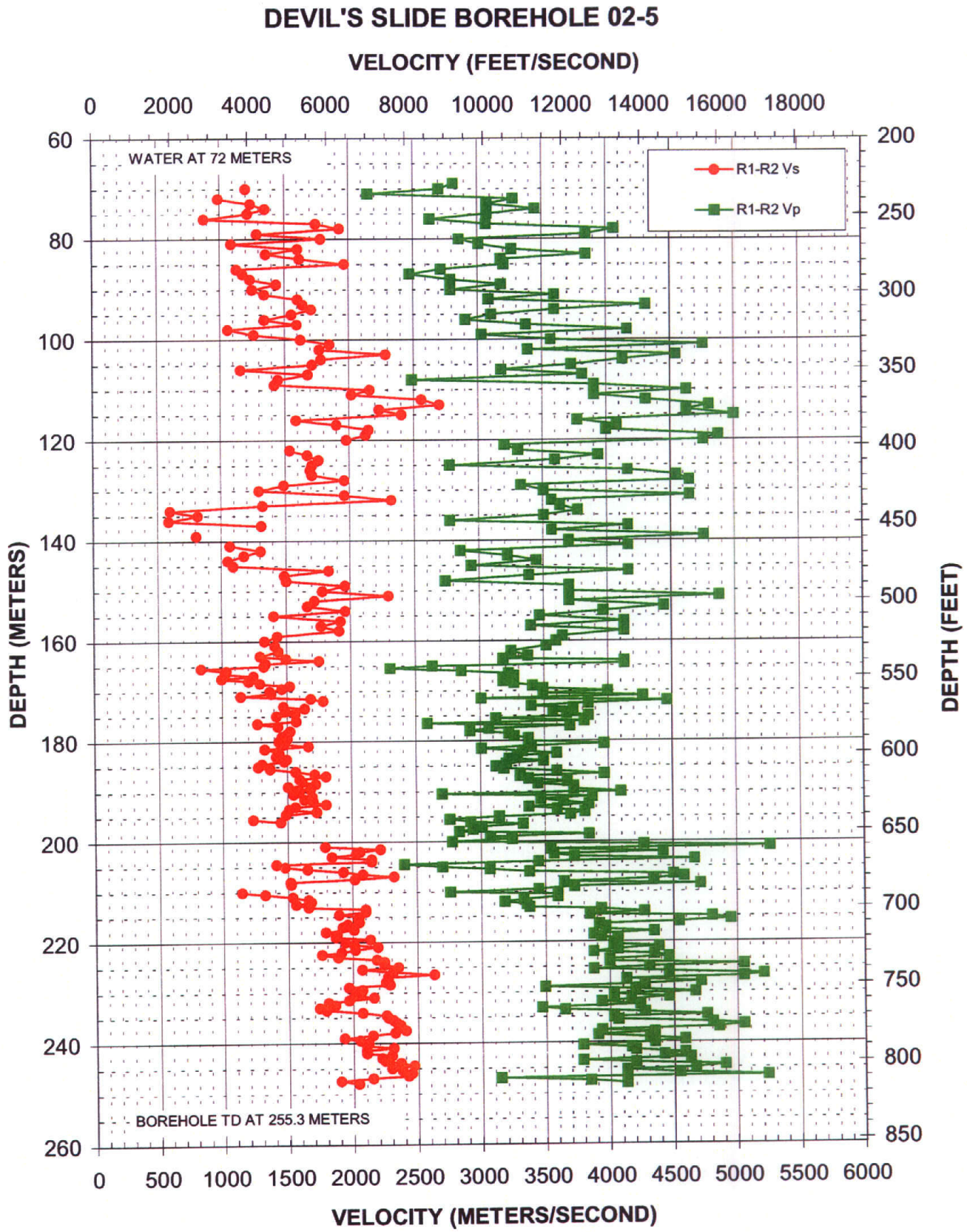

Figure 5. Borehole 02-5, Suspension P- and S_H-wave velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S_H (m/sec)	V-P (m/sec)	V-S_H (ft/sec)	V-P (ft/sec)
68.0	223.1										
69.0	226.4			5.23			4.88		2817		9242
70.0	229.7	7.29	7.28	5.14	6.39	6.52	4.77	1205	2703	3953	8867
71.0	232.9			5.25			4.78		2151		7056
72.0	236.2	6.46	6.54	5.10	5.48	5.50	4.79	990	3279	3248	10757
73.0	239.5	7.03	6.89	5.12	6.10	6.21	4.79	1242	3077	4076	10095
74.0	242.8	7.10	7.12	5.01	6.33	6.41	4.72	1351	3448	4434	11313
75.0	246.1	6.62	6.37	5.17	5.71	5.64	4.84	1220	3077	4001	10095
76.0	249.3	7.47		5.24	6.33		4.86	877	2632	2878	8634
77.0	252.6	6.15	5.96	5.13	5.56	5.41	4.81	1747	3067	5731	10064
78.0	255.9	6.04	5.76	4.93	5.50	5.27	4.68	1932	4065	6340	13337
79.0	259.2	6.27	6.31	5.09	5.53	5.50	4.83	1290	3846	4233	12619
80.0	262.5	5.89	5.68	5.12	5.32	5.13	4.77	1786	2857	5859	9374
81.0	265.7	6.21	6.18	5.07	5.28	5.27	4.74	1090	3012	3576	9882
82.0	269.0	6.14	6.33	5.01	5.51	5.71	4.70	1606	3268	5270	10722
83.0	272.3	6.46	6.63	4.98	5.72	5.90	4.72	1361	3846	4464	12619
84.0	275.6	7.42	7.47	5.19	6.74	6.92	4.88	1619	3185	5313	10449
85.0	278.9	6.86	6.68	5.25	6.41	6.11	4.93	1970	3205	6465	10516
86.0	282.2	6.77	6.66	5.10	5.91	5.75	4.74	1133	2717	3718	8915
87.0	285.4	6.51	6.37	5.12	5.59	5.59	4.72	1180	2475	3871	8121
88.0	288.7	6.45	6.45	5.11	5.57	5.71	4.75	1235	2793	4050	9164
89.0	292.0	6.30	6.32	5.03	5.55	5.68	4.72	1439	3185	4721	10449
90.0	295.3	6.49	6.61	5.15	5.68	5.83	4.79	1254	2793	4114	9164
91.0	298.6	6.31	6.44	5.12	5.58	5.68	4.84	1347	3597	4419	11802
92.0	301.8	6.47	6.35	5.01	5.82	5.75	4.68	1606	3086	5270	10126
93.0	305.1	6.55	6.68	4.93	5.98	6.03	4.70	1645	4310	5396	14142
94.0	308.4	6.29	6.47	5.07	5.72	5.87	4.79	1709	3597	5608	11802
95.0	311.7	6.12	6.22	4.98	5.50	5.55	4.65	1556	3106	5106	10189
96.0	315.0	6.41	6.54	4.98	5.71	5.75	4.64	1347	2907	4419	9537
97.0	318.2	6.39	6.49	4.90	5.76	5.87	4.60	1600	3378	5249	11084
98.0	321.5	6.38	6.48	4.94	5.44	5.54	4.70	1064	4167	3490	13670
99.0	324.8	6.02	6.11	4.93	5.23	5.32	4.60	1262	3030	4140	9942
100.0	328.1	5.71	5.83	4.93	5.10	5.21	4.65	1626	3571	5335	11717
101.0	331.4	5.58	5.72	4.83	5.04	5.18	4.62	1852	4762	6076	15623
102.0	334.6	5.53	5.66	4.90	4.96	5.10	4.61	1770	3390	5807	11121
103.0	337.9	5.53	5.64	4.92	5.10	5.19	4.70	2286	4545	7499	14913
104.0	341.2	5.77	5.91	4.96	5.20	5.36	4.72	1786	4132	5859	13557
105.0	344.5	5.82	5.91	4.93	5.23	5.34	4.66	1717	3731	5632	12242
106.0	347.8	6.17	6.45	4.86	5.32	5.58	4.55	1159	3185	3804	10449
107.0	351.0	5.82	5.99	4.80	5.24	5.38	4.54	1681	3817	5514	12522
108.0	354.3	5.95	6.04	4.94	5.25	5.36	4.54	1449	2488	4755	8161
109.0	357.6	5.72	5.86	4.74	5.02	5.15	4.48	1423	3906	4670	12816
110.0	360.9	5.33	5.44	4.77	4.87	4.97	4.56	2162	4630	7094	15189
111.0	364.2	5.31	5.44	4.78	4.83	4.94	4.53	2020	3906	6628	12816
112.0	367.5	5.24	5.44	4.71	4.87	5.03	4.48	2564	4310	8412	14142
113.0	370.7	5.26	5.32	4.69	4.85	4.98	4.48	2703	4808	8867	15773
114.0	374.0	5.52	5.57	4.75	5.07	5.13	4.53	2235	4630	7331	15189
115.0	377.3	5.57	5.61	4.76	5.16	5.19	4.56	2410	5000	7906	16404
116.0	380.6	5.57	5.73	4.82	4.95	5.09	4.55	1587	3774	5208	12381
117.0	383.9	5.53	5.55	4.78	5.00	5.03	4.54	1905	4082	6249	13391

Table 4. Borehole 02-5, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	$V\text{-}S_H$ (m/sec)	V-P (m/sec)	$V\text{-}S_H$ (ft/sec)	V-P (ft/sec)
118.0	387.1	5.42	5.53	4.81	4.94	5.08	4.56	2151	4000	7056	13123
119.0	390.4	5.45		4.79	4.98		4.58	2128	4878	6981	16004
120.0	393.7	5.46	5.46	4.84	4.96	4.95	4.63	1980	4762	6497	15623
121.0	397.0			4.86			4.55		3205	0	10516
122.0	400.3	5.52		4.82	4.87		4.52	1538	3311	5047	10864
123.0	403.5	5.59	5.59	4.79	4.99	5.00	4.54	1674	3937	5491	12917
124.0	406.8	5.78	5.90	4.90	5.20	5.34	4.62	1762	3597	5781	11802
125.0	410.1	5.95	6.19	4.88	5.38	5.59	4.52	1709	2778	5608	9113
126.0	413.4	5.84	5.99	4.84	5.24	5.41	4.60	1695	4167	5561	13670
127.0	416.7	5.93	6.09	4.87	5.31	5.54	4.65	1709	4545	5608	14913
128.0	419.9	5.98	6.15	4.78	5.44	5.67	4.57	1961	4651	6433	15260
129.0	423.2	5.92	6.11	4.80	5.25	5.44	4.50	1493	3333	4897	10936
130.0	426.5	5.85	5.96	4.72	5.06	5.21	4.43	1299	3509	4261	11512
131.0	429.8	5.68	5.86	4.74	5.18	5.34	4.53	1961	4651	6433	15260
132.0	433.1	6.20	6.30	4.91	5.73	5.91	4.63	2326	3571	7630	11717
133.0	436.4	7.00	7.15	4.95	6.20	6.44	4.67	1325	3636	4345	11930
134.0	439.6	7.87	8.06	4.97	6.27	6.33	4.70	601	3774	1970	12381
135.0	442.9	7.95	8.14	4.91	6.79	6.86	4.62	820	3509	2689	11512
136.0	446.2	7.63	7.39	5.01	5.92	5.72	4.65	592	2778	1941	9113
137.0	449.5	6.14	6.26	4.82	5.39	5.49	4.58	1316	4167	4317	13670
138.0	452.8			4.90	6.26	6.21	4.62		3571	0	11717
139.0	456.0	7.05	7.11	4.77	5.82	5.86	4.56	806	4762	2646	15623
140.0	459.3			4.83			4.56		3704	0	12151
141.0	462.6	6.89	6.95	4.80	5.89	6.08	4.56	1070	4167	3509	13670
142.0	465.9	6.52	6.54	4.95	5.78	5.75	4.60	1307	2857	4289	9374
143.0	469.2	6.89	6.53	5.09	6.02	5.70	4.78	1176	3226	3860	10583
144.0	472.4	6.22	6.55	4.88	5.37	5.50	4.59	1053	3448	3454	11313
145.0	475.7	6.38	6.40	4.95	5.43	5.52	4.61	1093	2941	3586	9650
146.0	479.0	5.85	5.98	4.88	5.33	5.41	4.64	1835	4167	6020	13670
147.0	482.3	5.93	5.92	4.97	5.25	5.26	4.67	1493	3390	4897	11121
148.0	485.6	6.07	6.06	4.98	5.44	5.36	4.62	1504	2740	4934	8989
149.0	488.8	5.73	5.69	4.91	5.16	5.24	4.64	1961	3704	6433	12151
150.0	492.1	5.71	5.85	4.90	5.16	5.28	4.63	1786	3704	5859	12151
151.0	495.4	5.81	5.92	4.88	5.42	5.44	4.68	2299	4878	7542	16004
152.0	498.7	5.92	5.97	4.95	5.36	5.37	4.68	1724	3704	5657	12151
153.0	502.0	6.06	6.13	4.96	5.45	5.54	4.74	1667	4444	5468	14582
154.0	505.2	6.14	6.16	5.05	5.65	5.63	4.80	1961	3968	6433	13019
155.0	508.5	6.27	6.18	4.95	5.53	5.50	4.66	1404	3472	4605	11392
156.0	511.8	6.04	6.16	4.86	5.50	5.65	4.62	1923	4132	6309	13557
157.0	515.1	5.59	5.69	4.97	5.03	5.12	4.67	1770	3401	5807	11159
158.0	518.4	6.12	6.24	4.90	5.62	5.70	4.66	1914	4132	6279	13557
159.0	521.7	6.70	6.87	5.00	6.01	6.17	4.72	1434	3650	4704	11974
160.0	524.9	6.22	6.68	4.98	5.51	5.89	4.70	1333	3597	4374	11802
161.0	528.2	6.09	6.21	4.97	5.37	5.51	4.68	1413	3521	4637	11552
162.0	531.5	6.01	6.10	5.05	5.28	5.45	4.74	1439	3247	4721	10652
163.0	534.8	6.24	6.22	5.06	5.45	5.47	4.77	1299	3378	4261	11084
163.5	536.4	6.62	6.83	5.09	5.98	6.14	4.77	1498	3185	4915	10449
164.0	538.1	6.64	6.79	5.07	6.03	6.26	4.83	1754	4132	5756	13557
164.5	539.7	7.02	7.17	5.07	6.30	6.40	4.83	1338	4132	4389	13557
165.0	541.3	7.42	7.57	5.13	6.72	6.76	4.75	1325	2632	4345	8634

Table 4, continued. Borehole 02-5, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S_H (m/sec)	V-P (m/sec)	V-S_H (ft/sec)	V-P (ft/sec)
165.5	543.0	7.63	7.66	5.11	6.45	6.45	4.68	839	2304	2751	7560
166.0	544.6	6.44	6.58	4.95	5.49	5.60	4.60	1036	2857	3400	9374
166.5	546.3	6.99	7.15	4.93	6.00	6.19	4.62	1023	3226	3356	10583
167.0	547.9	6.42	6.46	4.90	5.61	5.67	4.59	1246	3268	4088	10722
167.5	549.5	6.70	6.97	4.90	5.73	5.94	4.58	998	3185	3273	10449
168.0	551.2	6.58	6.76	4.90	5.77	5.91	4.58	1208	3185	3965	10449
168.5	552.8	6.42	6.57	4.99	5.64	5.80	4.68	1294	3268	4247	10722
169.0	554.5	6.31	6.44	4.99	5.65	5.80	4.70	1527	3413	5009	11197
169.5	556.1	5.99	6.12	5.02	5.33	5.42	4.74	1465	3497	4807	11471
170.0	557.7	6.03	6.18	5.02	5.33	5.42	4.77	1370	4000	4494	13123
170.5	559.4	6.08	6.22	5.02	5.35	5.50	4.74	1379	3497	4525	11471
171.0	561.0	6.70	6.78	4.86	5.82	5.92	4.63	1146	4274	3760	14021
171.5	562.7	6.16	6.30	5.07	5.58	5.69	4.74	1688	3012	5537	9882
172.0	564.3	6.14	6.25	4.90	5.59	5.68	4.67	1786	4464	5859	14647
172.5	565.9			4.92			4.66		3846	0	12619
173.0	567.6	6.20	6.31	5.03	5.51	5.64	4.74	1476	3401	4843	11159
173.5	569.2	6.17	6.31	5.02	5.58	5.69	4.75	1639	3731	5378	12242
174.0	570.9	6.03	6.15	4.98	5.36	5.48	4.70	1493	3571	4897	11717
174.5	572.5	6.19	6.32	5.08	5.54	5.70	4.81	1569	3676	5146	12062
175.0	574.1	6.35	6.43	5.05	5.64	5.74	4.79	1423	3846	4670	12619
175.5	575.8			5.11			4.79		3125	0	10253
176.0	577.4	6.61	6.71	5.04	5.96	6.09	4.78	1575	3817	5167	12522
176.5	579.1	6.67	6.85	5.09	5.85	6.10	4.70	1274	2591	4179	8500
177.0	580.7	6.44	6.55	4.97	5.74	5.86	4.70	1434	3704	4704	12151
177.5	582.3			5.02	5.32		4.70		3067	0	10064
178.0	584.0	5.99		5.01	5.34		4.67	1527	2924	5009	9593
178.5	585.6	5.89	6.30	4.97	5.24	5.62	4.66	1504	3226	4934	10583
179.0	587.3	5.97	6.09	4.96	5.30	5.40	4.65	1465	3268	4807	10722
179.5	588.9	5.89	5.99	4.93	5.21	5.34	4.64	1506	3378	4941	11084
180.0	590.6	5.91	6.32	5.03	5.28	5.56	4.74	1439	3378	4721	11084
180.5	592.2	5.92	6.25	4.95	5.33	5.49	4.70	1481	3968	4861	13019
181.0	593.8	5.87	5.89	4.99	5.27	5.29	4.70	1667	3401	5468	11159
181.5	595.5	6.17	6.32	4.99	5.44	5.55	4.66	1329	3012	4360	9882
182.0	597.1	6.21	6.33	5.12	5.49	5.65	4.82	1434	3333	4704	10936
182.5	598.8	6.23	6.37	4.94	5.54	5.68	4.66	1444	3597	4738	11802
183.0	600.4	6.21	6.40	4.99	5.52	5.68	4.69	1418	3289	4654	10792
183.5	602.0	6.21	6.35	4.98	5.55	5.68	4.67	1498	3226	4915	10583
184.0	603.7	6.14	6.26	4.98	5.45	5.59	4.69	1481	3497	4861	11471
184.5	605.3	6.06	6.27	4.96	5.34	5.46	4.65	1307	3205	4289	10516
185.0	607.0	6.11	6.29	4.93	5.33	5.51	4.61	1278	3125	4193	10253
185.5	608.6	5.95	6.12	4.88	5.23	5.38	4.56	1370	3185	4494	10449
186.0	610.2	5.88	6.03	4.87	5.25	5.39	4.59	1569	3597	5146	11802
186.5	611.9	5.84	6.00	4.84	5.27	5.41	4.59	1717	3968	5632	13019
187.0	613.5	5.90		4.90	5.35		4.60	1802	3311	5911	10864
187.5	615.2	5.95	6.11	4.89	5.34	5.47	4.59	1600	3378	5249	11084
188.0	616.8	6.06	6.18	4.91	5.43	5.58	4.64	1619	3676	5313	12062
188.5	618.4	5.93	6.09	4.95	5.35	5.51	4.66	1724	3448	5657	11313
189.0	620.1	6.00	6.18	4.89	5.34	5.51	4.63	1509	3731	4952	12242
189.5	621.7	5.81	5.94	4.99	5.21	5.34	4.72	1681	3731	5514	12242
190.0	623.4	5.80	5.91	4.92	5.16	5.29	4.68	1594	4098	5228	13446

Table 4, continued. Borehole 02-5, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S_H (m/sec)	V-P (m/sec)	V-S_H (ft/sec)	V-P (ft/sec)
190.5	625.0	5.83	5.98	4.99	5.19	5.33	4.62	1550	2703	5087	8867
191.0	626.6	5.97	6.15	5.00	5.38	5.55	4.74	1695	3876	5561	12716
191.5	628.3	5.99	6.20	4.90	5.39	5.58	4.61	1633	3472	5356	11392
192.0	629.9	6.09	6.28	4.92	5.54	5.66	4.65	1702	3650	5584	11974
192.5	631.6	6.14	6.30	5.02	5.55	5.78	4.76	1802	3846	5911	12619
193.0	633.2	6.38	6.57	4.97	5.75	5.92	4.68	1563	3378	5126	11084
193.5	634.8	6.18	6.29	4.98	5.54	5.61	4.70	1515	3597	4971	11802
194.0	636.5	6.37	6.56	4.99	5.78	5.99	4.73	1732	3817	5681	12522
194.5	638.1	6.43	6.64	5.02	5.76	5.98	4.75	1493	3704	4897	12151
195.0	639.8			5.04			4.72		3145		10317
195.5	641.4	6.51	6.68	5.05	5.70	5.87	4.69	1235	2762	4050	9063
196.0	643.0	6.40	6.57	5.03	5.70	5.89	4.69	1449	2924	4755	9593
196.5	644.7			5.00			4.70		3333		10936
197.0	646.3			4.97			4.64		3012		9882
197.5	648.0			4.99			4.65		2941		9650
198.0	649.6			4.95			4.59		2833		9294
198.5	651.2			4.89			4.63		3846		12619
199.0	652.9		4.95	4.95			4.63		3077		10095
199.5	654.5			4.75			4.44		3247		10652
200.0	656.2			4.91			4.55		2778		9113
200.5	657.8			4.77			4.54		4274		14021
201.0	659.4	6.00	6.11	4.76	5.41	5.59	4.57	1794	5263	5885	17268
201.5	661.1	5.58	5.83	4.79	5.15	5.36	4.51	2222	3546	7291	11634
202.0	662.7	5.64	5.83	4.84	5.17	5.33	4.61	2062	4425	6765	14517
202.5	664.4	5.73	5.84	4.85	5.24	5.34	4.57	2030	3571	6662	11717
203.0	666.0	5.73	5.98	4.85	5.23	5.39	4.58	1843	3731	6048	12242
203.5	667.7	5.70	5.79	4.83	5.20	5.37	4.61	2151	4673	7056	15331
204.0	669.3	5.60	5.73	4.84	5.13	5.27	4.55	2151	3448	7056	11313
204.5	670.9	5.68	5.78	4.87	4.95	5.10	4.45	1413	2404	4637	7887
205.0	672.6	5.61	4.83	4.82	4.93	5.08	4.45	1481	2703	4861	8867
205.5	674.2	5.54	5.68	4.80	4.93	5.08	4.48	1653	3067	5423	10064
206.0	675.9	5.52	5.69	4.76	4.99	5.18	4.47	1932	3378	6340	11084
206.5	677.5	5.49	5.67	4.66	5.01	5.19	4.44	2083	4505	6835	14779
207.0	679.1		5.80	4.84		5.37	4.62	2326	4587	7630	15050
207.5	680.8	6.00	6.27	4.82	5.56	5.72	4.59	2020	4348	6628	14265
208.0	682.4	5.96	6.08	4.90	5.30	5.42	4.62	1521	3650	4990	11974
208.5	684.1	6.26		4.80	5.61		4.59	1527	4717	5009	15476
209.0	685.7			4.87			4.60		3731		12242
209.5	687.3			4.88			4.59		3448		11313
210.0	689.0	6.23	6.42	4.88	5.37	5.53	4.52	1146	2762	3760	9063
210.5	690.6	6.05	6.21	4.89	5.31	5.44	4.62	1325	3597	4345	11802
211.0	692.3	5.88	6.03	4.91	5.23	5.38	4.63	1538	3597	5047	11802
211.5	693.9	5.79	5.96	4.95	5.20	5.35	4.65	1660	3333	5445	10936
212.0	695.5	5.77	5.93	4.98	5.18	5.34	4.66	1681	3185	5514	10449
212.5	697.2	5.71	5.89	4.87	5.07	5.24	4.58	1563	3356	5126	11010
213.0	698.8	5.63	5.79	4.87	5.02	5.20	4.58	1660	3378	5445	11084
213.5	700.5	5.57	5.69	4.80	5.09	5.22	4.54	2105	3937	6907	12917
214.0	702.1	5.53	5.66	4.83	5.04	5.20	4.59	2105	4274	6907	14021
214.5	703.7	5.59	5.75	4.76	5.07	5.21	4.50	1896	3846	6220	12619
215.0	705.4	5.57	5.73	4.76	5.09	5.24	4.55	2051	4808	6730	15773

Table 4, continued. Borehole 02-5, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S_H (m/sec)	V-P (m/sec)	V-S_H (ft/sec)	V-P (ft/sec)
215.5	707.0	5.60	5.76	4.74	5.11	5.27	4.54	2041	4950	6696	16242
216.0	708.7	5.65	5.80	4.77	5.16	5.32	4.55	2051	4545	6730	14913
216.5	710.3	5.67	5.84	4.80	5.16	5.33	4.54	1961	3922	6433	12866
217.0	711.9	5.65	5.81	4.79	5.13	5.30	4.54	1923	3968	6309	13019
217.5	713.6	5.69	5.87	4.81	5.20	5.37	4.55	2010	3968	6595	13019
218.0	715.2	5.66	5.85	4.80	5.11	5.29	4.57	1794	4348	5885	14265
218.5	716.9	5.60	5.77	4.77	5.07	5.24	4.51	1878	3876	6161	12716
219.0	718.5	5.63	5.80	4.79	5.10	5.25	4.54	1869	3937	6132	12917
219.5	720.1	5.58	5.74	4.77	5.11	5.27	4.52	2139	4065	7018	13337
220.0	721.8	5.62	5.76	4.78	5.10	5.25	4.54	1942	4065	6371	13337
220.5	723.4	5.64	5.77	4.79	5.13	5.28	4.54	2010	4032	6595	13229
221.0	725.1	5.59	5.75	4.78	5.14	5.29	4.55	2198	4386	7211	14390
221.5	726.7	5.58	5.76	4.86	5.10	5.25	4.62	2020	4065	6628	13337
222.0	728.3	5.57	5.71	4.91	5.04	5.20	4.65	1914	3876	6279	12716
222.5	730.0	5.54	5.71	4.82	4.97	5.14	4.59	1762	4348	5781	14265
223.0	731.6	5.51	5.66	4.78	4.97	5.14	4.56	1887	4464	6190	14647
223.5	733.3	5.46	5.59	4.84	5.00	5.14	4.59	2186	4000	7171	13123
224.0	734.9	5.42	5.56	4.83	4.98	5.11	4.58	2247	4000	7373	13123
224.5	736.5	5.41	5.60	4.75	4.97	5.16	4.56	2247	5051	7373	16570
225.0	738.2	5.39	5.56	4.77	4.96	5.13	4.54	2353	4310	7720	14142
225.5	739.8	5.41	5.57	4.79	4.92	5.09	4.54	2073	3876	6800	12716
226.0	741.5	5.39	5.53	4.74	4.95	5.11	4.51	2312	4464	7586	14647
226.5	743.1	5.41	5.52	4.78	5.01	5.16	4.59	2632	5208	8634	17088
227.0	744.8	5.45	5.61	4.87	5.01	5.17	4.67	2273	5051	7456	16570
227.5	746.4	5.45	5.60	4.85	5.01	5.15	4.61	2273	4132	7456	13557
228.0	748.0	5.48	5.64	4.75	5.04	5.19	4.54	2257	4717	7406	15476
228.5	749.7	5.48	5.65	4.76	5.03	5.22	4.52	2286	4274	7499	14021
229.0	751.3	5.52	5.64	4.74	5.00	5.15	4.45	1970	3497	6465	11471
229.5	753.0	5.56	5.71	4.74	5.08	5.22	4.50	2073	4202	6800	13785
230.0	754.6	5.56	5.72	4.69	5.08	5.23	4.48	2062	4673	6765	15331
230.5	756.2	5.61	5.79	4.74	5.14	5.26	4.49	2010	4032	6595	13229
231.0	757.9	5.64	5.83	4.73	5.17	5.37	4.50	2162	4464	7094	14647
231.5	759.5	5.61	5.83	4.86	5.11	5.31	4.62	1970	4167	6465	13670
232.0	761.2	5.61	5.82	4.88	5.07	5.25	4.62	1810	3937	5938	12917
232.5	762.8	5.46	5.76	4.74	4.92	5.23	4.50	1860	4237	6104	13902
233.0	764.4	5.42	5.70	4.84	4.83	5.13	4.55	1742	3472	5716	11392
233.5	766.1	5.49	5.65	4.83	4.93	5.10	4.55	1794	3650	5885	11974
234.0	767.7	5.40	5.56	4.75	4.92	5.08	4.52	2073	4274	6800	14021
234.5	769.4	5.35	5.52	4.74	4.91	5.08	4.53	2260	4762	7414	15623
235.0	771.0	5.36	5.51	4.81	4.92	5.07	4.56	2273	4032	7456	13229
235.5	772.6	5.35	5.51	4.90	4.92	5.08	4.65	2312	4065	7586	13337
236.0	774.3	5.38	5.54	4.78	4.95	5.12	4.57	2339	4808	7674	15773
236.5	775.9	5.43	5.58	4.77	5.00	5.16	4.57	2367	5051	7765	16570
237.0	777.6	5.45	5.61	4.76	5.02	5.19	4.56	2367	4854	7765	15926
237.5	779.2	5.48	5.63	4.79	5.06	5.22	4.54	2410	3937	7906	12917
238.0	780.8	5.50	5.68	4.86	5.07	5.25	4.63	2326	4348	7630	14265
238.5	782.5	5.39	5.66	4.83	4.92	5.20	4.57	2151	3906	7056	12816
239.0	784.1	5.52	5.69	4.81	5.01	5.17	4.58	1932	4310	6340	14142
239.5	785.8	5.51	5.69	4.79	5.02	5.20	4.58	2051	4587	6730	15050
240.0	787.4	5.38	5.65	4.79	4.90	5.18	4.56	2116	4348	6944	14265

Table 4, continued. Borehole 02-5, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	$V\text{-}S_H$ (m/sec)	V-P (m/sec)	$V\text{-}S_H$ (ft/sec)	V-P (ft/sec)
240.5	789.0	5.37	5.66	4.76	4.89	5.19	4.49	2105	3788	6907	12427
241.0	790.7	5.37	5.53	4.80	4.92	5.11	4.56	2312	4167	7586	13670
241.5	792.3	5.48		4.82	5.00		4.58	2105	4202	6907	13785
242.0	794.0	5.47		4.80	4.99		4.58	2105	4587	6907	15050
242.5	795.6	5.40		4.81	4.97		4.59	2299	4425	7542	14517
243.0	797.2	5.39		4.81	4.94		4.59	2222	4630	7291	15189
243.5	798.9	5.23		4.79	4.79		4.53	2247	3788	7373	12427
244.0	800.5	5.37	5.49	4.78	4.93	5.08	4.55	2367	4202	7765	13785
244.5	802.2	5.37	5.53	4.78	4.96	5.13	4.57	2469	4902	8101	16083
245.0	803.8	5.43	5.61	4.81	5.00	5.18	4.59	2299	4673	7542	15331
245.5	805.4	5.41	5.61	4.79	4.99	5.19	4.55	2381	4132	7812	13557
246.0	807.1	5.42	5.60	4.79	5.01	5.20	4.57	2454	4545	8051	14913
246.5	808.7	5.49	5.66	4.81	5.08	5.25	4.62	2424	5236	7954	17177
247.0	810.4	5.52	4.60	4.81	5.06	5.23	4.49	2151	3145	7056	10317
247.5	812.0	5.67	5.78	4.83	5.15	5.26	4.57	1905	3846	6249	12619
248.0	813.6	5.49		4.83	5.00		4.59	2041	4132	6696	13557
248.6	815.6										
249.0	816.9										
249.5	818.6										

Table 4, continued. Borehole 02-5, Suspension R1-R2 depth, pick times, and velocities

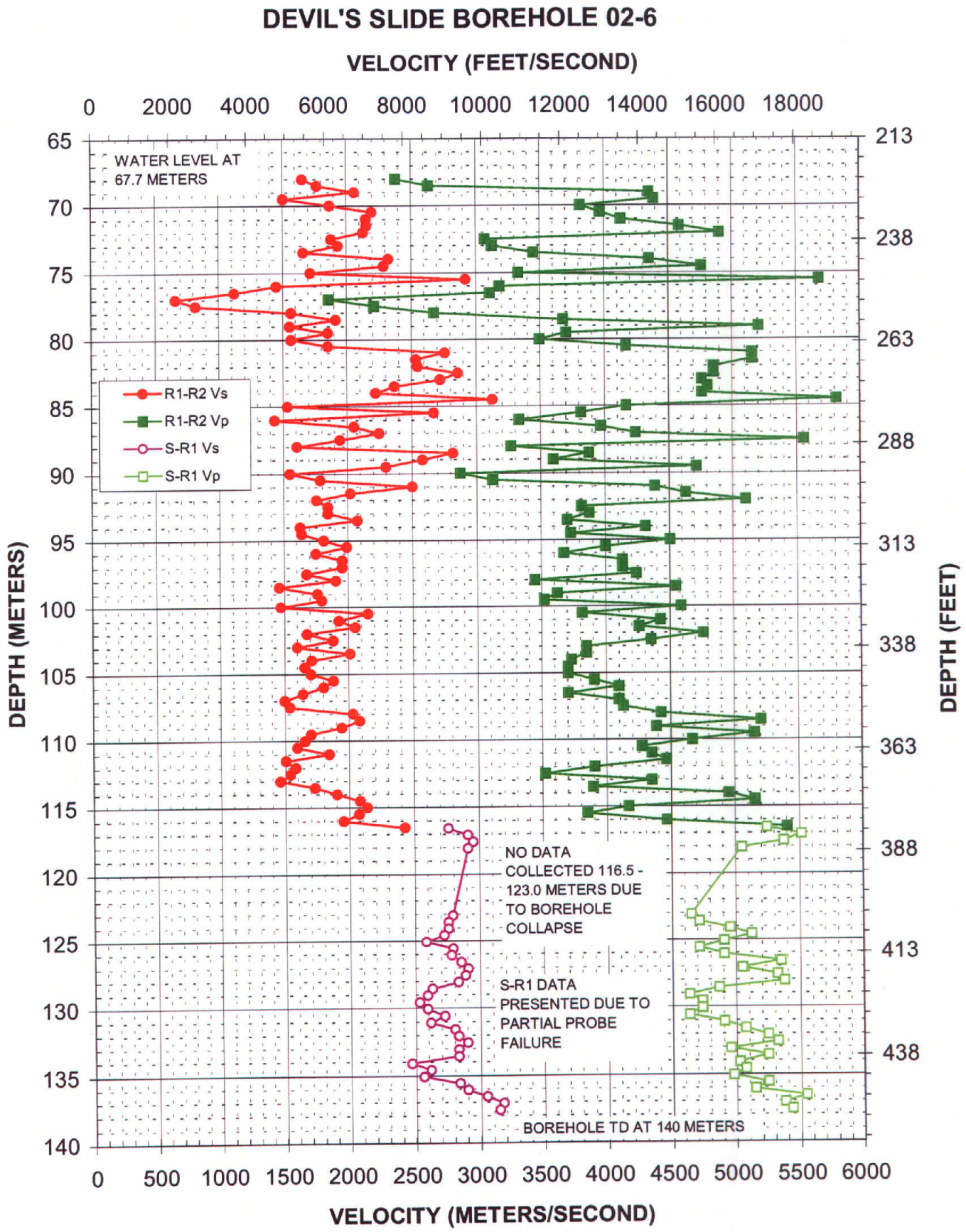

Figure 6. Borehole 02-6, Suspension P- and S_H-wave velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	$V\text{-}S_H$ (m/sec)	V-P (m/sec)	$V\text{-}S_H$ (ft/sec)	V-P (ft/sec)
67.0	219.8				4.89		4.43			0	0
67.5	221.5				4.89		4.61			0	0
68.0	223.1	5.48		4.81	4.87		4.39	1653	2381	5423	7812
68.5	224.7	5.44		4.82	4.87		4.44	1767	2632	5797	8634
69.0	226.4	5.38		4.64	4.89		4.41	2062	4348	6765	14265
69.5	228.0	5.55		4.65	4.88		4.42	1504	4386	4934	14390
70.0	229.7	5.47		4.91	4.93		4.65	1869	3817	6132	12522
70.5	231.3	5.49		4.87	5.03		4.62	2198	3968	7211	13019
71.0	232.9	5.51		4.63	5.04		4.39	2151	4132	7056	13557
71.5	234.6	5.52	5.67	4.61	5.04	5.22	4.39	2155	4587	7071	15050
72.0	236.2	5.58	5.49	4.63	5.07	5.05	4.42	2128	4902	6981	16083
72.5	237.9	5.84	5.79	4.86	5.33	5.24	4.54	1878	3067	6161	10064
73.0	239.5	5.89	5.95	4.81	5.37	5.44	4.49	1932	3125	6340	10253
73.5	241.1	5.83	6.04	4.81	5.21	5.46	4.52	1660	3448	5445	11313
74.0	242.8	6.02	6.13	4.80	5.60	5.69	4.57	2326	4348	7630	14265
74.5	244.4	5.94	6.18	4.87	5.55	5.70	4.66	2286	4762	7499	15623
75.0	246.1	5.97	6.12	4.91	5.40	5.53	4.61	1717	3333	5632	10936
75.5	247.7	5.76	5.82	4.76	5.42	5.48	4.59	2920	5682	9579	18641
76.0	249.3	6.90	6.86	5.25	6.16	6.22	4.94	1449	3185	4755	10449
76.5	251.0	6.07	6.06	4.92	5.17	5.18	4.59	1120	3106	3676	10189
77.0	252.6	6.67	6.64	5.05	5.17	5.11	4.51	662	1859	2173	6098
77.5	254.3	6.22	6.14	4.87	4.95	4.96	4.42	818	2212	2684	7258
78.0	255.9	5.46	5.62	4.66	4.85	4.95	4.28	1563	2674	5126	8772
78.5	257.5	5.37	5.34	4.54	4.85	4.81	4.27	1914	3676	6279	12062
79.0	259.2	5.36		4.51	4.72		4.32	1553	5208	5094	17088
79.5	260.8	5.36	5.52	4.57	4.86	4.94	4.30	1852	3704	6076	12151
80.0	262.5	5.43	5.44	4.66	4.79	4.80	4.38	1563	3497	5126	11471
80.5	264.1	5.41	5.43	4.64	4.86	4.90	4.40	1852	4167	6076	13670
81.0	265.7	5.24	5.33	4.60	4.89	4.95	4.41	2759	5155	9051	16912
81.5	267.4	5.44	5.38	4.66	5.05	4.99	4.46	2532	5155	8306	16912
82.0	269.0	5.43	5.26	4.66	5.04	4.87	4.46	2548	4854	8359	15926
82.5	270.7	5.33	5.35	4.68	4.95	5.03	4.48	2857	4854	9374	15926
83.0	272.3	5.29	5.30	4.74	4.89	4.96	4.53	2721	4762	8927	15623
83.5	274.0	5.91	5.53	4.71	5.53	5.07	4.51	2367	4808	7765	15773
84.0	275.6	5.77	5.93	4.69	5.32	5.48	4.48	2222	4762	7291	15623
84.5	277.2	5.52	5.57	4.69	5.21	5.25	4.52	3125	5814	10253	19075
85.0	278.9	5.83	5.90	4.70	5.24	5.18	4.46	1533	4167	5028	13670
85.5	280.5	5.56		4.71	5.19		4.45	2667	3817	8749	12522
86.0	282.2	5.70	5.83	4.73	5.05	5.08	4.43	1434	3333	4704	10936
86.5	283.8	5.44	5.32	4.62	4.94	4.84	4.36	2051	3968	6730	13019
87.0	285.4	5.33		4.68	4.88		4.45	2247	4237	7373	13902
87.5	287.1	5.49		4.72	4.97		4.54	1942	5556	6371	18227
88.0	288.7	5.62	5.55	4.80	4.98	4.94	4.49	1606	3268	5270	10722
88.5	290.4	5.49		4.78	5.13		4.53	2817	3876	9242	12716
89.0	292.0	5.56	5.40	4.76	5.23	4.96	4.48	2581	3597	8467	11802
89.5	293.6	5.44	5.48	4.75	5.03	5.02	4.54	2299	4717	7542	15476
90.0	295.3	5.98		4.79	5.34		4.44	1550	2874	5087	9428
90.5	296.9	5.85		4.86	5.29		4.54	1786	3125	5859	10253
91.0	298.6	5.67		4.71	5.27		4.48	2500	4386	8202	14390
91.5	300.2	5.78		4.73	5.29		4.51	2020	4630	6628	15189

Table 5. Borehole 02-6, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S_H (m/sec)	V-P (m/sec)	V-S_H (ft/sec)	V-P (ft/sec)
92.0	301.8	5.86		4.71	5.29		4.51	1754	5102	5756	16739
92.5	303.5	5.70	5.79	4.75	5.19	5.21	4.49	1843	3817	6048	12522
93.0	305.1	5.59	5.62	4.72	5.07	5.06	4.46	1843	3876	6048	12716
93.5	306.8	5.65	5.55	4.76	5.15	5.09	4.49	2073	3704	6800	12151
94.0	308.4	5.77	5.62	4.72	5.11	5.06	4.49	1626	4310	5335	14142
94.5	310.0	5.62	5.71	4.68	5.03	5.07	4.42	1635	3731	5365	12242
95.0	311.7	5.67	5.67	4.65	5.12	5.12	4.43	1810	4505	5938	14779
95.5	313.3	5.52	5.63	4.72	5.05	5.10	4.47	1990	4000	6529	13123
96.0	315.0	5.65	5.62	4.76	5.07	5.05	4.49	1747	3676	5731	12062
96.5	316.6	5.64	5.67	4.74	5.13	5.15	4.50	1951	4132	6402	13557
97.0	318.2	5.67	5.67	4.83	5.16	5.15	4.58	1951	4132	6402	13557
97.5	319.9	5.74	5.79	4.78	5.15	5.18	4.55	1674	4237	5491	13902
98.0	321.5	5.58	5.70	4.73	5.04	5.20	4.44	1905	3448	6249	11313
98.5	323.2	5.72	5.71	4.64	5.04	5.02	4.42	1460	4545	4790	14913
99.0	324.8	5.61	5.64	4.70	4.99	5.13	4.43	1759	3623	5771	11887
99.5	326.4	5.59	5.64	4.78	5.03	5.08	4.49	1794	3521	5885	11552
100.0	328.1	5.53	5.63	4.71	4.83	4.97	4.49	1471	4587	4825	15050
100.5	329.7	5.52	5.43	4.71	5.02	4.99	4.44	2151	3817	7056	12522
101.0	331.4	5.70	5.62	4.63	5.17	5.11	4.40	1923	4425	6309	14517
101.5	333.0	5.53	5.53	4.70	5.05	5.03	4.47	2051	4255	6730	13961
102.0	334.6	5.61	5.61	4.61	5.02	5.01	4.40	1674	4762	5491	15623
102.5	336.3	5.59	5.80	4.74	5.07	5.26	4.51	1878	4348	6161	14265
103.0	337.9	5.74	5.69	4.74	5.13	5.05	4.48	1600	3846	5249	12619
103.5	339.6	5.51	5.61	4.73	5.04	5.08	4.47	2010	3846	6595	12619
104.0	341.2	5.72	5.74	4.74	5.18	5.11	4.47	1709	3731	5608	12242
104.5	342.8	5.90	5.96	4.98	5.30	5.34	4.71	1653	3704	5423	12151
105.0	344.5	5.83	5.84	4.78	5.27	5.23	4.51	1702	3704	5584	12151
105.5	346.1	5.77	5.74	4.73	5.21	5.24	4.48	1878	3906	6161	12816
106.0	347.8	5.70	5.71	4.73	5.11	5.19	4.49	1802	4098	5911	13446
106.5	349.4	5.72	5.79	4.73	5.12	5.17	4.46	1639	3704	5378	12151
107.0	351.0	5.68	5.65	4.70	5.02	4.98	4.45	1498	4098	4915	13446
107.5	352.7	5.64	5.77	4.69	5.03	5.08	4.45	1538	4132	5047	13557
108.0	354.3	5.51	5.62	4.67	5.01	5.13	4.45	2030	4425	6662	14517
108.5	356.0	5.52	5.60	4.65	5.04	5.12	4.46	2083	5208	6835	17088
109.0	357.6	5.59	5.51	4.64	5.07	5.01	4.42	1942	4386	6371	14390
109.5	359.3	5.94	5.92	4.70	5.38	5.30	4.50	1702	5155	5584	16912
110.0	360.9	5.92	5.86	4.71	5.32	5.25	4.49	1653	4673	5423	15331
110.5	362.5	5.85	5.77	4.67	5.25	5.12	4.44	1594	4274	5228	14021
111.0	364.2	5.88	5.86	4.71	5.36	5.30	4.48	1843	4348	6048	14265
111.5	365.8	5.79	6.10	4.72	5.19	5.38	4.49	1504	4464	4934	14647
112.0	367.5	5.79	5.92	4.68	5.16	5.29	4.42	1581	3906	5187	12816
112.5	369.1	5.78	6.18	4.74	5.10	5.56	4.46	1538	3521	5047	11552
113.0	370.7	5.70	5.72	4.71	5.05	5.00	4.48	1460	4348	4790	14265
113.5	372.4	5.47	5.50	4.71	4.92	4.90	4.45	1732	3891	5681	12766
114.0	374.0	5.40	5.41	4.65	4.87	4.89	4.45	1905	4950	6249	16242
114.5	375.7	5.32	5.35	4.62	4.85	4.86	4.42	2083	5155	6835	16912
115.0	377.3	5.30	5.24	4.56	4.80	4.81	4.32	2139	4167	7018	13670
115.5	378.9	5.20	5.06	4.57	4.71	4.59	4.31	2073	3846	6800	12619
116.0	380.6	5.20	5.28	4.55	4.70	4.76	4.32	1951	4464	6402	14647
116.5	382.2	5.12	5.25	4.56	4.70	4.84	4.38	2424	5405	7954	17734

Table 5, continued. Borehole 02-6, Suspension R1-R2 depth, pick times, and velocities

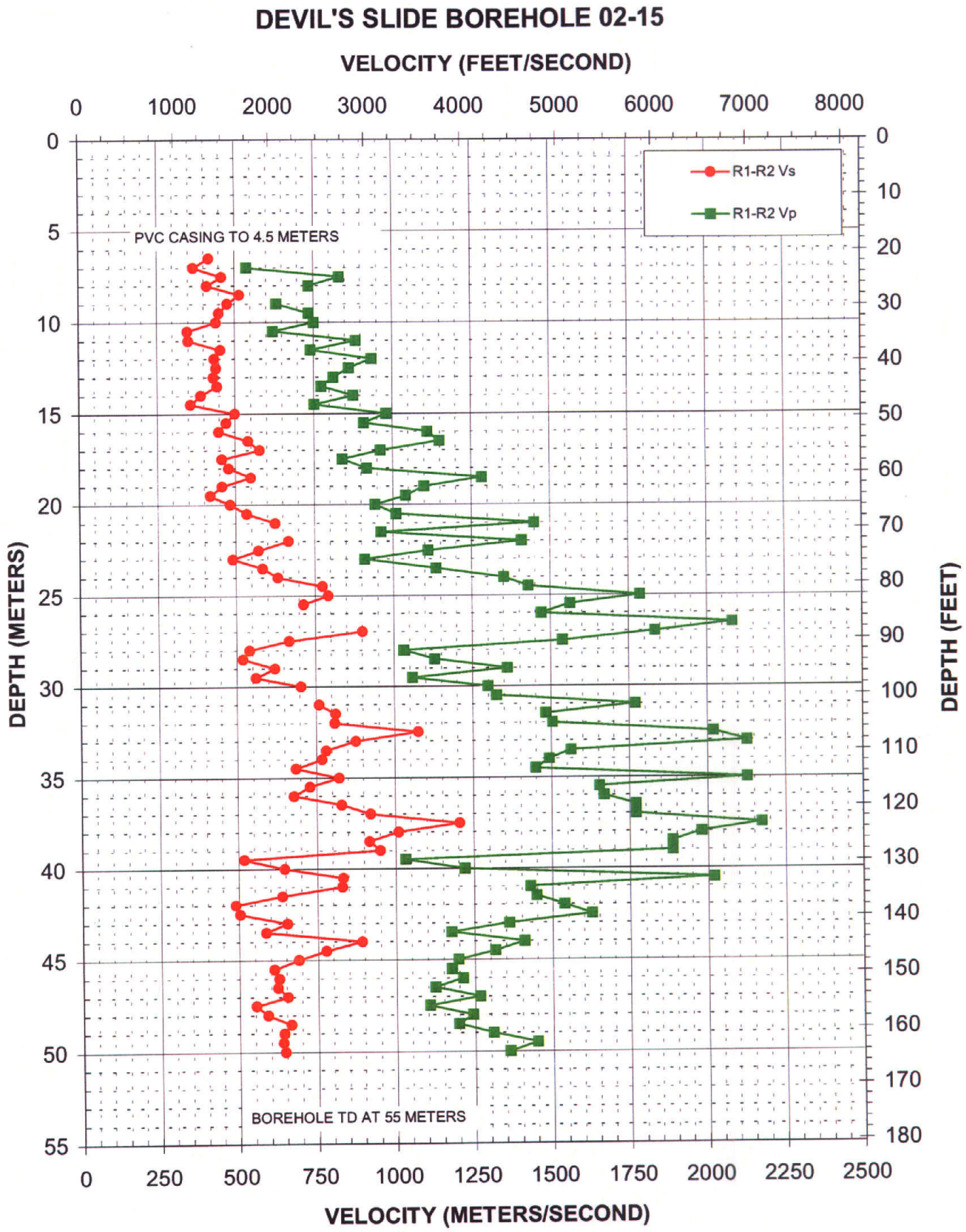

Figure 7. Borehole 02-15, Suspension P- and S_H-wave velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	$V\text{-}S_H$ (m/sec)	V-P (m/sec)	$V\text{-}S_H$ (ft/sec)	V-P (ft/sec)
6.0	19.7									0	0
6.5	21.3	10.40			8.00			417		1367	0
7.0	23.0	12.42		8.99	9.70		7.13	368	538	1206	1764
7.5	24.6	12.28		8.64	10.10		7.44	459	833	1505	2734
8.0	26.2	12.40	12.98	9.31	10.04	10.48	7.95	412	735	1350	2412
8.5	27.9	11.64	11.64		9.66	9.74		515		1691	0
9.0	29.5	11.40		9.15	9.30		7.57	476	633	1562	2076
9.5	31.2	11.30	12.15	8.64	9.15	9.85	7.28	449	735	1475	2412
10.0	32.8	11.20	12.00	8.65	8.85	9.80	7.32	440	752	1442	2467
10.5	34.4	11.70	12.50	8.55	8.85	9.60	6.94	348	621	1141	2038
11.0	36.1	10.95		7.73	8.10		6.60	351	885	1151	2903
11.5	37.7	10.25	7.50	7.50	8.05		6.15	455	741	1491	2430
12.0	39.4	11.05	10.90	7.27	8.75	8.60	6.20	435	935	1426	3066
12.5	41.0	11.24	11.12	7.88	8.92	8.90	6.72	441	862	1445	2828
13.0	42.7	10.84		7.28	8.52		6.05	431	813	1414	2667
13.5	44.3	10.82	11.66	7.44	8.38	9.58	6.15	442	775	1452	2543
14.0	45.9	10.52	10.58	7.33	8.06	7.92	6.19	391	877	1282	2878
14.5	47.6	10.94		7.56	8.14		6.23	357	752	1172	2467
15.0	49.2	10.16		7.36	8.16		6.34	500	980	1640	3217
15.5	50.9	10.20	10.44	7.44	8.16	8.24	6.34	472	909	1548	2983
16.0	52.5	10.78	10.88	6.60	8.54	8.64	5.70	446	1111	1465	3645
16.5	54.1	11.48	11.64	6.62	9.62	9.80	5.75	541	1149	1773	3771
17.0	55.8	10.36	10.34	7.70	8.58	8.66	6.66	578	962	1896	3155
17.5	57.4	10.60	10.58	7.79	8.46	8.34	6.60	457	840	1498	2757
18.0	59.1	10.60	10.68	7.84	8.52	8.58	6.75	478	917	1570	3010
18.5	60.7	9.96	10.04	7.14	8.08	8.28	6.36	549	1282	1803	4206
19.0	62.3	9.96	9.80	7.01	7.64	7.74	6.10	457	1099	1498	3605
19.5	64.0	10.12	10.24	6.92	7.74	7.84	5.96	418	1042	1373	3418
20.0	65.6	9.44	9.64	7.11	7.42	7.52	6.05	483	943	1585	3095
20.5	67.3	9.78	9.78	6.71	7.86	7.96	5.72	535	1010	1754	3314
21.0	68.9	9.38	9.52	6.13	7.78	7.92	5.44	625	1449	2051	4755
21.5	70.5			7.08			6.04		962	0	3155
22.0	72.2	8.84	8.82	6.81	7.30	7.36	6.10	667	1408	2187	4621
22.5	73.8	9.20	8.98	6.90	7.58	7.10	6.00	571	1111	1875	3645
23.0	75.5	8.88	8.86	6.78	6.78	6.88	5.68	490	909	1608	2983
23.5	77.1	8.36	8.52	6.47	6.66	6.80	5.59	585	1136	1919	3728
24.0	78.7	8.18	8.42	6.21	6.66	6.78	5.47	633	1351	2076	4434
24.5	80.4	7.98	8.14	6.05	6.68	6.86	5.35	775	1429	2543	4687
25.0	82.0	8.12	8.10	6.11	6.80	6.90	5.55	794	1786	2604	5859
25.5	83.7	8.70		6.24	7.30		5.60	714	1563	2343	5126
26.0	85.3			6.22			5.54		1471	0	4825
26.5	86.9			6.26			5.78		2083	0	6835
27.0	88.6	8.68	8.95	6.46	7.57	7.84	5.92	901	1835	2956	6020
27.5	90.2	9.13		6.61	7.63		5.96	667	1538	2187	5047
28.0	91.9	9.02	9.38	6.99	7.20	7.50	6.02	541	1031	1773	3382
28.5	93.5	8.92	9.20	6.46	6.98	7.29	5.57	519	1130	1704	3707
29.0	95.1	8.54	8.74	6.26	6.94	7.12	5.53	621	1361	2038	4464
29.5	96.8	9.23	9.56	6.45	7.44	7.78	5.50	560	1058	1838	3472
30.0	98.4	8.80		6.11	7.38		5.34	704	1299	2310	4261
30.5	100.1			6.04			5.29		1325	0	4345

Table 6. Borehole 02-15, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	$V\text{-}S_H$ (m/sec)	V-P (m/sec)	$V\text{-}S_H$ (ft/sec)	V-P (ft/sec)
31.0	101.7	8.13	8.59	6.58	6.85	7.24	6.02	760	1770	2495	5807
31.5	103.3	8.19	8.51	6.69	6.92	7.32	6.02	813	1481	2667	4861
32.0	105.0	8.53	8.79	6.55	7.27	7.58	5.88	810	1504	2657	4934
32.5	106.6	7.66		6.18	6.73		5.69	1075	2020	3528	6628
33.0	108.3	8.32	8.47	6.21	7.10	7.41	5.74	877	2128	2878	6981
33.5	109.9	8.18	8.39	6.14	6.83	7.18	5.50	781	1563	2563	5126
34.0	111.5	8.16	8.43	6.04	6.88	7.11	5.37	769	1493	2524	4897
34.5	113.2	8.17	8.40	6.33	6.75	6.90	5.64	685	1449	2247	4755
35.0	114.8	7.56	7.76	5.76	6.37	6.52	5.29	823	2128	2700	6981
35.5	116.5	7.97	7.77	6.02	6.60	6.40	5.41	730	1653	2395	5423
36.0	118.1	8.30	8.46	6.25	6.82	6.99	5.65	678	1667	2224	5468
36.5	119.8	7.64	8.00	6.02	6.49	6.74	5.45	830	1770	2723	5807
37.0	121.4	7.69	7.88	6.02	6.57	6.83	5.45	922	1770	3024	5807
37.5	123.0	7.60	7.83	6.03	6.78	6.99	5.57	1205	2174	3953	7132
38.0	124.7	8.73	8.97	5.95	7.77	7.95	5.45	1010	1980	3314	6497
38.5	126.3	8.75	8.91	6.03	7.60	7.88	5.50	917	1887	3010	6190
39.0	128.0	8.13	8.16	6.33	7.05	7.14	5.80	952	1887	3125	6190
39.5	129.6		9.82	6.74		7.89	5.77	518	1031	1700	3382
40.0	131.2	8.72	8.86	6.51	7.22	7.27	5.69	647	1220	2124	4001
40.5	132.9	8.24	8.42	6.51	7.13	7.13	6.01	833	2020	2734	6628
41.0	134.5	9.29	9.42	6.95	8.07	8.23	6.25	830	1429	2723	4687
41.5	136.2	9.76	9.77	6.95	8.12	8.28	6.26	639	1449	2096	4755
42.0	137.8	9.95	10.16	6.80	7.91	8.11	6.15	489	1538	1604	5047
42.5	139.4	10.10	10.15	6.99	8.10	8.18	6.37	504	1626	1653	5335
43.0	141.1	9.52	9.63	6.53	7.94	8.15	5.80	654	1361	2144	4464
43.5	142.7	9.69	9.76	7.13	7.94	8.10	6.28	587	1176	1924	3860
44.0	144.4	8.78	8.98	6.91	7.67	7.85	6.20	893	1408	2929	4621
44.5	146.0	8.84	8.99	7.09	7.58	7.68	6.33	778	1316	2553	4317
45.0	147.6	8.88	9.21	7.06	7.49	7.70	6.23	690	1198	2263	3929
45.5	149.3	9.09	9.28	7.12	7.47	7.63	6.27	612	1176	2007	3860
46.0	150.9	8.90	9.12	6.95	7.30	7.53	6.12	627	1212	2057	3977
46.5	152.6	8.63	9.07	6.82	6.98	7.51	5.93	623	1124	2044	3686
47.0	154.2	8.52	9.05	6.92	7.02	7.49	6.13	654	1266	2144	4153
47.5	155.8	8.80	9.21	6.92	6.98	7.42	6.02	554	1105	1818	3625
48.0	157.5	9.38	9.48	6.93	7.69	7.78	6.12	590	1242	1936	4076
48.5	159.1	8.56	8.77	6.73	7.10	7.22	5.90	664	1198	2180	3929
49.0	160.8	9.20	9.38	6.80	7.65	7.81	6.04	641	1307	2103	4289
49.5	162.4	9.16	9.31	6.52	7.59	7.75	5.83	639	1449	2096	4755
50.0	164.0	9.00	9.17	6.48	7.46	7.61	5.74	645	1361	2117	4464

Table 6, continued. Borehole 02-15, Suspension R1-R2 depth, pick times, and velocities

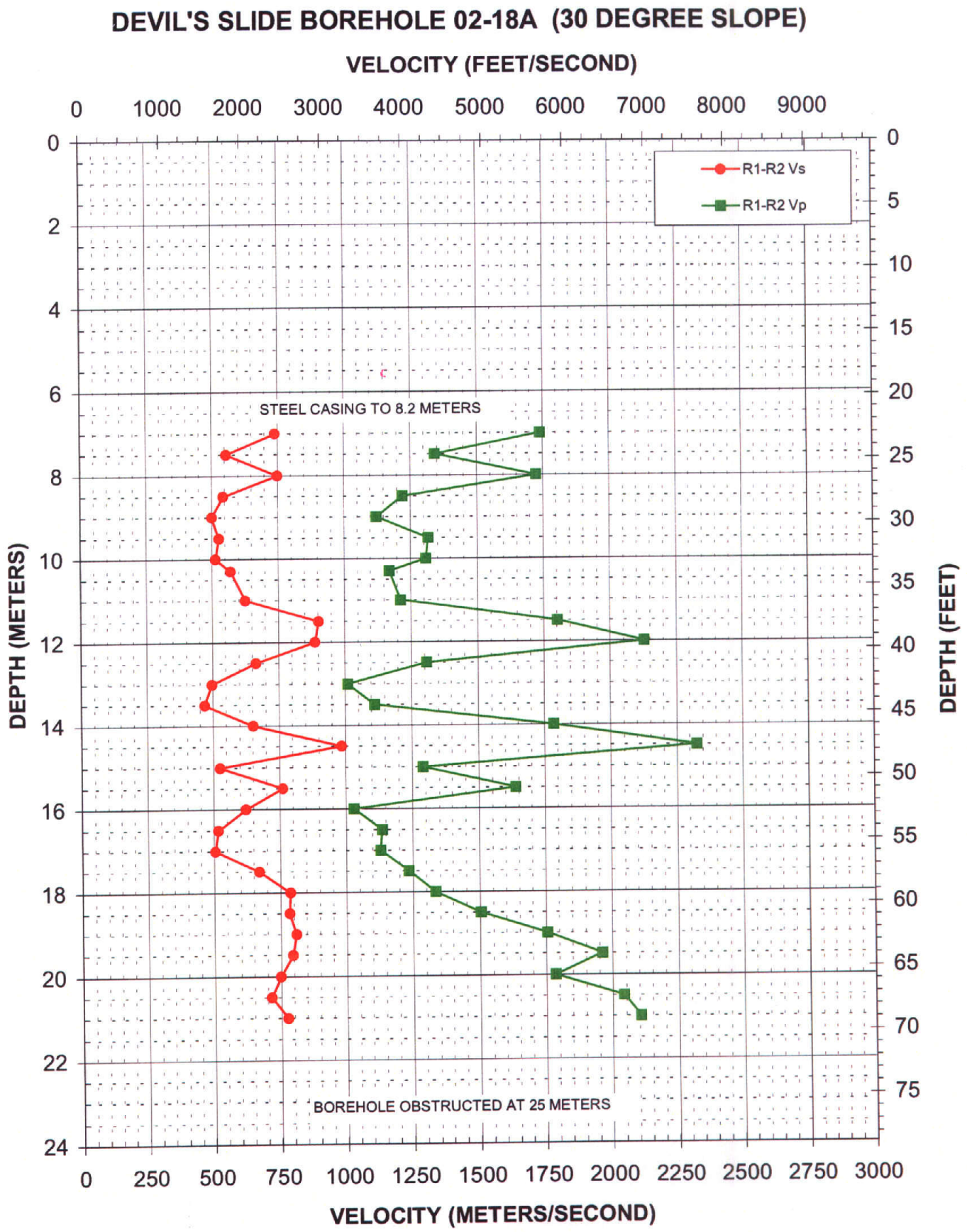

Figure 8. Borehole 02-18A, Suspension P- and S_H-wave velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	$V\text{-}S_H$ (m/sec)	V-P (m/sec)	$V\text{-}S_H$ (ft/sec)	V-P (ft/sec)
6.5	21.3				6.79					0	0
7.0	23.0	8.18	7.96	6.69	6.80	6.64	6.11	741	1739	2430	5706
7.5	24.6	10.49	9.86	6.79	8.67	8.08	6.04	556	1342	1823	4404
8.0	26.2	10.41	10.01	6.98	9.07	8.68	6.40	749	1724	2458	5657
8.5	27.9	10.27	9.67	6.82	8.50	7.76	6.00	543	1220	1783	4001
9.0	29.5	10.15	9.82	6.90	8.21	7.75	6.01	499	1124	1636	3686
9.5	31.2	9.74	8.85	6.64	7.64	7.15	5.88	526	1316	1727	4317
10.0	32.8	9.41	9.36	6.78	7.41	7.46	6.01	513	1307	1682	4289
10.3	33.8	10.66	10.02	6.91	8.90	8.27	6.06	570	1170	1869	3837
11.0	36.1	9.53	9.16	6.59	7.84	7.65	5.76	625	1212	2051	3977
11.5	37.7	8.94	9.10	6.39	7.96	7.86	5.83	901	1802	2956	5911
12.0	39.4	9.51	9.09	6.46	8.42	7.93	5.99	889	2128	2916	6981
12.5	41.0	9.41	9.44	6.64	7.91	7.93	5.88	664	1307	2180	4289
13.0	42.7	9.59	9.32	6.89	7.47	7.41	5.90	496	1010	1628	3314
13.5	44.3	9.62	9.41	6.77	7.42	7.34	5.87	468	1111	1537	3645
14.0	45.9	9.46	9.21	6.55	7.78	7.82	5.99	651	1786	2137	5859
14.5	47.6	8.96	8.63	6.55	7.82	7.74	6.12	985	2326	3232	7630
15.0	49.2	9.58	9.58	6.86	7.65	7.70	6.08	525	1290	1722	4233
15.5	50.9	8.82	8.71	6.64	7.47	7.44	6.03	763	1639	2504	5378
16.0	52.5	8.96	8.79	6.75	7.33	7.20	5.78	621	1031	2038	3382
16.5	54.1	8.90	8.88	6.46	6.97	6.93	5.58	515	1136	1691	3728
17.0	55.8	8.88	8.65	6.24	6.84	6.73	5.36	505	1130	1657	3707
17.5	57.4	8.24	8.24	6.30	6.74	6.76	5.49	671	1235	2202	4050
18.0	59.1	8.09	8.11	5.99	6.85	6.81	5.24	787	1333	2583	4374
18.5	60.7	8.27	8.32	6.10	6.98	7.06	5.44	784	1504	2573	4934
19.0	62.3	8.14	8.01	5.90	6.92	6.76	5.33	810	1754	2657	5756
19.5	64.0	8.01	7.94	5.86	6.78	6.66	5.35	797	1961	2614	6433
20.0	65.6	8.03	7.96	5.83	6.69	6.63	5.27	749	1786	2458	5859
20.5	67.3	8.07	7.96	5.70	6.67	6.56	5.21	714	2041	2343	6696
21.0	68.9	7.88	7.81	5.62	6.57	6.54	5.14	775	2105	2543	6907

Table 7. Borehole 02-18A, Suspension R1-R2 depth, pick times, and velocities

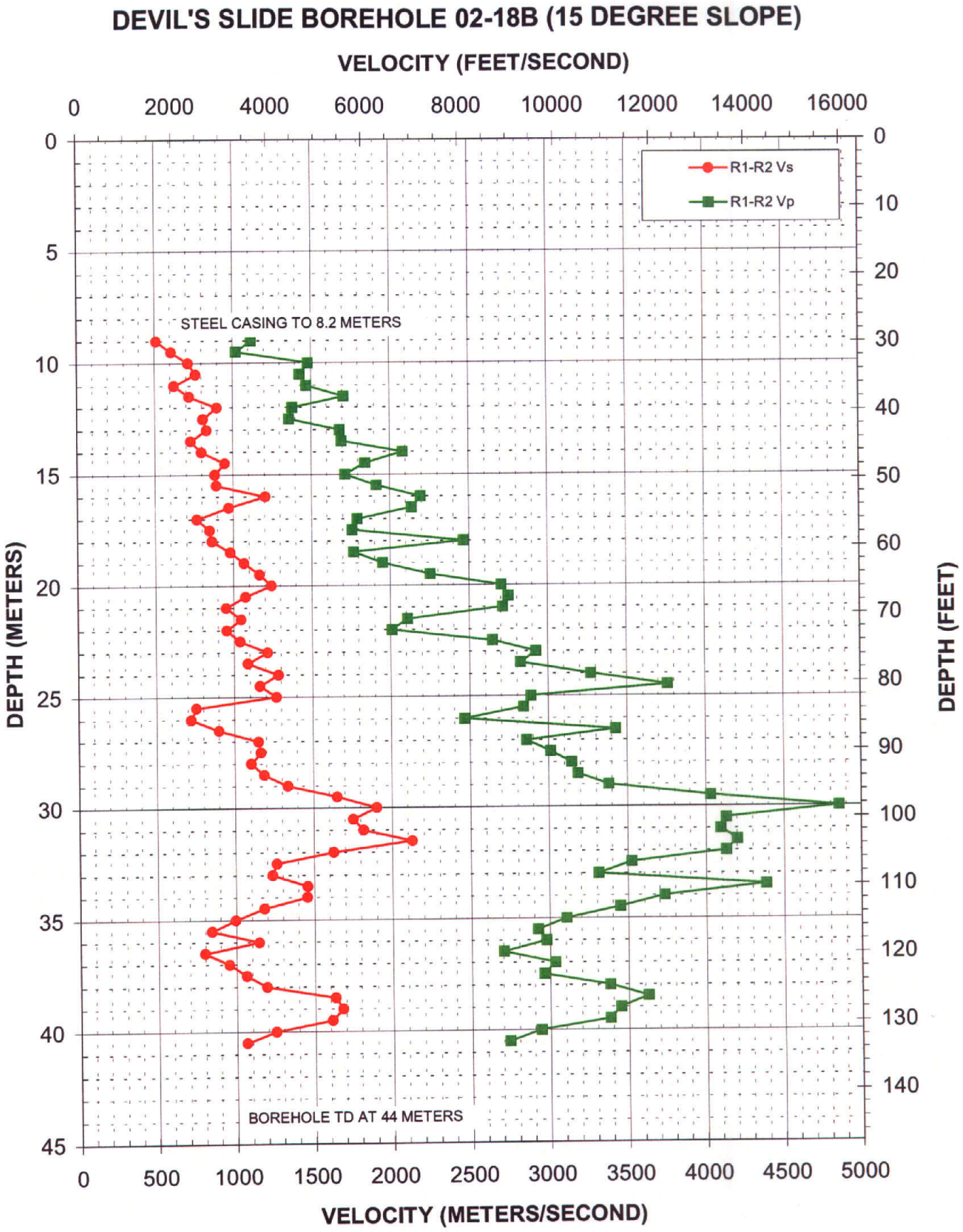

Figure 9. Borehole 02-18B, Suspension P- and S_H-wave velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	$V\text{-}S_H$ (m/sec)	V-P (m/sec)	$V\text{-}S_H$ (ft/sec)	V-P (ft/sec)
9.0	29.5	8.36	8.61	6.58	6.39	6.67	5.69	512	1117	1678	3666
9.5	31.2	8.45	8.63	6.68	6.72	7.06	5.70	606	1020	1988	3348
10.0	32.8	8.11	8.15	6.13	6.71	6.75	5.45	714	1481	2343	4861
10.5	34.4	8.10	8.40	6.44	6.88	7.00	5.74	763	1429	2504	4687
11.0	36.1	8.56	8.60	6.41	6.96	6.99	5.73	623	1471	2044	4825
11.5	37.7	8.04	8.30	6.15	6.66	6.90	5.56	719	1709	2360	5608
12.0	39.4	7.65	7.70	6.25	6.50	6.62	5.52	897	1379	2942	4525
12.5	41.0	7.66	7.61	6.08	6.44	6.36	5.35	808	1359	2651	4458
13.0	42.7	7.59	7.54	6.15	6.36	6.36	5.55	832	1683	2728	5523
13.5	44.3	7.47	7.42	5.79	6.06	6.09	5.20	730	1695	2395	5561
14.0	45.9	7.52	7.49	5.72	6.24	6.27	5.24	798	2083	2619	6835
14.5	47.6	7.48	7.27	5.76	6.39	6.25	5.22	948	1845	3110	6053
15.0	49.2	7.34	7.46	5.87	6.24	6.29	5.29	883	1718	2897	5637
15.5	50.9	7.45	7.39	5.78	6.34	6.26	5.26	891	1916	2923	6285
16.0	52.5	7.23	7.12	5.89	6.41	6.28	5.43	1205	2193	3953	7195
16.5	54.1	7.19	7.12	5.58	6.15	6.10	5.11	971	2137	3185	7010
17.0	55.8	7.40	7.25	5.69	6.05	6.00	5.13	766	1792	2514	5880
17.5	57.4	6.99	6.94	5.63	5.86	5.70	5.07	847	1761	2780	5776
18.0	59.1	7.11	7.15	5.51	5.94	6.01	5.11	864	2463	2834	8081
18.5	60.7	6.92	6.91	5.49	5.88	5.90	4.93	978	1767	3209	5797
19.0	62.3	6.87	7.03	5.40	5.95	6.07	4.89	1067	1953	3500	6408
19.5	64.0	6.86	6.89	5.39	6.00	6.03	4.95	1166	2252	3826	7389
20.0	65.6	6.89	6.87	5.21	6.04	6.11	4.84	1242	2703	4076	8867
20.5	67.3	6.88	6.81	5.44	5.94	5.89	5.08	1075	2747	3528	9013
21.0	68.9	6.89	6.94	5.30	5.87	5.86	4.94	950	2710	3117	8891
21.5	70.5	6.67	6.73	5.13	5.73	5.76	4.66	1047	2110	3435	6922
22.0	72.2	6.63	6.71	5.08	5.60	5.64	4.58	952	2008	3125	6588
22.5	73.8	6.54	6.53	5.03	5.53	5.61	4.65	1039	2646	3409	8679
23.0	75.5	6.65	6.73	4.98	5.81	5.92	4.64	1216	2924	3989	9593
23.5	77.1	6.80	6.83	5.03	5.87	5.92	4.67	1087	2825	3566	9268
24.0	78.7	6.74	6.79	5.09	5.97	6.00	4.78	1282	3268	4206	10722
24.5	80.4	6.81	6.89	5.07	5.96	6.02	4.81	1163	3759	3815	12334
25.0	82.0	6.87	6.86	4.90	6.10	6.06	4.55	1270	2890	4166	9482
25.5	83.7	6.95	6.99	4.95	5.62	5.67	4.60	755	2841	2476	9321
26.0	85.3	6.99	7.07	5.18	5.62	5.67	4.77	721	2463	2365	8081
26.5	86.9	6.75	6.69	4.91	5.67	5.55	4.62	901	3425	2956	11236
27.0	88.6	6.38	6.39	4.87	5.52	5.51	4.52	1153	2857	3782	9374
27.5	90.2	6.26	6.30	4.92	5.40	5.44	4.58	1166	3012	3826	9882
28.0	91.9	6.16	6.05	4.81	5.25	5.15	4.49	1105	3145	3625	10317
28.5	93.5	5.92	6.22	4.75	5.13	5.32	4.44	1187	3185	3894	10449
29.0	95.1	5.63	5.82	4.75	4.91	5.05	4.46	1338	3378	4389	11084
29.5	96.8	5.72	5.72	4.66	5.15	5.08	4.41	1653	4032	5423	13229
30.0	98.4	5.89	5.89	4.72	5.35	5.39	4.51	1905	4854	6249	15926
30.5	100.1	5.88	5.80	4.66	5.32	5.22	4.42	1754	4132	5756	13557
31.0	101.7	5.93	5.86	4.70	5.42	5.27	4.46	1818	4098	5965	13446
31.5	103.3	5.89	5.96	4.73	5.46	5.45	4.49	2128	4202	6981	13785
32.0	105.0	6.21	6.19	4.79	5.65	5.52	4.55	1626	4132	5335	13557
32.5	106.6	6.26	6.37	4.83	5.57	5.48	4.54	1262	3521	4140	11552
33.0	108.3	6.70	6.74	4.89	5.84	5.98	4.59	1235	3311	4050	10864
33.5	109.9	6.68	6.65	4.90	5.96	6.00	4.67	1460	4386	4790	14390

Table 8. Borehole 02-18B, Suspension R1-R2 depth, pick times, and velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	$V\text{-}S_H$ (m/sec)	V-P (m/sec)	$V\text{-}S_H$ (ft/sec)	V-P (ft/sec)
34.0	111.5	6.90	7.00	5.02	6.22	6.31	4.75	1455	3731	4772	12242
34.5	113.2	7.13	7.22	5.03	6.25	6.40	4.74	1180	3448	3871	11313
35.0	114.8	7.27	7.02	4.99	6.25	6.03	4.67	995	3106	3265	10189
35.5	116.5	7.32	7.39	5.04	6.27	6.07	4.70	844	2924	2769	9593
36.0	118.1	6.80	6.86	4.84	5.89	6.03	4.50	1146	2976	3760	9764
36.5	119.8	6.87	6.85	4.75	5.60	5.61	4.38	798	2703	2619	8867
37.0	121.4	6.66	6.68	4.92	5.64	5.60	4.59	955	3030	3132	9942
37.5	123.0	6.60	6.60	5.01	5.61	5.71	4.67	1064	2959	3490	9707
38.0	124.7	6.50	6.35	4.93	5.65	5.53	4.64	1194	3378	3917	11084
38.5	126.3	6.36	6.24	4.86	5.69	5.68	4.58	1633	3623	5356	11887
39.0	128.0	6.52		4.95	5.92		4.66	1681	3448	5514	11313
39.5	129.6	6.54		4.93	5.92		4.64	1613	3378	5292	11084
40.0	131.2	6.62		5.01	5.82		4.67	1250	2941	4101	9650
40.5	132.9	6.72		4.99	5.78		4.62	1064	2740	3490	8989

Table 8, continued. Borehole 02-18B, Suspension R1-R2 depth, pick times, and velocities

APPENDIX A

SUSPENSION VELOCITY MEASUREMENT QUALITY ASSURANCE SUSPENSION SOURCE TO RECEIVER ANALYSIS RESULTS

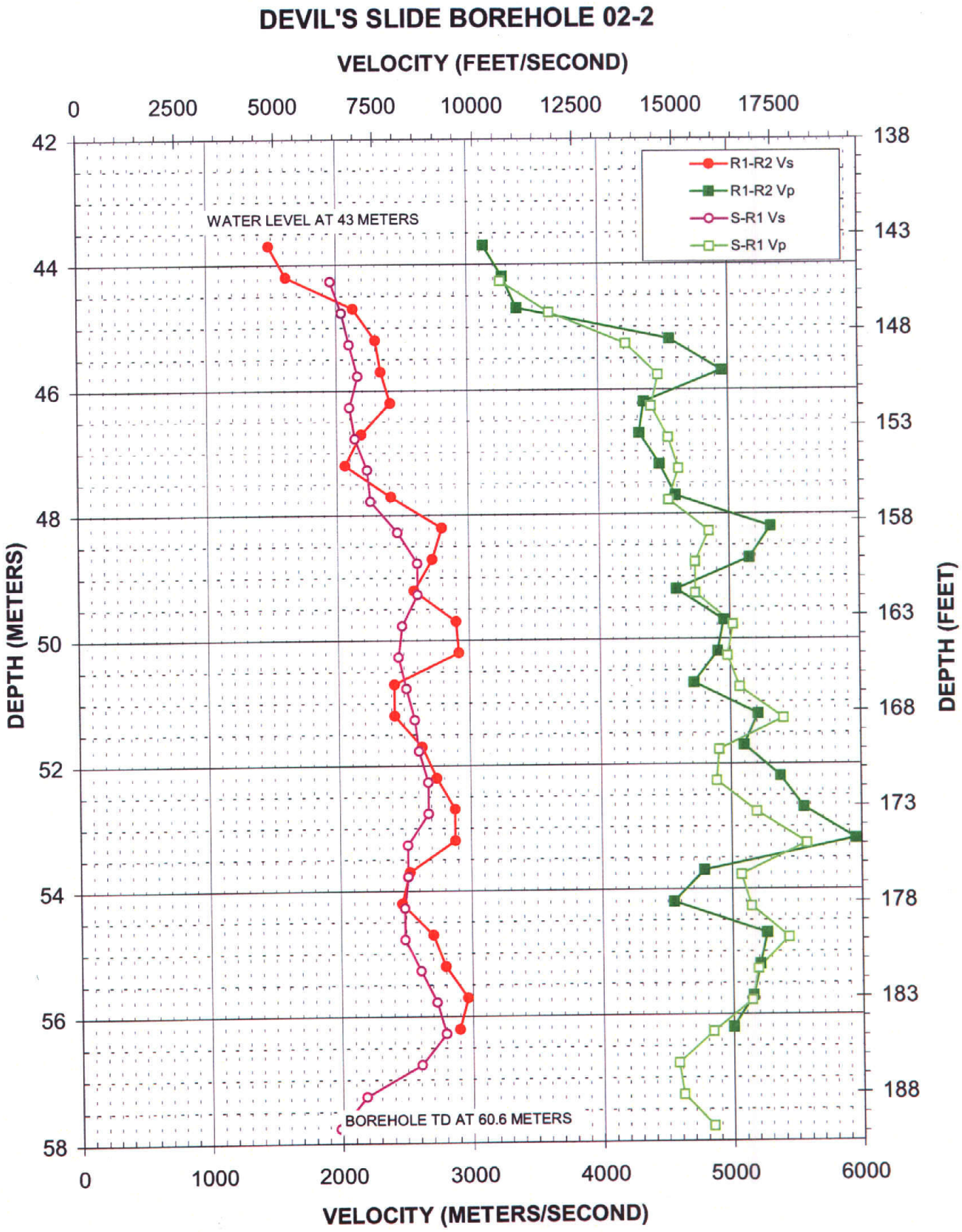

Figure A-1. Borehole 02-2, R1 - R2 high resolution analysis and S-R1 quality assurance analysis P- and S_H-wave data

Depth (meters)	Velocity		Depth (feet)	Velocity	
	V-S_H (m/sec)	V-p (m/sec)		V- S_H (ft/sec)	V-p (ft/sec)
44.3	1954	3252	145.2	6412	10670
44.8	2038	3627	146.9	6687	11900
45.3	2098	4213	148.5	6883	13821
45.8	2162	4458	150.2	7092	14627
46.3	2098	4403	151.8	6883	14446
46.8	2140	4534	153.4	7021	14875
47.3	2229	4612	155.1	7314	15131
47.8	2253	4534	156.7	7391	14875
48.3	2460	4842	158.4	8070	15885
48.8	2610	4735	160.0	8562	15533
49.3	2610	4735	161.6	8562	15533
49.8	2488	5023	163.3	8164	16481
50.3	2460	4977	164.9	8070	16328
50.8	2518	5071	166.6	8260	16637
51.3	2578	5404	168.2	8459	17730
51.8	2610	4908	169.8	8562	16103
52.3	2675	4886	171.5	8776	16030
52.8	2675	5194	173.1	8776	17041
53.3	2518	5573	174.8	8260	18284
53.8	2518	5071	176.4	8260	16637
54.3	2488	5144	178.1	8164	16877
54.8	2488	5431	179.7	8164	17820
55.3	2610	5194	181.3	8562	17041
55.8	2726	5144	183.0	8944	16877
56.3	2797	4842	184.6	9178	15885
56.8	2610	4573	186.3	8562	15002
57.3	2184	4612	187.9	7164	15131
57.8	1981	4842	189.5	6501	15885

Table A-1. Borehole 02-2, S - R1 quality assurance analysis P- and S_H-wave data

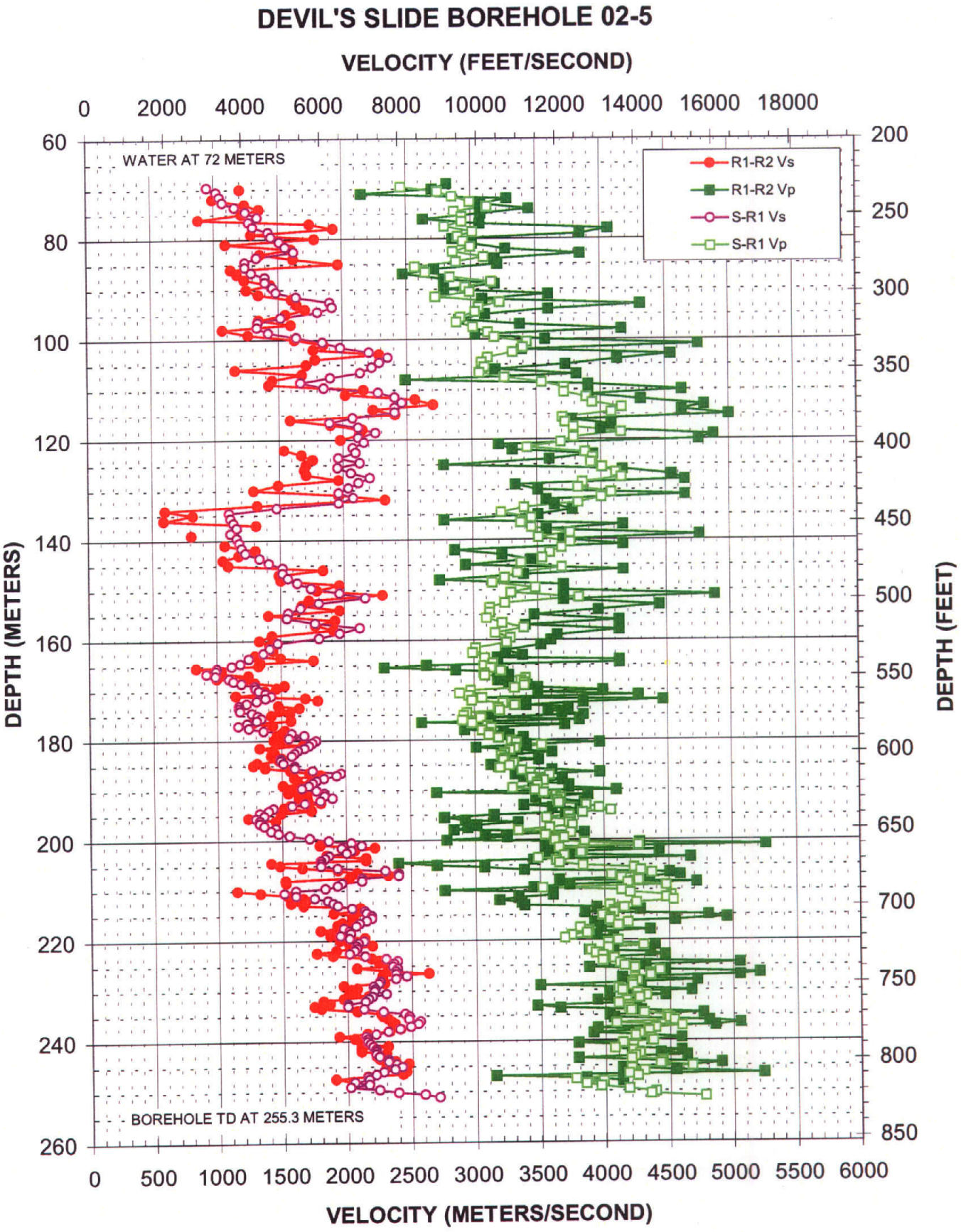

Figure A-2. Borehole 02-5, R1 - R2 high resolution analysis and S-R1 quality assurance analysis P- and S_H-wave data

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
69.6	947	2460	228.2	3107	8070
70.6	1019	2744	231.5	3343	9001
71.6	1046	2853	234.8	3433	9361
72.6	1070	2993	238.1	3510	9820
73.6	1163	3124	241.4	3816	10250
74.6	1248	2872	244.7	4094	9424
75.6	1338	2932	247.9	4388	9618
76.6	1274	2932	251.2	4179	9618
77.6	1305	2797	254.5	4281	9178
78.6	1427	3014	257.8	4681	9889
79.6	1446	2900	261.1	4744	9514
80.6	1512	2940	264.3	4962	9644
81.6	1556	2997	267.6	5106	9833
82.6	1621	2861	270.9	5319	9386
83.6	1333	3101	274.2	4374	10175
84.6	1241	2884	277.5	4070	9462
85.6	1241	2566	280.7	4070	8418
86.6	1289	2649	284.0	4230	8689
87.6	1399	2838	287.3	4589	9312
88.6	1399	3156	290.6	4589	10355
89.6	1456	2956	293.9	4776	9698
90.6	1486	2989	297.1	4876	9806
91.6	1640	2723	300.4	5380	8933
92.6	1902	3223	303.7	6241	10574
93.6	1919	3057	307.0	6297	10030
94.6	1806	3031	310.3	5925	9945
95.6	1518	2916	313.5	4979	9565
96.6	1338	2884	316.8	4388	9462
97.6	1333	3014	320.1	4374	9889
98.6	1422	3129	323.4	4665	10265
99.6	1640	3175	326.7	5380	10417
100.6	1845	3429	330.0	6053	11252
101.6	1981	3397	333.2	6501	11144
102.6	2206	3318	336.5	7238	10885
103.6	2352	3124	339.8	7715	10250
104.6	2289	3075	343.1	7509	10088
105.6	2229	3101	346.4	7314	10175
106.6	2140	3057	349.6	7021	10030
107.6	1902	3252	352.9	6241	10670
108.6	1672	3543	356.2	5485	11624

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
109.6	1851	3715	359.5	6074	12189
110.6	2277	3715	362.8	7469	12189
111.6	2404	3891	366.0	7889	12765
112.6	2460	3934	369.3	8070	12906
113.6	2404	4163	372.6	7889	13660
114.6	2404	4084	375.9	7889	13399
115.6	2078	3702	379.2	6817	12147
116.6	1894	3722	382.4	6213	12210
117.6	2119	3788	385.7	6951	12427
118.6	2253	4155	389.0	7391	13633
119.6	2119	3788	392.3	6951	12427
120.6	2162	3690	395.6	7092	12105
121.6	2078	3424	398.9	6817	11234
122.6	2098	3877	402.1	6883	12719
123.6	1963	3934	405.4	6441	12906
124.6	2129	3919	408.7	6986	12859
125.6	1954	4007	412.0	6412	13148
126.6	2058	4115	415.3	6751	13502
127.6	2206	4155	418.5	7238	13633
128.6	2119	3856	421.8	6951	12650
129.6	2038	3821	425.1	6687	12537
130.6	1963	4076	428.4	6441	13373
131.6	2078	4000	431.7	6817	13123
132.6	1963	3821	434.9	6441	12537
133.6	1476	3397	438.2	4842	11144
134.6	1103	3218	441.5	3619	10558
135.6	1115	3452	444.8	3657	11324
136.6	1138	3370	448.1	3735	11057
137.6	1163	3452	451.3	3816	11324
138.6	1115	3754	454.6	3657	12318
139.6	1163	3508	457.9	3816	11510
140.6	1182	3754	461.2	3879	12318
141.6	1202	3690	464.5	3944	12105
142.6	1230	3597	467.7	4035	11800
143.6	1338	3537	471.0	4388	11605
144.6	1413	3370	474.3	4634	11057
145.6	1518	3690	477.6	4979	12105
146.6	1518	3344	480.9	4979	10970
147.6	1562	3242	484.2	5125	10638
148.6	1634	3147	487.4	5360	10325

Table A-2. Borehole 02-5, S - R1 quality assurance analysis P- and S_H-wave data

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V-S_H (ft/sec)	Velocity V-p (ft/sec)
149.6	1740	3480	490.7	5708	11416
150.6	1963	3292	494.0	6441	10802
151.6	2162	3821	497.3	7092	12537
152.6	1798	3242	500.6	5900	10638
153.6	1659	3124	503.8	5443	10250
154.6	1562	3124	507.1	5125	10250
155.6	1551	3101	510.4	5088	10175
156.6	1769	3223	513.7	5802	10574
157.6	2119	3386	517.0	6951	11109
158.6	1963	3166	520.2	6441	10386
159.6	1798	3282	523.5	5900	10768
160.6	1476	3252	526.8	4842	10670
161.6	1413	3014	530.1	4634	9889
162.6	1363	2989	533.4	4472	9806
163.6	1248	3084	536.6	4094	10117
164.6	1182	3147	539.9	3879	10325
165.1	1115	3075	541.6	3657	10088
165.6	1000	3129	543.2	3281	10265
166.1	990	3204	544.8	3247	10510
166.6	916	3075	546.5	3007	10088
167.1	986	3084	548.1	3235	10117
167.6	1092	3397	549.8	3582	11144
168.1	1126	3365	551.4	3695	11039
168.6	1189	3386	553.1	3901	11109
169.1	1293	3386	554.7	4242	11109
169.6	1301	3313	556.3	4268	10868
170.1	1325	2972	558.0	4347	9751
170.6	1376	2884	559.6	4515	9462
171.1	1422	2956	561.3	4665	9698
171.6	1376	3057	562.9	4515	10030
172.1	1309	2981	564.5	4294	9779
172.6	1230	3223	566.2	4035	10574
173.1	1169	3313	567.8	3837	10868
173.6	1169	3185	569.5	3837	10448
174.1	1176	3194	571.1	3858	10479
174.6	1270	2940	572.7	4167	9644
175.1	1316	2916	574.4	4318	9565
175.6	1342	3048	576.0	4402	10001
176.1	1309	2908	577.7	4294	9539
176.6	1233	2981	579.3	4047	9779

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V-S_H (ft/sec)	Velocity V-p (ft/sec)
177.1	1163	3101	580.9	3816	10175
177.6	1246	3129	582.6	4087	10265
178.1	1359	3057	584.2	4458	10030
178.6	1579	3110	585.9	5182	10205
179.1	1678	3110	587.5	5507	10205
179.6	1556	3185	589.1	5106	10448
180.1	1769	3282	590.8	5802	10768
180.6	1740	3323	592.4	5708	10902
181.1	1712	3520	594.1	5617	11548
181.6	1678	3313	595.7	5507	10868
182.1	1627	3272	597.3	5339	10735
182.6	1603	3233	599.0	5259	10606
183.1	1579	3204	600.6	5182	10510
183.6	1491	3233	602.3	4893	10606
184.1	1491	3223	603.9	4893	10574
184.6	1512	3302	605.5	4962	10835
185.1	1603	3267	607.2	5259	10719
185.6	1603	3194	608.8	5259	10479
186.1	1740	3365	610.5	5708	11039
186.6	1963	3429	612.1	6441	11252
187.1	1928	3579	613.7	6325	11741
187.6	1826	3441	615.4	5991	11288
188.1	1769	3531	617.0	5802	11586
188.6	1740	3480	618.7	5708	11416
189.1	1709	3485	620.3	5608	11435
189.6	1653	3292	621.9	5422	10802
190.1	1769	3463	623.6	5802	11361
190.6	1829	3531	625.2	6001	11586
191.1	1829	3627	626.9	6001	11900
191.6	1894	3664	628.5	6213	12022
192.1	1798	3639	630.2	5900	11940
192.6	1678	3652	631.8	5507	11981
193.1	1579	3863	633.4	5182	12673
193.6	1431	3963	635.1	4696	13002
194.1	1394	4053	636.7	4574	13297
194.6	1325	3835	638.4	4347	12582
195.1	1359	3728	640.0	4458	12232
195.6	1293	3555	641.6	4242	11663
196.1	1325	3741	643.3	4347	12274
196.6	1325	3728	644.9	4347	12232

Table A-2, continued. Borehole 02-5, S - R1 quality assurance analysis P- and S_H-wave data

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
197.1	1359	3754	646.6	4458	12318
197.6	1451	3579	648.2	4760	11741
198.1	1413	3333	649.8	4634	10936
198.6	1471	3741	651.5	4825	12274
199.1	1557	3543	653.1	5110	11624
199.6	1712	3690	654.8	5617	12105
200.1	1861	3615	656.4	6105	11860
200.6	2038	3849	658.0	6687	12628
201.1	2119	4263	659.7	6951	13986
201.6	1963	3652	661.3	6441	11981
202.1	2038	3835	663.0	6687	12582
202.6	2000	3821	664.6	6562	12537
203.1	1861	3690	666.2	6105	12105
203.6	1829	3485	667.9	6001	11435
204.1	1798	3627	669.5	5900	11900
204.6	1798	3652	671.2	5900	11981
205.1	1798	3835	672.8	5900	12582
205.6	1928	4229	674.4	6325	13875
206.1	2301	4280	676.1	7549	14042
206.6	2404	4367	677.7	7889	14329
207.1	2404	4053	679.4	7889	13297
207.6	2119	4131	681.0	6951	13554
208.1	2119	4263	682.6	6951	13986
208.6	1963	4180	684.3	6441	13713
209.1	1928	4477	685.9	6325	14688
209.6	1829	3520	687.6	6001	11548
210.1	1603	4131	689.2	5259	13554
210.6	1513	4196	690.8	4965	13767
211.1	1603	4515	692.5	5259	14812
211.6	1747	4477	694.1	5731	14688
212.1	1851	4534	695.8	6074	14875
212.6	1894	4246	697.4	6213	13931
213.1	1928	4038	699.0	6325	13247
213.6	2038	4147	700.7	6687	13607
214.1	2140	4068	702.3	7021	13348
214.6	2151	4068	704.0	7056	13348
215.1	2195	3978	705.6	7201	13050
215.6	2195	4038	707.3	7201	13247
216.1	2151	4038	708.9	7056	13247
216.6	2098	4180	710.5	6883	13713
217.1	2068	4100	712.2	6784	13450
217.6	1972	3808	713.8	6471	12493
218.1	2019	3877	715.5	6624	12719
218.6	2028	3863	717.1	6655	12673
219.1	1945	3741	718.7	6383	12274
219.6	2019	3690	720.4	6624	12105
220.1	2129	4100	722.0	6986	13450
220.6	2088	4023	723.7	6850	13197
221.1	2068	4297	725.3	6784	14098
221.6	2078	4023	726.9	6817	13197
222.1	2054	3891	728.6	6738	12765
222.6	2019	3927	730.2	6624	12883
223.1	2140	3978	731.9	7021	13050
223.6	2301	4068	733.5	7549	13348
224.1	2391	3978	735.1	7845	13050
224.6	2365	4115	736.8	7758	13502
225.1	2352	4147	738.4	7715	13607
225.6	2391	4229	740.1	7845	13875
226.1	2378	4421	741.7	7801	14506
226.6	2378	4350	743.3	7801	14270
227.1	2460	4350	745.0	8070	14270
227.6	2378	4229	746.6	7801	13875
228.1	2253	4246	748.3	7391	13931
228.6	2243	4213	749.9	7360	13821
229.1	2202	4213	751.5	7223	13821
229.6	2215	4100	753.2	7268	13450
230.1	2206	4131	754.8	7238	13554
230.6	2301	4246	756.5	7549	13931
231.1	2195	4315	758.1	7201	14155
231.6	2162	4263	759.7	7092	13986
232.1	2140	4163	761.4	7021	13660
232.6	2000	4100	763.0	6562	13450
233.1	2000	4180	764.7	6562	13713
233.6	2123	4180	766.3	6965	13713
234.1	2277	4196	767.9	7469	13767
234.6	2446	4297	769.6	8024	14098
235.1	2477	4477	771.2	8126	14688
235.6	2474	4496	772.9	8117	14750
236.1	2563	4534	774.5	8408	14875
236.6	2548	4084	776.1	8358	13399

Table A-2, continued. Borehole 02-5, S - R1 quality assurance analysis P- and S_H-wave data

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
237.1	2488	4592	777.8	8164	15067
237.6	2404	4385	779.4	7889	14387
238.1	2314	4332	781.1	7590	14213
238.6	2218	4263	782.7	7276	13986
239.1	2140	4229	784.4	7021	13875
239.6	2151	4350	786.0	7056	14270
240.1	2151	4367	787.6	7056	14329
240.6	2173	4131	789.3	7128	13554
241.1	2195	4213	790.9	7201	13821
241.6	2218	4068	792.6	7276	13348
242.1	2218	4213	794.2	7276	13821
242.6	2218	4263	795.8	7276	13986
243.1	2241	4229	797.5	7352	13875
243.6	2314	4196	799.1	7590	13767
244.1	2314	4440	800.8	7590	14566
244.6	2378	4421	802.4	7801	14506
245.1	2418	4672	804.0	7933	15330
245.6	2365	4196	805.7	7758	13767
246.1	2277	4297	807.3	7469	14098
246.6	2218	4180	809.0	7276	13713
247.1	2151	4246	810.6	7056	13931
247.6	2162	3768	812.2	7092	12361
248.1	2048	3978	813.9	6719	13050
248.6	2162	3849	815.5	7092	12628
249.1	2019	3963	817.2	6624	13002
249.6	2241	4180	818.8	7352	13713
250.2	2391	4385	820.8	7845	14387
250.6	2594	4350	822.1	8510	14270
251.1	2709	4777	823.7	8887	15672

Table A-2, continued. Borehole 02-5, S - R1 quality assurance analysis P- and S_H-wave data

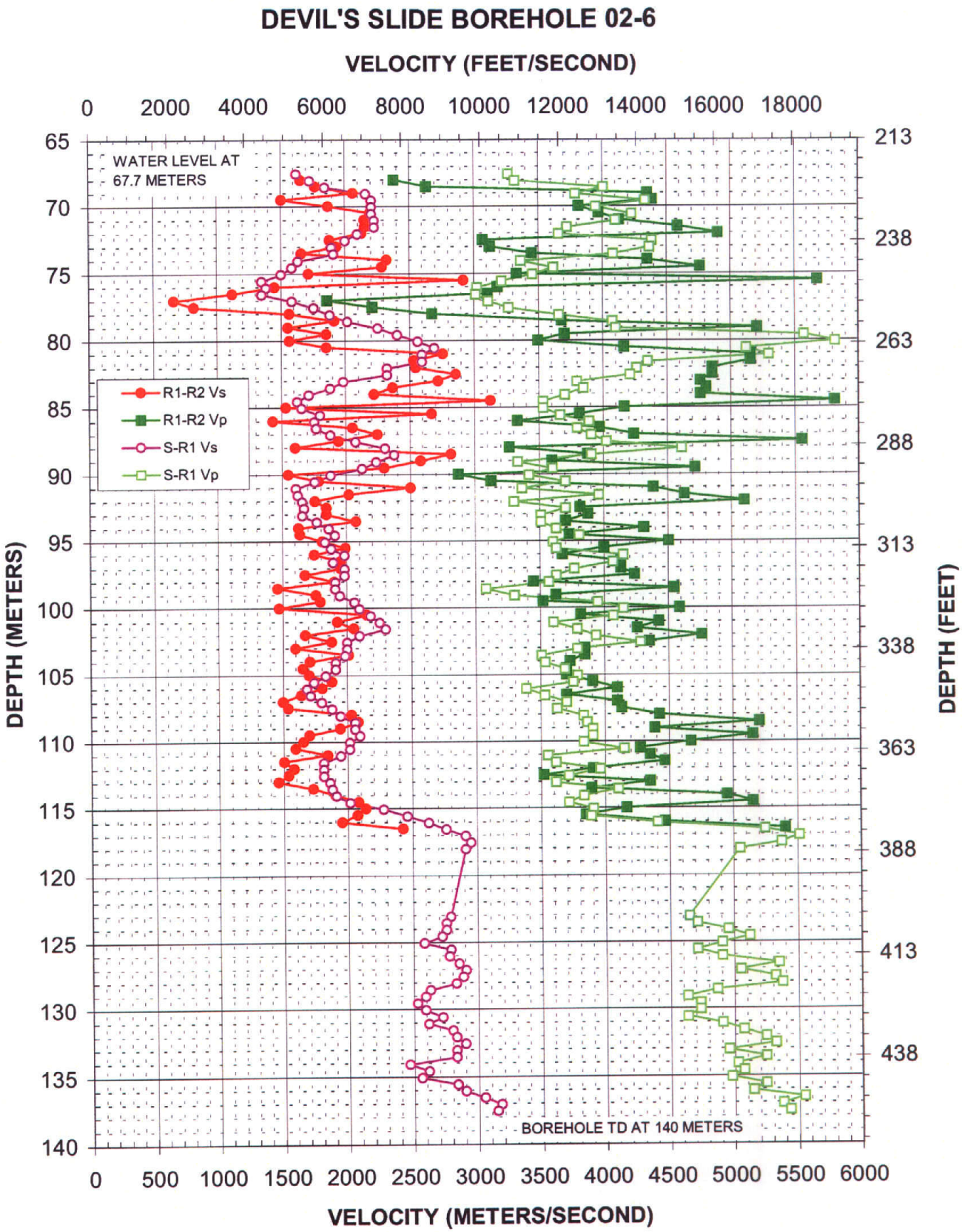

Figure A-3. Borehole 02-6, R1 - R2 high resolution analysis and S-R1 quality assurance analysis

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
67.6	1621	3267	221.7	5319	10719
68.1	1726	3318	223.3	5662	10885
68.6	1845	4007	225.0	6053	13148
69.1	2162	3788	226.6	7092	12427
69.6	2206	4332	228.2	7238	14213
70.1	2206	3948	229.9	7238	12954
70.6	2206	4229	231.5	7238	13875
71.1	2229	4100	233.2	7314	13450
71.6	2229	3722	234.8	7314	12210
72.1	2098	3658	236.5	6883	12002
72.6	2000	4385	238.1	6562	14387
73.1	1894	4367	239.7	6213	14329
73.6	1911	4084	241.4	6269	13399
74.1	1634	3365	243.0	5360	11039
74.6	1585	3615	244.7	5201	11860
75.1	1503	3452	246.3	4930	11324
75.6	1350	3213	247.9	4430	10542
76.1	1385	3023	249.6	4544	9917
76.6	1351	3014	251.2	4432	9889
77.1	1585	3110	252.9	5201	10205
77.6	1754	3267	254.5	5755	10719
78.1	1877	3658	256.1	6159	12002
78.6	2019	4076	257.8	6624	13373
79.1	2253	4100	259.4	7391	13450
79.6	2404	5573	261.1	7889	18284
80.1	2563	5815	262.7	8408	19079
80.6	2692	5120	264.3	8831	16797
81.1	2594	5297	266.0	8510	17379
81.6	2594	4350	267.6	8510	14270
82.1	2326	4263	269.3	7632	13986
82.6	2326	4213	270.9	7632	13821
83.1	1981	3794	272.5	6501	12449
83.6	1877	3849	274.2	6159	12628
84.1	1712	3702	275.8	5617	12147
84.6	1621	3531	277.5	5319	11586
85.1	1659	3531	279.1	5443	11586
85.6	1798	3664	280.7	5900	12022
86.1	1754	3891	282.4	5755	12765
86.6	1769	3794	284.0	5802	12449
87.1	1877	3905	285.7	6159	12812

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
87.6	2078	4023	287.3	6817	13197
88.1	2306	4612	288.9	7566	15131
88.6	2378	3905	290.6	7801	12812
89.1	2234	3333	292.2	7329	10936
89.6	2123	3603	293.9	6965	11820
90.1	1877	3419	295.5	6159	11216
90.6	1754	3702	297.1	5755	12147
91.1	1609	3365	298.8	5279	11039
91.6	1621	3963	300.4	5319	13002
92.1	1659	3302	302.1	5443	10835
92.6	1672	3702	303.7	5485	12147
93.1	1659	3508	305.3	5443	11510
93.6	1769	3508	307.0	5802	11510
94.1	1861	3627	308.6	6105	11900
94.6	1911	3808	310.3	6269	12493
95.1	1829	3603	311.9	6001	11820
95.6	1877	3627	313.5	6159	11900
96.1	1981	4147	315.2	6501	13607
96.6	1894	4068	316.8	6213	13348
97.1	1981	3768	318.5	6501	12361
97.6	1981	3627	320.1	6501	11900
98.1	1911	3567	321.8	6269	11702
98.6	1911	3079	323.4	6269	10102
99.1	1945	3302	325.0	6383	10835
99.6	2058	3948	326.7	6751	12954
100.1	2098	4147	328.3	6883	13607
100.6	2184	4068	330.0	7164	13348
101.1	2257	3603	331.6	7406	11820
101.6	2301	3788	333.2	7549	12427
102.1	2098	3934	334.9	6883	12906
102.6	2000	4280	336.5	6562	14042
103.1	2000	3788	338.2	6562	12427
103.6	1981	3508	339.8	6501	11510
104.1	1911	3537	341.4	6269	11605
104.6	1911	3690	343.1	6269	12105
105.1	1829	3788	344.7	6001	12427
105.6	1740	3754	346.4	5708	12318
106.1	1685	3386	348.0	5528	11109
106.6	1712	3531	349.6	5617	11586
107.1	1798	3702	351.3	5900	12147

Table A-3. Borehole 02-6, S - R1 quality assurance analysis P- and S_H-wave

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
107.6	1877	3627	352.9	6159	11900
108.1	1945	3835	354.6	6383	12582
108.6	2058	3863	356.2	6751	12673
109.1	2058	3905	357.8	6751	12812
109.6	2098	3905	359.5	6883	12812
110.1	2019	3835	361.1	6624	12582
110.6	2019	4147	362.8	6624	13607
111.1	1945	3555	364.4	6383	11663
111.6	1814	3615	366.0	5950	11860
112.1	1814	3963	367.7	5950	13002
112.6	1814	3715	369.3	5950	12189
113.1	1861	3615	371.0	6105	11860
113.6	1877	4100	372.6	6159	13450
114.1	1911	3835	374.2	6269	12582
114.6	2019	3715	375.9	6624	12189
115.1	2277	3905	377.5	7469	12812
115.6	2460	3891	379.2	8070	12765
116.1	2626	4403	380.8	8615	14446
116.6	2761	5245	382.4	9059	17208
117.1	2912	5515	384.1	9552	18095
117.6	2952	5377	385.7	9684	17641
118.1	2912	5047	387.4	9552	16559
123.1	2794	4652	403.8	9166	15263
123.6	2758	4714	405.4	9048	15465
124.1	2758	4954	407.1	9048	16252
124.6	2723	5120	408.7	8933	16797
125.1	2585	4908	410.3	8479	16103
125.6	2794	4714	412.0	9166	15465
126.1	2779	4908	413.6	9118	16103
126.6	2853	5350	415.3	9361	17552
127.1	2908	5047	416.9	9539	16559
127.6	2884	5323	418.5	9462	17465
128.1	2831	5377	420.2	9287	17641
128.6	2629	4864	421.8	8625	15957
129.1	2591	4632	423.5	8500	15197
129.6	2530	4735	425.1	8299	15533
130.1	2591	4735	426.7	8500	15533
130.6	2723	4632	428.4	8933	15197
131.1	2616	4908	430.0	8583	16103
131.6	2801	5071	431.7	9190	16637

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
132.1	2831	5245	433.3	9287	17208
132.6	2900	5323	434.9	9514	17465
133.1	2831	4954	436.6	9287	16252
133.6	2831	5245	438.2	9287	17208
134.1	2465	5023	439.9	8089	16481
134.6	2616	5071	441.5	8583	16637
135.1	2560	4977	443.1	8398	16328
135.6	2838	5245	444.8	9312	17208
136.1	2900	5144	446.4	9514	16877
136.6	3048	5544	448.1	10001	18189
137.1	3175	5377	449.7	10417	17641
137.6	3147	5431	451.3	10325	17820

Table A-3, continued. Borehole 02-6, S - R1 quality assurance analysis P- and S_H-wave data

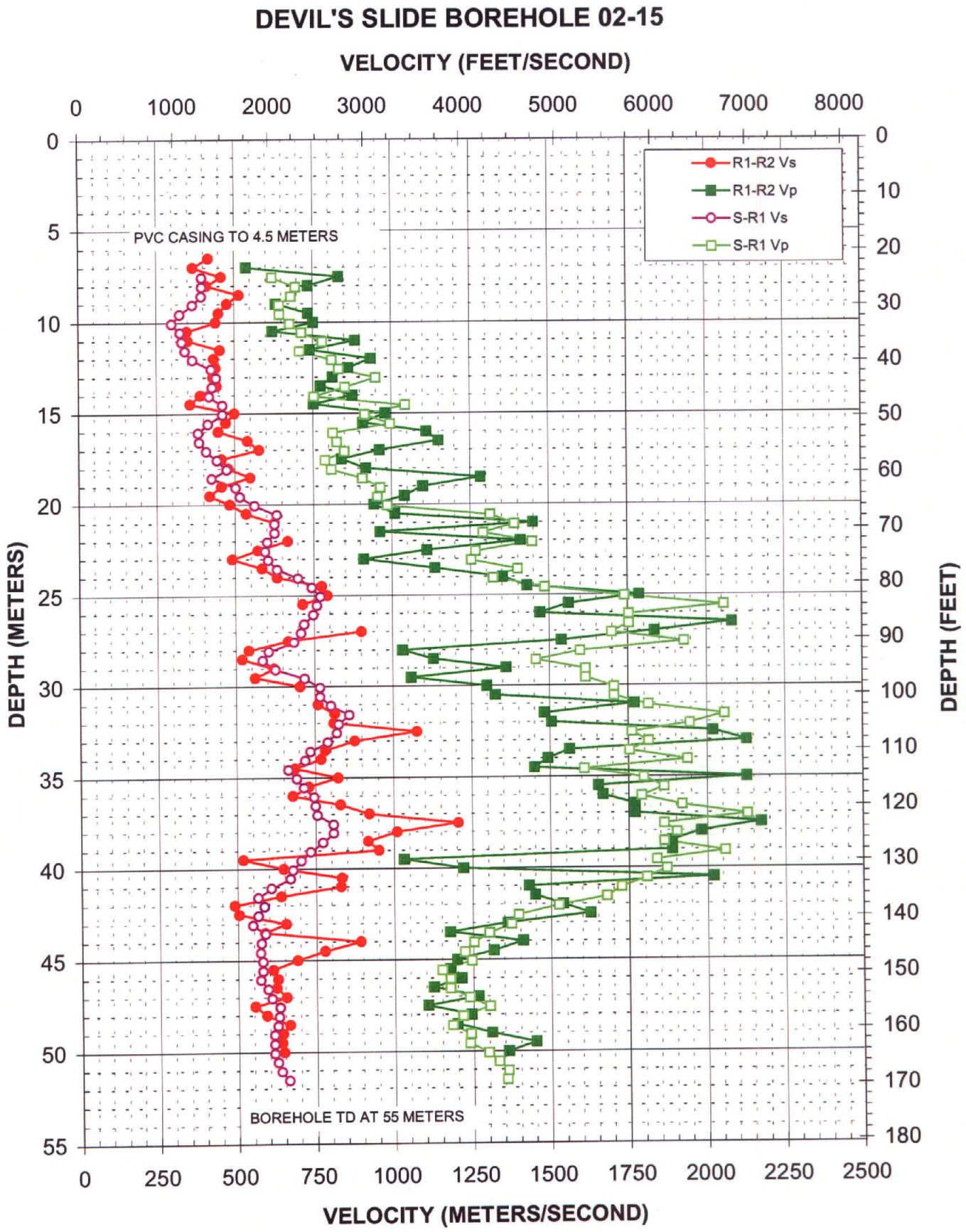

Figure A-4. Borehole 02-15, R1 - R2 high resolution analysis and S-R1 quality assurance analysis P- and S_H-wave data

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
7.6	396	620	24.8	1300	2035
8.1	396	695	26.5	1300	2280
8.6	394	682	28.1	1293	2236
9.1	366	643	29.8	1202	2108
9.6	324	645	31.4	1064	2115
10.1	300	677	33.0	983	2222
10.6	327	713	34.7	1072	2340
11.1	332	781	36.3	1090	2562
11.6	342	709	38.0	1123	2325
12.1	366	811	39.6	1200	2659
12.6	426	833	41.2	1399	2732
13.1	441	951	42.9	1448	3120
13.6	428	853	44.5	1404	2797
14.1	418	754	46.2	1371	2472
14.6	461	1044	47.8	1513	3425
15.1	461	915	49.4	1513	3000
15.6	415	995	51.1	1361	3266
16.1	384	814	52.7	1258	2670
16.6	386	826	54.4	1267	2711
17.1	408	849	56.0	1340	2786
17.6	442	787	57.6	1451	2581
18.1	473	808	59.3	1553	2649
18.6	426	907	60.9	1399	2975
19.1	502	964	62.6	1648	3163
19.6	514	955	64.2	1688	3134
20.1	562	986	65.8	1843	3235
20.6	633	1313	67.5	2077	4307
21.1	626	1390	69.1	2053	4559
21.6	626	1289	70.8	2053	4230
22.1	601	1446	72.4	1972	4744
22.6	594	1266	74.0	1950	4154
23.1	605	1251	75.7	1983	4106
23.6	633	1399	77.3	2077	4589
24.1	699	1321	79.0	2294	4334
24.6	743	1486	80.6	2438	4876
25.1	770	1740	82.3	2526	5708
25.6	759	2058	83.9	2490	6751
26.1	748	1754	85.5	2455	5755
26.6	718	1754	87.2	2356	5755
27.1	709	1698	88.8	2325	5572

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
27.6	686	1928	90.5	2250	6325
28.1	605	1597	92.1	1983	5240
28.6	585	1456	93.7	1918	4776
29.1	626	1615	95.4	2053	5299
29.6	718	1615	97.0	2356	5299
30.1	767	1705	98.7	2516	5594
30.6	767	1705	100.3	2516	5594
31.1	801	1814	101.9	2630	5950
31.6	859	2058	103.6	2820	6751
32.1	826	1945	105.2	2711	6383
32.6	820	1761	106.9	2690	5779
33.1	790	1814	108.5	2591	5950
33.6	735	1754	110.1	2413	5755
34.1	718	1937	111.8	2356	6354
34.6	665	1609	113.4	2180	5279
35.1	690	1798	115.1	2265	5900
35.6	713	1861	116.7	2340	6105
36.1	746	1791	118.3	2446	5875
36.6	751	1919	120.0	2464	6297
37.1	756	2129	121.6	2481	6986
37.6	808	1861	123.3	2649	6105
38.1	808	1902	124.9	2649	6241
38.6	773	1861	126.5	2535	6105
39.1	733	2058	128.2	2404	6751
39.6	704	1837	129.8	2310	6027
40.1	677	1869	131.5	2222	6132
40.6	669	1806	133.1	2194	5925
41.1	608	1726	134.7	1995	5662
41.6	565	1678	136.4	1853	5507
42.1	585	1523	138.0	1918	4997
42.6	565	1394	139.7	1853	4574
43.1	547	1372	141.3	1796	4501
43.6	588	1301	142.9	1929	4268
44.1	575	1251	144.6	1887	4106
44.6	572	1223	146.2	1877	4012
45.1	578	1244	147.9	1898	4082
45.6	578	1151	149.5	1898	3775
46.1	572	1176	151.1	1877	3858
46.6	594	1176	152.8	1950	3858
47.1	608	1237	154.4	1995	4058

Table A-4. Borehole 02-15, S - R1 quality assurance analysis P- and S_H-wave data

Depth (meters)	Velocity		Depth (feet)	Velocity	
	V-S_H (m/sec)	V-p (m/sec)		V- S_H (ft/sec)	V-p (ft/sec)
47.6	633	1301	156.1	2077	4268
48.1	629	1216	157.7	2065	3989
48.6	626	1182	159.4	2053	3879
49.1	615	1241	161.0	2018	4070
49.6	615	1237	162.6	2018	4058
50.1	615	1297	164.3	2018	4255
50.6	626	1329	165.9	2053	4361
51.1	637	1359	167.6	2090	4458
51.6	660	1354	169.2	2167	4444

Table A-4, continued. Borehole 02-15, S - R1 quality assurance analysis P- and S_H-wave data

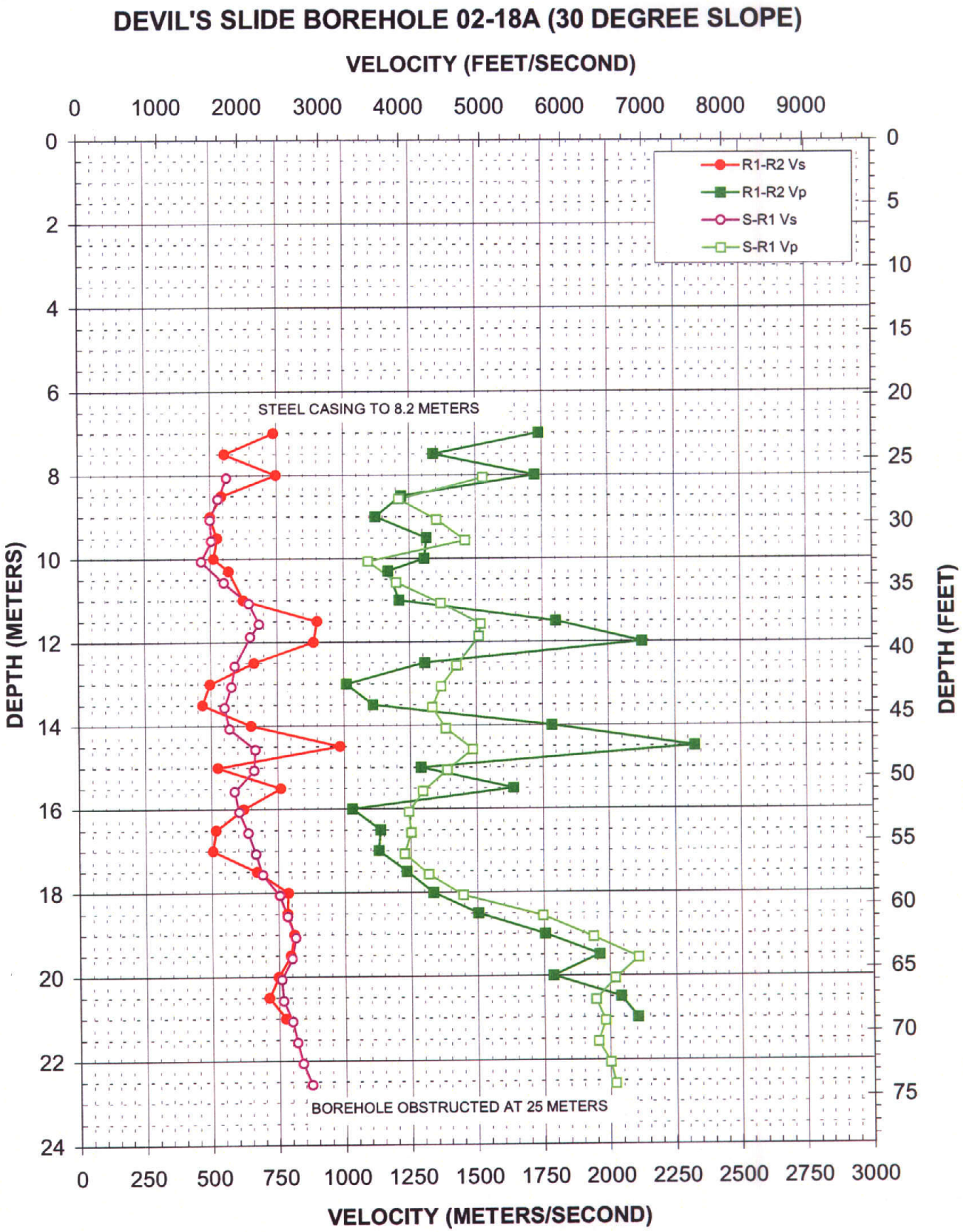

Figure A-5. Borehole 02-18A, R1 - R2 high resolution analysis and S-R1 quality assurance analysis P- and S_H-wave data

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
8.1	563	1529	26.5	1848	5015
8.6	530	1212	28.1	1738	3978
9.1	499	1354	29.8	1639	4444
9.6	505	1461	31.4	1656	4792
10.1	465	1095	33.0	1526	3591
10.6	552	1202	34.7	1810	3944
11.1	646	1367	36.3	2118	4486
11.6	684	1518	38.0	2243	4979
11.9	650	1512	38.9	2134	4962
12.6	591	1427	41.2	1940	4681
13.1	578	1367	42.9	1898	4486
13.6	552	1333	44.5	1810	4374
14.1	569	1385	46.2	1867	4544
14.6	667	1486	47.8	2187	4876
15.1	663	1390	49.4	2174	4559
15.6	588	1297	51.1	1929	4255
16.1	605	1244	52.7	1983	4082
16.6	639	1251	54.4	2096	4106
17.1	667	1226	56.0	2187	4023
17.6	693	1317	57.6	2272	4321
18.1	756	1446	59.3	2481	4744
18.6	784	1747	60.9	2572	5731
19.1	814	1937	62.6	2670	6354
19.6	801	2108	64.2	2630	6917
20.1	762	2019	65.8	2499	6624
20.6	767	1945	67.5	2516	6383
21.1	801	1981	69.1	2630	6501
21.6	820	1954	70.8	2690	6412
22.1	839	2000	72.4	2753	6562
22.6	873	2019	74.0	2866	6624

Table A-5. Borehole 02-18A, S - R1 quality assurance analysis P- and S_H -wave data

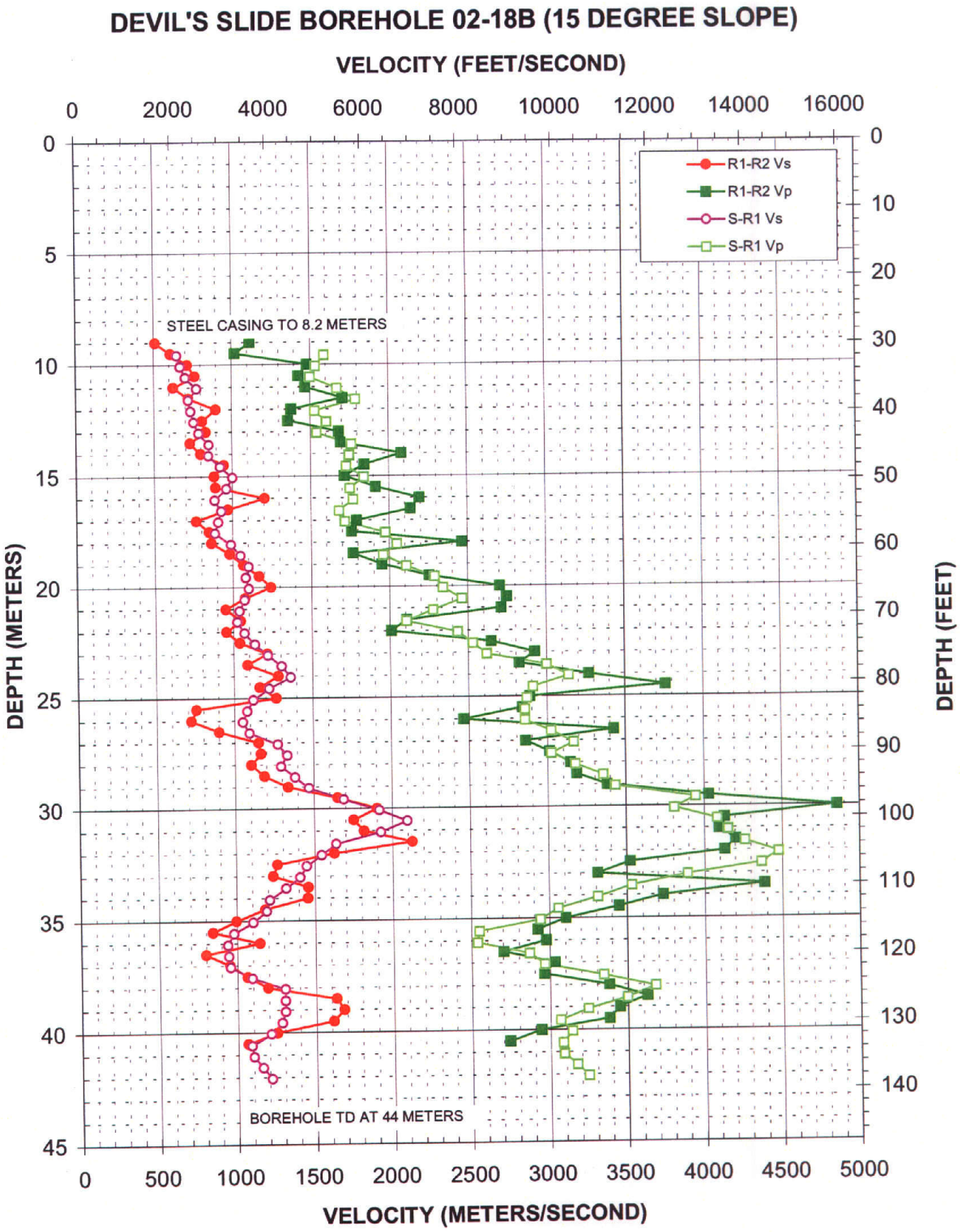

Figure A-6. Borehole 02-18B, R1 - R2 high resolution analysis and S-R1 quality assurance analysis P- and S_H-wave data

Depth (meters)	Velocity V-S_H (m/sec)	Velocity V-p (m/sec)	Depth (feet)	Velocity V- S_H (ft/sec)	Velocity V-p (ft/sec)
9.6	647	1591	31.4	2121	5220
10.1	671	1534	33.0	2201	5033
10.6	702	1502	34.7	2302	4927
11.1	775	1672	36.3	2544	5485
11.6	722	1791	38.0	2368	5875
12.1	735	1529	39.6	2413	5015
12.6	754	1603	41.2	2472	5259
13.1	787	1540	42.9	2581	5051
13.6	853	1761	44.5	2797	5779
14.1	849	1748	46.2	2786	5736
14.6	922	1729	47.8	3026	5671
15.1	1002	1842	49.4	3289	6042
15.6	962	1751	51.1	3156	5745
16.1	886	1772	52.7	2907	5812
16.6	928	1680	54.4	3046	5511
17.1	907	1717	56.0	2975	5635
17.6	886	1974	57.6	2907	6477
18.1	986	2050	59.3	3235	6725
18.6	1049	1960	60.9	3442	6429
19.1	1100	2108	62.6	3610	6917
19.6	1081	2286	64.2	3546	7501
20.1	1100	2341	65.8	3610	7682
20.6	1073	2460	67.5	3519	8070
21.1	1039	2277	69.1	3408	7469
21.6	1024	2106	70.8	3359	6910
22.1	1070	2432	72.4	3510	7978
22.6	1135	2530	74.0	3725	8299
23.1	1217	2616	75.7	3994	8583
23.6	1305	2997	77.3	4281	9833
24.1	1363	3138	79.0	4472	10295
24.6	1223	2908	80.6	4012	9539
25.1	1120	2869	82.3	3676	9412
25.6	1081	2853	83.9	3546	9361
26.1	1052	2853	85.5	3450	9361
26.6	1095	3023	87.2	3591	9917
27.1	1274	3166	88.8	4179	10386
27.6	1333	3023	90.5	4374	9917
28.1	1293	3175	92.1	4242	10417
28.6	1381	3354	93.7	4530	11005
29.1	1471	3429	95.4	4825	11252
29.6	1692	3948	97.0	5550	12954
30.1	1919	3808	98.7	6297	12493
30.6	2098	4084	100.3	6883	13399
31.1	1928	4155	101.9	6325	13633
31.6	1640	4263	103.6	5380	13986
32.1	1545	4477	105.2	5069	14688
32.6	1451	4367	106.9	4760	14329
33.1	1408	3891	108.5	4619	12765
33.6	1317	3531	110.1	4321	11586
34.1	1212	3313	111.8	3978	10868
34.6	1192	3057	113.4	3911	10030
35.1	1103	2940	115.1	3619	9644
35.6	979	2548	116.7	3213	8358
36.1	939	2536	118.3	3079	8319
36.6	945	2869	120.0	3100	9412
37.1	955	2964	121.6	3134	9724
37.6	1095	3344	123.3	3591	10970
38.1	1305	3677	124.9	4281	12064
38.6	1305	3497	126.5	4281	11472
39.1	1305	3242	128.2	4281	10638
39.6	1281	3066	129.8	4204	10059
40.1	1212	3138	131.5	3978	10295
40.6	1086	3079	133.1	3564	10102
41.1	1100	3084	134.7	3610	10117
41.6	1157	3170	136.4	3795	10401
42.1	1216	3242	138.0	3989	10638

Table A-6. Borehole 02-18B, S - R1 quality assurance

APPENDIX B

OYO 170 VELOCITY LOGGING SYSTEM

NIST TRACEABLE

CALIBRATION PROCEDURE

TABLE B1

GEOVISION VELOCITY LOGGING EQUIPMENT DESCRIPTION AND CALIBRATION PROCEDURES

EQUIPMENT	FUNCTION	CALIBRATION REQUIREMENTS	MAINTENANCE REQUIREMENTS
OYO Model 170 Suspension Logging Data Logger	Records data from probe and sends control signals to probe	Every twelve months, calibrate sample clock using an NTIS-traceable external signal counter and signal generator per attached procedure. (see Attachment B2)	Diagnose and repair by manufacturer's authorized representative if sample clock is out of specification or instrument fails.
OYO Model 170 Suspension Logging Probe	Suspended in borehole to provide both seismic source and sense wave arrivals at two locations 1 meter apart	No sensor calibration is necessary, as amplitude is not important to the velocity measurement.	Repair as needed by manufacturer-trained personnel.
Winch System (several interchangeable models available)	The winch and cable suspend the probe in the borehole and connect it to the data logger	No calibration required	Repair as needed. Lubricate moving parts frequently, and keep cable clean.

ATTACHMENT B2

CALIBRATION PROCEDURE FOR GEOVISION'S VELOCITY LOGGING SYSTEM

1.0 OYO Model 170 Data Logger Unit

1.1 Purpose

The purpose of this calibration procedure is to verify that the sample clock of the OYO Model 170 is accurate to within 1%.

1.2 Calibration Frequency

The calibration described in this procedure shall be performed every twelve months minimum.

1.3 Test Equipment

- Function Generator, Krohn Hite 5400B or equivalent
- Frequency Counter, HP 5315A or equivalent, current NIST traceable calibration
- Test cable, function generator to OYO 170 Data Logger input channels

1.4 Procedure

- Connect function generator to OYO Model 170 data logger using test cable
- Set up function generator to produce a 100.0 Hz, 0.250 volt peak square wave
- Record a data record with 100 microsecond sample period
- Measure the square wave frequency in the digital data using the data logger's screen display or utility software

1.5 Calibration Criteria

The measured square wave frequency in the digital data must fall between 99.0 and 101.0 Hz to be deemed acceptable. If outside this range, the data logger must be repaired and retested.

Calibration Report

RO PRECISION
ALIBRATION INC.
11562 Knott Street, Ste. 3, Garden Grove, CA 92841
Ph. 714-901-5659 Fax: 714-901-5649

Customer: **GEOVISION Corona CA 92882**

Account: **15214**

Instrument: **BB9414 Digital Universal Test Center**

Mfg: **Tenma**	Model: **72-5085**	Serial #: **MB00006378**
Size:	Resltn:	Location:

Cust Ctrl:	Dept:	P.O.: **2236-020220-2**
Job Number: **L16939**	Report Number: **115406**	Report Date: **022502**

Work Performed: **Inspected, cleaned, and calibrated.** Page **1** of **1**

Parts Replaced: **None**

Received Condition: **In tolerance** Returned Condition: **In tolerance**

Function Tested	
Multimeter	Function Generator cont'
AC/DC Volts & Current	Amplitude
Resistance & Capacitance	Sine wave distortion& flatness
Power Supply	Square wave symmetry, rise & fall time
Voltage	Triangle wave linearity
Current	TTL rise & fall time, output level
Ripple	
Frequency Counter	
Frequency range & Accuracy	
Input Sensitivity	
Function Generator	
Frequency	

Ctrl #	Manufacture, Model #, & Description of standards used for calibration	Due Date	Traceability
L8100	L8100 Wavetek 4800A Multifunction Calibr	031202	35951031201
L1600	L1600 Hewlett Packard 34401A Multimeter	040502	97906
T1100	T1100 Hewlett Packard 53131A Counter	060402	100795
P5300	P5300 Taktronix THS710 Oscilloscope w/DMM	022003	114723
K4350	K4350 Hewlett Packard 8903A Audio Analyzer	053102	99604

Services provided conform to ANSI/NCSL Z540-1-1994 (Formerly Mil-Std 45662A) and ISO 10012-1:1992
All work performed complies with MPC Quality System QM 540-94, Rev 1e.

Environmental: 72 Deg F / 42% Rh

Uncertainty: Accuracy Ratio > 4:1

Cal Procedure: Manufacture Man

Technician: ERIC BRADLEY

Test Date: 022502

Cycle: 12

Due Date: 022503

QC 3

Quality Approval: _____

Form Cert 2-25-02

All standards used are either traceable to the National Institute of Standards or have intrinsic accuracy. All services performed have used proper manufacturer and industrial service techniques and are warranted for no less than (30) days. This report may not be reproduced in part without written permission of Micro Precision's Quality Assurance Manager.

GE Vision
geophysical services
a division of Blackhawk Geometrics

SEISMOGRAPH CALIBRATION DATA SHEET REV 2/16/99

INSTRUMENT DATA

SYSTEM MFR:	640	MODEL NO.:	3331 A
SERIAL NO.:	19029	CALIBRATION DATE:	2/26/02
BY:	R. STELLER	DUE DATE:	2/26/03
COUNTER MFR:	TENMA	MODEL NO.:	72-5085
SERIAL NO.:	MB00006378	CALIBRATION DATE:	2/25/02
BY:	MICROPRECISION CAL	DUE DATE:	2/25/03
FCTN GEN MFR:	TENMA	MODEL NO.:	72-5085
SERIAL NO.:	MB00006378	CALIBRATION DATE:	2/25/02
BY:	MICRO PRECISION CAL	DUE DATE:	2/25/03

SYSTEM SETTINGS:

GAIN:	10
FILTER:	20KHZ
RANGE:	100 MSEC
DELAY:	0
STACK: 1 (STD)	1
PULSE:	1.6 MSEC
DISPLAY:	VARIABLE
SYSTEM: DATE = CORRECT DATE & TIME	2/26/02 2:26 PM

PROCEDURE:

SET FREQUENCY TO 100.0HZ SQUAREWAVE WITH AMPLITUDE APPROXIMATELY 0.25 VOLT PEAK. RECORD BOTH ON DISKETTE AND PAPER TAPE. ANALYZE AND PRINT WAVEFORMS FROM ANALYSIS UTILITY. ATTACH PAPER COPIES OF PRINTOUT AND PAPER TAPES TO THIS FORM. AVERAGE FREQUENCY MUST BE BETWEEN 99.0 AND 101.0 HZ.

AS FOUND 100.0 AS LEFT 100.0

WAVEFORM	FILE NO	FREQUENCY	TIME FOR 9 CYCLES Hn	TIME FOR 9 CYCLES Hr	TIME FOR 9 CYCLES V	AVERAGE FREQ.
SQUARE	201	100.0	90.0	90.0	90.0	100.0
SQUARE	202	100.0	90.0	90.0	90.0	100.0
SINE	203	100.0	90.0	90.0	90.0	100.0
SINE	204	100.0	90.1	90.1	90.1	99.9

CALIBRATED BY: ROBERT STELLER 2/26/02 [signature]
NAME DATE SIGNATURE

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a division of Blackhawk Geometrics

SEISMOGRAPH CALIBRATION DATA SHEET REV 2/16/99

INSTRUMENT DATA

SYSTEM MFR:	OYO	MODEL NO.:	3331
SERIAL NO.:	12004	CALIBRATION DATE:	2/26/02
BY:	R. STELLER	DUE DATE:	2/26/03
COUNTER MFR:	TENMA	MODEL NO.:	72-5085
SERIAL NO.:	MB00006378	CALIBRATION DATE:	2/25/02
BY:	MICRO PRECISION CAL	DUE DATE:	2/25/03
FCTN GEN MFR:	TENMA	MODEL NO.:	72-5085
SERIAL NO.:	MB00006378	CALIBRATION DATE:	2/25/02
BY:	MICROPRECISION CAL	DUE DATE:	2/25/03

SYSTEM SETTINGS:

GAIN:	10
FILTER:	20 KHZ
RANGE:	100 MSEC
DELAY:	0
STACK: 1 (STD)	1
PULSE:	1.6 MSEC
DISPLAY:	VARIABLE
SYSTEM: DATE = CORRECT DATE & TIME	2/26/02 1:54 PM

PROCEDURE:

SET FREQUENCY TO 100.0HZ SQUAREWAVE WITH AMPLITUDE APPROXIMATELY 0.25 VOLT PEAK. RECORD BOTH ON DISKETTE AND PAPER TAPE. ANALYZE AND PRINT WAVEFORMS FROM ANALYSIS UTILITY. ATTACH PAPER COPIES OF PRINTOUT AND PAPER TAPES TO THIS FORM. AVERAGE FREQUENCY MUST BE BETWEEN 99.0 AND 101.0 HZ.

AS FOUND 100.0 AS LEFT 100.0

WAVEFORM	FILE NO	FREQUENCY	TIME FOR 9 CYCLES Hn	TIME FOR 9 CYCLES Hr	TIME FOR 9 CYCLES V	AVERAGE FREQ.
SQUARE	101	100.0	90.0	90.0	90.0	100.0
SQUARE	102	100.0	90.0	90.0	90.0	100.0
SINE	103	100.0	90.0	89.9	90.0	100.1
SINE	104	100.0	89.9	90.0	90.1	100.0

CALIBRATED BY: ROBERT STELLER 2/26/02 [signature]

NAME DATE SIGNATURE

GE Vision
geophysical services
a division of Blackhawk Geometrics

SEISMOGRAPH CALIBRATION DATA SHEET REV 2/16/99

INSTRUMENT DATA

SYSTEM MFR:	GYO	MODEL NO.:	3331
SERIAL NO.:	15014	CALIBRATION DATE:	2/26/02
BY:	R. STELLER	DUE DATE:	2/26/03
COUNTER MFR:	TENMA	MODEL NO.:	72-5085
SERIAL NO.:	MB0000 6378	CALIBRATION DATE:	2/25/02
BY:	MICRO PRECISION CAL.	DUE DATE:	2/25/03
FCTN GEN MFR:	TENMA	MODEL NO.:	72-5085
SERIAL NO.:	MB0000 6378	CALIBRATION DATE:	2/25/02
BY:	MICRO PRECISION CAL	DUE DATE:	2/25/03

SYSTEM SETTINGS:

GAIN:	10
FILTER:	20kHZ
RANGE:	100 mSEC
DELAY:	0
STACK: 1 (STD)	1
PULSE:	1.6 mSEC
DISPLAY:	VARIABLE
SYSTEM: DATE = CORRECT DATE & TIME	2/26/02 1:30 PM

PROCEDURE:

SET FREQUENCY TO 100.0HZ SQUAREWAVE WITH AMPLITUDE APPROXIMATELY 0.25 VOLT PEAK. RECORD BOTH ON DISKETTE AND PAPER TAPE. ANALYZE AND PRINT WAVEFORMS FROM ANALYSIS UTILITY. ATTACH PAPER COPIES OF PRINTOUT AND PAPER TAPES TO THIS FORM. AVERAGE FREQUENCY MUST BE BETWEEN 99.0 AND 101.0 HZ.

AS FOUND 100.0 AS LEFT 100.0

WAVEFORM	FILE NO	FREQUENCY	TIME FOR 9 CYCLES Hn	TIME FOR 9 CYCLES Hr	TIME FOR 9 CYCLES V	AVERAGE FREQ.
SQUARE	001	100.0	90.0	89.9	89.9	100.1
SQUARE	002	100.0	90.0	90.0	90.0	100.0
SINE	003	100.0	90.0	90.1	90.1	99.9
SINE	004	100.0	89.9	90.0	90.0	100.1

CALIBRATED BY: ROBERT STELLER 2/26/02 [signature]

NAME DATE SIGNATURE

APPENDIX C-3

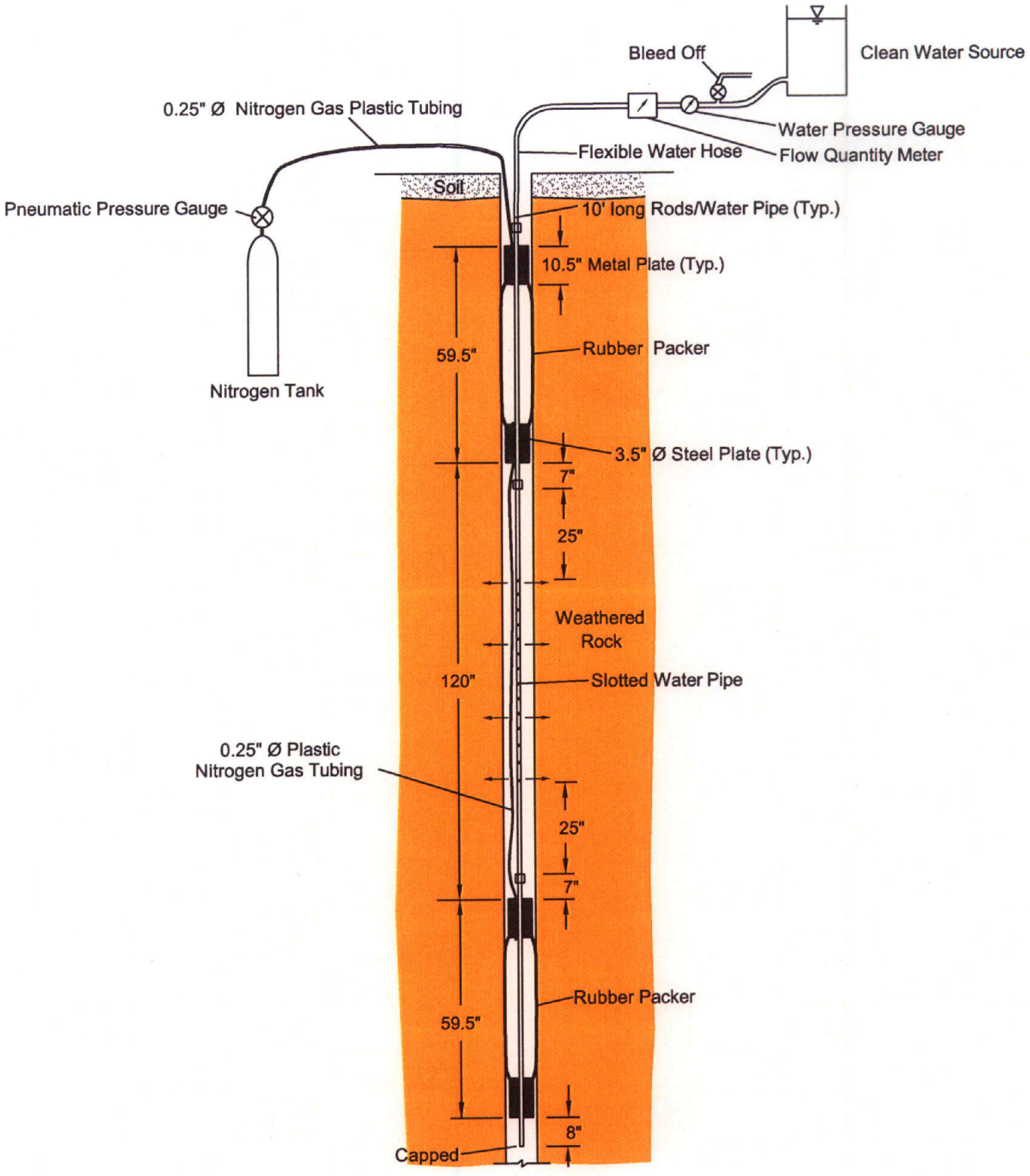
PACKER TESTING RESULTS BY EARTH MECHANICS

Table 1. Packer Testing Results

Bore-hole	Borehole					Packer Test	
	GSE (m)	As-Drilled Length (m) [ft]	Dip / Inclination	Azimuth	Rock Type	Test Interval (Depths in m)	Test Interval (Depths in ft)
02-5	292.2	255.6 [838.5]	90~86° / 0~4°	N79°W	Sandstone, Siltstone, Claystone, Granodiorite	83.3~85.4 114.3~117.4 150.9~154.0 166.2~169.2 205.8~208.8 63.7~66.7 199.7~202.7 196.6~199.7 193.6~196.6	270 ~ 280 375 ~ 385 495 ~ 505 545 ~ 555 675 ~ 685 665 ~ 675 655 ~ 665 645 ~ 655 635 ~ 645
02-6	223.8	139.6 [458]	75° / 15°	S66°E	Sandstone, Siltstone, Claystone	41.1 ~ 44.2 85.3 ~ 88.4 119.0 ~ 122.1 135.8 ~ 139.6 126.5 ~ 130.4	135 ~ 145 280 ~ 290 390.5 ~ 400.5 445.5 ~ 458 415 ~ 428
02-7	183.0	123.6 [405.5]	45° / 45°	S25°W	Sandstone, Siltstone, Claystone	70.1 ~ 76.2 82.3 ~ 85.3 88.4 ~ 94.5 94.5 ~ 100.6 102.1 ~ 108.2 109.7 ~ 116.1 117.5 ~ 123.6	230 ~ 250 270 ~ 280 290 ~ 310 310 ~ 330 335 ~ 355 360 ~ 381 385.5 ~ 405.5
02-8A	162.8	52.4 [172]	53° / 33°	N29°W	Sandstone, Siltstone, Claystone	12.8 ~ 15.8 26.5 ~ 29.5 37.9 ~ 41.0	42 ~ 52 87 ~ 97 124.5 ~ 134.5
02-21	186.1	162.2 [532]	50° / 40°	N25°E	Granodiorite, Granitic	115.8 ~ 118.9 121.9 ~ 125.0 126.5 ~ 129.5 144.5 ~ 147.5	380 ~ 390 400 ~ 410 415 ~ 425 474 ~ 484
Total 5 Boreholes					***Total 28 Tests, 346.5 m (1,136.5 ft)***		

Note:

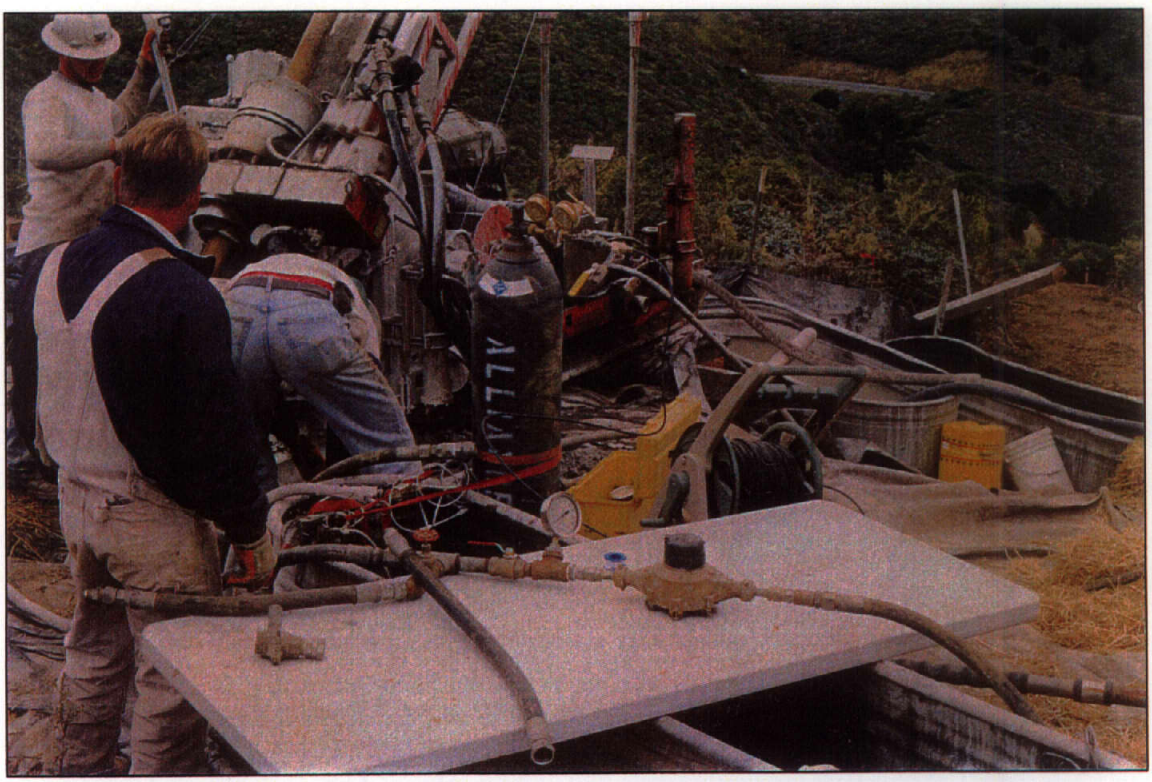
See Volume 1 for discussion of test procedures and data evaluation.



PACKER TEST EQUIPMENT

Devil's Slide Tunnels

Packer Testing at Borehole 02-7



Packer Test Equipment (Flowmeter, pressure gauge, nitrogen gas, bleed line)

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-5	GW Depth (ft)	167.6	Test No.	9
Borehole Dia.	3.75 " (HQ)	Logger	T. Bodkin	Depth to Top Packer (ft)	265
Borehole Dip	90°-86°	Date	30-Sep-02	Depth to Bottom Packer (ft)	285
Borehole Dip Dir.	N79W	Time	15:30	Test Interval	270'-280'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
SANDSTONE, with thin interbedded fine grained SANDSTONE, intensely fractured

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	(see note)					
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)

Note: Packer test was not conducted due to water loss between packers @ 0 psi constant water pressure

BOX 20 (277' - 296')

PACKER TEST RESULTS AT BOREHOLE 02-5, DEPTH 270' TO 280'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-5	GW Depth (ft)	167.6	Test No.	8
Borehole Dia.	3.75 " (HQ)	Logger	T. Bodkin	Depth to Top Packer (ft)	370
Borehole Dip	90°-86°	Date	30-Sep-02	Depth to Bottom Packer (ft)	390
Borehole Dip Dir.	N79W	Time	11:22	Test Interval	375'-385'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
CONGLOMERATE, fresh, moderately fractured, brecciated, hard, boulder-sized subangular to subrounded igneous and sedimentary clasts (RDQ range = 34% to 60%)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	0		20		30	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	35.6	0.0	36.0	0.3	47.1	3.7
2	35.7	0.0	36.3	0.3	50.8	1.7
3	35.7	0.1	36.6	0.5	52.5	2.7
4	35.8	0.0	37.1	0.5	55.2	2.7
5	35.8	0.0	37.6	0.5	57.9	2.7
6	35.8	0.0	38.1	0.5	60.6	
7	35.8		38.6	0.6		
8			39.2			

Range of K= 3E-7 to 4E-8

BOX 26 (376' - 387')

PACKER TEST RESULTS AT BOREHOLE 02-5, DEPTH 375' TO 385'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-5	GW Depth (ft)	167.6	Test No.	7
Borehole Dia.	3.75 " (HQ)	Logger	T. Bodkin	Depth to Top Packer (ft)	490
Borehole Dip	90°-86°	Date	30-Sep-02	Depth to Bottom Packer (ft)	510
Borehole Dip Dir.	N79W	Time	10:00	Test Interval	495'-505'

1' = 0.3048 m

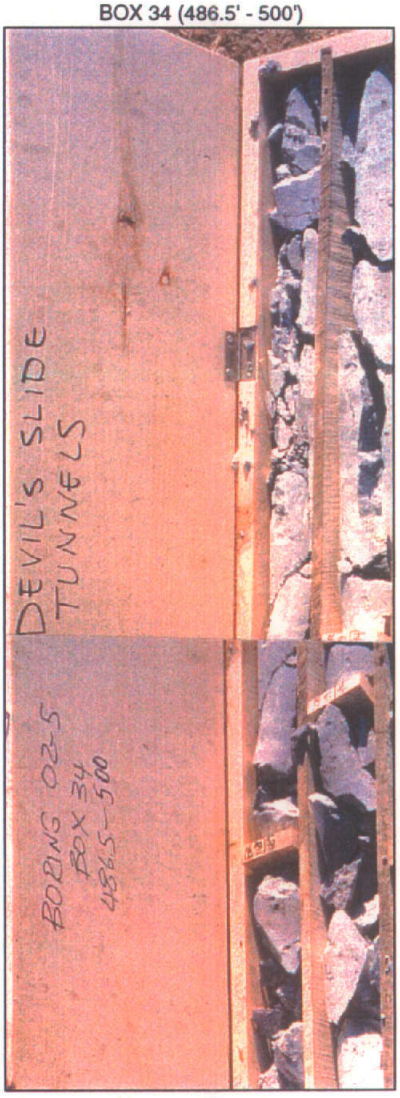
1 psi = 6.894 kPa

Rock Description
CONGLOMERATE, fresh, intensely to moderately fractured, brecciated, hard, gravelly to boulder-sized subangular to subrounded igneous and sedimentary clasts (RDQ range = 7% to 26%)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	0		20		40	
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	904.0	17.0	2.0	2.5	15.3	2.0
2	921.0	28.2	4.5	2.1	17.3	2.0
3	949.2	7.8	6.6	1.4	19.3	2.0
4	957.0	15.0	8.0	1.5	21.3	2.0
5	972.0	9.2	9.5	1.9	23.3	2.1
6	981.2	9.3	11.4	1.7	25.4	
7	990.5		13.1			
8						

Range of k = 1.5E-07 to 1.8 E-07

BOX 34 (486.5' - 500')



PACKER TEST RESULTS AT BOREHOLE 02-5, DEPTH 495' TO 505'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-5	GW Depth (ft)	167.6	Test No.	6
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	540
Borehole Dip	90°-86°	Date	27-Sep-02	Depth to Bottom Packer (ft)	560
Borehole Dip Dir.	N79W	Time	12:30	Test Interval	545'-555'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
SANDSTONE/CLAYSTONE, intensely fractured, brecciated, soft to moderately soft, with fracture zones. Poor recoveries (RDQ range = 0)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	(see note)		(see note)		(see note)	
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)

Note: Attempt to seal the interval failed, test aborted at 17:00

CORE (546.5' - 550')

PACKER TEST RESULTS AT BOREHOLE 02-5, DEPTH 545' TO 555'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-5	GW Depth (ft)	560	Test No.	1
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	670
Borehole Dip	90°-86°	Date	27-Sep-02	Depth to Bottom Packer (ft)	690
Borehole Dip Dir.	N79W	Time		Test Interval	675'-685'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
GRANODIORITE, light green, fresh to slightly weathered, moderately fractured, hard [footwall rock] (RDQ range = 38% to 63%)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	60*		0		20	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	0.0	0.0	43.0	3.0	70.0	13.0
2	0.0	0.0	46.0	5.0	83.0	12.0
3	0.0	0.0	51.0	5.0	95.0	12.5
4	0.0	0.0	56.0	5.0	107.5	12.5
5	0.0	0.0	61.0	5.0	120.0	
6			66.0			
7						
8						

Note: Test at 60 psi not valid - water meter malfunction. Probably hydrofracturing occurred @ 60 psi when meter was not recording

BOX 44 (678.5' - 693.5')

PACKER TEST RESULTS AT BOREHOLE 02-5, DEPTH 675' TO 685'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-5	GW Depth (ft)	560	Test No.	2
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	660
Borehole Dip	90°-86°	Date	27-Sep-02	Depth to Bottom Packer (ft)	680
Borehole Dip Dir.	N79W	Time		Test Interval	665'-675'

1' = 0.3048 m

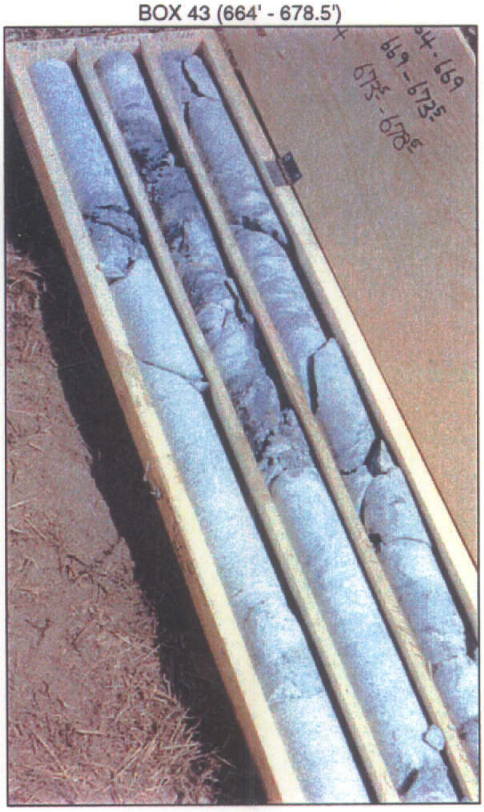
1 psi = 6.894 kPa

Rock Description
FAULT CONTACT CONGLOMERATE/GRANODIORITE, slightly to moderately fractured [contact @ 671.5'] (RQD range = 50% to 28%)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	0		20		40	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	15.0	8.0	77.0	18.0		
2	23.0	9.5	95.0	23.0		
3	32.5	10.0	118.0	(flowing)"		
4	42.5	10.0				
5	52.5	10.5				
6	63.0					
7						
8						

Note: Probably hydrofracturing occurred: formation started taking a large amount of water without pressure build-up, cannot achieve higher pressures

BOX 43 (664' - 678.5')



PACKER TEST RESULTS AT BOREHOLE 02-5, DEPTH 665' TO 675'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-5	GW Depth (ft)	560	Test No.	3
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	650
Borehole Dip	90°-86°	Date	27-Sep-02	Depth to Bottom Packer (ft)	670
Borehole Dip Dir.	N79W	Time		Test Interval	655'-665'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
CONGLOMERATE, fresh, moderately to intensely fractured (brecciated), hard (RDQ range = 43% to 41%)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	10		20		40	
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	51.0	1.0	55.0	0.5	58.5	2.5
2	52.0	1.0	55.5	0.5	61.0	3.0
3	53.0	1.0	56.0	0.6	64.0	4.0
4	54.0	1.0	56.6	0.7	68.0	4.0
5	55.0		57.3	0.5	72.0	4.0
6			57.8	0.5	76.0	
7			58.3			
8						

BOX 42 (649' - 664')

PACKER TEST RESULTS AT BOREHOLE 02-5, DEPTH 655' TO 665'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-5	GW Depth (ft)	560	Test No.	4
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	640
Borehole Dip	90°-86°	Date	27-Sep-02	Depth to Bottom Packer (ft)	660
Borehole Dip Dir.	N79W	Time		Test Interval	645'-655'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
SILTSTONE/CLAYSTONE, intensely fractured, brecciated, moderately hard to soft in gouge areas, in contact with CONGLOMERATE, fresh, moderately to intensely fractured (brecciated) (RDQ range = 0 to 15%)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	0		10		40	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	74.0	6.0	2.0	18.0	2.0	10.0
2	80.0	6.0	20.0	22.0	12.0	10.0
3	86.0	5.7	42.0	22.0	22.0	11.0
4	91.7	6.3	64.0	4.0	33.0	9.0
5	98.0		68.0	(see note)	42.0	
6						
7						
8						

Note: Suspicious test, increasing pressure water flow decreased (probably some of the fractures closed)

BOX 42 (649' - 664')

PACKER TEST RESULTS AT BOREHOLE 02-5, DEPTH 645' TO 655'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-5	GW Depth (ft)	560	Test No.	5
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	630
Borehole Dip	90°-86°	Date	27-Sep-02	Depth to Bottom Packer (ft)	650
Borehole Dip Dir.	N79W	Time		Test Interval	635'-645'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
SILTSTONE/CLAYSTONE, intensely fractured, brecciated, soft to moderately soft, with fracture zones. Poor recoveries (RDQ range = 0)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	0		20		40	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	94.0	0.0	96.0	6.0	27.0	4.0
2	94.0	0.0	102.0	6.0	31.0	7.0
3	94.0	0.0	108.0	6.0	38.0	7.0
4	94.0		114.0	6.0	45.0	7.0
5			120.0		52.0	
6						
7						
8						

BOX 41 (632' - 649')

PACKER TEST RESULTS AT BOREHOLE 02-5, DEPTH 635' TO 645'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-6	Depth to GW (ft)	225.1	Test No.	5
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	130
Borehole Dip	75°	Date	12-Aug-02	Depth to Bottom Packer (ft)	150
Borehole Dip Dir.	S66°E	Time		Test Interval	135' - 145'

1' = 0.3048 m

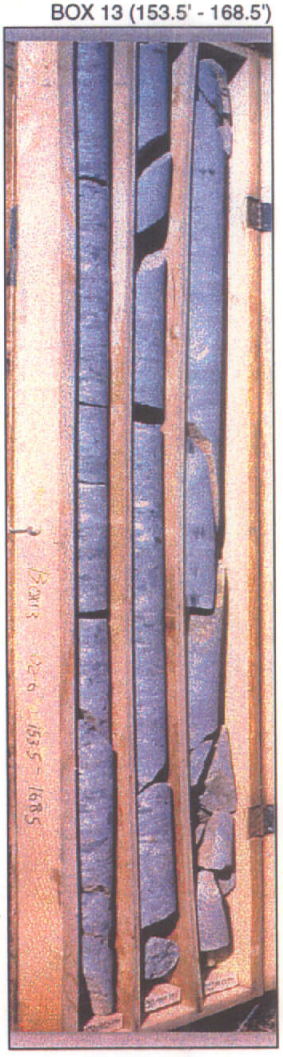
1 psi = 6.894 kPa

Rock Description
conglomeratic, silgtly freactured, fresh to slightly weathered (granodiorite boulder @ 139'; RQD = 43% - 71%)

Packer Pressure (psi)	350		350		350	
Constant Water Pressure (psi)	30		45		55	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
0.0	87.0	3.0	0.0	5.0	21.0	7.0
1.0	90.0	3.0	5.0	5.0	28.0	7.0
2.0	93.0	3.0	10.0	5.0	35.0	7.0
3.0	96.0	3.0	15.0		42.0	7.0
4.0	99.0				49.0	
5.0						

Use core picture of Box 13 since the core picture of Box 12 could not be found.

BOX 13 (153.5' - 168.5')



PACKER TEST RESULTS AT BOREHOLE 02-6, DEPTH 135' TO 145'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-6	Depth to GW (ft)	225.1	Test No.	4
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	275
Borehole Dip	75°	Date	12-Aug-02	Depth to Bottom Packer (ft)	295
Borehole Dip Dir.	S66°E	Time		Test Interval	280' - 290'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
conglomeratic sandstone + siltstone, moderately to intensely fractured (RQD = 0 - 68%)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	0		20		40	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
0.0	68.0	3.0	81.0	3.0	93.0	7.0
1.0	71.0	2.5	84.0	3.5	100.0	8.5
2.0	73.5	2.5	87.5	3.5	108.5	8.5
3.0	76.0	2.5	91.0	3.5	117.0	8.5
4.0	78.5		94.5		125.5	
5.0						

BOX 22 (271.5' - 282')

BOX 23 (282' - 297')

PACKER TEST RESULTS AT BOREHOLE 02-6, DEPTH 280' TO 290'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-6	Depth to GW (ft)	225.1	Test No.	3
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	385.5
Borehole Dip	75°	Date	12-Aug-02	Depth to Bottom Packer (ft)	405.5
Borehole Dip Dir.	S66°E	Time		Test Interval	390.5' - 400.5'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
Sandstone. Light gray, moderately fresh to fresh (siltstone interbedded / gouge @ 396')

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	0		10			
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
0.0	19.0	2.0	70.0	22.0		*
1.0	21.0	8.0	92.0	19.0		
2.0	29.0	9.0	111.0	20.0		
3.0	38.0	8.0	131.0	0.0		
4.0	46.0	8.0	131.0			
5.0	54.0	0.0				
6.0	54.0					
7.0						

* : hydrofrit problem occurred @ 10 psi (22 gpm)! No sense in testing 3rd pressure increment.

BOX 32 (388' - 403')

PACKER TEST RESULTS AT BOREHOLE 02-6, DEPTH 390.5' TO 400.5'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-6	Depth to GW (ft)	225.1	Test No.	1
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	410
Borehole Dip	75°	Date	12-Aug-02	Depth to Bottom Packer (ft)	433
Borehole Dip Dir.	S66°E	Time		Test Interval	415'-428'

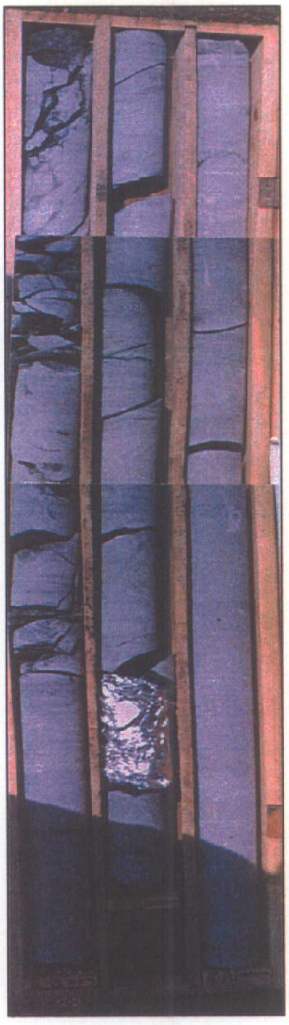
1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
Sandstone, light gray, fresh, slightly fractured - modertately fractured (section 424' - 427')

Packer Pressure (psi)	375		375		375	
Constant Water Pressure (psi)	10		40		60	
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
0.0	80.0	3.0	84.0	1.0	88.0	1.0
1.0	83.0	0.0	85.0	0.5	89.0	0.5
2.0	83.0	0.0	85.5	0.5	89.5	0.5
3.0	83.0		86.0	1.0	90.0	1.0
4.0			87.0	0.5	91.0	0.5
5.0			87.5	0.0	91.5	1.0
6.0			87.5	0.0	92.5	0.5
7.0			87.5		93.0	0.0
8.0					93.0	

BOX 34 (413' - 428')



PACKER TEST RESULTS AT BOREHOLE 02-6, DEPTH 415' TO 428'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-6	Depth to GW (ft)	225.1	Test No.	2
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	440.5
Borehole Dip	75°	Date	12-Aug-02	Depth to Bottom Packer (ft)	463
Borehole Dip Dir.	S66°E	Time	16:40	Test Interval	445.5' - 458'

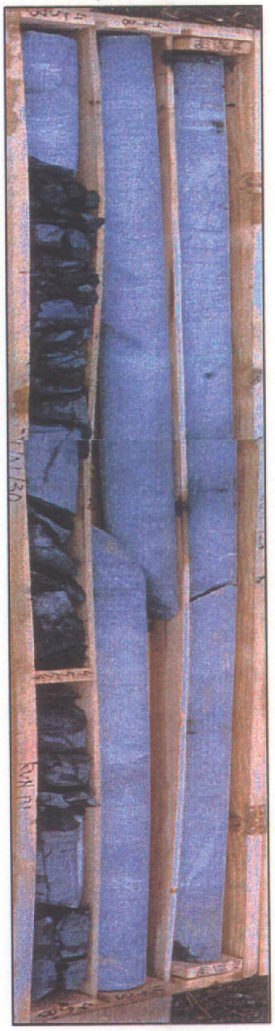
1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
Sandstone, light gray, fresh, unfractured, with siltstone / claystone interbedded @ bottom of section, intensely fractured

Packer Pressure (psi)	350		350		350	
Constant Water Pressure (psi)	30		50		65	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
0.0	94.0	1.0	1.5	1.0	8.5	1.5
1.0	95.0	0.7	2.5	1.5	10.0	1.5
2.0	95.7	1.3	4.0	1.5	11.5	1.5
3.0	97.0	1.2	5.5	1.5	13.0	1.5
4.0	98.2	1.3	7.0	1.5	14.5	1.5
5.0	99.5	1.5	8.5	0.0	16.0	0.0
6.0	101.0	0.0	8.5		16.0	
7.0	101.0					
8.0						

BOX 36 (443' - 458')



PACKER TEST RESULTS AT BOREHOLE 02-6, DEPTH 445.5' TO 458'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-7	GW Depth (ft)	129.6	Test No.	8
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	225
Borehole Dip	45°	Date	24-Jul-02	Depth to Bottom Packer (ft)	255
Borehole Dip Dir.	S25W	Time		Test Interval	230'-250'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
CONGLOMERATE, light gray, fresh, moderately fractured, hard, fine to medium grained matrix with clasts up to boulder size of igneous and sedimentary rocks, with a claystone interbed (RQD range = 77% to 92%)

Packer Pressure (psi)	350		350		350	
Constant Water Pressure (psi)	10		30		60	
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	81.0	2.0	85.0	2.0	88.0	1.0
2	83.0	1.0	87.0	0.0	89.0	1.0
3	84.0	0.0	87.0	0.0	90.0	0.5
4	84.0	0.0	87.0	0.0	90.5	0.5
5	84.0	0.0	87.0	0.0	91.0	0.5
6	84.0		87.0		91.5	
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						

Note: very good test.

BOX 18 (230' - 251')

PACKER TEST RESULTS AT BOREHOLE 02-7, DEPTH 230' TO 250'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-7	GW Depth (ft)	129.6	Test No.	7
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	265
Borehole Dip	45°	Date	24-Jul-02	Depth to Bottom Packer (ft)	285
Borehole Dip Dir.	S25W	Time		Test Interval	270'-280'

1' = 0.3048 m

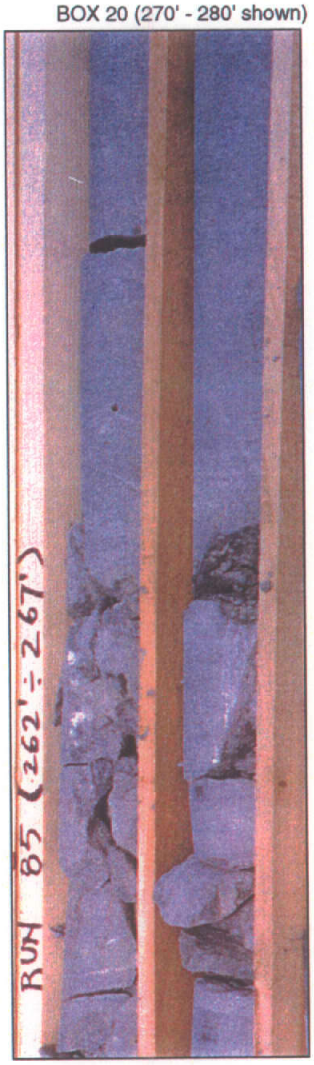
1 psi = 6.894 kPa

Rock Description
SANDSTONE, light gray, fresh, moderately to intensely fractured, hard, fine to medium grained with few small fractures zones (RQD range = 18% to 29%)

Packer Pressure (psi)	350		350		350	
Constant Water Pressure (psi)	0		20		40	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	65.0	0.0	72.0	2.0	97.0	9.0
2	65.0	1.0	74.0	3.0	106.0	15.0
3	66.0	0.0	77.0	4.0	121.0	flowing
4	66.0	1.0	81.0	4.0		(jacking occurred)
5	67.0	0.0	85.0	4.0		
6	67.0	0.0	89.0	4.0		
7	67.0	0.0	93.0			
8	67.0					
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						

Note: very good test. Jacking and hydrofracturing possibly occurred @ 40 psi

BOX 20 (270' - 280' shown)



PACKER TEST RESULTS AT BOREHOLE 02-7, DEPTH 270' TO 280'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-7	GW Depth (ft)	129.6	Test No.	6
Borehole Dia.	3.75" (HQ)	Logger	S.Siciliano	Depth to Top Packer (ft)	286
Borehole Dip	45°	Date	24-Jul-02	Depth to Bottom Packer (ft)	315
Borehole Dip Dir.	S25W	Time		Test Interval	290'-310'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
SANDSTONE, light gray, fresh, moderately to intensely fractured, hard, fine to coarse grained, with few fracture zones occasionally clay filled (RQD range = 26% to 72%)

Packer Pressure (psi)	400		400		400	
Constant Water Pressure (psi)	0		10		50	
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	0.0	0.0	505.0	0.0	512.0	0.0
2	0.0	0.0	505.0	0.0	510.0	2.0
3	0.0	0.0	505.0	0.0	512.0	0.0
4	0.0	0.0	505.0	0.0	512.0	0.0
5	0.0	0.0	505.0	0.0	512.0	0.0
6	0.0	0.0	505.0	0.0	512.0	0.0
7	0.0		505.0		512.0	
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						

Note: the interval did not take any water flow - suspecious test

NO PHOTO AVAILABLE

PACKER TEST RESULTS AT BOREHOLE 02-7, DEPTH 290' TO 310'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-7	GW Depth (ft)	129.6	Test No.	4
Borehole Dia.	3.75" (HQ)	Logger	S.Siciliano	Depth to Top Packer (ft)	305
Borehole Dip	45°	Date	25-Jul-02	Depth to Bottom Packer (ft)	335
Borehole Dip Dir.	S25W	Time	9:30	Test Interval	310'-330'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
SANDSTONE, fresh, slightly to locally intensely fractured, hard, fine to medium grained, with few gravel-size angular clasts, calcite veins (RQD range = 39% to 77%)

Packer Pressure (psi)	300		300		300	
Constant Water Pressure (psi)	10		50		50	
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1		(see note)		(see note)		(see note)
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
Note: water came out of borehole collar at 10 psi, test aborted after several attempts to seal interval						

NO PHOTO AVAILABLE

PACKER TEST RESULTS AT BOREHOLE 02-7, DEPTH 310' TO 330'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.

Borehole ID	02-7	GW Depth (ft)	129.6	Test No.	3
Borehole Dia.	3.75" (HQ)	Logger	S.Siciliano	Depth to Top Packer (ft)	330
Borehole Dip	45°	Date	26-Jul-02	Depth to Bottom Packer (ft)	360
Borehole Dip Dir.	825W	Time	9:30	Test Interval	335'-355'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
SANDSTONE, fresh, moderately fractured, hard, fine to medium grained, with few gravel-size angular clasts, calcite veins and few clay filled fractures up to 0.5" thick (RQD range = 35% to 48%)

Packer Pressure (psi)	300		300		300	
Constant Water Pressure (psi)	15		20		50	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	119.0	17.0	259.0	15.0		(see note)
2	136.0	17.0	274.0	14.0		
3	153.0	17.0	288.0	15.0		
4	170.0	13.0	303.0	11.0		
5	183.0	15.0	314.0			
6	198.0					
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						

Note: water came out of borehole collar at 50 psi, test interrupted

NO PHOTO AVAILABLE

PACKER TEST RESULTS AT BOREHOLE 02-7, DEPTH 335' TO 355'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-7	GW Depth (ft)	129.6	Test No.	2
Borehole Dia.	3.75" (HQ)	Logger	B.Schell	Depth to Top Packer (ft)	355
Borehole Dip	45°	Date	24-Jul-02	Depth to Bottom Packer (ft)	386
Borehole Dip Dir.	S25W	Time		Test Interval	360'-381'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
SANDSTONE, fresh, slightly fractured, hard to very hard, fine to medium grained

Packer Pressure (psi)	400		400			
Constant Water Pressure (psi)	211		220			
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	317.0	18.0	590.0	15.0		
2	335.0	20.0	605.0	33.0		
3	355.0	20.0	638.0	13.0		
4	375.0	19.0	651.0	33.0		
5	394.0	20.0	674.0	22.0		
6	414.0	19.0	696.0	25.0		
7	433.0		721.0	22.0		
8			743.0			
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						

NO PHOTO AVAILABLE

PACKER TEST RESULTS AT BOREHOLE 02-7, DEPTH 360' TO 381'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-7	GW Depth (ft)	129.6	Test No.	1
Borehole Dia.	3.75 " (HQ)	Logger	B.Schell	Depth to Top Packer (ft)	380.5
Borehole Dip	45°	Date	24-Jul-02	Depth to Bottom Packer (ft)	410.5
Borehole Dip Dir.	S25W	Time		Test Interval	385.5'-405.5'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
SANDSTONE, fresh, slightly fractured, hard to very hard, fine to medium grained

Packer Pressure (psi)	400		400			
Constant Water Pressure (psi)	110		180			
Starting Time	12:42					
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	84.0	12.0	37.0	24.0		
2	96.0	23.0	61.0	24.0		
3	119.0	6.0	85.0	26.0		
4	125.0	6.0	111.0	24.0		
5	131.0	13.0	135.0	25.0		
6	144.0	11.0	160.0	24.0		
7	155.0	15.0	184.0	25.0		
8	170.0	9.0	209.0	25.0		
9	179.0	13.0	234.0	24.0		
10	192.0	11.0	258.0	25.0		
11	203.0	12.0	283.0	43.0		
12	215.0		326.0			
13						
14						
15						
16						
17						
18						
19						
20						
21						

BOX 28 (387' - 400.5')

PACKER TEST RESULTS AT BOREHOLE 02-7, DEPTH 385.5' TO 405.5'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-8A	GW Depth (ft)	-	Test No.	3
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	47'
Borehole Dip	53°	Date	10-Aug-02	Depth to Bottom Packer (ft)	57'
Borehole Dip Dir.	N29°E	Time		Test Interval	42'-52'

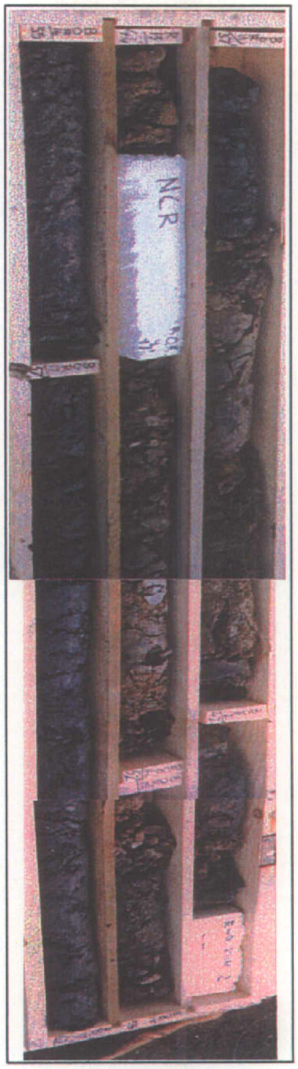
1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
Siltstone / Sandstone (RDQ = 0 %). Intensely weathered, Intensely fractured.

Packer Pressure (psi)						
Constant Water Pressure (psi)	0		10		20	
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
cannot seal the hole with parckers above 85'. Because of casing.						

BOX 3 (37' - 62')



PACKER TEST RESULTS AT BOREHOLE 02-8A, DEPTH 42' TO 52'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-8A	GW Depth (ft)	-	Test No.	2
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	82'
Borehole Dip	53°	Date	10-Aug-02	Depth to Bottom Packer (ft)	102'
Borehole Dip Dir.	N29°E	Time		Test Interval	87'-97'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
Siltstone / Sandstone Interbedded (RDQ range = 0 % to 23%).

Packer Pressure (psi)						
Constant Water Pressure (psi)	0		10		20	
Starting Time						
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
Packer test became trapped with casing material. Test aborted						

BOX 5 (82' - 97')

PACKER TEST RESULTS AT BOREHOLE 02-8A, DEPTH 87' TO 97'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-8A	GW Depth (ft)	-	Test No.	1
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	119.5'
Borehole Dip	53°	Date	10-Aug-02	Depth to Bottom Packer (ft)	139.5'
Borehole Dip Dir.	N29°E	Time		Test Interval	124.5'-134.5'

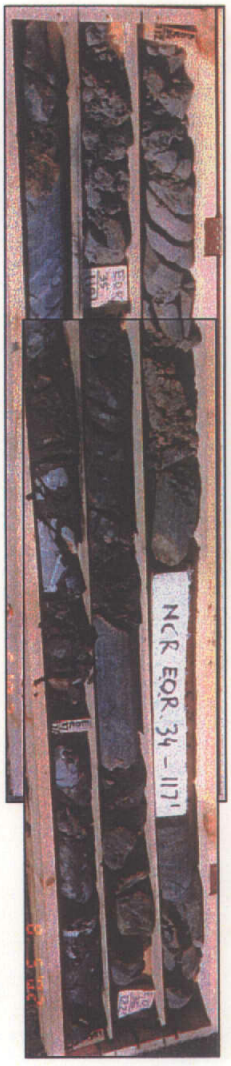
1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
Interbedded sandstone / siltstone / claystone (RDQ range = 0 % to 7%)

Packer Pressure (psi)	400					
Constant Water Pressure (psi)	0		30		45	
Starting Time						
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
6	90.0	8.0	152.0	8.0	190.0	10.0
7	98.0	9.0	160.0	8.0	200.0	10.0
8	107.0	8.0	168.0	7.0	208.0	8.0
9	115.0	7.0	175.0	9.0	215.5	7.5
10	122.0	9.0	184.0	8.0	223.5	8.0
11	131.0	8.0	192.0	8.0	232.0	8.5
12	139.0		200.0		240.0	8.0
					248.0	

BOX 7 (112' - 128')



BOX 8 (128' - 146')

PACKER TEST RESULTS AT BOREHOLE 02-8A, DEPTH 124.5' TO 134.5'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-21	GW Depth (ft)	-	Test No.	4
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	375
Borehole Dip	50°	Date	13-Sep-02	Depth to Bottom Packer (ft)	395
Borehole Dip Dir.	N25E	Time	10:30	Test Interval	380'-390'

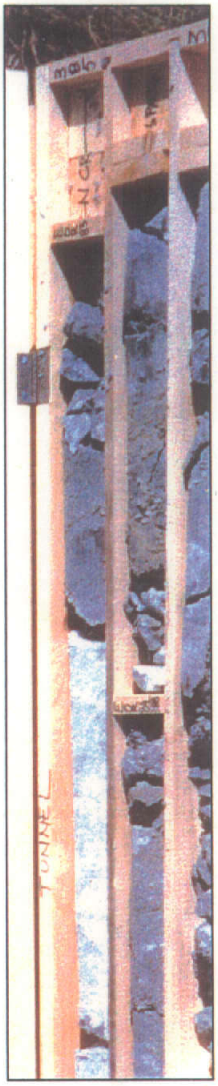
1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
GRANODIORITE, light green, fresh, moderately to intensely fractured, hard to locally soft in fracture zones, microcristalline (RDQ range = 19% to 58%)

Packer Pressure (psi)	350		350		350	
Constant Water Pressure (psi)	20		40		55	
Starting Time	10:35		10:50		11:15	
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	80.0	3.0	97.0	4.5	15.0	8.0
2	83.0	2.7	101.5	4.5	23.0	6.5
3	85.7	2.8	106.0	4.0	29.5	7.5
4	88.5	2.5	110.0	4.0	37.0	7.0
5	91.0	2.5	114.0		44.0	
6	93.5					
7						
8						

BOX 26 (380' - 394')



PACKER TEST RESULTS AT BOREHOLE 02-21, DEPTH 380' TO 390'

DEVIL'S SLIDE TUNNELS

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Borehole ID	02-21	GW Depth (ft)	-	Test No.	3
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	395
Borehole Dip	50°	Date	13-Sep-02	Depth to Bottom Packer (ft)	415
Borehole Dip Dir.	N25E	Time	9:00	Test Interval	400'-410'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
GRANODIORITE, light green, fresh, moderately fractured, hard to locally soft in fracture zones, porfiric structure with phenocrysts up to 1 cm. (RDQ range = 53% to 60%)

Packer Pressure (psi)	350		350		350	
Constant Water Pressure (psi)	30		50		80	
Starting Time	9:30		10:00		10:15	
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	28.0	0.2	28.7	0.0	29.5	0.2
2	28.2	0.0	28.7	0.0	29.7	0.2
3	28.2	0.0	28.7	0.1	29.9	0.4
4	28.2	0.0	28.8	0.0	30.3	0.2
5	28.2		28.8		30.5	0.3
6					30.8	
7						
8						

BOX 27 (394' - 408.5')

PACKER TEST RESULTS AT BOREHOLE 02-21, DEPTH 400' TO 410'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-21	GW Depth (ft)	-	Test No.	2
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	410
Borehole Dip	50°	Date	13-Sep-02	Depth to Bottom Packer (ft)	430
Borehole Dip Dir.	N25E	Time	15:30	Test Interval	415'-425'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
GRANODIORITE, light green, fresh, slightly fractured, hard to very hard, porfiric structure with phenocrysts up to 1 cm. (RDQ range = 75% to 100%)

Packer Pressure (psi)	350		350		350	
Constant Water Pressure (psi)	30		60		90	
Starting Time	15:30		16:00		16:30	
	Water Flow		Water Flow		Water Flow	
Time (min)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	0.0	0.0	0.0	0.0	20.0	0.3
2	0.0	0.0	0.0	0.0	20.3	0.3
3	0.0	0.0	0.0	0.0	20.5	0.2
4	0.0	0.0	0.0	0.0	20.7	0.2
5	0.0	0.0	0.0	0.0	20.9	0.2
6					21.1	0.2
7						
8						

NOTE: Rock section extremely tight and impermeable, decided not to increase pressure too much to avoid jacking and hydrofracturing

BOX 28 (408.5' - 422')

PACKER TEST RESULTS AT BOREHOLE 02-21, DEPTH 415' TO 425'

DEVIL'S SLIDE TUNNELS

Borehole ID	02-21	GW Depth (ft)	-	Test No.	1
Borehole Dia.	3.75 " (HQ)	Logger	S. Siciliano	Depth to Top Packer (ft)	469
Borehole Dip	50°	Date	12-Sep-02	Depth to Bottom Packer (ft)	489
Borehole Dip Dir.	N25E	Time	16:15	Test Interval	474'-484'

1' = 0.3048 m

1 psi = 6.894 kPa

Rock Description
GRANODIORITE (CATACLASITE), light green, fresh, slightly fractured, moderately hard. (RDQ range = 86% to 100%)

Packer Pressure (psi)	350		350		350	
Constant Water Pressure (psi)	50		130		150	
Starting Time	16:15		16:27		16:53	
Time (min)	Water Flow		Water Flow		Water Flow	
	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)	Flow (gal)	Flow Rate (gpm)
1	0.0	0.0	5.0	0.7	88.0	3.0
2	0.0	0.0	5.7	0.3	91.0	3.0
3	0.0	0.0	6.0	0.4	95.0	4.0
4	0.0		6.4	0.2	98.5	3.5
5			6.6	0.4	102.0	
6			7.0			
7						
8						

NOTE: Rock section extremely tight and impermeable, was not taking any water until constant water pressure of 130 psi

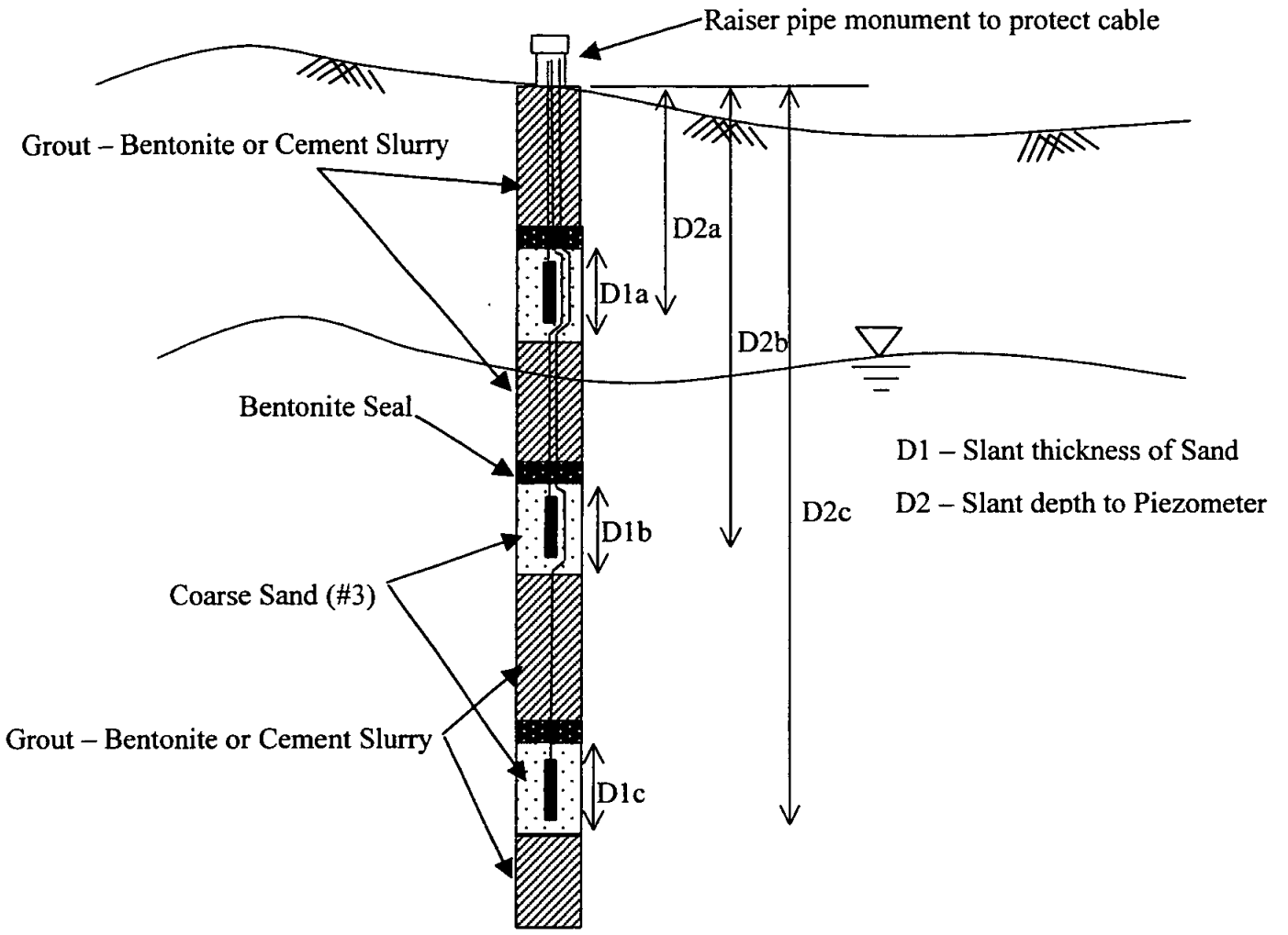
BOX 32 (465' - 477')

PACKER TEST RESULTS AT BOREHOLE 02-21, DEPTH 474' TO 484'

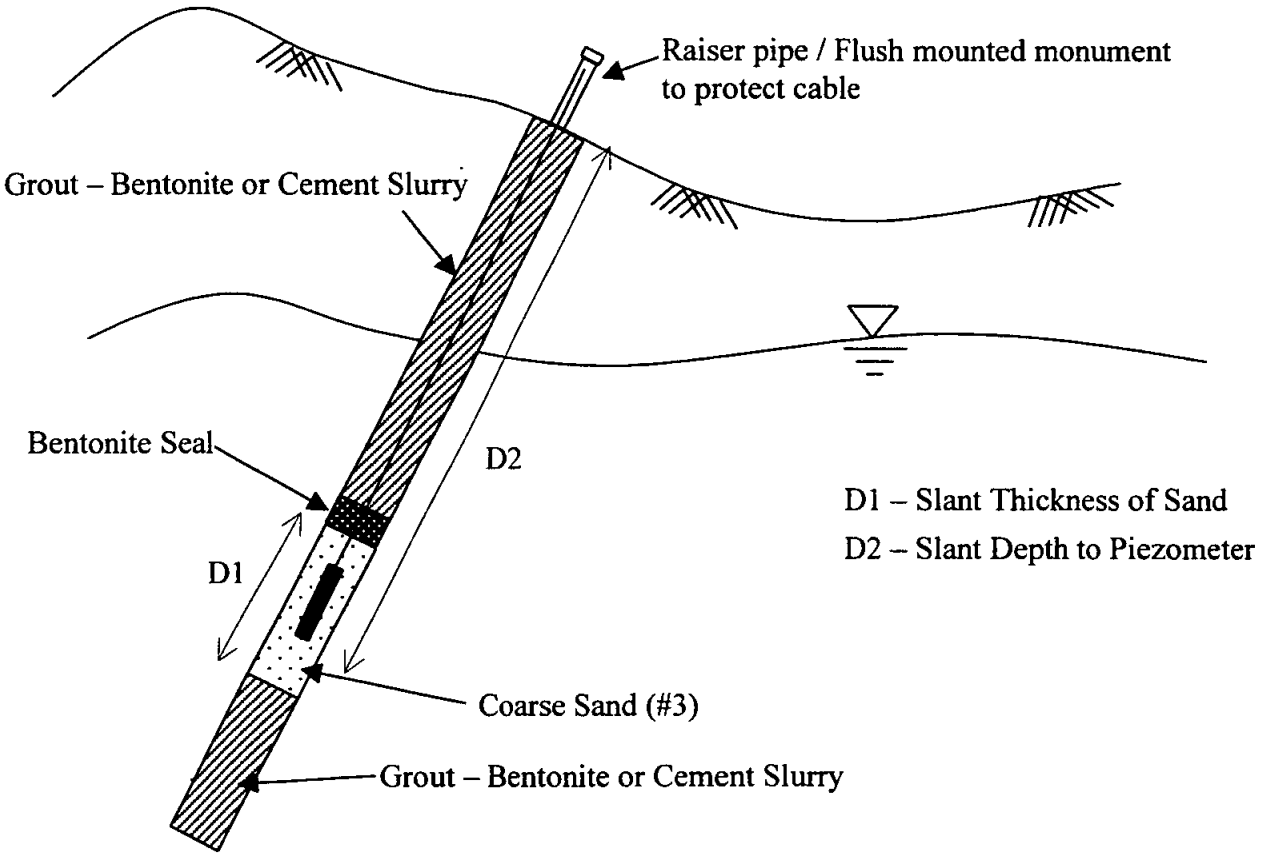
DEVIL'S SLIDE TUNNELS

APPENDIX D-3

PIEZOMETER INSTALLATION RECORDS AND INITIAL DATA BY EARTH MECHANICS



Schematic of Multi Piezometer Installation



Schematic of Single Piezometer Installation

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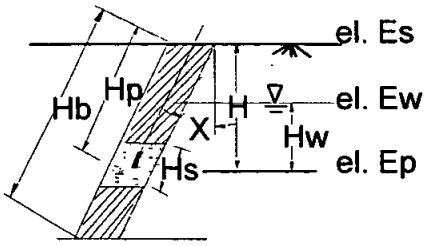
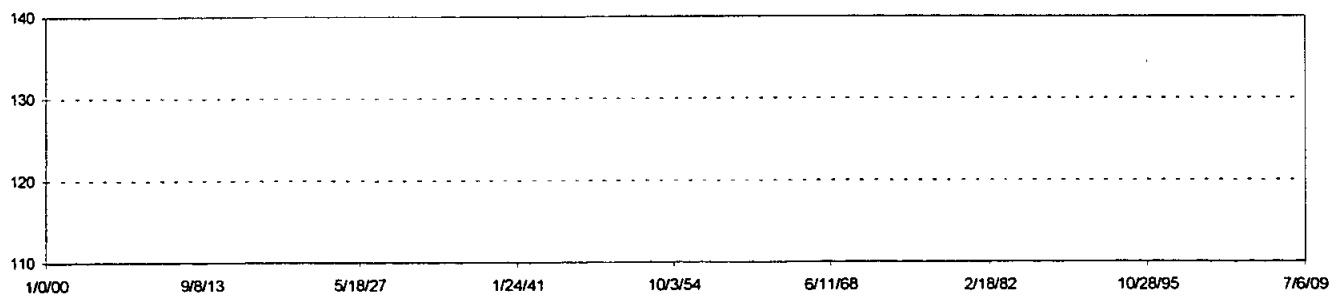
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	**02-2B**	**Piezometer Transducer**	
El. Es (m) =	131.4	Serial No:	74659
Hb (m) =	86.3	Max Pressure:	250 psi
Hp (m) =	54.9	Factor A =	-0.00035719
Hs (m) =	3.2	Factor B =	0.167440
X (deg) =	30.0	Factor C =	2980.70
El. Ep (m) =	83.9	Date Installed:	10/04/02



Date	Vibration Reading (Hz)	Temperature Reading (^{0}C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
11/4/02	3136.1	15.3	0.00	0.00	not known	CMK	no rain since May



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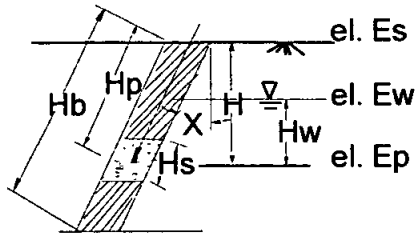
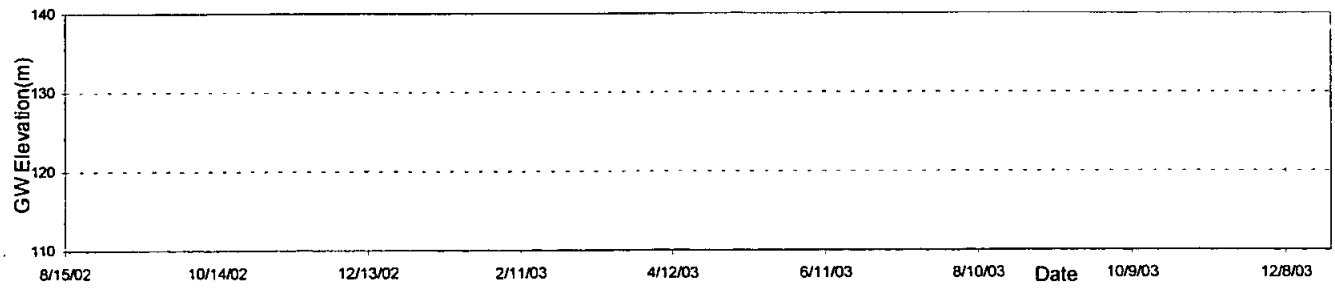
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	02-5 (Piezo A)	**Piezometer Transducer**	
El. Es (m) =	292.2	Serial No:	74661
Hb (m) =	255.6	Max Pressure:	250 psi
Hp (m) =	61.0	Factor A =	-0.00031368
Hs (m) =	6.1	Factor B =	0.117250
X (deg) =	0.0	Factor C =	2698.70
El. Ep (m) =	231.2	Date Installed:	10/03/02



Date	Vibration Reading (Hz)	Temperature Reading (^{0}C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
10/2/02				3.96	235.19	RV	Measured by tape?
10/3/02	3129.8	16.3	0.00	0.00	not known	S.S	
11/4/02	3073.2	20.6	96.46	9.83	241.06	CMK	



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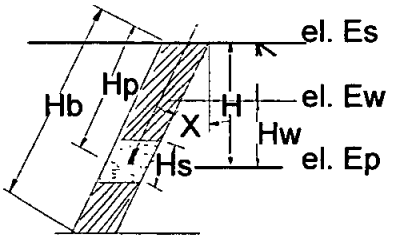
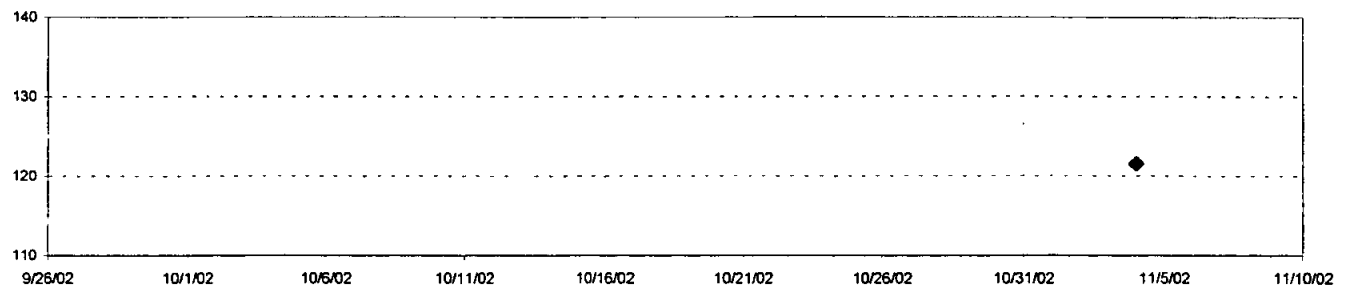
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	**02-5 (Piezo B)**	**Piezometer Transducer**	
El. Es (m) =	292.2	Serial No:	74664
Hb (m) =	255.6	Max Pressure:	250 psi
Hp (m) =	182.9	Factor A =	-0.00034307
Hs (m) =	6.1	Factor B =	0.166400
X (deg) =	0.0	Factor C =	2774.40
El. Ep (m) =	109.3	Date Installed:	10/02/02



Date	Vibration Reading (Hz)	Temperature Reading (^{0}C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
10/2/02				125.91	235.19	RV	Measured by tape?
10/3/02	2893.7	21.4	383.22	39.06	148.34	S.S	
11/4/02	3034.5	19.8	120.29	12.26	121.53	CMK	



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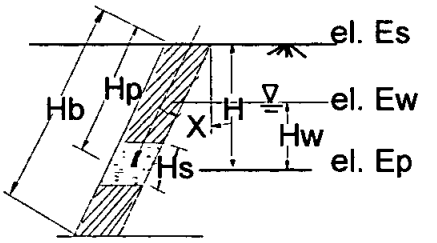
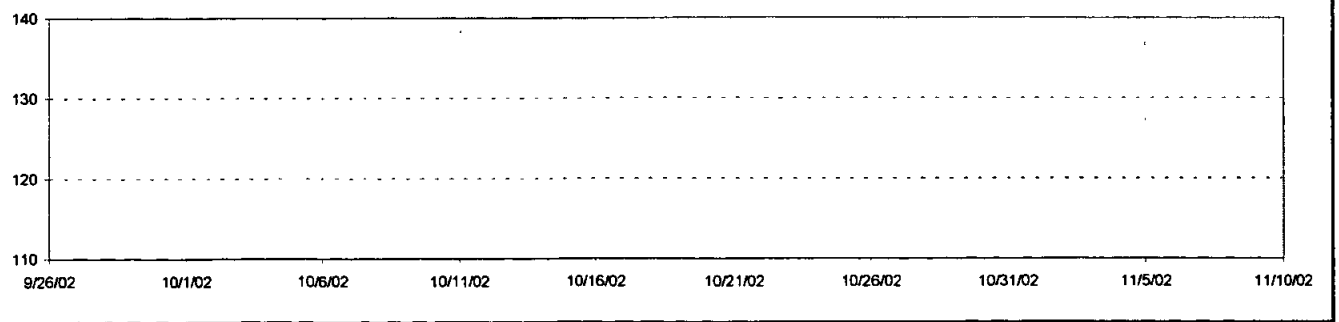
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	02-5 (Piezo C)	**Piezometer Transducer**	
El. Es (m) =	292.2	Serial No:	74665
Hb (m) =	255.6	Max Pressure:	250 psi
Hp (m) =	213.0	Factor A =	-0.00031144
Hs (m) =	6.1	Factor B =	0.011234
X (deg) =	0.0	Factor C =	3018.90
El. Ep (m) =	79.2	Date Installed:	10/02/02



Date	Vibration Reading (Hz)	Temperature Reading (^{0}C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
10/2/02				156.40	235.60	RV	Measured by Tape?
10/3/02	3048.7	21.0	158.45	16.15	95.35	S.S	
11/4/02	3129.6	14.5	3.69	0.38	79.58	CMK	



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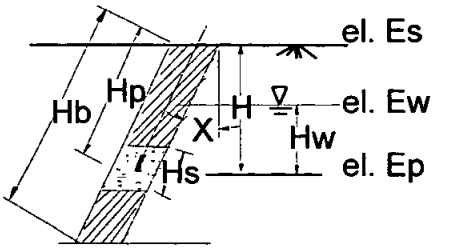
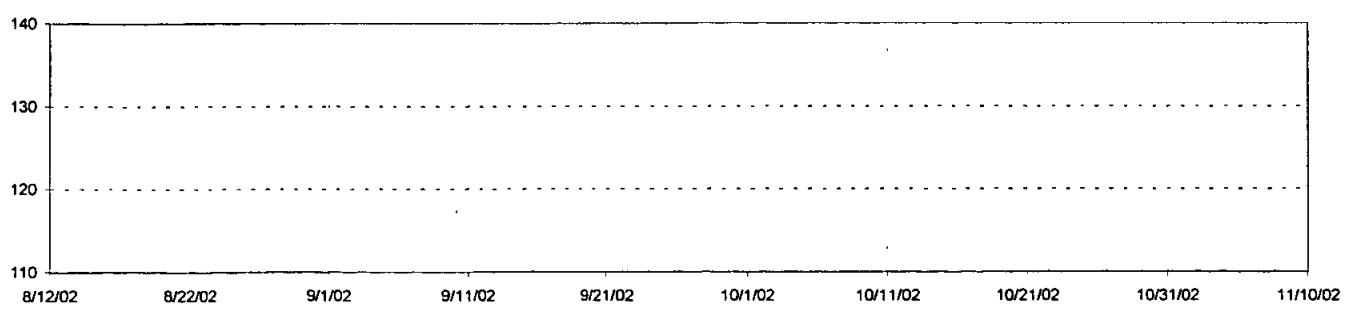
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	**02-6**	**Piezometer Transducer**	
El. Es (m) =	223.8	Serial No:	74663
Hb (m) =	139.6	Max Pressure:	250 psi
Hp (m) =	115.5	Factor A =	-0.00032747
Hs (m) =	7.6	Factor B =	0.146160
X (deg) =	15.0	Factor C =	2695.40
El. Ep (m) =	112.2	Date Installed:	8/16/02



Date	Vibration Reading (Hz)	Temperature Reading (°C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
8/16/02				46.50	158.74	RV	Measured by tape
8/16/02	3105.0	19.1	0.00	0.00	not known	RV	at Surface
8/16/02	2846.5	17.5	458.10	46.70	158.93	RV	at bottom no top sand
8/16/02	2846.1	17.3	458.79	46.77	159.00	RV	at bottom after top sand
9/27/02	2851.2	16.5	450.02	45.87	158.11	C.K	
11/4/02	2854.9	16.3	443.64	45.22	157.46	CMK	



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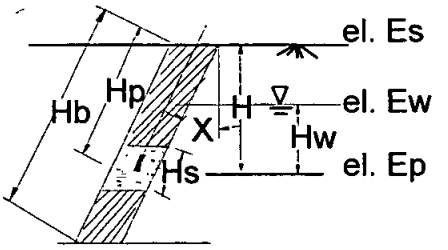
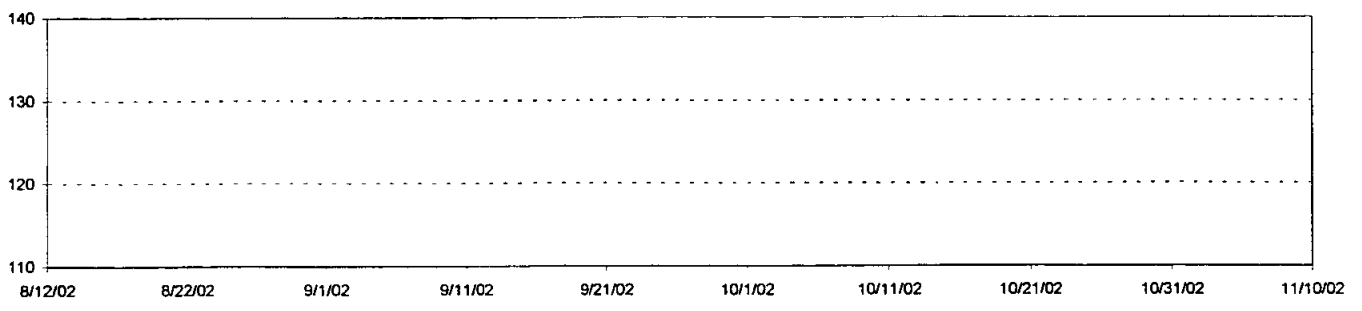
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	**02-7**	**Piezometer Transducer**	
El. Es (m) =	183.0	Serial No:	74662
Hb (m) =	123.6	Max Pressure:	250 psi
Hp (m) =	97.6	Factor A =	-0.00038113
Hs (m) =	4.6	Factor B =	0.208390
X (deg) =	45.0	Factor C =	3026.50
El. Ep (m) =	114.0	Date Installed:	8/23/02



Date	Vibration Reading (Hz)	Temperature Reading (°C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
8/23/02	3104.6	17.4	0.00	0.00	not known	S.S	
8/23/02	2892.8	15.5	439.92	44.84	158.86	S.S	
8/24/02	2902.0	15.8	421.52	42.97	156.98	S.S	
9/27/02	2908.6	15.4	408.28	41.62	155.63	C.K	
11/4/02	2911.4	15.5	402.65	41.05	155.06	CMK	



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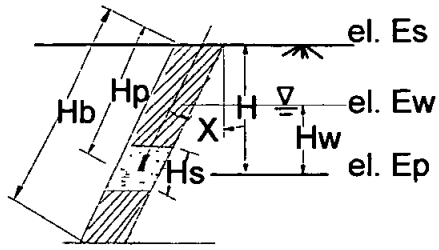
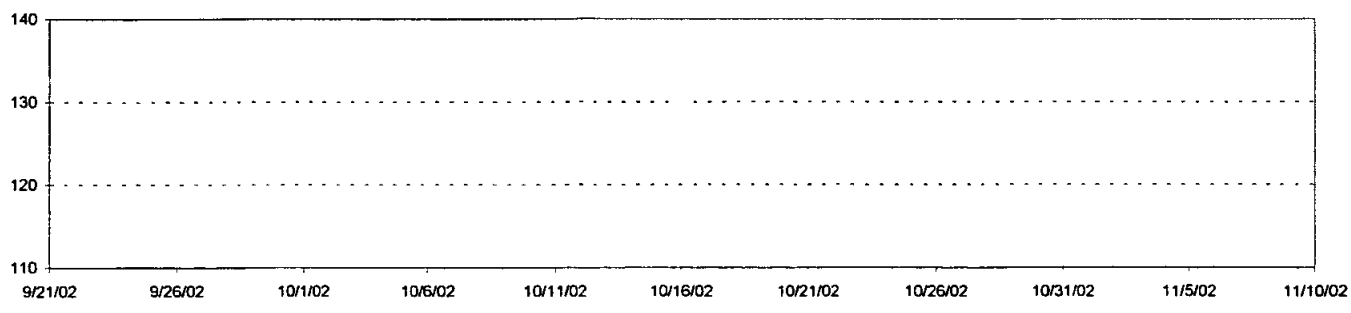
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	**02-8C**	**Piezometer Transducer**	
El. Es (m) =	162.8	Serial No:	74660
Hb (m) =	68.9	Max Pressure:	250 psi
Hp (m) =	49.1	Factor A =	-0.00033831
Hs (m) =	5.9	Factor B =	0.149340
X (deg) =	40.0	Factor C =	2814.50
El. Ep (m) =	125.2	Date Installed:	08/26/02



Date	Vibration Reading (Hz)	Temperature Reading (^{o}C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
9/27/02	3115.8	13.8	0.00	0.00	not known	C.K	
11/4/02	3115.4	13.8	0.00	0.00	not known	CMK	



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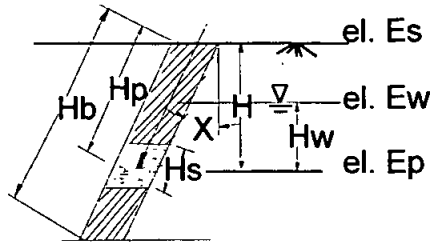
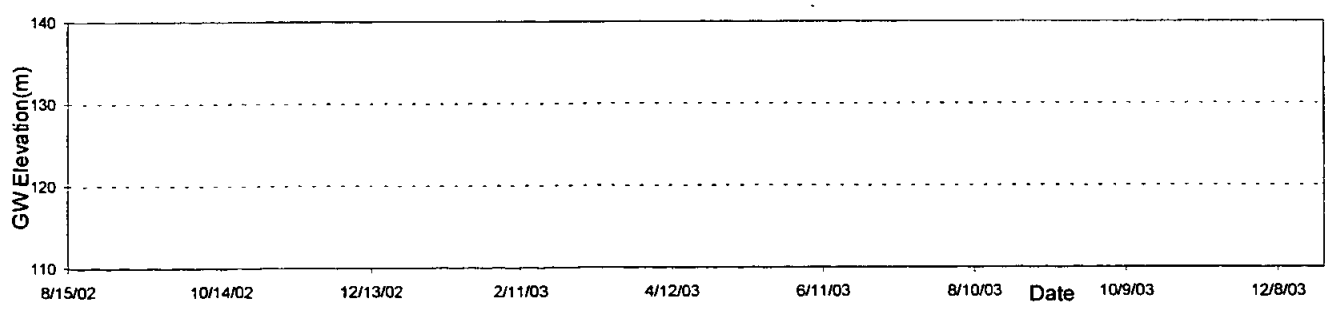
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	**02-18A**	**Piezometer Transducer**	
El. Es (m) =	136.0	Serial No:	73866
Hb (m) =	40.1	Max Pressure:	100 PSI
Hp (m) =	24.1	Factor A =	-0.00016319
Hs (m) =	2.7	Factor B =	0.056464
X (deg) =	32.0	Factor C =	1439.8
El. Ep (m) =	115.6	Date Installed:	8/24/02



Date	Vibration Reading (Hz)	Temperature Reading (^{0}C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
8/24/02	3149.3	14.3	0.00	0.00	not known	ss	
9/27/02	3151.8	13.3	0.00	0.00	not known	C.K	
11/4/02	3150.7	12.5	0.00	0.00	not known	CMK	



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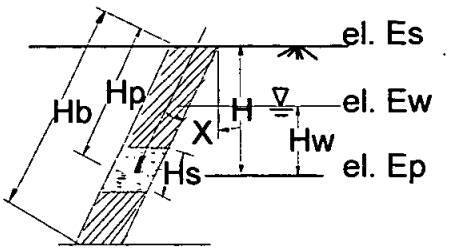
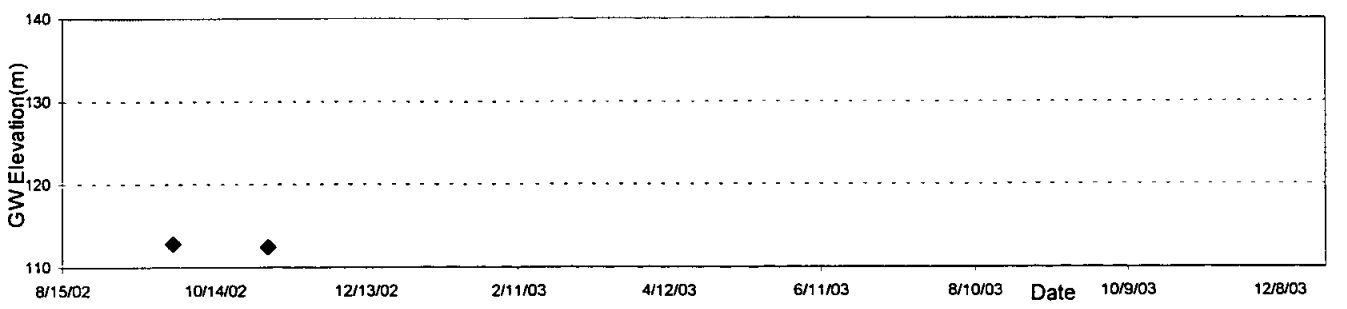
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	**02-18B**	**Piezometer Transducer**	
El. Es (m) =	136.0	Serial No:	73865
Hb (m) =	45.4	Max Pressure:	100 PSI
Hp (m) =	26.7	Factor A =	-0.00015157
Hs (m) =	3.6	Factor B =	0.04955
X (deg) =	13.0	Factor C =	1339.1
El. Ep (m) =	110.0	Date Installed:	8/23/02



Date	Vibration Reading (Hz)	Temperature Reading (°C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
8/23/02	3148.5	17.2	0.00	0.00	not known	S.S	
9/27/02	3109.2	13.3	27.91	2.85	112.83	C.K	
11/4/02	3113.4	13.0	24.16	2.46	112.45	CMK	

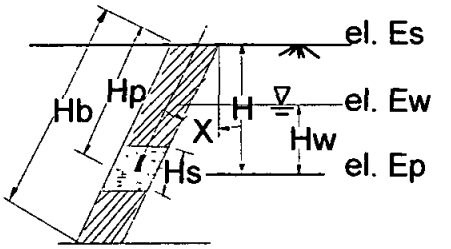


Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

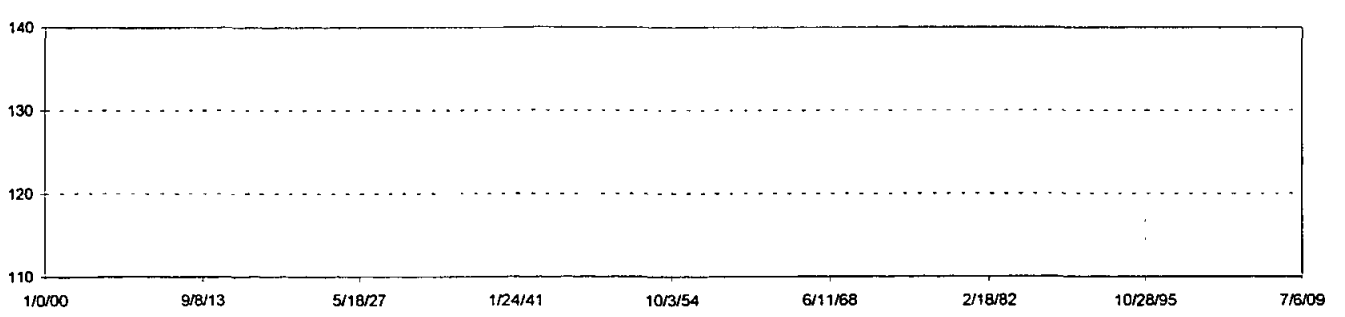
PIEZOMETER DATA RECORD

DEVIL'S SLIDE TUNNELS T.O. 2B

Borehole ID:	**02-20**	**Piezometer Transducer**	
El. Es (m) =	66.3	Serial No:	74658
Hb (m) =	22.0	Max Pressure:	250 psi
Hp (m) =	21.3	Factor A =	-0.00034537
Hs (m) =	2.1	Factor B =	0.153250
X (deg) =	0.0	Factor C =	2943.90
El. Ep (m) =	44.96	Date Installed:	09/28/02



Date	Vibration Reading (Hz)	Temperature Reading (°C)	Water Pressure (kPa)	Water Column Hw (m)	Ground Water el. Ew (m)	Logged By	Weather / Comments
11/4/02	3148.1	14.8	3.55	0.36	45.32	CMK	



SLOPE INDICATOR

02-2B

VW Piezometer

Customer	Earth Mechanics	Serial No.	74659
Cust. No.	32120	Part No.	52611040
Order No.	5089	Range	0-250 PSI
Date	02-Aug-02	Cable	50613524
Cal. By.	kb	Length	55 m ✓
Note			

Conversion Factors for Serial No. 74659

Referenced To Standard Atmosphere*

	Manual ABC Factors			IDA ABC Factors		
Units	A	B	C	A	B	C
psi	-0.000051806	0.024286	432.31	-92.100	82.381	432.31
ft H2O	-0.00011950	0.056018	997.19	-212.44	74.691	997.19
kN/m² (kPa)	-0.00035719	0.16744	2980.7	-635.01	223.26	2980.7
m H2O	-0.000036423	0.017074	303.94	-64.753	22.766	303.94
bar	-0.0000035719	0.0016744	29.807	-6.3501	2.2326	29.807
kg/cm²	-0.0000036423	0.0017074	30.394	-6.4753	2.2766	30.394
				IF Factor = T		

Temperature Coefficient = 0.0302 PSI/°C

RTD Offset: 0.1 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3149.14	0.01
0.0	3132.57	0.01
25.0	3048.12	0.00
50.0	2961.09	-0.01
75.0	2871.09	0.00
100.0	2777.99	-0.01
125.0	2681.31	-0.01
150.0	2580.53	0.00
175.0	2475.12	0.02
200.0	2364.73	0.02
225.0	2248.32	0.01
250.0	2125.17	-0.02

Calibrated at = 21.9 °C

RTD Reading = 22.0 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

SLOPE INDICATOR

VW Piezometer 02-5 (Piezo A)

Customer	Earth Mechanics	Serial No.	74661
Cust. No.	32120	Part No.	52611040
Order No.	5089	Range	0-250 PSI
Date	02-Aug-02	Cable	50613524
Cal. By.	kb	Length	70 m ✓
Note			

Conversion Factors for Serial No. 74661

Referenced To Standard Atmosphere*

	Manual ABC Factors			IDA ABC Factors		
Units	A	B	C	A	B	C
psi	-0.000045495	0.017006	391.41	-80.879	22.675	391.41
ft H2O	-0.00010494	0.039227	902.86	-186.56	52.303	902.86
kN/m² (kPa)	-0.00031368	0.11725	2698.7	-557.64	156.34	2698.7
m H2O	-0.000031986	0.011956	275.19	-56.864	15.942	275.19
bar	-0.0000031368	0.0011725	26.987	-5.5764	1.5634	26.987
kg/cm²	-0.0000031986	0.0011956	27.519	-5.6864	1.5942	27.519
				IF Factor = T		

Temperature Coefficient = 0.0377 PSI/°C

RTD Offset: 0.4 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3144.30	0.04
0.0	3125.72	0.03
25.0	3031.21	-0.02
50.0	2933.19	-0.05
75.0	2831.16	-0.04
100.0	2725.07	-0.04
125.0	2613.80	0.02
150.0	2497.74	0.02
175.0	2375.59	0.02
200.0	2246.15	0.03
225.0	2108.39	0.01
250.0	1960.49	-0.04

Calibrated at = 21.9 °C

RTD Reading = 22.3 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

SLOPE INDICATOR

02-5 (Piezo B)

VW Piezometer

Customer	Earth Mechanics	Serial No.	74664
Cust. No.	32120	Part No.	52611040
Order No.	5089	Range	0-250 PSI
Date	02-Aug-02	Cable	50613524
Cal. By.	kb	Length	240 m
Note			

Conversion Factors for Serial No. 74664

Referenced To Standard Atmosphere*

	Manual ABC Factors			IDA ABC Factors		
Units	A	B	C	A	B	C
psi	-0.000049758	0.024135	402.39	-88.459	32.180	402.39
ft H2O	-0.00011478	0.055671	928.18	-204.05	74.228	928.18
kN/m² (kPa)	-0.00034307	0.16640	2774.4	-609.91	221.87	2774.4
m H2O	-0.000034984	0.016969	282.91	-62.193	22.625	282.91
bar	-0.0000034307	0.0016640	27.744	-6.0991	2.2187	27.744
kg/cm²	-0.0000034984	0.0016969	28.291	-6.2193	2.2625	28.291

IF Factor = T

Temperature Coefficient = -0.0112 PSI/°C RTD Offset: 2.4 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3113.86	0.03
0.0	3096.42	0.02
25.0	3007.30	-0.01
50.0	2915.12	-0.04
75.0	2819.28	-0.02
100.0	2719.72	-0.01
125.0	2616.09	0.00
150.0	2507.56	0.02
175.0	2393.66	0.03
200.0	2273.51	0.03
225.0	2146.01	0.01
250.0	2009.76	-0.03

Calibrated at = 21.9 °C RTD Reading = 24.3 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

SLOPE INDICATOR

02-5 (Piezo C)

VW Piezometer

Customer	Earth Mechanics	Serial No.	74665
Cust. No.	32120	Part No.	52611040
Order No.	5089	Range	0-250 PSI
Date	02-Aug-02	Cable	50613524
Cal. By.	kb	Length	260 m
Note			

Conversion Factors for Serial No. 74665

Referenced To Standard Atmosphere*

	Manual ABC Factors			IDA ABC Factors		
Units	A	B	C	A	B	C
psi	-0.000045170	0.0016294	437.85	-80.302	2.1725	437.85
ft H2O	-0.00010419	0.0037584	1010.0	-185.23	5.0111	1010.0
kN/m² (kPa)	-0.00031144	0.011234	3018.9	-553.66	14.979	3018.9
m H2O	-0.000031758	0.0011455	307.84	-56.458	1.5274	307.84
bar	-0.0000031144	0.00011234	30.189	-5.5366	0.14979	30.189
kg/cm²	-0.0000031758	0.00011455	30.784	-5.6458	0.15274	30.784
				IF Factor = T		

Temperature Coefficient = 0.0438 PSI/°C RTD Offset: 2.7 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3148.95	0.03
0.0	3131.29	0.02
25.0	3041.63	-0.03
50.0	2948.47	-0.01
75.0	2852.64	-0.03
100.0	2753.28	-0.03
125.0	2649.90	-0.01
150.0	2542.35	0.01
175.0	2430.08	0.03
200.0	2312.40	0.03
225.0	2188.51	0.03
250.0	2058.10	-0.05

Calibrated at = 21.9 °C RTD Reading = 24.6 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

SLOPE INDICATOR

VW Piezometer 02-6

Customer	Earth Mechanics	Serial No.	74663
Cust. No.	32120	Part No.	52611040
Order No.	5089	Range	0-250 PSI
Date	02-Aug-02	Cable	50613524
Cal. By.	kb	Length	120 m ✓
Note			

Conversion Factors for Serial No. 74663

Referenced To Standard Atmosphere*

	Manual ABC Factors			IDA ABC Factors		
Units	A	B	C	A	B	C
psi	-0.000047495	0.021199	390.93	-84.436	28.265	390.93
ft H2O	-0.00010956	0.048899	901.74	-194.76	65.199	901.74
kN/m² (kPa)	-0.00032747	0.14616	2695.4	-582.16	194.88	2695.4
m H2O	-0.000033392	0.014904	274.85	-59.364	19.873	274.85
bar	-0.0000032747	0.0014616	26.954	-5.8216	1.9488	26.954
kg/cm²	-0.0000033392	0.0014904	27.485	-5.9364	1.9873	27.485
				IF Factor = T		

Temperature Coefficient = 0.0275 PSI/°C RTD Offset: 1.6 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3118.64	0.04
0.0	3100.54	0.03
25.0	3008.18	-0.04
50.0	2912.00	-0.03
75.0	2812.29	-0.04
100.0	2708.35	-0.02
125.0	2599.94	0.00
150.0	2486.22	0.02
175.0	2366.55	0.04
200.0	2240.25	0.02
225.0	2105.42	0.01
250.0	1960.69	-0.04

Calibrated at = 21.9 °C RTD Reading = 23.5 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

SLOPE INDICATOR

VW Piezometer 02-7

Customer	Earth Mechanics	Serial No.	74662
Cust. No.	32120	Part No.	52611040
Order No.	5089	Range	0-250 PSI
Date	02-Aug-02	Cable	50613524
Cal. By.	kb	Length	100 m ✓
Note			

Conversion Factors for Serial No. 74662

Referenced To Standard Atmosphere*

	Manual ABC Factors			IDA ABC Factors		
Units	A	B	C	A	B	C
psi	-0.000055278	0.030224	438.96	-98.272	40.299	438.96
ft H2O	-0.00012751	0.069717	1012.5	-226.68	92.957	1012.5
kN/m² (kPa)	-0.00038113	0.20839	3026.5	-677.56	277.85	3026.5
m H2O	-0.000038864	0.021250	308.62	-69.092	28.333	308.62
bar	-0.0000038113	0.0020839	30.265	-6.7756	2.7785	30.265
kg/cm²	-0.0000038864	0.0021250	30.862	-6.9092	2.8333	30.862
				IF Factor = T		

Temperature Coefficient = 0.0237 PSI/°C RTD Offset: 0.0 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3120.32	0.02
0.0	3104.46	0.02
25.0	3023.55	0.00
50.0	2940.34	-0.03
75.0	2854.10	-0.03
100.0	2764.86	-0.02
125.0	2672.28	-0.01
150.0	2575.86	0.02
175.0	2475.32	0.03
200.0	2370.20	0.02
225.0	2259.44	0.02
250.0	2142.83	-0.04

Calibrated at = 21.9 °C RTD Reading = 21.9 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

SLOPE INDICATOR

VW Piezometer

02-8C

Customer	Earth Mechanics	Serial No.	74660
Cust. No.	32120	Part No.	52611040
Order No.	5089	Range	0-250 PSI
Date	02-Aug-02	Cable	50613524
Cal. By.	kb	Length	50 m ✓
Note			

Conversion Factors for Serial No. 74660

Referenced To Standard Atmosphere*

Units	Manual ABC Factors A	B	C	IDA ABC Factors A	B	C
psi	-0.000049067	0.021660	408.21	-87.230	28.880	408.21
ft H2O	-0.00011318	0.049963	941.60	-201.21	66.617	941.60
kN/m² (kPa)	-0.00033831	0.14934	2814.5	-601.43	199.12	2814.5
m H2O	-0.000034498	0.015229	287.00	-61.329	20.305	287.00
bar	-0.0000033831	0.0014934	28.145	-6.0143	1.9912	28.145
kg/cm²	-0.0000034498	0.0015229	28.700	-6.1329	2.0305	28.700
				IF Factor = T		

Temperature Coefficient = -0.0331 PSI/°C RTD Offset: 0.0 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3130.81	0.03
0.0	3113.33	0.02
25.0	3024.20	-0.02
50.0	2931.90	-0.03
75.0	2836.23	-0.02
100.0	2736.90	-0.02
125.0	2633.41	-0.01
150.0	2525.09	0.02
175.0	2411.66	0.03
200.0	2292.14	0.03
225.0	2165.52	0.01
250.0	2030.32	-0.03

Calibrated at = 21.9 °C RTD Reading = 21.9 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

SLOPE INDICATOR

02-18A

VW Piezometer

Customer	Earth Mechanics	Serial No.	73866
Cust. No.	32120	Part No.	52611033
Order No.	5086	Range	0-100 PSI
Date	30-Jul-02	Cable	50613524
Cal. By.	kb	Length	30 m
Note			

Conversion Factors for Serial No. 73866

Referenced To Standard Atmosphere*

	Manual ABC Factors			IDA ABC Factors		
Units	A	B	C	A	B	C
psi	-0.000023668	0.0081895	208.82	-42.077	10.919	208.82
ft H2O	-0.000054595	0.018890	481.68	-97.058	25.187	481.68
kN/m² (kPa)	-0.00016319	0.056464	1439.8	-290.11	75.286	1439.8
m H2O	-0.000016641	0.0057578	146.82	-29.583	7.6770	146.82
bar	-0.0000016319	0.00056464	14.398	-2.9011	0.75286	14.398
kg/cm²	-0.0000016641	0.00057578	14.682	-2.9583	0.76770	14.682
				IF Factor = T		

Temperature Coefficient = 0.0163 PSI/°C RTD Offset: 0.3 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3183.37	0.04
0.0	3148.24	0.02
10.0	3076.63	-0.02
20.0	3002.98	-0.02
30.0	2927.48	-0.04
40.0	2849.68	-0.04
50.0	2769.54	-0.04
60.0	2686.11	0.05
70.0	2600.46	0.06
80.0	2511.96	0.05
90.0	2420.25	0.00
100.0	2324.78	-0.06

Calibrated at = 21.3 °C RTD Reading = 21.6 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

SLOPE INDICATOR

02-18B

VW Piezometer

Customer	Earth Mechanics	Serial No.	73865
Cust. No.	32120	Part No.	52611033
Order No.	5086	Range	0-100 PSI
Date	30-Jul-02	Cable	50613524
Cal. By.	kb	Length	30 m
Note			

Conversion Factors for Serial No. 73865

Referenced To Standard Atmosphere*

	Manual ABC Factors			IDA ABC Factors		
Units	A	B	C	A	B	C
psi	-0.000021984	0.0071866	194.21	-39.082	9.5821	194.21
ft H2O	-0.000050709	0.016577	447.98	-90.149	22.103	447.98
kN/m² (kPa)	-0.00015157	0.049550	1339.1	-269.46	66.066	1339.1
m H2O	-0.000015456	0.0050527	136.55	-27.477	6.7369	136.55
bar	-0.0000015157	0.00049550	13.391	-2.6946	0.66066	13.391
kg/cm²	-0.0000015456	0.00050527	13.655	-2.7477	0.67369	13.655
				IF Factor = T		

Temperature Coefficient = -0.0075 PSI/°C RTD Offset: 0.3 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3177.84	0.04
0.0	3140.09	0.01
10.0	3062.98	-0.03
20.0	2983.50	-0.03
30.0	2901.84	-0.06
40.0	2817.32	-0.04
50.0	2730.06	-0.02
60.0	2639.27	0.04
70.0	2545.64	0.04
80.0	2448.29	0.03
90.0	2346.80	0.00
100.0	2240.57	-0.05

Calibrated at = 21.3 °C RTD Reading = 21.6 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

SLOPE INDICATOR

VW Piezometer

02-20

Customer	Earth Mechanics	Serial No.	74658
Cust. No.	32120	Part No.	52611040
Order No.	5089	Range	0-250 PSI
Date	02-Aug-02	Cable	50613524
Cal. By.	kb	Length	35 m
Note			

Conversion Factors for Serial No. 74658

Referenced To Standard Atmosphere*

	Manual ABC Factors			IDA ABC Factors		
Units	A	B	C	A	B	C
psi	-0.000050091	0.022228	426.98	-89.051	29.637	426.98
ft H2O	-0.00011554	0.051272	984.89	-205.41	68.362	984.89
kN/m² (kPa)	-0.00034537	0.15325	2943.9	-613.98	204.34	2943.9
m H2O	-0.000035217	0.015628	300.19	-62.609	20.837	300.19
bar	-0.0000034537	0.0015325	29.439	-6.1398	2.0434	29.439
kg/cm²	-0.0000035217	0.0015628	30.019	-6.2609	2.0837	30.019
				IF Factor = T		

Temperature Coefficient = 0.0339 PSI/°C

RTD Offset: -0.1 °C

Test Data

Referenced To Standard Atmosphere*

PSI	Frequency	% FS Error
-5.0	3166.64	0.03
0.0	3149.75	0.02
25.0	3063.44	0.00
50.0	2974.45	-0.03
75.0	2882.22	-0.03
100.0	2786.55	-0.01
125.0	2687.27	-0.01
150.0	2583.66	0.01
175.0	2475.40	0.03
200.0	2361.67	0.04
225.0	2241.99	0.01
250.0	2115.06	-0.04

Calibrated at = 21.9 °C

RTD Reading = 21.8 °C

*Standard Atmosphere = 14.696 psi, 1013 millibar.

GEOLOGIC AND GEOTECHNICAL SITE CHARACTERIZATION

VOLUME 4 – LABORATORY TESTING

DEVIL'S SLIDE TUNNELS PROJECT

Prepared for
Caltrans
and
HNTB Corporation

December 9, 2002

By
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VOLUME 4 – LABORATORY TESTING

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SOIL LABORATORY TEST RESULTS BY EARTH MECHANICS

TABLE 1. SUMMARY OF SOIL LABORATORY TEST RESULTS
PHASE 2B GEOTECHNICAL FIELD EXPLORATION 2002

Boring No.	Sample No.	Depth	Soil Type	Geologic Unit	Pocket Penetrometer	Torvane Shear	Moisture Content	Dry Unit Weight	Void Ratio	Porosity	Grain Size Distribution					Atterberg Limits			Soil Corrosivitiy				R-Value	Compaction Test		Direct Shear Test				Uncons. Undrained Triaxial	Potential Reactivity	
					SoilTest CL-700A	Humboldt E-265, ASTM D-4648	ASTM D-2216	ASTM D-2937			CT 202, 203					CT 204			CT 532, 643		CT 417	CT 422	ASTM D-2844	CT 216		ASTM D-3080				ASTM D-2850	ASTM C-289	
					q_u	S_u	w	γ_d	e	n	Gravel	Sand	Fines	C_u	C_c	LL	PL	PI	Minimum Resistivity	pH	SS	SC	R	Max γ_d	w^*	ϕ_{peak}	c_{peak}	ϕ_{ult}	c_{ult}	S_u	Dissolved Silica	Alkalinity Reduction
(-)	(-)	(m)	(USCS)	(-)	(x100 kPa)	(kg/cm^2)	(%)	(kN/m^3)	(-)	(%)	(%)	(%)	(%)	(-)	(-)	(%)	(%)	(%)	(ohm-cm)	(-)	(ppm)	(ppm)	(-)	(kN/m^3)	(%)	(deg)	(kPa)	(deg)	(kPa)	(kPa)	(millimoles/l)	(millimoles/l)
ST-1	B-0	0-0.76	CL	Km																				19.8	12.5							
	S-1	0.76	CL	Km			12.6				1	44	55						3500	6.3	31	252										
	D-2	1.52	CL	Km			14.6	18.6	0.43	29.8	*1	44	55																			
	S-3	3.05	SC	Km			14.6				*8	72	20			29	16	13														
	D-4	4.57	SP-SM	Km			8.2	19.7	0.34	25.6	*20	74	6													46.9	33.9	41.9	9.5			
	S-5	6.10	SC	Km			11.0				0	56	44																			
	D-6	7.62	SC	Km			13.3	18.7	0.41	29.3	*3	60	37																			
	S-7	9.15		Km																												
	D-8	10.67	SP-SM	Km			7.1				*15	78	7																			
ST-2	B-0	0-0.76	CL	Km																				18.7	14.5							
	S-1	0.76	SC	Km			13.7				*5	60	35																			
	D-2	1.52	CL	Km			12.8	18.8	0.40	28.8	*7	40	53			33	16	17														
	S-3	3.05	CL	Km			14.9				3	38	59																			
	D-4	4.57	CL	Km	4.10	>1.5	17.1	18.0	0.47	32.1	*12	35	57													24.3	63.5	25.9	35.1			
	S-5	6.10	SC	Km			17.2				2	52	46			33	17	16														
	D-6	7.62	SC	Km			14.0	18.3	0.44	30.8	*7	73	20																			
	S-7	9.15	SC	Km			16.1				1	57	42																			
	D-8	10.67	SM	Km			10.5	17.4	0.52	34.3	*12	70	18																			
	S-9	12.20	SC	Km			14.6				*12	63	25																			
	D-10	13.72	CL	Km			17.4	17.8	0.49	32.8	*15	31	54													32.6	12.4	30.8	13.2			
	S-11	15.24		Km																												
ST-3	B-0	0-0.76	CL	Km																				20.1	10.0							
	S-1	0.76	SC	Km			9.4				*7	68	25																			
	D-2	1.52	SC	Km			8.6	21.5	0.23	18.6	*7	75	18																			
ST-4	D-2	1.52	SM	Km			9.7	18.7	0.41	29.2																40.6	41.9	35.3	1.7			
	S-3	3.05	SC	Km			15.0																									
	D-4	4.57	SC	Km			14.0	18.9	0.40	28.5																38.1	53.4	36.0	3.7			
	S-5	6.10	SC	Km			13.6																									
	D-6	7.62	SP-SM	Km			8.9	17.5	0.51	33.9																						
ST-5	S-1	0.76	CL	Km			14.1				1	42	57																			
	D-2	1.52	CL	Km			13.2	18.6	0.42	29.8	*0	45	55																			
	S-3	3.05	SC	Km			14.4				*2	58	40			34	18	16	1200	6.6	21	304										
	D-4	4.57	SC	Km			16.1	18.4	0.44	30.4	*10	55	35													25.4	58.0	28.0	30.5			
	S-5	6.10	CL	Km			19.2				2	41	57																			
	D-6	7.62	SC	Km			15.1	18.4	0.44	30.7	*5	70	25																			
	S-7	9.15	SC	Km			16.9				*5	70	25																			
	D-8	10.67	SC	Km			17.7	17.8	0.49	32.8	*7	63	30																			
	S-9	12.20	SC	Km			13.2				*8	65	27																			
	D-10	13.72	SM	Km																												

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Boring No.	Sample No.	Depth	Soil Type	Geologic Unit	Pocket Penetrometer	Torvane Shear	Moisture Content	Dry Unit Weight	Void Ratio	Porosity	Grain Size Distribution					Atterberg Limits			Soil Corrosivity				R-Value	Compaction Test		Direct Shear Test				Uncons. Undrained Triaxial	Potential Reactivity	
					SoilTest CL-700A	Humboldt E-285, ASTM D-4648	ASTM D-2216	ASTM D-2937			CT 202, 203					CT 204			CT 532, 643		CT 417	CT 422	ASTM D-2844	CT 216		ASTM D-3080				ASTM D-2850	ASTM C-289	
					q_u	S_u	w	γ_d	e	n	Gravel	Sand	Fines	C_u	C_c	LL	PL	PI	Minimum Resistivity	pH	SS	SC	R	Max γ_d	w^s	ϕ_{peak}	c_{peak}	ϕ_{ult}	c_{ult}	S_u	Dissolved Silica	Alkalinity Reduction
(-)	(-)	(m)	(USCS)	(-)	(x100 kPa)	(kg/cm^2)	(%)	(kN/m^3)	(-)	(%)	(%)	(%)	(%)	(-)	(-)	(%)	(%)	(%)	(ohm-cm)	(-)	(ppm)	(ppm)	(-)	(kN/m^3)	(%)	(deg)	(kPa)	(deg)	(kPa)	(kPa)	(millimoles/l)	(millimoles/l)
ST-6	B-0	0-0.76	CL	Km																				19.9	11.5							
	S-1	0.76	CL	Km			12.4				*0	40	60																			
	D-2	1.52	CL	Km			14.1	18.4	0.44	30.5	*0	40	60													25.0	109.2	22.3	67.2			
	S-3	3.05	SC	Km			12.8				3	53	44																			
	D-4	4.57	SC	Km			13.6	19.2	0.38	27.4	*3	53	44																			
	S-5	6.10	SM	Km			9.6				*3	82	15																			
ST-7	S-1	0.76	SC	Km			14.7				*5	55	40			43	19	24	1900	6.5	19											
	D-2	1.52	SC	Km			15.6	18.0	0.47	31.9	3	54	43													25.3	72.1	30.4	19.8			
	S-3	3.05	SC	Km			16.5				*5	70	25																			
	D-4	4.57	SC	Km			8.0	20.1	0.32	24.1	*8	74	18																			
	S-5	6.10	SM	Km			11.7				4	77	19						3100	7.2	42	272										
	D-6	7.62	SM	Km			7.8	17.5	0.51	33.7	*4	77	19																			
ST-8	S-1	0.76	SM	Km			5.2				6	75	19																			
	D-2	1.52	SM	Km			9.4	19.2	0.38	27.6	*6	75	19																			
	S-3	3.05	SM	Km			9.2				*6	75	19																			
	D-4	4.57	SM	Km			6.2	19.8	0.34	25.3	*6	75	19													35.0	61.8	27.6	23.8			
ST-9	B-0	0-0.76	CL	Km																				19.8	11.0							
	S-1	0.76	SC	Km			8.9				*5	60	35																			
	D-2	1.52	CL	Km			13.5	18.9	0.40	28.5	1	45	54			25	14	11														
	S-3	3.05	CL	Km			14.0				*5	40	55																			
	D-4	4.57	SC	Km			16.2	18.1	0.46	31.7	*10	50	40													24.2	83.3	27.7	36.8			
	S-5	6.10	CL	Km			19.5				1	45	54																			
	D-6	7.62	CL	Km			22.9	16.4																					224.1			
	S-7	9.15	CL	Km			16.2				*5	40	55																			
	D-8	10.67	SC	Km			13.0	19.3	0.37	27.1	*5	70	25																			
	S-9	12.20	CL	Km			16.2				3	42	55			30	15	15														
	D-10	13.72	CL	Km			16.2	18.3	0.45	30.8	*3	42	55																			
	S-11	15.24	CL	Km			15.2				4	43	53																			
	D-12	16.77	CL	Km			15.8	18.3	0.45	30.9	*5	40	55													31.9	61.5	31.5	21.0			
	D-13	18.29	CL	Km			15.0	17.8	0.48	32.6	*5	40	55																			
	S-14	18.51	SC	Km			13.3				*5	70	25																			
ST-10	S-1	0.76	CL	Km			14.5				*0	40	60																			
	D-2	1.52	CL	Km			16.7	17.7	0.50	33.1	*0	35	65													11.6	154.6	18.5	80.2			
	S-3	3.05	CL	Km			17.0				1	43	56			41	18	23	1100	6.8	55	50										
	D-4	4.57	SC	Km			12.7	19.2	0.38	27.5	*15	55	30																			
	S-5	6.10	SC	Km			12.7				*8	67	25																			
	D-6	7.62	SC	Km			12.2	18.9	0.40	28.6	*7	70	23																			
	S-7	9.15	SC	Km			16.2				*12	63	25																			
	D-8	10.67	SC	Km			14.9	18.6	0.42	29.7	*18	62	20													31.8	80.2	27.9	57.8			
	S-9	12.20	SC	Km			15.7				*10	60	30																			
	D-10	13.72	SC	Km																												

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Boring No.	Sample No.	Depth	Soil Type	Geologic Unit	Pocket Penetrometer	Torvane Shear	Moisture Content	Dry Unit Weight	Void Ratio	Porosity	Grain Size Distribution					Atterberg Limits			Soil Corrosivitiy				R-Value	Compaction Test		Direct Shear Test				Uncons. Undrained Triaxial	Potential Reactivity	
					SoilTest CL-700A	Humboldt E-265, ASTM D-4648	ASTM D-2216	ASTM D-2937			CT 202, 203					CT 204			CT 532, 643		CT 417	CT 422	ASTM D-2844	CT 216		ASTM D-3080				ASTM D-2850	ASTM C-289	
					q_u	S_u	w	γ_d	e	n	Gravel	Sand	Fines	C_u	C_c	LL	PL	PI	Minimum Resistivity	pH	SS	SC	R	Max γ_d	W^*	ϕ_{peak}	c_{peak}	ϕ_{ult}	c_{ult}	S_u	Dissolved Silica	Alkalinity Reduction
(-)	(-)	(m)	(USCS)	(-)	(x100 kPa)	(kg/cm^2)	(%)	(kN/m^3)	(-)	(%)	(%)	(%)	(%)	(-)	(-)	(%)	(%)	(%)	(ohm-cm)	(-)	(ppm)	(ppm)	(-)	(kN/m^3)	(%)	(deg)	(kPa)	(deg)	(kPa)	(kPa)	(millimoles/l)	(millimoles/l)
02-19	B-0	0-1.52	CL	A_f																			38									
	D-1	1.52	SC	A_f			15.9	18.7	0.41	29.3	*5	70	25						3400	7.5	20	285				38.9	25.6	34.2	3.5			
	S-2	3.05	SP-SM	A_f			17.9				12	76	12																			
	D-3	4.57	SP-SM	A_f			11.3	19.7	0.34	25.6	*12	76	12																			
	S-4	6.10	SP-SM	A_f			18.3				*10	80	10																			
	D-5	7.62	SM	A_f			13.4	19.6	0.31	25.9	10	72	18																			
	S-6	9.15		Km																												
	D-7	10.67	SM	Km			14.3	19.0	0.40	28.4	6	79	15																			
	S-8	12.20	SM	Km			15.2				*10	75	15																			
	D-9	13.72	SP-SM	Km			13.0	19.2	0.38	27.7	*18	74	8													38.9	26.5	34.0	0.0			
	S-10	15.24	SM	Km			17.6				4	77	19																			
	D-11	16.77	SM	Km			16.3	18.3	0.45	31.0	*15	70	15													34.1	41.1	33.0	13.8			
	S-12	18.29	SM	Km			19.4				8	74	18																			
	D-13	19.82	SC	Km			17.8	18.1	0.47	31.8	*7	75	18																			
	S-14	21.34	SC	Km			18.2				*7	70	23																			
	D-14A	21.95	SC	Km			17.5	17.8	0.49	32.9	*10	65	25																			
	D-15	22.87	SC	Km			20.0	17.1	0.55	35.6	*8	72	20																			
	S-16	24.39	SM	Km			17.1				*15	65	20																			
02-20	D-1	1.52	SP-SM	A_f			10.9	19.4	0.36	26.7	*5	83	12						5200	7.4	31	250										
	S-2	3.05	SM	A_f			13.4				5	81	14																			
	D-3	4.57	SM	A_f			12.5	19.4	0.36	26.6	*12	70	18																			
	S-4	6.10	SM	A_f			15.0				*12	70	18																			
	D-5	7.62	SC	A_f			13.1	19.8	0.33	25.1	*10	72	18													42.1	24.7	31.1	17.0			
	S-6	9.15	SC/SM	A_f			13.5				4	78	18																			
	D-7	10.67	SM	A_f			12.9	19.5	0.36	26.3	*5	77	18																			
	S-8-1	12.20	SM	A_f			15.9				*8	74	18																			
	S-8-2	12.25	SM	A_f			19.7				*0	65	35																			
	D-9	13.72	SC	Km			22.3	17.7	0.49	33.1	*10	65	25													33.3	54.3	32.0	17.3			
	S-10	15.24	CL/SC	Km			19.2				0	50	50			35	18	17														
	D-11	16.77	CL	Km			15.0	18.4	0.44	30.6	*18	40	52																			
	S-12	18.29	CL	Km			17.7				*5	40	55																			
	D-13	19.82	SC	Km			16.6	18.6	0.43	29.9	6	54	40													34.2	33.1	31.9	17.8			
	S-14	21.34	SM	Km			22.5				*8	72	20																			
	D-15	21.95	SM	Km			10.8	20.9	0.27	21.0	*8	72	20																			
	S-16	22.20	SM	Km			14.0				*8	72	20																			

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Boring No.	Sample No.	Depth	Soil Type	Geologic Unit	Pocket Penetrometer	Torvane Shear	Moisture Content	Dry Unit Weight	Void Ratio	Porosity	Grain Size Distribution					Atterberg Limits			Soil Corrosivitiy				R-Value	Compaction Test		Direct Shear Test				Uncons. Undrained Triaxial	Potential Reactivity	
					SoilTest CL-700A	Humboldt E-285, ASTM D-4648	ASTM D-2216	ASTM D-2937			CT 202, 203					CT 204			CT 532, 643		CT 417	CT 422	ASTM D-2844	CT 216		ASTM D-3080				ASTM D-2850	ASTM C-289	
					q_u	S_u	w	γ_d	e	n	Gravel	Sand	Fines	C_u	C_c	LL	PL	PI	Minimum Resistivity	pH	SS	SC	R	Max γ_d	w^*	ϕ_{peak}	c_{peak}	ϕ_{ult}	c_{ult}	S_u	Dissolved Silica	Alkalinity Reduction
(-)	(-)	(m)	(USCS)	(-)	(x100 kPa)	(kg/cm^2)	(%)	(kN/m^3)	(-)	(%)	(%)	(%)	(%)	(-)	(-)	(%)	(%)	(%)	(ohm-cm)	(-)	(ppm)	(ppm)	(-)	(kN/m^3)	(%)	(deg)	(kPa)	(deg)	(kPa)	(kPa)	(millimoles/l)	(millimoles/l)
02-5		195.00	CL	Tsh /Tss/Tc												21	13	8														
		195.10	CL-ML	Tsh /Tss/Tc												21	14	7														
02-6		111.74		Tsh /Tss/Tc																											92.9	100
02-7		123.48		Tsh/Tss/Tc																											124.9	90
02-11		68.60	CL	Tsh /Tss/Tc												25	15	10														
TOTAL	113				1	1	103	51	50	50	24	97	97	0	0	12	12	12	6	6	6	5	1	4	4	19	19	19	19	1	2	2

Abbreviations:

A_f Artificial Fill
Km Jurassic Montara Quartz Diorite / Granodiorite
Tsh Paleocene Shale
Tss Paleocene Sandstone
Tc Paleocene Conglomerate
S_u Undrained shear strength
w In-situ water content
w* Optimum water content
γ_d Dry unit weight
Max γ_d Maximum dry unit weight
e Void ratio (Calculated)
n Porosity (Calculated)
* visual estimate of grain size distribution
C_u Coefficient of uniformity
C_c Coefficient of curvature
LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
SS Soluble Sulfate Content
SC Soluble Chloride Content
ϕ_{peak} Peak soil friction angle
c_{peak} Peak cohesive strength
ϕ_{ult} Post-peak ("ultimate") soil friction angle at large displacement
c_{ult} Post-peak ("ultimate") cohesive strength at large displacement

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *HNTB / Devil's Silde Tunnels*
Project No.	: *02-134*
Tested Standard :	☐ **ASTM** ☑ **CAL. TRANS.**

Boring No.	: *ST-1*	**Prepared By :** *R.J*	**Date :** *10/12/02*
Sample No.	: *S-1*	**Tested By :** *PA*	**Date :** *10/26/02*
Depth (ft/m)	: *2.5* | *0.76*	**Sieved By :**	**Date :**
Description	: *Sandy Clay with Gravel*	**Calculated By :** *SV*	**Date :** *11/08/02*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:**	**Date :**

Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 1

Setup Container No. :	*S-1*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*6*	**No. 8 & 10 Retained**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor**	
Container No.		*S-1*	*77*	*J-18*	*78*	*S-1*	*S-17*	**for difference S.G.**	
Wt. of Wet Soil + Container (gm)		*266.16*	*150.25*	*75.68*	*154.13*			*0.99*	
Wt. of Dry Soil + Container (gm)			*148.99*		*152.84*	*3.12*	*148.93*	**Hydrometer Type**	
Wt. of Container (gm)			*59.11*		*58.94*		*114.94*	*152H*	
Wt. of Dry Soil (gm)		*262.48*		*74.65*		*3.12*	*33.99*	**(K) Value**	**Temp. °C**
Moisture Content (%)			*1.40*		*1.37*			*0.01312*	*22.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	*12.47*		*83.30*	***82.31***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*19.40*		*74.01*	***73.13***
1.0"					No. 40				
3/4"				-	No. 50	*25.17*		*66.28*	***65.50***
1/2"					No. 60				
3/8"	*0.00*		***100.00***	Plastic Index	No. 100	*29.31*		*60.74*	***60.02***
No. 4	*3.12*		***98.81***		No. 140				
No. 8	*4.73*		***92.55***	-	No. 200	*33.51*		*55.11*	***54.46***
No. 10					Pan	*34.05*			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient		Correction Dia. (mm) (D)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
10/26/02 10:08	***0:00:00***			*7.0*							
10/26/02 10:10	*0:02:00*	*21.0*	*38.0*	*7.0*	*31.0*	*41.11*	***40.62***	*0.05500*	*0.01312*	*11.2*	***0.03106***
10/26/02 10:13	*0:05:00*	*21.0*	*35.0*	*7.0*	*28.0*	*37.13*	***36.69***	*0.03500*	*0.01312*	*11.7*	***0.02007***
10/26/02 10:23	*0:15:00*	*21.0*	*32.0*	*7.0*	*25.0*	*33.15*	***32.76***	*0.02000*	*0.01312*	*12.2*	***0.01183***
10/26/02 10:38	*0:30:00*	*21.0*	*29.5*	*7.0*	*22.5*	*29.84*	***29.48***	*0.01400*	*0.01312*	*12.6*	***0.00850***
10/26/02 11:08	*1:00:00*	*21.0*	*28.0*	*7.0*	*21.0*	*27.85*	***27.52***	*0.01000*	*0.01312*	*12.9*	***0.00607***
10/26/02 12:08	*2:00:00*	*21.5*	*26.0*	*7.0*	*19.0*	*25.20*	***24.90***	*0.00700*	*0.01312*	*13.2*	***0.00435***
10/26/02 14:08	*4:00:00*	*22.0*	*24.0*	*7.0*	*17.0*	*22.54*	***22.28***	*0.00500*	*0.01312*	*13.5*	***0.00305***
10/27/02 10:08	*24:00:00*	*21.0*	*21.0*	*7.0*	*14.0*	*18.57*	***18.34***	*0.00100*	*0.01312*	*14.0*	***0.00129***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***1***	***44***	***55***

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *HNTB / Devil's Silde Tunnels*		
Project No.	: *02-134*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *ST-10*	**Prepared By :** *R.J*	**Date :** *10/12/02*
Sample No.	: *S-3*	**Tested By :** *PA*	**Date :** *10/26/02*
Depth (ft/m)	: *10.0* | *3.05*	**Sieved By :**	**Date :**
Description	: *Lean Clay with Sand and Gravel*	**Calculated By :** *SV*	**Date :** *11/11/02*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:**	**Date :**

Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 2

Setup Container No. :	*M-2*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*1*	**+ No. 4 & 10**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor for difference S.G.**	
Container No.		*M-2*	*69*	*J-13*	*72*	*M-2*	*S-15*		
Wt. of Wet Soil + Container (gm)		*287.70*	*162.09*	*72.75*	*168.24*			*0.99*	
Wt. of Dry Soil + Container (gm)			*158.84*		*164.75*	*2.98*	*145.08*	**Hydrometer Type**	
Wt. of Container (gm)			*59.95*		*59.20*		*114.84*	*152H*	
Wt. of Dry Soil (gm)		*278.55*		*70.42*		*2.98*	*30.24*	**(K) Value**	**Temp. °C**
Moisture Content (%)			*3.29*		*3.31*			*0.01312*	*22.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	*8.36*		*88.13*	***87.19***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*14.67*		*79.17*	***78.32***
1.0"					No. 40				
3/4"				-	No. 50	*20.62*		*70.72*	***69.96***
1/2"					No. 60				
3/8"	*0.00*		***100.00***	Plastic Index	No. 100	*25.94*		*63.16*	***62.49***
No. 4	*2.98*		***98.93***		No. 140				
No. 8	*2.91*		***94.84***	-	No. 200	*30.47*		*56.73*	***56.13***
No. 10					Pan	*30.77*			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient		Correction Dia. (mm) (D)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
10/26/02 10:00	***0:00:00***			*7.0*							
10/26/02 10:02	***0:02:00***	*21.0*	*41.0*	*7.0*	*34.0*	*47.80*	***47.29***	*0.05500*	*0.01312*	*10.7*	***0.03037***
10/26/02 10:05	***0:05:00***	*21.0*	*38.0*	*7.0*	*31.0*	*43.58*	***43.11***	*0.03500*	*0.01312*	*11.2*	***0.01965***
10/26/02 10:15	***0:15:00***	*21.0*	*35.0*	*7.0*	*28.0*	*39.36*	***38.94***	*0.02000*	*0.01312*	*11.7*	***0.01159***
10/26/02 10:30	***0:30:00***	*21.0*	*33.0*	*7.0*	*26.0*	*36.55*	***36.16***	*0.01400*	*0.01312*	*12.0*	***0.00831***
10/26/02 11:00	***1:00:00***	*21.0*	*31.5*	*7.0*	*24.5*	*34.44*	***34.07***	*0.01000*	*0.01312*	*12.3*	***0.00593***
10/26/02 12:00	***2:00:00***	*21.5*	*29.5*	*7.0*	*22.5*	*31.63*	***31.29***	*0.00700*	*0.01312*	*12.6*	***0.00425***
10/26/02 14:00	***4:00:00***	*22.0*	*27.5*	*7.0*	*20.5*	*28.82*	***28.51***	*0.00500*	*0.01312*	*12.9*	***0.00298***
10/27/02 10:00	***24:00:00***	*21.0*	*25.0*	*7.0*	*18.0*	*25.30*	***25.03***	*0.00100*	*0.01312*	*13.3*	***0.00126***

Remark :	*Sample greater than No. 20 Sieve are Shell Fragments*	**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***1***	***43***	***56***

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *HNTB / Devil's Silde Tunnels*		
Project No.	: *02-134*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *ST-5*	**Prepared By :** *R.J*	**Date :** *10/14/02*
Sample No.	: *S-5*	**Tested By :** *PA*	**Date :** *10/26/02*
Depth (ft/m)	: *20.0* | *6.10*	**Sieved By :**	**Date :**
Description	: *Brown to dark yellowish brown Lean Clay with Sand (CL)*	**Calculated By :** *SV*	**Date :** *11/11/02*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:**	**Date :**
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand.			3

		Sample Before Washing				After Washing		Specific Gravity	
Setup Container No. :	*S-7*	+ No. 8 & 10		Hydrometer		Retained	Hydrometer	*2.70*	
Test Cylinder No. :	*8*								
Computer File No. :		Tested	Moisture	Tested	Moisture	No. 4 & 10	Sample	Correction factor for difference S.G.	
Container No.		*S-7*	*75*	*J-17*	*76*	*S-7*	*S-19*		
Wt. of Wet Soil + Container (gm)		*339.48*	*187.07*	*75.38*	*188.42*			*0.99*	
Wt. of Dry Soil + Container (gm)			*184.51*		*185.76*	*5.42*	*148.09*	**Hydrometer Type**	
Wt. of Container (gm)			*60.11*		*59.81*	*0.00*	*116.69*	*152H*	
Wt. of Dry Soil (gm)		*332.63*		*73.82*		*5.42*	*31.40*	**(K) Value**	**Temp. °C**
Moisture Content (%)			*2.06*		*2.11*			*0.01312*	*22.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	*13.13*		*82.21*	***80.87***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*19.14*		*74.07*	***72.87***
1.0"					No. 40				
3/4"				-	No. 50	*24.25*		*67.15*	***66.06***
1/2"					No. 60				
3/8"	*0.00*		***100.00***	Plastic Index	No. 100	*28.06*		*61.99*	***60.98***
No. 4	*5.42*		***98.37***		No. 140				
No. 8	*5.36*		***91.23***	-	No. 200	*31.06*		*57.93*	***56.98***
No. 10					Pan	*31.36*			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient		Correction Dia. (mm) (D)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
10/26/02 10:16	***0:00:00***			*7.0*							
10/26/02 10:18	***0:02:00***	*21.0*	*40.0*	*7.0*	*33.0*	*44.26*	***43.53***	*0.05500*	*0.01312*	*10.9*	***0.03061***
10/26/02 10:21	***0:05:00***	*21.0*	*36.5*	*7.0*	*29.5*	*39.56*	***38.92***	*0.03500*	*0.01312*	*11.5*	***0.01986***
10/26/02 10:31	***0:15:00***	*21.0*	*34.0*	*7.0*	*27.0*	*36.21*	***35.62***	*0.02000*	*0.01312*	*11.9*	***0.01167***
10/26/02 10:46	***0:30:00***	*21.0*	*31.5*	*7.0*	*24.5*	*32.86*	***32.32***	*0.01400*	*0.01312*	*12.3*	***0.00839***
10/26/02 11:16	***1:00:00***	*21.0*	*29.0*	*7.0*	*22.0*	*29.50*	***29.02***	*0.01000*	*0.01312*	*12.7*	***0.00603***
10/26/02 12:16	***2:00:00***	*21.5*	*27.0*	*7.0*	*20.0*	*26.82*	***26.38***	*0.00700*	*0.01312*	*13.0*	***0.00432***
10/26/02 14:16	***4:00:00***	*22.0*	*25.0*	*7.0*	*18.0*	*24.14*	***23.75***	*0.00500*	*0.01312*	*13.3*	***0.00303***
10/27/02 10:16	***24:00:00***	*21.0*	*21.5*	*7.0*	*14.5*	*19.45*	***19.13***	*0.00100*	*0.01312*	*13.9*	***0.00129***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***2***	***41***	***57***

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *HNTB / Devil's Silde Tunnels*		
Project No.	: *02-134*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *ST-7*	**Prepared By :** *R.J*	**Date :** *10/14/02*
Sample No.	: *D-2*	**Tested By :** *PA*	**Date :** *10/26/02*
Depth (ft/m)	: *5.0* | *1.53*	**Sieved By :**	**Date :**
Description	: *Clayey Sand with Gravel*	**Calculated By :** *SV*	**Date :** *11/11/02*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:**	**Date :**

Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 4

Setup Container No. :	*S-9*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*7*	**+ No. 8 & 10**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor for difference S.G.**	
Container No.		*S-9*	*73*	*J-16*	*74*	*S-9*	*S-18*		
Wt. of Wet Soil + Container (gm)		*279.27*	*151.53*	*77.79*	*155.9*			*0.99*	
Wt. of Dry Soil + Container (gm)			*149.88*		*154.18*	*8.21*	*158.90*	**Hydrometer Type**	
Wt. of Container (gm)			*57.46*		*59.32*	*0.00*	*115.69*	*152H*	
Wt. of Dry Soil (gm)		*274.37*		*76.40*		*8.21*	*43.21*	**(K) Value**	**Temp. °C**
Moisture Content (%)			*1.79*		*1.81*			*0.01312*	*22.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	*14.87*		*80.54*	***78.13***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*23.56*		*69.16*	***67.09***
1.0"					No. 40				
3/4"				-	No. 50	*31.41*		*58.89*	***57.13***
1/2"	*0.00*		***100.00***		No. 60				
3/8"	*2.31*		***99.16***	Plastic Index	No. 100	*37.66*		*50.71*	***49.19***
No. 4	*8.21*		***97.01***		No. 140				
No. 8	*5.83*		***89.61***	-	No. 200	*42.87*		*43.89*	***42.58***
No. 10					Pan	*43.26*			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	(D)
10/26/02 10:12	***0:00:00***			*7.0*							
10/26/02 10:14	*0:02:00*	*21.0*	*35.0*	*7.0*	*28.0*	*36.28*	***35.19***	*0.05500*	*0.01312*	*11.7*	***0.03174***
10/26/02 10:17	*0:05:00*	*21.0*	*32.5*	*7.0*	*25.5*	*33.04*	***32.05***	*0.03500*	*0.01312*	*12.1*	***0.02042***
10/26/02 10:27	*0:15:00*	*21.0*	*30.0*	*7.0*	*23.0*	*29.80*	***28.91***	*0.02000*	*0.01312*	*12.5*	***0.01199***
10/26/02 10:42	*0:30:00*	*21.0*	*28.0*	*7.0*	*21.0*	*27.21*	***26.40***	*0.01400*	*0.01312*	*12.9*	***0.00859***
10/26/02 11:12	*1:00:00*	*21.0*	*26.5*	*7.0*	*19.5*	*25.27*	***24.51***	*0.01000*	*0.01312*	*13.1*	***0.00613***
10/26/02 12:12	*2:00:00*	*21.5*	*25.0*	*7.0*	*18.0*	*23.32*	***22.63***	*0.00700*	*0.01312*	*13.3*	***0.00437***
10/26/02 14:12	*4:00:00*	*22.0*	*23.5*	*7.0*	*16.5*	*21.38*	***20.74***	*0.00500*	*0.01312*	*13.6*	***0.00306***
10/27/02 10:12	***24:00:00***	*21.0*	*20.5*	*7.0*	*13.5*	*17.49*	***16.97***	*0.00100*	*0.01312*	*14.1*	***0.00130***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***3***	***54***	***43***

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *HNTB / Devil's Silde Tunnels*		
Project No.	: *02-134*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *ST-9*	**Prepared By :** *R.J*	**Date :** *10/17/02*
Sample No.	: *S-5*	**Tested By :** *PA*	**Date :** *10/26/02*
Depth (ft/m)	: *20.0* | *6.10*	**Sieved By :**	**Date :**
Description	: *Lean Clay with Sand and Gravel*	**Calculated By :** *SV*	**Date :** *11/11/02*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:**	**Date :**

Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 5

Setup Container No. :	*M-1*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*2*	**+ No. 8 & 10**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor for difference S.G.**	
Container No.		*M-1*	*70*	*J-19*	*71*	*M-1*	*S-16*		
Wt. of Wet Soil + Container (gm)		*295.05*	*150.40*	*70.34*	*188.77*			*0.99*	
Wt. of Dry Soil + Container (gm)			*147.94*		*185.02*	*1.79*	*145.51*	**Hydrometer Type**	
Wt. of Container (gm)			*58.85*		*58.45*		*114.32*	*152H*	
Wt. of Dry Soil (gm)		*287.12*		*68.32*		*1.79*	*31.19*	**(K) Value**	**Temp. °C**
Moisture Content (%)			*2.76*		*2.96*			*0.01312*	*22.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	**No. 16**	*4.30*		*93.71*	***93.12***
2.0"					**No. 20**				
1.5"				**Plastic Limit**	**No. 30**	*10.97*		*83.94*	***83.42***
1.0"					**No. 40**				
3/4"				-	**No. 50**	*18.46*		*72.98*	***72.52***
1/2"					**No. 60**				
3/8"	*0.00*		***100.00***	**Plastic Index**	**No. 100**	*25.24*		*63.05*	***62.66***
No. 4	*1.79*		***99.38***		**No. 140**				
No. 8	*0.84*		***98.15***	-	**No. 200**	*30.68*		*55.09*	***54.75***
No. 10					**Pan**	*31.24*			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient		Correction Dia. (mm) (D)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	
10/26/02 10:04	***0:00:00***			*7.0*							
10/26/02 10:06	***0:02:00***	*21.0*	*39.0*	*7.0*	*32.0*	*46.37*	***46.08***	*0.05500*	*0.01312*	*11.0*	***0.03083***
10/26/02 10:09	***0:05:00***	*21.0*	*36.0*	*7.0*	*29.0*	*42.03*	***41.76***	*0.03500*	*0.01312*	*11.5*	***0.01993***
10/26/02 10:19	***0:15:00***	*21.0*	*34.0*	*7.0*	*27.0*	*39.13*	***38.88***	*0.02000*	*0.01312*	*11.9*	***0.01167***
10/26/02 10:34	***0:30:00***	*21.0*	*32.0*	*7.0*	*25.0*	*36.23*	***36.00***	*0.01400*	*0.01312*	*12.2*	***0.00836***
10/26/02 11:04	***1:00:00***	*21.0*	*30.5*	*7.0*	*23.5*	*34.06*	***33.84***	*0.01000*	*0.01312*	*12.4*	***0.00597***
10/26/02 12:04	***2:00:00***	*21.5*	*29.0*	*7.0*	*22.0*	*31.88*	***31.68***	*0.00700*	*0.01312*	*12.7*	***0.00427***
10/26/02 14:04	***4:00:00***	*22.0*	*27.0*	*7.0*	*20.0*	*28.98*	***28.80***	*0.00500*	*0.01312*	*13.0*	***0.00299***
10/27/02 10:04	***24:00:00***	*21.0*	*24.0*	*7.0*	*17.0*	*24.64*	***24.48***	*0.00100*	*0.01312*	*13.5*	***0.00127***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***1***	***45***	***54***

REGULAR HYDROMETER TEST

ASTM D-422-63 (Reapproved 1990) / CT - 203

Project Name	: *HNTB / Devil's Silde Tunnels*		
Project No.	: *02-134*	**Tested Standard :** ☐ ASTM ☑ CAL. TRANS.	
Boring No.	: *02-20*	**Prepared By :** *R.J*	**Date :** *10/19/02*
Sample No.	: *S-10*	**Tested By :** *PA*	**Date :** *10/26/02*
Depth (ft/m)	: *50.0* | *15.25*	**Sieved By :**	**Date :**
Description	: *Black Sandy Clay / Clayey Sand (CL / SC)*	**Calculated By :** *SV*	**Date :** *11/11/02*
Deflocculant 125cc of 4% Sodium Hexametaphosphate Solution		**Checked By:**	**Date :**

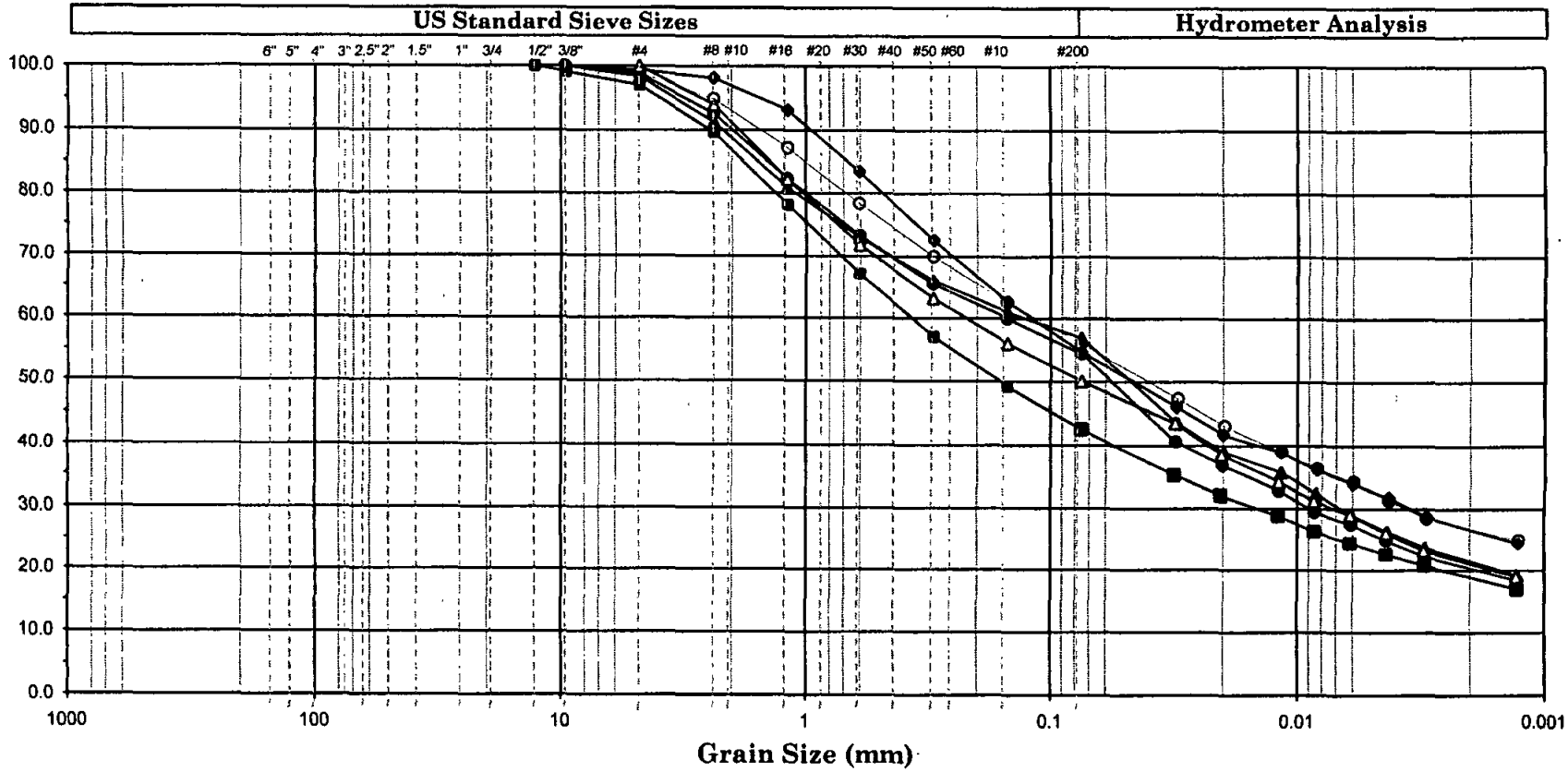
Sample for Hydrometer should passing (No.10 -ASTM) & (No.4 -Cal. Tran.), 65 gm for fine & 115 gm for Sand. 6

Setup Container No. :	*M-3*	**Sample Before Washing**				**After Washing**		**Specific Gravity**	
Test Cylinder No. :	*10*	**+ No. 8 & 10**		**Hydrometer**		**Retained**	**Hydrometer**	*2.70*	
Computer File No. :		**Tested**	**Moisture**	**Tested**	**Moisture**	**No. 4 & 10**	**Sample**	**Correction factor for difference S.G.**	
Container No.		*M-3*		*J-15*	*68*		*S-20*		
Wt. of Wet Soil + Container (gm)		*257.53*		*69.69*	*151.07*			*0.99*	
Wt. of Dry Soil + Container (gm)					*149.04*		*149.63*	**Hydrometer Type**	
Wt. of Container (gm)					*58.98*		*115.22*	*152H*	
Wt. of Dry Soil (gm)		*#VALUE!*		*68.15*			*34.41*	**(K) Value**	**Temp. °C**
Moisture Content (%)					*2.25*			*0.01312*	*22.0*

U.S. Sieve Size	Cumulative Wt. of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	Liquid Limit	U.S. Sieve Size	Cumulative Weight of Dry Soil (gm)	Wt. of Dry Soil (gm)	% Finer Than	% Total Sample
2.5"				-	No. 16	*12.14*		*82.19*	***82.19***
2.0"					No. 20				
1.5"				Plastic Limit	No. 30	*19.26*		*71.74*	***71.74***
1.0"					No. 40				
3/4"				-	No. 50	*25.12*		*63.14*	***63.14***
1/2"					No. 60				
3/8"				Plastic Index	No. 100	*29.89*		*56.14*	***56.14***
No. 4	*0.00*		***100.00***		No. 140				
No. 8	*4.11*		***93.97***	-	No. 200	*34.06*		*50.02*	***50.02***
No. 10					Pan	*34.45*			

Obersved Time	EL. Time (min.) (T)	Temp. (oC)	Hydrometer Reading			100 Ra / w	% Total Sample	Grain Diameter (mm)	Correction Coefficient		Correction Dia. (mm)
			Orginal	Composite Correction	Correction (R)				(K)	(L)	(D)
10/26/02 10:20	***0:00:00***			*7.0*							
10/26/02 10:22	*0:02:00*	*21.0*	*37.0*	*7.0*	*30.0*	*43.58*	***43.58***	*0.05500*	*0.01312*	*11.4*	***0.03129***
10/26/02 10:25	*0:05:00*	*21.0*	*33.5*	*7.0*	*26.5*	*38.49*	***38.49***	*0.03500*	*0.01312*	*11.9*	***0.02028***
10/26/02 10:35	*0:15:00*	*21.0*	*30.5*	*7.0*	*23.5*	*34.14*	***34.14***	*0.02000*	*0.01312*	*12.4*	***0.01195***
10/26/02 10:50	*0:30:00*	*21.0*	*28.5*	*7.0*	*21.5*	*31.23*	***31.23***	*0.01400*	*0.01312*	*12.8*	***0.00856***
10/26/02 11:20	*1:00:00*	*21.0*	*27.0*	*7.0*	*20.0*	*29.05*	***29.05***	*0.01000*	*0.01312*	*13.0*	***0.00611***
10/26/02 12:20	*2:00:00*	*21.5*	*25.0*	*7.0*	*18.0*	*26.15*	***26.15***	*0.00700*	*0.01312*	*13.3*	***0.00437***
10/26/02 14:20	*4:00:00*	*22.0*	*23.0*	*7.0*	*16.0*	*23.24*	***23.24***	*0.00500*	*0.01312*	*13.7*	***0.00307***
10/27/02 10:20	*24:00:00*	*21.0*	*20.0*	*7.0*	*13.0*	*18.88*	***18.88***	*0.00100*	*0.01312*	*14.2*	***0.00130***

Remark :		**Cu :**	**Gravel**	**Sand**	**Fine**
		Cc :	***0***	***50***	***50***



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	ST-1	S-1	2.5	4.0	0.76	1.22	Dark Yellow-Brown	Sandy Clay	CL
▲	ST-5	S-5	20.0	21.5	6.10	6.56	Brwon to Dark Yellow-Brown	Lean Clay with Sand	CL
■	ST-7	D-2	5.0	6.5	1.53	1.98	Dark Yellow-Brown	Clayey sand	SC
◆	ST-9	S-5	20.0	21.5	6.10	6.56	Reddish Brown	Sandy silt	ML
○	ST-10	S-3	10.0	11.5	3.05	3.51	Brown	Lean Clay with Sand	CL
△	02-20	S-10	50.0	51.5	15.25	15.71	Black	Sandy Clay / Clayey Sand	CL/SC
Remark									

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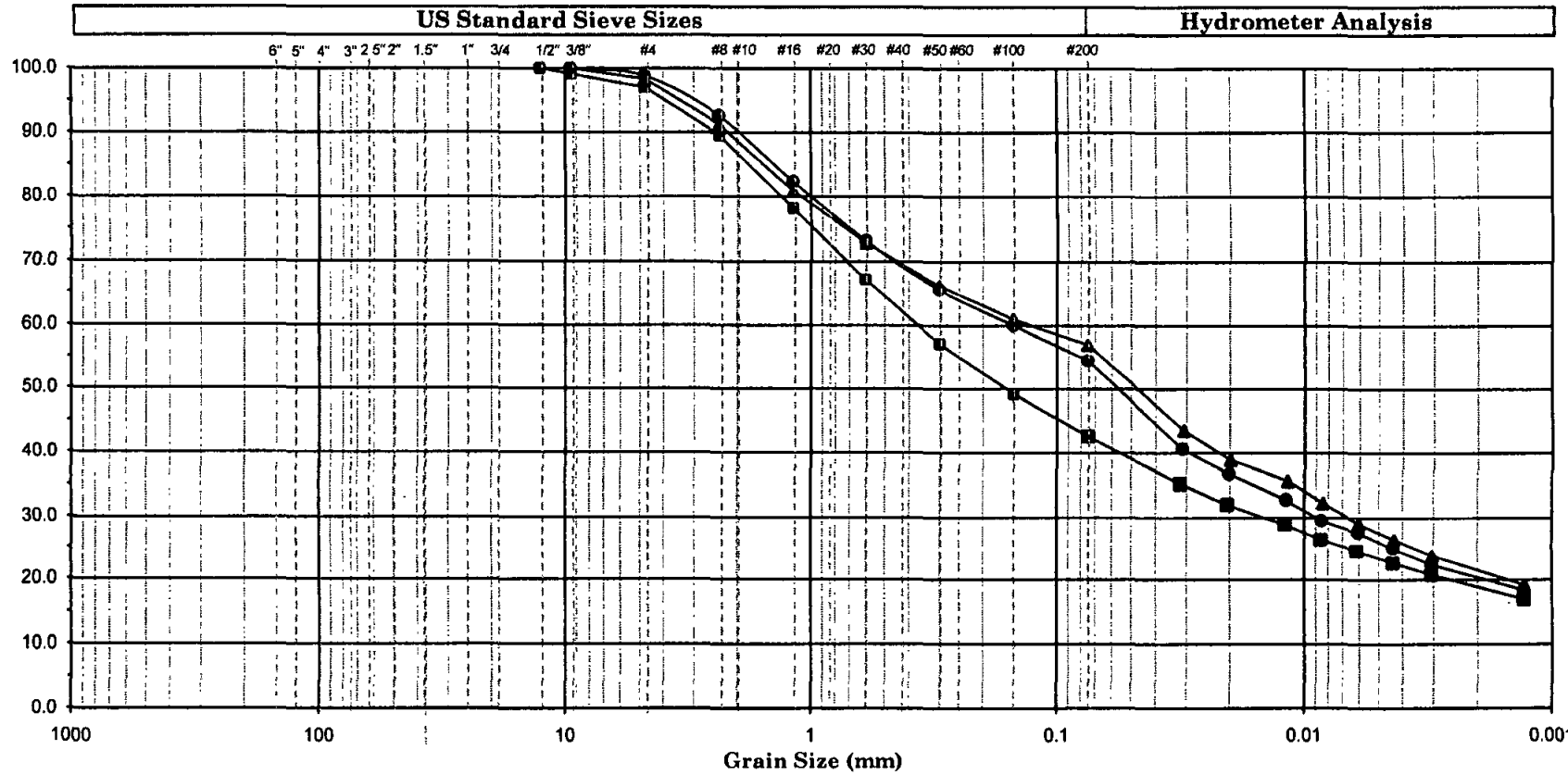
HNTB/Devil's Silde Tunnels

Project No. : 02-134 T.O.2B **Date : 11/11/02**

GRAIN SIZE ANALYSIS
(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	ST-1	S-1	2.5	4.0	0.76	1.22	Dark Yellow-Brown	Sandy Clay	CL
▲	ST-5	S-5	20.0	21.5	6.10	6.56	Brwon to Dark Yellow-Brown	Lean Clay with Sand	CL
■	ST-7	D-2	5.0	6.5	1.53	1.98	Dark Yellow-Brown	Clayey Sand	SC
Remark									

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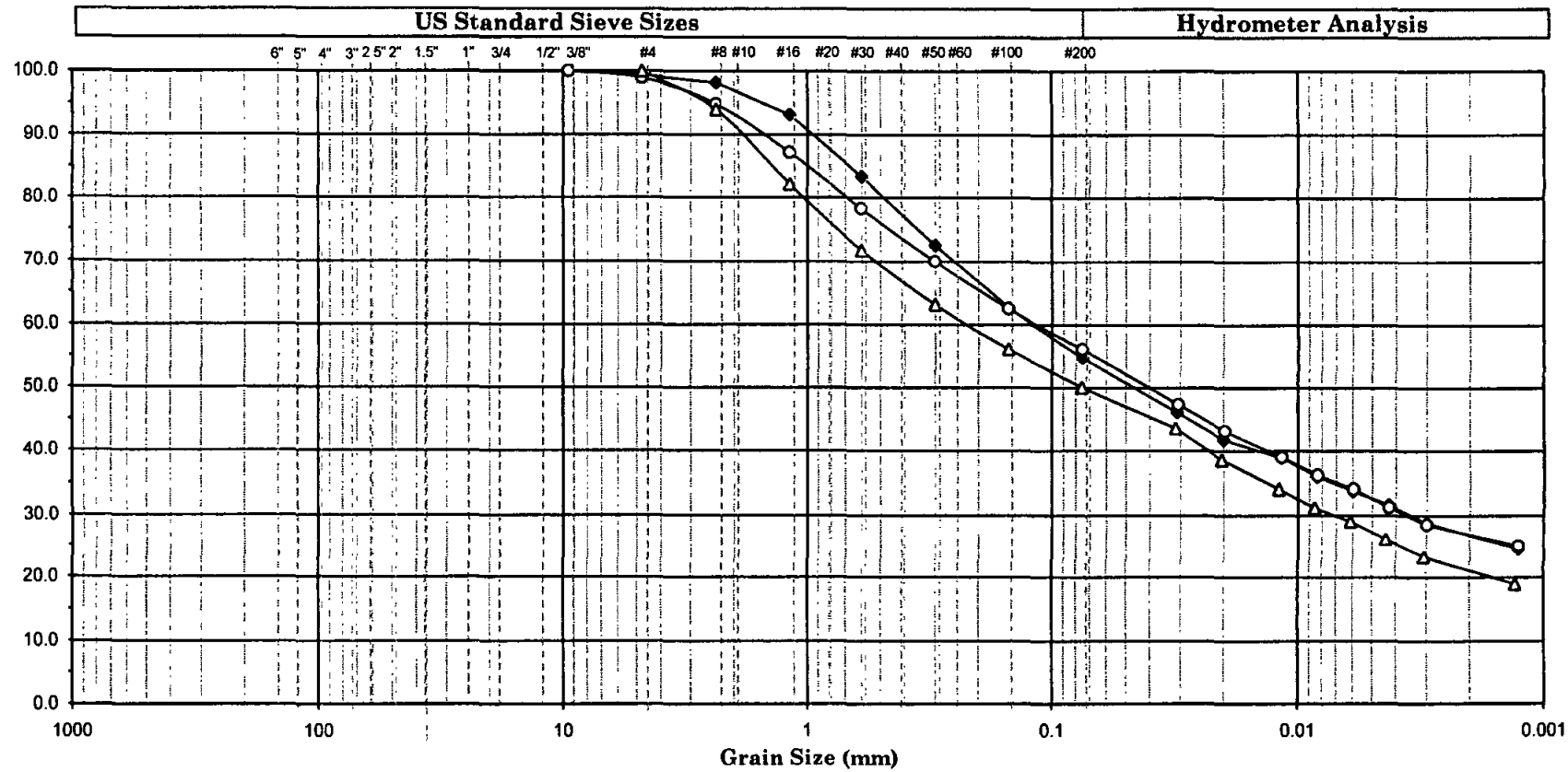
HNTB/Devil's Silde Tunnels

Project No. : 02-134 T.O.2B Date : 11/11/02

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
◆	ST-9	S-5	20.0	21.5	6.10	6.56	Reddish Brown	Lean Clay with Sand	CL
○	ST-10	S-3	10.0	11.5	3.05	3.51	Brown	Lean Clay with Sand	CL
△	02-20	S-10	50.0	51.5	15.25	15.71	Black	Sandy Clay / Clayey Sand	CL/SC
Remark									

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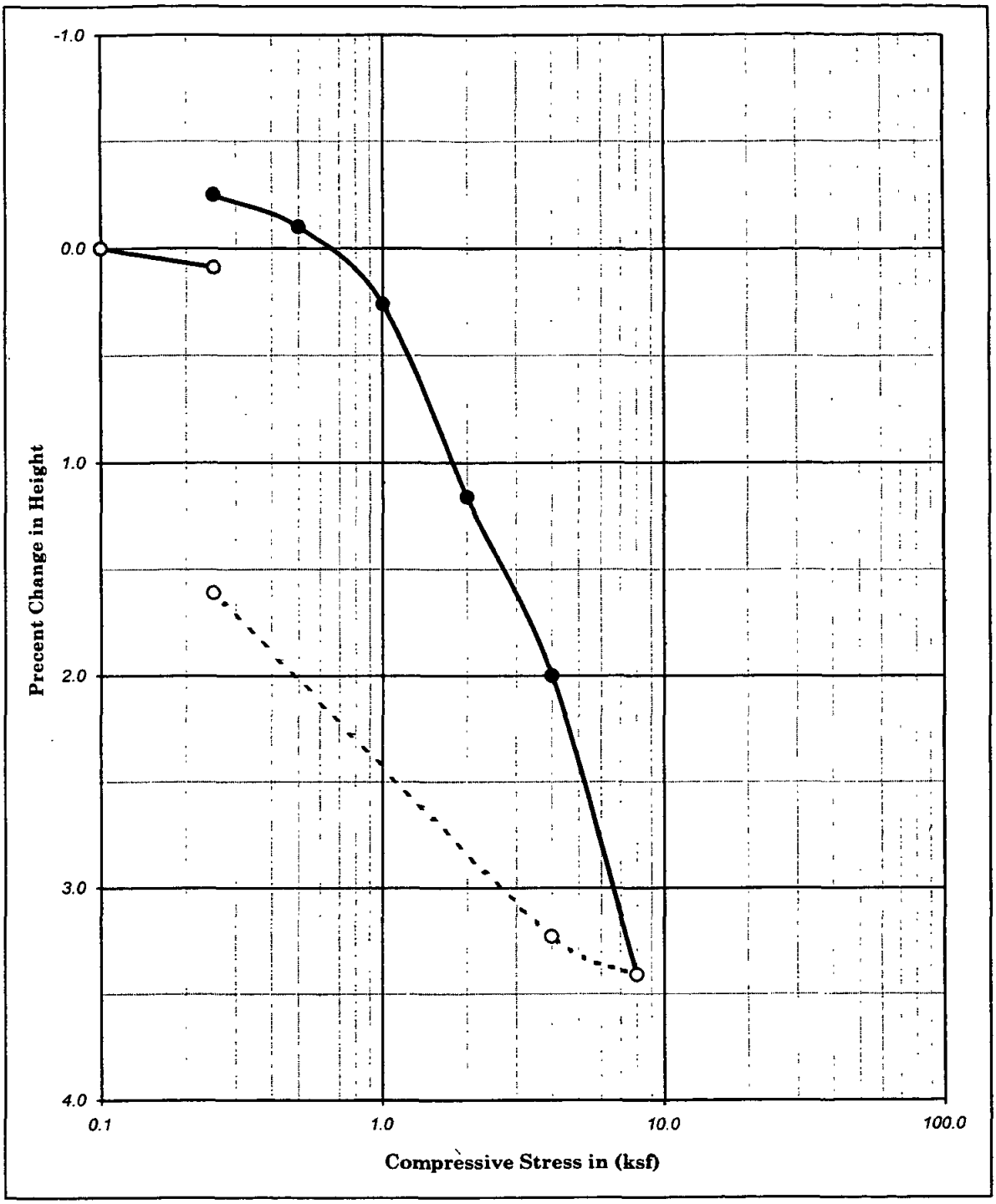
Project No. : 02-134 T.O.2B **Date : 11/11/02**

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :



Boring No. : ST-1				Liquid Limit : -			Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-2				Plastic Limit : -							
Depth	(ft) :	5.0	6.5	Plastic Index : -		Initial	15.40	113.67	17.89	86.09	0.48
	(m) :	1.53	1.98	Specific Gravity :	2.70	Final	17.68	113.67	17.89	98.88	0.48

Description : *Dark Yellowish Brown Clayey Sand (SC)*

Load Increment	0.10	0.25	0.25	0.50	1.00	2.00	4.00	8.00	8.00	4.00	0.25
% Delta H	0.00	0.09	-0.25	-0.10	0.26	1.16	2.00	3.41	3.41	3.23	1.61

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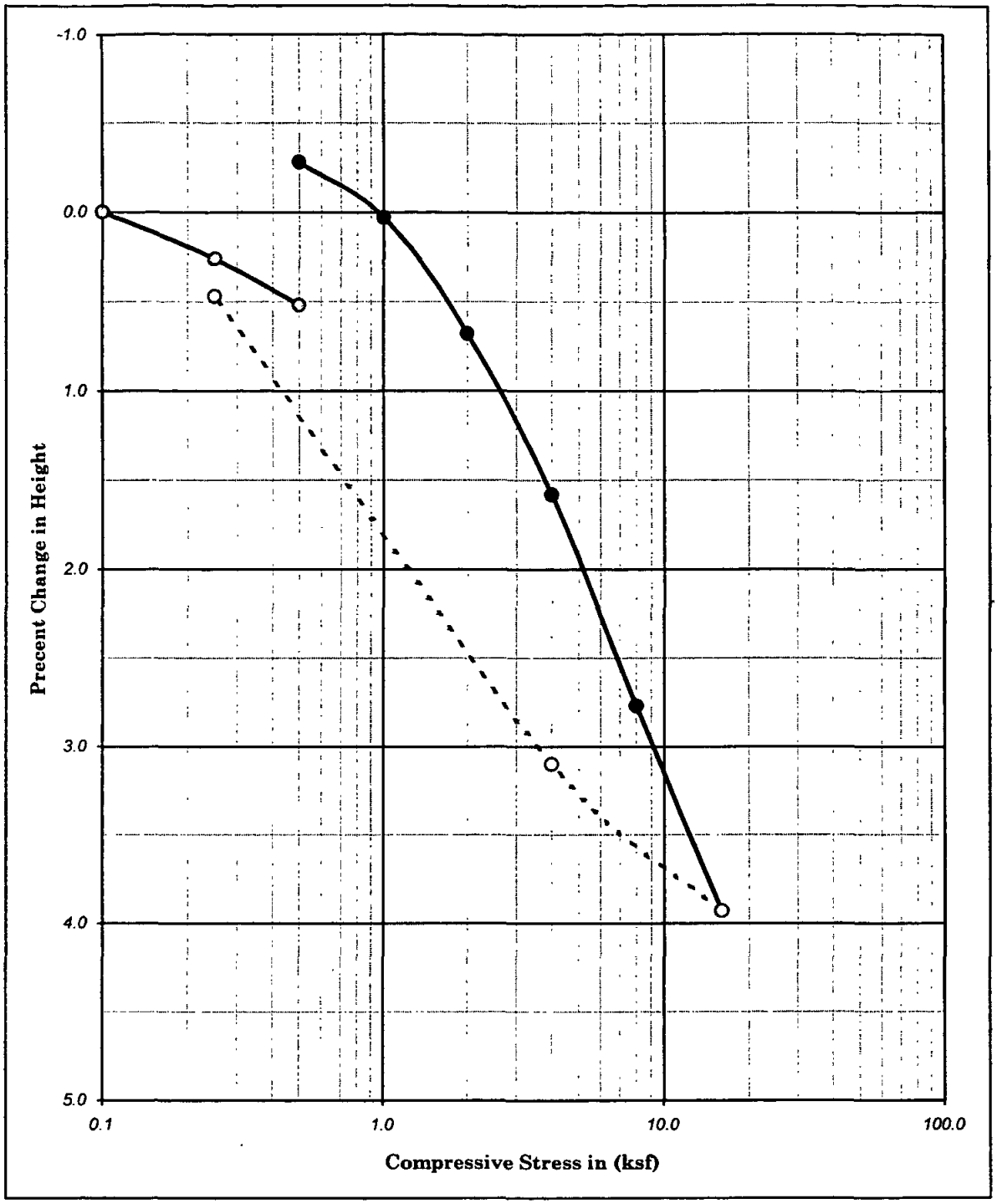
CONSOLIDATION TEST
(ASTM D-2435 / CT-219) Figure No. :



Boring No. : ST-2				Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-2				Plastic Limit :	-						
Depth	(ft) :	5.0	6 5	Plastic Index :	-	Initial	15.21	116.96	18.41	93.09	0.44
	(m) :	1 53	1.98	Specific Gravity :	2.70	Final	16.84	116.96	18.41	103.06	0.44

Description : *Lean Clay with Sand*

Load Increment	0.10	0.25	0.50	0.50	1.00	2.00	4.00	8.00	16.00	16.00	4.00	0.25
% Delta H	0.00	0.26	0.52	-0.28	0.03	0.68	1.58	2.77	3.93	3.93	3.10	0.47

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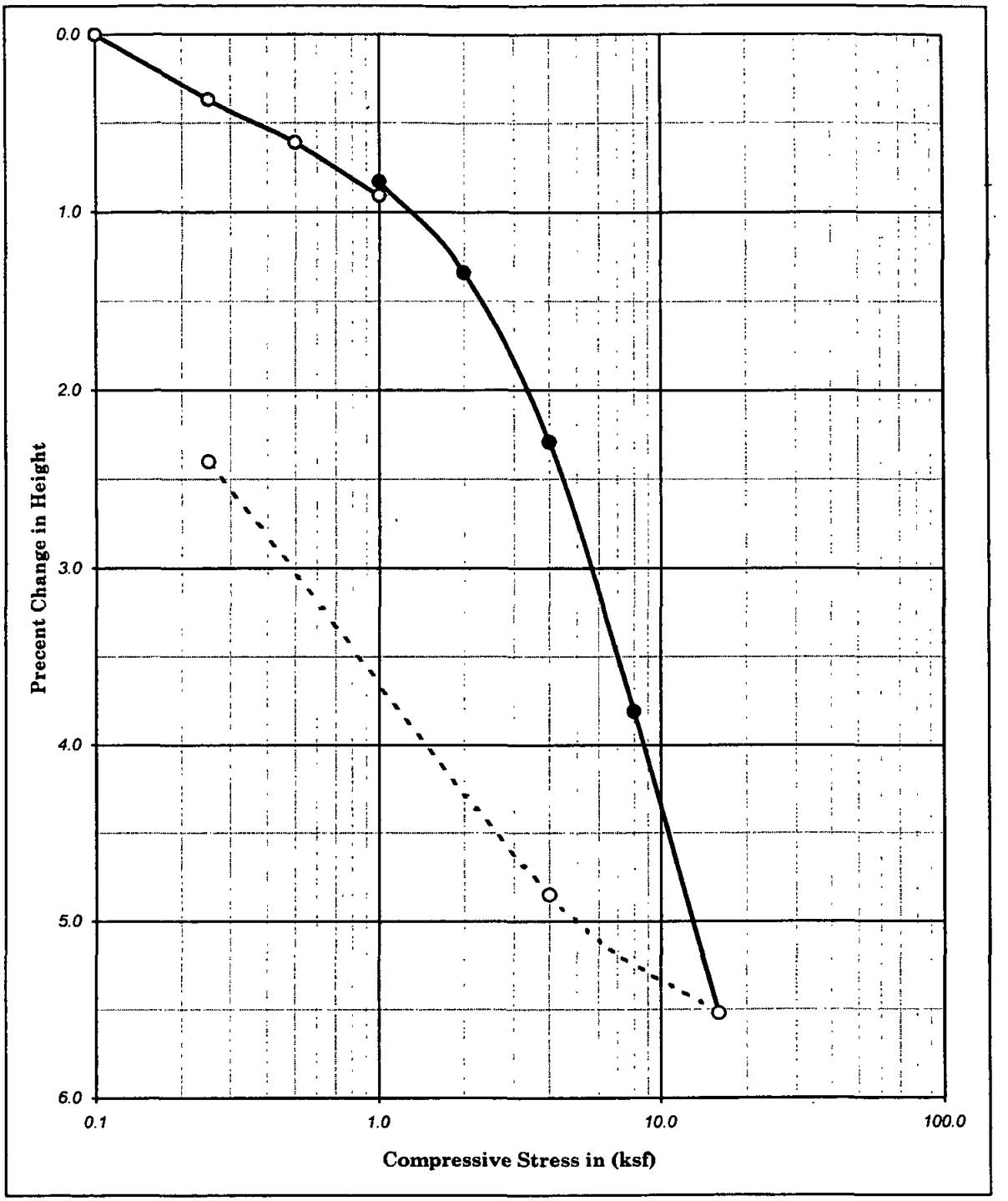
CONSOLIDATION TEST
(ASTM D-2435 / CT-219) Figure No. :



Boring No. : ST-2			Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	(kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-4			Plastic Limit :	-						
Depth (ft) :	15.0	16.5	Plastic Index :	-	Initial	16.72	112.42	17.69	90.37	0.50
(m) :	4.58	5.03	Specific Gravity :	2.70	Final	17.84	112.42	17.69	96.43	0.50

Description: *Lean Clay with Sand*

Load Increment	0.10	0.25	0.50	1.00	1.00	2.00	4.00	8.00	16.00		16.00	4.00	0.25
% Delta H	0.00	0.37	0.61	0.91	0.83	1.34	2.29	3.81	5.52		5.52	4.85	2.40

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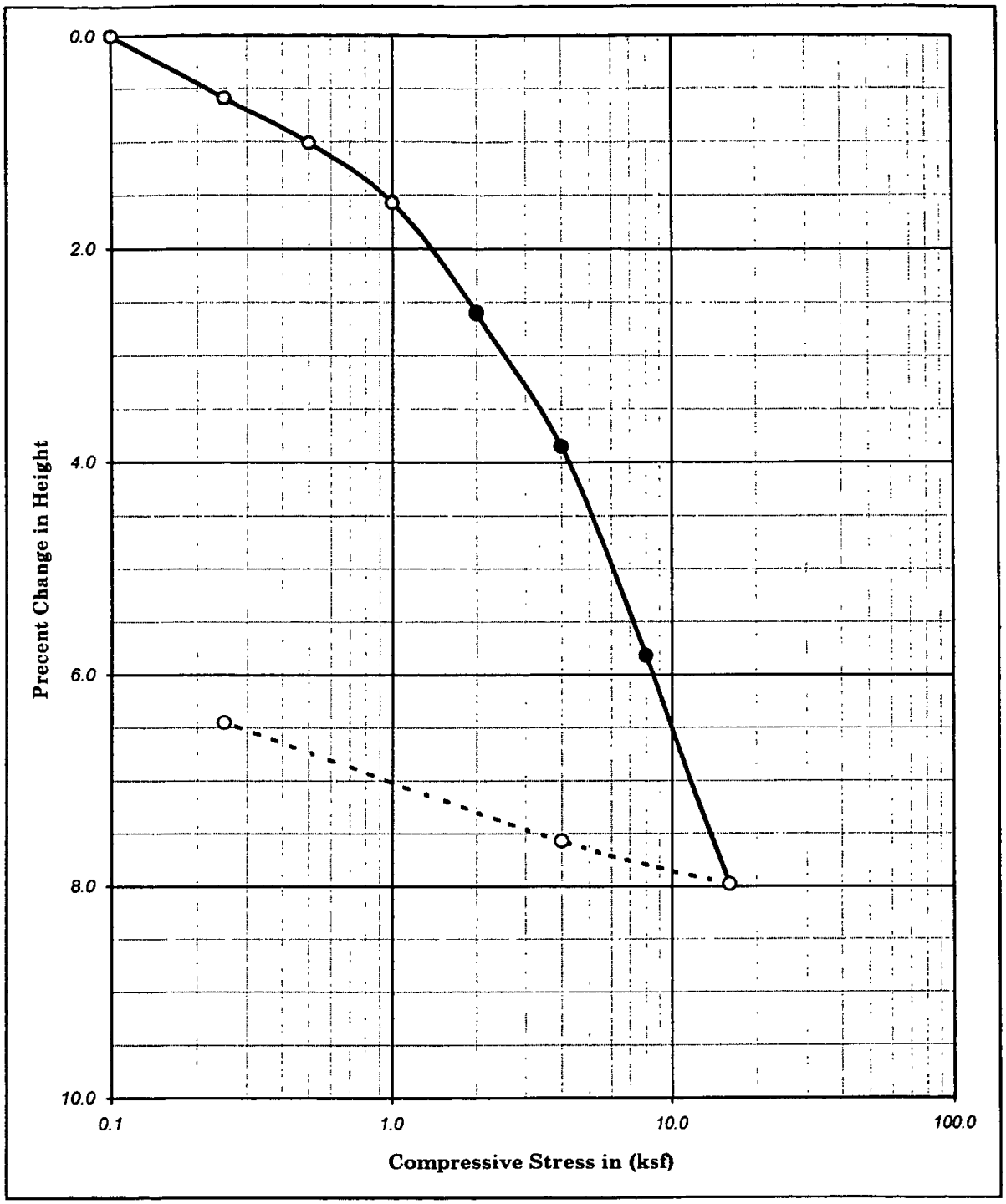
CONSOLIDATION TEST
(ASTM D-2435 / CT-219) Figure No. :



Boring No. : ST-2			Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	(kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-10			Plastic Limit :	-						
Depth	(ft) : 45.0	46.5	Plastic Index :	-	Initial	18.60	111.07	17.48	97.05	0.52
	(m) : 13.73	14.18	Specific Gravity :	2.70	Final	15.43	111.07	17.48	80.48	0.52
Description: Lean Clay with Sand and Gravel										

Load Increment	0.25	0.50	1.00	2.00	2.00	4.00	8.00	16.00	16.00	4.00	0.25
% Delta H	0.59	1.01	1.57	2.59	2.61	3.85	5.82	7.98	7.98	7.57	6.45

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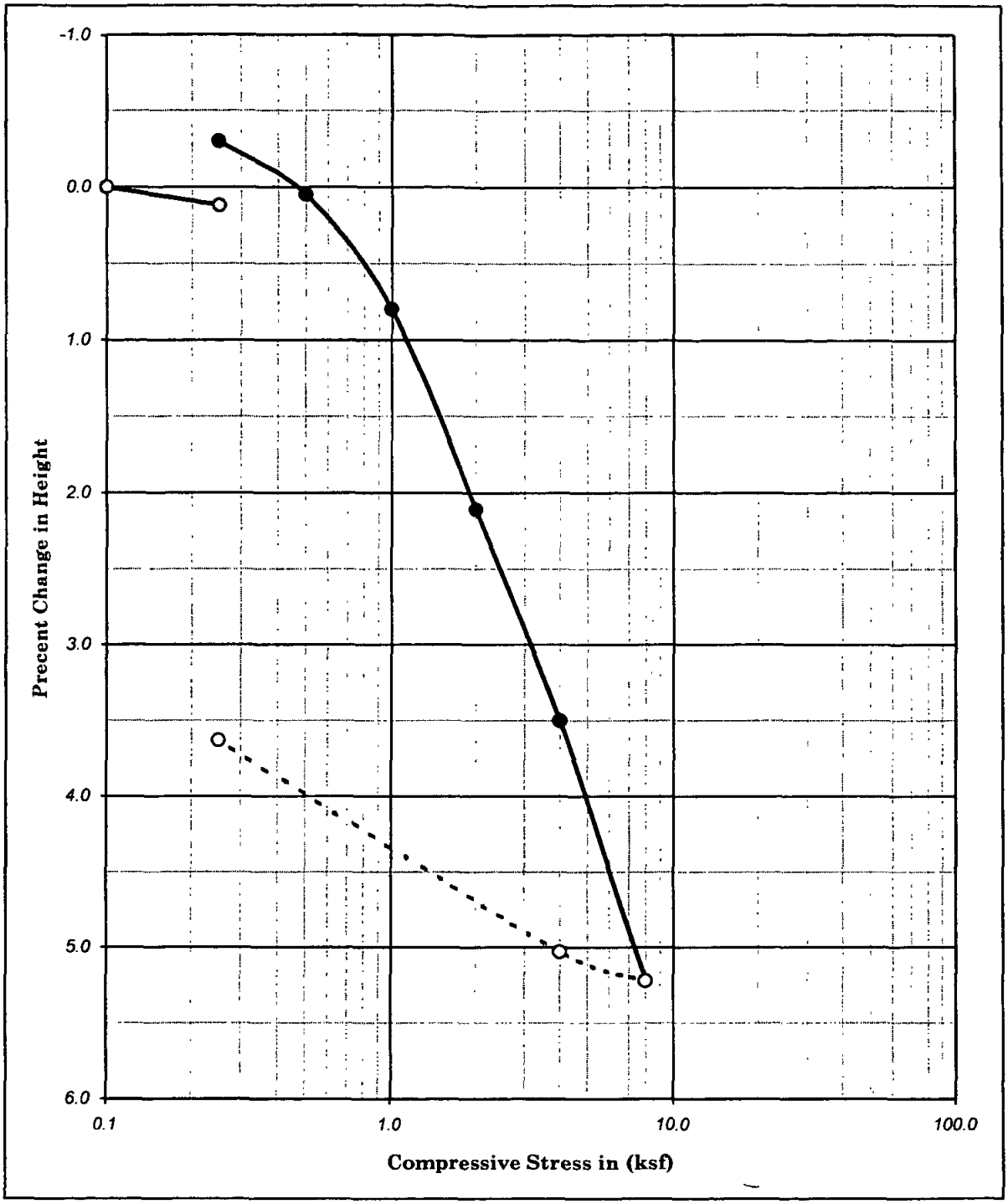
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

Figure No. :



Boring No. : ST-4			Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-2			Plastic Limit :	-						
Depth (ft) :	5.0	6.5	Plastic Index :	-	Initial	10.60	112.88	17.77	58.03	0.49
Depth (m) :	1.53	1.98	Specific Gravity :	2.70	Final	15.64	112.88	17.77	85.62	0.49

Description: *very dark brown Silty Sand*

Load Increment	0.10	0.25	0.25	0.50	1.00	2.00	4.00	8.00	8.00	4.00	0.25
% Delta H	0.00	0.12	-0.30	0.05	0.80	2.11	3.50	5.22	5.22	5.03	3.63

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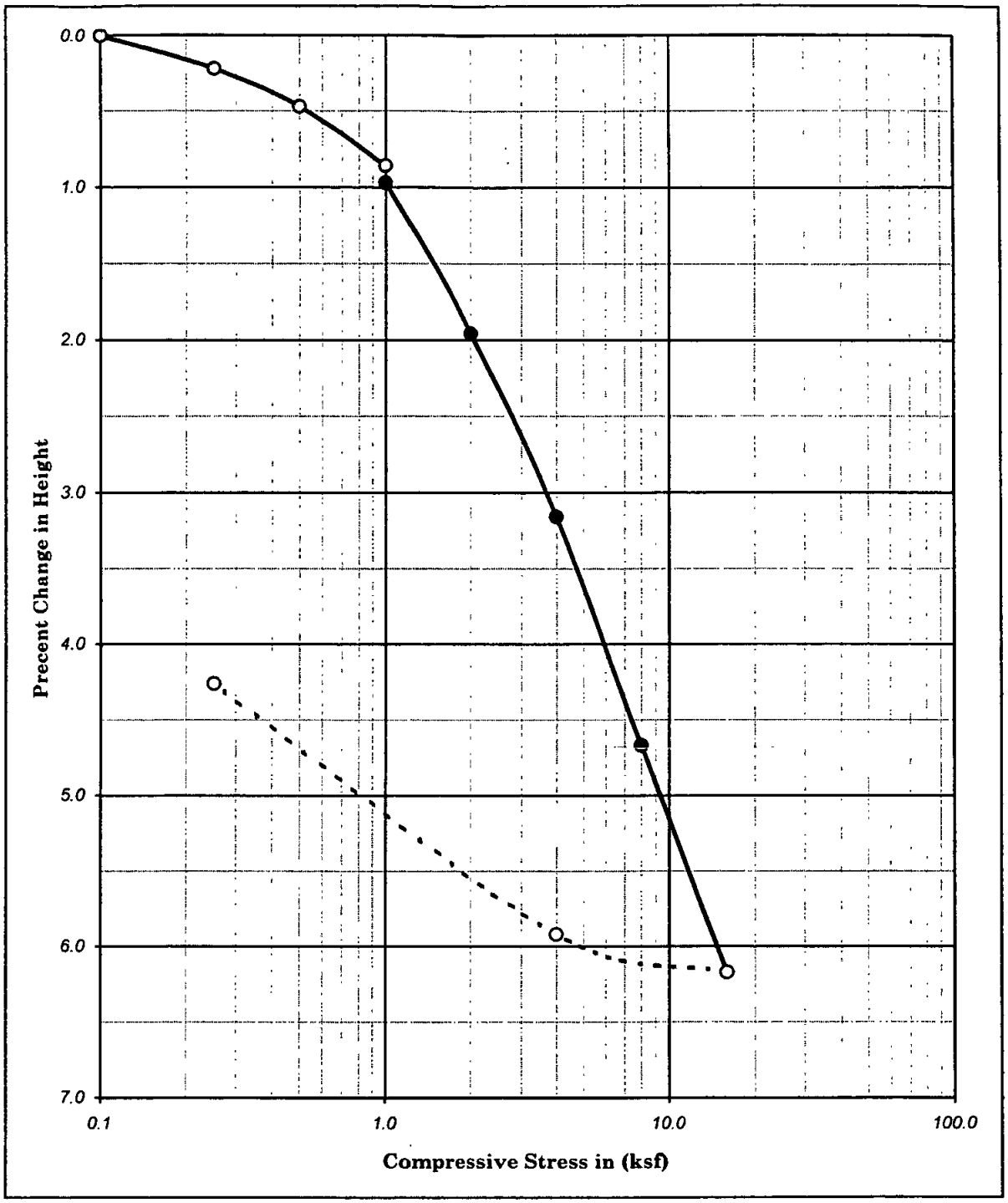
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

Figure No. :



Boring No. : ST-5				Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-4				Plastic Limit :	-						
Depth	(ft) :	15.0	16.5	Plastic Index :	-	Initial	15.90	117.81	18.54	99.66	0.43
	(m) :	4.58	5.03	Specific Gravity :	2.70	Final	14.67	117.81	18.54	91.95	0.43

Description: *Brown to dark yellowish brown Clayey Sand*

Load Increment	0.10	0.25	0.50	1.00	1.00	2.00	4.00	8.00	16.00			16.00	4.00	0.25
% Delta H	0.00	0.22	0.47	0.86	0.97	1.95	3.16	4.67	6.17			6.17	5.92	4.26

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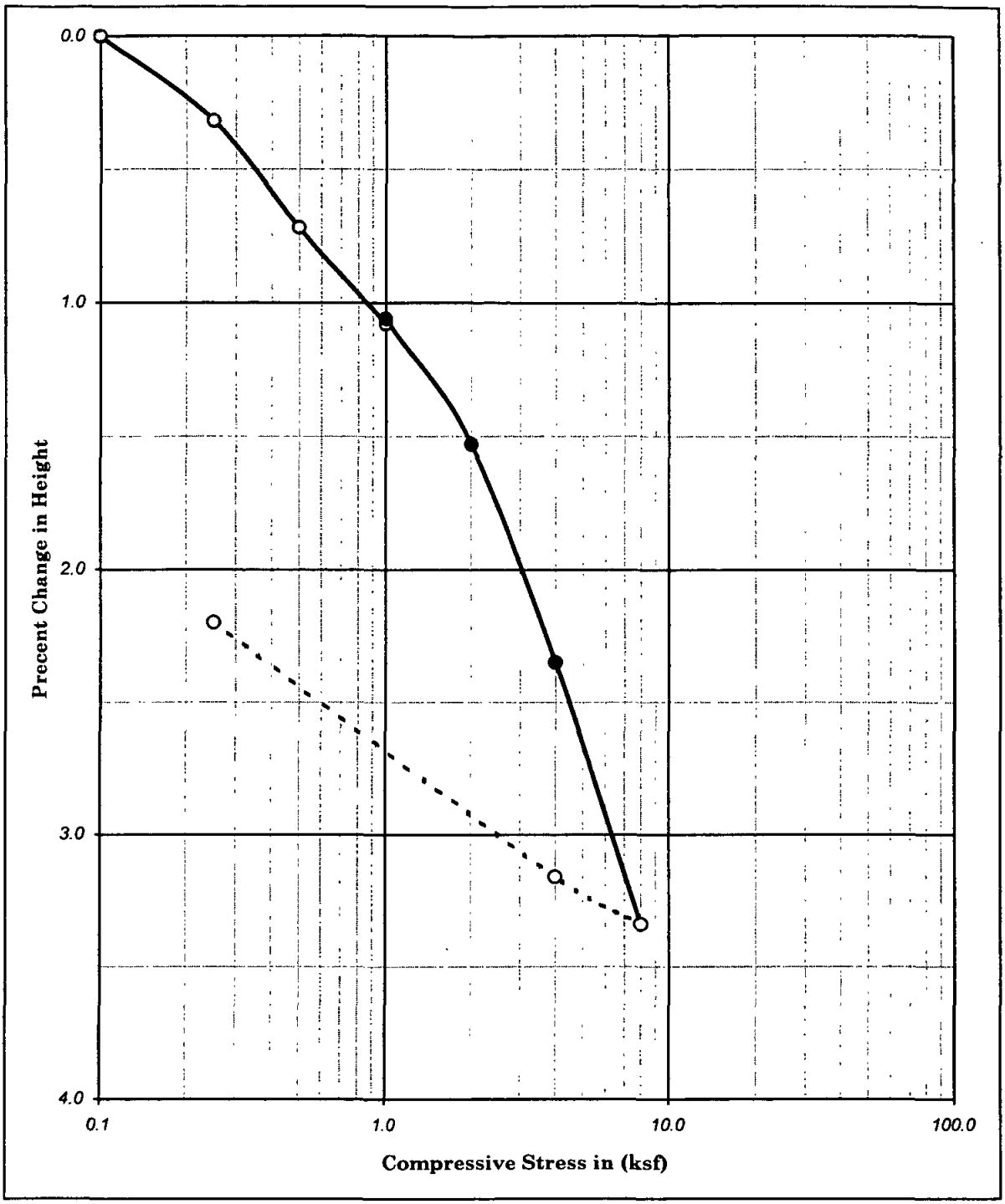
CONSOLIDATION TEST
(ASTM D-2435 / CT-219)

Figure No. :



Boring No. : ST-6			Liquid Limit :	-		Moisture Content (%)	Dry Density (pcf)	(kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-4			Plastic Limit :	-						
Depth	(ft) : 15.0	16.5	Plastic Index :	-	Initial	14.08	122.57	19.29	101.33	0.38
	(m) : 4.58	5.03	Specific Gravity :	2.70	Final	13.75	122.57	19.29	98.95	0.38

Description: *Dark brown Clayey Sand*

Load Increment	0.10	0.25	0.50	1.00	1.00	2.00	4.00	8.00	8.00	4.00	0.25
% Delta H	0.00	0.32	0.72	1.08	1.06	1.53	2.35	3.34	3.34	3.16	2.20

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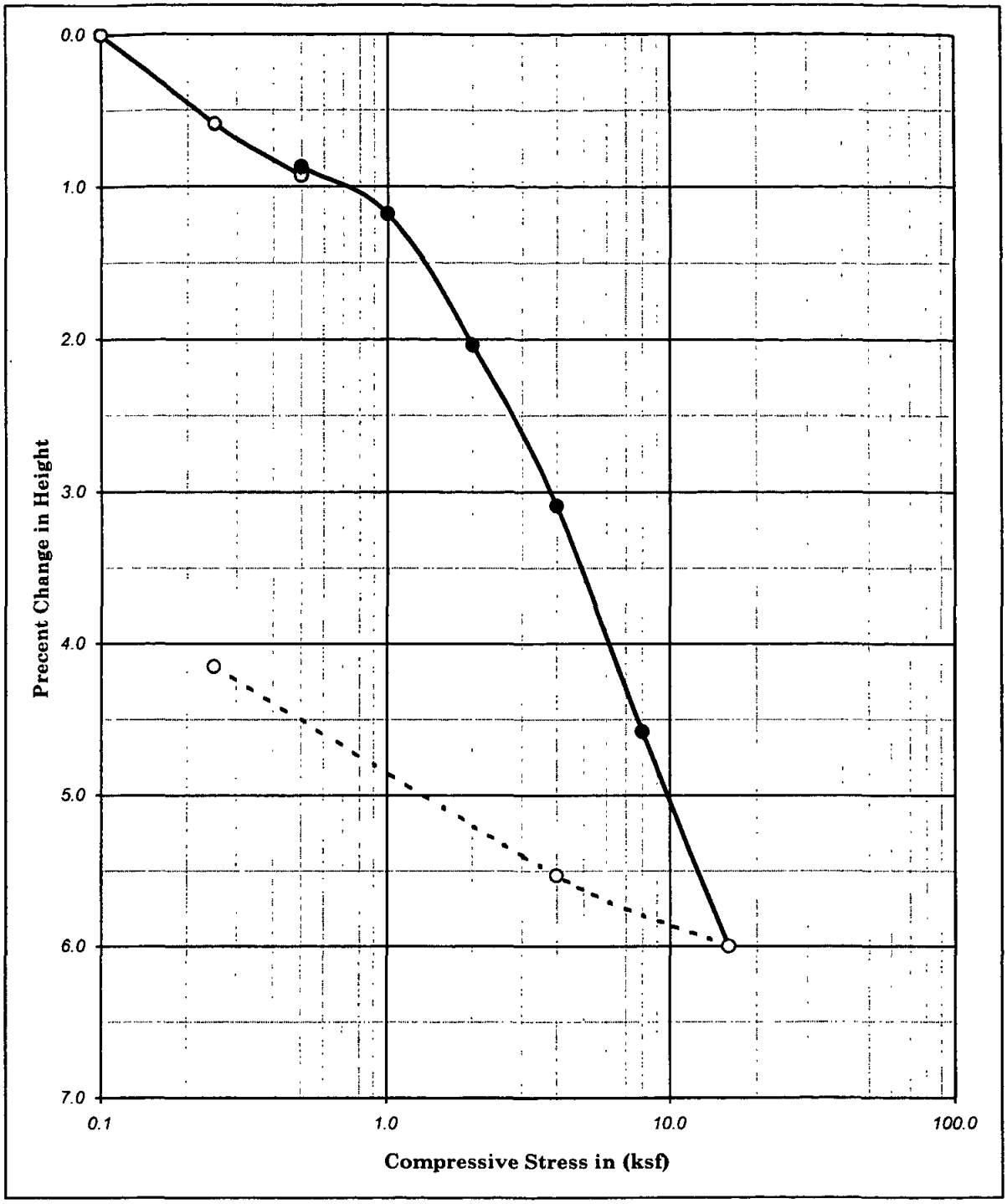
CONSOLIDATION TEST
(ASTM D-2435 / CT-219) Figure No. :



Boring No. : ST-9			Liquid Limit : -		Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-2			Plastic Limit : -						
Depth (ft) :	5.0	6.5	Plastic Index : -	Initial	15.60	117.38	18.48	96.61	0.44
Depth (m) :	1.53	1.98	Specific Gravity : 2.70	Final	14.46	117.38	18.48	89.58	0.41

Description: *Very dark brown Lean Clay with Silt*

Load Increment	0.10	0.25	0.50	0.50	1.00	2.00	4.00	8.00	16.00	16.00	4.00	0.25
% Delta H	0.00	0.59	0.93	0.87	1.18	2.04	3.09	4.58	6.00	6.00	5.53	4.15

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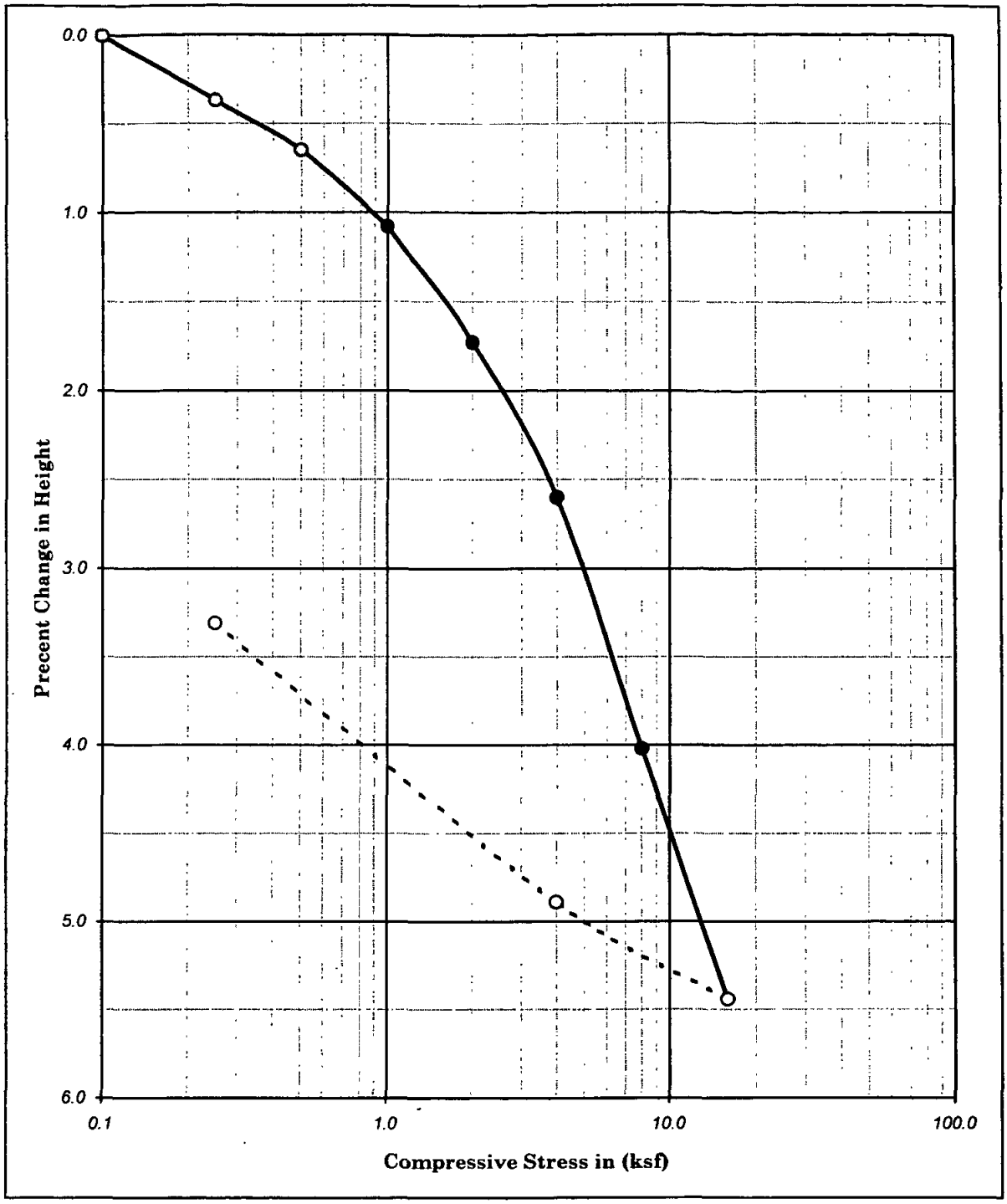
HNTB / Devil's Slide Tunnels

Project No. : 02-134 11/12/02

CONSOLIDATION TEST
(ASTM D-2435 / CT-219) Figure No. :



Boring No. : ST-10				Liquid Limit : -			Moisture Content (%)	Dry Density (pcf)	Dry Density (kN/m³)	Percent Saturation	Void Ratio
Sample No. : D-4				Plastic Limit : -							
Depth	(ft) :	15.0	16.5	Plastic Index : -		Initial	15.13	118.16	18.60	95.80	0.43
	(m) :	4.58	5.03	Specific Gravity : 2.70		Final	15.13	118.16	18.60	95.80	0.43

Description: *Brown Clayey Sand (SC)*

Load Increment	0.10	0.25	0.50	1.00	1.00	2.00	4.00	8.00	16.00	16.00	4.00	0.25
% Delta H	0.00	0.37	0.65	1.08	1.08	1.73	2.60	4.02	5.44	5.44	4.89	3.31

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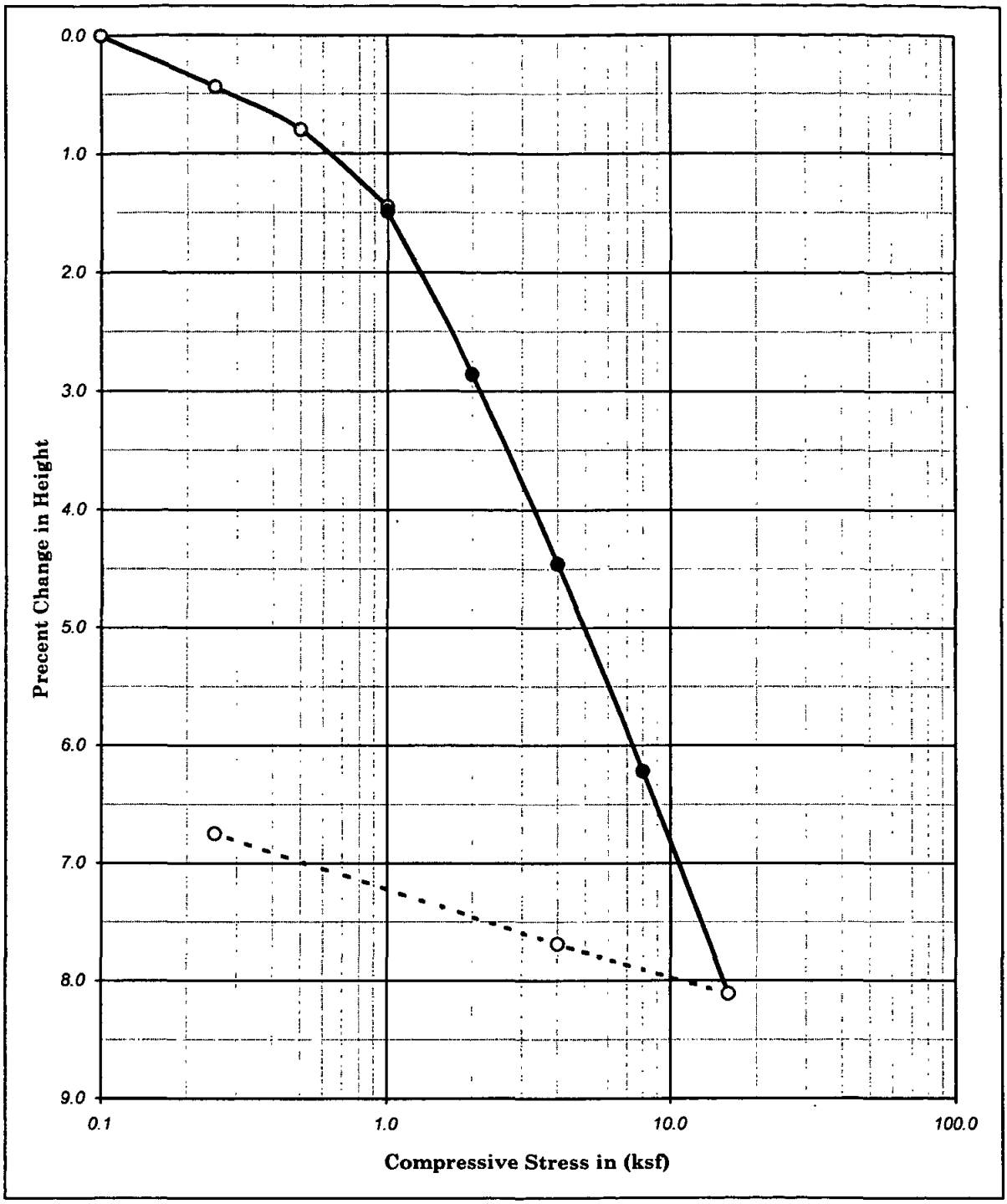
HNTB / Devil's Slide Tunnels

Project No. : 02-134 11/12/02

CONSOLIDATION TEST
(ASTM D-2435 / CT-219) Figure No. :



Boring No. : *02-20*				**Liquid Limit :**	-		**Moisture Content (%)**	**Dry Density**		**Percent Saturation**	**Void Ratio**
Sample No. : *D-11*				**Plastic Limit :**	-			**(pcf)**	**(kN/m³)**		
Depth	**(ft)** : *55.0*	*56.5*		**Plastic Index :**	-	**Initial**	*15.59*	*110.97*	*17.47*	*81.12*	*0.52*
	(m) : *16.78*	*17.23*		**Specific Gravity :**	*2.70*	**Final**	*13.34*	*110.97*	*17.47*	*69.43*	*0.52*

Description: *Very dark brown Lean Clay with Sand (CL)*

Load Increment	*0.10*	*0.25*	*0.50*	*1.00*	*1.00*	*2.00*	*4.00*	*8.00*	*16.00*		*16.00*	*4.00*	*0.25*
% Delta H	*0.00*	*0.44*	*0.80*	*1.45*	*1.49*	*2.86*	*4.46*	*6.22*	*8.11*		*8 11*	*7.69*	*6.75*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

HNTB / Devil's Slide Tunnels

Project No. : *02-134* *11/12/02*

CONSOLIDATION TEST
(ASTM D-2435 / CT-219) **Figure No. :**

PARTICLE SIZE ANALYSIS OF SOIL

ASTM D-422-63 (Rev. 1990) / CT - 202, 203

Project No : 02-134	Project Name : HNTB/Devil's Slide Tunnels
Standard : ☑ CAL. TRAN. ☐ ASTM ☐ OTHER	

Prepared By : R.J	Date : 10/12/02	Tested By : R.J	Date : 10/19/02	Checked By :
Washed By : B.C	Date : 10/16/02	Computed By : SV	Date : 11/11/02	Date :

Boring No. : ST-2	Depth : (ft) : 30.0	31.5
Sample No. : S-7	(m) : 9.15	9.61

Description : Yellowish red Clayey Sand (SC)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-5	S-5	S-5
Wet Wt. of Soil + Cont. (gm)	513.34	513.34	
Dry Wt. of Soil + Cont. (gm)		458.64	316.68
Weight of Container (gm)	117.80	117.80	117.80
Weight of Dry Soil (gm)	340.84	340.84	198.88
Moisture Content (%)		16.05	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	22.22	93.48
4"			No. 10		
3"			No. 16	62.17	81.76
2.5"			No. 20		
2.0"			No. 30	100.77	70.43
1.5"			No. 40		
1.0"			No. 50	136.88	59.84
3/4"			No. 60		
1/2"			No. 100	169.70	50.21
3/8"	0.00	100.00	No. 200	198.81	41.67
No. 4	2.00	99.41	Pan	198.97	
Cu :			Gravel	Sand	Fine
Cc :			1	57	42

Remark :

1

Prepared By : R.J	Date : 10/14/02	Tested By : R.J	Date : 10/19/02	Checked By :
Washed By : B.C	Date : 10/16/02	Computed By : S.V	Date : 11/11/02	Date :

Boring No. : ST-7	Depth : (ft) : 20.0	21.5
Sample No. : S-5	(m) : 6.10	6.56

Description : Brown to Dark Brown, Silty Sand

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-10	S-10	S-10
Wet Wt. of Soil + Cont. (gm)	483.07	483.07	
Dry Wt. of Soil + Cont. (gm)		445.11	385.22
Weight of Container (gm)	119.20	119.20	119.20
Weight of Dry Soil (gm)	325.91	325.91	266.02
Moisture Content (%)		11.65	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	56.22	82.75
4"			No. 10		
3"			No. 16	117.91	63.82
2.5"			No. 20		
2.0"			No. 30	166.99	48.76
1.5"			No. 40		
1.0"			No. 50	207.88	36.22
3/4"			No. 60		
1/2"	0.00	100.00	No. 100	241.25	25.98
3/8"	2.44	99.25	No. 200	264.70	18.78
No. 4	13.63	95.82	Pan	266.31	
Cu :			Gravel	Sand	Fine
Cc :			4	77	19

Remark :

2

Prepared By : R.J	Date : 10/14/02	Tested By : R.J	Date : 10/19/02	Checked By :
Washed By : B.C	Date : 10/14/02	Computed By : S.V	Date : 11/11/02	Date :

Boring No. : ST-6	Depth : (ft) : 10.0	11.5
Sample No. : S-3	(m) : 3.05	3.51

Description : Dark Olive Brown Clayey Sand (SC)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-8	S-8	S-8
Wet Wt. of Soil + Cont. (gm)	434.50	434.50	
Dry Wt. of Soil + Cont. (gm)		398.57	276.90
Weight of Container (gm)	118.30	118.30	118.30
Weight of Dry Soil (gm)	280.27	280.27	158.6
Moisture Content (%)		12.82	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	36.40	87.01
4"			No. 10		
3"			No. 16	75.48	73.07
2.5"			No. 20		
2.0"			No. 30	104.50	62.71
1.5"			No. 40		
1.0"			No. 50	128.25	54.24
3/4"			No. 60		
1/2"			No. 100	145.11	48.22
3/8"	0.00	100.00	No. 200	158.04	43.61
No. 4	7.46	97.34	Pan	158.54	
Cu :			Gravel	Sand	Fine
Cc :			3	53	44

Remark :

3

PARTICLE SIZE ANALYSIS OF SOIL

ASTM D-422-63 (Rev. 1990) / CT - 202, 203

Project No : 02-134	Project Name : HNTB/Devil's Slide Tunnels
Standard : ☑ CAL. TRAN. ☐ ASTM ☐ OTHER	

Prepared By : R.J	Date : 10/14/02	Tested By : R.J	Date : 10/19/02	Checked By :
Washed By : B.C	Date : 10/14/02	Computed By : S.V	Date : 11/11/02	Date :

Boring No. : ST-5	Depth : (ft) : 5.0	6.5
Sample No. : S-1	(m) : 1.53	1.98

Description : Brown to dark Yellow brown, Lean Clay w/ Sand

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-6	S-6	S-6
Wet Wt. of Soil + Cont. (gm)	439.54	439.54	
Dry Wt. of Soil + Cont. (gm)		399.74	240.54
Weight of Container (gm)	116.76	116.76	116.76
Weight of Dry Soil (gm)	282.98	282.98	123.78
Moisture Content (%)		14.06	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	10.97	96.12
4"			No. 10		
3"			No. 16	28.38	89.97
2.5"			No. 20		
2.0"			No. 30	51.55	81.78
1.5"			No. 40		
1.0"			No. 50	78.11	72.40
3/4"			No. 60		
1/2"			No. 100	101.83	64.02
3/8"	0.00	100.00	No. 200	123.21	56.46
No. 4	3.37	98.81	Pan	124.02	
Cu :			Gravel	Sand	Fine
Cc :			1	42	57

Remark :

4

Prepared By : R.J	Date : 10/14/02	Tested By : R.J	Date : 10/19/02	Checked By :
Washed By : B.C	Date : 10/14/02	Computed By : S.V	Date : 11/11/02	Date :

Boring No. : ST-9	Depth : (ft) :	
Sample No. : D-2	(m) :	

Description : Very Dark Brown Lean Clay with Sand (CL)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-12	S-12	S-12
Wet Wt. of Soil + Cont. (gm)	447.24	447.24	
Dry Wt. of Soil + Cont. (gm)		404.83	248.98
Weight of Container (gm)	114.36	114.36	114.36
Weight of Dry Soil (gm)	290.47	290.47	134.62
Moisture Content (%)		14.60	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	17.56	93.95
4"			No. 10		
3"			No. 16	41.93	85.56
2.5"			No. 20		
2.0"			No. 30	67.96	76.60
1.5"			No. 40		
1.0"			No. 50	93.49	67.81
3/4"			No. 60		
1/2"			No. 100	114.99	60.41
3/8"	0.00	100.00	No. 200	134.56	53.68
No. 4	3.97	98.63	Pan	134.58	
Cu :			Gravel	Sand	Fine
Cc :			1	45	54

Remark :

5

Prepared By : R.J	Date : 10/14/02	Tested By : R.J	Date : 10/19/02	Checked By :
Washed By : B.C	Date : 10/14/02	Computed By : S.V	Date : 11/11/02	Date :

Boring No. : ST-9	Depth : (ft) : 50.0	
Sample No. : S-11	(m) : 15.25	

Description : Brown Lean Clay with Sand (CL)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-14	S-14	S-14
Wet Wt. of Soil + Cont. (gm)	480.74	480.74	
Dry Wt. of Soil + Cont. (gm)		432.60	265.63
Weight of Container (gm)	115.91	115.91	115.91
Weight of Dry Soil (gm)	316.69	316.69	149.72
Moisture Content (%)		15.20	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	31.50	90.05
4"			No. 10		
3"			No. 16	63.76	79.87
2.5"			No. 20		
2.0"			No. 30	91.66	71.06
1.5"			No. 40		
1.0"			No. 50	116.23	63.30
3/4"			No. 60		
1/2"	0.00	100.00	No. 100	135.66	57.16
3/8"	1.90	99.40	No. 200	149.84	52.69
No. 4	12.38	96.09	Pan	149.91	
Cu :			Gravel	Sand	Fine
Cc :			4	43	53

Remark :

6

PARTICLE SIZE ANALYSIS OF SOIL

ASTM D-422-63 (Rev. 1990) / CT - 202, 203

Project No : 02-134	Project Name : HNTB/Devil's Slide Tunnels
Standard : ☑ CAL. TRAN. ☐ ASTM ☐ OTHER	

Prepared By : R.J	Date : 10/14/02	Tested By : R.J	Date : 10/19/02	Checked By :
Washed By : B.C	Date : 10/14/02	Computed By : S.V	Date : 11/11/02	Date :

Boring No. : 02-20	Depth : (ft) : 65.0
Sample No. : D-13	(m) : 19.83

Description : Dark Yellow Brown Clayey Sand with Gravel (SC)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-22	S-22	S-22
Wet Wt. of Soil + Cont. (gm)	434.05	434.05	
Dry Wt. of Soil + Cont. (gm)		388.75	281.00
Weight of Container (gm)	115.20	115.20	115.20
Weight of Dry Soil (gm)	273.55	273.55	165.8
Moisture Content (%)		16.56	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	29.55	89.20
4"			No. 10		
3"			No. 16	49.57	81.88
2.5"			No. 20		
2.0"			No. 30	75.27	72.48
1.5"			No. 40		
1.0"			No. 50	106.28	61.15
3/4"	0.00	100.00	No. 60		
1/2"	5.50	97.99	No. 100	140.16	48.76
3/8"	7.21	97.36	No. 200	165.63	39.45
No. 4	15.62	94.29	Pan	165.87	
Cu :			Gravel	Sand	Fine
Cc :			6	54	40

Remark :

7

Prepared By : R.J	Date : 10/14/02	Tested By : R.J	Date : 10/19/02	Checked By :
Washed By : B.C	Date : 10/14/02	Computed By : S.V	Date : 11/11/02	Date :

Boring No. : 02-20	Depth : (ft) : 30.0
Sample No. : S-6	(m) : 9.15

Description : Dark Yellowish Brown Clayey Sand (SC/SM)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-8	S-8	S-8
Wet Wt. of Soil + Cont. (gm)	412.66	412.66	
Dry Wt. of Soil + Cont. (gm)		377.77	332.69
Weight of Container (gm)	118.30	118.30	118.30
Weight of Dry Soil (gm)	259.47	259.47	214.39
Moisture Content (%)		13.45	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	57.86	77.70
4"			No. 10		
3"			No. 16	112.53	56.63
2.5"			No. 20		
2.0"			No. 30	151.09	41.77
1.5"			No. 40		
1.0"			No. 50	177.75	31.49
3/4"			No. 60		
1/2"			No. 100	198.32	23.57
3/8"	0.00	100.00	No. 200	213.75	17.62
No. 4	11.09	95.73	Pan	214.65	
Cu :			Gravel	Sand	Fine
Cc :			4	78	18

Remark :

8

Prepared By : R.J	Date : 10/14/02	Tested By : R.J	Date : 10/19/02	Checked By :
Washed By : B.C	Date : 10/14/02	Computed By : S.V	Date : 11/11/02	Date :

Boring No. : 02-19	Depth : (ft) : 35.0
Sample No. : D-7	(m) : 10.68

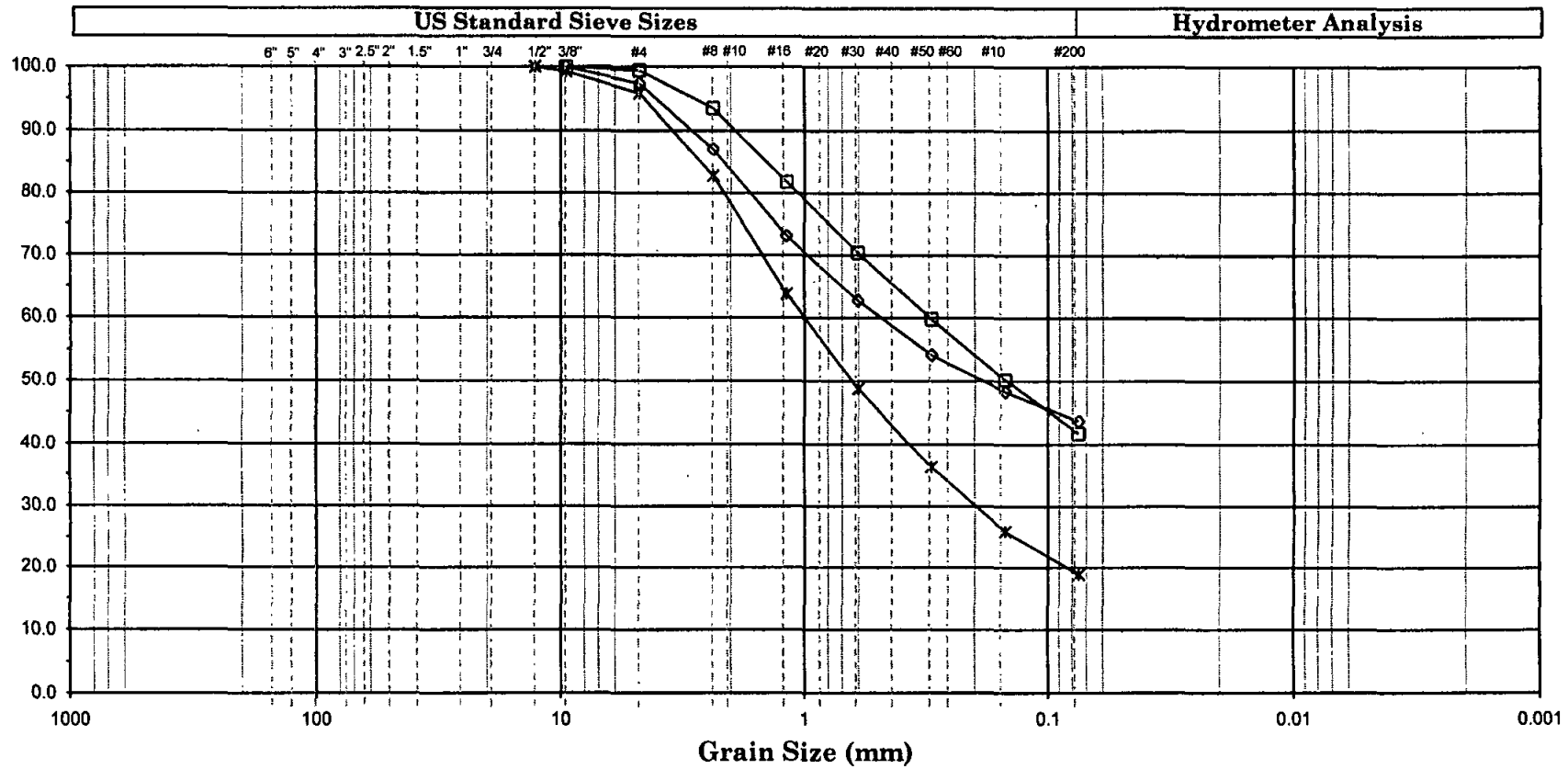
Description : Dark Brown Silty Sand (SM)

	Before Washing Sample		After Wet Sieve
	Tested	Moisture	
Container Number	S-18	S-18	S-18
Wet Wt. of Soil + Cont. (gm)	474.98	474.98	
Dry Wt. of Soil + Cont. (gm)		430.07	382.82
Weight of Container (gm)	115.68	115.68	115.68
Weight of Dry Soil (gm)	314.39	314.39	267.14
Moisture Content (%)		14.28	

Sieve	Cimulative Weight	(%)	Sieve	Cimulative Weight	(%)
5"			No. 8	59.95	80.93
4"			No. 10		
3"			No. 16	123.71	60.65
2.5"			No. 20		
2.0"			No. 30	178.08	43.36
1.5"			No. 40		
1.0"			No. 50	219.05	30.33
3/4"			No. 60		
1/2"	0.00	100.00	No. 100	248.25	21.04
3/8"	2.97	99.06	No. 200	267.25	14.99
No. 4	17.35	94.48	Pan	267.39	
Cu :			Gravel	Sand	Fine
Cc :			6	79	15

Remark :

9



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
□	ST-2	S-7	30.0	31.5	9.15	9.61	Yellowish Red	Clayey Sand	SC
✳	ST-7	S-5	20.0	21.5	6.10	6.56	Brown to Dark Brown	Silty Sand	SM
◇	ST-6	S-3	10.0	11.5	3.05	3.51	Dark Olive Brown	Clayey Sand	SC
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

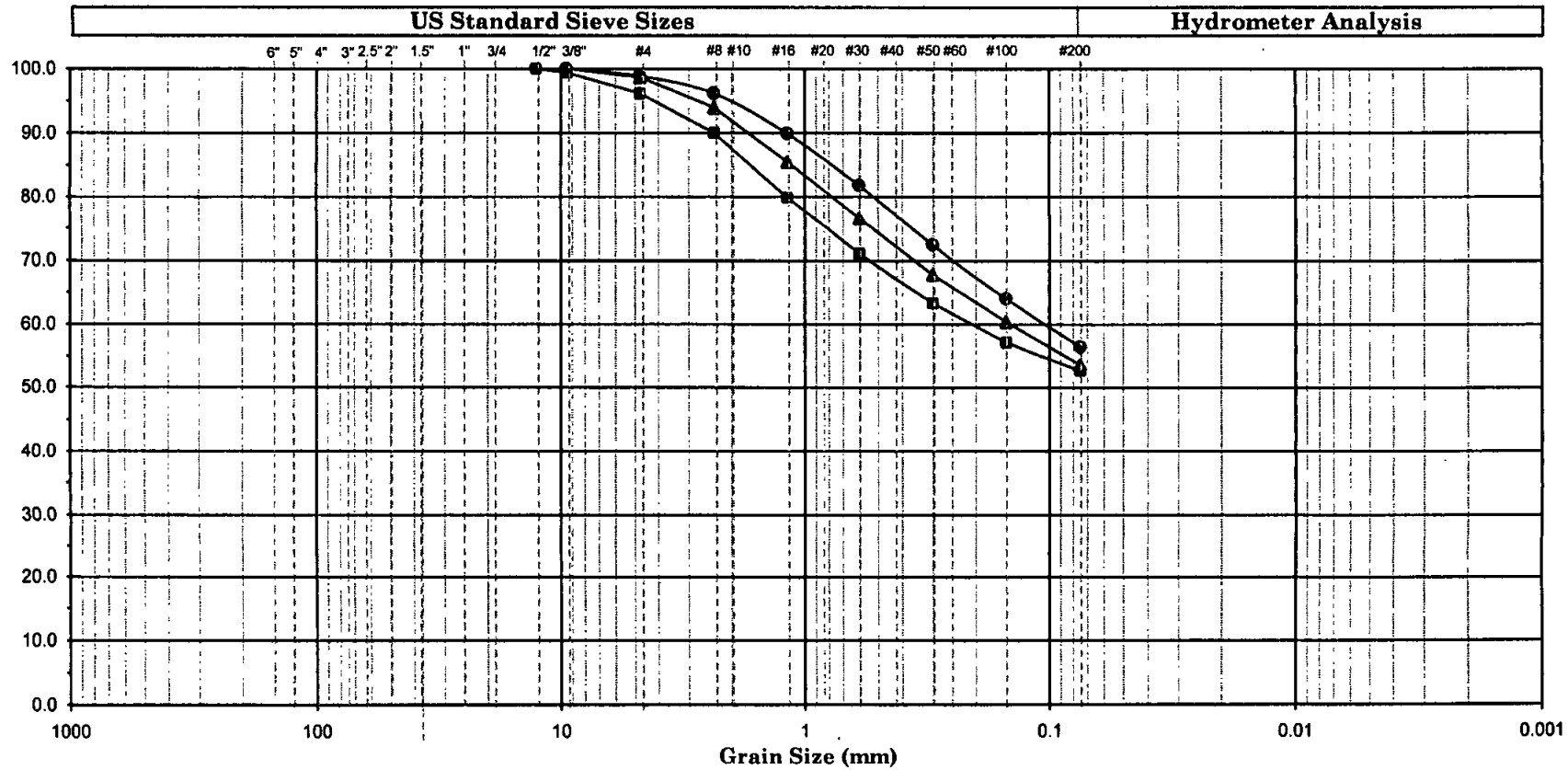
HNTB/Devil's Silde Tunnels

Project No. : 02-134 T.O.2B Date : 11/11/02

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	ST-5	S-1	2.5	4.0	0.76	1.22	Brwon to Dark Yellow-Brown	Lean Clay with Sand	CL
▲	ST-9	D-2	5.0	6.5	1.53	1.98	Very Dark Brown	Lean Clay with Sand	CL
■	ST-9	S-11	50.0	51.5	15.25	15.71	Brown	Lean Clay with Sand	CL
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

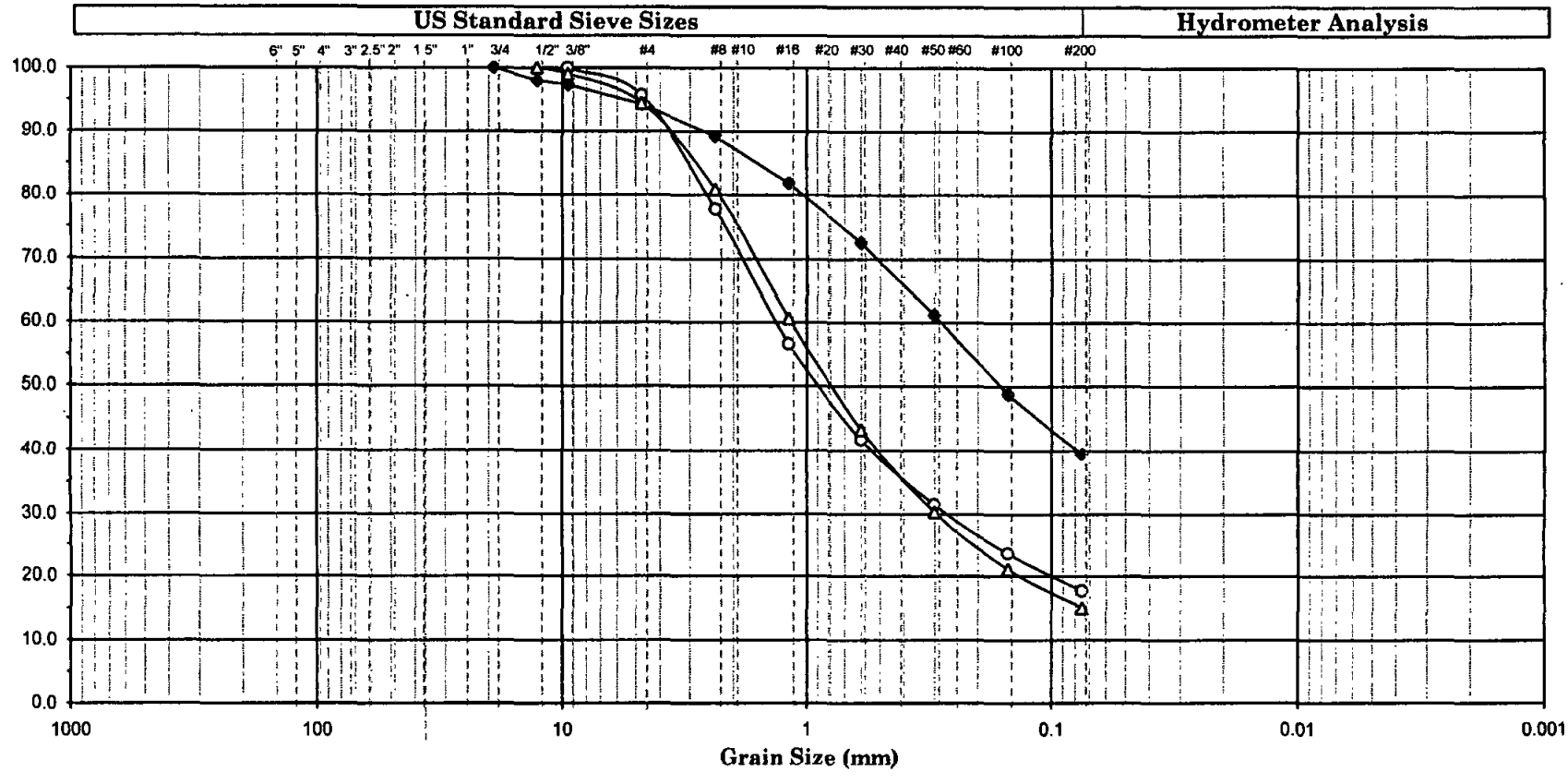
HNTB/Devil's Silde Tunnels

Project No. : 02-134 T.O.2B **Date : 11/11/02**

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
◆	02-20	D-13	65.0	66.5	19.83	20.28	Dark Yellow-Brown	Clayey Sand	SC
○	02-20	S-6	30.0	31.5	9.15	9.61	Dark Yellow-Brown	Clayey Sand	SC
△	02-19	D-7	35.0	36.5	10.68	11.13	Dark Brown	Silty Sand	SM
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

HNTB/Devil's Silde Tunnels

Project No. : 02-134 T.O.2B Date : 11/11/02

GRAIN SIZE ANALYSIS

(ASTM D-422-63)

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-90

Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : ST-1		Saturated	x	Field Moisiture	x	Inundated		**Specific Gravity** (Assumed) : 2.70	
Sample No. : D-4	x	Undisturbed		Remolded		Consolidated-Drained		**Shear Rate** (inch/min) : 0.02	
Depth (ft/m) : 15.0 4.58	x	Shear Once		Reshear		Residual		**Data File Number :** 213401	
Description : Sand with Silt and Gravel (SP-SM)									

Percent Saturation (%)	111.77	**File No. :**	213401 1																	
Prepared By : RJ	**Date :** 10/18/02	**Normal Stress**																		
Tested By : RJ	**Date :** 10/18/02																			
Computed By : LCC	**Date :** 10/23/02	1.00	(ksf)																	
Checked By :	**Date :**																			
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		204.83																		
Weight of Ring (gm)		43.61																		
Weight of Wet Soil + Cont. (gm)				173.30																
Weight of Dry Soil + Cont. (gm)				149.38																
Weight of Cont. (gm) No.				3.64																
Moisture Content (%)		10.62		16.41																
Wet Density (pcf / kN/m³)		133.53	21.02	140.52	22.12															
Dry Density (pcf / kN/m³)		120.71	19.00	120.71	19.00															
Percent Saturation (%)	126.96	**File No. :**	213401 2																	
Prepared By : RJ	**Date :** 10/18/02	**Normal Stress**																		
Tested By : RJ	**Date :** 10/18/02	2.00	(ksf)																	
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		213.41																		
Weight of Ring (gm)		45.46																		
Weight of Wet Soil + Cont. (gm)				180.27																
Weight of Dry Soil + Cont. (gm)				156.26																
Weight of Cont. (gm) No.				3.8																
Moisture Content (%)		10.16		15.75																
Wet Density (pcf / kN/m³)		139.10	21.89	146.16	23.01															
Dry Density (pcf / kN/m³)		126.27	19.88	126.27	19.88															
Percent Saturation (%)	112.05	**File No. :**	213401 3																	
Prepared By : RJ	**Date :** 10/18/02	**Normal Stress**																		
Tested By : RJ	**Date :** 10/18/02	4.00	(ksf)																	
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		208.31																		
Weight of Ring (gm)		45.72																		
Weight of Wet Soil + Cont. (gm)				174.82																
Weight of Dry Soil + Cont. (gm)				151.78																
Weight of Cont. (gm) No.				3.78																
Moisture Content (%)		9.86		15.57																
Wet Density (pcf / kN/m³)		134.66	21.20	141.66	22.30															
Dry Density (pcf / kN/m³)		122.58	19.29	122.58	19.29															

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	1.57	75.27	3.16	151.11	4.88	233.85
Ultimate	1.06	50.56	2.05	98.25	3.77	180.41

Shear Deflection (inch)	(mm)	**Normal Stress (psf/ksf/kPa)** 1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0
0.010	0.03	660	0.66	31.6	768	0.77	36.8	960	0.96	45.8
0.020	0.05	948	0.95	45.4	1200	1.20	57.5	1620	1.62	77.3
0.030	0.08	1116	1.12	53.4	1536	1.54	73.5	2196	2.20	104.8
0.040	0.10	1260	1.26	60.3	1824	1.82	87.3	2748	2.75	131.1
0.050	0.13	1380	1.38	66.1	2112	2.11	101.1	3156	3.16	150.5
0.060	0.15	1476	1.48	70.7	2352	2.35	112.6	3516	3.52	167.7
0.070	0.18	1524	1.52	73.0	2580	2.58	123.5	3804	3.80	181.5
0.080	0.20	1572	1.57	75.3	2772	2.77	132.7	4056	4.06	193.5
0.090	0.23	1572	1.57	75.3	2904	2.90	139.0	4308	4.31	205.5
0.100	0.25	1560	1.56	74.7	3036	3.04	145.4	4500	4.50	214.7
0.110	0.28	1548	1.55	74.1	3108	3.11	148.8	4656	4.66	222.1
0.120	0.30	1524	1.52	73.0	3144	3.14	150.5	4812	4.81	229.5
0.130	0.33	1500	1.50	71.8	3156	3.16	151.1	4884	4.88	233.0
0.140	0.36	1464	1.46	70.1	3144	3.14	150.5	4884	4.88	233.0
0.150	0.38	1452	1.45	69.5	3132	3.13	150.0	4860	4.86	231.8
0.160	0.41	1452	1.45	69.5	3084	3.08	147.7	4740	4.74	226.1
0.170	0.43	1404	1.40	67.2	3048	3.05	145.9	4716	4.72	225.0
0.180	0.46	1380	1.38	66.1	3012	3.01	144.2	4644	4.64	221.5
0.190	0.48	1284	1.28	61.5	2916	2.92	139.6	4596	4.60	219.2
0.200	0.51	1296	1.30	62.1	2832	2.83	135.6	4536	4.54	216.4
0.210	0.53	1260	1.26	60.3	2724	2.72	130.4	4452	4.45	212.4
0.220	0.56	1260	1.26	60.3	2700	2.70	129.3	4392	4.39	209.5
0.230	0.58	1224	1.22	58.6	2676	2.68	128.1	4320	4.32	206.1
0.240	0.61	1224	1.22	58.6	2604	2.60	124.7	4296	4.30	204.9
0.250	0.64	1236	1.24	59.2	2484	2.48	118.9	4236	4.24	202.1
0.260	0.66	1188	1.19	56.9	2436	2.44	116.6	4176	4.18	199.2
0.270	0.69	1164	1.16	55.7	2424	2.42	116.1	4128	4.13	196.9
0.280	0.71	1176	1.18	56.3	2388	2.39	114.3	4092	4.09	195.2
0.290	0.74	1164	1.16	55.7	2328	2.33	111.5	4008	4.01	191.2
0.300	0.76	1116	1.12	53.4	2304	2.30	110.3	3924	3.92	187.2
0.310	0.79	1116	1.12	53.4	2208	2.21	105.7	3900	3.90	186.0
0.320	0.81	1092	1.09	52.3	2124	2.12	101.7	3900	3.90	186.0
0.330	0.84	1092	1.09	52.3	2112	2.11	101.1	3828	3.83	182.6
0.340	0.86	1056	1.06	50.6	2064	2.06	98.8	3804	3.80	181.5
0.350	0.89	1056	1.06	50.6	2052	2.05	98.2	3768	3.77	179.7
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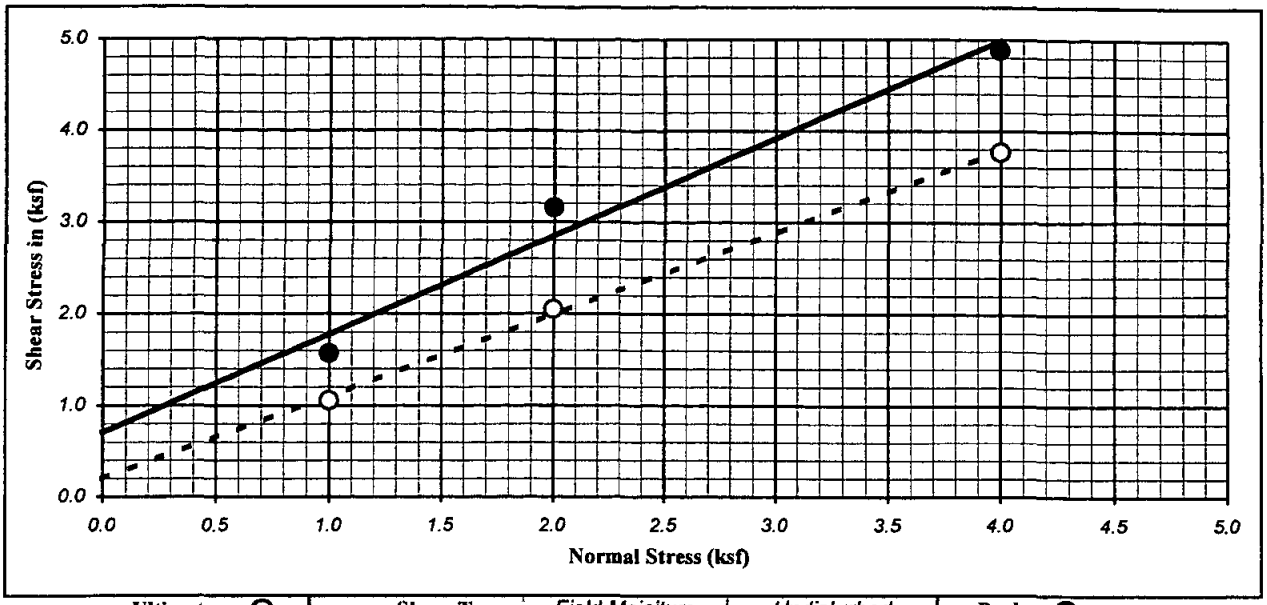
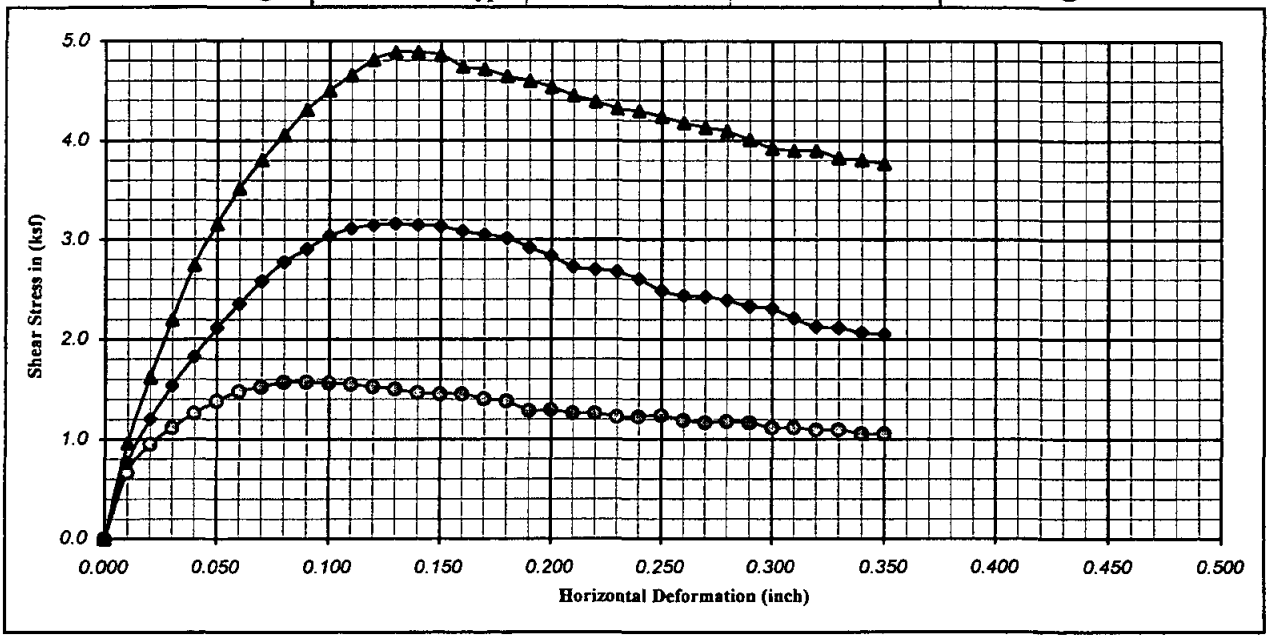


Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: ST-1	**Strength Intercept (C) :**	0.71	(ksf)	**Peak**	0.20	(ksf)	**Ultimate**	
Sample No.	: D-4		33.90	(kPa)		9.48	(kPa)		
Depth (ft/m)	: 15.0 4.58	**Friction Angle (ϕ) :**	46.93	Degree		41.91	Degree		
Description	: Sand with Silt and Gravel (SP-SM)						**Shear Rate** (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	16.41	120.71	19.00	0.40	1.00	47.88	1.57	75.27	1.06	50.56
◆	15.75	126.27	19.88	0.33	2.00	95.76	3.16	151.11	2.05	98.25
▲	15.57	122.58	19.29	0.38	4.00	191.52	4.88	233.85	3.77	180.41

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | **Date :** 10/18/02 | **Figure No. :**

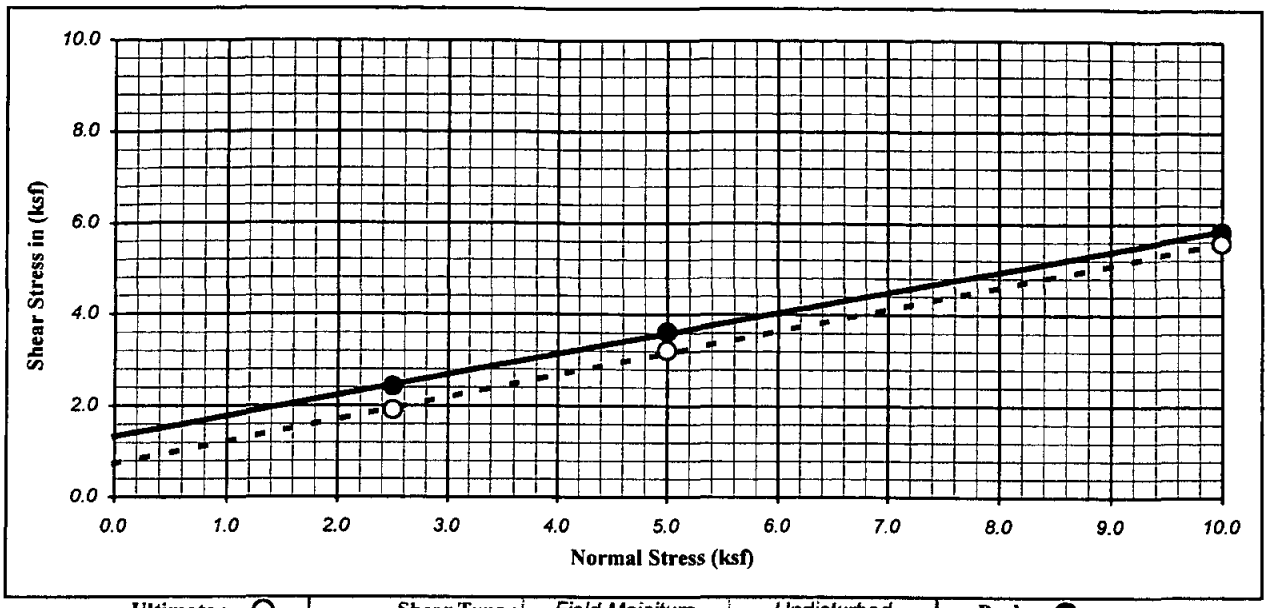
DIRECT SHEAR TEST

ASTM D-3080-90

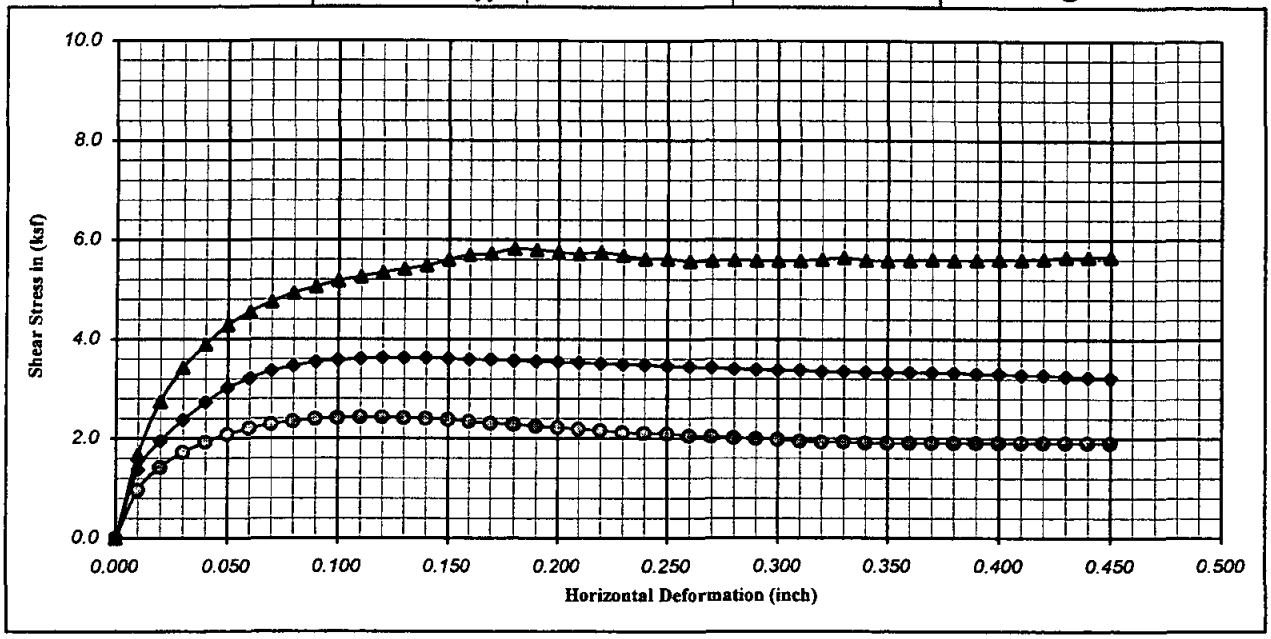
Project No.: 02-134 **Project Name:** Devil's Slide Tunnel

Boring No.: ST-2			Saturated	x	Field Moisiture	x	Inundated	**Specific Gravity (Assumed):** 2.70	
Sample No.: D-4		x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate (inch/min):** 0.015	
Depth (ft/m): 15.0	4.58	x	Shear Once		Reshear		Residual	**Data File Number:** 213402	
Description: Lean Clay with Sand and Gravel (CL)									

Precent Saturation (%)	105.71	**File No.:**	213402 1				**Shear Deflection**		**Normal Stress (psf/ksf/kPa)**											
Prepared By: RJ	**Date:** 10/12/02	**Normal Stress**							2500	2.50	119.7	5000	5.0	239.4	10000	10.0	478.8	
Tested By: RJ	**Date:** 10/12/02																			
Computed By: LCC	**Date:** 10/18/02	2.50	(ksf)				(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**											
Checked By:	**Date:**						0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0			
Precent Consolidation (%)		**Before**		**After**			0.010	0.03	960	0.96	46.0	1368	1.37	65.5	1668	1.67	79.6			
Height of Sample (inch)		1.00		1.0000			0.020	0.05	1416	1.42	67.8	1944	1.94	93.1	2736	2.74	130.5			
Diameter of Sample (inch)		2.42		2.42			0.030	0.08	1716	1.72	82.2	2364	2.36	113.2	3420	3.42	163.1			
Dial Reading-Consolidation (inch)							0.040	0.10	1920	1.92	91.9	2724	2.72	130.4	3900	3.90	186.0			
Weight of Soil + Ring (gm)		201.46					0.050	0.13	2076	2.08	99.4	3012	3.01	144.2	4284	4.28	204.4			
Weight of Ring (gm)		43.46					0.060	0.15	2196	2.20	105.1	3204	3.20	153.4	4548	4.55	216.9			
Weight of Wet Soil + Cont. (gm)				164.63			0.070	0.18	2280	2.28	109.2	3360	3.36	160.9	4752	4.75	226.7			
Weight of Dry Soil + Cont. (gm)				137.25			0.080	0.20	2340	2.34	112.0	3456	3.46	165.5	4932	4.93	235.3			
Weight of Cont. (gm) No.				3.66			0.090	0.23	2388	2.39	114.3	3540	3.54	169.5	5052	5.05	241.0			
Moisture Content (%)		18.27		20.50			0.100	0.25	2412	2.41	115.5	3576	3.58	171.2	5172	5.17	246.7			
Wet Density (pcf / kN/m³)		130.86	20.60	133.32	20.98		0.110	0.28	2424	2.42	116.1	3600	3.60	172.4	5256	5.26	250.7			
Dry Density (pcf / kN/m³)		110.64	17.42	110.64	17.42		0.120	0.30	2424	2.42	116.1	3624	3.62	173.5	5340	5.34	254.7			
Precent Saturation (%)	104.56	**File No.:**	213402 2				0.130	0.33	2412	2.41	115.5	3624	3.62	173.5	5412	5.41	258.2			
Prepared By: RJ	**Date:** 10/12/02	**Normal Stress**					0.140	0.36	2400	2.40	114.9	3624	3.62	173.5	5483	5.48	261.6			
Tested By: RJ	**Date:** 10/12/02	5.00	(ksf)				0.150	0.38	2376	2.38	113.8	3612	3.61	172.9	5603	5.60	267.3			
Precent Consolidation (%)		**Before**		**After**			0.160	0.41	2340	2.34	112.0	3588	3.59	171.8	5699	5.70	271.9			
Height of Sample (inch)		1.00		1.0000			0.170	0.43	2304	2.30	110.3	3588	3.59	171.8	5723	5.72	273.0			
Diameter of Sample (inch)		2.42		2.42			0.180	0.46	2280	2.28	109.2	3564	3.56	170.6	5819	5.82	277.6			
Dial Reading-Consolidation (inch)							0.190	0.48	2244	2.24	107.4	3552	3.55	170.1	5795	5.80	276.4			
Weight of Soil + Ring (gm)		207.70					0.200	0.51	2220	2.22	106.3	3540	3.54	169.5	5747	5.75	274.1			
Weight of Ring (gm)		45.38					0.210	0.53	2184	2.18	104.6	3528	3.53	168.9	5723	5.72	273.0			
Weight of Wet Soil + Cont. (gm)				167.12			0.220	0.56	2160	2.16	103.4	3504	3.50	167.8	5747	5.75	274.1			
Weight of Dry Soil + Cont. (gm)				141.79			0.230	0.58	2124	2.12	101.7	3492	3.49	167.2	5687	5.69	271.3			
Weight of Cont. (gm) No.				3.68			0.240	0.61	2100	2.10	100.5	3480	3.48	166.6	5615	5.62	267.8			
Moisture Content (%)		17.53		18.34			0.250	0.64	2088	2.09	100.0	3456	3.46	165.5	5615	5.62	267.8			
Wet Density (pcf / kN/m³)		134.44	21.16	135.37	21.31		0.260	0.66	2052	2.05	98.2	3444	3.44	164.9	5567	5.57	265.6			
Dry Density (pcf / kN/m³)		114.39	18.00	114.39	18.00		0.270	0.69	2040	2.04	97.7	3420	3.42	163.7	5579	5.58	266.1			
Precent Saturation (%)	109.19	**File No.:**	213402 3				0.280	0.71	2016	2.02	96.5	3396	3.40	162.6	5591	5.59	266.7			
Prepared By: RJ	**Date:** 10/12/02	**Normal Stress**					0.290	0.74	1992	1.99	95.4	3384	3.38	162.0	5579	5.58	266.1			
Tested By: RJ	**Date:** 10/12/02	10.00	(ksf)				0.300	0.76	1980	1.98	94.8	3372	3.37	161.5	5579	5.58	266.1			
Precent Consolidation (%)		**Before**		**After**			0.310	0.79	1944	1.94	93.1	3372	3.37	161.5	5579	5.58	266.1			
Height of Sample (inch)		1.00		1.0000			0.320	0.81	1932	1.93	92.5	3348	3.35	160.3	5603	5.60	267.3			
Diameter of Sample (inch)		2.42		2.42			0.330	0.84	1932	1.93	92.5	3348	3.35	160.3	5639	5.64	269.0			
Dial Reading-Consolidation (inch)							0.340	0.86	1908	1.91	91.4	3336	3.34	159.7	5591	5.59	266.7			
Weight of Soil + Ring (gm)		208.98					0.350	0.89	1908	1.91	91.4	3324	3.32	159.2	5579	5.58	266.1			
Weight of Ring (gm)		44.76					0.360	0.91	1908	1.91	91.4	3336	3.34	159.1	5591	5.59	266.7			
Weight of Wet Soil + Cont. (gm)				169.31			0.370	0.94	1908	1.91	91.4	3324	3.32	158.6	5603	5.60	267.3			
Weight of Dry Soil + Cont. (gm)				143.57			0.380	0.97	1908	1.91	91.4	3324	3.32	158.6	5591	5.59	266.7			
Weight of Cont. (gm) No.				3.7			0.390	0.99	1908	1.91	91.4	3300	3.30	157.4	5591	5.59	266.7			
Moisture Content (%)		17.41		18.40			0.400	1.02	1908	1.91	91.4	3300	3.30	157.4	5603	5.60	267.3			
Wet Density (pcf / kN/m³)		136.01	21.41	137.16	21.59		0.410	1.04	1908	1.91	91.4	3276	3.28	156.3	5603	5.60	267.3			
Dry Density (pcf / kN/m³)		115.84	18.23	115.84	18.23		0.420	1.07	1908	1.91	91.4	3276	3.28	156.3	5615	5.62	267.8			
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)	0.430	1.09	1908	1.91	91.4	3252	3.25	155.1	5651	5.65	269.6			
Peak	2.42	116.06	3.62	173.52	5.82	278.61	0.440	1.12	1908	1.91	91.4	3228	3.23	154.0	5651	5.65	269.6			
Ultimate	1.91	91.36	3.22	153.98	5.57	266.55	0.450	1.14	1908	1.91	91.4	3216	3.22	153.4	5663	5.66	270.1			



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : ST-2		**Strength Intercept (C) :**	1.33	(ksf)	**Peak**	0.73	(ksf)	**Ultimate**	
Sample No. : D-4			63.51	(kPa)		35.07	(kPa)		
Depth (ft/m) : 15.0	4.58	**Friction Angle (ϕ) :**	24.26	Degree		25.89	Degree		
Description : Lean Clay with Sand and Gravel (CL)							**Shear Rate** (inch/minute) :		0.015

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
⊙	20.50	110.64	17.42	0.52	2.50	119.70	2.42	116.06	1.91	91.36
◆	18.34	114.39	18.00	0.47	5.00	239.40	3.62	173.52	3.22	153.98
▲	18.40	115.84	18.23	0.46	10.00	478.80	5.82	278.61	5.57	266.55

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | **Date :** 10/12/02

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-90

Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : ST-2			Saturated	x	Field Moisiture	x	Inundated	**Specific Gravity** (Assumed) :	2.70
Sample No. : D-10		x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate** (inch/min) :	0.02
Depth (ft/m) :	45.0 / 13.73	x	Shear Once		Reshear		Residual	**Data File Number :**	213403
Description :	Lean Clay with Sand and Gravel (CL)								

Percent Saturation (%)	90.78	**File No. :**	213403 1																
Prepared By : RJ	**Date :** 10/18/02	**Normal Stress**																	
Tested By : RJ	**Date :** 10/18/02																		
Computed By : LCC	**Date :** 10/23/02	2.50	(ksf)																
Checked By :	**Date :**																		
Percent Consolidation (%)		**Before**		**After**															
Height of Sample (inch)		1.00		1.0000															
Diameter of Sample (inch)		2.42		2.42															
Dial Reading-Consolidation (inch)																			
Weight of Soil + Ring (gm)		205.13																	
Weight of Ring (gm)		44.48																	
Weight of Wet Soil + Cont. (gm)				161.77															
Weight of Dry Soil + Cont. (gm)				138.80															
Weight of Cont. (gm) **No.**				3.6															
Moisture Content (%)		18.82		16.99															
Wet Density (pcf / kN/m³)		133.05	20.94	131.00	20.62														
Dry Density (pcf / kN/m³)		111.98	17.63	111.98	17.63														
Percent Saturation (%)	90.70	**File No. :**	213403 2																
Prepared By : RJ	**Date :** 10/18/02	**Normal Stress**																	
Tested By : RJ	**Date :** 10/18/02	5.00	(ksf)																
Percent Consolidation (%)		**Before**		**After**															
Height of Sample (inch)		1.00		1.0000															
Diameter of Sample (inch)		2.42		2.42															
Dial Reading-Consolidation (inch)																			
Weight of Soil + Ring (gm)		203.42																	
Weight of Ring (gm)		42.91																	
Weight of Wet Soil + Cont. (gm)				160.86															
Weight of Dry Soil + Cont. (gm)				137.47															
Weight of Cont. (gm) **No.**				3.58															
Moisture Content (%)		19.88		17.47															
Wet Density (pcf / kN/m³)		132.94	20.92	130.26	20.50														
Dry Density (pcf / kN/m³)		110.89	17.45	110.89	17.45														
Percent Saturation (%)	85.04	**File No. :**	213403 3																
Prepared By : RJ	**Date :** 10/18/02	**Normal Stress**																	
Tested By : RJ	**Date :** 10/18/02	10.00	(ksf)																
Percent Consolidation (%)		**Before**		**After**															
Height of Sample (inch)		1.00		1.0000															
Diameter of Sample (inch)		2.42		2.42															
Dial Reading-Consolidation (inch)																			
Weight of Soil + Ring (gm)		206.10																	
Weight of Ring (gm)		45.22																	
Weight of Wet Soil + Cont. (gm)				160.36															
Weight of Dry Soil + Cont. (gm)				138.87															
Weight of Cont. (gm) **No.**				3.58															
Moisture Content (%)		18.91		15.88															
Wet Density (pcf / kN/m³)		133.25	20.97	129.85	20.44														
Dry Density (pcf / kN/m³)		112.05	17.64	112.05	17.64														

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	1.90	90.78	3.40	162.60	6.67	319.41
Ultimate	1.75	83.89	3.28	156.85	6.23	298.15

Shear Deflection		**Normal Stress (psf/ksf/kPa)**								
		2500	2.50	119.7	5000	5.0	239.4	10000	10.0	478.8
(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**								
0.000	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0
0.010	0.03	588	0.59	28.2	1164	1.16	55.7	1548	1.55	73.8
0.020	0.05	588	0.59	28.2	1608	1.61	77.0	2388	2.39	113.9
0.030	0.08	660	0.66	31.6	1920	1.92	91.9	3012	3.01	143.7
0.040	0.10	840	0.84	40.2	2184	2.18	104.6	3528	3.53	168.3
0.050	0.13	1092	1.09	52.3	2412	2.41	115.5	4128	4.13	196.9
0.060	0.15	1260	1.26	60.3	2604	2.60	124.7	4500	4.50	214.7
0.070	0.18	1380	1.38	66.1	2760	2.76	132.1	4824	4.82	230.1
0.080	0.20	1452	1.45	69.5	2880	2.88	137.9	5076	5.08	242.1
0.090	0.23	1572	1.57	75.3	3000	3.00	143.6	5328	5.33	254.2
0.100	0.25	1632	1.63	78.1	3084	3.08	147.7	5531	5.53	263.8
0.110	0.28	1716	1.72	82.2	3168	3.17	151.7	5723	5.72	273.0
0.120	0.30	1764	1.76	84.5	3216	3.22	154.0	5879	5.88	280.4
0.130	0.33	1800	1.80	86.2	3264	3.26	156.3	6023	6.02	287.3
0.140	0.36	1836	1.84	87.9	3300	3.30	158.0	6131	6.13	292.5
0.150	0.38	1860	1.86	89.1	3300	3.30	158.0	6227	6.23	297.0
0.160	0.41	1884	1.88	90.2	3312	3.31	158.6	6311	6.31	301.0
0.170	0.43	1896	1.90	90.8	3276	3.28	156.9	6275	6.28	299.3
0.180	0.46	1896	1.90	90.8	3276	3.28	156.9	6467	6.47	308.5
0.190	0.48	1896	1.90	90.8	3288	3.29	157.4	6503	6.50	310.2
0.200	0.51	1884	1.88	90.2	3300	3.30	158.0	6551	6.55	312.5
0.210	0.53	1896	1.90	90.8	3312	3.31	158.6	6587	6.59	314.2
0.220	0.56	1896	1.90	90.8	3312	3.31	158.6	6599	6.60	314.8
0.230	0.58	1884	1.88	90.2	3324	3.32	159.2	6611	6.61	315.4
0.240	0.61	1884	1.88	90.2	3336	3.34	159.7	6647	6.65	317.1
0.250	0.64	1860	1.86	89.1	3348	3.35	160.3	6635	6.64	316.5
0.260	0.66	1812	1.81	86.8	3348	3.35	160.3	6671	6.67	318.2
0.270	0.69	1800	1.80	86.2	3348	3.35	160.3	6659	6.66	317.6
0.280	0.71	1812	1.81	86.8	3384	3.38	162.0	6647	6.65	317.1
0.290	0.74	1812	1.81	86.8	3396	3.40	162.6	6623	6.62	315.9
0.300	0.76	1800	1.80	86.2	3372	3.37	161.5	6647	6.65	317.1
0.310	0.79	1788	1.79	85.6	3336	3.34	159.7	6635	6.64	316.5
0.320	0.81	1788	1.79	85.6	3300	3.30	158.0	6659	6.66	317.6
0.330	0.84	1788	1.79	85.6	3312	3.31	158.6	6635	6.64	316.5
0.340	0.86	1752	1.75	83.9	3276	3.28	156.9	6635	6.64	316.5
0.350	0.89	1752	1.75	83.9	3276	3.28	156.9	6635	6.64	316.5
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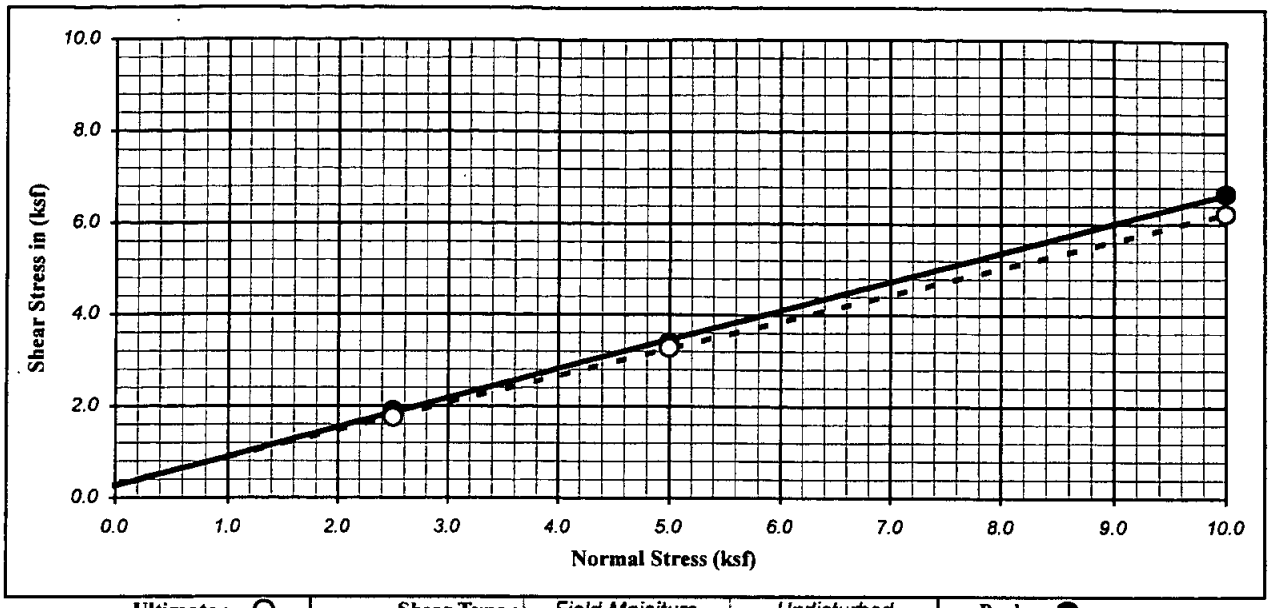
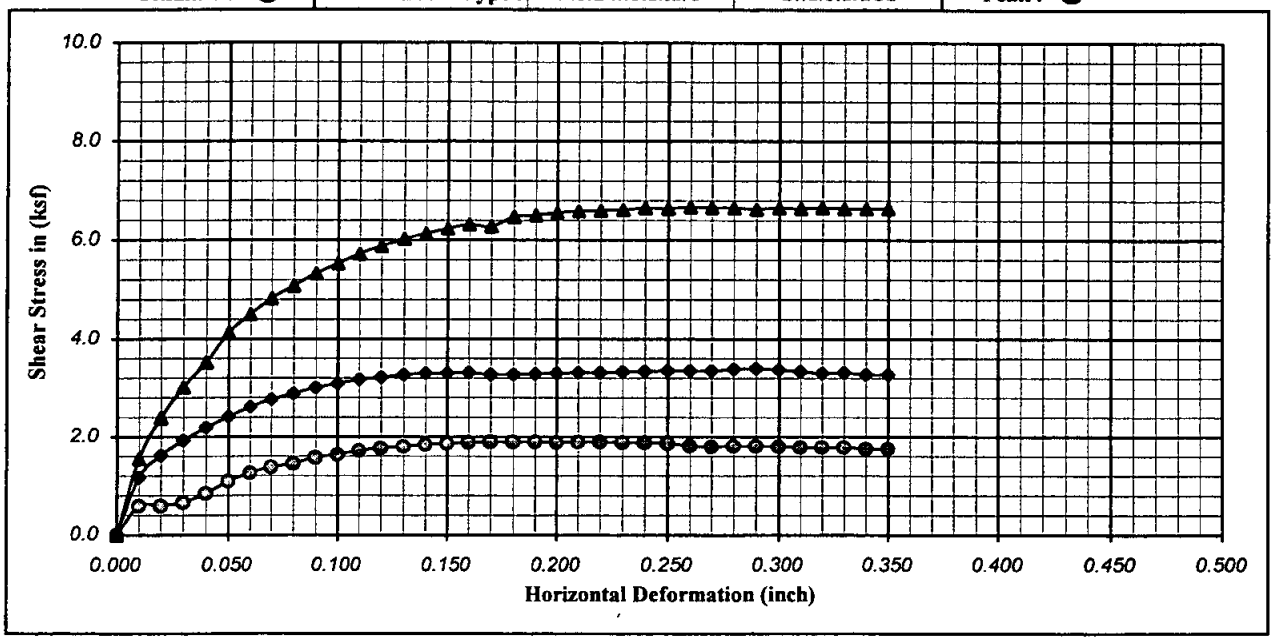


Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : ST-2		Strength Intercept (C) :	0.26	(ksf)	Peak	0.28	(ksf)	Ultimate
Sample No. : D-10			12.38	(kPa)		13.24	(kPa)	
Depth (ft/m) : 45.0	13.73	Friction Angle (ϕ) :	32.59	Degree		30.78	Degree	
Description : Lean Clay with Sand and Gravel (CL)						Shear Rate (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	16.99	111.98	17.63	0.51	2.50	119.70	1.90	90.78	1.75	83.89
◆	17.47	110.89	17.45	0.52	5.00	239.40	3.40	162.60	3.28	156.85
▲	15.88	112.05	17.64	0.50	10.00	478.80	6.67	319.41	6.23	298.15

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | Date : 10/18/02

Figure No. :

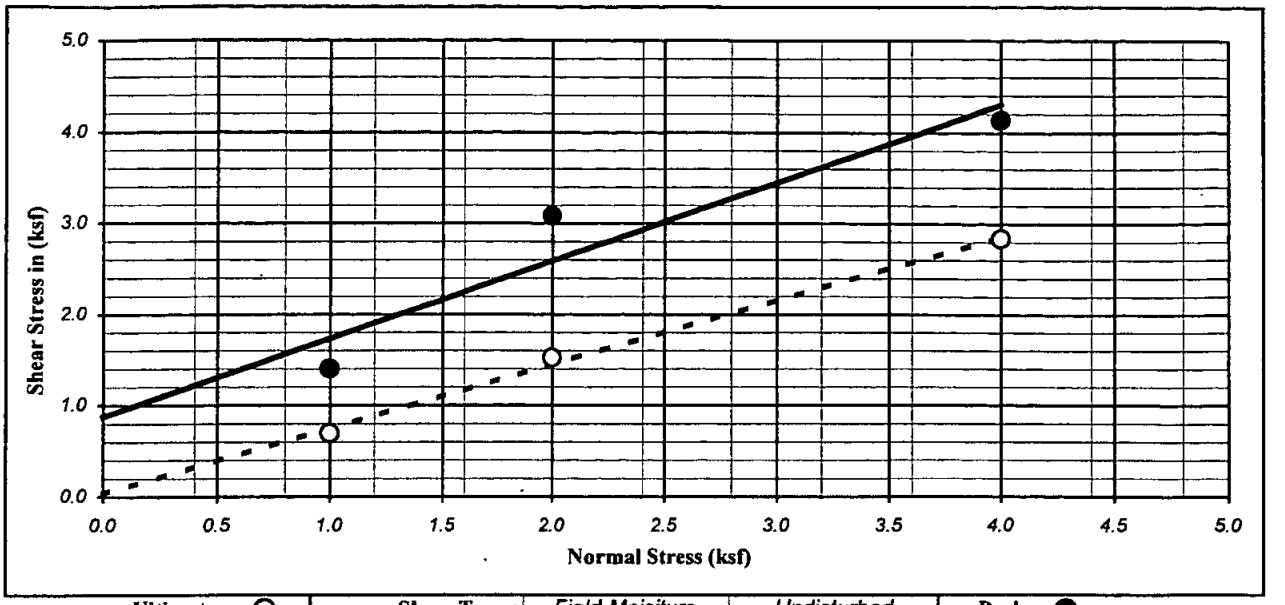
DIRECT SHEAR TEST

ASTM D-3080-90

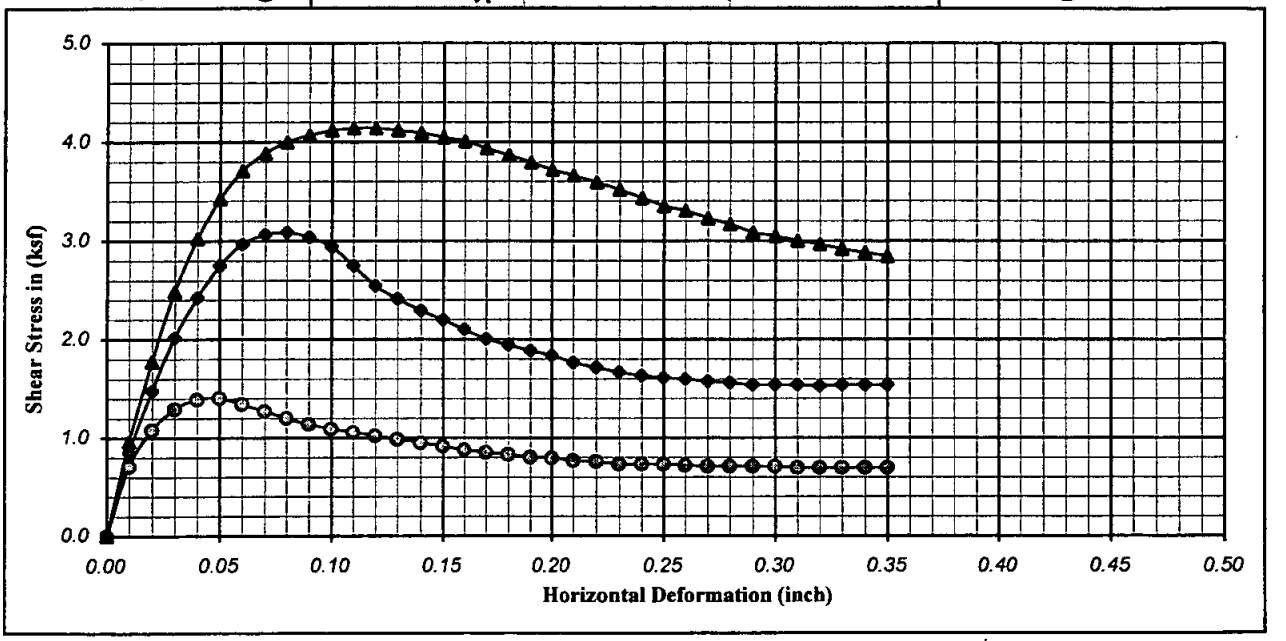
Project No.: 02-134 **Project Name:** Devil's Slide Tunnel

Boring No.: ST-4			Saturated	x	Field Moisiture	x	Inundated	**Specific Gravity** (Assumed): 2.70	
Sample No.: D-2		x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate** (inch/min): 0.02	
Depth (ft/m): 5.0	1.53	x	Shear Once		Reshear		Residual	**Data File Number:** 213404	
Description: Silty Sand with Gravel (SM)									

Percent Saturation (%)	106.45	**File No.:** 213404 1					**Shear Deflection**		**Normal Stress (psf/ksf/kPa)**											
Prepared By: RJ	**Date:** 10/18/02	**Normal Stress**							1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5			
Tested By: RJ	**Date:** 10/18/02						(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**											
Computed By: LCC	**Date:** 10/23/02	1.00	(ksf)				0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0			
Checked By:	**Date:**						0.010	0.03	708	0.71	33.9	852	0.85	40.8	960	0.96	45.8			
Percent Consolidation (%)	0.00	**Before**		**After**			0.020	0.05	1080	1.08	51.7	1476	1.48	70.7	1776	1.78	84.7			
Height of Sample (inch)		1.00		1.0000			0.030	0.08	1296	1.30	62.1	2016	2.02	96.5	2484	2.48	118.5			
Diameter of Sample (inch)		2.42		2.42			0.040	0.10	1392	1.39	66.6	2424	2.42	116.1	3024	3.02	144.3			
Dial Reading-Consolidation (inch)							0.050	0.13	1404	1.40	67.2	2748	2.75	131.6	3420	3.42	163.1			
Weight of Soil + Ring (gm)		203.36					0.060	0.15	1344	1.34	64.4	2964	2.96	141.9	3708	3.71	176.9			
Weight of Ring (gm)		45.52					0.070	0.18	1272	1.27	60.9	3060	3.06	146.5	3888	3.89	185.5			
Weight of Wet Soil + Cont. (gm)				169.54			0.080	0.20	1200	1.20	57.5	3084	3.08	147.7	3996	4.00	190.6			
Weight of Dry Soil + Cont. (gm)				145.08			0.090	0.23	1140	1.14	54.6	3036	3.04	145.4	4068	4.07	194.1			
Weight of Cont. (gm) No.				3.6			0.100	0.25	1092	1.09	52.3	2940	2.94	140.8	4116	4.12	196.3			
Moisture Content (%)		11.56		17.29			0.110	0.28	1056	1.06	50.6	2748	2.75	131.6	4140	4.14	197.5			
Wet Density (pcf / kN/m³)		130.73	20.58	137.44	21.63		0.120	0.30	1020	1.02	48.8	2544	2.54	121.8	4140	4.14	197.5			
Dry Density (pcf / kN/m³)		117.18	18.44	117.18	18.44		0.130	0.33	984	0.98	47.1	2412	2.41	115.5	4116	4.12	196.3			
Percent Saturation (%)	102.18	**File No.:** 213404 2					0.140	0.36	948	0.95	45.4	2292	2.29	109.7	4092	4.09	195.2			
Prepared By: RJ	**Date:** 10/18/02	**Normal Stress**					0.150	0.38	912	0.91	43.7	2196	2.20	105.1	4044	4.04	192.9			
Tested By: RJ	**Date:** 10/18/02	2.00	(ksf)				0.160	0.41	876	0.88	41.9	2100	2.10	100.5	4008	4.01	191.2			
Percent Consolidation (%)	0.00	**Before**		**After**			0.170	0.43	852	0.85	40.8	2004	2.00	96.0	3936	3.94	187.8			
Height of Sample (inch)		1.00		1.0000			0.180	0.46	828	0.83	39.6	1944	1.94	93.1	3864	3.86	184.3			
Diameter of Sample (inch)		2.42		2.42			0.190	0.48	804	0.80	38.5	1884	1.88	90.2	3792	3.79	180.9			
Dial Reading-Consolidation (inch)							0.200	0.51	792	0.79	37.9	1836	1.84	87.9	3720	3.72	177.5			
Weight of Soil + Ring (gm)		201.13					0.210	0.53	768	0.77	36.8	1764	1.76	84.5	3660	3.66	174.6			
Weight of Ring (gm)		41.77					0.220	0.56	756	0.76	36.2	1716	1.72	82.2	3588	3.59	171.2			
Weight of Wet Soil + Cont. (gm)				169.60			0.230	0.58	732	0.73	35.0	1668	1.67	79.9	3516	3.52	167.7			
Weight of Dry Soil + Cont. (gm)				146.76			0.240	0.61	732	0.73	35.0	1632	1.63	78.1	3432	3.43	163.7			
Weight of Cont. (gm) No.				3.59			0.250	0.64	732	0.73	35.0	1608	1.61	77.0	3348	3.35	159.7			
Moisture Content (%)		11.31		15.95			0.260	0.66	720	0.72	34.5	1596	1.60	76.4	3300	3.30	157.4			
Wet Density (pcf / kN/m³)		131.99	20.77	137.49	21.64		0.270	0.69	708	0.71	33.9	1572	1.57	75.3	3228	3.23	154.0			
Dry Density (pcf / kN/m³)		118.58	18.66	118.58	18.66		0.280	0.71	708	0.71	33.9	1560	1.56	74.7	3168	3.17	151.1			
Percent Saturation (%)	93.89	**File No.:** 213404 3					0.290	0.74	708	0.71	33.9	1536	1.54	73.5	3084	3.08	147.1			
Prepared By: RJ	**Date:** 10/18/02	**Normal Stress**					0.300	0.76	708	0.71	33.9	1536	1.54	73.5	3048	3.05	145.4			
Tested By: RJ	**Date:** 10/18/02	4.00	(ksf)				0.310	0.79	696	0.70	33.3	1536	1.54	73.5	3000	3.00	143.1			
Percent Consolidation (%)	0.00	**Before**		**After**			0.320	0.81	696	0.70	33.3	1524	1.52	73.0	2964	2.96	141.4			
Height of Sample (inch)		1.00		1.0000			0.330	0.84	696	0.70	33.3	1536	1.54	73.5	2916	2.92	139.1			
Diameter of Sample (inch)		2.42		2.42			0.340	0.86	696	0.70	33.3	1536	1.54	73.5	2880	2.88	137.4			
Dial Reading-Consolidation (inch)							0.350	0.89	696	0.70	33.3	1536	1.54	73.5	2844	2.84	135.7			
Weight of Soil + Ring (gm)		200.20						0.00												
Weight of Ring (gm)		44.65						0.00												
Weight of Wet Soil + Cont. (gm)				165.52				0.00												
Weight of Dry Soil + Cont. (gm)				143.34				0.00												
Weight of Cont. (gm) No.				3.6				0.00												
Moisture Content (%)		11.31		15.87				0.00												
Wet Density (pcf / kN/m³)		128.83	20.28	134.11	21.11			0.00												
Dry Density (pcf / kN/m³)		115.74	18.22	115.74	18.22			0.00												
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)		0.00												
Peak	1.40	67.22	3.08	147.66	4.14	198.22		0.00												
Ultimate	0.70	33.32	1.52	72.97	2.84	136.17		0.00												



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: ST-4		**Strength Intercept (C) :**	0.88	(ksf)	**Peak**	0.04	(ksf)	**Ultimate**
Sample No.	: D-2			41.94	(kPa)		1.72	(kPa)	
Depth (ft/m)	: 5.0	1.53	**Friction Angle (ϕ) :**	40.60	Degree		35.30	Degree	
Description	: Silty Sand with Gravel (SM)						**Shear Rate** (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	17.29	117.18	18.44	0.44	1.00	47.88	1.40	67.22	0.70	33.32
◆	15.95	118.58	18.66	0.42	2.00	95.76	3.08	147.66	1.52	72.97
▲	15.87	115.74	18.22	0.46	4.00	191.52	4.14	198.22	2.84	136.17

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | **Date :** 10/18/02 | **Figure No. :**

DIRECT SHEAR TEST

ASTM D-3080-90

Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : ST-4		**Saturated**	x	**Field Moisiture**	x	**Inundated**	**Specific Gravity (Assumed) :** 2.70	
Sample No. : D-4	x	**Undisturbed**		**Remolded**		**Consolidated-Drained**	**Shear Rate (inch/min) :** 0.02	
Depth (ft/m) : 15.0 / 4.58	x	**Shear Once**		**Reshear**		**Residual**	**Data File Number :** 213405	
Description : Clayey Sand with Gravel (SC)								

Precent Saturation (%)	110.43	**File No. :**	213405 1																	
Prepared By : RJ	**Date :** 10/14/02	**Normal Stress**																		
Tested By : RJ	**Date :** 10/14/02																			
Computed By : LCC	**Date :** 10/18/02	1.00	(ksf)																	
Checked By :	**Date :**																			
Precent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		211.99																		
Weight of Ring (gm)		45.13																		
Weight of Wet Soil + Cont. (gm)				172.47																
Weight of Dry Soil + Cont. (gm)				148.31																
Weight of Cont. (gm) No.				3.86																
Moisture Content (%)		15.51		16.73																
Wet Density (pcf / kN/m³)		138.20	21.75	139.65	21.98															
Dry Density (pcf / kN/m³)		119.64	18.83	119.64	18.83															
Precent Saturation (%)	111.43	**File No. :**	213405 2																	
Prepared By : RJ	**Date :** 10/14/02	**Normal Stress**																		
Tested By : RJ	**Date :** 10/14/02	2.00	(ksf)																	
Precent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		210.75																		
Weight of Ring (gm)		44.20																		
Weight of Wet Soil + Cont. (gm)				172.97																
Weight of Dry Soil + Cont. (gm)				148.76																
Weight of Cont. (gm) No.				3.9																
Moisture Content (%)		14.97		16.71																
Wet Density (pcf / kN/m³)		137.94	21.71	140.03	22.04															
Dry Density (pcf / kN/m³)		119.98	18.88	119.98	18.88															
Precent Saturation (%)	107.94	**File No. :**	213405 3																	
Prepared By : RJ	**Date :** 10/14/02	**Normal Stress**																		
Tested By : RJ	**Date :** 10/14/02	4.00	(ksf)																	
Precent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		208.18																		
Weight of Ring (gm)		42.85																		
Weight of Wet Soil + Cont. (gm)				171.67																
Weight of Dry Soil + Cont. (gm)				147.85																
Weight of Cont. (gm) No.				3.91																
Moisture Content (%)		14.86		16.55																
Wet Density (pcf / kN/m³)		136.93	21.55	138.94	21.87															
Dry Density (pcf / kN/m³)		119.21	18.76	119.21	18.76															

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	1.85	88.48	2.76	132.15	4.22	202.25
Ultimate	0.78	37.35	1.57	75.27	2.98	142.49

Shear Deflection		**Normal Stress (psf/ksf/kPa)**								
		1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5
(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**								
0.000	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0
0.010	0.03	684	0.68	32.7	1008	1.01	48.3	1344	1.34	64.1
0.020	0.05	1020	1.02	48.8	1584	1.58	75.8	2208	2.21	105.3
0.030	0.08	1284	1.28	61.5	1968	1.97	94.2	2796	2.80	133.4
0.040	0.10	1500	1.50	71.8	2232	2.23	106.9	3216	3.22	153.4
0.050	0.13	1668	1.67	79.9	2436	2.44	116.6	3516	3.52	167.7
0.060	0.15	1776	1.78	85.0	2568	2.57	123.0	3756	3.76	179.2
0.070	0.18	1848	1.85	88.5	2676	2.68	128.1	3924	3.92	187.2
0.080	0.20	1836	1.84	87.9	2736	2.74	131.0	4056	4.06	193.5
0.090	0.23	1824	1.82	87.3	2760	2.76	132.1	4140	4.14	197.5
0.100	0.25	1740	1.74	83.3	2748	2.75	131.6	4200	4.20	200.3
0.110	0.28	1572	1.57	75.3	2688	2.69	128.7	4224	4.22	201.5
0.120	0.30	1428	1.43	68.4	2604	2.60	124.7	4212	4.21	200.9
0.130	0.33	1356	1.36	64.9	2508	2.51	120.1	4200	4.20	200.3
0.140	0.36	1284	1.28	61.5	2388	2.39	114.3	4152	4.15	198.1
0.150	0.38	1236	1.24	59.2	2184	2.18	104.6	4068	4.07	194.1
0.160	0.41	1176	1.18	56.3	2052	2.05	98.2	4008	4.01	191.2
0.170	0.43	1116	1.12	53.4	1968	1.97	94.2	3924	3.92	187.2
0.180	0.46	1020	1.02	48.8	1908	1.91	91.4	3852	3.85	183.7
0.190	0.48	972	0.97	46.5	1872	1.87	89.6	3780	3.78	180.3
0.200	0.51	948	0.95	45.4	1836	1.84	87.9	3744	3.74	178.6
0.210	0.53	912	0.91	43.7	1824	1.82	87.3	3672	3.67	175.2
0.220	0.56	900	0.90	43.1	1800	1.80	86.2	3612	3.61	172.3
0.230	0.58	900	0.90	43.1	1788	1.79	85.6	3516	3.52	167.7
0.240	0.61	888	0.89	42.5	1776	1.78	85.0	3504	3.50	167.1
0.250	0.64	876	0.88	41.9	1764	1.76	84.5	3456	3.46	164.9
0.260	0.66	852	0.85	40.8	1752	1.75	83.9	3396	3.40	162.0
0.270	0.69	852	0.85	40.8	1728	1.73	82.7	3360	3.36	160.3
0.280	0.71	840	0.84	40.2	1704	1.70	81.6	3300	3.30	157.4
0.290	0.74	828	0.83	39.6	1680	1.68	80.4	3264	3.26	155.7
0.300	0.76	816	0.82	39.1	1668	1.67	79.9	3228	3.23	154.0
0.310	0.79	816	0.82	39.1	1668	1.67	79.9	3180	3.18	151.7
0.320	0.81	816	0.82	39.1	1656	1.66	79.3	3156	3.16	150.5
0.330	0.84	816	0.82	39.1	1632	1.63	78.1	3120	3.12	148.8
0.340	0.86	804	0.80	38.5	1608	1.61	77.0	3084	3.08	147.1
0.350	0.89	780	0.78	37.3	1620	1.62	77.6	3072	3.07	146.5
0.360	0.91	780	0.78	37.3	1608	1.61	76.7	3036	3.04	144.8
0.370	0.94	780	0.78	37.3	1584	1.58	75.6	3012	3.01	143.7
0.380	0.97	780	0.78	37.3	1572	1.57	75.0	2988	2.99	142.5
0.390	0.99	780	0.78	37.3	1572	1.57	75.0	2976	2.98	142.0
0.400	1.02	780	0.78	37.3	1572	1.57	75.0	2988	2.99	142.5
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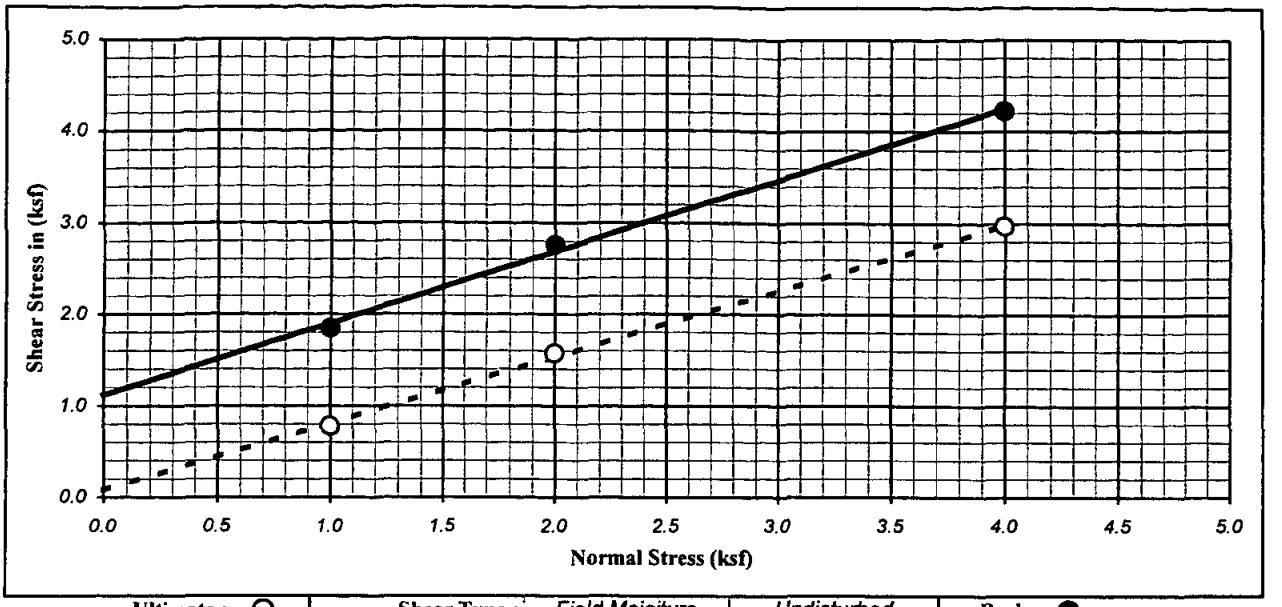
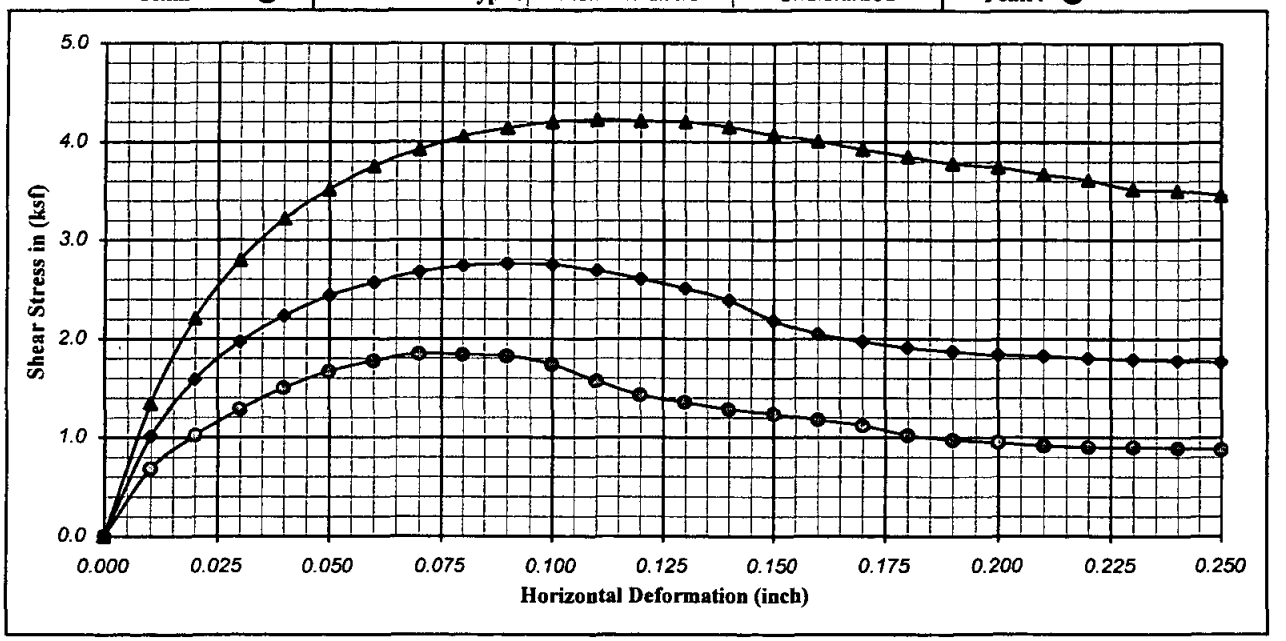


Ultimate : ○	Shear Type : Field Moisiture	Undisturbed	Peak : ●



Boring No. : ST-4	Strength Intercept (C) :	1.12	(ksf)	Peak	0.08	(ksf)	Ultimate
Sample No. : D-4		53.43	(kPa)		3.73	(kPa)	
Depth (ft/m) : 15.0 | 4.58	Friction Angle (ϕ) :	38.08	Degree		36.04	Degree	
Description : Clayey Sand with Gravel (SC)					Shear Rate (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	16.73	119.64	18.83	0.41	1.00	47.88	1.85	88.48	0.78	37.35
◆	16.71	119.98	18.88	0.40	2.00	95.76	2.76	132.15	1.57	75.27
▲	16.55	119.21	18.76	0.41	4.00	191.52	4.22	202.25	2.98	142.49

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | Date : 10/14/02

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-90

Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : ST-5			Saturated	x	Field Moisiture	x	Inundated	**Specific Gravity** (Assumed) :	2.70
Sample No. : D-4		x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate** (inch/min) :	0.02
Depth (ft/m) :	15.0 4.58	x	Shear Once		Reshear		Residual	**Data File Number :**	213406
Description :	Clayey Sand with Gravel (SC)								

Precent Saturation (%)	102.58	**File No. :**	213406 1																	
Prepared By : RJ	**Date :** 10/14/02	**Normal Stress**																		
Tested By : RJ	**Date :** 10/14/02																			
Computed By : LCC	**Date :** 10/18/02	2.00	(ksf)																	
Checked By :	**Date :**																			
Precent Consolidation (%)	0.00	**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		208.73																		
Weight of Ring (gm)		42.69																		
Weight of Wet Soil + Cont. (gm)				169.15																
Weight of Dry Soil + Cont. (gm)				145.85																
Weight of Cont. (gm) **No.**				3.66																
Moisture Content (%)		16.77		16.39																
Wet Density (pcf / kN/m³)		137.52	21.65	137.06	21.57															
Dry Density (pcf / kN/m³)		117.77	18.54	117.77	18.54															
Precent Saturation (%)	102.47	**File No. :**	213406 2																	
Prepared By : RJ	**Date :** 10/14/02	**Normal Stress**																		
Tested By : RJ	**Date :** 10/14/02	4.00	(ksf)																	
Precent Consolidation (%)	0.00	**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		212.19																		
Weight of Ring (gm)		46.18																		
Weight of Wet Soil + Cont. (gm)				169.22																
Weight of Dry Soil + Cont. (gm)				146.00																
Weight of Cont. (gm) **No.**				3.66																
Moisture Content (%)		16.63		16.31																
Wet Density (pcf / kN/m³)		137.49	21.64	137.12	21.58															
Dry Density (pcf / kN/m³)		117.89	18.56	117.89	18.56															
Precent Saturation (%)	97.27	**File No. :**	213406 3																	
Prepared By : RJ	**Date :** 10/14/02	**Normal Stress**																		
Tested By : RJ	**Date :** 10/14/02	8.00	(ksf)																	
Precent Consolidation (%)	0.00	**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		207.89																		
Weight of Ring (gm)		43.98																		
Weight of Wet Soil + Cont. (gm)				166.54																
Weight of Dry Soil + Cont. (gm)				143.66																
Weight of Cont. (gm) **No.**				3.65																
Moisture Content (%)		17.07		16.34																
Wet Density (pcf / kN/m³)		135.75	21.37	134.91	21.23															
Dry Density (pcf / kN/m³)		115.96	18.25	115.96	18.25															

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	2.12	101.70	3.17	151.68	4.99	239.02
Ultimate	1.66	79.29	2.82	135.02	4.86	232.70

Shear Deflection (inch)	(mm)	**Normal Stress (psf/ksf/kPa)** 2000 2.00 95.8	4000 4.0 191.5	8000 8.0 383.0
		Shear Stress (psf/ksf/kPa)		
0.00	0.00	0.0 0.0 0.0	0.00 0.0 0.00	0.0 0.0 0.0
0.010	0.03	780 0.78 37.3	1092 1.09 52.3	1572 1.57 75.0
0.020	0.05	1140 1.14 54.6	1548 1.55 74.1	2316 2.32 110.5
0.030	0.08	1404 1.40 67.2	1860 1.86 89.1	2832 2.83 135.1
0.040	0.10	1596 1.60 76.4	2076 2.08 99.4	3252 3.25 155.1
0.050	0.13	1752 1.75 83.9	2280 2.28 109.2	3576 3.58 170.6
0.060	0.15	1872 1.87 89.6	2460 2.46 117.8	3864 3.86 184.3
0.070	0.18	1968 1.97 94.2	2604 2.60 124.7	4092 4.09 195.2
0.080	0.20	2028 2.03 97.1	2724 2.72 130.4	4260 4.26 203.2
0.090	0.23	2076 2.08 99.4	2820 2.82 135.0	4428 4.43 211.2
0.100	0.25	2100 2.10 100.5	2916 2.92 139.6	4548 4.55 216.9
0.110	0.28	2124 2.12 101.7	2988 2.99 143.1	4644 4.64 221.5
0.120	0.30	2124 2.12 101.7	3036 3.04 145.4	4740 4.74 226.1
0.130	0.33	2124 2.12 101.7	3084 3.08 147.7	4788 4.79 228.4
0.140	0.36	2100 2.10 100.5	3108 3.11 148.8	4836 4.84 230.7
0.150	0.38	2100 2.10 100.5	3144 3.14 150.5	4872 4.87 232.4
0.160	0.41	2076 2.08 99.4	3168 3.17 151.7	4884 4.88 233.0
0.170	0.43	2052 2.05 98.2	3168 3.17 151.7	4920 4.92 234.7
0.180	0.46	2028 2.03 97.1	3168 3.17 151.7	4932 4.93 235.3
0.190	0.48	2004 2.00 96.0	3144 3.14 150.5	4980 4.98 237.6
0.200	0.51	1992 1.99 95.4	3144 3.14 150.5	4980 4.98 237.6
0.210	0.53	1956 1.96 93.7	3120 3.12 149.4	4992 4.99 238.1
0.220	0.56	1944 1.94 93.1	3108 3.11 148.8	4980 4.98 237.6
0.230	0.58	1908 1.91 91.4	3084 3.08 147.7	4956 4.96 236.4
0.240	0.61	1896 1.90 90.8	3060 3.06 146.5	4932 4.93 235.3
0.250	0.64	1896 1.90 90.8	3048 3.05 145.9	4908 4.91 234.1
0.260	0.66	1884 1.88 90.2	3036 3.04 145.4	4884 4.88 233.0
0.270	0.69	1848 1.85 88.5	3036 3.04 145.4	4896 4.90 233.5
0.280	0.71	1848 1.85 88.5	3000 3.00 143.6	4920 4.92 234.7
0.290	0.74	1836 1.84 87.9	2988 2.99 143.1	4932 4.93 235.3
0.300	0.76	1824 1.82 87.3	2964 2.96 141.9	4908 4.91 234.1
0.310	0.79	1812 1.81 86.8	2952 2.95 141.3	4920 4.92 234.7
0.320	0.81	1800 1.80 86.2	2964 2.96 141.9	4860 4.86 231.8
0.330	0.84	1800 1.80 86.2	2952 2.95 141.3	4908 4.91 234.1
0.340	0.86	1764 1.76 84.5	2916 2.92 139.6	4908 4.91 234.1
0.350	0.89	1752 1.75 83.9	2892 2.89 138.5	4908 4.91 234.1
0.360	0.91	1728 1.73 82.7	2880 2.88 137.4	4920 4.92 234.7
0.370	0.94	1704 1.70 81.6	2856 2.86 136.2	4884 4.88 233.0
0.380	0.97	1680 1.68 80.4	2844 2.84 135.7	4908 4.91 234.1
0.390	0.99	1668 1.67 79.9	2844 2.84 135.7	4908 4.91 234.1
0.400	1.02	1656 1.66 79.3	2820 2.82 134.5	4896 4.90 233.5
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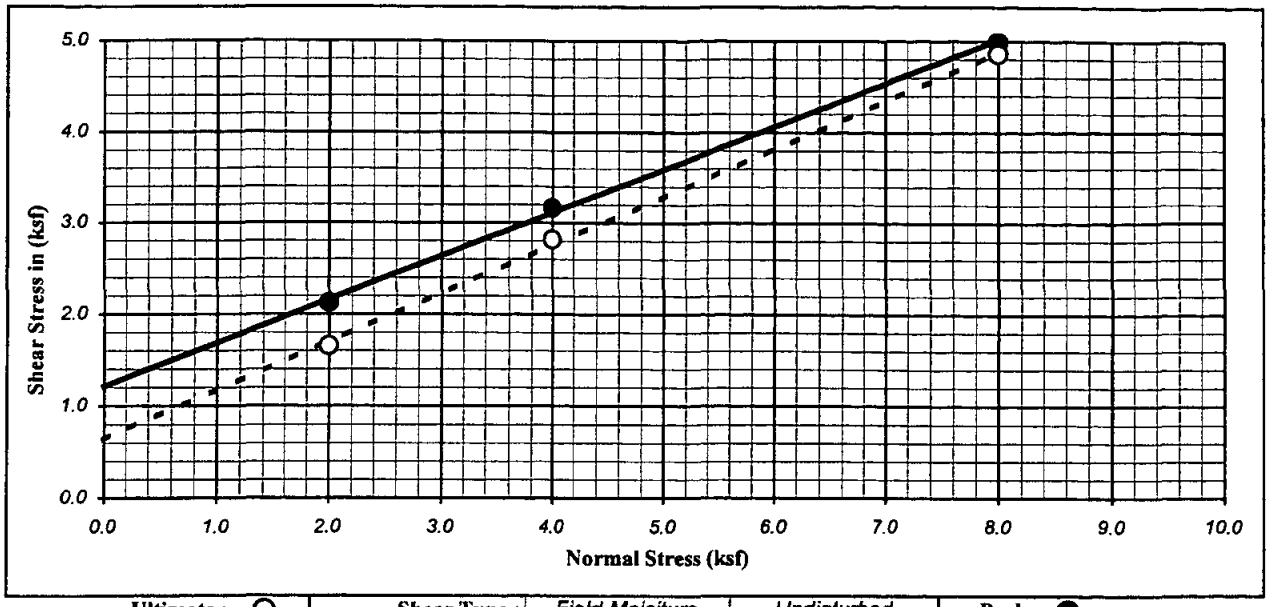
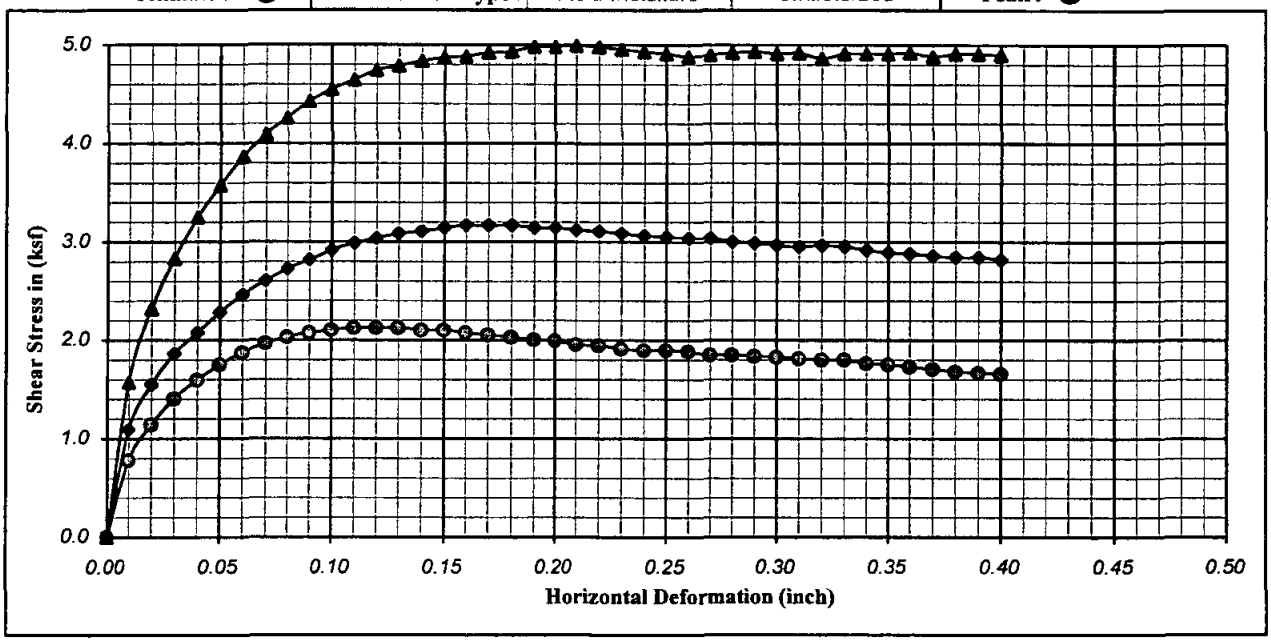


Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: ST-5	**Strength Intercept (C) :**	1.21	(ksf)	**Peak**	0.64	(ksf)	**Ultimate**	
Sample No.	: D-4		58.03	(kPa)		30.45	(kPa)		
Depth (ft/m)	: 15.0 | 4.58	**Friction Angle (ϕ) :**	25.40	Degree		27.95	Degree		
Description	: Clayey Sand with Gravel (SC)						**Shear Rate** (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	16.39	117.77	18.54	0.43	2.00	95.76	2.12	101.70	1.66	79.29
◆	16.31	117.89	18.56	0.43	4.00	191.52	3.17	151.68	2.82	135.02
▲	16.34	115.96	18.25	0.45	8.00	383.04	4.99	239.02	4.86	232.70

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | **Date :** 10/14/02

Figure No. :

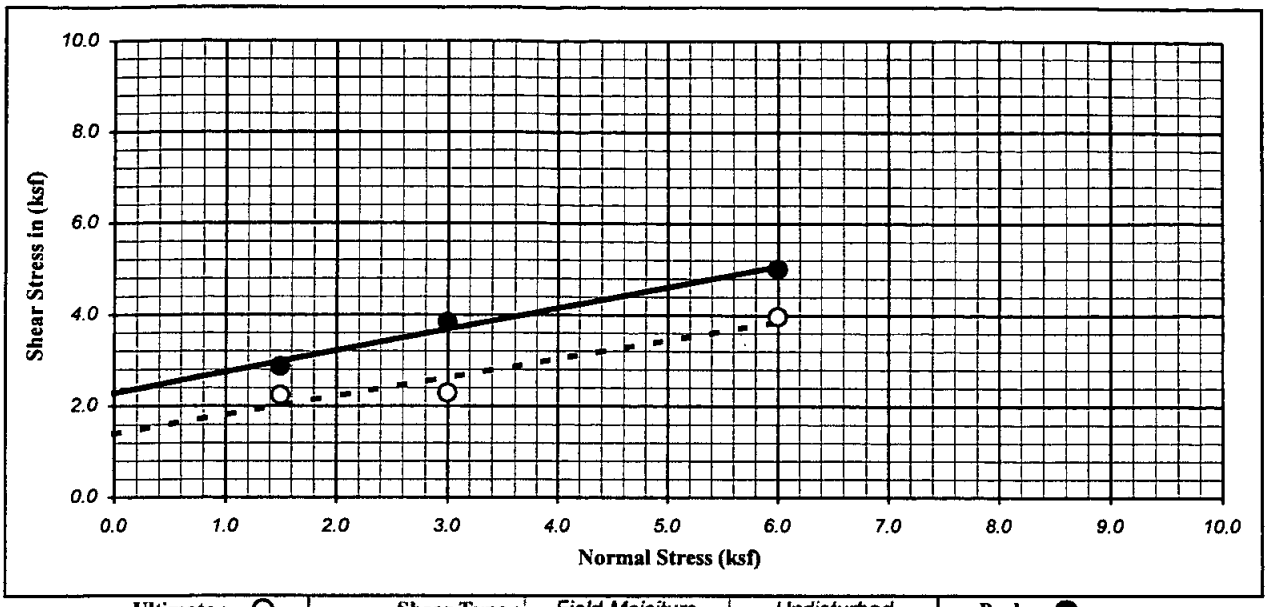
DIRECT SHEAR TEST

ASTM D-3080-90

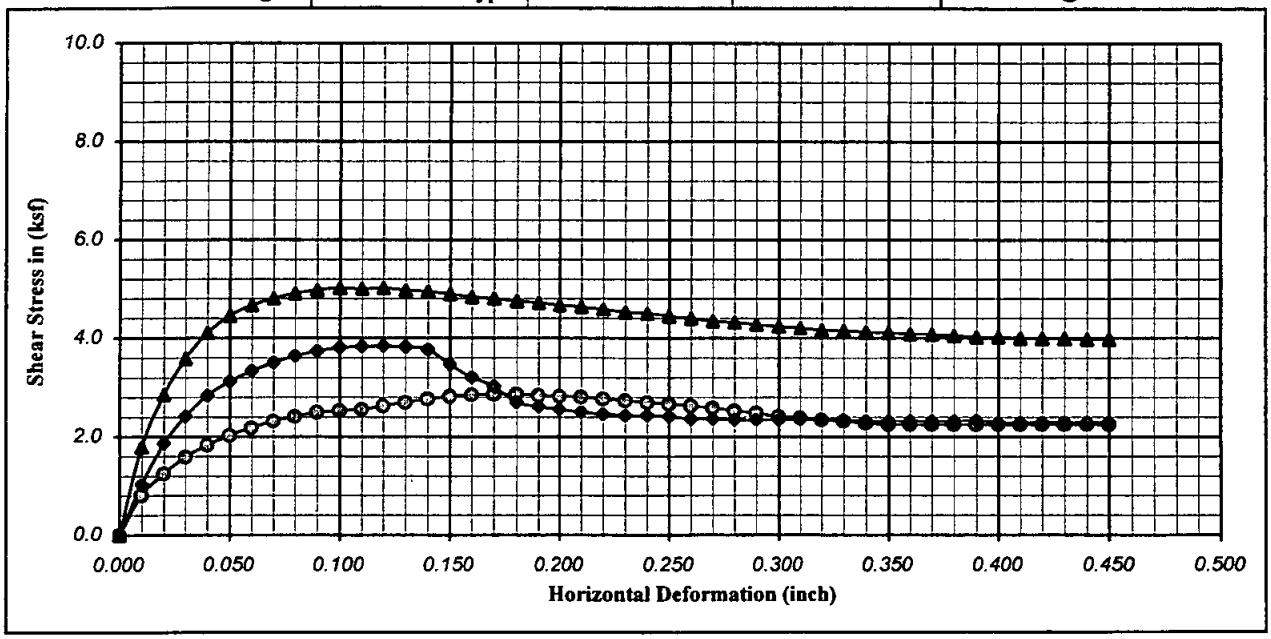
Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : ST-6			**Saturated**		x	**Field Moisture**	x	**Inundated**	**Specific Gravity (Assumed) :** 2.70
Sample No. : D-2		x	**Undisturbed**			**Remolded**		**Consolidated-Drained**	**Shear Rate (inch/min) :** 0.015
Depth (ft/m) : 5.0	1.53	x	**Shear Once**			**Reshear**		**Residual**	**Data File Number :** 213407
Description : Lean Clay with Sand (CL)									

Percent Saturation (%)	108.79		**File No. :**	213407 1				**Shear Deflection**	**Normal Stress (psf/ksf/kPa)**											
Prepared By : RJ	**Date :** 10/19/02		**Normal Stress**						1500	1.50	71.8	3000	3.0	143.6	6000	6.0	287.3			
Tested By : RJ	**Date :** 10/19/02																			
Computed By : LCC	**Date :** 10/23/02		1.50	(ksf)				(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**										
Checked By :	**Date :**							0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0		
Percent Consolidation (%)		**Before**		**After**				0.010	0.03	804	0.80	38.5	1020	1.02	48.8	1788	1.79	85.3		
Height of Sample (inch)		1.00		1.0000				0.020	0.05	1248	1.25	59.8	1860	1.86	89.1	2856	2.86	136.2		
Diameter of Sample (inch)		2.42		2.42				0.030	0.08	1584	1.58	75.8	2412	2.41	115.5	3588	3.59	171.2		
Dial Reading-Consolidation (inch)								0.040	0.10	1824	1.82	87.3	2832	2.83	135.6	4104	4.10	195.8		
Weight of Soil + Ring (gm)		202.04						0.050	0.13	2028	2.03	97.1	3120	3.12	149.4	4452	4.45	212.4		
Weight of Ring (gm)		45.44						0.060	0.15	2184	2.18	104.6	3336	3.34	159.7	4668	4.67	222.7		
Weight of Wet Soil + Cont. (gm)				163.97				0.070	0.18	2316	2.32	110.9	3504	3.50	167.8	4812	4.81	229.5		
Weight of Dry Soil + Cont. (gm)				134.85				0.080	0.20	2412	2.41	115.5	3636	3.64	174.1	4908	4.91	234.1		
Weight of Cont. (gm) No.				3.6				0.090	0.23	2496	2.50	119.5	3732	3.73	178.7	4980	4.98	237.6		
Moisture Content (%)		19.31		22.19				0.100	0.25	2532	2.53	121.2	3804	3.80	182.1	5016	5.02	239.3		
Wet Density (pcf / kN/m³)		129.70	20.41	132.82	20.91			0.110	0.28	2556	2.56	122.4	3828	3.83	183.3	5004	5.00	238.7		
Dry Density (pcf / kN/m³)		108.70	17.11	108.70	17.11			0.120	0.30	2628	2.63	125.8	3840	3.84	183.9	5016	5.02	239.3		
Percent Saturation (%)	109.44		**File No. :**	213407 2				0.130	0.33	2700	2.70	129.3	3816	3.82	182.7	4968	4.97	237.0		
Prepared By : RJ	**Date :** 10/19/02		**Normal Stress**					0.140	0.36	2772	2.77	132.7	3768	3.77	180.4	4944	4.94	235.8		
Tested By : RJ	**Date :** 10/19/02		3.00	(ksf)				0.150	0.38	2820	2.82	135.0	3468	3.47	166.0	4896	4.90	233.5		
Percent Consolidation (%)		**Before**		**After**				0.160	0.41	2856	2.86	136.7	3204	3.20	153.4	4836	4.84	230.7		
Height of Sample (inch)		1.00		1.0000				0.170	0.43	2868	2.87	137.3	3024	3.02	144.8	4800	4.80	229.0		
Diameter of Sample (inch)		2.42		2.42				0.180	0.46	2868	2.87	137.3	2700	2.70	129.3	4752	4.75	226.7		
Dial Reading-Consolidation (inch)								0.190	0.48	2844	2.84	136.2	2616	2.62	125.3	4716	4.72	225.0		
Weight of Soil + Ring (gm)		200.98						0.200	0.51	2820	2.82	135.0	2556	2.56	122.4	4668	4.67	222.7		
Weight of Ring (gm)		42.95						0.210	0.53	2808	2.81	134.4	2508	2.51	120.1	4632	4.63	221.0		
Weight of Wet Soil + Cont. (gm)				166.95				0.220	0.56	2772	2.77	132.7	2460	2.46	117.8	4584	4.58	218.7		
Weight of Dry Soil + Cont. (gm)				139.55				0.230	0.58	2736	2.74	131.0	2436	2.44	116.6	4524	4.52	215.8		
Weight of Cont. (gm) No.				3.63				0.240	0.61	2700	2.70	129.3	2436	2.44	116.6	4500	4.50	214.7		
Moisture Content (%)		16.27		20.16				0.250	0.64	2664	2.66	127.6	2412	2.41	115.5	4440	4.44	211.8		
Wet Density (pcf / kN/m³)		130.88	20.60	135.27	21.29			0.260	0.66	2628	2.63	125.8	2364	2.36	113.2	4392	4.39	209.5		
Dry Density (pcf / kN/m³)		112.57	17.72	112.57	17.72			0.270	0.69	2592	2.59	124.1	2364	2.36	113.2	4344	4.34	207.2		
Percent Saturation (%)	103.61		**File No. :**	213407 3				0.280	0.71	2532	2.53	121.2	2340	2.34	112.0	4320	4.32	206.1		
Prepared By : RJ	**Date :** 10/19/02		**Normal Stress**					0.290	0.74	2484	2.48	118.9	2340	2.34	112.0	4272	4.27	203.8		
Tested By : RJ	**Date :** 10/19/02		6.00	(ksf)				0.300	0.76	2412	2.41	115.5	2340	2.34	112.0	4236	4.24	202.1		
Percent Consolidation (%)		**Before**		**After**				0.310	0.79	2388	2.39	114.3	2352	2.35	112.6	4200	4.20	200.3		
Height of Sample (inch)		1.00		1.0000				0.320	0.81	2340	2.34	112.0	2352	2.35	112.6	4164	4.16	198.6		
Diameter of Sample (inch)		2.42		2.42				0.330	0.84	2316	2.32	110.9	2340	2.34	112.0	4152	4.15	198.1		
Dial Reading-Consolidation (inch)								0.340	0.86	2280	2.28	109.2	2316	2.32	110.9	4116	4.12	196.3		
Weight of Soil + Ring (gm)		203.80						0.350	0.89	2244	2.24	107.4	2316	2.32	110.9	4104	4.10	195.8		
Weight of Ring (gm)		46.02						0.360	0.91	2244	2.24	107.4	2316	2.32	110.5	4080	4.08	194.6		
Weight of Wet Soil + Cont. (gm)				163.49				0.370	0.94	2244	2.24	107.4	2316	2.32	110.5	4068	4.07	194.1		
Weight of Dry Soil + Cont. (gm)				136.31				0.380	0.97	2244	2.24	107.4	2316	2.32	110.5	4044	4.04	192.9		
Weight of Cont. (gm) No.				3.62				0.390	0.99	2244	2.24	107.4	2328	2.33	111.1	4020	4.02	191.8		
Moisture Content (%)		18.91		20.48				0.400	1.02	2244	2.24	107.4	2292	2.29	109.3	4020	4.02	191.8		
Wet Density (pcf / kN/m³)		130.68	20.57	132.41	20.84			0.410	1.04	2244	2.24	107.4	2292	2.29	109.3	3996	4.00	190.6		
Dry Density (pcf / kN/m³)		109.90	17.30	109.90	17.30			0.420	1.07	2244	2.24	107.4	2292	2.29	109.3	3984	3.98	190.0		
Strength	**(ksf)**	**(kPa)**	(ksf)	(kPa)	(ksf)	(kPa)		0.430	1.09	2244	2.24	107.4	2292	2.29	109.3	3984	3.98	190.0		
Peak	2.87	137.32	3.84	183.86	5.02	240.17		0.440	1.12	2244	2.24	107.4	2292	2.29	109.3	3972	3.97	189.5		
Ultimate	2.24	107.44	2.29	109.74	3.97	190.18		0.450	1.14	2244	2.24	107.4	2292	2.29	109.3	3972	3.97	189.5		



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: ST-6		**Strength Intercept (C) :**	2.28	(ksf)	**Peak**	1.40	(ksf)	**Ultimate**
Sample No.	: D-2			109.17	(kPa)		67.22	(kPa)	
Depth (ft/m)	: 5.0	1.53	**Friction Angle (ϕ) :**	24.95	Degree		22.25	Degree	
Description	: Lean Clay with Sand (CL)						**Shear Rate** (inch/minute) :		0.015

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	22.19	108.70	17.11	0.55	1.50	71.82	2.87	137.32	2.24	107.44
◆	20.16	112.57	17.72	0.50	3.00	143.64	3.84	183.86	2.29	109.74
▲	20.48	109.90	17.30	0.53	6.00	287.28	5.02	240.17	3.97	190.18

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | **Date :** 10/19/02 | **Figure No. :**

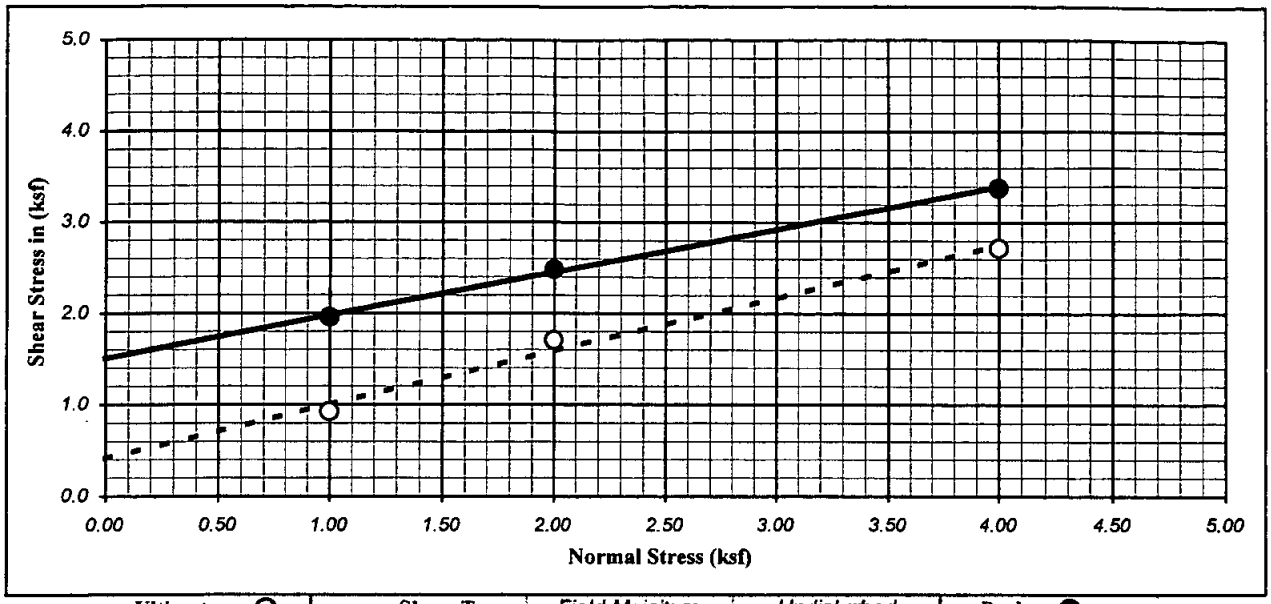
DIRECT SHEAR TEST

ASTM D-3080-90

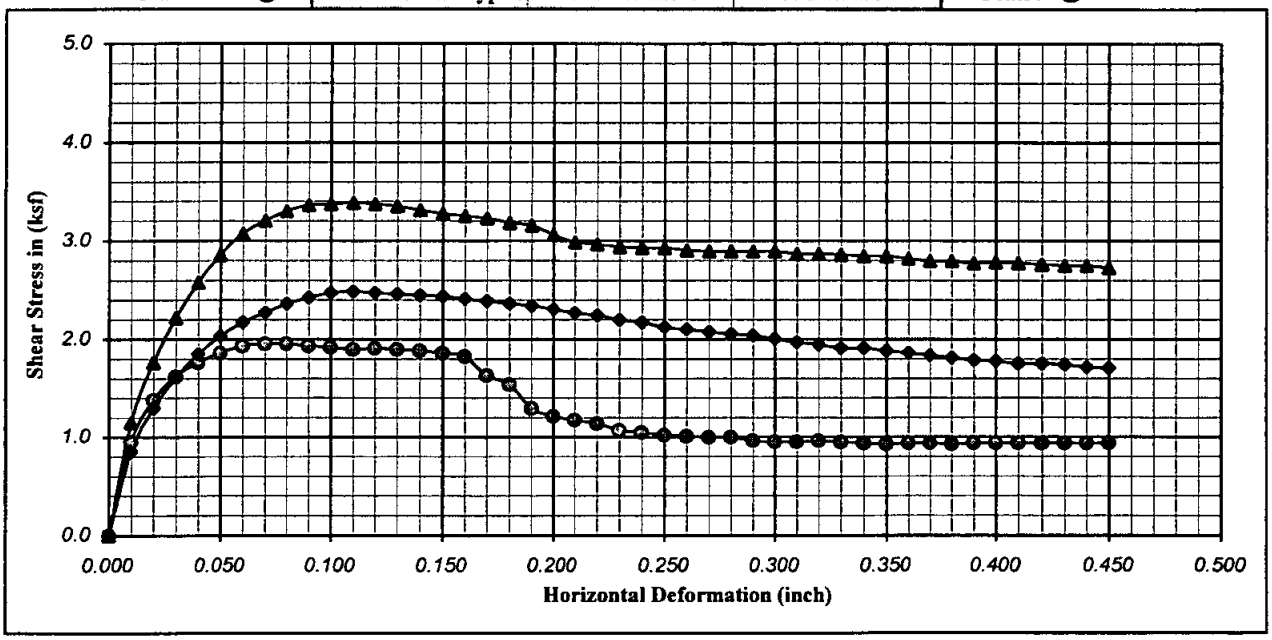
Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : ST-7			Saturated	x	Field Moisture	x	Inundated	**Specific Gravity (Assumed) :**	2.70
Sample No. : D-2		x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate (inch/min) :**	0.02
Depth (ft/m) : 5.0	1.53	x	Shear Once		Reshear		Residual	**Data File Number :**	213408
Description : Clayey Sand (SC)									

Percent Saturation (%)	115.82		**File No. :**	213408 1			**Shear Deflection**		**Normal Stress (psf/ksf/kPa)**										
Prepared By : RJ	**Date :** 10/19/02		**Normal Stress**						1000	1.00	47.9	2000	2.0	95.8	4000	4.0	191.5		
Tested By : RJ	**Date :** 10/19/02								**Shear Stress (psf/ksf/kPa)**										
Computed By : LCC	**Date :** 10/23/02		1.00	(ksf)			(inch)	(mm)											
Checked By :	**Date :**						0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0		
Percent Consolidation (%)		**Before**		**After**			0.010	0.03	948	0.95	45.4	852	0.85	40.8	1152	1.15	55 0		
Height of Sample (inch)		1.00		1.0000			0.020	0.05	1380	1.38	66.1	1296	1.30	62.1	1764	1.76	84.1		
Diameter of Sample (inch)		2.42		2.42			0.030	0.08	1620	1.62	77.6	1608	1.61	77.0	2220	2.22	105.9		
Dial Reading-Consolidation (inch)							0.040	0.10	1764	1.76	84.5	1848	1.85	88.5	2580	2.58	123.1		
Weight of Soil + Ring (gm)		206.49					0.050	0.13	1860	1.86	89.1	2028	2.03	97.1	2856	2.86	136.2		
Weight of Ring (gm)		43.87					0.060	0.15	1932	1.93	92.5	2172	2.17	104.0	3072	3.07	146.5		
Weight of Wet Soil + Cont. (gm)				170.86			0.070	0.18	1956	1.96	93.7	2268	2.27	108.6	3204	3.20	152.8		
Weight of Dry Soil + Cont. (gm)				143.59			0.080	0.20	1956	1.96	93.7	2364	2.36	113.2	3300	3.30	157.4		
Weight of Cont. (gm) No.				3.64			0.090	0.23	1932	1.93	92.5	2424	2.42	116.1	3360	3.36	160.3		
Moisture Content (%)		16.20		19.49			0.100	0.25	1920	1.92	91.9	2472	2.47	118.4	3372	3.37	160.9		
Wet Density (pcf / kN/m³)		134.69	21.20	138.50	21.80		0.110	0.28	1896	1.90	90.8	2484	2.48	118.9	3384	3.38	161.4		
Dry Density (pcf / kN/m³)		115.91	18.24	115.91	18.24		0.120	0.30	1908	1.91	91.4	2472	2.47	118.4	3372	3.37	160.9		
Percent Saturation (%)	114.91		**File No. :**	213408 2			0.130	0.33	1896	1.90	90.8	2460	2.46	117.8	3348	3.35	159.7		
Prepared By : RJ	**Date :** 10/19/02		**Normal Stress**				0.140	0.36	1884	1.88	90.2	2448	2.45	117.2	3312	3.31	158.0		
Tested By : RJ	**Date :** 10/19/02		2.00	(ksf)			0.150	0.38	1860	1.86	89.1	2436	2.44	116.6	3276	3.28	156.3		
Percent Consolidation (%)		**Before**		**After**			0.160	0.41	1824	1.82	87.3	2412	2.41	115.5	3252	3.25	155.1		
Height of Sample (inch)		1.00		1.0000			0.170	0.43	1632	1.63	78.1	2388	2.39	114.3	3228	3.23	154.0		
Diameter of Sample (inch)		2.42		2.42			0.180	0.46	1536	1.54	73.5	2364	2.36	113.2	3180	3.18	151.7		
Dial Reading-Consolidation (inch)							0.190	0.48	1296	1.30	62.1	2340	2.34	112.0	3156	3.16	150.5		
Weight of Soil + Ring (gm)		201.08					0.200	0.51	1212	1.21	58.0	2304	2.30	110.3	3060	3.06	146.0		
Weight of Ring (gm)		42.41					0 210	0.53	1176	1.18	56.3	2268	2.27	108.6	2988	2.99	142.5		
Weight of Wet Soil + Cont. (gm)				167.56			0.220	0.56	1140	1.14	54.6	2244	2.24	107.4	2964	2.96	141.4		
Weight of Dry Soil + Cont. (gm)				138.18			0.230	0.58	1068	1.07	51.1	2196	2.20	105.1	2940	2.94	140.2		
Weight of Cont. (gm) No.				3.69			0.240	0.61	1044	1.04	50.0	2172	2.17	104.0	2928	2.93	139.7		
Moisture Content (%)		17.98		21.85			0.250	0.64	1020	1.02	48.8	2124	2.12	101.7	2928	2.93	139.7		
Wet Density (pcf / kN/m³)		131.41	20.68	135.72	21.36		0.260	0.66	1008	1.01	48.3	2100	2.10	100.5	2904	2.90	138.5		
Dry Density (pcf / kN/m³)		111.39	17.53	111.39	17.53		0 270	0.69	996	1.00	47.7	2076	2.08	99.4	2892	2.89	138.0		
Percent Saturation (%)	117.89		**File No. :**	213408 3			0.280	0.71	996	1.00	47.7	2052	2.05	98.2	2892	2.89	138.0		
Prepared By : RJ	**Date :** 10/19/02		**Normal Stress**				0.290	0.74	960	0 96	46.0	2040	2 04	97.7	2892	2.89	138.0		
Tested By : RJ	**Date :** 10/19/02		4.00	(ksf)			0 300	0.76	948	0.95	45.4	2004	2.00	96.0	2892	2.89	138.0		
Percent Consolidation (%)		**Before**		**After**			0.310	0.79	948	0.95	45.4	1968	1.97	94.2	2868	2.87	136.8		
Height of Sample (inch)		1.00		1.0000			0.320	0.81	960	0.96	46.0	1944	1.94	93.1	2868	2.87	136.8		
Diameter of Sample (inch)		2.42		2.42			0.330	0.84	948	0.95	45.4	1908	1.91	91.4	2856	2.86	136.2		
Dial Reading-Consolidation (inch)							0.340	0.86	936	0.94	44.8	1908	1.91	91.4	2844	2.84	135.7		
Weight of Soil + Ring (gm)		206.59					0.350	0.89	924	0.92	44.2	1884	1.88	90.2	2844	2.84	135.7		
Weight of Ring (gm)		45.27					0.360	0.91	936	0.94	44.8	1860	1.86	88.7	2820	2.82	134.5		
Weight of Wet Soil + Cont. (gm)				170.67			0.370	0.94	936	0.94	44.8	1836	1.84	87.6	2796	2.80	133.4		
Weight of Dry Soil + Cont. (gm)				142.38			0.380	0.97	924	0.92	44.2	1812	1.81	86.4	2796	2.80	133.4		
Weight of Cont. (gm) No.				3.65			0.390	0.99	936	0.94	44.8	1788	1.79	85.3	2772	2.77	132.2		
Moisture Content (%)		16.28		20.39			0.400	1.02	936	0.94	44.8	1776	1.78	84.7	2784	2.78	132.8		
Wet Density (pcf / kN/m³)		133.61	21.03	138.33	21.77		0.410	1.04	936	0.94	44.8	1752	1.75	83.6	2772	2.77	132.2		
Dry Density (pcf / kN/m³)		114.90	18.09	114.90	18.09		0.420	1.07	936	0.94	44.8	1752	1.75	83.6	2760	2.76	131.7		
Strength	(ksf) (kPa)	(ksf)	(kPa)	(ksf)	(kPa)		0.430	1.09	936	0.94	44.8	1740	1.74	83.0	2748	2.75	131.1		
Peak	1.96 93.65	2.48	118 93	3.38	162.03		0.440	1.12	936	0.94	44.8	1716	1.72	81.9	2748	2.75	131.1		
Ultimate	0.92 44.24	1.70	81.59	2.72	130.43		0.450	1.14	936	0.94	44.8	1704	1.70	81.3	2724	2.72	129.9		



Ultimate : ○ | Shear Type : *Field Moisiture* | *Undisturbed* | Peak : ●



Boring No. : *ST-7*		**Strength Intercept (C) :**	*1.51*	(ksf)	**Peak**	*0.41*	(ksf)	**Ultimate**
Sample No. : *D-2*			*72.11*	(kPa)		*19.82*	(kPa)	
Depth (ft/m) : *5.0*	*1.53*	**Friction Angle (ϕ) :**	*25.28*	Degree		*30.42*	Degree	
Description : *Clayey Sand (SC)*						**Shear Rate** (inch/minute) :		*0.02*

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	*19.49*	*115.91*	*18.24*	*0.45*	*1.00*	*47.88*	*1.96*	*93.65*	*0.92*	*44.24*
◆	*21.85*	*111.39*	*17.53*	*0.51*	*2.00*	*95.76*	*2.48*	*118.93*	*1.70*	*81.59*
▲	*20.39*	*114.90*	*18.09*	*0.47*	*4.00*	*191.52*	*3.38*	*162.03*	*2.72*	*130.43*

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : *02-134* | **Date :** *10/19/02*

Figure No. :

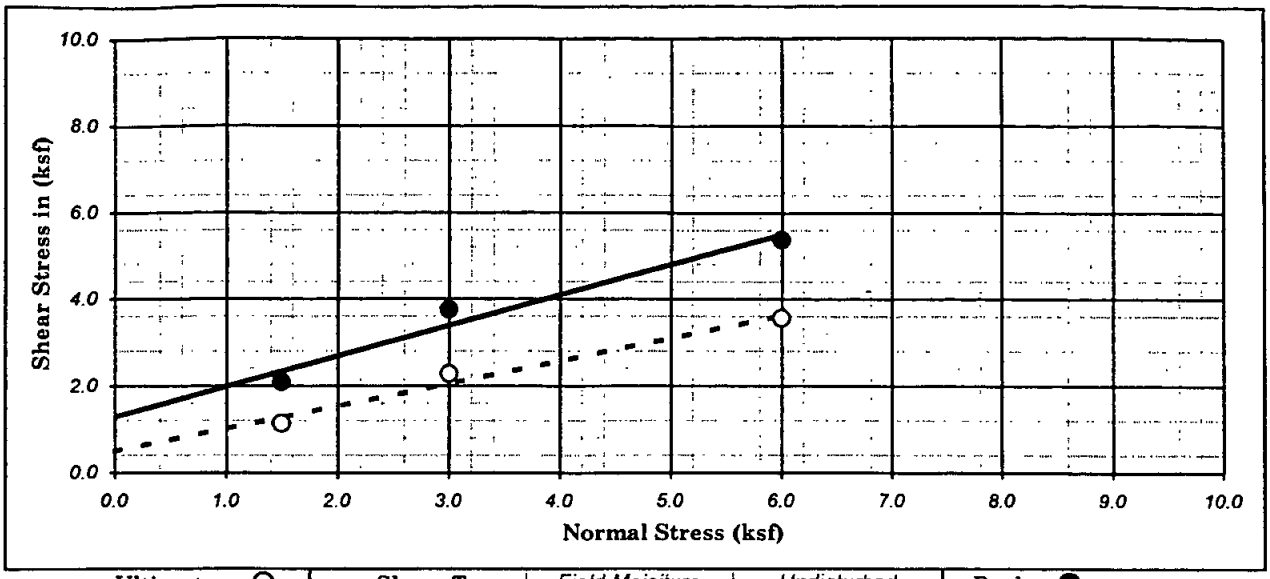
DIRECT SHEAR TEST

ASTM D-3080-90

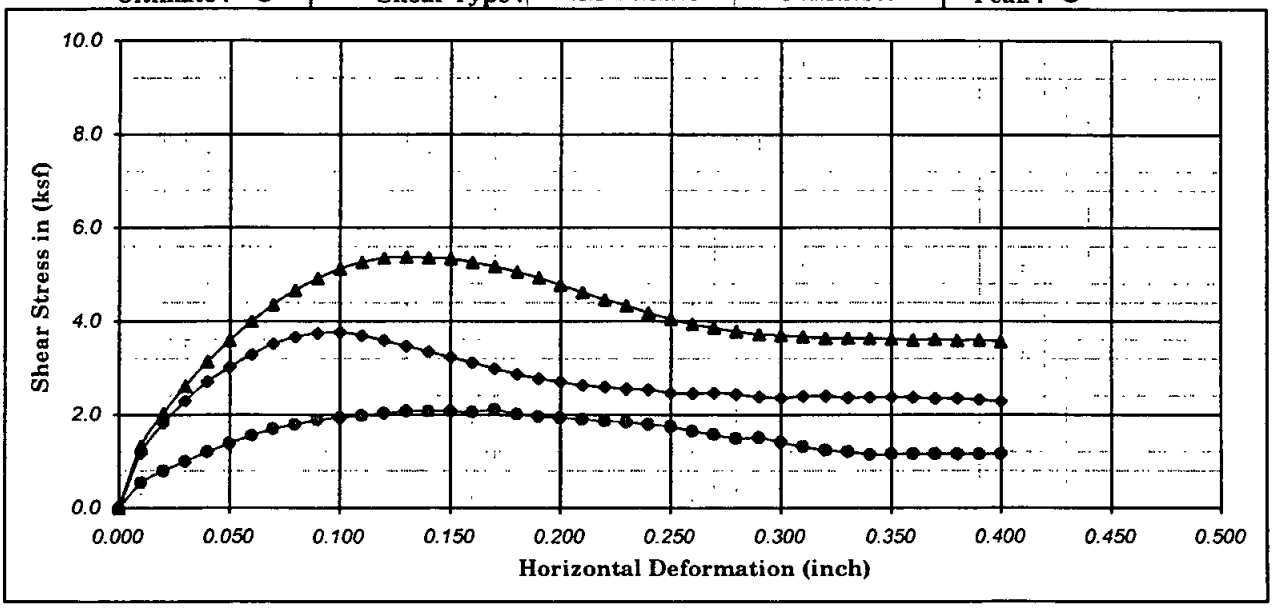
Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : ST-8		Saturated	x	Field Moisiture	x	Inundated	**Specific Gravity (Assumed) :** 2.70	
Sample No. : D-4	x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate (inch/min) :** 0.02	
Depth (ft/m) : 15.0 4.58	x	Shear Once		Reshear		Residual	**Data File Number :** 213409	
Description : Silty Sand (SM)								

Precent Saturation (%)	93.25	**File No. :**	213409 1					**Shear**	**Normal Stress (psf/ksf/kPa)**											
Prepared By : RJ	**Date :** 10/16/02			**Normal Stress**				**Deflection**	1500	1.50	71.8	3000	3.0	143.6	6000	6 0	287.3			
Tested By : RJ	**Date :** 10/16/02							(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**										
Computed By : LCC	**Date :** 10/18/02			1.50	(ksf)			0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0		
Checked By :	**Date :**							0.010	0.03	540	0.54	25.9	1176	1.18	56.3	1332	1.33	63.5		
Precent Consolidation (%)		**Before**		**After**				0.020	0.05	792	0.79	37.9	1812	1.81	86.8	2028	2.03	96.7		
Height of Sample (inch)		1.00		1.0000				0.030	0.08	996	1.00	47.7	2292	2.29	109.7	2604	2.60	124.2		
Diameter of Sample (inch)		2.42		2.42				0.040	0.10	1200	1.20	57.5	2700	2.70	129.3	3132	3.13	149.4		
Dial Reading-Consolidation (inch)								0.050	0 13	1380	1.38	66.1	3012	3.01	144.2	3588	3.59	171.2		
Weight of Soil + Ring (gm)		198.07						0.060	0.15	1548	1.55	74.1	3288	3.29	157.4	3996	4.00	190.6		
Weight of Ring (gm)		44.47						0.070	0.18	1692	1.69	81.0	3516	3.52	168.3	4356	4.36	207.8		
Weight of Wet Soil + Cont. (gm)				165.59				0.080	0.20	1788	1.79	85.6	3660	3.66	175.2	4668	4 67	222 7		
Weight of Dry Soil + Cont. (gm)				143.57				0.090	0.23	1884	1.88	90.2	3744	3.74	179.3	4920	4.92	234.7		
Weight of Cont. (gm) No.				3.81				0.100	0.25	1932	1.93	92.5	3756	3.76	179.8	5124	5.12	244.4		
Moisture Content (%)		9.90		15.76				0.110	0.28	1980	1.98	94.8	3696	3.70	177.0	5268	5.27	251.3		
Wet Density (pcf / kN/m³)		127.22	20.02	133.99	21.09			0.120	0.30	2028	2.03	97.1	3588	3.59	171.8	5352	5.35	255.3		
Dry Density (pcf / kN/m³)		115.75	18.22	115.75	18 22			0.130	0.33	2076	2.08	99.4	3468	3 47	166.0	5376	5.38	256.4		
Precent Saturation (%)	109.02	**File No. :**	213409 2					0.140	0.36	2064	2.06	98.8	3348	3.35	160.3	5364	5.36	255.9		
Prepared By : RJ	**Date :** 10/16/02			**Normal Stress**				0.150	0.38	2076	2.08	99.4	3228	3.23	154.6	5340	5.34	254.7		
Tested By : RJ	**Date :** 10/16/02			3.00	(ksf)			0.160	0.41	2052	2.05	98.2	3108	3.11	148.8	5256	5.26	250.7		
Precent Consolidation (%)		**Before**		**After**				0.170	0.43	2100	2.10	100.5	2988	2.99	143.1	5172	5.17	246.7		
Height of Sample (inch)		1.00		1.0000				0.180	0.46	2004	2.00	96.0	2868	2.87	137.3	5052	5.05	241.0		
Diameter of Sample (inch)		2.42		2.42				0.190	0.48	1956	1.96	93.7	2772	2.77	132.7	4932	4.93	235 3		
Dial Reading-Consolidation (inch)								0.200	0.51	1932	1.93	92.5	2700	2.70	129.3	4776	4.78	227.8		
Weight of Soil + Ring (gm)		207.70						0.210	0.53	1896	1.90	90.8	2628	2.63	125 8	4620	4.62	220.4		
Weight of Ring (gm)		44.21						0.220	0.56	1860	1.86	89.1	2592	2.59	124.1	4464	4.46	212.9		
Weight of Wet Soil + Cont. (gm)				172.51				0.230	0.58	1836	1.84	87.9	2544	2.54	121.8	4332	4.33	206.6		
Weight of Dry Soil + Cont. (gm)				148.78				0.240	0.61	1788	1.79	85.6	2532	2 53	121.2	4176	4.18	199.2		
Weight of Cont. (gm) No.				4.03				0.250	0.64	1740	1.74	83.3	2460	2.46	117.8	4044	4.04	192.9		
Moisture Content (%)		12.95		16.39				0.260	0.66	1644	1.64	78.7	2448	2.45	117.2	3936	3.94	187.8		
Wet Density (pcf / kN/m³)		135.41	21.31	139.54	21.96			0.270	0.69	1572	1.57	75 3	2460	2.46	117.8	3852	3 85	183.7		
Dry Density (pcf / kN/m³)		119.89	18 87	119.89	18.87			0.280	0 71	1488	1 49	71.2	2436	2.44	116 6	3780	3.78	180.3		
Precent Saturation (%)	100.18	**File No. :**	213409 3					0.290	0.74	1500	1.50	71.8	2376	2.38	113.8	3720	3.72	177.5		
Prepared By : RJ	**Date :** 10/16/02			**Normal Stress**				0.300	0 76	1404	1.40	67.2	2352	2.35	112.6	3696	3 70	176 3		
Tested By : RJ	**Date :** 10/16/02			6.00	(ksf)			0.310	0.79	1308	1 31	62.6	2388	2.39	114 3	3672	3.67	175.2		
Precent Consolidation (%)		**Before**		**After**				0.320	0.81	1236	1 24	59.2	2388	2 39	114.3	3636	3 64	173.4		
Height of Sample (inch)		1.00		1.0000				0.330	0.84	1200	1 20	57.5	2352	2.35	112.6	3636	3.64	173.4		
Diameter of Sample (inch)		2.42		2.42				0.340	0.86	1140	1.14	54.6	2364	2.36	113.2	3636	3 64	173 4		
Dial Reading-Consolidation (inch)								0.350	0.89	1152	1.15	55.2	2364	2.36	113.2	3624	3 62	172 9		
Weight of Soil + Ring (gm)		203.56						0.360	0.91	1152	1.15	55.2	2364	2.36	112.8	3600	3.60	171.7		
Weight of Ring (gm)		43.57						0.370	0 94	1152	1 15	55.2	2340	2.34	111 6	3612	3.61	172.3		
Weight of Wet Soil + Cont. (gm)				170.20				0.380	0.97	1152	1.15	55.2	2340	2.34	111.6	3588	3.59	171.2		
Weight of Dry Soil + Cont. (gm)				148.22				0.390	0.99	1152	1.15	55.2	2316	2.32	110.5	3600	3.60	171 7		
Weight of Cont. (gm) No.				3.94				0.400	1.02	1152	1.15	55 2	2280	2 28	108.8	3564	3 56	170 0		
Moisture Content (%)		10.89		15.23					0 00											
Wet Density (pcf / kN/m³)		132.51	20.86	137.70	21.67				0 00											
Dry Density (pcf / kN/m³)		119.50	18.81	119.50	18.81				0.00											
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)			0.00											
Peak	2.10	100.55	3.76	179.84	5.38	257.40			0.00											
Ultimate	1.14	54.58	2.28	109.17	3.56	170 64			0.00											



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : ST-8		**Strength Intercept (C) :**	1.29	(ksf)	**Peak**	0.50	(ksf)	**Ultimate**	
Sample No. : D-4			61.77	(kPa)		23.84	(kPa)		
Depth (ft/m) : 15.0	4.58	**Friction Angle (ϕ) :**	35.04	Degree		27.60	Degree		
Description : Silty Sand (SM)						**Shear Rate** (inch/minute) :		0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	15.76	115.75	18.22	0.46	1.50	71.82	2.10	100.55	1.14	54.58
◆	16.39	119.89	18.87	0.41	3.00	143.64	3.76	179.84	2.28	109.17
▲	15.23	119.50	18.81	0.41	6.00	287.28	5.38	257.40	3.56	170.64

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | **Date :** 10/16/02 | Figure No. :

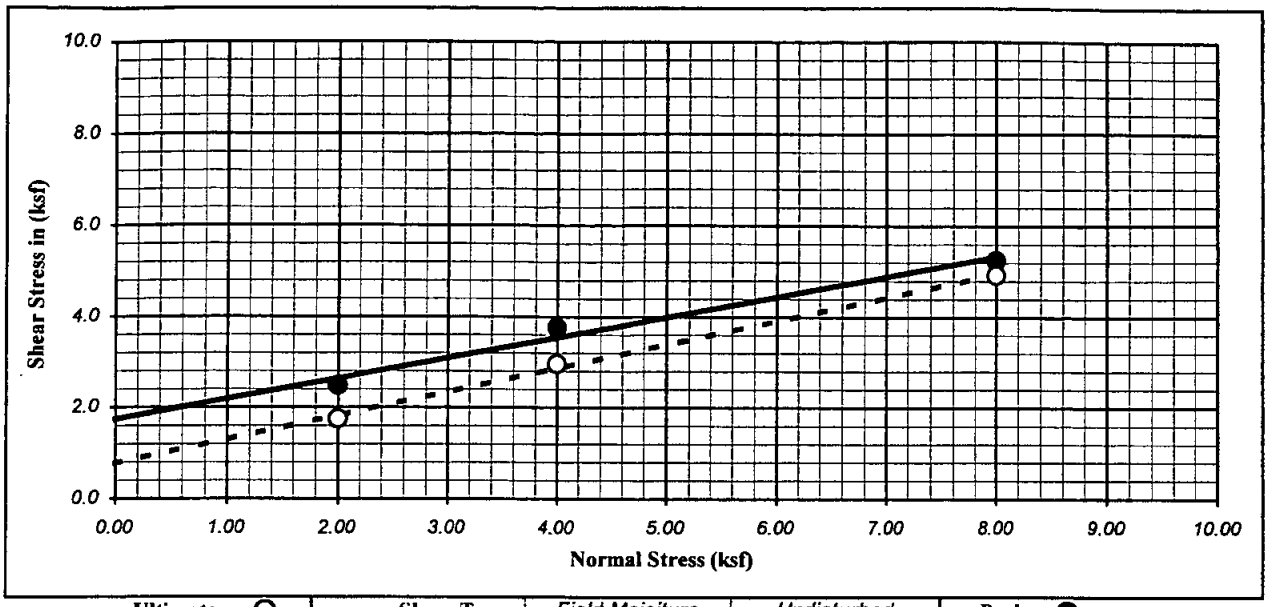
DIRECT SHEAR TEST

ASTM D-3080-90

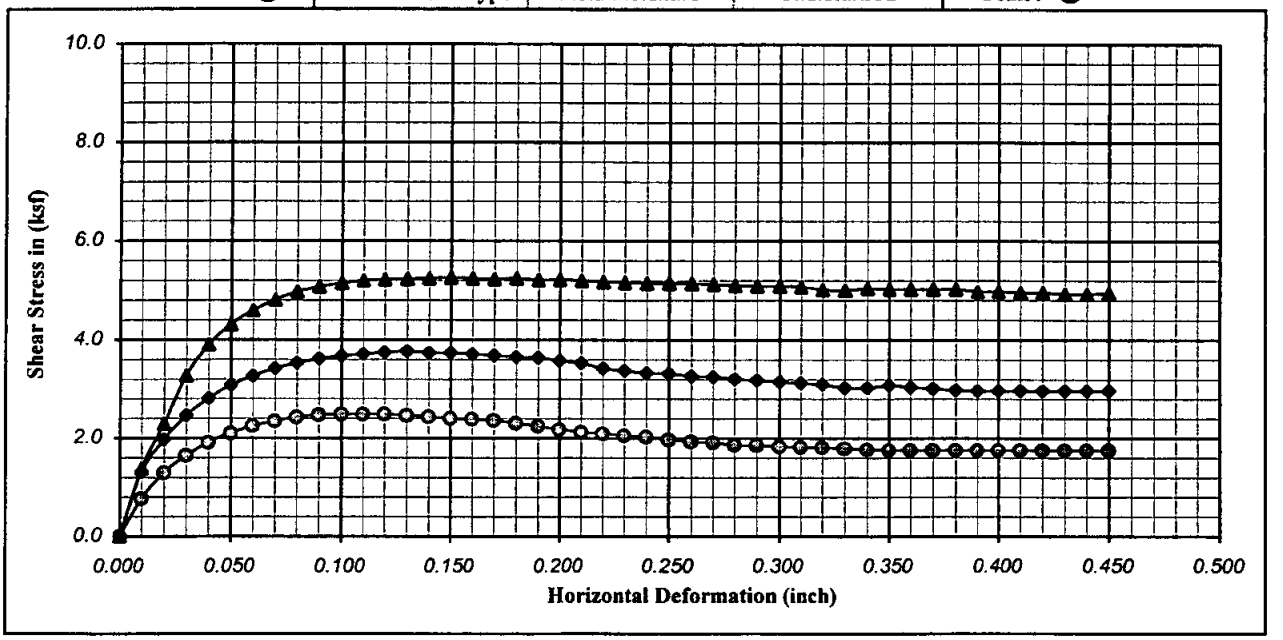
Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : ST-9			**Saturated**	x	**Field Moisiture**	x	**Inundated**	**Specific Gravity** (Assumed) : 2.70	
Sample No. : D-4		x	**Undisturbed**		**Remolded**		**Consolidated-Drained**	**Shear Rate** (inch/min) : 0.015	
Depth (ft/m) : 15.0	4.58	x	**Shear Once**		**Reshear**		**Residual**	**Data File Number :** 213410	
Description : Clayey Sand with Gravel (SC)									

Precent Saturation (%)	115.14		**File No. :**	213410 1			**Shear Deflection**		**Normal Stress (psf/ksf/kPa)**											
Prepared By : RJ	**Date :** 10/17/02		**Normal Stress**						2000	2.00	95.8	4000	4.0	191.5	8000	8.0	383.0			
Tested By : RJ	**Date :** 10/17/02																			
Computed By : LCC	**Date :** 10/18/02		2.00	(ksf)			(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**											
Checked By :	**Date :**						0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0			
Precent Consolidation (%)		**Before**		**After**			0.010	0.03	768	0.77	36.8	1308	1.31	62.6	1380	1.38	65.8			
Height of Sample (inch)		1.00		1.0000			0.020	0.05	1296	1.30	62.1	1968	1.97	94.2	2292	2.29	109.3			
Diameter of Sample (inch)		2.42		2.42			0.030	0.08	1644	1.64	78.7	2460	2.46	117.8	3276	3.28	156.3			
Dial Reading-Consolidation (inch)							0.040	0.10	1908	1.91	91.4	2808	2.81	134.4	3900	3.90	186.0			
Weight of Soil + Ring (gm)		205.51					0.050	0.13	2100	2.10	100.5	3072	3.07	147.1	4308	4.31	205.5			
Weight of Ring (gm)		43.25					0.060	0.15	2244	2.24	107.4	3264	3.26	156.3	4596	4.60	219.2			
Weight of Wet Soil + Cont. (gm)				169.38			0.070	0.18	2340	2.34	112.0	3420	3.42	163.7	4812	4.81	229.5			
Weight of Dry Soil + Cont. (gm)				141.14			0.080	0.20	2424	2.42	116.1	3528	3.53	168.9	4980	4.98	237.6			
Weight of Cont. (gm) **No.**				3.84			0.090	0.23	2472	2.47	118.4	3612	3.61	172.9	5076	5.08	242.1			
Moisture Content (%)		18.18		20.57			0.100	0.25	2484	2.48	118.9	3672	3.67	175.8	5148	5.15	245.6			
Wet Density (pcf / kN/m³)		134.39	21.15	137.10	21.58		0.110	0.28	2484	2.48	118.9	3708	3.71	177.5	5196	5.20	247.9			
Dry Density (pcf / kN/m³)		113.72	17.90	113.72	17.90		0.120	0.30	2484	2.48	118.9	3744	3.74	179.3	5220	5.22	249.0			
Precent Saturation (%)	110.26		**File No. :**	213410 2			0.130	0.33	2460	2.46	117.8	3768	3.77	180.4	5232	5.23	249.6			
Prepared By : RJ	**Date :** 10/17/02		**Normal Stress**				0.140	0.36	2436	2.44	116.6	3732	3.73	178.7	5244	5.24	250.2			
Tested By : RJ	**Date :** 10/17/02		4.00	(ksf)			0.150	0.38	2400	2.40	114.9	3732	3.73	178.7	5256	5.26	250.7			
Precent Consolidation (%)		**Before**		**After**			0.160	0.41	2388	2.39	114.3	3708	3.71	177.5	5244	5.24	250.2			
Height of Sample (inch)		1.00		1.0000			0.170	0.43	2364	2.36	113.2	3684	3.68	176.4	5232	5.23	249.6			
Diameter of Sample (inch)		2.42		2.42			0.180	0.46	2304	2.30	110.3	3648	3.65	174.7	5244	5.24	250.2			
Dial Reading-Consolidation (inch)							0.190	0.48	2244	2.24	107.4	3636	3.64	174.1	5208	5.21	248.4			
Weight of Soil + Ring (gm)		205.27					0.200	0.51	2172	2.17	104.0	3576	3.58	171.2	5220	5.22	249.0			
Weight of Ring (gm)		43.49					0.210	0.53	2124	2.12	101.7	3528	3.53	168.9	5196	5.20	247.9			
Weight of Wet Soil + Cont. (gm)				169.14			0.220	0.56	2088	2.09	100.0	3420	3.42	163.7	5172	5.17	246.7			
Weight of Dry Soil + Cont. (gm)				142.76			0.230	0.58	2052	2.05	98.2	3372	3.37	161.5	5160	5.16	246.1			
Weight of Cont. (gm) **No.**				3.84			0.240	0.61	2028	2.03	97.1	3324	3.32	159.2	5148	5.15	245.6			
Moisture Content (%)		16.46		18.99			0.250	0.64	1968	1.97	94.2	3312	3.31	158.6	5148	5.15	245.6			
Wet Density (pcf / kN/m³)		133.99	21.09	136.91	21.55		0.260	0.66	1932	1.93	92.5	3264	3.26	156.3	5136	5.14	245.0			
Dry Density (pcf / kN/m³)		115.06	18.11	115.06	18.11		0.270	0.69	1908	1.91	91.4	3252	3.25	155.7	5124	5.12	244.4			
Precent Saturation (%)	104.33		**File No. :**	213410 3			0.280	0.71	1860	1.86	89.1	3204	3.20	153.4	5100	5.10	243.3			
Prepared By : RJ	**Date :** 10/17/02		**Normal Stress**				0.290	0.74	1848	1.85	88.5	3180	3.18	152.3	5088	5.09	242.7			
Tested By : RJ	**Date :** 10/17/02		8.00	(ksf)			0.300	0.76	1824	1.82	87.3	3144	3.14	150.5	5088	5.09	242.7			
Precent Consolidation (%)		**Before**		**After**			0.310	0.79	1812	1.81	86.8	3120	3.12	149.4	5076	5.08	242.1			
Height of Sample (inch)		1.00		1.0000			0.320	0.81	1812	1.81	86.8	3096	3.10	148.2	5016	5.02	239.3			
Diameter of Sample (inch)		2.42		2.42			0.330	0.84	1788	1.79	85.6	3024	3.02	144.8	5004	5.00	238.7			
Dial Reading-Consolidation (inch)							0.340	0.86	1764	1.76	84.5	3024	3.02	144.8	5040	5.04	240.4			
Weight of Soil + Ring (gm)		205.81					0.350	0.89	1752	1.75	83.9	3072	3.07	147.1	5028	5.03	239.8			
Weight of Ring (gm)		45.55					0.360	0.91	1752	1.75	83.9	3036	3.04	144.8	5028	5.03	239.8			
Weight of Wet Soil + Cont. (gm)				167.00			0.370	0.94	1752	1.75	83.9	3012	3.01	143.7	5028	5.03	239.8			
Weight of Dry Soil + Cont. (gm)				141.54			0.380	0.97	1752	1.75	83.9	2976	2.98	142.0	5028	5.03	239.8			
Weight of Cont. (gm) **No.**				3.91			0.390	0.99	1752	1.75	83.9	2964	2.96	141.4	4980	4.98	237.6			
Moisture Content (%)		16.44		18.50			0.400	1.02	1752	1.75	83.9	2964	2.96	141.4	4980	4.98	237.6			
Wet Density (pcf / kN/m³)		132.73	20.89	135.08	21.26		0.410	1.04	1752	1.75	83.9	2964	2.96	141.4	4956	4.96	236.4			
Dry Density (pcf / kN/m³)		113.99	17.94	113.99	17.94		0.420	1.07	1752	1.75	83.9	2964	2.96	141.4	4956	4.96	236.4			
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)	0.430	1.09	1752	1.75	83.9	2964	2.96	141.4	4932	4.93	235.3			
Peak	2.48	118.93	3.77	180.41	5.26	251.66	0.440	1.12	1752	1.75	83.9	2964	2.96	141.4	4932	4.93	235.3			
Ultimate	1.75	83.89	2.96	141.92	4.93	236.14	0.450	1.14	1752	1.75	83.9	2964	2.96	141.4	4944	4.94	235.8			



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: ST-9	**Strength Intercept (C) :**	1.74	(ksf)	**Peak**	0.77	(ksf)	**Ultimate**	
Sample No.	: D-4		83.31	(kPa)		36.77	(kPa)		
Depth (ft/m)	: 15.0 | 4.58	**Friction Angle (ϕ) :**	24.19	Degree		27.68	Degree		
Description	: Clayey Sand with Gravel (SC)						**Shear Rate** (inch/minute) :	0.015	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	20.57	113.72	17.90	0.48	2.00	95.76	2.48	118.93	1.75	83.89
◆	18.99	115.06	18.11	0.47	4.00	191.52	3.77	180.41	2.96	141.92
▲	18.50	113.99	17.94	0.48	8.00	383.04	5.26	251.66	4.93	236.14

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | **Date :** 10/17/02

Figure No. :

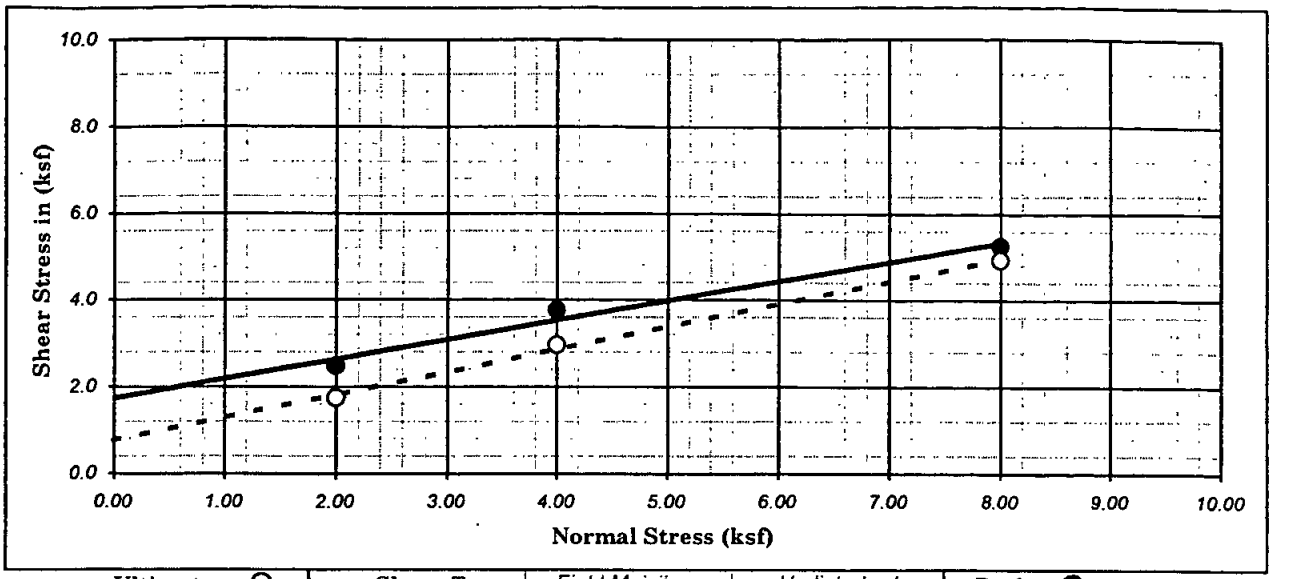
DIRECT SHEAR TEST

ASTM D-3080-90

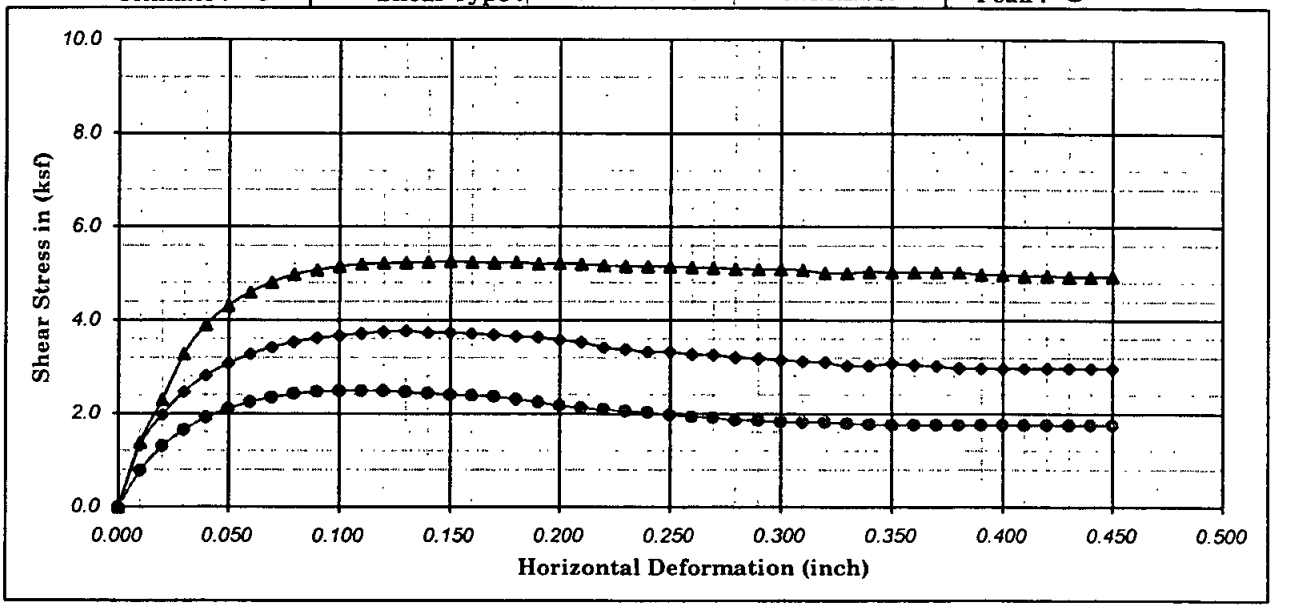
Project No. : *02-134* **Project Name :** *Devil's Slide Tunnel*

Boring No. : *ST-9*			**Saturated**	x	**Field Moisiture**	x	**Inundated**	**Specific Gravity (Assumed) :** *2.70*	
Sample No. : *D-12*		x	**Undisturbed**		**Remolded**		**Consolidated-Drained**	**Shear Rate (inch/min) :** *0.015*	
Depth (ft/m) : *55.0*	*16.78*	x	**Shear Once**		**Reshear**		**Residual**	**Data File Number :** *213411*	
Description : *Sandy Clay (CL)*									

Precent Saturation (%)	*109.16*		**File No. :**	*213411 1*			**Shear**	**Normal Stress (psf/ksf/kPa)**												
Prepared By : *RJ*	**Date :** *10/17/02*		**Normal Stress**				**Deflection**	*2500*	*2.50*	*119.7*	*5000*	*5.0*	*239.4*	*10000*	*10.0*	*478.8*				
Tested By : *RJ*	**Date :** *10/17/02*						(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**											
Computed By : *LCC*	**Date :** *10/18/02*		*2.50*	(ksf)			*0.00*	*0.00*	*0.0*	*0.0*	*0.0*	*0.00*	*0.0*	*0.00*	*0.0*	*0.0*	*0.0*			
Checked By :	**Date :**						*0.010*	*0.03*	840	*0.84*	*40.2*	1188	*1.19*	*56.9*	1776	*1.78*	*84.7*			
Precent Consolidation (%)		**Before**		**After**			*0.020*	*0.05*	1284	*1.28*	*61.5*	1896	*1.90*	*90.8*	2772	*2.77*	*132.2*			
Height of Sample (inch)		*1.00*		*1.0000*			*0.030*	*0.08*	1608	*1.61*	*77.0*	2436	*2.44*	*116.6*	3696	*3.70*	*176.3*			
Diameter of Sample (inch)		*2.42*		*2.42*			*0.040*	*0.10*	1872	*1.87*	*89.6*	2892	*2.89*	*138.5*	4452	*4.45*	*212.4*			
Dial Reading-Consolidation (inch)							*0.050*	*0.13*	2100	*2.10*	*100.5*	3300	*3.30*	*158.0*	5112	*5.11*	*243.9*			
Weight of Soil + Ring (gm)		*210.52*					*0.060*	*0.15*	2268	*2.27*	*108.6*	3636	*3.64*	*174.1*	5711	*5.71*	*272.4*			
Weight of Ring (gm)		*46.44*					*0.070*	*0.18*	2436	*2.44*	*116.6*	3900	*3.90*	*186.7*	6143	*6.14*	*293.0*			
Weight of Wet Soil + Cont. (gm)				*170.00*			*0.080*	*0.20*	2556	*2.56*	*122.4*	4116	*4.12*	*197.1*	6611	*6.61*	*315.4*			
Weight of Dry Soil + Cont. (gm)				*144.67*			*0.090*	*0.23*	2652	*2.65*	*127.0*	4272	*4.27*	*204.5*	6899	*6.90*	*329.1*			
Weight of Cont. (gm) No.				*3.8*			*0.100*	*0.25*	2712	*2.71*	*129.9*	4392	*4.39*	*210.3*	7127	*7.13*	*340.0*			
Moisture Content (%)		*16.48*		*17.98*			*0.110*	*0.28*	2748	*2.75*	*131.6*	4464	*4.46*	*213.7*	7223	*7.22*	*344.6*			
Wet Density (pcf / kN/m³)		*135.90*	*21.39*	*137.65*	*21.67*		*0.120*	*0.30*	2772	*2.77*	*132.7*	4500	*4.50*	*215.5*	7415	*7.42*	*353.7*			
Dry Density (pcf / kN/m³)		*116.67*	*18.36*	*116.67*	*18.36*		*0.130*	*0.33*	2760	*2.76*	*132.1*	4500	*4.50*	*215.5*	7475	*7.48*	*356.6*			
Precent Saturation (%)	*103.65*	**File No. :**		*213411 2*			*0.140*	*0.36*	2724	*2.72*	*130.4*	4452	*4.45*	*213.2*	7475	*7.48*	*356.6*			
Prepared By : *RJ*	**Date :** *10/17/02*	**Normal Stress**					*0.150*	*0.38*	2676	*2.68*	*128.1*	4404	*4.40*	*210.9*	7439	*7.44*	*354.9*			
Tested By : *RJ*	**Date :** *10/17/02*	*5.00*	(ksf)				*0.160*	*0.41*	2628	*2.63*	*125.8*	4344	*4.34*	*208.0*	7391	*7.39*	*352.6*			
Precent Consolidation (%)		**Before**		**After**			*0.170*	*0.43*	2568	*2.57*	*123.0*	4260	*4.26*	*204.0*	7319	*7.32*	*349.1*			
Height of Sample (inch)		*1.00*		*1.0000*			*0.180*	*0.46*	2496	*2.50*	*119.5*	4164	*4.16*	*199.4*	7259	*7.26*	*346.3*			
Diameter of Sample (inch)		*2.42*		*2.42*			*0.190*	*0.48*	2436	*2.44*	*116.6*	4080	*4.08*	*195.4*	7199	*7.20*	*343.4*			
Dial Reading-Consolidation (inch)							*0.200*	*0.51*	2364	*2.36*	*113.2*	4020	*4.02*	*192.5*	7163	*7.16*	*341.7*			
Weight of Soil + Ring (gm)		*212.12*					*0.210*	*0.53*	2316	*2.32*	*110.9*	3996	*4.00*	*191.3*	7115	*7.12*	*339.4*			
Weight of Ring (gm)		*45.62*					*0.220*	*0.56*	2268	*2.27*	*108.6*	3972	*3.97*	*190.2*	7079	*7.08*	*337.7*			
Weight of Wet Soil + Cont. (gm)				*170.73*			*0.230*	*0.58*	2220	*2.22*	*106.3*	3948	*3.95*	*189.0*	7043	*7.04*	*336.0*			
Weight of Dry Soil + Cont. (gm)				*148.03*			*0.240*	*0.61*	2184	*2.18*	*104.6*	3912	*3.91*	*187.3*	7043	*7.04*	*336.0*			
Weight of Cont. (gm) No.				*3.64*			*0.250*	*0.64*	2148	*2.15*	*102.8*	3900	*3.90*	*186.7*	6995	*7.00*	*333.7*			
Moisture Content (%)		*15.31*		*15.72*			*0.260*	*0.66*	2100	*2.10*	*100.5*	3876	*3.88*	*185.6*	6911	*6.91*	*329.7*			
Wet Density (pcf / kN/m³)		*137.90*	*21.71*	*138.39*	*21.78*		*0.270*	*0.69*	2076	*2.08*	*99.4*	3852	*3.85*	*184.4*	6887	*6.89*	*328.5*			
Dry Density (pcf / kN/m³)		*119.59*	*18.82*	*119.59*	*18.82*		*0.280*	*0.71*	2052	*2.05*	*98.2*	3828	*3.83*	*183.3*	6899	*6.90*	*329.1*			
Precent Saturation (%)	*100.43*	**File No. :**		*213411 3*			*0.290*	*0.74*	2016	*2.02*	*96.5*	3804	*3.80*	*182.1*	6803	*6.80*	*324.5*			
Prepared By : *RJ*	**Date :** *10/17/02*	**Normal Stress**					*0.300*	*0.76*	2004	*2.00*	*96.0*	3804	*3.80*	*182.1*	6743	*6.74*	*321.7*			
Tested By : *RJ*	**Date :** *10/17/02*	*10.00*	(ksf)				*0.310*	*0.79*	2004	*2.00*	*96.0*	3780	*3.78*	*181.0*	6755	*6.76*	*322.2*			
Precent Consolidation (%)		**Before**		**After**			*0.320*	*0.81*	1980	*1.98*	*94.8*	3768	*3.77*	*180.4*	6683	*6.68*	*318.8*			
Height of Sample (inch)		*1.00*		*1.0000*			*0.330*	*0.84*	1968	*1.97*	*94.2*	3696	*3.70*	*177.0*	6659	*6.66*	*317.6*			
Diameter of Sample (inch)		*2.42*		*2.42*			*0.340*	*0.86*	1944	*1.94*	*93.1*	3672	*3.67*	*175.8*	6635	*6.64*	*316.5*			
Dial Reading-Consolidation (inch)							*0.350*	*0.89*	1920	*1.92*	*91.9*	3648	*3.65*	*174.7*	6587	*6.59*	*314.2*			
Weight of Soil + Ring (gm)		*207.16*					*0.360*	*0.91*	1920	*1.92*	*91.9*	3636	*3.64*	*173.4*	6587	*6.59*	*314.2*			
Weight of Ring (gm)		*42.70*					*0.370*	*0.94*	1896	*1.90*	*90.8*	3636	*3.64*	*173.4*	6527	*6.53*	*311.4*			
Weight of Wet Soil + Cont. (gm)				*168.07*			*0.380*	*0.97*	1896	*1.90*	*90.8*	3636	*3.64*	*173.4*	6539	*6.54*	*311.9*			
Weight of Dry Soil + Cont. (gm)				*144.83*			*0.390*	*0.99*	1896	*1.90*	*90.8*	3624	*3.62*	*172.9*	6515	*6.52*	*310.8*			
Weight of Cont. (gm) No.				*3.79*			*0.400*	*1.02*	1884	*1.88*	*90.2*	3636	*3.64*	*173.4*	6515	*6.52*	*310.8*			
Moisture Content (%)		*16.61*		*16.48*				*0.00*												
Wet Density (pcf / kN/m³)		*136.21*	*21.44*	*136.06*	*21.42*			*0.00*												
Dry Density (pcf / kN/m³)		*116.81*	*18.39*	*116.81*	*18.39*			*0.00*												
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)		*0.00*												
Peak	*2.77*	*132.72*	*4.50*	*215.46*	*7.48*	*357.90*		*0.00*												
Ultimate	*1.88*	*90.21*	*3.62*	*173.52*	*6.52*	*311.94*		*0.00*												



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : ST-9		Strength Intercept (C) :	1.28	(ksf)	Peak	0.44	(ksf)	Ultimate
Sample No. : D-12			61.50	(kPa)		21.00	(kPa)	
Depth (ft/m) : 55.0	16.78	Friction Angle (ϕ) :	31.90	Degree		31.46	Degree	
Description : Sandy Clay (CL)					Shear Rate (inch/minute) :		0.015	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	17.98	116.67	18.36	0.44	2.50	119.70	2.77	132.72	1.88	90.21
◆	15.72	119.59	18.82	0.41	5.00	239.40	4.50	215.46	3.62	173.52
▲	16.48	116.81	18.39	0.44	10.00	478.80	7.48	357.90	6.52	311.94

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Figure No. :

Project No. : 02-134

Date : 10/17/02

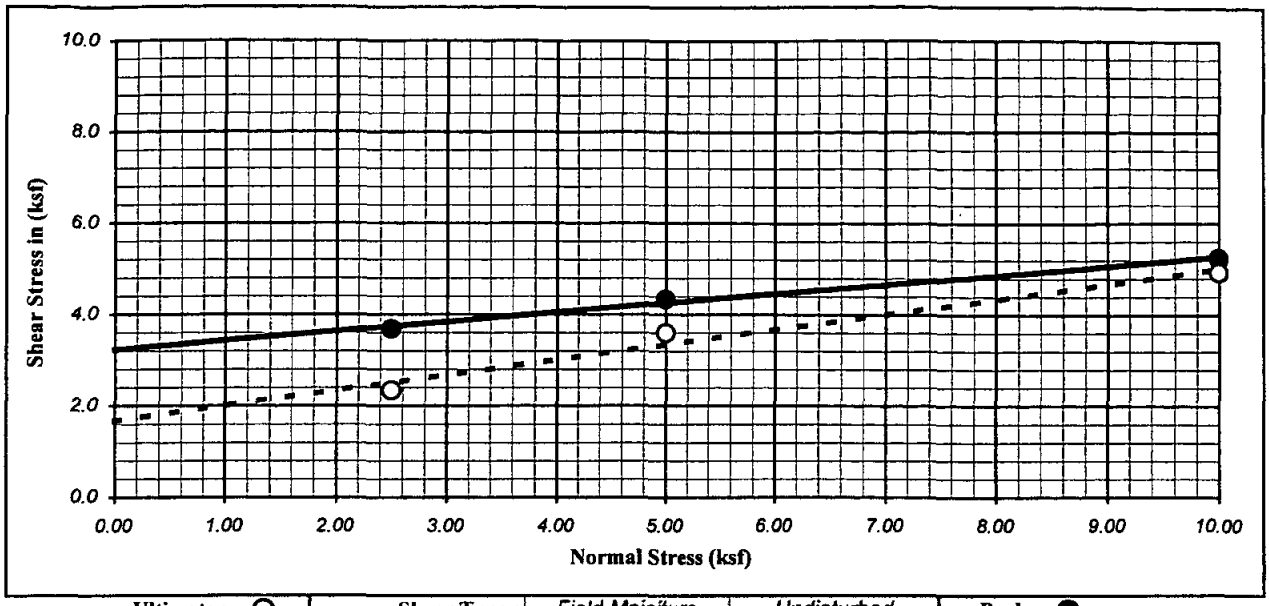
DIRECT SHEAR TEST

ASTM D-3080-90

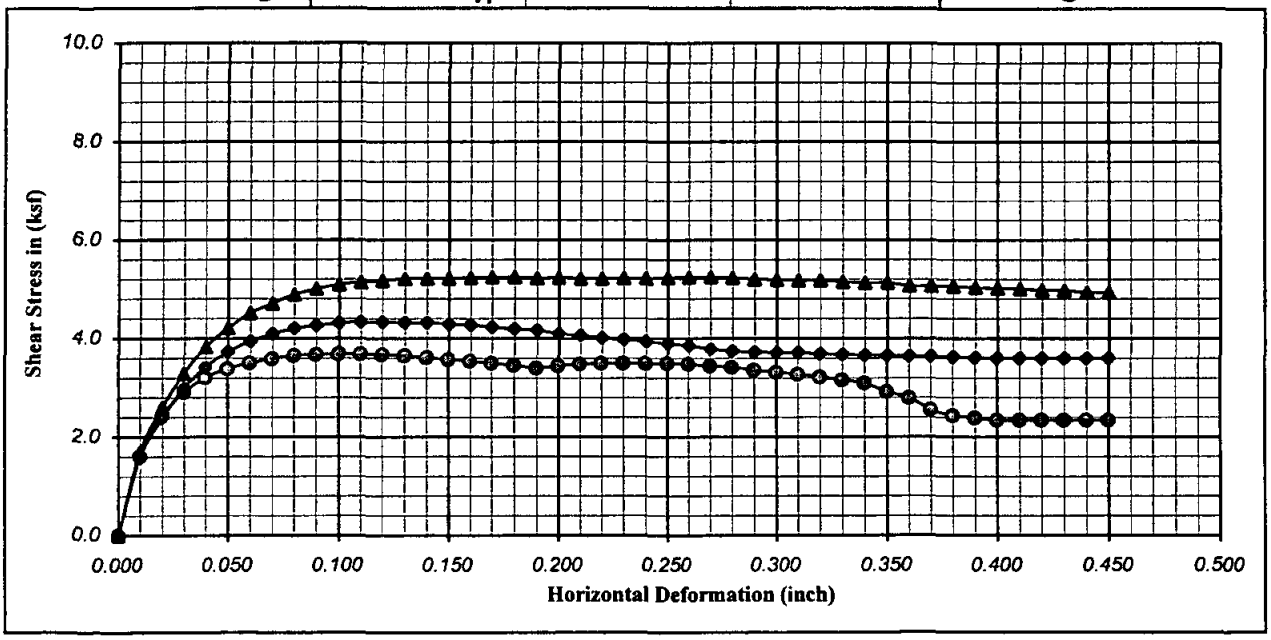
Project No.: 02-134 **Project Name:** Devil's Slide Tunnel

Boring No.: ST-10			Saturated	x	Field Moisiture	x	Inundated	**Specific Gravity** (Assumed):	2.70
Sample No.: D-2		x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate** (inch/min):	0.015
Depth (ft/m): 5.0	1.53	x	Shear Once		Reshear		Residual	**Data File Number:**	213412
Description: Lean Clay with Sand (CL)									

Percent Saturation (%)	119.77		**File No.:**	213412 1			**Shear Deflection**		**Normal Stress (psf/ksf/kPa)**												
Prepared By: RJ	**Date:** 10/23/02		**Normal Stress**						2500	2.50	119.7	5000	5.0	239.4	10000	10.0	478.8				
Tested By: RJ	**Date:** 10/23/02								**Shear Stress (psf/ksf/kPa)**												
Computed By: LCC	**Date:** 11/01/02		2.50	(ksf)			(inch)	(mm)													
Checked By:	**Date:**						0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0				
Percent Consolidation (%)		**Before**		**After**			0.010	0.03	1608	1.61	77.0	1572	1.57	75.3	1680	1.68	80.1				
Height of Sample (inch)		1.00		1.0000			0.020	0.05	2436	2.44	116.6	2388	2.39	114.3	2604	2.60	124.2				
Diameter of Sample (inch)		2.42		2.42			0.030	0.08	2904	2.90	139.0	2988	2.99	143.1	3288	3.29	156.8				
Dial Reading-Consolidation (inch)							0.040	0.10	3204	3.20	153.4	3408	3.41	163.2	3828	3.83	182.6				
Weight of Soil + Ring (gm)		199.48					0.050	0.13	3384	3.38	162.0	3720	3.72	178.1	4200	4.20	200.3				
Weight of Ring (gm)		42.27					0.060	0.15	3504	3.50	167.8	3936	3.94	188.5	4512	4.51	215.2				
Weight of Wet Soil + Cont. (gm)				167.25			0.070	0.18	3588	3.59	171.8	4092	4.09	195.9	4704	4.70	224.4				
Weight of Dry Soil + Cont. (gm)				135.41			0.080	0.20	3648	3.65	174.7	4200	4.20	201.1	4884	4.88	233.0				
Weight of Cont. (gm) No.				3.67			0.090	0.23	3672	3.67	175.8	4260	4.26	204.0	5004	5.00	238.7				
Moisture Content (%)		19.33		24.17			0.100	0.25	3684	3.68	176.4	4308	4.31	206.3	5088	5.09	242.7				
Wet Density (pcf / kN/m³)		130.21	20.49	135.48	21.32		0.110	0.28	3684	3.68	176.4	4332	4.33	207.4	5136	5.14	245.0				
Dry Density (pcf / kN/m³)		109.11	17.17	109.11	17.17		0.120	0.30	3672	3.67	175.8	4332	4.33	207.4	5172	5.17	246.7				
Percent Saturation (%)	109.06		**File No.:**	213412 2			0.130	0.33	3648	3.65	174.7	4320	4.32	206.8	5208	5.21	248.4				
Prepared By: RJ	**Date:** 10/23/02		**Normal Stress**				0.140	0.36	3612	3.61	172.9	4320	4.32	206.8	5220	5.22	249.0				
Tested By: RJ	**Date:** 10/23/02		5.00	(ksf)			0.150	0.38	3576	3.58	171.2	4284	4.28	205.1	5220	5.22	249.0				
Percent Consolidation (%)		**Before**		**After**			0.160	0.41	3540	3.54	169.5	4272	4.27	204.5	5232	5.23	249.6				
Height of Sample (inch)		1.00		1.0000			0.170	0.43	3504	3.50	167.8	4224	4.22	202.2	5244	5.24	250.2				
Diameter of Sample (inch)		2.42		2.42			0.180	0.46	3456	3.46	165.5	4188	4.19	200.5	5244	5.24	250.2				
Dial Reading-Consolidation (inch)							0.190	0.48	3396	3.40	162.6	4164	4.16	199.4	5220	5.22	249.0				
Weight of Soil + Ring (gm)		202.09					0.200	0.51	3444	3.44	164.9	4092	4.09	195.9	5232	5.23	249.6				
Weight of Ring (gm)		43.94					0.210	0.53	3480	3.48	166.6	4056	4.06	194.2	5208	5.21	248.4				
Weight of Wet Soil + Cont. (gm)				165.64			0.220	0.56	3492	3.49	167.2	4008	4.01	191.9	5208	5.21	248.4				
Weight of Dry Soil + Cont. (gm)				137.49			0.230	0.58	3492	3.49	167.2	3972	3.97	190.2	5220	5.22	249.0				
Weight of Cont. (gm) No.				3.66			0.240	0.61	3492	3.49	167.2	3936	3.94	188.5	5220	5.22	249.0				
Moisture Content (%)		18.17		21.03			0.250	0.64	3492	3.49	167.2	3888	3.89	186.2	5232	5.23	249.6				
Wet Density (pcf / kN/m³)		130.98	20.62	134.16	21.12		0.260	0.66	3480	3.48	166.6	3852	3.85	184.4	5244	5.24	250.2				
Dry Density (pcf / kN/m³)		110.84	17.45	110.84	17.45		0.270	0.69	3444	3.44	164.9	3780	3.78	181.0	5244	5.24	250.2				
Percent Saturation (%)	103.36		**File No.:**	213412 3			0.280	0.71	3420	3.42	163.7	3744	3.74	179.3	5232	5.23	249.6				
Prepared By: RJ	**Date:** 10/23/02		**Normal Stress**				0.290	0.74	3360	3.36	160.9	3720	3.72	178.1	5196	5.20	247.9				
Tested By: RJ	**Date:** 10/23/02		10.00	(ksf)			0.300	0.76	3312	3.31	158.6	3708	3.71	177.5	5184	5.18	247.3				
Percent Consolidation (%)		**Before**		**After**			0.310	0.79	3276	3.28	156.9	3708	3.71	177.5	5172	5.17	246.7				
Height of Sample (inch)		1.00		1.0000			0.320	0.81	3216	3.22	154.0	3684	3.68	176.4	5172	5.17	246.7				
Diameter of Sample (inch)		2.42		2.42			0.330	0.84	3156	3.16	151.1	3672	3.67	175.8	5136	5.14	245.0				
Dial Reading-Consolidation (inch)							0.340	0.86	3096	3.10	148.2	3660	3.66	175.2	5124	5.12	244.4				
Weight of Soil + Ring (gm)		203.08					0.350	0.89	2916	2.92	139.6	3648	3.65	174.7	5124	5.12	244.4				
Weight of Ring (gm)		45.49					0.360	0.91	2796	2.80	133.9	3636	3.64	173.4	5064	5.06	241.6				
Weight of Wet Soil + Cont. (gm)				163.94			0.370	0.94	2556	2.56	122.4	3636	3.64	173.4	5064	5.06	241.6				
Weight of Dry Soil + Cont. (gm)				137.12			0.380	0.97	2436	2.44	116.6	3624	3.62	172.9	5052	5.05	241.0				
Weight of Cont. (gm) No.				3.66			0.390	0.99	2388	2.39	114.3	3612	3.61	172.3	5028	5.03	239.8				
Moisture Content (%)		18.08		20.10			0.400	1.02	2340	2.34	112.0	3600	3.60	171.7	5016	5.02	239.3				
Wet Density (pcf / kN/m³)		130.52	20.54	132.75	20.89		0.410	1.04	2340	2.34	112.0	3600	3.60	171.7	5004	5.00	238.7				
Dry Density (pcf / kN/m³)		110.54	17.40	110.54	17.40		0.420	1.07	2340	2.34	112.0	3600	3.60	171.7	4980	4.98	237.6				
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)	0.430	1.09	2340	2.34	112.0	3600	3.60	171.7	4968	4.97	237.0				
Peak	3.68	176.39	4.33	207.42	5.24	251.08	0.440	1.12	2340	2.34	112.0	3600	3.60	171.7	4932	4.93	235.3				
Ultimate	2.34	112.04	3.60	172.37	4.93	236.14	0.450	1.14	2340	2.34	112.0	3600	3.60	171.7	4932	4.93	235.3				



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: ST-10		Strength Intercept (C) :	3.23	(ksf)	Peak	1.67	(ksf)	Ultimate
Sample No.	: D-2			154.56	(kPa)		80.15	(kPa)	
Depth (ft/m)	: 5.0	1.53	Friction Angle (ϕ) :	11.55	Degree		18.48	Degree	
Description	: Lean Clay with Sand (CL)					Shear Rate (inch/minute) :			0.015

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	24.17	109.11	17.17	0.54	2.50	119.70	3.68	176.39	2.34	112.04
◆	21.03	110.84	17.45	0.52	5.00	239.40	4.33	207.42	3.60	172.37
▲	20.10	110.54	17.40	0.52	10.00	478.80	5.24	251.08	4.93	236.14

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | **Date :** 10/23/02

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-90

Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : ST-10			Saturated	x	Field Moisture	x	Inundated
Sample No. : D-8		x	Undisturbed		Remolded		Consolidated-Drained
Depth (ft/m) :	35.0	10.68	x	Shear Once		Reshear	Residual

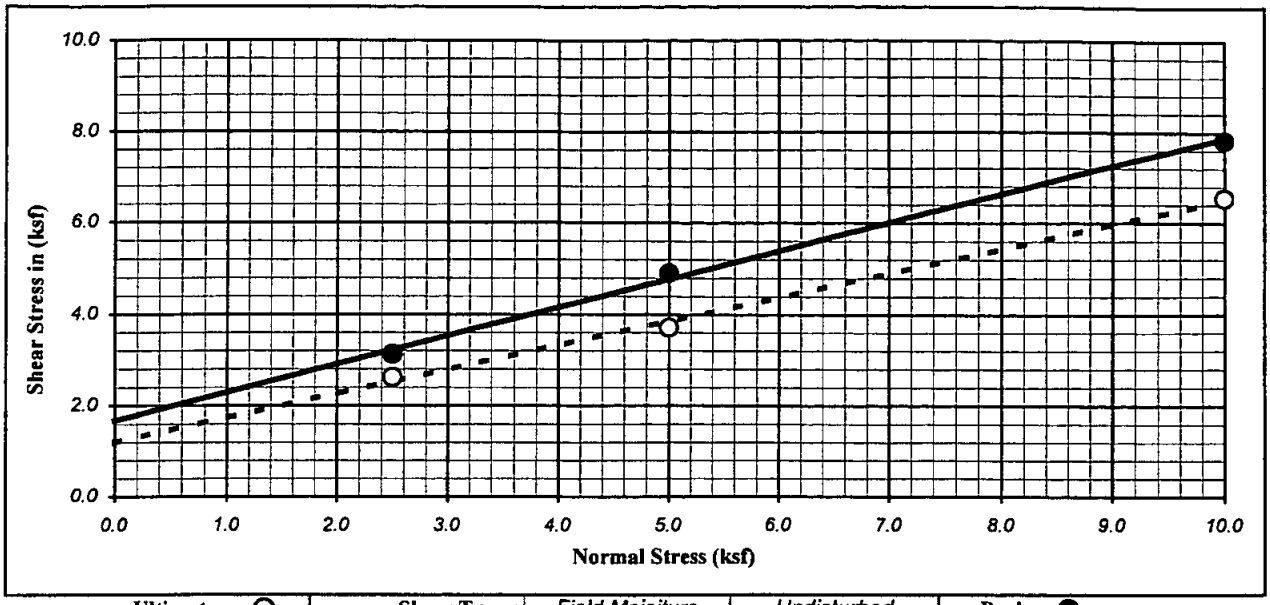
Specific Gravity (Assumed) : 2.70
Shear Rate (inch/min) : 0.02
Data File Number : 213413

Description : Clayey Sand with Gravel (SC)

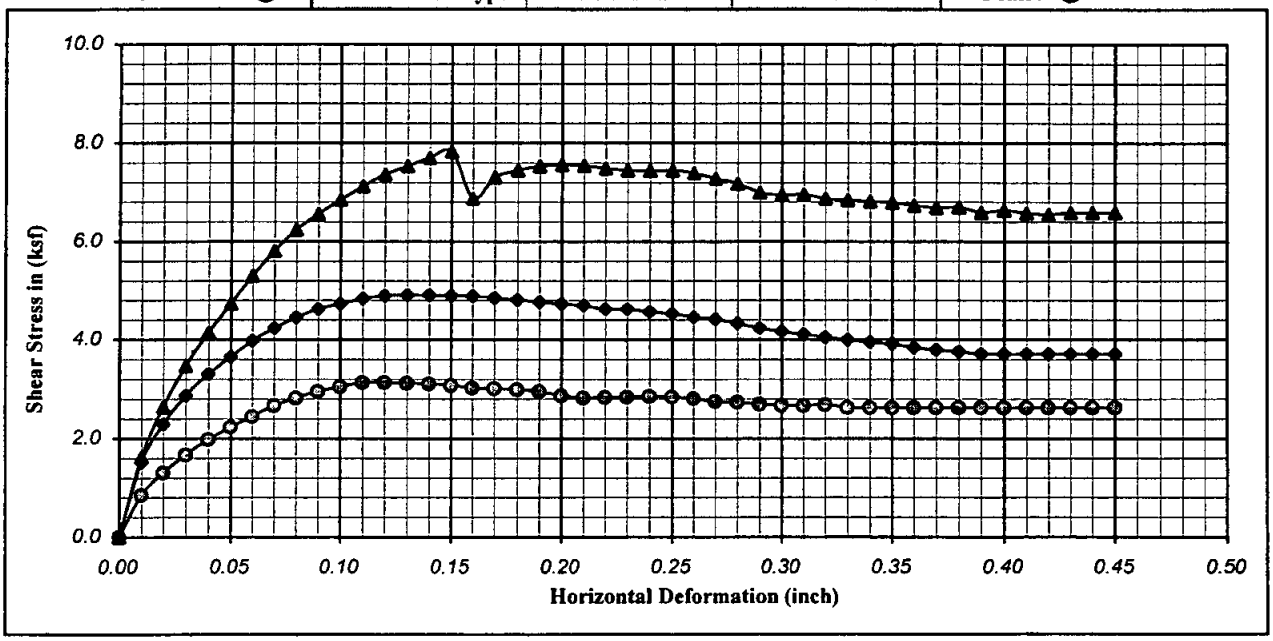
Percent Saturation (%)	121.92	**File No. :**	213413 1		
Prepared By : RJ	**Date :** 10/27/02		**Normal Stress**		
Tested By : RJ	**Date :** 10/27/02				
Computed By : LCC	**Date :** 10/29/02		2.50	(ksf)	
Checked By :	**Date :**				
Percent Consolidation (%)	0.00	**Before**		**After**	
Height of Sample (inch)		1.00		1.0000	
Diameter of Sample (inch)		2.42		2.42	
Dial Reading-Consolidation (inch)					
Weight of Soil + Ring (gm)		215.43			
Weight of Ring (gm)		45.19			
Weight of Wet Soil + Cont. (gm)				177.03	
Weight of Dry Soil + Cont. (gm)				152.19	
Weight of Cont. (gm) No.				3.68	
Moisture Content (%)		14.63		16.73	
Wet Density (pcf / kN/m³)		141.00	22.19	143.57	22.60
Dry Density (pcf / kN/m³)		123.00	19.36	123.00	19.36
Percent Saturation (%)	97.13	**File No. :**	213413 2		
Prepared By : RJ	**Date :** 10/27/02		**Normal Stress**		
Tested By : RJ	**Date :** 10/27/02		5.00	(ksf)	
Percent Consolidation (%)	0.00	**Before**		**After**	
Height of Sample (inch)		1.00		1.0000	
Diameter of Sample (inch)		2.42		2.42	
Dial Reading-Consolidation (inch)					
Weight of Soil + Ring (gm)		202.29			
Weight of Ring (gm)		43.01			
Weight of Wet Soil + Cont. (gm)				166.36	
Weight of Dry Soil + Cont. (gm)				143.42	
Weight of Cont. (gm) No.				3.67	
Moisture Content (%)		13.97		16.42	
Wet Density (pcf / kN/m³)		131.92	20.76	134.74	21.21
Dry Density (pcf / kN/m³)		115.74	18.22	115.74	18.22
Percent Saturation (%)	92.99	**File No. :**	213413 3		
Prepared By : RJ	**Date :** 10/27/02		**Normal Stress**		
Tested By : RJ	**Date :** 10/27/02		10.00	(ksf)	
Percent Consolidation (%)	0.00	**Before**		**After**	
Height of Sample (inch)		1.00		1.0000	
Diameter of Sample (inch)		2.42		2.42	
Dial Reading-Consolidation (inch)					
Weight of Soil + Ring (gm)		208.18			
Weight of Ring (gm)		44.77			
Weight of Wet Soil + Cont. (gm)				165.90	
Weight of Dry Soil + Cont. (gm)				144.21	
Weight of Cont. (gm) No.				3.67	
Moisture Content (%)		16.27		15.43	
Wet Density (pcf / kN/m³)		135.34	21.30	134.36	21.15
Dry Density (pcf / kN/m³)		116.40	18.32	116.40	18.32

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	3.13	149.96	4.91	235.00	7.82	374.57
Ultimate	2.63	125.83	3.71	177.54	6.55	313.66

Shear Deflection (inch)	(mm)	Normal Stress (psf/ksf/kPa) 2500	2.50	119.7	5000	5.0	239.4	10000	10.0	478.8
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0
0.010	0.03	852	0.85	40.8	1524	1.52	73.0	1620	1.62	77.3
0.020	0.05	1308	1.31	62.6	2292	2.29	109.7	2640	2.64	125.9
0.030	0.08	1668	1.67	79.9	2868	2.87	137.3	3468	3.47	165.4
0.040	0.10	1980	1.98	94.8	3300	3.30	158.0	4140	4.14	197.5
0.050	0.13	2232	2.23	106.9	3648	3.65	174.7	4740	4.74	226.1
0.060	0.15	2448	2.45	117.2	3972	3.97	190.2	5304	5.30	253.0
0.070	0.18	2664	2.66	127.6	4236	4.24	202.8	5807	5.81	277.0
0.080	0.20	2820	2.82	135.0	4452	4.45	213.2	6239	6.24	297.6
0.090	0.23	2952	2.95	141.3	4620	4.62	221.2	6563	6.56	313.1
0.100	0.25	3048	3.05	145.9	4728	4.73	226.4	6851	6.85	326.8
0.110	0.28	3132	3.13	150.0	4836	4.84	231.5	7127	7.13	340.0
0.120	0.30	3132	3.13	150.0	4896	4.90	234.4	7367	7.37	351.4
0.130	0.33	3120	3.12	149.4	4908	4.91	235.0	7535	7.54	359.4
0.140	0.36	3108	3.11	148.8	4908	4.91	235.0	7703	7.70	367.4
0.150	0.38	3072	3.07	147.1	4896	4.90	234.4	7823	7.82	373.2
0.160	0.41	3024	3.02	144.8	4884	4.88	233.8	6875	6.88	328.0
0.170	0.43	3012	3.01	144.2	4848	4.85	232.1	7307	7.31	348.6
0.180	0.46	2988	2.99	143.1	4812	4.81	230.4	7451	7.45	355.4
0.190	0.48	2952	2.95	141.3	4764	4.76	228.1	7535	7.54	359.4
0.200	0.51	2868	2.87	137.3	4728	4.73	226.4	7559	7.56	360.6
0.210	0.53	2820	2.82	135.0	4692	4.69	224.7	7547	7.55	360.0
0.220	0.56	2832	2.83	135.6	4620	4.62	221.2	7487	7.49	357.1
0.230	0.58	2844	2.84	136.2	4620	4.62	221.2	7451	7.45	355.4
0.240	0.61	2856	2.86	136.7	4560	4.56	218.3	7439	7.44	354.9
0.250	0.64	2844	2.84	136.2	4524	4.52	216.6	7451	7.45	355.4
0.260	0.66	2808	2.81	134.4	4452	4.45	213.2	7391	7.39	352.6
0.270	0.69	2748	2.75	131.6	4416	4.42	211.4	7283	7.28	347.4
0.280	0.71	2736	2.74	131.0	4332	4.33	207.4	7175	7.18	342.3
0.290	0.74	2700	2.70	129.3	4236	4.24	202.8	6995	7.00	333.7
0.300	0.76	2676	2.68	128.1	4164	4.16	199.4	6947	6.95	331.4
0.310	0.79	2664	2.66	127.6	4104	4.10	196.5	6959	6.96	332.0
0.320	0.81	2688	2.69	128.7	4044	4.04	193.6	6875	6.88	328.0
0.330	0.84	2628	2.63	125.8	3996	4.00	191.3	6839	6.84	326.2
0.340	0.86	2628	2.63	125.8	3948	3.95	189.0	6815	6.82	325.1
0.350	0.89	2628	2.63	125.8	3912	3.91	187.3	6791	6.79	323.9
0.360	0.91	2628	2.63	125.8	3840	3.84	183.2	6731	6.73	321.1
0.370	0.94	2628	2.63	125.8	3792	3.79	180.9	6683	6.68	318.8
0.380	0.97	2628	2.63	125.8	3756	3.76	179.2	6695	6.70	319.4
0.390	0.99	2628	2.63	125.8	3708	3.71	176.9	6587	6.59	314.2
0.400	1.02	2628	2.63	125.8	3708	3.71	176.9	6635	6.64	316.5
0.410	1.04	2628	2.63	125.8	3708	3.71	176.9	6575	6.58	313.6
0.420	1.07	2628	2.63	125.8	3708	3.71	176.9	6551	6.55	312.5
0.430	1.09	2628	2.63	125.8	3708	3.71	176.9	6587	6.59	314.2
0.440	1.12	2628	2.63	125.8	3708	3.71	176.9	6587	6.59	314.2
0.450	1.14	2628	2.63	125.8	3708	3.71	176.9	6587	6.59	314.2



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: ST-10	**Strength Intercept (C) :**	1.67	(ksf)	**Peak**	1.21	(ksf)	**Ultimate**	
Sample No.	: D-8		80.18	(kPa)		57.77	(kPa)		
Depth (ft/m)	: 35.0 10.68	**Friction Angle (ϕ) :**	31.77	Degree		27.90	Degree		
Description	: Clayey Sand with Gravel (SC)						**Shear Rate** (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	16.73	123.00	19.36	0.37	2.50	119.70	3.13	149.96	2.63	125.83
◆	16.42	115.74	18.22	0.46	5.00	239.40	4.91	235.00	3.71	177.54
▲	15.43	116.40	18.32	0.45	10.00	478.80	7.82	374.57	6.55	313.66

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 **Date :** 10/27/02

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-90

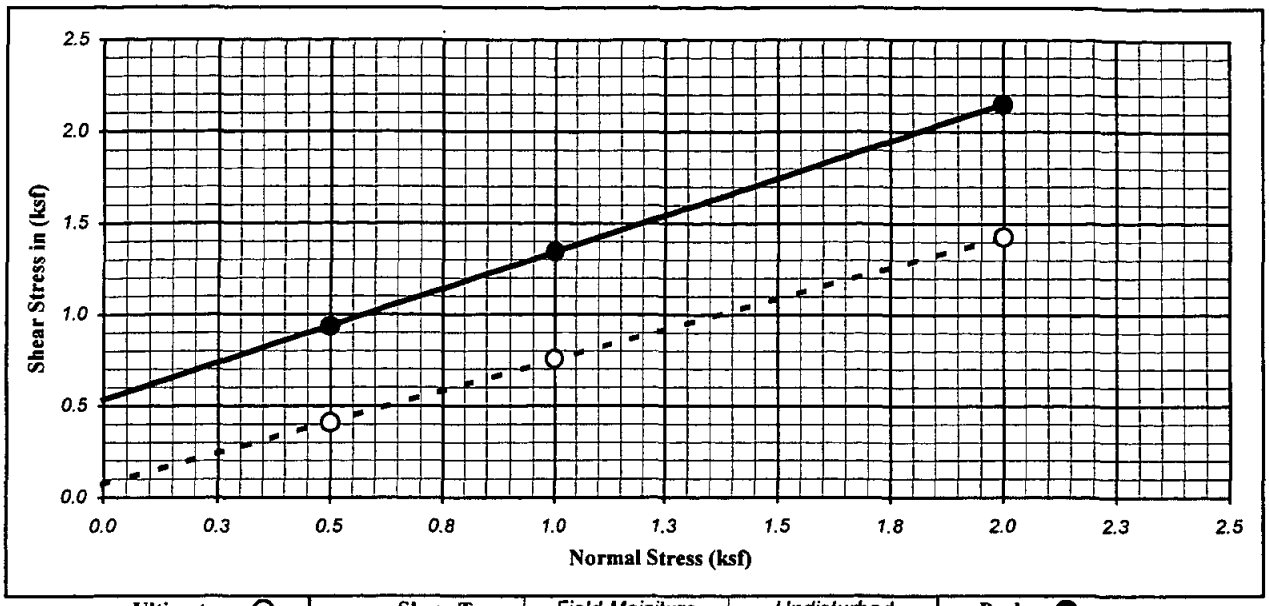
Project No.: 02-134 **Project Name:** Devil's Slide Tunnel

Boring No.: 02-19			**Saturated**	x	**Field Moisture**	x	**Inundated**	**Specific Gravity (Assumed):** 2.70	
Sample No.: D-1		x	**Undisturbed**		**Remolded**		**Consolidated-Drained**	**Shear Rate (inch/min):** 0.02	
Depth (ft/m): 5.0	1.53	x	**Shear Once**		**Reshear**		**Residual**	**Data File Number:** 213414	
Description: Clayey Sand (SC)									

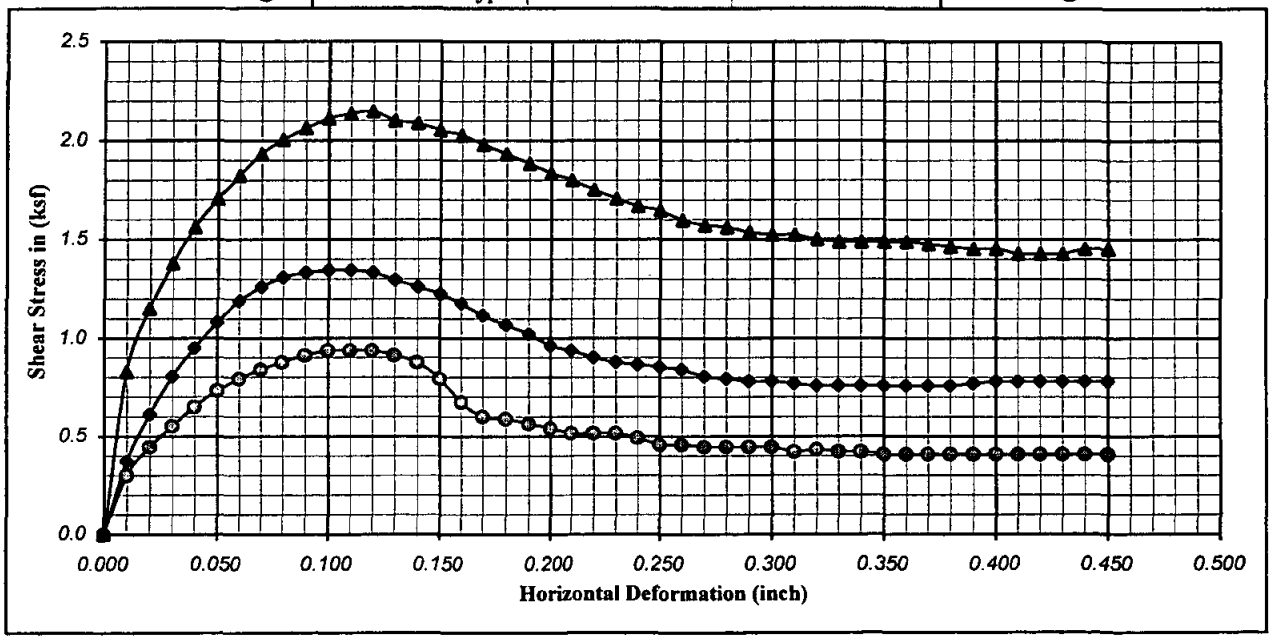
Percent Saturation (%)	106.67		**File No.:** 213414 1																	
Prepared By: RJ	**Date:** 10/27/02		**Normal Stress**																	
Tested By: RJ	**Date:** 10/27/02																			
Computed By: LCC	**Date:** 10/29/02		0.50	(ksf)																
Checked By:	**Date:**																			
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		210.17																		
Weight of Ring (gm)		46.86																		
Weight of Wet Soil + Cont. (gm)				168.70																
Weight of Dry Soil + Cont. (gm)				143.41																
Weight of Cont. (gm) No.				3.9																
Moisture Content (%)		17.06		18.13																
Wet Density (pcf / kN/m³)		135.26	21.29	136.49	21.48															
Dry Density (pcf / kN/m³)		115.55	18.19	115.55	18.19															
Percent Saturation (%)	106.52		**File No.:** 213414 2																	
Prepared By: RJ	**Date:** 10/27/02		**Normal Stress**																	
Tested By: RJ	**Date:** 10/27/02		1.00	(ksf)																
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		210.43																		
Weight of Ring (gm)		46.82																		
Weight of Wet Soil + Cont. (gm)				169.14																
Weight of Dry Soil + Cont. (gm)				144.17																
Weight of Cont. (gm) No.				3.94																
Moisture Content (%)		16.67		17.81																
Wet Density (pcf / kN/m³)		135.51	21.33	136.82	21.54															
Dry Density (pcf / kN/m³)		116.14	18.28	116.14	18.28															
Percent Saturation (%)	98.91		**File No.:** 213414 3																	
Prepared By: RJ	**Date:** 10/27/02		**Normal Stress**																	
Tested By: RJ	**Date:** 10/27/02		2.00	(ksf)																
Percent Consolidation (%)		**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		207.39																		
Weight of Ring (gm)		44.85																		
Weight of Wet Soil + Cont. (gm)				166.34																
Weight of Dry Soil + Cont. (gm)				142.58																
Weight of Cont. (gm) No.				3.92																
Moisture Content (%)		17.22		17.14																
Wet Density (pcf / kN/m³)		134.62	21.19	134.52	21.17															
Dry Density (pcf / kN/m³)		114.84	18.08	114.84	18.08															

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	0.94	44.82	1.34	64.35	2.15	102.85
Ultimate	0.41	19.54	0.76	36.20	1.43	68.37

Shear Deflection		**Normal Stress (psf/ksf/kPa)**								
		500	0.50	23.9	1000	1.0	47.9	2000	2.0	95.8
(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**								
0.000	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0
0.010	0.03	300	0.30	14.4	372	0.37	17.8	828	0.83	39.5
0.020	0.05	444	0.44	21.3	612	0.61	29.3	1152	1.15	55.0
0.030	0.08	552	0.55	26.4	804	0.80	38.5	1380	1.38	65.8
0.040	0.10	648	0.65	31.0	948	0.95	45.4	1560	1.56	74.4
0.050	0.13	732	0.73	35.0	1080	1.08	51.7	1704	1.70	81.3
0.060	0.15	792	0.79	37.9	1188	1.19	56.9	1824	1.82	87.0
0.070	0.18	840	0.84	40.2	1260	1.26	60.3	1932	1.93	92.2
0.080	0.20	876	0.88	41.9	1308	1.31	62.6	2004	2.00	95.6
0.090	0.23	912	0.91	43.7	1332	1.33	63.8	2064	2.06	98.5
0.100	0.25	936	0.94	44.8	1344	1.34	64.4	2112	2.11	100.7
0.110	0.28	936	0.94	44.8	1344	1.34	64.4	2136	2.14	101.9
0.120	0.30	936	0.94	44.8	1332	1.33	63.8	2148	2.15	102.5
0.130	0.33	912	0.91	43.7	1296	1.30	62.1	2100	2.10	100.2
0.140	0.36	876	0.88	41.9	1260	1.26	60.3	2088	2.09	99.6
0.150	0.38	792	0.79	37.9	1224	1.22	58.6	2052	2.05	97.9
0.160	0.41	672	0.67	32.2	1176	1.18	56.3	2028	2.03	96.7
0.170	0.43	600	0.60	28.7	1116	1.12	53.4	1980	1.98	94.5
0.180	0.46	588	0.59	28.2	1068	1.07	51.1	1932	1.93	92.2
0.190	0.48	564	0.56	27.0	1020	1.02	48.8	1884	1.88	89.9
0.200	0.51	540	0.54	25.9	960	0.96	46.0	1836	1.84	87.6
0.210	0.53	516	0.52	24.7	936	0.94	44.8	1800	1.80	85.9
0.220	0.56	516	0.52	24.7	900	0.90	43.1	1752	1.75	83.6
0.230	0.58	516	0.52	24.7	876	0.88	41.9	1704	1.70	81.3
0.240	0.61	492	0.49	23.6	864	0.86	41.4	1668	1.67	79.6
0.250	0.64	456	0.46	21.8	852	0.85	40.8	1644	1.64	78.4
0.260	0.66	456	0.46	21.8	840	0.84	40.2	1596	1.60	76.1
0.270	0.69	444	0.44	21.3	804	0.80	38.5	1572	1.57	75.0
0.280	0.71	444	0.44	21.3	792	0.79	37.9	1560	1.56	74.4
0.290	0.74	444	0.44	21.3	780	0.78	37.3	1536	1.54	73.3
0.300	0.76	444	0.44	21.3	780	0.78	37.3	1524	1.52	72.7
0.310	0.79	420	0.42	20.1	768	0.77	36.8	1524	1.52	72.7
0.320	0.81	432	0.43	20.7	756	0.76	36.2	1500	1.50	71.6
0.330	0.84	420	0.42	20.1	756	0.76	36.2	1488	1.49	71.0
0.340	0.86	420	0.42	20.1	756	0.76	36.2	1488	1.49	71.0
0.350	0.89	408	0.41	19.5	756	0.76	36.2	1488	1.49	71.0
0.360	0.91	408	0.41	19.5	756	0.76	36.1	1488	1.49	71.0
0.370	0.94	408	0.41	19.5	756	0.76	36.1	1476	1.48	70.4
0.380	0.97	408	0.41	19.5	756	0.76	36.1	1464	1.46	69.8
0.390	0.99	408	0.41	19.5	768	0.77	36.6	1452	1.45	69.3
0.400	1.02	408	0.41	19.5	780	0.78	37.2	1452	1.45	69.3
0.410	1.04	408	0.41	19.5	780	0.78	37.2	1428	1.43	68.1
0.420	1.07	408	0.41	19.5	780	0.78	37.2	1428	1.43	68.1
0.430	1.09	408	0.41	19.5	780	0.78	37.2	1428	1.43	68.1
0.440	1.12	408	0.41	19.5	780	0.78	37.2	1452	1.45	69.3
0.450	1.14	408	0.41	19.5	780	0.78	37.2	1452	1.45	69.3



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : 02-19		Strength Intercept (C) :	0.53	(ksf)	Peak	0.07	(ksf)	Ultimate
Sample No. : D-1			25.57	(kPa)		3.45	(kPa)	
Depth (ft/m) : 5.0	1.53	Friction Angle (ϕ) :	38.92	Degree		34.17	Degree	
Description : Clayey Sand (SC)						Shear Rate (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	18.13	115.55	18.19	0.46	0.50	23.94	0.94	44.82	0.41	19.54
◆	17.81	116.14	18.28	0.45	1.00	47.88	1.34	64.35	0.76	36.20
▲	17.14	114.84	18.08	0.47	2.00	95.76	2.15	102.85	1.43	68.37

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | Date : 10/27/02 | Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-90

Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : 02-19			Saturated	x	Field Moisture	x	Inundated	**Specific Gravity** (Assumed) :	2.70
Sample No. : D-9		x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate** (inch/min) :	0.02
Depth (ft/m) : 45.0	13.73	x	Shear Once		Resbear		Residual	**Data File Number :**	213415
Description : Sand with Silt and Gravel (SP-SM)									

Percent Saturation (%)	106.97	**File No. :**	213415 1						
Prepared By : RJ	**Date :** 10/27/02	**Normal Stress**							
Tested By : RJ	**Date :** 10/27/02								
Computed By : LCC	**Date :** 10/29/02	**2.50**	(ksf)						
Checked By :	**Date :**								

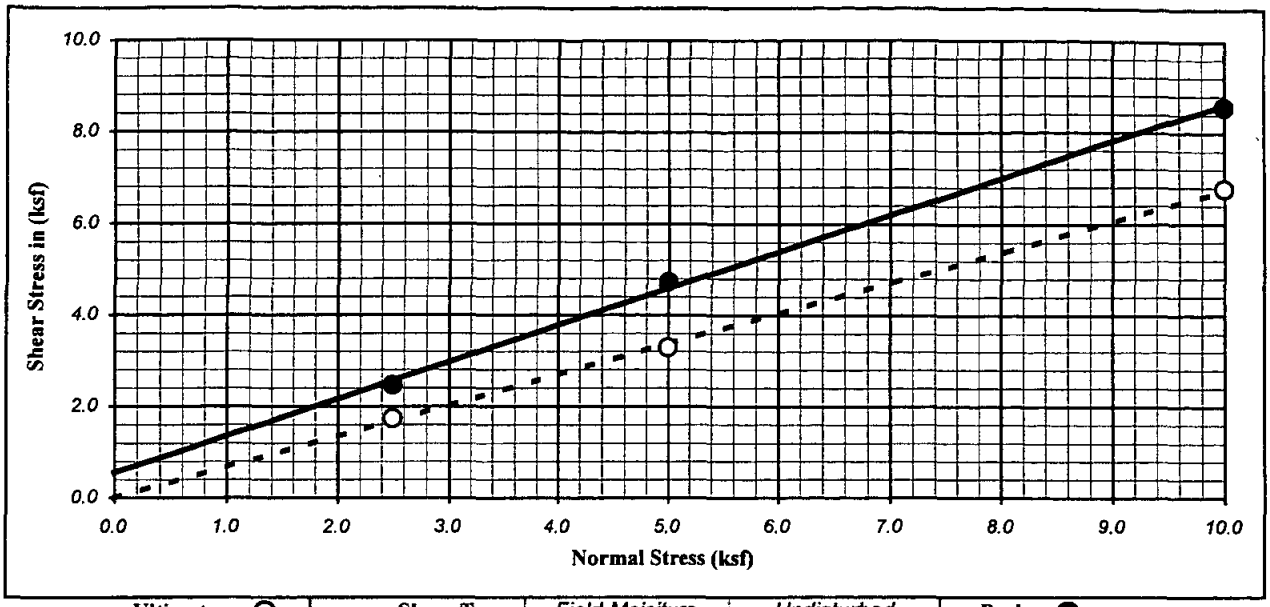
Percent Consolidation (%)		**Before**		**After**					
Height of Sample (inch)		1.00		1.0000					
Diameter of Sample (inch)		2.42		2.42					
Dial Reading-Consolidation (inch)									
Weight of Soil + Ring (gm)		212.36							
Weight of Ring (gm)		46.99							
Weight of Wet Soil + Cont. (gm)				171.47					
Weight of Dry Soil + Cont. (gm)				147.92					
Weight of Cont. (gm) **No.**				3.84					
Moisture Content (%)		14.78		16.35					
Wet Density (pcf / kN/m³)		136.96	21.56	138.84	21.85				
Dry Density (pcf / kN/m³)		119.33	18.78	119.33	18.78				

Percent Saturation (%)	99.03	**File No. :**	213415 2						
Prepared By : RJ	**Date :** 10/27/02	**Normal Stress**							
Tested By : RJ	**Date :** 10/27/02	**5.00**	(ksf)						
Percent Consolidation (%)		**Before**		**After**					
Height of Sample (inch)		1.00		1.0000					
Diameter of Sample (inch)		2.42		2.42					
Dial Reading-Consolidation (inch)									
Weight of Soil + Ring (gm)		207.46							
Weight of Ring (gm)		45.76							
Weight of Wet Soil + Cont. (gm)				166.78					
Weight of Dry Soil + Cont. (gm)				143.20					
Weight of Cont. (gm) **No.**				3.97					
Moisture Content (%)		16.14		16.94					
Wet Density (pcf / kN/m³)		133.92	21.08	134.84	21.22				
Dry Density (pcf / kN/m³)		115.31	18.15	115.31	18.15				

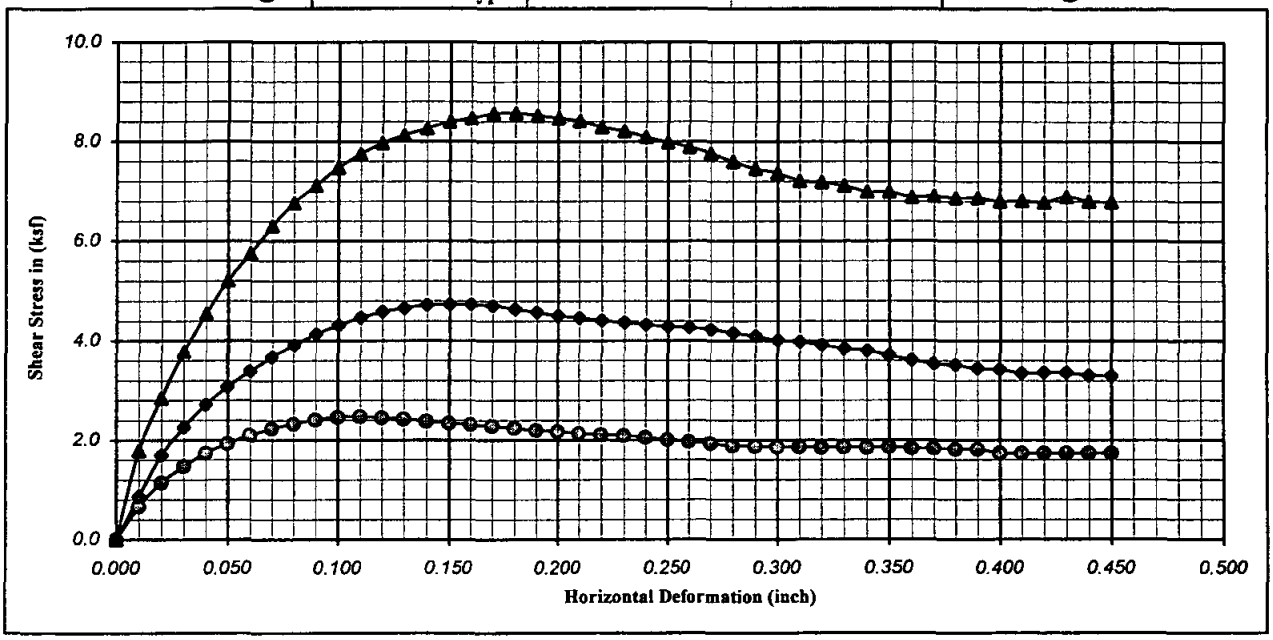
Percent Saturation (%)	92.66	**File No. :**	213415 3						
Prepared By : RJ	**Date :** 10/27/02	**Normal Stress**							
Tested By : RJ	**Date :** 10/27/02	**10.00**	(ksf)						
Percent Consolidation (%)		**Before**		**After**					
Height of Sample (inch)		1.00		1.0000					
Diameter of Sample (inch)		2.42		2.42					
Dial Reading-Consolidation (inch)									
Weight of Soil + Ring (gm)		205.29							
Weight of Ring (gm)		42.35							
Weight of Wet Soil + Cont. (gm)				166.48					
Weight of Dry Soil + Cont. (gm)				145.09					
Weight of Cont. (gm) **No.**				3.9					
Moisture Content (%)		15.40		15.15					
Wet Density (pcf / kN/m³)		134 95	21.24	134.65	21.19				
Dry Density (pcf / kN/m³)		116.94	18 41	116.94	18.41				

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	2.47	118.36	4.73	226.38	8.57	410.19
Ultimate	1.74	83.31	3.29	157.43	6.78	324.58

Shear Deflection (inch)	Shear Deflection (mm)	Normal Stress (psf/ksf/kPa)								
		2500	2.50	119.7	5000	5.0	239.4	10000	10.0	478.8
		Shear Stress (psf/ksf/kPa)								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0
0.010	0.03	660	0.66	31.6	864	0.86	41.4	1788	1.79	85.3
0.020	0.05	1140	1.14	54.6	1692	1.69	81.0	2844	2.84	135.7
0.030	0.08	1476	1.48	70.7	2256	2.26	108.0	3780	3.78	180.3
0.040	0.10	1740	1.74	83.3	2712	2.71	129.9	4548	4.55	216.9
0.050	0.13	1932	1.93	92.5	3072	3.07	147.1	5208	5.21	248.4
0.060	0.15	2100	2.10	100.5	3384	3.38	162.0	5747	5.75	274.1
0.070	0.18	2232	2.23	106.9	3672	3.67	175.8	6299	6.30	300.5
0.080	0.20	2328	2.33	111.5	3912	3.91	187.3	6767	6.77	322.8
0.090	0.23	2412	2.41	115.5	4128	4.13	197.6	7115	7.12	339.4
0.100	0.25	2460	2.46	117.8	4308	4.31	206.3	7475	7.48	356.6
0.110	0.28	2472	2.47	118.4	4464	4.46	213.7	7751	7.75	369.7
0.120	0.30	2448	2.45	117.2	4584	4.58	219.5	7967	7.97	380.0
0.130	0.33	2424	2.42	116.1	4656	4.66	222.9	8123	8.12	387.5
0.140	0.36	2376	2.38	113.8	4716	4.72	225.8	8255	8.26	393.8
0.150	0.38	2340	2.34	112.0	4728	4.73	226.4	8399	8.40	400.7
0.160	0.41	2316	2.32	110.9	4728	4.73	226.4	8471	8.47	404.1
0.170	0.43	2280	2.28	109.2	4704	4.70	225.2	8555	8.56	408.1
0.180	0.46	2244	2.24	107.4	4632	4.63	221.8	8567	8.57	408.7
0.190	0.48	2196	2.20	105.1	4572	4.57	218.9	8519	8.52	406.4
0.200	0.51	2172	2.17	104.0	4500	4.50	215.5	8471	8.47	404.1
0.210	0.53	2136	2.14	102.3	4464	4.46	213.7	8411	8.41	401.2
0.220	0.56	2112	2.11	101.1	4404	4.40	210.9	8291	8.29	395.5
0.230	0.58	2088	2.09	100.0	4368	4.37	209.1	8207	8.21	391.5
0.240	0.61	2052	2.05	98.2	4320	4.32	206.8	8087	8.09	385.8
0.250	0.64	2004	2.00	96 0	4284	4.28	205.1	7979	7.98	380.6
0.260	0.66	1968	1.97	94.2	4260	4.26	204.0	7883	7.88	376.0
0.270	0.69	1932	1.93	92.5	4224	4.22	202.2	7763	7.76	370.3
0.280	0.71	1884	1.88	90.2	4152	4.15	198.8	7595	7.60	362.3
0.290	0.74	1872	1.87	89.6	4092	4.09	195.9	7451	7.45	355.4
0.300	0.76	1860	1.86	89.1	4008	4.01	191.9	7367	7.37	351.4
0.310	0.79	1860	1.86	89.1	3972	3.97	190.2	7211	7.21	344.0
0.320	0.81	1848	1.85	88.5	3912	3.91	187.3	7187	7.19	342.8
0.330	0.84	1860	1.86	89.1	3840	3.84	183.9	7115	7.12	339.4
0.340	0.86	1848	1.85	88.5	3804	3.80	182.1	6995	7.00	333.7
0.350	0.89	1860	1.86	89.1	3708	3.71	177.5	6995	7.00	333.7
0.360	0.91	1836	1.84	87.9	3612	3.61	172.3	6887	6.89	328.5
0.370	0.94	1836	1.84	87.9	3540	3.54	168.9	6911	6.91	329.7
0.380	0.97	1812	1.81	86.8	3516	3.52	167.7	6875	6.88	328.0
0 390	0.99	1812	1.81	86.8	3444	3.44	164.3	6875	6.88	328.0
0.400	1.02	1740	1.74	83.3	3420	3.42	163.1	6803	6.80	324.5
0 410	1.04	1740	1.74	83.3	3348	3.35	159.7	6815	6.82	325.1
0.420	1.07	1740	1.74	83.3	3360	3.36	160.3	6779	6.78	323.4
0.430	1.09	1740	1.74	83.3	3360	3.36	160.3	6899	6.90	329.1
0.440	1.12	1740	1.74	83.3	3300	3.30	157.4	6803	6.80	324.5
0.450	1.14	1740	1.74	83.3	3288	3.29	156.8	6791	6.79	323.9



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: 02-19	Strength Intercept (C) :	0.55	(ksf)	Peak	0.00	(ksf)	Ultimate	
Sample No.	: D-9		26.45	(kPa)		0.00	(kPa)		
Depth (ft/m)	: 45.0 13.73	Friction Angle (ϕ) :	38.88	Degree		34.02	Degree		
Description	: Sand with Silt and Gravel (SP-SM)						Shear Rate (inch/minute) :	0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	16.35	119.33	18.78	0.41	2.50	119.70	2.47	118.36	1.74	83.31
◆	16.94	115.31	18.15	0.46	5.00	239.40	4.73	226.38	3.29	157.43
▲	15.15	116.94	18.41	0.44	10.00	478.80	8.57	410.19	6.78	324.58

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | Date : 10/27/02 | Figure No. :

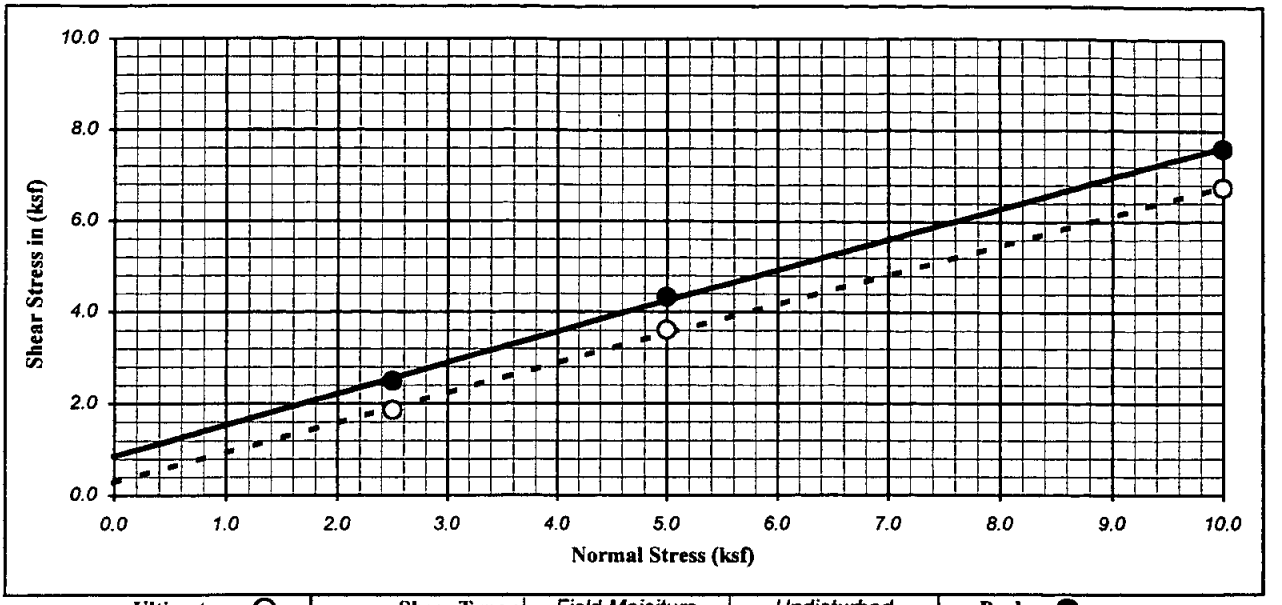
DIRECT SHEAR TEST

ASTM D-3080-90

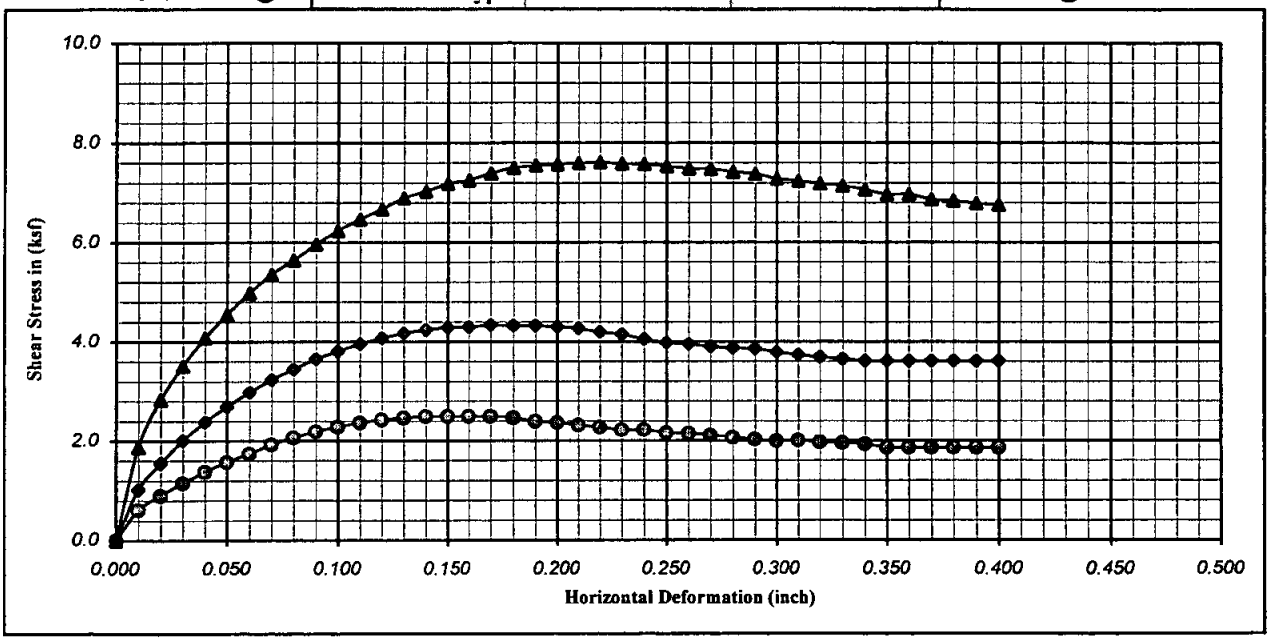
Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : 02-19			**Saturated**	x	**Field Moisture**	x	**Inundated**	**Specific Gravity (Assumed) :** 2.70	
Sample No. : D-11		x	**Undisturbed**		**Remolded**		**Consolidated-Drained**	**Shear Rate (inch/min) :** 0.02	
Depth (ft/m) : 55.0	16.78	x	**Shear Once**		**Reshear**		**Residual**	**Data File Number :** 213416	
Description : Silty Sand (SM)									

Percent Saturation (%)	99.89		**File No. :**	213416 1			**Shear Deflection**	**Normal Stress (psf/ksf/kPa)**												
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**					2500	2.50	119.7	5000	5.0	239.4	10000	10.0	478.8				
Tested By : RJ	**Date :** 10/30/02							**Shear Stress (psf/ksf/kPa)**												
Computed By : LCC	**Date :** 11/01/02		2.50	(ksf)			(inch)	(mm)												
Checked By :	**Date :**						0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0			
Percent Consolidation (%)		**Before**		**After**			0.010	0.03	612	0.61	29.3	1020	1.02	48.8	1872	1.87	89.3			
Height of Sample (inch)		1.00		1.0000			0.020	0.05	900	0.90	43.1	1548	1.55	74.1	2832	2.83	135.1			
Diameter of Sample (inch)		2.42		2.42			0.030	0.08	1152	1.15	55.2	2004	2.00	96.0	3516	3.52	167.7			
Dial Reading-Consolidation (inch)							0.040	0.10	1380	1.38	66.1	2376	2.38	113.8	4080	4.08	194.6			
Weight of Soil + Ring (gm)		208.12					0.050	0.13	1572	1.57	75.3	2688	2.69	128.7	4548	4.55	216.9			
Weight of Ring (gm)		45.33					0.060	0.15	1740	1.74	83.3	2976	2.98	142.5	4980	4.98	237.6			
Weight of Wet Soil + Cont. (gm)				165.17			0.070	0.18	1920	1.92	91.9	3228	3.23	154.6	5352	5.35	255.3			
Weight of Dry Soil + Cont. (gm)				140.39			0.080	0.20	2064	2.06	98.8	3444	3.44	164.9	5639	5.64	269.0			
Weight of Cont. (gm) No.				3.85			0.090	0.23	2184	2.18	104.6	3648	3.65	174.7	5963	5.96	284.4			
Moisture Content (%)		19.23		18.15			0.100	0.25	2280	2.28	109.2	3804	3.80	182.1	6239	6.24	297.6			
Wet Density (pcf / kN/m³)		134.83	21.22	133.61	21.03		0.110	0.28	2364	2.36	113.2	3948	3.95	189.0	6467	6.47	308.5			
Dry Density (pcf / kN/m³)		113.09	17.80	113.09	17.80		0.120	0.30	2424	2.42	116.1	4068	4.07	194.8	6671	6.67	318.2			
Percent Saturation (%)	95.43		**File No. :**	213416 2			0.130	0.33	2460	2.46	117.8	4164	4.16	199.4	6899	6.90	329.1			
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**				0.140	0.36	2496	2.50	119.5	4236	4.24	202.8	7031	7.03	335.4			
Tested By : RJ	**Date :** 10/30/02		5.00	(ksf)			0.150	0.38	2496	2.50	119.5	4284	4.28	205.1	7187	7.19	342.8			
Percent Consolidation (%)		**Before**		**After**			0.160	0.41	2496	2.50	119.5	4296	4.30	205.7	7259	7.26	346.3			
Height of Sample (inch)		1.00		1.0000			0.170	0.43	2496	2.50	119.5	4332	4.33	207.4	7391	7.39	352.6			
Diameter of Sample (inch)		2.42		2.42			0.180	0.46	2460	2.46	117.8	4320	4.32	206.8	7499	7.50	357.7			
Dial Reading-Consolidation (inch)							0.190	0.48	2388	2.39	114.3	4320	4.32	206.8	7547	7.55	360.0			
Weight of Soil + Ring (gm)		202.51					0.200	0.51	2364	2.36	113.2	4296	4.30	205.7	7571	7.57	361.2			
Weight of Ring (gm)		42.80					0.210	0.53	2316	2.32	110.9	4260	4.26	204.0	7595	7.60	362.3			
Weight of Wet Soil + Cont. (gm)				161.91			0.220	0.56	2268	2.27	108.6	4188	4.19	200.5	7607	7.61	362.9			
Weight of Dry Soil + Cont. (gm)				137.06			0.230	0.58	2220	2.22	106.3	4140	4.14	198.2	7583	7.58	361.7			
Weight of Cont. (gm) No.				3.85			0.240	0.61	2220	2.22	106.3	4044	4.04	193.6	7571	7.57	361.2			
Moisture Content (%)		19.89		18.65			0.250	0.64	2160	2.16	103.4	3972	3.97	190.2	7535	7.54	359.4			
Wet Density (pcf / kN/m³)		132.28	20.82	130.91	20.61		0.260	0.66	2148	2.15	102.8	3948	3.95	189.0	7487	7.49	357.1			
Dry Density (pcf / kN/m³)		110.33	17.37	110.33	17.37		0.270	0.69	2112	2.11	101.1	3900	3.90	186.7	7475	7.48	356.6			
Percent Saturation (%)	79.18		**File No. :**	213416 3			0.280	0.71	2064	2.06	98.8	3864	3.86	185.0	7415	7.42	353.7			
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**				0.290	0.74	2028	2.03	97.1	3852	3.85	184.4	7379	7.38	352.0			
Tested By : RJ	**Date :** 10/30/02		10.00	(ksf)			0.300	0.76	1992	1.99	95.4	3780	3.78	181.0	7283	7.28	347.4			
Percent Consolidation (%)		**Before**		**After**			0.310	0.79	2004	2.00	96.0	3732	3.73	178.7	7235	7.24	345.1			
Height of Sample (inch)		1.00		1.0000			0.320	0.81	1968	1.97	94.2	3684	3.68	176.4	7187	7.19	342.8			
Diameter of Sample (inch)		2.42		2.42			0.330	0.84	1956	1.96	93.7	3648	3.65	174.7	7139	7.14	340.5			
Dial Reading-Consolidation (inch)							0.340	0.86	1932	1.93	92.5	3612	3.61	172.9	7067	7.07	337.1			
Weight of Soil + Ring (gm)		203.05					0.350	0.89	1860	1.86	89.1	3612	3.61	172.9	6971	6.97	332.5			
Weight of Ring (gm)		45.28					0.360	0.91	1860	1.86	89.1	3612	3.61	172.3	6971	6.97	332.5			
Weight of Wet Soil + Cont. (gm)				158.79			0.370	0.94	1860	1.86	89.1	3612	3.61	172.3	6863	6.86	327.4			
Weight of Dry Soil + Cont. (gm)				138.61			0.380	0.97	1860	1.86	89.1	3612	3.61	172.3	6839	6.84	326.2			
Weight of Cont. (gm) No.				3.9			0.390	0.99	1860	1.86	89.1	3612	3.61	172.3	6791	6.79	323.9			
Moisture Content (%)		17.12		14.98			0.400	1.02	1860	1.86	89.1	3612	3.61	172.3	6755	6.76	322.2			
Wet Density (pcf / kN/m³)		130.67	20.57	128.28	20.19			0.00												
Dry Density (pcf / kN/m³)		111.57	17.56	111.57	17.56			0.00												
Strength	(ksf) (kPa)	(ksf)	(kPa)	(ksf)	(kPa)			0.00												
Peak	2.50 119.51	4.33	207.42	7.61	364.22			0.00												
Ultimate	1.86 89.06	3.61	172.94	6.76	323.43			0.00												



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : 02-19		**Strength Intercept (C) :**	0.86	(ksf)	**Peak**	0.29	(ksf)	**Ultimate**
Sample No. : D-11			41.10	(kPa)		13.81	(kPa)	
Depth (ft/m) : 55.0	16.78	**Friction Angle (ϕ) :**	34.12	Degree		32.99	Degree	
Description : Silty Sand (SM)						**Shear Rate** (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	18.15	113.09	17.80	0.49	2.50	119.70	2.50	119.51	1.86	89.06
◆	18.65	110.33	17.37	0.53	5.00	239.40	4.33	207.42	3.61	172.94
▲	14.98	111.57	17.56	0.51	10.00	478.80	7.61	364.22	6.76	323.43

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | **Date :** 10/30/02

Figure No. :

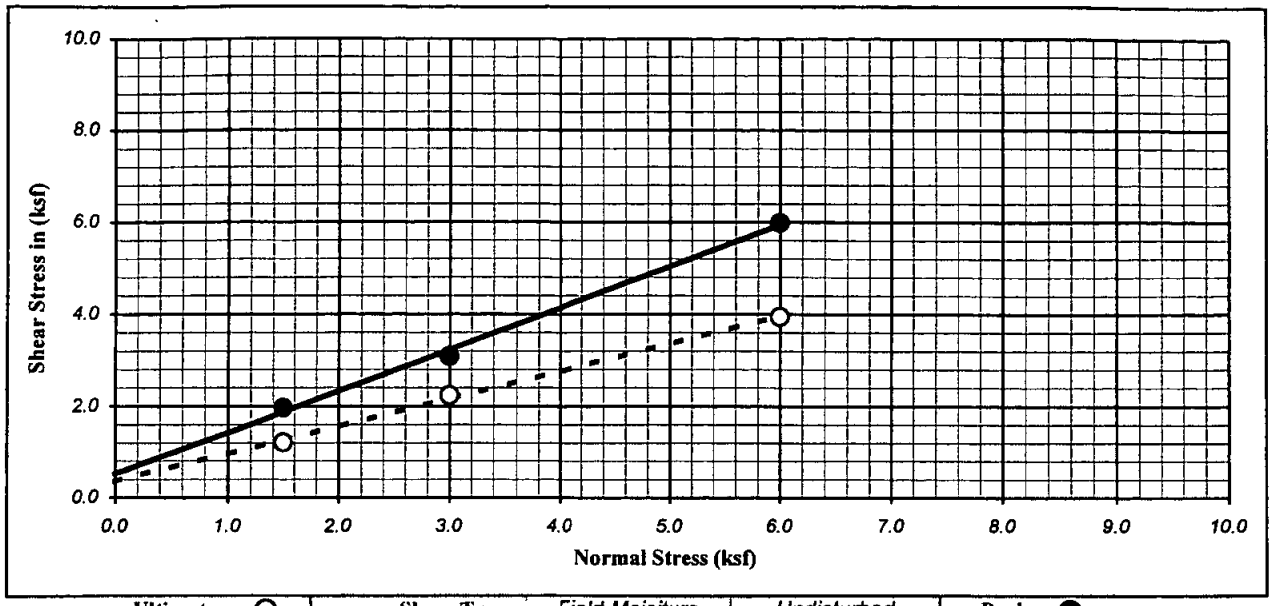
DIRECT SHEAR TEST

ASTM D-3080-90

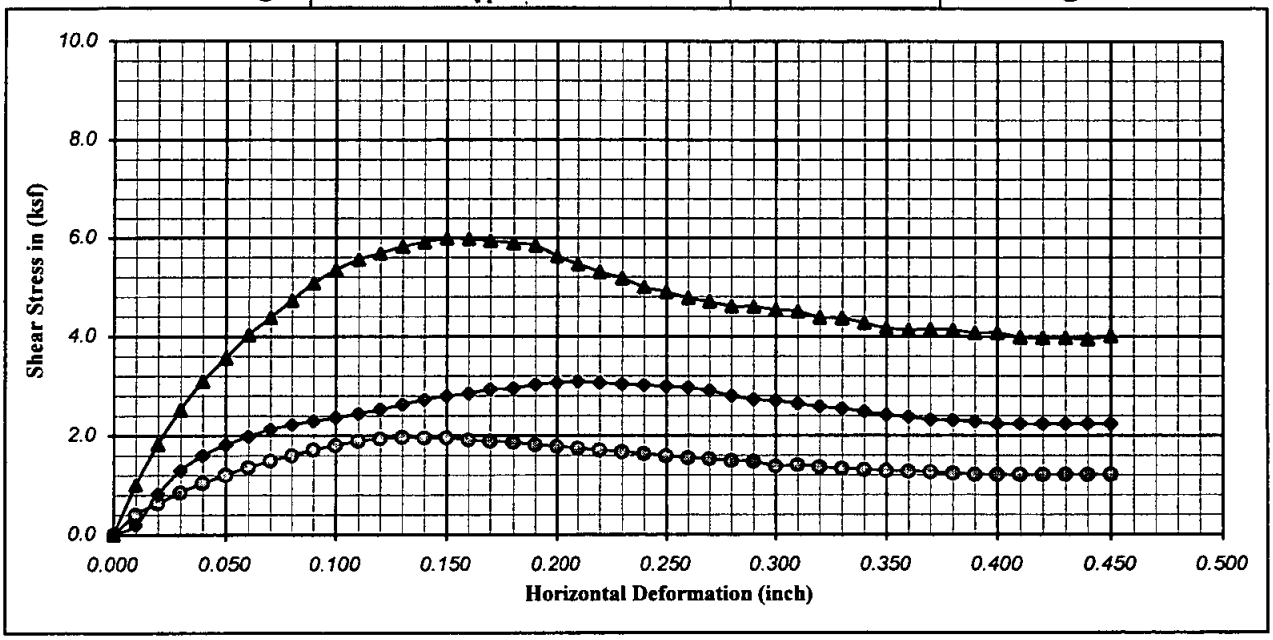
Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : 02-20			Saturated	x	Field Moisture	x	Inundated	**Specific Gravity** (Assumed) :	2.70
Sample No. : D-5		x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate** (inch/min) :	0.02
Depth (ft/m) : 25.0	7.63	x	Shear Once		Reshear		Residual	**Data File Number :**	213417
Description : Clayey Sand (SC)									

Percent Saturation (%)	108.73		**File No. :**	213417 1			**Shear Deflection**		**Normal Stress (psf/ksf/kPa)**											
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**						1500	1.50	71.8	3000	3.0	143.6	6000	6.0	287.3			
Tested By : RJ	**Date :** 10/30/02																			
Computed By : LCC	**Date :** 11/01/02		1.50	(ksf)			(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**											
Checked By :	**Date :**						0.000	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0			
Percent Consolidation (%)		**Before**		**After**			0.010	0.03	408	0.41	19.5	192	0.19	9.2	1008	1.01	48.1			
Height of Sample (inch)		1.00		1.0000			0.020	0.05	636	0.64	30.5	816	0.82	39.1	1824	1.82	87.0			
Diameter of Sample (inch)		2.42		2.42			0.030	0.08	852	0.85	40.8	1296	1.30	62.1	2520	2.52	120.2			
Dial Reading-Consolidation (inch)							0.040	0.10	1044	1.04	50.0	1596	1.60	76.4	3096	3.10	147.7			
Weight of Soil + Ring (gm)		214.62					0.050	0.13	1212	1.21	58.0	1812	1.81	86.8	3564	3.56	170.0			
Weight of Ring (gm)		46.76					0.060	0.15	1356	1.36	64.9	1980	1.98	94.8	4032	4.03	192.3			
Weight of Wet Soil + Cont. (gm)				172.76			0.070	0.18	1488	1.49	71.2	2124	2.12	101.7	4380	4.38	208.9			
Weight of Dry Soil + Cont. (gm)				149.44			0.080	0.20	1596	1.60	76.4	2220	2.22	106.3	4728	4.73	225.5			
Weight of Cont. (gm) **No.**				3.83			0.090	0.23	1716	1.72	82.2	2292	2.29	109.7	5076	5.08	242.1			
Moisture Content (%)		15.28		16.02			0.100	0.25	1800	1.80	86.2	2364	2.36	113.2	5340	5.34	254.7			
Wet Density (pcf / kN/m^3)		139.03	21.88	139.91	22.02		0.110	0.28	1884	1.88	90.2	2436	2.44	116.6	5555	5.56	265.0			
Dry Density (pcf / kN/m^3)		120.60	18.98	120.60	18.98		0.120	0.30	1932	1.93	92.5	2532	2.53	121.2	5687	5.69	271.3			
Percent Saturation (%)	112.76		**File No. :**	213417 2			0.130	0.33	1968	1.97	94.2	2628	2.63	125.8	5819	5.82	277.6			
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**				0.140	0.36	1956	1.96	93.7	2724	2.72	130.4	5915	5.92	282.2			
Tested By : RJ	**Date :** 10/30/02		3.00	(ksf)			0.150	0.38	1956	1.96	93.7	2796	2.80	133.9	5987	5.99	285.6			
Percent Consolidation (%)		**Before**		**After**			0.160	0.41	1908	1.91	91.4	2844	2.84	136.2	5975	5.98	285.0			
Height of Sample (inch)		1.00		1.0000			0.170	0.43	1884	1.88	90.2	2928	2.93	140.2	5939	5.94	283.3			
Diameter of Sample (inch)		2.42		2.42			0.180	0.46	1860	1.86	89.1	2952	2.95	141.3	5891	5.89	281.0			
Dial Reading-Consolidation (inch)							0.190	0.48	1812	1.81	86.8	3024	3.02	144.8	5843	5.84	278.7			
Weight of Soil + Ring (gm)		218.06					0.200	0.51	1776	1.78	85.0	3060	3.06	146.5	5627	5.63	268.4			
Weight of Ring (gm)		46.97					0.210	0.53	1740	1.74	83.3	3084	3.08	147.7	5459	5.46	260.4			
Weight of Wet Soil + Cont. (gm)				176.23			0.220	0.56	1704	1.70	81.6	3060	3.06	146.5	5304	5.30	253.0			
Weight of Dry Soil + Cont. (gm)				154.02			0.230	0.58	1668	1.67	79.9	3036	3.04	145.4	5172	5.17	246.7			
Weight of Cont. (gm) **No.**				3.68			0.240	0.61	1632	1.63	78.1	3012	3.01	144.2	4992	4.99	238.1			
Moisture Content (%)		13.80		14.77			0.250	0.64	1584	1.58	75.8	2988	2.99	143.1	4896	4.90	233.5			
Wet Density (pcf / kN/m^3)		141.70	22.30	142.91	22.49		0.260	0.66	1548	1.55	74.1	2964	2.96	141.9	4776	4.78	227.8			
Dry Density (pcf / kN/m^3)		124.52	19.60	124.52	19.60		0.270	0.69	1524	1.52	73.0	2904	2.90	139.0	4704	4.70	224.4			
Percent Saturation (%)	111.29		**File No. :**	213417 3			0.280	0.71	1488	1.49	71.2	2796	2.80	133.9	4608	4.61	219.8			
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**				0.290	0.74	1476	1.48	70.7	2724	2.72	130.4	4596	4.60	219.2			
Tested By : RJ	**Date :** 10/30/02		6.00	(ksf)			0.300	0.76	1380	1.38	66.1	2700	2.70	129.3	4536	4.54	216.4			
Percent Consolidation (%)		**Before**		**After**			0.310	0.79	1404	1.40	67.2	2640	2.64	126.4	4500	4.50	214.7			
Height of Sample (inch)		1.00		1.0000			0.320	0.81	1368	1.37	65.5	2580	2.58	123.5	4380	4.38	208.9			
Diameter of Sample (inch)		2.42		2.42			0.330	0.84	1332	1.33	63.8	2544	2.54	121.8	4368	4.37	208.4			
Dial Reading-Consolidation (inch)							0.340	0.86	1308	1.31	62.6	2484	2.48	118.9	4272	4.27	203.8			
Weight of Soil + Ring (gm)		216.96					0.350	0.89	1284	1.28	61.5	2412	2.41	115.5	4164	4.16	198.6			
Weight of Ring (gm)		46.79					0.360	0.91	1272	1.27	60.9	2376	2.38	113.3	4128	4.13	196.9			
Weight of Wet Soil + Cont. (gm)				175.81			0.370	0.94	1260	1.26	60.3	2316	2.32	110.5	4140	4.14	197.5			
Weight of Dry Soil + Cont. (gm)				153.70			0.380	0.97	1236	1.24	59.2	2304	2.30	109.9	4128	4.13	196.9			
Weight of Cont. (gm) **No.**				3.82			0.390	0.99	1212	1.21	58.0	2280	2.28	108.8	4068	4.07	194.1			
Moisture Content (%)		13.54		14.75			0.400	1.02	1212	1.21	58.0	2232	2.23	106.5	4068	4.07	194.1			
Wet Density (pcf / kN/m^3)		140.94	22.18	142.45	22.42		0.410	1.04	1212	1.21	58.0	2232	2.23	106.5	3984	3.98	190.0			
Dry Density (pcf / kN/m^3)		124.13	19.54	124.13	19.54		0.420	1.07	1212	1.21	58.0	2232	2.23	106.5	3972	3.97	189.5			
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)	0.430	1.09	1212	1.21	58.0	2232	2.23	106.5	3972	3.97	189.5			
Peak	1.97	94.23	3.08	147.66	5.99	286.66	0.440	1.12	1212	1.21	58.0	2232	2.23	106.5	3948	3.95	188.3			
Ultimate	1.21	58.03	2.23	106.87	3.95	189.03	0.450	1.14	1212	1.21	58.0	2232	2.23	106.5	4008	4.01	191.2			



Ultimate : ○ | Shear Type : Field Moisiture | Undisturbed | Peak : ●



Boring No. : 02-20		Strength Intercept (C) :	0.52	(ksf)	Peak	0.35	(ksf)	Ultimate
Sample No. : D-5			24.73	(kPa)		16.95	(kPa)	
Depth (ft/m) : 25.0	7.63	Friction Angle (ϕ) :	42.11	Degree		31.08	Degree	
Description : Clayey Sand (SC)					Shear Rate (inch/minute) :		0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	16.02	120.60	18.98	0.40	1.50	71.82	1.97	94.23	1.21	58.03
◆	14.77	124.52	19.60	0.35	3.00	143.64	3.08	147.66	2.23	106.87
▲	14.75	124.13	19.54	0.36	6.00	287.28	5.99	286.66	3.95	189.03

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | Date : 10/30/02

Figure No. :

DIRECT SHEAR TEST

ASTM D-3080-90

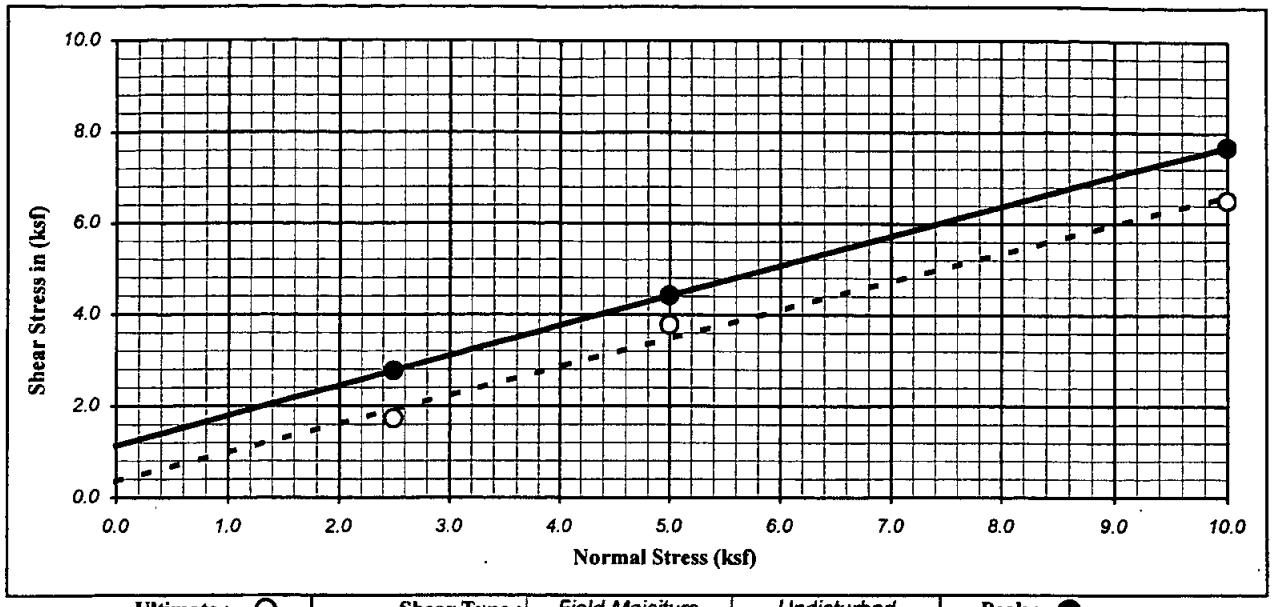
Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : 02-20			Saturated	x	Field Moisiture	x	Inundated	**Specific Gravity (Assumed) :** 2.70	
Sample No. : D-9		x	Undisturbed		Remolded		Consolidated-Drained	**Shear Rate (inch/min) :** 0.02	
Depth (ft/m) : 45.0	13.73	x	Shear Once		Reshear		Residual	**Data File Number :** 213418	
Description : Clayey Sand (SC)									

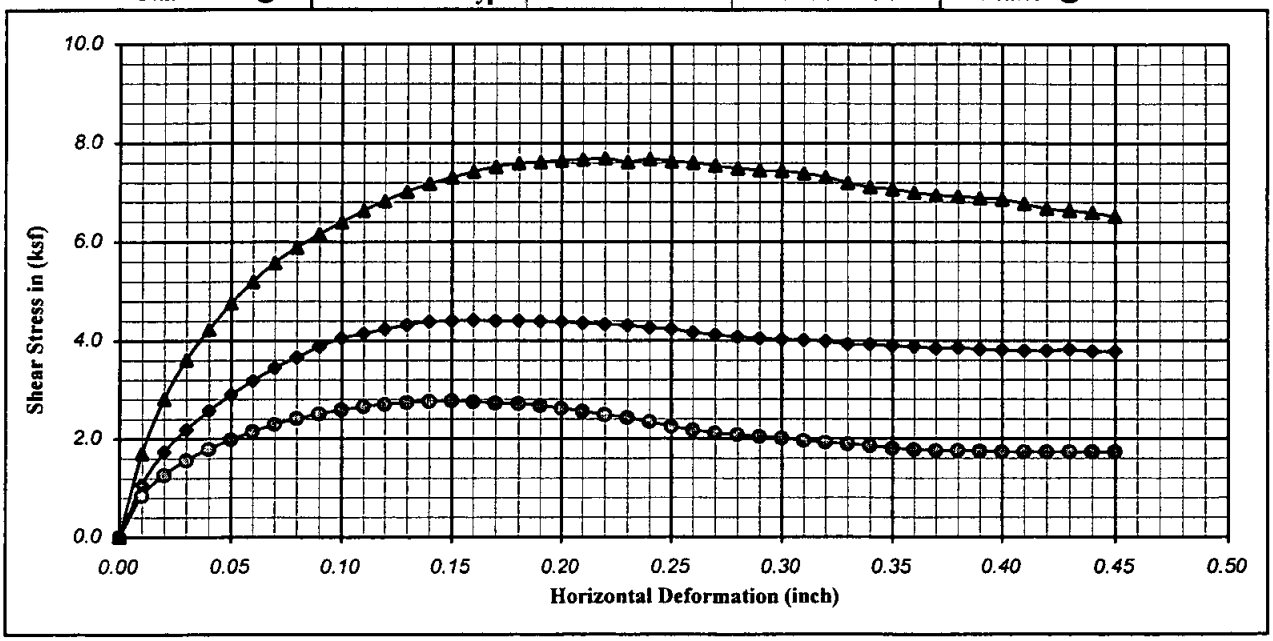
Percent Saturation (%)	107.78		**File No. :**	213418 1																
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**																	
Tested By : RJ	**Date :** 10/30/02																			
Computed By : LCC	**Date :** 11/01/02		**2.50**	(ksf)																
Checked By :	**Date :**																			
Percent Consolidation (%)	0.00	**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		212.26																		
Weight of Ring (gm)		46.96																		
Weight of Wet Soil + Cont. (gm)				170.38																
Weight of Dry Soil + Cont. (gm)				145.95																
Weight of Cont. (gm) No.				3.63																
Moisture Content (%)		16.15		17.17																
Wet Density (pcf / kN/m³)		136.91	21.55	138.11	21.74															
Dry Density (pcf / kN/m³)		117.87	18.55	117.87	18.55															
Percent Saturation (%)	109.56		**File No. :**	213418 2																
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**																	
Tested By : RJ	**Date :** 10/30/02		**5.00**	(ksf)																
Percent Consolidation (%)	0.00	**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		215.30																		
Weight of Ring (gm)		46.72																		
Weight of Wet Soil + Cont. (gm)				173.15																
Weight of Dry Soil + Cont. (gm)				149.92																
Weight of Cont. (gm) No.				3.65																
Moisture Content (%)		15.25		15.88																
Wet Density (pcf / kN/m³)		139.62	21.98	140.38	22.10															
Dry Density (pcf / kN/m³)		121.14	19.07	121.14	19.07															
Percent Saturation (%)	93.40		**File No. :**	213418 3																
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**																	
Tested By : RJ	**Date :** 10/30/02		**10.00**	(ksf)																
Percent Consolidation (%)	0.00	**Before**		**After**																
Height of Sample (inch)		1.00		1.0000																
Diameter of Sample (inch)		2.42		2.42																
Dial Reading-Consolidation (inch)																				
Weight of Soil + Ring (gm)		207.29																		
Weight of Ring (gm)		46.64																		
Weight of Wet Soil + Cont. (gm)				164.01																
Weight of Dry Soil + Cont. (gm)				141.20																
Weight of Cont. (gm) No.				3.62																
Moisture Content (%)		16.77		16.58																
Wet Density (pcf / kN/m³)		133.05	20.94	132.84	20.91															
Dry Density (pcf / kN/m³)		113.95	17.94	113.95	17.94															

Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)
Peak	2.77	132.72	4.42	211.44	7.69	368.25
Ultimate	1.73	82.74	3.78	180.99	6.52	311.94

Shear Deflection		**Normal Stress (psf/ksf/kPa)**								
		2500	2.50	119.7	5000	5.0	239.4	10000	10.0	478.8
(inch)	(mm)	**Shear Stress (psf/ksf/kPa)**								
0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0
0.010	0.03	840	0.84	40.2	1068	1.07	51.1	1704	1.70	81.3
0.020	0.05	1260	1.26	60.3	1728	1.73	82.7	2808	2.81	133.9
0.030	0.08	1560	1.56	74.7	2184	2.18	104.6	3612	3.61	172.3
0.040	0.10	1788	1.79	85.6	2568	2.57	123.0	4224	4.22	201.5
0.050	0.13	1980	1.98	94.8	2892	2.89	138.5	4764	4.76	227.3
0.060	0.15	2148	2.15	102.8	3180	3.18	152.3	5196	5.20	247.9
0.070	0.18	2292	2.29	109.7	3444	3.44	164.9	5579	5.58	266.1
0.080	0.20	2412	2.41	115.5	3660	3.66	175.2	5891	5.89	281.0
0.090	0.23	2508	2.51	120.1	3876	3.88	185.6	6155	6.16	293.6
0.100	0.25	2592	2.59	124.1	4044	4.04	193.6	6395	6.40	305.1
0.110	0.28	2652	2.65	127.0	4140	4.14	198.2	6635	6.64	316.5
0.120	0.30	2700	2.70	129.3	4236	4.24	202.8	6827	6.83	325.7
0.130	0.33	2736	2.74	131.0	4320	4.32	206.8	7019	7.02	334.8
0.140	0.36	2760	2.76	132.1	4380	4.38	209.7	7175	7.18	342.3
0.150	0.38	2772	2.77	132.7	4404	4.40	210.9	7307	7.31	348.6
0.160	0.41	2748	2.75	131.6	4416	4.42	211.4	7427	7.43	354.3
0.170	0.43	2724	2.72	130.4	4404	4.40	210.9	7523	7.52	358.9
0.180	0.46	2712	2.71	129.9	4404	4.40	210.9	7595	7.60	362.3
0.190	0.48	2676	2.68	128.1	4392	4.39	210.3	7619	7.62	363.4
0.200	0.51	2616	2.62	125.3	4380	4.38	209.7	7643	7.64	364.6
0.210	0.53	2556	2.56	122.4	4356	4.36	208.6	7667	7.67	365.7
0.220	0.56	2484	2.48	118.9	4332	4.33	207.4	7691	7.69	366.9
0.230	0.58	2424	2.42	116.1	4308	4.31	206.3	7619	7.62	363.4
0.240	0.61	2340	2.34	112.0	4260	4.26	204.0	7679	7.68	366.3
0.250	0.64	2244	2.24	107.4	4236	4.24	202.8	7631	7.63	364.0
0.260	0.66	2172	2.17	104.0	4164	4.16	199.4	7607	7.61	362.9
0.270	0.69	2112	2.11	101.1	4116	4.12	197.1	7547	7.55	360.0
0.280	0.71	2076	2.08	99.4	4068	4.07	194.8	7487	7.49	357.1
0.290	0.74	2040	2.04	97.7	4044	4.04	193.6	7451	7.45	355.4
0.300	0.76	2004	2.00	96.0	4020	4.02	192.5	7439	7.44	354.9
0.310	0.79	1956	1.96	93.7	4008	4.01	191.9	7391	7.39	352.6
0.320	0.81	1920	1.92	91.9	3984	3.98	190.8	7319	7.32	349.1
0.330	0.84	1884	1.88	90.2	3924	3.92	187.9	7199	7.20	343.4
0.340	0.86	1848	1.85	88.5	3924	3.92	187.9	7115	7.12	339.4
0.350	0.89	1800	1.80	86.2	3888	3.89	186.2	7067	7.07	337.1
0.360	0.91	1776	1.78	85.0	3876	3.88	184.9	6995	7.00	333.7
0.370	0.94	1752	1.75	83.9	3840	3.84	183.2	6947	6.95	331.4
0.380	0.97	1752	1.75	83.9	3852	3.85	183.7	6923	6.92	330.2
0.390	0.99	1740	1.74	83.3	3816	3.82	182.0	6887	6.89	328.5
0.400	1.02	1728	1.73	82.7	3804	3.80	181.5	6863	6.86	327.4
0.410	1.04	1728	1.73	82.7	3792	3.79	180.9	6767	6.77	322.8
0.420	1.07	1728	1.73	82.7	3792	3.79	180.9	6671	6.67	318.2
0.430	1.09	1728	1.73	82.7	3816	3.82	182.0	6635	6.64	316.5
0.440	1.12	1728	1.73	82.7	3780	3.78	180.3	6587	6.59	314.2
0.450	1.14	1728	1.73	82.7	3780	3.78	180.3	6515	6.52	310.8



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: 02-20		Strength Intercept (C) :	1.13	(ksf)	Peak	0.36	(ksf)	Ultimate
Sample No.	: D-9			54.32	(kPa)		17.26	(kPa)	
Depth (ft/m)	: 45.0	13.73	Friction Angle (ϕ) :	33.25	Degree		32.01	Degree	
Description	: Clayey Sand (SC)					Shear Rate (inch/minute) :		0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	17.17	117.87	18.55	0.43	2.50	119.70	2.77	132.72	1.73	82.74
◆	15.88	121.14	19.07	0.39	5.00	239.40	4.42	211.44	3.78	180.99
▲	16.58	113.95	17.94	0.48	10.00	478.80	7.69	368.25	6.52	311.94

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 02-134 | Date : 10/30/02

Figure No. :

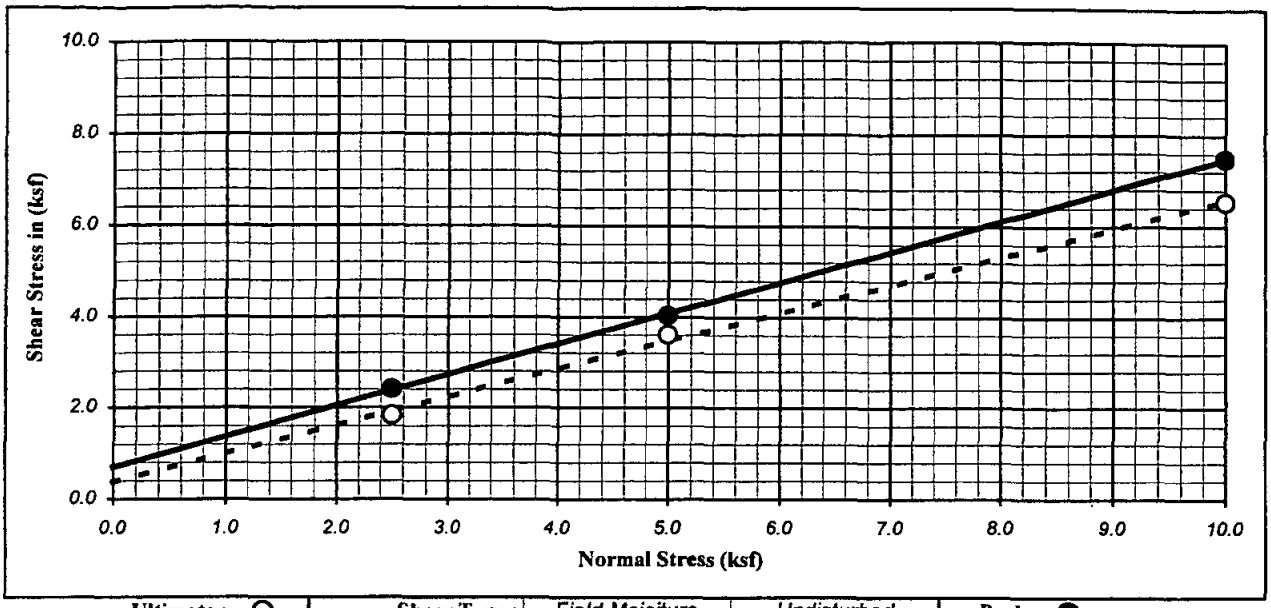
DIRECT SHEAR TEST

ASTM D-3080-90

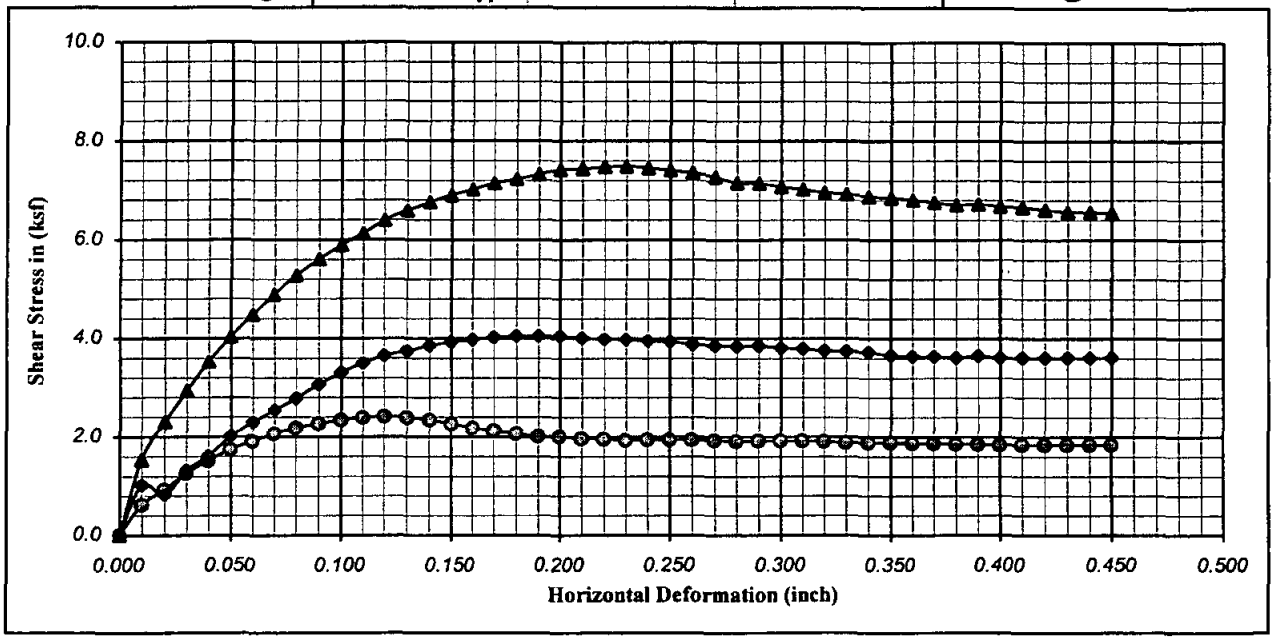
Project No. : 02-134 **Project Name :** Devil's Slide Tunnel

Boring No. : 02-20			**Saturated**	x	**Field Moisture**	x	**Inundated**	**Specific Gravity (Assumed) :** 2.70	
Sample No. : D-13		x	**Undisturbed**		**Remolded**		**Consolidated-Drained**	**Shear Rate (inch/min) :** 0.02	
Depth (ft/m) : 65.0	19.83	x	**Shear Once**		**Reshear**		**Residual**	**Data File Number :** 213419	
Description : Clayey Sand (SC)									

Percent Saturation (%)	99.87		**File No. :**	213419 1			**Shear Deflection**	**Normal Stress (psf/ksf/kPa)**												
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**					2500	2.50	119.7	5000	5.0	239.4	10000	10.0	478.8				
Tested By : RJ	**Date :** 10/30/02							**Shear Stress (psf/ksf/kPa)**												
Computed By : LCC	**Date :** 11/01/02		2.50	(ksf)			(inch)	(mm)												
Checked By :	**Date :**						0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.0	0.0			
Percent Consolidation (%)		**Before**		**After**			0.010	0.03	624	0.62	29.9	1020	1.02	48.8	1536	1.54	73.3			
Height of Sample (inch)		1.00		1.0000			0.020	0.05	924	0.92	44.2	828	0.83	39.6	2304	2.30	109.9			
Diameter of Sample (inch)		2.42		2.42			0.030	0.08	1260	1.26	60.3	1320	1.32	63.2	2940	2.94	140.2			
Dial Reading-Consolidation (inch)							0.040	0.10	1512	1.51	72.4	1608	1.61	77.0	3528	3.53	168.3			
Weight of Soil + Ring (gm)		207.40					0.050	0.13	1740	1.74	83.3	2004	2.00	96.0	4032	4.03	192.3			
Weight of Ring (gm)		46.83					0.060	0.15	1908	1.91	91.4	2292	2.29	109.7	4476	4.48	213.5			
Weight of Wet Soil + Cont. (gm)				163.83			0.070	0.18	2064	2.06	98.8	2544	2.54	121.8	4896	4.90	233.5			
Weight of Dry Soil + Cont. (gm)				138.36			0.080	0.20	2184	2.18	104.6	2784	2.78	133.3	5280	5.28	251.9			
Weight of Cont. (gm) No.				3.7			0.090	0.23	2268	2.27	108.6	3060	3.06	146.5	5603	5.60	267.3			
Moisture Content (%)		19.24		18.91			0.100	0.25	2340	2.34	112.0	3300	3.30	158.0	5891	5.89	281.0			
Wet Density (pcf / kN/m³)		132.99	20.93	132.62	20.88		0.110	0.28	2388	2.39	114.3	3492	3.49	167.2	6131	6.13	292.5			
Dry Density (pcf / kN/m³)		111.53	17.55	111.53	17.55		0.120	0.30	2412	2.41	115.5	3648	3.65	174.7	6395	6.40	305.1			
Percent Saturation (%)	101.95		**File No. :**	213419 2			0.130	0.33	2388	2.39	114.3	3744	3.74	179.3	6587	6.59	314.2			
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**				0.140	0.36	2340	2.34	112.0	3852	3.85	184.4	6755	6.76	322.2			
Tested By : RJ	**Date :** 10/30/02		5.00	(ksf)			0.150	0.38	2256	2.26	108.0	3924	3.92	187.9	6899	6.90	329.1			
Percent Consolidation (%)		**Before**		**After**			0.160	0.41	2184	2.18	104.6	3972	3.97	190.2	7019	7.02	334.8			
Height of Sample (inch)		1.00		1.0000			0.170	0.43	2124	2.12	101.7	4020	4.02	192.5	7139	7.14	340.5			
Diameter of Sample (inch)		2.42		2.42			0.180	0.46	2064	2.06	98.8	4044	4.04	193.6	7223	7.22	344.6			
Dial Reading-Consolidation (inch)							0.190	0.48	2016	2.02	96.5	4044	4.04	193.6	7319	7.32	349.1			
Weight of Soil + Ring (gm)		213.57					0.200	0.51	2004	2.00	96.0	4044	4.04	193.6	7415	7.42	353.7			
Weight of Ring (gm)		47.06					0.210	0.53	1968	1.97	94.2	4008	4.01	191.9	7439	7.44	354.9			
Weight of Wet Soil + Cont. (gm)				168.92			0.220	0.56	1956	1.96	93.7	3984	3.98	190.8	7475	7.48	356.6			
Weight of Dry Soil + Cont. (gm)				145.66			0.230	0.58	1932	1.93	92.5	3972	3.97	190.2	7487	7.49	357.1			
Weight of Cont. (gm) No.				3.74			0.240	0.61	1944	1.94	93.1	3948	3.95	189.0	7451	7.45	355.4			
Moisture Content (%)		17.33		16.39			0.250	0.64	1944	1.94	93.1	3936	3.94	188.5	7403	7.40	353.1			
Wet Density (pcf / kN/m³)		137.91	21.71	136.81	21.53		0.260	0.66	1944	1.94	93.1	3876	3.88	185.6	7355	7.36	350.8			
Dry Density (pcf / kN/m³)		117.54	18.50	117.54	18.50		0.270	0.69	1932	1.93	92.5	3852	3.85	184.4	7271	7.27	346.8			
Percent Saturation (%)	97.14		**File No. :**	213419 3			0.280	0.71	1908	1.91	91.4	3840	3.84	183.9	7151	7.15	341.1			
Prepared By : RJ	**Date :** 10/30/02		**Normal Stress**				0.290	0.74	1920	1.92	91.9	3852	3.85	184.4	7139	7.14	340.5			
Tested By : RJ	**Date :** 10/30/02		6.00	(ksf)			0.300	0.76	1920	1.92	91.9	3804	3.80	182.1	7067	7.07	337.1			
Percent Consolidation (%)		**Before**		**After**			0.310	0.79	1920	1.92	91.9	3792	3.79	181.6	7019	7.02	334.8			
Height of Sample (inch)		1.00		1.0000			0.320	0.81	1908	1.91	91.4	3756	3.76	179.8	6959	6.96	332.0			
Diameter of Sample (inch)		2.42		2.42			0.330	0.84	1884	1.88	90.2	3744	3.74	179.3	6923	6.92	330.2			
Dial Reading-Consolidation (inch)							0.340	0.86	1884	1.88	90.2	3720	3.72	178.1	6875	6.88	328.0			
Weight of Soil + Ring (gm)		212.62					0.350	0.89	1884	1.88	90.2	3660	3.66	175.2	6851	6.85	326.8			
Weight of Ring (gm)		46.73					0.360	0.91	1872	1.87	89.6	3636	3.64	173.4	6803	6.80	324.5			
Weight of Wet Soil + Cont. (gm)				167.17			0.370	0.94	1872	1.87	89.6	3636	3.64	173.4	6755	6.76	322.2			
Weight of Dry Soil + Cont. (gm)				144.59			0.380	0.97	1860	1.86	89.1	3612	3.61	172.3	6707	6.71	319.9			
Weight of Cont. (gm) No.				3.83			0.390	0.99	1848	1.85	88.5	3648	3.65	174.0	6719	6.72	320.5			
Moisture Content (%)		17.85		16.04			0.400	1.02	1836	1.84	87.9	3612	3.61	172.3	6671	6.67	318.2			
Wet Density (pcf / kN/m³)		137.39	21.63	135.28	21.29		0.410	1.04	1836	1.84	87.9	3612	3.61	172.3	6659	6.66	317.6			
Dry Density (pcf / kN/m³)		116.58	18.35	116.58	18.35		0.420	1.07	1836	1.84	87.9	3612	3.61	172.3	6611	6.61	315.4			
Strength	(ksf)	(kPa)	(ksf)	(kPa)	(ksf)	(kPa)	0.430	1.09	1836	1.84	87.9	3612	3.61	172.3	6563	6.56	313.1			
Peak	2.41	115.49	4.04	193.63	7.49	358.48	0.440	1.12	1836	1.84	87.9	3612	3.61	172.3	6563	6.56	313.1			
Ultimate	1.84	87.91	3.61	172.94	6.54	313.09	0.450	1.14	1836	1.84	87.9	3612	3.61	172.3	6539	6.54	311.9			



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No.	: 02-20		Strength Intercept (C) :	0.69	(ksf)	Peak	0.37	(ksf)	Ultimate
Sample No.	: D-13			33.06	(kPa)		17.84	(kPa)	
Depth (ft/m)	: 65.0	19.83	Friction Angle (ϕ) :	34.15	Degree		31.85	Degree	
Description	: Clayey Sand (SC)						Shear Rate (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
○	18.91	111.53	17.55	0.51	2.50	119.70	2.41	115.49	1.84	87.91
◆	16.39	117.54	18.50	0.43	5.00	239.40	4.04	193.63	3.61	172.94
▲	16.04	116.58	18.35	0.45	10.00	478.80	7.49	358.48	6.54	313.09

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Devil's Slide Tunnel

DIRECT SHEAR TEST (ASTM D-3080)

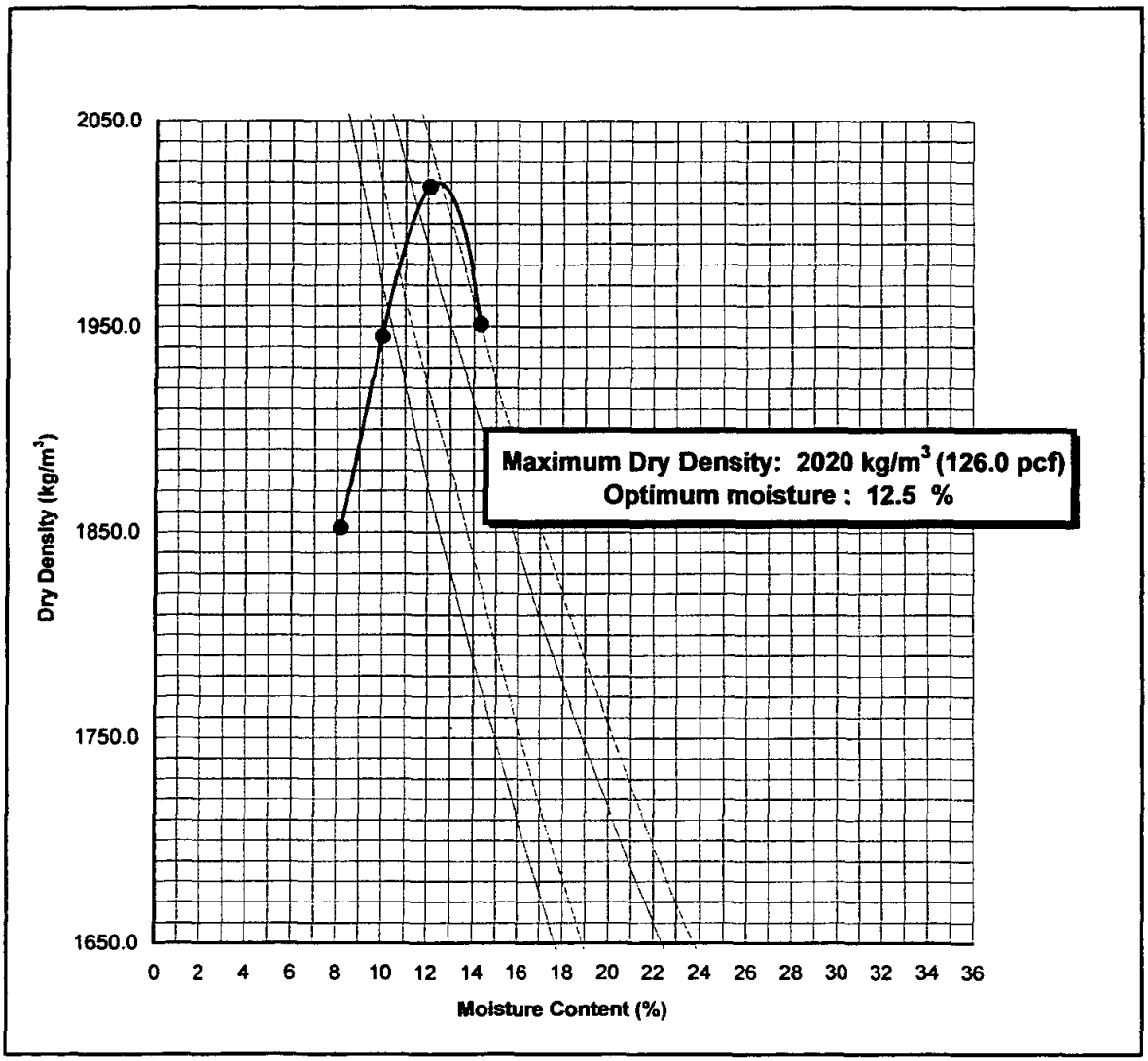
Project No. : 02-134 | **Date :** 10/30/02 | Figure No. :

MAXIMUM DENSITY TEST
CAL. IMPACT No. 216

Client / Job No.: Earth Mechanics Inc. / 02-134
Agra Reference: 2001-038
Boring/Sample No. 02-ST-1 / B-0 @ 0 - 5'
Description: Orange Brown, F.C. Sandy Clay

Date: 10/17/02
By: LD

Method: **Cal. Impact 216**	Blows:	**20**	Layers:	**5**	Hammers: **4.536 kg**	
Specimen		A	B	C	D	E
Initial Wet Weight	(grams)	**2500**	**2500**	**2500**	**2500**	
Water added	(c.c.)	**50**	**100**	**0**	**-50**	
Height of Specimen	(in.)	**10.50**	**10.65**	**11.10**	**11.85**	
Wet Density	(kg/m^3)	2261.8	2230.0	2139.6	2004.2	
Water Content	(%)	**12.1**	**14.3**	**10.0**	**8.2**	
Dry Density	(kg/m^3)	2017.7	1951.0	1945.1	1852.3	

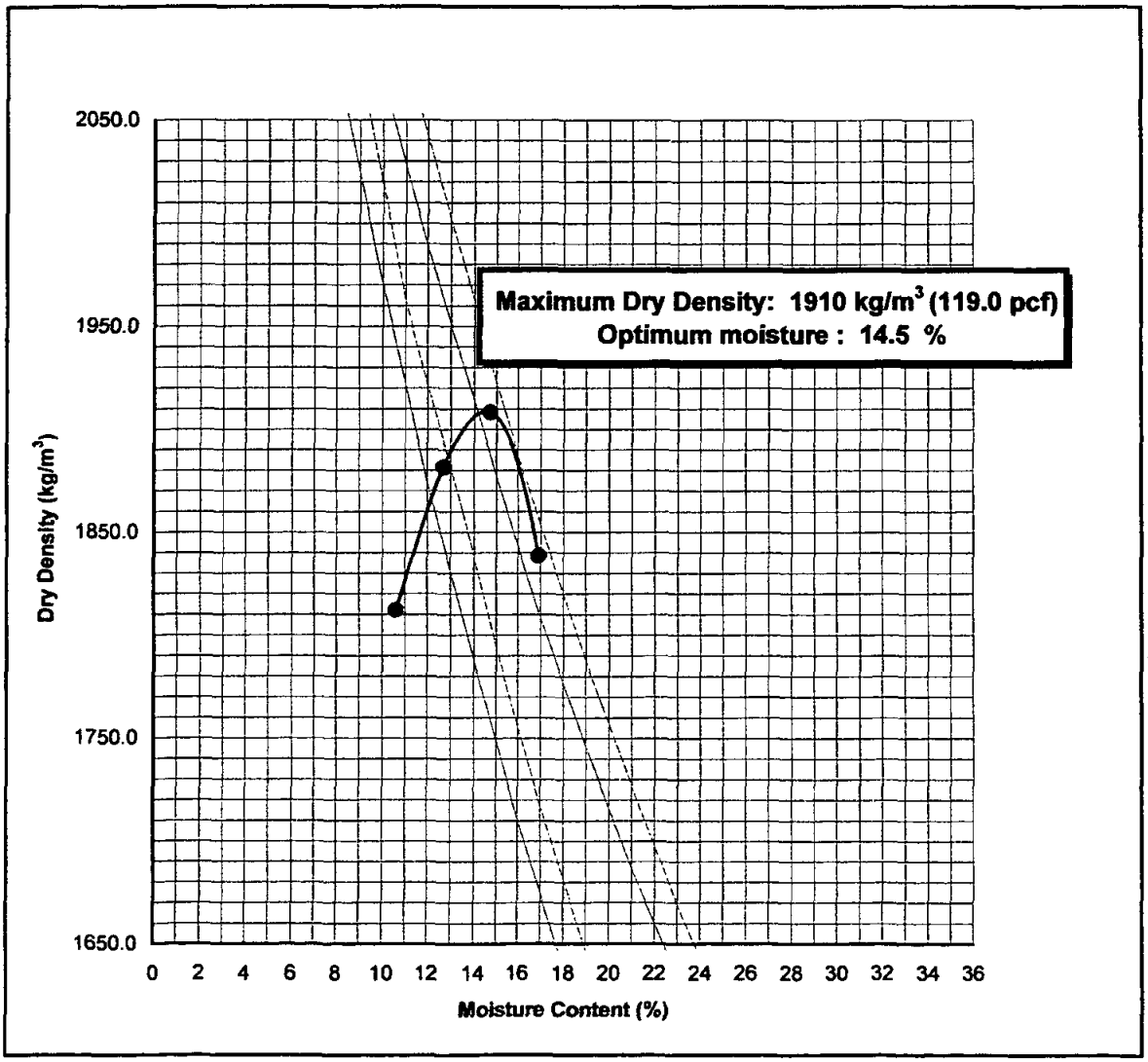


MAXIMUM DENSITY TEST
CAL. IMPACT No. 216

Client / Job No.: Earth Mechanics Inc. / 02-134
Agra Reference: 2001-038
Boring/Sample No. 02-ST-2 / B-0 @ 0 - 5'
Description: Brown Gray Mottled, F.M. Sandy Clay

Date: 10/17/02
By: LD

Method: **Cal. Impact 216**	Blows:	**20**	Layers:	**5**	Hammers: **4.536 kg**	
Specimen		A	B	C	D	E
Initial Wet Weight	(grams)	**2500**	**2500**	**2500**	**2500**	
Water added	(c.c.)	**50**	**100**	**150**	**0**	
Height of Specimen	(in.)	**11.20**	**10.85**	**11.05**	**11.85**	
Wet Density	(kg/m^3)	2120.5	2188.9	2149.3	2004.2	
Water Content	(%)	**12.7**	**14.7**	**16.9**	**10.6**	
Dry Density	(kg/m^3)	1881.5	1908.3	1838.5	1812.1	



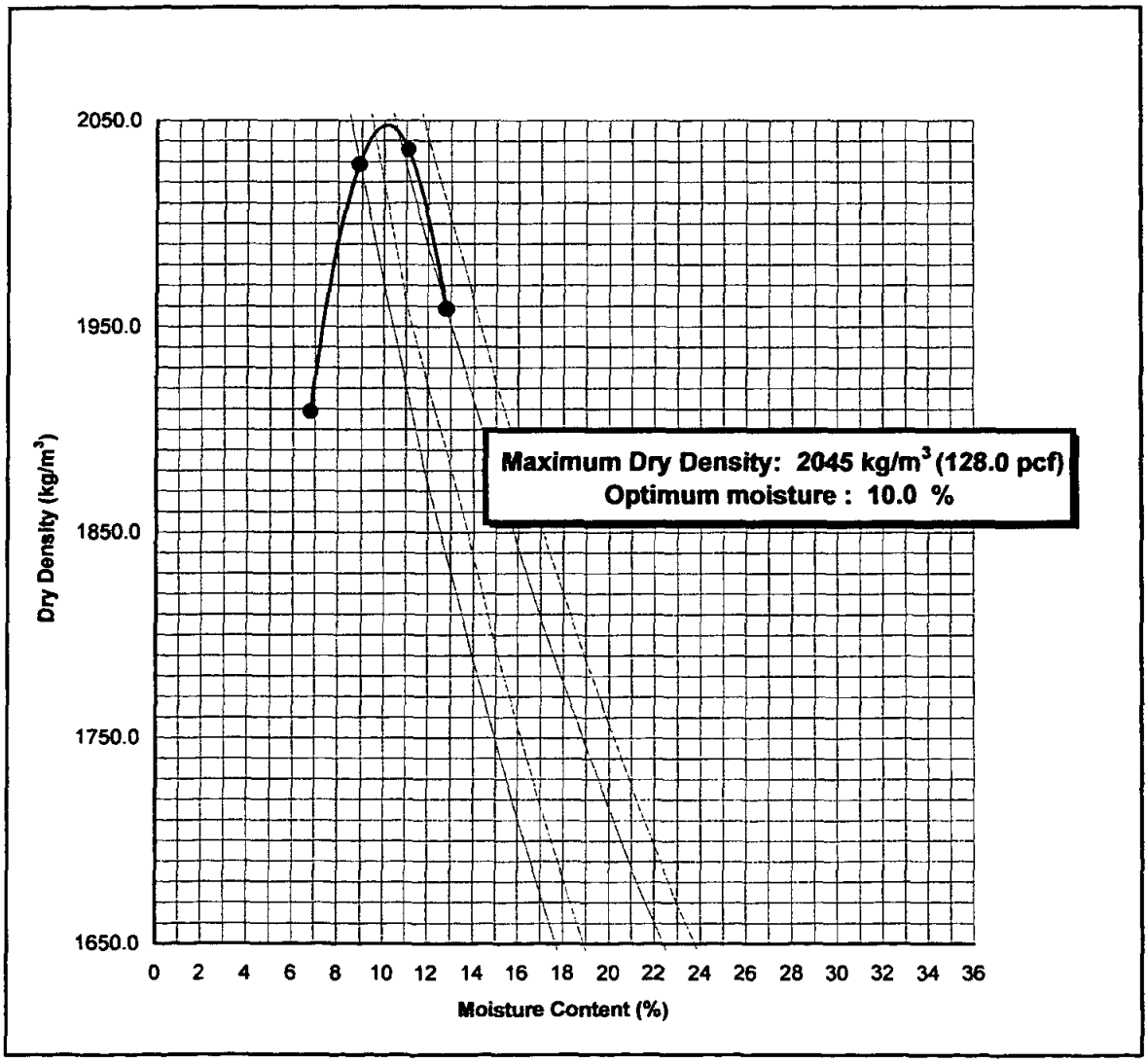
GeoLogic Associates

MAXIMUM DENSITY TEST
CAL. IMPACT No. 216

Client / Job No.: Earth Mechanics Inc. / 02-134
Agra Reference: 2001-038
Boring/Sample No. 02-ST-3 / B-0 @ 0 - 5'
Description: Orange Brown, F.C. Sandy Clay

Date: 10/17/02
By: LD

Method: **Cal. Impact 216**	Blows:	**20**	Layers:	**5**	Hammers: **4.536 kg**	
Specimen		A	B	C	D	E
Initial Wet Weight	(grams)	**2500**	**2500**	**2500**	**2500**	
Water added	(c.c.)	**50**	**100**	**150**	**0**	
Height of Specimen	(in.)	**10.75**	**10.50**	**10.75**	**11.65**	
Wet Density	(kg/m^3)	2209.2	2261.8	2209.2	2038.6	
Water Content	(%)	**8.9**	**11.1**	**12.8**	**6.8**	
Dry Density	(kg/m^3)	2028.7	2035.9	1958.5	1908.8	

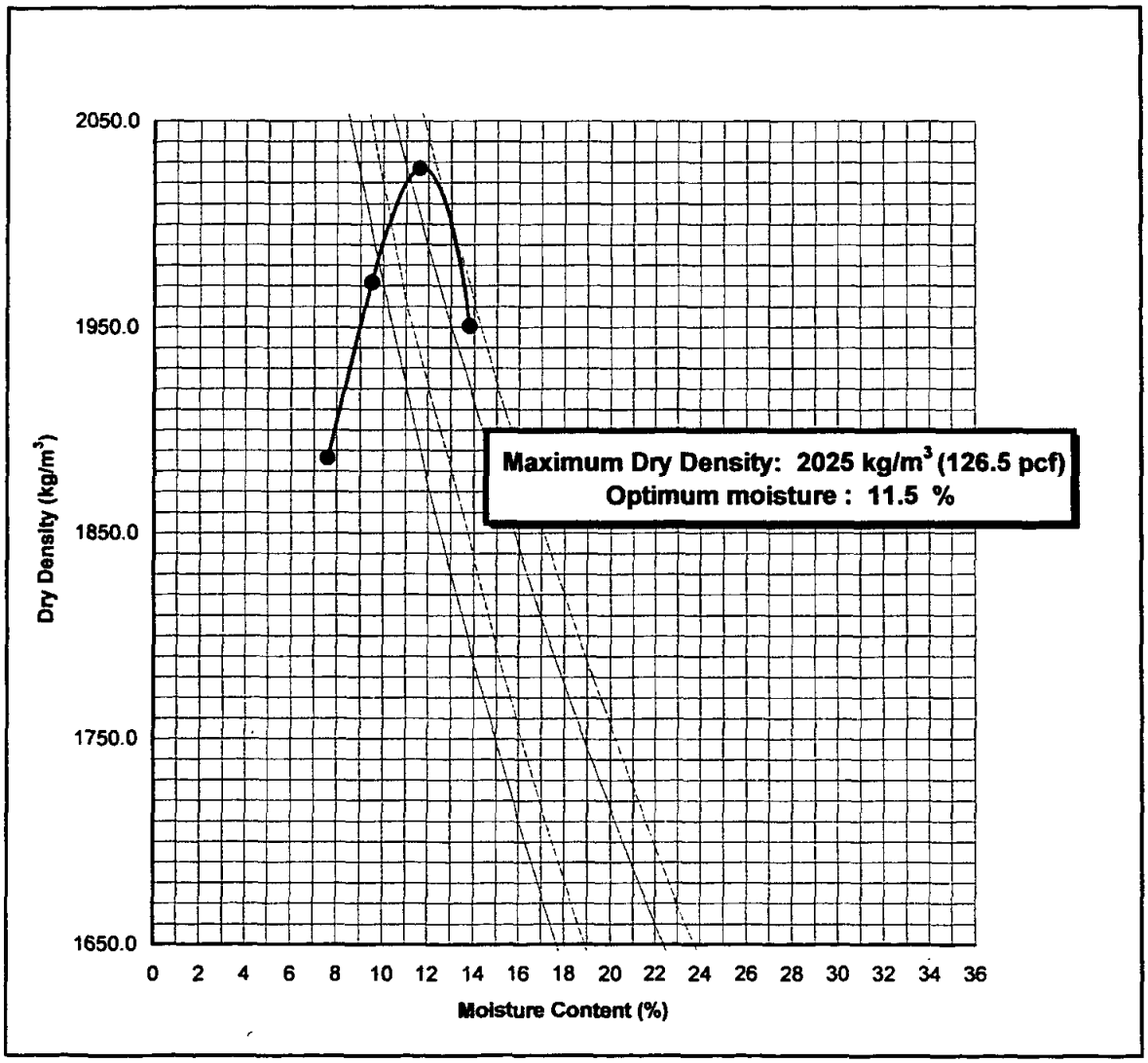


MAXIMUM DENSITY TEST
CAL. IMPACT No. 216

Client / Job No.: Earth Mechanics Inc. / 02-134
Agra Reference: 2001-038
Boring/Sample No. 02-ST-6 / B-0 @ 0 - 5'
Description: Gray Brown, F.C. Sandy Clay

Date: 10/17/02
By: LD

Method: **Cal. Impact 216**	Blows:	**20**	Layers:	**5**	Hammers: **4.536 kg**	
Specimen		A	B	C	D	E
Initial Wet Weight	(grams)	**2500**	**2500**	**2500**	**2500**	
Water added	(c.c.)	**50**	**100**	**150**	**0**	
Height of Specimen	(in.)	**11.00**	**10.50**	**10.70**	**11.70**	
Wet Density	(kg/m^3)	2159.0	2261.8	2219.6	2029.9	
Water Content	(%)	**9.5**	**11.6**	**13.8**	**7.6**	
Dry Density	(kg/m^3)	1971.7	2026.7	1950.4	1886.5	



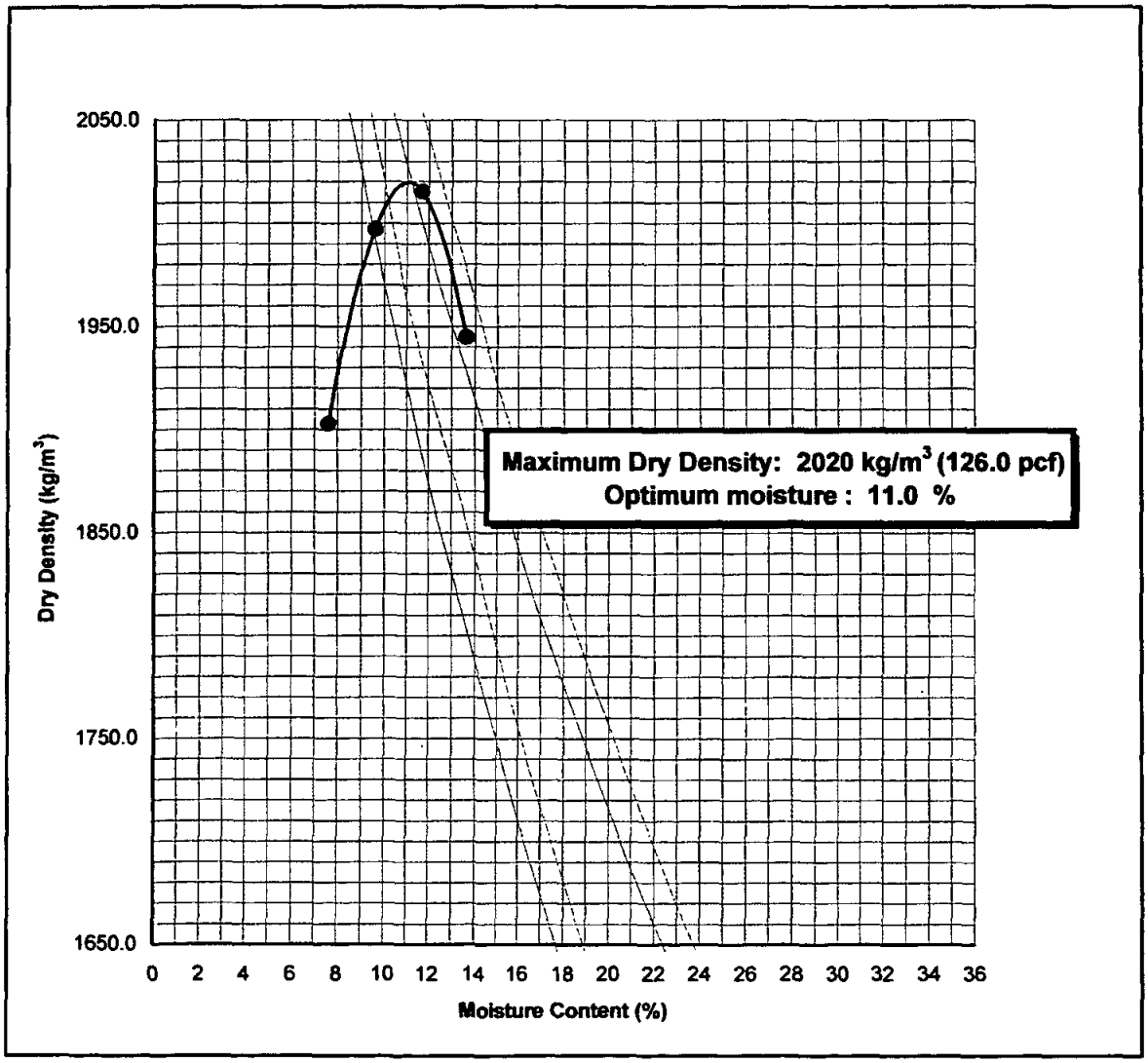
GeoLogic Associates

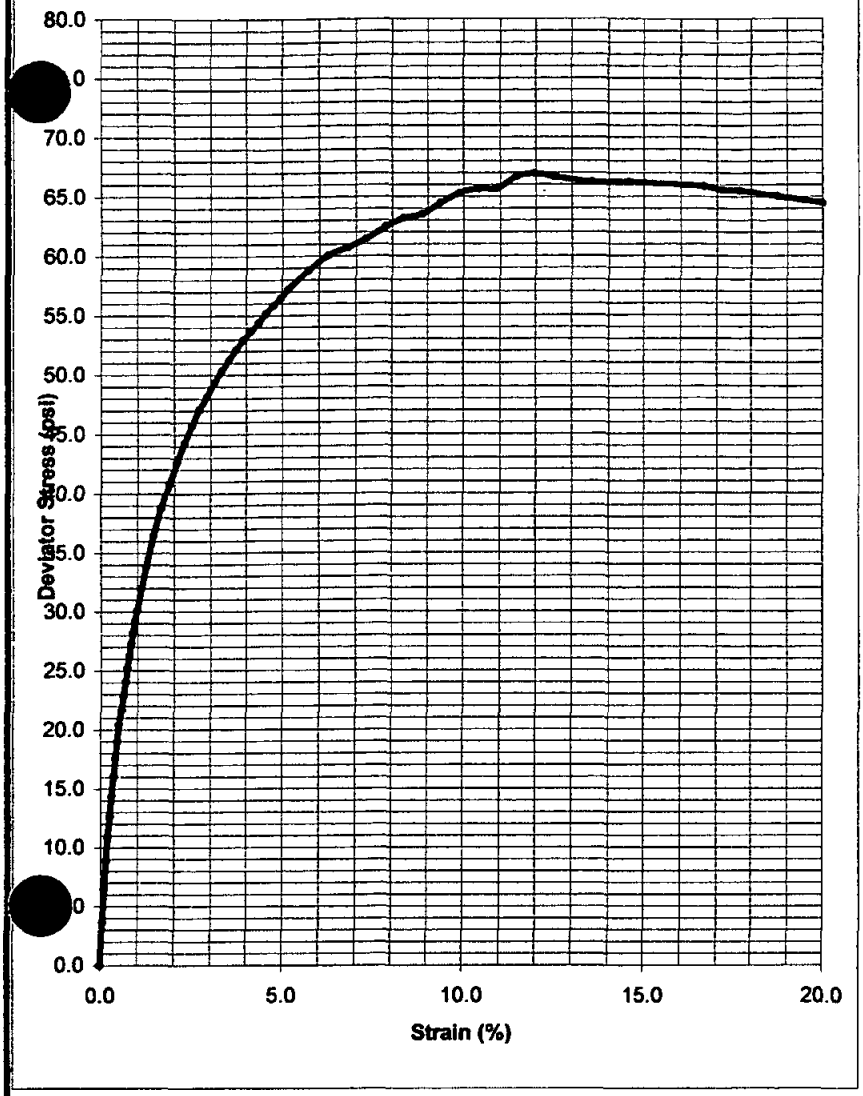
MAXIMUM DENSITY TEST
CAL. IMPACT No. 216

Client / Job No.: Earth Mechanics Inc. / 02-134
Agra Reference: 2001-038
Boring/Sample No. 02-ST-9 / B-0 @ 0 - 5'
Description: Gray Brown, F.C. Sandy Clay w. Gravel

Date: 10/17/02
By: LD

Method: **Cal. Impact 216**	Blows:	**20**	Layers:	**5**	Hammers: **4.536 kg**	
Specimen		A	B	C	D	E
Initial Wet Weight	(grams)	**2500**	**2500**	**2500**	**2500**	
Water added	(c.c.)	**50**	**100**	**150**	**0**	
Height of Specimen	(in.)	**10.85**	**10.55**	**10.75**	**11.60**	
Wet Density	(kg/m^3)	2188.9	2251.1	2209.2	2047.4	
Water Content	(%)	**9.6**	**11.7**	**13.6**	**7.6**	
Dry Density	(kg/m^3)	1997.1	2015.3	1944.8	1902.7	

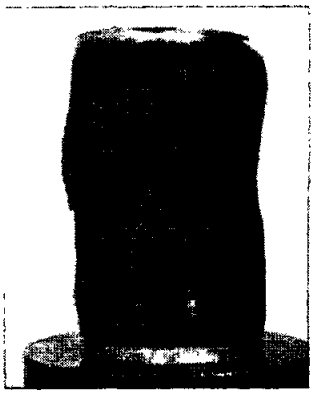




Soil Description: Brown Mottled, Silty Clay w. F.C. Sand

Type of Specimen: *Undisturbed*

			A	B	C
	SPECIMEN				
INITIAL	Wet Density (pcf)		128.5		
	Water Content (%)		22.9		
	Dry Density (pcf)		104.6		
FINAL	Wet Density (pcf)				
	Water Content (%)				
	Dry Density (pcf)				
SATURATION STAGE	Initial pwp	psi			
	Saturated pwp				
	Final Cell pressure				
	B value				
CONSOLIDATION STAGE	Cell Pressure	psi			
	Back Pressure				
	Initial pwp				
	Final pwp				
COMPRESSION STAGE	Cell Pressure	psi			
	Initial pwp				
	Initial σ'_3				
	Strain Rate (in./min.)		0.005		
FAILURE CONDITION	**Strain %**		12.0		
	$(\sigma_1 - \sigma_3)_f$	psi	67.0		
	$(\sigma_1/\sigma_3)_f$				
	σ_3		40.0		
	σ_{1f}		107.0		
	c_v				
	m_v				
	k				
SAMPLE SIZE			D = 2.41 in.		
			H = 5.0 in.		



UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

ASTM D-2850

Job Name EMI #02-134 | Date: 10-14-02

Job No. 2001-038 | Sample : 02-ST-9/D-6

GeoLogic Associates

CONSTRUCTION MATERIALS TESTING, INC.

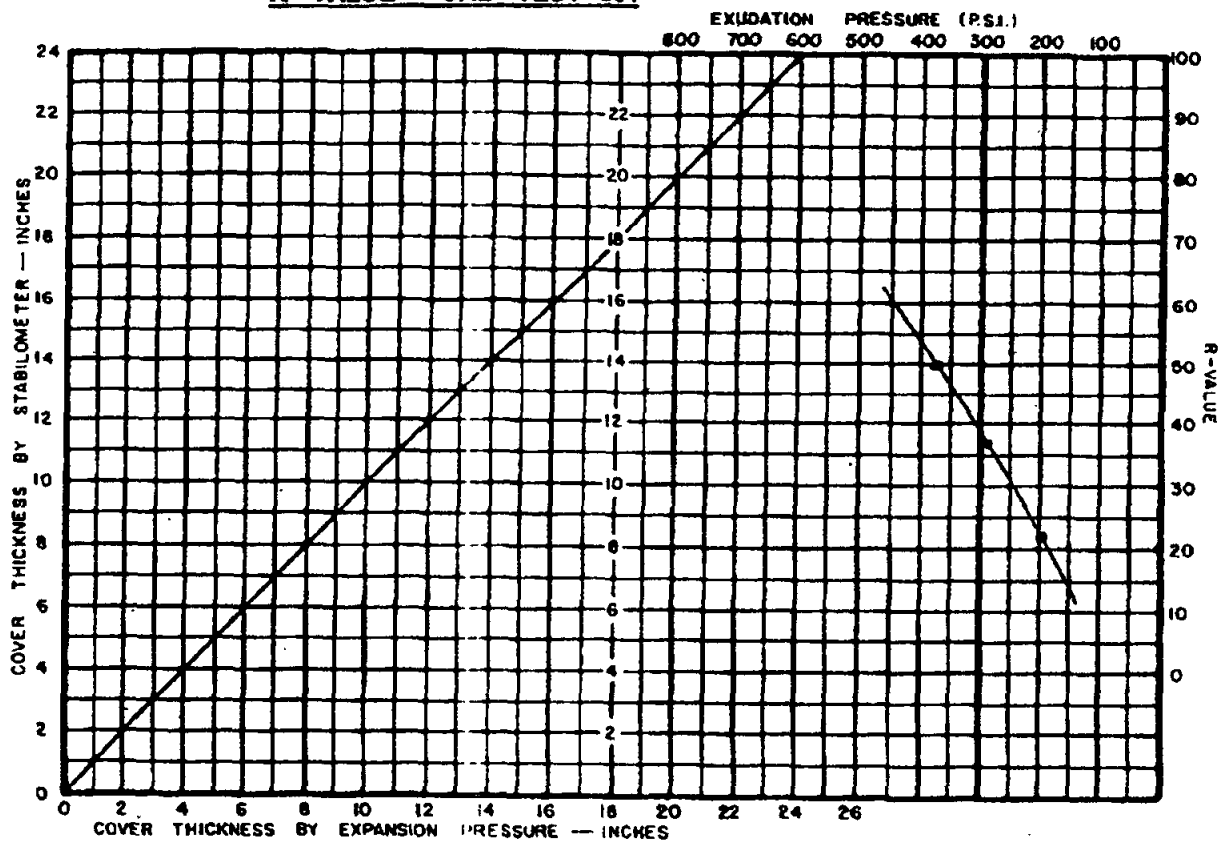
Job Name: Devil's Slide 02-19 Job No: 93063

Sample Description: Dk Brn Gr Sd Cl Sample No:

Source: Date: 11/20/02

Client Name: Earth Mechanics Sampled: Client Tested: MR/BR

R - VALUE CAL - TEST 301



Exudation psi	Expansion (.0001")	Expansion psf	Moisture %	Dry Density pcf	Resistance Value
374	0	0	8.6	132.4	50
290	0	0	9.0	130.0	37
196	0	0	9.6	129.2	22

Remarks:

Resistance Value
38

2278-F Pike Court • Concord, CA 94520-1252
(925) 825-2840 • FAX (925) 682-7953

APPENDIX B-4

ROCK LABORATORY TESTING BY GEOTEST

Geo Test Unlimited GTU

Test Equipment Design & Fabrication
Laboratory & Field Testing
Consulting Services

Dr. Anders Bro

November 21, 2002

Rock Testing for
Devil's Slide Tunnels
San Mateo Co. , California

Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708
Attention: Hubert Law

At your request, on August 23rd and 24th, 2002, I visited the Devil's Slide site to see the rock in which the proposed tunneling project is to be situated, and collected samples from Borings 02-6, 02-6A, 02-7, and 02-11. These samples were taken to GTU's laboratory in Nevada City and subsequently tested during the first phase of testing from September 6-25. After these tests were completed, a second trip was taken on October 4th and 5th to collect another set of samples from Borings 02-2A, 02-2B, 02-5, 02-6A, 02-8B, 02-11A, 02-13, 02-14, and 02-21. These samples were tested between the dates of October 17-24, 2002.

Test Descriptions

The initial suite of tests included 30 unconfined compression, 14 modulus (with accompanying unconfined compression tests), and 10 direct shear tests. A few slaking tests were scheduled, but the claystone samples retrieved from the core boxes did not appear to exhibit slaking behavior and so were not performed. The second suite of tests included 31 unconfined compression, 6 modulus (with accompanying unconfined compression tests), 10 direct shear, 10 single stage triaxial tests, and one multistage triaxial test.

The following ASTM (American Society of Testing and Materials) test procedures were used to perform the tests:

ASTM D2664 - Standard Test Method for Triaxial Compressive Strength of Undrained Rock Core Specimens Without Pore Pressure Measurements

ASTM D2938 - Standard Test Method for Unconfined Compressive Strength of Intact Rock Core Specimens

ASTM D3148 - Standard Test Method for Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression

ASTM D5607 - Standard Test Method for Performing Laboratory Direct Shear Strength Tests of Rock Specimens Under Constant Normal Force

In addition, the multistage triaxial test was performed following a procedure developed at GTU which generally follows the ASTM procedure:

ASTM D4767 - Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@saber.net

The details of the procedures used for these tests are appended to this report. Additionally, a copy of the Technical Note, "Analysis of Multistage Triaxial Test Results for a Strain-Hardening Rock", is included which details the data reduction of the multistage triaxial test.

The load cells used to monitor the applied loads were matched to the expected test loads to reduce the relative amount of electrical noise and increase the signal to noise ratio. For this suite of tests, the high variability of sample strengths required that the load cells be changed depending on the estimated strength of the samples. For the weaker compression samples, a 222 kN (50 kip) load cell was used to monitor the axial loads and a 889 kN (200 kip) load cell was used for the stronger samples. The first two direct shear tests were performed using 44 kN (10 kip) load cells to monitor the normal and shear loads. These cells were deemed too large, resulting in excessive electrical noise in the load measurements. Subsequent direct shear tests were performed using 8.9 kN (2000 lb.) load cells and resulted in satisfactorily low levels of electrical noise in the load measurements.

In early discussions, the question arose of whether ASTM or ISRM (International Society of Rock Mechanics) test procedures should be used. The ASTM procedures are essentially equivalent to the ISRM procedures, with the exception of the triaxial procedure. The ISRM triaxial procedure calls for a spherical seat to be located at both ends of the sample, whereas the ASTM procedure calls for a spherical seat at one end of the sample and a rigid platen at the other. The ASTM configuration was used for these tests.

Sample Descriptions

A total of 112 samples were selected for testing from the following five categories:

Siltstone & Claystone

Much of the rock tested was sedimentary in nature. These sedimentary rocks ranged from what might be classified as shale through the range of a conglomerate containing large clasts of granodiorite. EMI geologists have indicated that the shale-like material would be more properly classified as a claystone due to a lack of persistent fissility. The sample descriptions in the raw data sheets and plots have used the shale designation (as they were prepared prior to the decision to use the claystone classification), but as they generally lack fissility, these samples are referred to as claystone in this report. This claystone had many characteristics of shale. When the rock was being cut, a fine black oily surface developed on the water tank of the rock saw, which typically occurs when shale is cut. This rock also was characterized by finely spaced beds along which the core could easily be broken. In fact during sample preparation, a certain amount of care was required to prevent the samples from breaking along these bedding planes. Finally, the samples appeared to exude water from along the beds when the samples were tested in compression. It should be noted that it was often difficult to predict the strength of these claystones from the appearance of the rock. Some of the claystone samples had strengths that were far in excess of what one might expect for a weakly bedded claystone. These strong samples tended to have higher densities. It may be that these rocks were subjected to a greater degree of metamorphism and thus had a more lithified structure. Often the claystone included thin beds of a lighter gray siltstone and fine-grained sandstone, further obfuscating the rock categorization.

Sandstone

The grain sizes of these sandstone samples ranged from fine to coarse. The samples often contained calcite healed joints and fractures, but these features generally did not appear to significantly weaken the samples. The unjointed samples resulted in some of the highest rock strengths.

Conglomerate

The conglomerate clasts included a continuum of grain sizes from the fine sand size into the coarse grained range, in which clasts reached about 50 mm (2 in.). Larger clast sizes were not encountered in these samples as they were excluded during the sample selection process. The matrix of the conglomerate ranged from claystone to fine sandstone. The dark gray claystone matrix appeared to significantly weaken the rock, in comparison to the conglomerate that was held together with a sandstone matrix. In a few cases, it was difficult to differentiate between the conglomerate and the sheared and brecciated granodiorite.

Granodiorite

At shallow depths this rock could be highly altered and stained, and was almost soil-like in nature. The rock still exhibited some rock structure and although it was easy to disaggregate, it still maintained a degree of strength. Some of the granodiorite appeared to be highly sheared, giving it the appearance of a conglomerate. In this case the rock contained many shear zones and the matrix appeared to be a granodiorite rock flour. The clasts were either angular, as defined by fracture and joint traces, or they were rounded and totally surrounded by the sheared rock flour. The sheared granodiorite samples were quite weak and fragile.

Gouge

The last rock category consisted of two samples, one from Boring 02-5 and another from Boring 02-11. This material consisted of a dark gray sheared clay-like material that was quite weak and plastic, and contained many small granodiorite clasts.

Test Objectives

Rock tests were performed to address the following five objectives:

Rock Strength Variability

The overriding objective of the testing program was to characterize the strength properties of the rock types encountered in the drilling program. The unconfined compression test was the test used to achieve this objective. 81 unconfined tests were performed to get a handle on the rock strength variability. It should be noted that most of the rock seen in the core boxes was heavily fractured and it was often difficult to obtain testable lengths of core. Thus the strengths measured in this testing program represent the strengths of the strongest rock, and do not represent the fractured rock. Many of the rocks failed by shear along existing joints, healed and otherwise. However, even these strengths would be higher than the unconfined strengths of the majority of the rock mass.

Intact Rock Deformability

20 modulus tests were also performed on the more intact pieces of rock. The objective of these modulus tests was to develop deformability parameters for numerical modeling. Again, it

should be noted that the modulus measurements are representative of the strongest, unjointed portions of the rock mass, and may be lower due to the fractured nature of the mass (although confinement may tend to increase the modulus of the jointed rock).

Intact Rock Strength Parameters

A third objective was to determine the failure envelopes of the rock types encountered in this drilling program. This objective appeared to be difficult to achieve as the rock composition was so highly variable and the extent of fracturing and jointing so pervasive and variable. Instead of trying to characterize all of the rock types, the two most common rock types were chosen. Claystone was chosen to represent the weak rock encountered in the rock mass, and sandstone was chosen to represent the strong rock type. For all but two claystone samples, single stage tests were performed on these samples.

Four sandstone samples were tested at one confining pressure. The intent was to perform enough tests at one confining pressure to be able to see a clustering of strengths at this one confining pressure and thereby build confidence in the representative strength chosen for design. It was thought that the claystone would exhibit less strength variability and for this reason two levels of confinement were used, resulting in the testing of three samples at one confining pressure and three additional samples at a second confining pressure.

Gouge Strength Parameters

A fourth objective was to characterize the strength of the gouge encountered in Boring 02-5. This gouge material was soil-like and permitted the use of multistage testing techniques to fully develop the failure envelope. Since the sample appeared to consist of a plastic, clay rich material, it was likely to exhibit a pore pressure response during loading. For this reason, a consolidated, undrained procedure was used in which sample pore pressures were measured during the test. These test results can be used to characterize the strain-hardening behavior of the gouge.

Joint Strength Parameters

A variety of rock joints were tested to evaluate the joint strength parameters for the purpose of analyzing block failures into the tunnel and onto a liner as well as to evaluate portal stability. To this end, only samples with fairly smooth joint surfaces were chosen, thus representing the lower strength joints. Many of the joints encountered in the core samples were rough and not chosen for testing. A problem with much of the core was that the rock mass was so jointed that it was difficult to find solitary joint surfaces. The most common situation was that a promising joint sample contained two or more joints intersecting in a very short length of core, making the core turn into rubble, or resulting in large steps on all of the joints in that sample, making the sample unsuitable for testing. Most of the clay-filled joints could not be used for shear testing as the samples were generally quite fractured and were highly disturbed during sampling and handling. Thus clay filled joints, characterized by the lowest friction angles, are under-represented in this testing program.

Test Results

The sample data sheets and test plots are presented in Appendices A - D as follows:

Appendix A - Unconfined Compression and Modulus Tests
Appendix B - Single Stage Triaxial Tests
Appendix C - Multistage Triaxial Test
Appendix D - Direct Shear Tests

Photographs of the unconfined and triaxial samples were taken prior to and following testing. Only post-test photographs were taken of the direct shear samples as the testing process did not significantly alter the appearance of the samples. These photographs are included in a loose form as a part of this report.

Tables 1 - 4 condense all of the test results presented in Appendices A - D. Tables 5 - 8 summarize the Unconfined Compression, Modulus, and Direct Shear Test Results, with the objective of making some of the results.

Observations Regarding Sample Behavior

Unconfined Compressive Strengths (Table 1)

The range of rock strengths (Table 5) is quite large, from a low of about 0.01 MPa (2 psi) for the sheared clayey gouge to a high of 194.66 MPa (28,233 psi) for the intact sandstone. Clearly the effect of jointing is to weaken the rock as expressed by the lower values for the jointed test results. Some of the rock samples are described as containing joints and fractures and yet did not necessarily fail along these planes of weakness. This trait could be attributed to the orientation of the load with respect to the planes of weakness. In the case of the bedded rock, the bedding was nearly perpendicular to the core axis (typically about 75°), and thus did not appear to play a role in the failure geometry. In fact, the induced fractures often ran parallel to the core axis in these samples.

Failure Modes

The failures are categorized into joint-controlled failures and intact failures (Table 6). These designations are based on the degree to which the failed samples appeared to separate along existing planes of weakness. Often the failure mode was simple to distinguish. But, as so often is the case in the field of rock mechanics, there is really a continuum of possible sample failure modes. Failure may start within the intact material, and propagate to a more favorable plane of weakness once failure has been initiated. Thus, sample strengths may be quite high even though a sample failure mode is categorized as a joint-controlled failure. At the other end of the spectrum, the weakest samples failed through the soft plastic matrix that surrounded the harder clasts. In these cases, the designation of the failure mode depends on whether the matrix is considered to be joint-like, in which case the failures would be evaluate as joint-controlled failures, or whether the matrix is classified as an intact material. In these tests, the matrix is considered as intact material and is not considered to have characteristics of a joint, and so these weak rock failures are designated as intact rock failures.

Ductility

One interesting characteristic of the bedded rocks (the claystone and the interbedded claystone with sandstone and siltstone) was that these rocks were often quite ductile, failing at strains of almost twice the failure strains of the sandstone or conglomerate samples. (Although some of the sandstone samples were quite ductile as well.) Some of these bedded rocks also have an interesting characteristic in that water was often expelled from the samples when they were being loaded. This behavior may impact the ultimate strength of the rock due to increased pore pressures when the rock mass is loaded in an undrained manner.

Strength Variability

The claystone exhibited some quite high strengths (e.g. Samples 11A-301 and 11A-306)[1] along with relatively high densities. These strengths are curiously high for claystone and may indicate a higher degree of metamorphism than characteristic of such materials. An interesting characteristic of these claystones is that the strength of immediately adjacent samples can be quite disparate. For instance, Sample 11A-302 had a very low strength and lower density even though it was within 0.15 m of Sample 11A-301, which had a high strength and high density. This rock variability appears to be characteristic of the rock mass in general. It may be that the rapid gradation between claystone and similar-appearing siltstone explains the rapid changes in strength and density.

Gouge Strength

The unconfined compressive strength of the gouge, Sample 11-225, was exceedingly low. The strength was so low that after the loading ram was advanced into contact with the end platen of the sample, the sample slowly crept away from the ram, solely due to the weight of the load platen (16.9 N - 3.8 lb.) and the weight of the sample. The inherently low strength of this gouge may also have been exacerbated by sample disturbance incurred during drilling, logging, transporting the sample to the lab, and sample preparation.

Granodiorite Failure Mode

The granodiorite appears to be one of the weaker rocks in this testing program, with strength generally less than 24 MPa (3500 psi.) This lack of strength is likely due to alteration, possibly with presence of chlorite, and due to in-situ shearing. Any cohesion found in the samples may be due to relithification, cementation, or possibly the samples maintained some cohesion due to the high level of confining pressure during in-situ shearing. (This sort of cohesion is exemplified by hitting a small piece of rock with a strong hammer blow. The pulverized piece can be seen to maintain some cohesion by the high pressure that develops under the hammer head, even though the rock is completely comminuted.)

Conglomerate Failure Mode

The conglomerate samples generally failed through the matrix surrounding the clasts. The clasts were generally quite competent granodiorite and appeared to be strong compared to the

[1] Samples are designated by boring number followed by the depth, catenating the decimal depth in feet. eg - 11A-301 signifies a sample from Boring 02-11A and a depth of 301.6-302.0 feet (see Tables 1-4).

matrix. Most of these failures were categorized as intact failures as the failures did not appear to follow joint or fracture traces. The nature of the matrix appeared to influence the rock strengths quite strongly. The weak claystone matrix yielded the weakest samples, whereas the lighter gray siltstone and sandstone matrix materials resulted in stronger samples.

Explanation of Negative Strains during UC Tests

It should be noted that some of the stress-strain curves developed during the unconfined compression tests exhibited negative trending strains when approaching the peak loads. These measurements are insignificant and develop due to sample rotations as a sample starts to fail. For the unconfined compression tests, the axial LVDT (the displacement measuring sensor - a Linear Variable Differential Transformer) is attached rigidly to the reaction frame, and bridges the load cell, the rigid end platen, and the sample. The LVDT core bears against a finger which protrudes from the spherical seat half which in turn abuts the sample. Thus as the sample starts to fail, internal deformations may rotate the spherical seat. In the event that the indicating finger rotates away from the LVDT head, negative deformations are recorded. It should also be noted that the deformations of the load cell, platens, interplatens, and interfaces all add compliance to the strain readings of the unconfined compression strain readings, making them unsuitable for determining the sample modulus. (For this reason the modulus tests are performed using a clip gauge which measures only sample deformations.)

Modulus of Elasticity (Tables 1 & 7) - method of evaluating

The modulus values presented in this report were determined from the unloading-reloading portions of the stress-strain curves of the modulus tests. The particular slopes used for these calculations are depicted on the stress-strain plots. It should be noted that the tangent slopes of the reloading/loading curves depend on the level of axial stress, and other choices may be more appropriate for design. Additionally, it should be noted that the initial loading modulus would be significantly lower than the reloading modulus. Any initial loading modulus derived from these test results is likely to have been strongly influenced (i.e. reduced) due to sample disturbance incurred by drilling, handling in the field, sample preparation, and reorientation of the stress state when the sample was extracted from the rock mass.

Poisson's Ratios - possibly explanation for values in excess of 0.5

During the modulus tests of most of the bedded samples, large lateral strains resulted in high poisson's ratios, sometimes in excess of 0.5 (Table 7). These high values are in contradiction to isotropic elastic theory and a lower value would likely be more appropriate. These high values may be due to sample dilation as might be expressed by outward bending of vertical columnar elements of the rock. The radial expansion of the sample is exemplified by Sample 11-214 in which the radial strain was becoming quite nonlinear by the end of the modulus test, and yet had reached only about 1/3 of the ultimate strength. (For most strong rocks the sample remains elastic for a much greater portion of the loading curve.) Another possibility is that these high values are a result of anisotropic behavior and may be valid material responses that may need to be accounted for in the numerical modeling effort.

Triaxial Strength Parameters (Table 2) - excessive strength variability

As anticipated, the single-stage triaxial test results exhibited a large amount of scatter. This scatter is clearly due to the inherent variability in the strength of the rock. Rock variability, fracture orientation, degree and strength of joint healing, and fracture frequency and extent, all contributed to the strength variability. When plotted in failure space, no clear failure envelope trend can be extracted from the Mohr failure circles, for either the sandstone samples or the claystone samples. One claystone sample, Sample 11A-493, failed in a gentle enough manner to perform a two-stage triaxial test, and one could plot these two Mohr circles to develop a failure envelop for this one sample.

Multistage Triaxial Strength Parameters (Table 3)

The multistage triaxial test on Sample 5-640 produced a typical strain hardening stress-strain curve. The reduction of the test measurements for such a material is detailed in the appended Technical Note. To use the results of this analysis, one can either incorporate the strain hardening behavior in the numerical algorithm of the failure envelope for the material (with an understanding that at some strain the sample starts to weaken), or one needs to define a level of strain which defines failure, and use the C and ϕ parameters which correspond to this level of strain. The parameters presented in this table and accompanying plot are in terms of effective stress, but can easily be converted to total stress parameters. It should be noted that the pore pressure response is quite significant and should not be overlooked in evaluating the short and long-term strengths of the gouge.

Joint Strength Behavior (Tables 4 & 8)

The granodiorite joints were generally characterized by final friction angles in the mid 30's, whereas the sandstone and claystone samples had lower friction angles, generally in the mid to upper 20's. As expected, the gouge filled and clay-coated samples had lower friction angles, generally in mid teens. The one sample with the high friction angle in the clay-coated category was composed of sandstone. Contact between the joint walls may explain the relatively high friction angles for this sample. The initial friction angles in the granodiorite were generally in the low 40's. The initial friction angles for the sandstone were more variable, ranging from 33.0 to 52.9°. The initial friction angle of the two claystone samples was quite high, at 37°. The difference between the initial and final friction angles of the gouge filled and clay-coated joints was not very significant, with the initial friction angles in the low 20's.

There does not appear to be any correlation between the joint roughness and the initial or final friction angles, although there does seem to be a general relationship between the shear intercept values and the roughness. The rougher joints appear to have higher shear intercepts than the undulating or planar joint surfaces. It is likely that the in-situ initial friction angles and shear intercepts would be higher than those measured in these tests. Joint disturbance due to coring and sampling would have degraded the mating of the joints and possibly washed out the more granular joint fillings.

GeoTest Unlimited

Dr. Anders Bro

TABLE 1
Unconfined Compression & Modulus Test Results

Boring	Depth (ft) (m)	Description	Density (kN/m^3)	Strength (MPa)	Modulus (GPa)	Poisson's Ratio
02-2B	127.3-127.8 38.80-38.95	Gray altered granodiorite with one weak healed joint.	25.4	16.79[j]		
	155.0-155.5 47.24-47.39	Gray altered granodiorite with a few calcite-healed fractures.	25.5	19.17[j]		
	164.8-165.3 50.23-50.38	Gray slightly altered granodiorite with a healed fracture zone at one end.	25.8	49.06[j]		
02-5	173.0-173.5 52.73-52.88	Medium-gray coarse-grained sandstone.	25.4	57.25[j]	29.4	.18
	203.4-203.9 62.00-62.15	Medium-gray coarse-grained sandstone with a few open voids along joint traces.	24.8	19.33[j]		
	229.2-229.7 69.86-70.01	Interbedded dark-gray claystone and medium-gray siltstone with numerous fractures parallel and perpendicular to bedding.	26.3	22.07[i?]		
	254.7-255.2 77.63-77.78	Medium-gray medium-grained sandstone with calcite-healed fractures perpendicular to bedding.	26.0	66.79[i?]		
	306.0-306.5 93.27-93.42	Medium-gray fine to medium-grained sandstone with a few axial calcite-healed fractures.	26.1	150.90[i]		
	328.4-328.9 100.10-100.25	Medium-gray fine to medium-grained sandstone with several axial calcite-healed axial fractures.	26.0	20.35[j]		
	337.7-338.1 102.93-103.05	Gray fine-grained sandstone with a few calcite-healed fractures.	25.9	155.62[i]	57.9	.36
	342.9-343.4 104.52-104.67	Medium gray fine-grained conglomerate with a few calcite-healed fractures.	25.9	117.42[i]		
	356.2-356.7 108.57-108.72	Medium-gray medium to coarse-grained conglomerate with weak dark-gray claystone matrix.	25.9	26.17[i]		
	664.3-664.8 202.48-202.63	Medium-gray coarse-grained conglomerate - or possibly a heavily sheared and recemented granodiorite.	25.6	3.92[j]		
	672.0-672.5 204.83-204.98	Medium-gray granodiorite.	25.9	24.31[i]	23.9	.30

TABLE 1 (Cont.)
Unconfined Compression & Modulus Test Results

Boring	Depth (ft) (m)	Description	Density (kN/m^3)	Strength (MPa)	Modulus (GPa)	Poisson's Ratio
02-5	684.1-684.6 208.51-208.66	Medium-gray granodiorite with numerous weak relithified shear zones.	25.4	16.61[i]		
	700.0-700.5 213.36-213.51	Greenish-gray granodiorite which has been sheared and weakly relithified.	25.6	5.07[i?]		
02-6	330.0-330.5 100.58-100.73	Gray conglomerate with several calcite-healed joints.	25.8	46.02[i]		
	336.1-336.6 102.44-102.59	Gray conglomerate with a few calcite-healed fractures.	25.9	68.31i	59.09	.21
	343.6-344.1 104.73-104.88	Gray conglomerate with a few calcite-healed fractures.	25.9	82.18[i]		
	349.4-349.9 106.50-106.65	Dark-gray siltstone with several calcite-healed fractures.	26.2	26.39[j]		
	354.6-355.1 108.08-108.23	Dark-gray heavily sheared and recemented fine-grained sandstone with numerous calcite-healed fractures.	25.4	14.53[j]	21.79	.28
	355.8-356.2 108.20-108.32	Gray fine-grained sandstone with several calcite-healed joints.	25.6	19.89[j]		
	379.2-379.7 115.58-115.73	Gray conglomerate with one calcite-healed joint and one weak joint.	26.0	67.48[j]		
	386.0-386.5 117.65-117.80	Gray medium-grained sandstone with two minor calcite-healed fractures.	26.0	164.22[i]		
	388.5-389.0 118.41-118.56	Gray medium-grained sandstone with a few calcite-healed joints.	26.0	117.49[i]		
	391.5-392.0 119.33-119.48	Gray medium-grained sandstone with no apparent fractures.	25.9	194.66[i]	53.37	.17
	403.2-403.7 122.40-122.55	Gray medium-grained sandstone with one minor calcite-healed joint.	25.9	131.39[i]		
	411.2-411.7 125.33-125.48	Gray conglomeratic sandstone with a few calcite-healed fractures.	26.0	152.21[i]		
	414.5-415.0 126.34-126.59	Gray sandstone with several calcite-healed joints.	26.0	96.09[j?]		
	418.3-418.8 127.50-127.65	Gray sandstone with several calcite-healed joints.	25.9	11.61[j]		

TABLE 1 (Cont.)
Unconfined Compression & Modulus Test Results

Boring	Depth (ft) (m)	Description	Density (kN/m^3)	Strength (MPa)	Modulus (GPa)	Poisson's Ratio
02-6	439.3-439.8 133.90-134.05	Gray sandstone with a few partially healed joints.	25.8	91.01[j]		
	446.4-446.9 136.06-136.21	Gray medium-grained sandstone with two minor calcite-healed fractures.	26.0	160.34[i]	6.74	.26
	453.1-453.6 138.10-138.25	Gray sandstone with several calcite-healed joints.	26.0	71.69[j]		
02-6A	530.2-530.7 161.60-161.75	Gray medium-grained sandstone with a few calcite-healed joints.	25.8	123.76[i?]		
	532.9-533.4 162.43-162.58	Gray medium-grained sandstone with a few calcite-healed joints.	25.8	146.02[i]	47.57	.16
02-7	318.8-319.3 97.17-97.32	Gray medium to coarse-grained sandstone with a few calcite-healed joints.	25.9	70.68[j]		
	322.8-323.3 98.39-98.54	Gray medium to coarse-grained sandstone with two calcite-healed joints.	25.9	68.40[j]		
	366.2-366.7 111.62-111.77	Gray conglomeratic sandstone with a few calcite-healed fractures.	26.2	106.08[i?]	66.19	.34
	370.0-370.5 112.78-112.93	Gray conglomeratic sandstone with several calcite-healed joints.	26.1	123.49[i]		
	402.5-403.0 122.68-122.83	Gray medium to coarse-grained sandstone with a few calcite-healed fractures.	26.0	168.27[i]	57.43	.21
02-8B	282.4-282.9 86.08-86.23	Medium-gray coarse-grained sandstone with several calcite-healed fractures.	25.6	22.17[j]		
	299.9-300.4 91.41-91.56	Medium-gray fine to medium-grained conglomerate with a few calcite-healed fractures.	26.2	58.23[i]		
	307.5-308.0 93.73-93.88	Medium-gray coarse-grained conglomerate with several calcite-healed joints.	25.7	54.16[i]		
	314.9-315.4 95.98-96.13	Medium-gray coarse-grained conglomerate with several calcite-healed fractures.	26.0	67.58[i]		
	327.8-328.3 99.91-100.06	Medium-gray coarse-grained conglomerate with a weak dark-gray claystone matrix.	25.9	19.79[i]		

TABLE 1 (Cont.)
Unconfined Compression & Modulus Test Results

Boring	Depth (ft) (m)	Description	Density (kN/m^3)	Strength (MPa)	Modulus (GPa)	Poisson's Ratio
02-11	92.5-93.0 28.19-28.34	Pale brownish-gray medium-grained sandstone with a few calcite-healed fractures.	26.0	133.83[j]	64.67	.30
	112.5-113.0 34.29-34.44	Pale brownish-gray fine to medium-grained sandstone with a few poorly healed fractures.	25.9	69.32[j]		
	127.1-127.6 38.74-38.89	Interbedded claystone and fine-grained sandstone.	26.7	17.97[i]	29.99	na (.63)
	131.0-131.5 39.93-40.08	Interbedded medium-gray fine-grained sandstone with dark-gray claystone, with partially healed fractures.	26.6	38.93[i?]		
	137.0-137.5 41.76-41.91	Dark-gray claystone with a few fine-grained sandstone beds.	26.0	27.74[i]	10.00	.31
	162.2-162.7 49.44-49.59	Dark-gray highly fractured claystone.	25.9	14.29[j]		
	181.0-181.4 55.17-55.32	Medium to dark-gray siltstone and claystone with calcite-healed fractures.	26.4	11.26[j]		
	211.2-211.7 64.37-64.52	Dark-gray claystone and fine-grained sandstone with calcite-healed fractures.	25.6	2.10[j]		
	214.7-215.2 65.44-65.59	Interbedded claystone and sandstone with two calcite-healed axial fractures.	25.8	26.57[i]	10.41	na(.60)
	225.0-225.5 68.58-68.73	Dark-gray heavily sheared clayey claystone (gouge?).	23.1	0.01[i]		
	239.1-239.6 72.88-73.03	Dark-gray claystone with a few fine sandstone beds and several calcite-healed hairline fractures oriented perpendicular to the bedding.	26.0	5.24[j]		
	241.5-242.0 73.61-73.76	Interbedded claystone and fine-grained sandstone with no visible joints.	25.8	30.09[i]	11.17	na(.49)
	244.7-245.2 74.58-74.73	Dark-gray claystone with a few fine-grained sandstone beds with no apparent fracturing.	25.8	23.88[i]		

TABLE 1 (Cont.)
Unconfined Compression & Modulus Test Results

Boring	Depth (ft) (m)	Description	Density (kN/m^3)	Strength (MPa)	Modulus (GPa)	Poisson's Ratio
02-11	247.0-247.5 75.29-75.44	Dark-gray claystone with one sandstone bed with several fractures.	25.8	21.26[i]		
	261.6-262.0 79.74-79.86	Dark-gray siltstone with medium-gray fine grained sandstone with two calcite-healed joints.	27.4	120.38[i?]		
	265.8-266.3 81.02-81.17	Interbedded medium and dark-gray sandstone (siltstone?) with a few calcite-healed hairline fractures perpendicular to bedding.	27.3	163.05[i]	87.56	.42 (na?)
	269.2-269.7 82.05-82.20	Dark-gray siltstone with a few fine-grained sandstone beds and a few hairline calcite-healed fractures.	27.0	46.88[j]		
	273.5-274.0 83.36-83.51	Dark-gray claystone with a few fine-grained sandstone beds.	26.2	36.09[i]		
	277.5-278.0 84.58-84.73	Dark-gray claystone	25.7	15.00[i]	7.65	.33
	311.1-311.6 94.82-94.97	Dark-gray finely interbedded siltstone with one calcite-healed fracture.	26.9	39.20[j]		
02-11A	295.5-296.0 90.07-90.22	Dark-gray claystone with a few bedding plane fractures.	26.5	45.96[j]		
	301.6-302.0 91.93-92.05	Dark-gray claystone with a few medium-gray thin siltstone beds, with a few bedding plane joints.	26.7	74.19[i]		
	302.7-303.2 92.26-92.41	Dark-gray claystone with several fractures.	26.1	3.75[j]		
	306.3-306.8 93.36-93.51	Dark-gray claystone with a few bedding plane joints and calcite-healed hairline fractures.	26.7	72.33[i]		
	520.2-520.7 158.56-158.71	Dark-gray claystone with a few joints.	26.1	31.23[j?]		
	528.6-529.1 161.12-161.27	Dark-gray claystone.	26.1	49.03[i]	22.96	.41(na?)
	542.8-543.3 165.45-165.60	Dark-gray siltstone sheared with dark-gray claystone and relithified.	26.1	57.99[j?]		

TABLE 1 (Cont.)
Unconfined Compression & Modulus Test Results

Boring	Depth (ft) (m)	Description	Density (kN/m^3)	Strength (MPa)	Modulus (GPa)	Poisson's Ratio
02-11A	552.0-552.5 168.25-168.40	Dark-gray interbedded sheared siltstone and claystone with siltstone.	26.1	61.03[i]		
	564.5-565.0 172.06-172.21	Dark-gray siltstone interbedded with a few beds of medium-gray fine grained sandstone.	26.4	57.07[i]	44.47	na(.54)
02-13	33.3-33.8 10.15-10.30	Brownish-gray heavily altered granodiorite.	23.6	1.19[i]		
	89.2-89.7 27.19-27.24	Greenish-gray granodiorite with two healed joints.	26.8	45.31[i]		
02-14	123.2-123.7 37.55-37.70	Brownish-gray heavily altered granodiorite.	23.5	0.60[i]		
02-21	380.1-380.6 115.85-116.00	Greenish-gray heavily sheared granodiorite, which may be weakly relithified.	25.7	23.98[j]		
	417.3-417.8 127.19-127-24	Greenish-gray heavily sheared granodiorite, which may be weakly relithified.	25.3	8.41[j]		
	442.8-443.3 134.97-135.12	Greenish-gray heavily sheared granodiorite, which may be weakly relithified.	25.8	16.97[j]		
	468.5-469.0 142.80-142.95	Light greenish-gray altered and heavily sheared granodiorite, which may be weakly relithified.	26.7	10.00[i]	16.62	.24

Notes: i – intact rock strength
j – joint controlled strength
na – not applicable
All of the metric units were derived from the english units with the following conversion factors: $0.3048 m^3/ft/$
0.15708662 kN/m3 / pcf
0.006894757 MPa/psi

TABLE 2
Single-Stage Triaxial Test Results

Boring	Depth (ft.) (m)	Description	Density (kN/m^3)	Conf. Press. (MPa)	Strength (MPa)
02-6A	606.0-606.5 184.71-184.86	Medium-gray coarse-grained sandstone with several calcite-healed fractures.	25.8	2.21	210.92
	614.2-614.7 187.21-187.36	Medium-gray coarse-grained sandstone with calcite-healed hairline fractures.	25.7	2.30	156.03
	626.0-626.5 190.80-190.95	Medium-gray coarse-grained sandstone with a few calcite-healed hairline fractures.	25.8	2.21	160.17
	629.2-629.7 191.78-191.93	Medium-gray coarse-grained sandstone with one calcite-healed hairline fracture.	25.8	2.26	194.07
02-11A	162.0-162.5 49.38-49.53	Dark-gray claystone with a few medium-gray fine-grained sandstone interbeds with several fractures.	25.7	0.69	9.47
	290.9-291.4 88.67-88.82	Dark-gray claystone with a few axial fractures.	26.3	0.70	31.55
	295.0-295.4 89.92-90.04	Dark-gray interbedded claystone and siltstone.	26.2	0.69	51.80
	479.8-480.2 146.24-146.36	Dark-gray interbedded claystone and medium-gray siltstone.	26.1	1.42	39.84
	493.0-493.5 150.27-150.42	Dark-gray highly fractured claystone.	25.7	1.39 2.83	15.69 29.14
	493.6-494.0 150.45-150.57	Interbedded dark-gray claystone and medium-gray siltstone with several fractures.	25.9	1.42	29.41

TABLE 3
Multistage Triaxial Test Results
Effective Stress Strength Parameters

Boring	Depth (ft.) (m)	Description	Density (kN/m^3)	Strain (mm/mm)	C' (kPa)	ϕ' (degrees)
02-5	640.0-640.5 195.07-195.22	Dark gray sheared claystone gouge.	24.6	0.016 0.030	69 41	13 18

TABLE 4
Direct Shear Test Results

Boring	Depth (ft.) (m)	Description	S_j (kPa)	ϕ (degrees)
02-2A	34.9 10.64	Rough joint in moderately altered granodiorite.	116[i] 28[f]	38.3[i] 34.0[f]
	44.5-45.0 13.56-13.71	Rough oxide coated joint in altered granodiorite.	88[i] 44[f]	40.3[i] 34.6[f]
	55.0 16.76	Planar joint in unaltered granodiorite.	28[i] 27[f]	36.5[i] 35.9[f]
	55.5 16.92	Rough non-through-going joint in altered granodiorite.	59[i*] 39[f]	41.8[i*] 34.2[f]
	59.0 17.98	Rough joint in altered granodiorite.	64[i] 37[f]	41.3[i] 37.6[f]
	60.4 18.41	Planar joint in altered granodiorite	37[i] 43[f]	34.8[i] 28.4[f]
02-2B	41.0 12.50	Undulating joint in altered granodiorite.	125[i] 0.0[f]	45.0[i] 31.2[f]
	95.4 29.08	Slightly rough joint in altered granodiorite.	191[i] 46[f]	36.8[i] 31.4[f]
	97.1 29.60	Planar joint in altered granodiorite.	55[i] 54[f]	41.0[i] 33.7[f]
	128.4 39.14	Undulating joint in altered granodiorite.	8[i] 17[f]	40.2[i] 34.7[f]
02-6	435.0 132.59	Gray sandy clay gouge-filled joint in gray sandstone. Filling to 1/8 inch thick.	51[i] 46[f]	22.2[i] 20.2[f]
02-11	64.8 19.75	Planar slightly-rough bedding joint at claystone/sandstone interface – mostly in the claystone.	na(-4)[i] 9[f]	37.4[i] 25.0[f]
	90.7-90.9 27.65-27.71	Slightly wavy clay-filled joint with oxide coating in pale brownish-gray sandstone.	3[i] 11[f]	35.1[i] 33.7[f]
	91.0 27.74	Planar bedding joint in pale brown sandstone.	8[i] 11[f]	33.0[i] 27.2[f]
	93.4 28.47	Bedding contact between claystone gouge and pale brown sandstone.	6[i]	9.3[i]
	93.6 28.53	Bedding contact between claystone gouge and claystone with slickensides.	41[i] 6[f]	7.1[i] 11.4[f]
	105.6 32.19	Wavy oxide-stained bedding contact between claystone and tan sandstone.	103[i] 31[f]	52.9[i] 37.9[f]

TABLE 4 (Cont.)
Direct Shear Test Results

Boring	Depth (ft.) (m)	Description	S_j (kPa)	ϕ (degrees)
02-11	122.8-123.2 37.43-37.55	Partially healed oxide-coated axial joint passing through claystone and gray sandstone.	52^i 18^f	40.6^i 26.9^f
	233.7-234.2 71.23-71.38	Intact interface between sheared clayey claystone gouge and claystone.	50^i 101^f	20.3^i 16.5^f
	317.6 96.80	Clean planar bedding plane in claystone, possibly a mechanical break.	210^i 57^f	37.0^i 29.9^f

Notes: i - initial strength values.
i* - intermediate strength value, after the peak value has been attained and some small amount of shear displacement has occurred.
f - final strength values.
na - denotes a value which is invalid (not appropriate).

TABLE 5
Summary of Unconfined Compression Strengths (MPa)

Clay Gouge	Claystone	Interbedded Claystone/ Siltstone	Siltstone	Fine to Coarse Sandstone	Congl. Sandstone to Fine Congl.	Med. to Coarse Congl.	Granodiorite
0.01	(j)3.75	(j)2.10	(j)26.39	(j)11.61	58.23	(j)3.92	0.60
	(j)5.24	(j)11.26	(j)39.20	(j)14.53	(i?)106.08	19.79	1.19
	(j)14.29	17.97	(j)46.88	(j)19.33	117.42	26.17	(i?)5.07
	15.00	(i?)22.07	57.07	(j)19.89	123.49	46.02	(j?)8.41
	21.26	26.57	(j?)57.99	(j)20.35	152.21	54.16	10.00
	23.88	30.09	120.38	(j)22.17		(j)67.48	16.61
	(j)27.74	38.93		(j)57.25		67.58	(j)16.79
	(j)31.23	61.03		(i?)66.79		68.31	(j)16.97
	36.09	74.19		(j)68.40		82.18	(j)19.17
	(j)45.96			(j)69.32			(j?)23.98
	49.03			(j)70.68			24.31
	72.33			(j)71.69			(i?)45.31
				(j)91.01			(j)49.06
				(j?)96.09			
				117.49			
				(i?)123.76			
				125.62			
				131.39			
				(j)133.83			
				146.02			
				150.90			
				160.34			
				163.05			
				164.22			
				168.27			
				194.66			

Notes: (j) - joint controlled failure
(j?) - possible joint controlled failure
(i?) - possible an intact rock failure
entries without a prefix indicate intact rock failure.

TABLE 6
Unconfined Strength Ranges as a Function of Failure Mode (MPa)

	Clay Gouge	Clayst.	Interbed. Clayst./ Siltst.	Siltst.	Fine to Coarse Sandst.	Congl. Sandst. to Fine Congl.	Med. to Coarse Congl.	Grano-diorite
Jointed Strength		3.75-45.96	2.10-11.26	26.39-57.99	11.61-133.83		3.92-67.48	8.41-49.06
Intact Strength	0.01	15.00-72.33	17.97-74.19	57.07-120.38	66.79-194.66	58.23-152.21	19.79-82.18	0.60-45.31

TABLE 7
Summary of Modulus Values

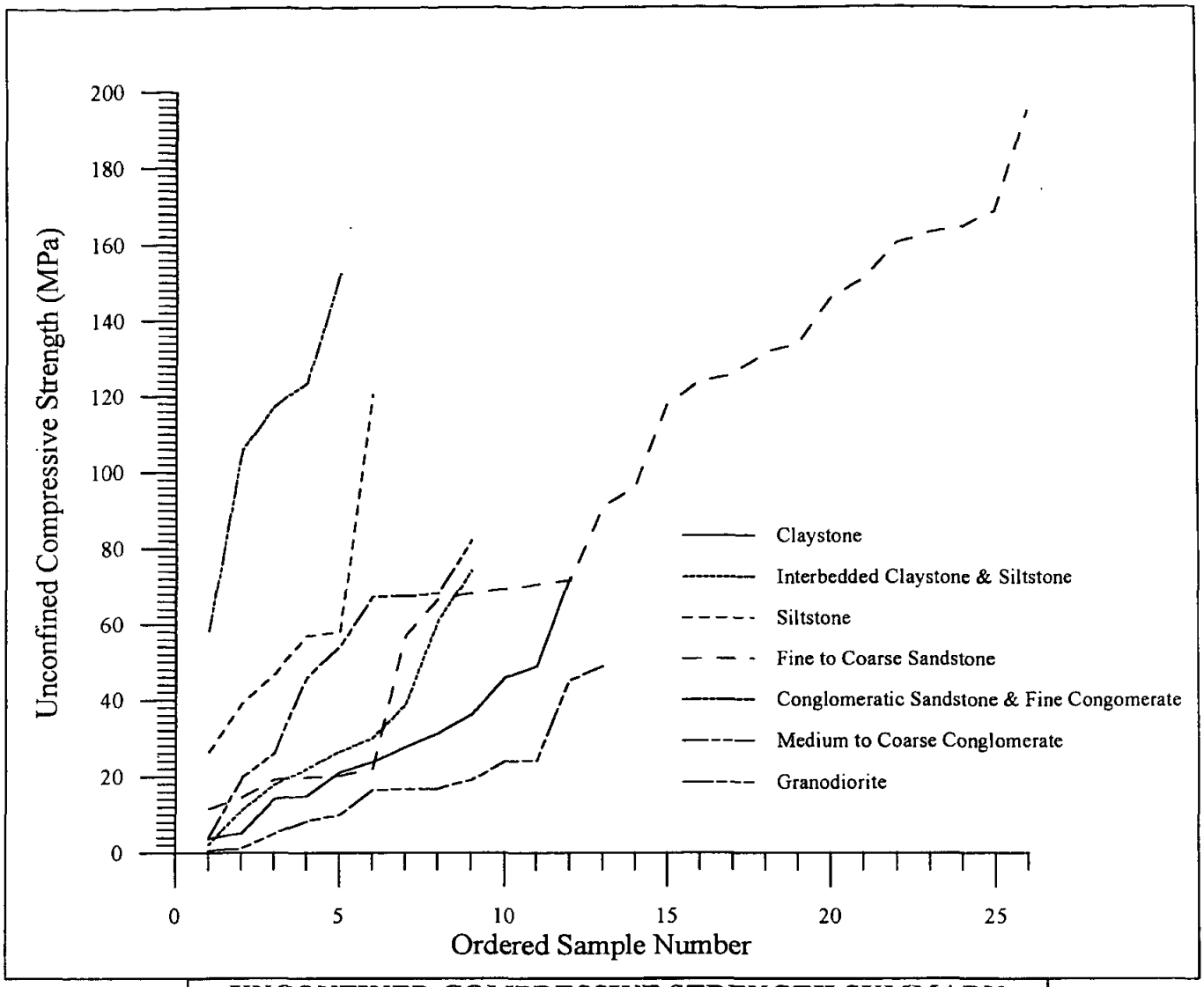
Claystone		Interbedded Claystone/ Siltstone		Interbedded Sandstone		Fine to Coarse Sandstone		Conglomerate		Granodiorite	
E (GPa)	ν	E (GPa)	ν	E (GPa)	ν	E (GPa)	ν	E (GPa)	ν	E (GPa)	ν
7.7	.33	10.4	na(.60)	44.5	na(.54)	21.8(f)	.28	59.1	.21	16.6	.24
10.0	.31	11.2	.49(na?)	87.6	.42(na?)	29.4(c)	.18			23.9	.30
23.0	.41(na?)	30.0	na(.63)			46.5(m)	.26				
						47.6(m)	.16				
						53.4(m)	.17				
						57.4(m-c)	.21				
						57.9(f)	.36				
						64.7(m)	.30				
						66.2(c)	.34				

Notes: (f) - fine-grained sandstone
(m) - medium-grained sandstone
(c) - coarse-grained
na - indicates not applicable - greater than 0.5
na? - indicates that the Poisson's ratio may be too high

TABLE 8
Direct Shear Test Strength Parameters
(all values are indicated as - initial/final)

Granodiorite		Sandstone		Claystone		Gouge filled/Clay coated	
S_i (kPa)	ϕ(degrees)	S_i (kPa)	ϕ(degrees)	S_i (kPa)	ϕ(degrees)	S_i (kPa)	ϕ(degrees)
37/43	34.8/28.4 (p)	52/18	40.6/26.9(m)	na(-4)/9	37.4/25.0(b)	6/-	9.3/- (s)
13/0	45.0/31.2(u)	8/11	33.0/27.2(b)	210/57	37.0/29.9(b)	41/6	7.1/11.4 (c)
191/46	36.8/31.4(r)	103/31	52.9/37.9(c)			50/101	20.3/16.5(c)
55/54	41.0/33.7(p)					51/46	22.2/20.2(s)
116/28	38.3/34.0(r)					3/11	35.1/33.7(s)
59/39	41.8/34.2(ntg)						
88/44	40.3/34.6(r)						
8/17	40.2/34.7(u)						
28/27	36.5/35.9(p)						
64/37	41.3/37.6(r)						

Notes: p - planar
u - undulating
r - rough
ntg - non-through-going
na - not applicable (negative shear intercept)
c - claystone joint
s - sandstone joint
m - mixed sandstone and claystone
b - bedding plane



UNCONFINED COMPRESSIVE STRENGTH SUMMARY
CUMMULATIVE PLOT

This cummulative graph plots the strength of each rock type in an ordered manner. It is compareable to a cummulative distribution plot but with the strength on the vertical axis rather than a percentage of maximum strength. From this plot one can see strength groupings for each rock type, as expressed by a horizontal trace, or a low slope.

Geo Test Unlimited G T U

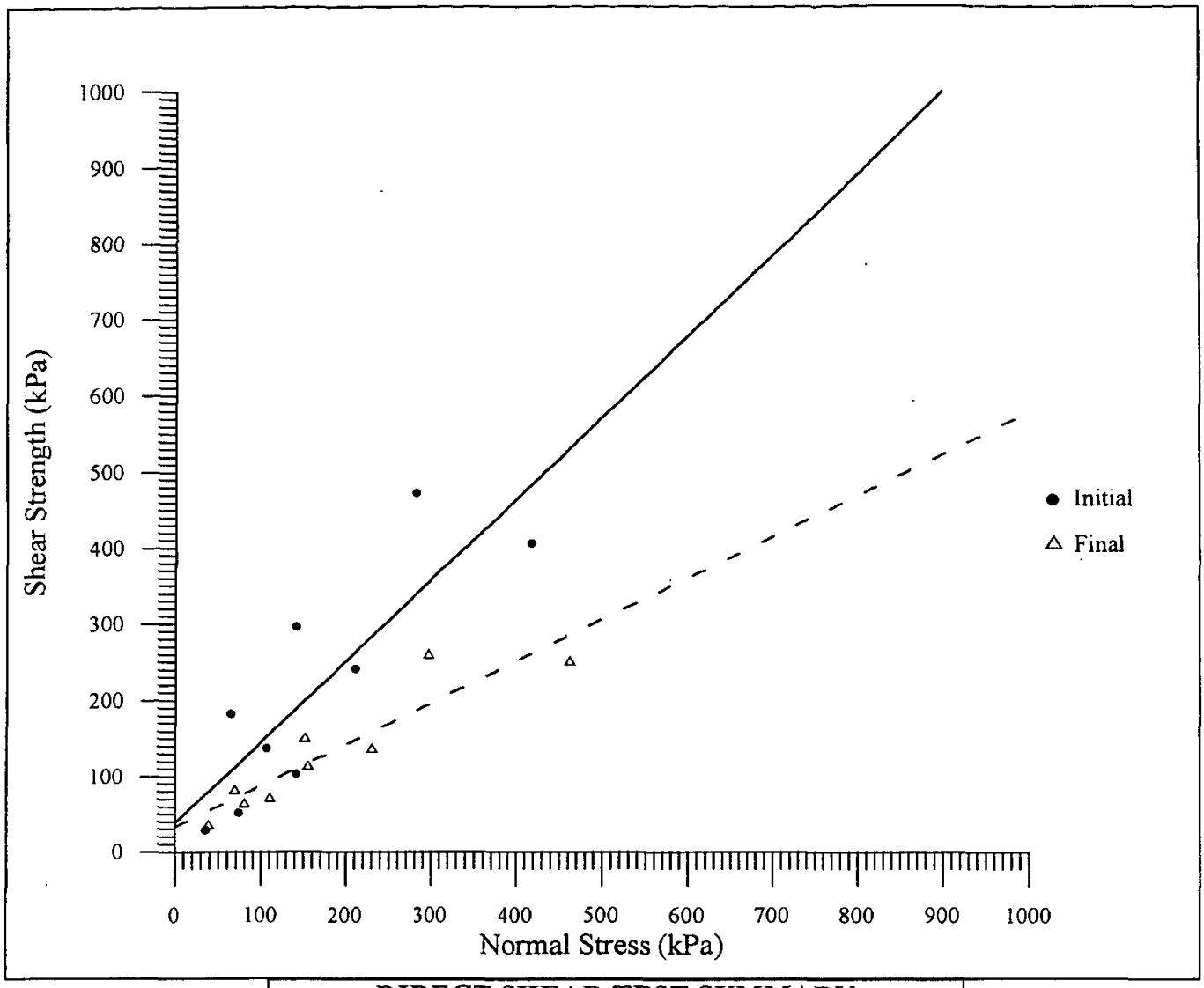
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: August 23 - October 24, 2002



DIRECT SHEAR TEST SUMMARY
SANDSTONE
Failure Envelope Normal Stress vs. Shear Strength

DESCRIPTION

Joints in sandstone.

	Shear Intercept (kPa)	Friction Angle (degrees)
Initial	39	46.8
Final	34	28.6

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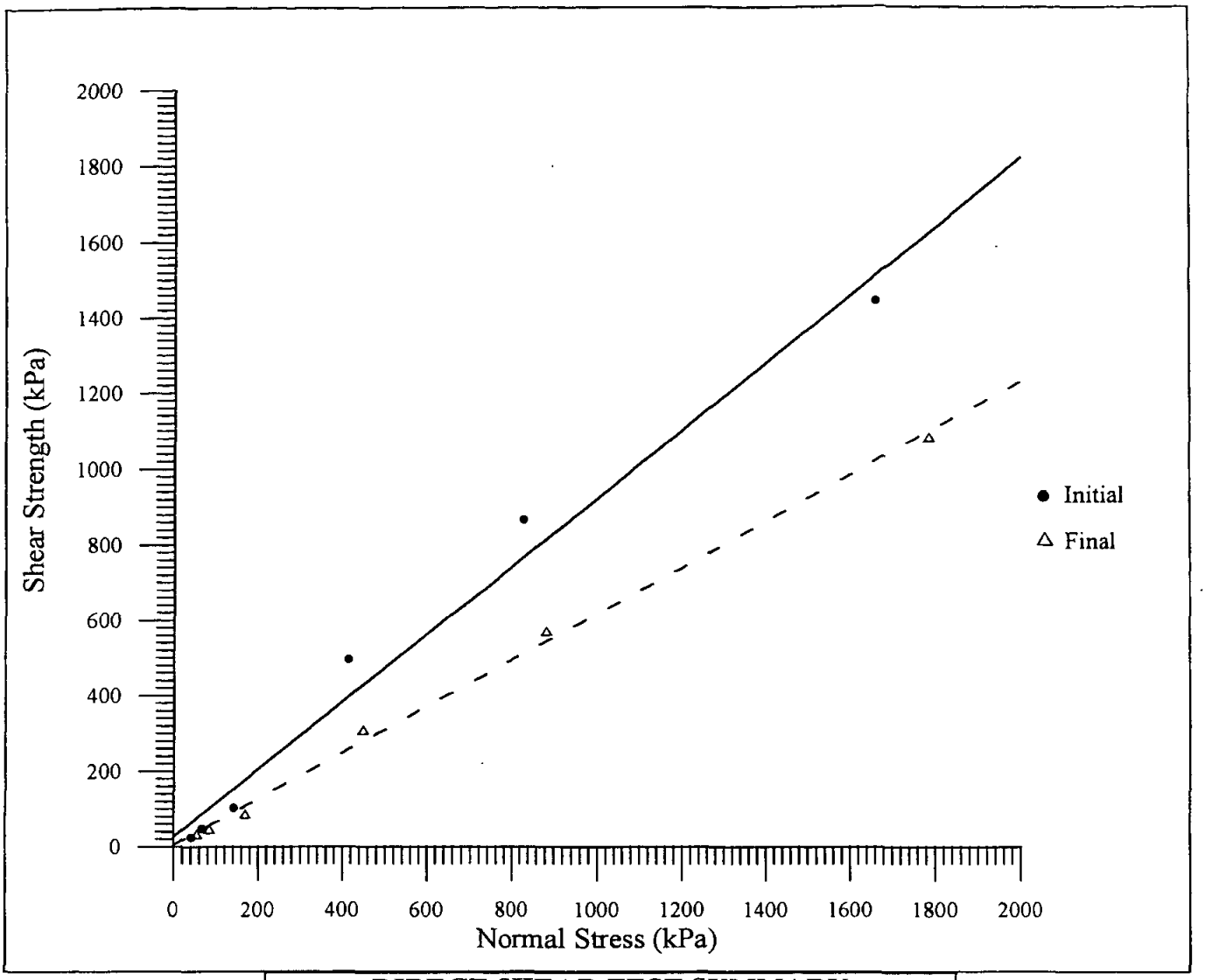
Project Number: none

Test Date: August 23 - October 24, 2002



DIRECT SHEAR TEST SUMMARY
CLAYSTONE
Failure Envelope Normal Stress vs. Shear Strength

DESCRIPTION

Joints in claystone.

	Shear Intercept (kPa)	Friction Angle (degrees)
Initial	29	41.8
Final	6	31.5

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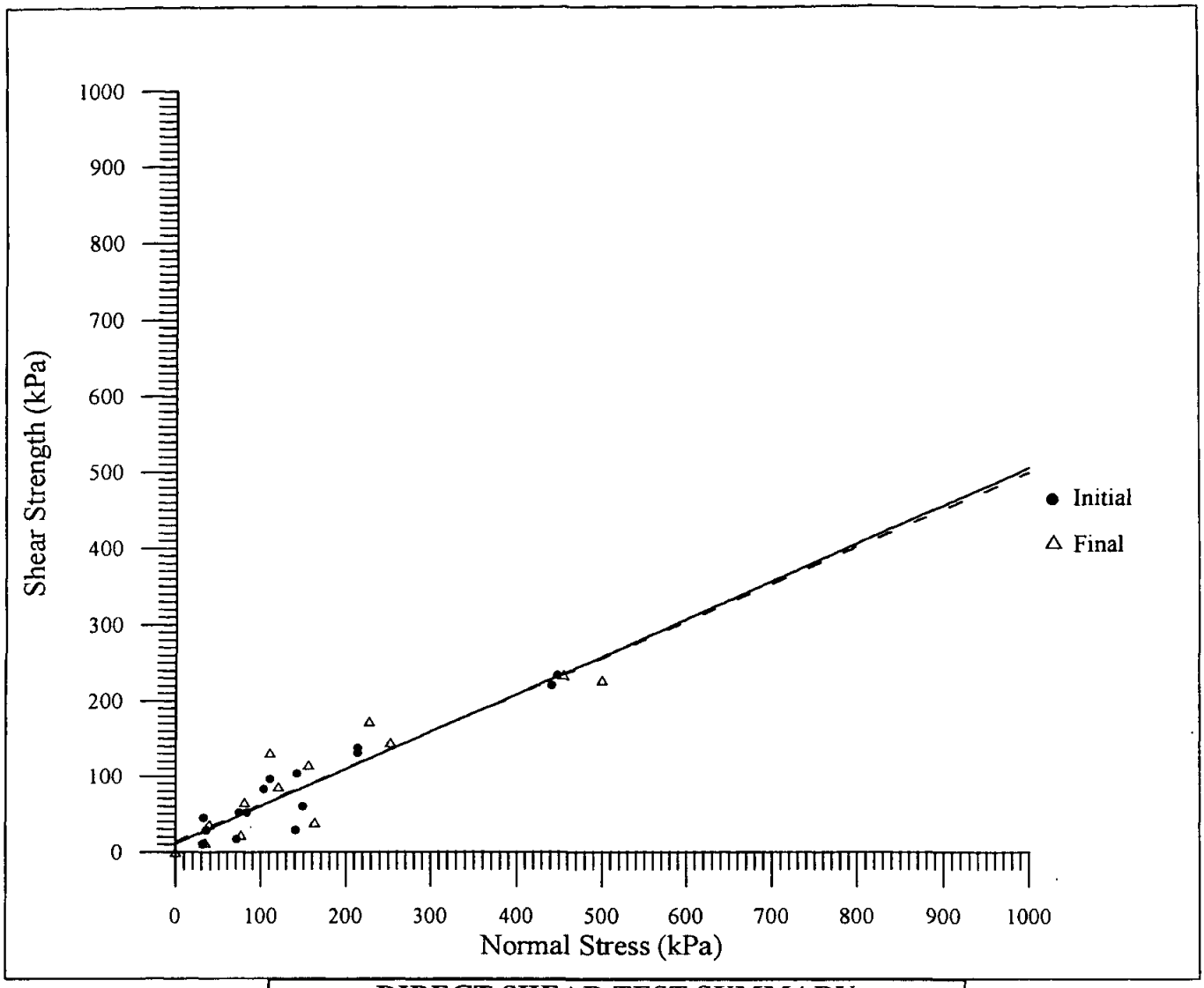
Project Number: none

Test Date: August 23 - October 24, 2002



DIRECT SHEAR TEST SUMMARY
GOUGE FILLED or CLAY COATED JOINTS
Failure Envelope Normal Stress vs. Shear Strength

DESCRIPTION

Gouge filled or clay coated joints.

	Shear Intercept (kPa)	Friction Angle (degrees)
Initial	11	26.3
Final	14	25.9

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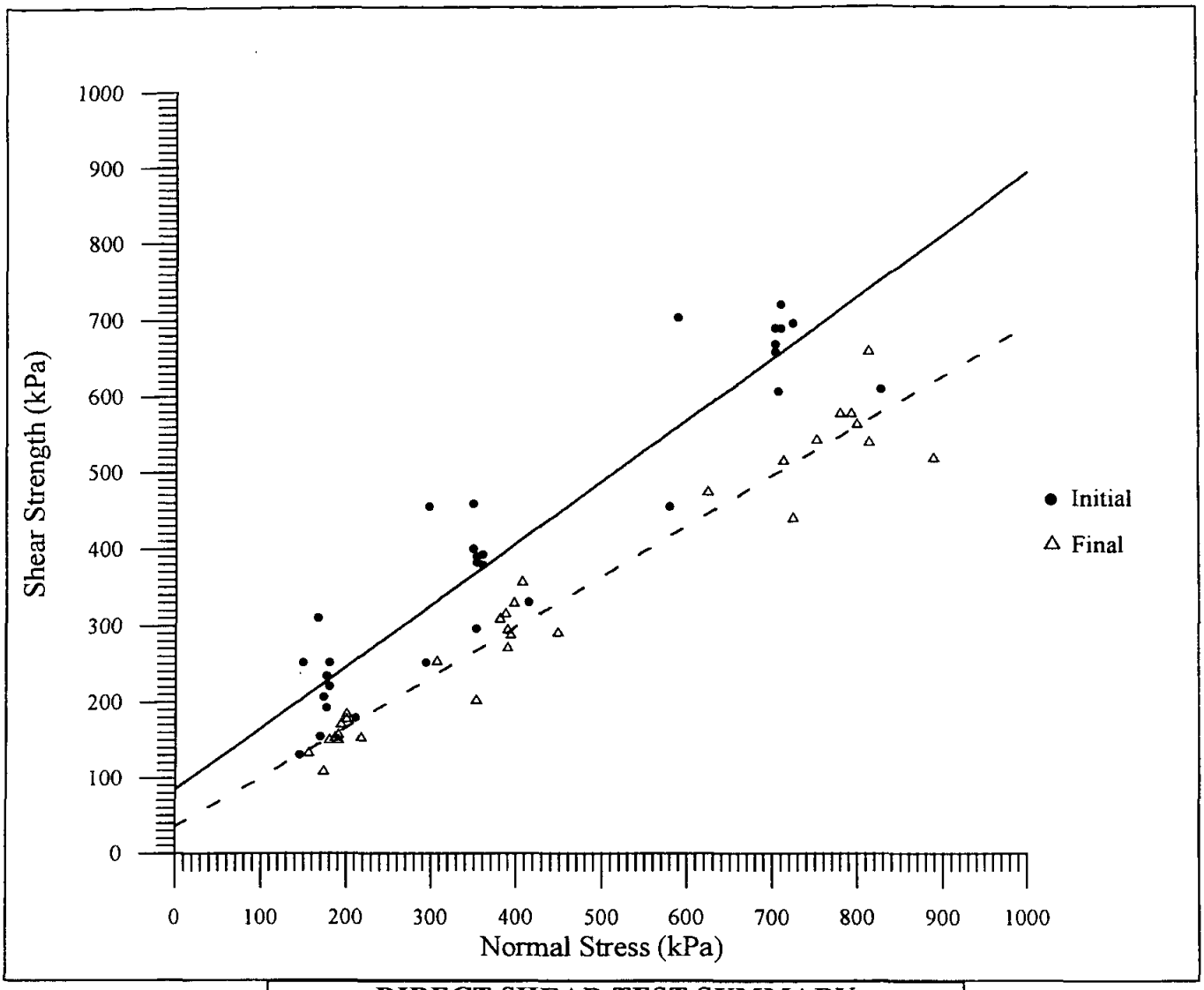
Project Number: none

Test Date: August 23 - October 24, 2002



DIRECT SHEAR TEST SUMMARY
GRANODIORITE
Failure Envelope Normal Stress vs. Shear Strength

DESCRIPTION

Joints in granodiorite.

	Shear Intercept (kPa)	Friction Angle (degrees)
Initial	86	38.9
Final	36	33.3

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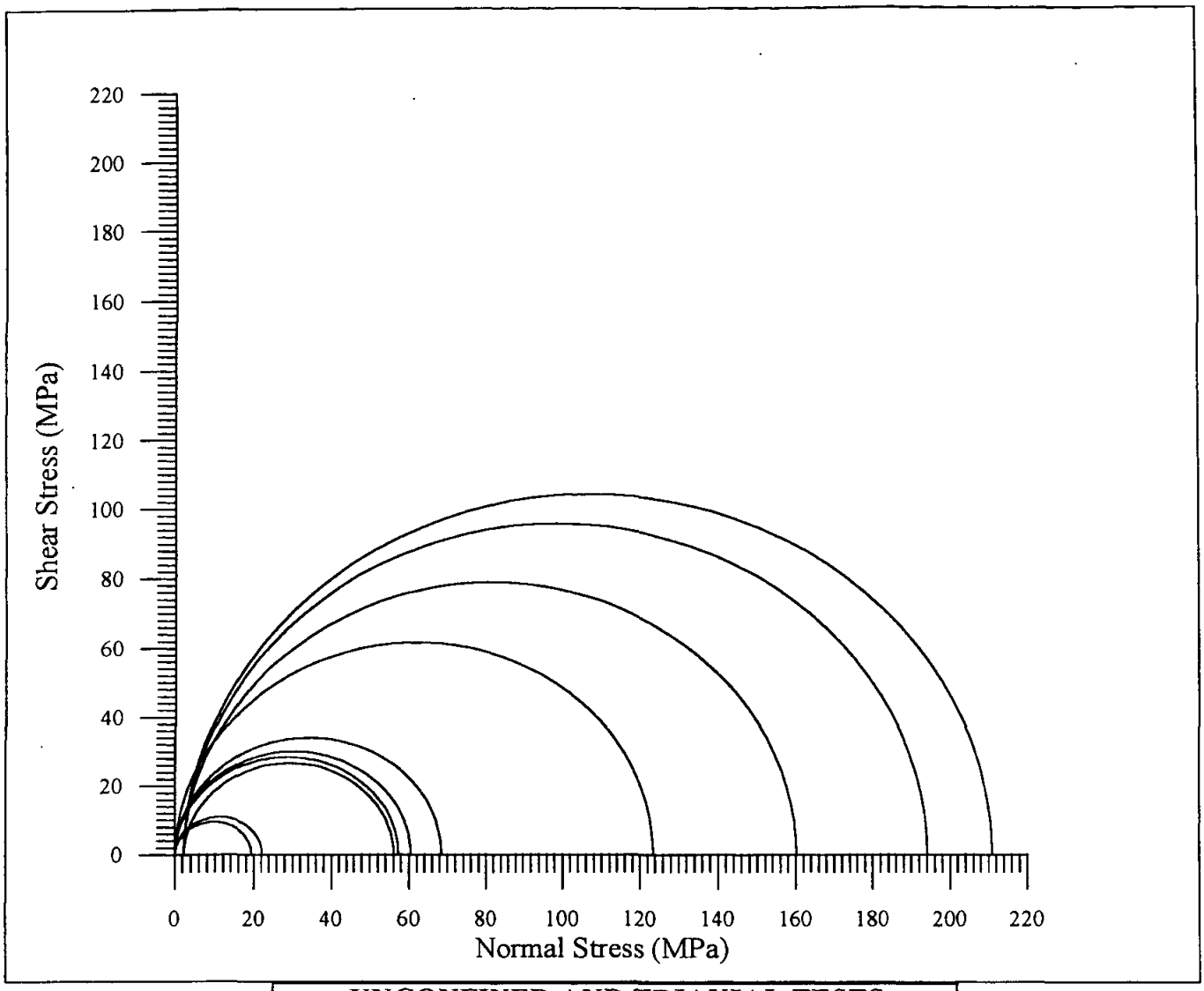
Project: Devil's Slide

Project Number: none

Test Date: August 23 - October 24, 2002



UNCONFINED AND TRIAXIAL TESTS
Mohr Failure Circles - Sandstone

DESCRIPTION
Medium gray coarse sandstone

NOTE: No failure envelope is drawn due to excessive scatter.

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Client: Earth Mechanics, Inc.
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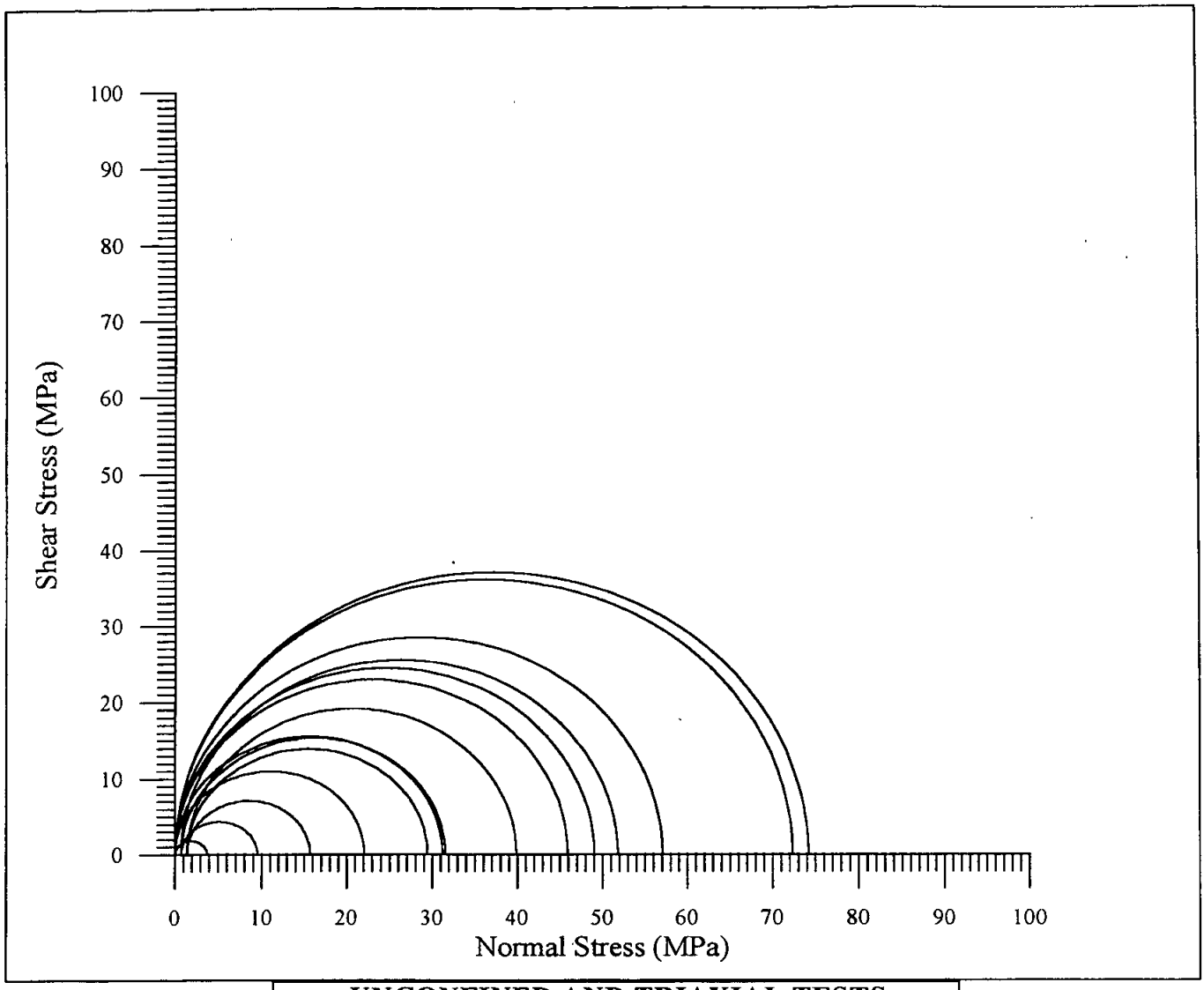
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: Sept. 16, Oct. 21,22, & 23, 2002



UNCONFINED AND TRIAXIAL TESTS
Mohr Failure Circles - Claystone

DESCRIPTION
Dark gray claystone interbedded with lighter gray siltstone.

NOTE: No failure envelope is drawn due to excessive scatter.

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Client: Earth Mechanics, Inc.
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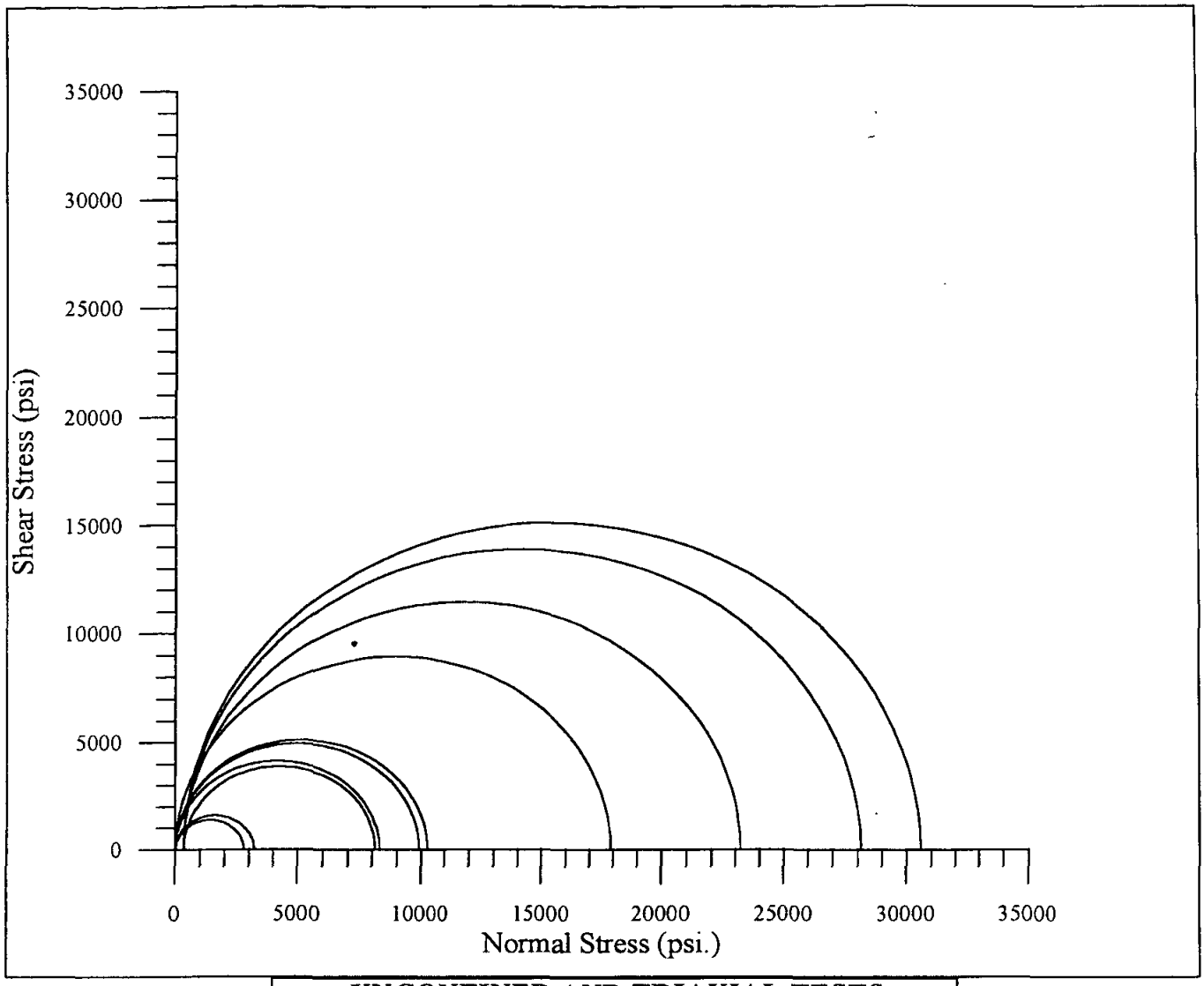
Project: Devil's Slide

Project Number: none

Test Date: Oct. 21 & 23, 2002



UNCONFINED AND TRIAXIAL TESTS
Mohr Failure Circles - Sandstone

DESCRIPTION
Medium gray coarse sandstone

NOTE: No failure envelope is drawn due to excessive scatter.

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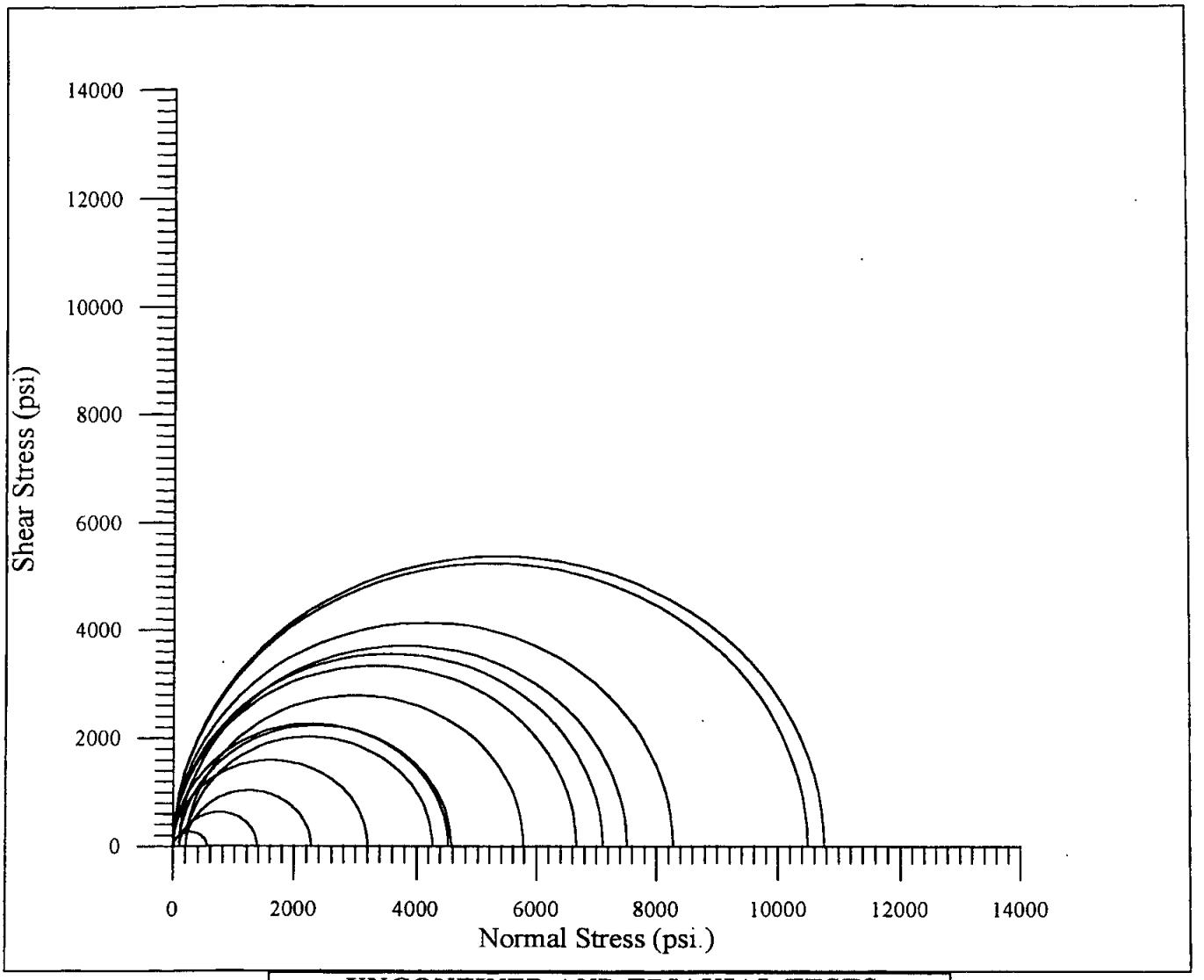
Project: Devil's Slide

Project Number: none

Test Date: Sept. 16, Oct. 21,22, & 23, 2002



UNCONFINED AND TRIAXIAL TESTS
Mohr Failure Circles - Shale

DESCRIPTION
Dark gray shale interbedded with lighter gray siltstone.

NOTE: No failure envelope is drawn due to excessive scatter.

Geo Test Unlimited GTU
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Nevada City, CA 95959

Client: Earth Mechanics, Inc.
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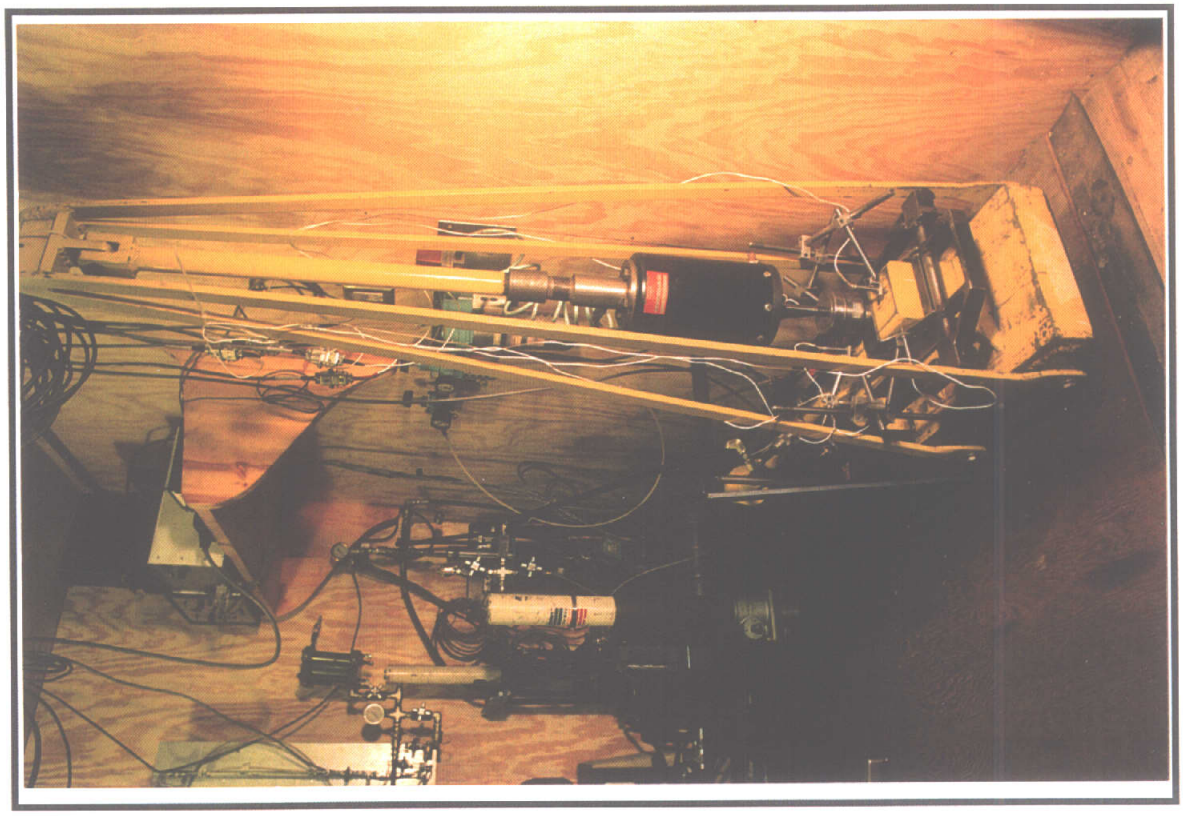
Fountain Valley, CA 92708

Project: Devil's Slide

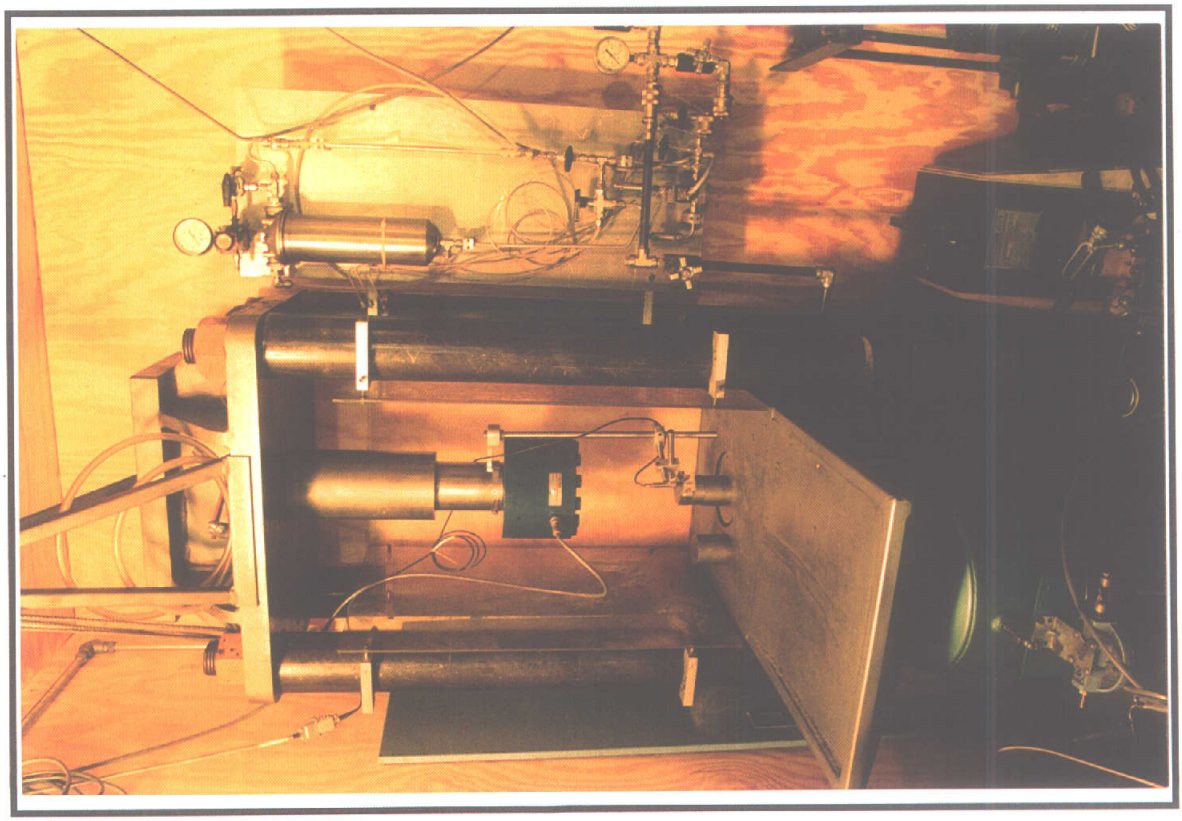
Project Number: none

Test Date: Oct. 21 & 23, 2002

LABORATORY ROCK TESTING
2002 PHASE 2B FIELD EXPLORATION



Direct Shear Test Device



Unconfined Compression Test Device

Geo GTU Test Unlimited

Modulus Determination of Rock Core
(in accordance with ASTM D3148)

Test Equipment

The samples are cut to length using an MK saw with a 14 inch diameter continuous rim diamond blade. The ends of the samples are ground flat and parallel to each other using a Norton surface grinder and a diamond wheel. The samples are held in a cylindrical sample holder which in turn is clamped in a Vee block and held to the grinding table. This arrangement precisely orients the sample so that the end surfaces are ground flat and parallel to each other (typically within a tolerance of 0.0005 inches across an HQ size sample).

An 8-inch digital Mitutoyo caliper (with a resolution of 0.0005 inches) is used to measure the sample diameters and the average sample length. A Federal dial gauge (with 0.0001 inch gradations) is used to determine the planarity of the sample ends.

A stiff, 4-post, 200 kip press fabricated by GTU is used to load the specimens. The loading platens consist of one fixed platen and one spherical seat (both made by GTU). The platens have the same diameter as the nominal core diameter.

The pressure is applied to the loading ram using a computer controlled loading system fabricated by GTU. The load is monitored with a suitably sized load cell. Four load cells can be incorporated into the system, a 200 kip cell, a 50 kip cell, a 10 kip cell and a 2 kip cell. The three highest capacity cells are shear web cells made by Interface, Inc. and the 2 kip cell is a shear web cell fabricated by Lebow.

The axial displacements are measured using a pair of clip gauges (fabricated by GTU) based on Macro Sensor $\pm$ 0.025 inch stroke LVDTs with a gauge length of 2 inches. The change in sample diameter is measured with a pair of LVDTs mounted perpendicular to the core axis on a floating ring supported by three soft springs. These two LVDTs are mounted 90° apart, thus measuring two orthogonal diameter changes. These gauges devices employ Schaevitz $\pm$ 0.02 inch stroke LVDTs to measure the displacements.

The time, axial load and axial and circumferential displacements are monitored using a Computer Boards, Inc. Data Acquisition System (CIO-DAS1600/16) which has a 16 bit resolution and can monitor up to 16 single ended channels. The LVDTs are conditioned using MacroSensor Model DCM-1000 LVDT conditioners. The load cell is conditioned with a Daytronic Model 9178A strain gauge conditioner.

Test Procedure

A representative section of core is identified for testing. It is cut to length (with a length to diameter ratio of a little more than 2:1) and the ends are ground flat and parallel. If the sample is very weak, special techniques may need to be used to prepare the sample ends with plaster or capping compound. The sample diameter and lengths are measured to determine the sample area and to evaluate the planarity and parallelness of the surfaced ends.

Power is applied to the data acquisition system and signal conditioners at least one hour prior to testing to permit the electronics to reach thermal equilibrium. Once stabilized, the load cell conditioning system is adjusted with the help of a shunt calibration resistor. The LVDT conditioners are also adjusted with the help of a Mitutoyo digital micrometer or a Federal Products precision micrometer head, LVDT holding jig.

The two axial clip gauges and the radial gauges are attached to the sample and the sample is installed in the loading frame, along with the loading platens. The LVDTs are then suitably positioned and the loading piston is then extended until a small load is applied to the sample.

The data acquisition system is directed to start acquiring data and the loading ram is slowly advanced under computer control. Loading continues until an indication of reaching the nonelastic region is seen (by a departure from linearity in the load-displacement curve) or until a clearly linear trend has been established. During this procedure, at least three partial unloading-loading cycles are attempted to capture the unloading-reloading modulus.

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All of the data are recorded in a computer data file which includes a title block identifying the client, job, sample and sample dimensions. The data block includes data legends and units along with columns of time, axial load, axial displacement, and change in circumference. These files are used to calculate the sample stresses and strains and develop computer generated plots of the sample behavior.

Geo GTU Test Unlimited

Unconfined Compression Test of Rock Core
(in accordance with ASTM D2938)

Test Equipment

The samples are cut to length using an MK saw with a 14 inch diameter continuous rim diamond blade. The ends of the samples are ground flat and parallel to each other using a Norton surface grinder with a diamond grinding wheel.

A Starrett dial gauge mounted to the height gauge is used to determine the planarity of the sample ends. An 8-inch Mitutoyo caliper is used to measure the sample diameters and the average sample length.

GTU's 200 kip loading frame is used to load the specimens. The loading platens consist of one fixed platen and one spherical seat (both made by GTU). The platens have the same diameter as the nominal core diameter.

The pressure is applied to the loading ram using a computer controlled loading system fabricated by GTU. The load is monitored with a suitably sized load cell. Four load cells can be incorporated into the system, a 200 kip cell, a 50 kip cell, a 10 kip cell and a 2 kip cell. The three highest capacity cells are shear web cells made by Interface, Inc. and the 2 kip cell is a shear web cell fabricated by Lebow.

The axial displacement is monitored using a $\pm$ 0.1 inch stroke Schaevitz LVDT measuring the displacement between the fixed pedestal just above the load cell and the bottom loading platen immediately adjacent to the specimen. Thus the measured axial displacement includes the deformation of the load cell.

The time, axial load and axial displacements are monitored using a Computer Boards, Inc. Data Acquisition System (CIO-DAS1600/16) which has a 16 bit resolution and can monitor up to 16 channels. The LVDT is conditioned using a Daytronics Model 9130 LVDT conditioner. The load cell is conditioned with a Daytronics Model 9178A strain gauge conditioner.

Test Procedure

A representative section of core is identified for testing. It is cut to length (with a length to diameter ratio of a little more than 2:1) and the ends are ground flat and parallel. If the sample is very weak, special techniques need to be used to prepare the sample ends with plaster or capping compound (many innovative procedures are required to prepare a weak rock sample). The sample diameter and lengths are measured for determining the sample area and to evaluate the planarity and parallelness of the surfaced ends.

Power is applied to the data acquisition system and signal conditioners at least one hour prior to testing to permit the electronics to reach thermal equilibrium. Once stabilized, the load cell conditioning system is adjusted with the help of a shunt calibration resistor. The LVDT conditioner is also adjusted (the null, zero, span and symmetry) with the help of a Mitutoyo digital micrometer and LVDT holding jig.

The sample is installed in the loading frame, along with the loading platens and the LVDT is properly positioned to maximize its travel during the test. The loading piston is extended until a small load is applied to the sample. The acquisition is directed to start acquiring data and the loading ram is slowly advanced under computer control. If failure is catastrophic, the test is terminated immediately after failure. If the failure is plastic, the test continues until a post-peak plateau develops.

The loads and displacements are printed on the computer screen along with a plot of axial load vs displacement. Thus one has a clear image of the sample behavior at any stage of the test.

All of the data are recorded in a computer data file which includes a title block identifying the client, job, sample and sample dimensions. The data block includes data legends and units along with columns of time, axial load and axial displacement. These files are used to develop computer generated plots of the sample behavior.

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Geo Test GTU Unlimited

Triaxial Compression Test of Rock Core
(in accordance with ASTM D2664)

Test Equipment

The samples are cut to length using an MK saw using a 14 inch diameter continuous rim diamond blade. The ends of the samples are ground flat and parallel to each other using a Norton Surface Grinder and a diamond grinding wheel. The samples are held in a cylindrical samnple holder which in turn is clamped in a Vee block. This arrangement precisely orients the sample so that the end surfaces are ground flat and parallel to each other (typically within a tolerance of 0.0005 inches across the sample diameter).

An 8-inch Mitutoyo digital caliper is used to measure the sample diameters (with a resolution of 0.0005 inch) and average sample length and a Federal dial gauge (with a resolution of 0.0001 inch) mounted to a precision stand is used to determine the planarity of the sample ends.

A stiff four post 200 kip press fabricated at GTU is used to load the specimens. The hydraulic pressure which drives the loading ram is developed under computer control with a loading system fabricated by GTU.

Two Hoek triaxial cells (fabricated by RocTest) are available which can handle NQ and HQ diameter cores. These cells are suitable for relatively strong rock. (For low confining pressures a sensitive soft membrane can be incorporated into these Hoek cells.) Weak rock or tests requiring very low confining pressures are better tested in a special triaxial cell (see the accompanying figure) built by GTU. In either case, the loading platens consist of one fixed platen and one spherical seat. The platens have the same diameter as the nominal core diameter.

The load is monitored by a suitably sized load cell. Four load cells can be incorporated into the system, a 200 kip cell, a 50 kip cell, a 10 kip cell, and a 2 kip cell. The three highest capacity cells are shear web cells made by Interface, Inc. and the 2 kip cell is a shear web cell fabricated by Lebow. For confining pressures in the 0-200 psi and 0-500 psi ranges, Viatran pressure transducers are used. Above this range, a variety of Foxboro/ICT pressure transducers are available (0-1000 psi, 0-2000 psi, and 0-3000 psi ranges)

The axial displacement is monitored using a $\pm$ 0.1 inch stroke Schaevitz LVDT. For the Hoek cells, the displacement readings are taken between the top of the cell (which moves upward with the hydraulic loading piston) and the fixed loading frame, just above the load cell. (Thus the displacement readings include the compliance of the load cell and the platen interfaces.) For GTU's weak rock triaxial cell, the displacement is measured between the loading piston which enters the triaxial cell and the triaxial cell body.

The time, axial load, confining pressure and axial displacements are monitored using a Computer Boards, Inc. Data Acquisition System (CIO-DAS1600/16) which has a 16 bit resolution and can monitor up to 16 channels. The LVDT is conditioned using a Daytronic Model 9130 LVDT conditioner. The load cell and pressure transducer are conditioned with Daytronic Model 9178A strain gauge conditioners.

Test Procedure

A representative section of core is identified for testing. It is cut to length (with a length to diameter ratio of a little more than 2:1) and the ends are ground flat and parallel. If the sample is very weak, special techniques need to be used to prepare the sample ends with plaster or capping compound (innovative procedures may be required to prepare a weak rock sample). The sample diameter and lengths are measured to determine the sample area and to evaluate the planarity and parallelness of the surfaced ends.

Power is applied to the data acquisition system and signal conditioners at least one hour prior to testing to permit the electronics to reach thermal equilibrium. Once stabilized, the load cell and pressure transducer conditioning systems are adjusted with the help of shunt calibration resistors. The LVDT conditioner is also adjusted (the null, zero, span and symmetry) with the help of a Mitutoyo digital micrometer and an LVDT holding jig.

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The sample and loading platens are installed in the triaxial cell and then placed in the loading frame. The LVDT is properly positioned to maximize its travel during the test and the loading piston is extended until a small load (typically 20 to 1000 lb, depending on the sample strength) is applied to the sample.

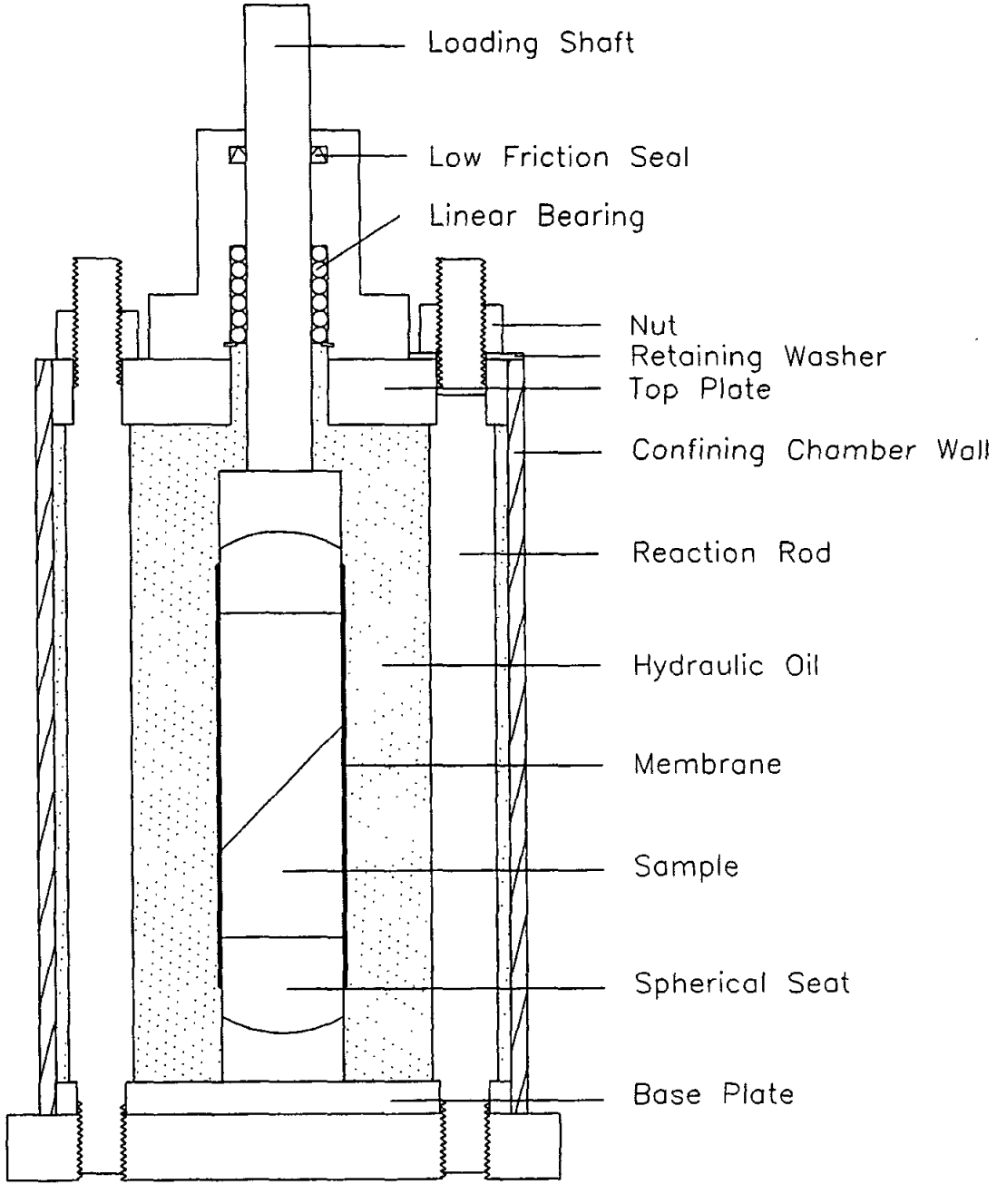
The confining pressure is then applied to the specimen in a manner which precludes sample splitting. Thus the confining pressure and the axial load are increased to result in a stress state which does not differ significantly from hydrostatic loading.

Once the confining pressure and initial load have been applied to the specimen, the data acquisition system is directed to start acquiring data and controlling the confining pressure. The computer compares the pressure transducer reading with the desired pressure setpoint, and directs the hydraulic loading system to increase or decrease the confining pressure to maintain the desired value. Hydraulic oil is also injected (under computer control) into the axial loading cylinder at a constant rate to load the test specimen.

If a multistage test is being performed, the confining pressure is increased at the first clear indication of failure. Following failure at the final confining pressure, the sample is deformed until a distinct post-peak plateau develops or until the range of the LVDT is exceeded.

The loads, pressures, and displacements are printed on the computer screen along with a plot of axial load vs displacement. Thus one has a clear image of the sample behavior at any stage of the test.

All of the data are recorded in a computer data file which includes a title block identifying the client, job, sample and sample dimensions. The data block includes data legends and units along with columns of time, axial load, confining pressure, and axial displacement. These files are used to develop computer generated plots of the sample behavior.


Loading Shaft
Low Friction Seal
Linear Bearing
Nut
Retaining Washer
Top Plate
Confining Chamber Wall
Reaction Rod
Hydraulic Oil
Membrane
Sample
Spherical Seat
Base Plate

Geo Test Unlimited

Triaxial Compression Test of Weak Rock Core with Pore Pressure Measurement (following the guidelines of ASTM D4767)

Test Equipment

The samples are cut to length using an MK saw using a 14 inch diameter continuous rim diamond blade. If the samples are so weak that the ends can easily deform to conform to the loading platens, then no further end preparation is required. Otherwise the ends of the samples are ground flat and parallel to each other using a diamond surfacing wheel mounted on a Norton surface grinder to which a core holding fixture is attached. This fixture (fabricated by GTU) precisely orients the sample so that the end surfaces are ground flat and parallel to each other.

A Mitutoyo digital caliper is used to measure the sample diameter and length.

A four post frame (made by GTU) with a maximum loading capacity of approximately 200 kips is used to axially load the samples. The pressure is applied to the loading ram using a computer controlled loading system fabricated by GTU.

The triaxial cell is fabricated by GTU specifically for testing weak rock, and incorporates pore pressure measuring ports on the top and bottom platens (see the accompanying figure). The top loading platen is fixed while the bottom platen permits sample rotation by means of a spherical seat. The PQ platens have a 3.345 inch diameter and the HQ platens have a 2.500 inch diameter.

A manifold (built by GTU) is used to control the flow of water through the sample and the pressure (and vacuum) applied to the sample ends. (See the accompanying figure.) The cell pressure is monitored by a Viatran pressure transducer. (200 and 500 psig transducers are available.) A Validyne differential pressure transducer (200 psid, 3000 psig line pressure) is used to measure the difference between the cell oil pressure and the sample water pressure. In this configuration the Validyne transducer directly monitors the effective stress applied to the sample.

The load is monitored by a suitably sized load cell. Four load cells can be incorporated into the system, a 200 kip cell, a 50 kip cell, a 10 kip cell and a 2 kip cell. The three highest capacity cells are shear web cells made by Interface, Inc. and the 2 kip cell is a shear web cell fabricated by Lebow.

The axial displacement is monitored using a $\pm$ 0.1 inch stroke Schaevitz LVDT. The displacement reading is measured between the top of the triaxial cell body and the loading piston.

The time, axial displacement, axial load, cell pressure, and effective confining stress are monitored using a Computer Boards, Inc. Data Acquisition System (CIO-DAS1600/16) which has a 16 bit resolution and can monitor up to 16 channels. The LVDTs and the differential pressure transducer are conditioned using Daytronic Model 9130 LVDT conditioners. The load cell and confining pressure transducer are conditioned with Daytronic Model 9178A strain gauge conditioners.

Test Procedure

Power is applied to the data acquisition system and signal conditioners at least one hour prior to testing to permit the electronics to reach thermal equilibrium. Once stabilized, the load cell and pressure transducer conditioning systems are adjusted with the help of shunt calibration resistors. The LVDT conditioner is also adjusted (the null, zero, span and symmetry) with the help of a Mitutoyo digital micrometer and an LVDT holding jig.

In the case of weak rocks which can sustain little abuse in handling, the samples are wrapped in heat shrink wrap and lightly heated to tightly encase the sample. The sample is further reinforced by wrapping it in vinyl.

The sample is then cut to length (with a length to diameter ratio of a little more than 2:1). If the ends are strong enough to sustain grinding without ruining the sample, the ends are ground flat and parallel. If the sample is very weak, special techniques need to be used to prepare the sample ends with plaster or capping compound. (Many novel procedures may be required to

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prepare a weak rock sample). Alternatively, if the sample ends are so soft that they will conform to the loading platens, the end surfaces are left in their sawn condition, relying on the initial axial load to seat the sample ends.

After cutting the sample and preparing the ends, the sample length is measured. After measuring the sample length, a disk of wet filter paper is placed on the base of the sample which in turn is placed on a porous bronze disk which in turn is placed on the bottom loading platen. The vinyl wrap is gently removed along with the heat shrink wrap and the sample diameter measured. If the sample is very delicate, the last wrap of heat shrink wrap may be left in place while measuring the sample diameter.

The top filter paper disk and bronze porous disk are placed on the sample and a dry filter paper skirt is taped to the sample. This skirt completely covers the free surface of the sample and extends past the ends of the porous disks. The rubber membrane (made from polyurethane rubber with a wall thickness of about 0.045 inch) is applied to the sample and sealed to the bottom platen using a hose clamp. Water is then introduced to the top porous disk and a rod inserted down the side of the sample between the filter paper and the membrane. The objective of this procedure is to remove as much free air as possible and replace it with water. Once no more air can be removed from the sample, the top loading platen is placed on the stack and the membrane rolled onto the platen and sealed with a hose clamp.

The package is then placed in the triaxial cell, and the axial loading piston inserted into the top loading platen. The internal and external water lines are bled and the internal water port lines are attached from the triaxial cell to the top and bottom platens. Then the outer shell is installed over the triaxial cell and the cell positioned over the loading ram. The ram is extended so that the loading piston just touches the load cell. The triaxial cell is then filled with hydraulic oil and the external water lines are re-bled and attached to the triaxial cell.

The bottom port is closed and the sample is evacuated via the top port. After water has ceased flowing out of the sample (as seen by the water column in the monitoring manifold) the top port is closed and water is reintroduced to the sample from the bottom port. Once the flow of water has stopped flowing into the sample, the valve is closed and the evacuation procedure repeated. The objective of this procedure is to displace as much air as possible from the sample using vacuum and flowing water.

The cell confining pressure is then increased to about 60 psi and the water pressure increased by about 50 psi. Water is allowed to flow into the sample during this back pressure saturation procedure via both top and bottom water ports. Saturation at this level of back pressure is considered to be completed when the sample water pressure does not change when the water pressure ports are closed. The B value is then evaluated. The B value is measured by closing the water ports to the sample, increasing the cell pressure by 10 to 20 psi (and monitoring the change in cell pressure on the differential pressure transducer) closing off the water pressure supply and opening the sample water ports while monitoring the change in sample water pressure. The B value is calculated as 1-(change in sample pressure/change in cell pressure).

An effort is made to obtain B values of greater than 0.95. If this B value is not attained, the back pressure is further increased by 20 psi. If the B value does not increase, the test will proceed if the B value is greater than 0.85. It should be noted that the B value is a function of both the water and rock stiffness and unlike soil, a completely saturated rock may be characterized by a B value of less than 1.0.

Once the sample is back pressure saturated, the cell pressure is increased to result in the desired effective confining pressure. This action is followed by a period of consolidation. Once the rate of water pressure generation has decreased (so that the pressure doesn't change by more than a few tenths of a psi over the period of a minute when the water port is closed), the water port is closed and the sample is loaded.

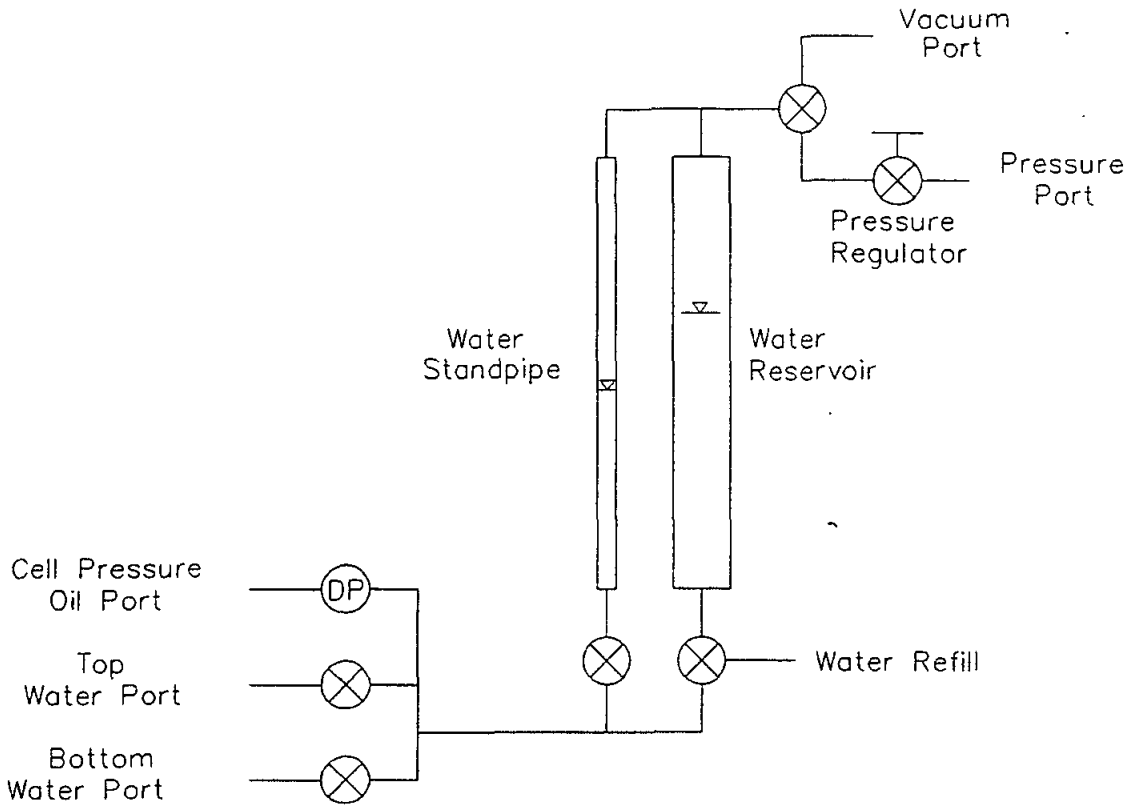
Once failure is clearly established, loading is stopped, the cell pressure is increased and the water port is opened, resulting in the next desired level of effective confining stress. As before, a period of time is required for the excess sample water pressures to dissipate and the sample to consolidate. Once the system approaches equilibrium, the water ports are closed and sample loading resumes. This process is repeated for the desired number of test stages. If a lower level of effective confining pressure is desired, the load is first reduced to prevent axial displacement while the effective confining pressure is being reduced.

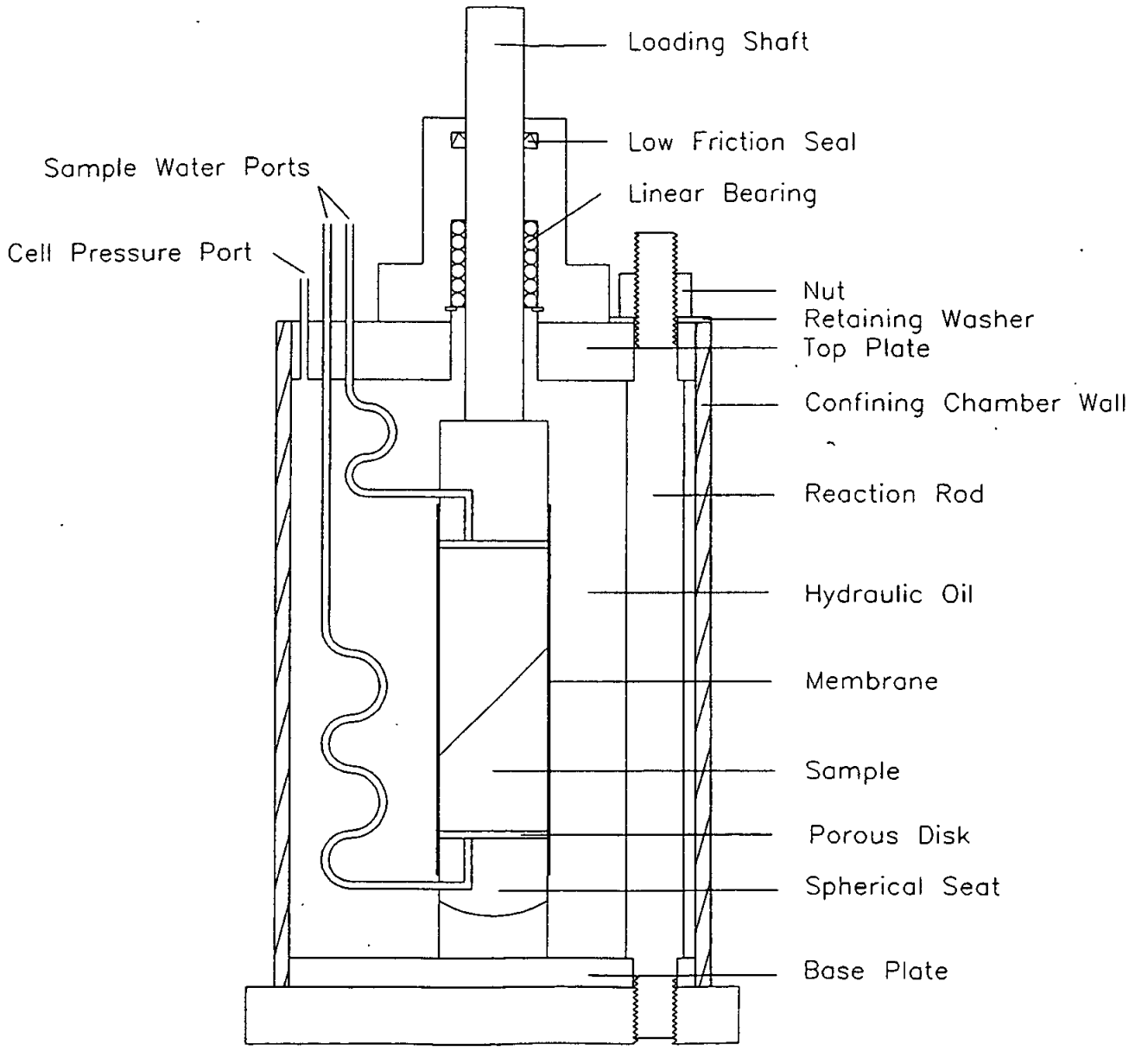
After the last loading stage, the water port is opened, releasing the sample water pressure, the load is released the cell is removed from the loading frame, and the sample is removed from the triaxial cell, completing the test.

At the start of the test, the data acquisition system is directed to start acquiring data and controlling the confining pressure. The computer compares the cell pressure transducer reading with the desired pressure setpoint, and directs the hydraulic loading system to increase or decrease the confining pressure to maintain the desired value. When so directed by the operator, hydraulic oil is also injected (under computer control) into the axial loading cylinder at a constant rate to load the test specimen.

The loads, pressures, and displacements are printed on the computer screen along with a plot of axial load vs displacement. Thus one has a clear image of the sample behavior at any stage of the test.

All of the data are recorded in a computer data file which includes a title block identifying the client, job, sample and sample dimensions. The data block includes data legends and units along with columns of time, axial load, confining pressure, axial displacement, and effective confining stress. These files are used to develop computer generated plots of the sample behavior. To prevent data files from becoming unmanageably long, the current data set is always being compared with the previously recorded data set. If any of the readings changes by more than a user specified amount, a new set of readings is acquired and used for the basis of subsequent comparison.


Vacuum
Port
Pressure
Port
Pressure
Regulator
Water
Standpipe
Water
Reservoir
Cell Pressure
Oil Port
DP
Top
Water Port
Bottom
Water Port
Water Refill


Loading Shaft
Low Friction Seal
Sample Water Ports
Linear Bearing
Cell Pressure Port
Nut
Retaining Washer
Top Plate
Confining Chamber Wall
Reaction Rod
Hydraulic Oil
Membrane
Sample
Porous Disk
Spherical Seat
Base Plate

Geo GTU Test Unlimited

Direct Shear Test of Rock Core
(in accordance with the ASTM D5607)

Test Equipment

The samples are cut to size using an MK Model 2001 "Brick Saw" using a 14 inch diameter continuous rim diamond blade.

A Mitutoyo caliper is used to measure the dimensions of the sample. A carpenter's profile gauge is used to transfer the joint surface profile to the data sheet.

The shear box (see accompanying figure) is one designed and fabricated by GTU. It consists of a tall reaction A-frame which applies the normal force to the sample. A column pivots at the top of the A-frame and bears against the sample at the bottom of the A-frame. Thus there is little resistance to shear (which can develop in roller bearing systems). A separate shear yoke is hung in balance at the level of the shear plane. Thus the shear yoke does not contribute to the normal load on the sample. The normal load is applied by either a pneumatic cylinder (up to 2000 lb) or a hydraulic cylinder (with a range of about 1000-20,000 lb) and the shear load is applied with hydraulic cylinder (up to about 20,000 lb). Either of two sized boxes can fit into the loading frame, one for smaller core samples (4 x 7 in) and another suited for large block samples (7 x 13 in).

The loads are monitored with load cells. (2, 10, and 50 kip cells can be used depending on the level of loads encountered in the test.) One LVDT with a $\pm$ 0.5 inch stroke is used to measure the shear displacement. Three $\pm$ 0.1 inch stroke LVDTs are used to monitor the normal displacement of the sample. Two $\pm$ 0.1 inch stroke LVDTs are used to monitor the sideways movement of the sample.

The pressure is applied to the loading rams using a computer controlled loading system fabricated by GTU. The normal load is measured by the data acquisition system and compared to the desired load. Two normal loading systems can be used. For normal loads less than 2000 lb, a pneumatic system is used for finer control of the load. For loads above this range, a hydraulic system is used. The control system outputs a signal to the pneumatic or hydraulic system to increase or decrease the normal load toward the desired value. The shear load is applied by injecting hydraulic oil into the shear loading system at a constant rate.

The time, shear load, normal load, and six displacements are monitored using a Computer Boards, Inc. Data Acquisition System (CIO-DAS1600/16) which has a 16 bit resolution and can monitor up to 16 channels. The LVDTs are conditioned using Daytronic Model 9130 LVDT conditioners. The load cells are conditioned with Daytronic Model 9178A strain gauge conditioners.

Test Procedure

The sample is trimmed to a suitable size to fit the chosen shear box. If the sample is an open joint which can be taken apart without changing the properties of the joint, three joint profiles are taken from the sample using a profile gauge. Otherwise, these profiles are taken after testing the sample. The dimensions of the shear surface are measured using a caliper. These measurements are used to estimate the sample area and thus the required normal loads during the test.

Typically, the sample is tied together using tape, thread or string to maintain the sample integrity. The sample is positioned in one shear box half so that the shear surface extends 1/4 inch above and parallel to the lip of the shear box half. Positioned thus, hydrostone (a strong plaster) is poured into the box to pot the sample in the box half. Once the plaster has set, the box half is inverted and placed on the second box half. 1/2 inch spacers are used to separate the box halves. Hydrostone is then used to pot the second half of the sample. Once the plaster has hardened, the sample is installed in the shear loading frame and any tape, thread or string which is holding the sample halves together is cut.

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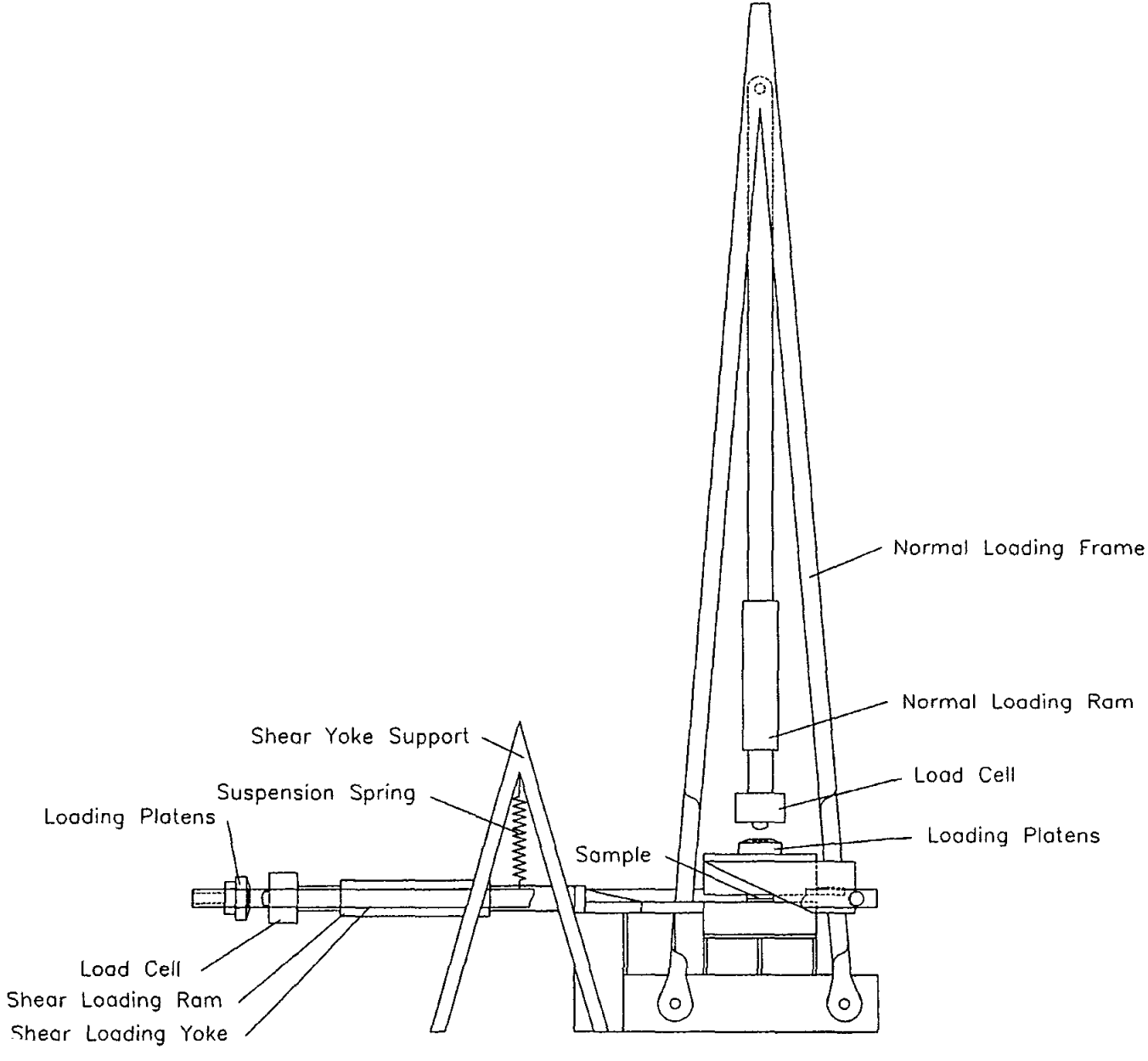
Power is applied to the data acquisition system and signal conditioners at least one hour prior to testing to permit the electronics to reach thermal equilibrium. Once stabilized, the load cell conditioning systems are adjusted with the help of shunt calibration resistors. The LVDT conditioners are also adjusted (the null, zero, span and symmetry) with the help of a Mitutoyo digital micrometer and LVDT holding jigs.

With the data acquisition system in a setup mode, the LVDTs are positioned and the desired normal load is applied to the sample. The shear loading piston is extended and a light seating load is applied (up to 100 lb, depending on the level of normal load).

Once the test setup is satisfactorily aligned, the data acquisition system is started and the test proceeds under computer control. The loads and displacements are printed on the computer screen along with a plot of shear load vs displacement. Thus one has a clear image of the sample behavior at any stage of the test.

If a multistage test is being performed, the normal load is increased at the first clear indication of shear failure. The final stage of testing proceeds until a clear shear strength plateau develops or until the shear LVDT reaches its extreme limit (this limit is usually on the order of 0.8 inches)

All of the data are recorded in a computer data file which includes a title block identifying the client, job, sample and sample dimensions. The data block includes data legends and units along with columns of time, shear and normal loads and shear, normal and lateral displacements. These files are used to develop computer generated plots of the sample behavior.


Normal Loading Frame
Normal Loading Ram
Load Cell
Loading Platens
Sample
Shear Yoke Support
Suspension Spring
Loading Platens
Load Cell
Shear Loading Ram
Shear Loading Yoke

Pergamon

PII: S0148-9062(96)00043-5

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0148-9062/97 $17.00 + 0.00

Technical Note

Analysis of Multistage Triaxial Test Results for a Strain-Hardening Rock

A. BRO†

INTRODUCTION

Some weak rocks appear to behave quite differently from conventional rocks in that failure is characterized by a significant amount of strain hardening. This behavior creates a problem if the results are to be interpreted using a conventional peak strength approach. An analysis is presented here which incorporates strain in the failure envelope. The final result of the data reduction is a relation between cohesion and strain, and friction angle and strain.

WEAK ROCK BEHAVIOR IN MULTISTAGE TRIAXIAL COMPRESSION

The procedure for performing a multistage test is to apply the first confining pressure, and then to steadily increase the axial load until the sample deforms plastically. The confining pressure is then increased and axial loading is resumed until the sample fails a second time. This procedure is repeated for as many stages as desired.

A typical stress–strain curve (Fig. 1) starts with a steep recoverable loading period (Section A). At some point, nonrecoverable deformations begin (Kinkpoint B) and the loading curve continues at a decreased, but fairly linear slope (Section C). The increase in the confining pressure occurs at Point D, after which the next loading cycle begins.

The initial slopes of the recoverable loading sections (e.g. Section A) appear to be fairly constant from one confining pressure to the next. On the other hand, the slopes of the post-kink stress–strain curves (e.g. Section C) appear to increase as the confining pressure increases. In addition, the post-kink slope appears to be fairly linear for the range of strains involved in these tests ($< 5\%$). However, if a sample is taken to very large strain (10–20%) the slope tends to decrease and ultimately becomes horizontal.

In light of the strain dependent strength and the large strains required to reach ultimate strength, conventional data reduction techniques may be unsuitable for these test results. Instead, a method of reducing the data is proposed which accounts for the strain hardening. With this analysis in hand, an engineer has a rational approach for determining the material strength.

DEVELOPING A STRAIN HARDENING FAILURE ENVELOPE

The steep sections of the stress–strain curve are treated as elastic, and the post-kink sections (e.g. Section C) represent strain hardening failure. To develop a failure envelope for a strain hardening material, one needs to evaluate the material strength when subjected to two different confining pressures, but at the same strain. This requirement is not physically possible. Instead, a small extrapolation is used to arrive at the desired information. In numerous tests, the post-kink slope continues in a nearly linear manner for a large range of strains. Thus, it is not unreasonable to make a small extrapolation of Section C outward to a strain greater than the kink-point of the next test stage (e.g. to Point E). A vertical line can then be drawn which intersects the second stage results (Point F) and the first stage results (Point G). These two points represent the strength of the material at this one strain, but at two different confining pressures. Thus, one can develop a pair of Mohr circles (the solid circles in Fig. 2) and develop a C and ϕ for this one strain. One repeats the process, extending the stress–strain curve for the second stage to past the third stage kink-point strain, and develops another pair of Mohr circles (the dashed circles in Fig. 2) and a failure envelope which is representative of this larger strain. Finally, the resulting cohesions and friction angles are plotted as a function of strain (Fig. 3).

The accuracy of this analysis can be checked by recovering the original stress–strain curve from the C and ϕ vs strain plot. Two back calculated strengths have been plotted in Fig. 1 as heavy crosses. These strengths are obtained by: (1) determining the cohesion and friction angle for the desired strain; (2) calculating the effective axial stress at failure using the equation:

$$\sigma_1 = 2C\tan\left(45 + \frac{\phi}{2}\right) + \sigma_3\tan^2\left(45 + \frac{\phi}{2}\right)$$

†GeoTest Unlimited, 800 Peralta Avenue, San Leandro, CA 94577, U.S.A.

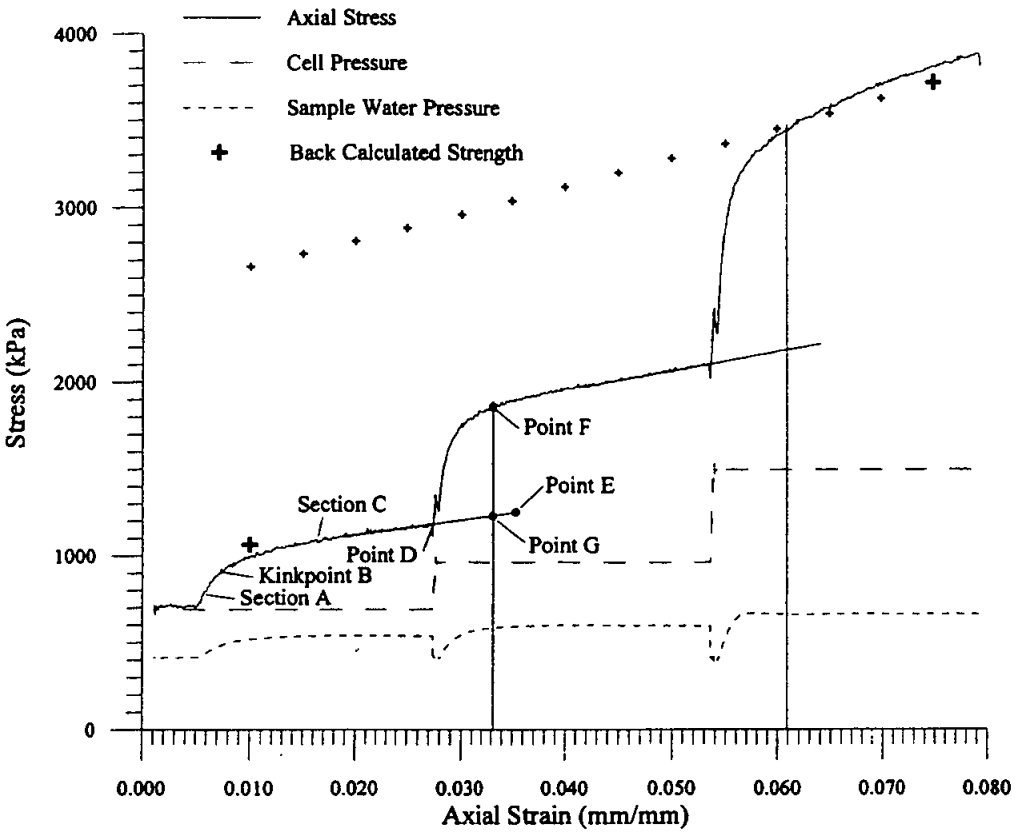


Fig. 1. Typical triaxial test result—axial stress, cell pressure and sample water pressure vs axial strain.

in which the confining pressure is the effective confining pressure; (3) adding the sample water pressure to arrive at the axial strengths as plotted in Fig. 1.

So, is the analysis any good? The two back calculated bold points appear to be somewhat representative of the sample strengths at two different confining pressures. But there seems to be a problem when the strength of the sample subjected to the highest confining pressure is projected backward to smaller strains (the small crosses in Fig. 1). This curve has a slight upward concavity, which is contrary to the expected behavior. One would expect the slope of the stress–strain to decrease with increasing strain. Despite these small inconsistencies, the results are quite reasonable considering that the analysis is based on only four points extracted from the stress–strain curve. The deviations from the measured strengths are likely due to the linear approximation of the strain hardening process. In fact, these post-kink slopes gradually decrease with strain. It should be possible to more accurately account for these nonlinearities using a four stage test. A second order relation could then be developed between the cohesion and strain, and the friction angle and strain using the strengths measured at three different strains. This refinement would increase the accuracy of the analysis, but make it more complicated and unwieldy. (Also, such refinements might not be warranted in light of the highly variable nature of these weak rocks.)

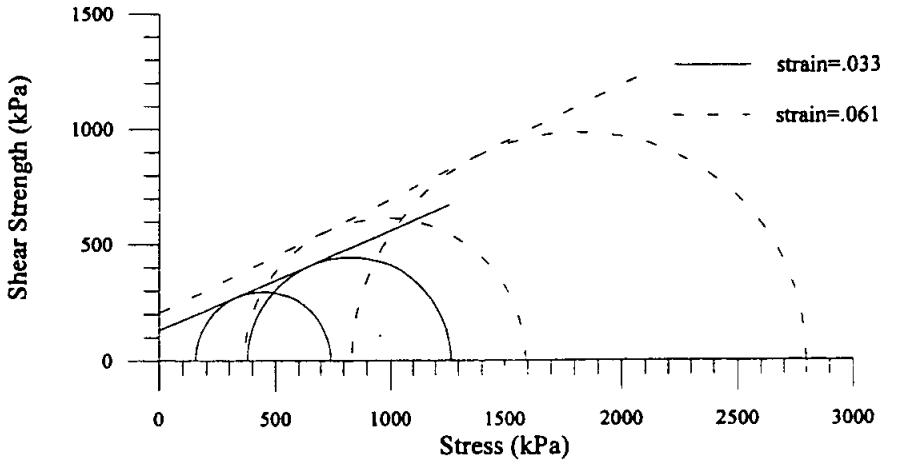


Fig 2 Failure envelopes at two different strains.

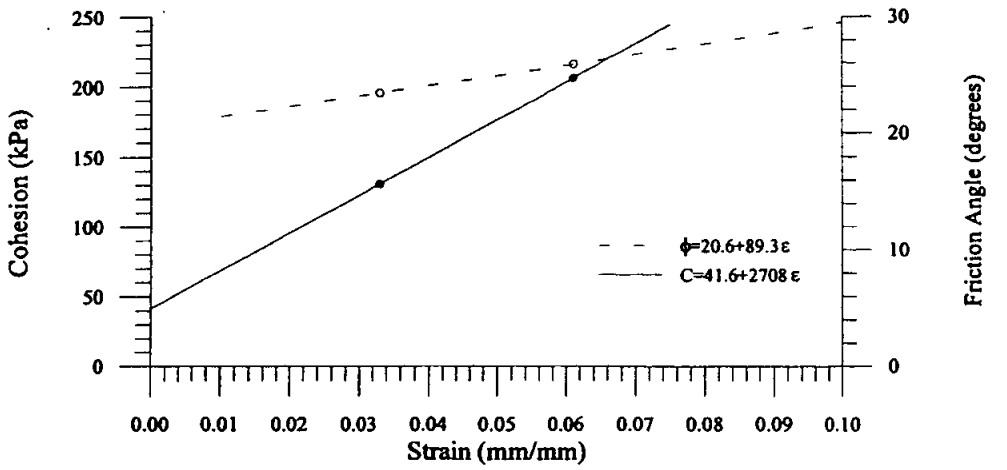


Fig. 3. Cohesion and friction angle as functions of strain.

POSSIBLE EXPLANATION FOR THE SAMPLE BEHAVIOR

Whereas homogeneous rocks tend to result in either elastic–plastic or elastic–brittle behavior, these strain hardening rocks consist of a highly heterogeneous mixture of weak and strong components. The weak rock could be thought of as a hard skeleton (comprised of relatively hard rock chips, layers and rounded aggregate) surrounded by a weak clayey matrix. As the sample begins to be loaded, the stiffer skeleton sustains the majority of the load, and the sample behaves in an elastic manner. As the load increases further, the contacts between the skeleton members exceed their shear strength and tend to slide, resulting in the start of plastic deformation. As sliding develops on the contacts, the skeleton is constrained by the weak matrix. The weak matrix starts to become stressed and the contacts come to a new state of equilibrium. As the sample is loaded further, the skeletal contacts are remobilized. As a larger proportion of the weak matrix constrains the contacts, the strengths of the skeletal contacts increase, thus resulting in a strain hardening behavior. After a large amount of strain, all of the matrix is mobilized to a fully plastic state, and can no longer constrain the skeleton. Subsequently, the sample becomes perfectly plastic, or possibly weakens as it starts to break apart.

One of the implications of this hypothetical mechanism of deformation is that it may be difficult to develop a model material with strain hardening behavior which would be suitable for performing parametric laboratory studies. If this model of weak rock is valid, the structure of the strong skeleton may prove to be just as important as the relative proportion of the weak and strong components. The difficulty may come in trying to replicate this skeletal structure.

USING A STRAIN HARDENING ENVELOPE FOR THE ANALYSIS OF STRUCTURES

Conventional limit analyses are generally based on the ultimate strength of the rock. For materials such as those discussed here, such an approach would be inappropriate. A structure would likely fail before the foundation materials could reach the large strains which accompany their ultimate strength. Thus, some strength less than the ultimate strength would be more suitable for design. The question is what should that strength be? Another, possibly more tractable approach is to ask the question of how much strain can be accommodated by the structure, and consequently the maximum strain which the ground can be allowed to sustain. Once this assessment is made, the rock strength parameters can be determined. One advantage of this approach is that the analysis could be confirmed directly with field measurements of displacement (as opposed to inferred stress measurements) as the structure is being constructed and after it is in-service.

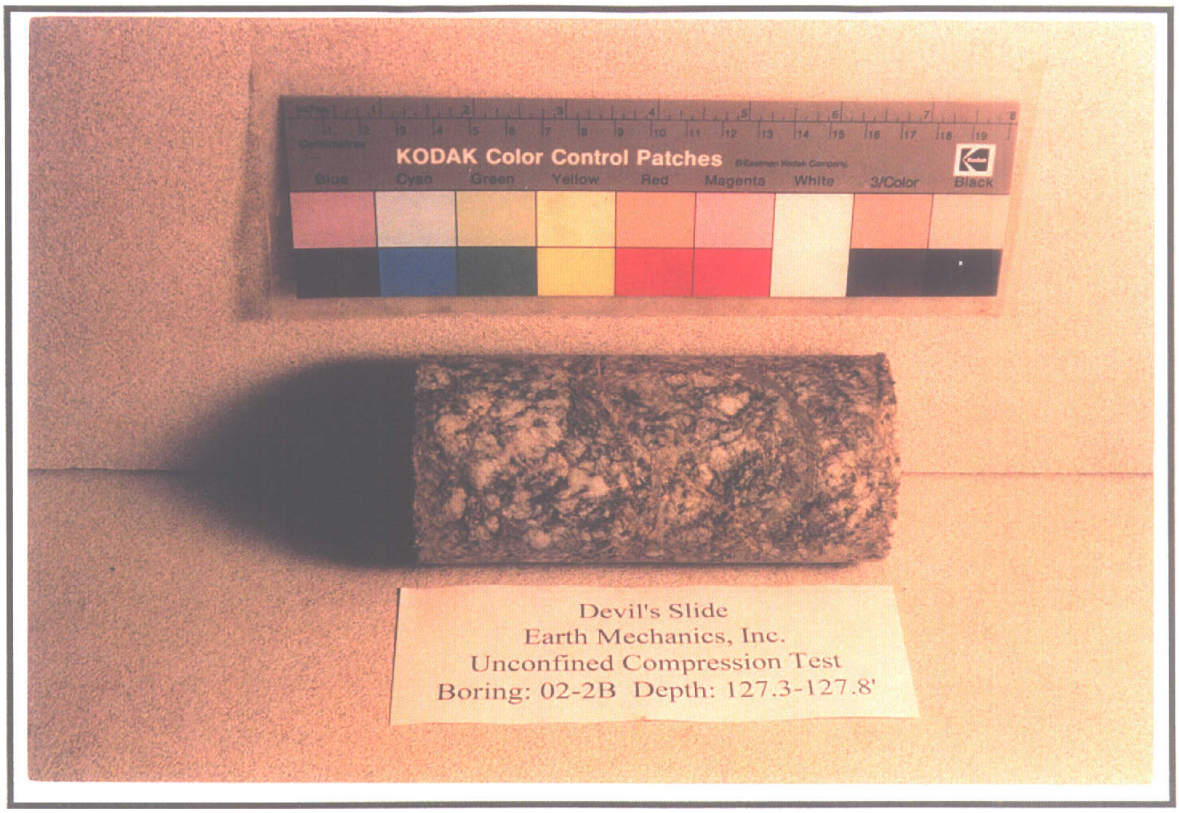
Acknowledgements—I would like to thank Richard E. Goodman, as well as Bob McManus and those in his group at Pacific Gas & Electric for their friendly help and discussions during the testing program when some of these ideas were developed.

Accepted for publication 14 July 1996.

APPENDIX A

UNCONFINED COMPRESSION TESTS AND MODULUS TESTS

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

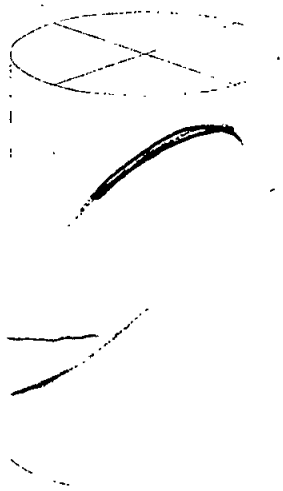
Date: 10-21-02
Technician: A. Bro

Client: EMT
Job: #151- Devil's Slide
Sample ID: Boring 02-2B
Sample Description: Gray altered granodiorite with a weak healed joint ~ 48° to core axis. (slightly granulated rock texture due to alteration weakening)

Sample Depth: 127.3-127.8 Sample Condition: received dry - tested moist

d_1	d_2
2.388	2.388
2.385	2.384
2.383	2.388
2.382	2.386
2.384	2.388

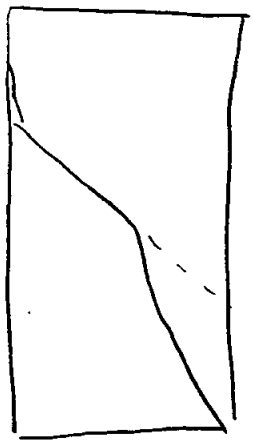
l_1	l_2
+.0007	+.0003
+.0003	+.0002
±.0001	±.0002
-.0003	-.0001
-.0006	-.0002



Avg. diameter : 2.386 Avg. length : 5.296"
Sample area : 4.471 l/d ratio : 2.22
Sample volume(in^3) : 23.680
Sample weight (g) : 1004.5g
Density : 42.42g/in^3 = 161.6 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED - Failed by shear partially along existing healed joint



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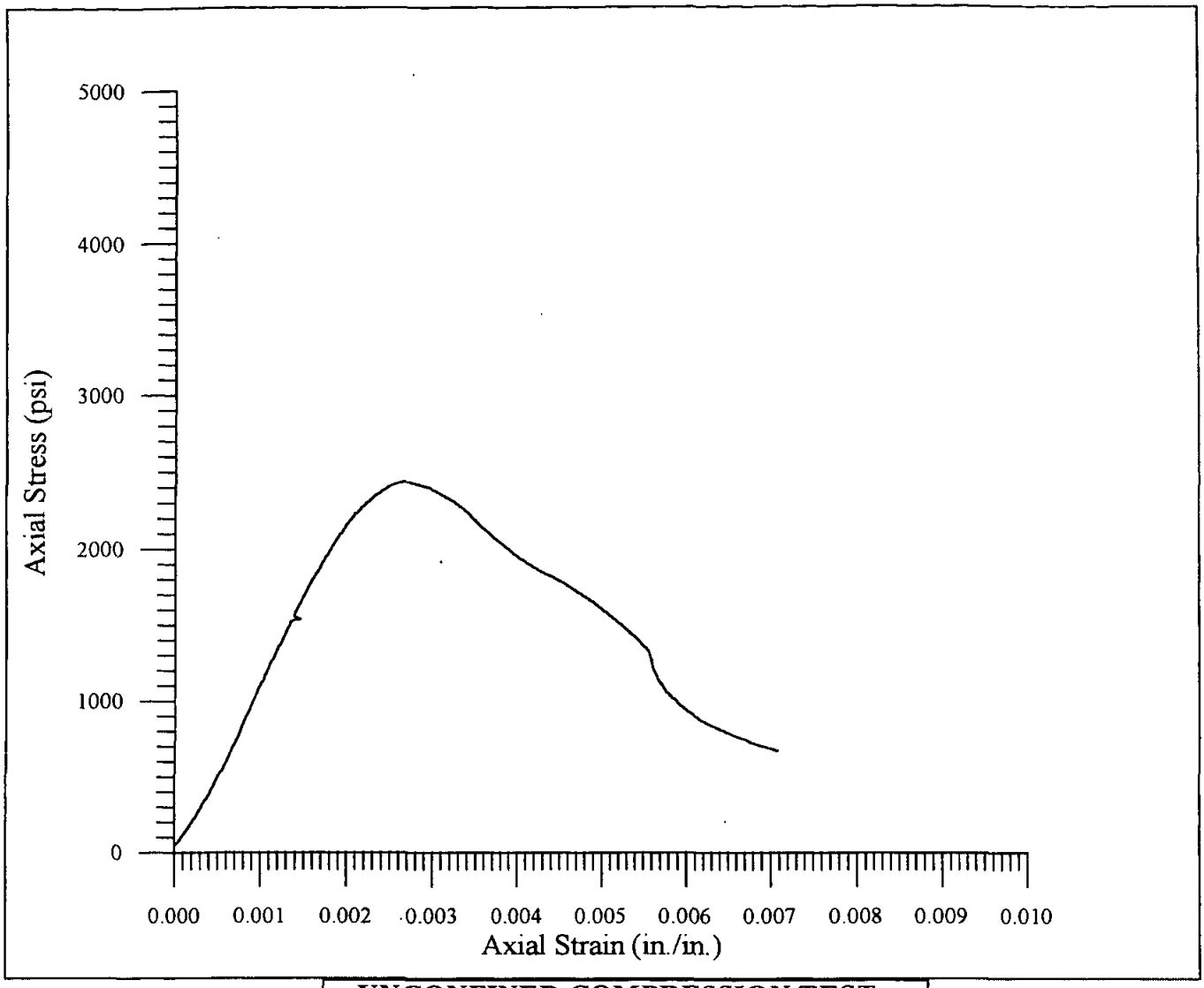


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 2B-127
Boring: 02-2B
Depth: 127.3-127.8'

DESCRIPTION

Gray altered granodiorite with a weak healed joint about 48 degrees to the core axis.

Density: 161.6 pcf
Strength: 2435 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

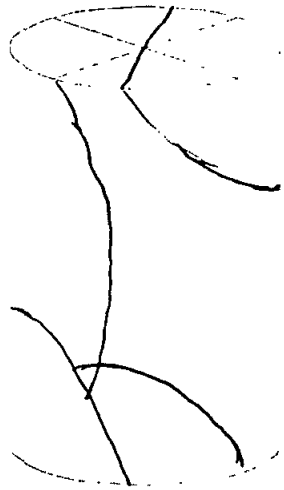
Date: 10/21/02
Technician: A. Bro

Client: ENI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2B
Sample Description: Grey altered granodiorite with a few calcite healed joints

Sample Depth: 155.0-155.5' Sample Condition: received dry - tested moist

d_1	d_2
2.385	2.383
2.385	2.381
2.382	2.385
2.385	2.383
2.386	2.381

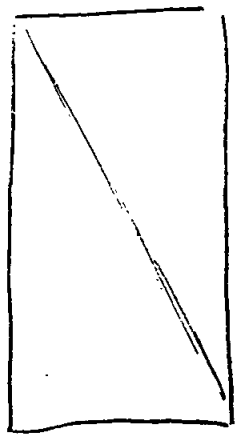
l_1	l_2
+.0008	+.0003
+.0004	+.0002
±.0001	±.0002
-.0003	-.0004
-.0007	-.0007



Avg. diameter : 2.384
Avg. length : 5.270"
Sample area : 4.464
l/d ratio : 2.21
Sample volume(in^3) : 23.524
Sample weight (g) : 1002.8g
Density : 42.63g/in^3 = 162.4pcF (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE Failed by shear along existing joint



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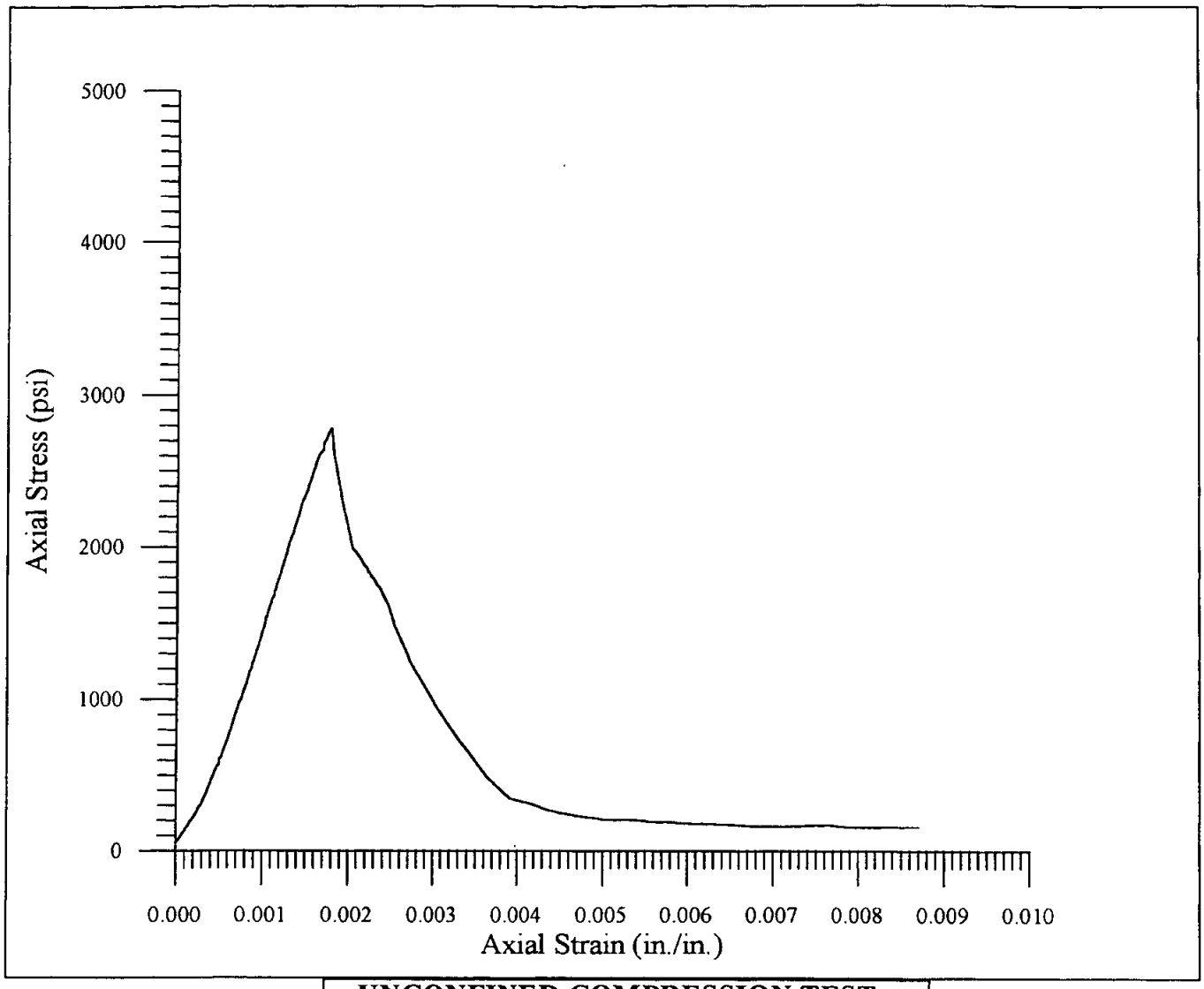


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 2B-155
Boring: 02-2B
Depth: 155.0-155.5'

DESCRIPTION
Gray altered granodiorite with a few calcite healed fractures.

Density: 162.4 pcf
Strength: 2780 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

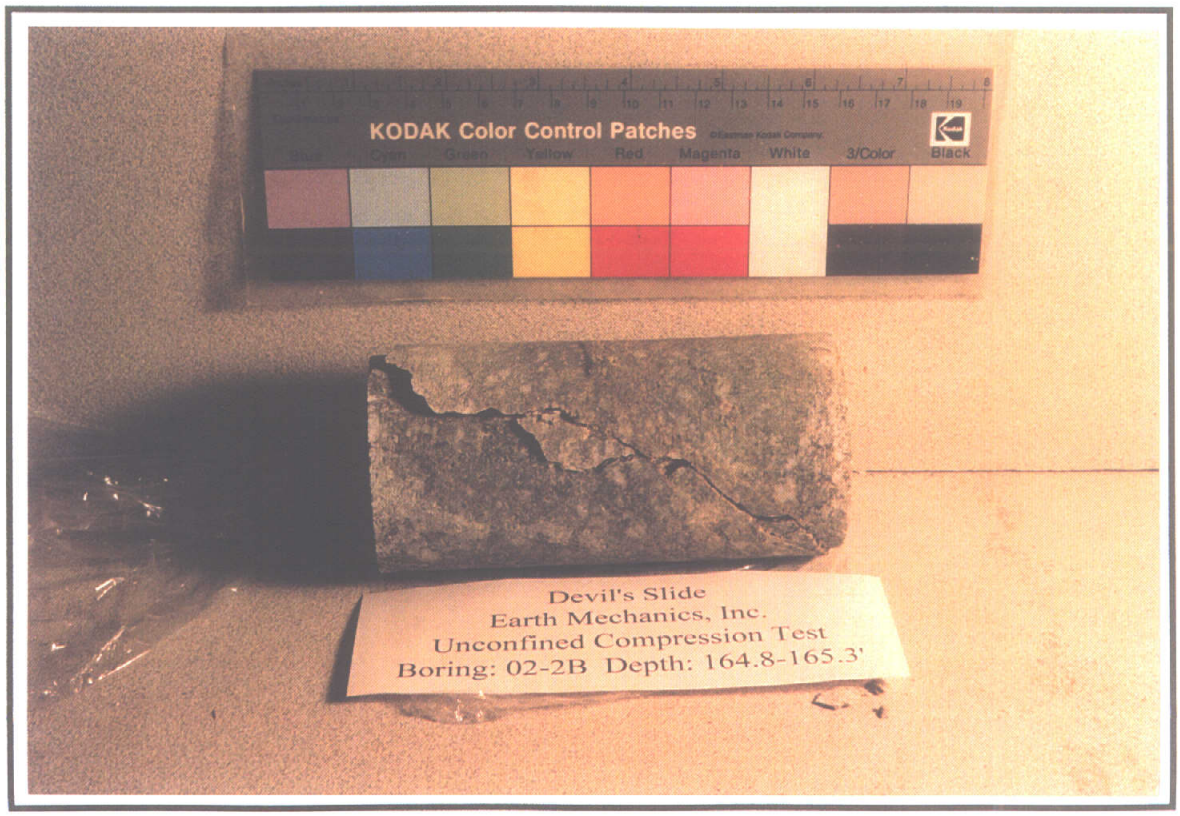
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

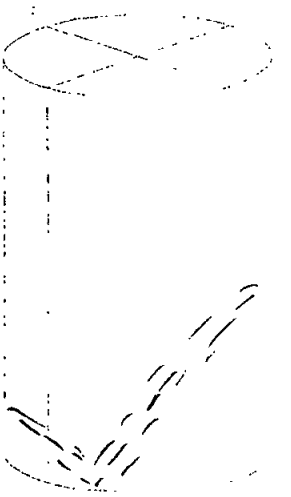
Date: 10/21/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2B
Sample Description: Gray slightly altered granodiorite with a healed fractured zone near one end

Sample Depth: 164.8-165.3' Sample Condition: received dry - tested moist

d_1	d_2
2.389	2.389
2.388	2.389
2.389	2.389
2.389	2.388
2.385	2.388

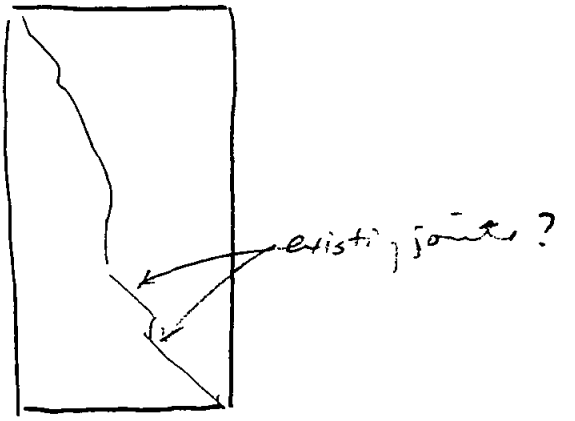
l_1	l_2
+.0007	0
+.0004	0
±.0001	±.0001
-.0003	0
-.0007	0



Avg. diameter : 2.388 Avg. length : 5.078
Sample area : 4.479 l/d ratio : 2.13
Sample volume(in^3) : 22.743
Sample weight (g) : 981.28
Density : 43.14 g/in^3 = 169.4pcF (1 g/in^3=3.8095lb/ft^3)

Comments:

SOME JOINT CONTROL - Failed by shear through intact rock & some along joint.



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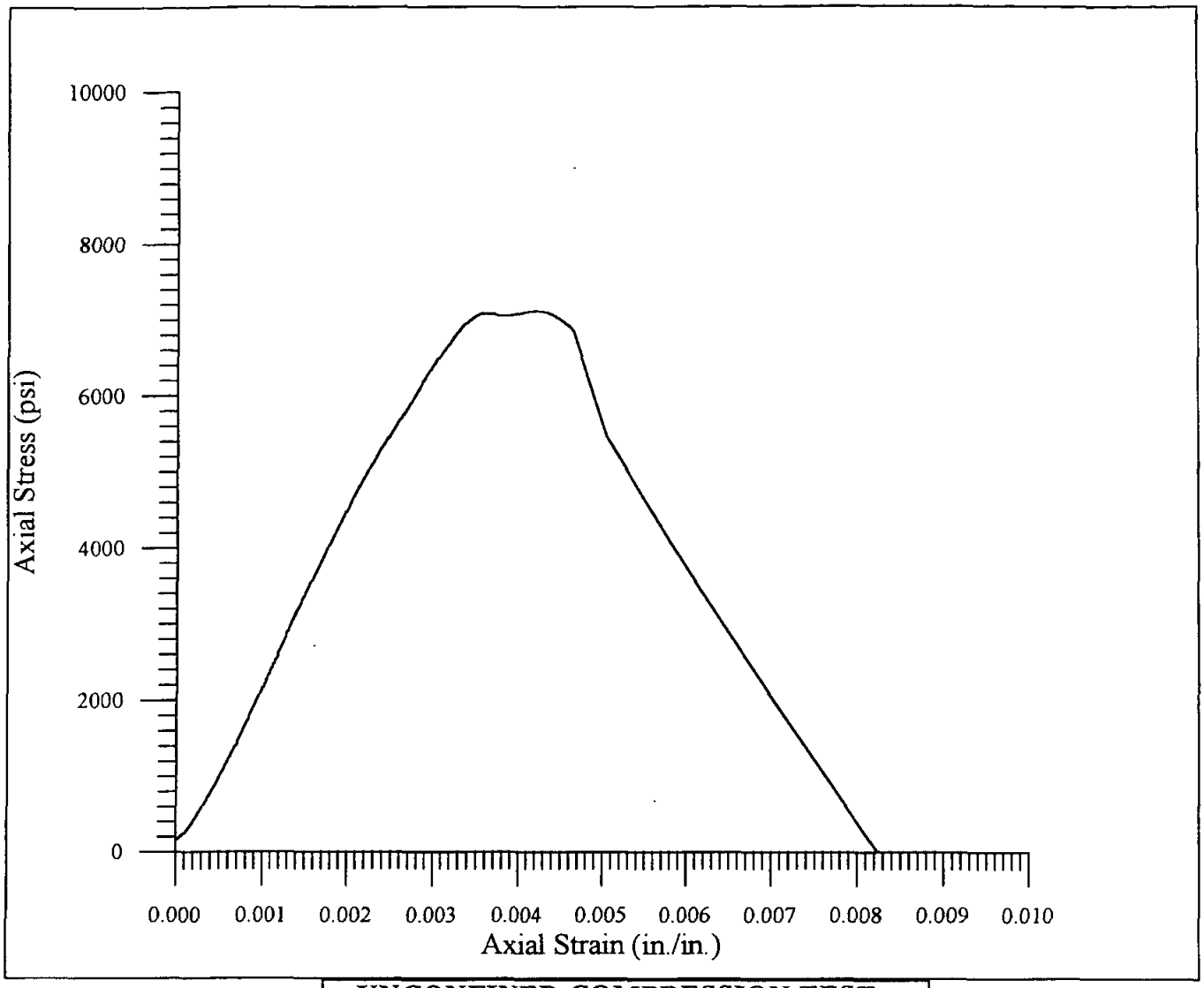


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 2B-164
Boring: 02-2B
Depth: 164.8-165.3'

DESCRIPTION
Gray slightly altered granodiorite with healed fracture zone at one end.

Density: 164.4 pcf
Strength: 7115 psi
Joint Control Failure?: partial

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo GTU Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/21/02
Technician: A.Brd

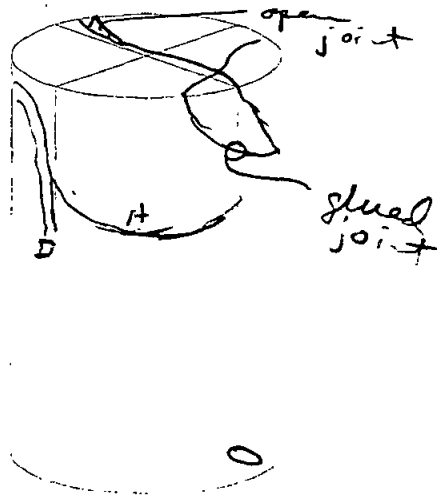
Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-5
Sample Description: Gray coarse grained sandstone (Fine grained conglomerate? - clasts up to 1/8") with a few open voids along joint traces. - one end chip (detached due to joint glued w/ CA).

Sample Depth: 203.4-203.9' Sample Condition: received dry - tested moist

d_1	d_2
2.395	2.395
2.394	2.393
2.389	2.391
2.395	2.391
2.391	2.392

(×.0001")

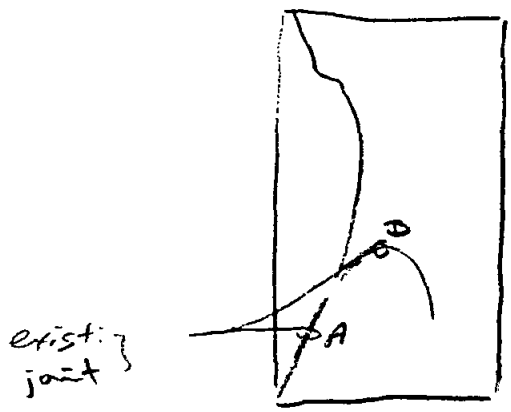
l_1	l_2
+4	+6
+2	+3
±1	±2
-4	-4
-8	-10



Avg. diameter: 2.393 Avg. length: 5.629
Sample area: 4.498 l/d ratio: 2.35
Sample volume(in^3): 25.317
Sample weight (g): 1047.6g
Density: 41.38g/in^3 = 157.6pcF (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED Failure - failed by shear, partially along existing joint.



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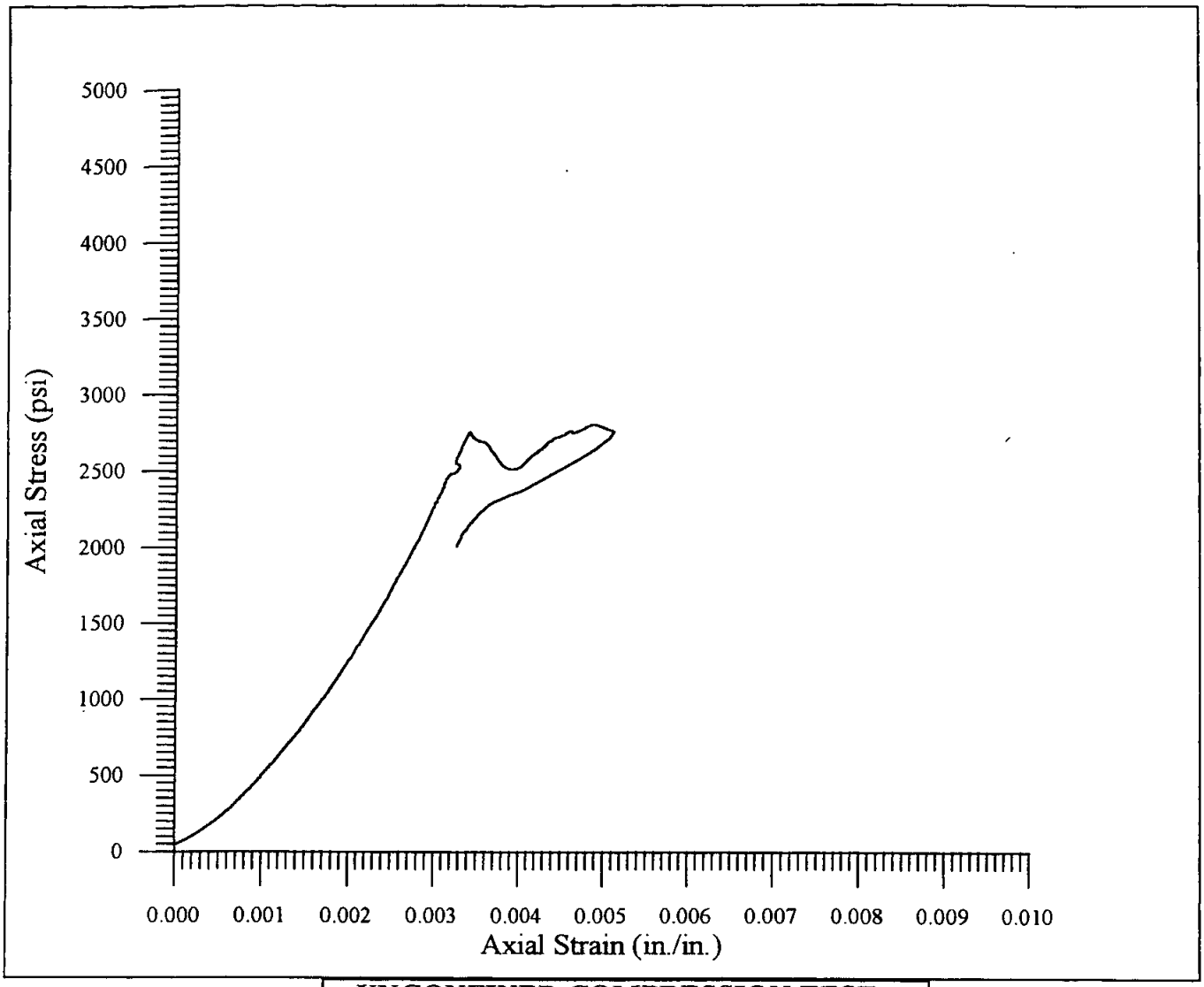


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-203
Boring: 02-5
Depth: 203.4-203.9'

DESCRIPTION
Medium gray coarse grained sandstone with a few open voids along joint traces.

Density: 157.6 pcf
Strength: 2804 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-5
Sample Description: Interbedded dark gray shale and medium gray siltstone with numerous fractures parallel and perpendicular to bedding. Bedding @ 45° to core axis

Sample Depth: 229.2-229.7' Sample Condition: received dry - tested moist

d_1	d_2
2.395	2.391
2.393	2.395
2.397	2.394
2.394	2.392
2.393	2.394

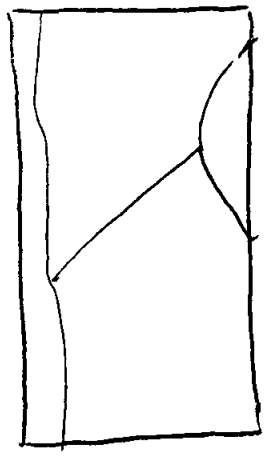
(x.0001")

l_1	l_2
+2	0
+2	0
±1	±2
−1	0
−3	0

Avg. diameter : 2.394
Avg. length : 5.772
Sample area : 4.501
l/d ratio : 2.41
Sample volume(in^3) : 25.982
Sample weight (g) : 1143.1g
Density : 44.00 g/in^3 = 167.6 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE (?) failed by shear and axial splitting



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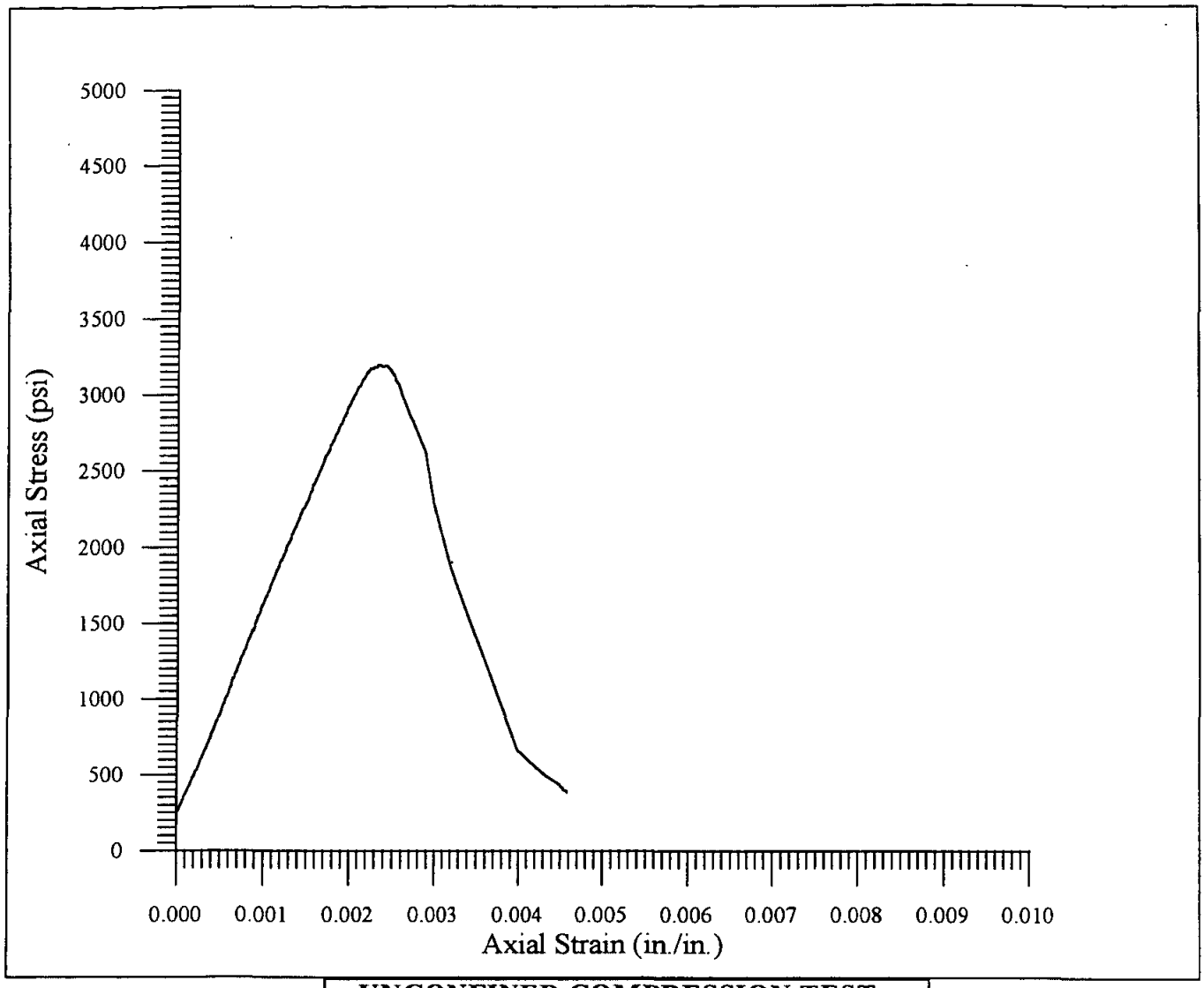


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-229
Boring: 02-5
Depth: 229.2-229.7'

DESCRIPTION

Interbedded dark gray shale and medium gray siltstone with numerous fractures parallel to and perpendicular to bedding (about 45 degrees to the core axis).

Density: 167.6 pcf
Strength: 3201 psi
Joint Control Failure?: no(?)

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

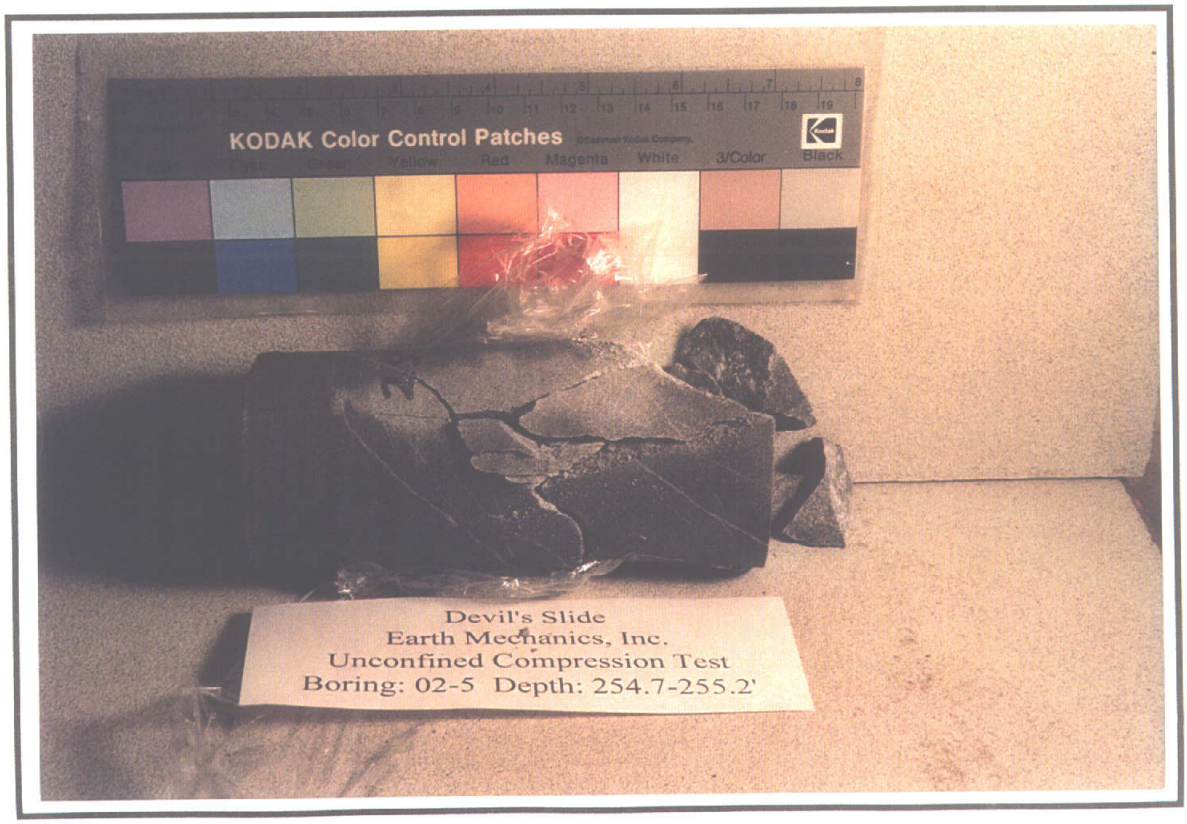
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-5
Sample Description: Gray medium grained sandstone w/ calcite healed fractures oriented perpendicular to bedding. Bedding ~ 43° to core axis

Sample Depth: 254.7-255.2' Sample Condition: received dry - tested moist

d_1	d_2
2.396	2.396
	2.396
	2.395
	2.395
	2.396

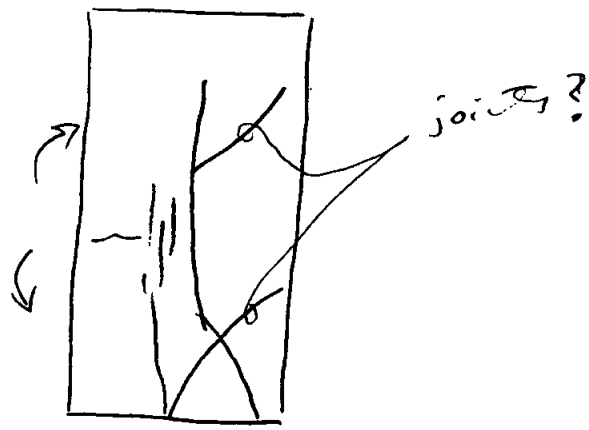
(x.0001")

l_1	l_2
+5	0
+3	0
±1	±2
-4	-1
-8	-3

Avg. diameter: 2.396 Avg. length: 5.374
Sample area: 4.509 l/d ratio: 2.24
Sample volume(in^3): 24.230
Sample weight (g): 1052.8g
Density: 43.458g/in^3 = 165.5pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE (?) - failed by axial splitting, shear, and bending



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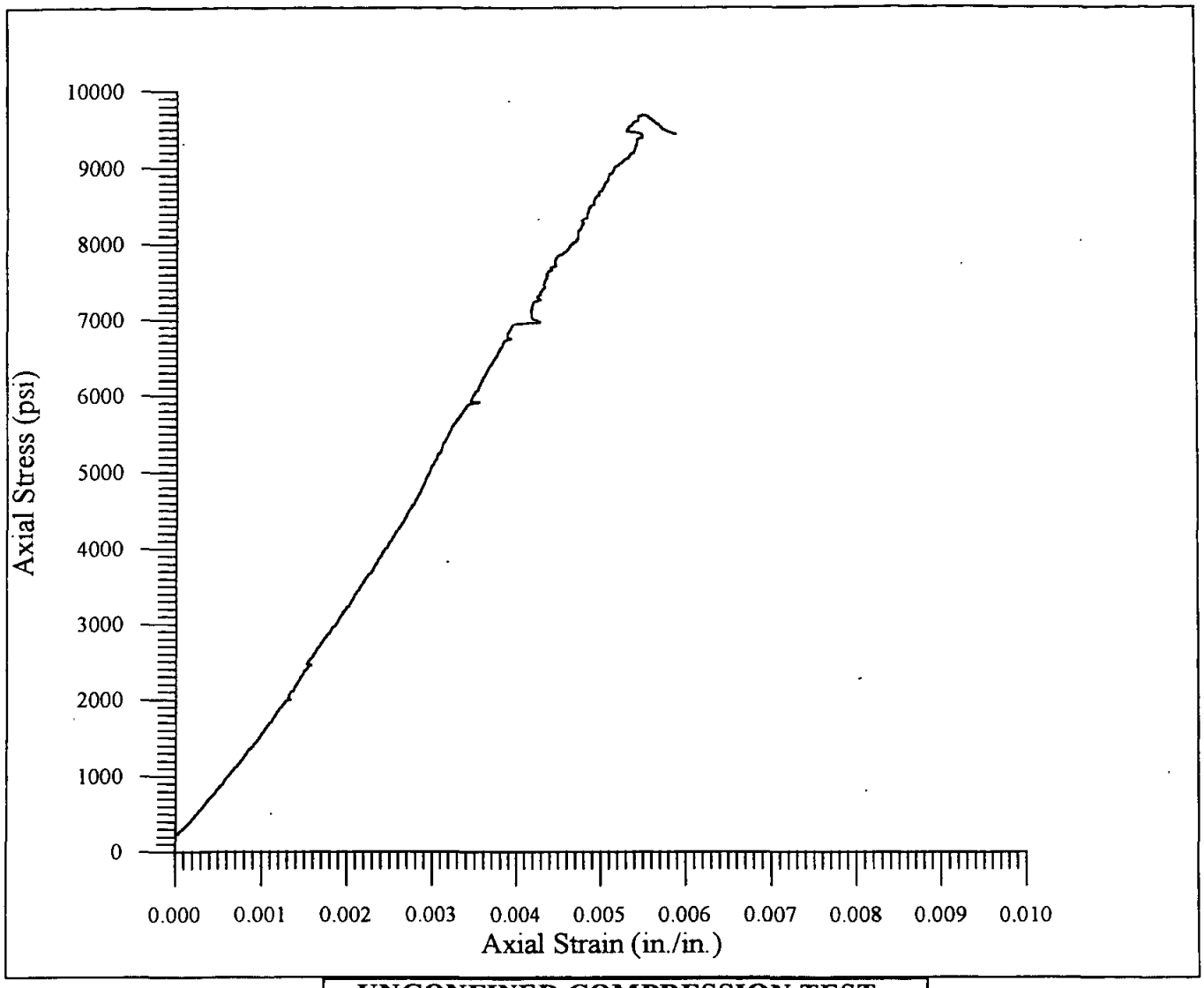


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-254
Boring: 02-5
Depth: 254.7-255.2'

DESCRIPTION

Medium gray medium grained sandstone with calcite healed fractures oriented perpendicular to bedding (about 43 degrees to the core axis).

Density: 165.5 pcf
Strength: 9687 psi
Joint Control Failure?: no(?)

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

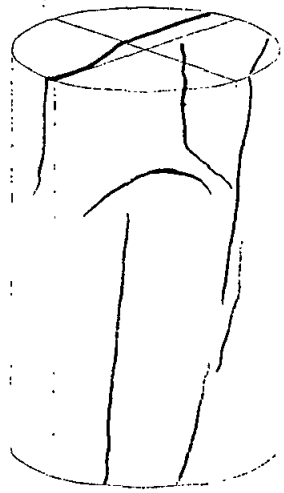
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-5
Sample Description: Gray medium to fine grained sandstone with a few axial calcite healed fractures.

Sample Depth: 306.0-306.5' Sample Condition: received dry - tested moist

d_1	d_2
2.393	2.395
2.396	2.394
2.394	2.396
2.394	2.392
2.392	2.392

(x.0001")

l_1	l_2
+7	-2
+5	0
±1	±2
-4	0
-7	+1



Avg. diameter : 2.394
Avg. length : 4.656"
Sample area : 4.501
l/d ratio : 1.94
Sample volume(in^3) : 20.958
Sample weight (g) : 912.9 g
Density : 43.56 g/in^3 = 165.9 pcf (1 g/in^3=3.8095lb/ft^3)

Comments: Backward snap @ about 36 kips may have been due to an axial fracture (Negative displacement due to indicator tab rotation) * But maybe not due to slight increase in load thereafter.

LVDT

INTACT FAILURE - Failed by axial splitting.

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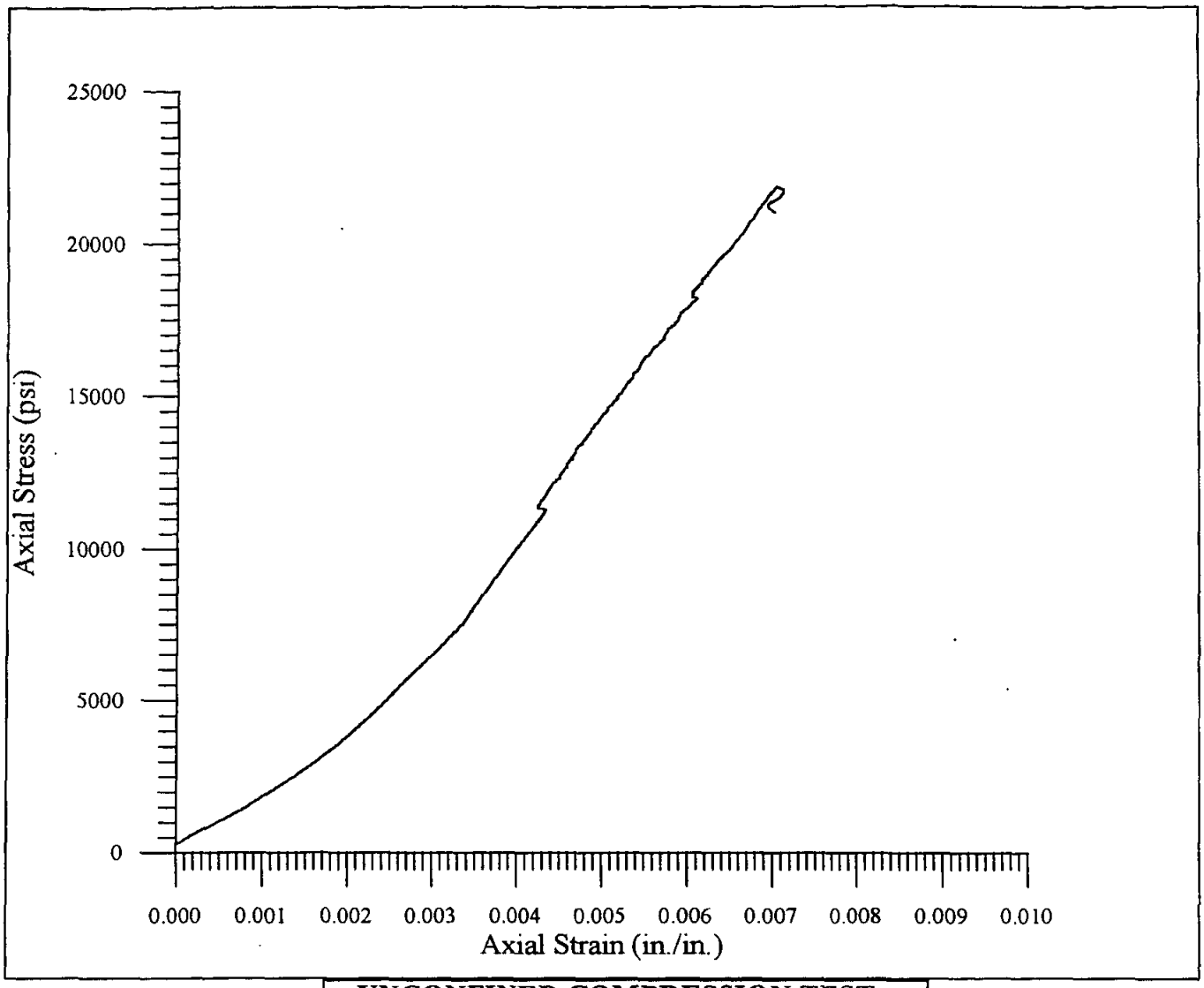


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-306
Boring: 02-5
Depth: 306.0-306.5'

DESCRIPTION

Medium gray fine to medium grained sandstone with a few axial calcite healed fractures.

Density: 165.9 pcf
Strength: 21,886 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

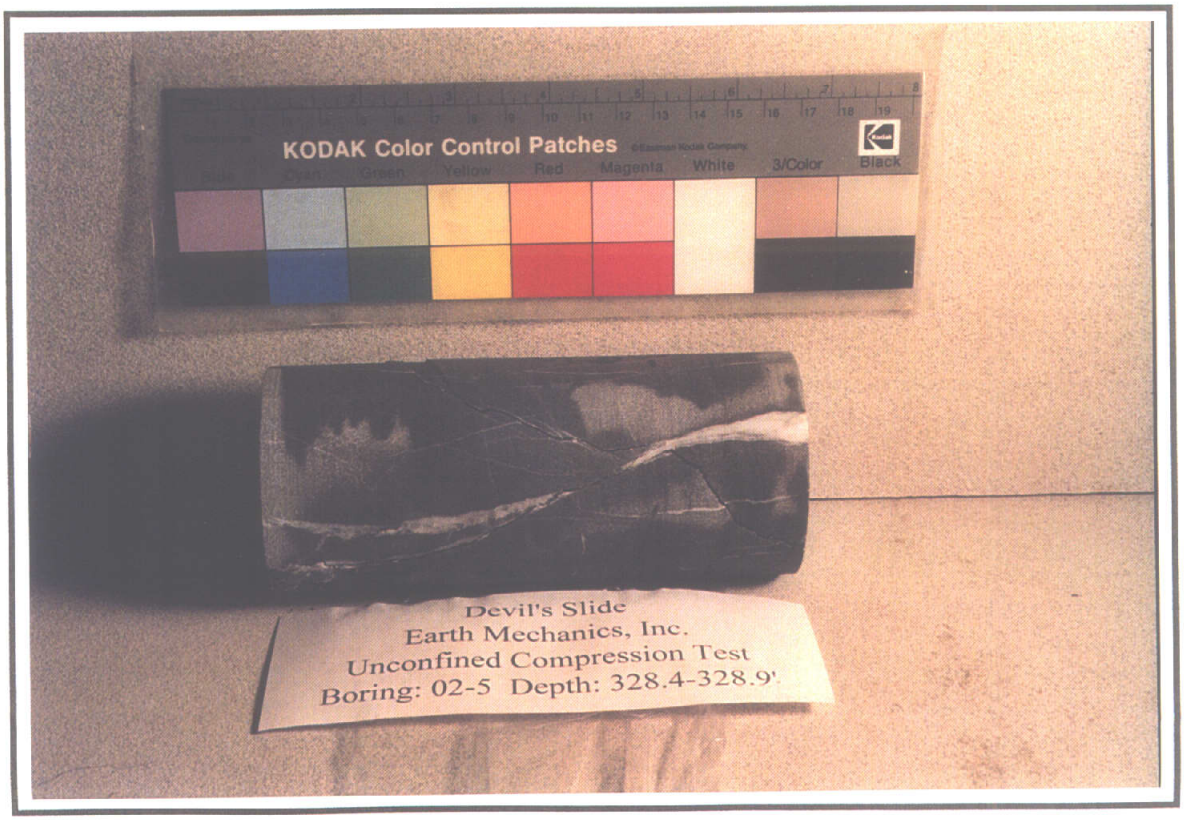
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

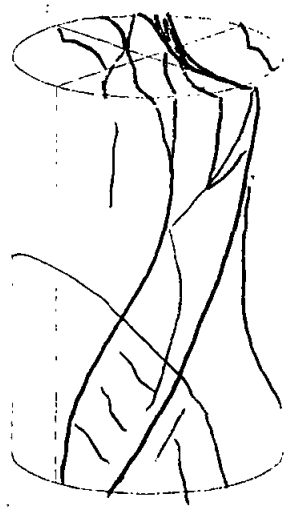
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-5
Sample Description: Gray fine to medium grained sandstone with several calcite healed & plastically healed axial fractures.

Sample Depth: 328.4-328.9 Sample Condition: received dry - tested moist

d_1	d_2
2.391	2.391
2.389	2.393
2.388	2.390
2.385	2.394
2.386	2.391

(x.0001")

l_1	l_2
+1	0
0	
±1	±2
0	
-1	0

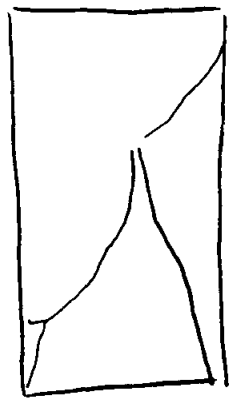


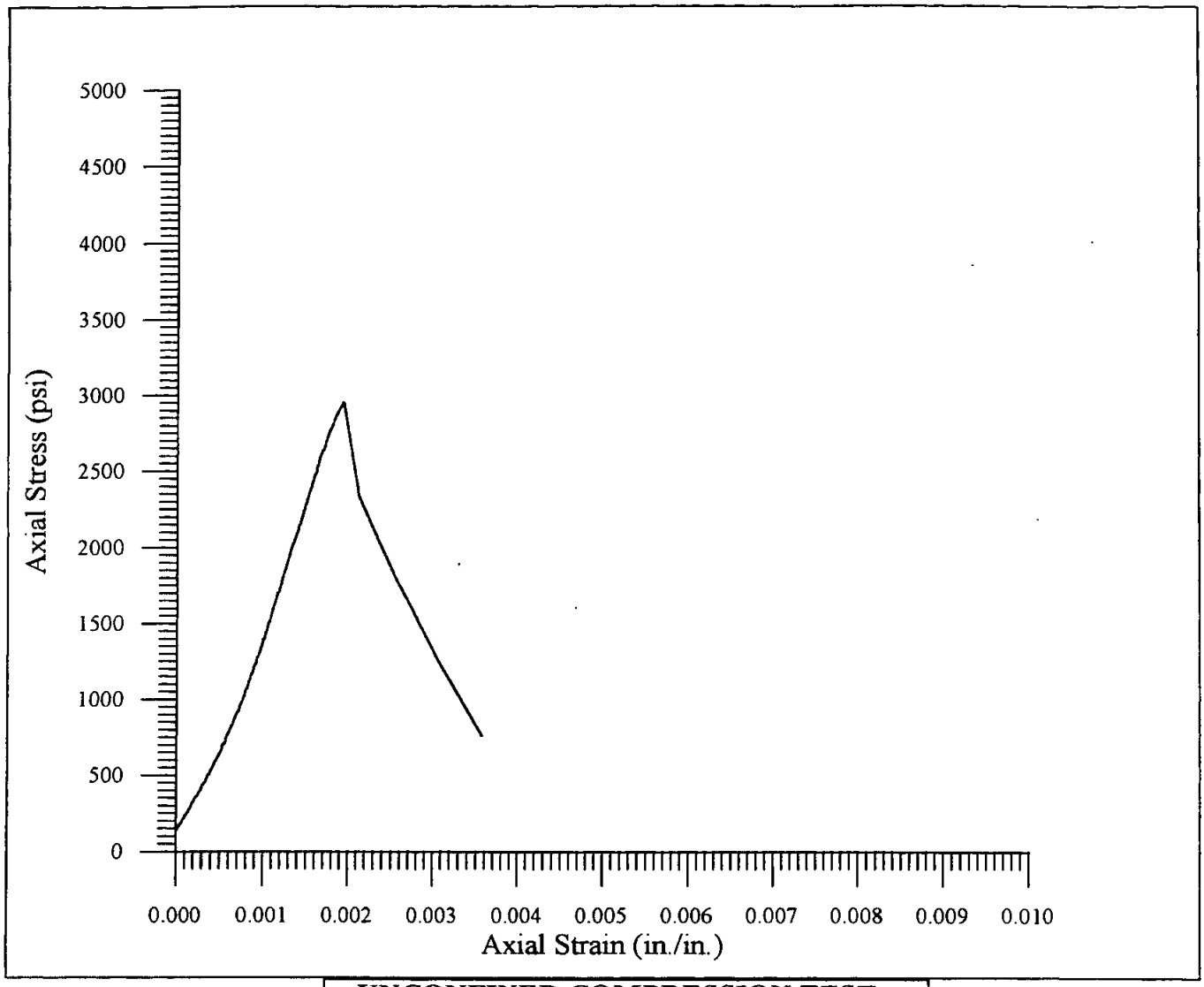
Avg. diameter : 2.390
Sample area : 4.486
Sample volume(in^3) : 25.128
Sample weight (g) : 1091.5g
Density : 43.44 g/in^3 = 165.5 pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.601"
l/d ratio : 2.34

Comments:

JOINT CONTROLLED FAILURE - failed by shear along calcite healed joint





UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-328
Boring: 02-5
Depth: 328.4-328.9'

DESCRIPTION

Medium gray fine to medium grained sandstone with several calcite healed and partially healed axial fractures.

Density: 165.5 pcf
Strength: 2952 psi
Joint Control Failure?: yes

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

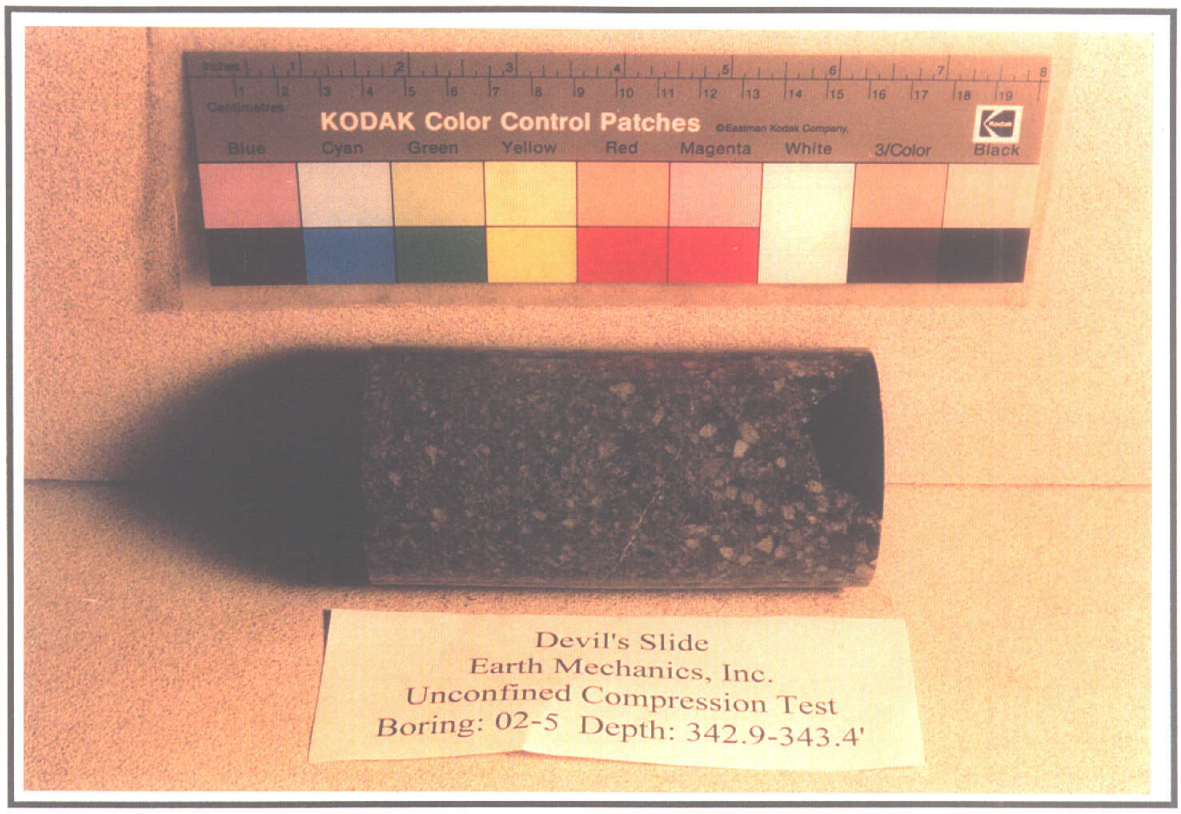
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

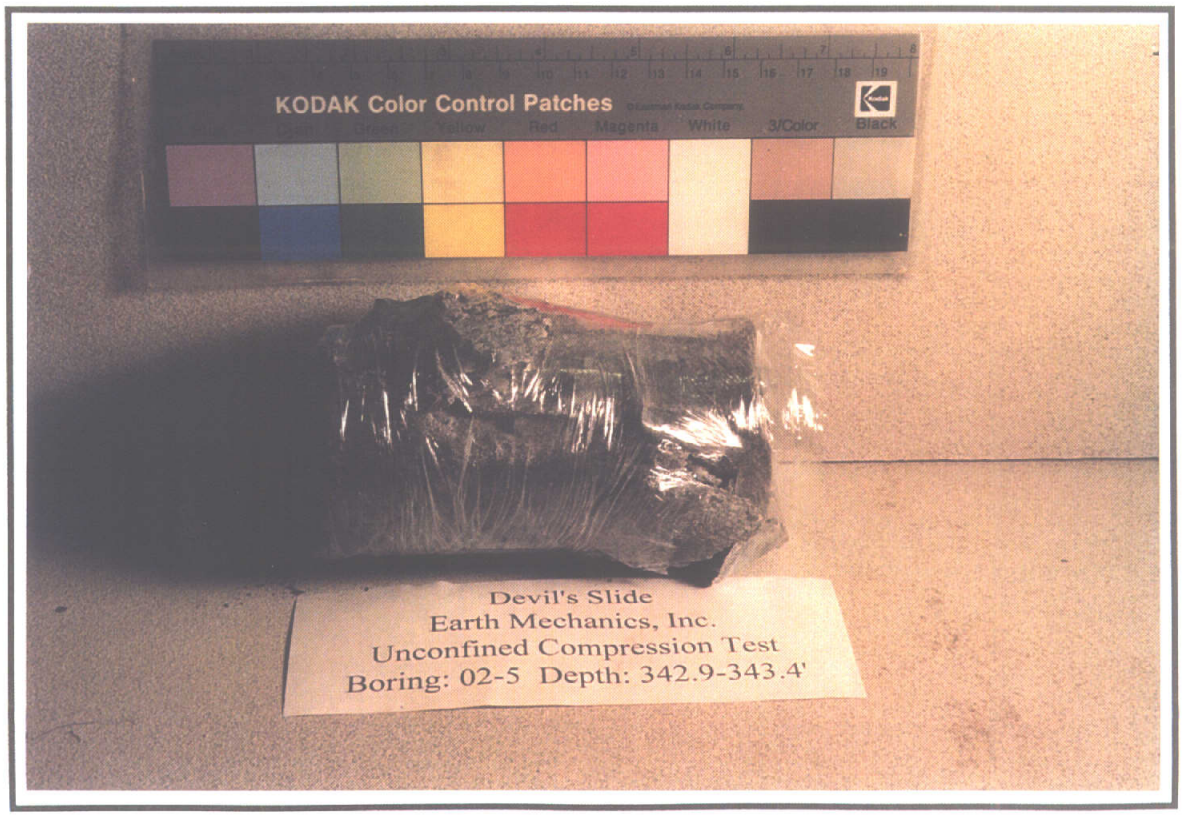
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

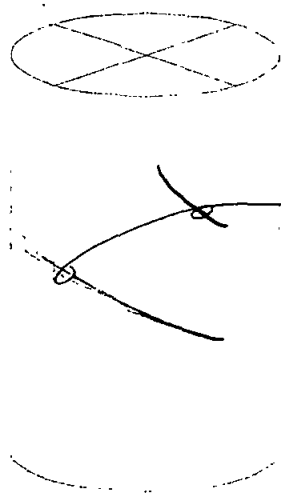
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-5
Sample Description: Gray, Fine grained conglomerate with a few calcite healed fractures.

Sample Depth: 342.9-343.4' Sample Condition: received dry - tested moist

d_1	d_2
2.395	2.397
2.395	2.397
2.397	2.395
2.394	2.397
2.393	2.395

(x.0001")

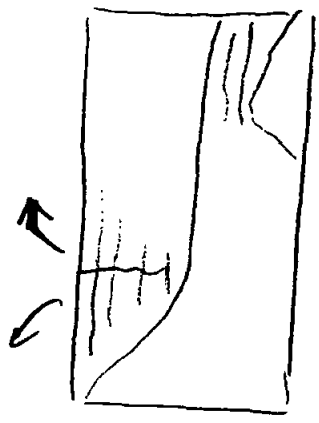
l_1	l_2
+10	+1
+4	0
±1	±2
-6	0
-10	-1



Avg. diameter : 2.396 Avg. length : 4.851"
Sample area : 4.509 l/d ratio : 2.02
Sample volume(in^3) : 21.872
Sample weight (g) : 948.0 g.
Density : 43.34 g/in^3 = 165.1 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE - failed by axial splitting



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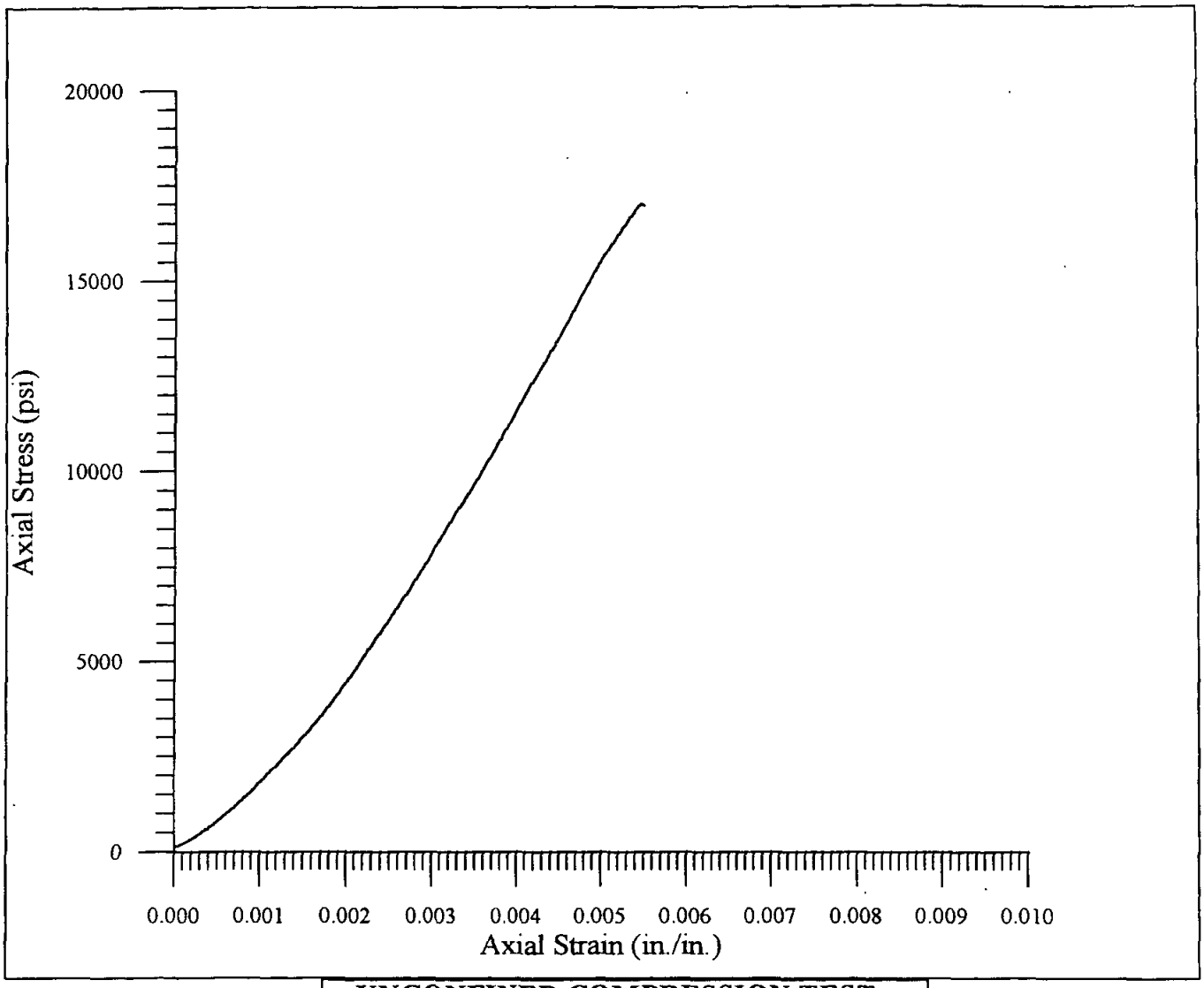


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-342
Boring: 02-5
Depth: 342.9-343.4'

DESCRIPTION
Medium gray fine grained conglomerate with a few calcite healed fractures.

Density: 165.1 pcf
Strength: 17,031 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

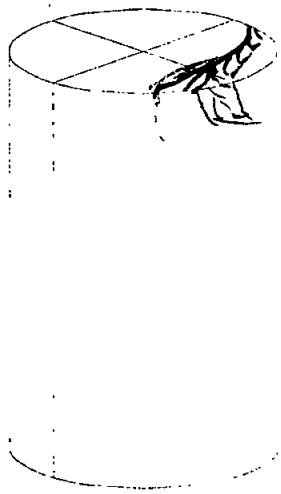
Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/21/02
Technician: A.Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-5
Sample Description: Gray medium to coarse grained conglomerate with a weak dark gray matrix. With one open joint at top

Sample Depth: 356.2-356.7' Sample Condition: received dry - tested moist



d_1	d_2
2.397	2.413 *
2.395	2.397
2.393	2.394
2.392	2.394
2.395	2.390

(excluded *)

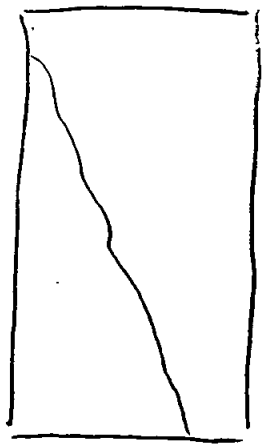
(x.0001")

l_1	l_2
+4	0
+3	
±1	±4 *
-5	
-9	0

Avg. diameter : 2.394
Avg. length : 4.652"
Sample area : 4.501
l/d ratio : 1.94
Sample volume(in^3) : 20.940
Sample weight (g) : 904.6
Density : 43.20 y/in^3 = 164.6 pcf (1 g/in^3=3.8095lb/ft^3)

Comments: * due to hard clasts & softness of matrix
& due to open joint

INTACT FAILURE - Failed by diagonal shear



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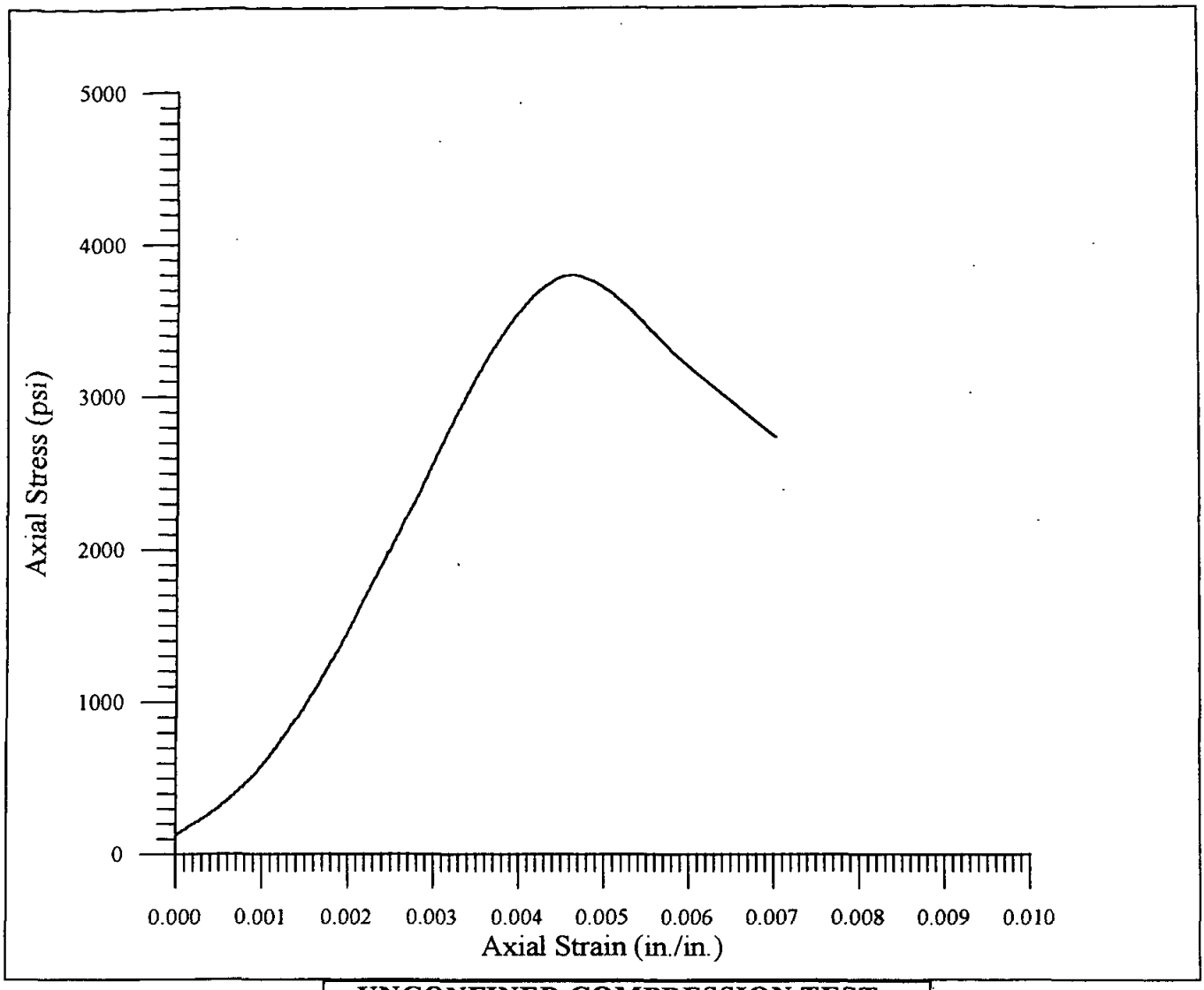


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-356
Boring: 02-5
Depth: 356.2-356.7'

DESCRIPTION

Medium gray medium to coarse grained conglomerate with weak dark gray matrix and an open joint at one end.

Density: 164.6 pcf
Strength: 3796 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/21/02
Technician: A.Bro

Client: EMI
Job: #151- Devil's Slide
Sample ID: Boring 02-5
Sample Description: Grey coarse grained conglomerate - or possibly heavily sheared and segregated granodiorite with weak matrix and calcite healed fractures

Sample Depth: 664.3-664.8' Sample Condition: received dry - tested moist

(x.ood")

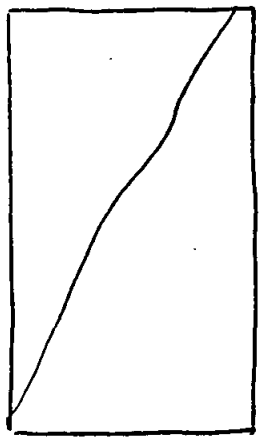
d_1	d_2
2.396	2.396
2.399	2.396
2.402	2.397
2.400	2.397
2.403	2.397

l_1	l_2
+20	+12
+17	+3
±2	±2
-1	0
-2	-5

Avg. diameter : 2.398 Avg. length : 5.645"
Sample area : 4.516 l/d ratio : 2.35
Sample volume(in^3) : 25494
Sample weight (g) : 1090.68
Density : 42.78 g/in^3 = 163.0 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE - Failed by sliding



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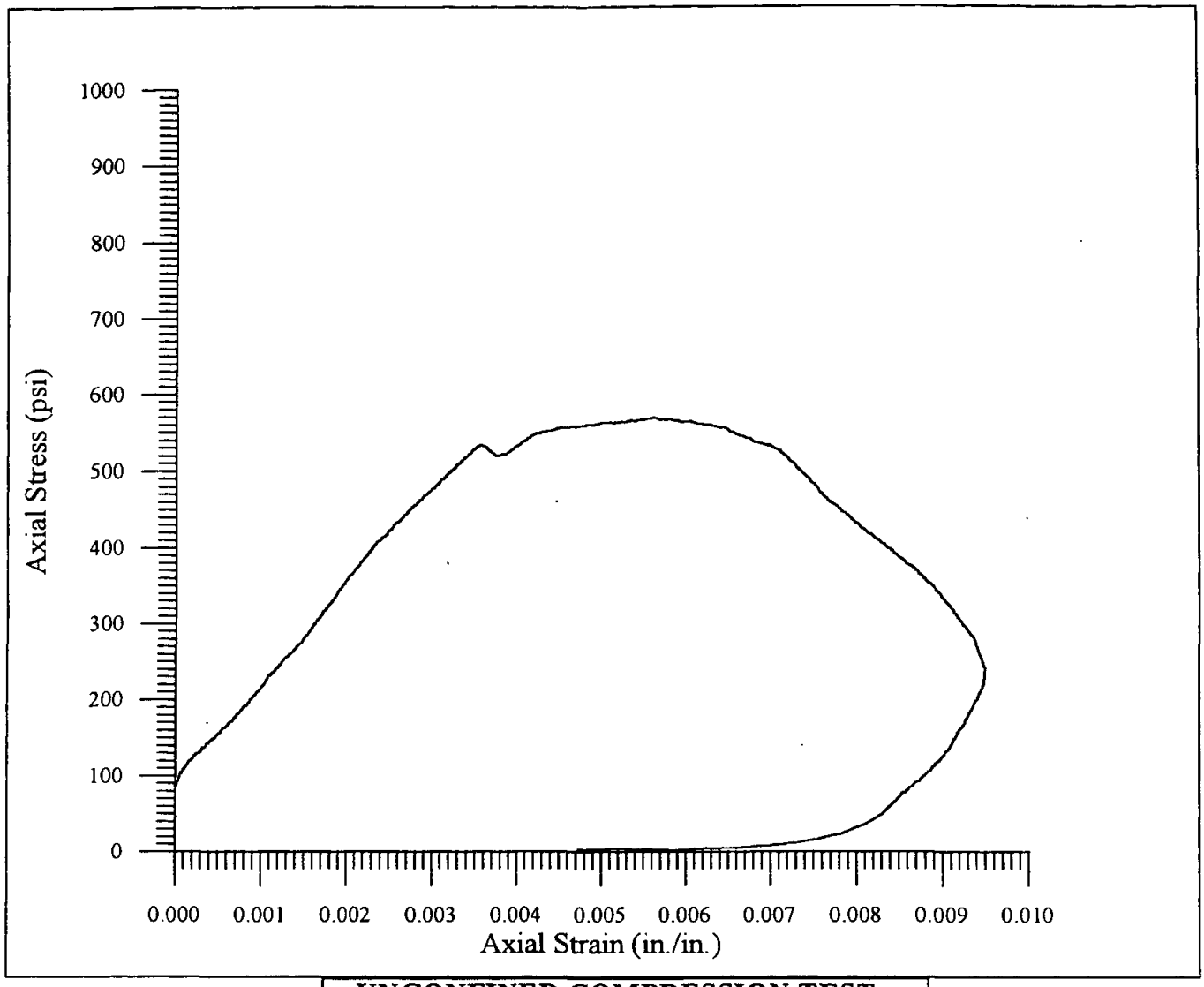


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-664
Boring: 02-5
Depth: 664.3-664.8'

DESCRIPTION

Medium gray coarse grained conglomerate - or possibly heavily sheared and recemented granodiorite with weak matrix and calcite healed fractures.

Density: 163.0 pcf
Strength: 569 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/21/02
Technician: A. Bro

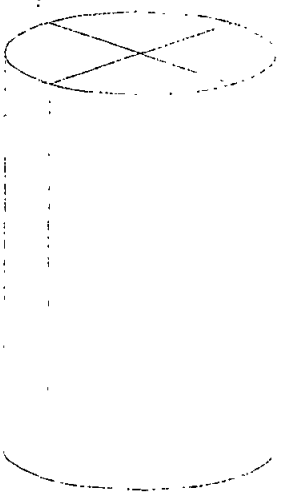
Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-5
Sample Description: greenish gray graywacke with numerous weak serpentinized shear zones

Sample Depth: 684.1-684.6 Sample Condition: received dry - tested moist

d_1	d_2
2.399	2.396
2.400	2.398
2.399	2.400
2.396	2.400
2.398	2.402

(x.0001")

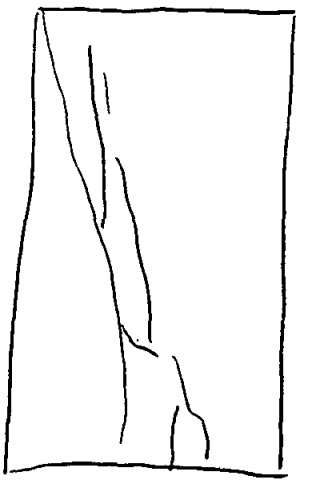
l_1	l_2
+5	+13
0	+5
±1	±2
+1	-7
+5	-13



Avg. diameter : 2.399
Avg. length : 5.623
Sample area : 4.520
l/d ratio : 2.34
Sample volume(in^3) : 25.417
Sample weight (g) : 1080.4 g
Density : 42.51 g/in^3 = 161.9 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE - failed by axial splitting & shear



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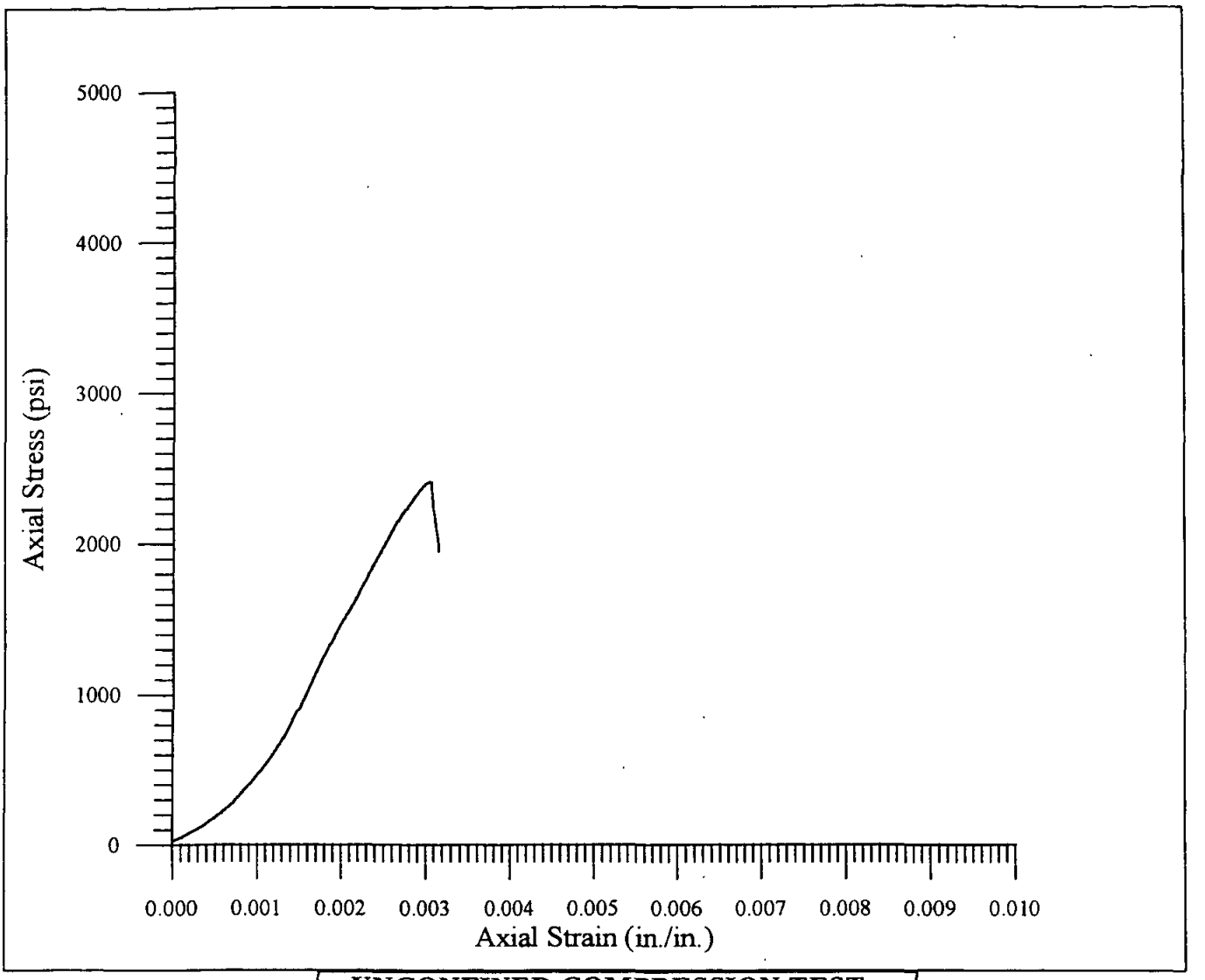


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-684
Boring: 02-5
Depth: 684.1-684.6'

DESCRIPTION

Medium gray granodiorite with numerous weak relithified shear zones.

Density: 161.9 pcf
Strength: 2409 psi
Joint Control Failure?: no

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

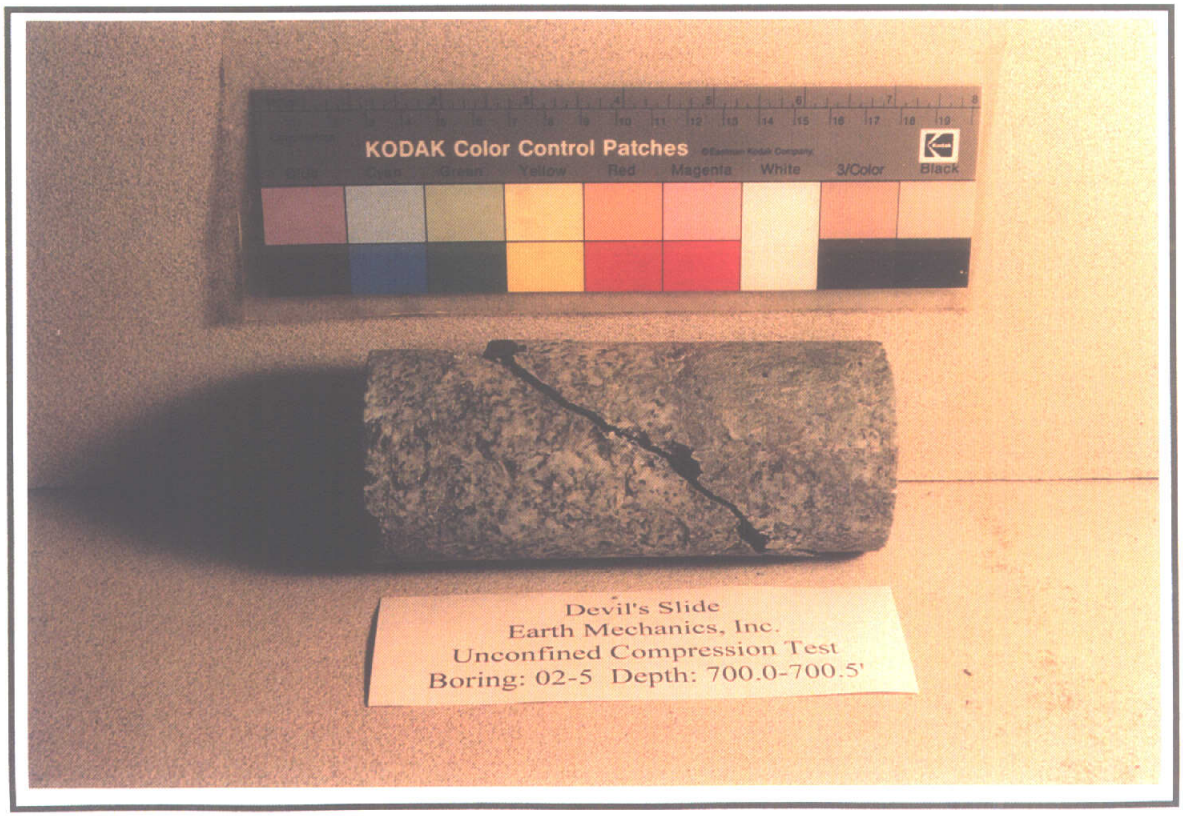
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



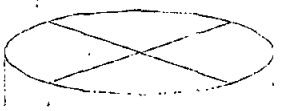
Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/21/02
Technician: A.Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-5
Sample Description: Greenish gray granodiorite which has been sheared & locally brecciated. Contains many weak zones.

Sample Depth: 700.0-700.5' Sample Condition: received dry - tested moist



d_1	d_2
2.400	2.400
2.398	2.395
2.400	2.398
2.397	2.397
2.397	2.398

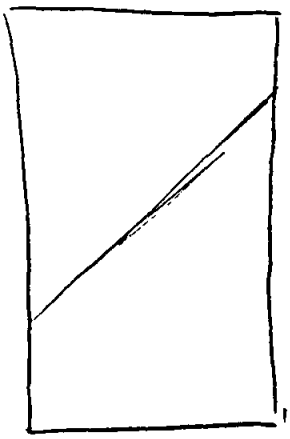
(x.0001")

l_1	l_2
+13	+13
+7	+8
±1	±2
-6	-3
-11	-7

Avg. diameter: 2.398 Avg. length: 5.676"
Sample area: 4.516 l/d ratio: 2.367
Sample volume(in^3): 25635
Sample weight (g): 1096.08
Density: 42.758/in^3 = 162.9 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE(?) Failed by shear - no apparent plane of weakness, but the planarity of failure indicates a pre-existing plane of weakness.



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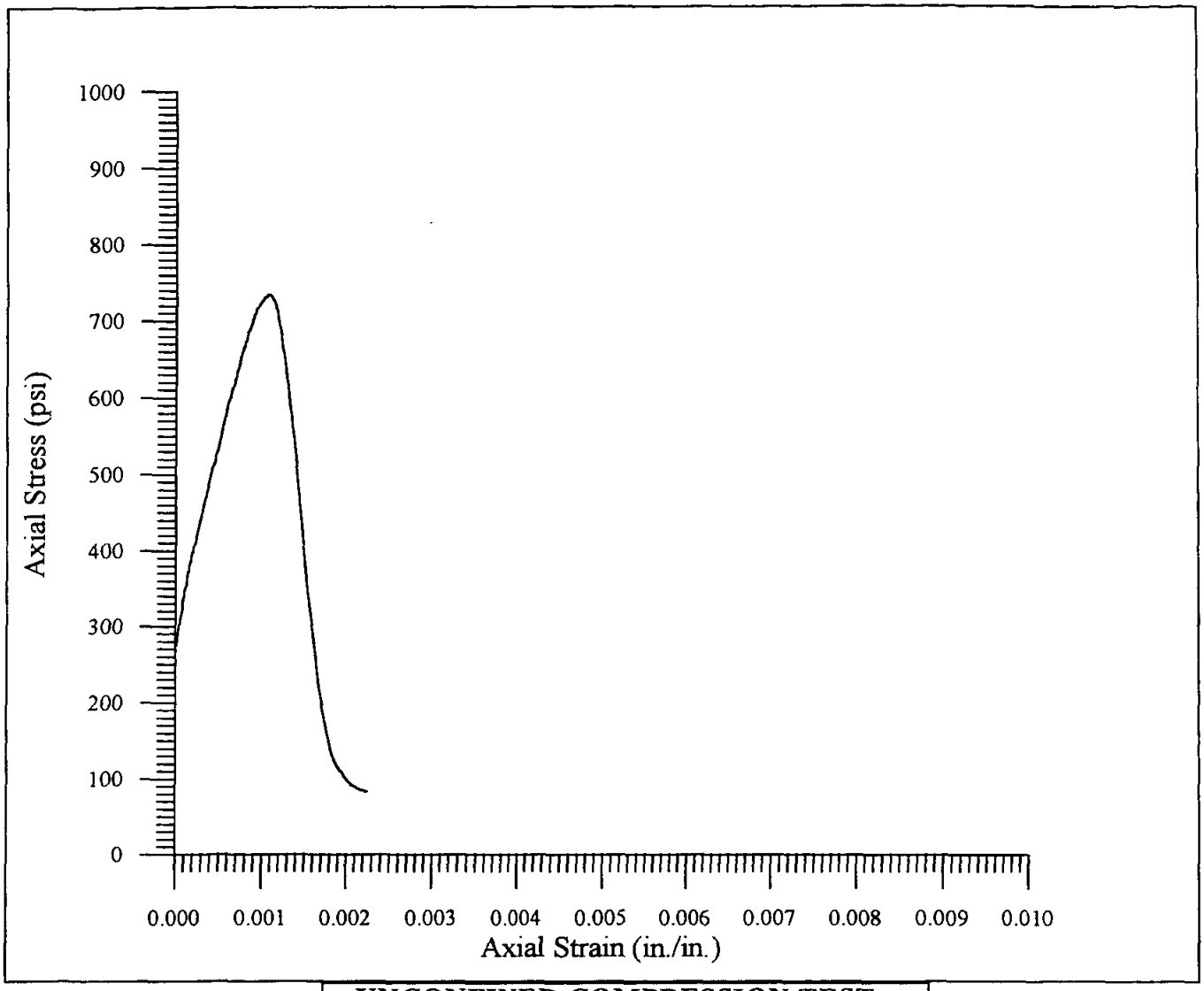


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-700
Boring: 02-5
Depth: 700.0-700.5'

DESCRIPTION

Greenish gray granodiorite which has been sheared and weakly relithified, with many weak zones..

Density: 162.9 pcf
Strength: 735 psi
Joint Control Failure?: no(?)

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

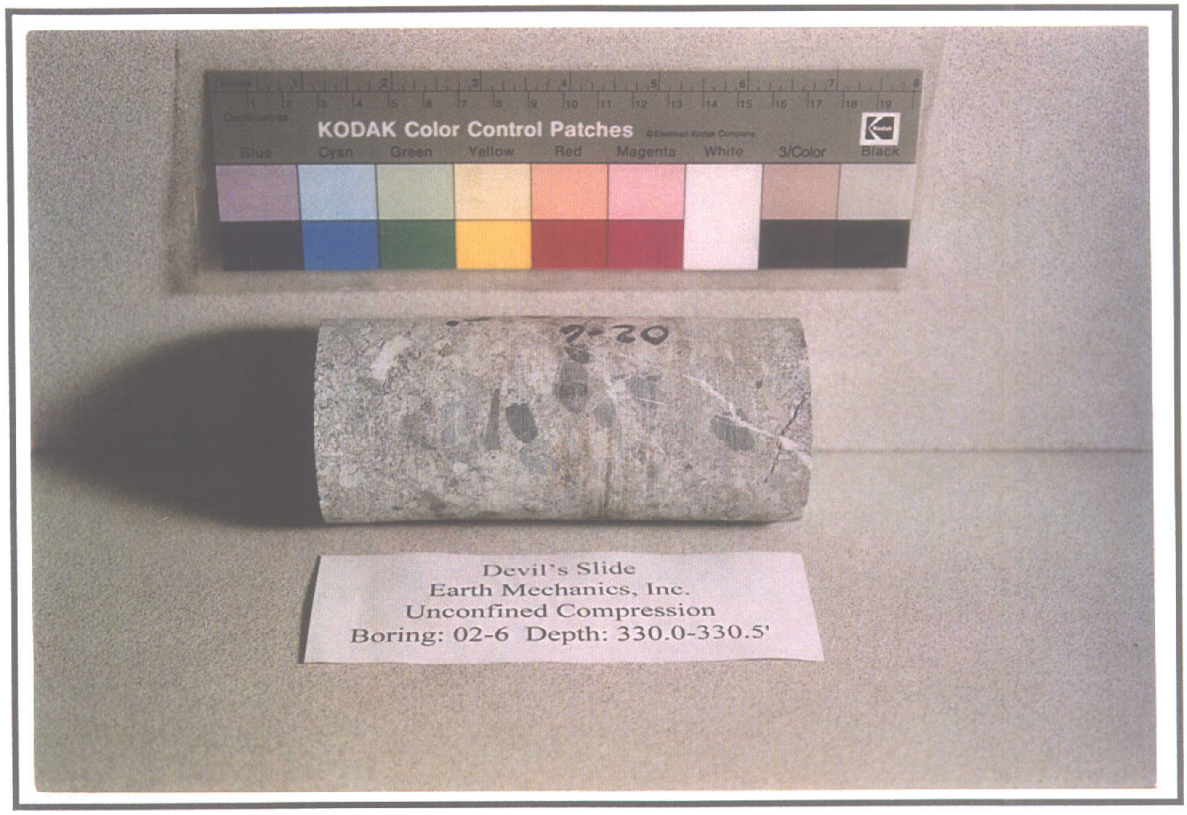
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

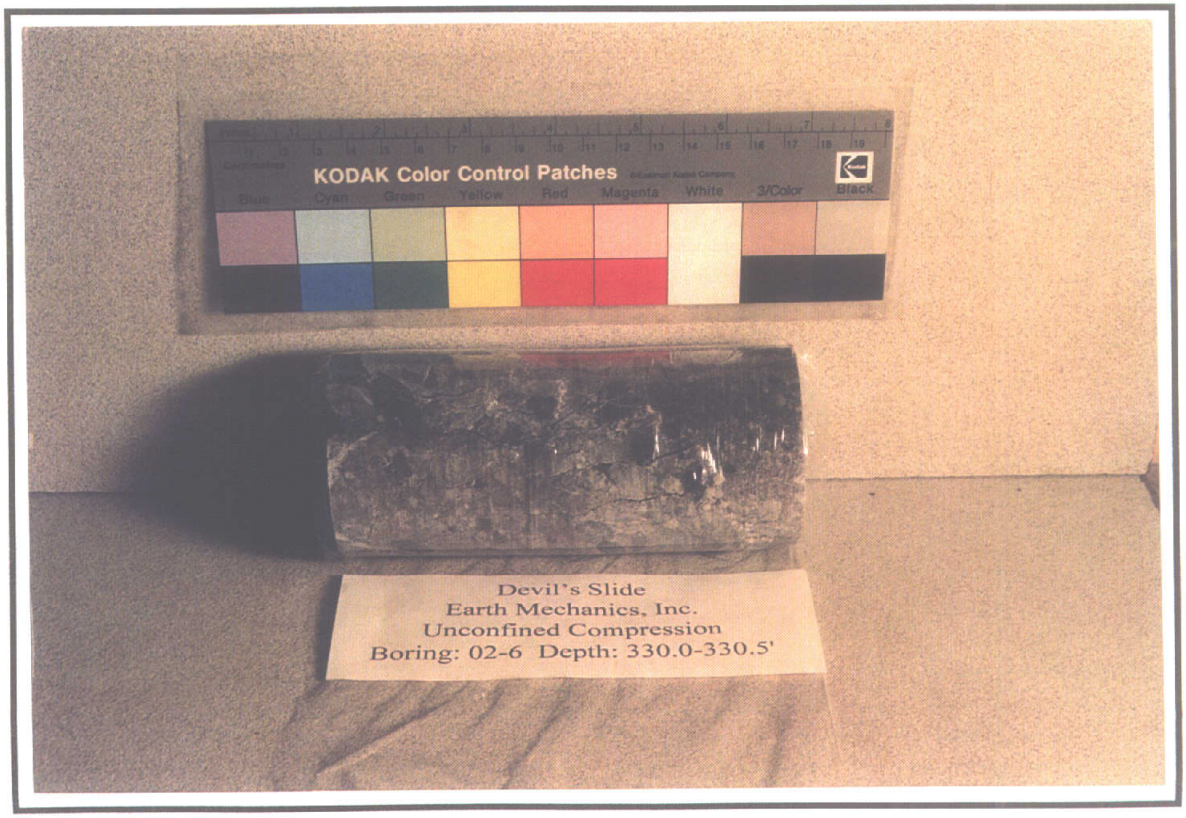
Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

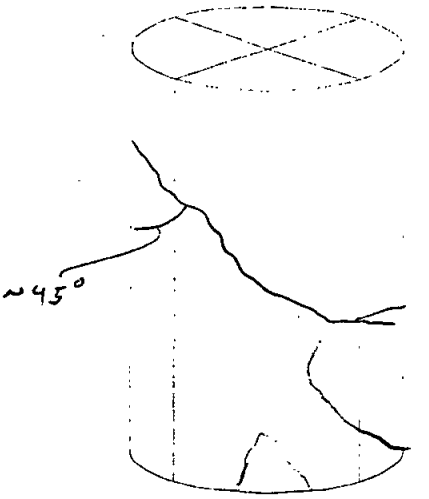
Date: 9/12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring: 02-6
Sample Description: grey conglomerate with rounded siltstone & granitic clasts. Contains several calcite healed joints

Sample Depth: 330.0-330.5 Sample Condition: received dry, tested moist

d_1	d_2
2.390	2.393
2.395	2.389
2.395	2.393
2.393	2.393
2.393	2.396

l_1	l_2
-.0012	0
-.0007	
±.0001	±.0002
+.0006	
+.0011	0



Avg. diameter: 2.393
Sample area: 4.498
Sample volume(in^3): 24.750
Sample weight (g): 1067.9g
Density: 43.15g/in^3 = 164.4pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length: 5.503
l/d ratio: 2.30

Comments:

INTACT FAILURE - failed by axial splitting along a general shear orientation

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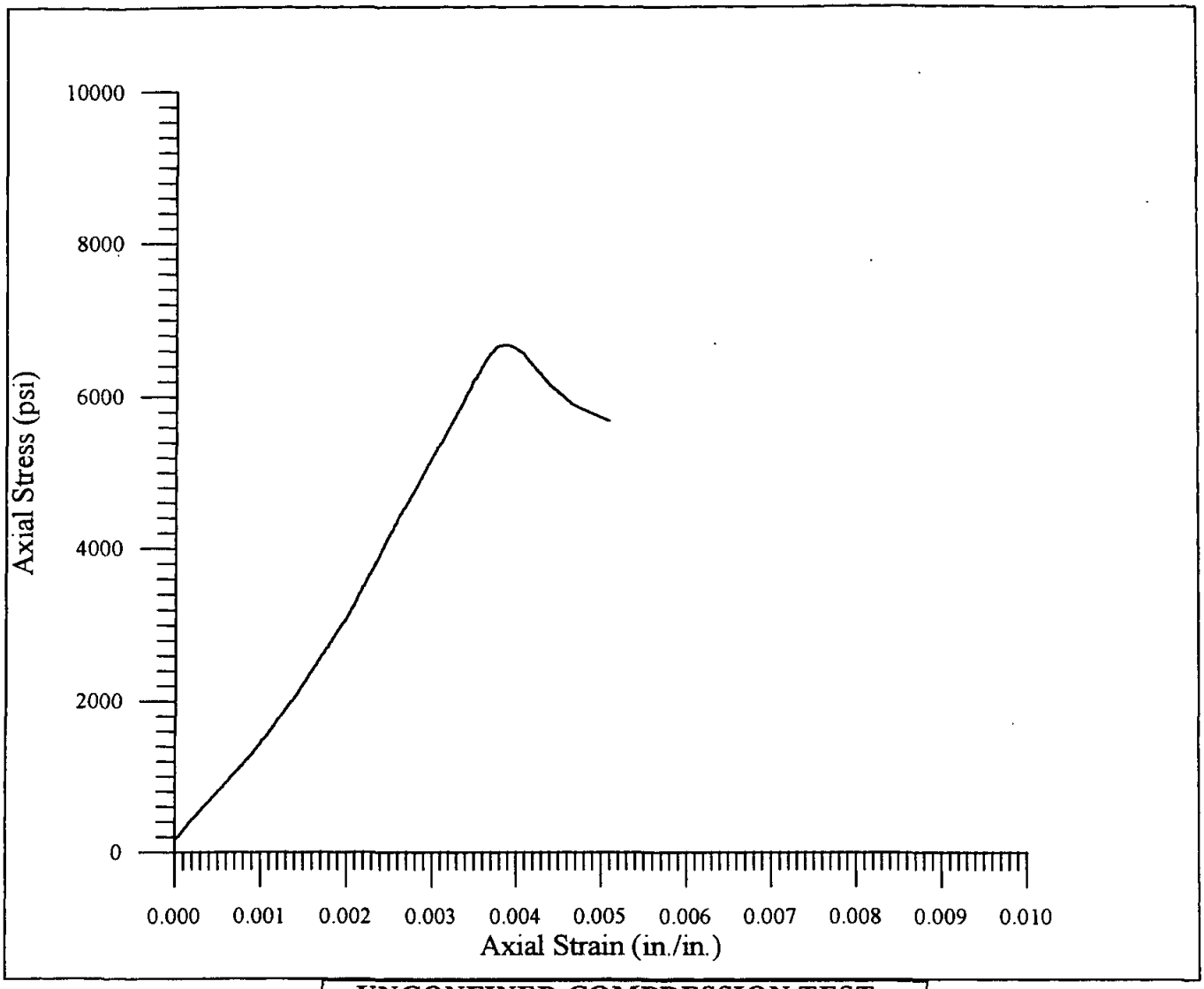


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-330
Boring: 02-6
Depth: 330.0-330.5'

DESCRIPTION

Gray conglomerate with rounded siltstone and granitic clasts. Contains several calcite healed joints.

Density: 164.4 pcf
Strength: 6675 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

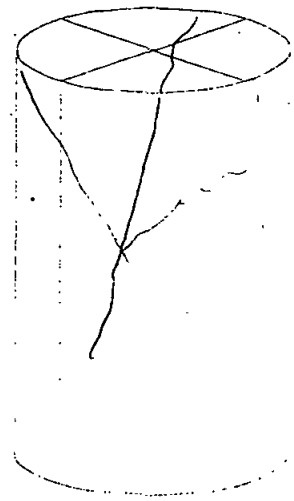
Date: 9/6&12/02
Technician: A. Bro

Client: E-I
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray conglomerate with granitic clasts up to 1" (1 shared by fracture). A few calcite healed fractures.

Sample Depth: 336.1-336.6' Sample Condition: received dry - tested moist

d_1	d_2
2.399	2.396
2.398	2.398
2.397	2.398
2.398	2.395
2.394	2.397

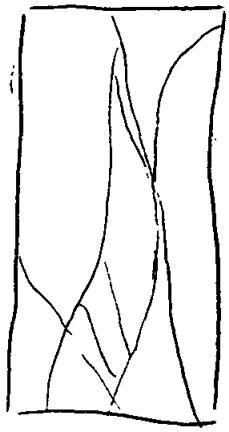
l_1	l_2
+.0005	0
+.0002	0
-.0001	±.0002
-.0002	0
-.0005	0



Avg. diameter: 2.397 Avg. length: 5.512"
Sample area: 4.513 l/d ratio: 2.30
Sample volume(in^3): 24.873
Sample weight (g): 1076.3 g
Density: 43.27 g/in^3 = 164.8 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments: Failed by axial splitting

INTACT FAILURE



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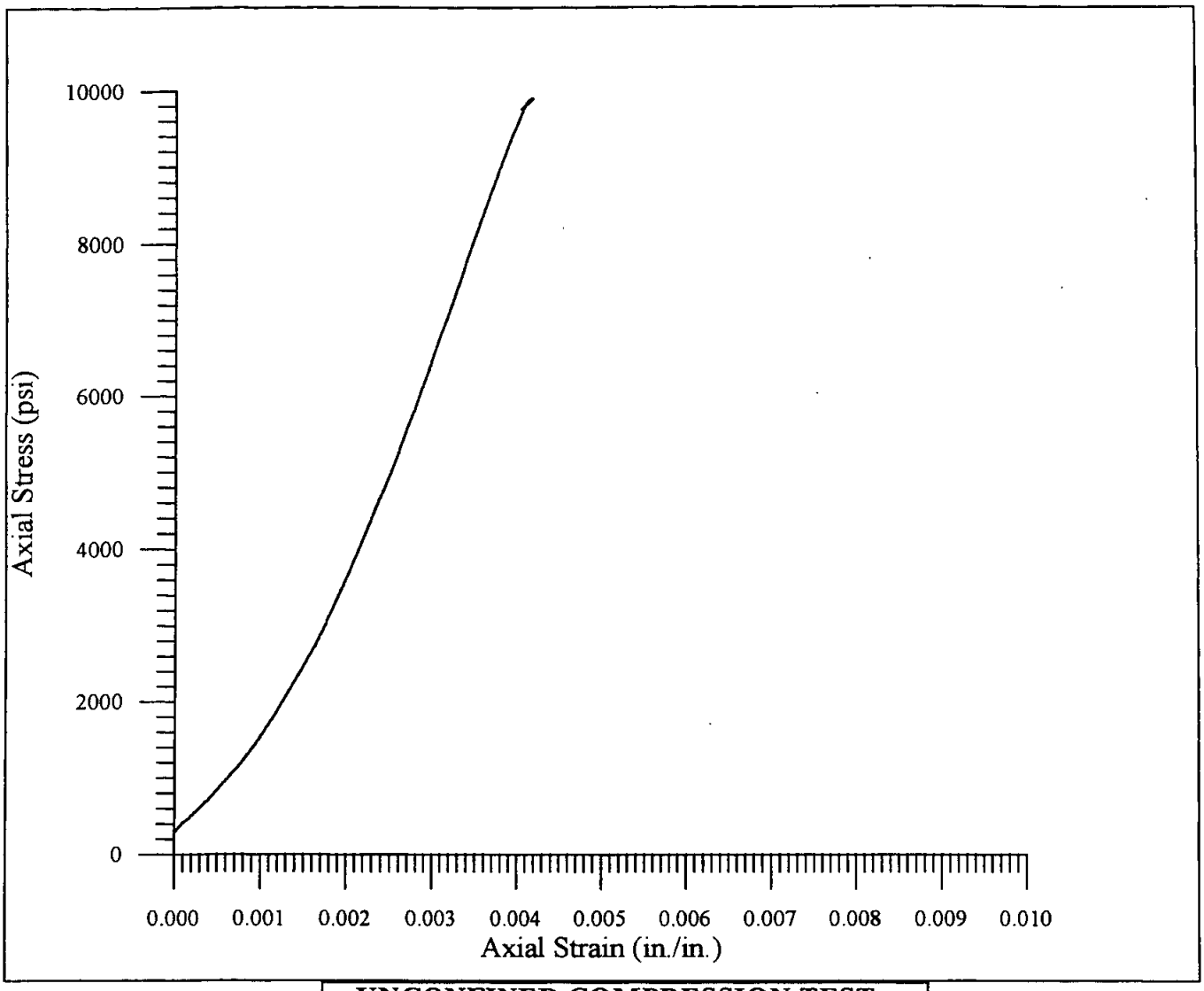


UNCONFINED COMPRESSION TEST
Axial Stress vs. Radial Strain

Sample: 6-336
Boring: 02-6
Depth: 336.1-336.6'

DESCRIPTION
Gray conglomerate with granitic clasts up to 1" and a few calcite healed fractures.

Density: 164.8 pcf
Strength: 9907 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

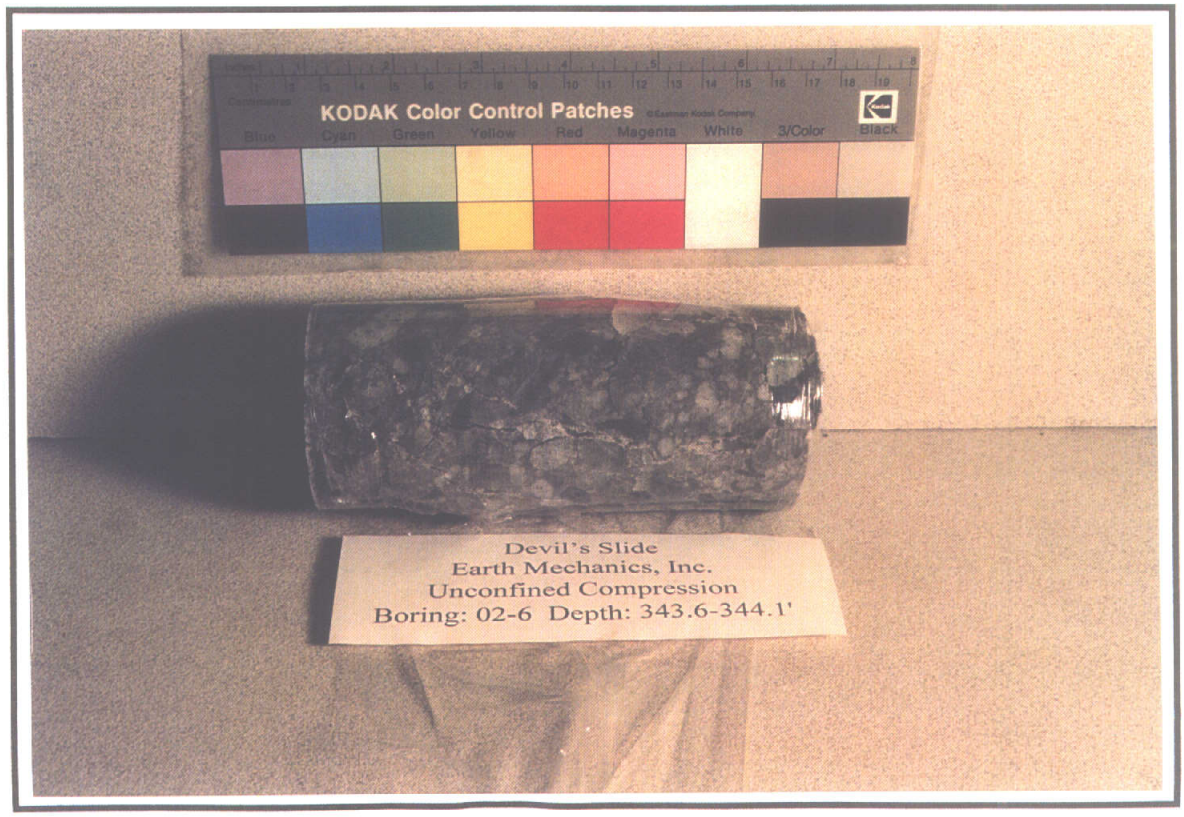
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

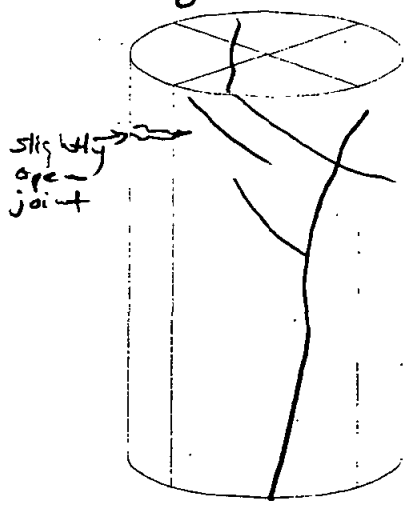
Date: 9/12/02
Technician: A. Bro

Client: E-I
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: Gray conglomerate with siltstone & granitic clasts up to about 3/4" with a few calcite healed fractures & one unhealed fracture near the end.

Sample Depth: 343.6 - 344.1' Sample Condition: received dry, tested dry

d_1	d_2
2.398	2.395
2.397	2.397
2.398	2.396
2.399	2.398
2.397	2.397

l_1	l_2
+.0009	+.0004
+.0004	+.0002
±.0001	±.0002
-.0002	-.0002
-.0009	-.0004



Avg. diameter : 2.397
Avg. length : 5.606"
Sample area : 4.513
l/d ratio : 2.34
Sample volume(in^3) : 25.298
Sample weight (g) : 1096.5g
Density : 43.34 g/in^3 = 165.1 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE - Failed by axial splitting

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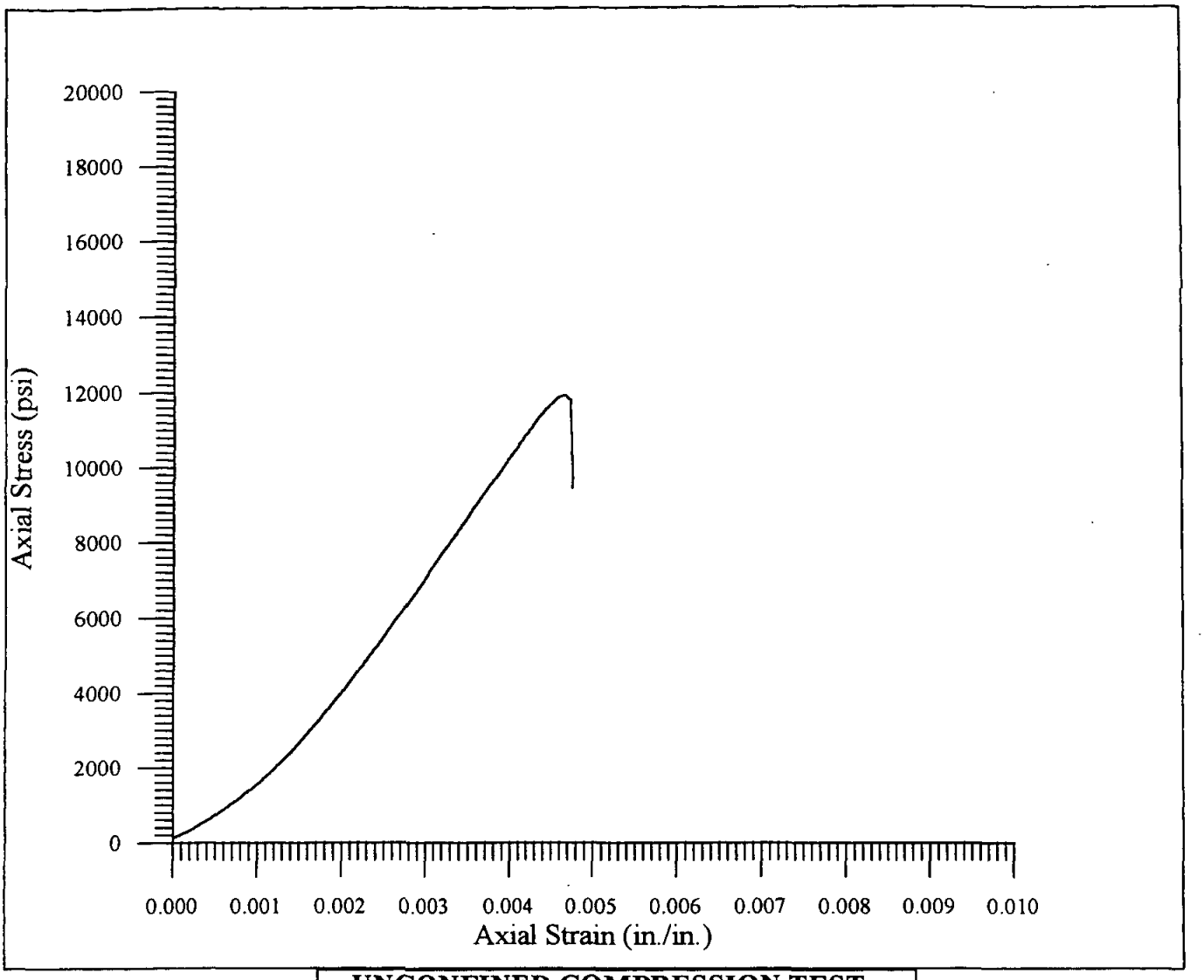


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-343
Boring: 02-6
Depth: 343.6-344.1'

DESCRIPTION

Gray conglomerate with siltstone and granitic clasts up to about 3/4 inch, with a few calcite healed fractures.

Density: 165.1 pcf
Strength: 11,919 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

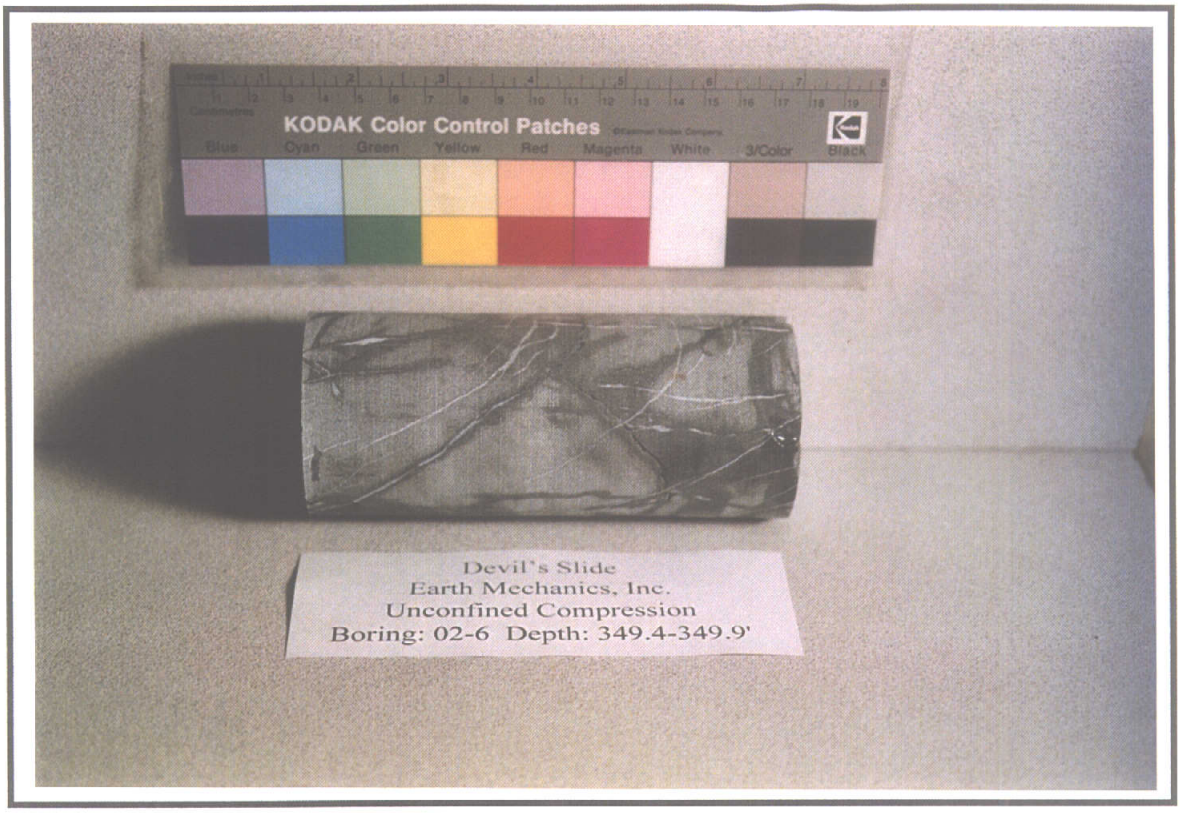
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

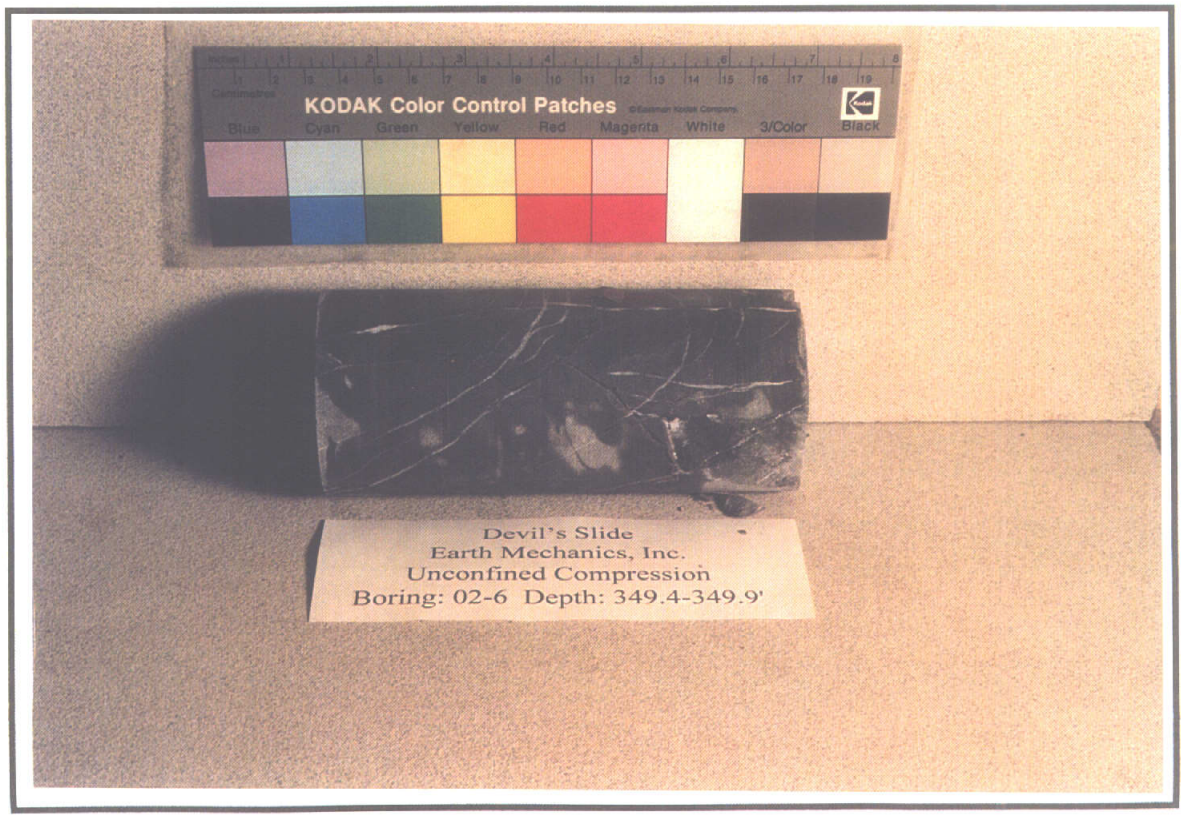
Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

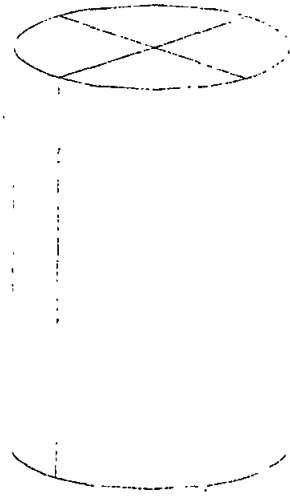
Date: 9/13/02
Technician: A Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: Dark gray siltstone with several calcite healed joints, some appear to be partially healed. ~25-30° to +/- core axis

Sample Depth: 349.4 - 349.9' Sample Condition: received dry, tested moist

d_1	d_2
2.394	2.397
2.398	2.395
2.398	2.397
2.397	2.397
2.397	2.398

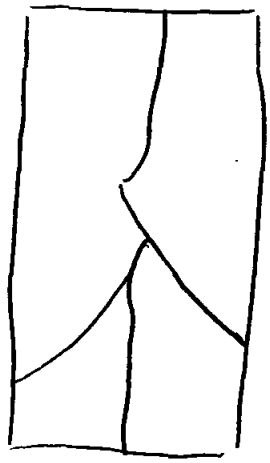
l_1	l_2
+.0006	+.0002
+.0003	0
±.0001	±.0001
-.0003	-.0002
-.0006	-.0004



Avg. diameter : 2.397 Avg. length : 5.528"
Sample area : 4.513 l/d ratio : 2.31
Sample volume(in^3) : 24.95
Sample weight (g) : 1094.2g
Density : 43.86 g/in^3 = 167.1 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE - Failed by shear along a healed joint & axial splitting.



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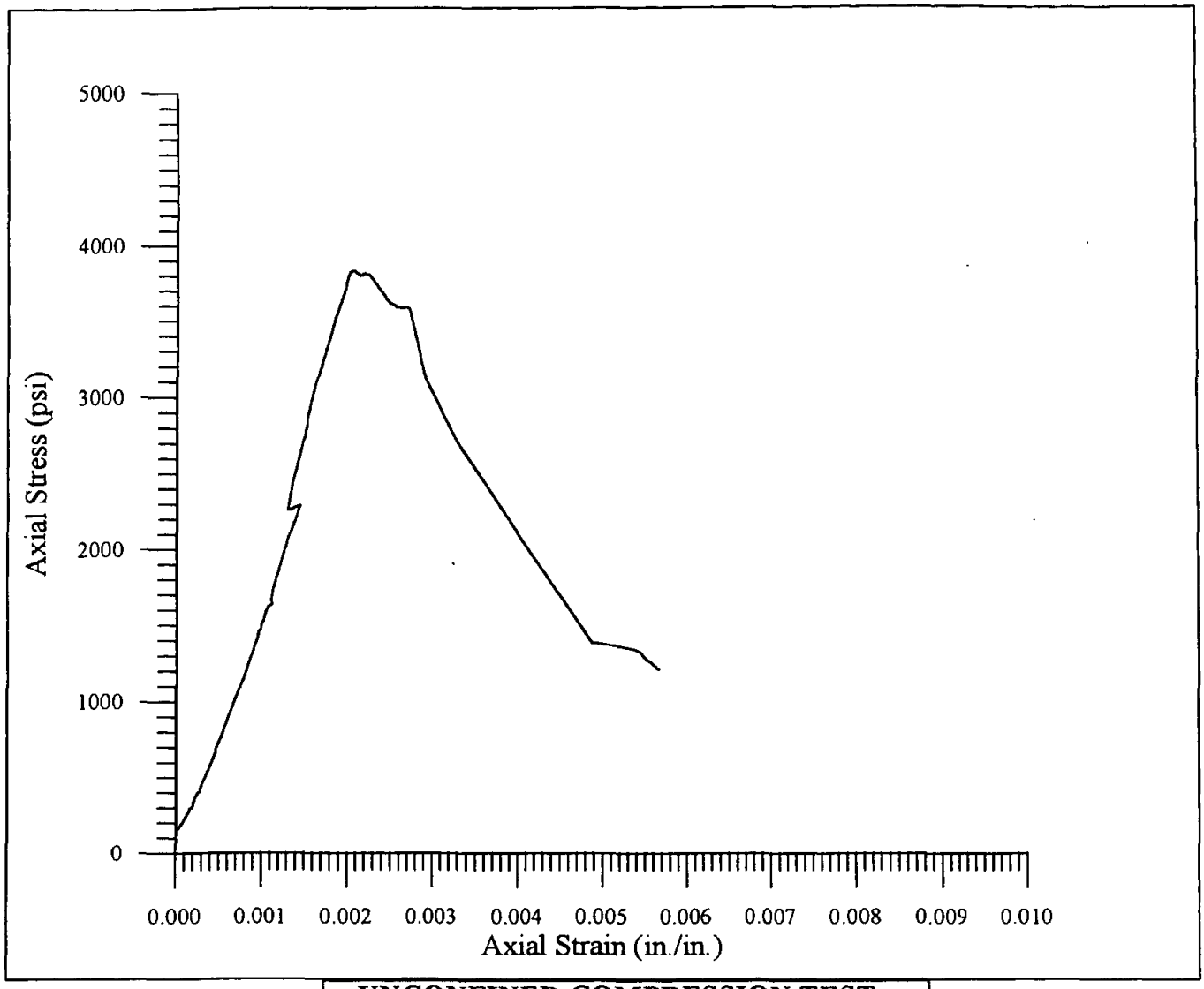


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-349
Boring: 02-6
Depth: 349.4-349.9'

DESCRIPTION

Dark gray siltstone with several calcite healed and partially healed joints about 25-30 degrees to the core axis.

Density: 167.1 pcf
Strength: 3827 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

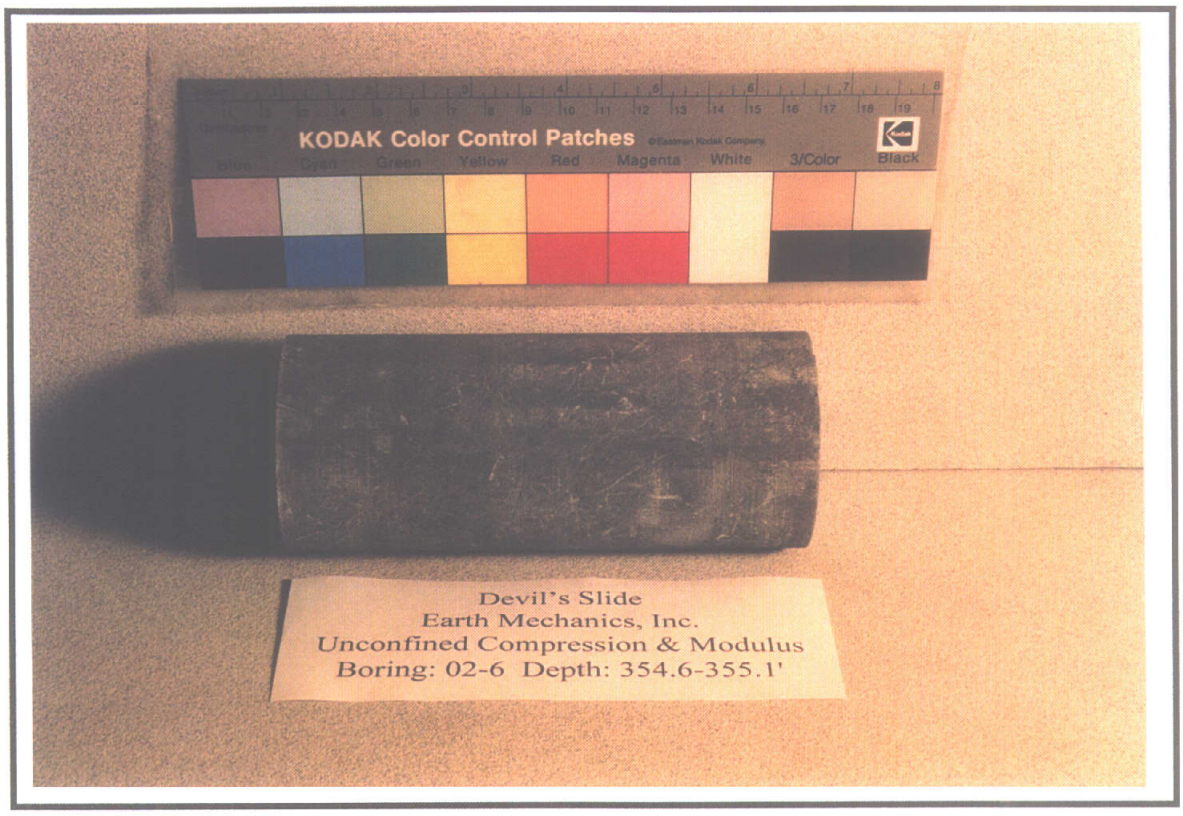
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

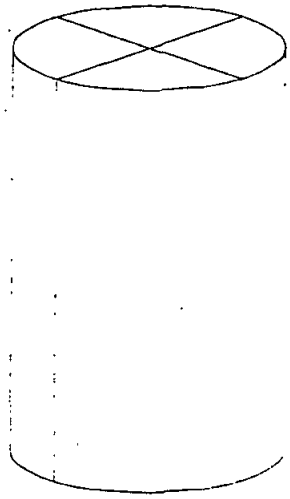
Date: 9/6&12/02
Technician: A. Brd

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: Dark gray heavily sheared & recemented fine grained sandstone with numerous calcite healed fractures.

Sample Depth: 354.6-355.1 Sample Condition: received dry - tested moist

d_1	d_2
2.399	2.400
2.404	2.401
2.402	2.400
2.402	2.400
2.403	2.400

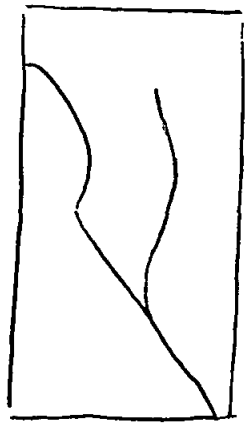
l_1	l_2
-.0004	-.0005
-.0003	-.0004
±.0003	±.0003
-.0013	-.0020
-.0020	-.0028



Avg. diameter : 2.401
Avg. length : 5.658
Sample area : 4.528
l/d ratio : 2.36
Sample volume(in^3) : 25.618
Sample weight (g) : 1087.5 g
Density : 42.458 g/in^3 = 161.7 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments: preloaded to about 6000 lb - mod test to incipient failure.

JOINT CONTROLLED FAILURE



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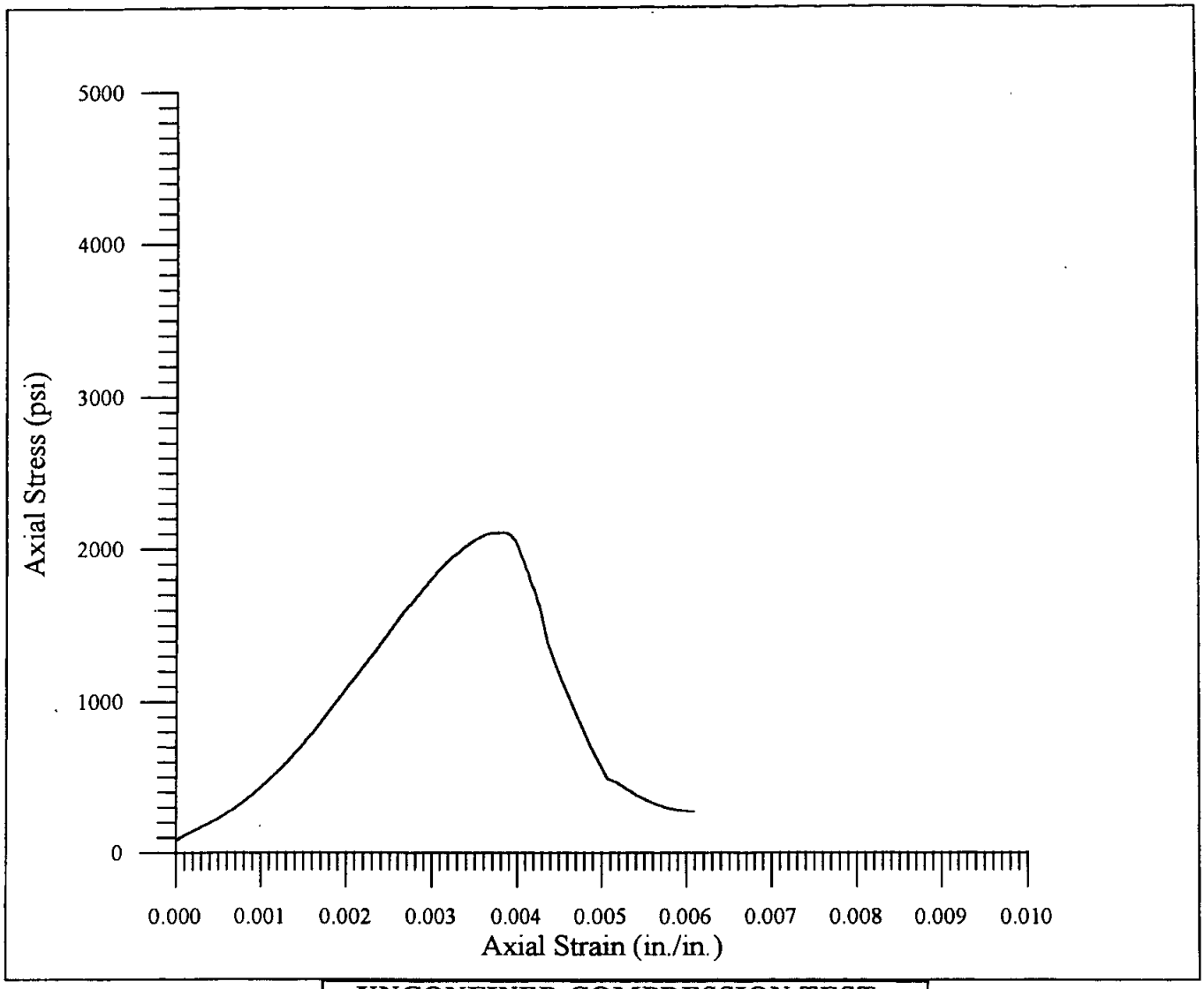


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-354
Boring: 02-6
Depth: 354.6-355.1'

DESCRIPTION
Dark gray heavily sheared and recemented fine grained sandstone with numerous calcite healed fractures.

Density: 161.7 pcf
Strength: 2107 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

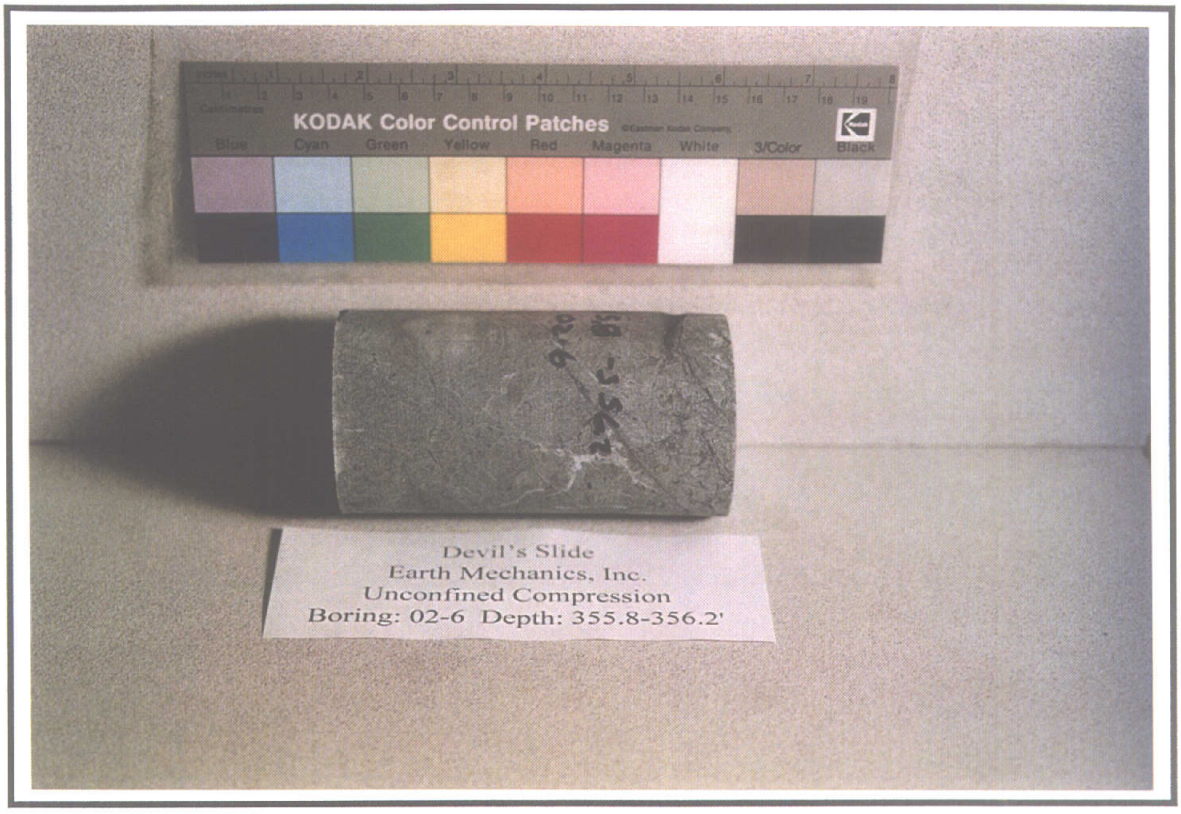
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

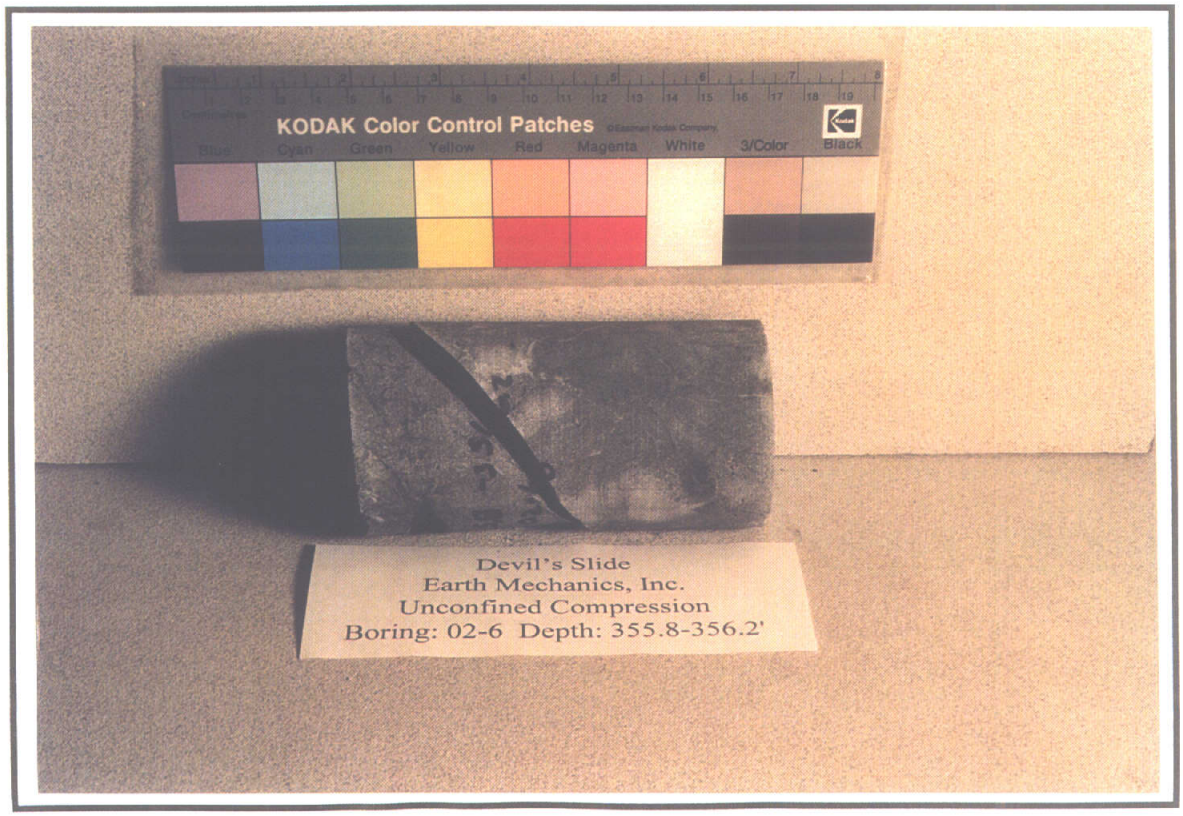
Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/13/02
Technician: A. Bro

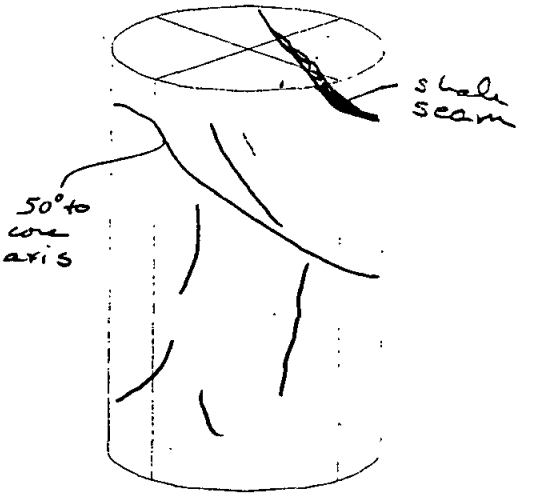
Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-6
Sample Description: grey Fine grained sandstone with calcite healed joints

Sample Depth: 355.3-356.2' Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.398
2.401	2.399
2.400	2.400
2.401	2.400
2.401	2.397

outlier ← ? don't use

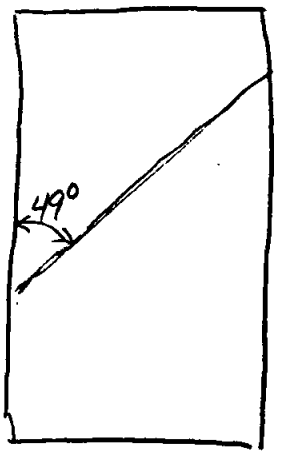
l_1	l_2
+.0019	+.0009
+.0009	+.0005
±.0001	±.0001
-.0011	-.0004
-.0023	-.0009



Avg. diameter: 2.400 Avg. length: 4.467
Sample area: 4.524 l/d ratio: 1.86
Sample volume(in^3): 20.208
Sample weight (g): 863.38
Density: 42.728 g/in^3 = 162.7 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE - sheared on 50° joint



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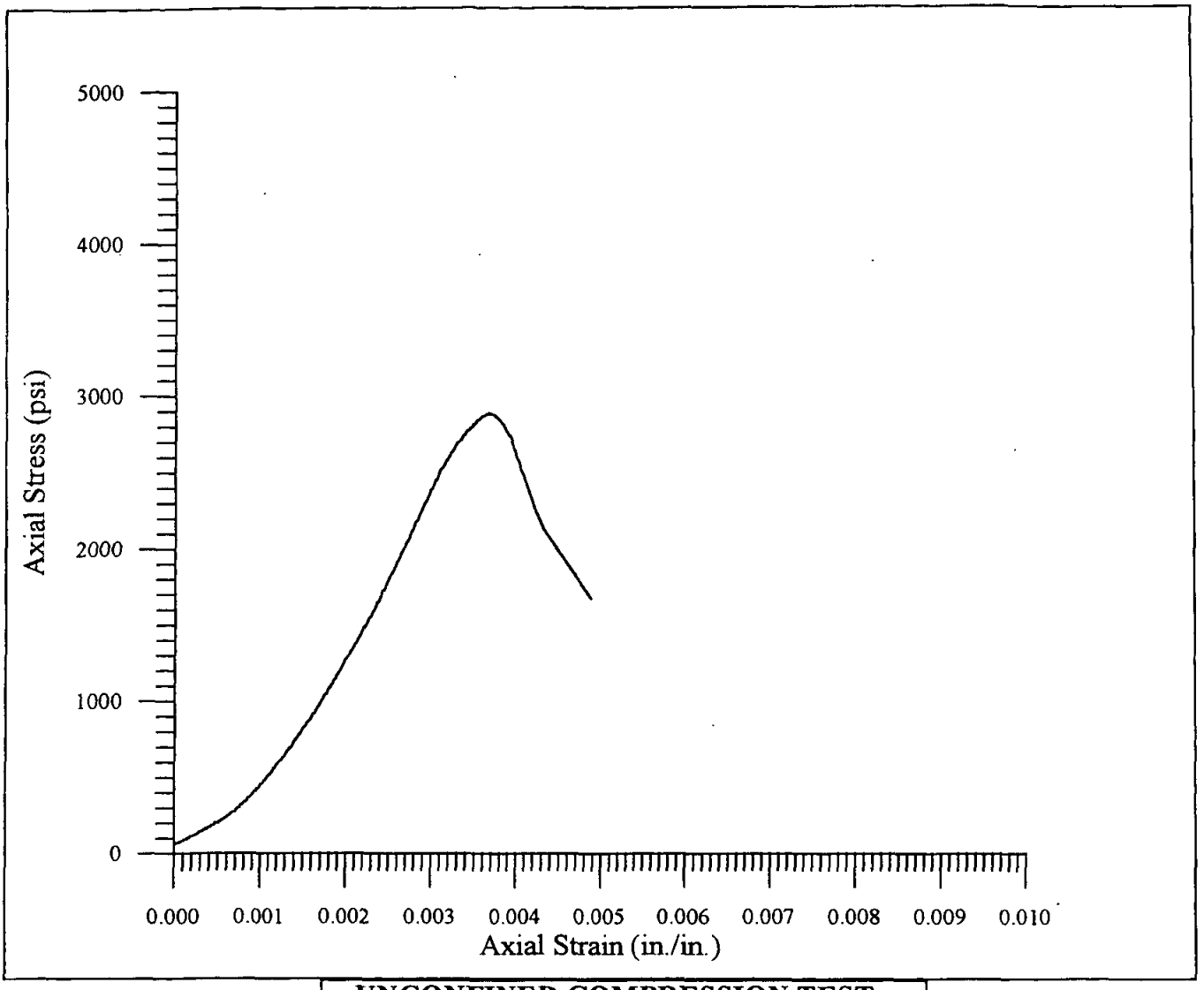


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-355
Boring: 02-6
Depth: 355.8-356.2'

DESCRIPTION

Gray fine grained sandstone with several calcite healed joints, one about 50 degrees to the core axis.

Density: 162.7 pcf
Strength: 2885 psi
Joint Control Failure?: yes

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

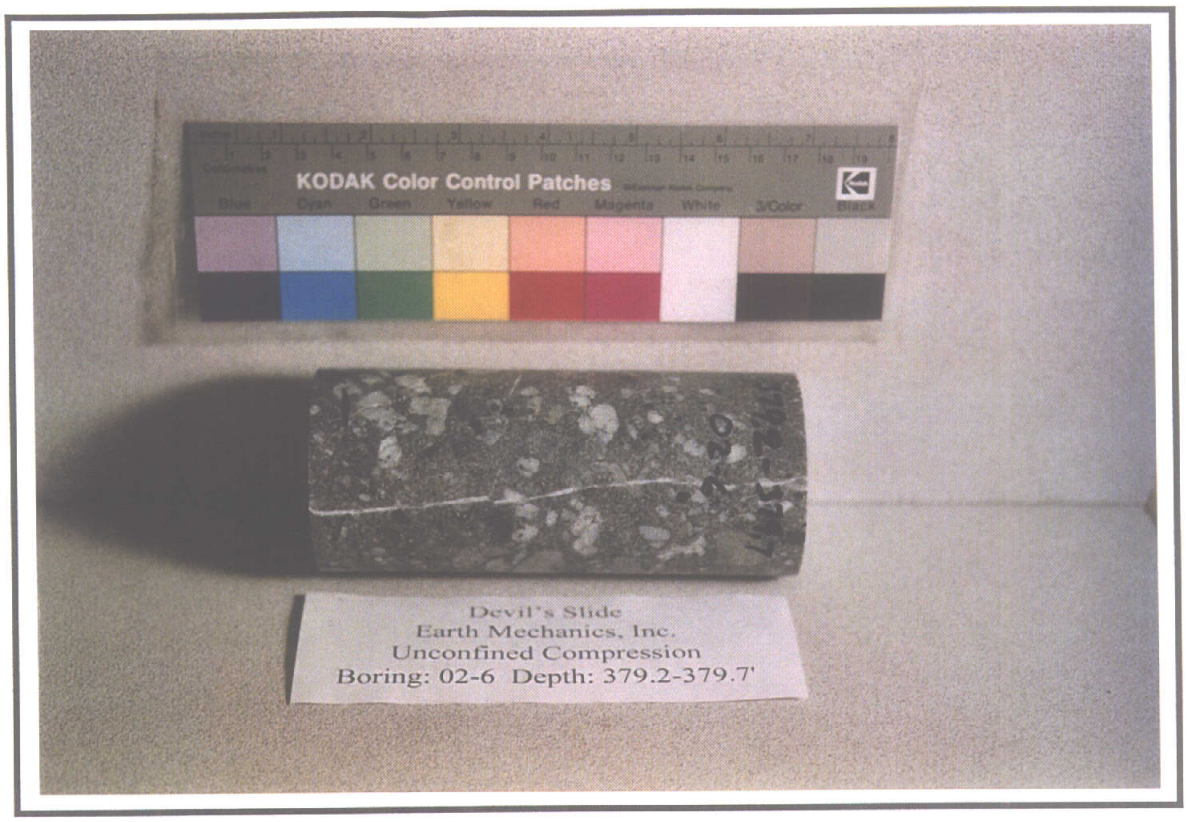
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/13/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: Gray conglomerate w/ rounded granitic clasts up to ~ 1/2" in a matrix of fine grained sandstone with a calcite healed axial joint and weak diagonal joint

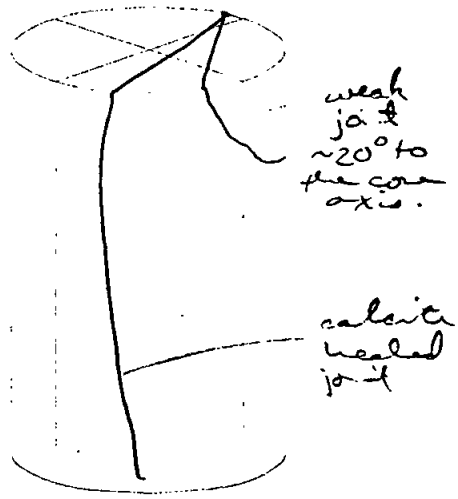
Sample Depth: 379.2-379.7' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.400
2.400	2.398
2.401	2.400
2.402	2.400
2.400	2.402

l_1	l_2
+.0006	+.0007
+.0003	+.0005
±.0001	±.0002
-.0003	-.0005
-.0005	-.0010

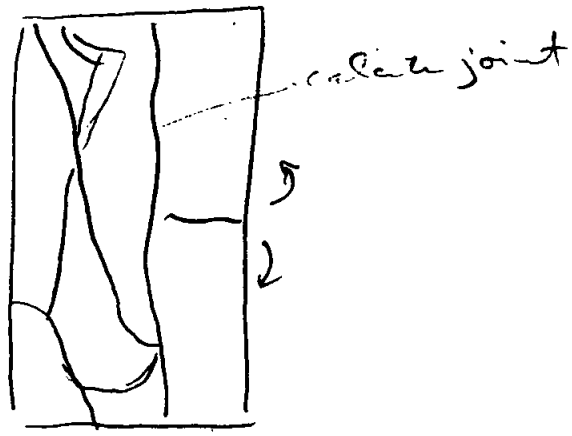
Avg. diameter : 2.400
Sample area : 4.524
Sample volume(in^3) : 24.927
Sample weight (g) : 1082.1 g
Density : 43.41 g/in^3 = 165.4 pcF (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.510
l/d ratio : 2.30



Comments:

JOINT CONTROLLED FAILURE & THROUGH INTACT ROCK by axial splitting & shear, then bending



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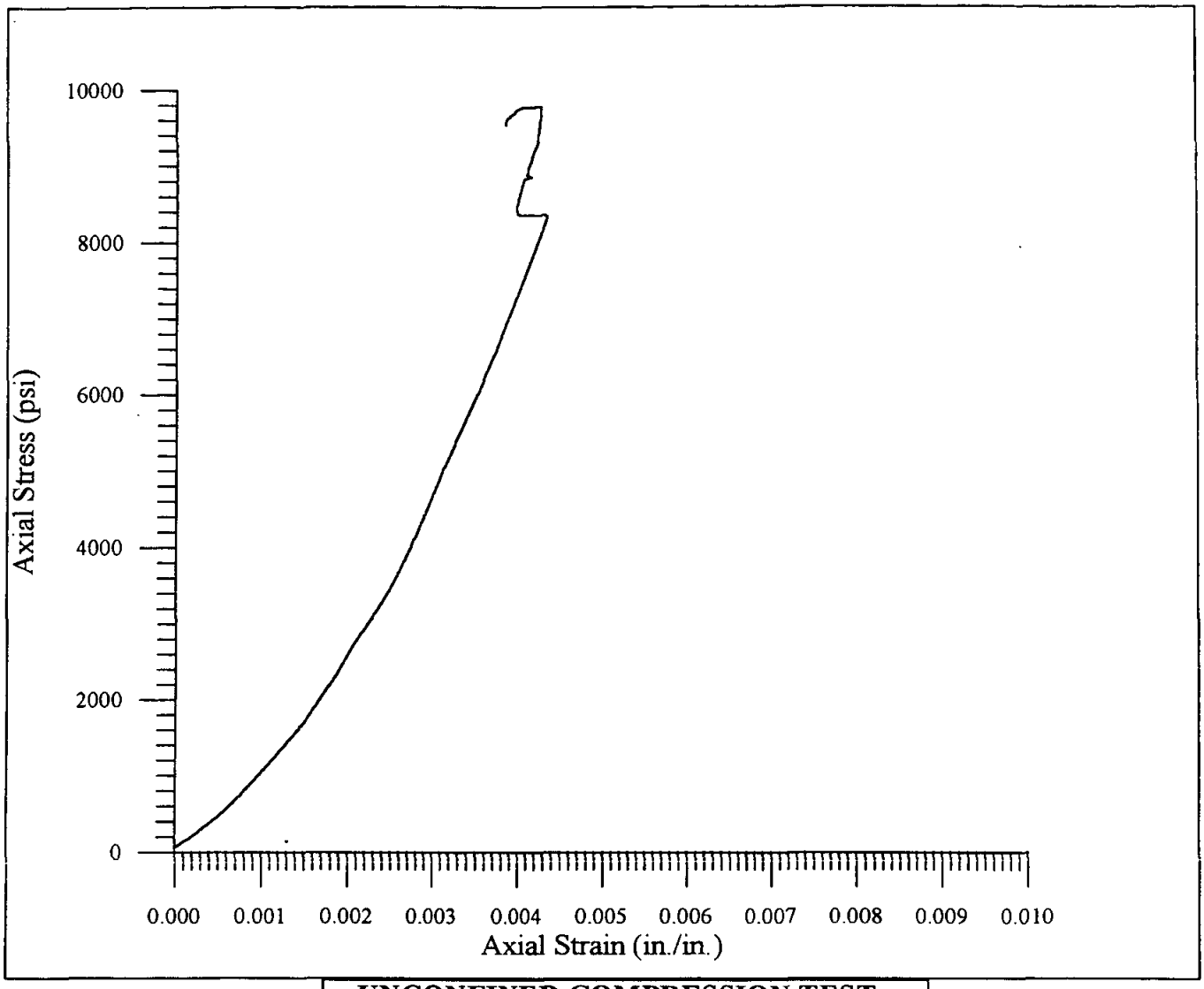


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-379
Boring: 02-6
Depth: 379.2-379.7'

DESCRIPTION

Gray conglomerate with rounded granitic clasts up to about 1/2 inch in a matrix of fine grained sandstone with a calcite healed axial joint and one weak diagonal joint.

Density: 165.4 pcf
Strength: 9787 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

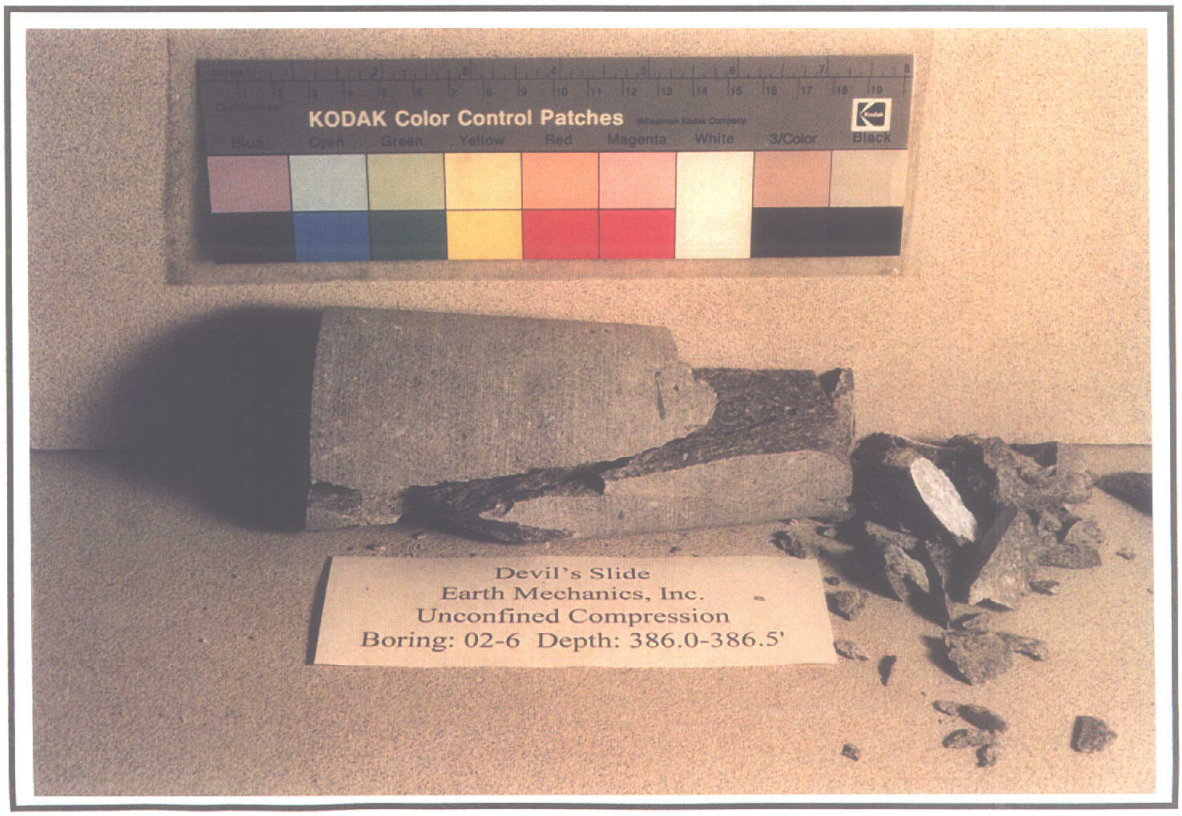
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



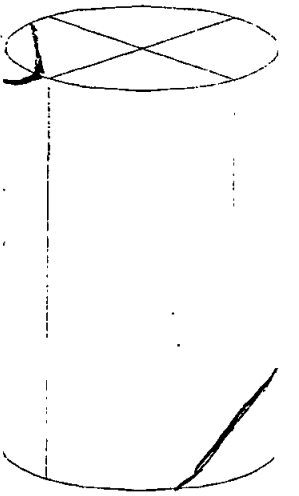
Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/13/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray med. grained sandstone w/ 2 calcite healed joints

Sample Depth: 386.0-386.5' Sample Condition: received dry - tested wet



d_1	d_2
2.400	2.400
2.400	2.400
2.400	2.400
2.401	2.401
2.400	2.400

l_1	l_2
+.0008	+.0001
+.0005	0
±.0001	±.0001
-.0004	-.0001
-.0008	-.0002

Avg. diameter : 2.400 Avg. length : 5.411
Sample area : 4.524 l/d ratio : 2.25
Sample volume(in^3) : 24.479
Sample weight (g) : 1062.3 g
Density : 43.40 g/in^3 = 165.3 pcF (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE - explosive - indications are by axial splitting

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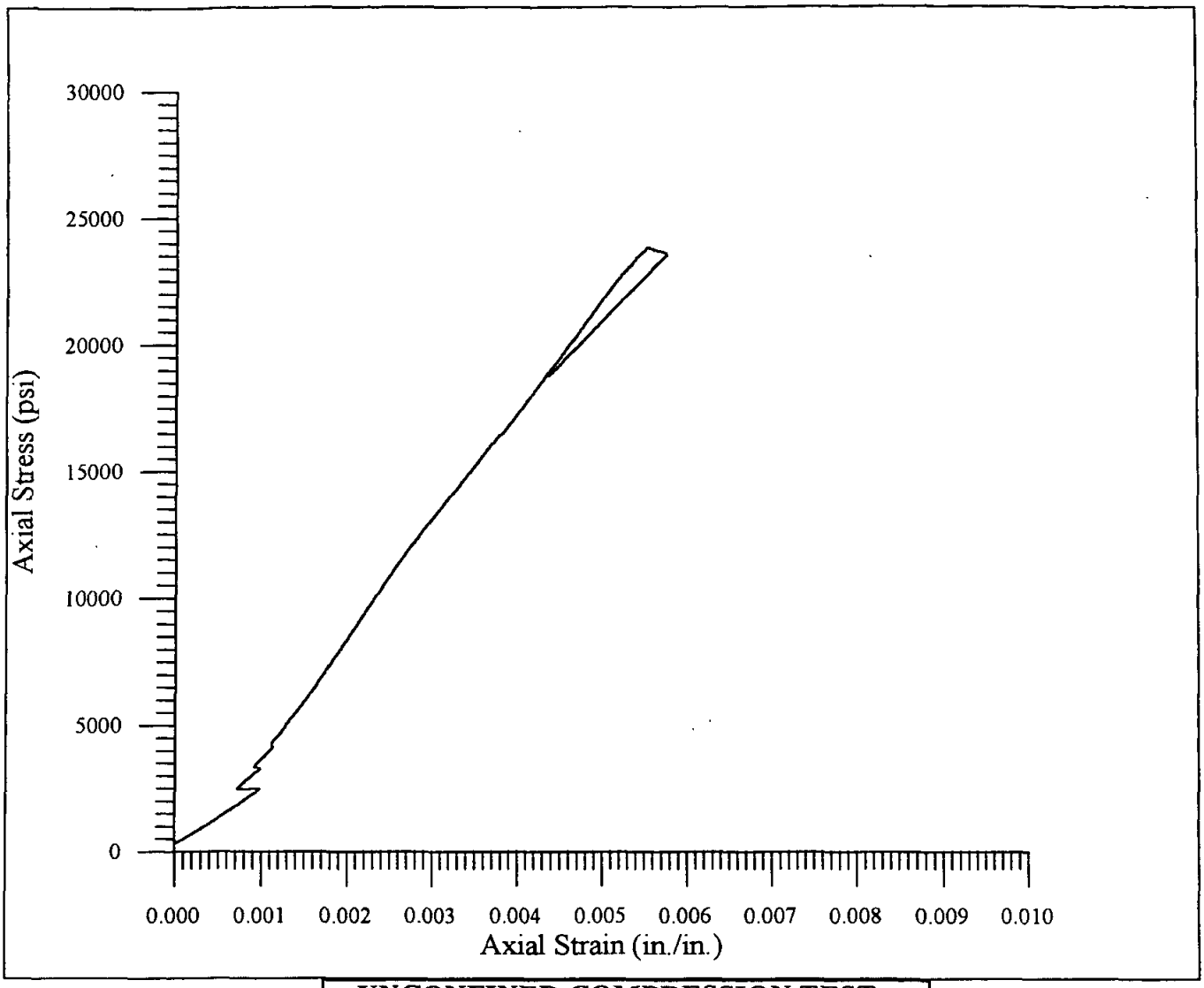


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-386
Boring: 02-6
Depth: 386.0-386.5'

DESCRIPTION
Gray medium grained sandstone with two minor calcite healed joints.

Density: 165.3 pcf
Strength: 23,818 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

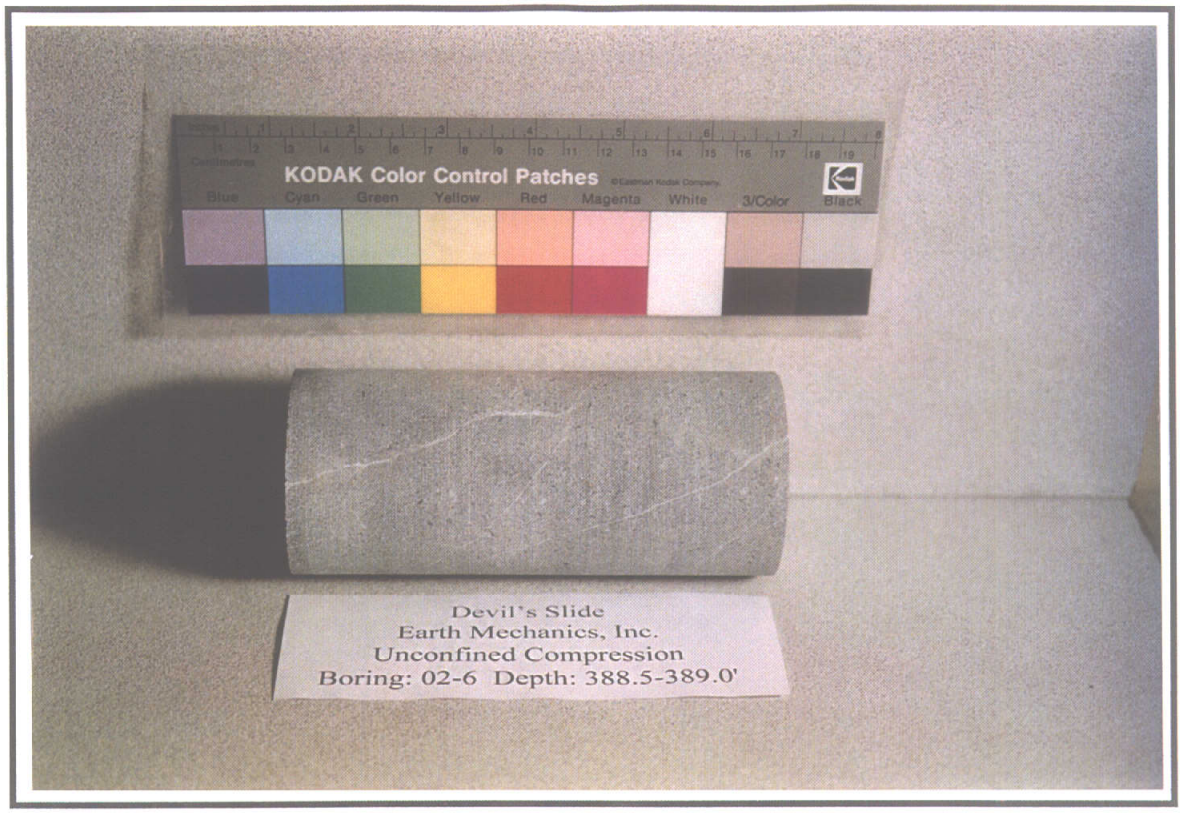
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

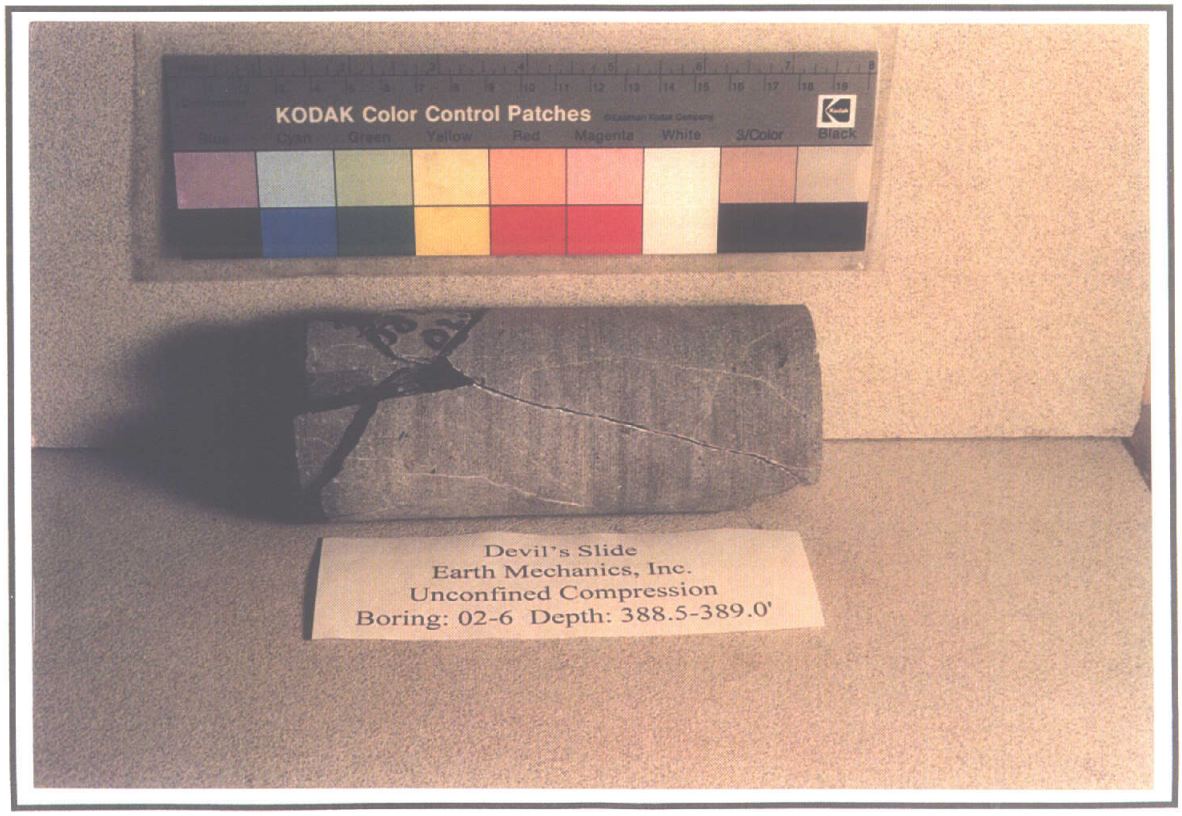
Project: Devil's Slide

Project Number: none

Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

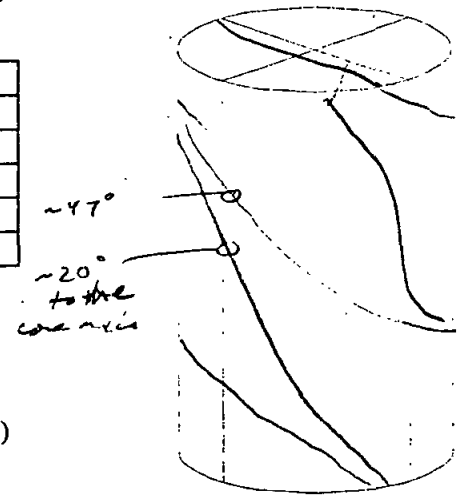
Date: 9/13/02
Technician: A. Bro

Client: EMI
Job: #151 - Devils Slide
Sample ID: Boring 02-6
Sample Description: Gray medium grained sandstone with a few calcite healed joints

Sample Depth: 388.5-389.0 Sample Condition: received dry - Tested - int

d_1	d_2
2.398	2.398
2.398	2.399
2.398	2.398
2.399	2.400
2.400	2.399

l_1	l_2
+.0010	0
+.0005	0
±.0001	±.0001
-.0005	0
-.0010	0

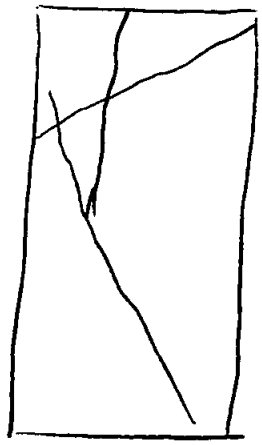


Avg. diameter : 2.399
Sample area : 4.520
Sample volume(in^3) : 25.060
Sample weight (g) : 1089.6
Density : 43.48 g/in^2 = 165.6 pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.544
l/d ratio : 2.31

Comments:

JOINT CONTROLLED FAILURE - Failed by sliding along 20° joint & axial splitting.



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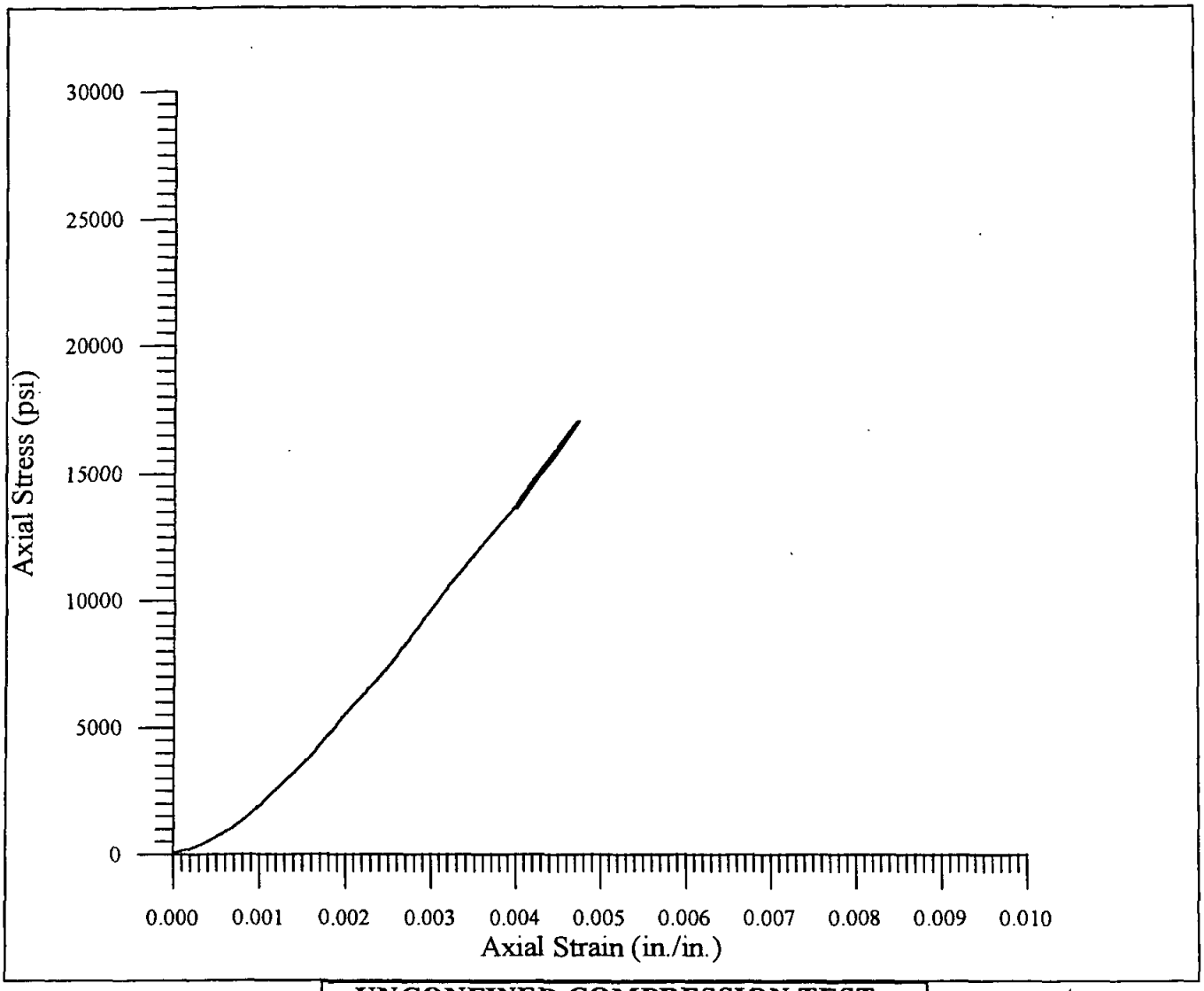


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-388
Boring: 02-6
Depth: 388.5-389.0'

DESCRIPTION

Gray medium grained sandstone with a few calcite healed joints.

Density: 165.6 pcf
Strength: 17,041 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

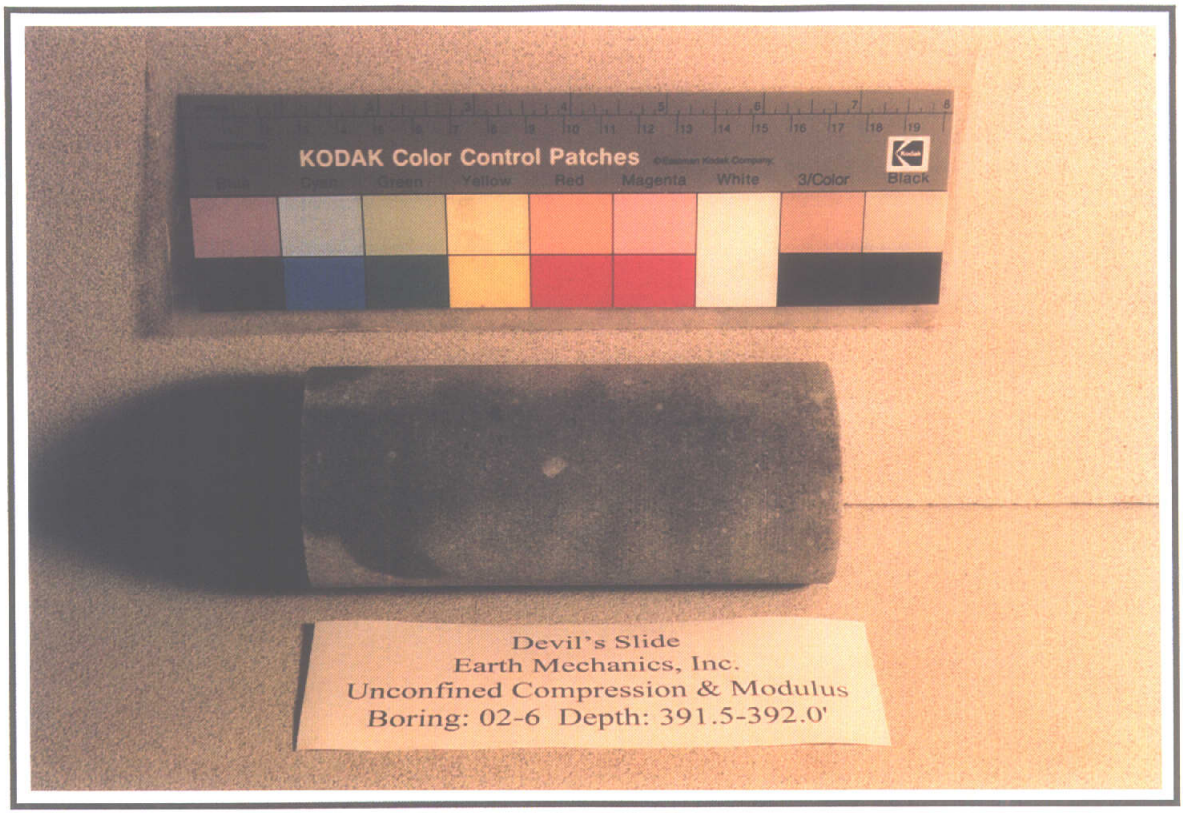
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

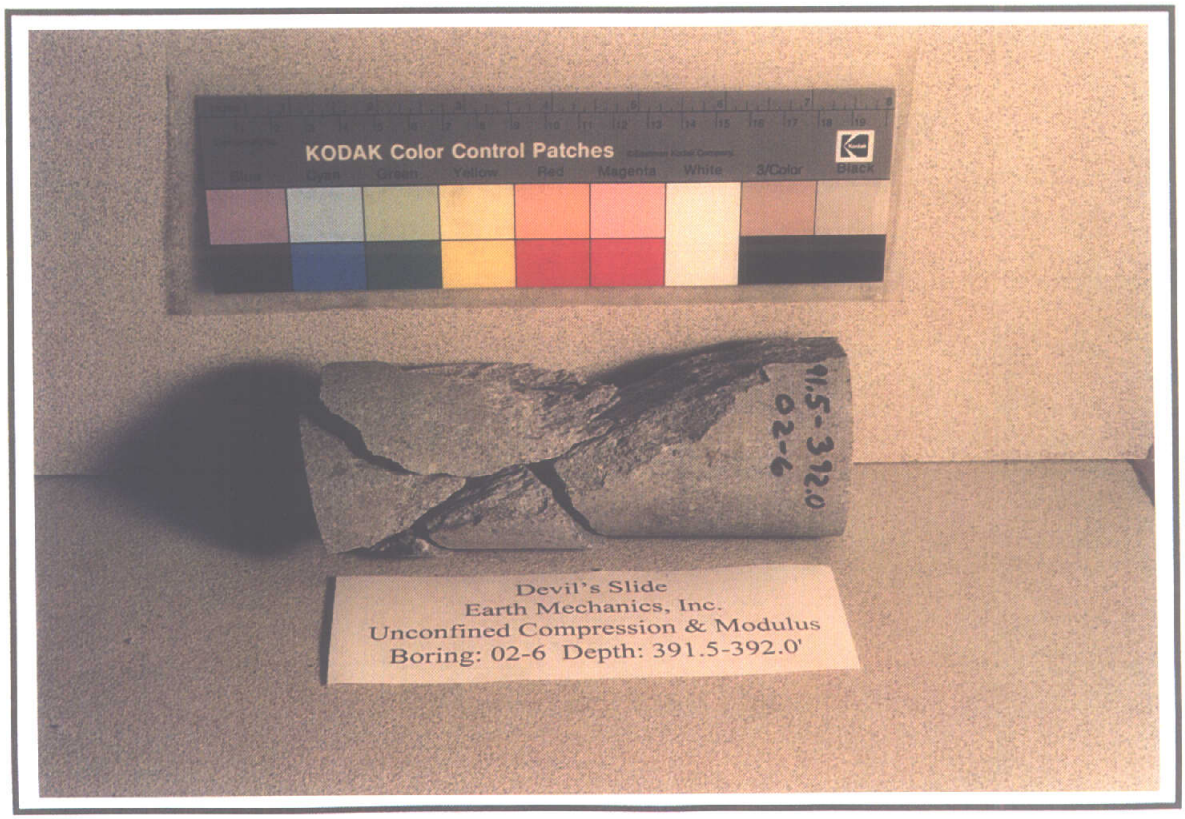
Project: Devil's Slide

Project Number: none

Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

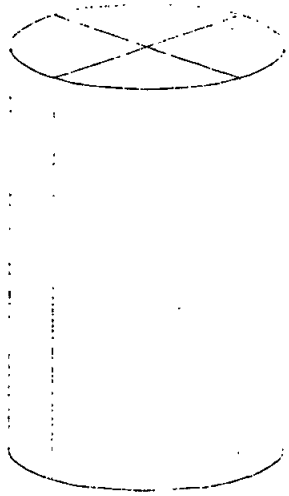
Date: 9/6 & 13/02
Technician: A. Bro

Client: ERT
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray medium grained sandstone. - No apparent Fractures.

Sample Depth: 391.5 - 392.0' Sample Condition: received dry - tested moist

d_1	d_2
2.398	2.398
2.400	2.400
2.399	2.399
2.398	2.397
2.400	2.397

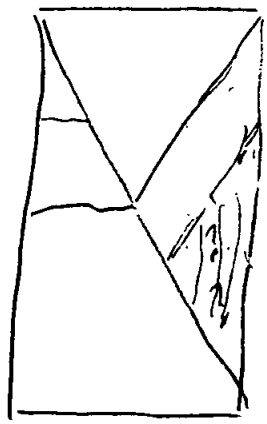
l_1	l_2
+.0008	+.0001
+.0004	0
±.0001	±.0002
-.0004	0
-.0008	-.0001



Avg. diameter : 2.399 Avg. length : 5.498"
Sample area : 4.520 l/d ratio : 2.29
Sample volume(in^3) : 24.852
Sample weight (g) : 1074.88
Density : 43.258 g/in^3 = 164.8 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000in

Comments: retested modulus after modifying DA program to increase resolution of LVDT readings.

INTACT FAILURE - Failed by shear & banding



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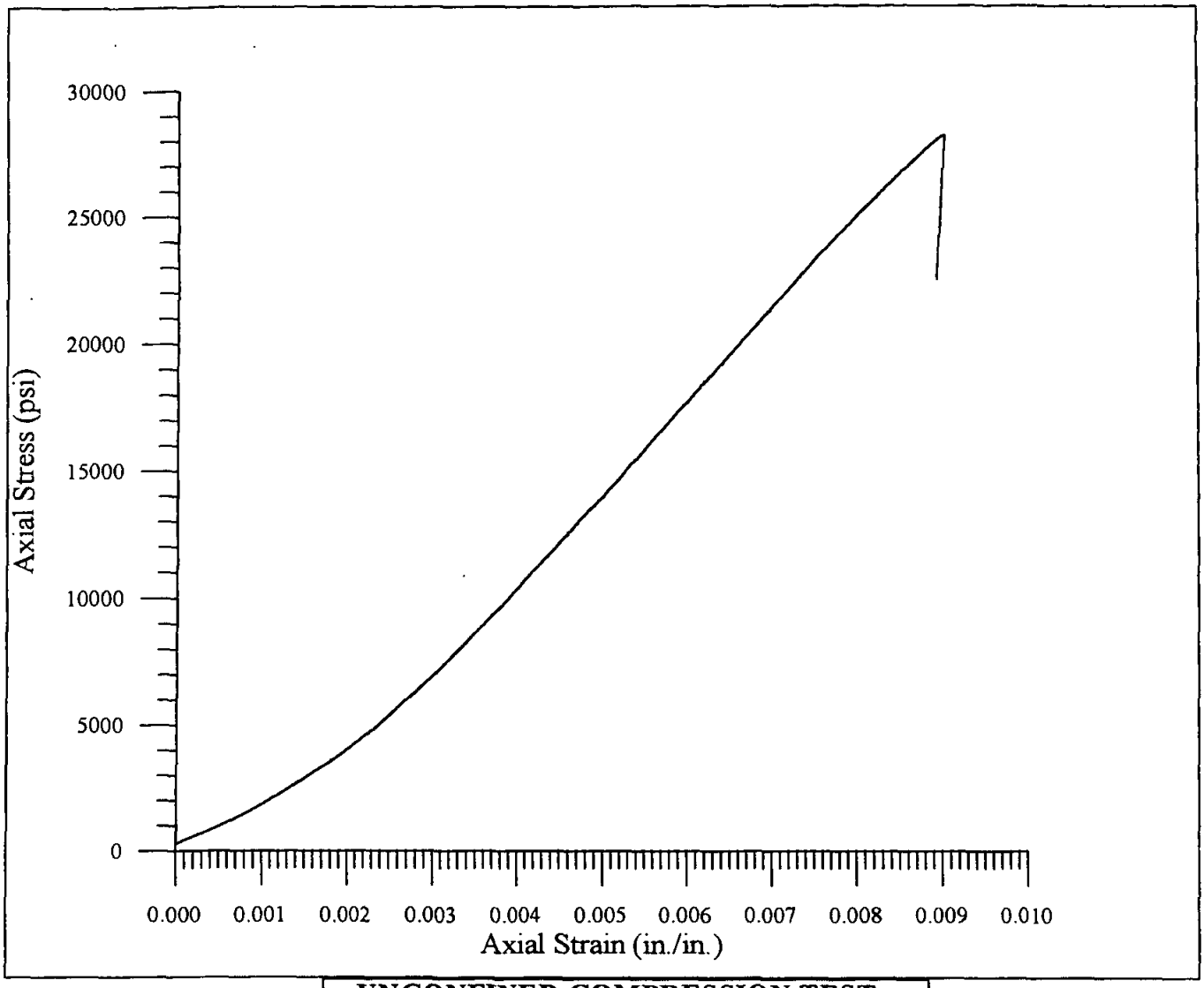


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-391
Boring: 02-6
Depth: 391.5-392.0'

DESCRIPTION
Gray medium grained sandstone
with no apparent fractures.

Density: **164.8 pcf**
Strength: 28,233 psi
Joint Control Failure?: **no**

Geo G T U *Test Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

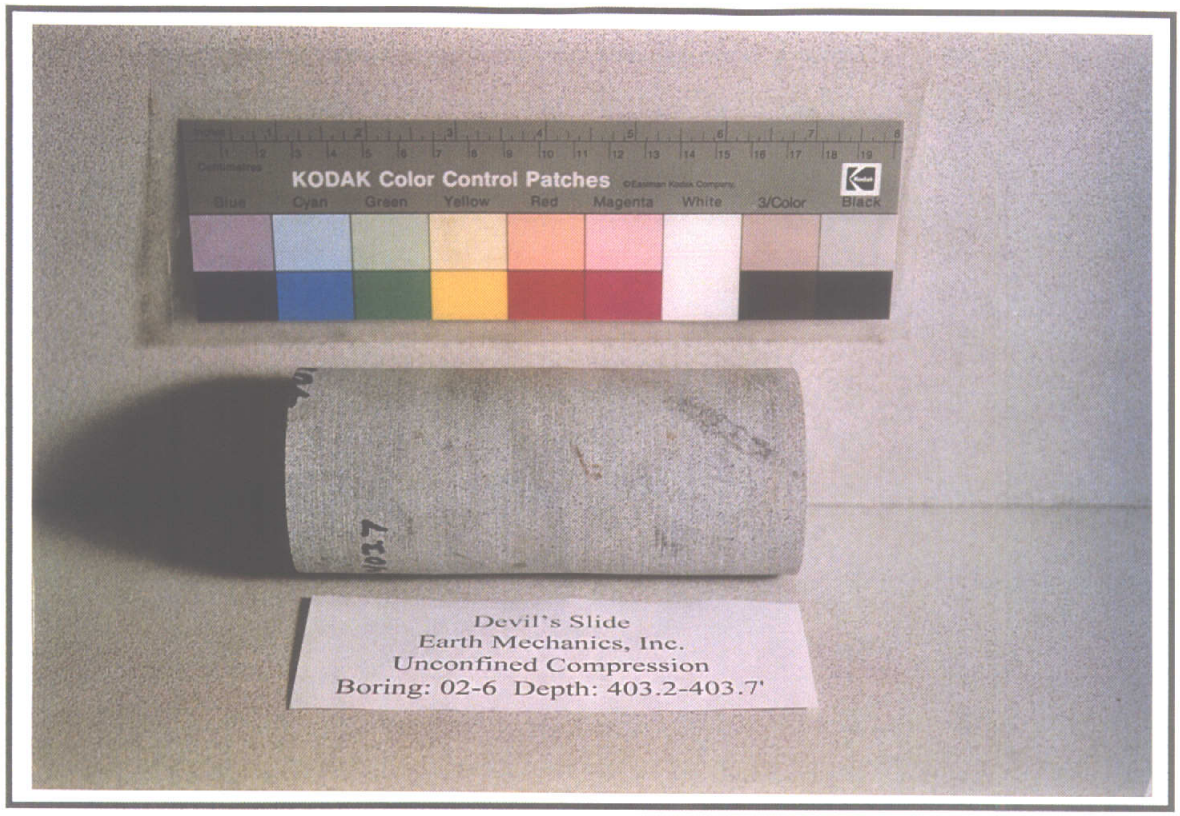
Client: **Earth Mechanics, Inc.**
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

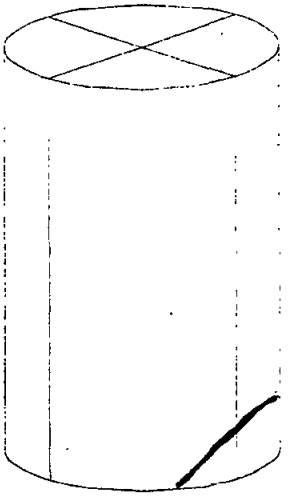
Date: 9/13/02
Technician: A. Bro

Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-6
Sample Description: Gray medium grained sandstone with one calcite healed joint.

Sample Depth: 403.2-403.7' Sample Condition: received dry - tested moist

d_1	d_2
2.394	2.396
2.395	2.391
2.393	2.393
2.390	2.392
2.385	2.389

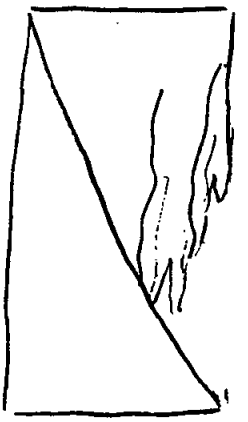
l_1	l_2
+.0009	0
+.0004	0
±.0001	±.0002
-.0005	0
-.0011	0



Avg. diameter : 2.392
Sample area : 4.494
Sample volume(in^3) : 25.507
Sample weight (g) : 1104.7 g
Density : 43.31 g/in^3 = 165.0 pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.676"
l/d ratio : 2.37

Comments:
INTACT FAILURE - by diagonal shear (possibly axial splitting?)



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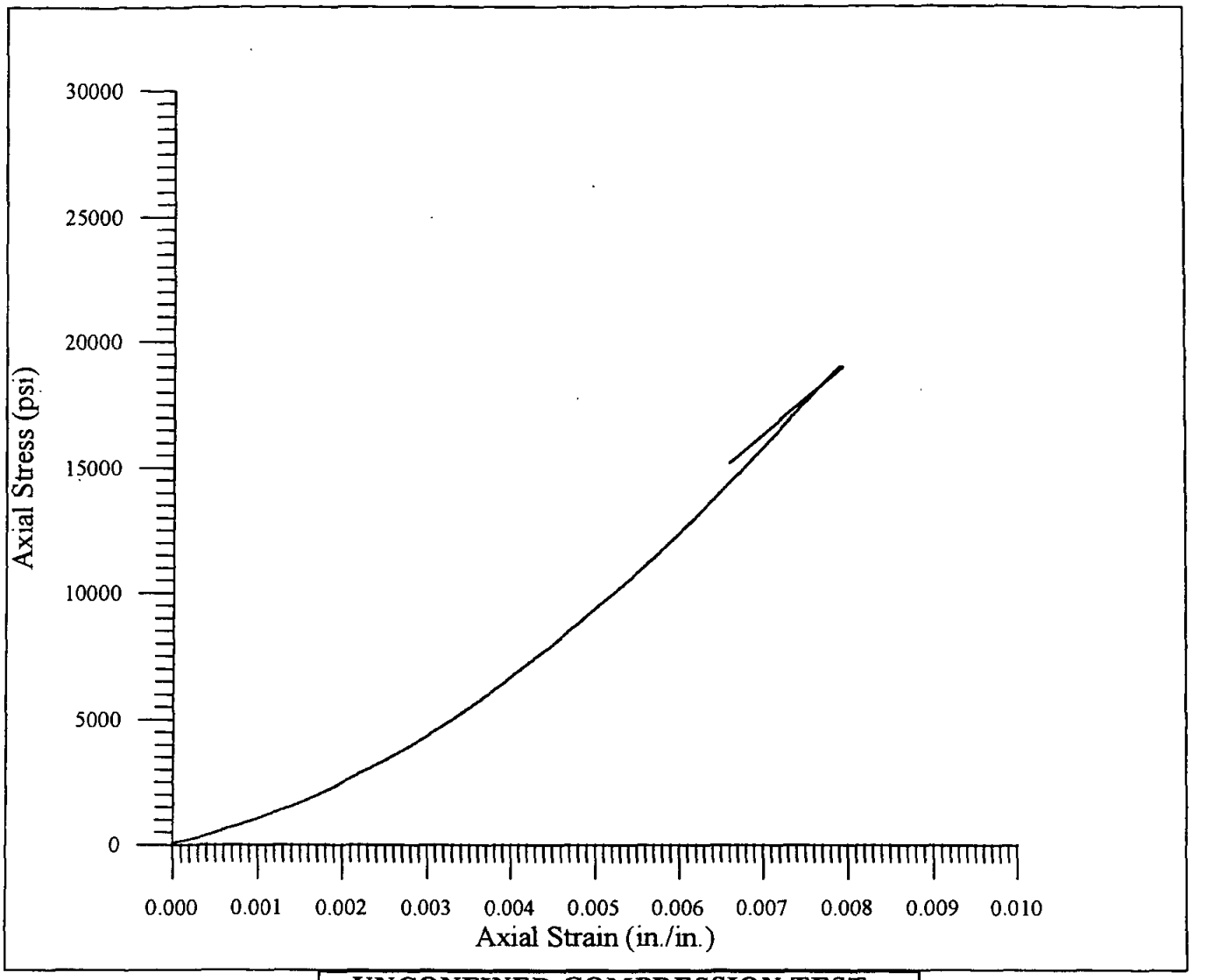


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-403
Boring: 02-6
Depth: 403.2-403.7'

DESCRIPTION
Gray medium grained sandstone with one minor calcite healed joint.

Density: 165.0 pcf
Strength: 19,056 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

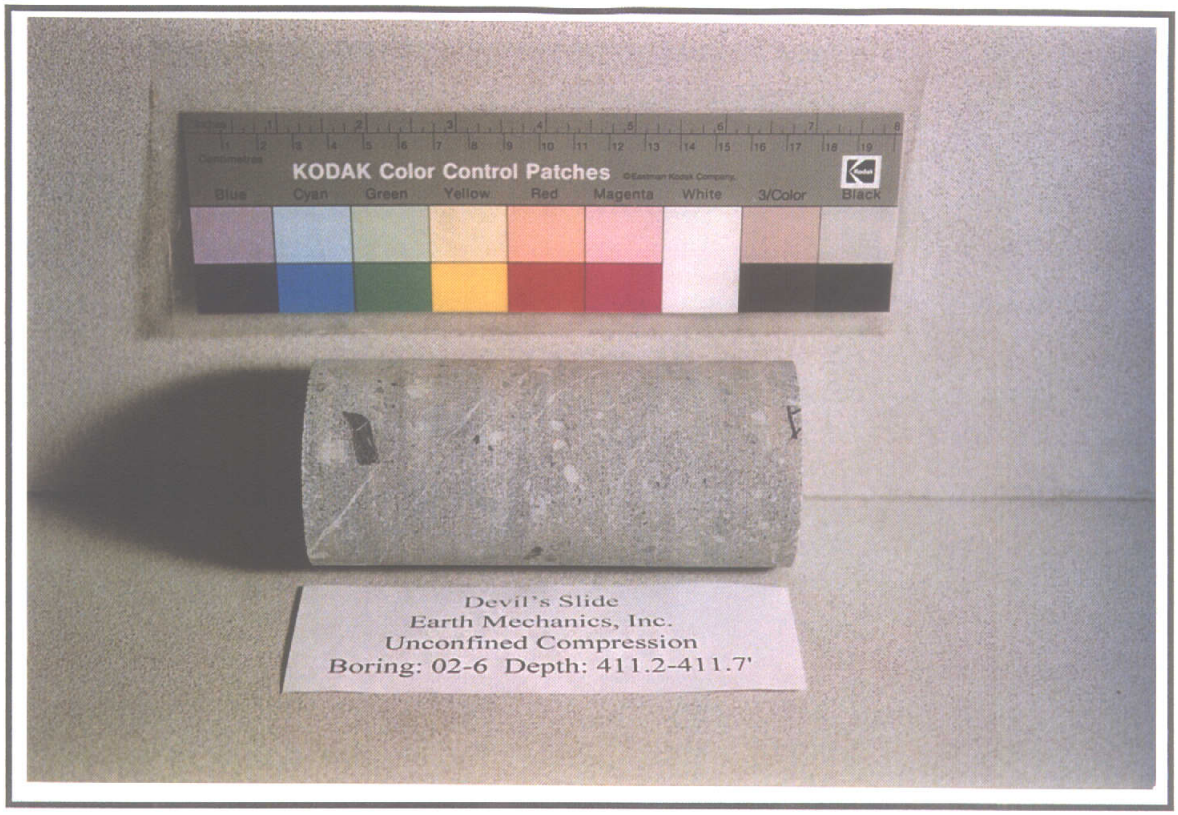
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

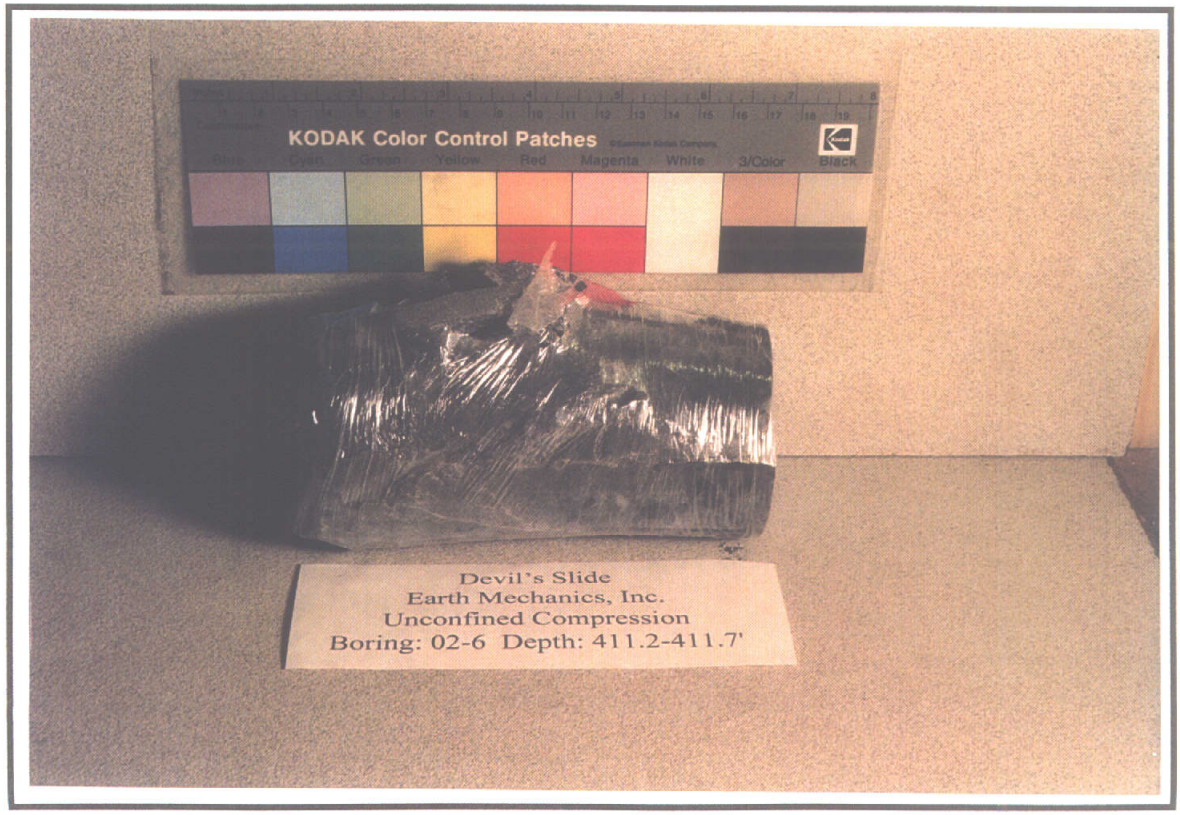
Project: Devil's Slide

Project Number: none

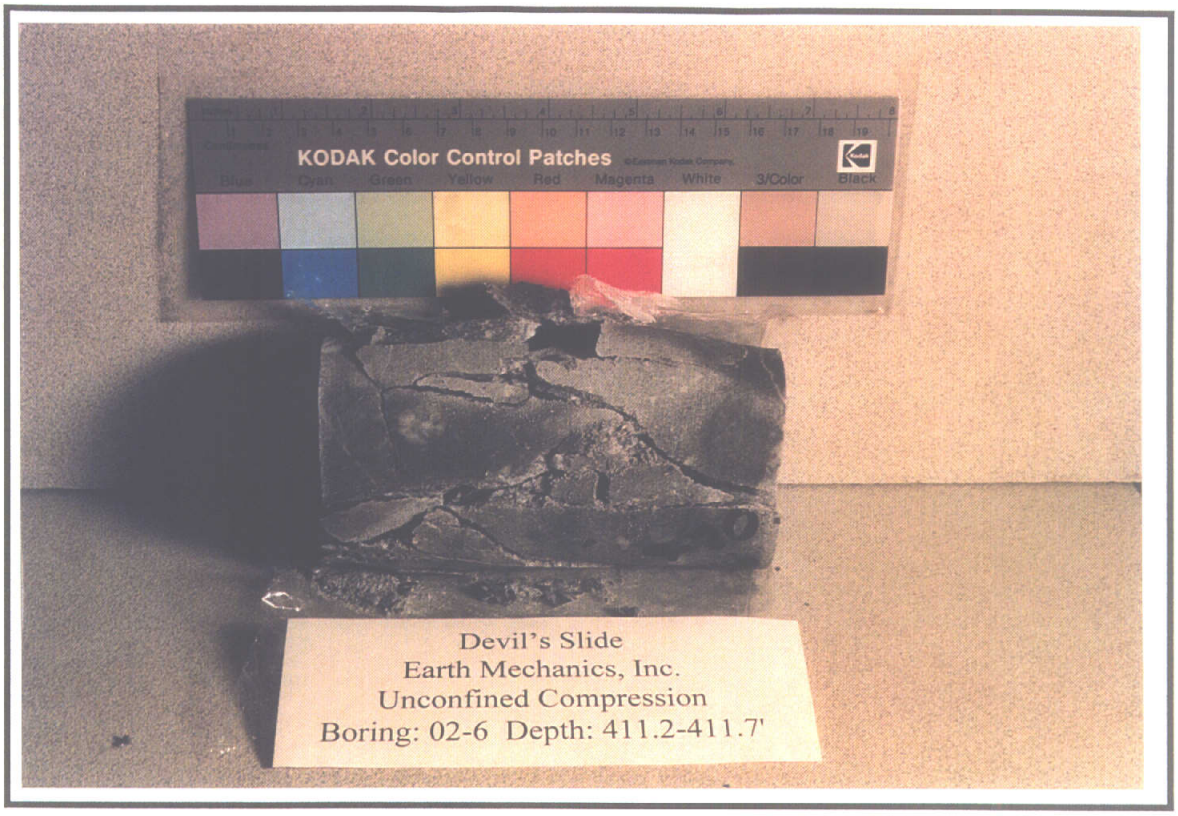
Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

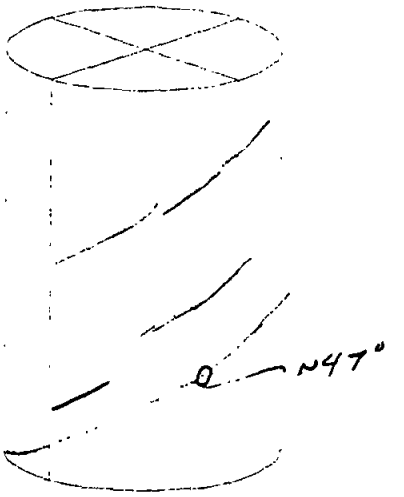
Date: 9/13/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray conglomeratic sandstone (<5% granitic clasts, up to about ½") with a few calcite healed joints

Sample Depth: 411.2-411.7' Sample Condition: received dry - tested moist

d_1	d_2
2.397	2.397
2.398	2.399
2.398	2.399
2.398	2.397
2.397	2.398

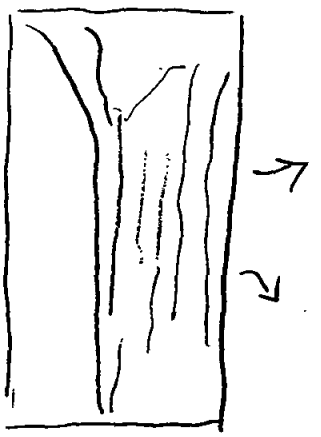
l_1	l_2
+.0012	+.0001
+.0006	0
1.0001	±.0001
-.0003	0
-.0007	-.0001



Avg. diameter: 2.398 Avg. length: 5.454
Sample area: 4.516 l/d ratio: 2.27
Sample volume(in³): 24.632
Sample weight (g): 1070.28
Density: 43.45 g/in³ = 165.5 pcF (1 g/in³=3.8095lb/ft³)

Comments:

INTACT FAILURE - by axial splitting



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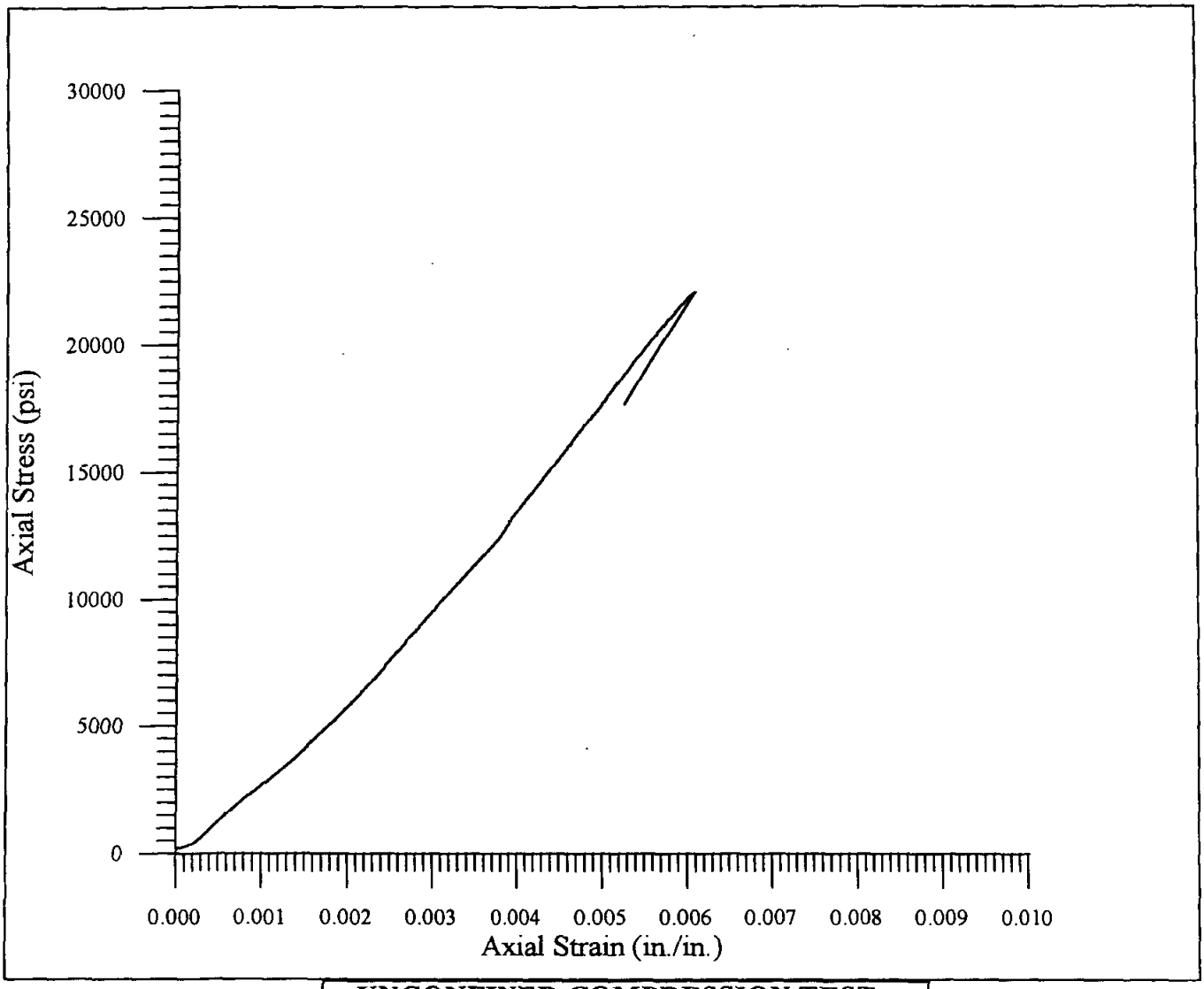


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-411
Boring: 02-6
Depth: 411.2-411.7'

DESCRIPTION

Gray conglomeratic sandstone with a few calcite healed joints about 47 degrees to the core axis.

Density: 165.5 pcf
Strength: 22,076 psi
Joint Control Failure?: no

Geo *G T U* *Test* *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

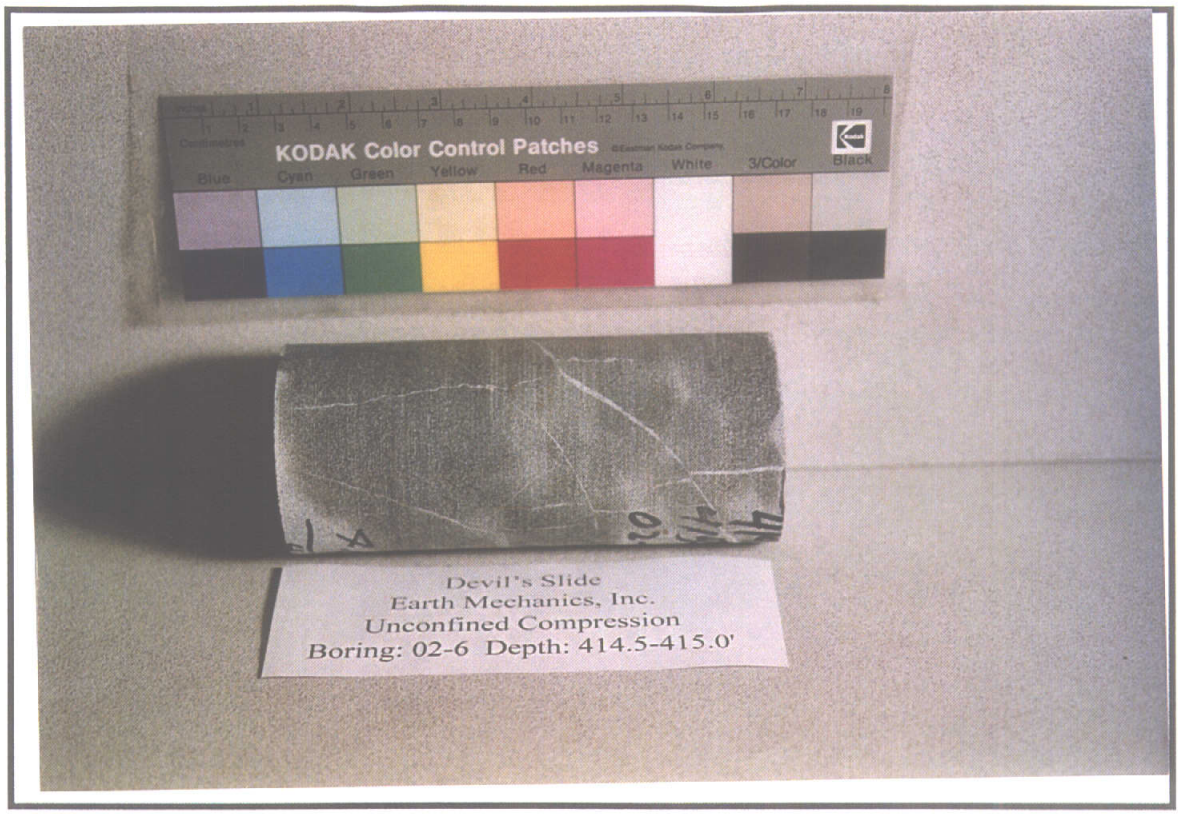
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

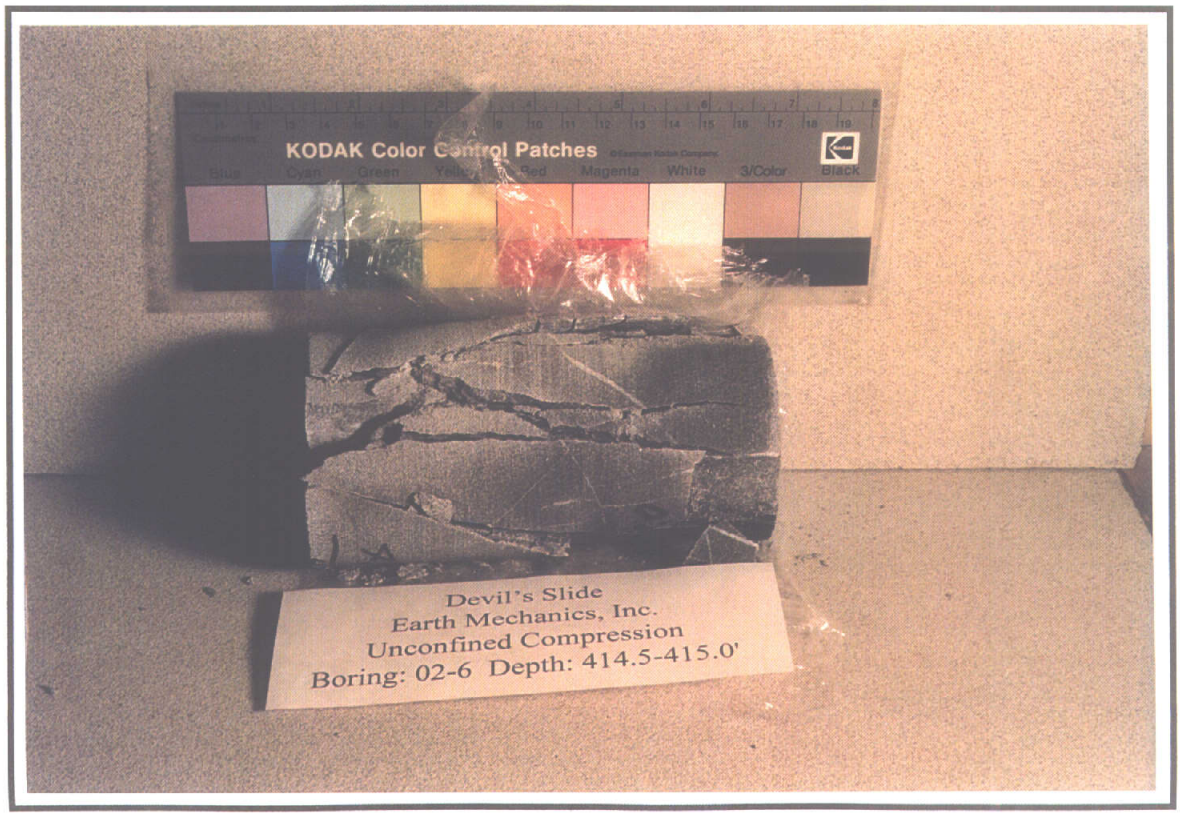
Project: Devil's Slide

Project Number: none

Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

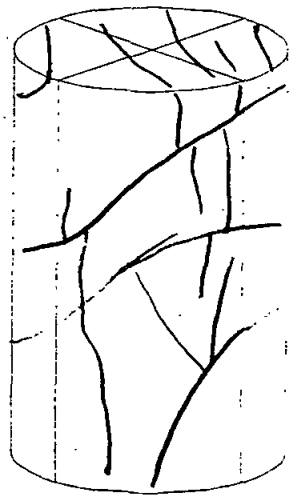
Date: 9/13/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray sandstone with several calcite healed joints

Sample Depth: 414.5-415.0' Sample Condition: received dry - tested moist

d_1	d_2
2.397	2.397
2.397	2.397
2.397	2.396
2.397	2.396
2.396	2.397

l_1	l_2
+.0007	0
+.0003	0
±.0001	±.0002
-.0004	0
-.0009	0

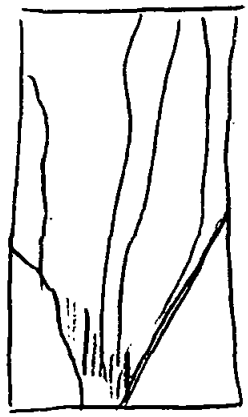


Avg. diameter : 2.397
Sample area : 4.513
Sample volume(in^3) : 24.779
Sample weight (g) : 1076.1 g
Density : 43.43 g/in^3 = 165.4 pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.491"
l/d ratio : 2.29

Comments:

JOINT CONTROLLED FAILURE ? generally axial splitting and some shear



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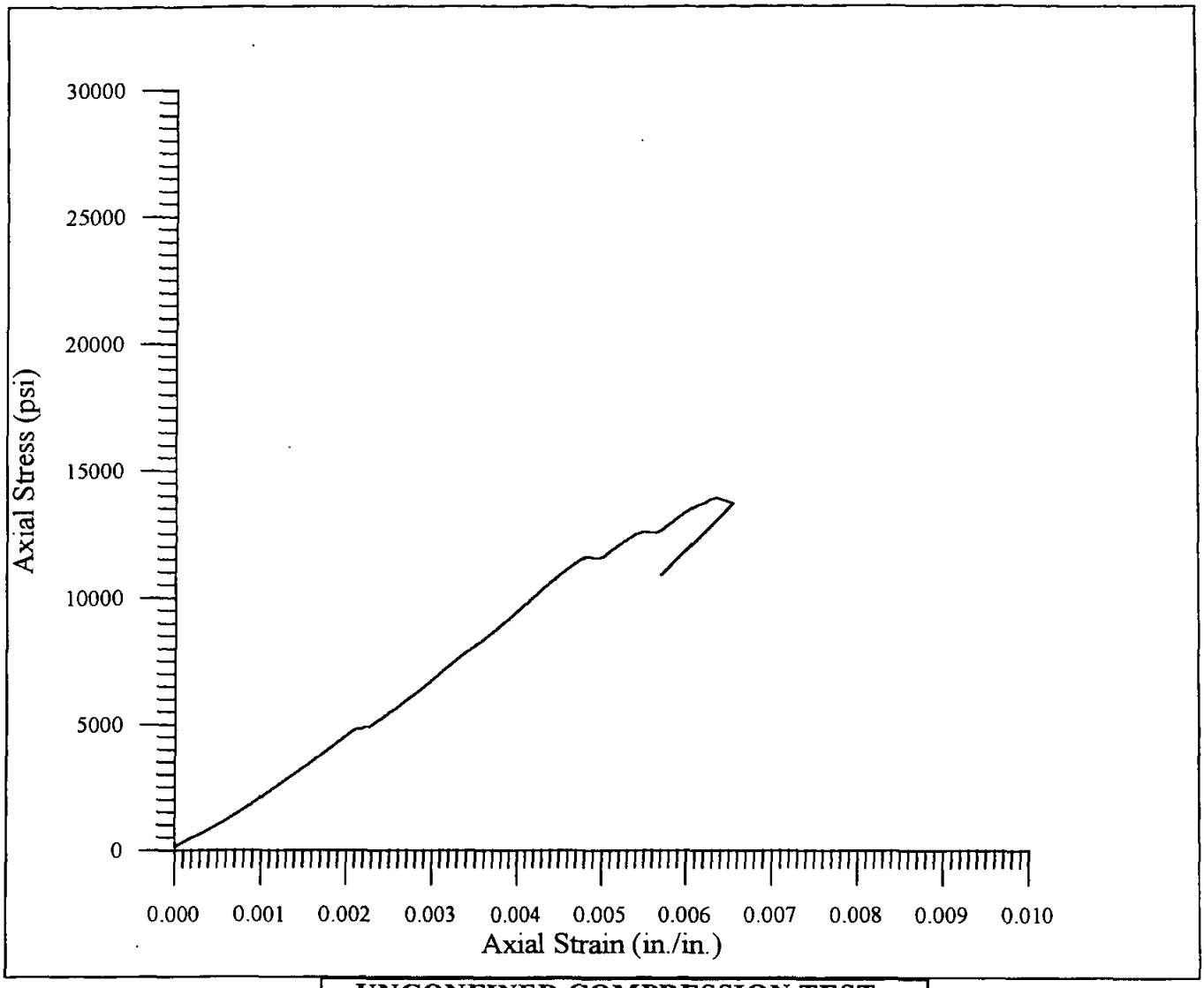


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-414
Boring: 02-6
Depth: 414.5-415.0'

DESCRIPTION
Gray sandstone with several calcite healed joints.

Density: 165.4 pcf
Strength: 13,937 psi
Joint Control Failure?: yes??

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

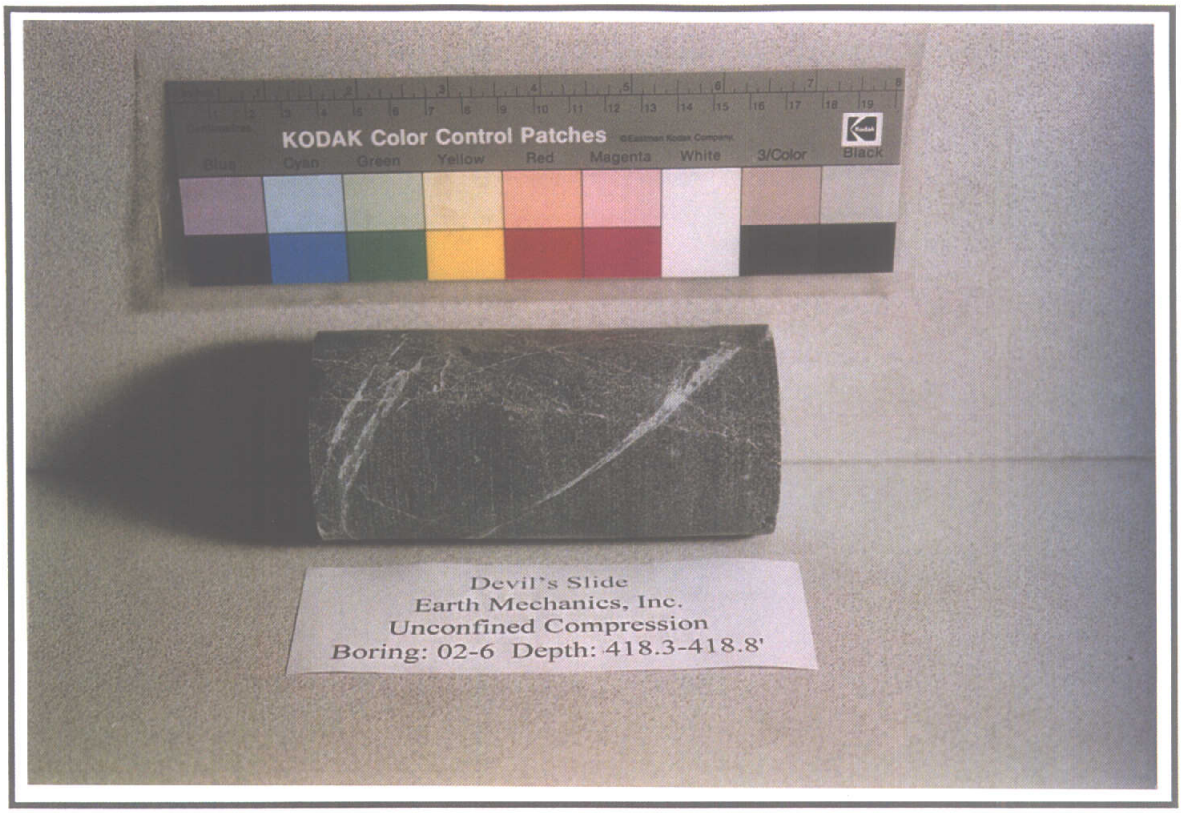
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

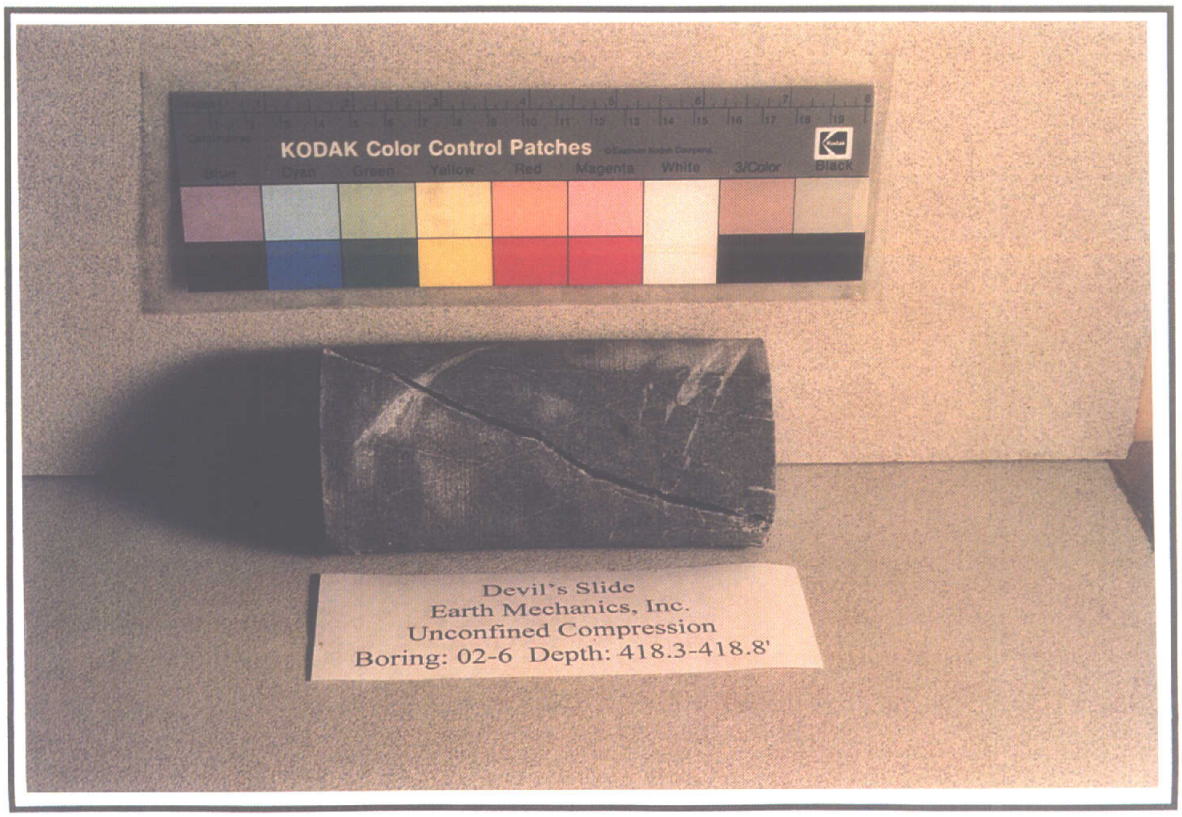
Project: Devil's Slide

Project Number: none

Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

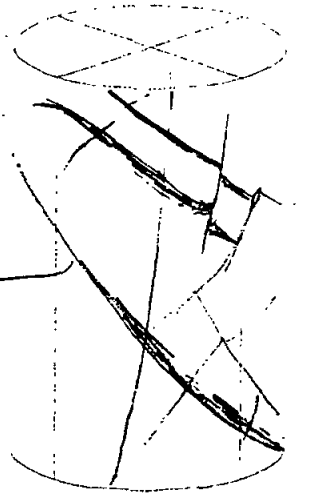
Date: 9/13/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray sandstone w/ several calcite healed joints (joint held some water - ie partially open)

Sample Depth: 418.3-418.8' Sample Condition: received dry - tested moist

d_1	d_2
2.397	2.398
2.398	2.396
2.397	2.399
2.398	2.397
2.399	2.395

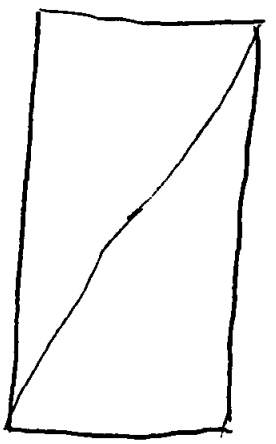
l_1	l_2
+.0007	+.0004
+.0003	0
±.0001	±.0002
-.0004	0
-.0008	-.0001



Avg. diameter : 2.397
Avg. length : 5.053
Sample area : 4.513
l/d ratio : 2.11
Sample volume(in^3) : 22.802
Sample weight (g) : 985.58
Density : 43.228/in^3 = 164.6 pcF (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE by shear on one joint surface.



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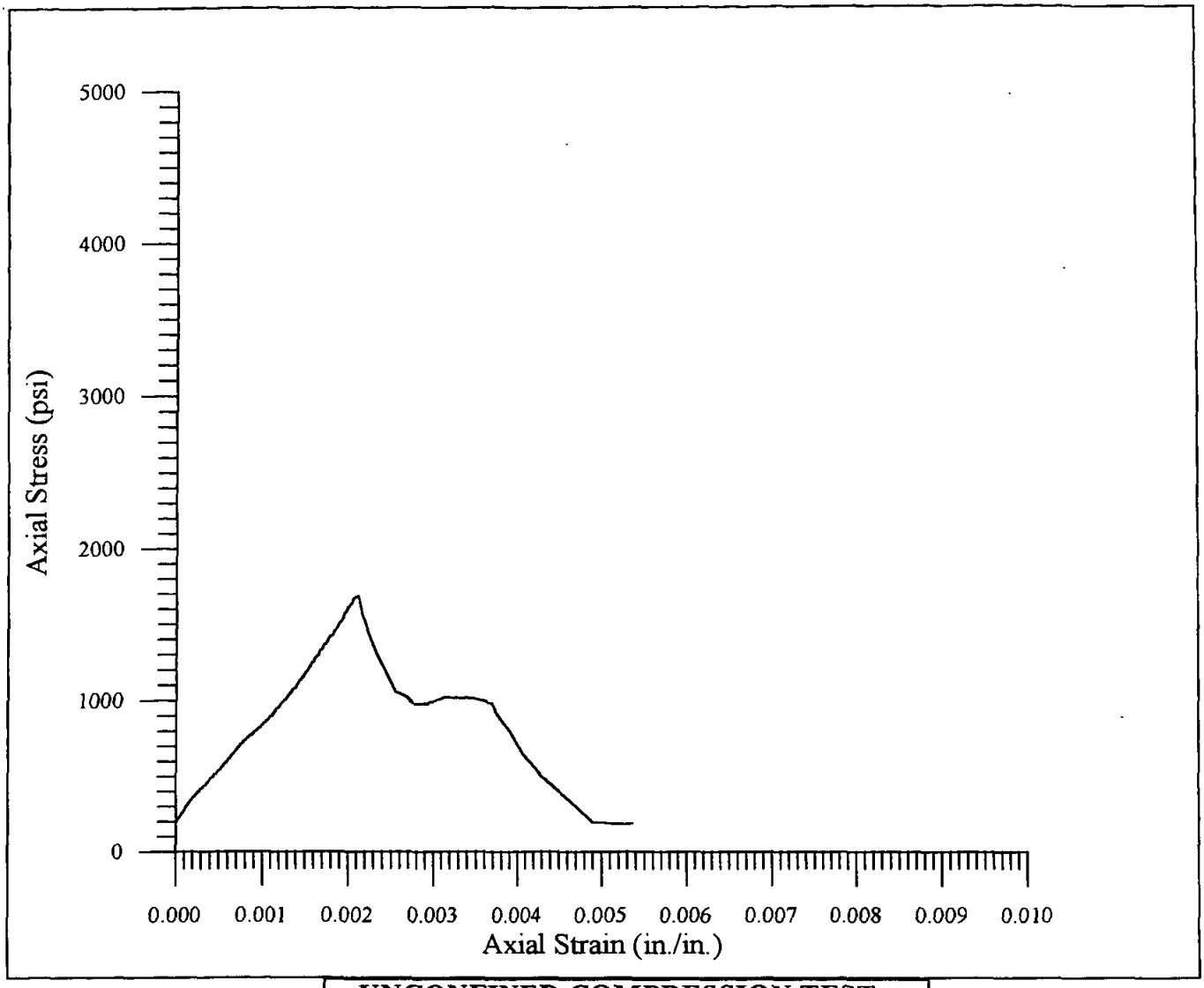


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-418
Boring: 02-6
Depth: 418.3-418.8'

DESCRIPTION

Gray sandstone with several calcite healed joints, about 35 degrees to the core axis.

Density: 164.6 pcf
Strength: 1684 psi
Joint Control Failure?: yes

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

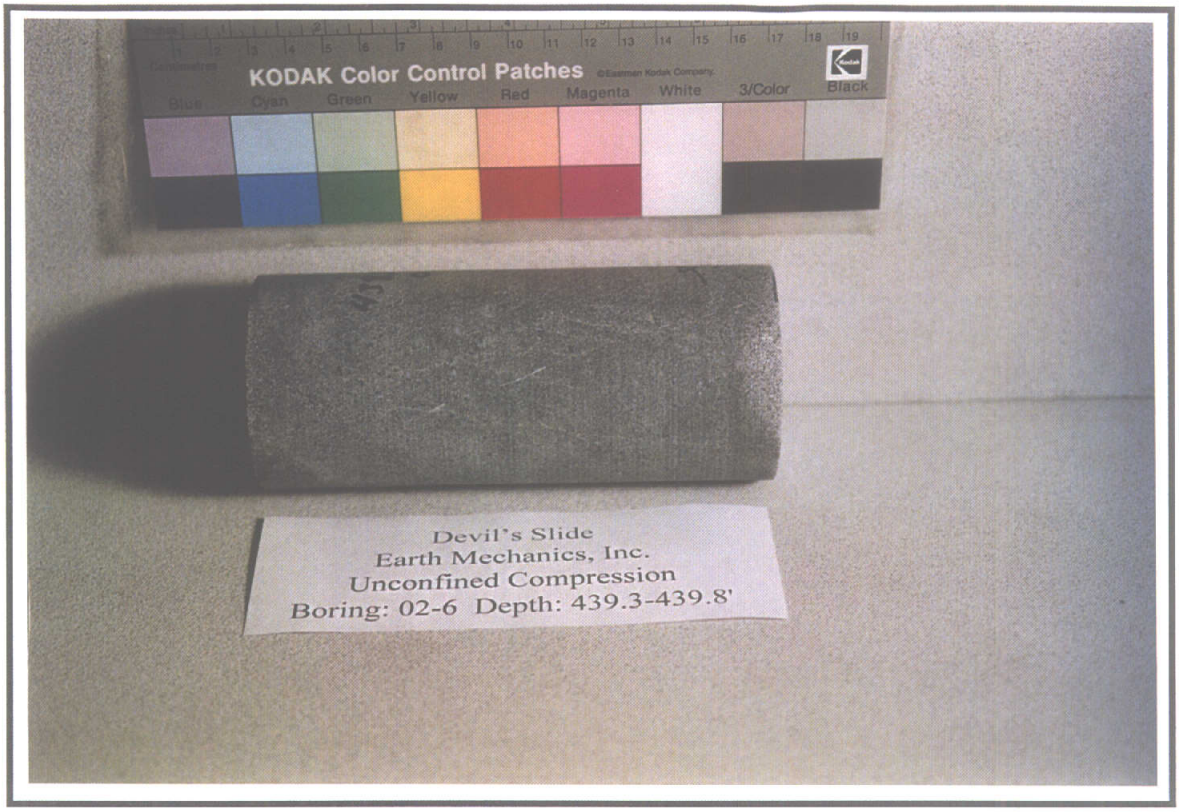
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

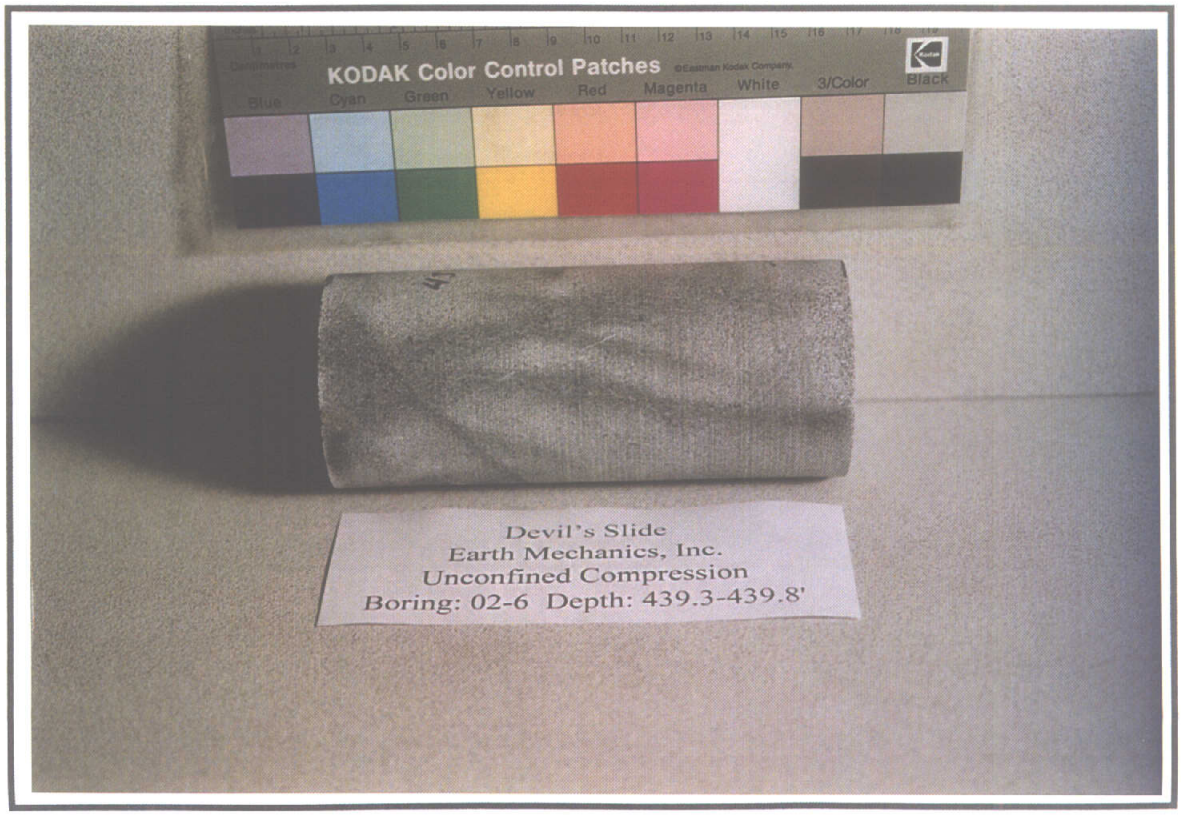
Project: Devil's Slide

Project Number: none

Test Date: September 13, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

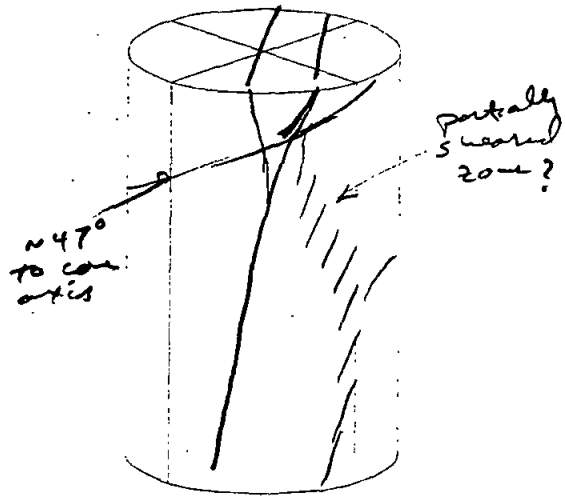
Date: 8/16/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray sandstone with partially healed fractures.

Sample Depth: 439.3-439.8' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.399
	2.400
	2.401
	2.400
	2.399

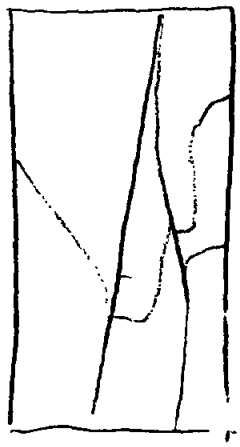
l_1	l_2
+.0010	0
+.0005	0
±.0001	±.0002
-.0004	0
-.0010	0



Avg. diameter : 2.400
Avg. length : 5.619"
Sample area : 4.524
l/d ratio : 2.34
Sample volume(in^3) : 25.420
Sample weight (g) : 1095.7g
Density : 43.10 g/in^3 = 164.2 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE - By axial splitting



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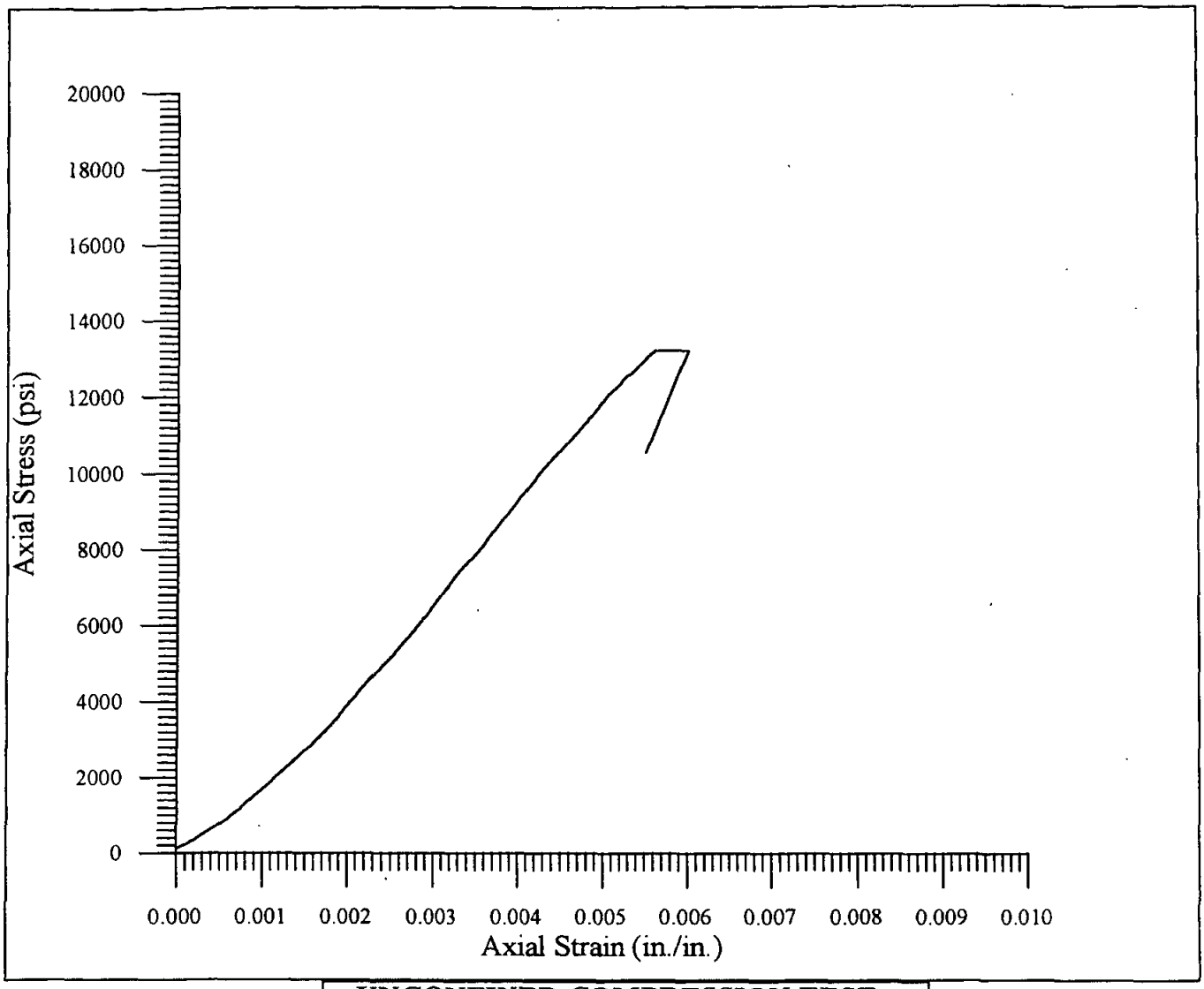


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-439
Boring: 02-6
Depth: 439.3-439.8'

DESCRIPTION
Gray sandstone with a few
partially healed joints.

Density: 164.2 pcf
Strength: 13,200 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

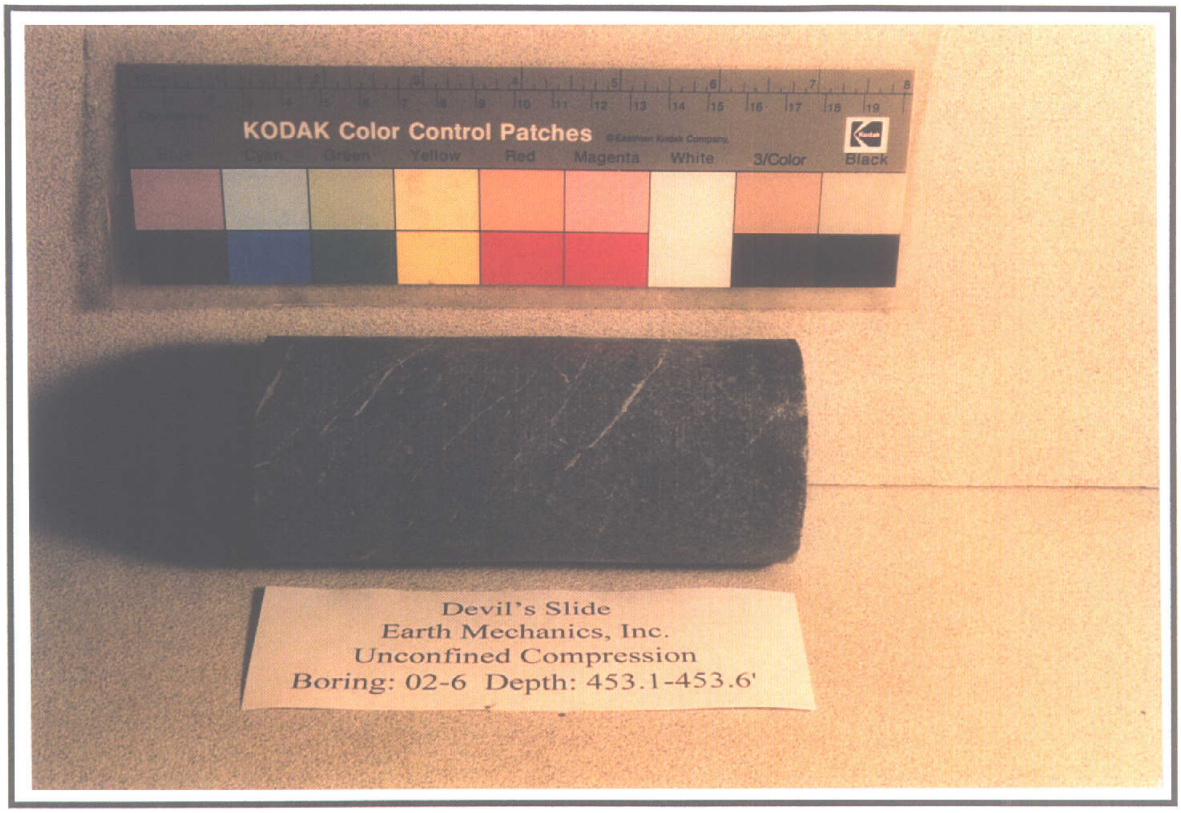
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/16/02
Technician: A. Bro

Client: ENT
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray medium grained sandstone with several calcite healed joints

Sample Depth: 453.1-453.6' Sample Condition: received dry - tested moist

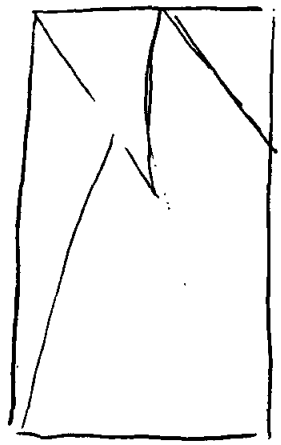
d_1	d_2
2.401	2.396
2.401	2.399
2.400	2.398
2.400	2.399
2.400	2.399

l_1	l_2
+.0007	+.0001
+.0004	
± 0001	±.0002
-.0004	
-.0009	-.0001

Avg. diameter : 2.399 Avg. length : 5.520"
Sample area : 4.520 l/d ratio : 2.30
Sample volume(in^3) : 24.951
Sample weight (g) : 1085.2 g
Density : 43.49 g/in^3 = 165.7 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE - failed by shear & splitting



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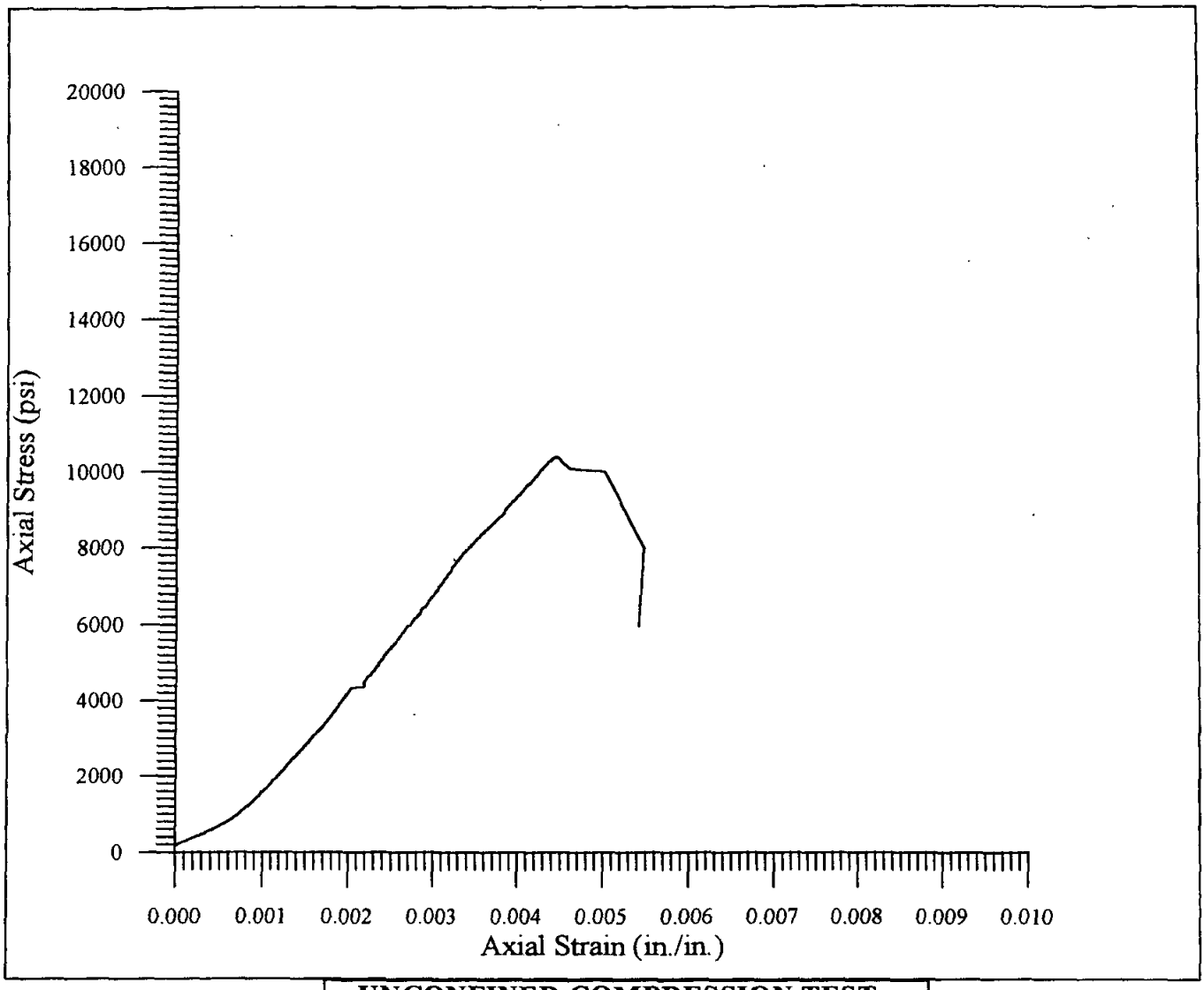


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-453
Boring: 02-6
Depth: 453.1-453.6'

DESCRIPTION

Gray medium grained sandstone with several calcite healed joints.

Density: 165.7 pcf
Strength: 10,398 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

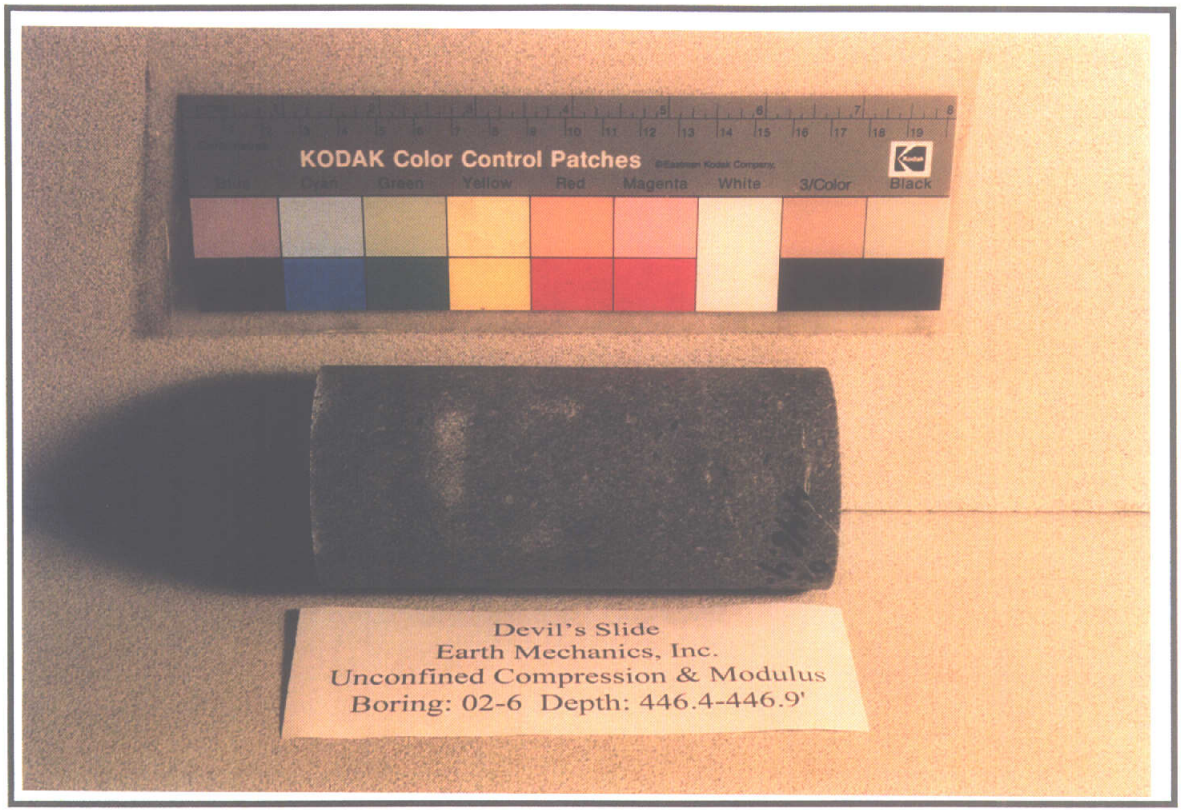
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

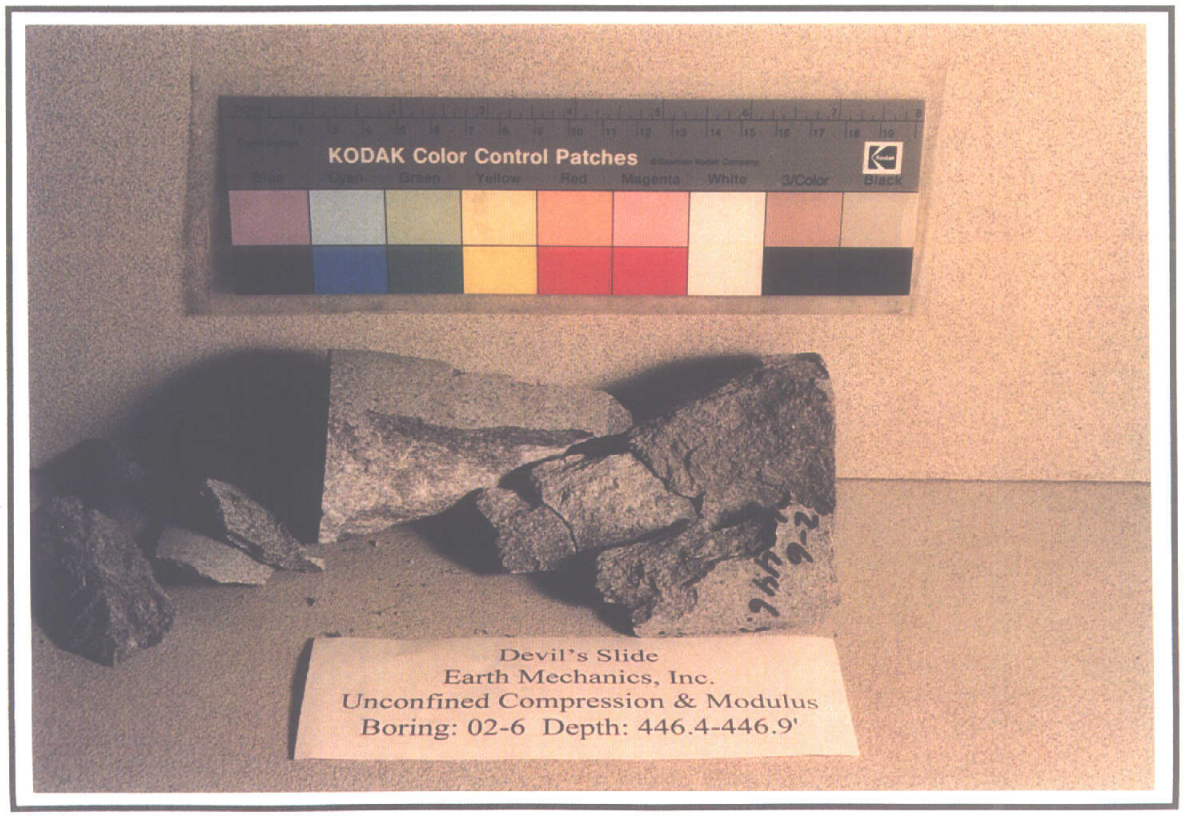
Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited GTU

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

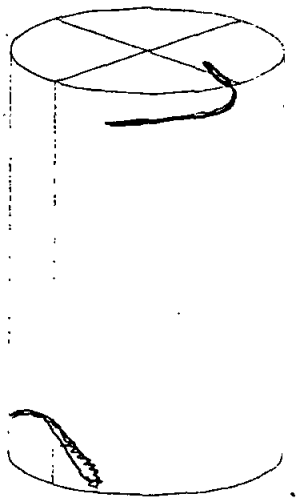
Date: 9/6 & 16/02
Technician: A. Bro

Client: EMT
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray medium grained sandstone with two minor calcite healed joints

Sample Depth: 446.4 - 446.9' Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.401

l_1	l_2
+.0006	+.0005
+.0003	+.0002
±.0001	±.0001
-.0005	-.0004
-.0008	-.0008



Avg. diameter : 2.401 Avg. length : 5.374"
Sample area : 4.528 l/d ratio : 2.24
Sample volume(in^3) : 24.332
Sample weight (g) : 1055.68
Density : 43.38 g/in^2 = 165.3 (1 g/in^3≈3.8095lb/ft^3)
Gauge length: 2.000 in

Comments:

INTACT FAILURE - failed by shear?

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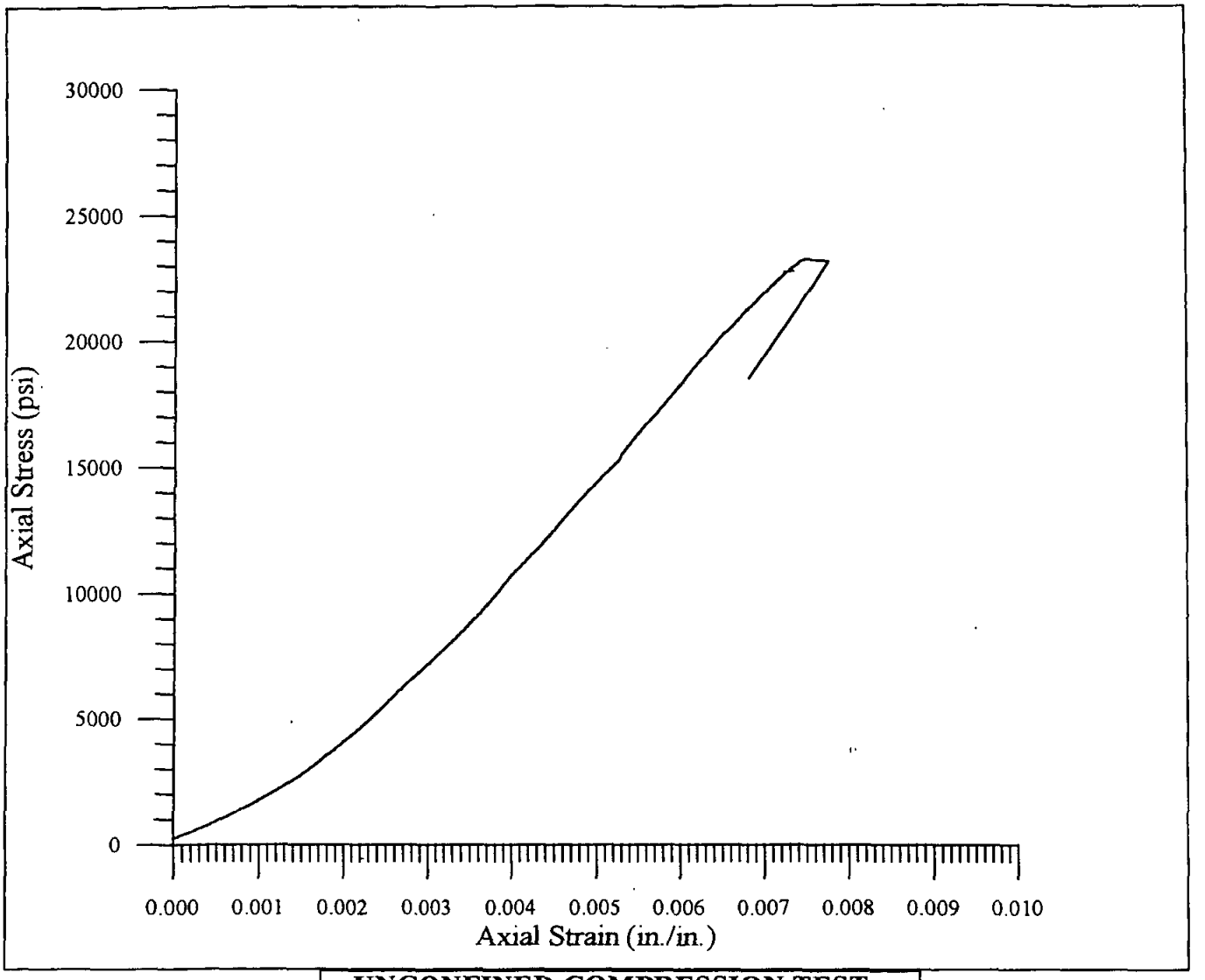


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6-446
Boring: 02-6
Depth: 446.4-446.9'

DESCRIPTION
Gray medium grained sandstone
with two minor calcite healed joints.

Density: 165.3 pcf
Strength: 23,256 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

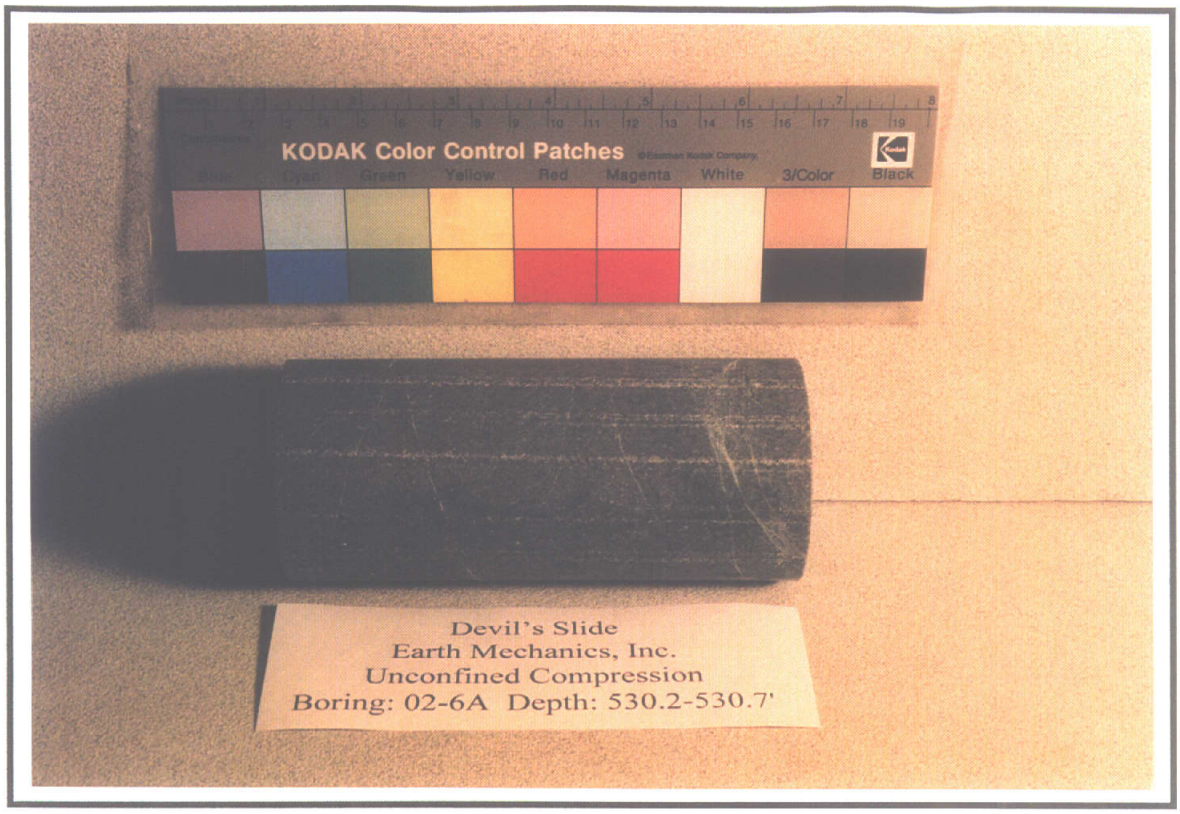
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

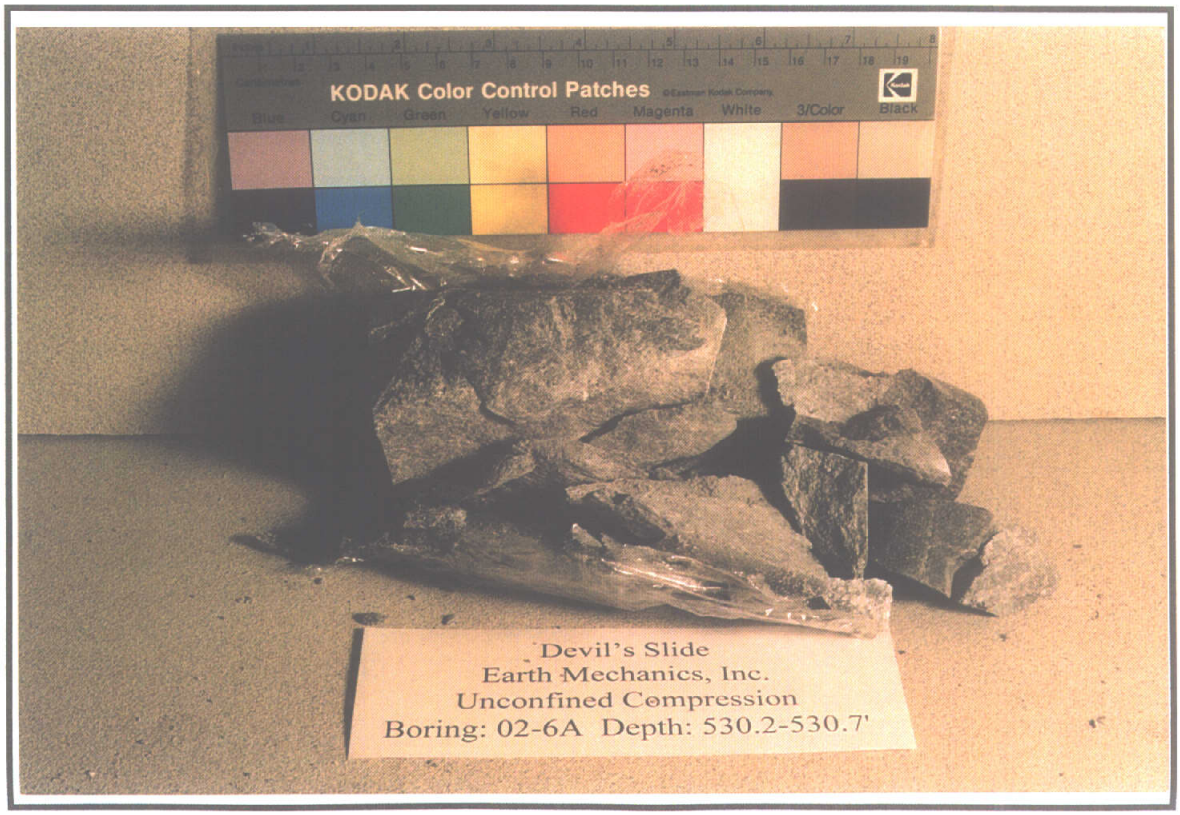
Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/16/02
Technician: A. Bro

Client: E-I
Job: #151 - Devil's Slide
Sample ID: Boring 02-6A
Sample Description: gray medium grained sandstone with one shale parting and a few calcite healed joints

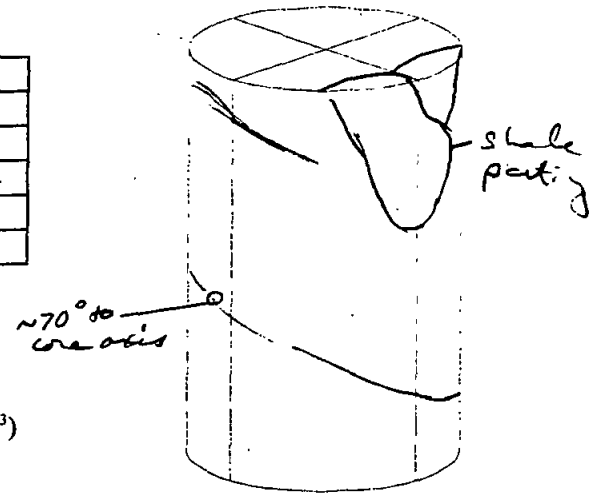
Sample Depth: 530.2-530.7' Sample Condition: received dry - tested moist

d_1	d_2
2.402	2.401
	2.401
	2.402
	2.402
	2.401

l_1	l_2
+.0011	0
+.0005	0
±.0001	±.0002
-.0005	0
-.0009	0

Avg. diameter : 2.402
Sample area : 4.531
Sample volume(in^3) : 24.542
Sample weight (g) : 1056.4
Density : 43.04 g/in^3 = 164.0 pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.416"
l/d ratio : 2.25



Comments:

INTACT FAILURE (?) - appeared to fail w/ splitting and shear.

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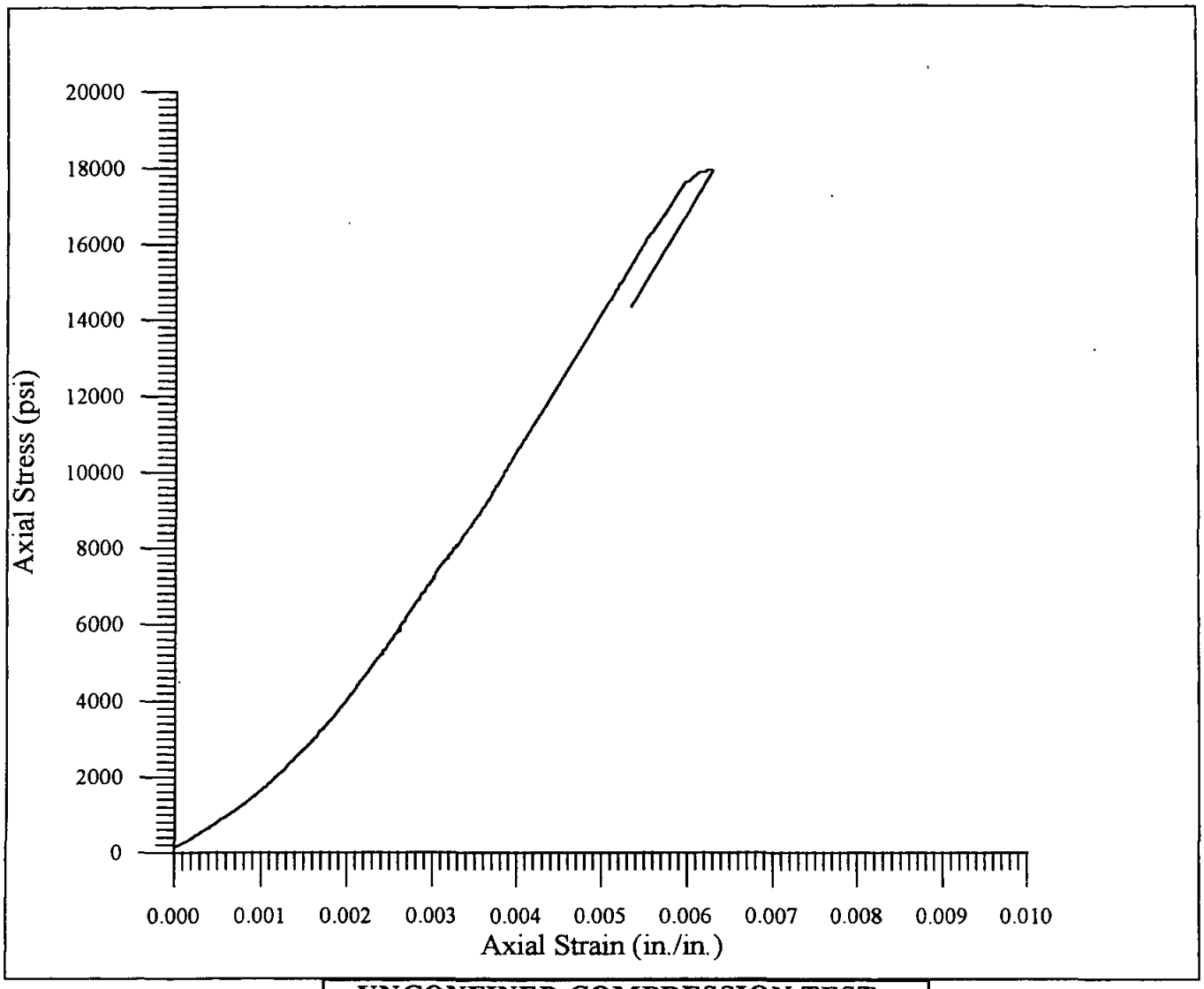


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6A-530
Boring: 02-6A
Depth: 530.2-530.7'

DESCRIPTION

Gray medium grained sandstone with one shale parting (?) and a few calcite healed joints.

Density: 164.0 pcf
Strength: 17,950 psi
Joint Control Failure?: no??

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited GTU

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 9/6 & 16/02
Technician: A. Bro

Client: EMT
Job: #151 - Devil's Slide
Sample ID: Boring 02-6A
Sample Description: Gray medium grained sandstone with a few calcite healed joints about 45° to the core axis

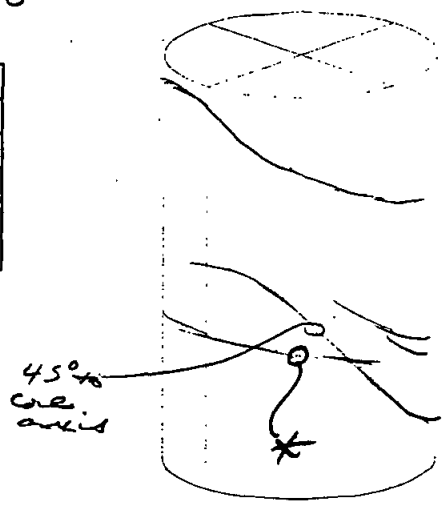
Sample Depth: 532.9 - 533.4' Sample Condition: received dry - tested - oist

d_1	d_2
2.401	2.402
2.402	2.401
2.400	2.402
2.401	2.402
2.399	2.402

l_1	l_2
+.0009	0
+.0004	0
±.0001	±.0002
-.0009	0
-.0009	0

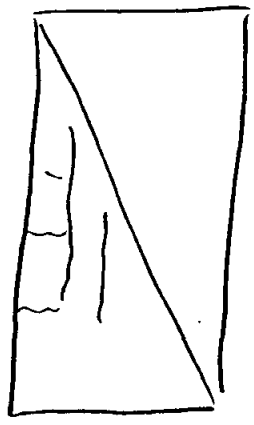
Avg. diameter : 2.401
Sample area : 4.528
Sample volume(in^3) : 24.649
Sample weight (g) : 1063.0 g
Density : 43.13 g/in^3 = 164.3 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Avg. length : 5.444
l/d ratio : 2.27



Comments:

INTACT FAILURE - possibly slightly weakened by the calcite healed bed * - failed by diagonal shear and splitting



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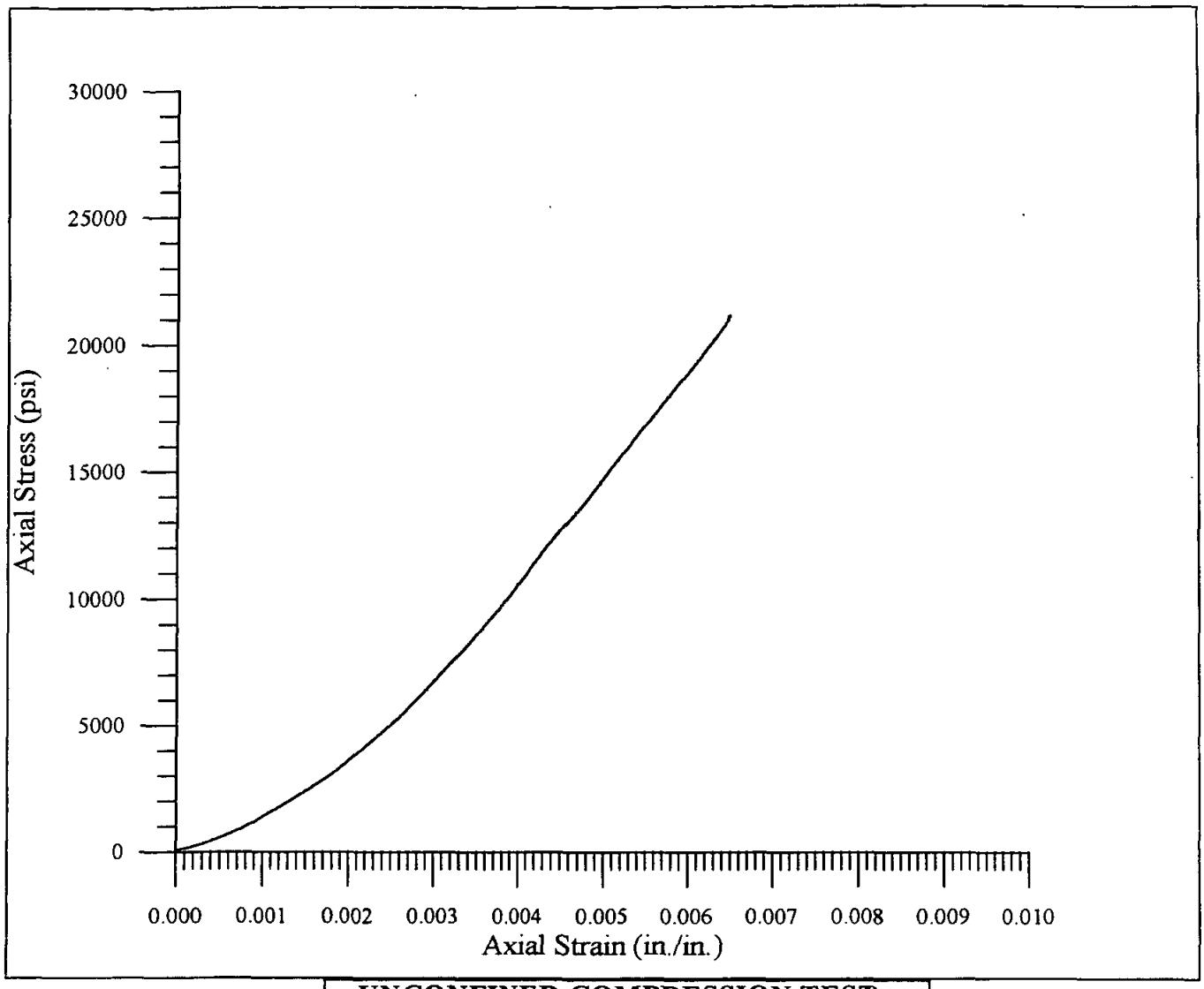


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 6A-532
Boring: 02-6A
Depth: 532.9-533.4'

DESCRIPTION
Gray medium grained sandstone with a few calcite healed joints about 45 degrees to the core axis.

Density: 164.3 pcf
Strength: 21,178 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

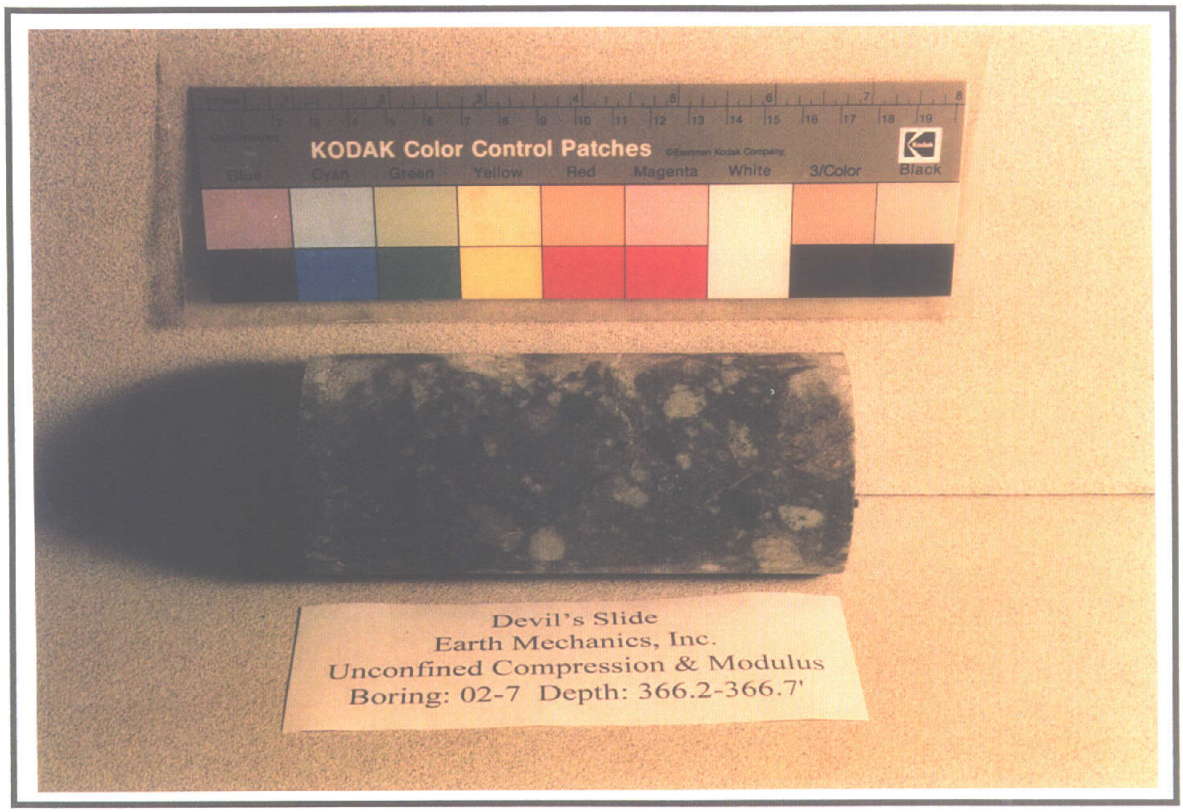
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

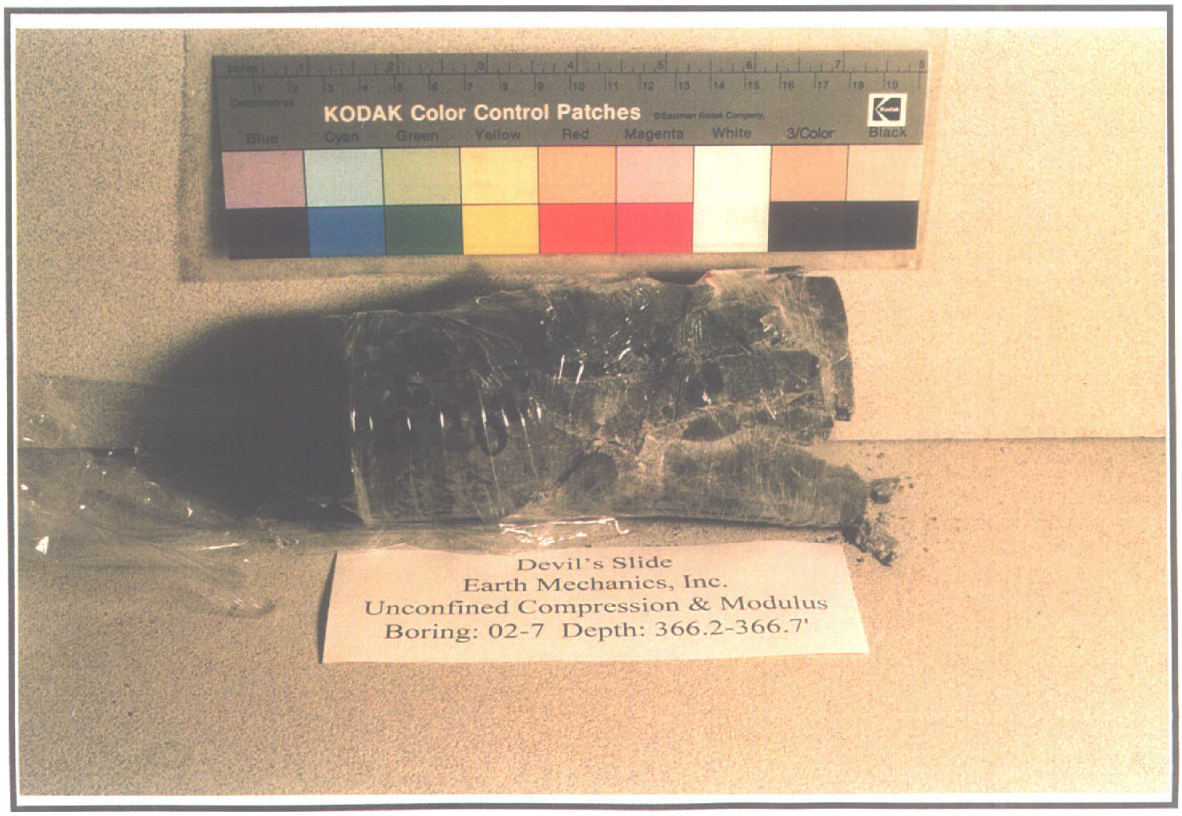
Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited — GTU

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 9/6&16/02
Technician: A. Bro

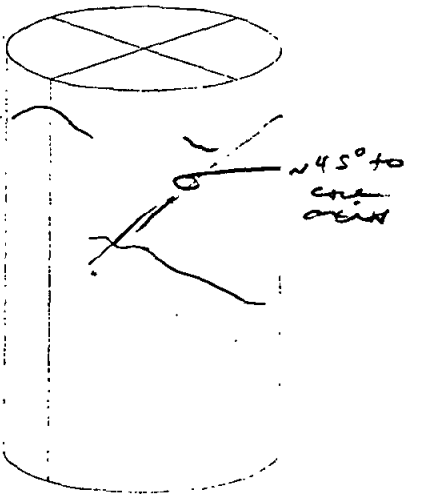
Client: EMI
Job: #151 Devil's Slide
Sample ID: Boring 02-7
Sample Description: gray conglomeratic sandstone with clasts up to 3/4", with a few calcite healed fractures.

Sample Depth: 366.2-366.7' Sample Condition: received dry - tested moist

d_1	d_2
2.403	2.402
2.399	2.401
2.401	2.402
2.402	2.402
2.402	2.402

l_1	l_2
+.0009	+.0001
+.0004	0
±.0001	±.0001
-.0004	0
-.0008	-.0001/-.0004

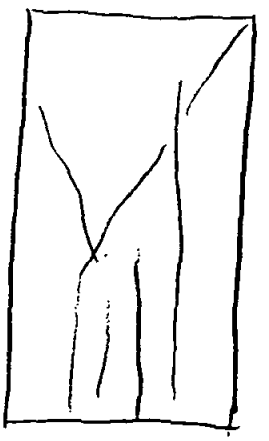
(on such clast)



Avg. diameter: 2.402
Avg. length: 5.669"
Sample area: 4.531
l/d ratio: 2.36
Sample volume(in³): 25.689
Sample weight (g): 1123.2 g
Density: 43.728/in³ = 166.6 pcf (1 g/in³=3.8095lb/ft³)
Gauge length: 2.000"

Comments:

INTACT FAILURE (?) - Failed by shear & splitting



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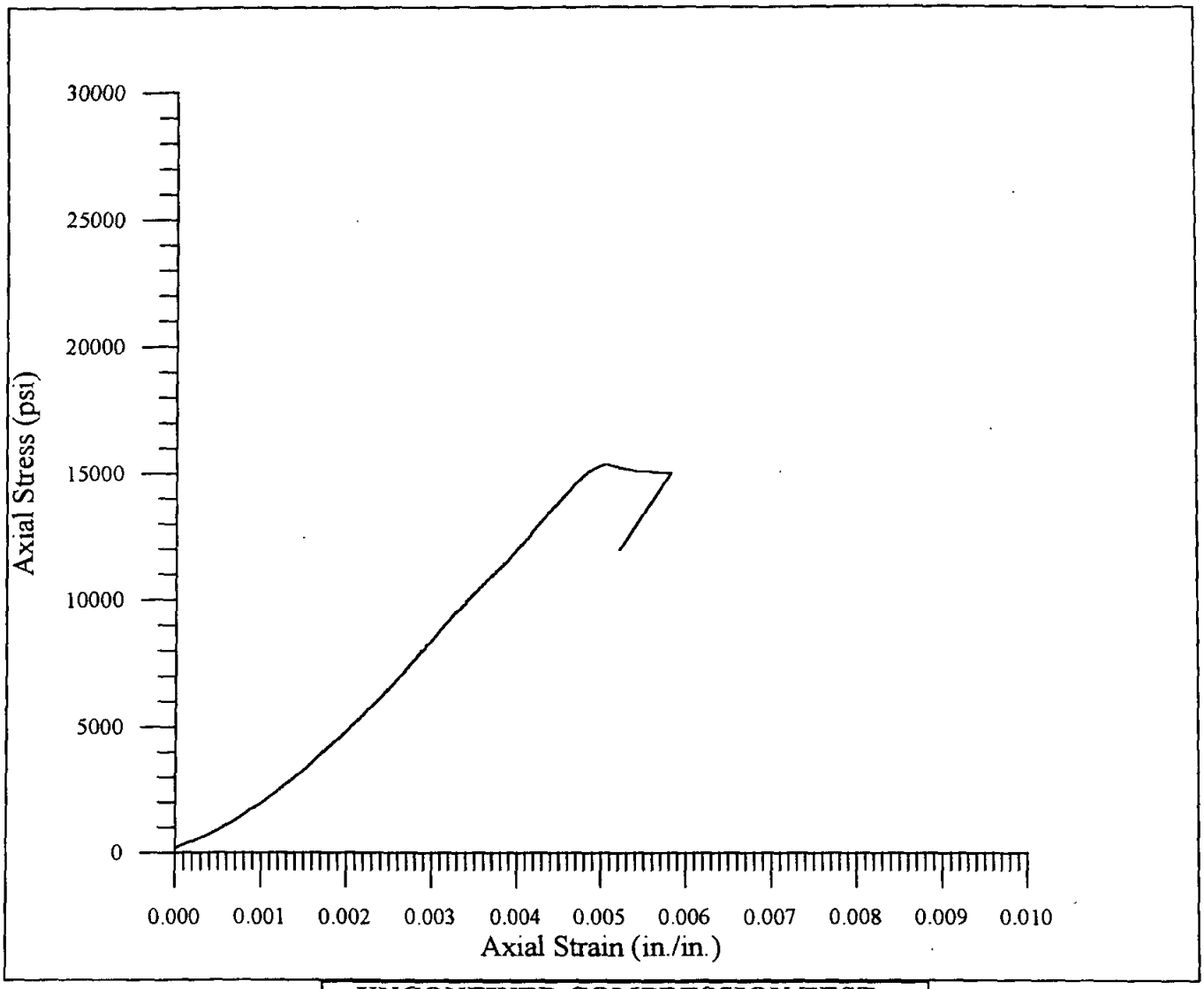


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 7-366
Boring: 02-7
Depth: 366.2-366.7'

DESCRIPTION
Gray conglomeratic sandstone with clasts up to 3/4 inch, with a few calcite healed fracture.

Density: 166.6 pcf
Strength: 15,386 psi
Joint Control Failure?: no (?)

Geo GTU *Test Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

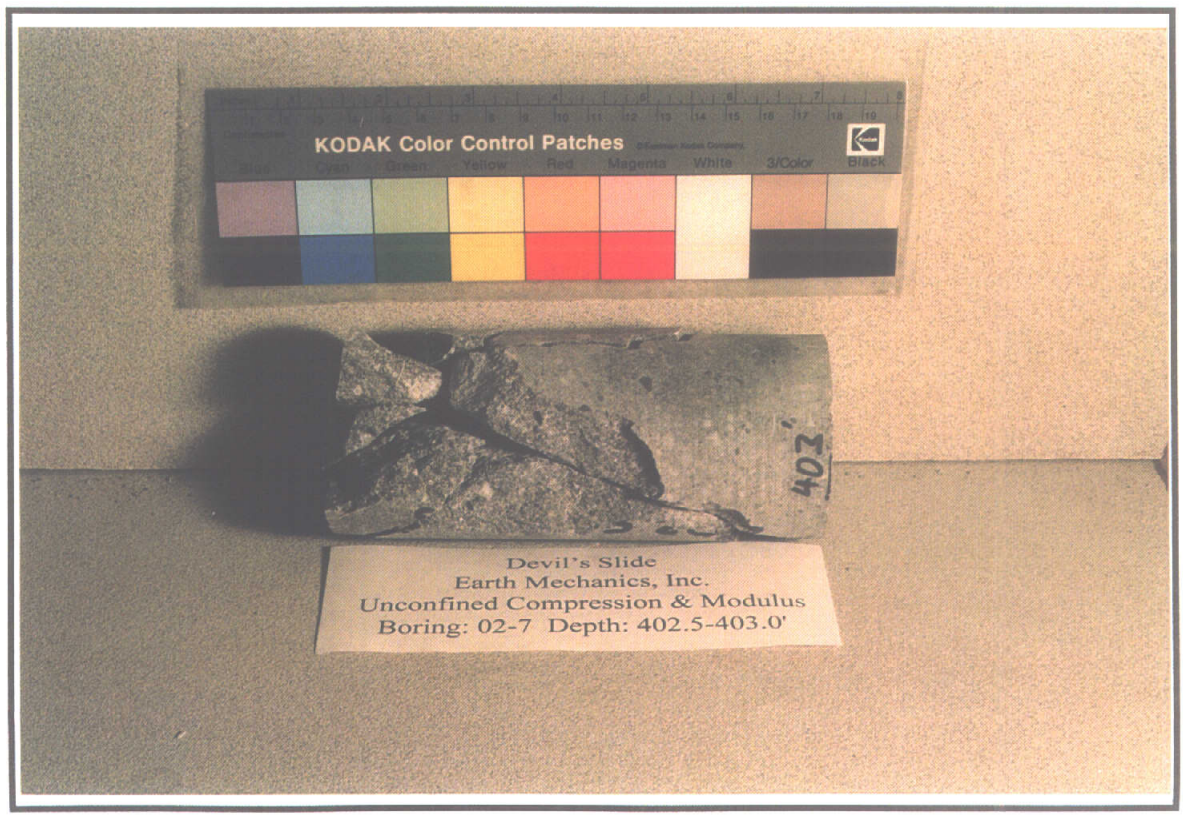
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 9/6 & 16/02
Technician: A. Bro

Client: ERI
Job: #151-Devil's Slide
Sample ID: Boring 02-7
Sample Description: Medium to coarse grained sandstone with a few calcite healed joints. (OK)

Sample Depth: 402.5-403.0 Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.398
2.400	2.399
2.401	2.399
2.401	2.400
2.401	2.400

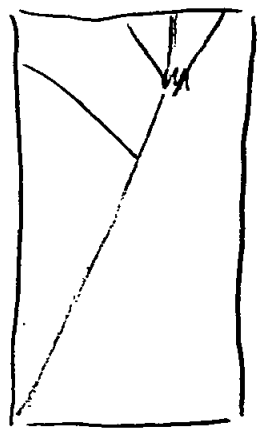
l_1	l_2
+.0009	+.0002
+.0005	+.0001
±.0001	±.0002
-.0004	-.0001
-.0008	-.0002

Avg. diameter : 2.400
Sample area : 4.524
Sample volume(in^3) : 24.922
Sample weight (g) : 1081.6 g.
Density : 43.40 lb/ft³ = 1.653 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Avg. length : 5.509"
l/d ratio : 2.30

Comments:

INTACT FAILURE - Failed by shear



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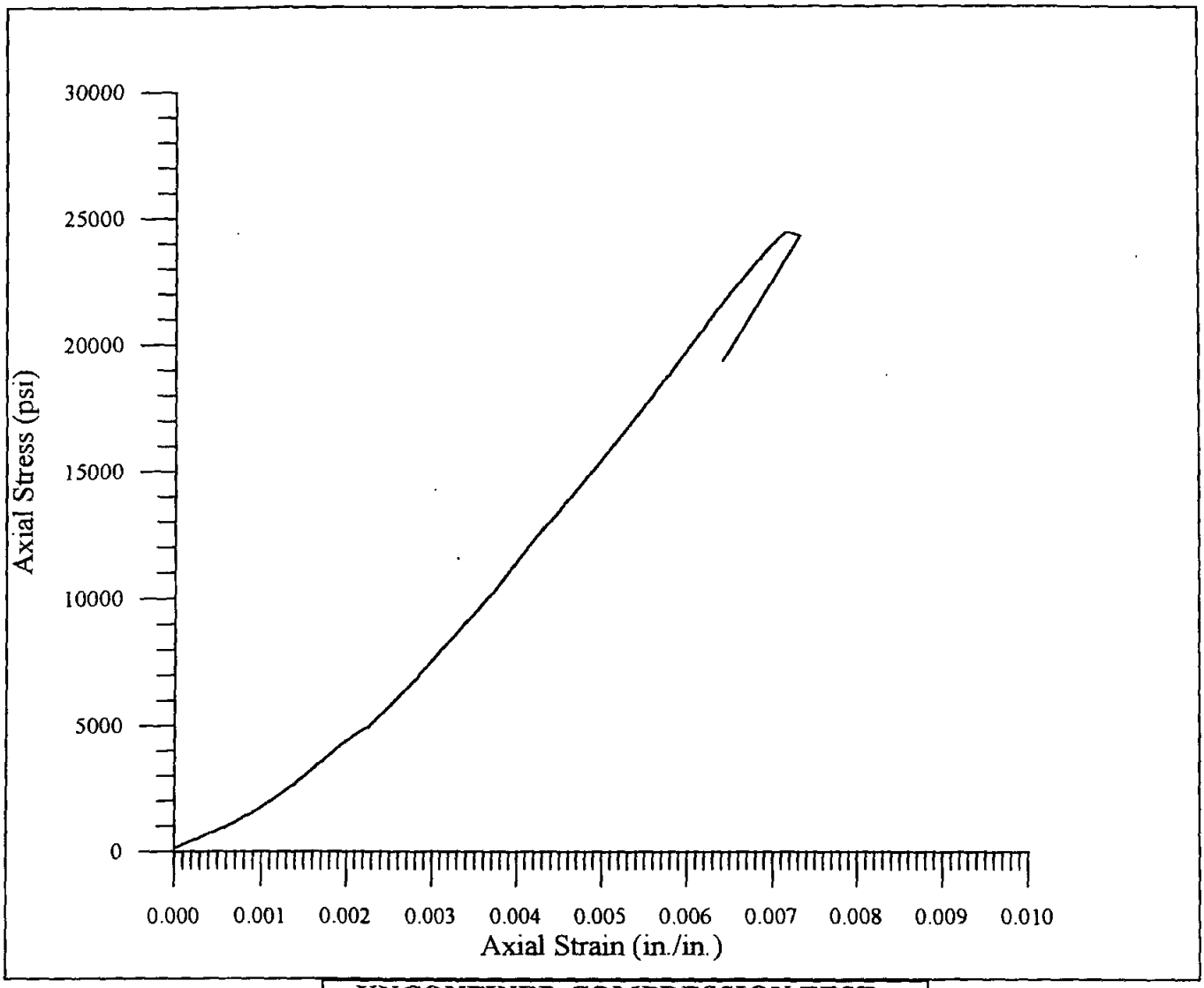


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 7-402
Boring: 02-7
Depth: 402.5-403.0'

DESCRIPTION
Gray medium to coarse grained sandstone with a few calcite healed fracture.

Density: 165.3 pcf
Strength: 24,406 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

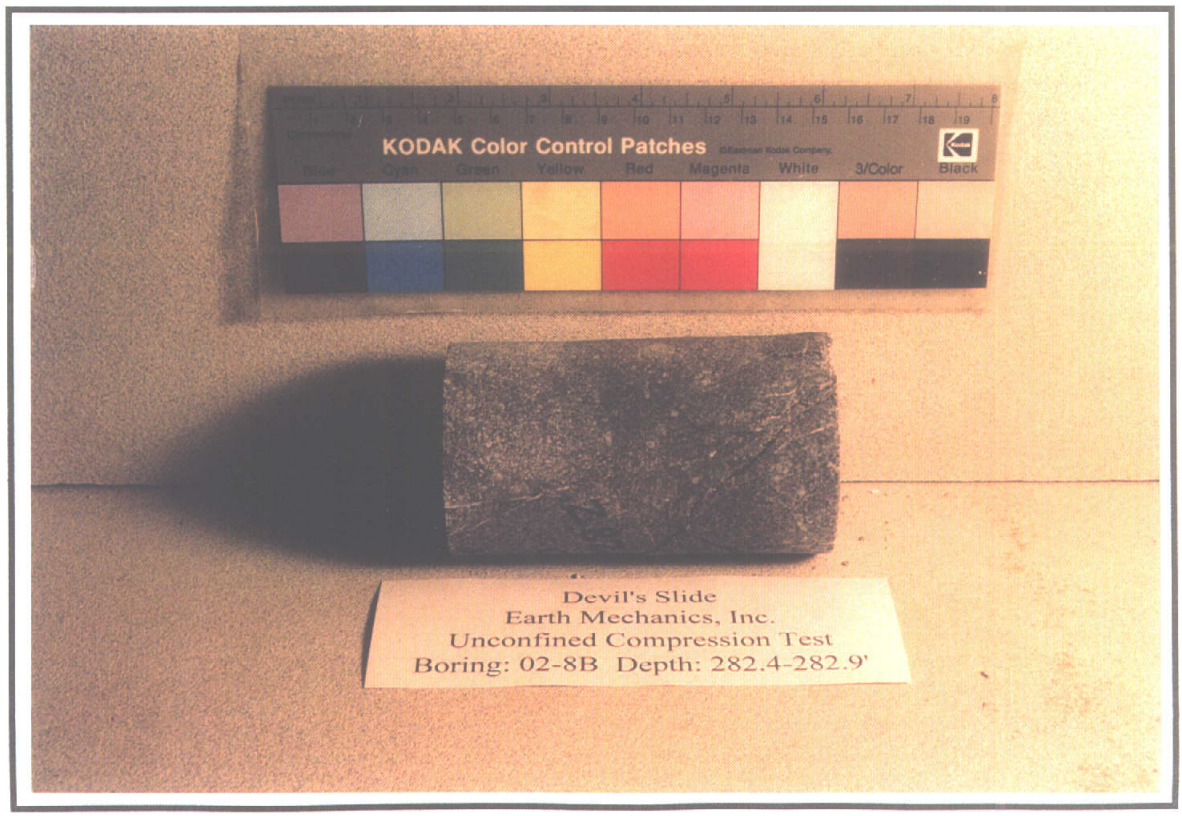
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/21/02
Technician: A. Bro

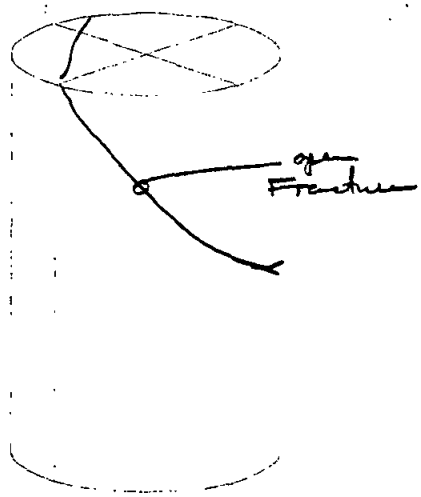
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-8B
Sample Description: gray coarse grained sandstone with several calcite healed fractures and one unhealed fracture ~42° to the core axis.

Sample Depth: 282.4-282.9' Sample Condition: received dry - tested moist

d_1	d_2
2.403	2.403
2.404	2.400
2.405	2.401
2.402	2.406
2.403	2.400

(x.0001")

l_1	l_2
+5	0
+1	0
±1	±3
-5	-5
-10	-10



Avg. diameter: 2.403 Avg. length: 4.268"
Sample area: 4.535 l/d ratio: 1.78
Sample volume(in^3): 19.356
Sample weight (g): 827.0g
Density: 42.73 g/in^3 = 162.8 pcF (1 g/in^3=3.8095lb/ft^3)

Comments: Snap during loading accompanied by "negative" displacement, probably due to end rotation.

JOINT CONTROLLED FAILURE - failed by shear on existing joint.

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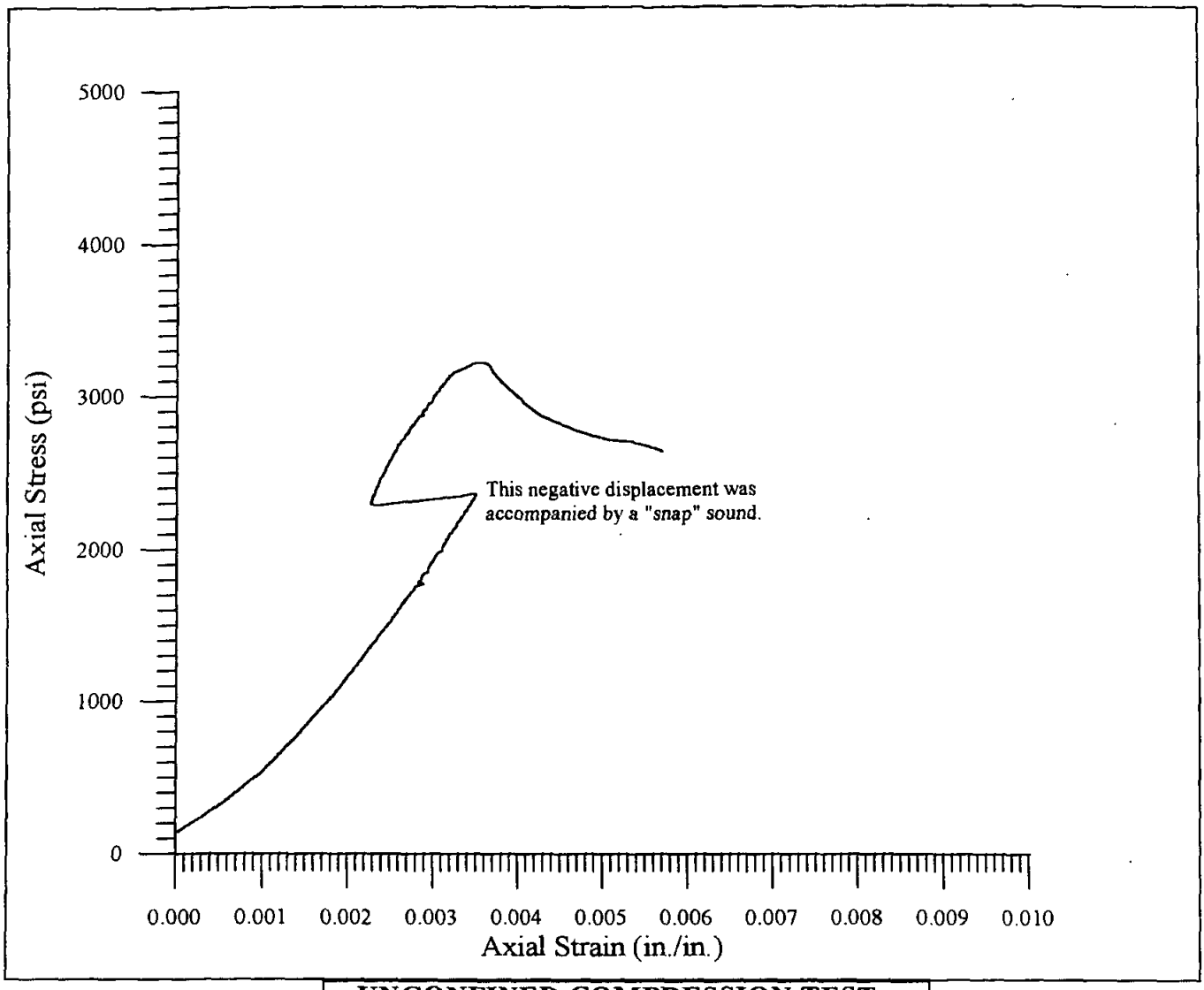


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 8B-282
Boring: 02-8B
Depth: 282.4-282.9'

DESCRIPTION

Medium gray coarse grained sandstone with several calcite healed fractures and one unhealed fracture about 42 degrees to the core axis.

Density: 162.8 pcf
Strength: 3216 psi
Joint Control Failure?: yes

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

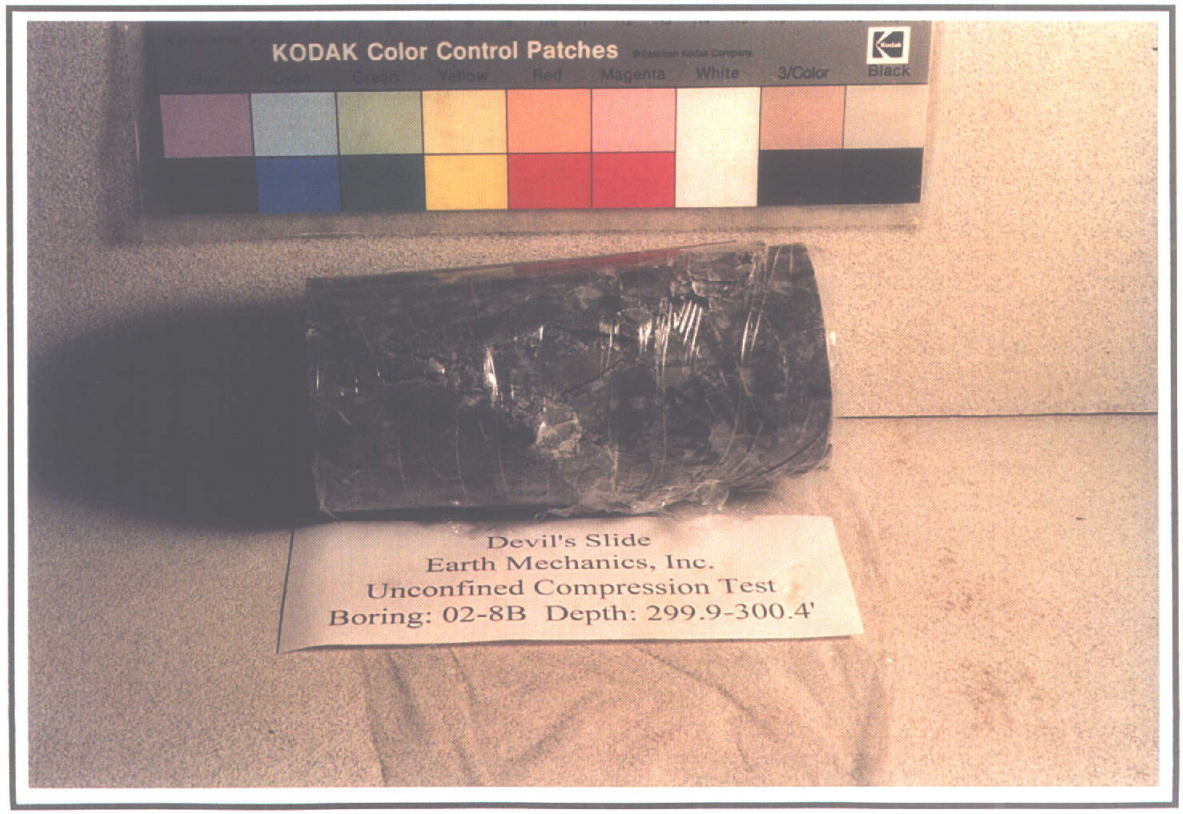
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-BB
Sample Description: Gray fine to medium grained conglomerate with a few calcite healed fractures

Sample Depth: 299.9-300.4' Sample Condition: received dry - tested moist

d_1	d_2
2.404	2.404
2.403	2.402
2.403	2.403
2.403	2.403
2.403	2.403

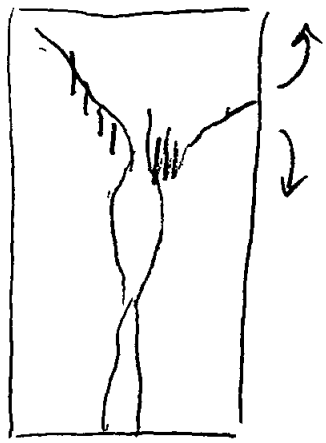
(x.0001")

l_1	l_2
+6	0
+3	0
±1	±2
-2	0
-6	0

Avg. diameter : 2.403 Avg. length : 5.289
Sample area : 4.535 l/d ratio : 2.20
Sample volume(in^3) : 22.987
Sample weight (g) : 1049.4 g
Density : 43.75 g/in^3 = 166.7 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE - failed by axial splitting & crushing



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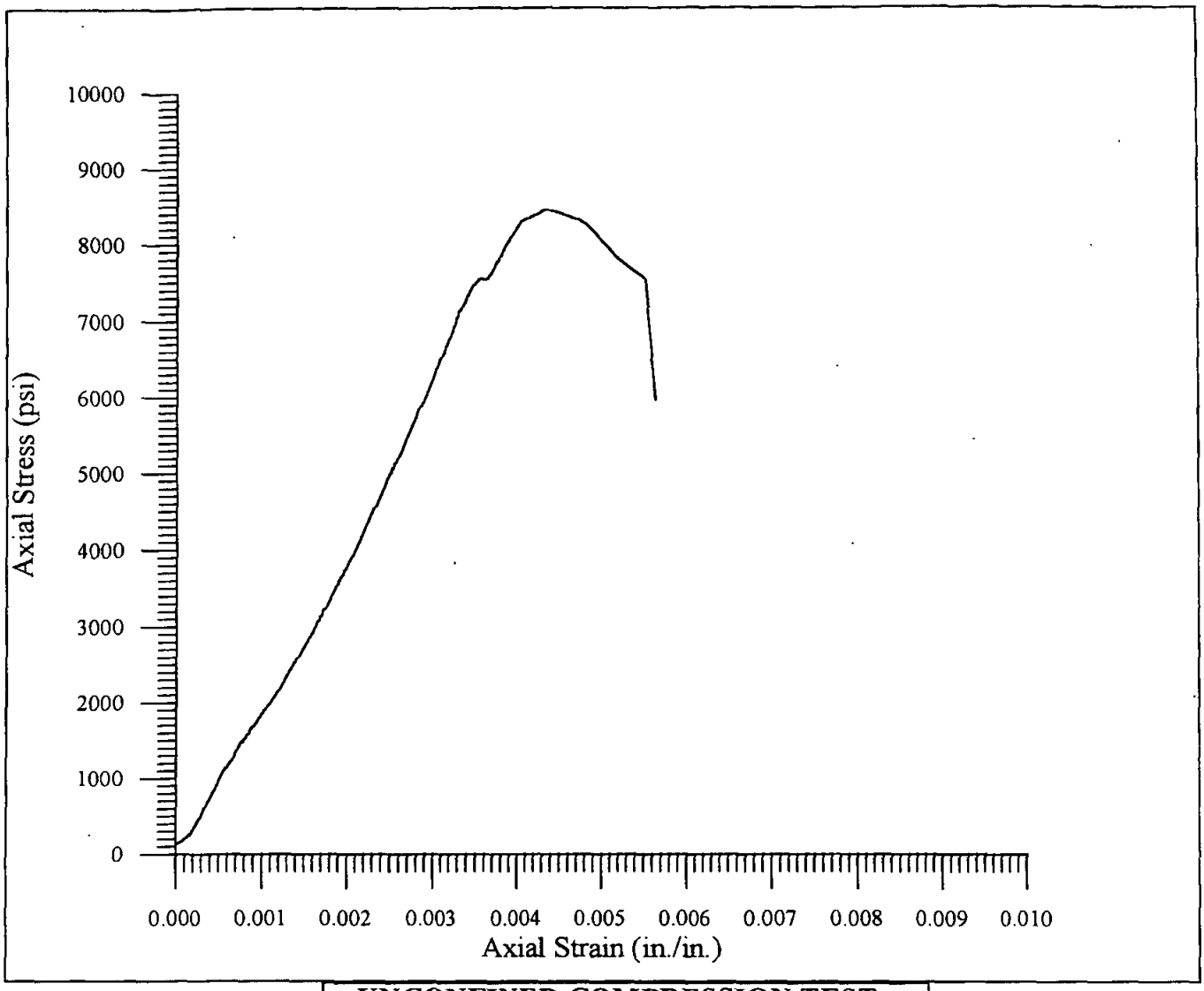


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 8B-299
Boring: 02-8B
Depth: 299.9-300.4'

DESCRIPTION

Medium gray fine to medium grained conglomerate with a few calcite healed fractures.

Density: 166.7 pcf
Strength: 8445 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

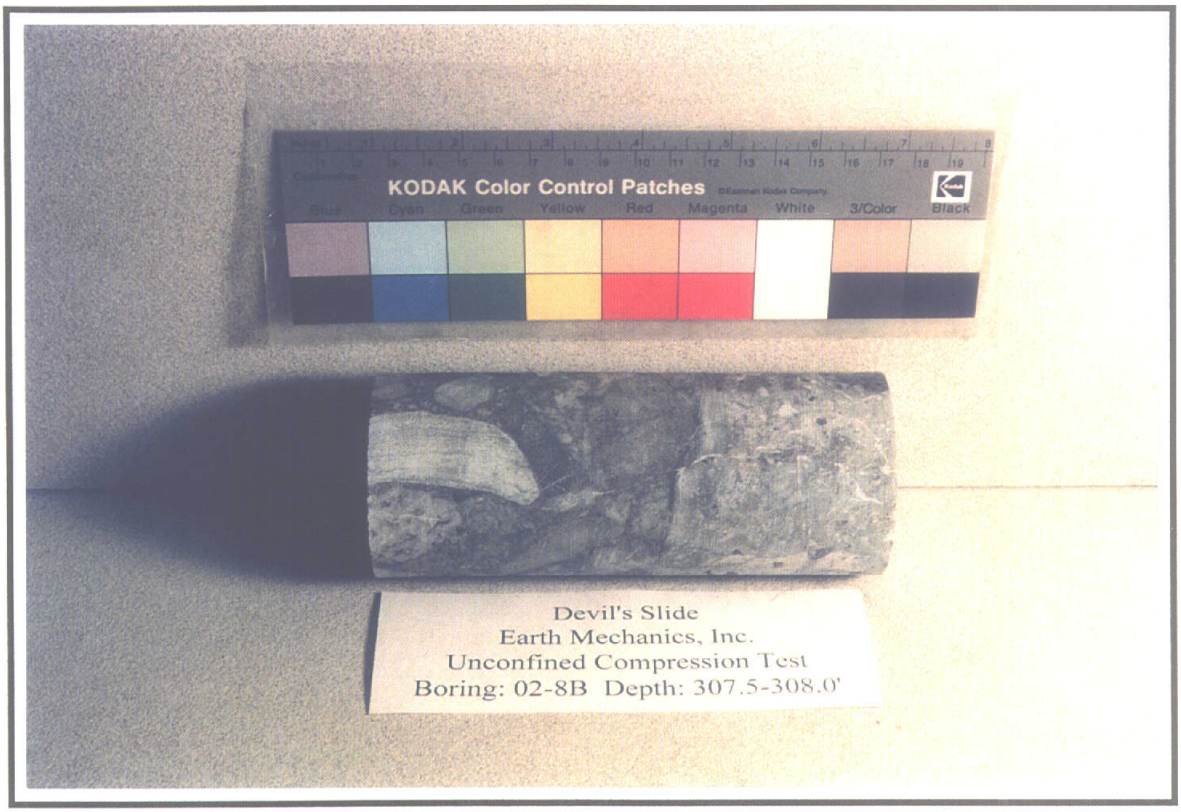
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

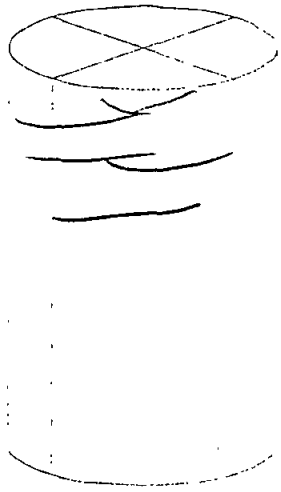
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02 - 8B
Sample Description: Coarse grained md. gray conglomerate with several calcite healed joints.

Sample Depth: 307.5-308.0 Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.403
2.403	2.402
2.402	2.401
2.402	2.401
2.401	2.399

(x.0001")

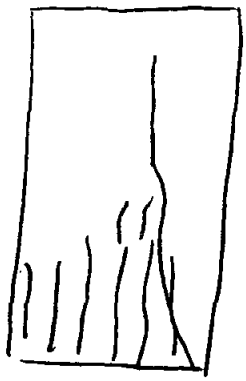
l_1	l_2
+8	0
+5	0
±1	±2
-4	0
-7	0



Avg. diameter : 2.402 Avg. length : 5.898
Sample area : 4.531 l/d ratio : 2.46
Sample volume(in^3) : 27.139
Sample weight (g) : 1166.8x
Density : 42.99 g/in^3 = 163.8 pcf (1 g/in^3=3.8095lb/ft^3)

Comments: initial failure by axial splitting

INTACT FAILURE - by axial splitting - crushing at one end



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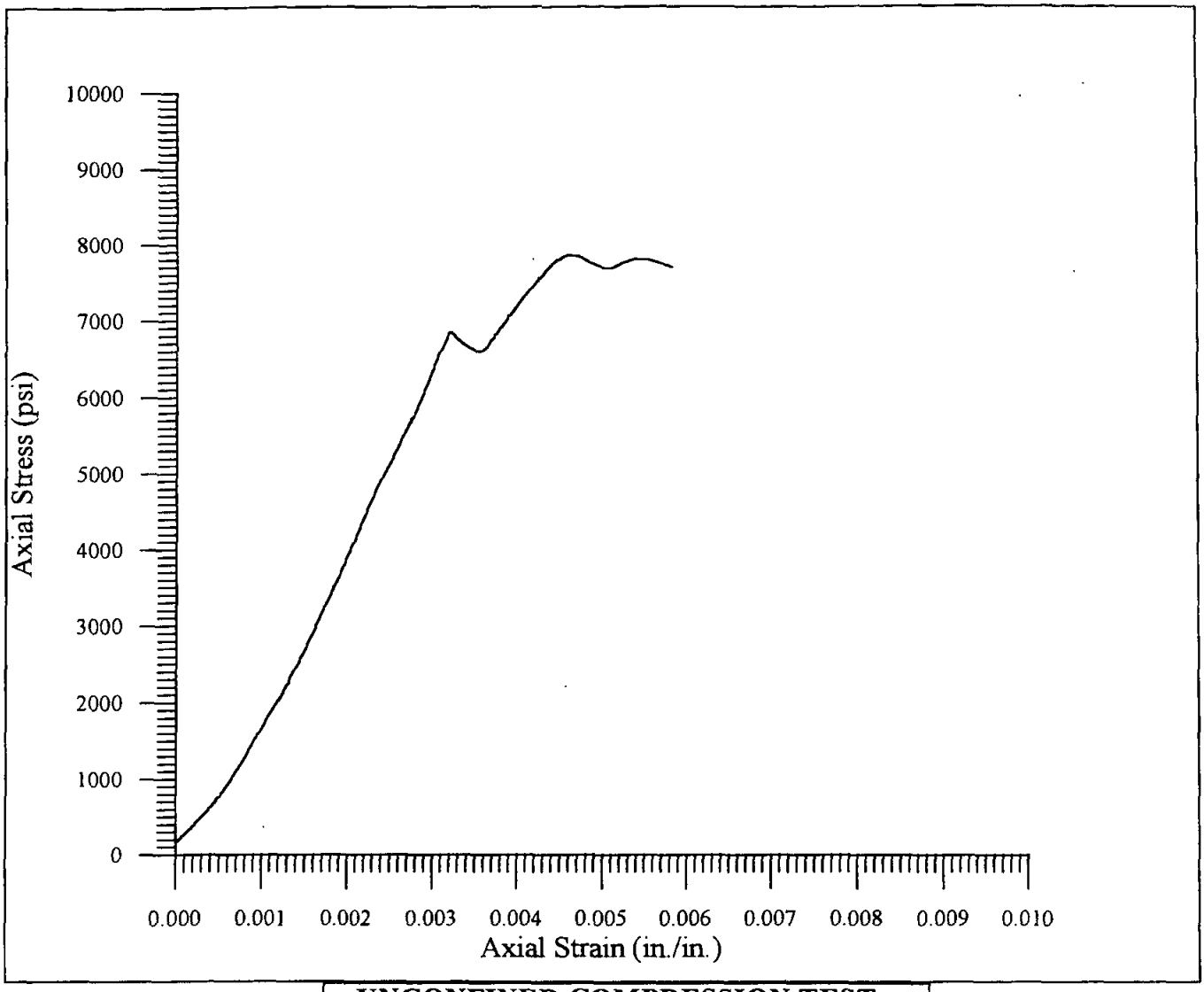


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 8B-307
Boring: 02-8B
Depth: 307.5-308.0'

DESCRIPTION
Medium gray coarse grained conglomerate with several calcite healed joints.

Density: 163.8 pcf
Strength: 7855 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

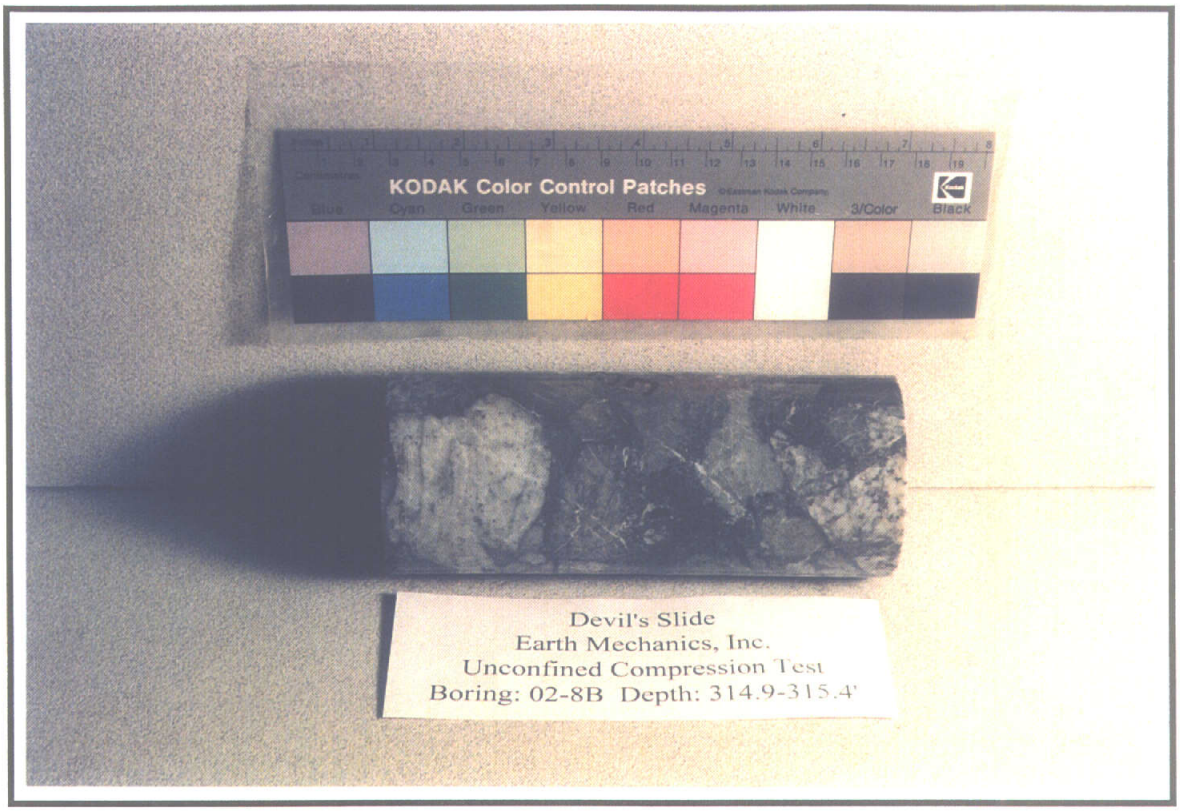
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

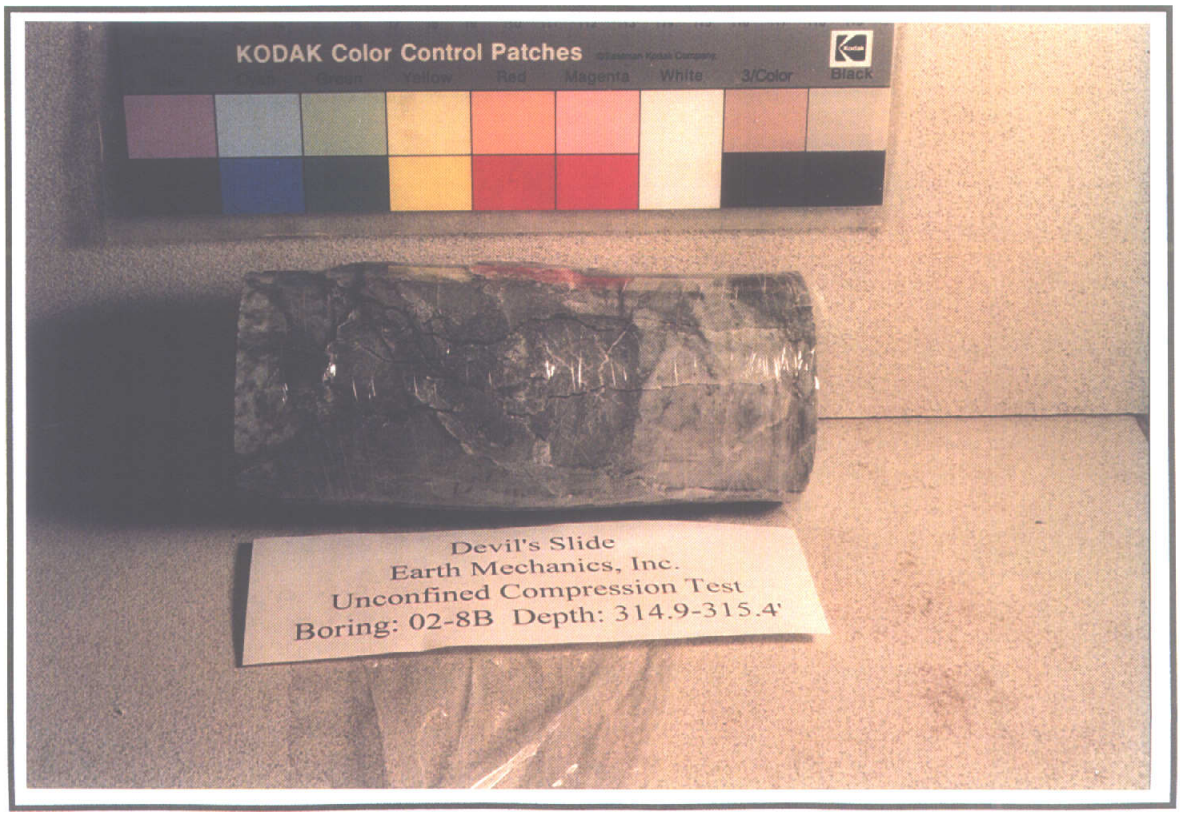
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: ABro

Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-8B
Sample Description: Gray coarse grained conglomerate (up to 2") with several calcite healed fractures.

Sample Depth: 314.9-315.4' Sample Condition: received dry - tested moist

d_1	d_2
2.402	2.403
2.401	2.398
2.402	2.403
2.402	2.402
2.403	2.402

(x.0001")

l_1	l_2
+7	-2
+3	0
±1	±2
-5	-2
-9	-4

Avg. diameter : 2.402 Avg. length : 5.862"
Sample area : 4.531 l/d ratio : 2.44
Sample volume(in^3) : 26.563
Sample weight (g) : 1155.8g
Density : 43.51 g/in^3 = 165.8 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE - failed by axial splitting & crushing

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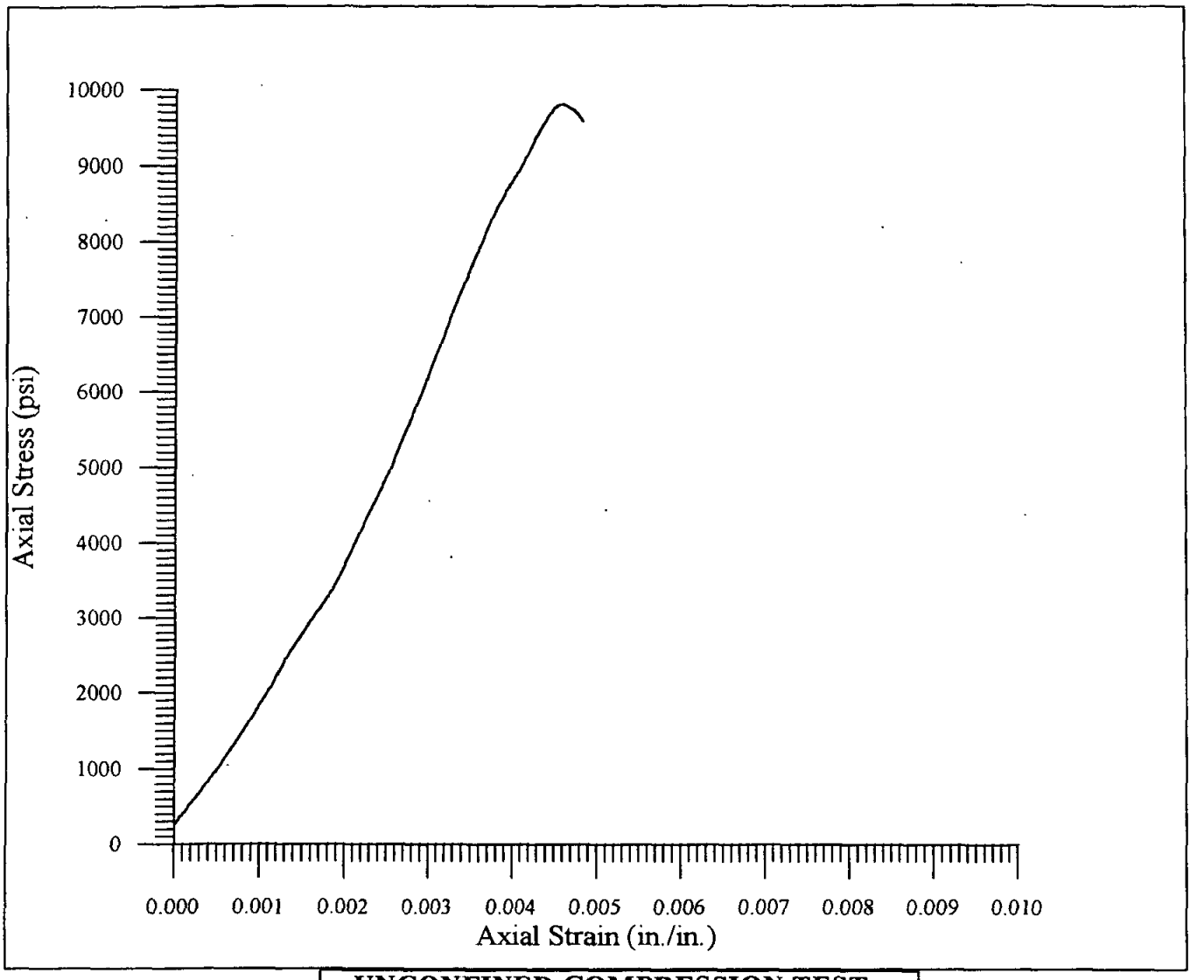


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 8B-314
Boring: 02-8B
Depth: 314.9-315.4'

DESCRIPTION

Medium gray coarse grained conglomerate with several calcite healed fractures.

Density: 165.8 pcf
Strength: 9801 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

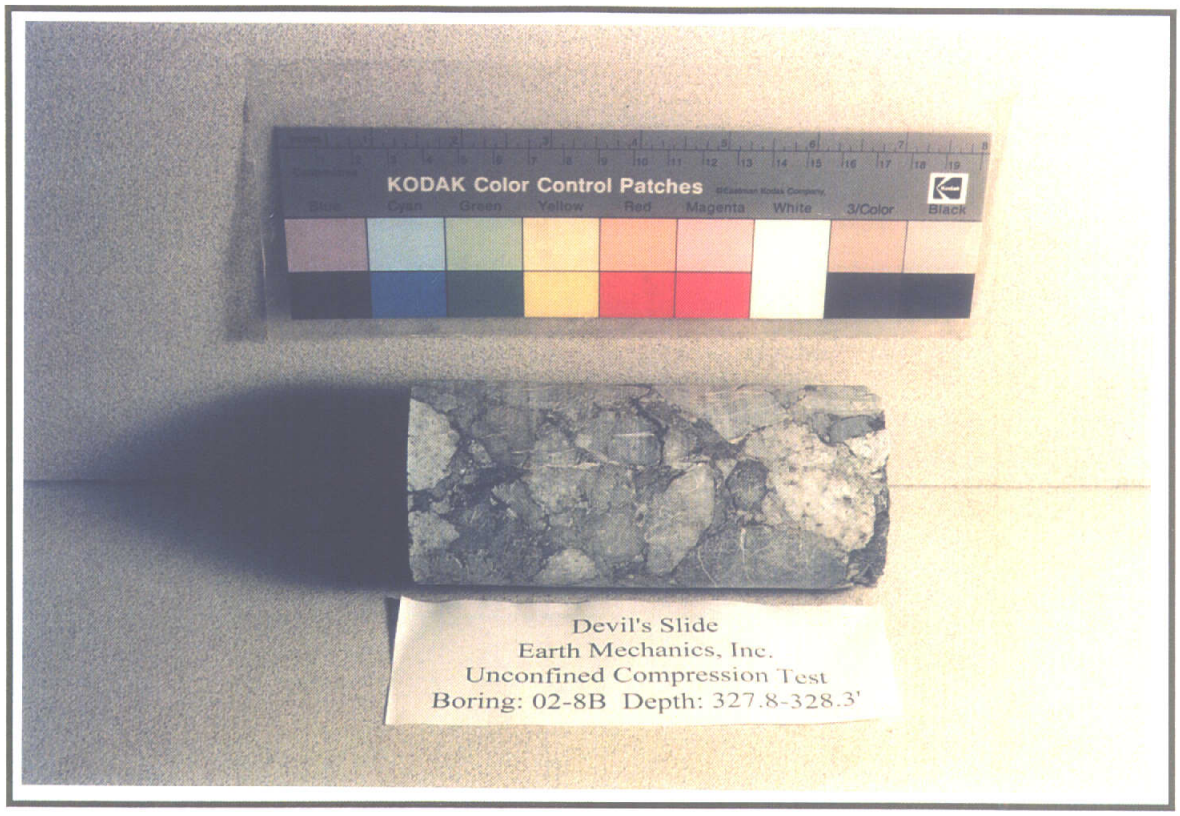
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

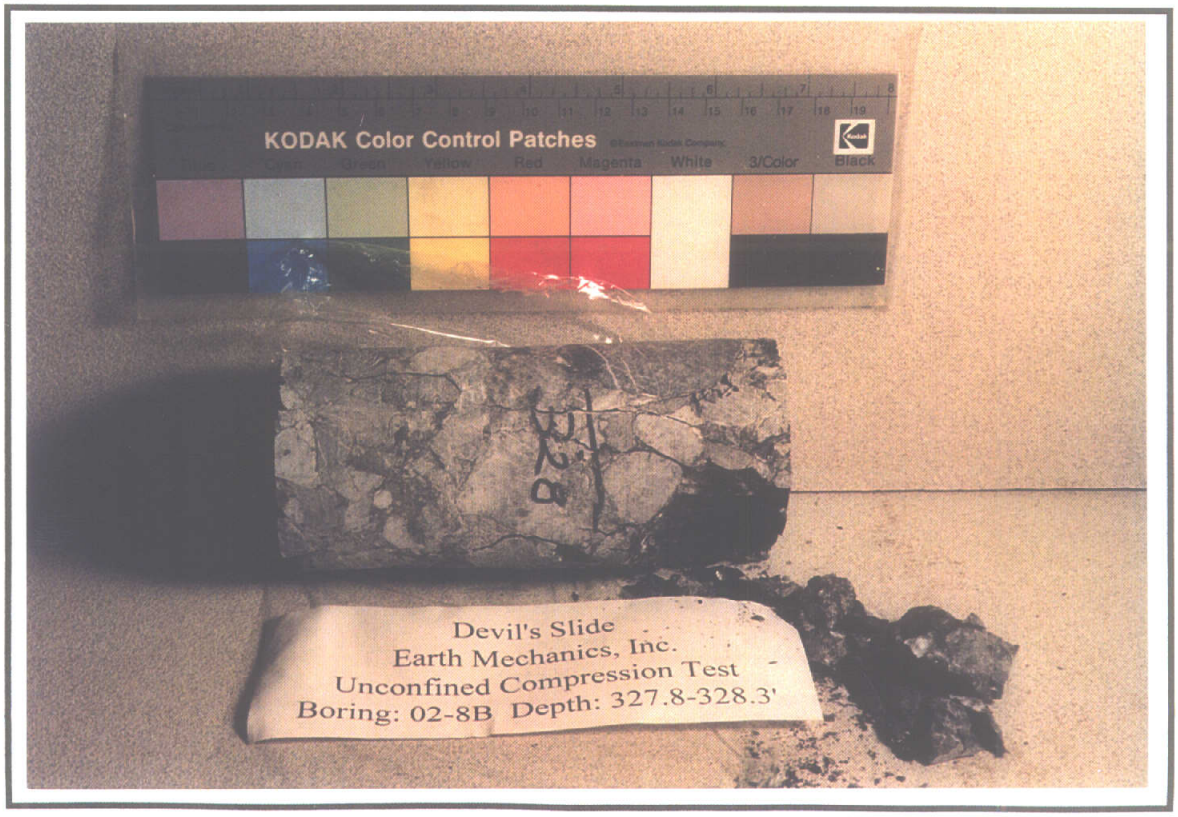
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bond

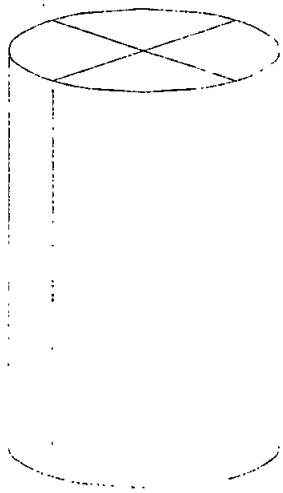
Client: EMI
Job: #151 - Dowil's Slide
Sample ID: Boring 02-BB
Sample Description: Gray large grained conglomerate with a weak dark gray clayston (?) matrix

Sample Depth: 327.8-328.3' Sample Condition: received dry - tested moist

d_1	d_2
2.404	2.404
2.390	2.397
2.399	2.400
2.399	2.402
2.403	2.402

(x.0001")

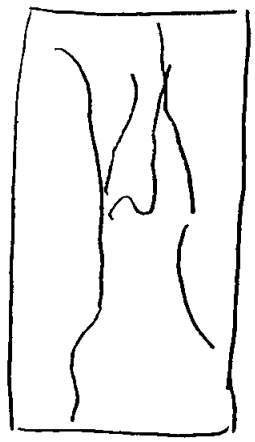
l_1	l_2
+9	+5
+5	+3
±2	±2
-3	0
-6	0



Avg. diameter : 2.400
Avg. length : 5.365
Sample area : 4.524
l/d ratio : 2.24
Sample volume(in^3) : 24.271
Sample weight (g) : 1050.58
Density : 43.28 g/in^3 = 164.9 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE - failed by splitting along clast boundaries. Primarily governed by weak matrix



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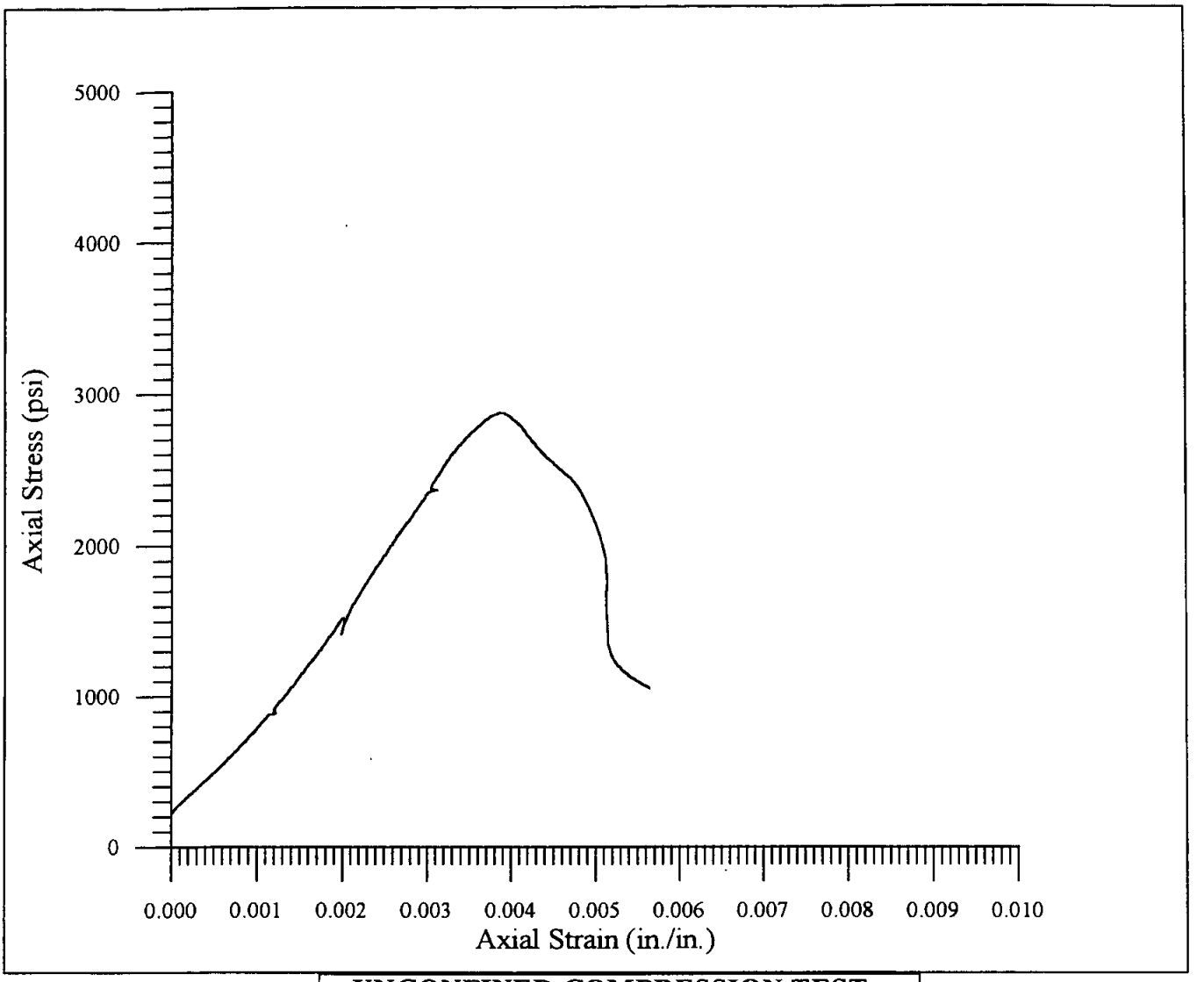


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 8B-327
Boring: 02-8B
Depth: 327.8-328.3'

DESCRIPTION

Medium gray coarse grained conglomerate with a weak dark gray claystone (?) matrix.

Density: 164.9 pcf
Strength: 2870 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

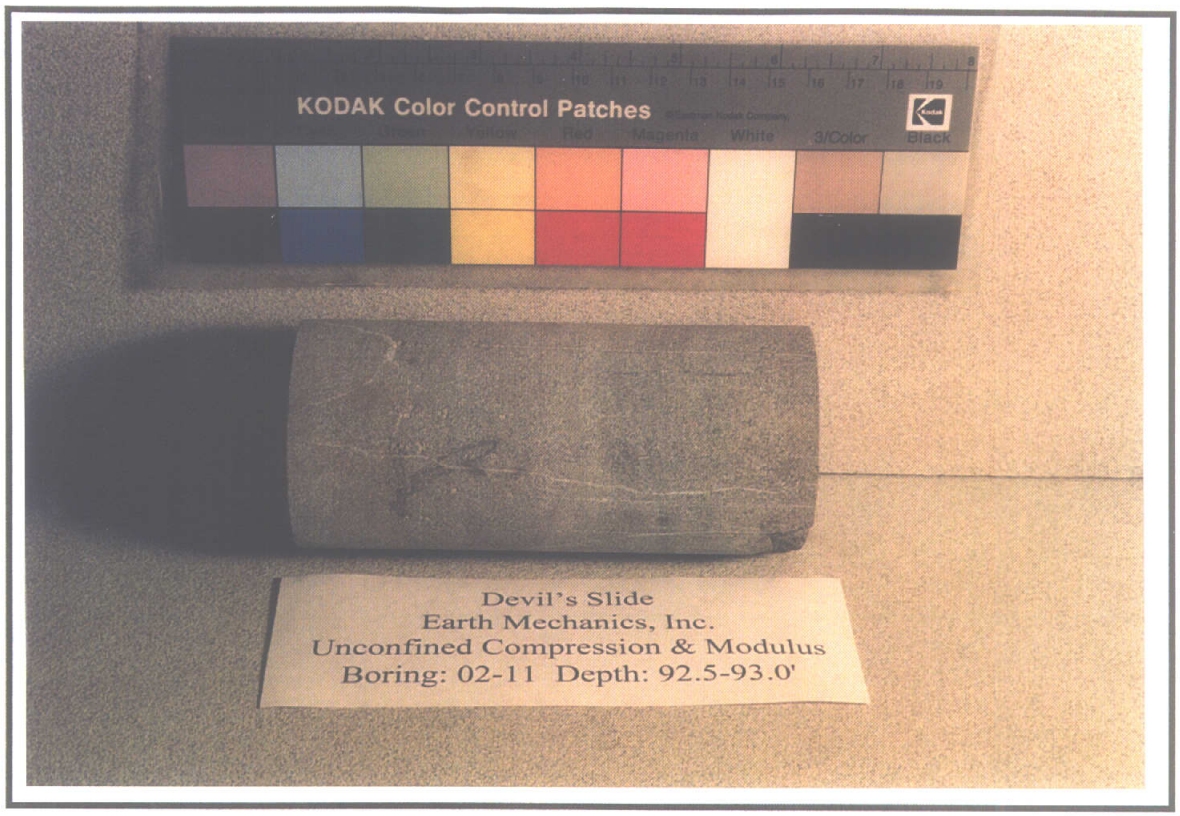
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

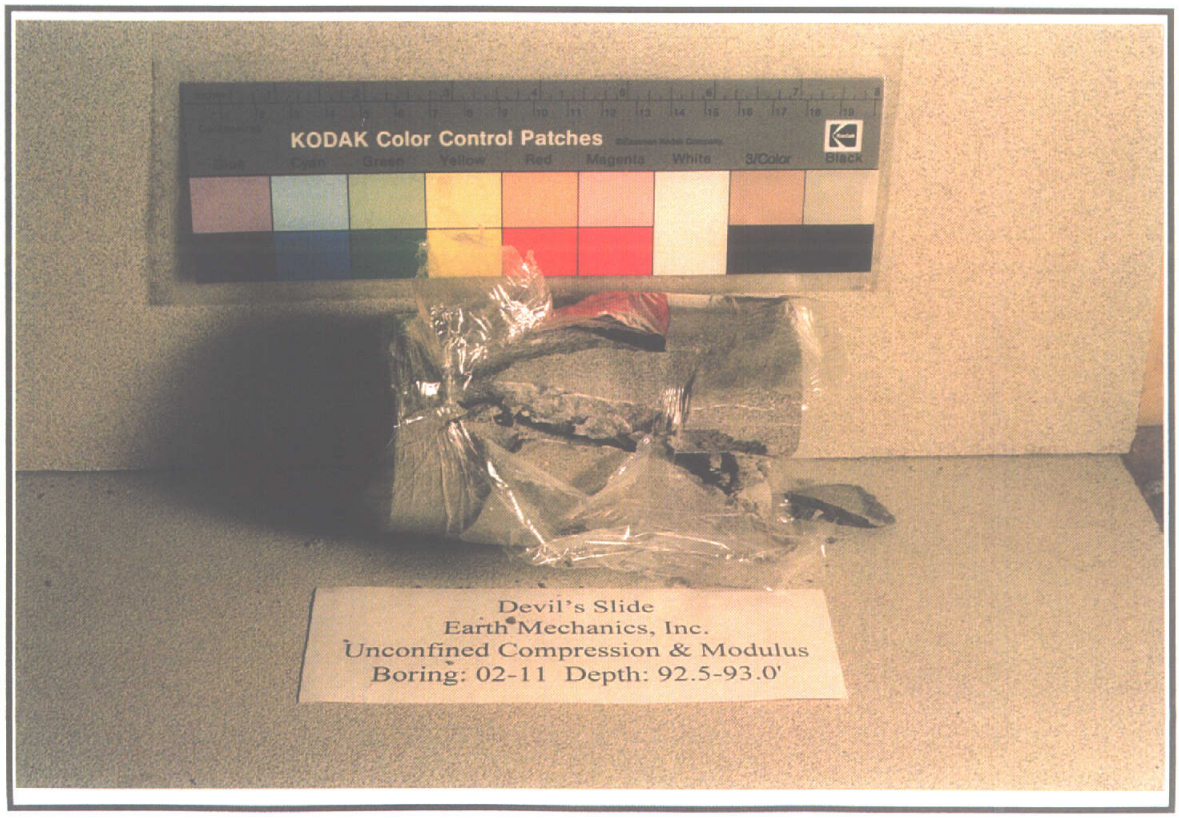
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

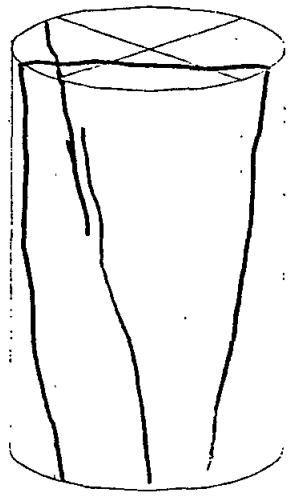
Date: 9/6 & 9/6/02
Technician: A.Bro

Client: EMS
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Tannish gray sandstone with a few oxid calcite healed fractures.

Sample Depth: 92.5-93.0' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.400
2.400	2.399
2.401	2.399
2.400	2.400
2.400	2.401

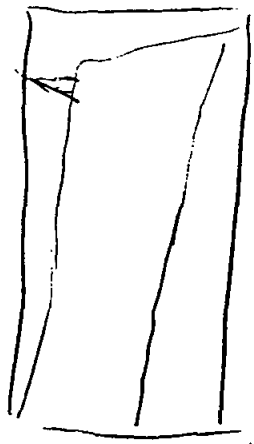
l_1	l_2
+.0010	+.0001
+.0005	
+.0001	±.0002
-.0006	
-.0011	-.0002



Avg. diameter : 2.400 Avg. length : 5.217"
Sample area : 4.524 l/d ratio : 2.17
Sample volume(in^3) : 23.601
Sample weight (g) : 1025.6 g
Density : 43.46 g/in^3 = 165.5 pcF (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments:

JOINT CONTROLLED FAILURE - failed by axial splitting along existing calcite healed joints and intact rock



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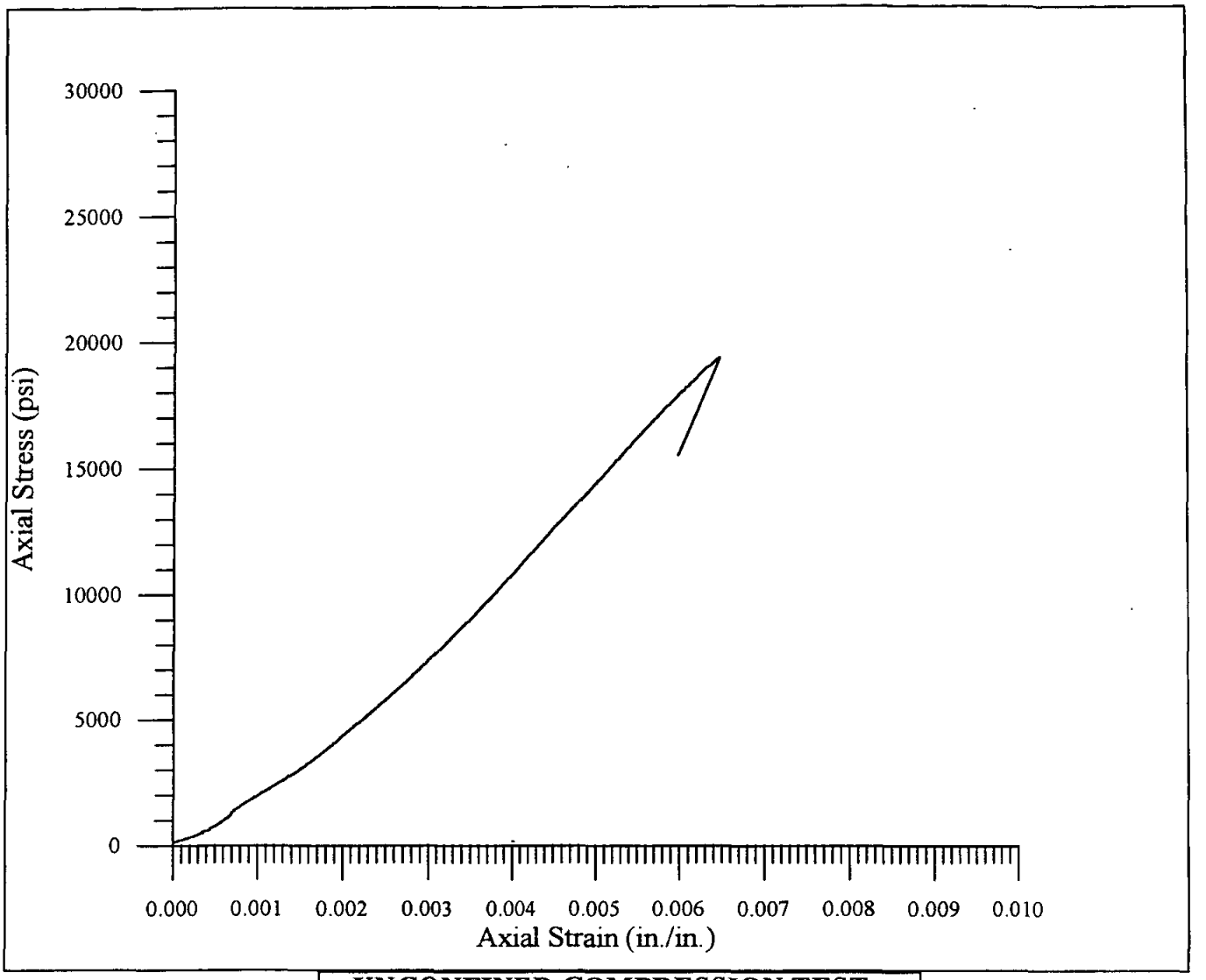


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-92
Boring: 02-11
Depth: 92.5-93.0'

DESCRIPTION
Tannish gray sandstone with a few calcite healed axial fractures.

Density: 165.5 pcf
Strength: 19,411 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

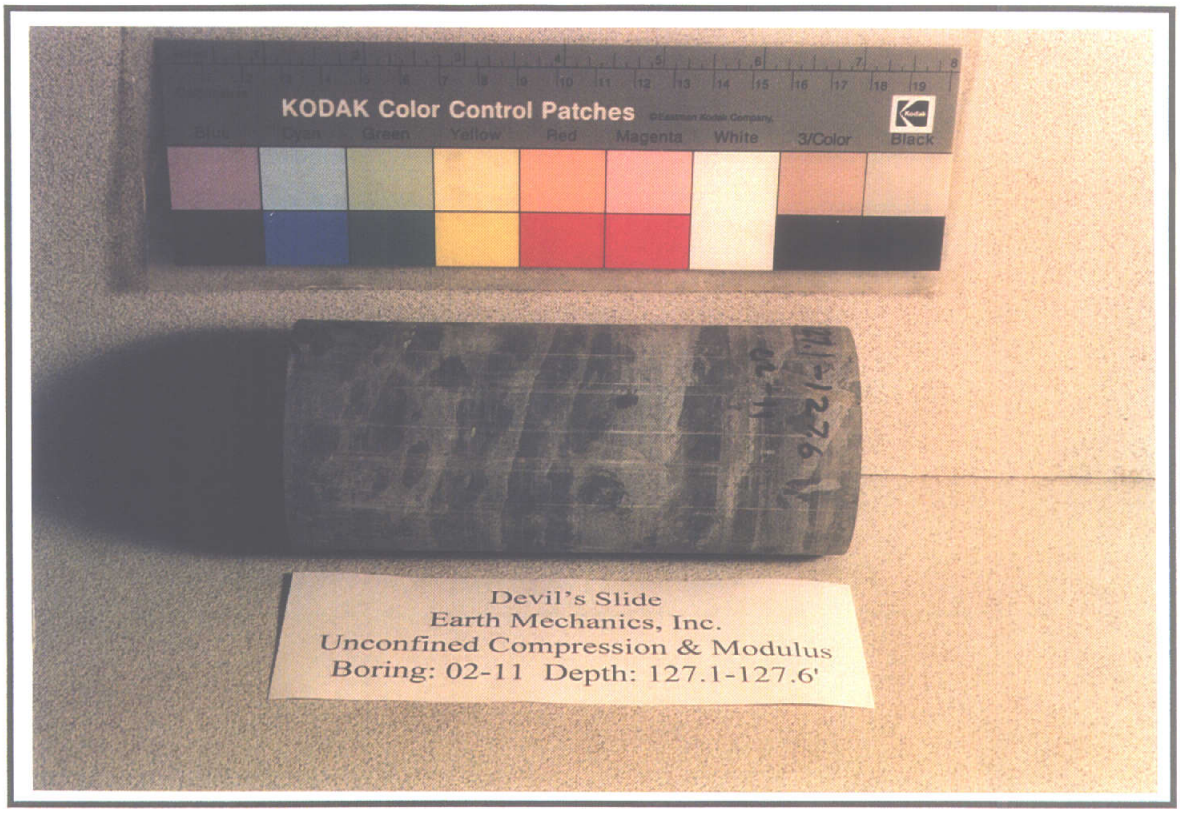
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 9/6-12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11 (2½" thick)
Sample Description: Interbedded shale & fine sandstone (<¼" typical, 3 layers to 3/4") Bedding ~ 75° to core axis.

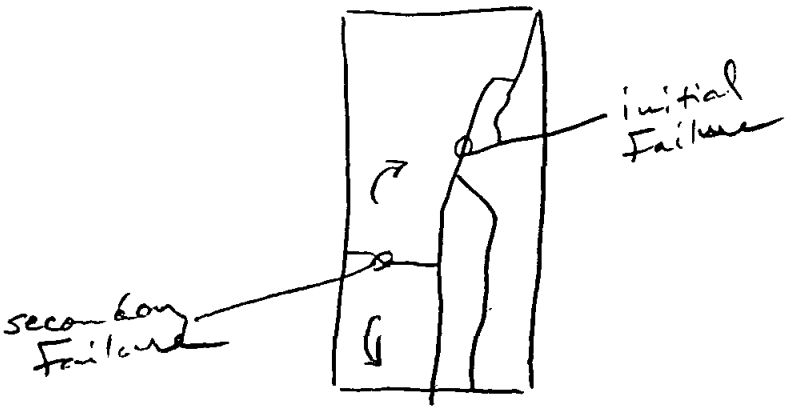
Sample Depth: 127.1-127.6' Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.401
2.402	2.400
2.401	2.401
2.402	2.402
2.399	2.401

l_1	l_2
+.0005	+.0011
+.0004	+.0007
±.0001	±.0002
-.0002	-.0007
-.0006	-.0015

Avg. diameter: 2.401 Avg. length: 5.674"
Sample area: 4.528 l/d ratio: 2.36
Sample volume(in^3): 25.690
Sample weight (g): 1145.3
Density: 44.58 g/in^3 = 169.8 pcF (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments: Failed by axial split (initial failure)
INTACT Failure



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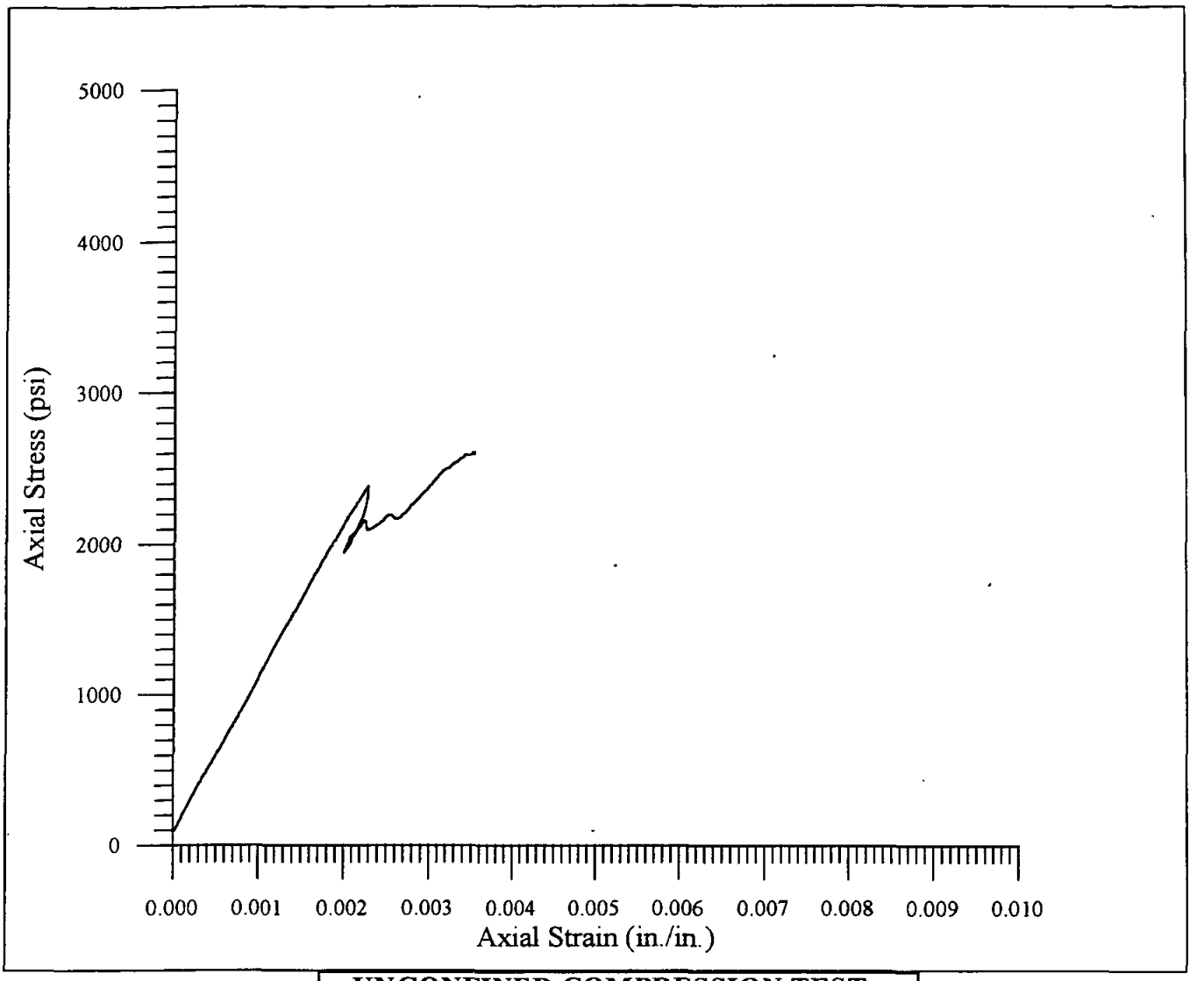


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-127
Boring: 02-11
Depth: 127.1-127.6'

DESCRIPTION
Interbedde shale and fine grained sandstone with bedding about 75 degrees to the core axis.

Density: 169.8 pcf
Strength: 2606 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

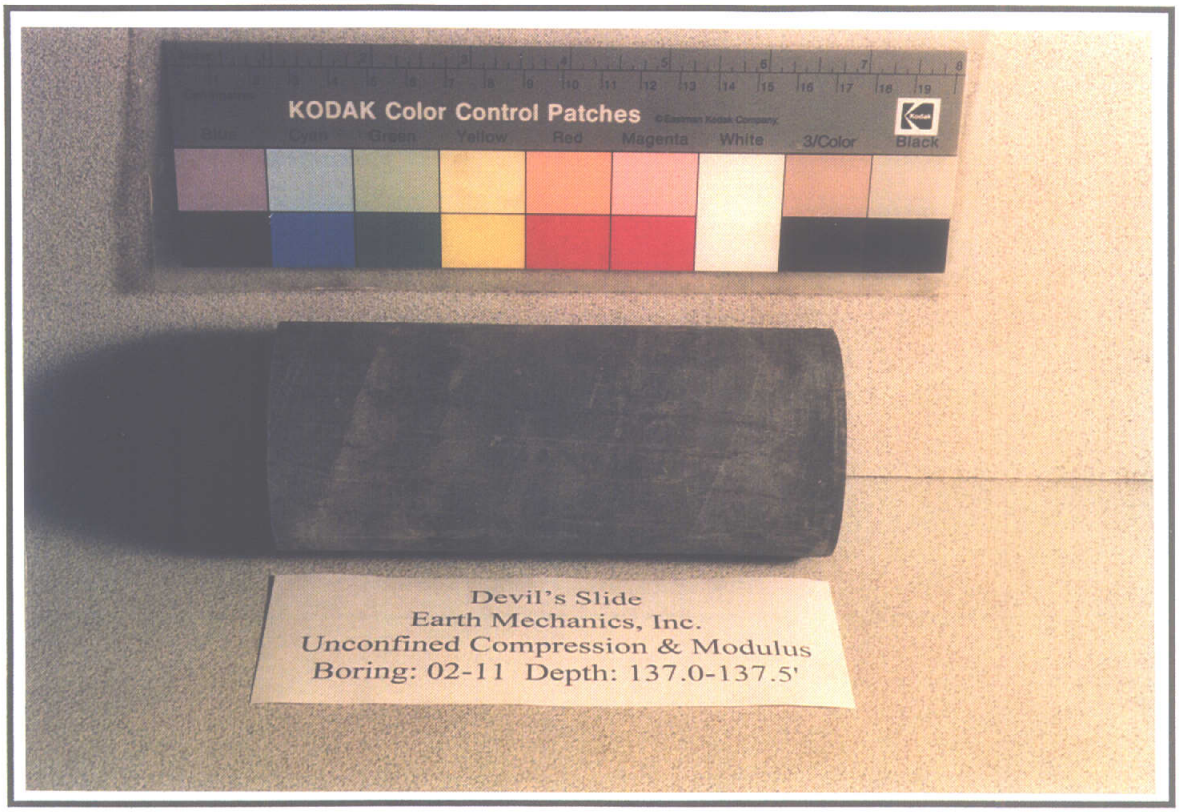
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

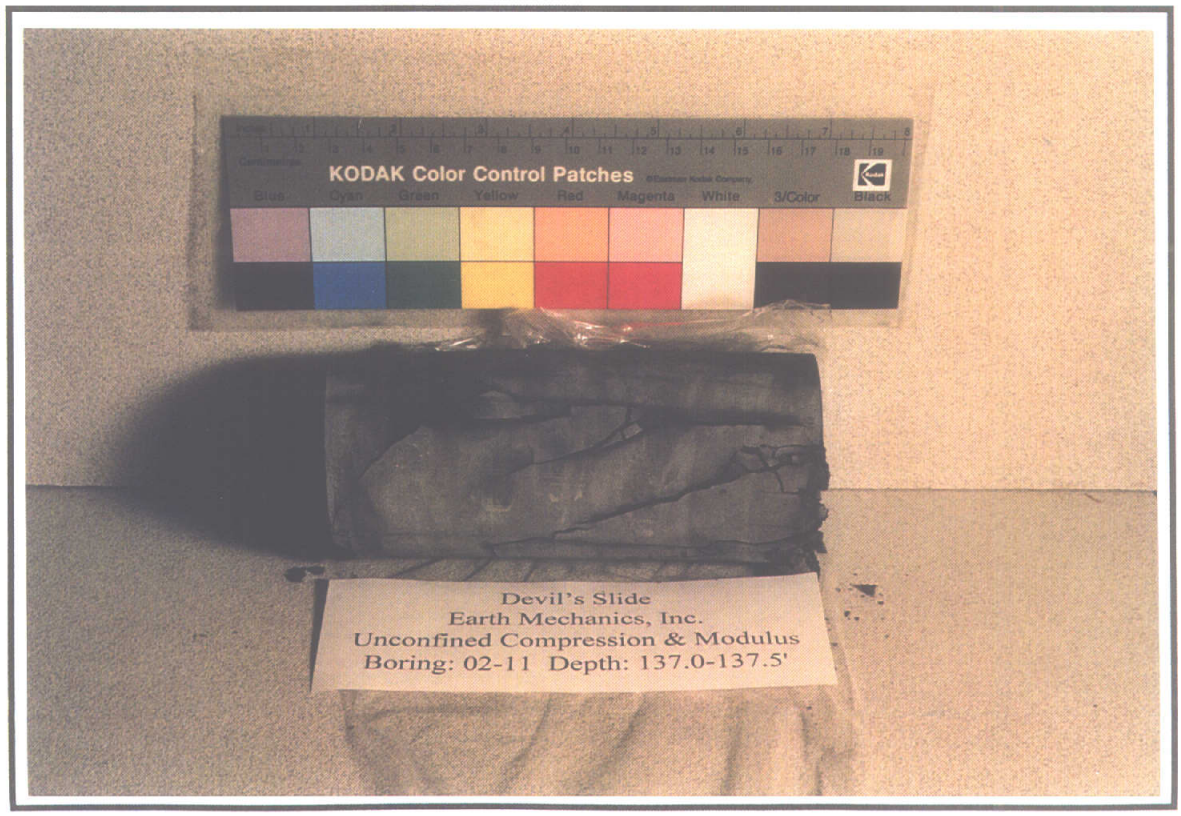
Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

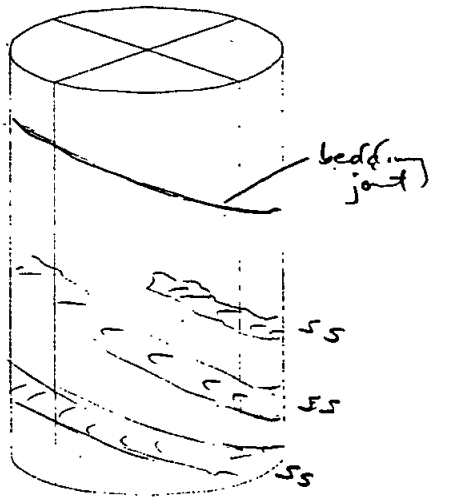
Date: 9/6&12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray shale with a few fine grained sandstone layers. Also contains healed bedding joint bedding ~72° to core axis.

Sample Depth: 137.0-137.5' Sample Condition: received dry - tested moist

d_1	d_2
2.402	2.402
2.402	2.402
2.403	2.403
2.402	2.397
2.402	2.397

l_1	l_2
+.0022	+.0031
+.0011	+.0015
±.0001	±.0002
-.0017	-.0017
-.0024	-.0033



Avg. diameter: 2.401
Sample area: 4.528
Sample volume(in^3): 25.830
Sample weight (g): 1123.8g
Density: 43.518g/in^3 = 165.7pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Avg. length: 5.705"
l/d ratio: 2.38

Comments: water extruded during UC test - Darkened whole sample. VERY DUCTILE! (High strain to failure)
Failed by axial splitting
INTACT FAILURE

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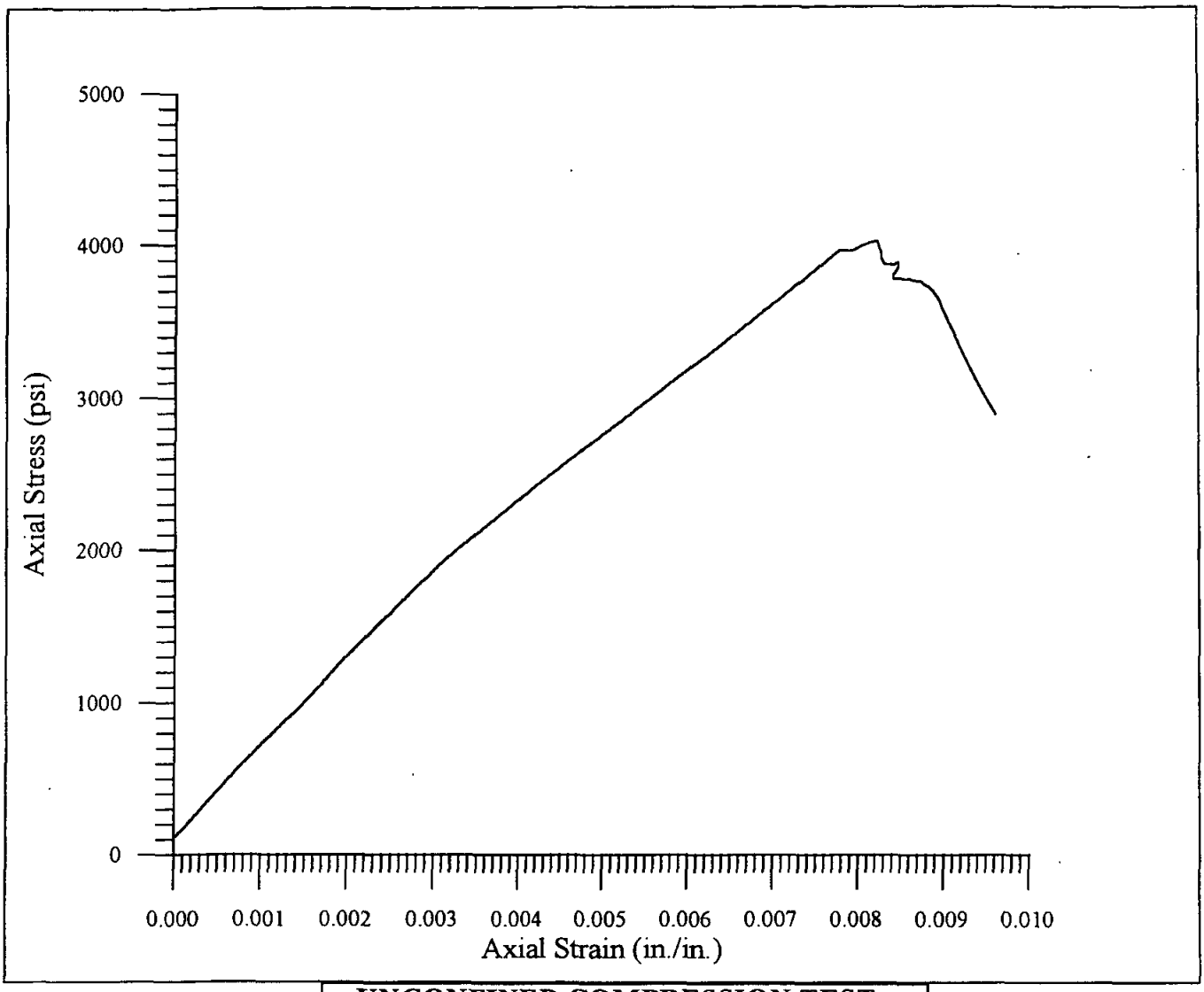


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-137
Boring: 02-11
Depth: 137.0-137.5'

DESCRIPTION
Dark gray shale with a few fine grained sandstone layers with one healed bedding plane joint. Bedding about 75 degrees to the core axis.

Density: 165.7 pcf
Strength: 4023 psi
Joint Control Failure?: no

Geo G T U *Test Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

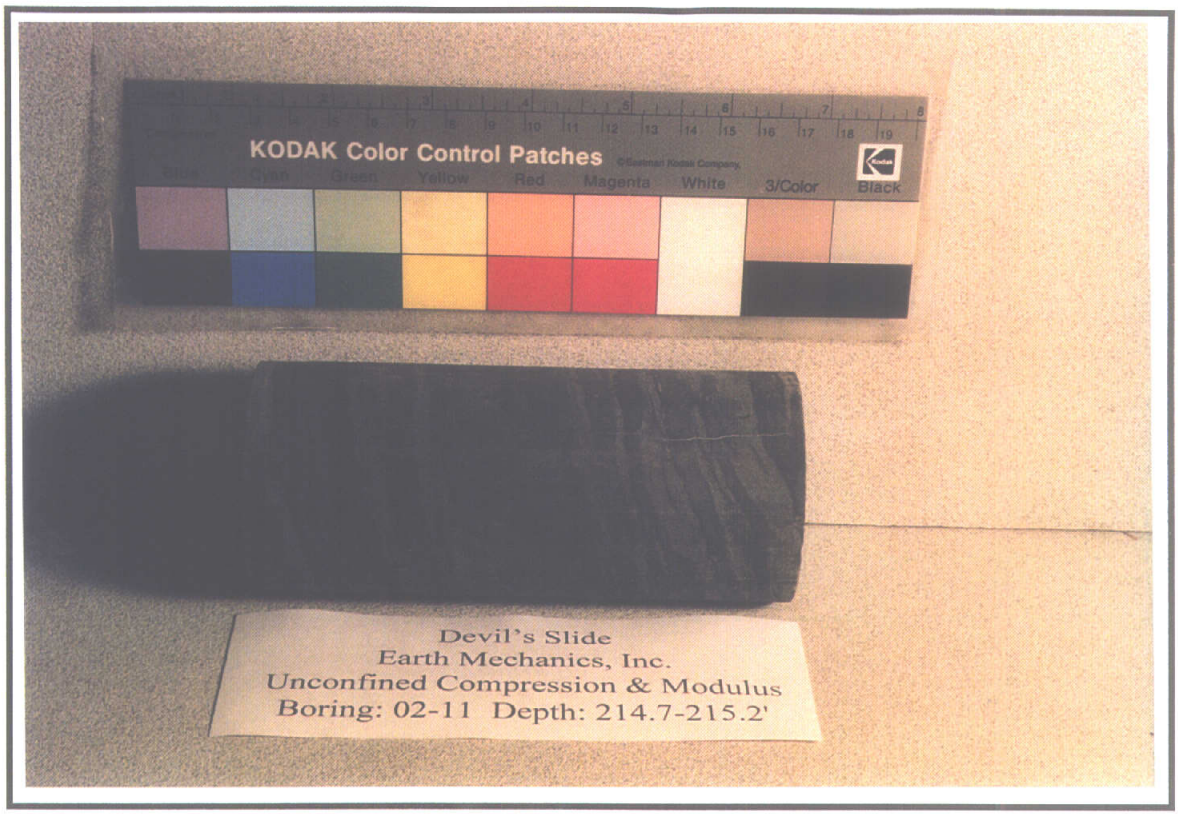
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

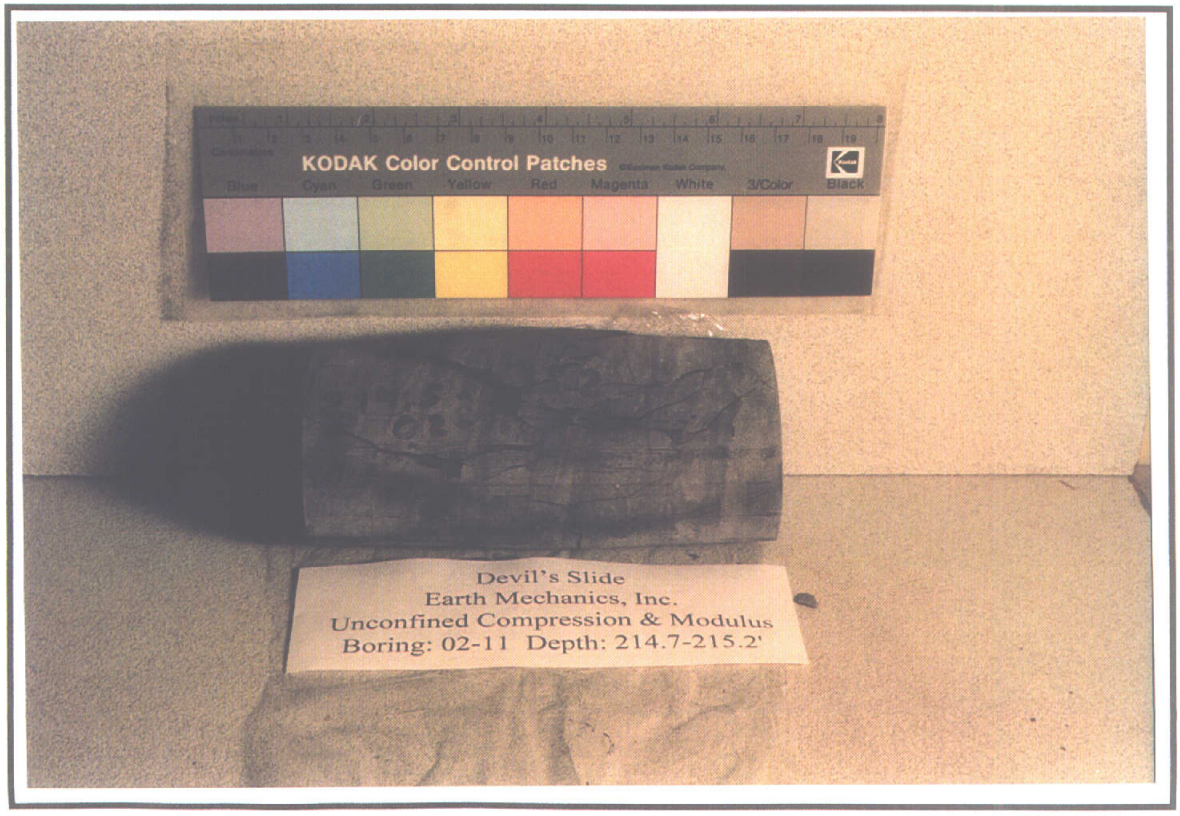
Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited GTU

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

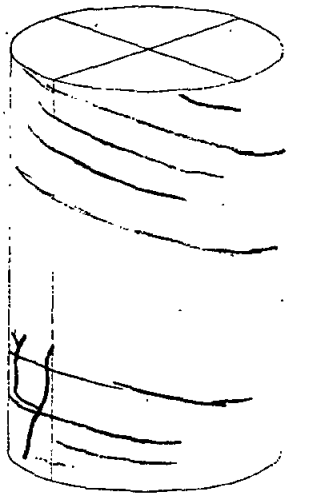
Date: 9/6&12/02
Technician: A.Bro

Client: EMI
Job: #151- Devil's Slide
Sample ID: Boring 02-11
Sample Description: Interbedded shale and sandstone with two axial calcite healed hairline fractures. Bedding ~75° to the core axis.

Sample Depth: 214.7-215.2' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.393
2.400	2.401
2.402	2.401
2.400	2.398
2.401	2.397

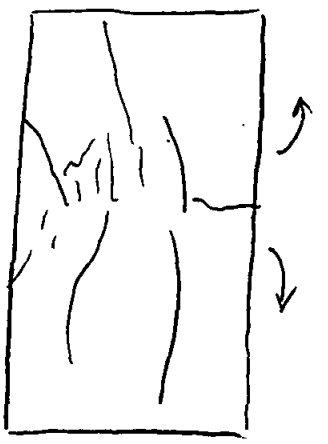
l_1	l_2
+.0025	+.0013
+.0014	+.0009
±.0001	±.0002
-.0011	-.0004
-.0024	-.0007



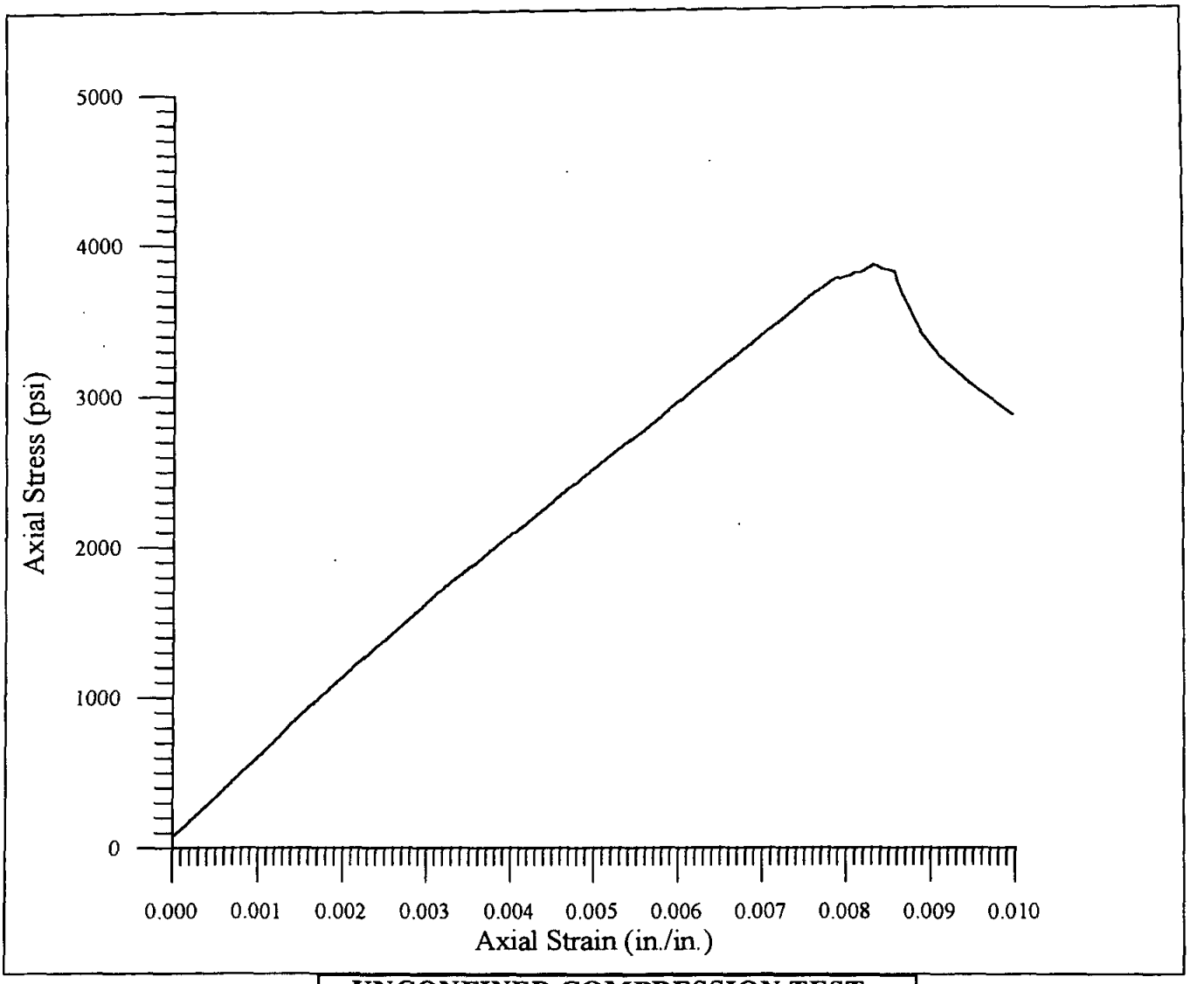
Avg. diameter: 2.399" Avg. length: 5.482"
Sample area: 4.520 l/d ratio: 2.29
Sample volume(in^3): 24.824
Sample weight (g): 1068.5 g
Density: 43.04 g/in^3 = 169.0 pcF (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000"

Comments: modulus sample loaded to incipient Failure. Very ductile

INTACT FAILURE - failed by axial splitting & buckling



27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-214
Boring: 02-11
Depth: 214.7-215.2'

DESCRIPTION
Interbedded shale and sandstone with two axial calcite healed hairline fractures. Bedding about 75 degrees to the core axis.

Density: 164.0 pcf
Strength: 3854 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

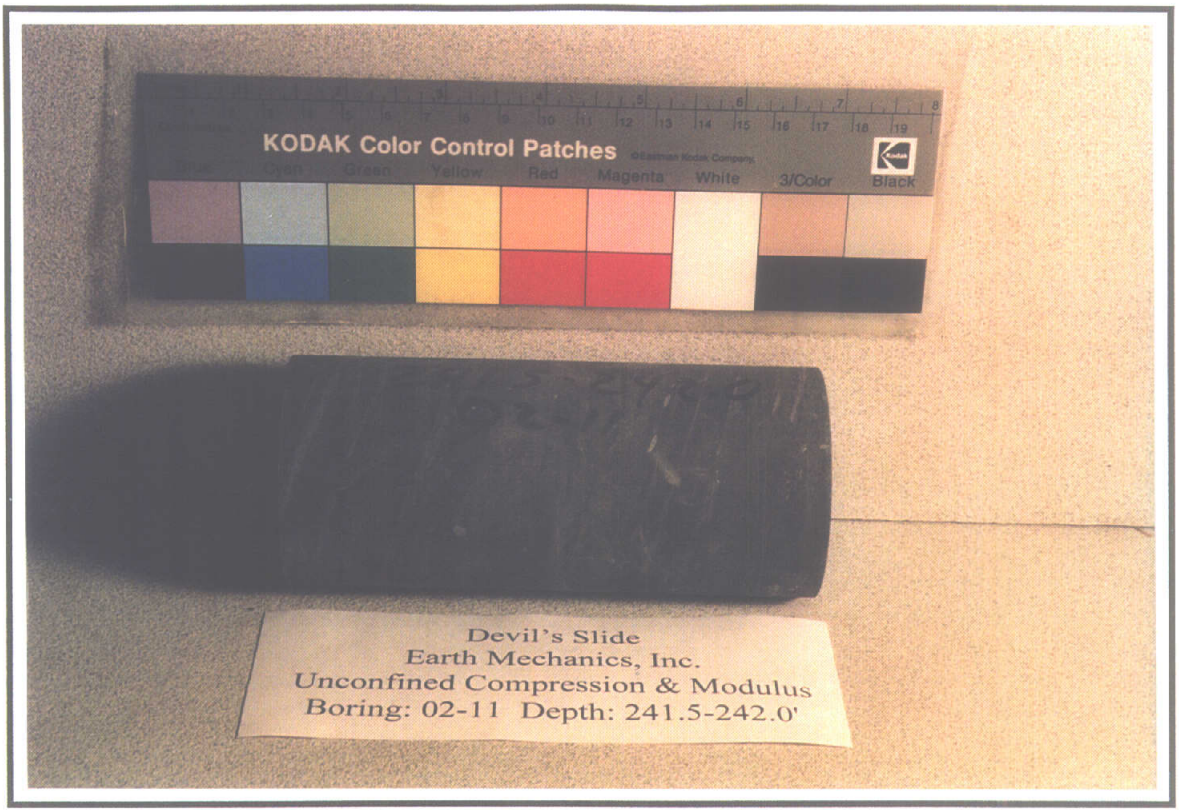
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

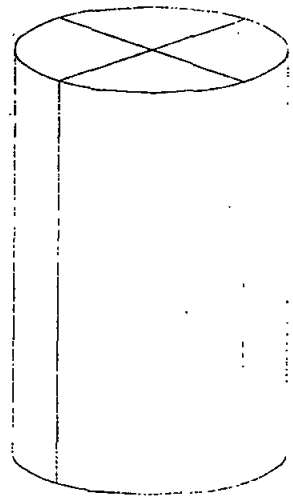
Date: 9/6 & 12/02
Technician: A. Bro

Client: E~I
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Interbedded shale & fine grained sandstone with bedding ~73° to core axis - no visible joints

Sample Depth: 241.5-242.0' Sample Condition: received dry - tested moist

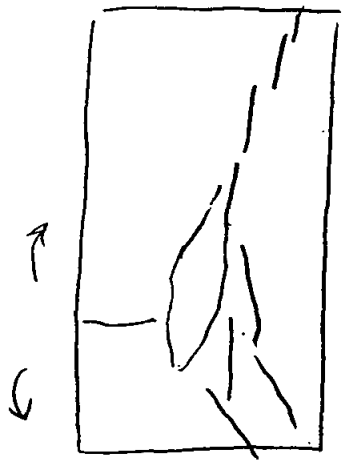
d_1	d_2
2.399	2.398
2.397	2.397
2.400	2.400
2.401	2.400
2.400	2.399

l_1	l_2
+.0008	+.0025
+.0006	+.0015
±.0001	±.0002
-.0006	-.0015
-.0017	-.0030

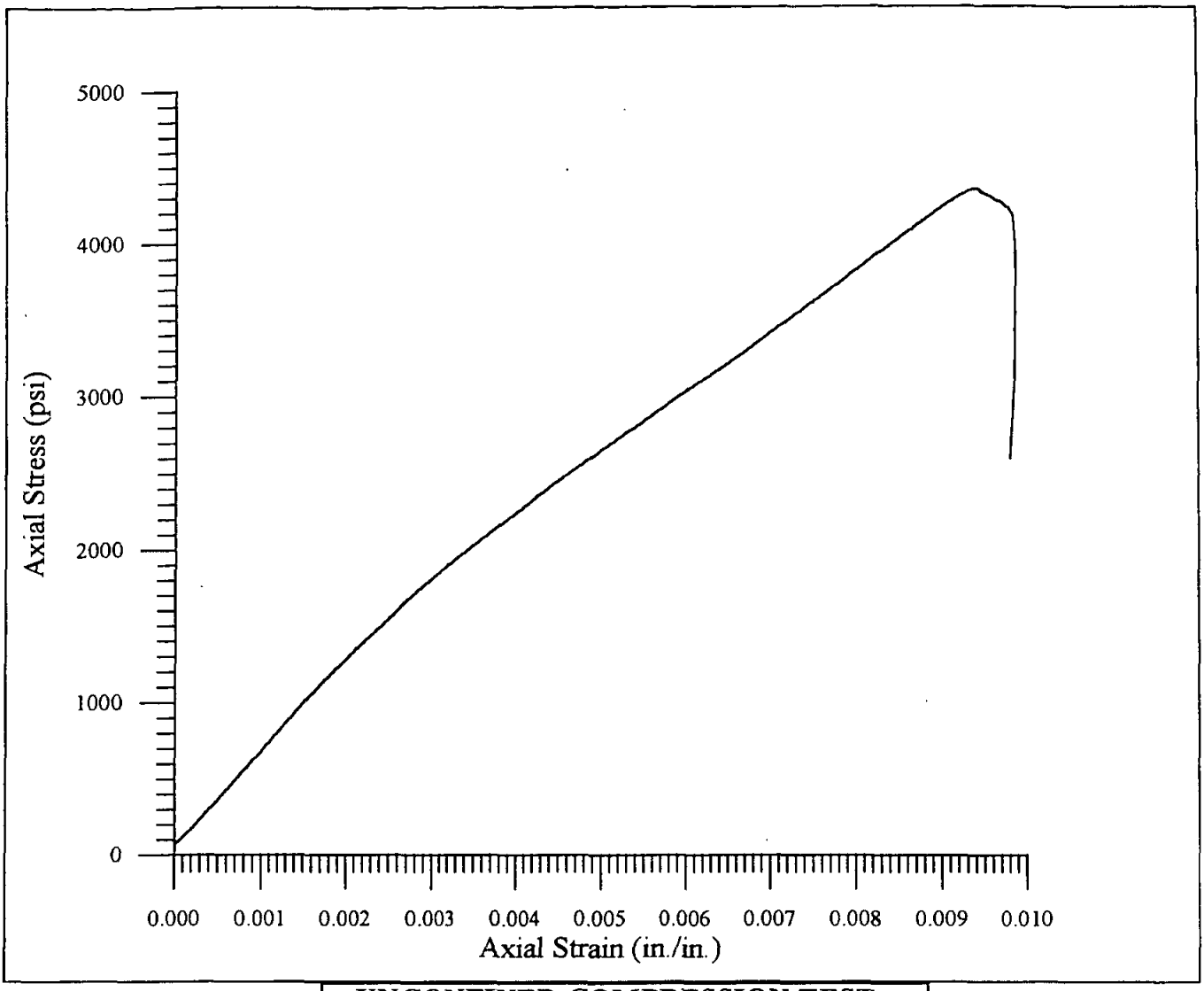


Avg. diameter : 2.399"
Avg. length : 5.404"
Sample area : 4.520
l/d ratio : 2.25
Sample volume(in^3) : 24.427
Sample weight (g) : 1051.78
Density : 43.068 g/in^3 = 164.0 pcF (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments: shale sections darken (w/pore water) during loading
DUCTILE FAILURE
INTACT FAILURE - by splitting & rotation



27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-241
Boring: 02-11
Depth: 241.5-242.0'

DESCRIPTION
Interbedded shale and sandstone with bedding about 73 degrees to the core axis. No visible joints.

Density: 164.0 pcf
Strength: 4364 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

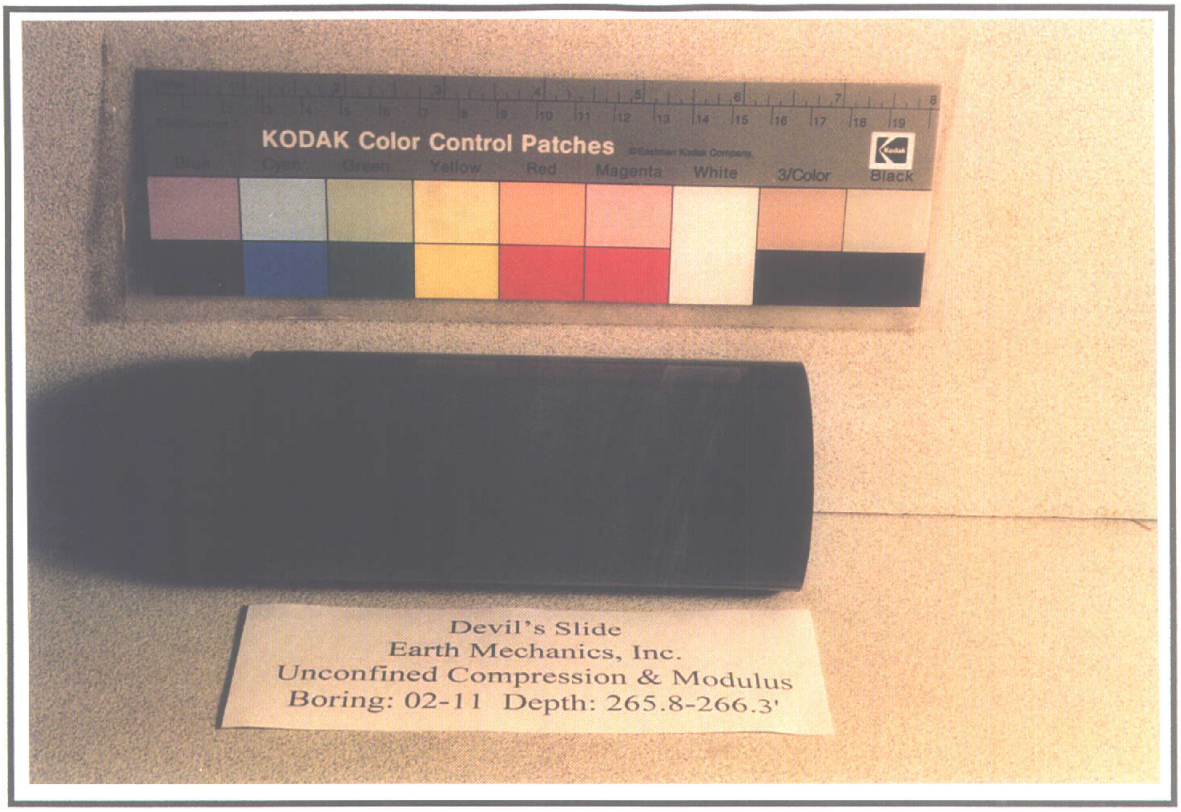
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

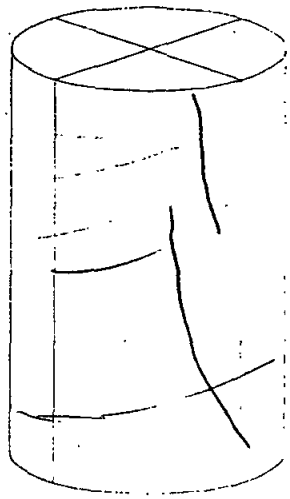
Date: 9/6-16/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Interbedded (Finely) medium to dark gray siltstone with a few calcite healed fractures crossing perpendicular to bedding - Bedding ~ 73° to the core axis.

Sample Depth: 265.8 - 266.3' Sample Condition: received dry tested moist

d_1	d_2
2.400	2.400
2.400	2.400
2.400	2.400
2.400	2.400
2.399	2.398

l_1	l_2
+.0013	+.0022
+.0007	+.0010
±.0001	±.0002
-.0007	-.0010
-.0015	-.0020

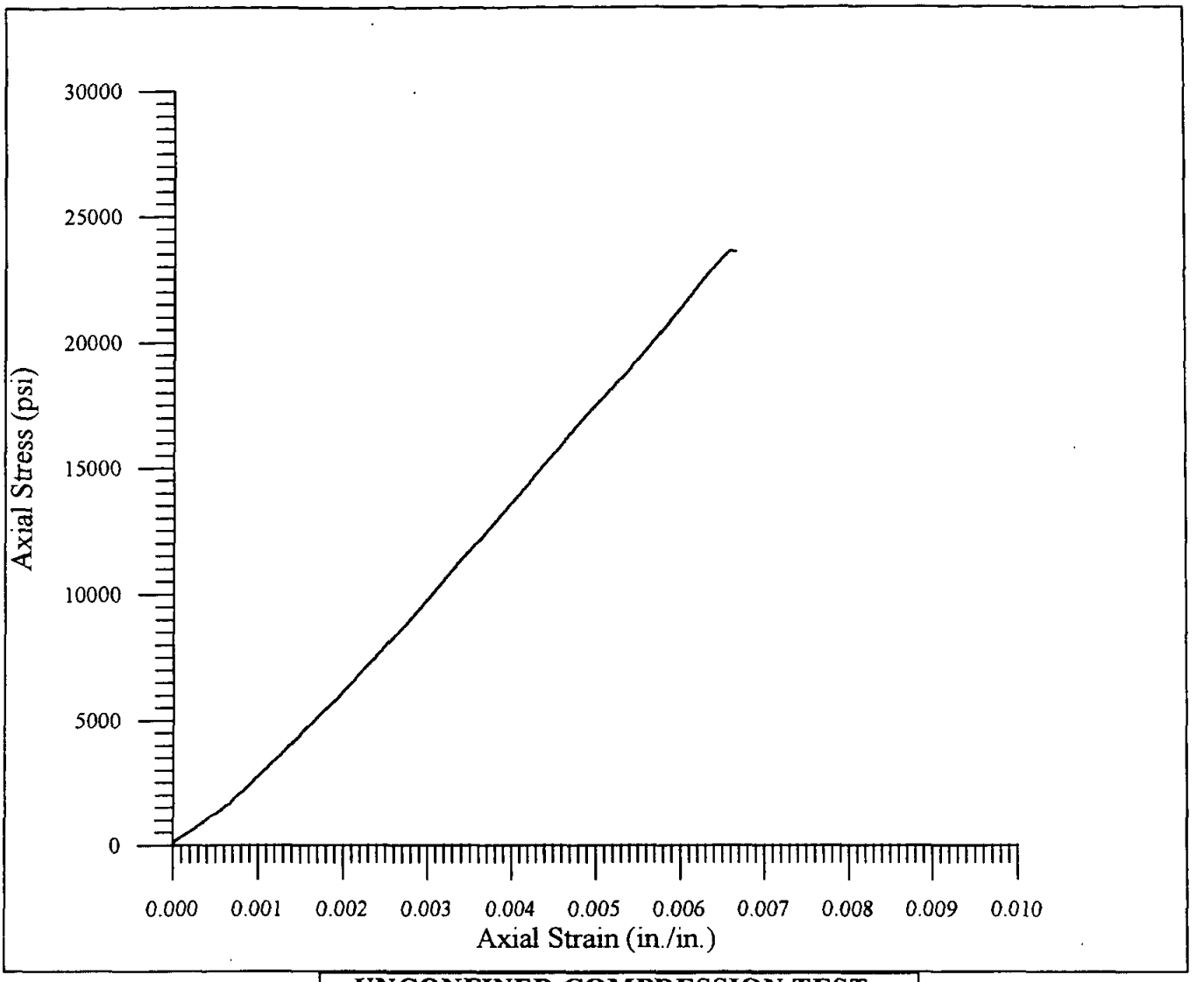


Avg. diameter : 2.400"
Avg. length : 5.623"
Sample area : 4.524
l/d ratio : 2.34
Sample volume(in^3) : 25.438
Sample weight (g) : 1160.1 g
Density : 45.618 g/in^3 = 173.7 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments:

INTACT FAILURE - by axial splitting

27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-265
Boring: 02-11
Depth: 265.8-266.3'

DESCRIPTION

Interbedded medium gray and dark gray fine grained sandstone (siltstone?) with a few calcite healed hairline fractures perpendicular to bedding. Bedding about 73 degrees to the core axis.

Density: 173.7 pcf
Strength: 23,648 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

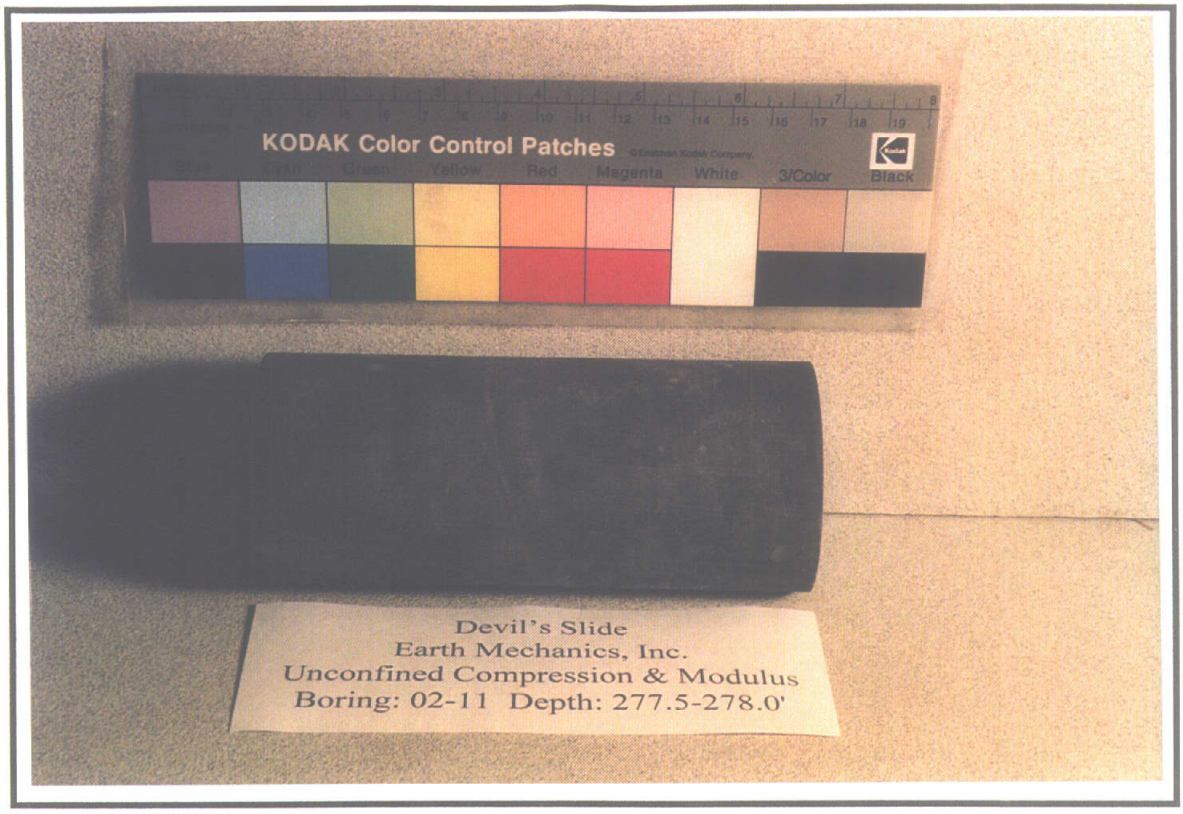
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

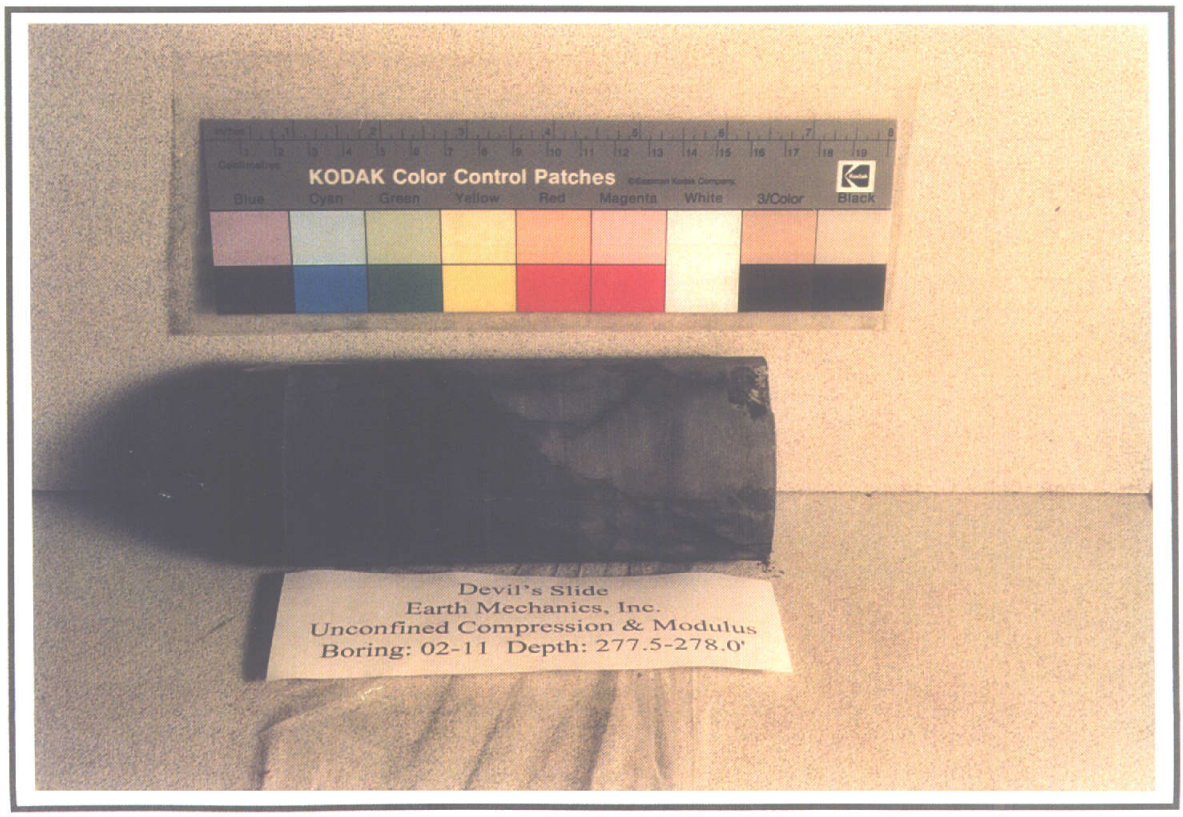
Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

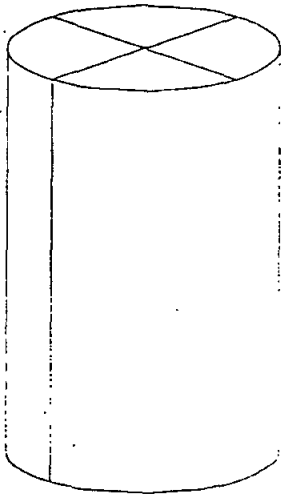
Date: 9/6&12/02
Technician: A. Bro

Client: E~I
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray shale, bedding ~ 74° to core axis

Sample Depth: 277.5-278.0 Sample Condition: received dry - tested moist

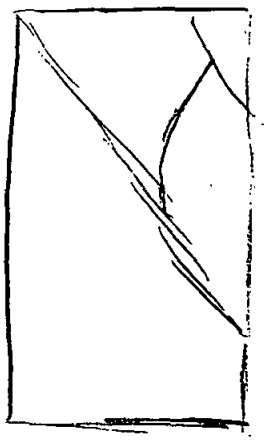
d_1	d_2
2.402	2.397
2.401	2.398
2.400	2.399
2.399	2.397
2.400	2.401

l_1	l_2*
+.0050	-.0007
+.0032	-.0006
±.0001	±.0002
-.0032	+.0002
-.0060	-.0004



Avg. diameter: 2.399 Avg. length: 5.601"
Sample area: 4.520 l/d ratio: 2.33
Sample volume(in³): 25.317
Sample weight (g): 1086.5g.
Density: 42.92 g/in³ = 163.5pcF (1 g/in³=3.8095lb/ft³)
Gauge length: 2.000 in

Comments: * uneven surface due to displacements across fractures which are barely visible on sample end.
modulus test taken to incipient failure.
water develops on surface during test
Failed by shear - INTACT FAILURE



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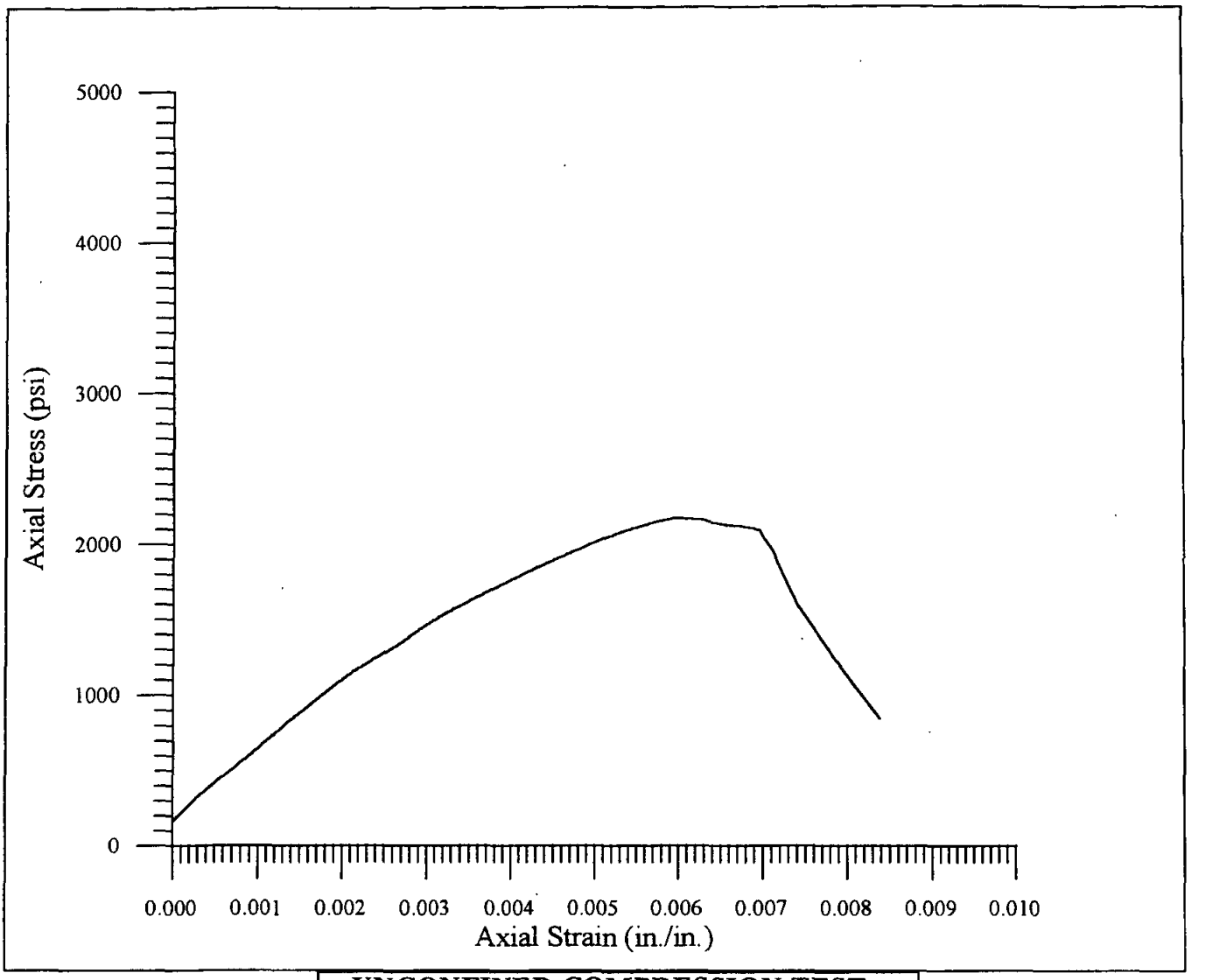


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-277
Boring: 02-11
Depth: 277.5-278.0'

DESCRIPTION

Interbedded medium gray and dark gray fine grained sandstone (siltstone?) with a few calcite healed hairline fractures perpendicular to bedding. Bedding about 73 degrees to the core axis.

Density: 163.5 pcf
Strength: 2175 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 8/16/02
Technician: A. Bro

Client: ENI
Job: #151 - Devil's Slide
Sample ID: Boring 02-7
Sample Description: Gray, medium to coarse grained sandstone (almost a F-c conglomeratic sandstone) with a few calcite healed joints.

Sample Depth: 318.8-319.3' Sample Condition: received dry - tested moist

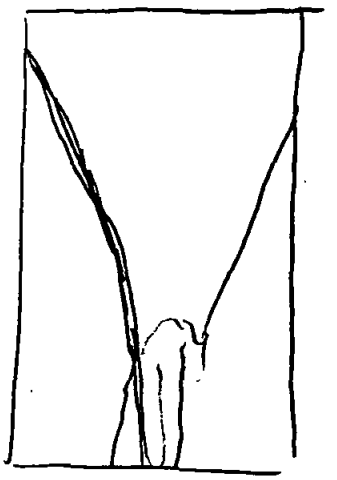
d_1	d_2
2.398	2.399
2.397	2.398
2.398	2.398
2.398	2.397
2.394	2.399

l_1	l_2
+.0013	0
+.0007	
±.0001	±.0001
-.0005	
-.0010	0

Avg. diameter: 2.398 Avg. length: 5.556
Sample area: 4.516 l/d ratio: 2.32
Sample volume(in^3): 25.093
Sample weight (g): 1085.48
Density: 43.26 g/in^3 = 164.8 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE - failed by shear on existing joint



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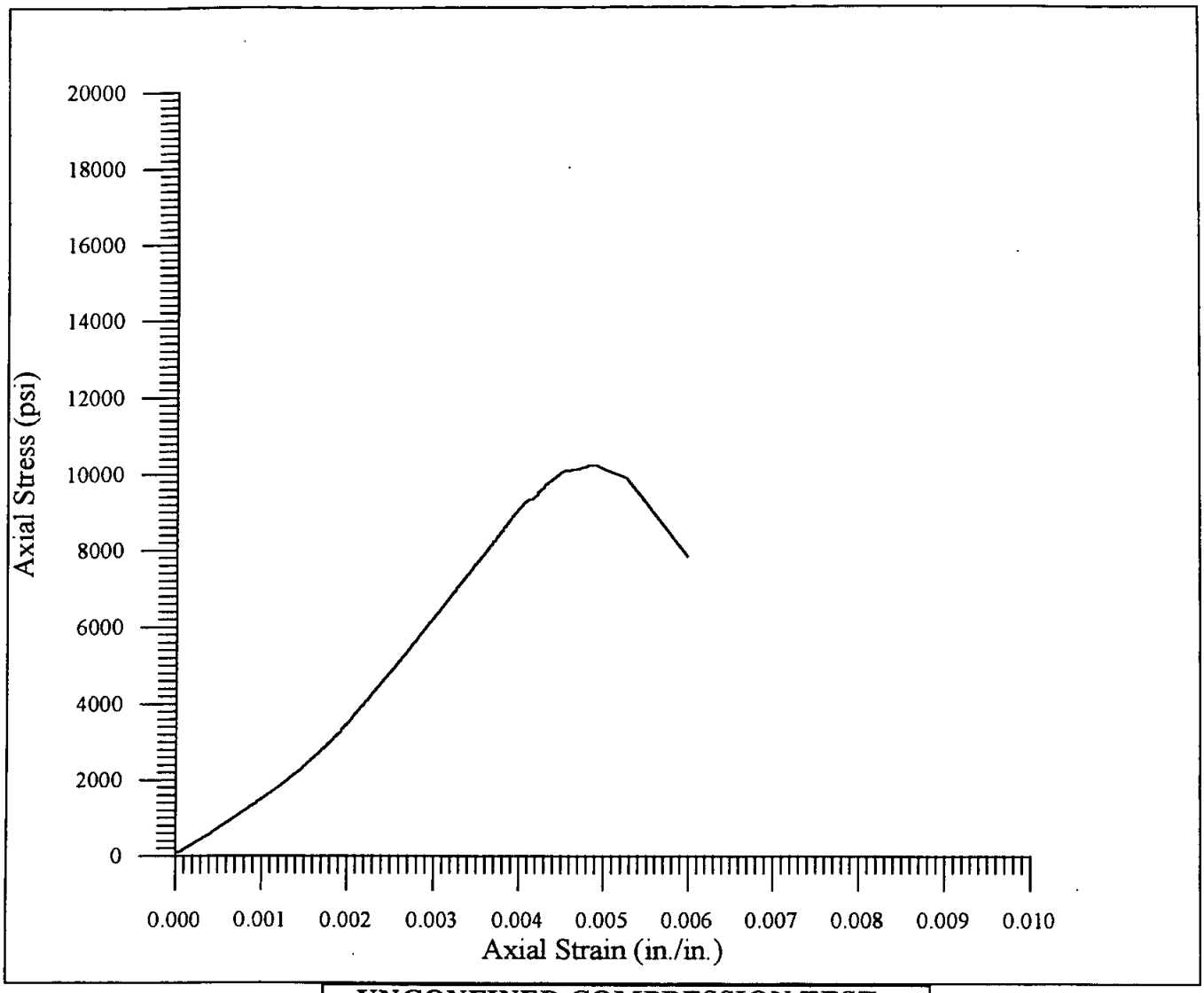


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 7-318
Boring: 02-7
Depth: 318.8-319.3'

DESCRIPTION

Gray medium to coarse grained sandstone with a few calcite healed joints.

Density: 164.8 pcf
Strength: 10,251 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

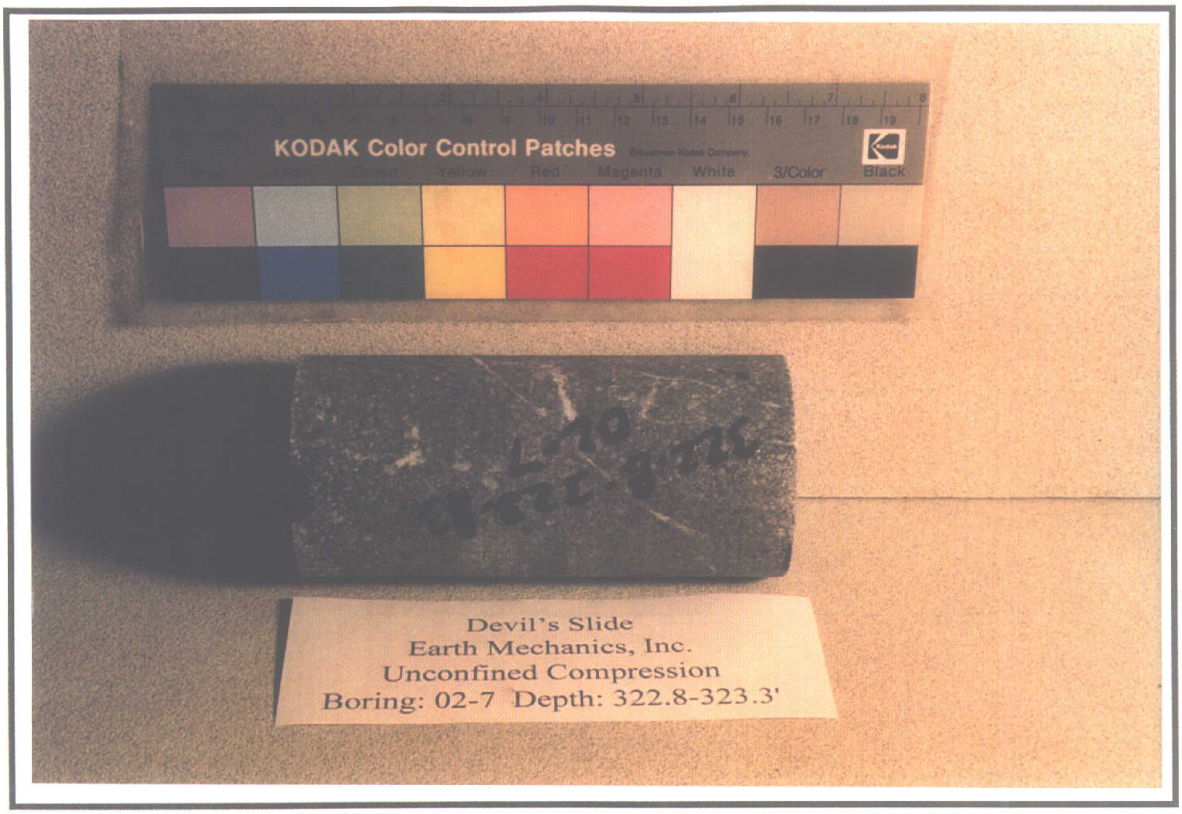
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

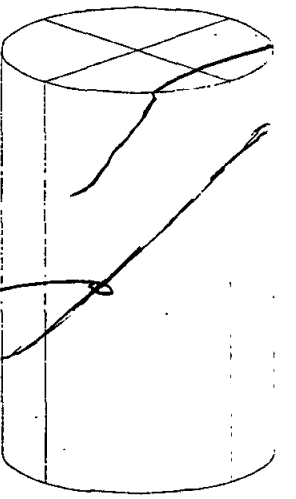
Date: 9/16/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-T
Sample Description: Gray, medium to coarse grained sandstone with two calcite healed joints,

Sample Depth: 322.8-323' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.399
	2.398
	2.400
	2.396
	2.397

l_1	l_2
+.0008	0
+.0004	0
±.0001	±.0002
−.0006	0
−.0012	0

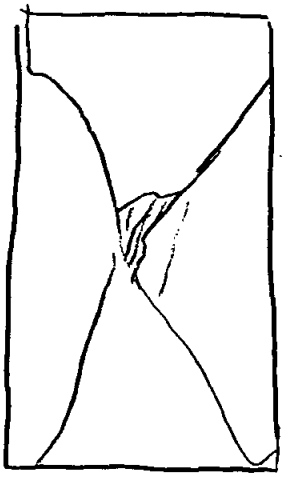


Avg. diameter : 2.399
Sample area : 4.520
Sample volume(in^3) : 23.211
Sample weight (g) : 1004.0g
Density : 43.26g/in^3 = 164.8pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.135
l/d ratio : 2.14

Comments:

JOINT CONTROLLED FAILURE - Failed by shear



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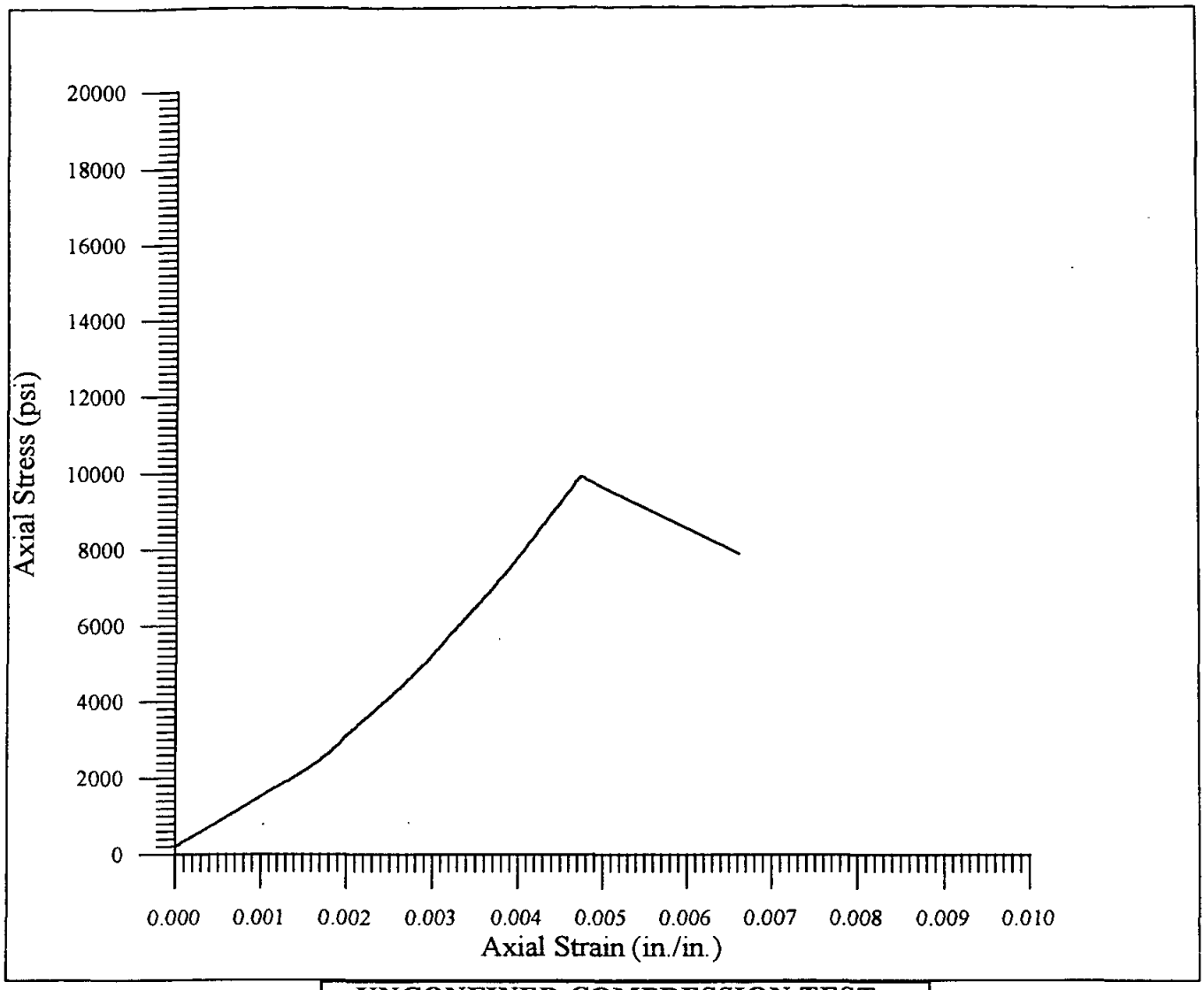


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 7-322
Boring: 02-7
Depth: 322.8-323.3'

DESCRIPTION

Gray medium to coarse grained sandstone with two calcite healed joints.

Density: 164.8 pcf
Strength: 9921 psi
Joint Control Failure?: yes

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/16/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-7
Sample Description: gray conglomeratic sandstone (<5% 2cm+ clasts up to about 1") with several calcite healed fractures.

Sample Depth: 370.0-370.5' Sample Condition: received dry - tested moist

d_1	d_2
2.402	2.402
2.402	2.402
2.401	2.402
2.399	2.401
2.399	2.401

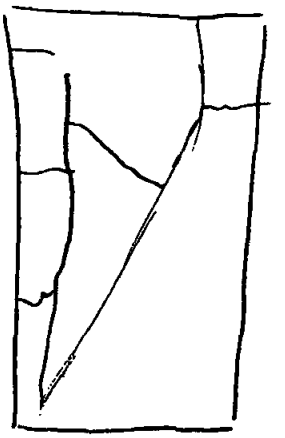
l_1	l_2
+.0008	+.0001
+.0004	
±.0001	±.0002
-.0004	
-.0008	-.0001

Avg. diameter: 2.401
Sample area: 4.528
Sample volume(in^3): 25.292
Sample weight (g): 1103.98
Density: 43.65 g/in^3 = 166.3 pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length: 5.586"
l/d ratio: 2.33

Comments:

JOINT CONTROLLED FAILURE - by shear along diagonal (not surgical healed joint) and by axial splitting along calcite healed joint



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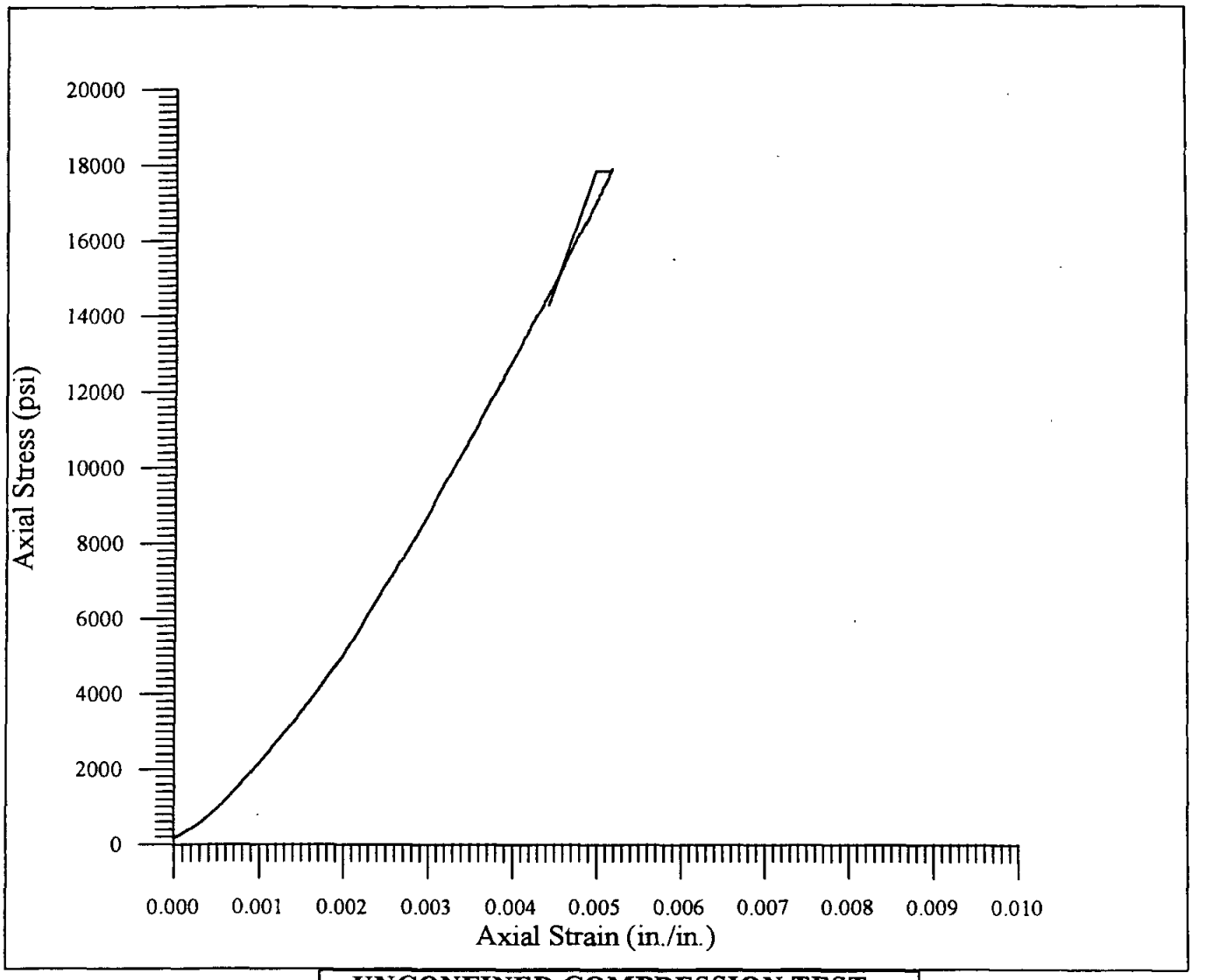


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 7-370
Boring: 02-7
Depth: 370.0-370.5'

DESCRIPTION

Gray congomeratic sandstone
with several calcite healed joints.

Density: 166.3 pcf
Strength: 17,911 psi
Joint Control Failure?: yes

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

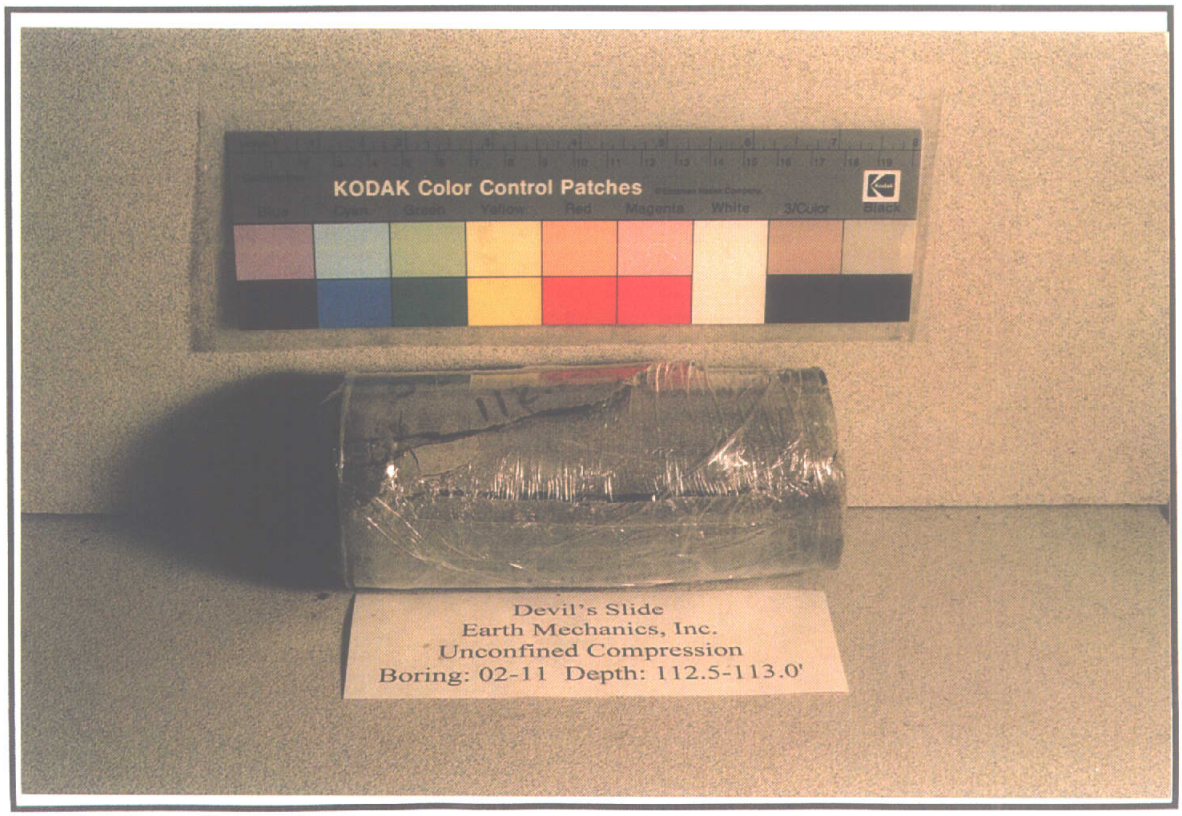
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

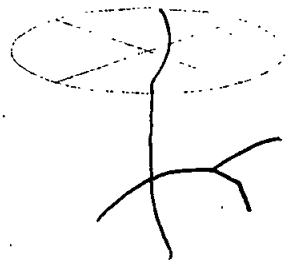
Date: 9/16/02
Technician: A. Bro

Client: ENI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: tannish gray Fine to medium grained sandstone with a few poorly healed fractures.

Sample Depth: 112.5-113.0' Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.400
2.400	
2.400	
2.401	
2.397	

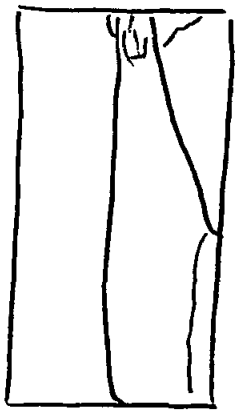
l_1	l_2
+.0011	+.0001
+.0006	0
±.0001	±.0002
-.0005	0
-.0010	0



Avg. diameter : 2.400 Avg. length : 5.658"
Sample area : 4.524 l/d ratio : 2.36
Sample volume(in^3) : 25.596
Sample weight (g) : 1109.0g
Density : 43.33 g/in^3 = 165.1 pcf (1 g/in^3=3.8095lb/ft^3)

Comments: Initial failure by axial splitting ↓ then by shear

JOINT CONTROLLED FAILURE by splitting & shear



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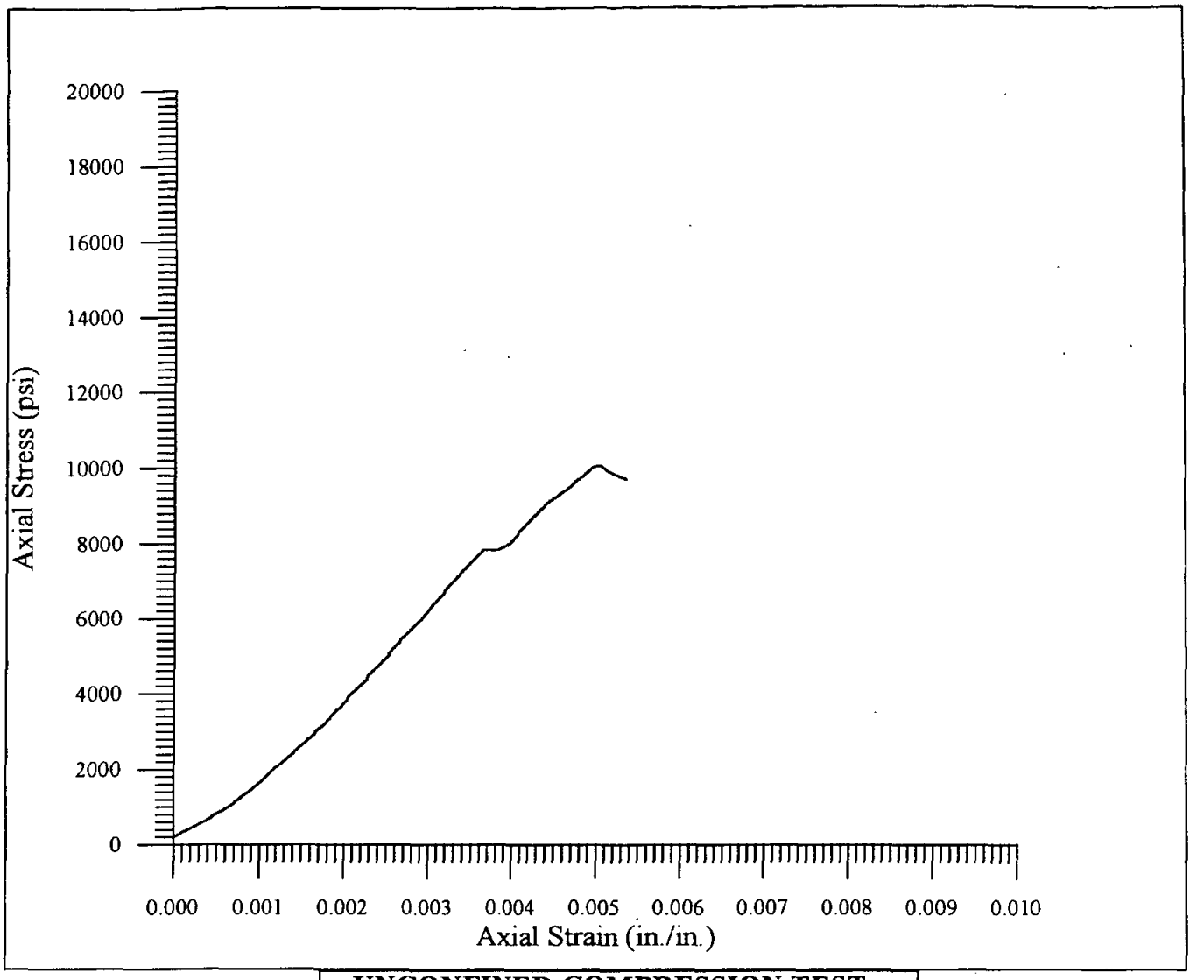


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-112
Boring: 02-11
Depth: 112.5-113.0'

DESCRIPTION

Tannish gray fine to medium grained sandstone with a few poorly healed fractures.

Density: 165.1 pcf
Strength: 10,054 psi
Joint Control Failure?: yes

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

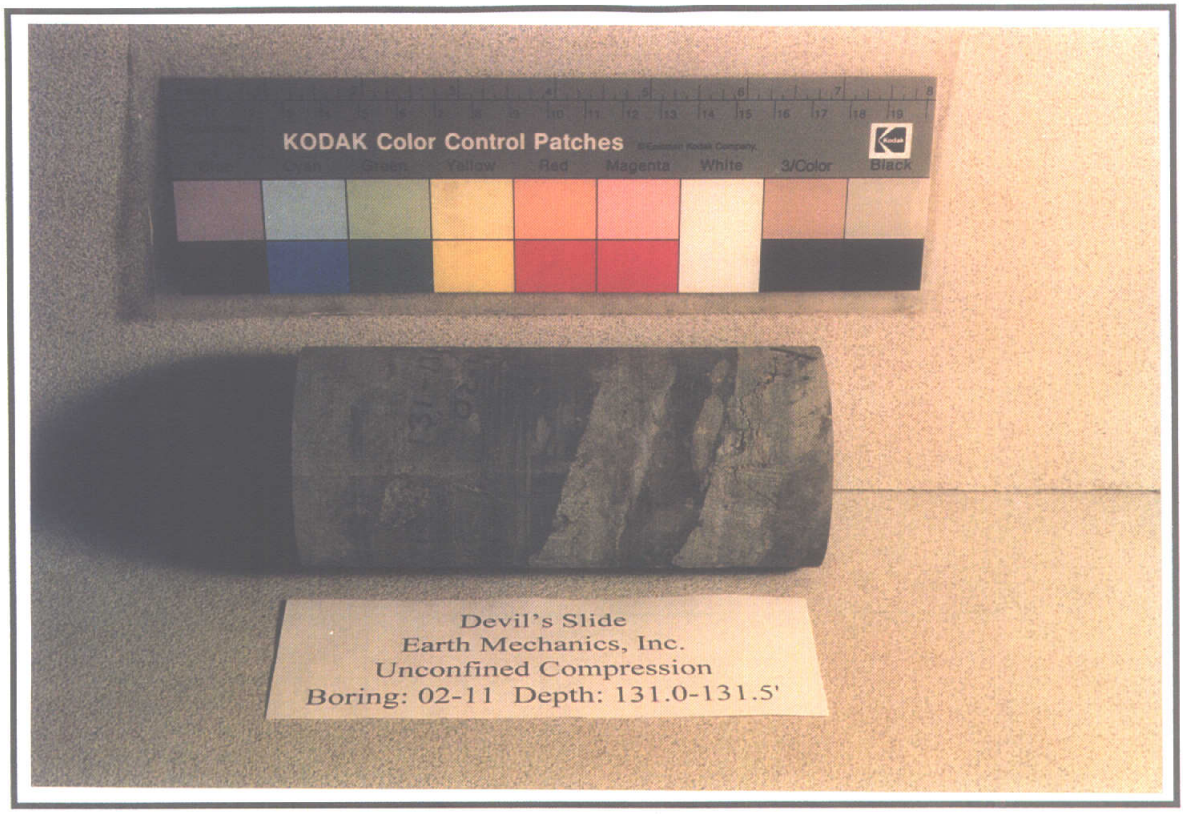
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

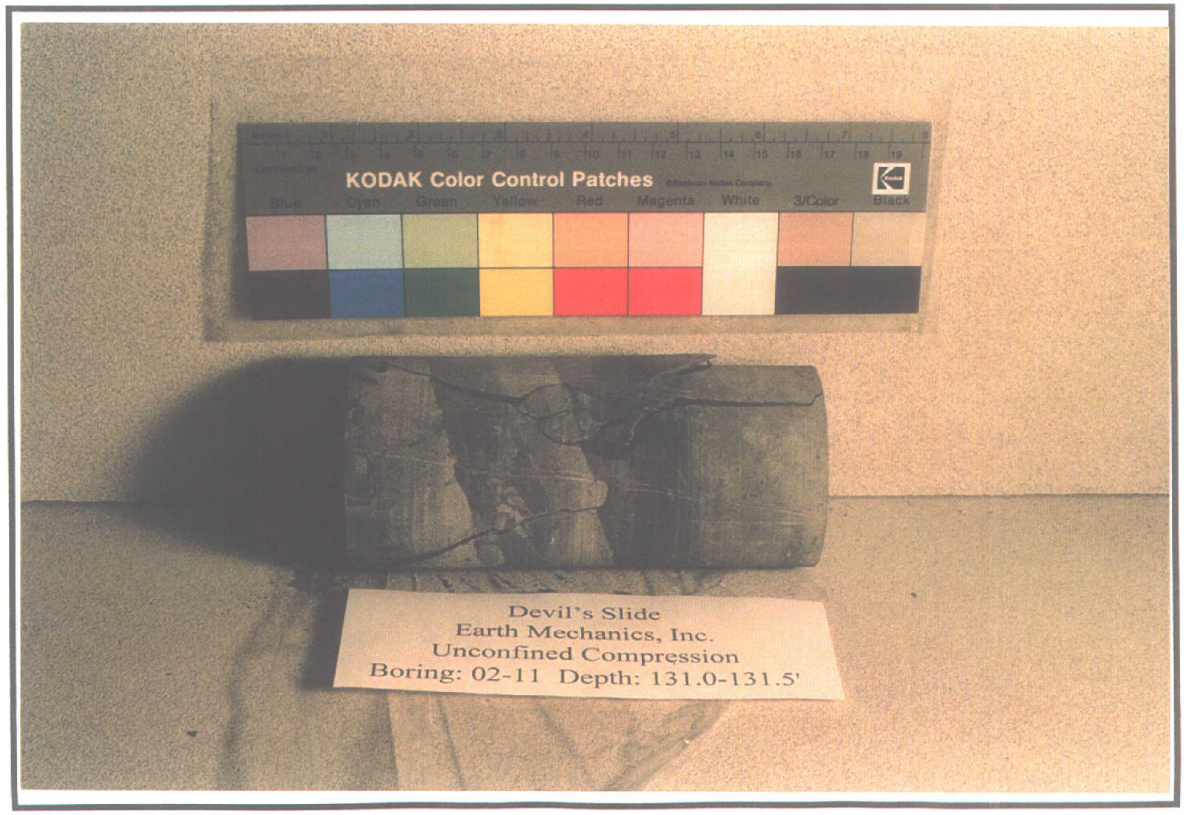
Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/16/02
Technician: A. Bro

Client: EMI
Job: #151 Devil's Slide
Sample ID: Boring 02-11
Sample Description: Interbedded med gray fine grained sandstone with dark gray shale with calcite (?) healed fractures partially

Sample Depth: 131.0-131.5' Sample Condition: received dry - tested moist

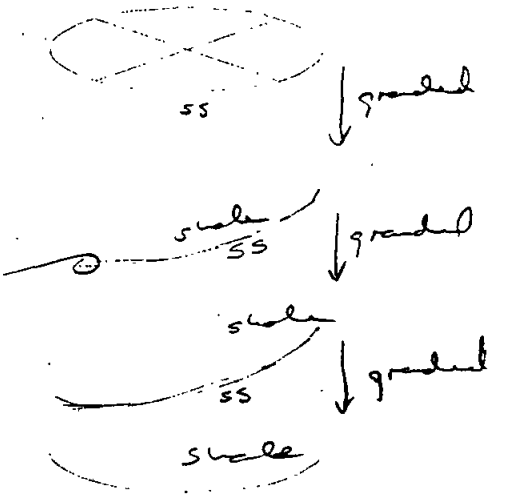
d_1	d_2
2.402	2.402
2.403	2.399
2.403	2.403
2.402	2.403
2.402	2.402

l_1	l_2
+.0023	+.0002
+.0012	
±.0001	±.0002
-.0013	
-.0025	-.0002

Avg. diameter : 2.402
Sample area : 4.531
Sample volume(in³) : 24.977
Sample weight (g) : 1111.1 g
Density : 44.48 g/in³ = 169.5 pcf (1 g/in³=3.8095lb/ft³)

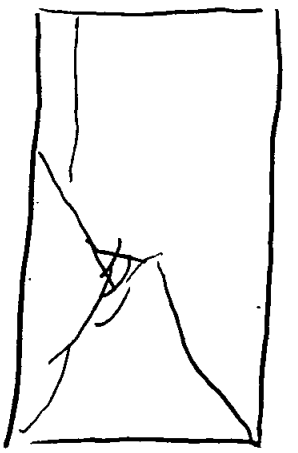
Avg. length : 5.512
l/d ratio : 2.29

-68° to core axis



Comments:

INTACT FAILURE (?) failed by axial splitting no apparent joint control.



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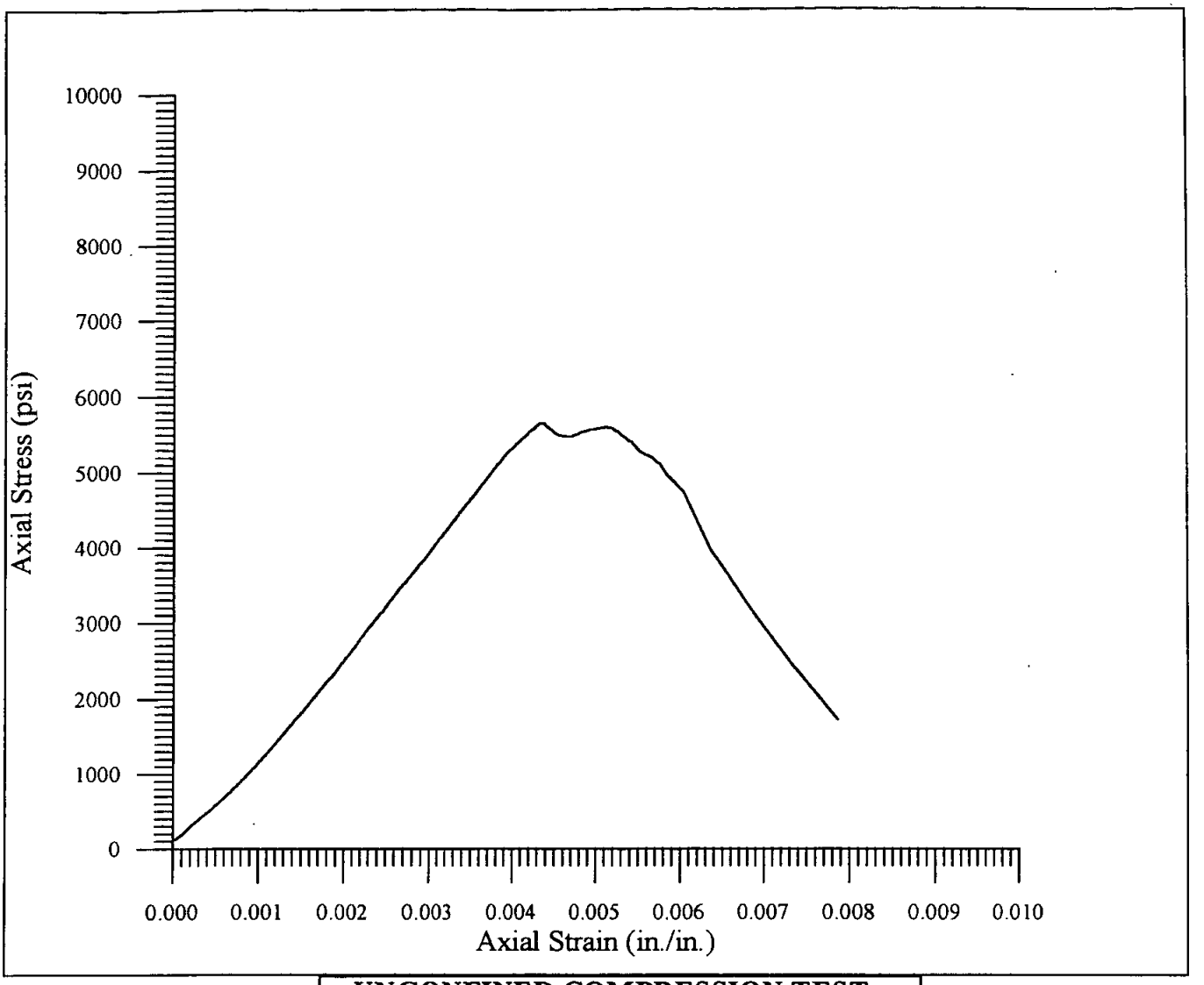


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-131
Boring: 02-11
Depth: 131.0-131.5'

DESCRIPTION

Interbedded medium gray fine grained sandstone with dark gray shale with calcite, partially healed fractures about 68 degrees to the core axis.

Density: 169.5 pcf
Strength: 5647 psi
Joint Control Failure?: no??

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

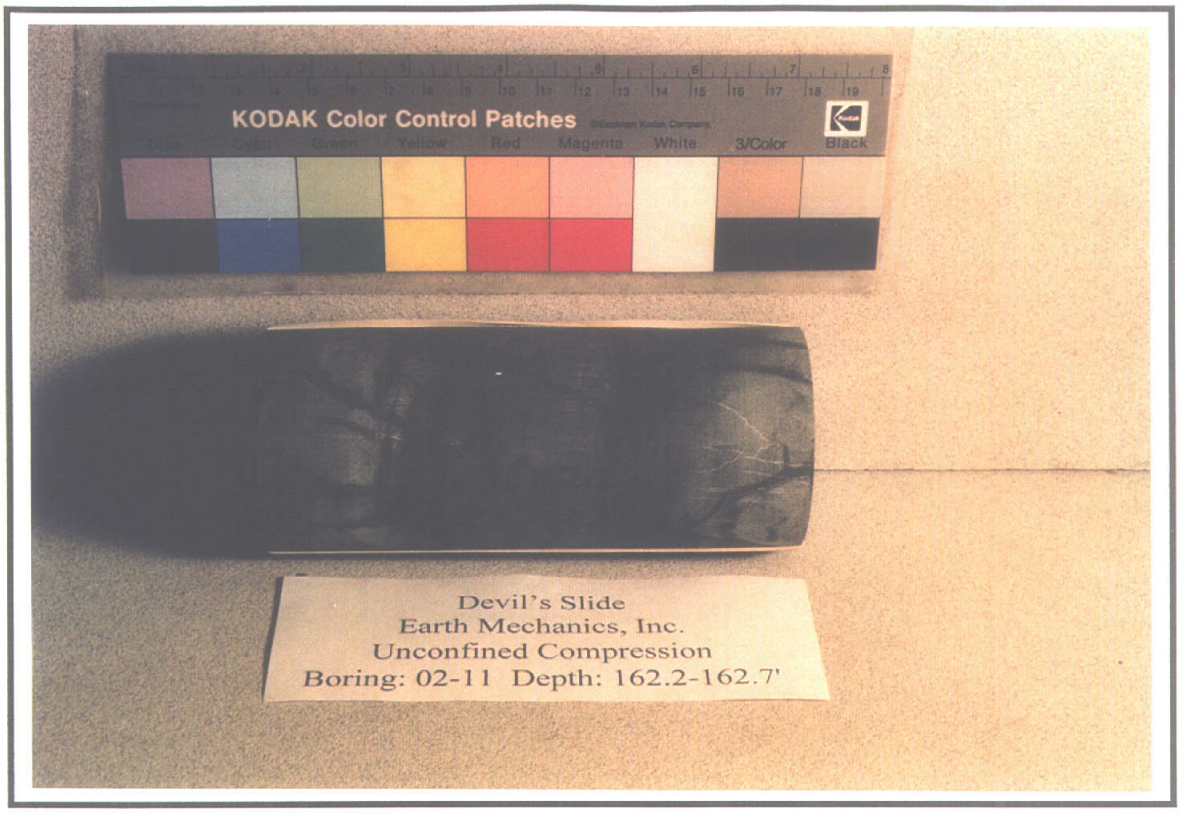
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

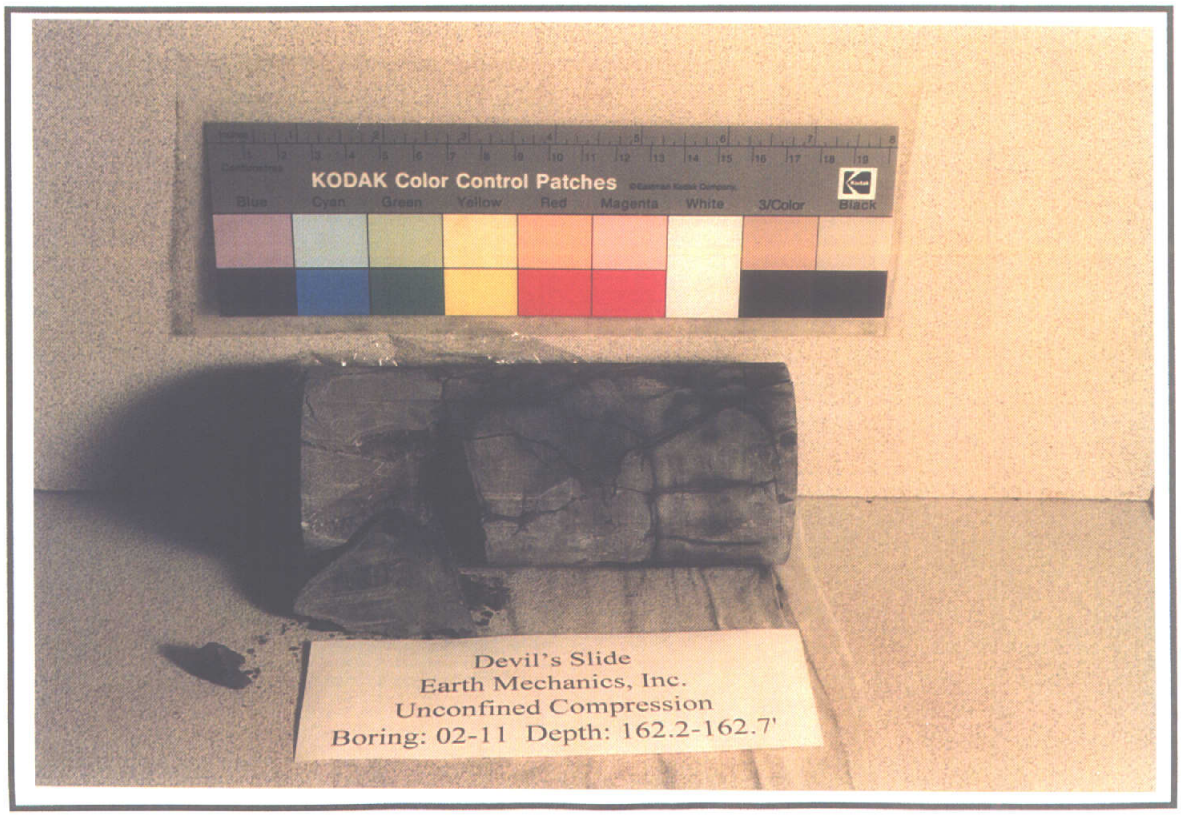
Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/12/02
Technician: A. Bro

Client: ENI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray mildly fractured shale with bedding about 75° to core axis

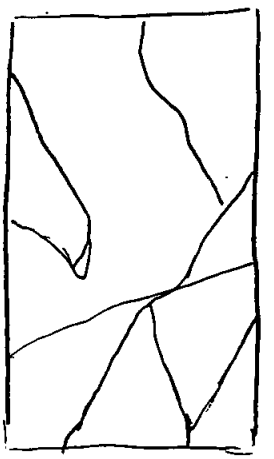
Sample Depth: 162.2-162.7' Sample Condition: received dry - tested moist

d_1	d_2
2.398	2.400
2.392	2.392
2.400	2.398
2.402	2.401
2.401	2.404

l_1	l_2
+.0008	+.0013
+.0005	+.0007
±.0001	±.0002
-.0005	-.0007
-.0009	-.0014

Avg. diameter: 2.399
Avg. length: 5.627
Sample area: 4.520
l/d ratio: 2.35
Sample volume(in^3): 25.434
Sample weight (g): 1102.2 g
Density: 43.33 g/in^3 = 165.1 pcf (1 g/in^3=3.8095lb/ft^3)

Comments: pore water extruded during test - less ductile
Failed by axial splitting -
FRACTURE CONTROLLED FAILURE



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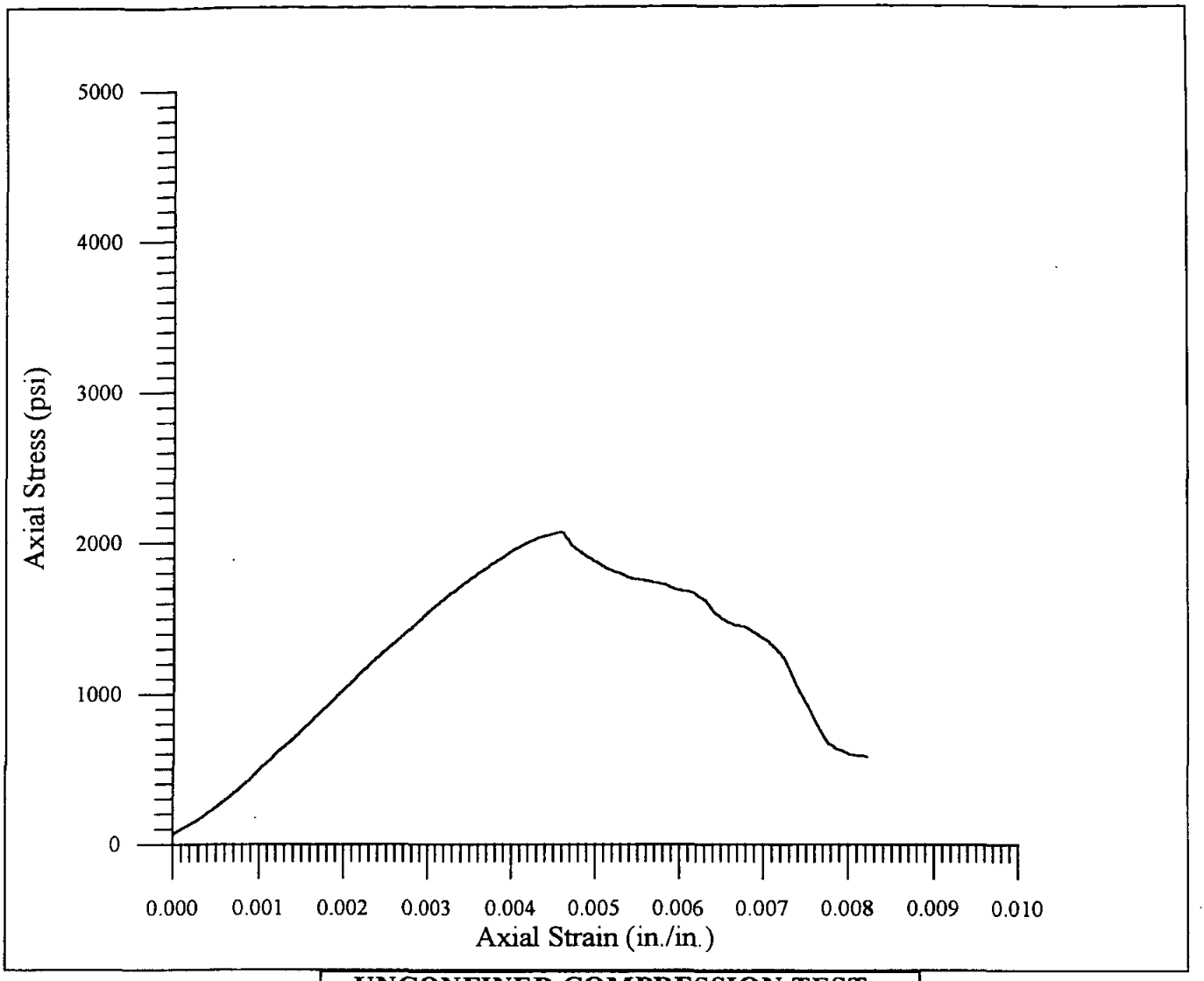


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-162
Boring: 02-11
Depth: 162.2-162.7'

DESCRIPTION

Dark gray highly fractured shale with bedding about 75 degrees to the core axis.

Density: 165.1 pcf
Strength: 2072 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

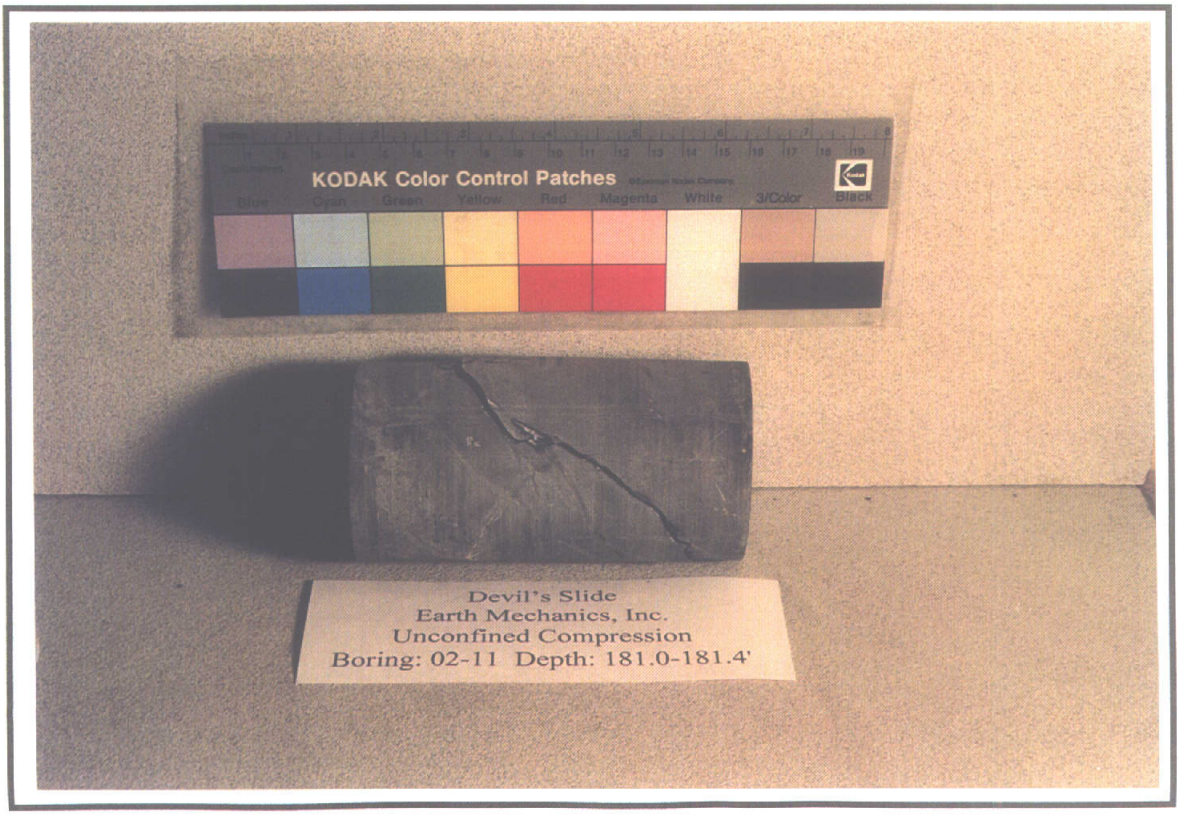
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: red to dark gray siltstone & shale (claystone?) (somewhat bedded appearance) with calcite healed fractures.

Sample Depth: 181.0-181.4' Sample Condition: received dry - tested moist

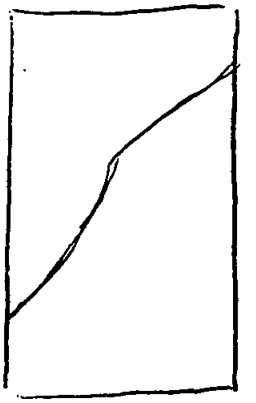
d_1	d_2
2.400	2.401
2.399	2.402
2.399	2.401
2.396	2.400
2.398	2.400

l_1	l_2
+.0020	+.0007
+.0011	+.0004
±.0001	±.0002
-.0008	-.0005
-.0018	-.0010

Avg. diameter : 2.400 Avg. length : 4.541
Sample area : 4.524 l/d ratio : 1.89
Sample volume(in^3) : 20.543
Sample weight (g) : 904.9g
Density : 44.05 g/in^3 = 167.8pcf (1 g/in^3=3.8095lb/ft^3)

Comments: Failed by shear along existing joint

JOINT CONTROLLED FAILURE



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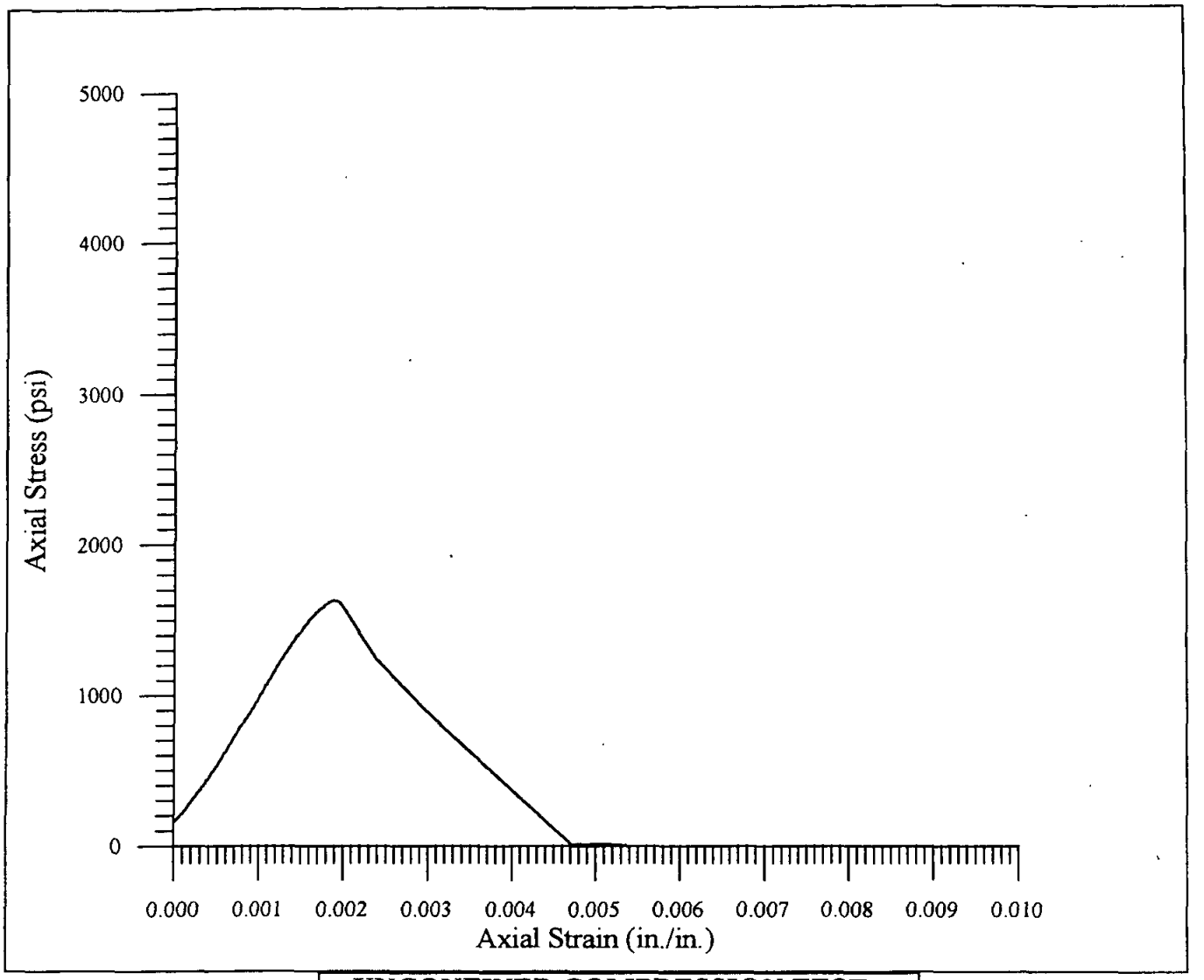


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-181
Boring: 02-11
Depth: 181.0-181.4'

DESCRIPTION

Medium to dark gray siltsone and shale (claystone?) with calcite healed fractures..

Density: 167.8 pcf
Strength: 1633 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

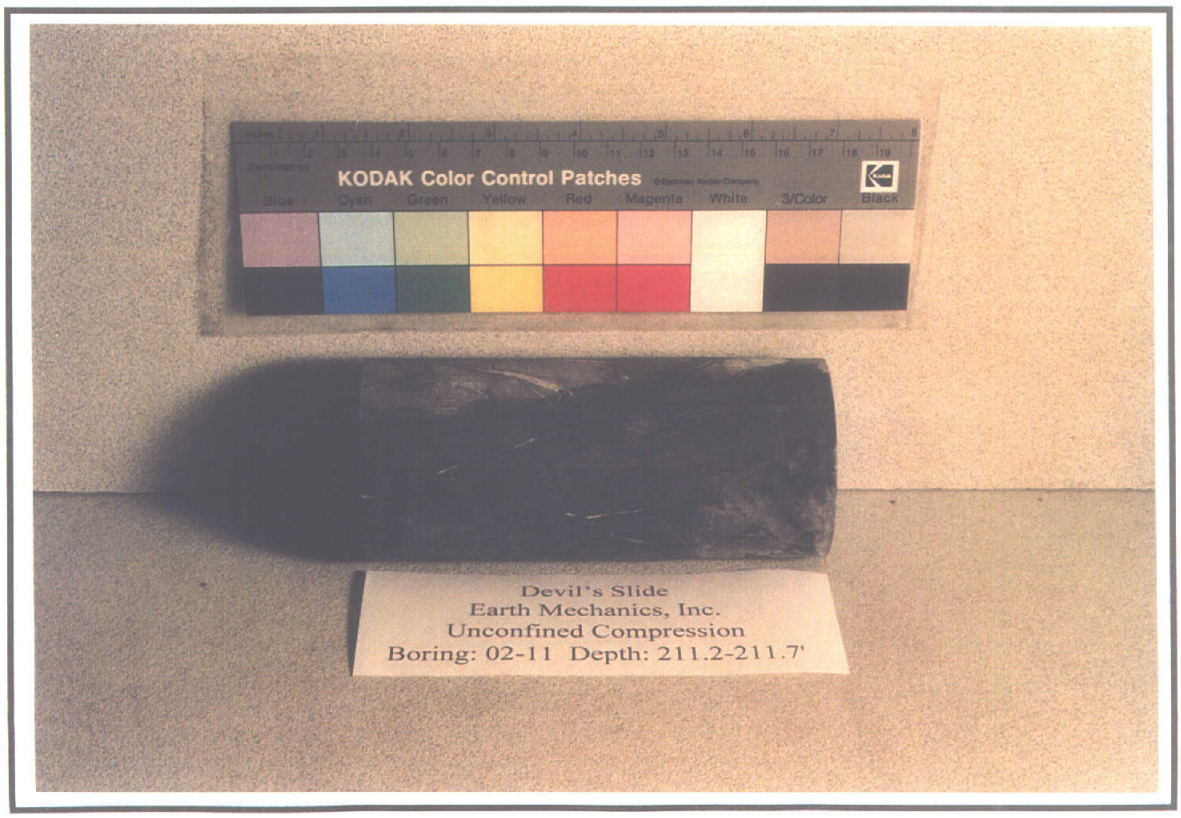
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

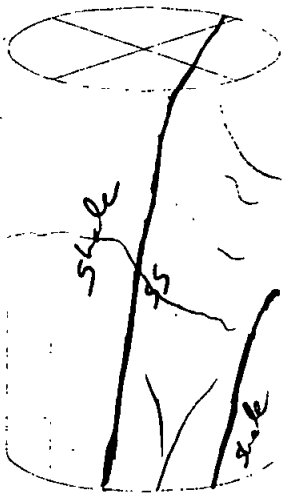
Date: 9/12/02
Technician: A. Bro

Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray shale and fine grained sandstone - Fractured with some calcite healing

Sample Depth: 211.2-211.7' Sample Condition: received dry - tested moist

d_1	d_2
2.398	2.403
2.398	2.403
2.402	2.404
2.401	2.406
2.400	2.409

l_1*	l_2*
+.0022	+.0047
+.0013	+.0018
±.0002	±.0002
-.0014	-.0030
-.0028	-.0058

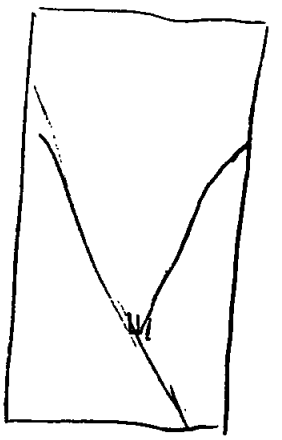


Avg. diameter: 2.402
Sample area: 4.531
Sample volume(in³): 24.864
Sample weight (g): 1062.68
Density: 42.74 g/in³ = 162.8 pcf (1 g/in³=3.8095lb/ft³)

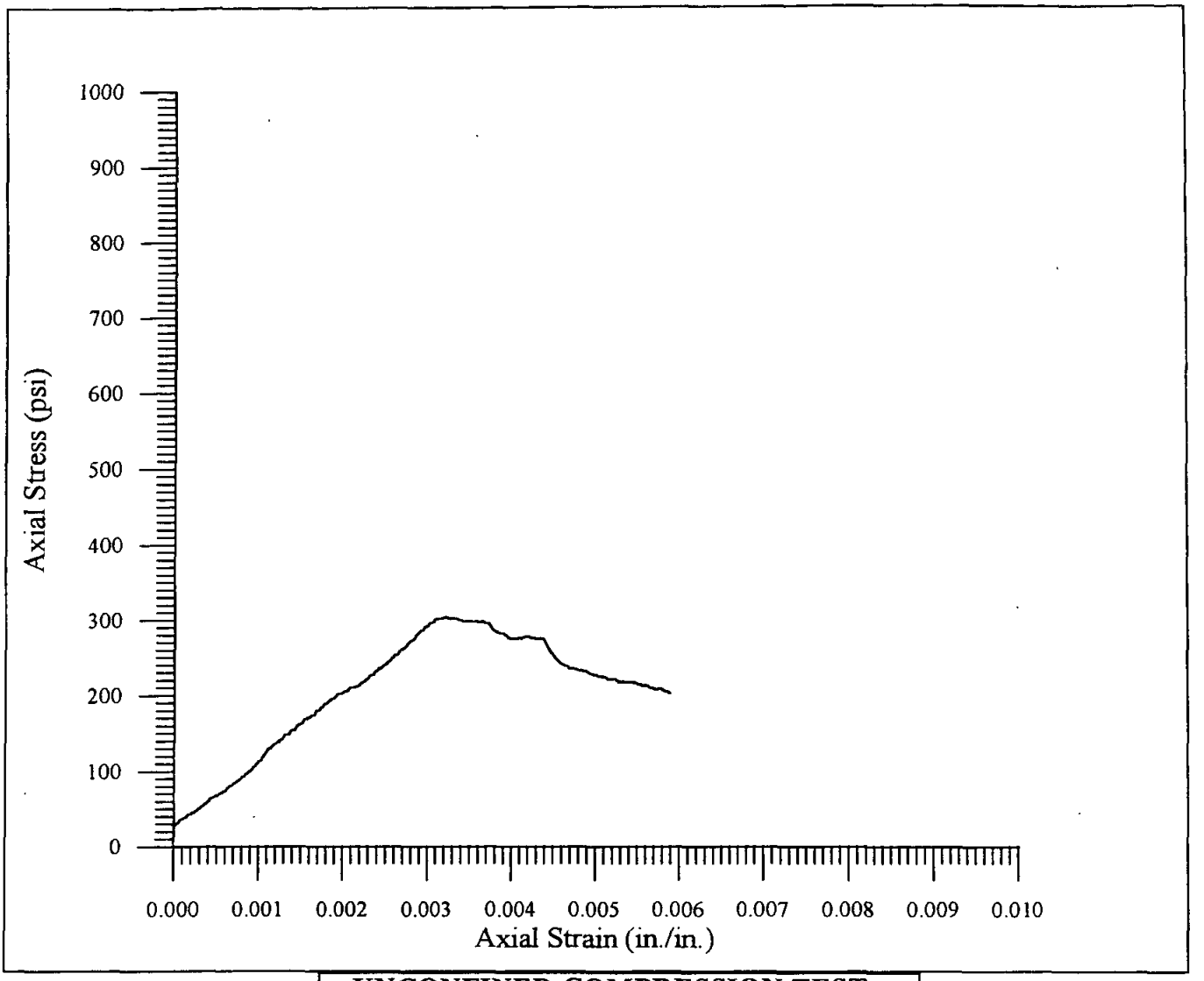
Avg. length: 5.487"
l/d ratio: 2.28

Comments: * irregularity may be due to fractured nature of sample?
Failed by shear along exist'g joint

JOINT CONTROLLED



27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-211
Boring: 02-11
Depth: 211.2-211.7'

DESCRIPTION
Dark gray shale and fine grained sandstone with calcite healed fractures.

Density: 162.8 pcf
Strength: 304 psi
Joint Control Failure?: yes

Geo Test Unlimited G T U
27069 N. Bloomfield Rd.
Nevada City, CA 95959

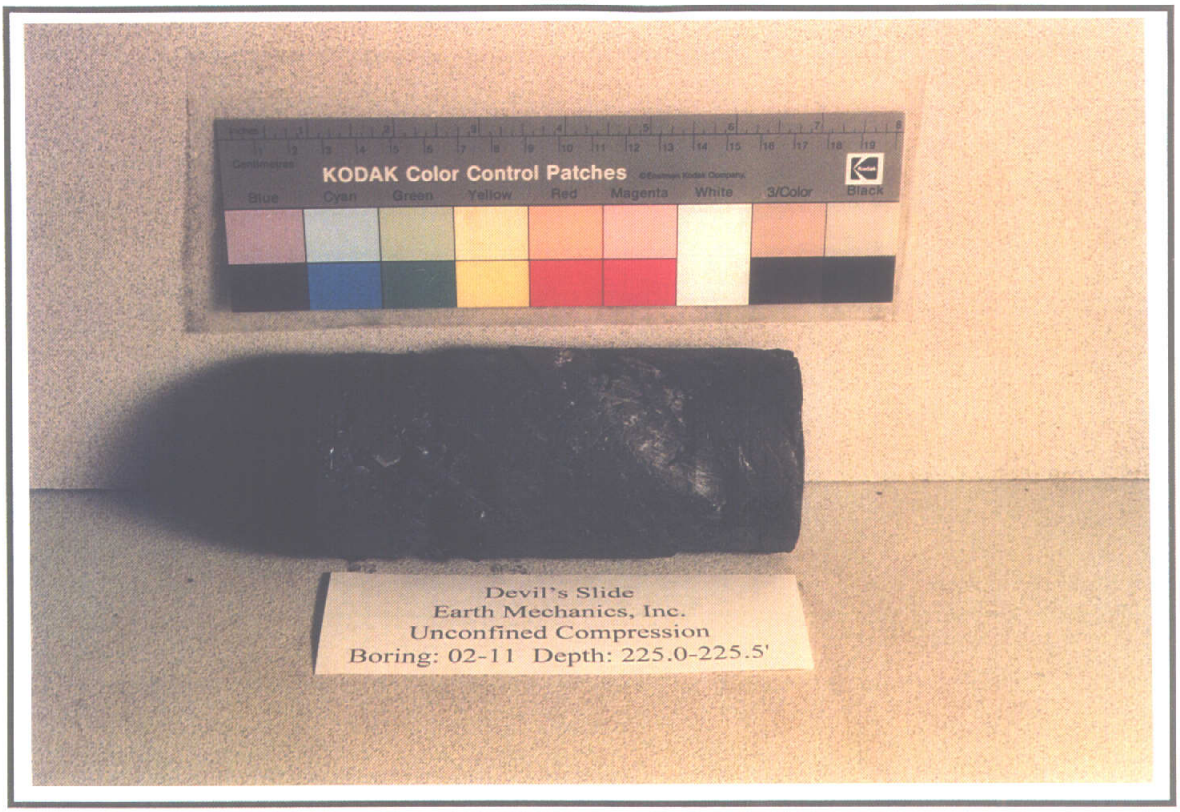
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray heavily sheared clayey shale

Sample Depth: 225.0 - 225.5' Sample Condition: received moist - tested moist

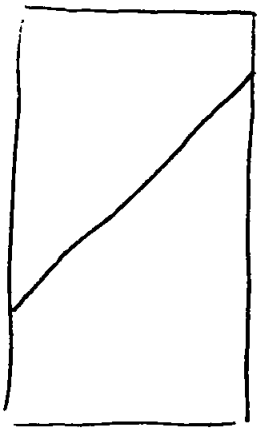
d_1 ✱	d_2 ✱
2.394	2.415
2.425	2.434
2.438	2.461
2.408	2.421
2.426	2.443

l_1 *	l_2 *

Avg. diameter : 2.427
Sample area : 4.626
Sample volume(in^3) : 25.902
Sample weight (g) : 1001.5 g (w/ plastic wrap)
Density : 38.66 g/in^3 = 147.3 pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.599
l/d ratio : 2.31

Comments: Too weak for pre-test plots (requires removal of plastic)
* Not recorded due to disk gauge point penetration
✱ with plastic wrap
So weak, the sample settles by its own weight
JOINT CONTROLLED FAILURE - sheared on joint



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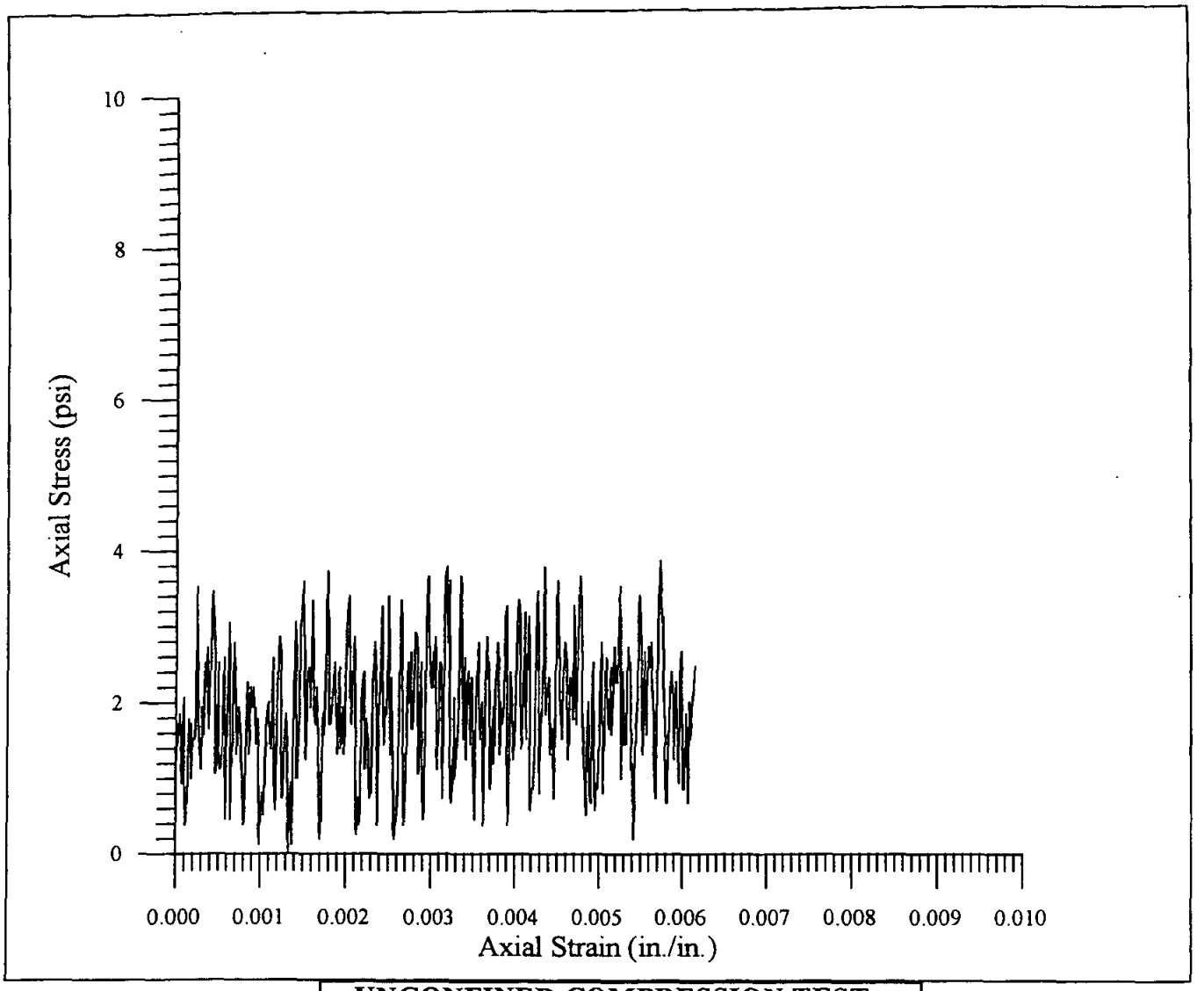


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-225
Boring: 02-11
Depth: 225.0-225.5'

DESCRIPTION
Dark gray heavily sheared clayey shale.

Density: 147.3 pcf
Strength: 2 psi
Joint Control Failure?: NA

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

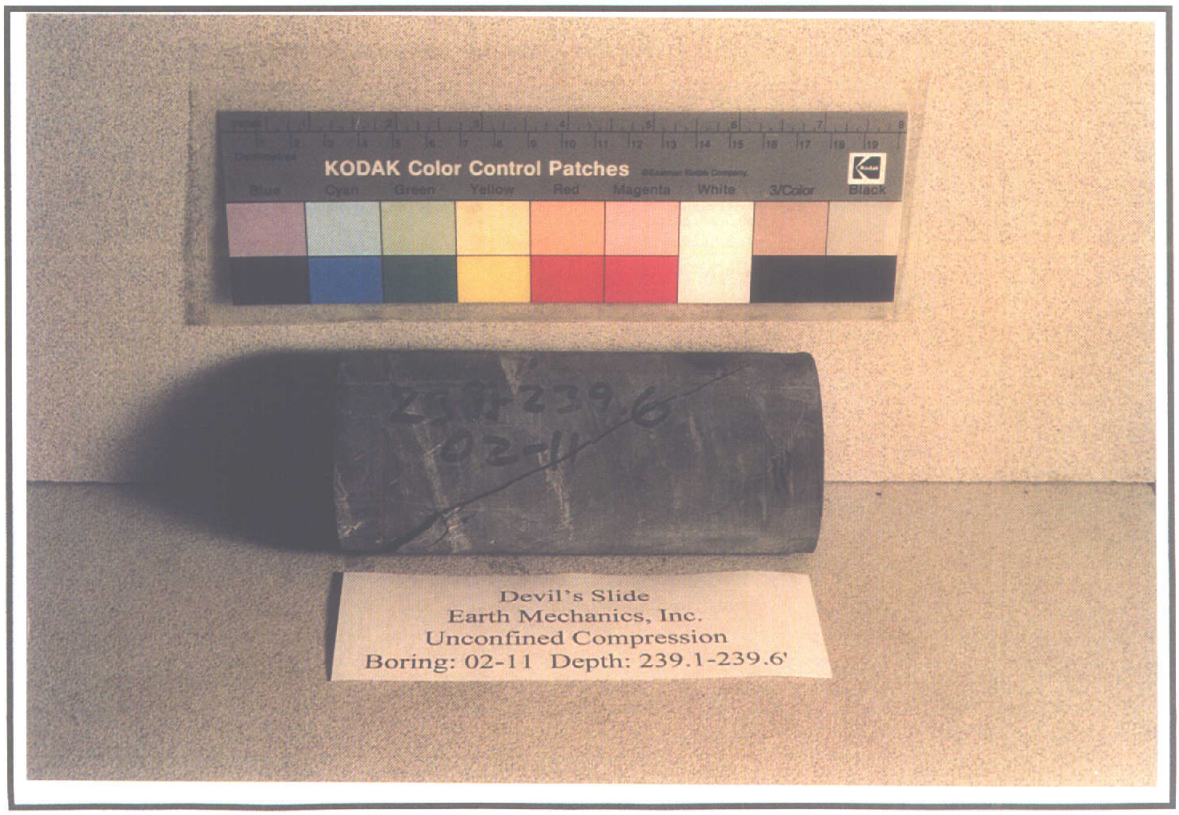
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

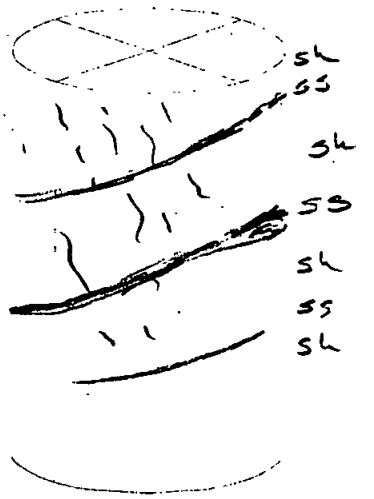
Date: 9/12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray shale with a few fine grained sandstone interbeds ~70° to the core axis. With sealed calcite healed hairline fractures that perpendicular to bedding.

Sample Depth: 239.1-239.6' Sample Condition: received dry - tested moist

d_1	d_2
2.399	2.398
2.399	2.399
2.400	2.400
2.400	2.398
2.398	2.398

l_1 *	l_2 *
+.0034	+.0006
+.0017	+.0003
±.0001	±.0001
-.0027	-.0007
-.0054	-.0015

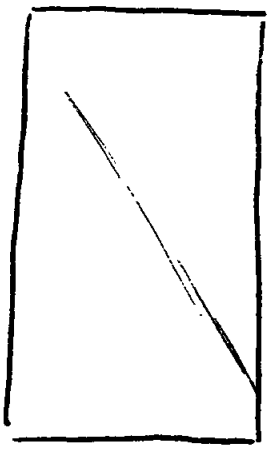


Avg. diameter : 2.399
Sample area : 4.520
Sample volume(in³) : 25.168
Sample weight (g) : 1093.4 g
Density : 43.44 g/in³ = 165.5 pcf (1 g/in³ = 3.8095 lb/ft³)

Avg. length : 5.568"
l/d ratio : 2.32

Comments: * this irregularity may be due to rock type - experience w/ wetting - drying & joints in shale? I have noticed that shales exhibit this behavior whereas sandstone, granite, etc. does not.

Failed by shear on pre-existing joint (prep. to bedding)
JOINT CONTROLLED FAILURE



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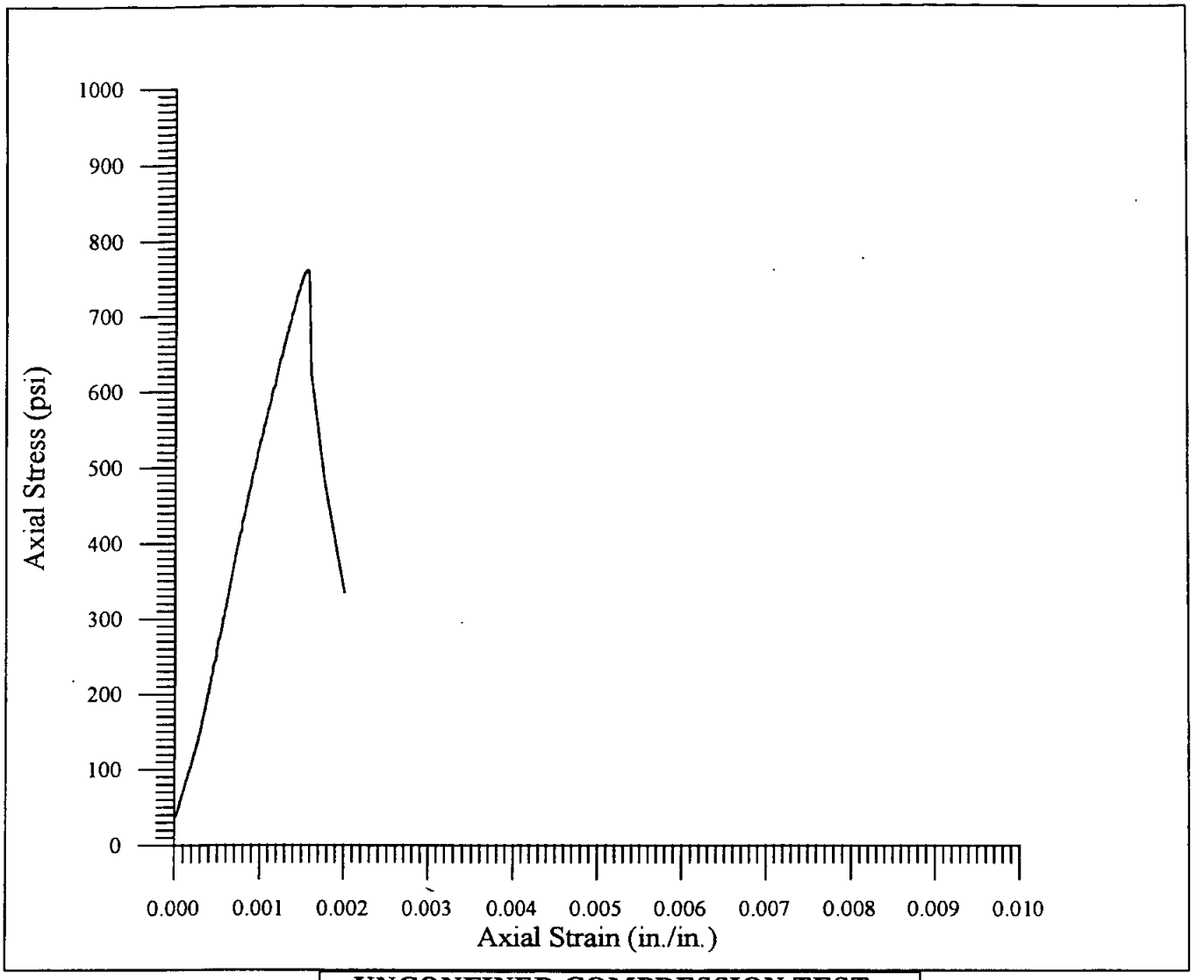


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-239
Boring: 02-11
Depth: 239.1-239.6'

DESCRIPTION

Dark gray shale with a few fine sandstone interbeds about 70 degrees to the core axis, with several calcite healed hairline fractures oriented perpendicular to beding.

Density: 165.5 pcf
Strength: 760 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

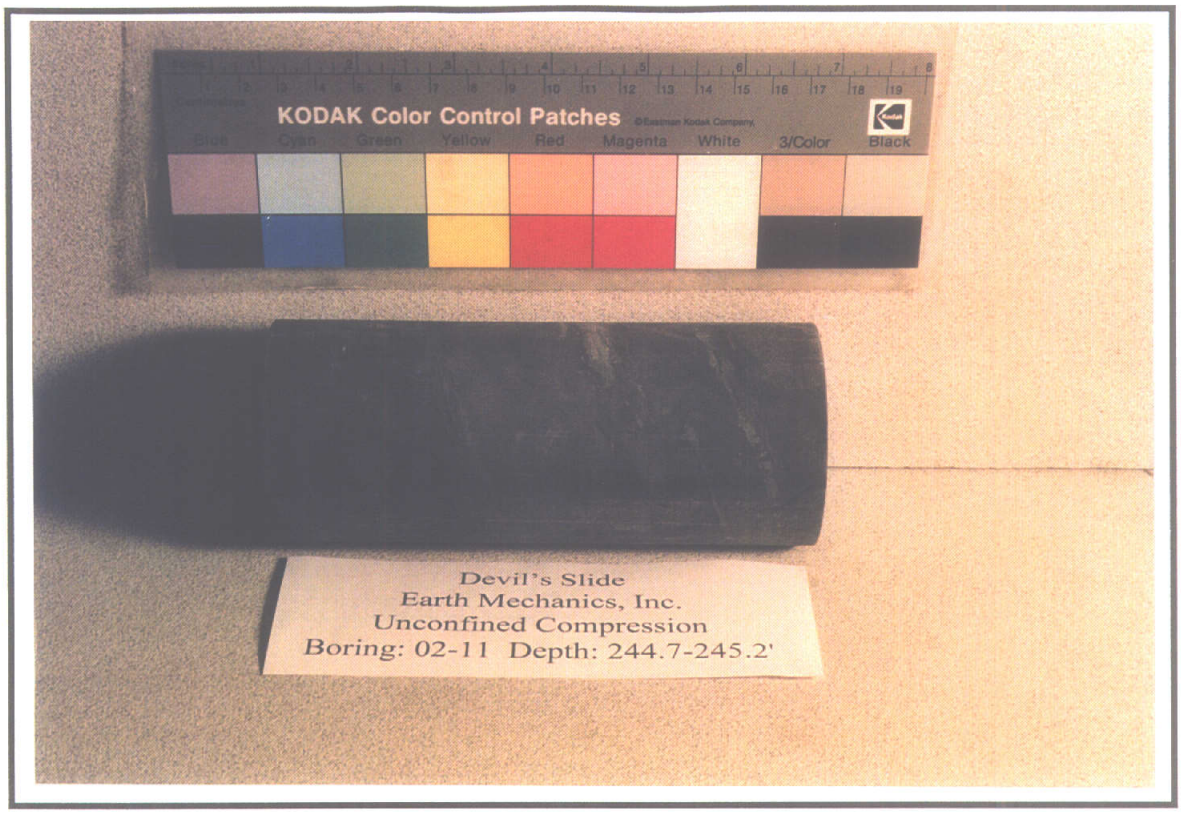
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

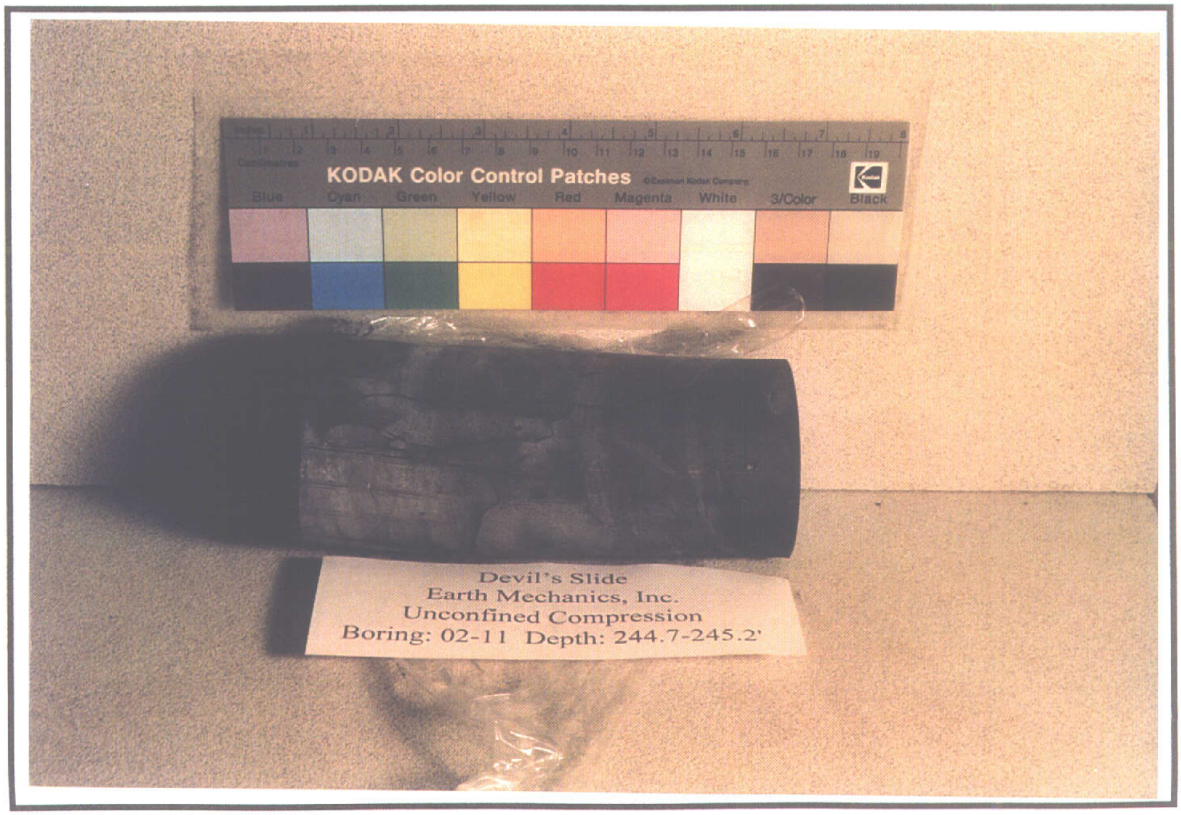
Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/12/02
Technician: A. Bro

Client: ENI
Job: #151-Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray shale with a few med. gray, fine grained sandstone interbeds. ~70° to the core axis. NB ribbons fracturing

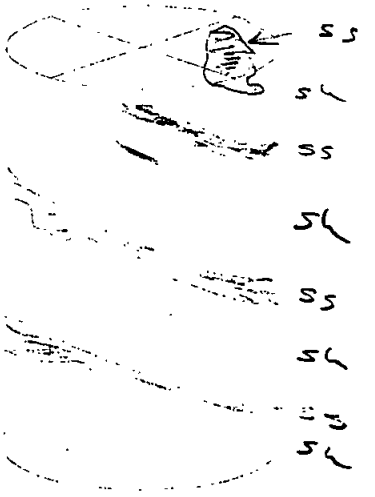
Sample Depth: 244.7-245.2' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.400
2.396	2.399
2.400	2.399
2.399	2.399
2.399	2.400

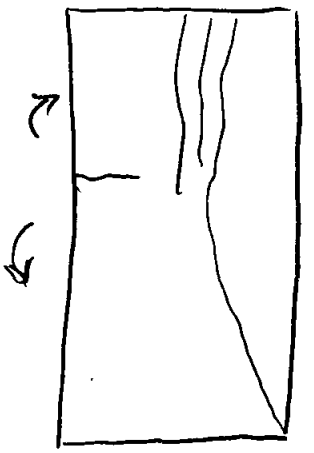
l_1	l_2
+.0018	+.0008
+.0009	+.0005
±.0001	±.0001
-.0012	-.0008
-.0026	-.0017

Avg. diameter : 2.399
Sample area : 4.520
Sample volume(in^3) : 25.923
Sample weight (g) : 1119.2 g
Density : 43.178 g/in^3 = 164.5 pcf (1 g/in^3=3.8095lb/ft^3)

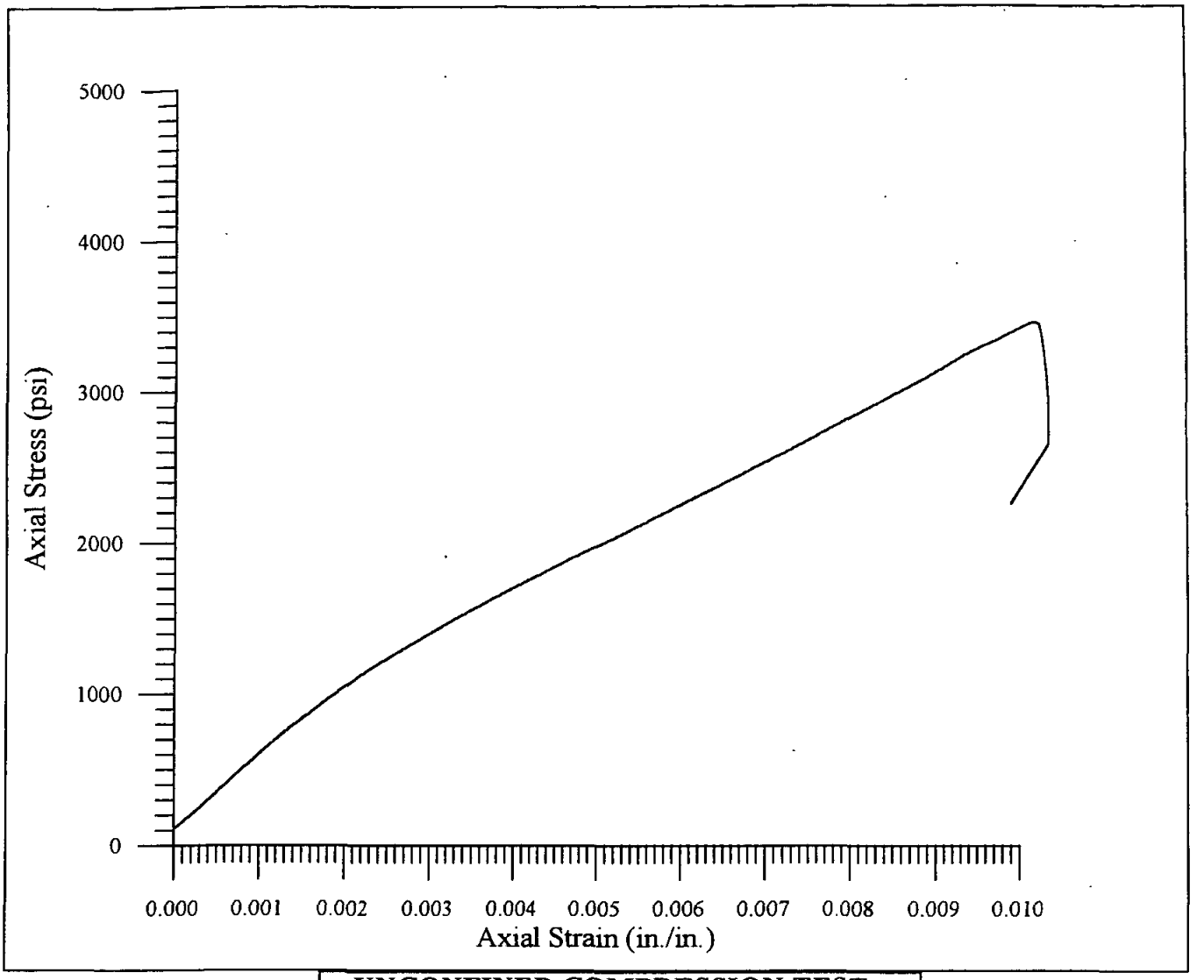
Avg. length : 5.735"
l/d ratio : 2.39



Comments: Ductile behavior
Failed by axial splitting and bending
INTACT FAILURE



27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-244
Boring: 02-11
Depth: 244.7-245.2'

DESCRIPTION

Dark gray shale with a few fine grained thin sandstone interbeds about 70 degrees to the core axis. No apparent fracturing.

Density: 164.5 pcf
Strength: 3463 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

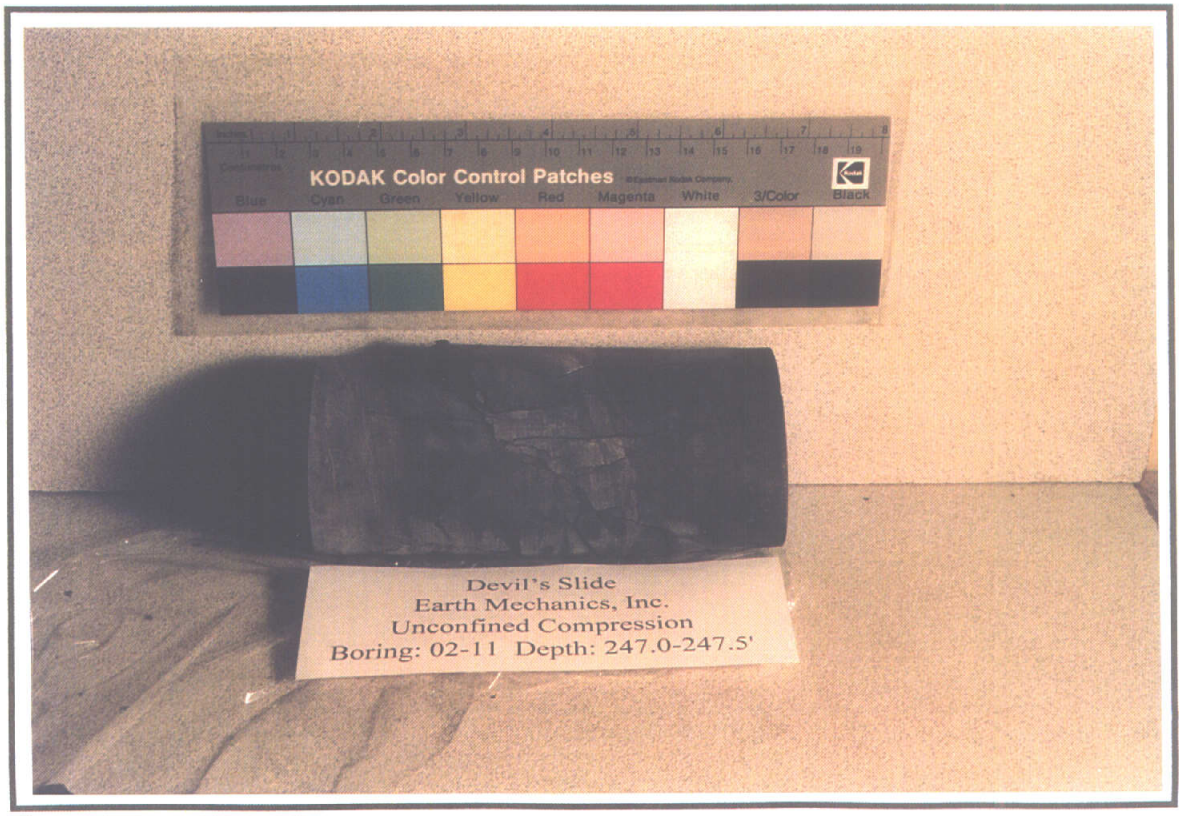
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

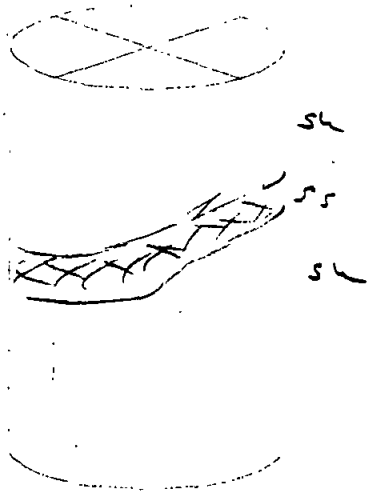
Date: 9/12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray shale w/ 1 sandstone bed. Contains several fractured. Bedding ~73° to core axis.

Sample Depth: 247.0-247.5' Sample Condition: received dry - tested moist

d_1	d_2
2.403	2.401
	2.400
	2.403
	2.402
	2.402

l_1	l_2
+.0022	+.0007
+.0011	+.0003
±.0001	±.0002
-.0008	-.0003
-.0012	-.0006

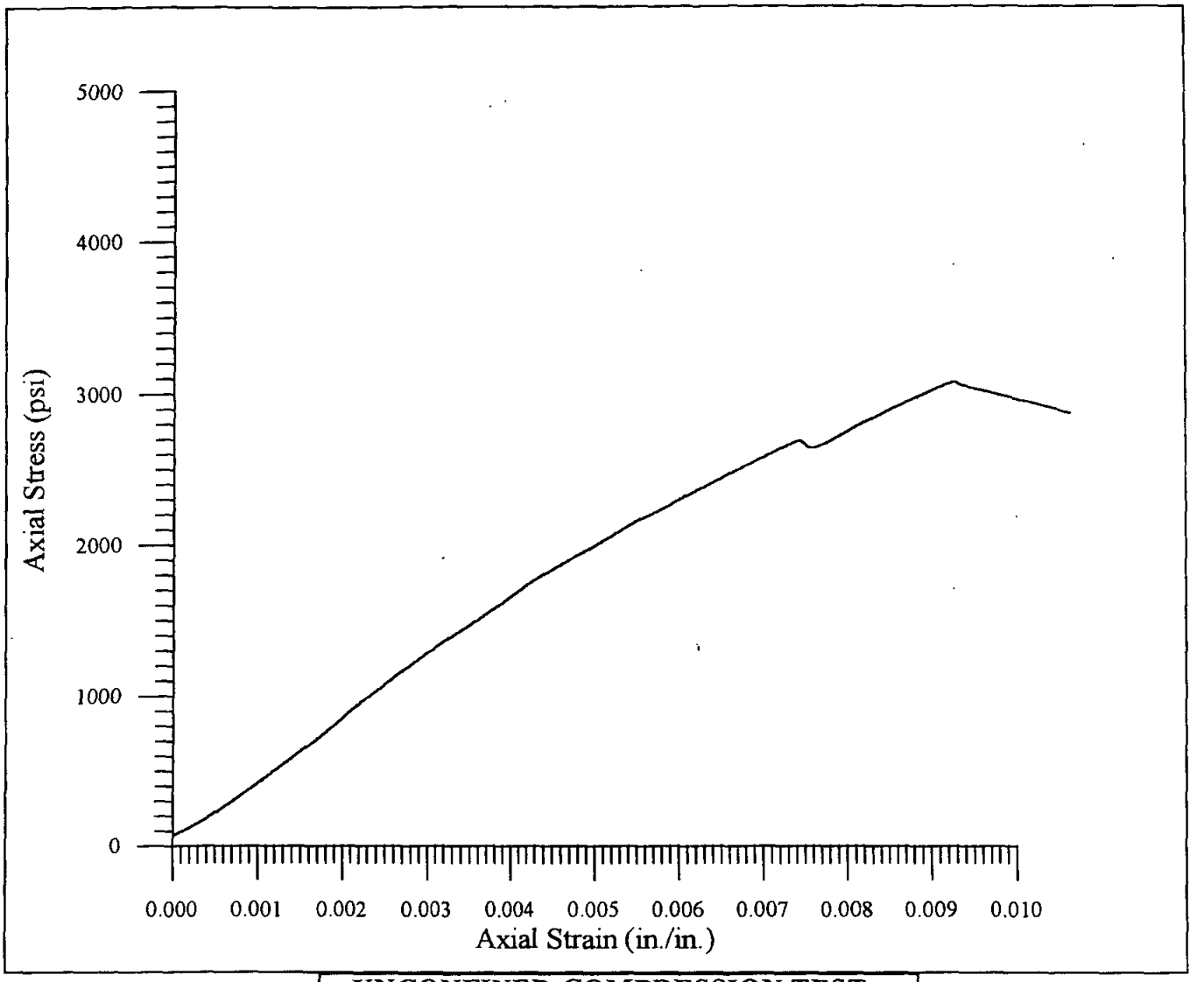


Avg. diameter : 2.402
Avg. length : 5.501
Sample area : 4.531
l/d ratio : 2.29
Sample volume(in^3) : 24.927
Sample weight (g) : 1074.2g
Density : 43.09 g/in^3 = 164.2 pcf (1 g/in^3=3.8095lb/ft^3)

Comments: initial failure by axial splitting

INTACT FAILURE

27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-247
Boring: 02-11
Depth: 247.0-247.5'

DESCRIPTION

Dark gray shale with one sandstone bed, with beding about 70 degrees to the core axis. Contains several fractures.

Density: 164.2 pcf
Strength: 3084 psi
Joint Control Failure?: no

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

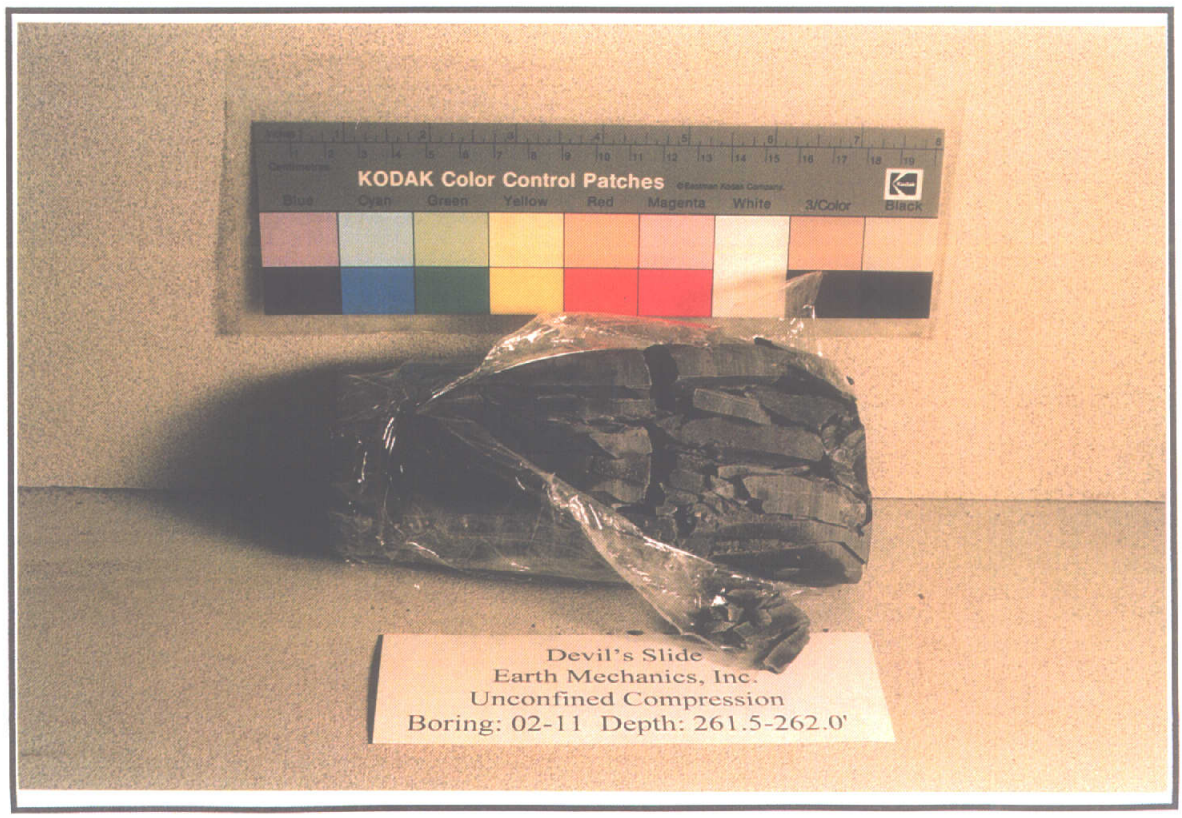
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 12, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

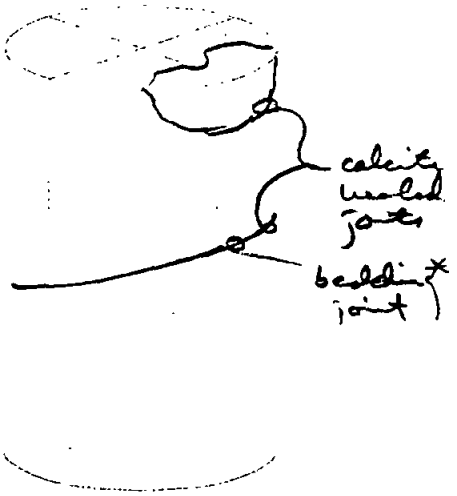
Date: 9/16/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Interbedded Dark (? siltstone) shale and med. gray fine grained sandstone (siltstone?) Shale beds < 1/4" sandstone beds < 1/2". Bedding ~ 68° to the core axis. Two calcite healed joints

Sample Depth: 261.5-262.0' Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.400
2.401	2.400
2.400	2.399
2.400	2.399
2.397	2.398

l_1	l_2
+.0013	0
+.0007	0
±.0001	±.0001
-.0005	0
-.0009	0



Avg. diameter: 2.399
Sample area: 4.520
Sample volume(in³): 23.694
Sample weight (g): 1083.7
Density: 45.74 g/in³ = 174.2 pcf (1 g/in³=3.8095lb/ft³)

Avg. length: 5.242"
l/d ratio: 2.19

Comments: water squeezing out of shale during test

INTACT FAILURE - by axial splitting (splintering) possibly weakened by bedding joint*

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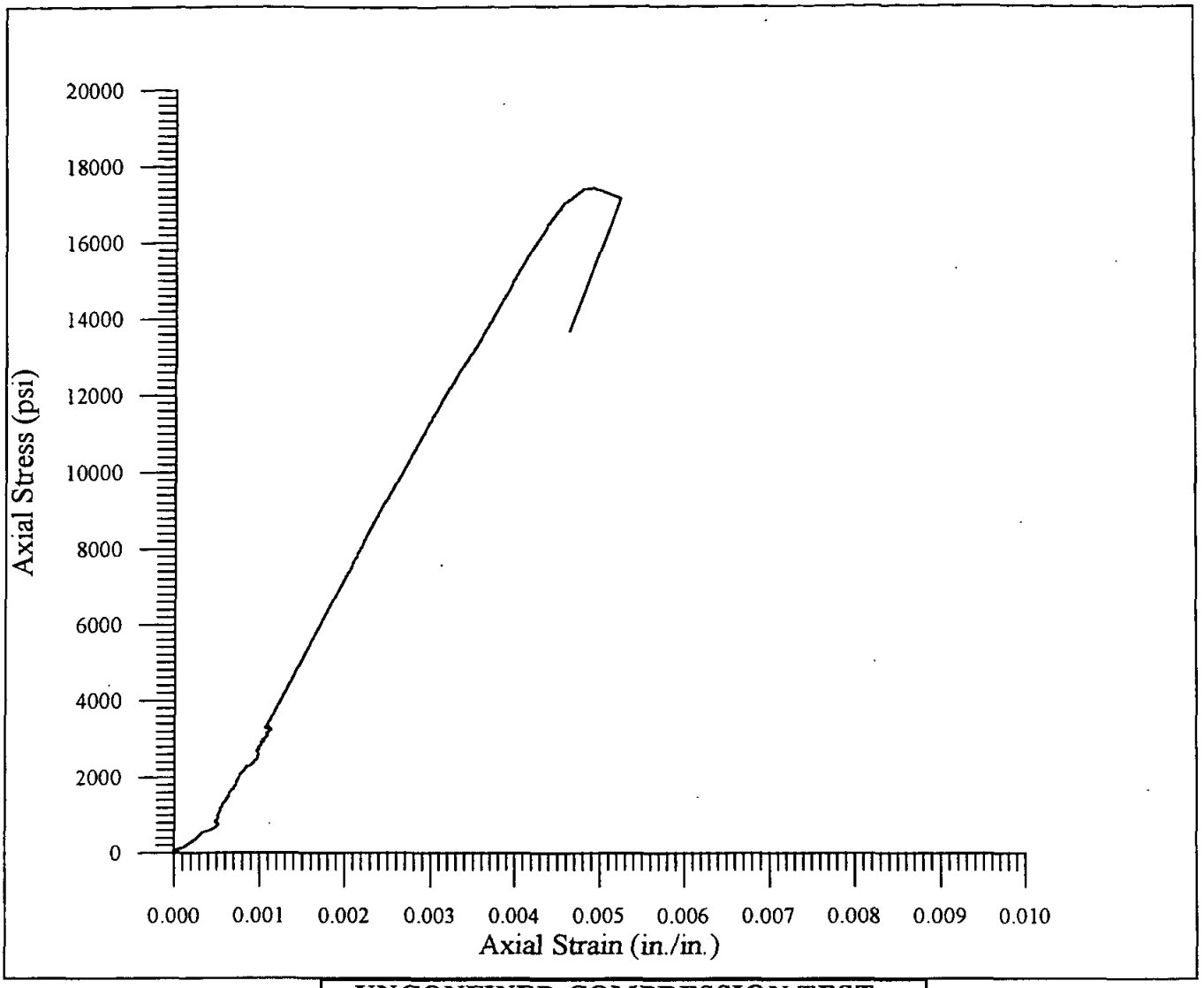


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-261
Boring: 02-11
Depth: 261.6-262.0'

DESCRIPTION

Dark gray siltstone interbedded with medium gray fine grained sandstone with bedding about 68 degrees to the core axis, with two calcite healed joints.

Density: 174.2 pcf
Strength: 17,460 psi
Joint Control Failure?: no??

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

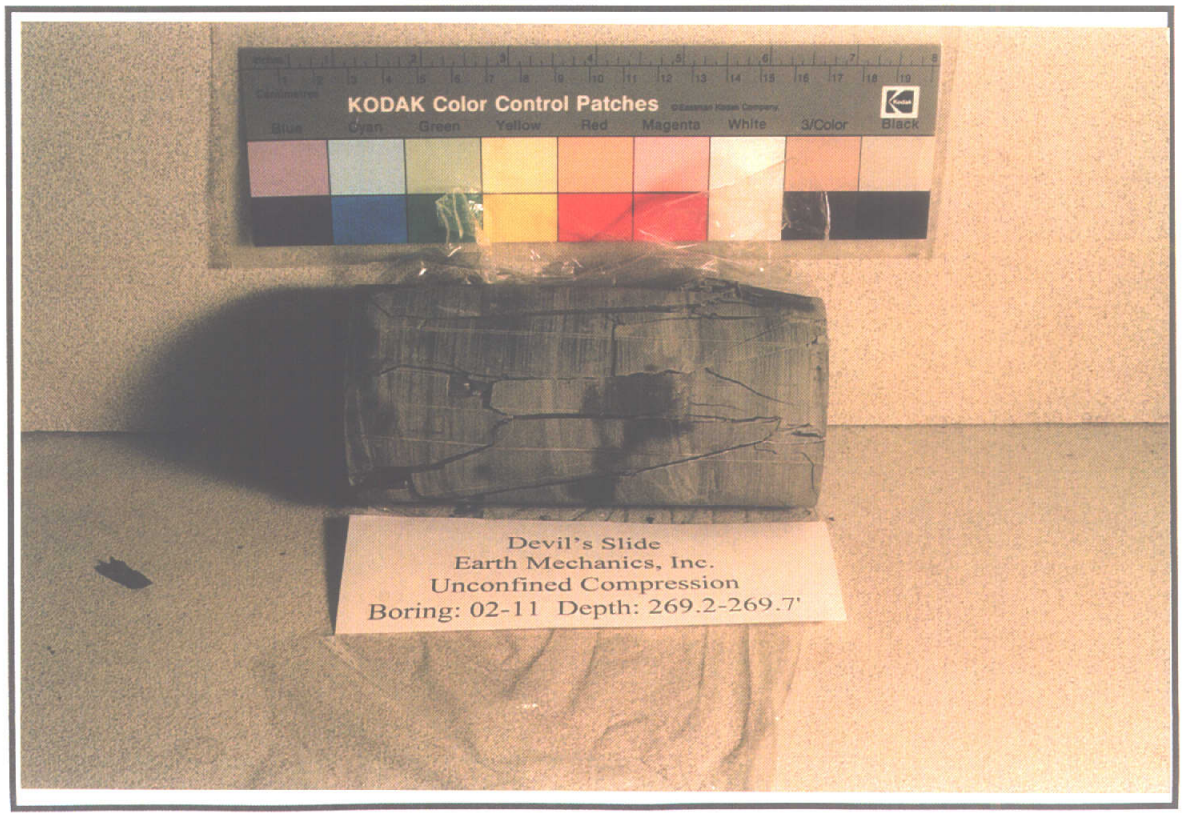
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 9/16/02
Technician: A. Bro

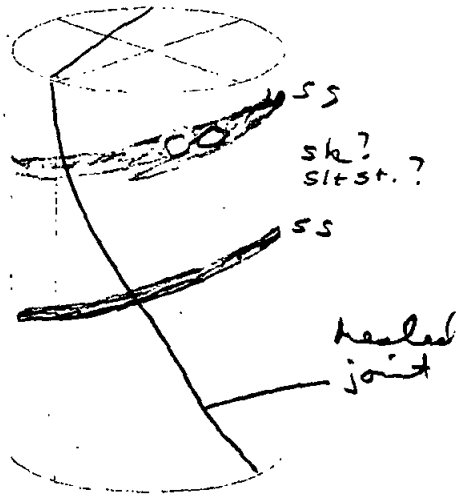
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray siltstone (shale?) - w/ a few thin fine grained sandstone interbeds. Contains a few calcite healed hairline fractures. Bedding ~ 75° to the core axis.

Sample Depth: 269.2-269.7' Sample Condition: received dry. tested moist

d_1	d_2
2.400	2.400
2.400	2.400
2.401	2.399
2.399	2.399
2.399	2.397

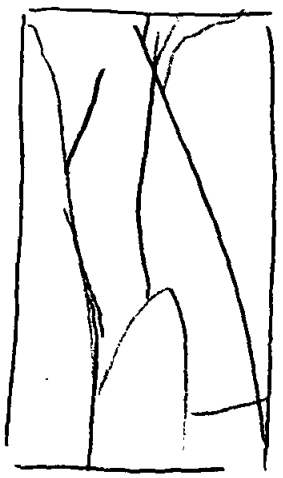
l_1	l_2
+.0011	+.0004
+.0007	+.0002
±.0001	±.0002
-.0007	-.0001
-.0013	-.0003

Avg. diameter : 2.399 Avg. length : 5.433"
Sample area : 4.520 l/d ratio : 2.26
Sample volume(in³) : 24.558
Sample weight (g) : 1107.8g
Density : 45.11g/in³ = 171.8 pcf (1 g/in³=3.8095lb/ft³)



Comments:

JOINT CONTROLLED FAILURE - failed by axial splitting - along existing healed joint



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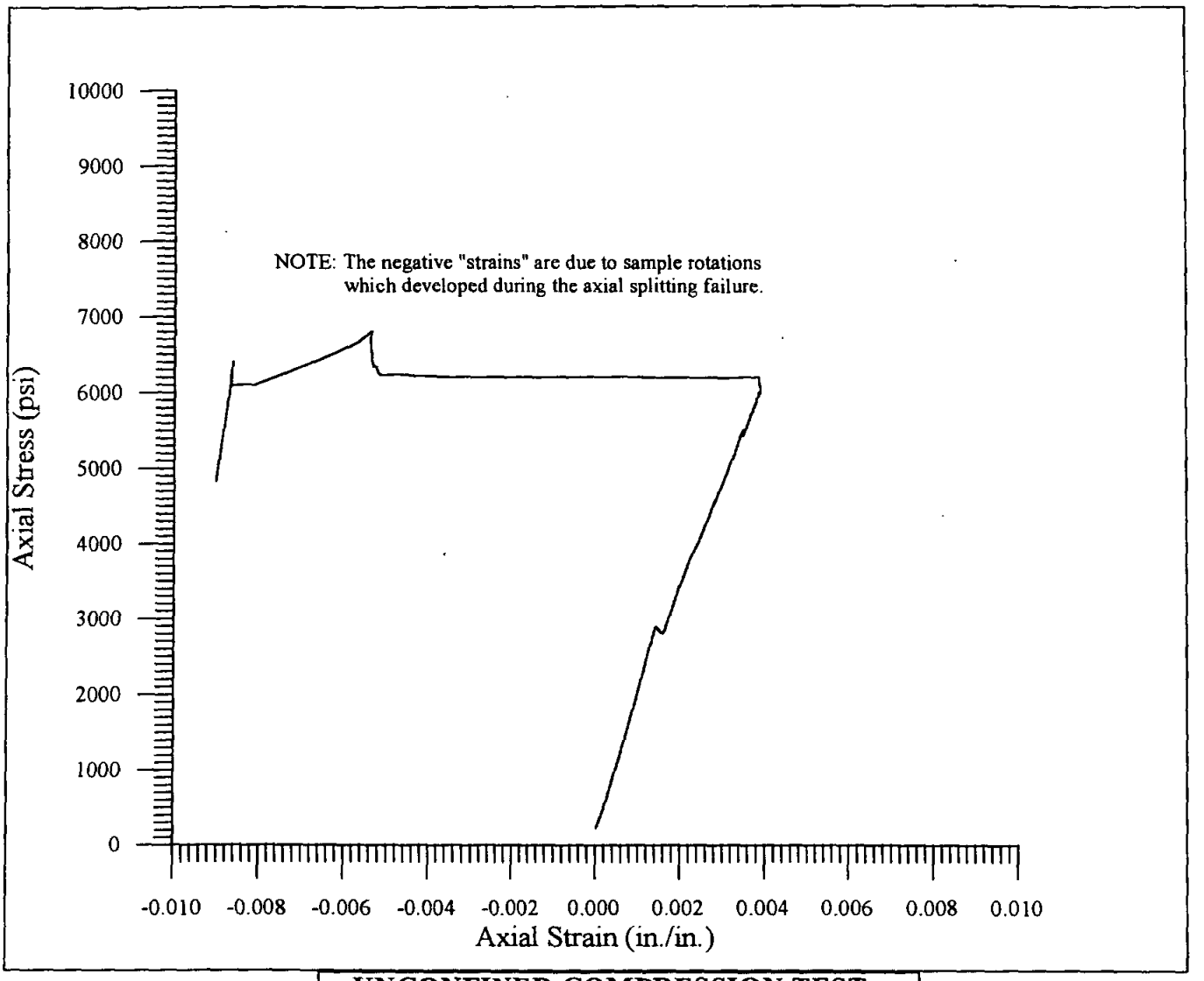


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-269
Boring: 02-11
Depth: 269.2-269.7'

DESCRIPTION

Dark gray siltstone interbedded with a few fine grained sandstone beds, with bedding about 75 degrees to the core axis, with a few calcite healed hairline fractures.

Density: 171.8 pcf
Strength: 6799 psi
Joint Control Failure?: yes

Geo Test Unlimited G T U
27069 N. Bloomfield Rd.
Nevada City, CA 95959

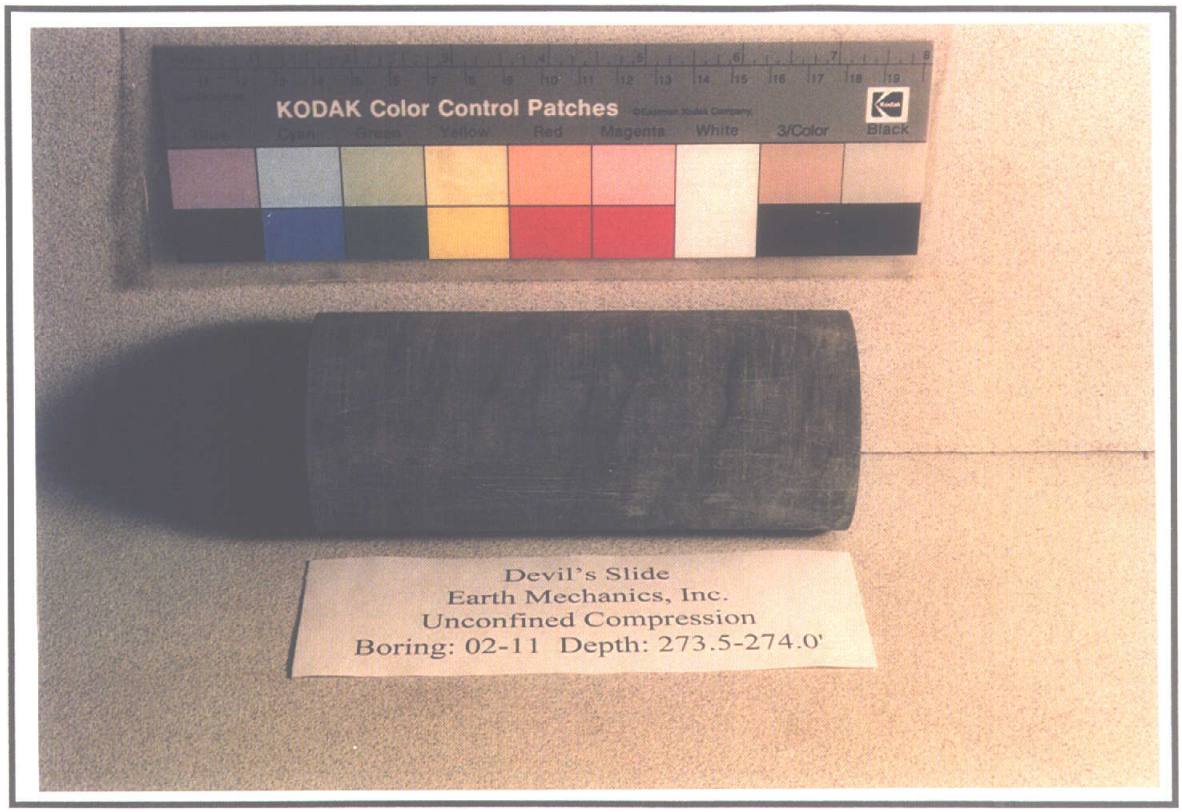
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

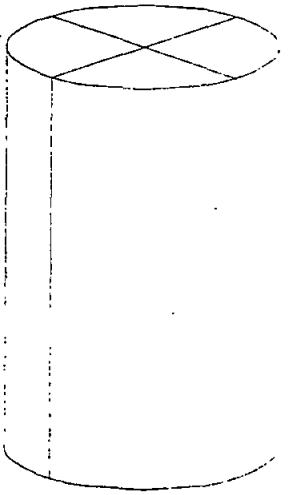
Date: 9/16/02
Technician: A. Bro

Client: EMI
Job: #151 - Devils Slide
Sample ID: Boring 02-11
Sample Description: Dark gray shale with a few very thin fine sandstone interbeds. Bedding N 72° to core axis. No apparent joints

Sample Depth: 273.5-274.0' Sample Condition: received dry - tested moist

d_1	d_2
2.398	2.396
2.398	2.396
2.394	2.392
2.397	2.396
2.393	2.392

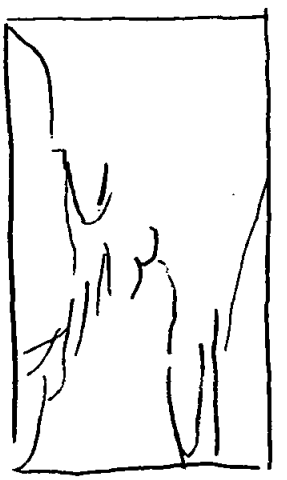
l_1	l_2
+.0025	+.0002
+.0012	+.0001
±.0001	±.0002
-.0015	-.0002
-.0031	-.0004



Avg. diameter : 2.395
Avg. length : 5.659"
Sample area : 4.505
l/d ratio : 2.36
Sample volume(in^3) : 25.494
Sample weight (g) : 1117.7g
Density : 43.84 g/in^3 = 167.0pcf (1 g/in^3=3.8095lb/ft^3)

Comments: ductile rock - performed a short unloading-reloading cycle prior to failure.

INTACT FAILURE - by axial splitting along a diagonal



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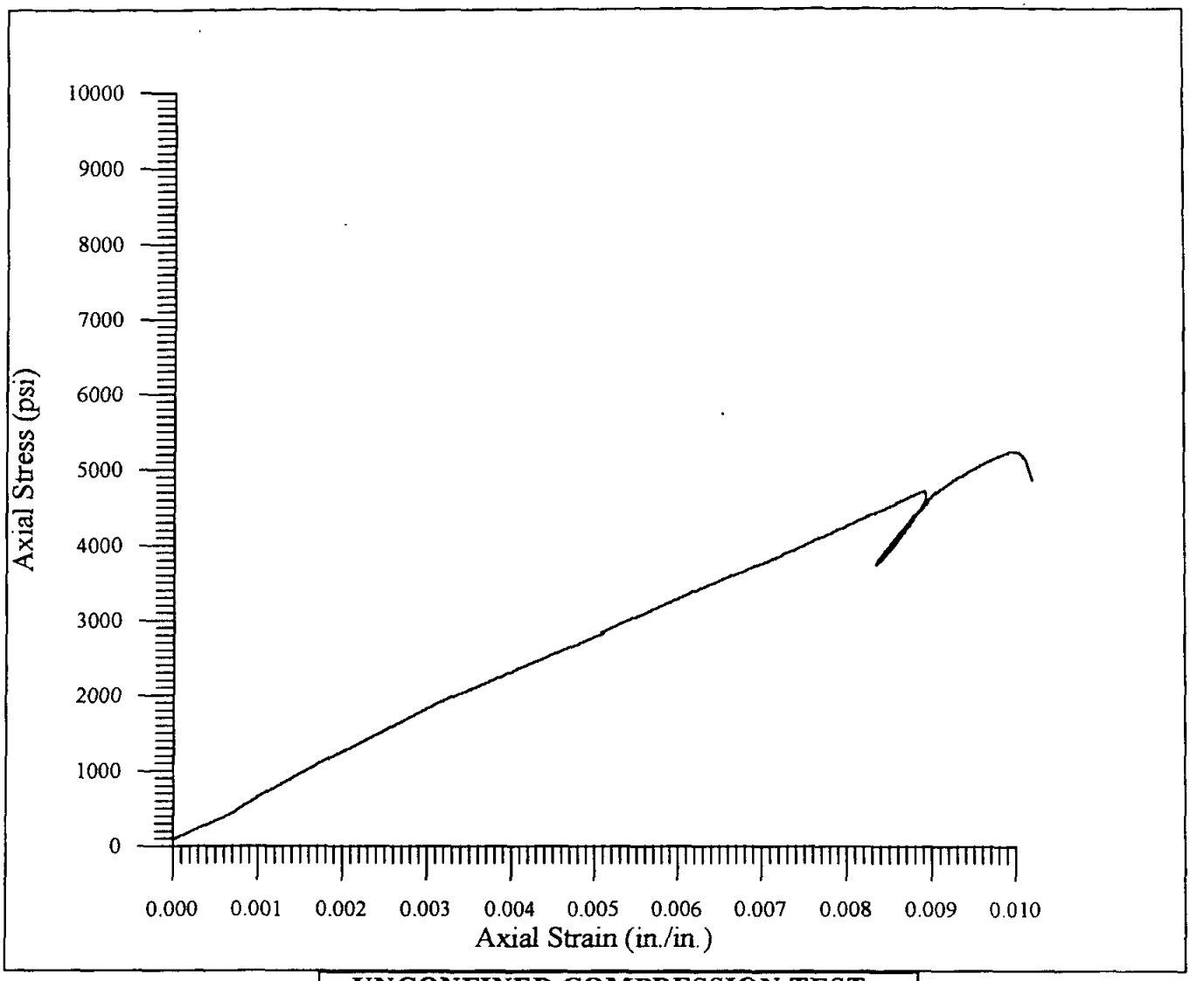


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-273
Boring: 02-11
Depth: 273.5-274.0'

DESCRIPTION

Dark gray shale with a few very thin fine grained sandstone beds about 73 degrees to the core axis.

Density: 167.0 pcf
Strength: 5234 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

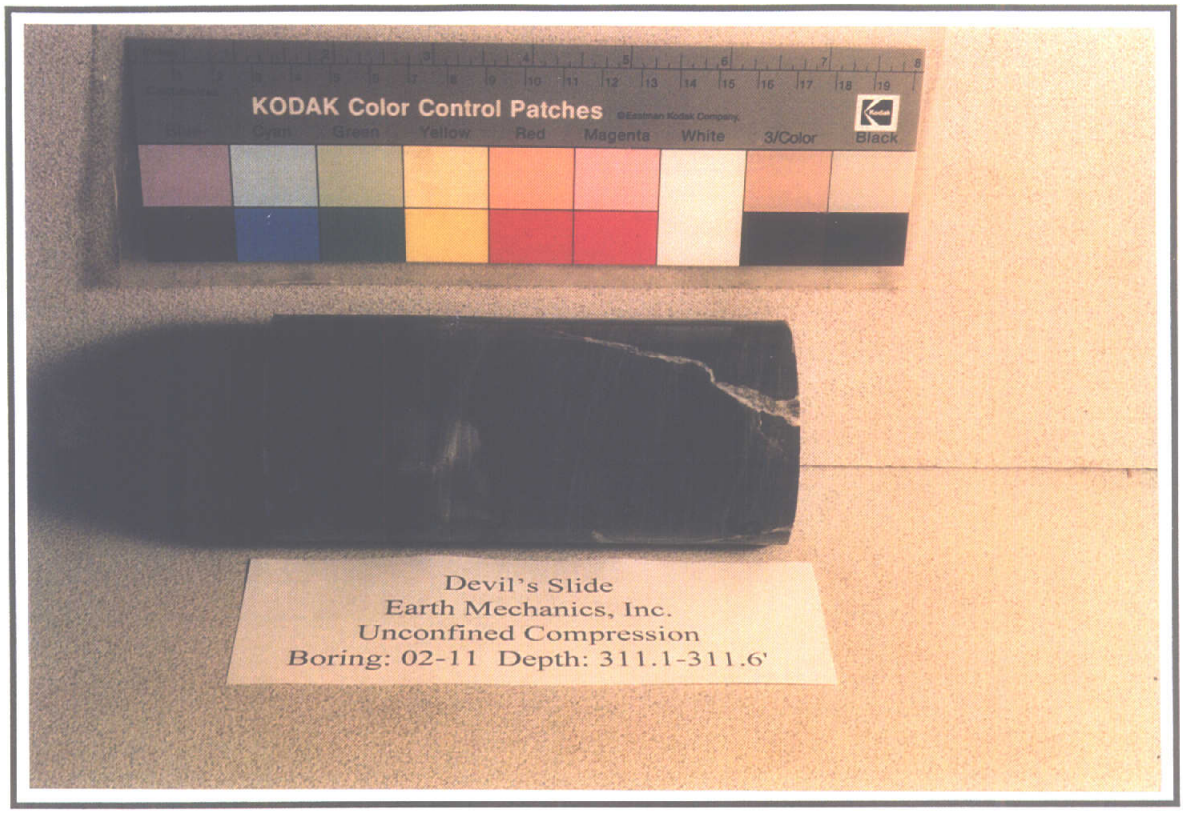
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

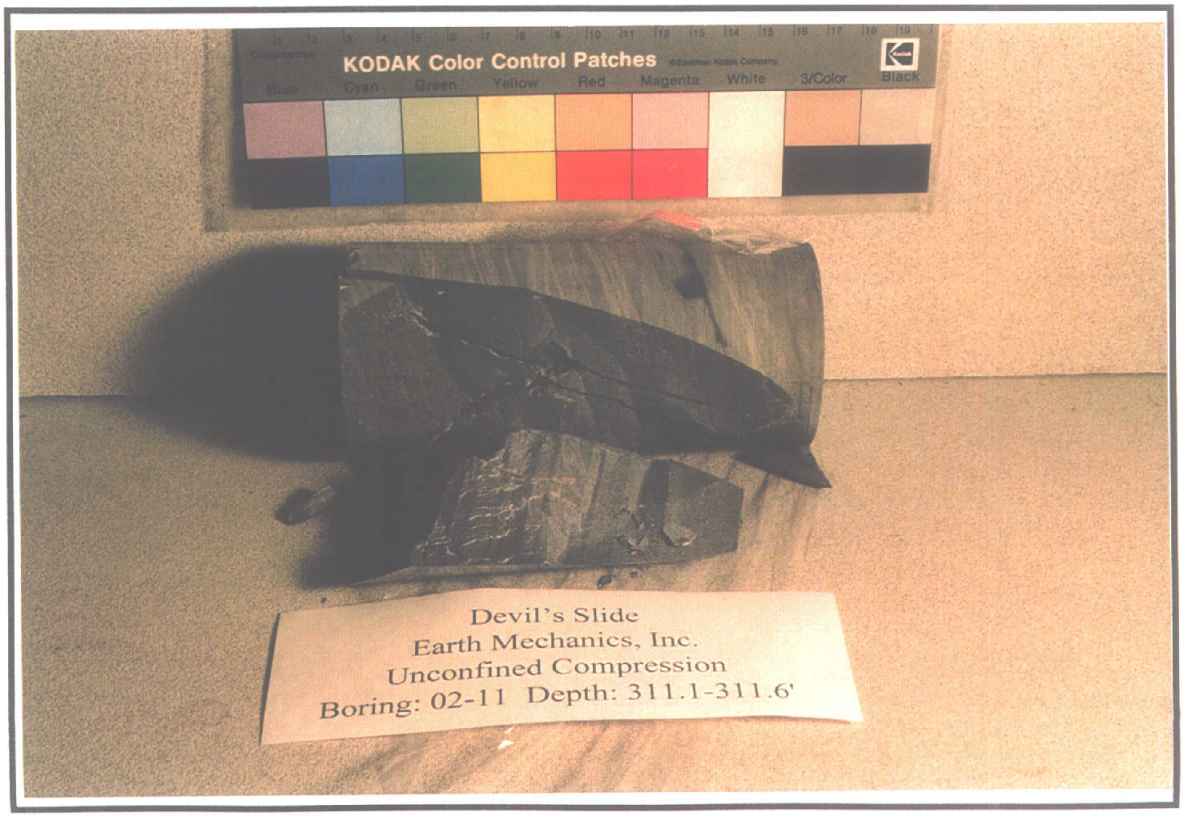
Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

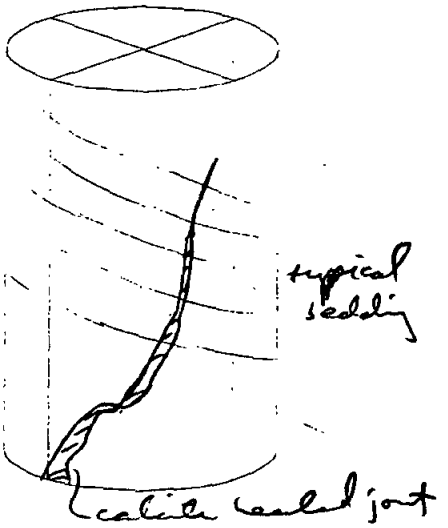
Date: 9/16/02
Technician: A. Bro

Client: EMI
Job: #151- Devil's Slide
Sample ID: Boring 02-11
Sample Description: Finely interbedded siltstone (beds typically < 1/8") with one calcite healed joint perpendicular to bedding. Bedding ~ 77° to core axis.

Sample Depth: 311.1-311.6' Sample Condition: received dry - tested moist

d_1	d_2
2.402	2.400
2.402	2.401
2.402	2.402
2.403	2.403
2.402	2.402

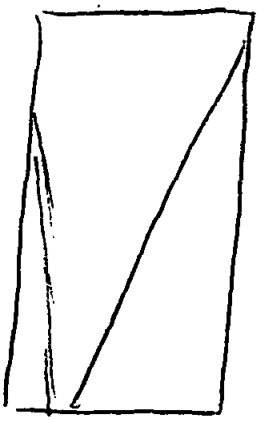
l_1	l_2
+.0006	0
+.0002	0
±.0001	±.0002
-.0005	-.0003
-.0009	-.0005



Avg. diameter : 2.402
Avg. length : 5.341"
Sample area : 4.531
l/d ratio : 2.22
Sample volume(in^3) : 24.202
Sample weight (g) : 1088.78
Density : 44.98 g/in^3 = 171.4 pcF (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE - failed by shear along previously unnoticed joint



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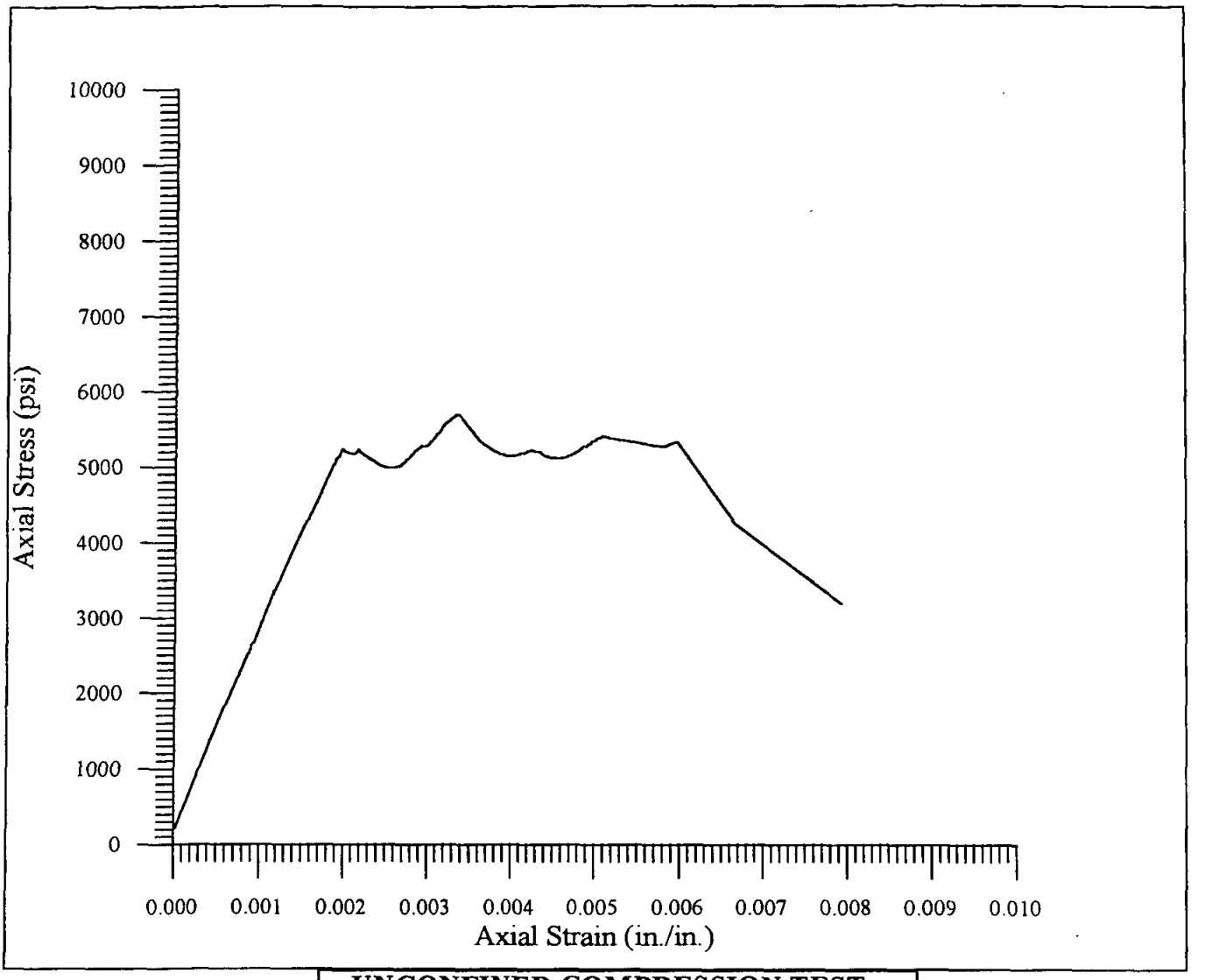


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11-311
Boring: 02-11
Depth: 311.1-311.6'

DESCRIPTION

Dark gray finely interbeded siltstone (shale?) with beds about 73 degrees to the core axis with one calcite healed joint perpendicular to the bedding.

Density: 171.4 pcf
Strength: 5685 psi
Joint Control Failure?: yes

Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

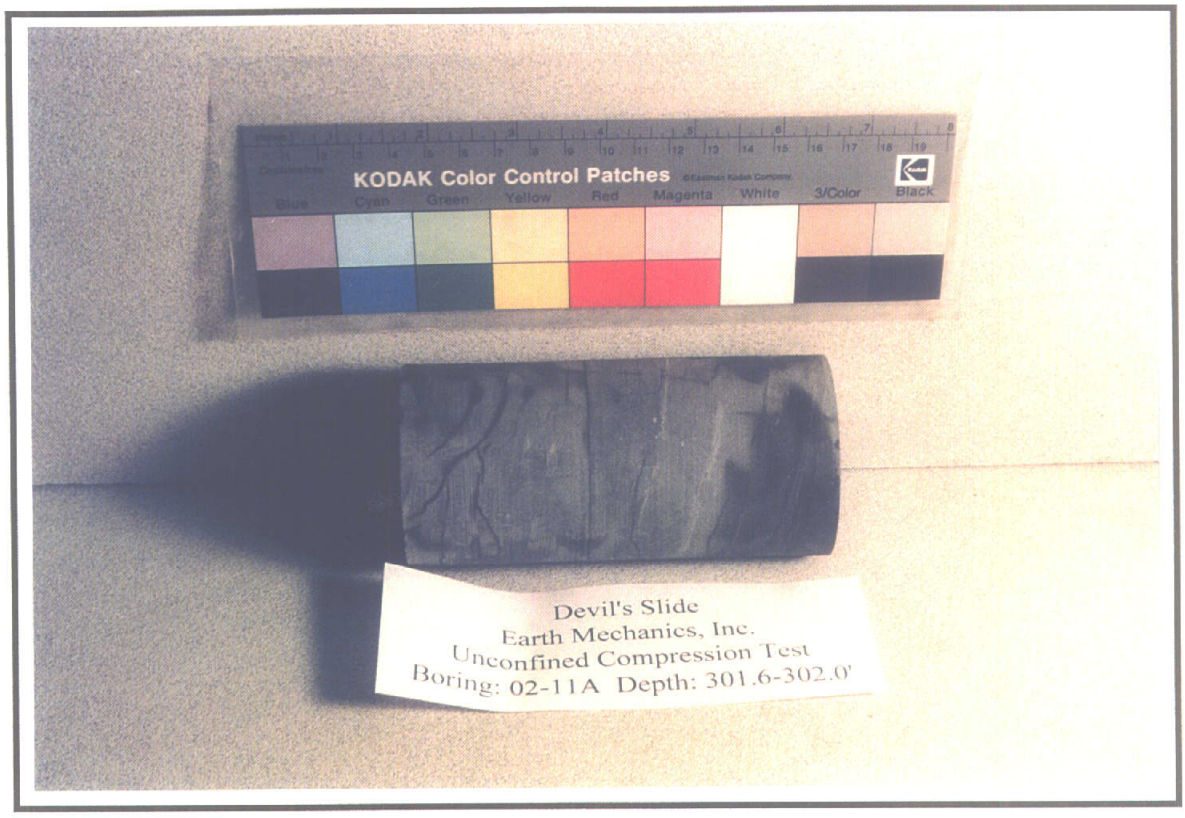
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

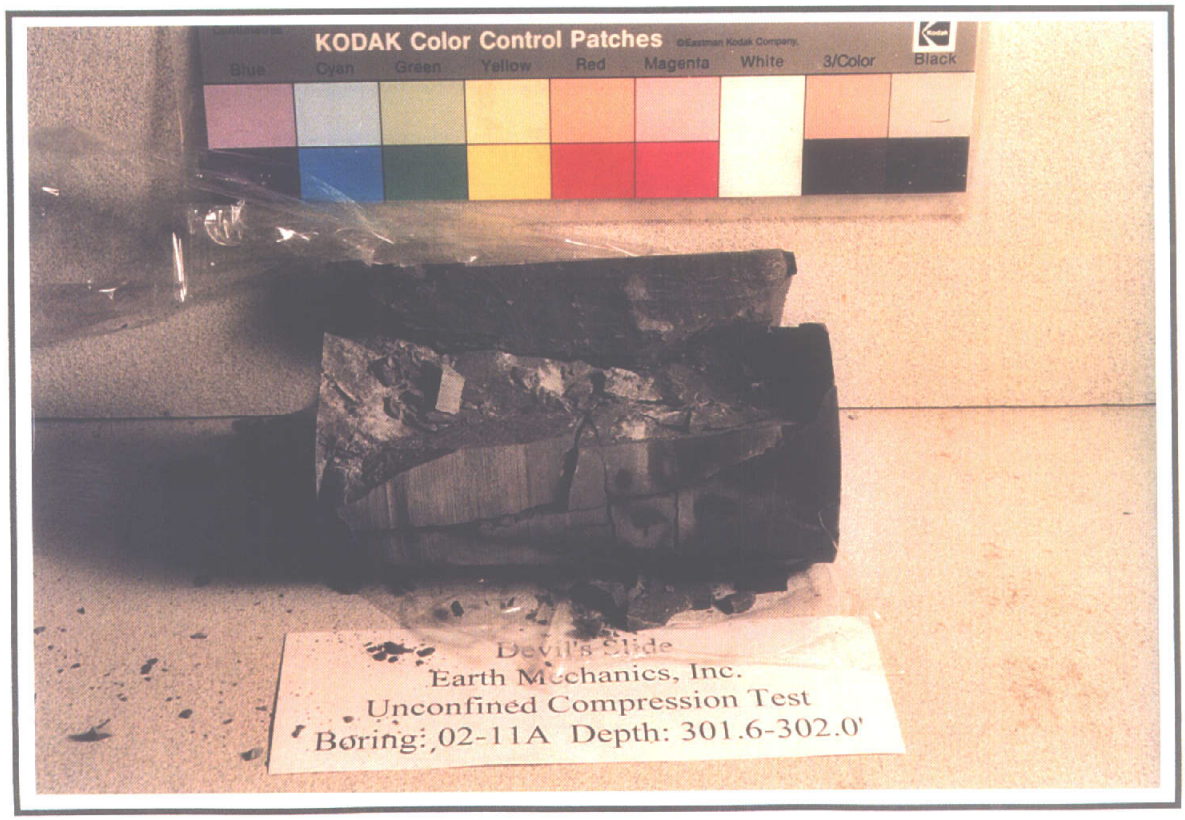
Project: Devil's Slide

Project Number: none

Test Date: September 16, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray shale with a few bedding plane joints interbedded with a few medium gray siltstone beds. One chip on end glued into place w/ CA glue (thin)
Bedding 75° to core axis.

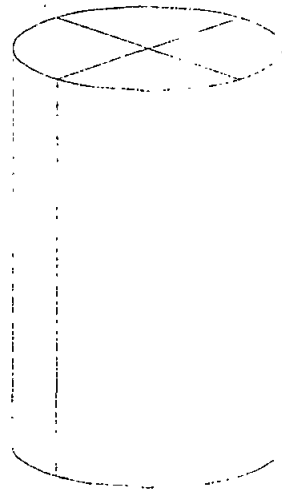
Sample Depth: 301.6-302.0' Sample Condition: received dry - tested moist

d_1	d_2
2.394	2.393
2.394	2.393
2.393	2.391
2.377	2.387
2.393	2.387

(x.0001")

l_1	l_2
+17	+12
+8	+7
±1	±2
-9	-7
-22	-15

- groove in sample - not included in avg. diam



Avg. diameter : 2.392
Avg. length : 4.940
Sample area : 4.494
l/d ratio : 2.07
Sample volume(in^3) : 22.199
Sample weight (g) : 989.3 g
Density : 44.56 g/in^3 = 169.8 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE - failed with numerous axial splits

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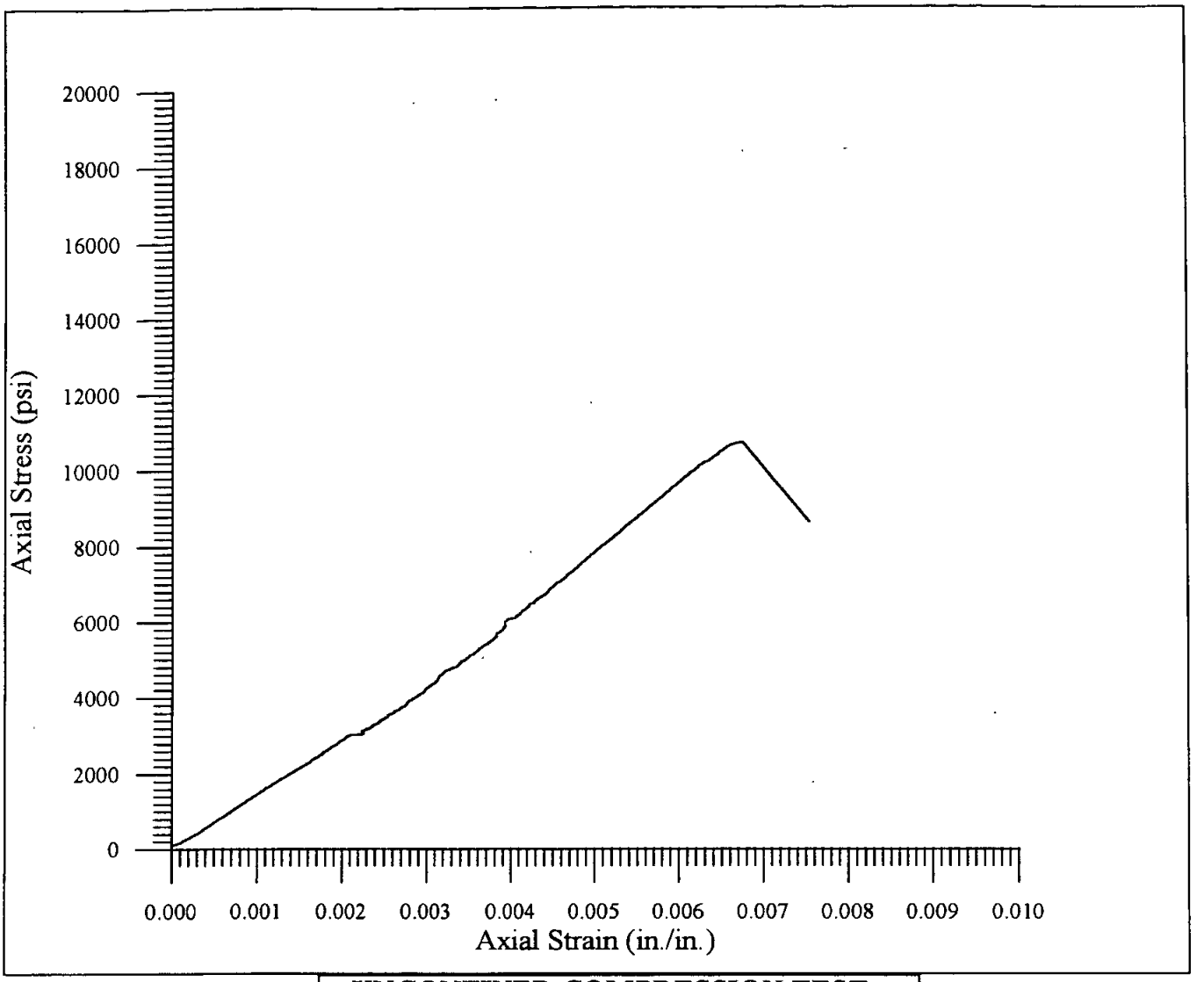


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-301
Boring: 02-11A
Depth: 301.6-302.0'

DESCRIPTION

Dark gray shale with a few bedding plane joints, interbedded with a few thin medium gray siltstone beds.

Density: 169.8 pcf
Strength: 10,761 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

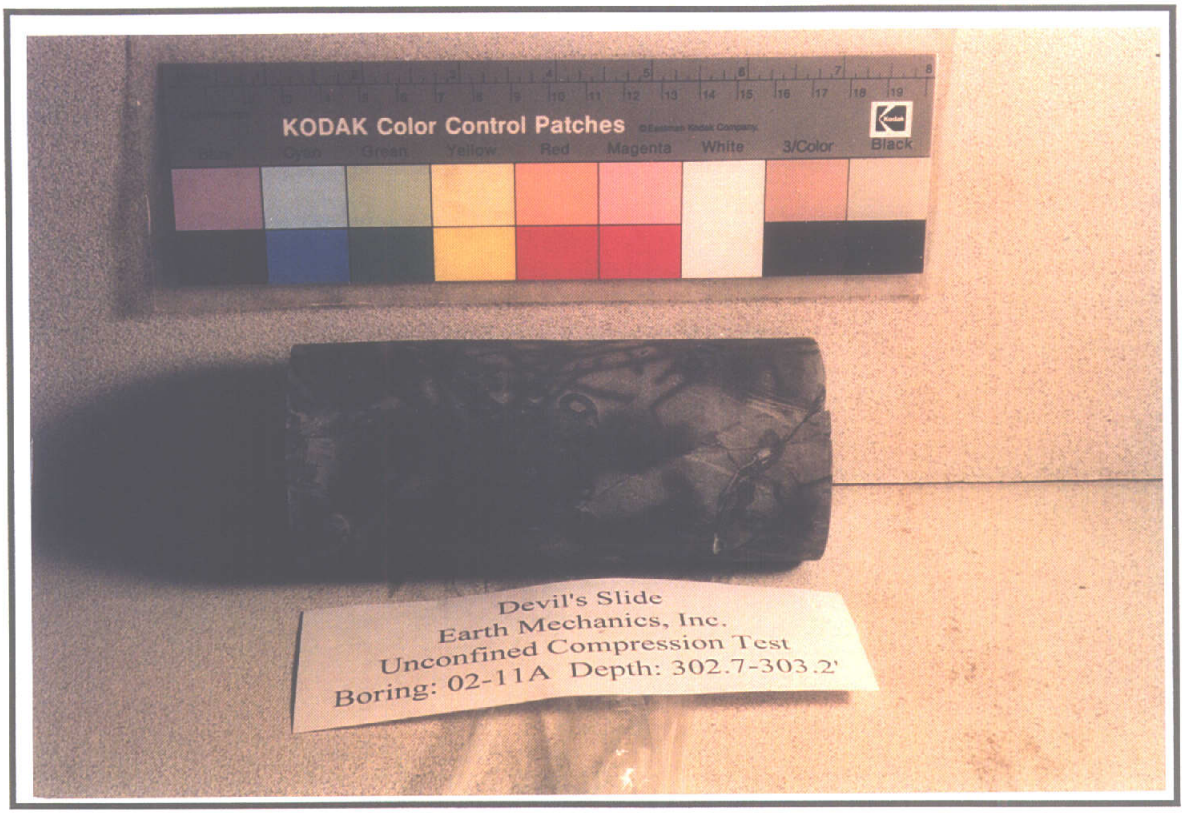
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

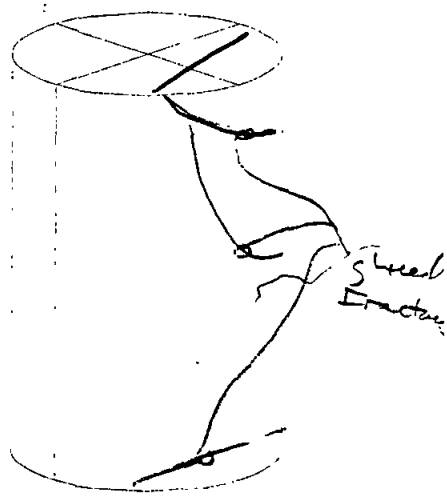
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray shale with several fractures - some glued with CA glue

Sample Depth: 302.7-303.2' Sample Condition: received dry - tested moist

d_1	d_2
2.395	2.402
	2.397
	2.396
	2.398
2.393	2.403

(x.0001")

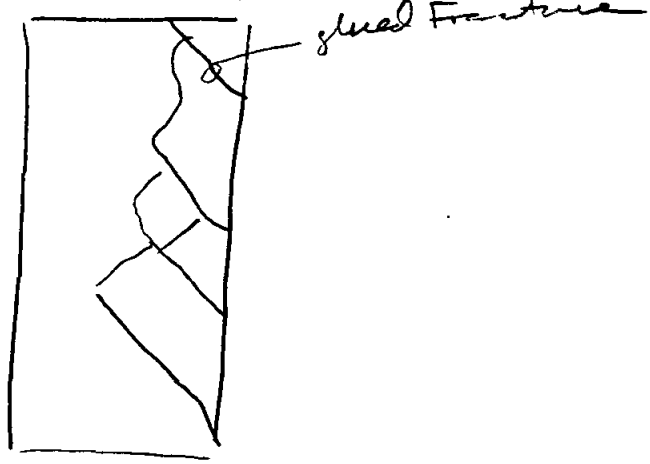
l_1	l_2
-4	+34
-4	+19
±3	±3
-5	-30
-3	-50



Avg. diameter : 2.397
Avg. length : 5.481"
Sample area : 4.513
l/d ratio : 2.29
Sample volume(in³) : 24.734
Sample weight (g) : 1079.1 g
Density : 43.63 g/in³ = 166.2 pcf (1 g/in³=3.8095lb/ft³)

Comments:

JOINT CONTROLLED FAILURE - Failed by shear on multiple joints of 1 joint set



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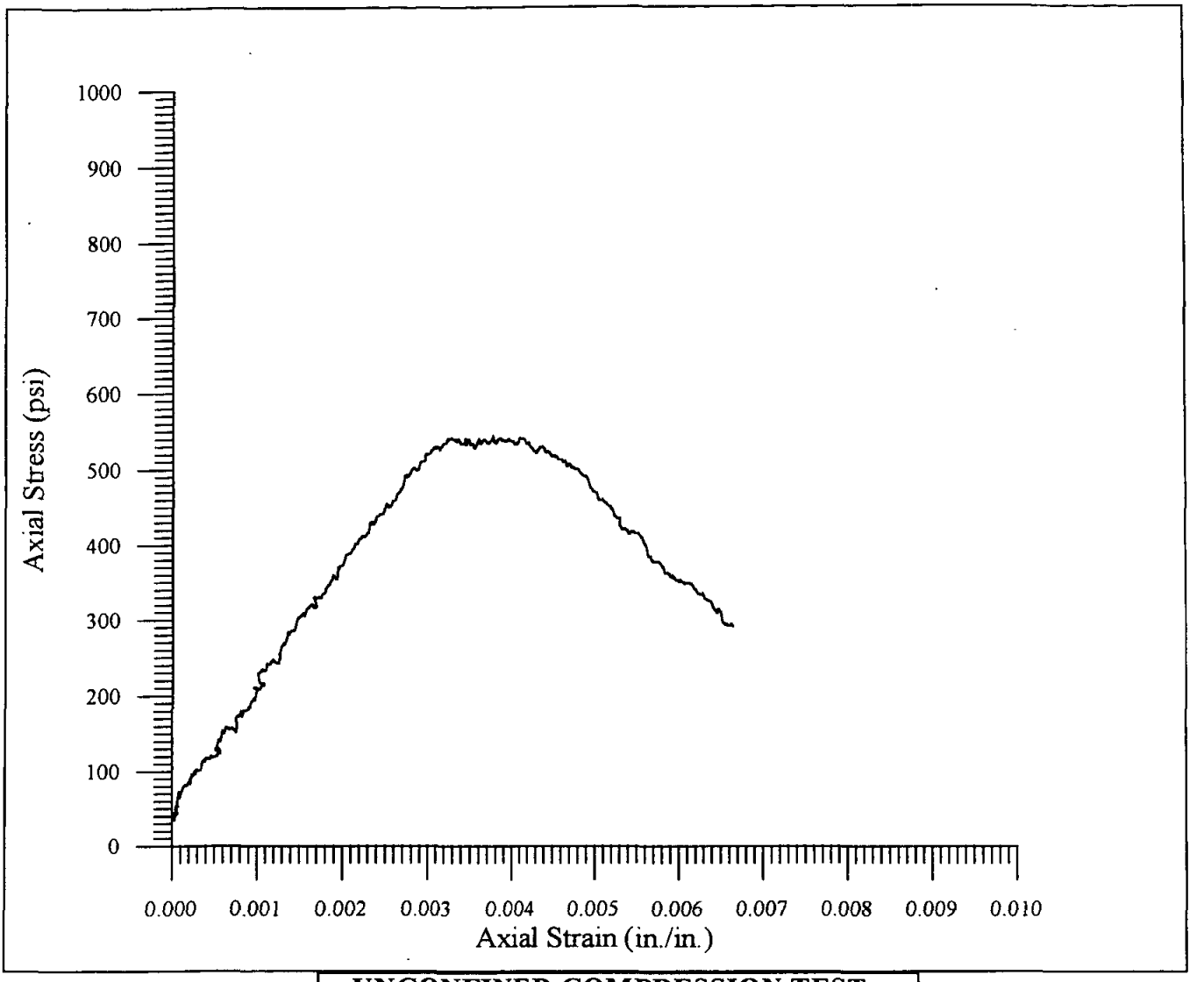


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-302
Boring: 02-11A
Depth: 302.7-303.2'

DESCRIPTION
Dark gray shale with several fractures.

Density: 166.2 pcf
Strength: 544 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

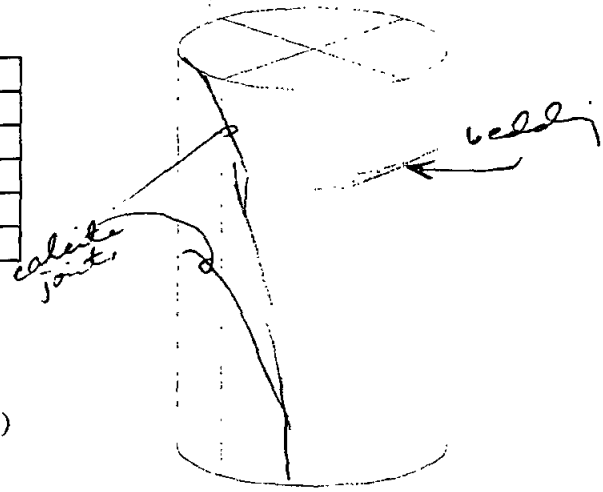
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray shale with a few bedding plane joints and a few calcite healed hairline joints. One joint glued w/ CA glue.

Sample Depth: 206.3-206.8 Sample Condition: received dry - tested moist

d_1	d_2
2.394	2.394
2.384	2.393
2.393	2.394
2.393	2.394
2.395	2.392

(x.0001")

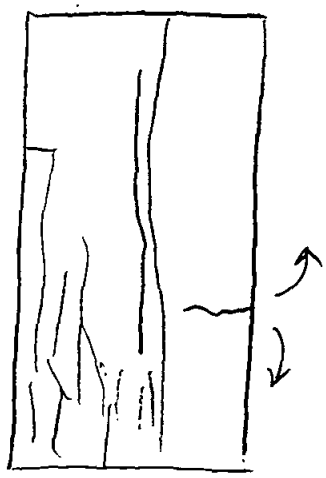
l_1	l_2
+7	+9
+4	+4
±1	
-7	-4
-15	-9



Avg. diameter : 2.394 Avg. length : 5.383"
Sample area : 4.501 l/d ratio : 2.25
Sample volume(in³) : 24.231
Sample weight (g) : 1081.4g
Density : 44.638/in³ = 1700pcf (1 g/in³=3.8095lb/ft³)

Comments:

INTACT FAILURE - failed by multiple axial splitting



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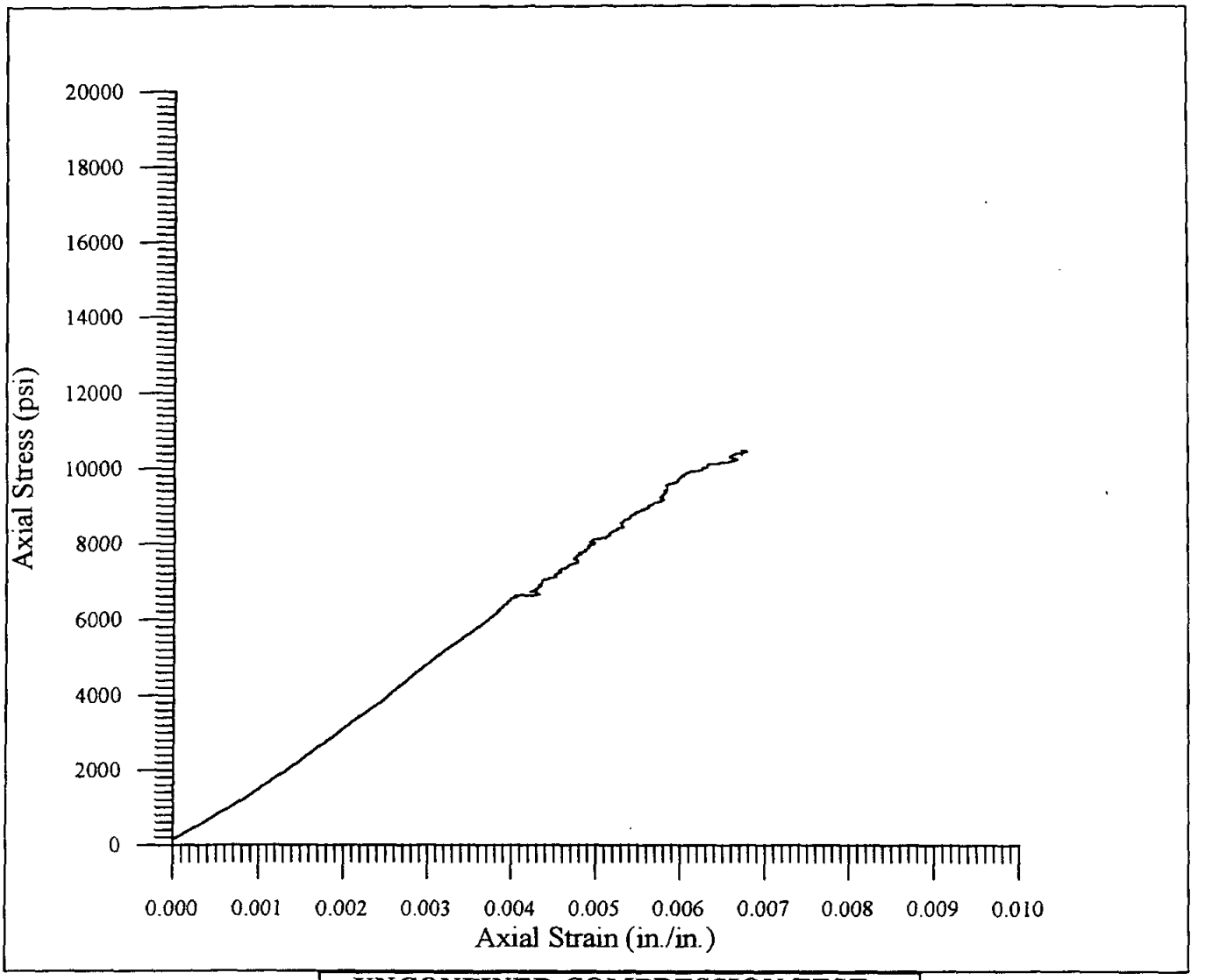


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-306
Boring: 02-11A
Depth: 306.3-306.8'

DESCRIPTION

Dark gray shale with a few bedding plane joints and a few calcite healed hairline fractures.

Density: 170.0 pcf
Strength: 10,490 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

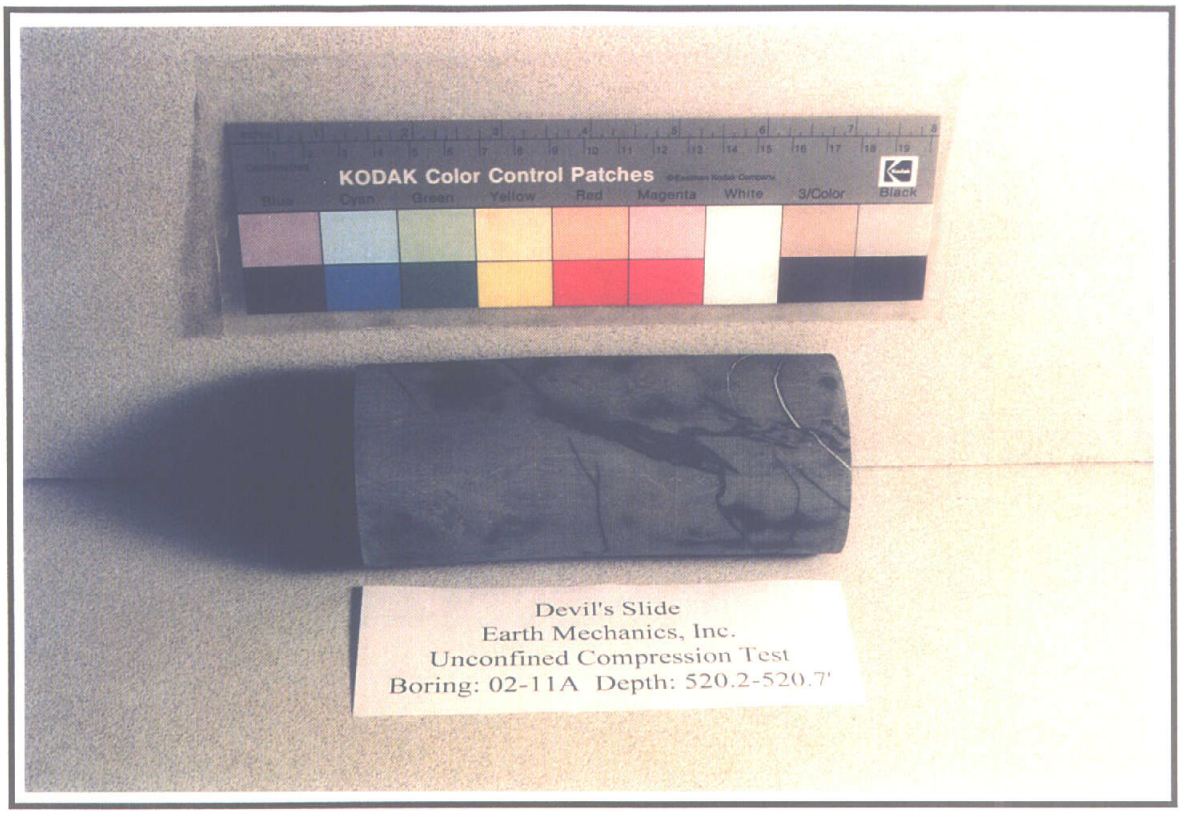
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bud

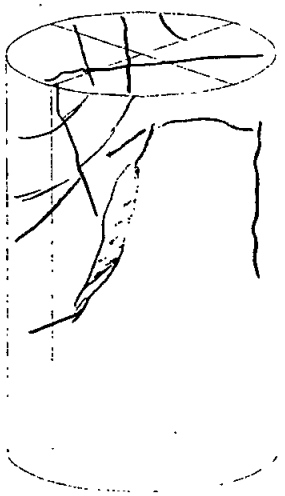
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray shale with a few joints

Sample Depth: 520.2-520.7 Sample Condition: received dry - tested moist

d_1	d_2
2.390	2.395
2.388	2.394
2.389	2.392
2.386	2.393
2.392	2.392

(x.0001")

l_1	l_2
+15	0
+9	0
±1	±2
-4	0
-11	0

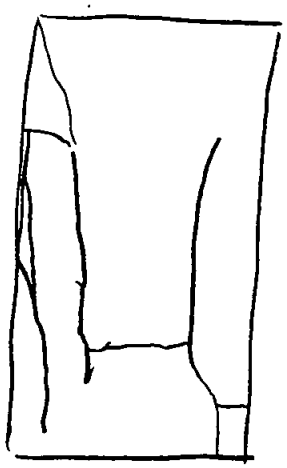


Avg. diameter : 2.391
Sample area : 4.490
Sample volume(in^3) : 25.081
Sample weight (g) : 109.28 g
Density : 43.578 g/in^3 = 166.0 pcF (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.586"
l/d ratio : 2.34

Comments:

JOINT CONTROLLED FAILURE? - failed by axial splitting, possibly along existing joints.



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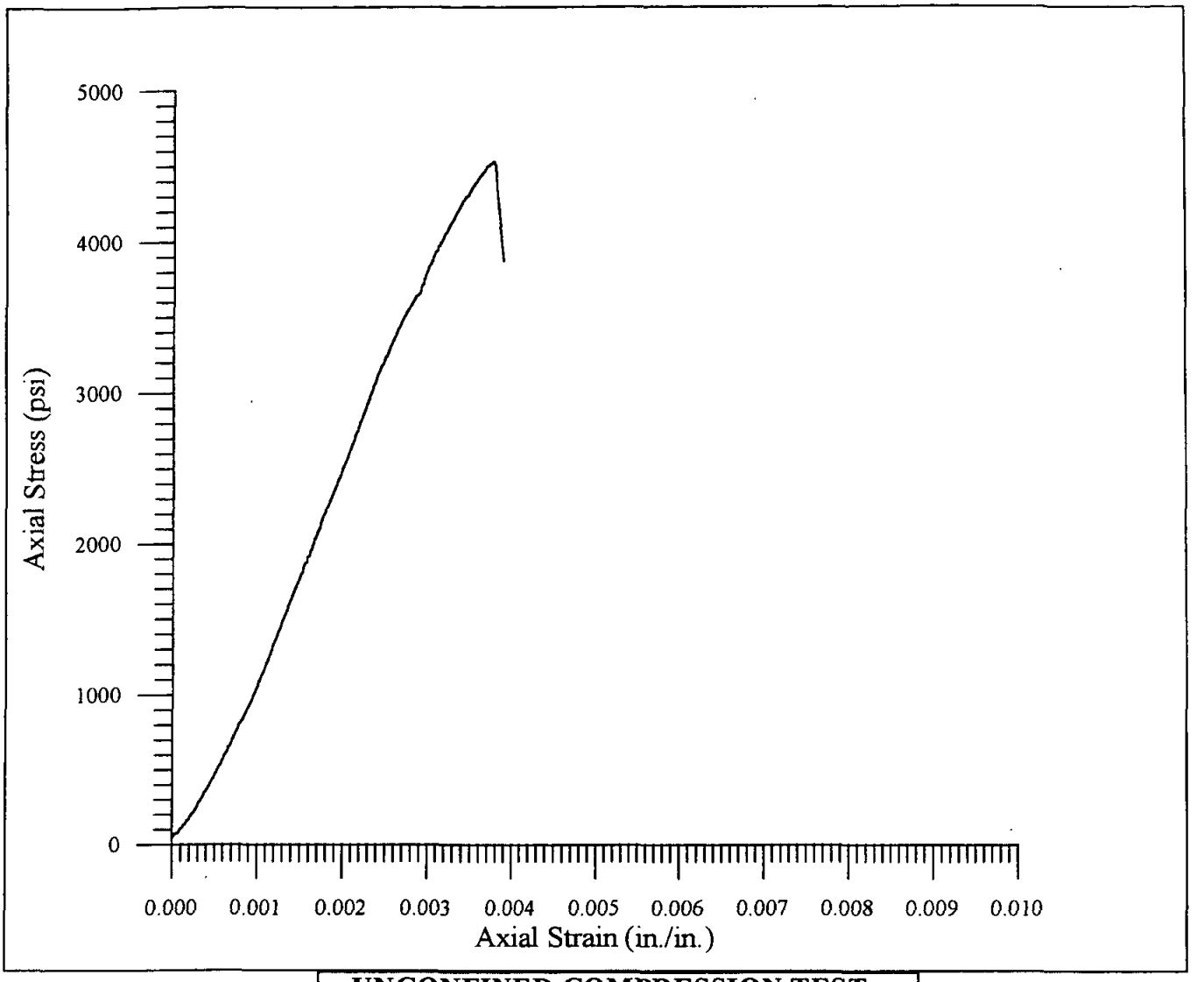


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-520
Boring: 02-11A
Depth: 520.2-520.7'

DESCRIPTION
Dark gray shale with a few joints.

Density: 166.0 pcf
Strength: 4529 psi
Joint Control Failure?: yes(?)

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

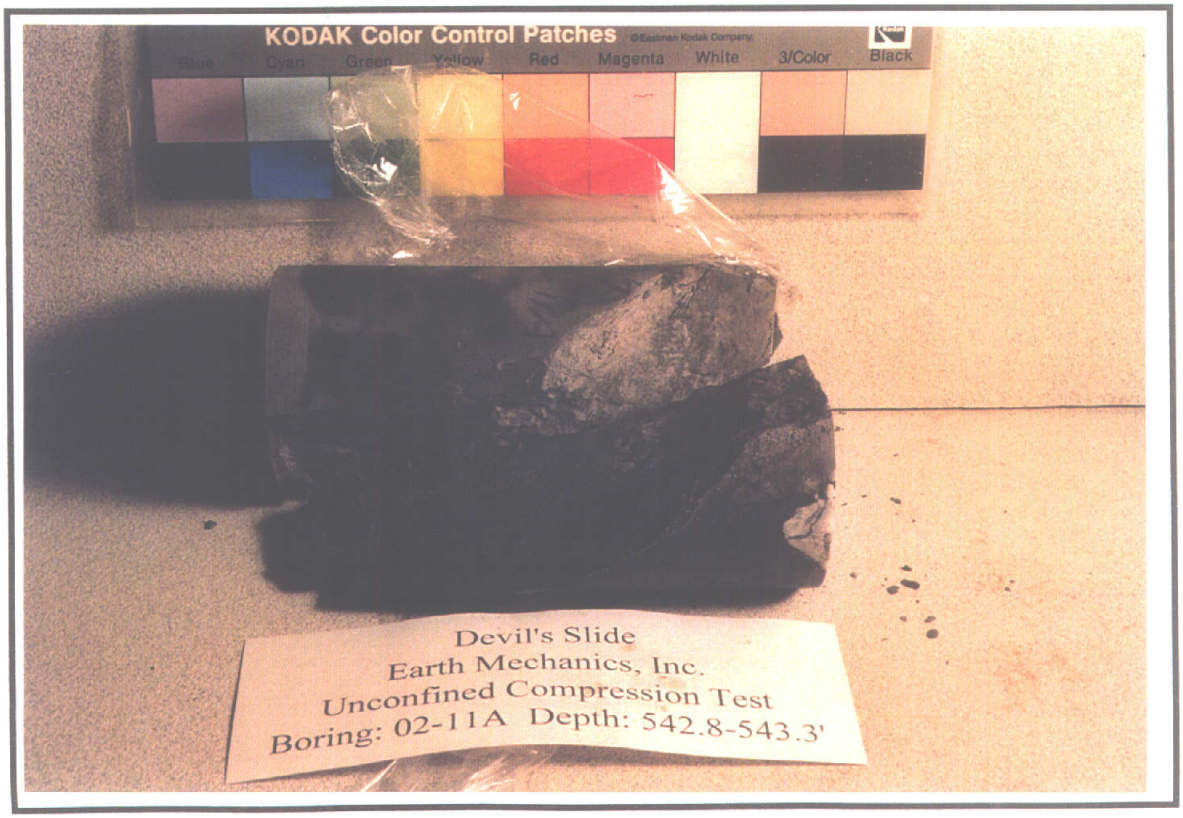
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

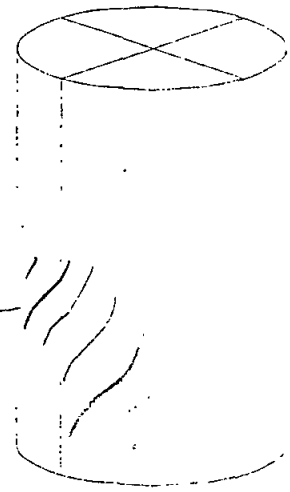
Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray siltstone sheared with dark gray shale, and calcite filled.

Sample Depth: 542.8-543.3' Sample Condition: received dry - tested moist

d_1	d_2
2.394	2.394
	2.392
	2.394
	2.394
	2.393

(x .0001")

l_1	l_2
+3	+6
+2	+3
±1	±2
-2	-4
-4	-8

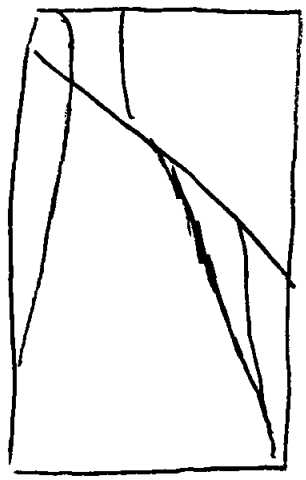


Avg. diameter : 2.394
Sample area : 4.501
Sample volume(in^3) : 23.510
Sample weight (g) : 1033.88
Density : 43.97 g/in^3 = 167.5 pcf (1 g/in^3=3.8095 lb/ft^3)

Avg. length : 5.223"
l/d ratio : 2.18

Comments:

JOINT CONTROLLED FAILURE? - failed by shearing and splitting



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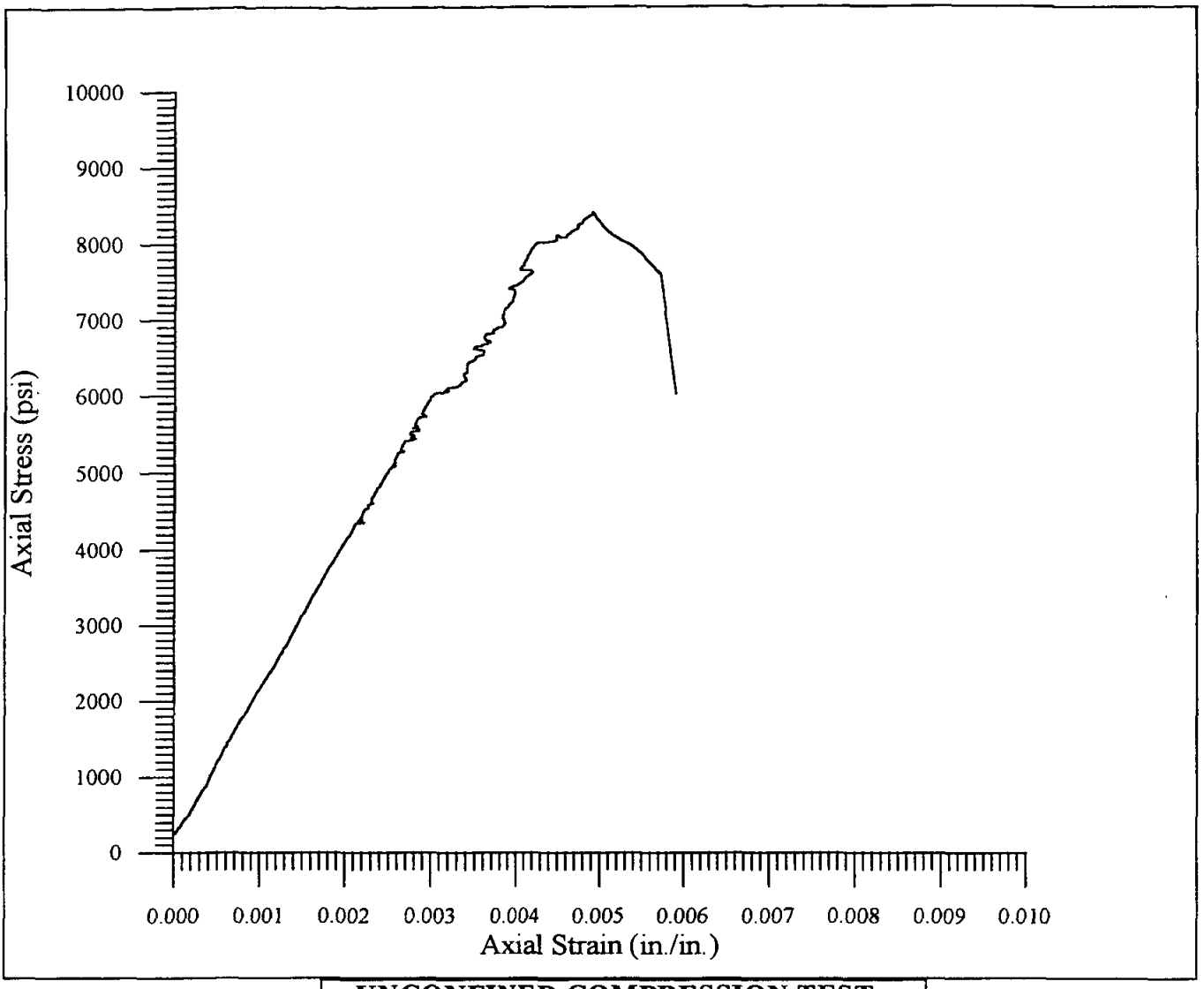


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-542
Boring: 02-11A
Depth: 542.8-543.3'

DESCRIPTION
Dark gray siltstone sheared with dark gray shale and relithified.

Density: 166.0 pcf
Strength: 8411 psi
Joint Control Failure?: yes(?)

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

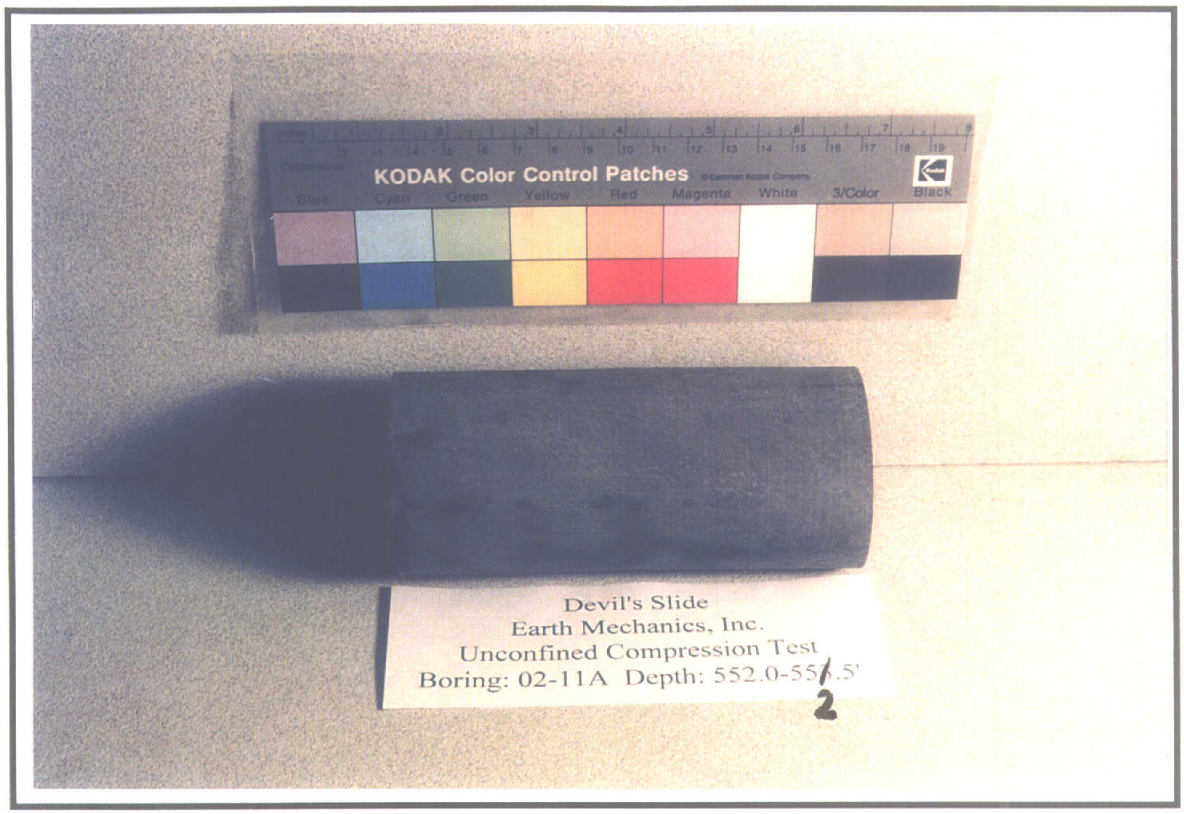
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

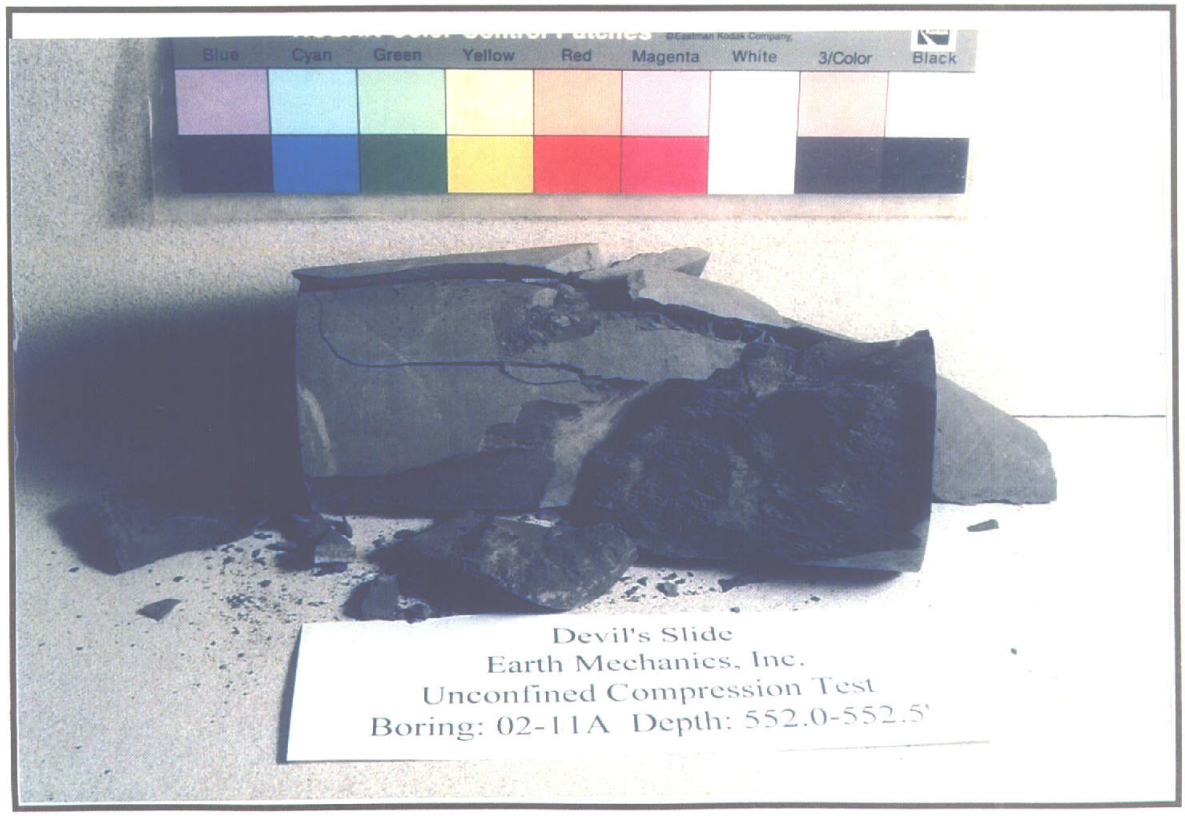
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

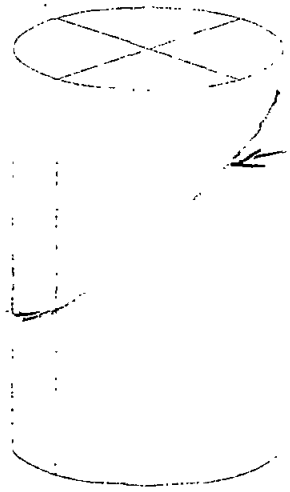
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray interbedded sheared siltstone & shale with siltstone. No apparent joints. Bedding ~ 47° to the core axis.

Sample Depth: 550.0-552.5 Sample Condition: received dry - tested moist

d_1	d_2
2.392	2.393
2.390	2.392
2.388	2.393
2.390	2.392
2.392	2.392

(x.0001")

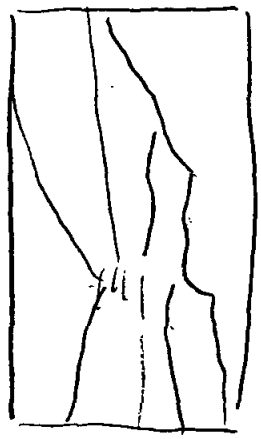
l_1	l_2
+7	+7
+3	+4
±1	±2
-5	-3
-10	-6



Avg. diameter : 2.391 Avg. length : 5.396
Sample area : 4.490 l/d ratio : 2.26
Sample volume(in^3) : 24.228
Sample weight (g) : 1058.48
Density : 43.68 g/in^3 = 166.4 pcF (1 g/in^3=3.8095lb/ft^3)

Comments:

INTACT FAILURE: failed by axial splitting and smash.



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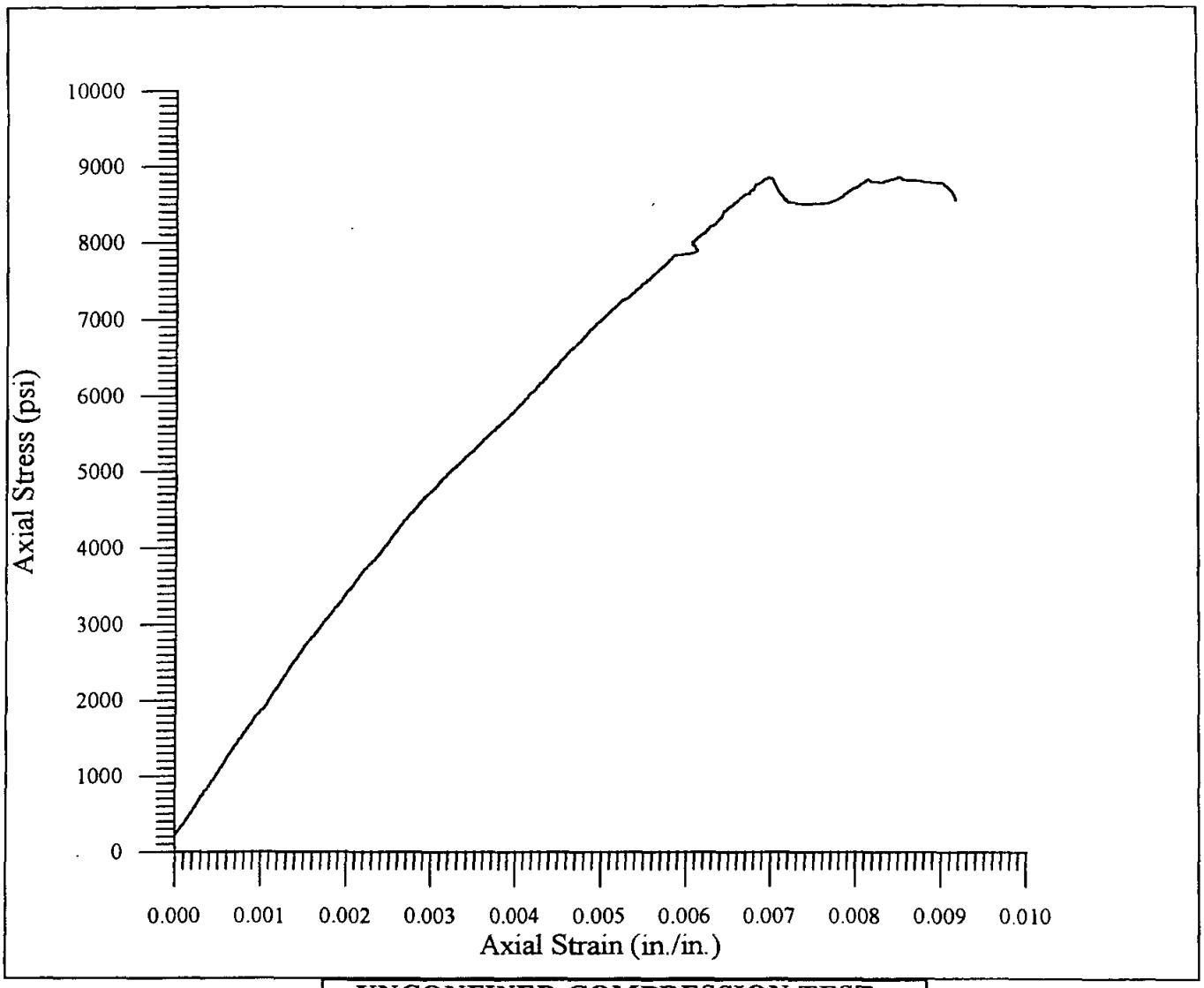


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-552
Boring: 02-11A
Depth: 552.0-552.5'

DESCRIPTION

Dark gray interbedded sheared siltstone and shale with siltstone. Bedding about 47 degrees to the core axis.

Density: 166.4 pcf
Strength: 8852 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

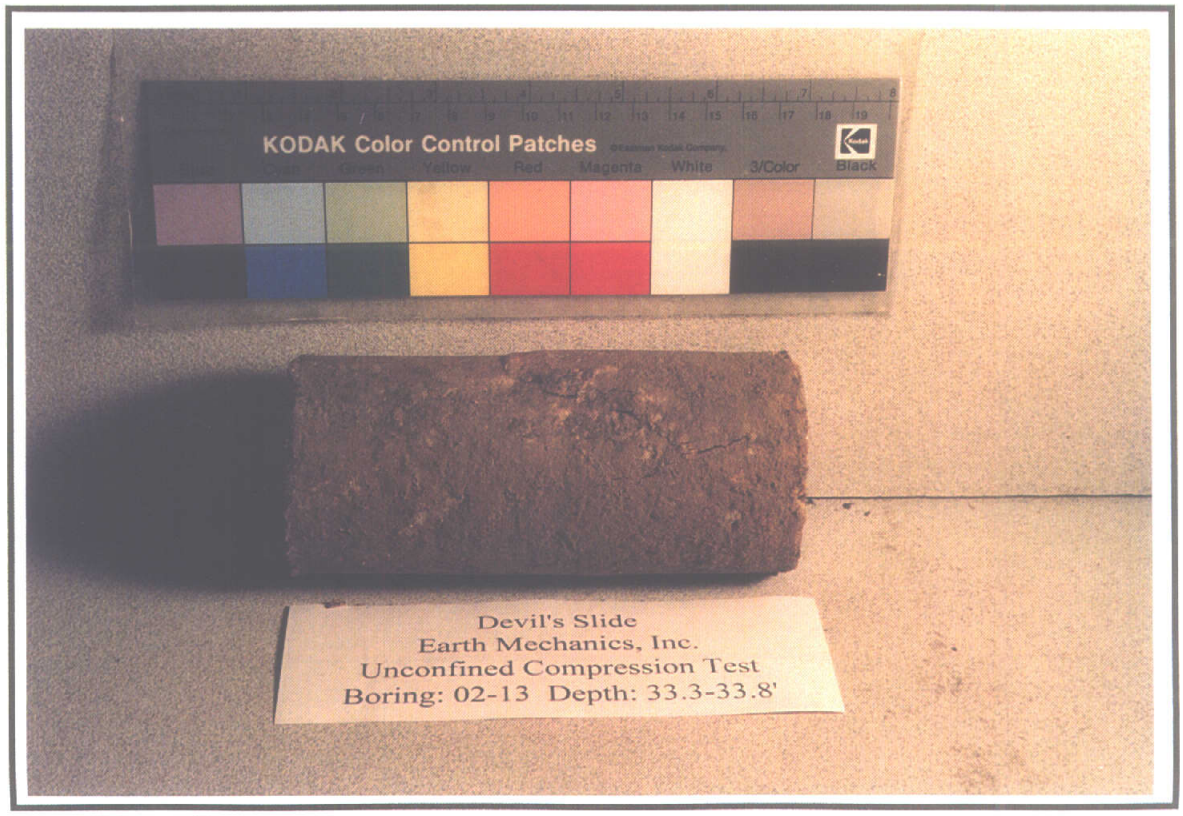
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

Client: ENI
Job: #151 - Devil's Slide
Sample ID: Boring 02-13
Sample Description: Brownish gray heavily altered granodiorite.

Sample Depth: 33.3 - 33.8 Sample Condition: received moist - tested moist

d_1	d_2
2.423	2.377
2.377	2.388
2.364	2.390
2.374	2.381
2.385	2.378

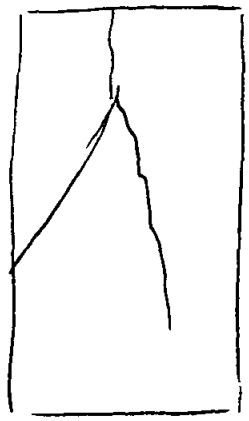
NA *

l_1	l_2

Avg. diameter : 2.384 Avg. length : 5.440"
Sample area : 4.464 l/d ratio : 2.28
Sample volume(in^3) : 24.283
Sample weight (g) : 958.68
Density : 39.48 g/in^3 = 150.4 pcf (1 g/in^3=3.8095lb/ft^3)

Comments: * Too rough for meaningful readings

INTACT FAILURE - Failed by axial splitting & shear



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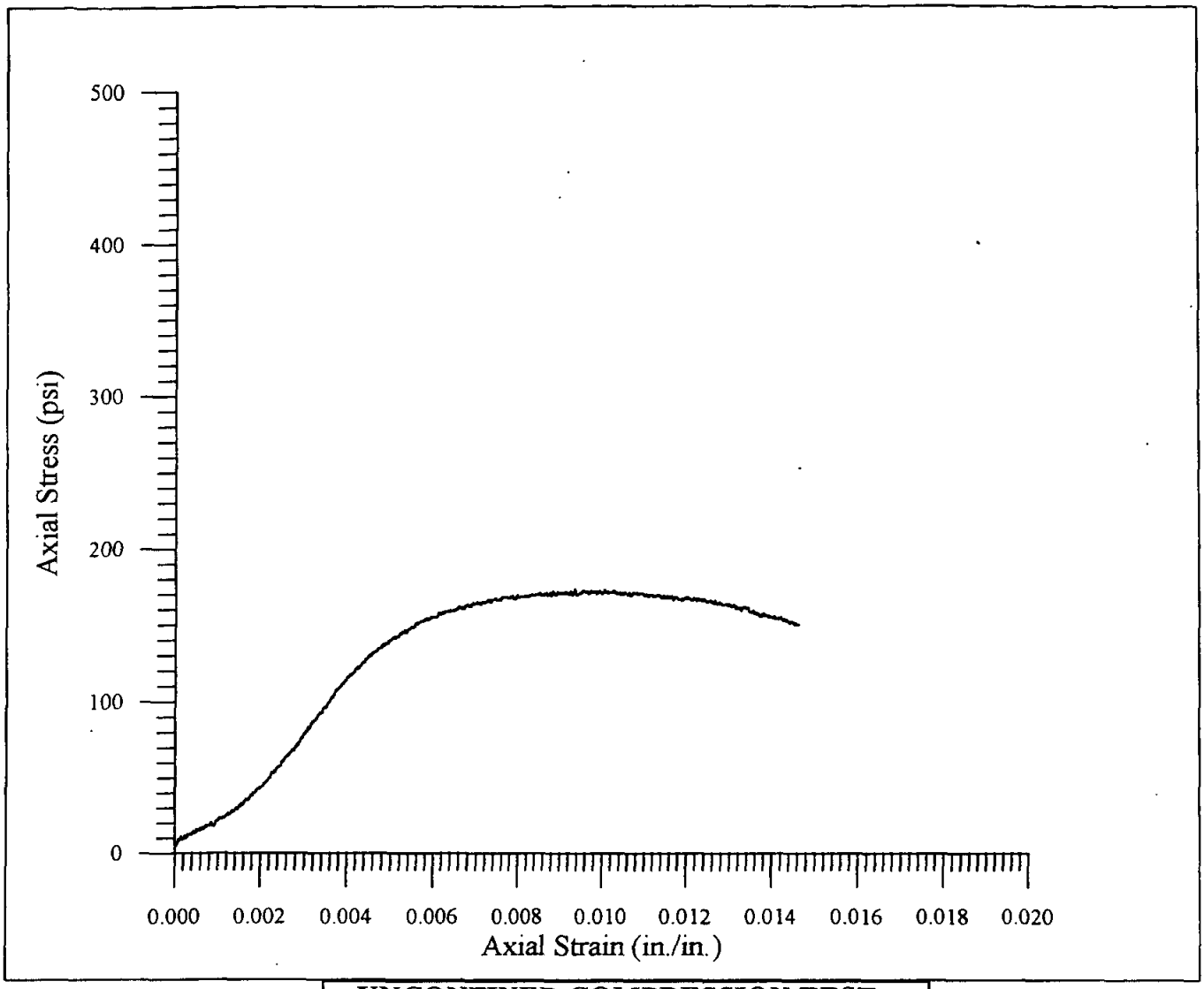


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 13-33
Boring: 02-13
Depth: 33.3-33.8'

DESCRIPTION
Brownish gray heavily altered granodiorite.

Density: 150.4 pcf
Strength: 173 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

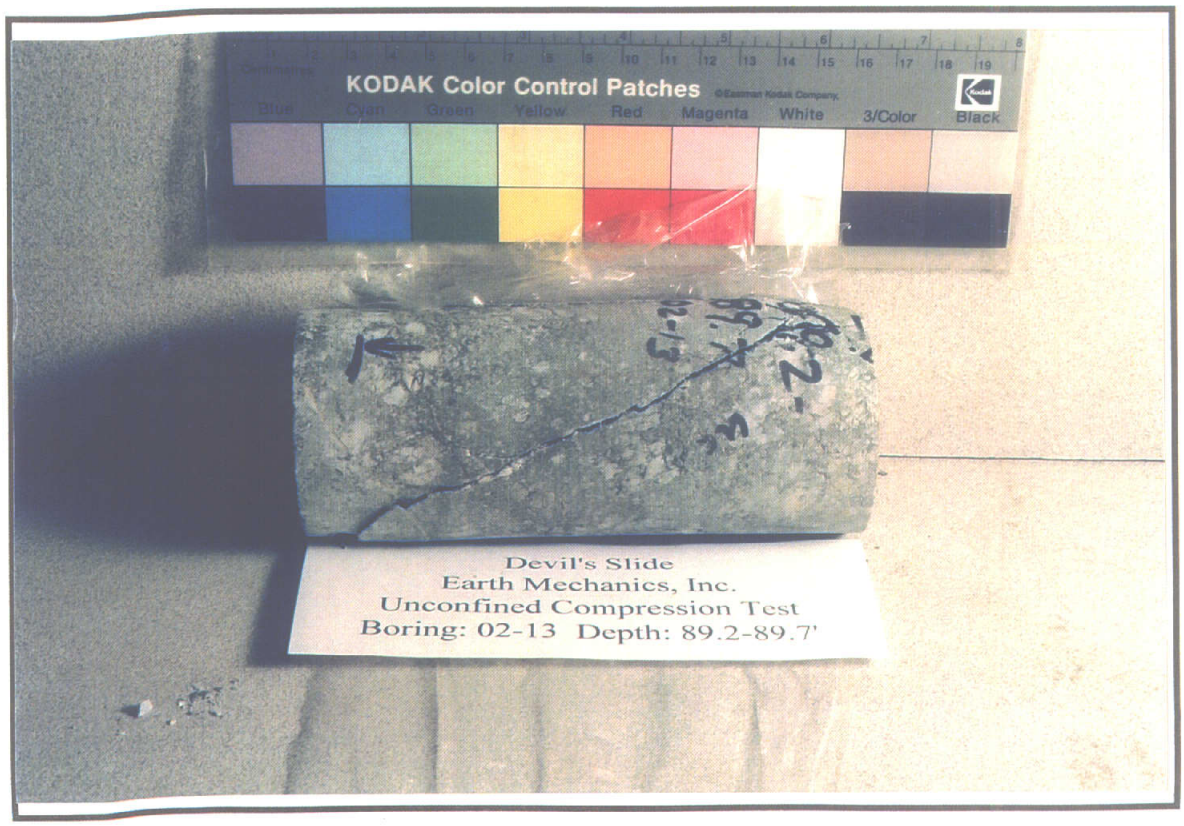
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

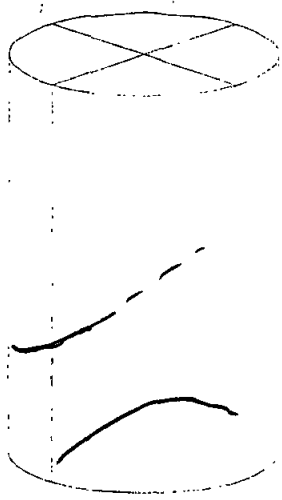
Client: EMJ
Job: #151 - Devil's Slide
Sample ID: Boring 02-13
Sample Description: Greenish gray granodiorite with 2 healed fractures.

Sample Depth: 89.2-89.7 Sample Condition: received dry - tested moist

d_1	d_2
2.385	2.386
2.382	2.383
2.386	2.385
2.381	2.383
2.386	2.380

(x.0001")

l_1	l_2
+8	+2
+5	+1
±1	±2
-4	-1
-8	-2

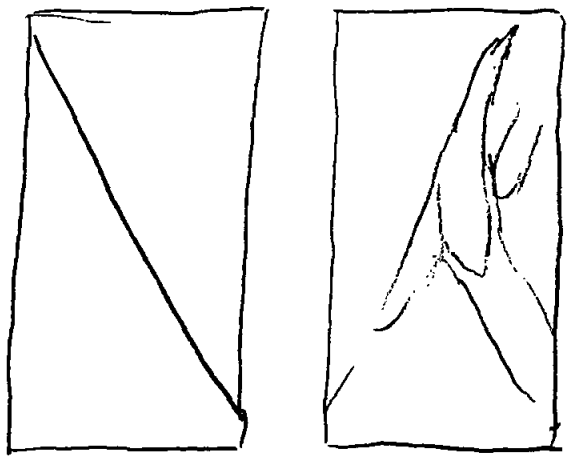


Avg. diameter : 2.384
Sample area : 4.464
Sample volume(in^3) : 25.341
Sample weight (g) : 1133.9 g
Density : 44.75 g/in^3 = 170.5 pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.677
l/d ratio : 2.38

Comments:

INTACT FAILURE (?): Failed by shear with some axial splitting (planar shear surface indicates possible plane of weakness.)



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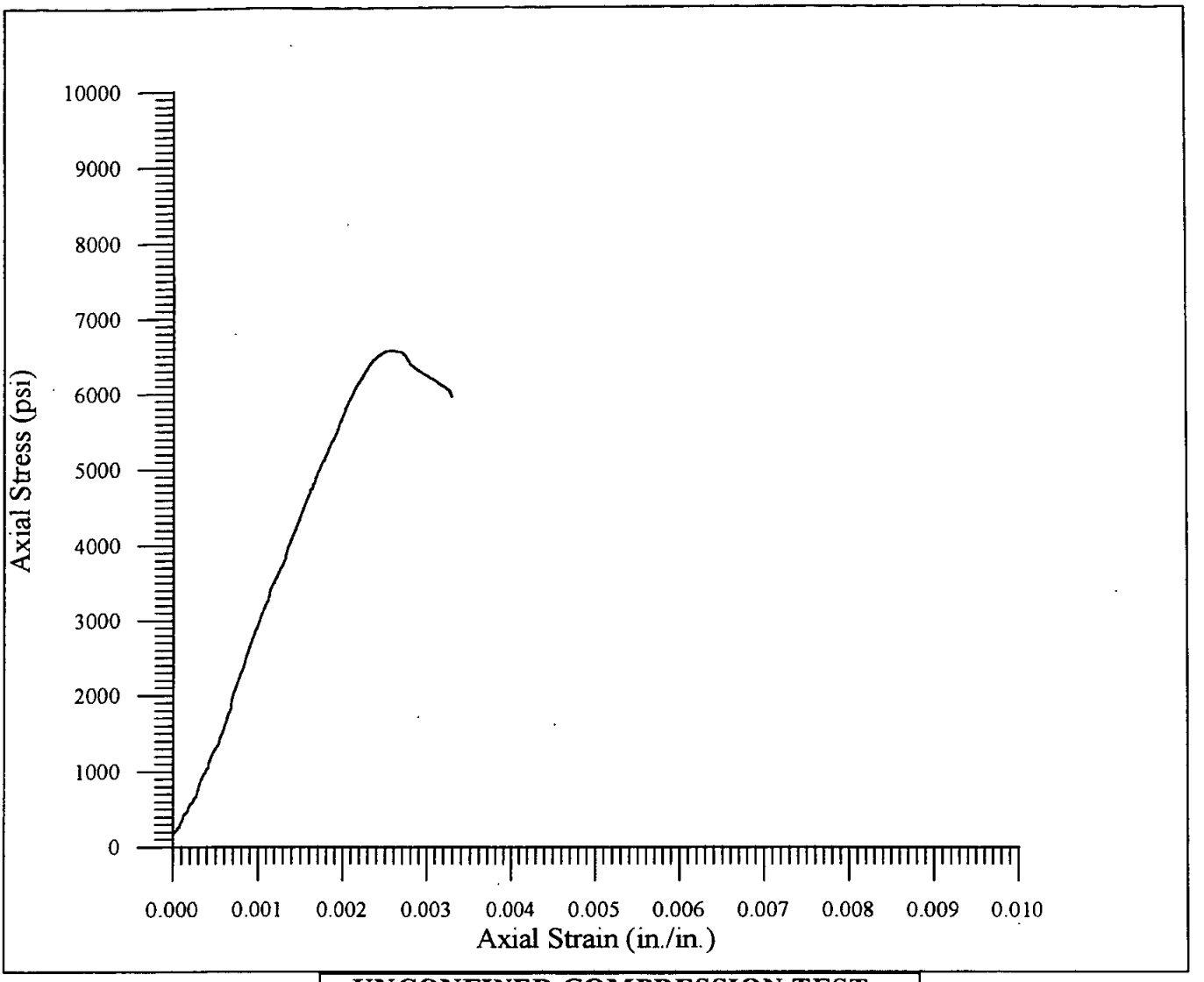


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 13-89
Boring: 02-13
Depth: 89.2-89.7'

DESCRIPTION
Greenish gray granodiorite with two healed joints.

Density: 170.5 pcf
Strength: 6572 psi
Joint Control Failure?: no(?)

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

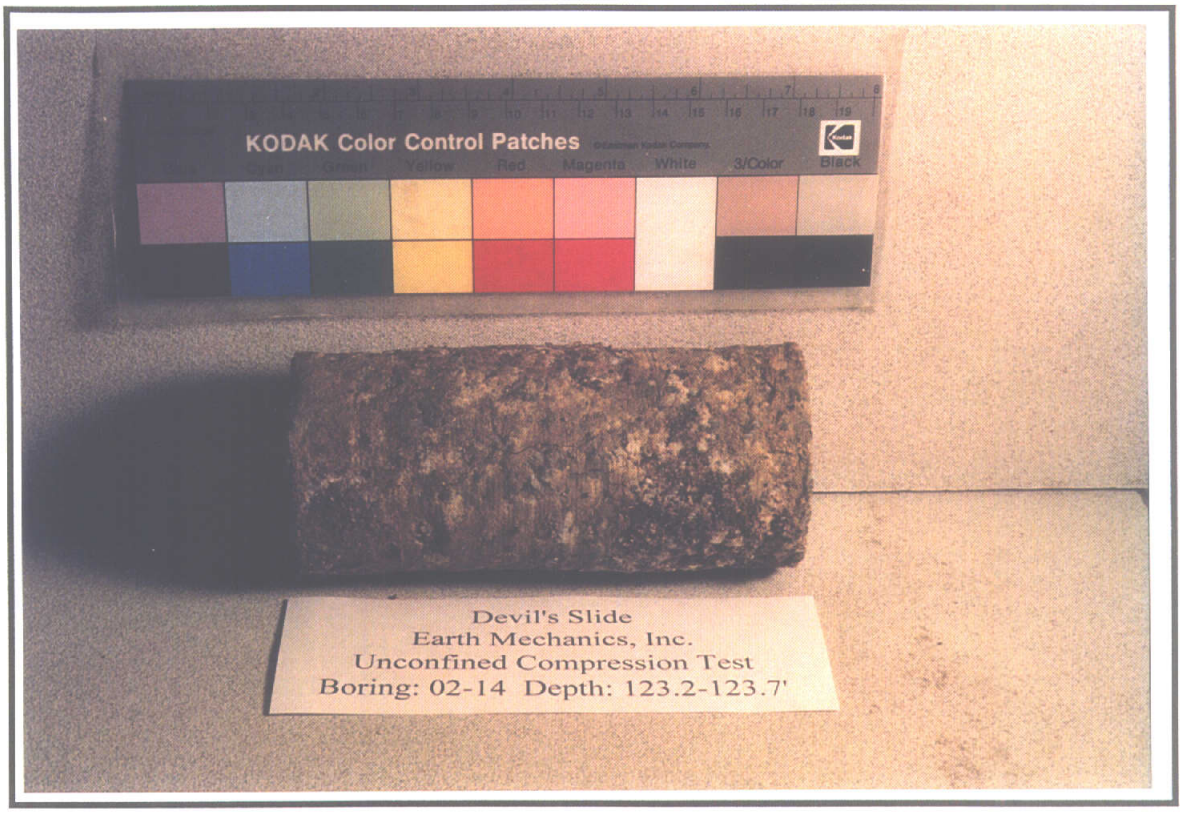
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

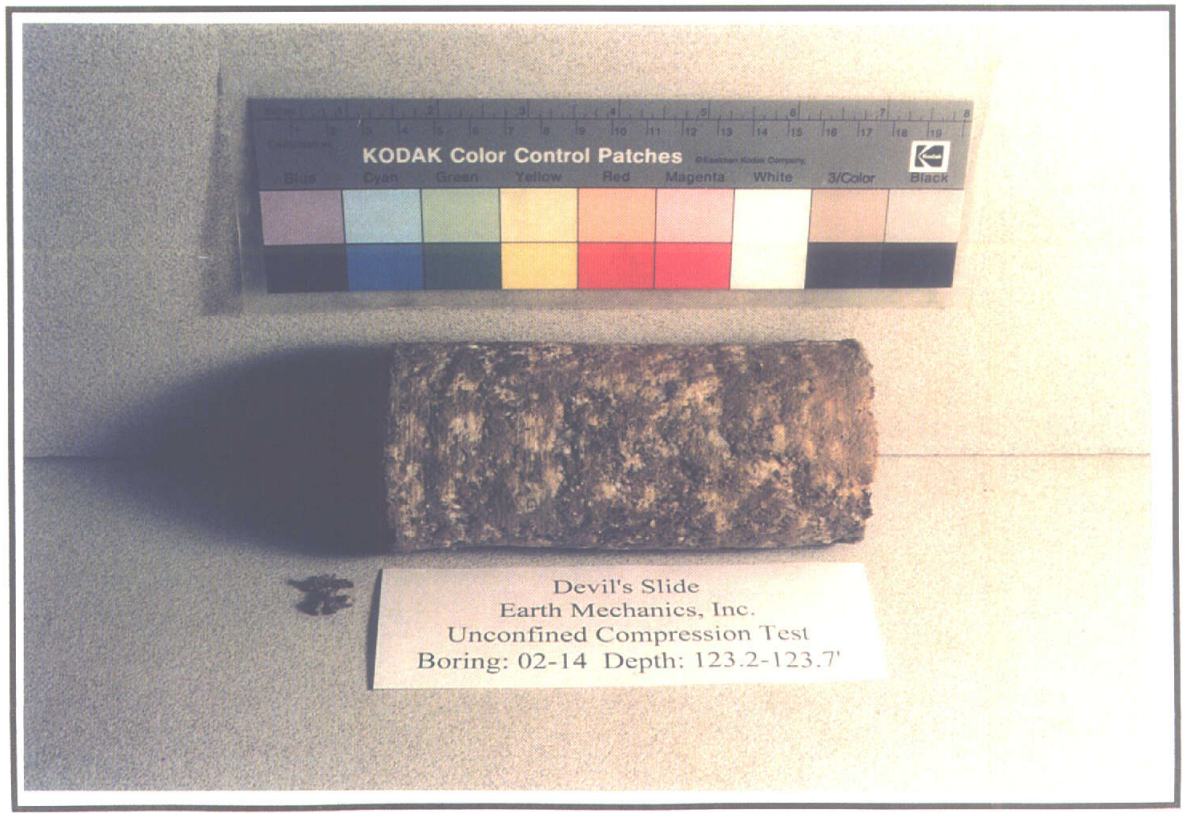
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: ABO

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-14
Sample Description: Brownish gray heavily altered granodiorite

Sample Depth: 1232 - 1237 Sample Condition: received & tested moist

d_1	d_2
2.397	2.398
2.397	2.396
2.398	2.398
2.399	2.404
2.416	2.399

l_1	l_2

Avg. diameter : 2.400 Avg. length : 5.427
Sample area : 4.524 l/d ratio : 2.27
Sample volume(in^3) : 24.596
Sample weight (g) : 966.0g
Density : 39.27g/in^3 = 149.6pcf (1 g/in^3=3.8095lb/ft^3)

Comments: # too rough for relevant measurements

INTACT FAILURE - Failed by axial splitting

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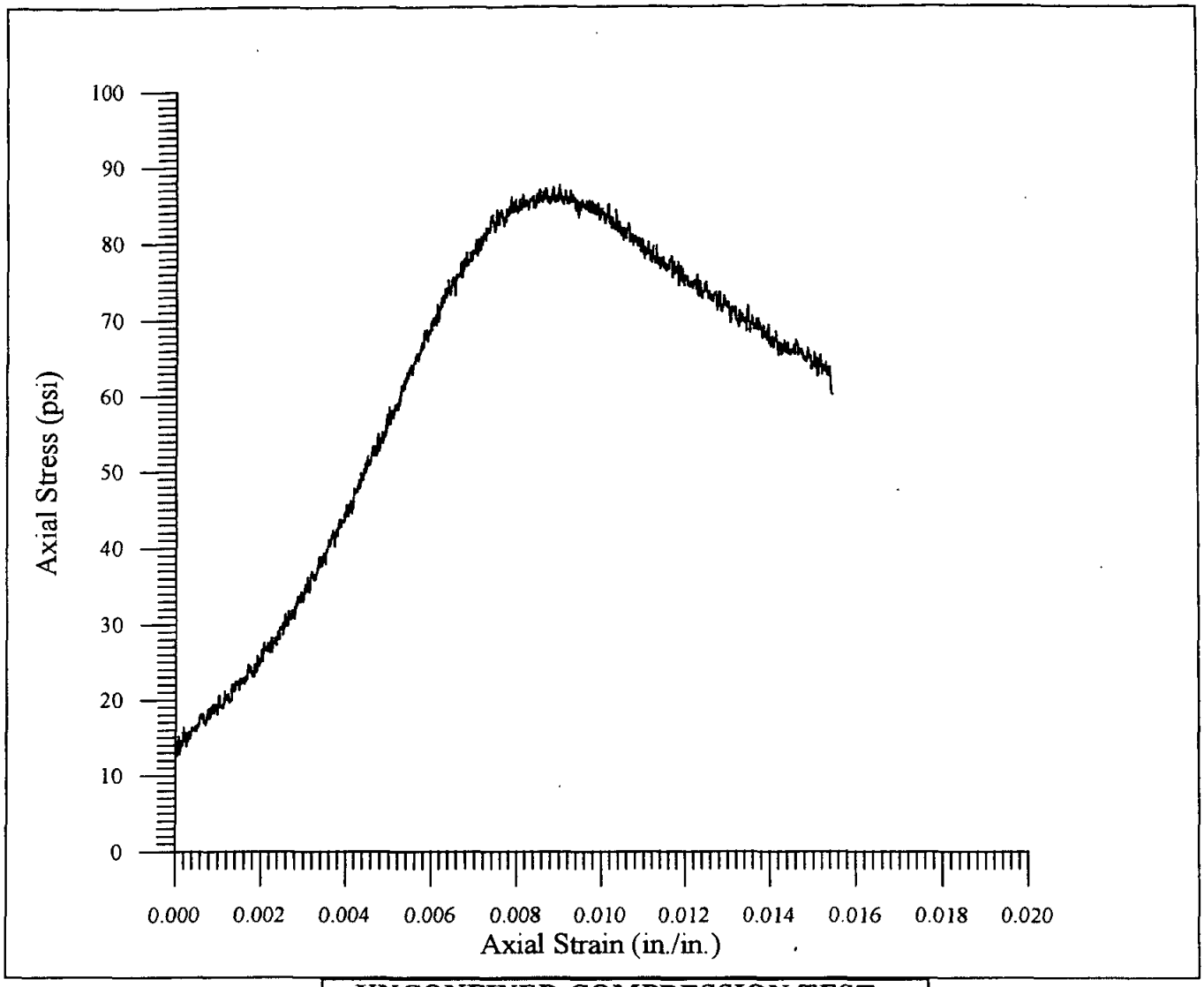


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 14-123
Boring: 02-14
Depth: 123.2-123.7'

DESCRIPTION
Brownish gray heavily altered granodiorite.

Density: 149.6 pcf
Strength: 87 psi
Joint Control Failure?: no

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-21
Sample Description: Greenish gray sheared granodiorite which appears to be saltrified, but retains a weak structure. The shear seems to have resulted in rounded clasts in a ground granodiorite flour matrix.

Sample Depth: 380.4-380.6' Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.400
2.398	2.402
2.402	2.402
2.399	2.399
2.401	2.401

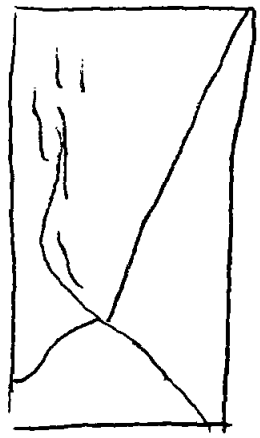
(x.0001")

l_1	l_2
+8	+1
±5	0
±1	±2
-4	0
-7	-1

Avg. diameter : 2.401
Avg. length : 5.707"
Sample area : 4.528
l/d ratio : 2.38
Sample volume(in^3) : 25.839
Sample weight (g) : 1109.5g
Density : 42.94g/in^3 = 163.6pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE ?- Failed by shear along a planar feature.



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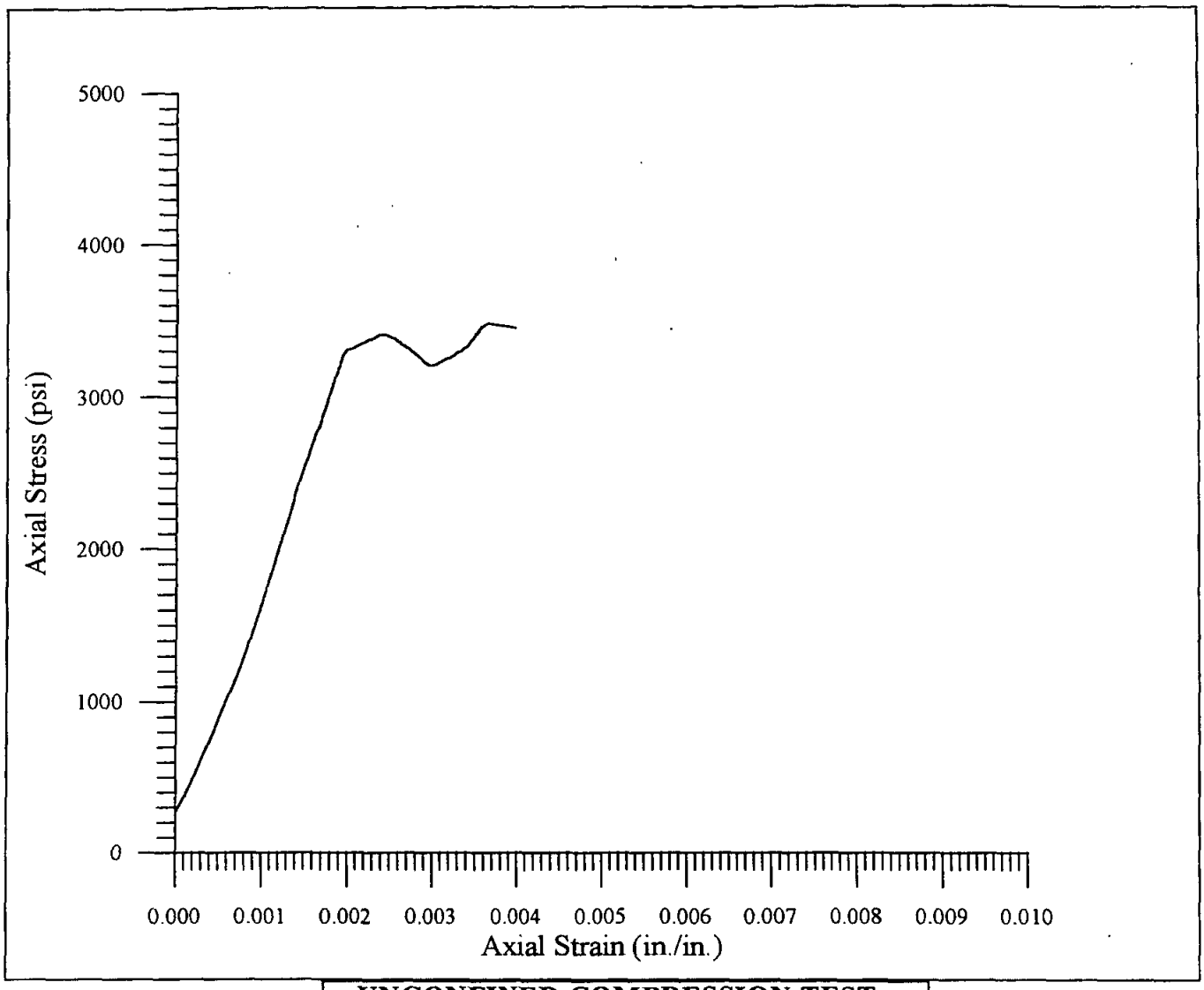


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 21-380
Boring: 02-21
Depth: 380.1-380.6'

DESCRIPTION

Greenish gray heavily sheared granodiorite which may be weakly relithified.

Density: 163.6 pcf
Strength: 3478 psi
Joint Control Failure?: yes (?)

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

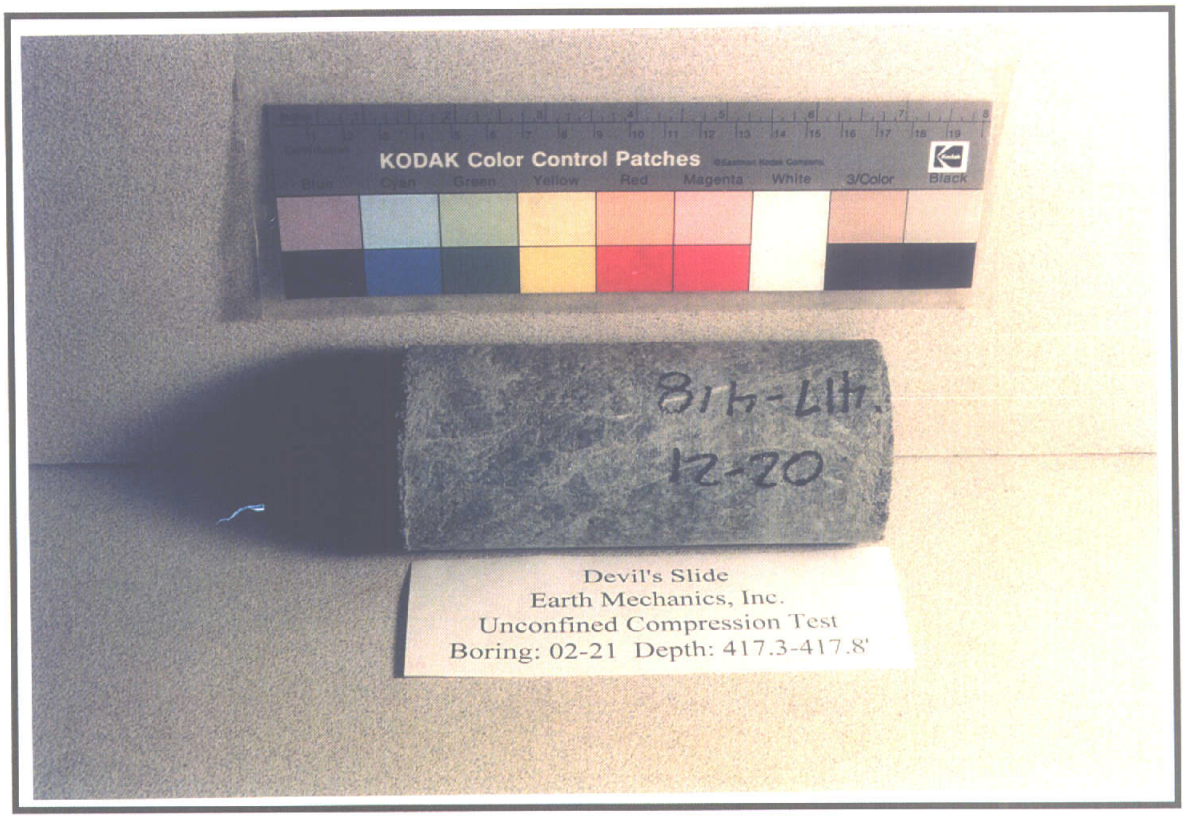
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

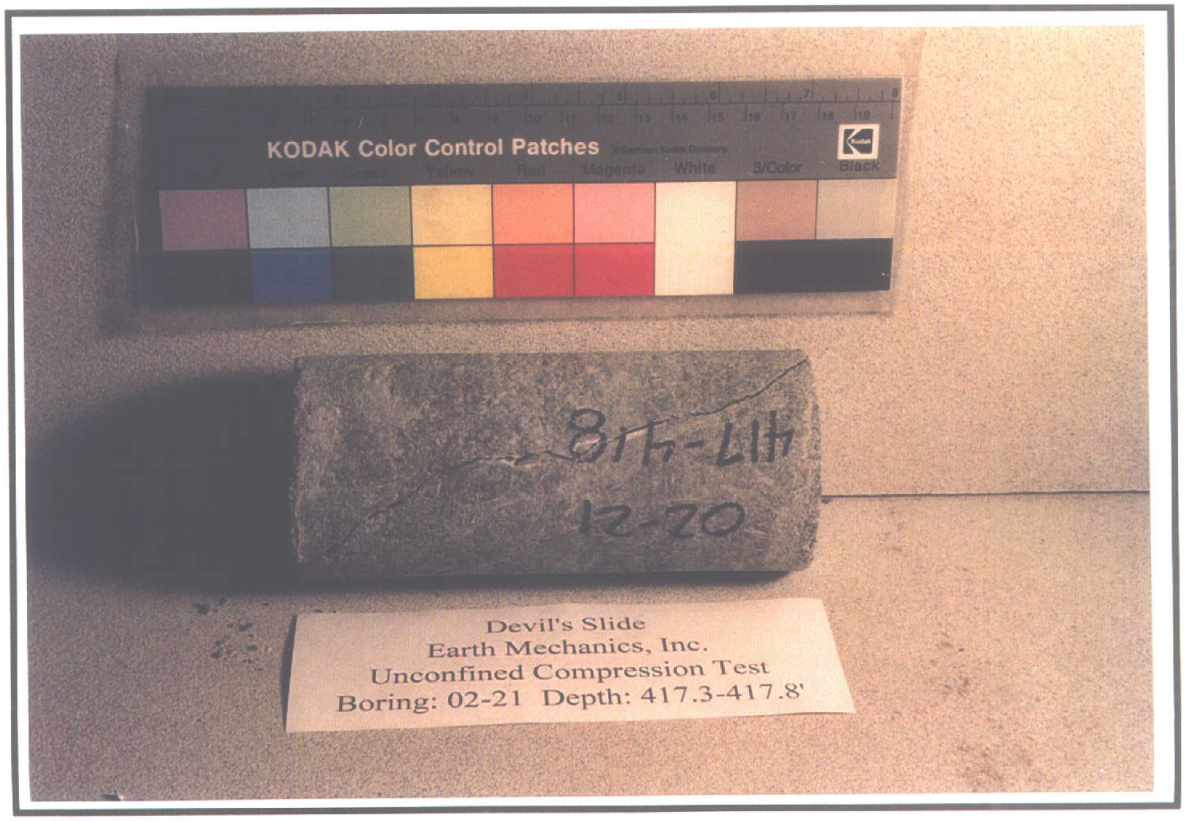
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited GTU

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

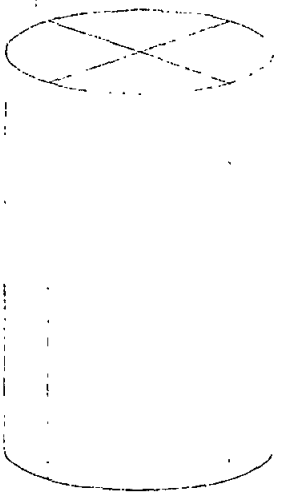
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-21
Sample Description: Greenish gray, sheared granodiorite which has been somewhat solidified, with several zones of weakness.

Sample Depth: 417.3-417.8' Sample Condition: received dry, tested moist

d_1	d_2
2.402	2.403
2.402	2.404
2.401	2.403
2.401	2.400
2.400	2.402

(x.0001")

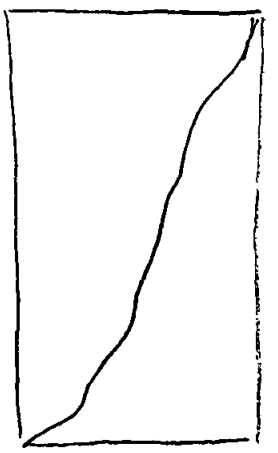
l_1	l_2
+11	0
+5	0
±1	±2
-6	0
-12	0



Avg. diameter: 2.402 Avg. length: 5.527"
Sample area: 4.531 l/d ratio: 2.30
Sample volume(in^3): 25.045
Sample weight (g): 1059.1 g
Density: 42.29 g/in^3 = 161.1 pcF (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED - failed by digonal shears since heavily sheared intact. Failure = joint controlled failure.



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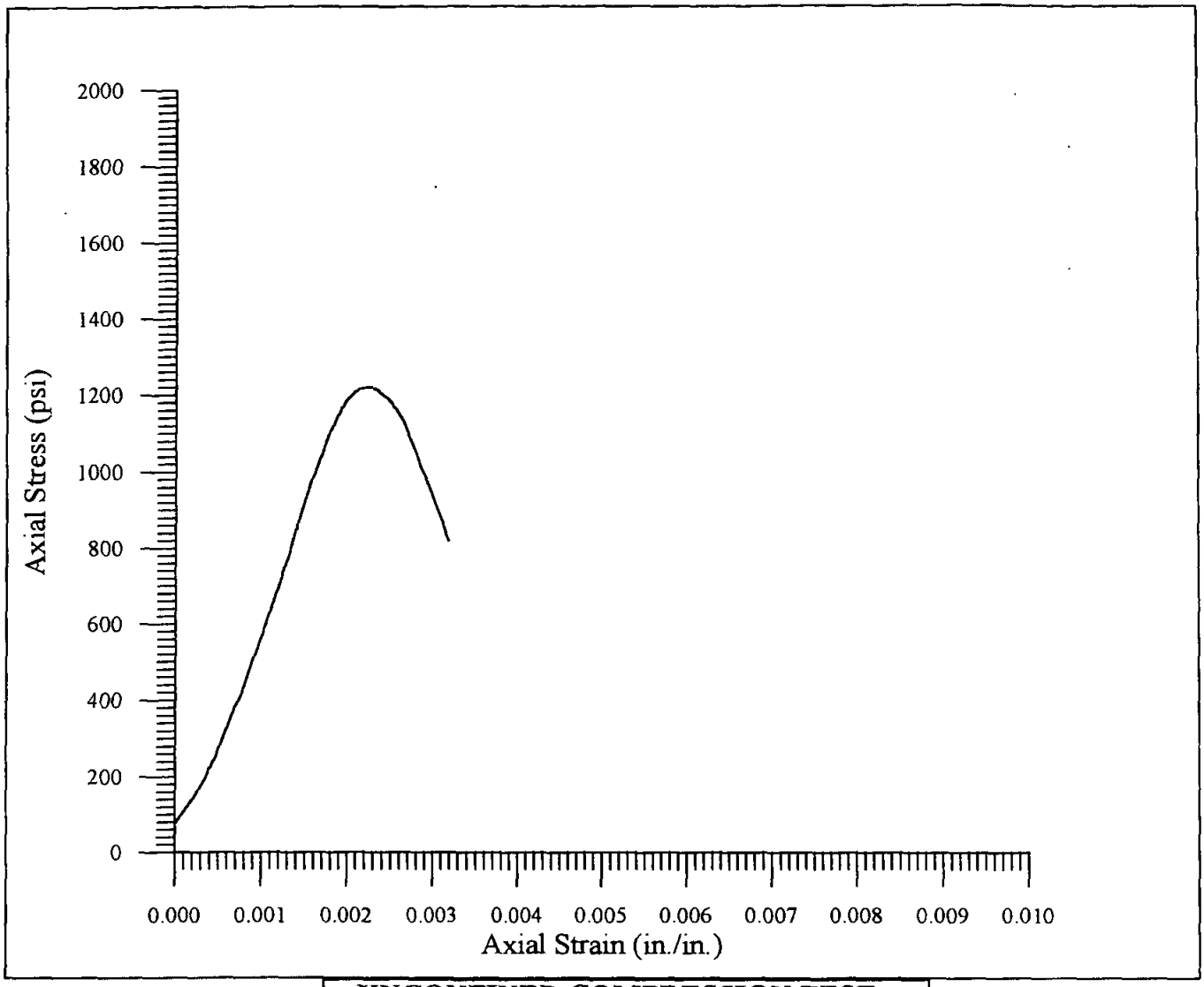


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 21-417
Boring: 02-21
Depth: 417.3-417.8'

DESCRIPTION

Greenish gray heavily sheared granodiorite which may be weakly relithified.

Density: 161.1 pcf
Strength: 1220 psi
Joint Control Failure?: yes (?)

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

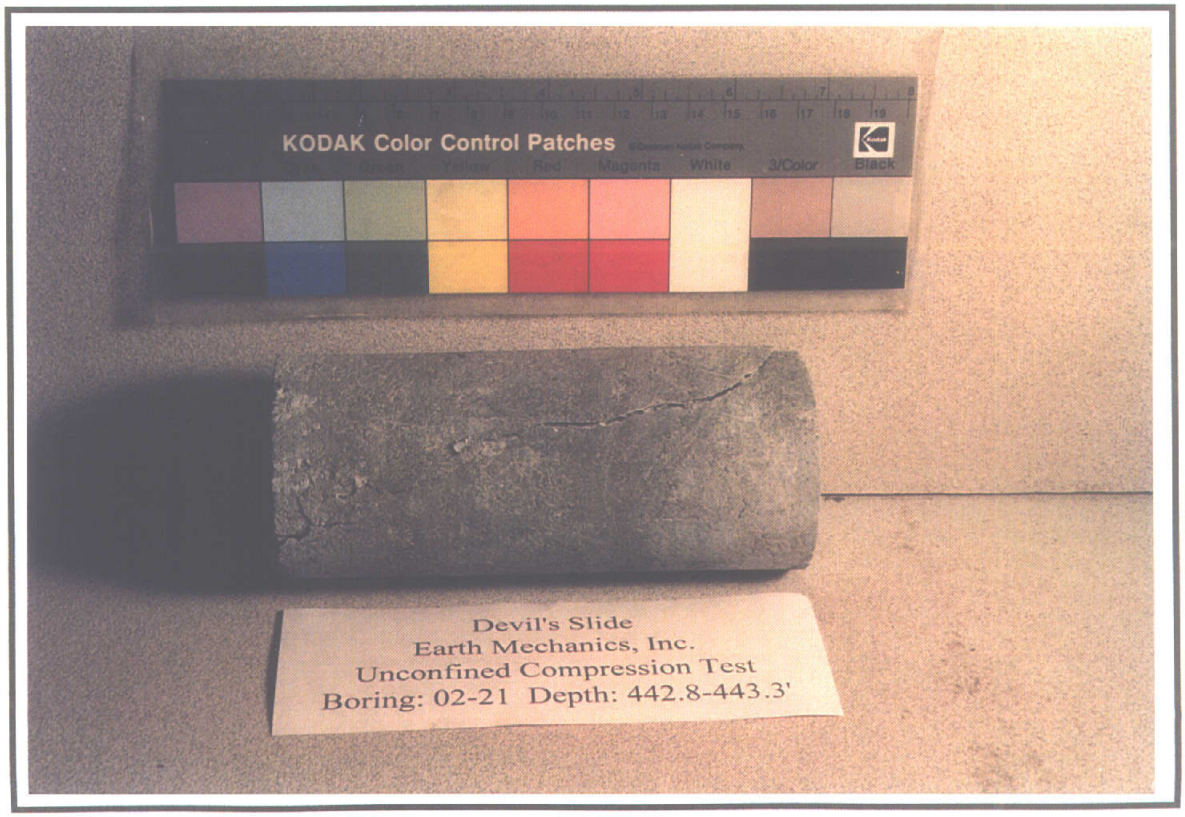
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

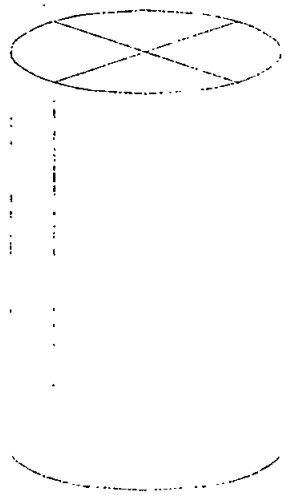
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-21
Sample Description: Greenish gray sheared & silicified granodiorite (possible alteration?)

Sample Depth: 442.8-443.3' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.399
2.399	2.400
2.400	2.400
2.399	2.399
2.400	2.396

(x.0001")

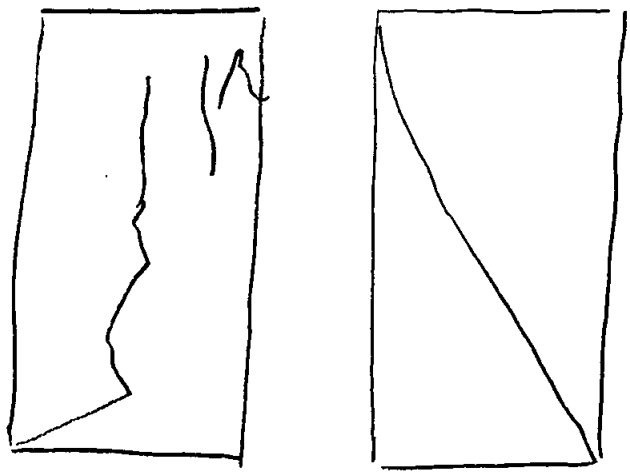
l_1	l_2
+6	+4
+2	+3
±1	±2
-4	-2
-7	-3



Avg. diameter: 2.399 Avg. length: 5.673
Sample area: 4.520 l/d ratio: 2.36
Sample volume(in^3): 25.643
Sample weight (g): 1104.38
Density: 43.06 g/in^3 = 164.1 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE: failed by axial splitting & shear at one end



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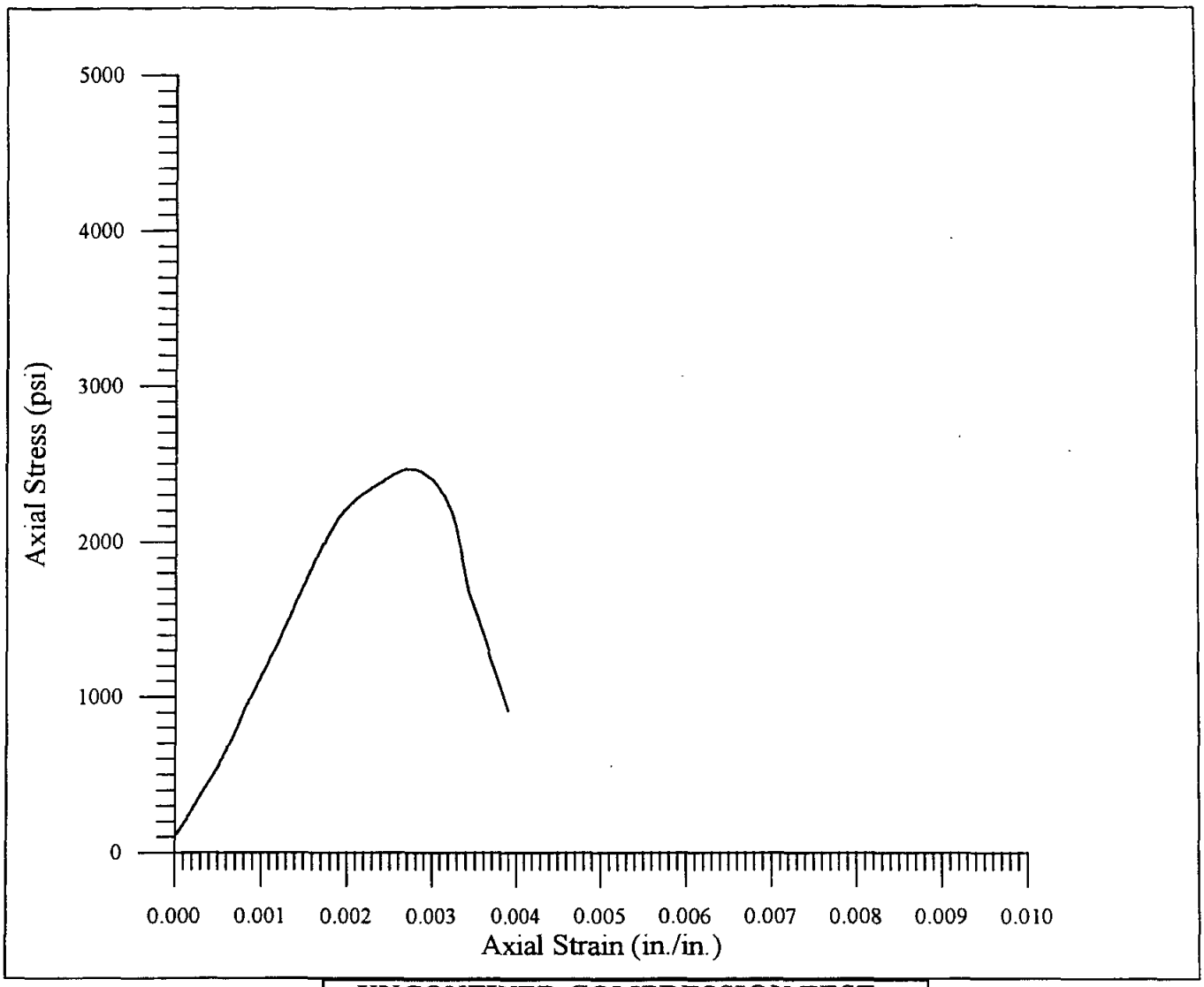


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 21-442
Boring: 02-21
Depth: 442.8-443.3'

DESCRIPTION
Greenish gray heavily sheared granodiorite which may be weakly relithified.

Density: 164.1 pcf
Strength: 2461 psi
Joint Control Failure?: yes

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

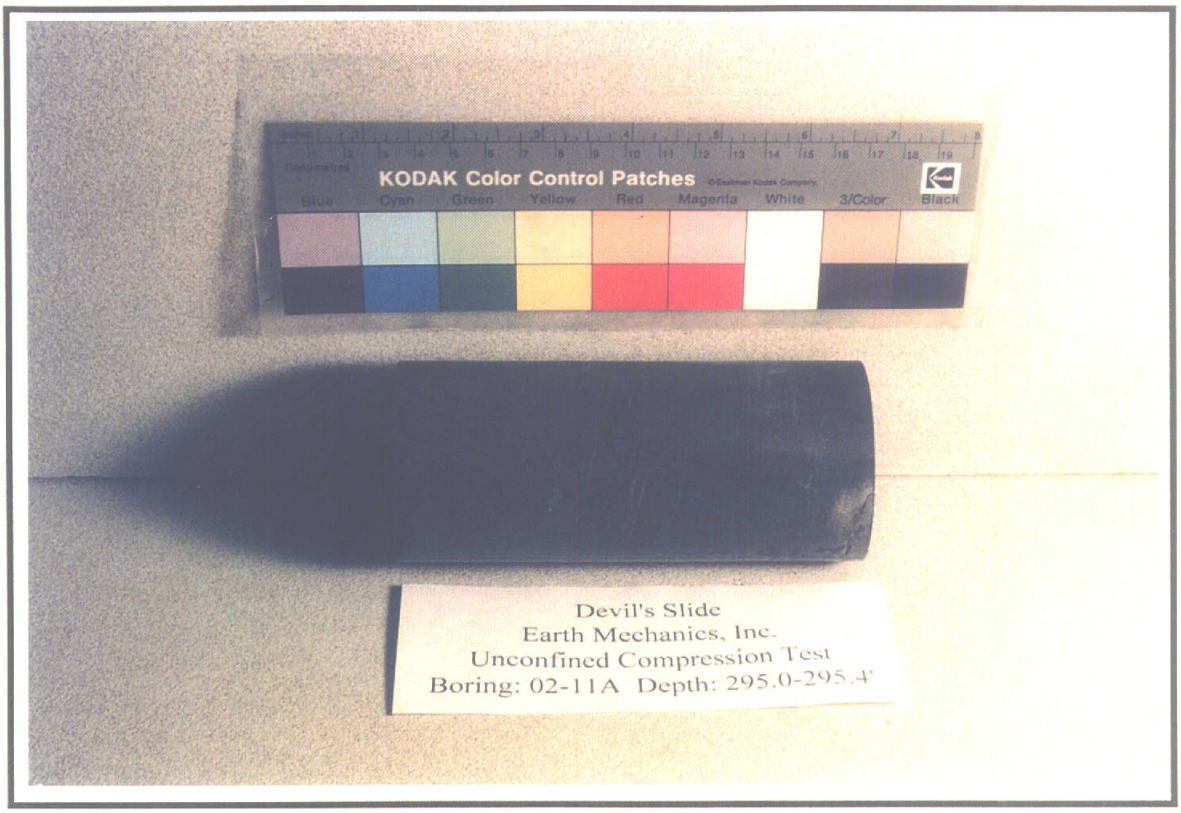
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

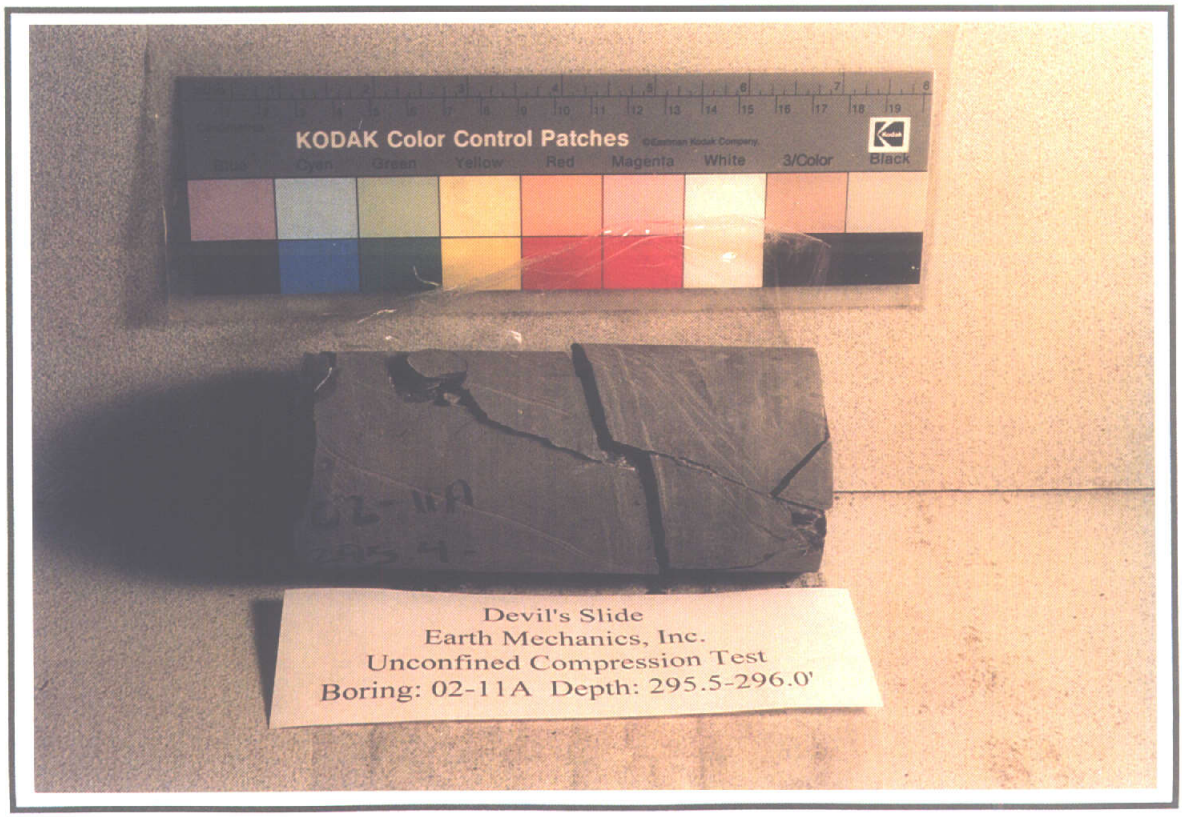
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

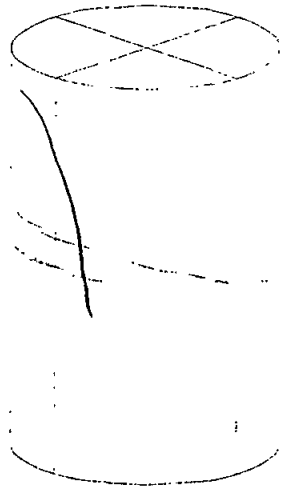
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray shale with a few bedding plane fractures and a few shale healed fractures. Axial end chips are glued back into place with CA glue.

Sample Depth: 295.5-296.0 Sample Condition: received dry - tested moist

d_1	d_2
2.394	2.393
2.393	2.393
2.393	2.393
2.392	2.393
2.392	2.393

(x.0001")

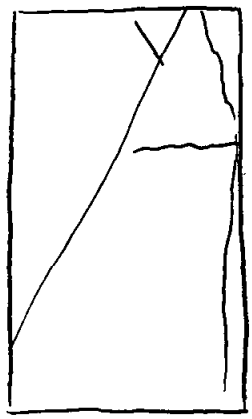
l_1	l_2
+30	+29
+15	+15
±1	±2
-13	-15
-30	-30



Avg. diameter: 2.393 Avg. length: 5.420"
Sample area: 4.500 l/d ratio: 2.26
Sample volume(in^3): 24.377
Sample weight (g): 1077.8g
Density: 44.21g/in^2 = 168.4 pcf (1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE - failed by sliding along existing joint (initial break) followed by axial splitting.



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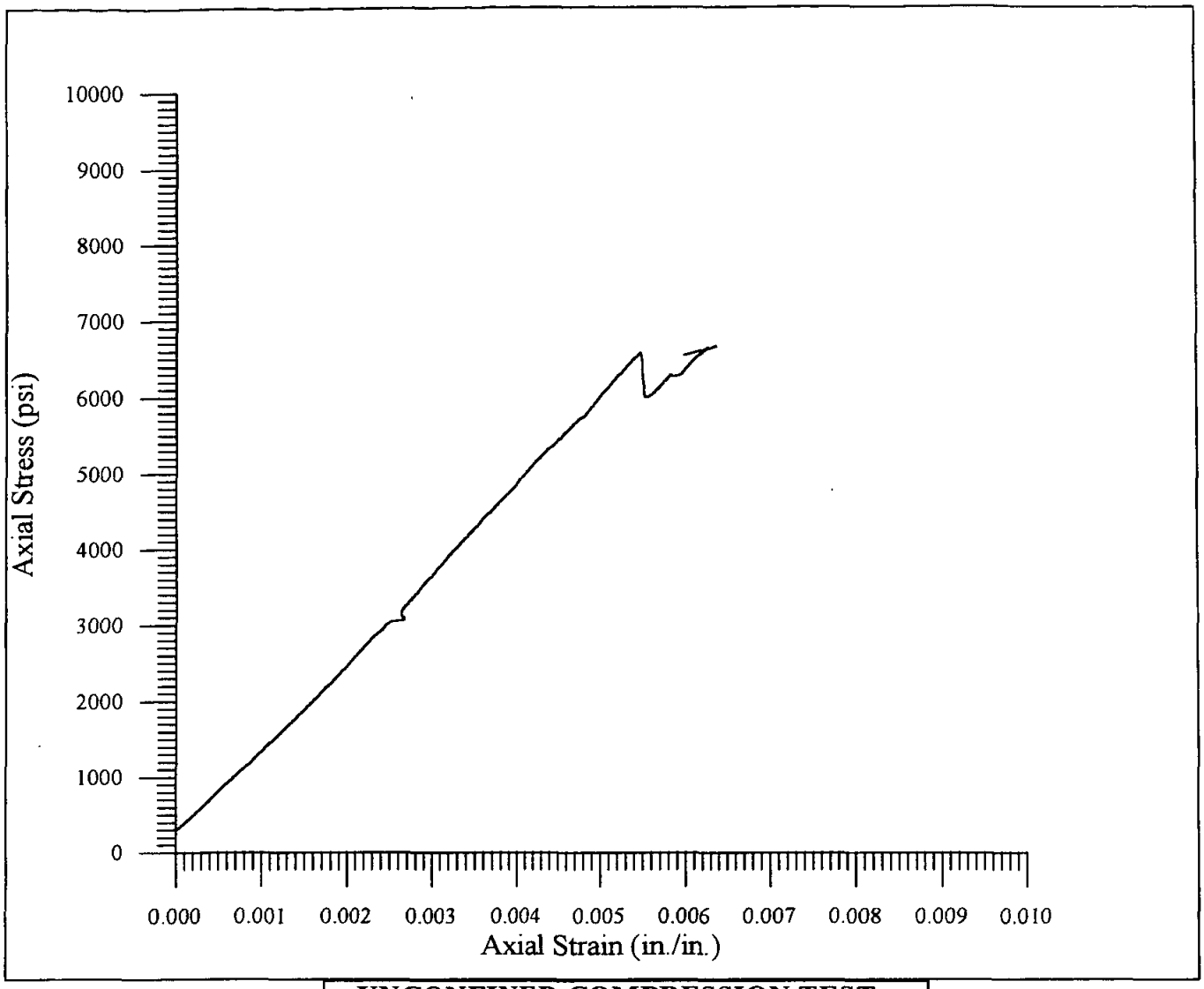


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-295
Boring: 02-11A
Depth: 295.5-296.0'

DESCRIPTION
Dark gray shale with a few bedding plane fractures and calcite healed fractures.

Density: 168.4 pcf
Strength: 6666 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

Geo Test Unlimited (GTU)

DATA SHEET
Unconfined Compression Test of Rock (ASTM D2938)

Date: 10/22/02
Technician: A. Bro

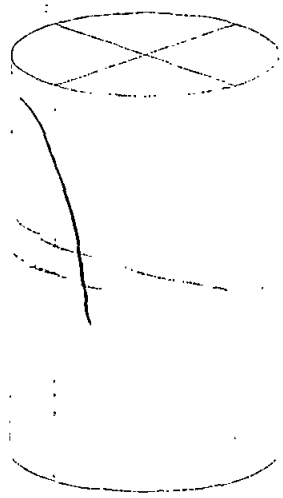
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray shale with a few bedding plane fractures and a few calcite healed fractures. Afew small chips are glued back into place with CA glue.

Sample Depth: 295.5-296.0 Sample Condition: received dry - tested moist

(x.0001")

d_1	d_2
2.394	2.393
2.393	2.393
2.393	2.393
2.392	2.393
2.392	2.393

l_1	l_2
+30	+29
+15	+15
±1	±2
-13	-15
-30	-30



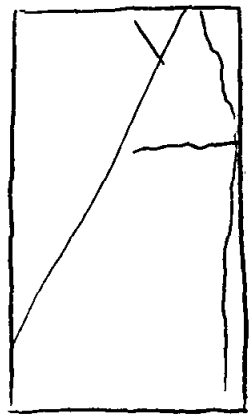
Avg. diameter : 2.393
Sample area : 4.500
Sample volume(in^3) : 24.377
Sample weight (g) : 1077.8g
Density : 44.21 g/in^3 = 168.4 pcf

Avg. length : 5.420"
l/d ratio : 2.26

(1 g/in^3=3.8095lb/ft^3)

Comments:

JOINT CONTROLLED FAILURE - failed by sliding along existing joint (initial break) followed by axial splitting?



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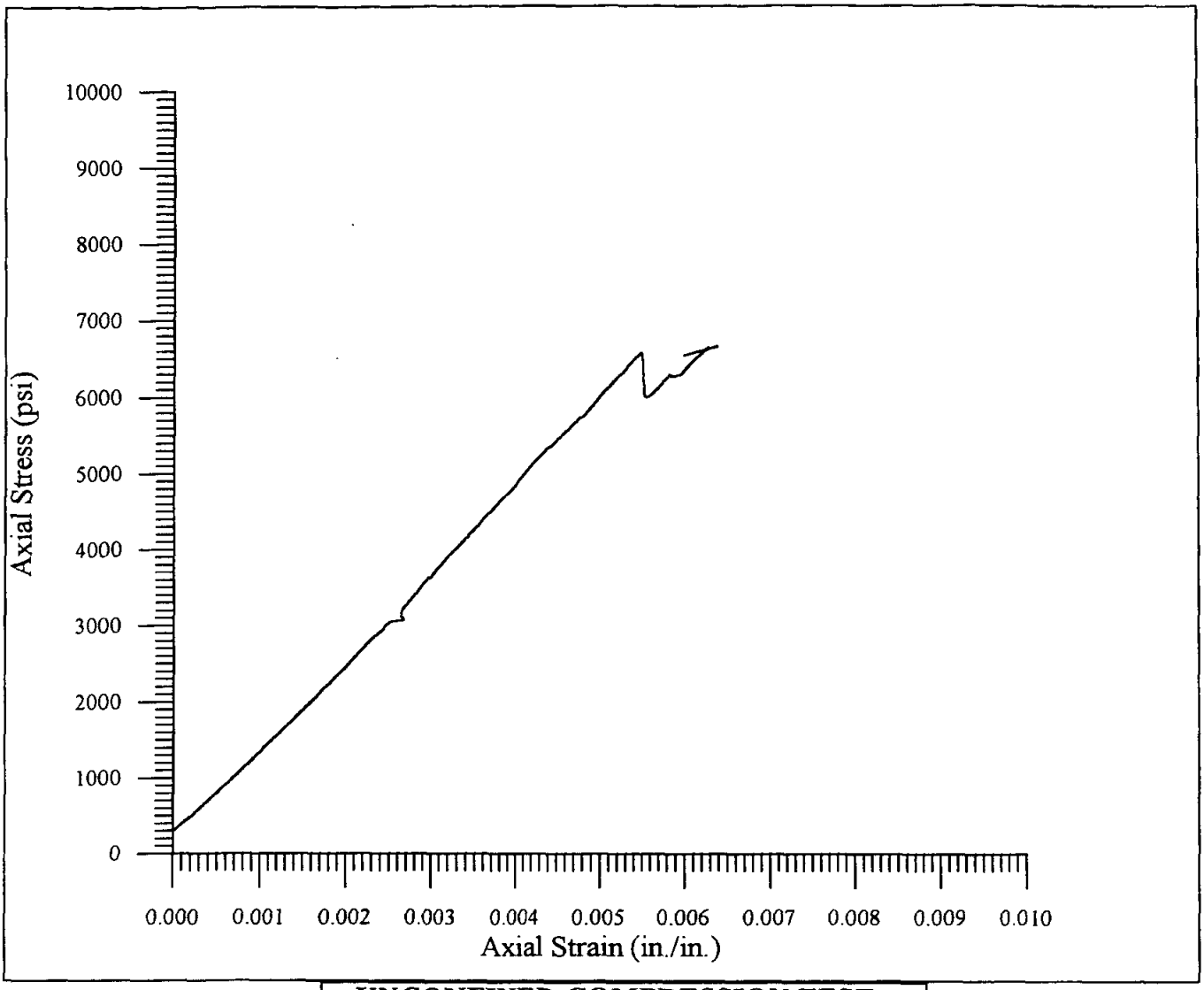


UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-295
Boring: 02-11A
Depth: 295.5-296.0'

DESCRIPTION

Dark gray shale with a few bedding plane fractures and calcite healed fractures.

Density: 168.4 pcf
Strength: 6666 psi
Joint Control Failure?: yes

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

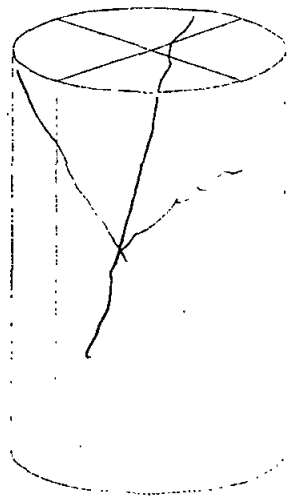
Date: 9/6&12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray conglomerate with granitic clasts up to 1" (1 sheared by a fracture). A few calcite healed fractures.

Sample Depth: 336.1 - 336.6' Sample Condition: received dry - tested moist

d_1	d_2
2.399	2.396
2.398	2.398
2.397	2.398
2.398	2.395
2.394	2.397

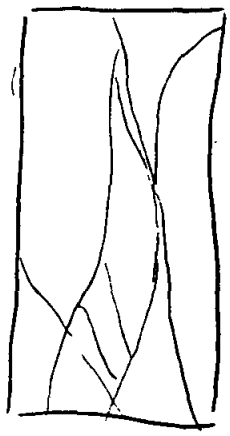
l_1	l_2
+.0005	0
+.0002	0
±.0001	±.0002
-.0002	0
-.0005	0



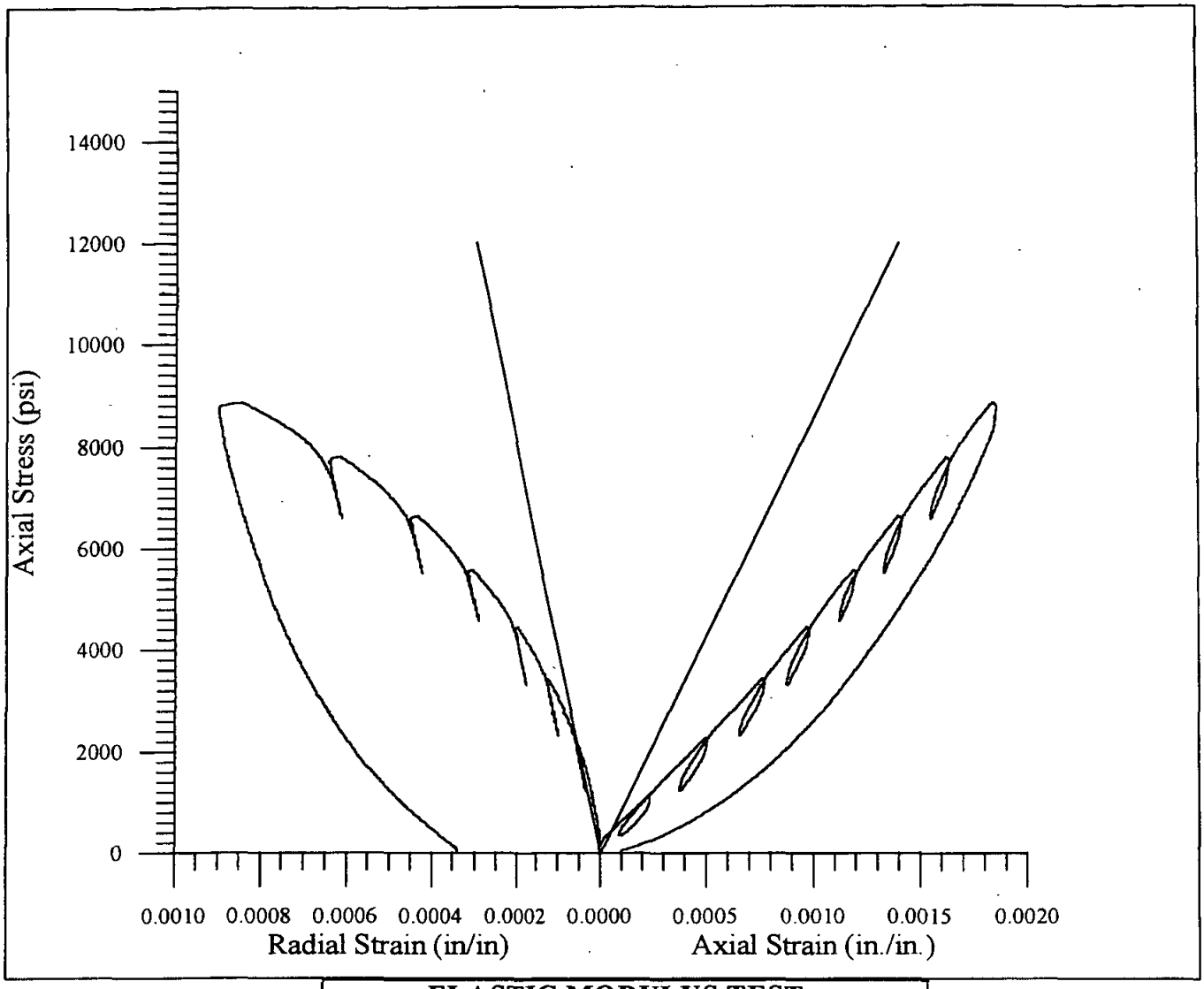
Avg. diameter : 2.397 Avg. length : 5.512"
Sample area : 4.513 l/d ratio : 2.30
Sample volume(in^3) : 24.873
Sample weight (g) : 1076.3 g
Density : 43.27 g/in^3 = 164.8 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000in

Comments: Failed by axial splitting

INTACT FAILURE



27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 6-336
Boring: 02-6
Depth: 336.1-336.6'

DESCRIPTION
Gray conglomerate with granitic clasts up to 1" and a few calcite healed fractures.

Modulus:	**8,570,000 psi**
Poisson's ratio:	**.21**
Density:	**164.8 pcf**

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

Geo GTU Test Unlimited

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

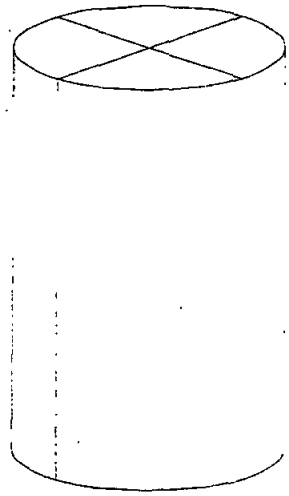
Date: 9/6&12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: Dark gray heavily sheared & recemented Fine grained Sandstone with numerious calcite healed fractures.

Sample Depth: 354.6-355.1 Sample Condition: received dry - tested moist

d_1	d_2
2.399	2.400
2.404	2.401
2.402	2.400
2.402	2.400
2.403	2.400

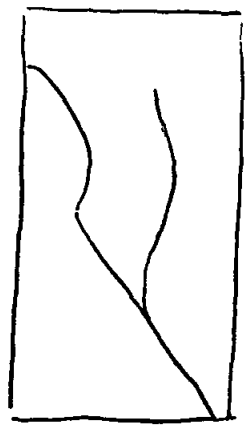
l_1	l_2
-.0004	-.0005
-.0003	-.0004
±.0003	±.0003
-.0013	-.0020
-.0020	-.0028



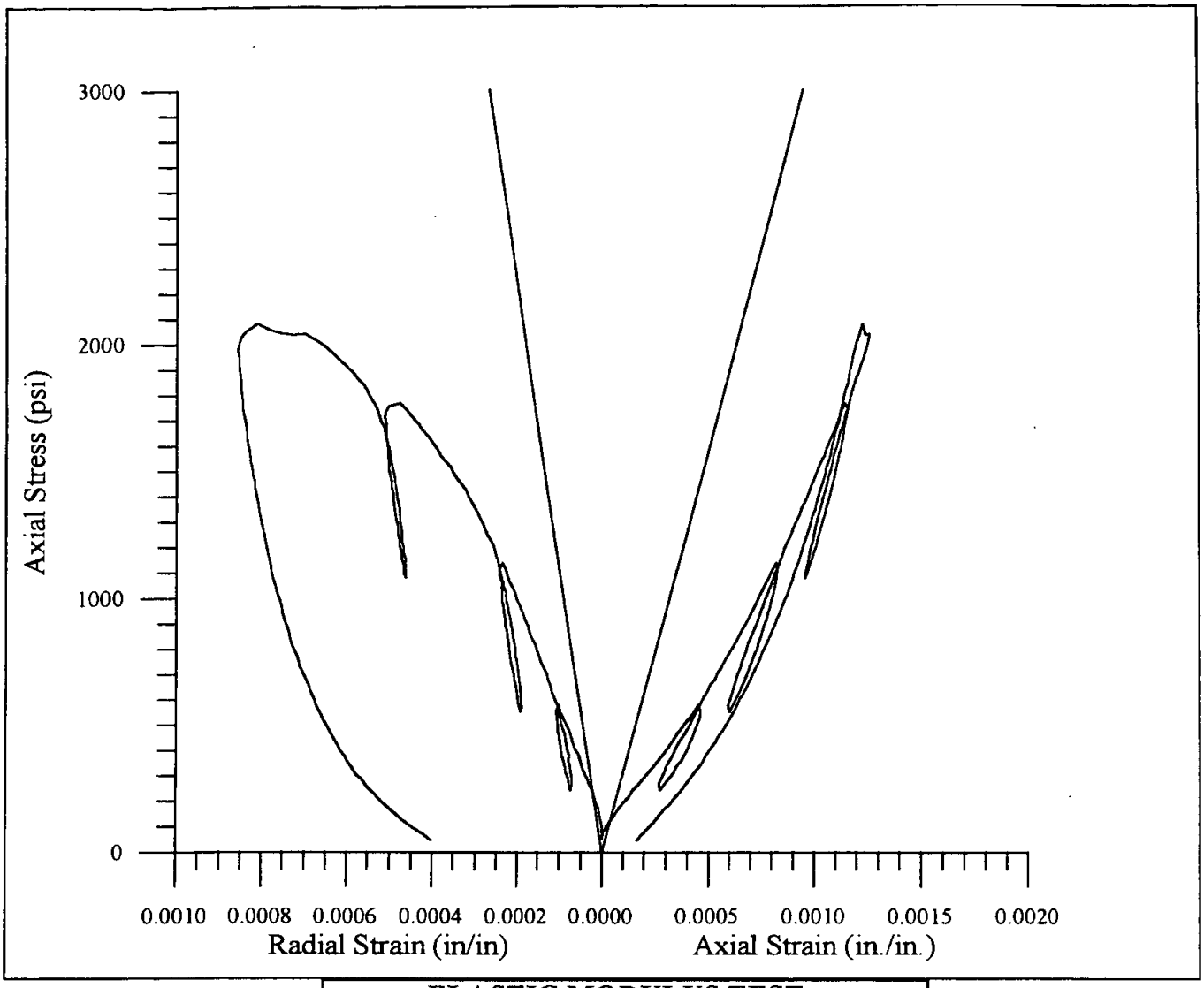
Avg. diameter : 2.401 Avg. length : 5.658
Sample area : 4.528 l/d ratio : 2.36
Sample volume(in^3) : 25.618
Sample weight (g) : 1087.5g
Density : 42.458 g/in^3 = 161.7 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments: preloaded to about 6000lb - mod test to incipient failure.

JOINT CONTROLLED FAILURE



27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 6-354
Boring: 02-6
Depth: 354.6-355.1'

DESCRIPTION
Dark gray heavily sheared and recemented fine grained sandstone with numerous calcite healed fractures.

Modulus:	**3,160,000 psi**
Poisson's ratio:	**.28**
Density:	**161.7 pcf**

Geo Test Unlimited G T U
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **Earth Mechanics, Inc.**
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: **Devil's Slide**

Project Number: none

Test Date: **September 6, 2002**

Geo Test Unlimited GTU

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

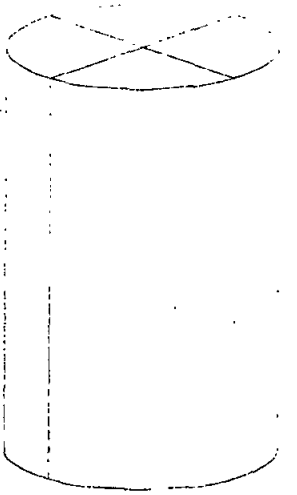
Date: 9/6 & 13/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray, medium grained sandstone. - No apparent Fractures.

Sample Depth: 391.5 - 392.0' Sample Condition: received dry - tested moist

d_1	d_2
2.398	2.398
2.400	2.400
2.399	2.399
2.398	2.397
2.400	2.397

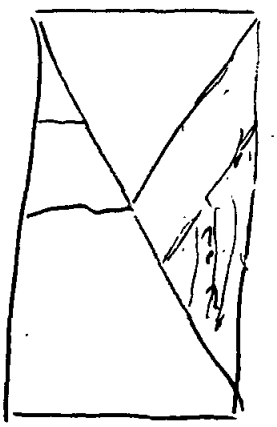
l_1	l_2
+.0008	+.0001
+.0004	0
±.0001	∓.0002
-.0004	0
-.0008	-.0001



Avg. diameter : 2.399 Avg. length : 5.498"
Sample area : 4.520 l/d ratio : 2.29
Sample volume(in^3) : 24.852
Sample weight (g) : 1074.88
Density : 43.258 g/in^3 = 164.8 pcF (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000in

Comments: retested modulus after modifying DA program to increase resolution of LVDT readings.

INTACT FAILURE - Failed by shear & bearing



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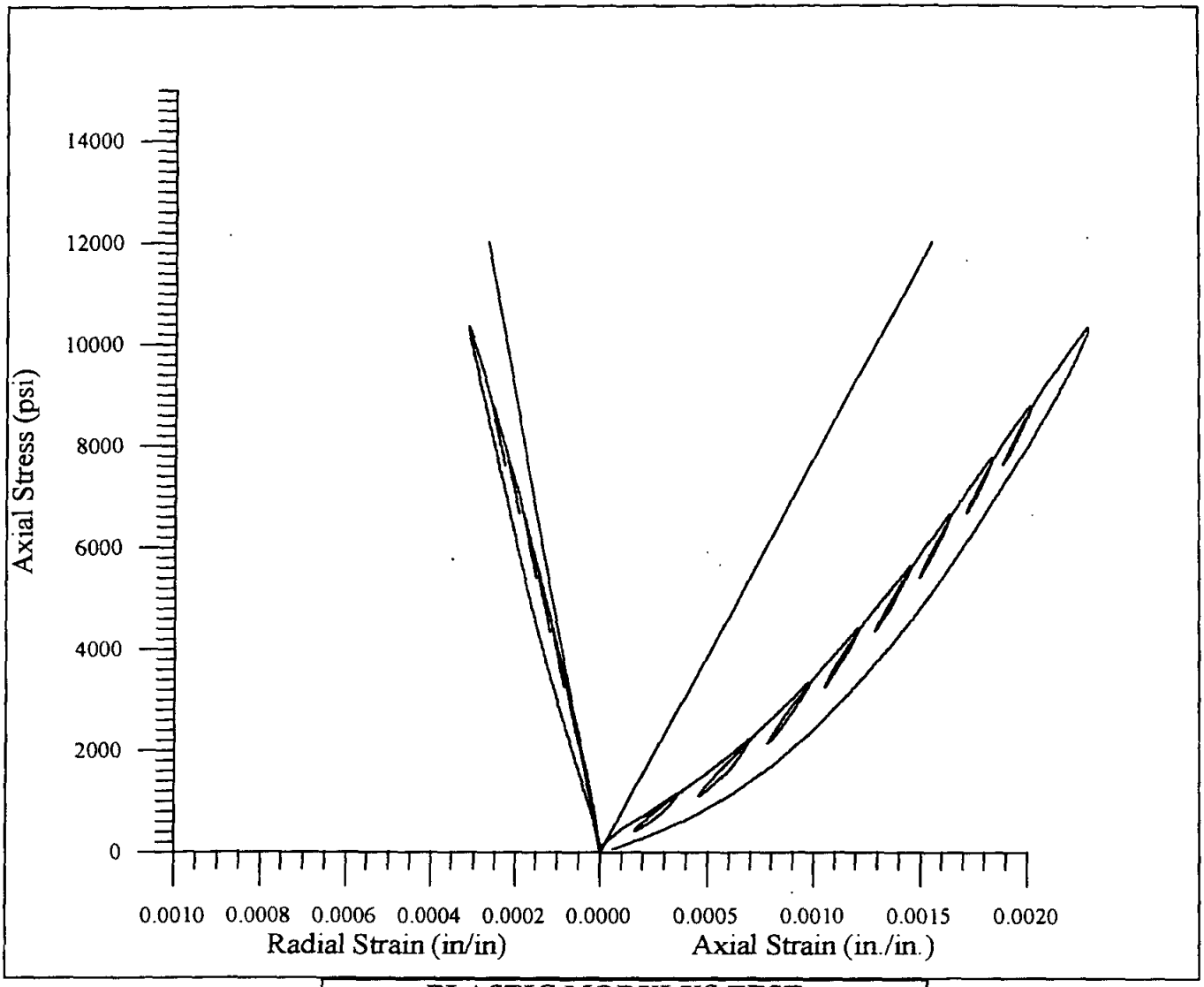


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 6-391
Boring: 02-6
Depth: 391.5-392.0'

DESCRIPTION
Gray medium grained sandstone
with no apparent fractures.

Modulus:	**7,740,000 psi**
Poisson's ratio:	**.17**
Density:	**164.8 pcf**

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

Geo Test Unlimited

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

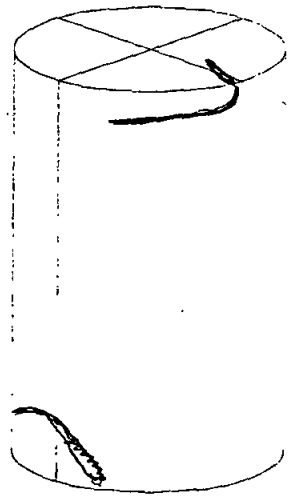
Date: 9/6 & 16/02
Technician: A. Bro

Client: EMT
Job: #151 - Devil's Slide
Sample ID: Boring 02-6
Sample Description: gray medium grained sandstone with two minor calcite healed joints

Sample Depth: 446.4 - 446.9' Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.401

l_1	l_2
+.0006	+.0005
+.0003	+.0002
±.0001	±.0001
-.0005	-.0004
-.0008	-.0008



Avg. diameter : 2.401 Avg. length : 5.374"
Sample area : 4.528 l/d ratio : 2.24
Sample volume(in^3) : 24.332
Sample weight (g) : 1055.68
Density : 43.38 g/in^3 = 165.3 (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments:

INTACT FAILURE - failed by shear?

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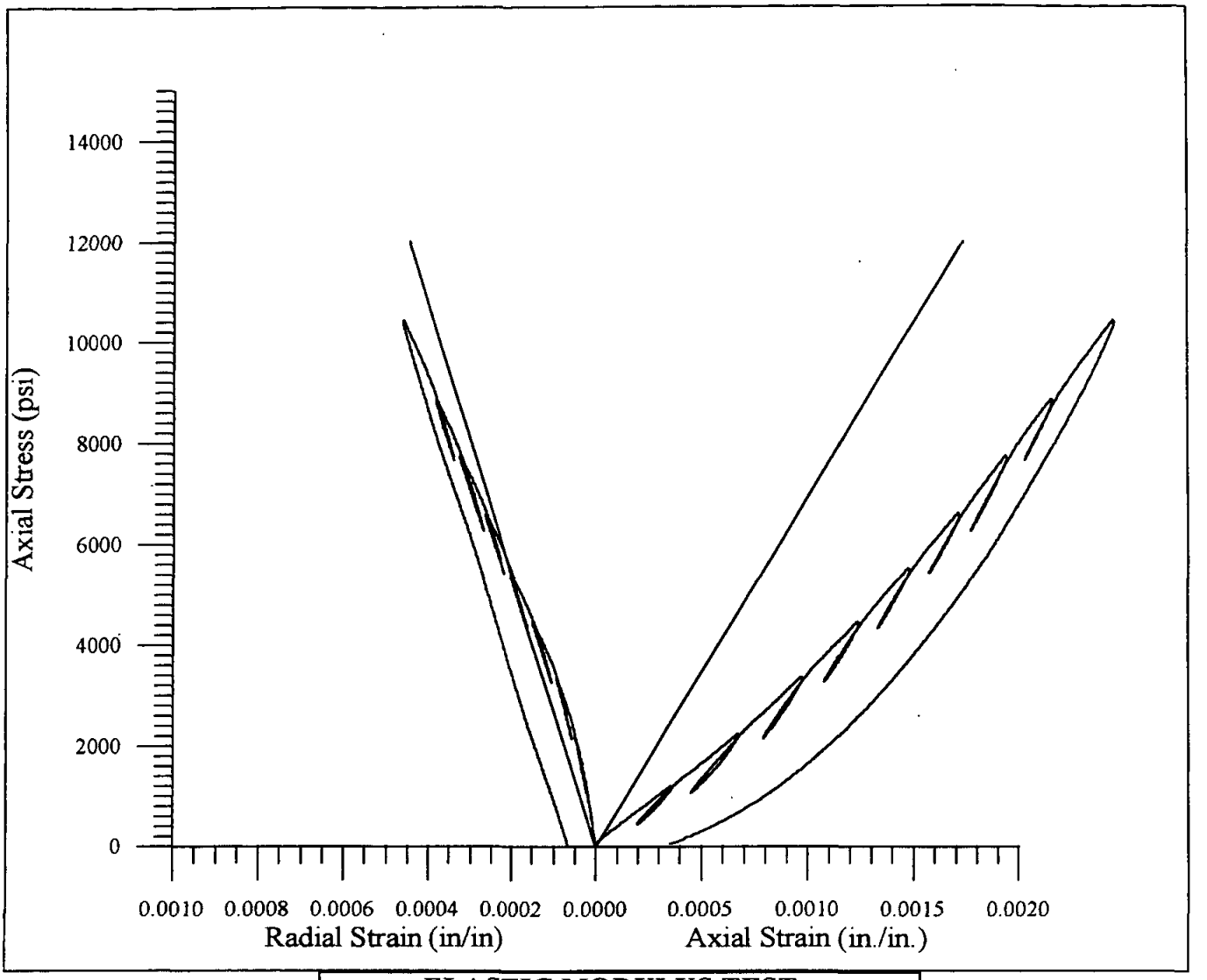


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 6-446
Boring: 02-6
Depth: 446.4-446.9'

DESCRIPTION
Gray medium grained sandstone
with two minor calcite healed joints.

Modulus:	**6,740,000 psi**
Poisson's ratio:	**.26**
Density:	**165.3 pcf**

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 9/6 & 16/02
Technician: A.Bro

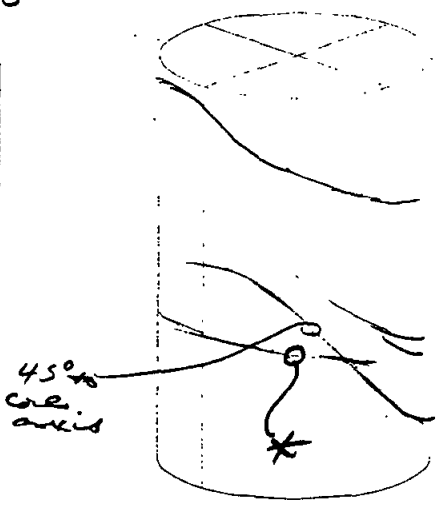
Client: EMT
Job: #151-Devil's Slide
Sample ID: Boring 02-6A
Sample Description: Gray, medium grained Sandstone with a few calcite healed joints about 45° to the core axis

Sample Depth: 532.9-533.4' Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.402
2.402	2.401
2.400	2.402
2.401	2.402
2.399	2.402

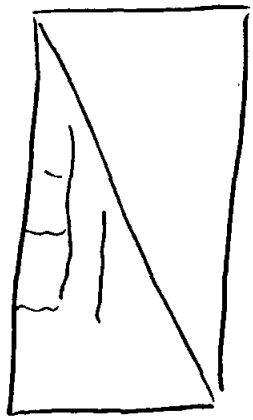
l_1	l_2
+.0009	0
+.0004	0
±.0001	±.0002
-.0004	0
-.0009	0

Avg. diameter : 2.401
Avg. length : 5.444
Sample area : 4.528
l/d ratio : 2.27
Sample volume(in³) : 24.649
Sample weight (g) : 1063.0g
Density : 43.13 g/in³ = 164.3 pcf (1 g/in³=3.8095lb/ft³)
Gauge length: 2.000 in



Comments:

INTACT FAILURE - possibly slightly weakened by the calcite healed bed * - failed by diagonal shear and splitting



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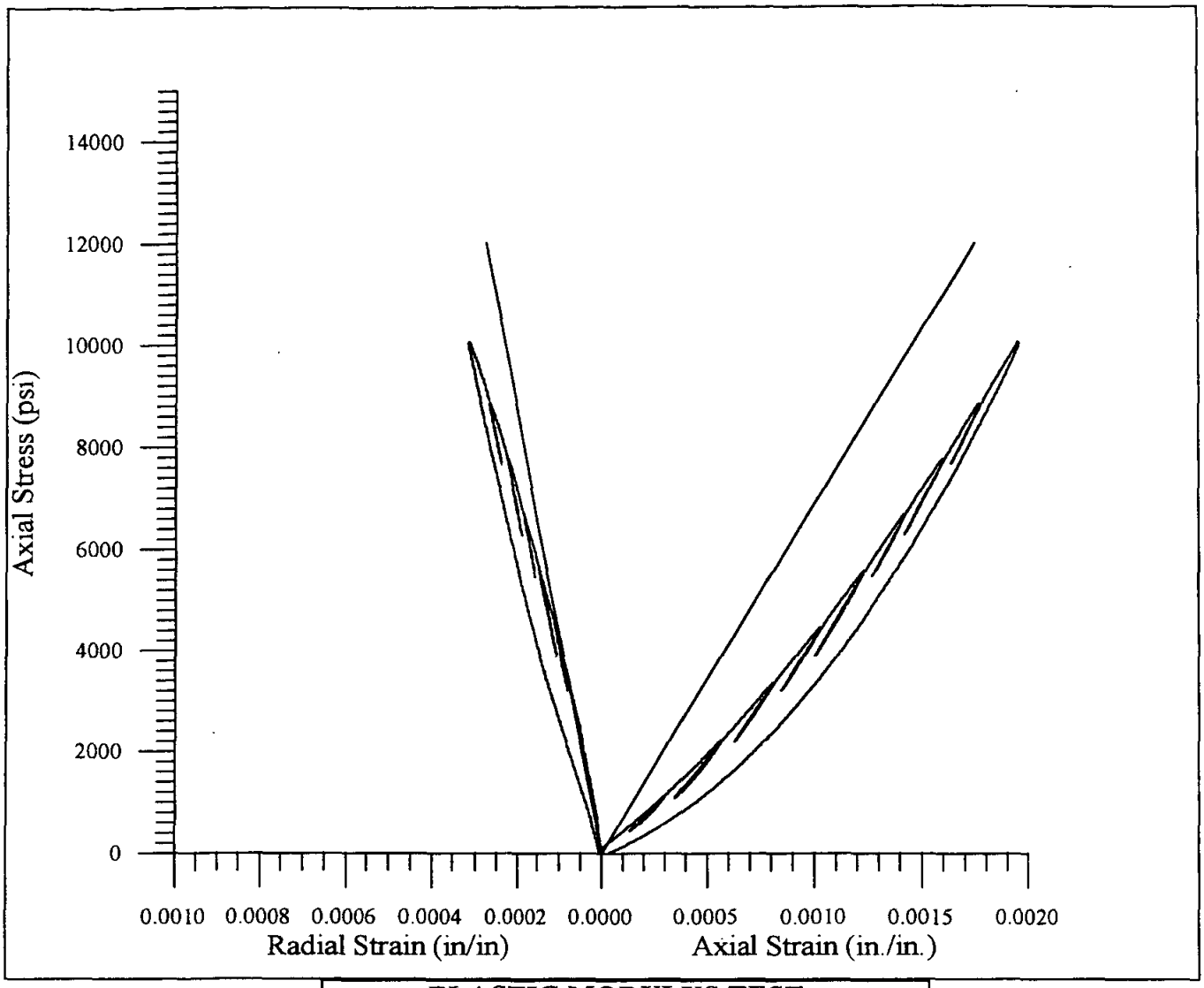


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 6A-532
Boring: 02-6A
Depth: 532.9-533.4'

DESCRIPTION
Gray medium grained sandstone with a few calcite healed joints about 45 degrees to the core axis.

Modulus:	**6,900,000 psi**
Poisson's ratio:	**.16**
Density:	**164.3 pcf**

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **Earth Mechanics, Inc.**
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: **Devil's Slide**

Project Number: none

Test Date: **September 6, 2002**

Geo Test Unlimited

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 9/6 & 16/02
Technician: A. Bro

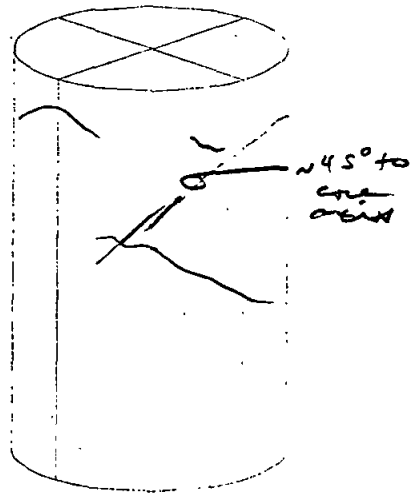
Client: EMI
Job: #151 Devil's Slide
Sample ID: Boring 02-7
Sample Description: gray conglomeratic sandstone with clasts up to 3/4", with a few calcite healed fractures.

Sample Depth: 366.2-366.7' Sample Condition: received dry - tested moist

d_1	d_2
2.403	2.402
2.399	2.401
2.401	2.402
2.402	2.402
2.402	2.402

l_1	l_2
+.0009	+.0001
+.0004	0
±.0001	±.0001
-.0004	0
-.0008	-.0001/+.0004

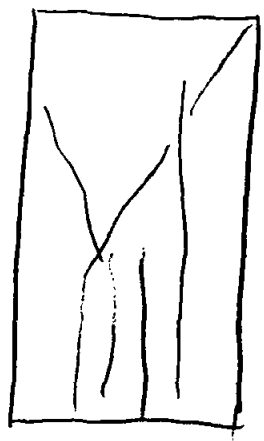
(on shale clast)



Avg. diameter: 2.402 Avg. length: 5.669"
Sample area: 4.531 l/d ratio: 2.36
Sample volume(in^3): 25.689
Sample weight (g): 1123.2 g
Density: 43.728 g/in^3 = 166.6 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000"

Comments:

INTACT FAILURE (?) - Failed by shear & splitting



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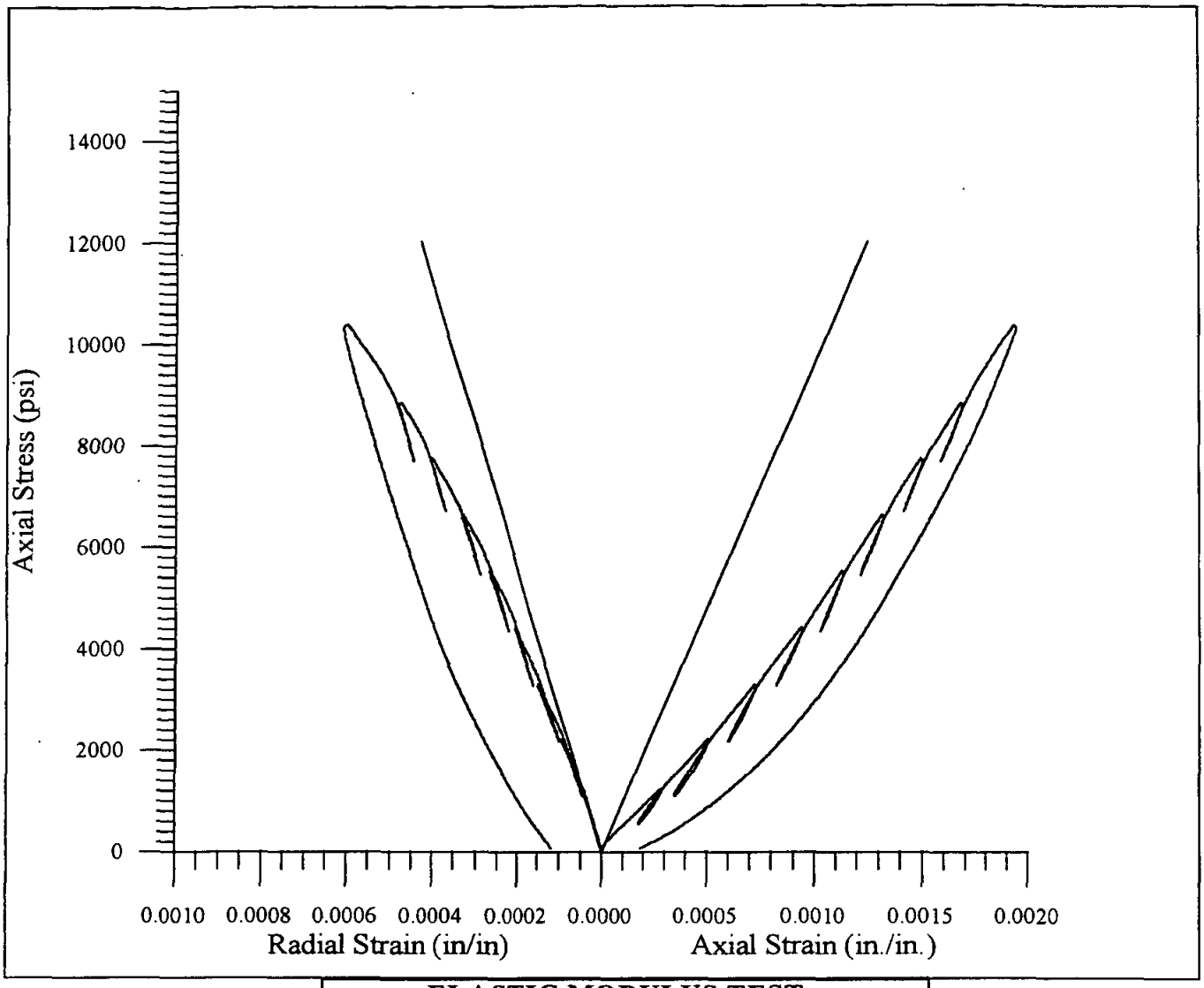


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 7-366
Boring: 02-7
Depth: 366.2-366.7'

DESCRIPTION
Gray conglomeratic sandstone with clasts up to 3/4 inch, with a few calcite healed fractures.

Modulus:	**9,600,000 psi**
Poisson's ratio:	**.34**
Density:	**166.6 pcf**

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

Geo Test Unlimited

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

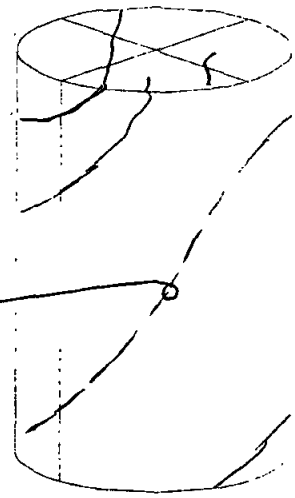
Date: 9/6 & 16/02
Technician: A. Bro

Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-7
Sample Description: Medium to coarse grained sandstone with a few calcite healed joints.

Sample Depth: 402.5-403.0 Sample Condition: received dry - tested moist

d_1	d_2
2.401	2.398
2.400	2.399
2.401	2.399
2.401	2.400
2.401	2.400

l_1	l_2
+.0009	+.0002
+.0005	+.0001
±.0001	±.0002
-.0004	-.0001
-.0008	-.0002



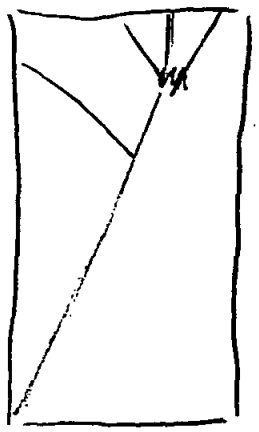
Avg. diameter : 2.400
Sample area : 4.524
Sample volume(in^3) : 24.922
Sample weight (g) : 1081.6 g.
Density : 43.40 g/in³ = 165.3 pcf
Gauge length: 2.000 in

Avg. length : 5.509"
l/d ratio : 2.30

($1\ g/in^3 = 3.8095\ lb/ft^3$)

Comments:

INTACT FAILURE - Failed by shear



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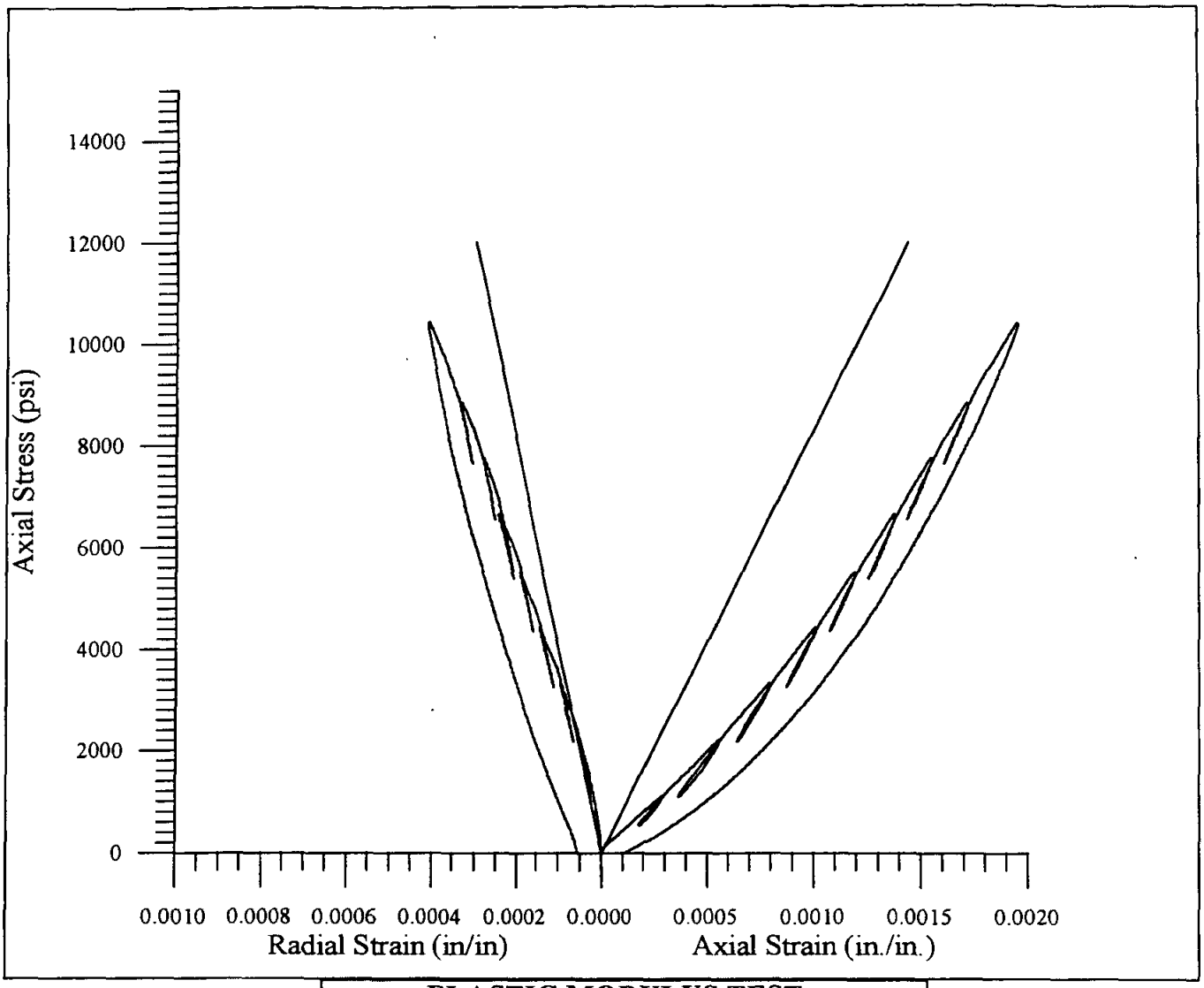


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 7-402
Boring: 02-7
Depth: 402.5-403.0'

DESCRIPTION
Gray medium to coarse grained sandstone with a few calcite healed fractures.

Modulus:	**8,330,000 psi**
Poisson's ratio:	**.21**
Density:	**165.3 pcf**

Geo Test Unlimited (GTU)
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

Geo Test Unlimited GTU

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

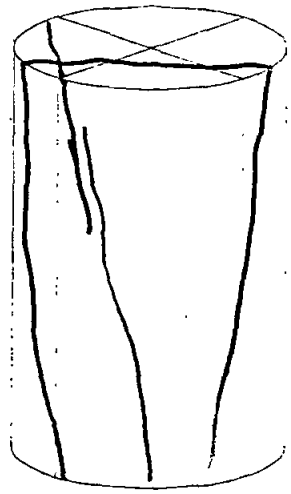
Date: 9/6&7/02
Technician: A. Bro

Client: EMI
Job: #15:- Devil's Slide
Sample ID: Boring 02-11
Sample Description: Tannish gray sandstone with a few oxid calcite healed fractures.

Sample Depth: 92.5-93.0' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.400
2.400	2.399
2.401	2.399
2.400	2.400
2.400	2.401

l_1	l_2
+.0010	+.0001
+.0005	
±.0001	±.0002
-.0006	
-.0011	-.0002

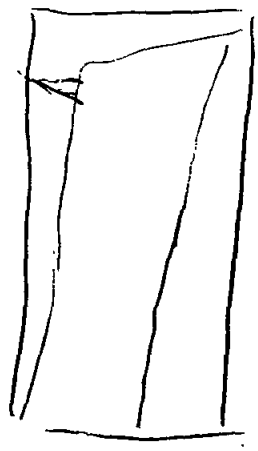


Avg. diameter : 2.400
Sample area : 4.524
Sample volume(in^3) : 23.601
Sample weight (g) : 1025.6 g
Density : 43.46 g/in^3 = 165.3 pcF (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Avg. length : 5.217"
l/d ratio : 2.17

Comments:

JOINT CONTROLLED FAILURE - failed by axial splitting along existing calcite healed joints and intact rock



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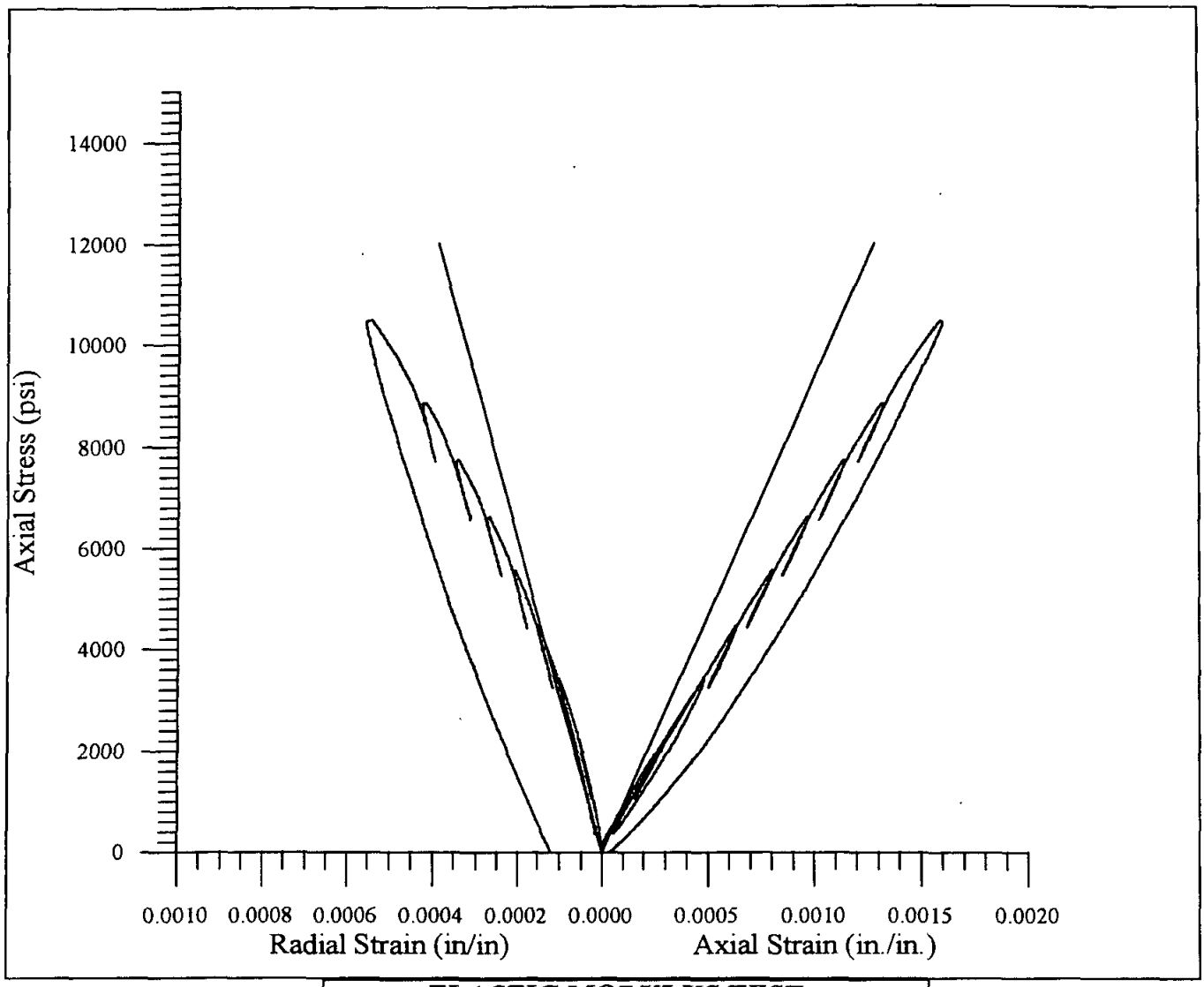


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 11-92
Boring: 02-11
Depth: 92.5-93.0'

DESCRIPTION
Tannish gray sandstone with a few calcite healed axial fractures.

Modulus:	**9,380,000 psi**
Poisson's ratio:	**.30**
Density:	**165.5 pcf**

Geo Test Unlimited G T U
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

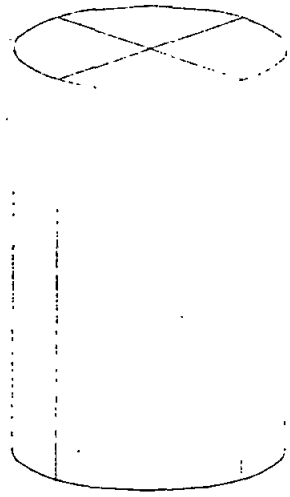
Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 9/6-12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Interbedded shale & fine sandstone (<½" typical (½" thick), 3 layers to 3/4") Bedding ~ 75° to core axis.

Sample Depth: 127.1-127.6' Sample Condition: received dry - tested moist

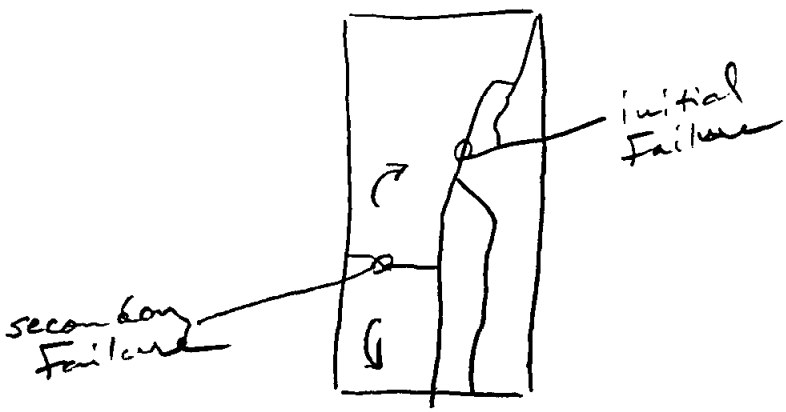


d_1	d_2
2.401	2.401
2.402	2.400
2.401	2.401
2.402	2.402
2.399	2.401

l_1	l_2
+.0005	+.0011
+.0004	+.0007
±.0001	±.0002
-.0002	-.0007
-.0006	-.0015

Avg. diameter: 2.401 Avg. length: 5.674"
Sample area: 4.528 l/d ratio: 2.36
Sample volume(in^3): 25.690
Sample weight (g): 1145.3
Density: 44.588 g/in^3 = 169.8 pcF (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments: Failed by axial split (initial failure)
INTACT Failure



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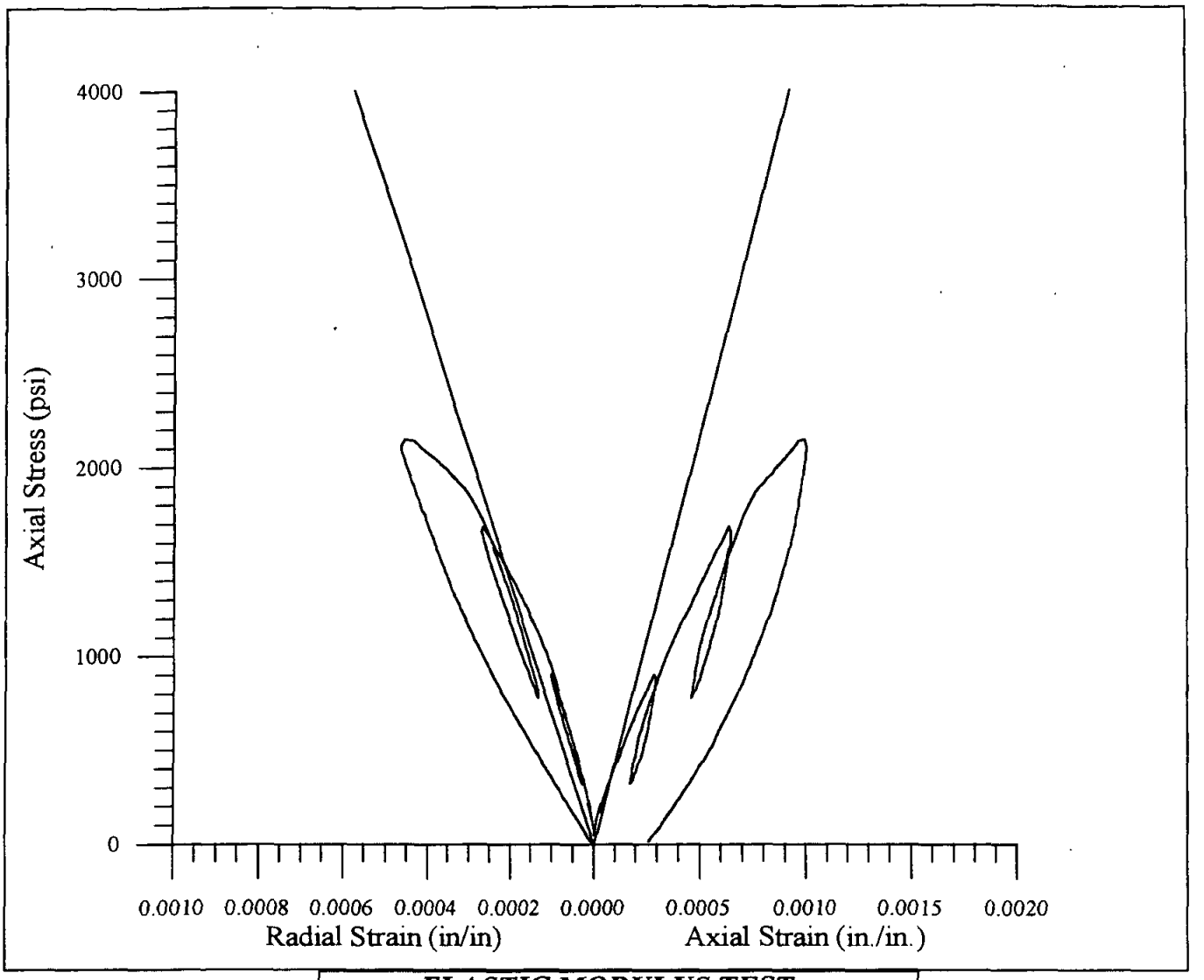


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 11-127
Boring: 02-11
Depth: 127.1-127.6'

DESCRIPTION
Interbedded shale and fine grained sandstone with bedding about 75 degrees to the core axis.

Modulus:	**4,350,000 *psi***
Poisson's ratio:	**NA (.63)**
Density:	**169.8 pcf**

Geo G T U *Test Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

Geo Test Unlimited

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 9/6&12/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray shale with a few fine grained sandstone layers. Also contained bedding joint bedding ~72° to core axis.

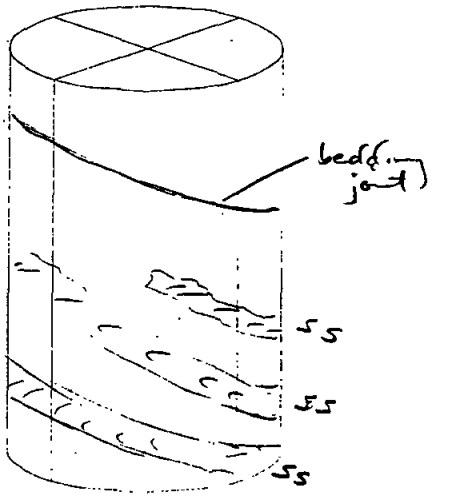
Sample Depth: 137.0-137.5' Sample Condition: received dry - tested moist

d_1	d_2
2.402	2.402
2.402	2.402
2.403	2.403
2.402	2.397
2.402	2.397

l_1	l_2
+.0022	+.0031
+.0011	+.0015
±.0001	±.0002
-.0017	-.0017
-.0024	-.0033

Avg. diameter : 2.401
Sample area : 4.528
Sample volume(in^3) : 25.830
Sample weight (g) : 1123.8 g
Density : 43.518/in^3 = 165.7 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Avg. length : 5.705"
l/d ratio : 2.38



Comments: water extruded during UC test - Darkened whole sample. VERY DUCTILE! (High strain to Failure)
Failed by axial splitting
INTACT FAILURE

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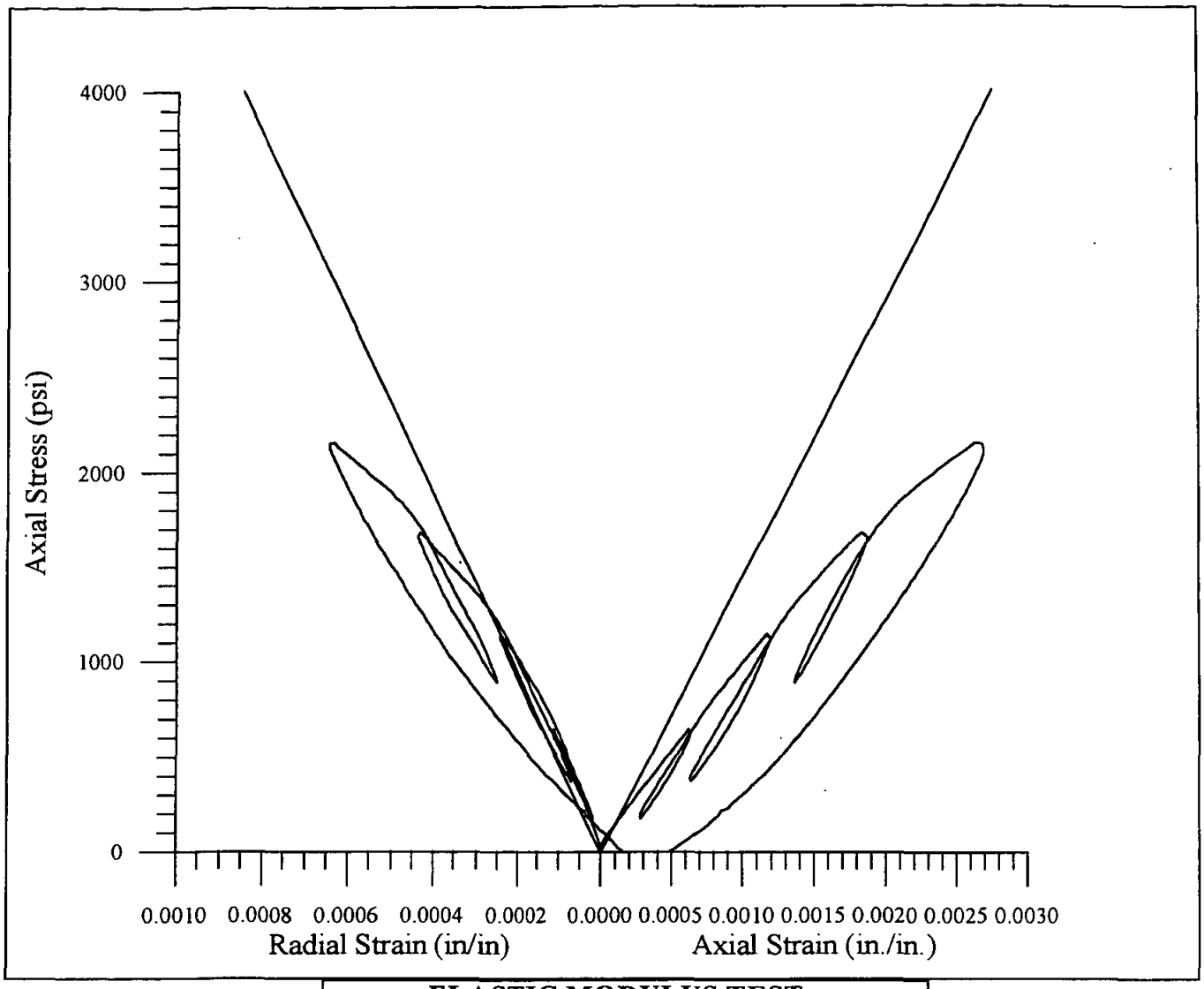


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 11-137
Boring: 02-11
Depth: 137.0-137.5'

DESCRIPTION

Dark gray shale with a few fine grained sandstone layers with one healed bedding plane joint. Bedding about 72 degrees to the core axis.

Modulus:	**1,450,000 psi**
Poisson's ratio:	**.31**
Density:	**165.7 pcf**

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **Earth Mechanics, Inc.**
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: **Devil's Slide**

Project Number: none

Test Date: **September 6, 2002**

Geo Test Unlimited (GTU)

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

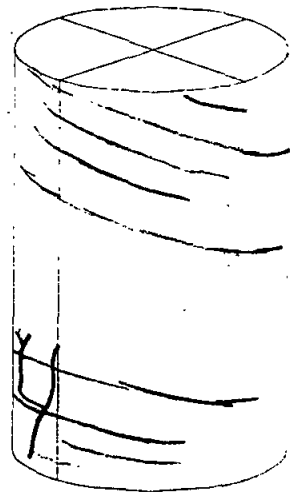
Date: 9/6&12/02
Technician: A. Bro

Client: EMI
Job: #151- Devil's Slide
Sample ID: Boring 02-11
Sample Description: Interbedded shale and sandstone with two axial calcite healed hairline fractures. Bedding ~75° to the core axis.

Sample Depth: 214.7-215.2' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.393
2.400	2.401
2.402	2.401
2.400	2.398
2.401	2.397

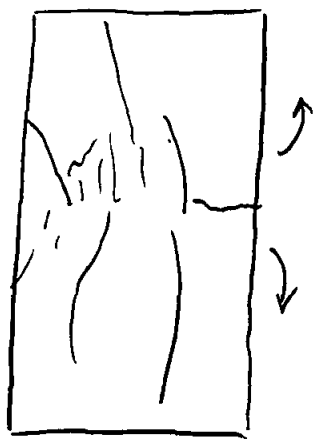
l_1	l_2
+.0025	+.0013
+.0014	+.0009
±.0001	±.0002
-.0011	-.0004
-.0024	-.0007



Avg. diameter : 2.399" Avg. length : 5.482"
Sample area : 4.520 l/d ratio : 2.29
Sample volume(in^3) : 24.824
Sample weight (g) : 1068.5 g
Density : 43.04 g/in^3 = 164.0 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000"

Comments: modulus sample loaded to incipient Failure. Very ductile

INTACT FAILURE - failed by axial splitting & buckling



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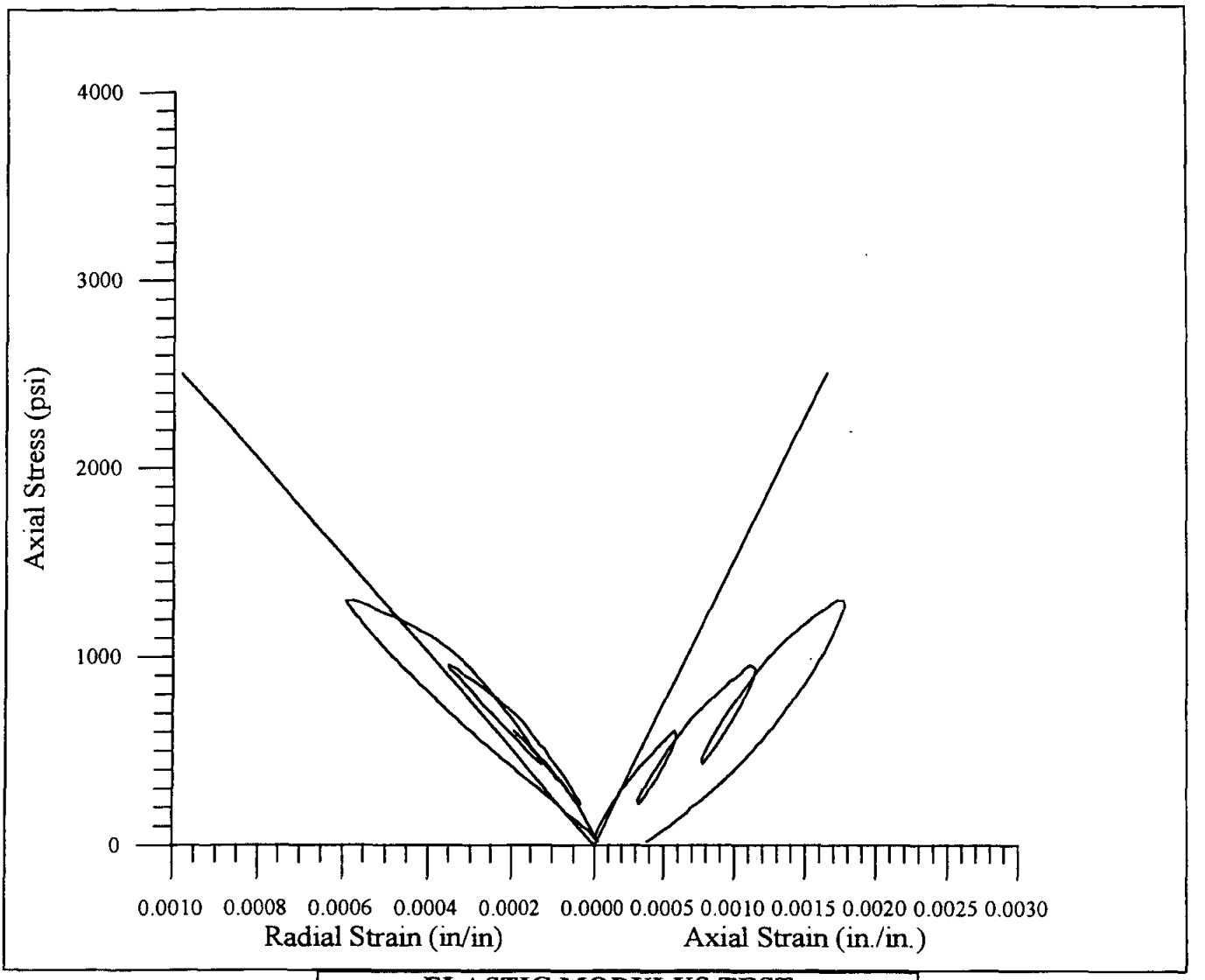


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 11-214
Boring: 02-11
Depth: 214.7-215.2'

DESCRIPTION
Interbedded shale and sandstone with two axial calcite healed hairline fractures. Bedding about 75 degrees to the core axis.

Modulus:	**1,510,000 psi**
Poisson's ratio:	**NA (.60)**
Density:	**164.0 pcf**

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

Geo Test Unlimited

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

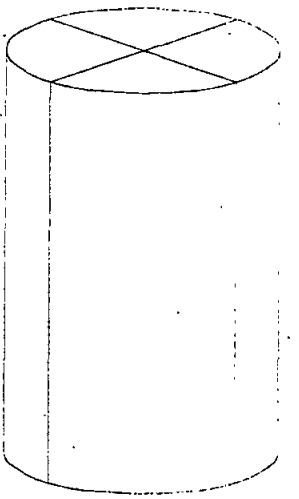
Date: 9/6 & 12/02
Technician: A. Bro

Client: E~I
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: interbedded shale & fine grained sandstone with bedding ~73° to core axis - no visible joints

Sample Depth: 241.5-242.0' Sample Condition: received dry - tested moist

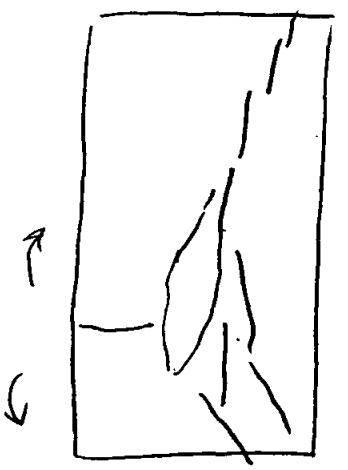
d_1	d_2
2.399	2.398
2.397	2.397
2.400	2.400
2.401	2.400
2.400	2.399

l_1	l_2
+.0008	+.0025
+.0006	+.0015
±.0001	±.0002
-.0006	-.0015
-.0017	-.0030



Avg. diameter : 2.399"
Avg. length : 5.404"
Sample area : 4.520
l/d ratio : 2.25
Sample volume(in³) : 24.427
Sample weight (g) : 1051.78
Density : 43.06 g/in³ = 164.0 pcF (1 g/in³=3.8095lb/ft³)
Gauge length: 2.000 in

Comments: shale sections darken (w/pore water) during loading
DUCTILE FAILURE
INTACT FAILURE - by splitting & rotation



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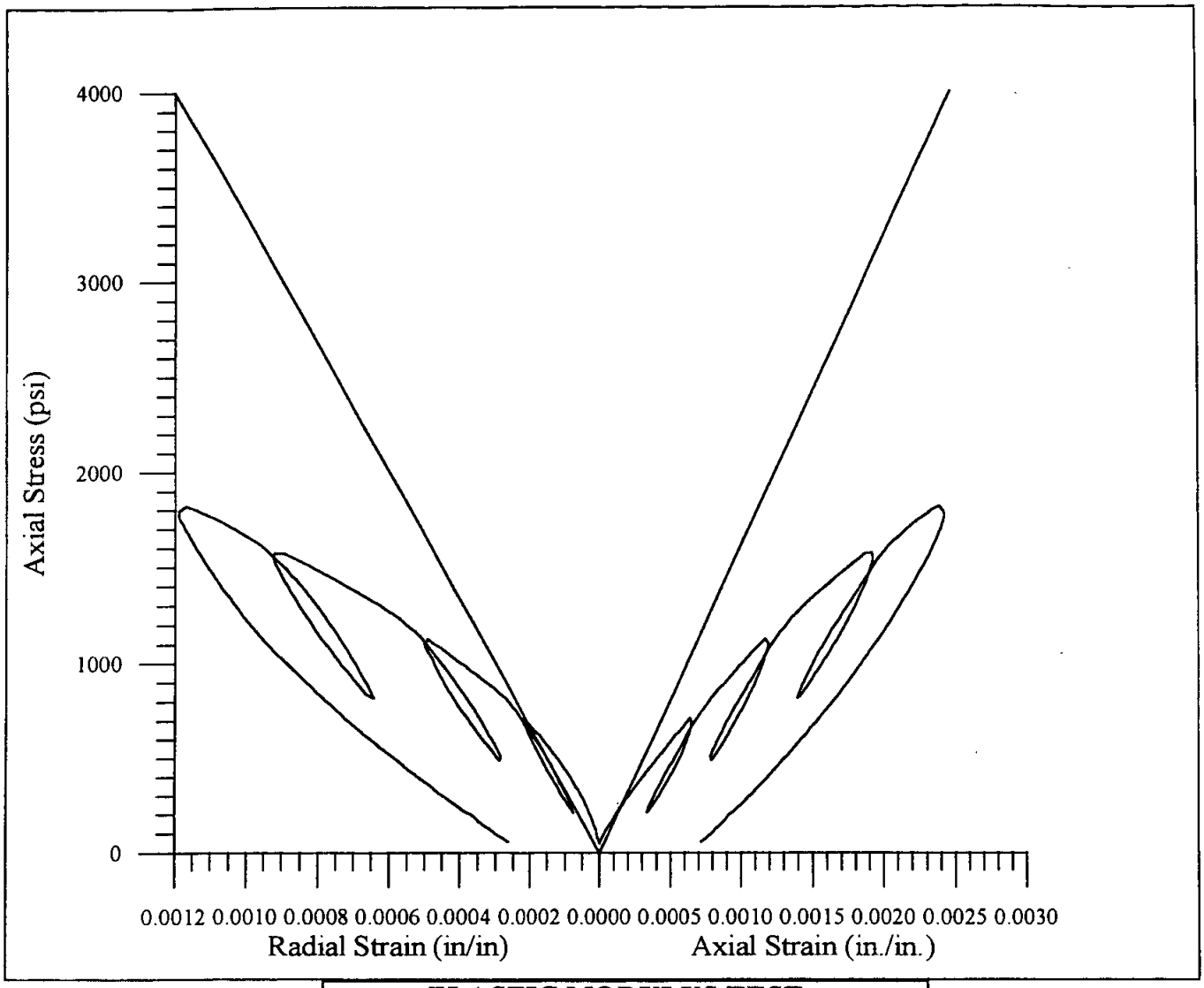


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 11-241
Boring: 02-11
Depth: 241.5-242.0'

DESCRIPTION
Interbedded shale and fine grained sandstone with bedding about 73 degrees to the core axis with no visible joints.

Modulus:	**1,620,000 psi**
Poisson's ratio:	**NA? (.49)**
Density:	**164.0 pcf**

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

Geo Test Unlimited (GTU)

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

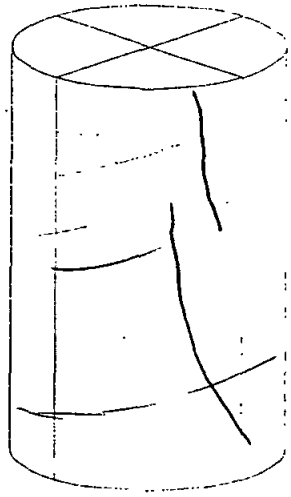
Date: 9/6-16/02
Technician: A. Bro

Client: ENI
Job: #151- Devil's Slide
Sample ID: Boring 02-11
Sample Description: Interbedded (Finely) medium to dark grey siltstone with a few calcite healed hairline cracks perpendicular to bedding - Bedding ~ 73° to the core axis.

Sample Depth: 265.8 - 266.3' Sample Condition: received dry tested moist

d_1	d_2
2.400	2.400
2.400	2.400
2.400	2.400
2.400	2.400
2.399	2.398

l_1	l_2
+.0013	+.0022
+.0007	+.0010
±.0001	±.0002
-.0007	-.00010
-.0015	-.00020



Avg. diameter : 2.400"
Avg. length : 5.623"
Sample area : 4.524
l/d ratio : 2.34
Sample volume(in^3) : 25.438
Sample weight (g) : 1160.1 g
Density : 45.618 g/in^3 = 173.7 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments:

INTACT FAILURE - by axial splitting

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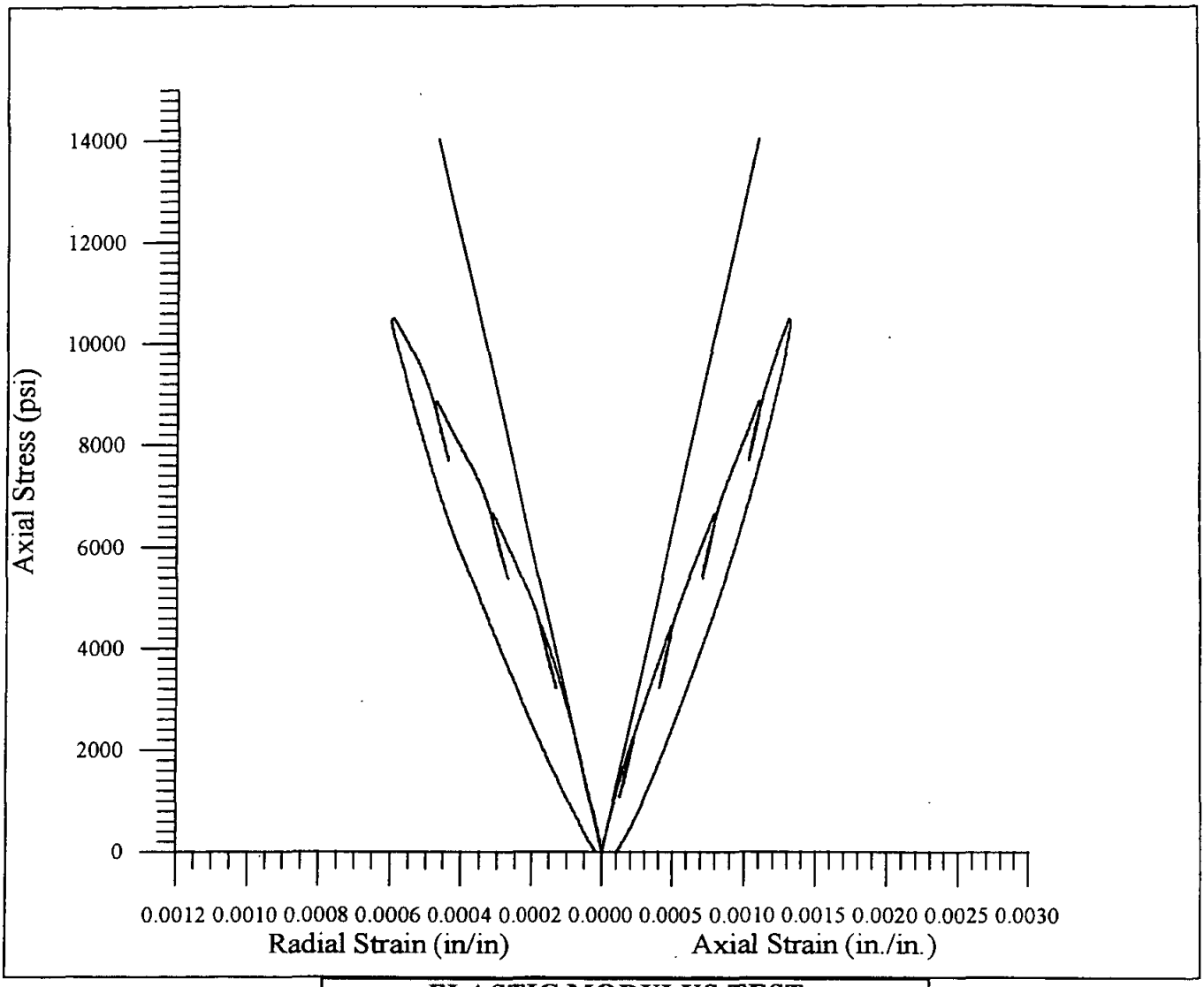


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 11-265
Boring: 02-11
Depth: 265.8-266.3'

DESCRIPTION
Interbedded medium gray and dark gray fine grained sandstone (siltstone?) with a few calcite healed hairline fractures perpendicular to bedding. Bedding about 73 degrees to the core axis.

Modulus:	**12,700,000 psi**
Poisson's ratio:	**NA? (.42)**
Density:	**173.7 pcf**

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **Earth Mechanics, Inc.**
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: **Devil's Slide**

Project Number: none

Test Date: **September 6, 2002**

Geo Test Unlimited (GTU)

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

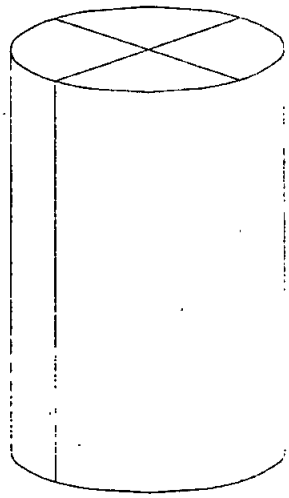
Date: 9/6&12/02
Technician: A. Bro

Client: E-I
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Dark gray shale, bedding ~ 74° to core axis

Sample Depth: 277.5-278.0 Sample Condition: received dry - tested moist

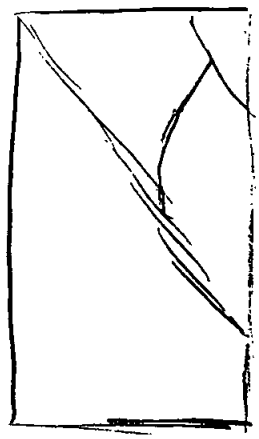
d_1	d_2
2.402	2.397
2.401	2.398
2.400	2.399
2.399	2.397
2.400	2.401

l_1	l_2*
+.0050	-.0007
+.0032	-.0006
±.0001	±.0002
-.0032	+.0002
-.0060	-.0004



Avg. diameter: 2.399 Avg. length: 5.601"
Sample area: 4.520 l/d ratio: 2.33
Sample volume(in^3): 25.317
Sample weight (g): 1086.5g.
Density: 42.92 g/in^3 = 163.5 pcF (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments: * uneven surface due to displacements across fractures which are barely visible on sample end.
modulus test taken to incipient failure.
water develops on surface during test
Failed by shear - INTACT FAILURE



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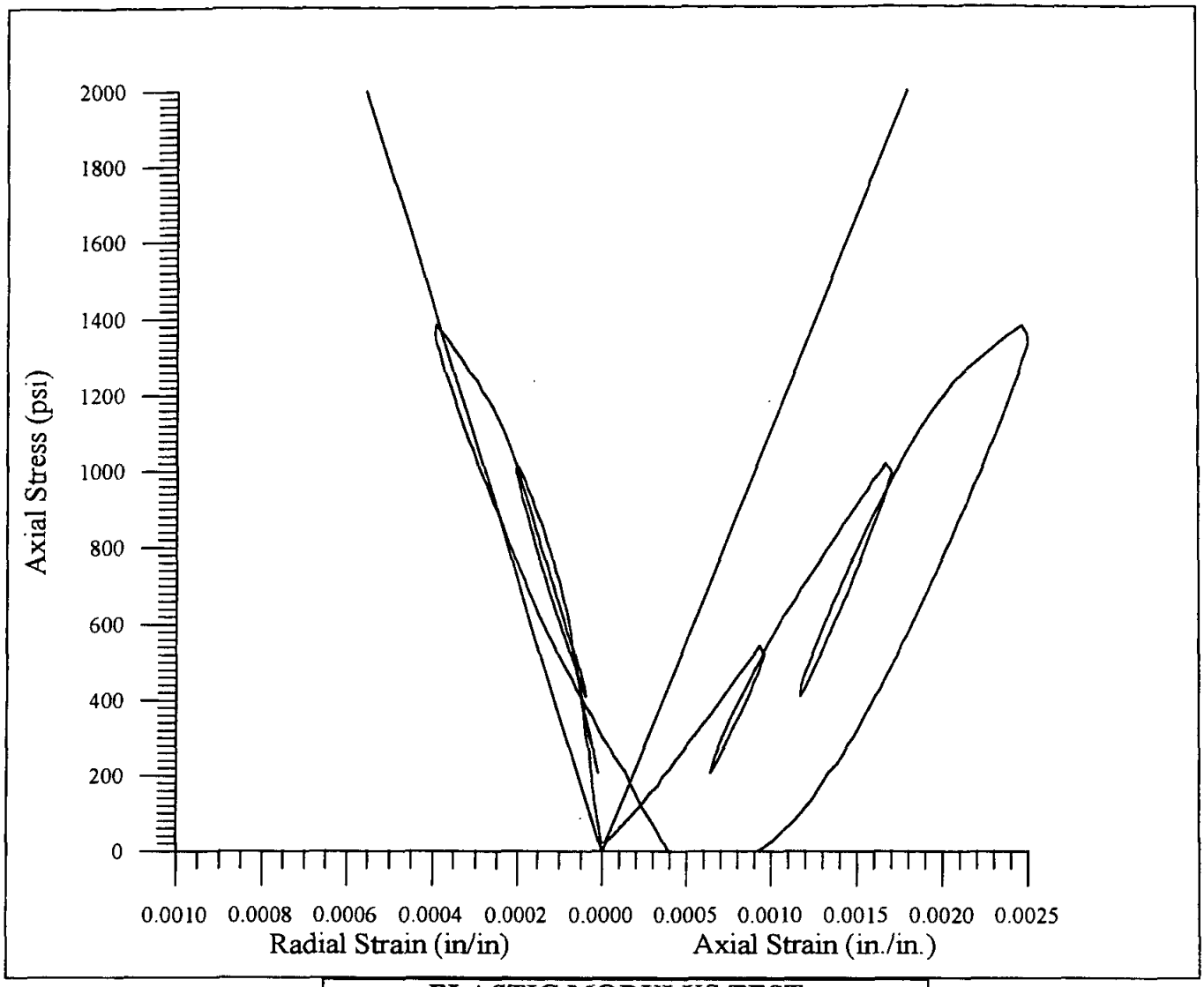


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 11-277
Boring: 02-11
Depth: 277.5-278.0'

DESCRIPTION
Dark gray shale with bedding about 75 degrees to the core axis.

Modulus:	**1,110,000 psi**
Poisson's ratio:	**.33**
Density:	**163.5 pcf**

Geo G T U *Test Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 6, 2002

Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

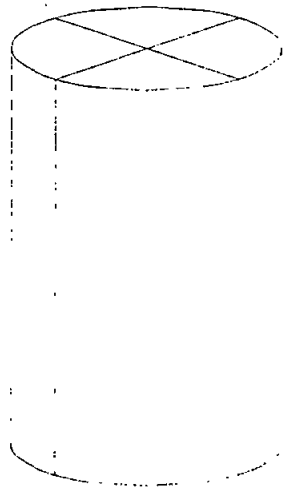
Date: 10-20 & 22-02
Technician: A.BRO

Client: EMI
Job: #151- Devil's Slide
Sample ID: Boring 02-5
Sample Description: Medium gray coarse grained sandstone

Sample Depth: 173.0-173.5' Sample Condition: received dry - tested moist

d_1	d_2
2.393	2.392
2.391	2.396
2.397	2.398
2.392	2.397
2.397	2.388

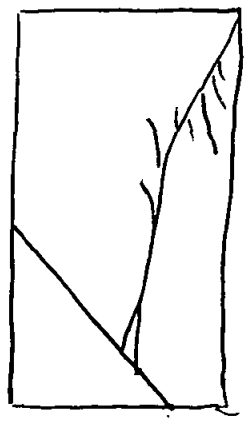
l_1	l_2
+.0008	+.0001
+.0004	
±.0001	±.0001
-.0004	
-.0008	-.0001



Avg. diameter : 2.394 Avg. length : 5.554
Sample area : 4.501 l/d ratio : 2.32
Sample volume(in^3) : 25.000 in^3
Sample weight (g) : 1062.7g
Density : 42.518/in^3 = 161.9pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments:

JOINT CONTROLLED FAILURE - failed by sliding on joint & axial splitting



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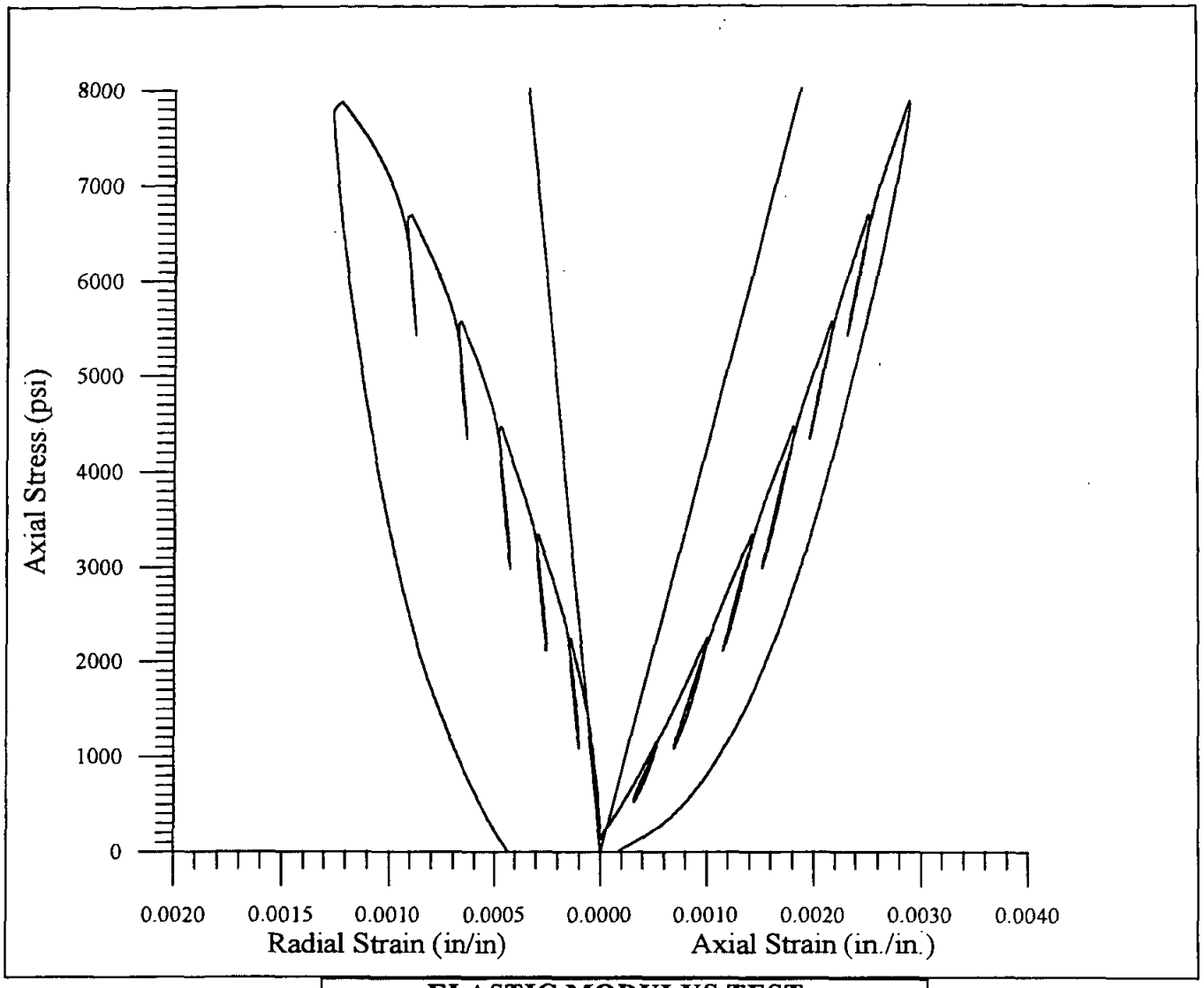
LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 5-173
Boring: 02-5
Depth: 173.0-173.5'

DESCRIPTION
Medium gray coarse grained sandstone.

Modulus:	**4,260,000 psi**
Poisson's ratio:	**.18**
Density:	**161.9 pcf**

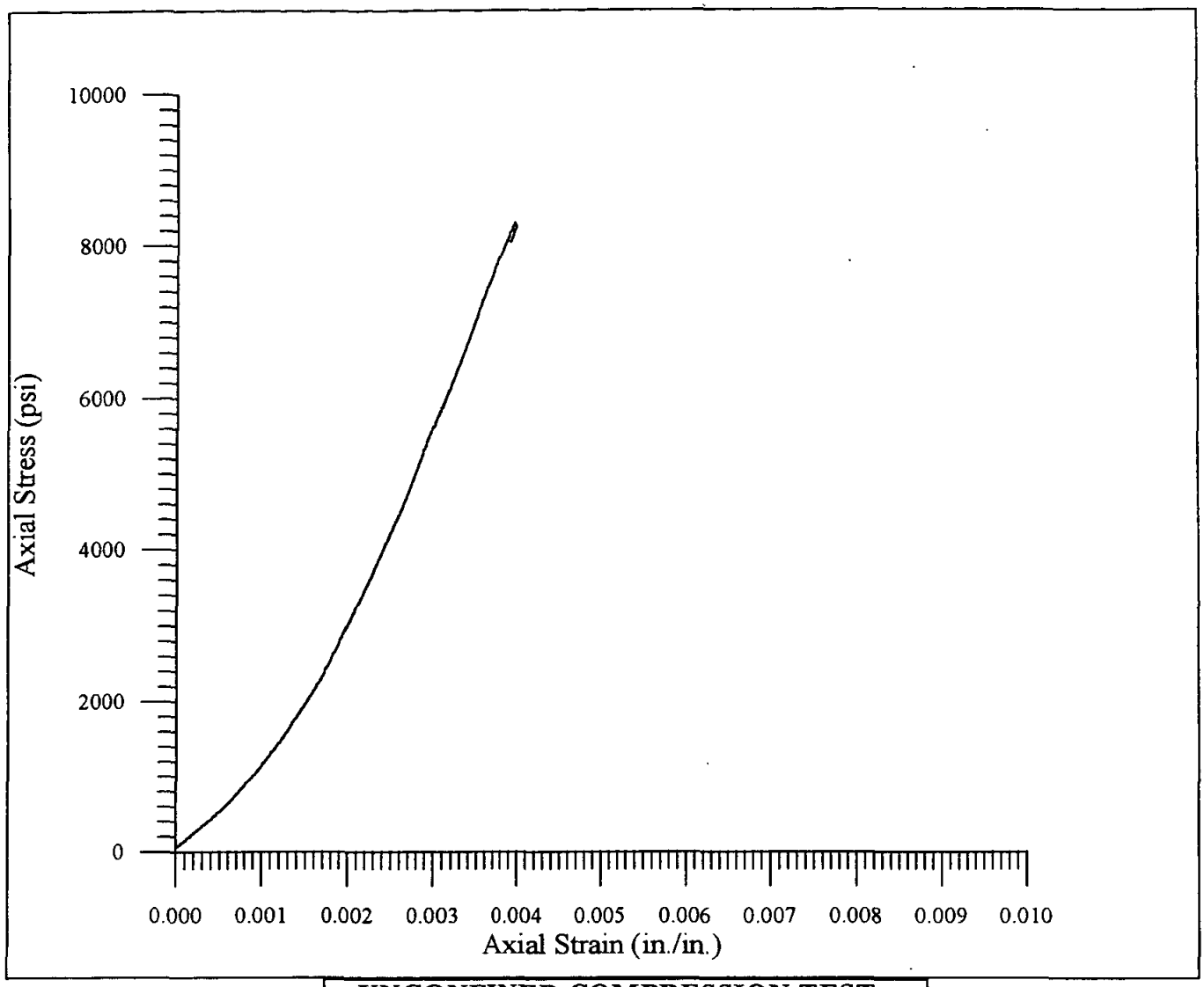
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 20, 2002



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-173
Boring: 02-5
Depth: 173.0-173.5'

DESCRIPTION
Medium gray coarse grained sandstone.

Density: 161.9 pcf
Strength: 8308 psi
Joint Control Failure?: yes

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

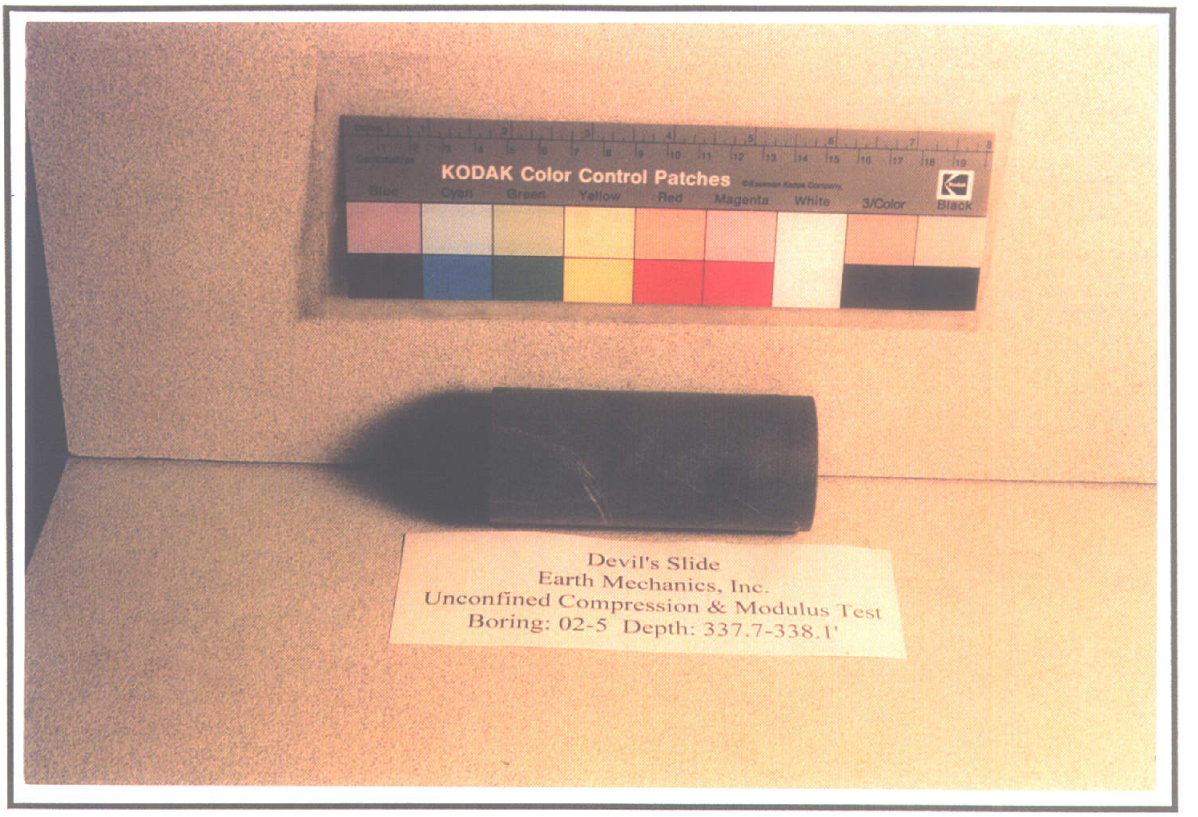
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

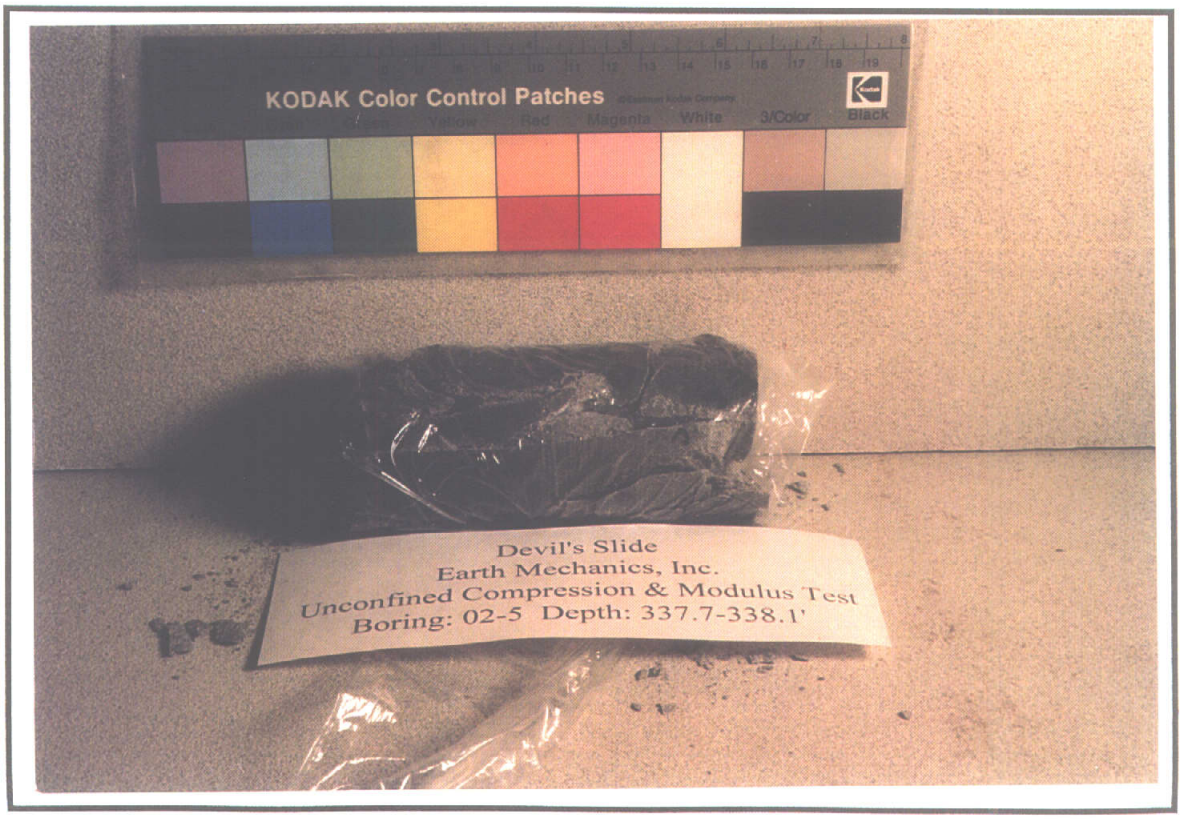
Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

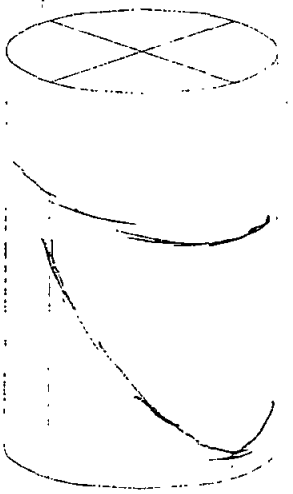
Date: 10/20 & 22/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-5
Sample Description: Gray fine grained sandstone with a few calcite healed fractures.

Sample Depth: 337.7-338.1 Sample Condition: received dry - tested moist

d_1	d_2
1.769	1.767
	1.767
	1.769
	1.768
1.768	1.767

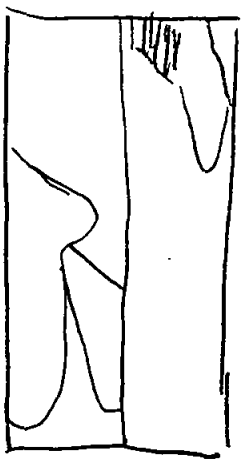
l_1	l_2
+.0003	0
±.0001	±.0001
-.0003	0



Avg. diameter : 1.768 Avg. length : 4.105
Sample area : 2.455 l/d ratio : 2.32
Sample volume(in^3) : 10.078 in^3
Sample weight (g) : 436.4 g
Density : 43.308/in^3 = 165.0 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in.

Comments: NX core - possibly in vicinity of pressure meter test
Axial gauge slipped at end of modulus test - during unloading (vertical axial strain trace due to gauge hitting its stop)

INTACT FAILURE - failed by axial splitting and shear



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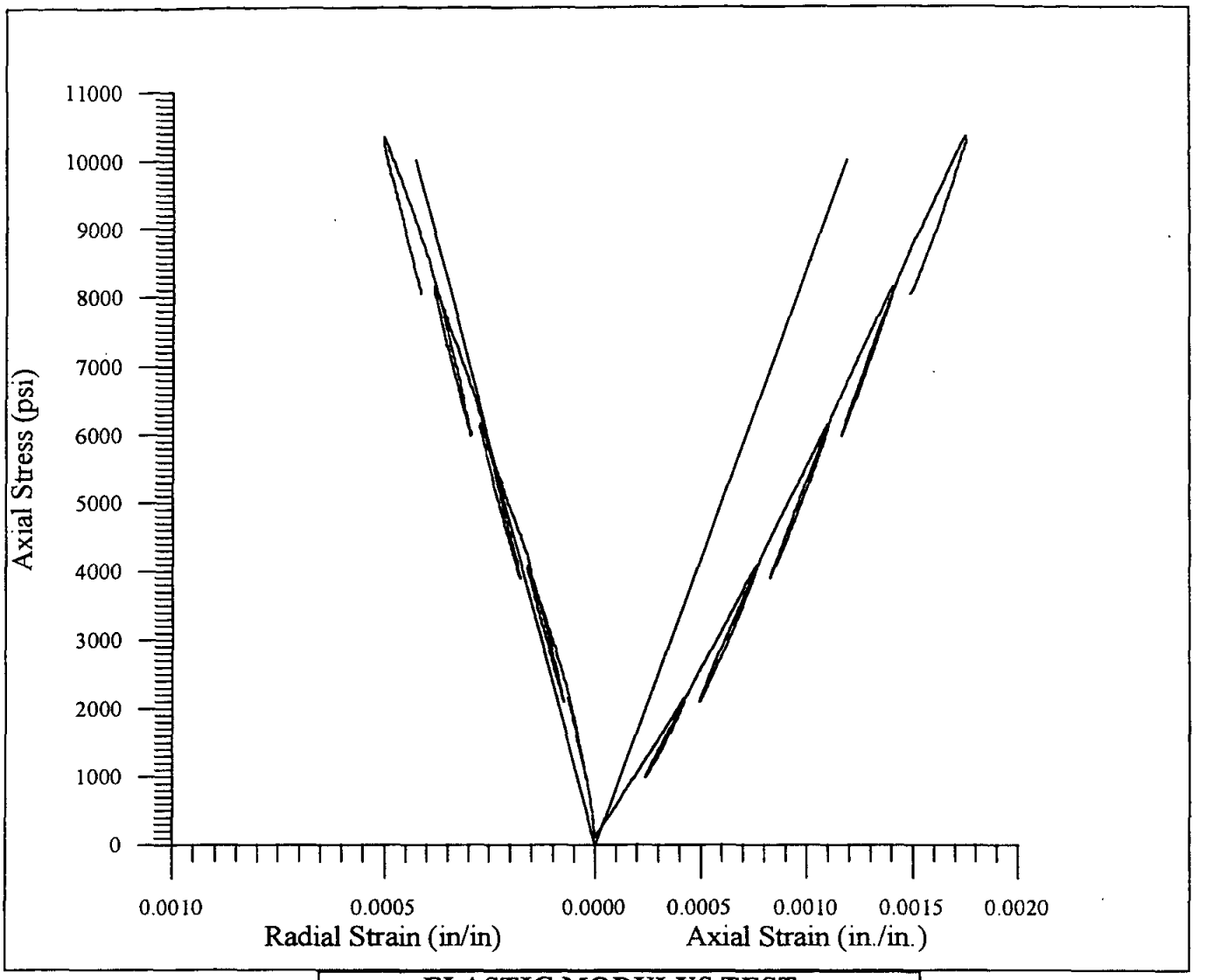


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 5-337
Boring: 02-5
Depth: 337.7-338.1'

DESCRIPTION
Gray fine grained sandstone with a few calcite healed fractures.

Modulus:	**8,400,000 psi**
Poisson's ratio:	**.36**
Density:	**165.0 pcf**

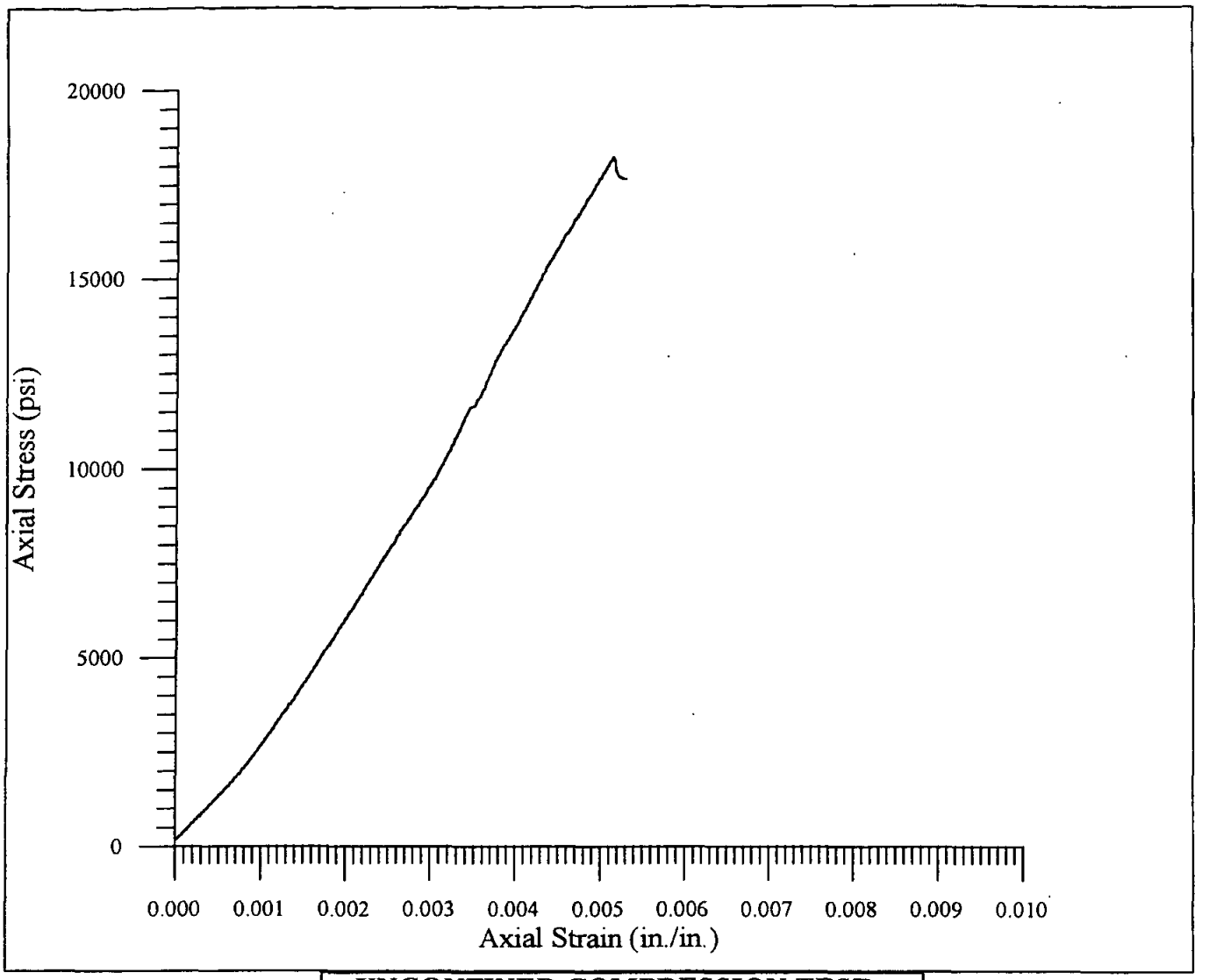
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 20, 2002



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-337
Boring: 02-5
Depth: 337.7-338.1'

DESCRIPTION
Gray fine grained sandstone with a few calcite healed fractures.

Density: 165.0 pcf
Strength: 18220 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited GTU

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

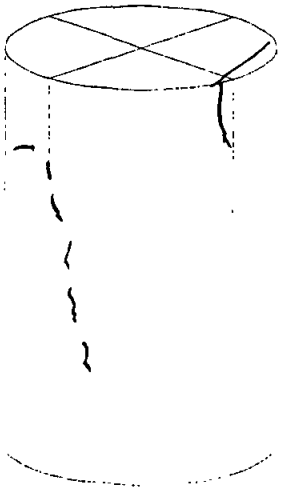
Date: 10-20a21-02
Technician: A.Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Bori-02-5
Sample Description: Medium gray granodiorite with a possible plane of weakness.

Sample Depth: 672.0-672.5' Sample Condition: received dry - tested moist

d_1	d_2
2.400	2.407
2.399	2.398
2.399	2.397
2.398	2.399
2.396	2.398

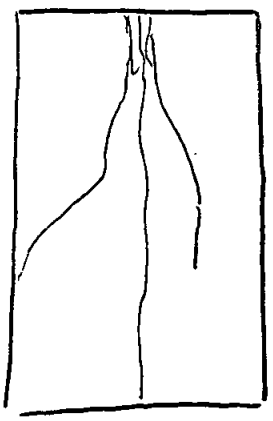
l_1	l_2
+.0012	+.0003
+.0003	+.0002
±.0001	±.0002
-.0004	-.0001
-.0007	-.0003

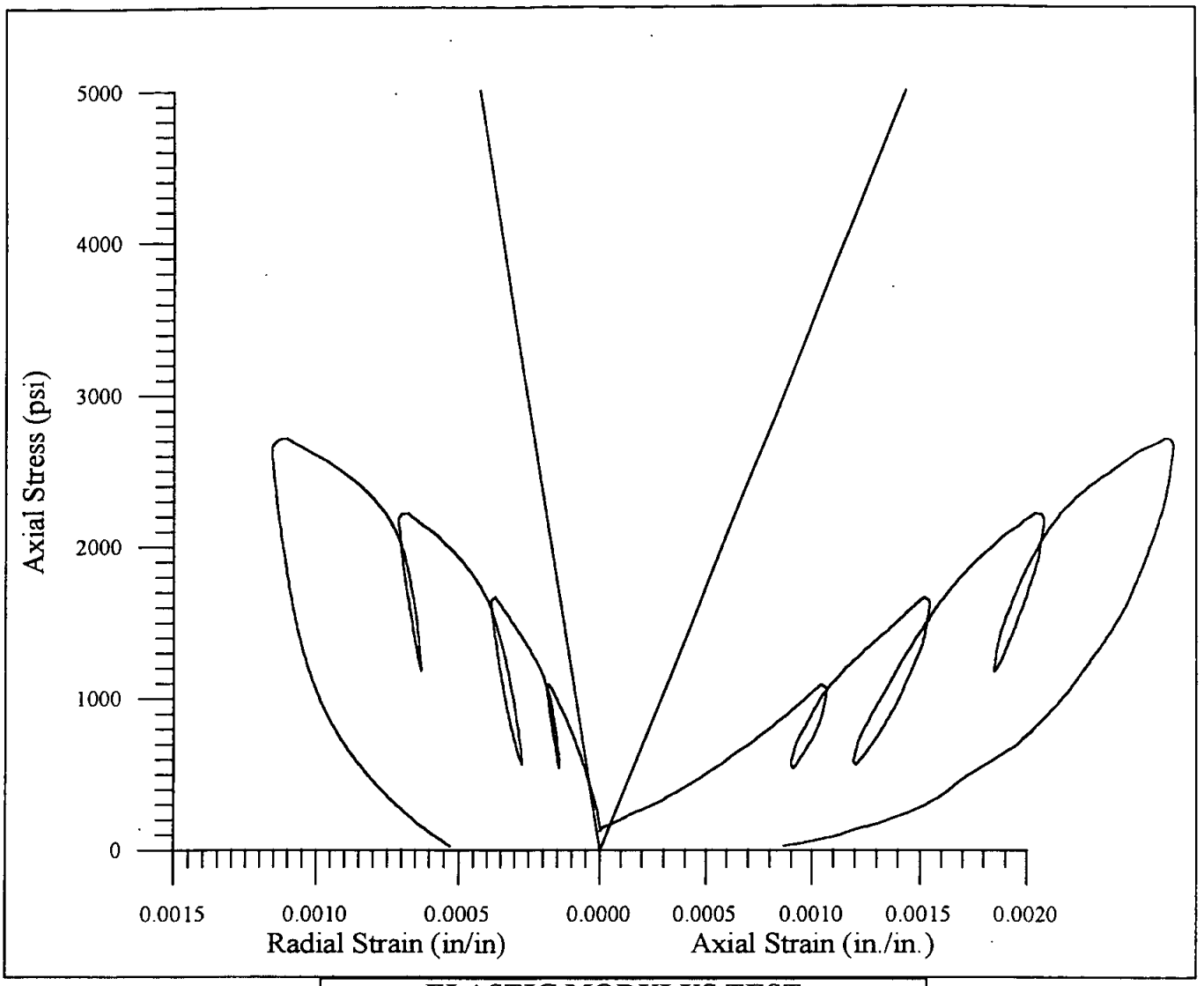


Avg. diameter : 2.399
Avg. length : 5.681"
Sample area : 4.520
l/d ratio : 2.37
Sample volume(in^3) : 25.679
Sample weight (g) : 1111.3g
Density : 43.28g/in^3 = 164.9 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments:

INTACT FAILURE - failed by axial splitting and some shear





ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 5-672
Boring: 02-5
Depth: 672.0-672.5'

DESCRIPTION
Medium gray granodiorite possibly with a steeply inclined plane of weakness.

Modulus:	**3,470,000 psi**
Poisson's ratio:	**.30**
Density:	**164.9 pcf**

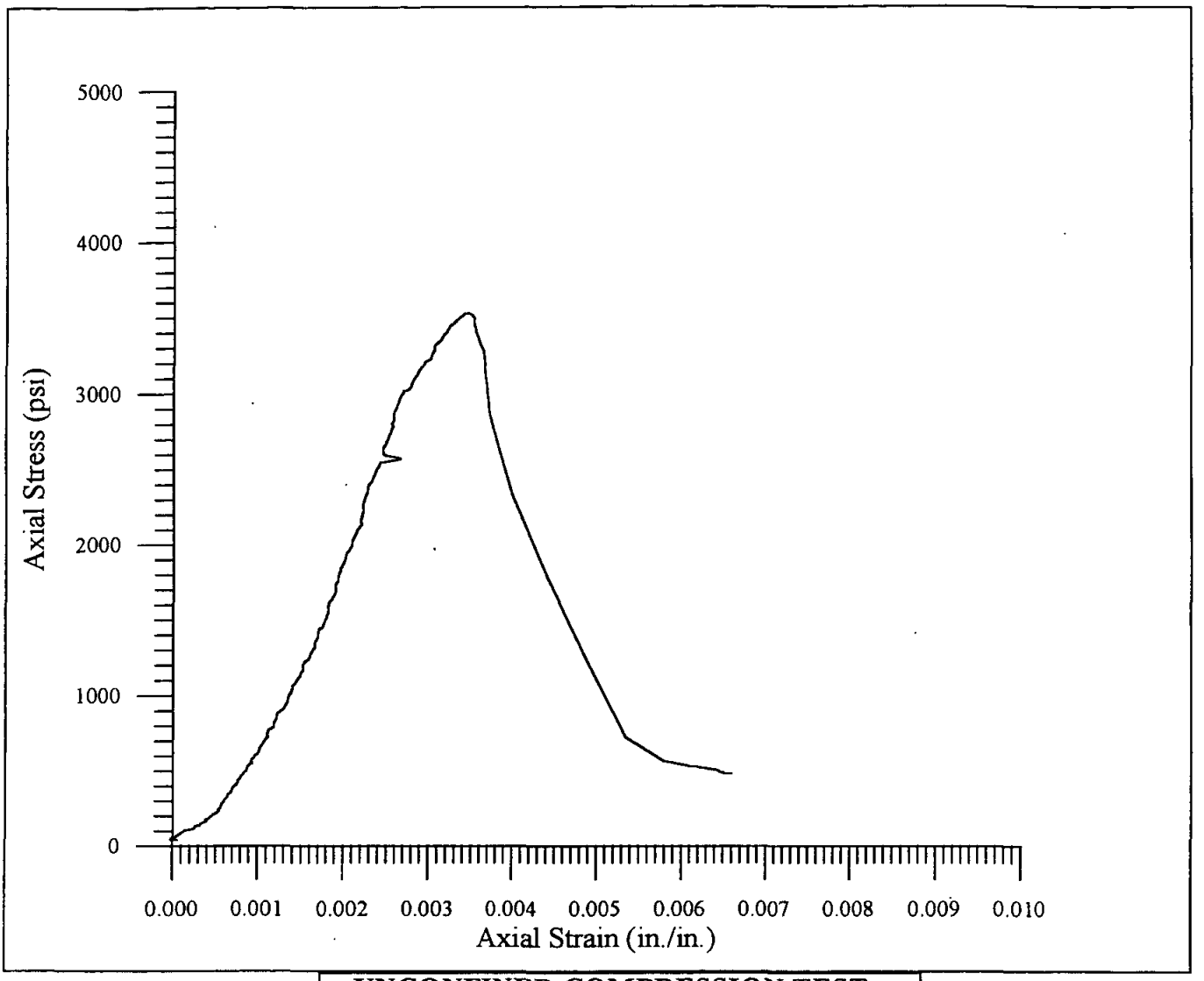
Geo Test Unlimited G T U
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 20, 2002



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 5-672
Boring: 02-5
Depth: 672.0-672.5'

DESCRIPTION
Medium gray granodiorite possibly with a steeply inclined plane of weakness.

Density: 164.9 pcf
Strength: 3526 psi
Joint Control Failure?: no

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

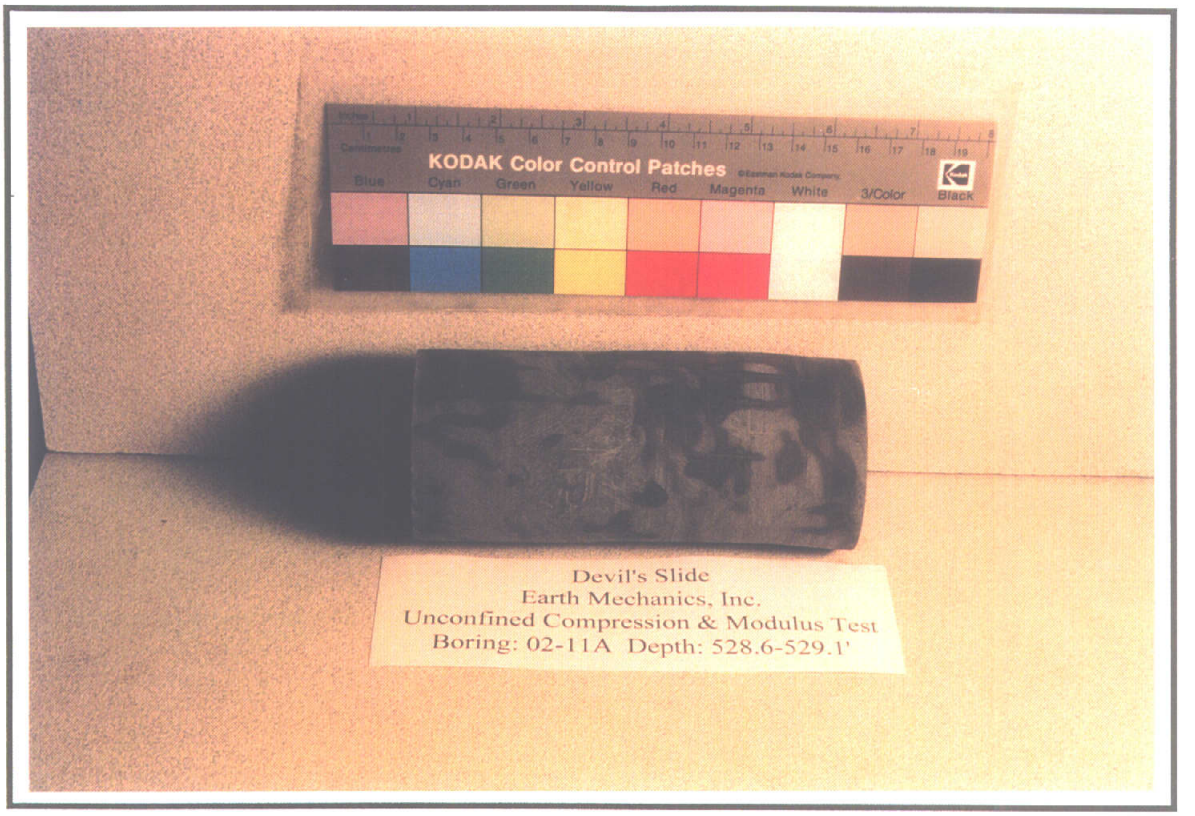
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 21, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo GTU Test Unlimited

DATA SHEET

Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

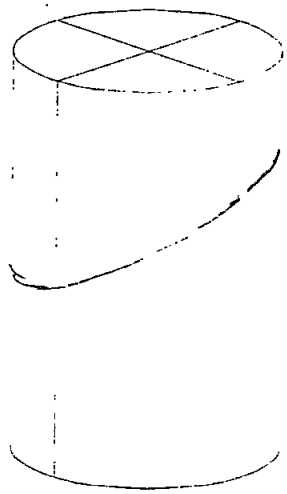
Date: 10/20 & 22/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray siltstone to non-Fissile shale with a bedding plane ~68° to core axis

Sample Depth: 528.6-529.1' Sample Condition: received dry - tested moist

d_1	d_2
2.391	2.378
2.393	2.392
2.376	2.385
2.389	2.385
2.389	2.386

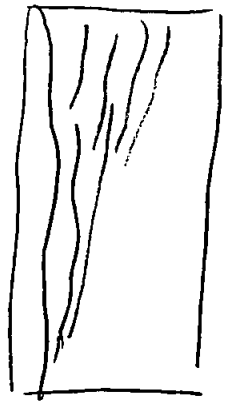
l_1	l_2
+.0001	+.0010
	+.0006
±.0001	±.0002
	−.0006
−.0001	−.0010

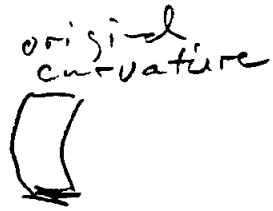


Avg. diameter : 2.386 Avg. length : 5.387"
Sample area : 4.471 l/d ratio : 2.26
Sample volume(in³) : 24.087
Sample weight (g) : 1049.8 g
Density : 43.58 g/in³ = 168.0 pcf (1 g/in³=3.8095lb/ft³)
Gauge length: 2.000 in

Comments: "bent" core ~1/8" →

INTACT FAILURE - failed by axial splitting & bending





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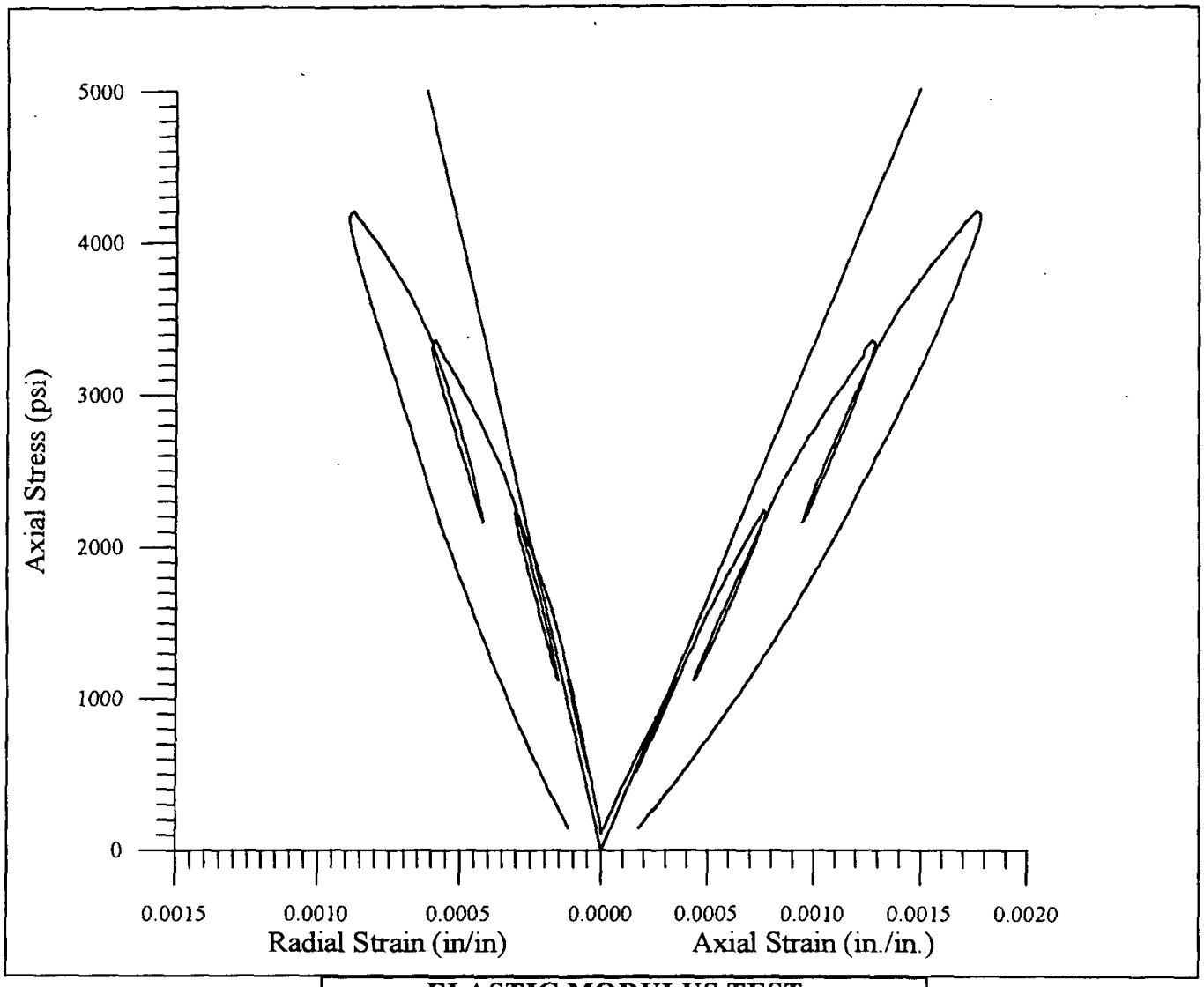


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 11A-528
Boring: 02-11A
Depth: 528.6-529.1'

DESCRIPTION
Dark gray siltstone or shale with a bedding plane about 68 degrees to the core axis.

Modulus:	**3,330,000 psi**
Poisson's ratio:	**.41**
Density:	**166.0 pcf**

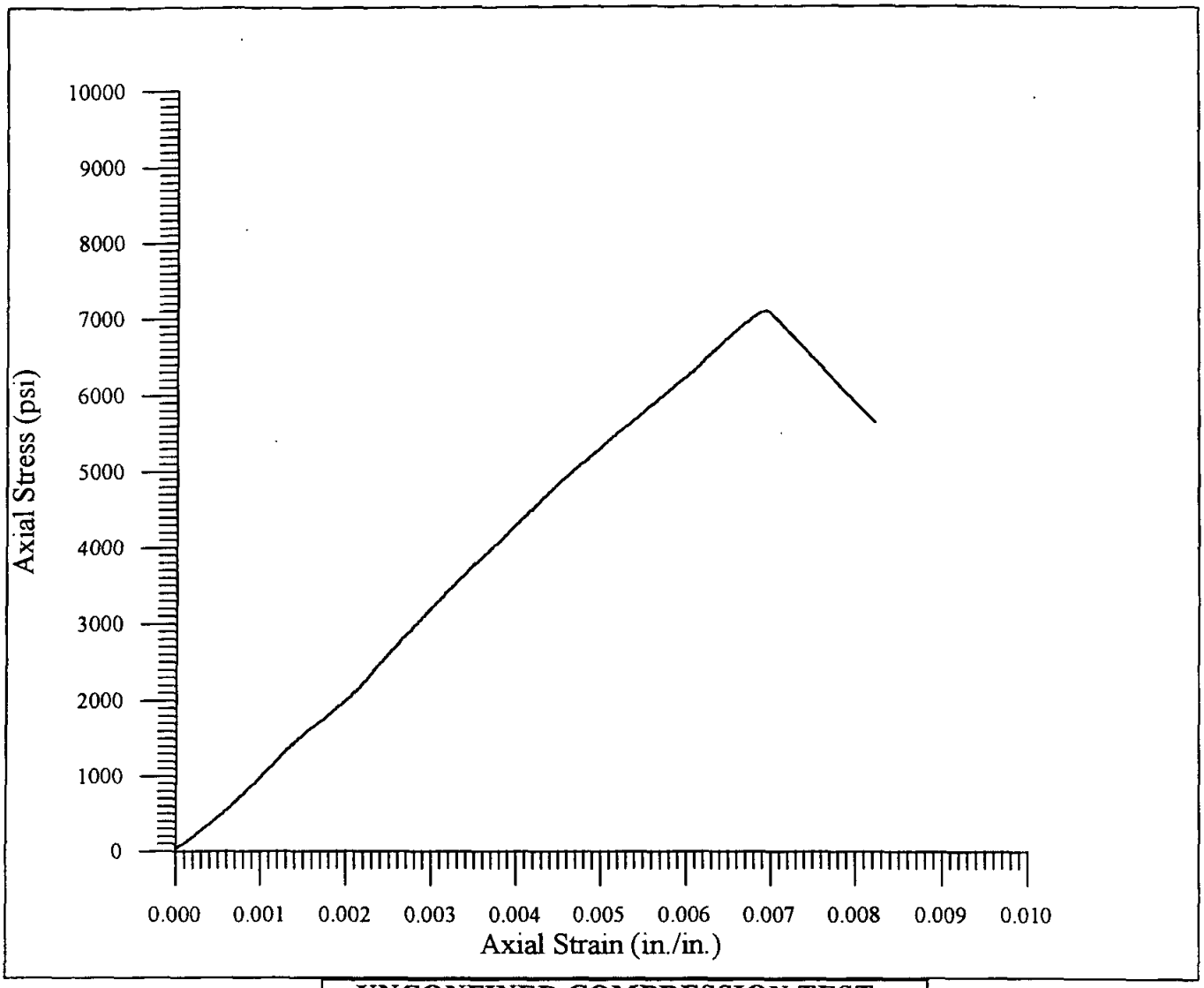
Geo Test Unlimited G T U
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 20, 2002



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-528
Boring: 02-11A
Depth: 528.6-529.1'

DESCRIPTION
Dark gray siltstone or shale with a bedding plane about 68 degrees to the core axis.

Density: 166.0 pcf
Strength: 7111 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

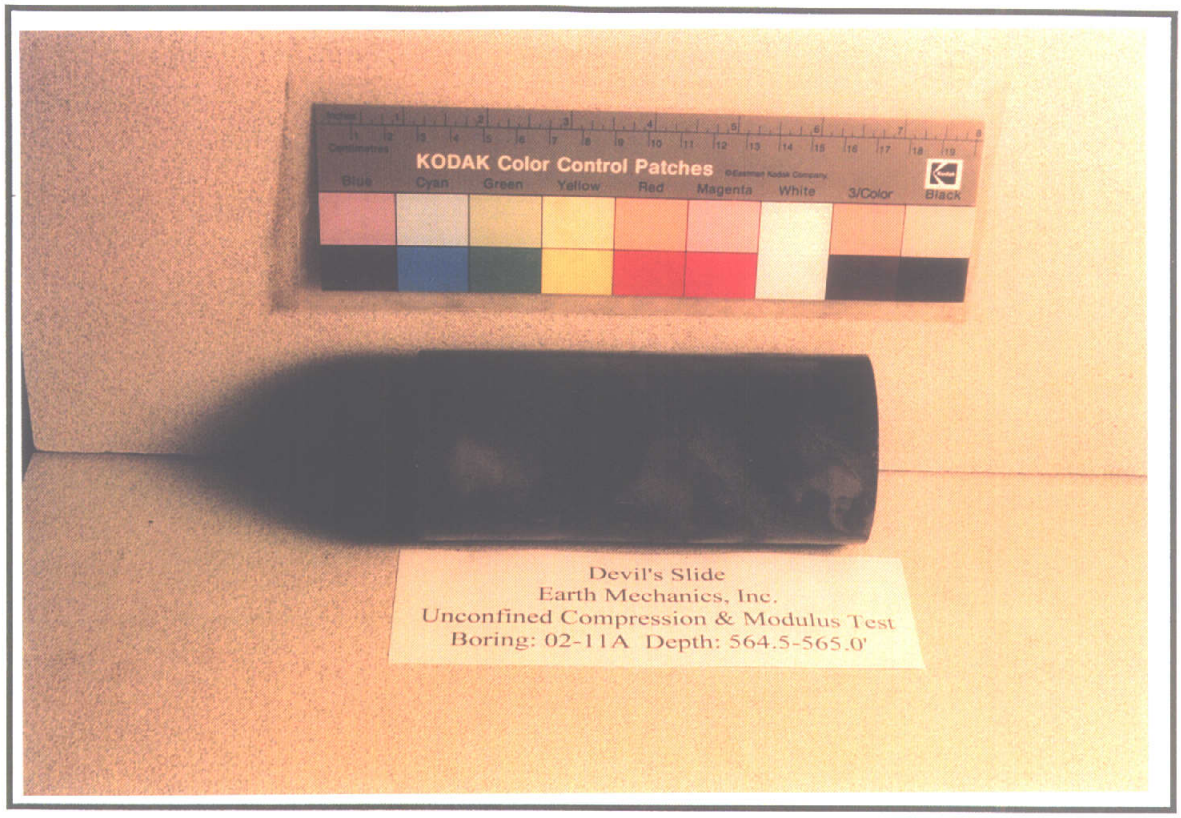
Client: **Earth Mechanics, Inc.**
17660 Newhope St., Suite E
Fountain Valley, CA 92708

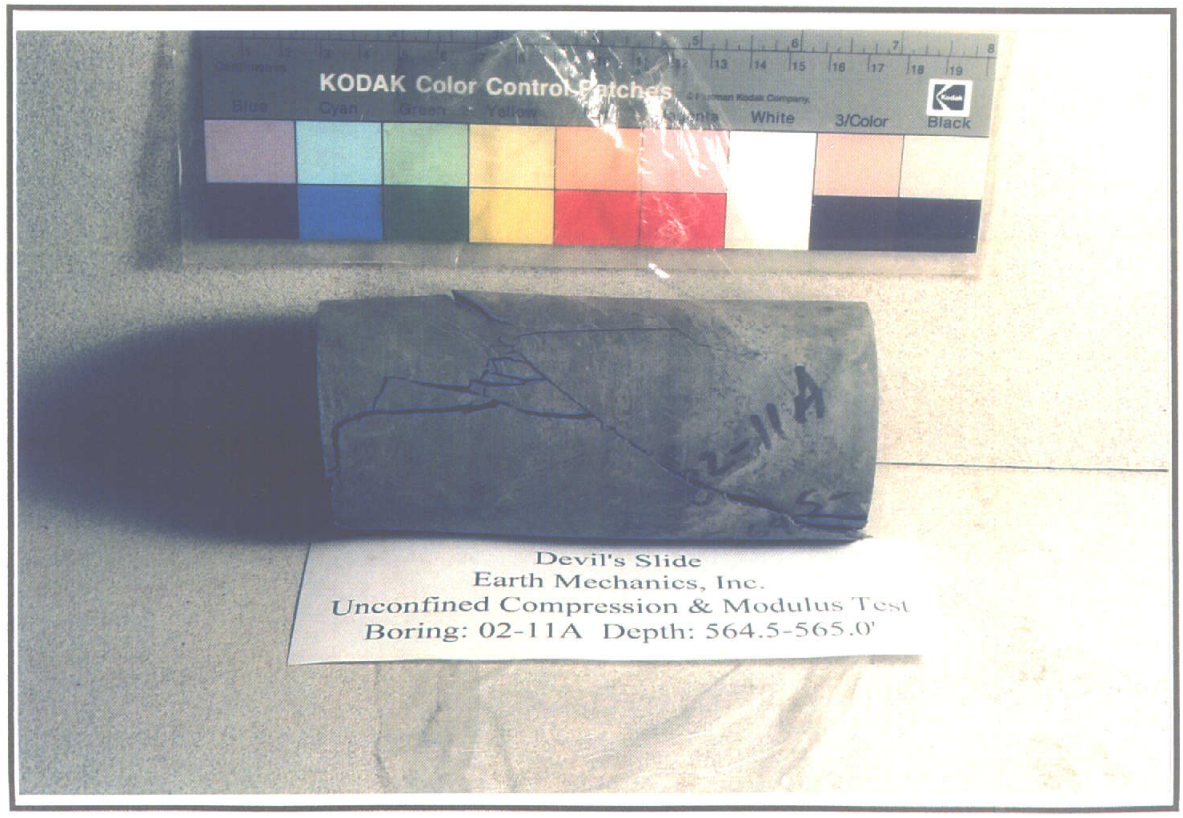
Project: **Devil's Slide**

Project Number: none

Test Date: **October 22, 2002**

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

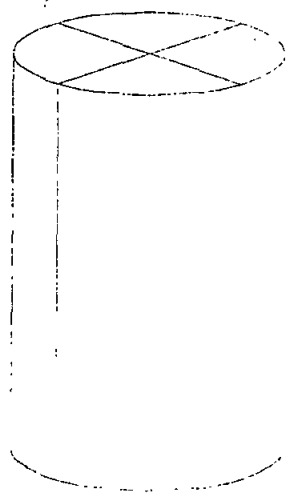
Date: 10/20 & 22/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray interbedded siltstone with a few beds of medium gray very fine grained sandstone - bedding ~50° to core axis

Sample Depth: 564.5-565.0 Sample Condition: received dry - tested moist

d_1	d_2
2.394	2.390
2.394	2.387
2.392	2.392
2.394	2.391
2.393	2.393

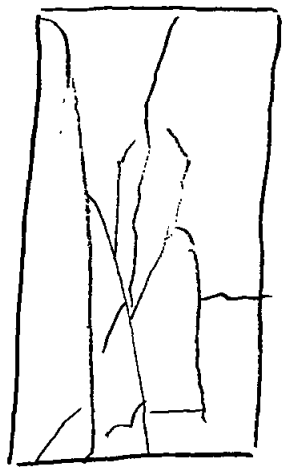
l_1	l_2
+.0008	+.0007
+.0004	+.0004
±.0001	±.0002
-.0003	-.0004
-.0007	-.0007



Avg. diameter : 2.392 Avg. length : 5.498"
Sample area : 4.494 l/d ratio : 2.30
Sample volume(in^3) : 24.707
Sample weight (g) : 1091.7g
Density : 44.19 g/in^3 = 168.3 pcf (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in.

Comments: odd "pop" in modulus test @ about 11 kips - not sure what caused the event

INTACT FAILURE - failed by axial splitting



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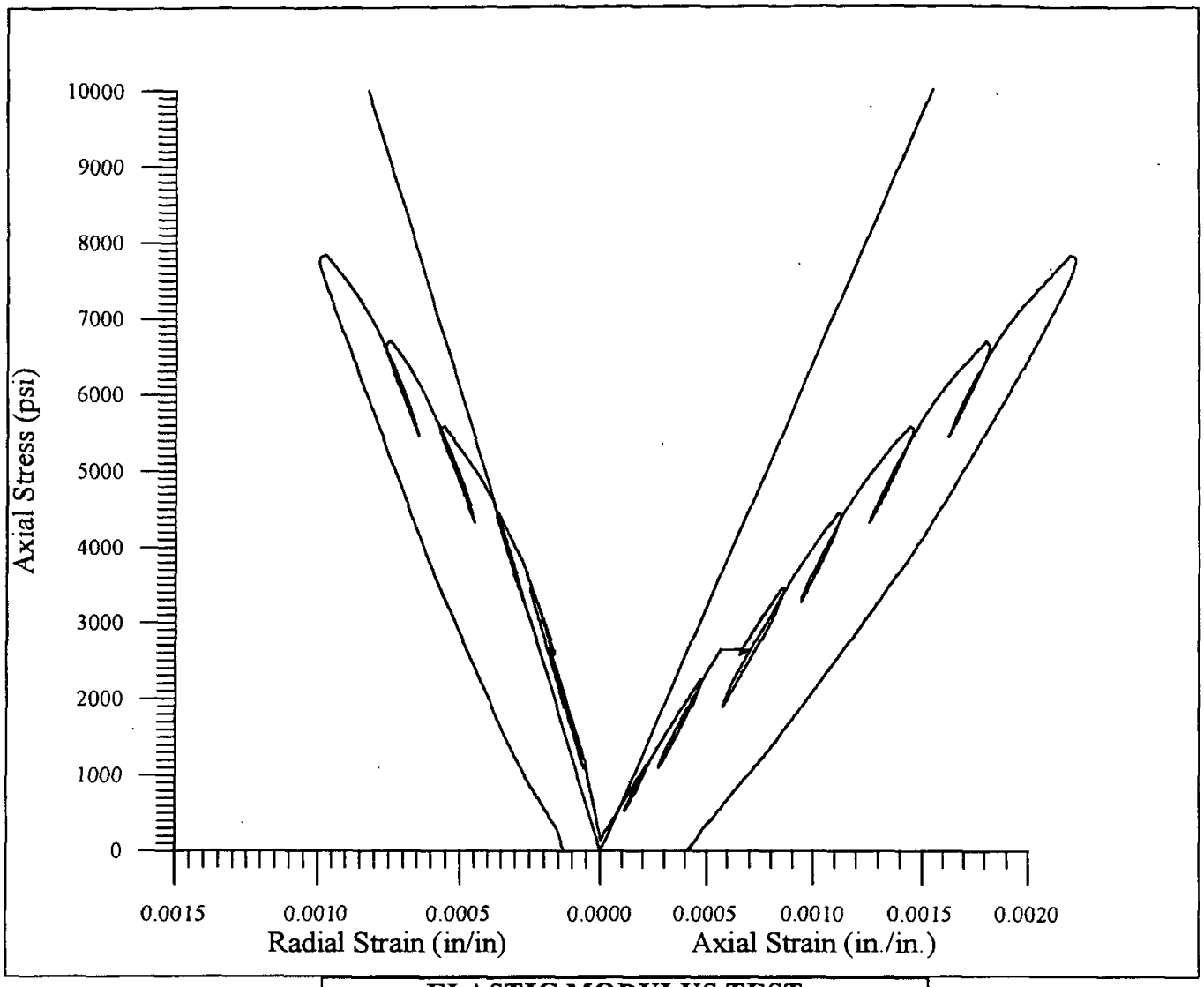


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 11A-564
Boring: 02-11A
Depth: 564.5-565.0'

DESCRIPTION
Dark gray interbedded siltstone with a few beds of medium gray fine grained sandstone with bedding about 50 degrees to the core axis.

Modulus:	**6,450,000 psi**
Poisson's ratio:	**NA (.54)**
Density:	**168.3 pcf**

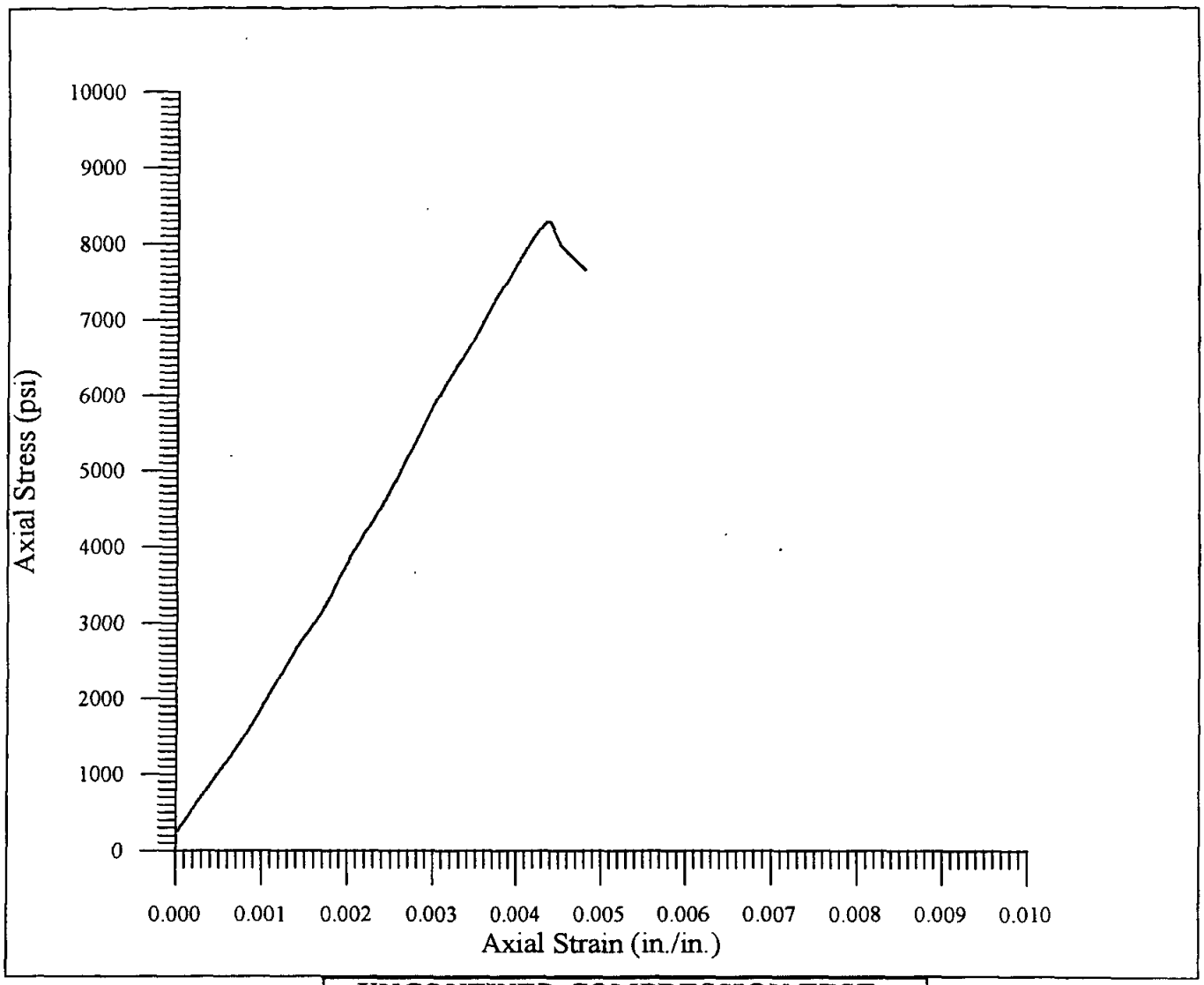
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 20, 2002



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 11A-564
Boring: 02-11A
Depth: 564.5-565.0'

DESCRIPTION

Dark gray interbedded siltstone with a few beds of medium gray fine grained sandstone with bedding about 50 degrees to the core axis.

Density: 168.3 pcf
Strength: 8278 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

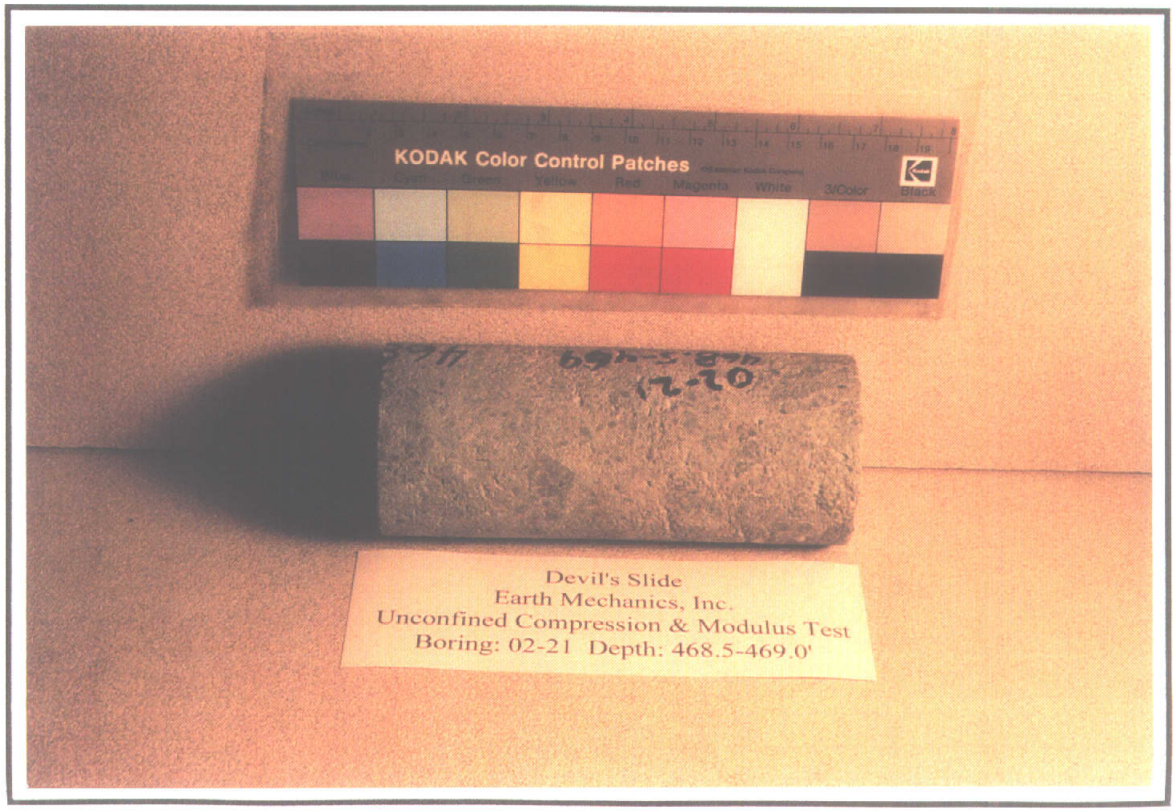
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Determination of Rock Modulus and Poisson's Ratio (ASTM D3148)

Date: 10/20 & 22/02
Technician: A. Bro

Client: ENI
Job: #151 - Devil's Slide
Sample ID: Boring 02-21
Sample Description: light green/grey altered granodiorite - appears to be heavily sheared and fractured resulting in small rounded clasts in a fine matrix.

Sample Depth: 468.5-469.0' Sample Condition: received dry - tested moist

d_1	d_2
2.405	2.405
2.405	2.402
2.400	2.403
2.402	2.400
2.401	2.396

l_1	l_2
+.0005	+.0006
+.0002	+.0004
±.0001	±.0001
-.0005	-.0003
-.0009	-.0007

Avg. diameter : 2.402 Avg. length : 5.784"
Sample area : 4.531 l/d ratio : 2.41
Sample volume(in^3) : 26.210
Sample weight (g) : 1168.1g
Density : 44.57g/in^3 = 169.8pcF (1 g/in^3=3.8095lb/ft^3)
Gauge length: 2.000 in

Comments: tested to incipient failure in modulus test

"INTACT" FAILURE - failed by shear and axial splitting

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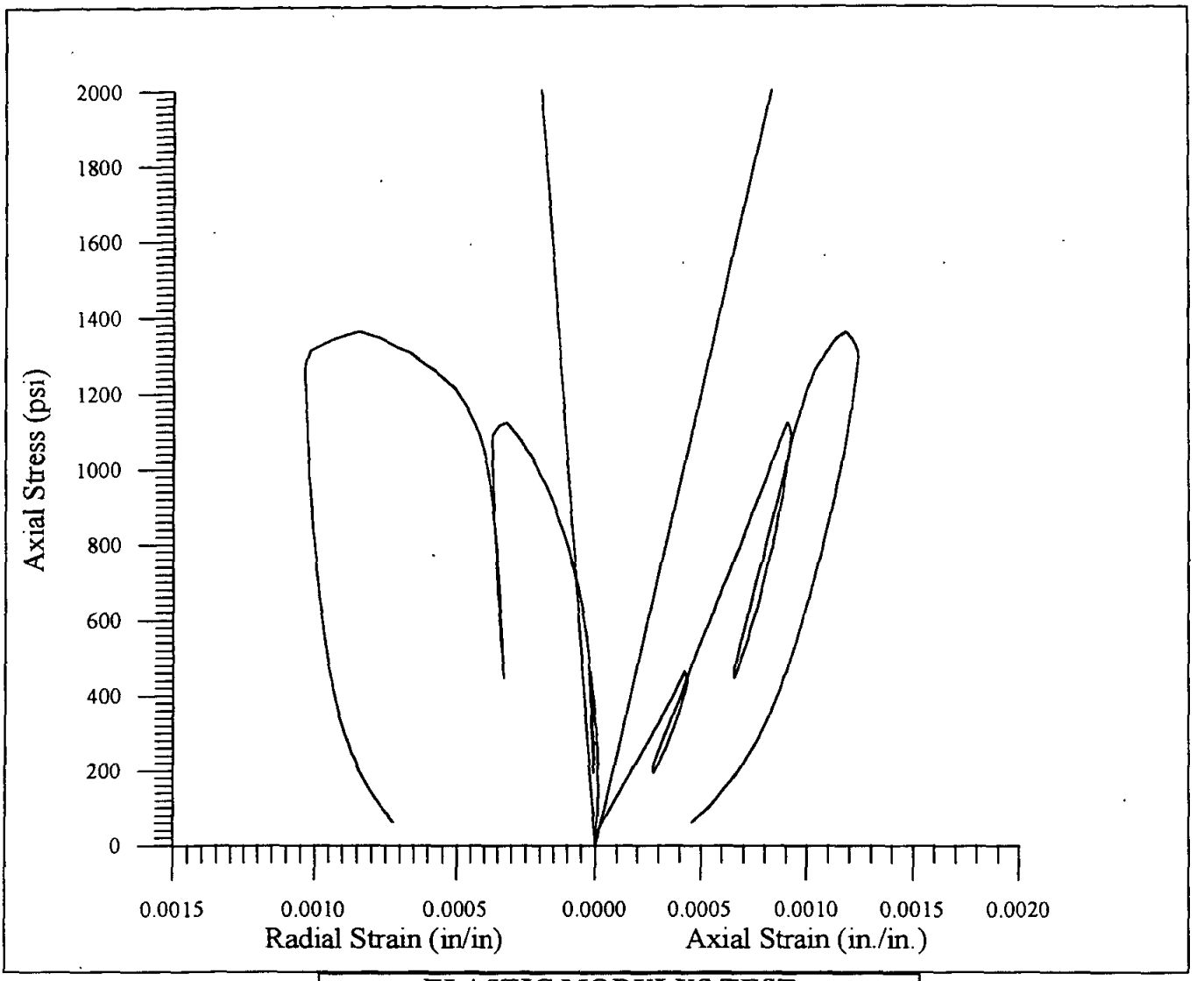


ELASTIC MODULUS TEST
Axial Stress vs. Axial & Radial Strain

Sample: 21-468
Boring: 02-21
Depth: 468.5-469.0'

DESCRIPTION
Light greenish gray altered granodiorite. It appears to be heavily sheared and recemented resulting in small rounded clasts in a fine matrix.

Modulus:	**2,410,000 psi**
Poisson's ratio:	**.24**
Density:	**169.8 pcf**

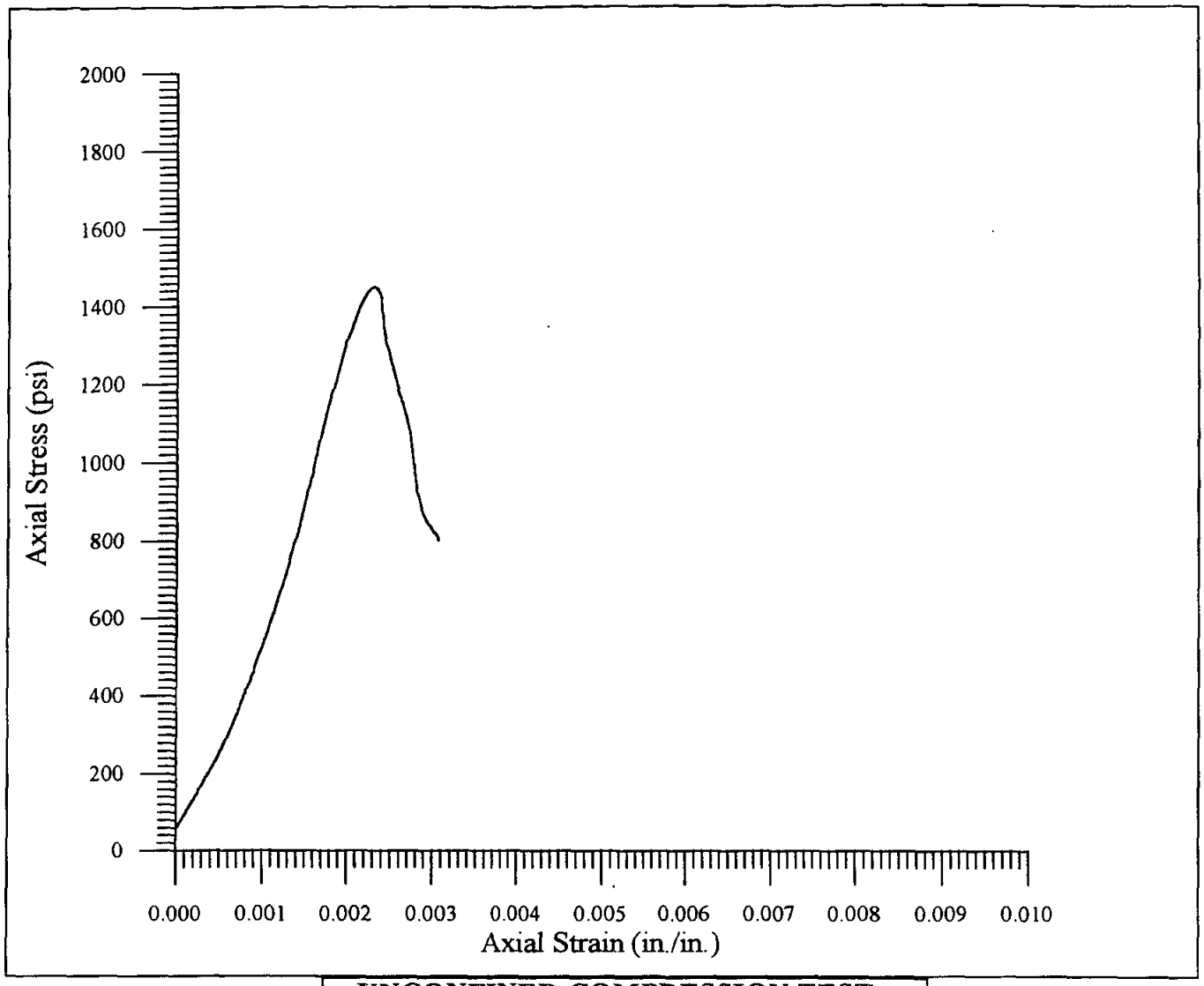
Geo Test Unlimited (GTU)
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **Earth Mechanics, Inc.**
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: **Devil's Slide**

Project Number: none

Test Date: **October 20, 2002**



UNCONFINED COMPRESSION TEST
Axial Stress vs. Strain

Sample: 21-468
Boring: 02-21
Depth: 468.5-469.0'

DESCRIPTION

Light greenish gray altered granodiorite. It appears to be heavily sheared and recemented resulting in small rounded clasts in a fine matrix.

Density: 169.8 pcf
Strength: 1450 psi
Joint Control Failure?: no

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 22, 2002

APPENDIX B

SINGLE-STAGE TRIAXIAL TESTS

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

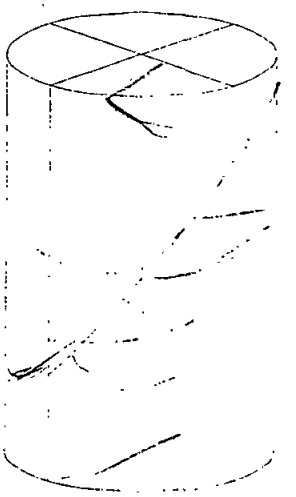
Date: 10/23/02
Technician: A. Bro

Client: EMI
Job: #151- Devil's Slide
Sample ID: Boring 02-CA
Sample Description: Gray coarse grained sandstone with several calcite healed hairline fractures.

Sample Depth: 606.0-606.5' Sample Condition: received dry - tested moist

d_1	d_2
2.404	2.404
2.405	2.403
2.403	2.403
2.404	2.404
2.404	2.403

l_1	l_2
+.0008	+.0001
+.0004	
±.0001	±.0001
-.0003	
-.00007	-.0001



Avg. diameter : 2.404
Sample area : 4.539
Sample volume(in^3) : 24.104
Sample weight (g) : 1126.6g
Density : 43.16g/in^3 = 164.4pcF (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.751
l/d ratio : 2.39

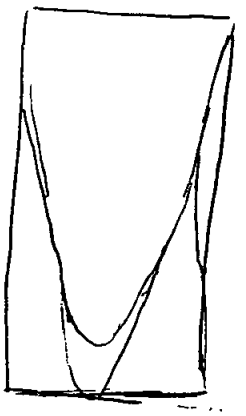
Test Confining Pressures (psi)

320		

1452# ax load => $T_1 = T_3$

Comments:

INTACT FAILURE - failed by shear



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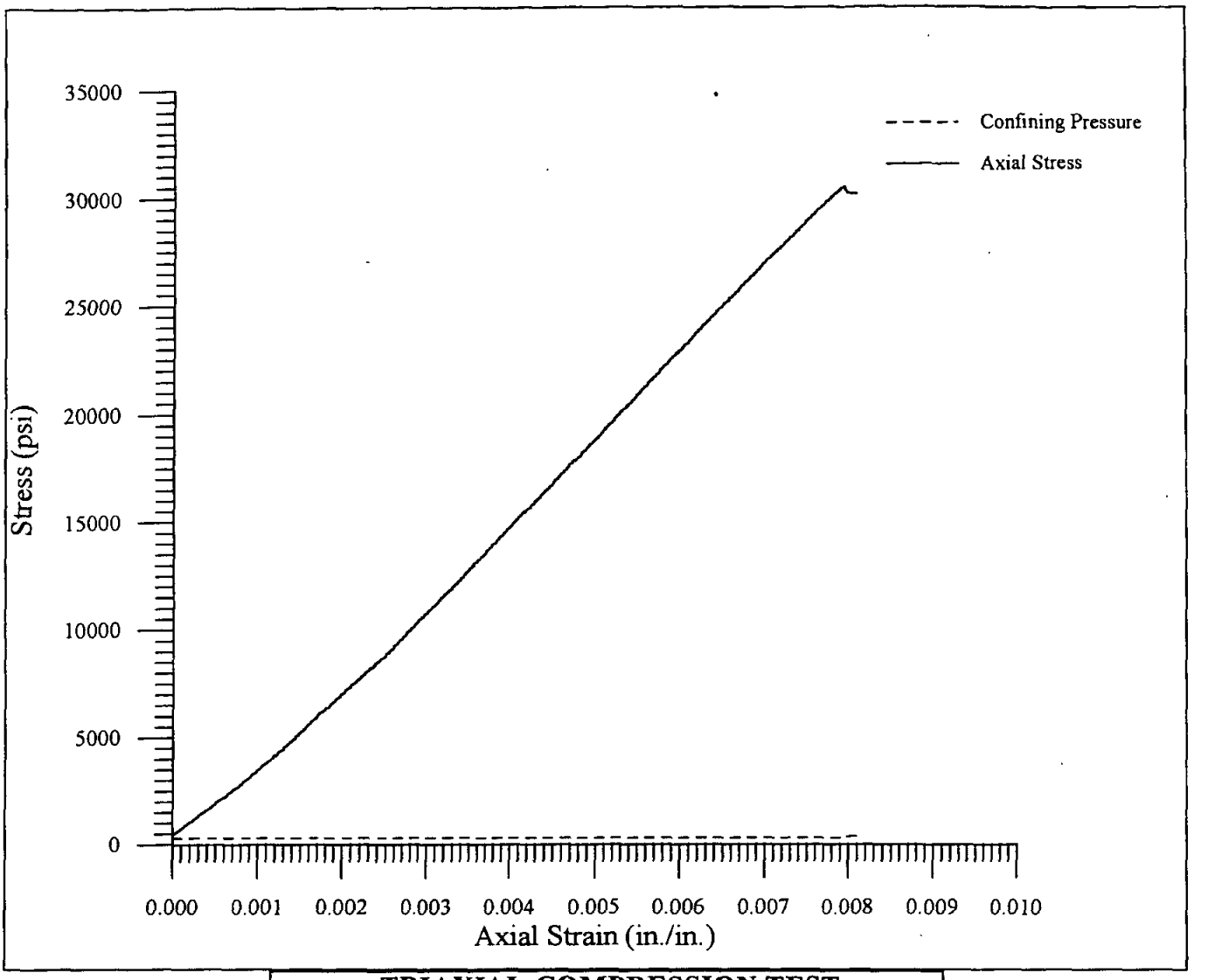


TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 6A-606
Boring: 02-6A
Depth: 606.0-606.5'
Density: 164.4 pcf

DESCRIPTION
Gray coarse grained sandstone with several calcite healed hairline fractures.

Conf. Pressure (psi)	Strength (psi)
320	30,592

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo GTU Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

Date: 10/23/02
Technician: A.Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6A
Sample Description: Gray coarse grained sandstone with calcite healed hairline fractures

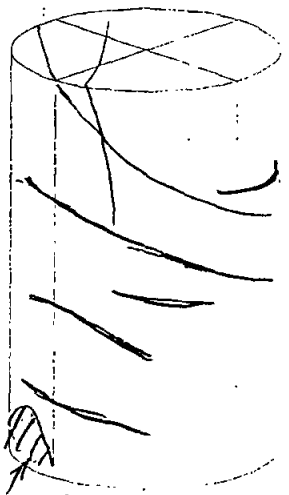
Sample Depth: 614.2-614.7' Sample Condition: received dry - tested moist

d_1	d_2
2.403	2.404
2.405	2.405
2.404	2.405
2.403	2.404
2.403	2.406

l_1	l_2
+.0008	+.0002
+.0004	+.0001
±.0001	±.0001
-.0003	-.0002
-.0006	-.0003

Avg. diameter : 2.404
Sample area : 4.539
Sample volume(in^3) : 24.025
Sample weight (g) : 1030.68
Density : 42.90 g/in^3 = 163.4 pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.293"
l/d ratio : 2.20



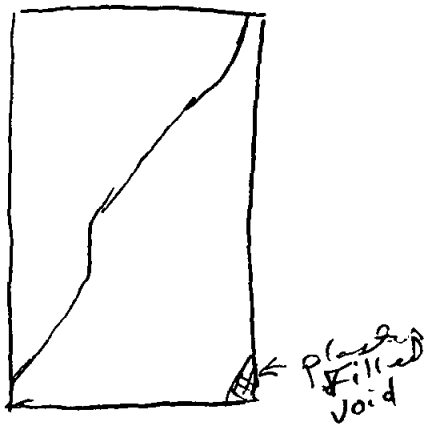
Test Confining Pressures (psi)

320		

F_{4_m} = 1453 lb

Comments:

POSSIBLY JOINT CONTROLLED? - failed by shear



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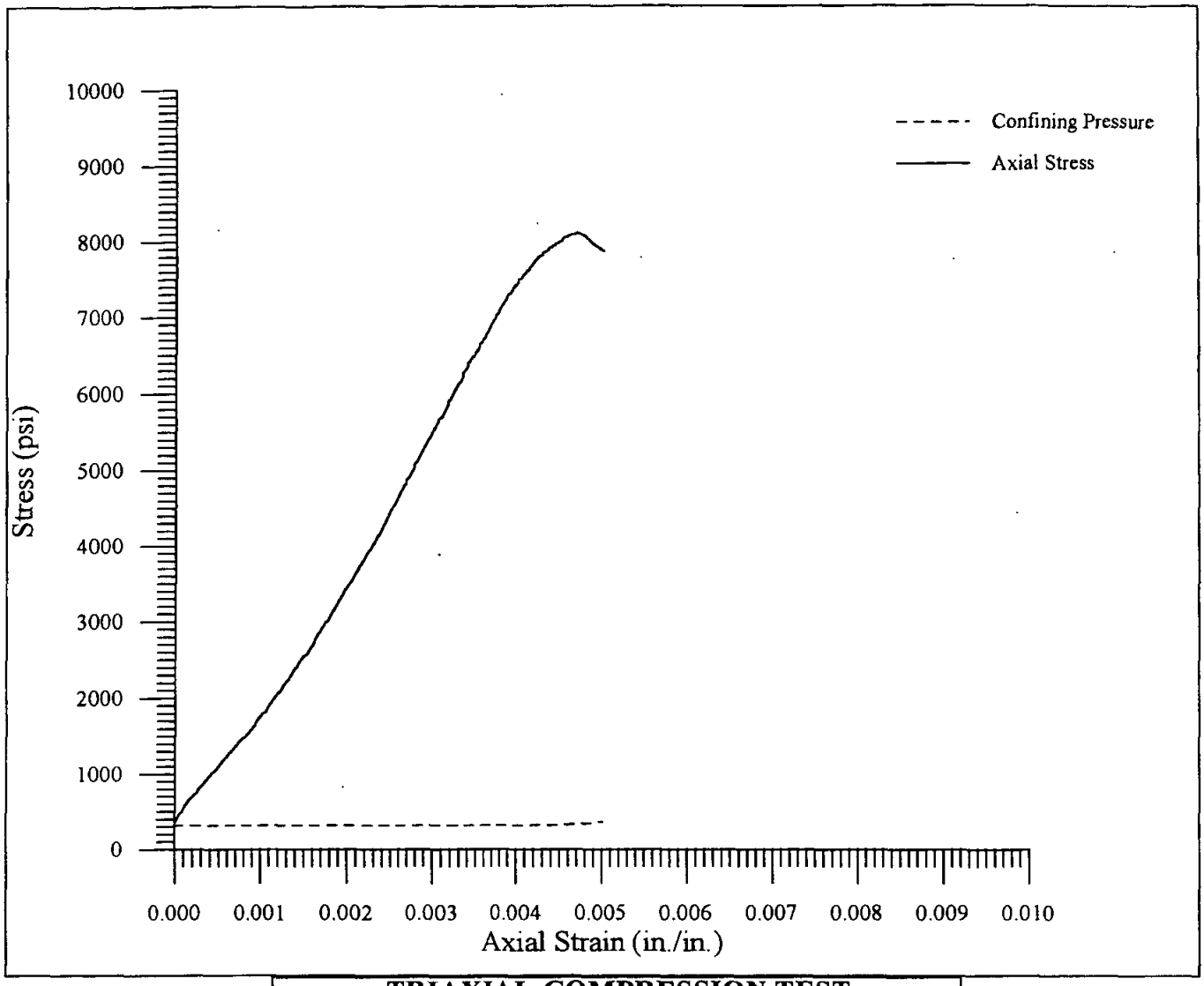


TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 6A-614
Boring: 02-6A
Depth: 614.2-614.7'
Density: 163.4 pcf

DESCRIPTION
Gray coarse grained sandstone with calcite healed hairline fractures.

Conf. Pressure (psi)	Strength (psi)
333	8127

Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo GTU Test Unlimited

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

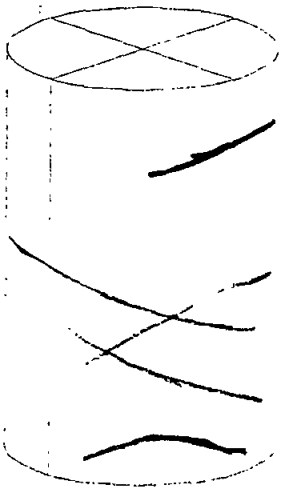
Date: 10/23/02
Technician: A.Bro

Client: EMI
Job: #151-Devils Slide
Sample ID: Boring 02-6A
Sample Description: Gray coarse grained sandstone with a few calcite healed hairline fractures.

Sample Depth: 622.0-622.5' Sample Condition: received dry - tested moist

d_1	d_2
2.404	2.403
2.404	2.404
2.404	2.403
2.403	2.404
2.403	2.402

l_1	l_2
+.0009	+.0006
+.0004	+.0006
±.0001	±.0002
-.0003	-.0002
-.0007	-.0004



Avg. diameter : 2.403
Sample area : 4.535
Sample volume(in^3) : 25.674
Sample weight (g) : 1106.9g
Density : 43.11g/in^3 = 164.2pcf (1 g/in^3=3.8095lb/ft^3)

Avg. length : 5.661"
l/d ratio : 2.36

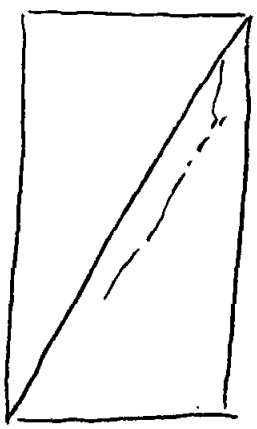
Test Confining Pressures (psi)

320		

F_{Ax} = 1451lb

Comments:

INTACT FAILURE - Failed by diagonal shear



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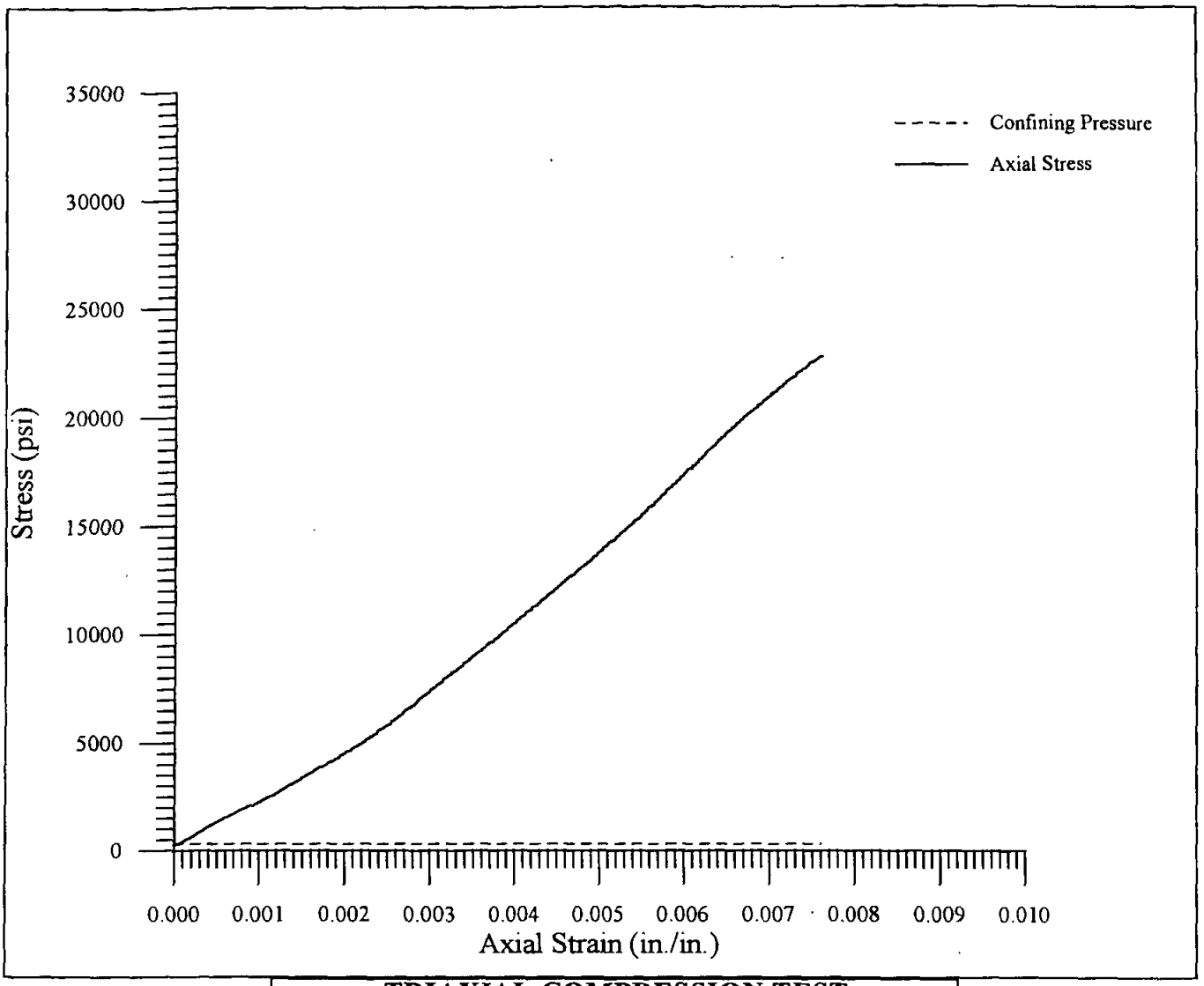


TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 6A-626
Boring: 02-6A
Depth: 626.0-626.5'
Density: 164.2 pcf

DESCRIPTION
Gray coarse grained sandstone with a few calcite healed hairline fractures.

Conf. Pressure (psi)	Strength (psi)
320	23,231

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

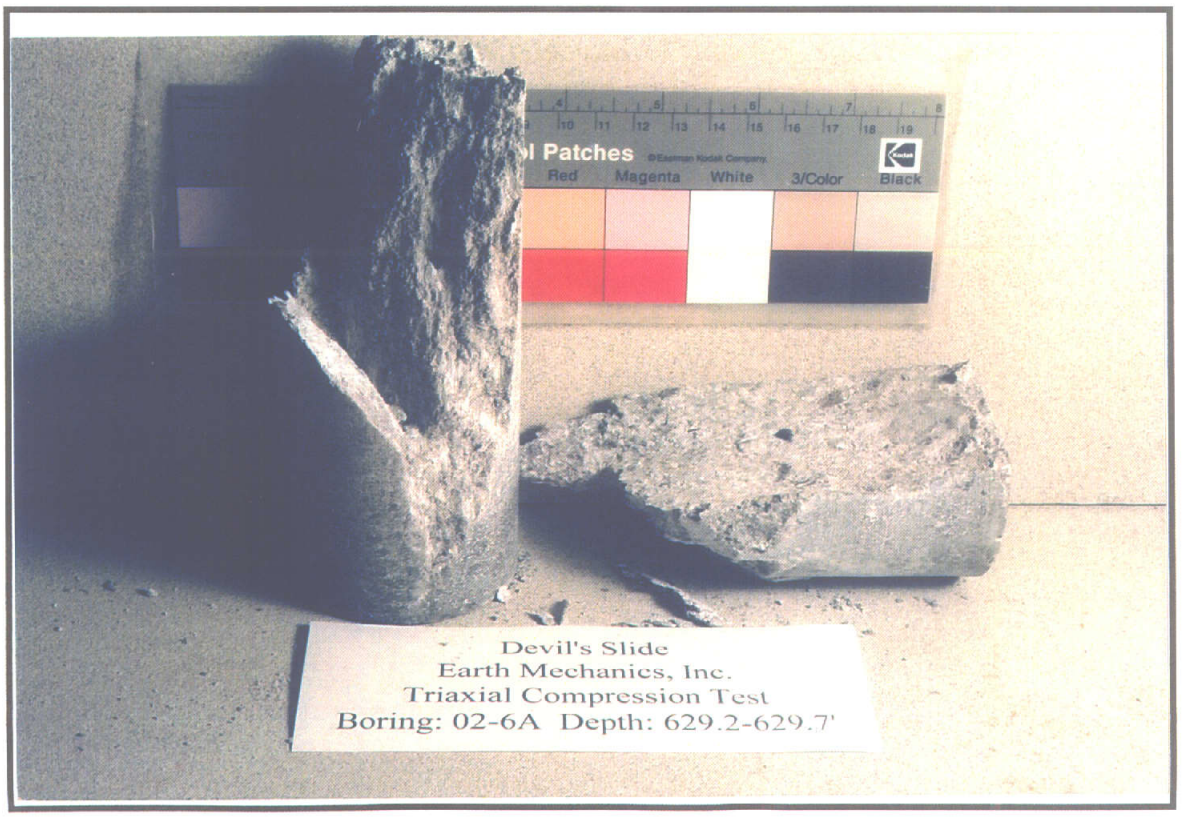
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

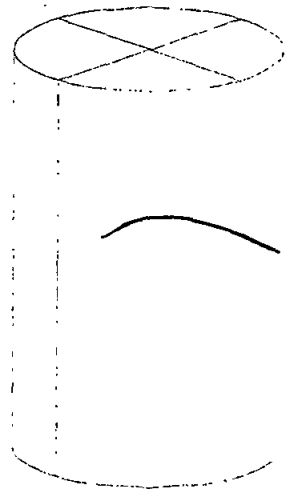
Date: 10/23/02
Technician: A. Bro

Client: ENI
Job: #151 - Devil's Slide
Sample ID: Boring 02-6A
Sample Description: Gray coarse grained sandstone with one calcite healed hairline fracture.

Sample Depth: 629.2 - 629.7' Sample Condition: received dry - tested moist

d_1	d_2
2.405	2.405
2.405	2.405
2.405	2.405
2.406	2.405
2.405	2.404

l_1	l_2
+.0008	0
+.0004	
±.0001	±.0001
-.0004	
-.0008	0



Avg. diameter : 2.405 Avg. length : 5.855"
Sample area : 4.543 l/d ratio : 2.43
Sample volume(in^3) : 26.598
Sample weight (g) : 1148.4 g
Density : 43.18 g/in^3 = 164.5 pcf (1 g/in^3=3.8095lb/ft^3)

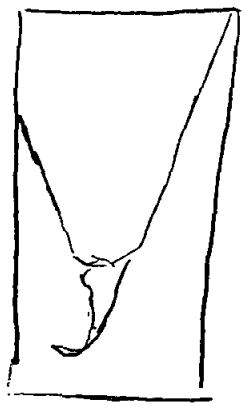
Test Confining Pressures (psi)

320		

F_{Av} = 1453 lb

Comments:

INTACT FAILURE - failed by shear



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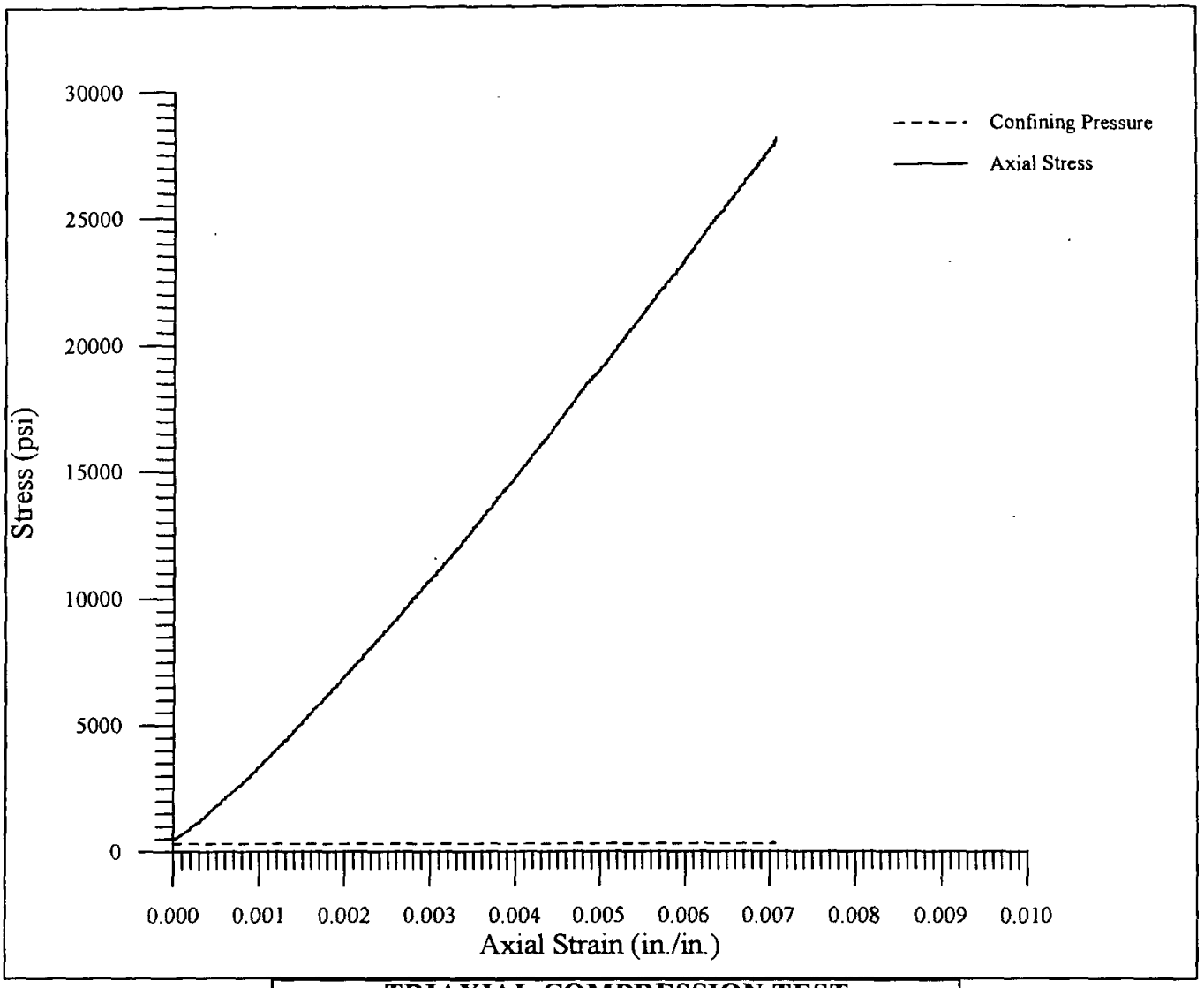


TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 6A-629
Boring: 02-6A
Depth: 629.2-629.7'
Density: 164.5 pcf

DESCRIPTION
Gray coarse grained sandstone with one calcite healed hairline fracture.

Conf. Pressure (psi)	Strength (psi)
328	28,147

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

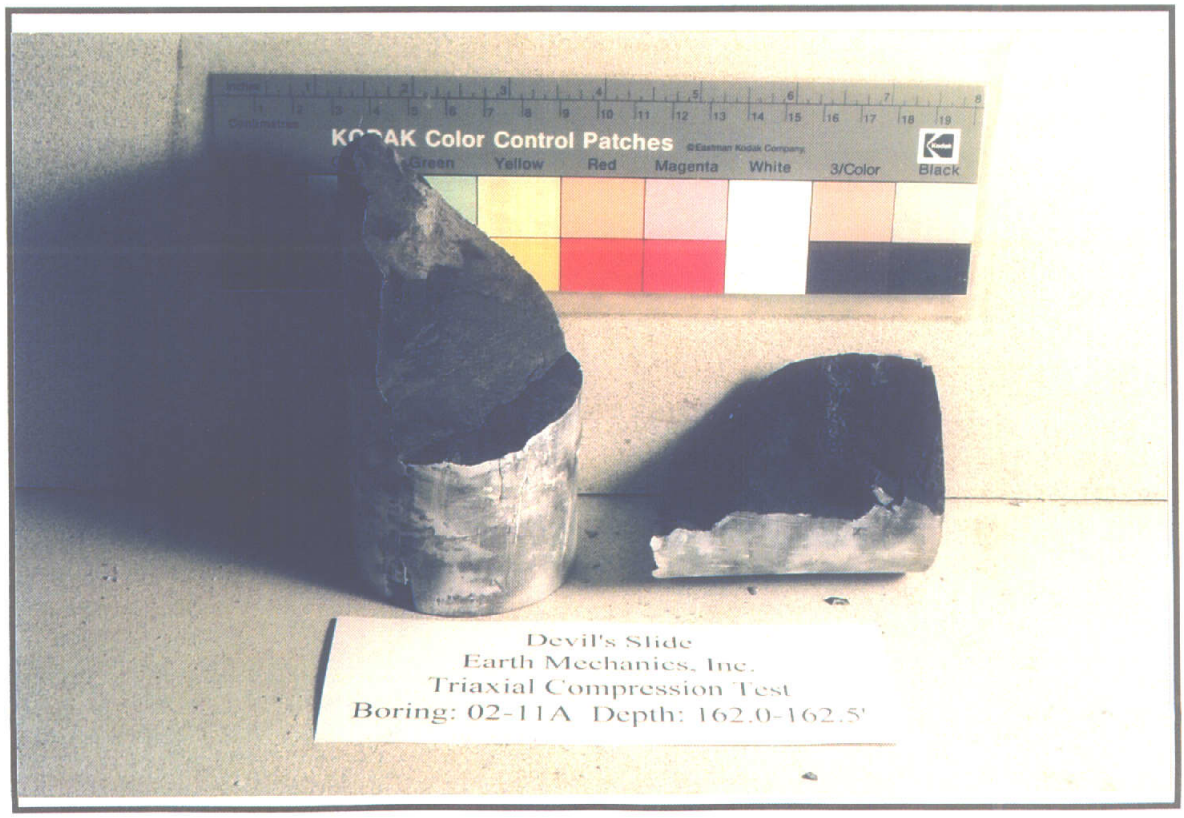
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

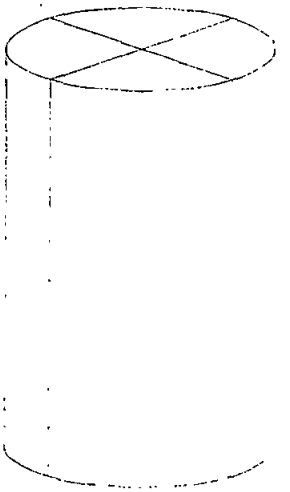
Date: 10/23/02
Technician: A Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray shale with a few medium gray fine sandstone interbeds with several fractures. Those on the ends are strengthened with CA glue.

Sample Depth: 162.0-162.5 Sample Condition: received & tested moist

d_1	d_2
2.402	2.391
2.402	2.401
2.407	2.402
2.403	2.404
2.402	2.403

l_1	l_2
+.0032	+.0035
+.0019	+.0014
±.0002	±.0002
-.0012	-.0017
-.0032	-.0033



Avg. diameter : 2.402 Avg. length : 4.826
Sample area : 4.531 l/d ratio : 2.01
Sample volume(in^3) : 21.869
Sample weight (g) : 938.8 g.
Density : 42.93 g/in^3 = 163.5 pcf (1 g/in^3=3.8095lb/ft^3)

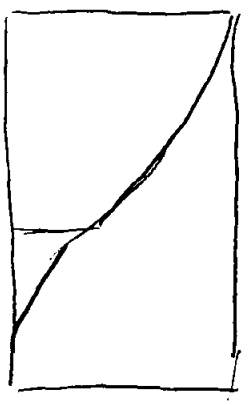
Test Confining Pressures (psi)

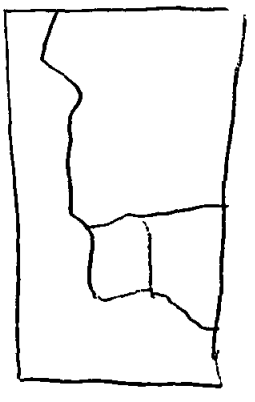
100		

453 = F_{AF}

Comments:

JOINT CONTROLLED FAILURE? Failed by shear and axial splitting.





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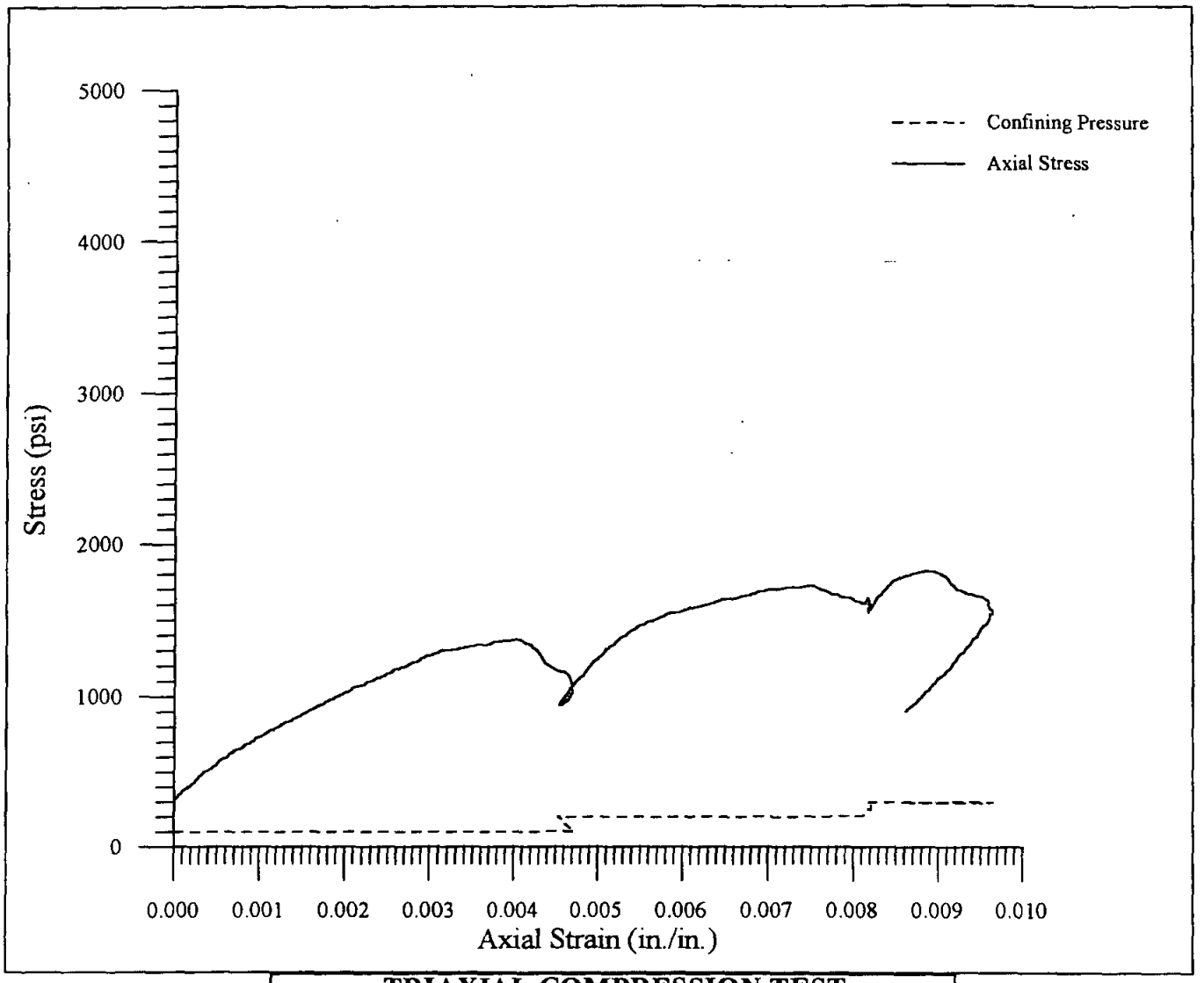


TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 11A-162
Boring: 02-11A
Depth: 162.0-162.5'
Density: 163.5 pcf

DESCRIPTION
Dark gray shale with a few medium gray fine sandstone interbeds with several fractures.

Conf. Pressure (psi)	Strength (psi)
100	1373
203	1727
301	1827

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

Date: 10/23/02
Technician: A. Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray shale with a few axial fractures

Sample Depth: 290.9-291.4' Sample Condition: received & tested in unit

d_1	d_2
2.393	2.395
2.383	2.393
↓	2.392
	2.392
	2.391

l_1	l_2
+.0002	+.0003
+.0002	+.0005
±.0001	±.0002
-.0002	-.0006
-.0005	-.0014

Avg. diameter : 2.393 Avg. length : 5.399"
Sample area : 4.498 l/d ratio : 2.26
Sample volume(in^3) : 24.282
Sample weight (g) : 1068.9g
Density : 44.02g/in^3 = 167.7pcf (1 g/in^3=3.8095lb/ft^3)

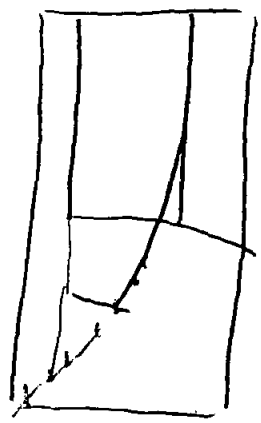
Test Confining Pressures (psi)

100		

450 = Eaf.

Comments:

JOINT CONTROLLED FAILURE - failed by axial splitting and shear along bedding



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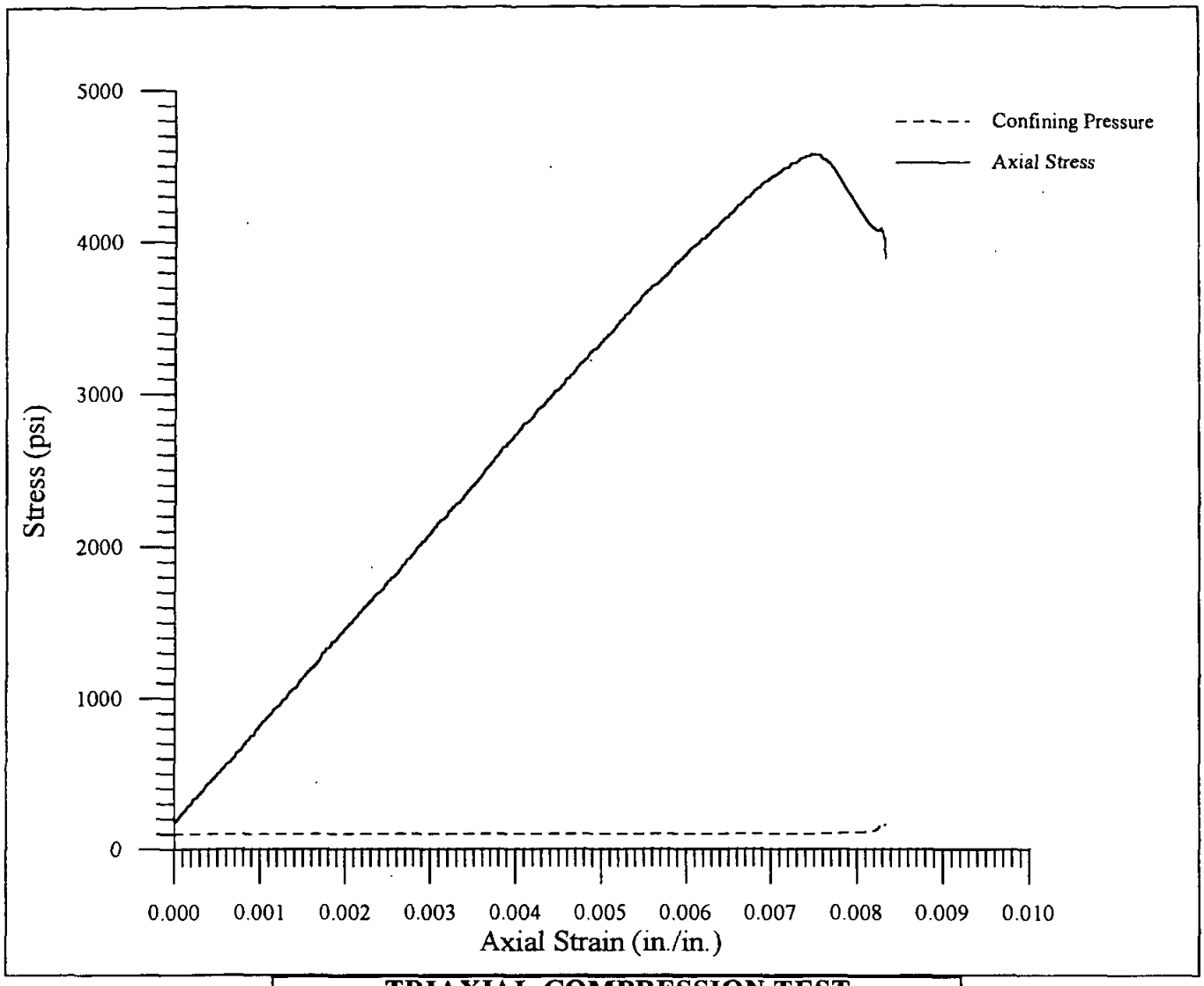


TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 11A-290
Boring: 02-11A
Depth: 290.9-291.4'
Density: 167.7 pcf

DESCRIPTION
Dark gray shale with a few axial fractures.

Conf. Pressure (psi)	Strength (psi)
102	4576

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

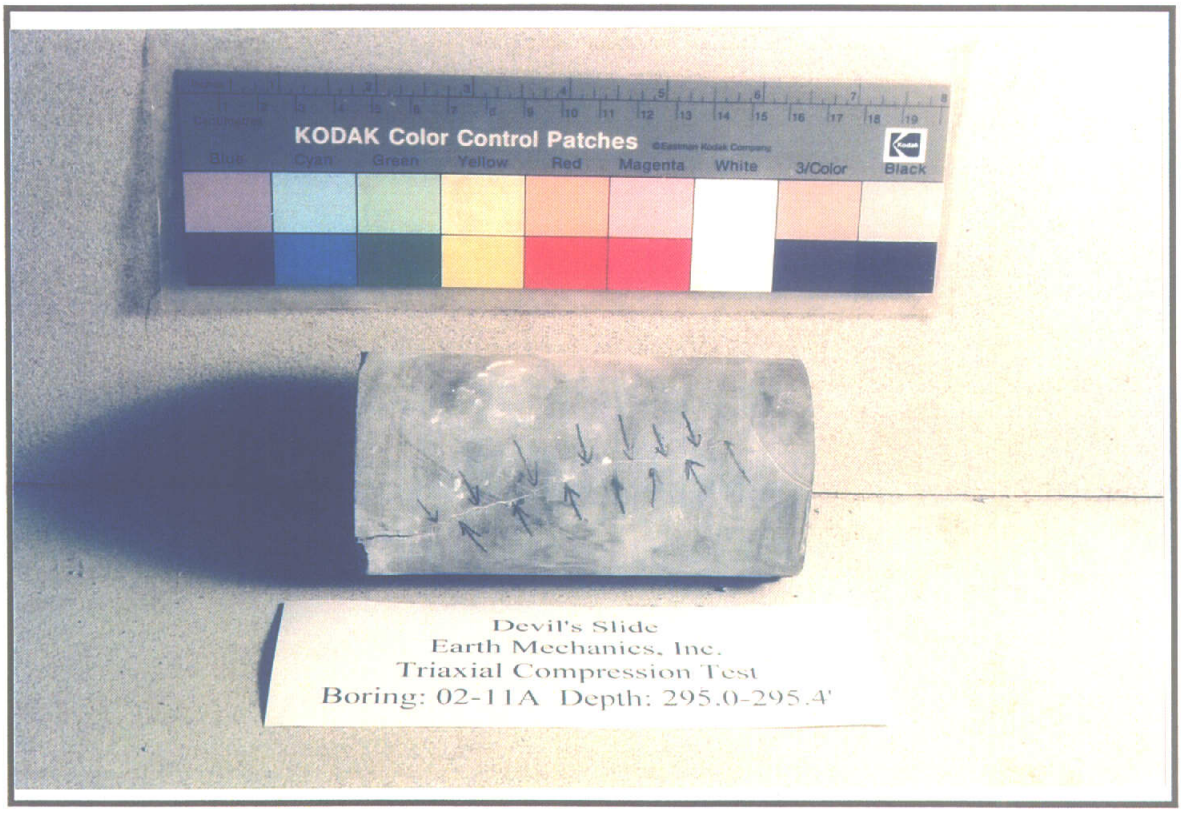
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

Date: 10/23/02
Technician: A. Bro

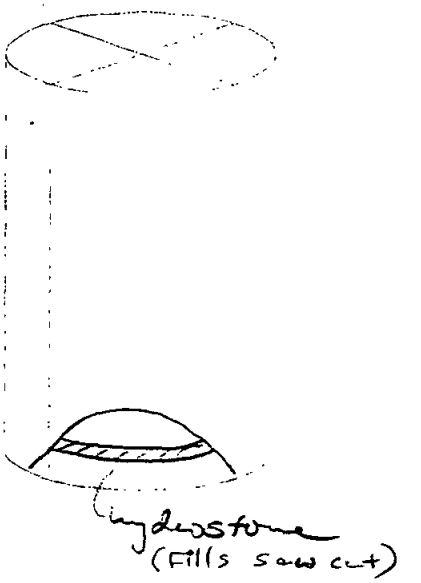
Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray interbedded shale and siltstone - chip on end "repaired" with hydrostone

Sample Depth: 295.0-295.4 Sample Condition: received & tested moist

d_1	d_2
2.394	2.394
2.394	2.394
2.394	2.393
2.395	2.397
2.394	2.397

l_1	l_2
+.0012	+.0040
+.0007	+.0021
±.0002	±.0002
-.0011	-.0017
-.0028	-.0045

Avg. diameter : 2.395 Avg. length : 4.573"
Sample area : 4.505 l/d ratio : 1.91
Sample volume(in^3) : 20.602
Sample weight (g) : 903.5g
Density : 43.86g/in^3 = 167.1pcF (1 g/in^3=3.8095lb/ft^3)



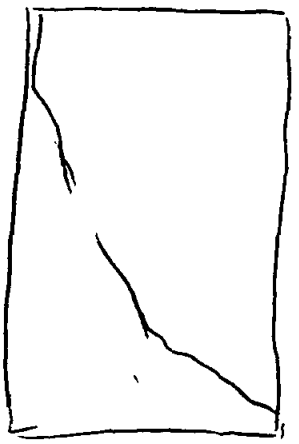
Test Confining Pressures (psi)

100		

450 = Fax

Comments:

INTACT ROCK FAILURE - failed by shear



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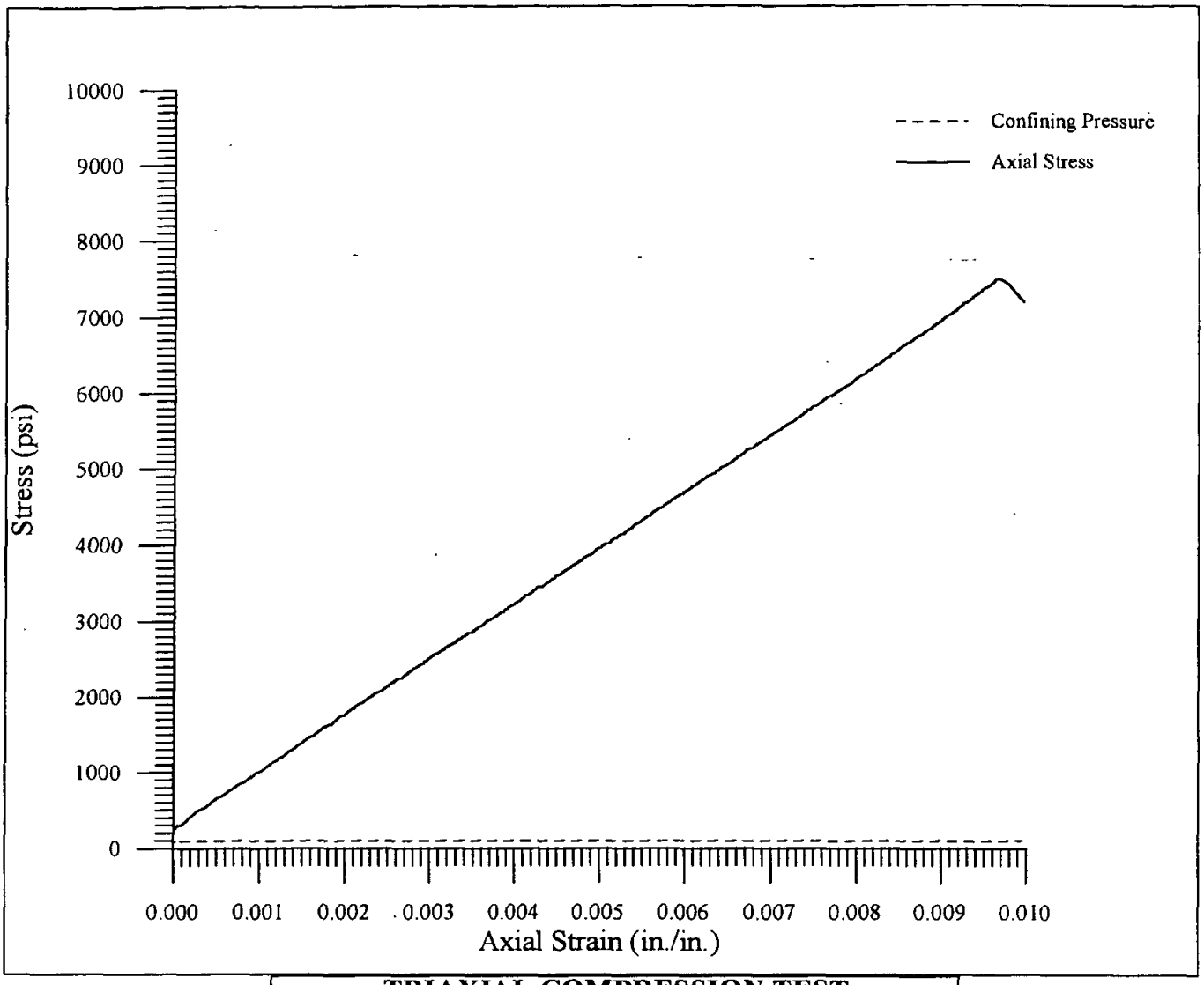


TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 11A-295
Boring: 02-11A
Depth: 295.0-295.4'
Density: 167.1 pcf

DESCRIPTION
Dark gray interbedded shale and siltstone.

Conf. Pressure (psi)	Strength (psi)
100	7513

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

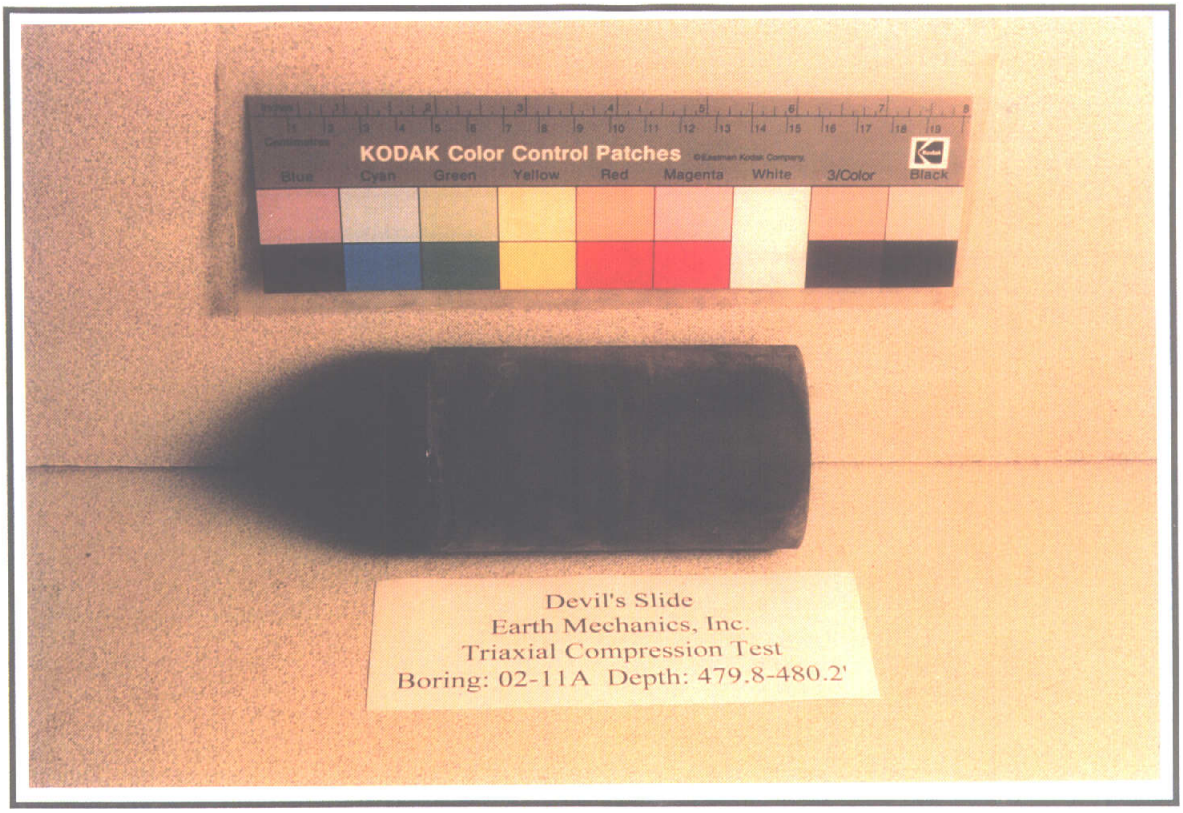
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

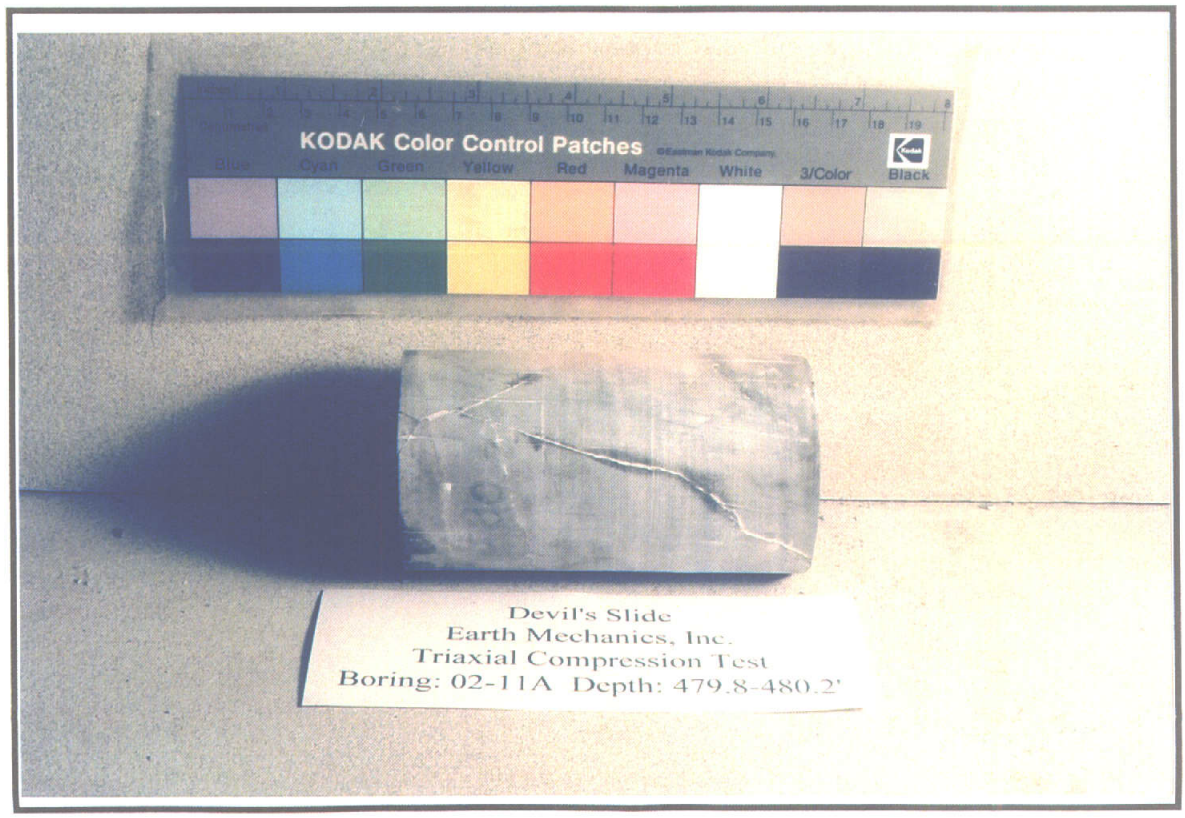
Project: Devil's Slide

Project Number: none

Test Date: October 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION





Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

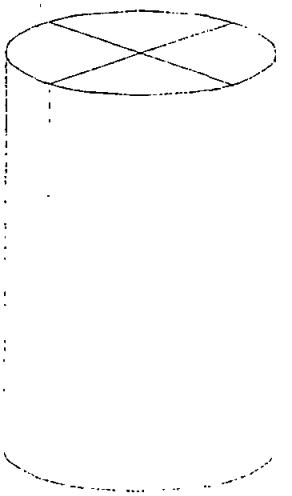
Date: 10/23/02
Technician: A. Bro

Client: E and E
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray & medium gray interbedded claystone and siltstone (shale?)

Sample Depth: 479.8-480.2' Sample Condition: received & tested moist

d_1	d_2
2.393	2.393
2.395	2.393
2.395	2.395
2.393	2.394
2.394	2.391

l_1	l_2
+.0032	+.0011
+.0015	+.0004
±.0002	±.0002
-.0017	-.0003
-.0023	-.0007



Avg. diameter : 2.394 Avg. length : 4.233
Sample area : 4.501 l/d ratio : 1.77
Sample volume(in^3) : 19.054
Sample weight (g) : 831.6g
Density : 43.64g/in^3 = 166.3 pcF (1 g/in^3=3.8095lb/ft^3)

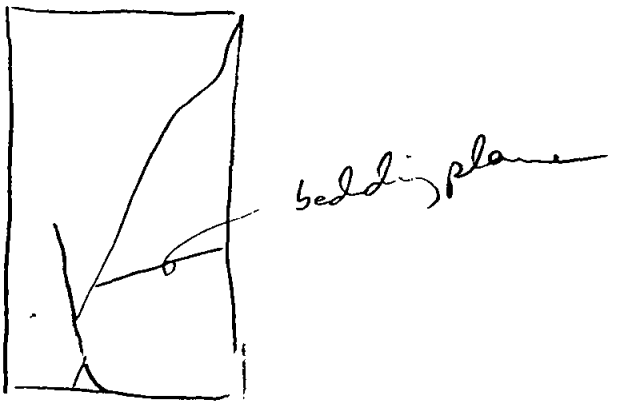
Test Confining Pressures (psi)

200		

900 = Fail

Comments:

INTACT ROCK FAILURE? - failed by shear



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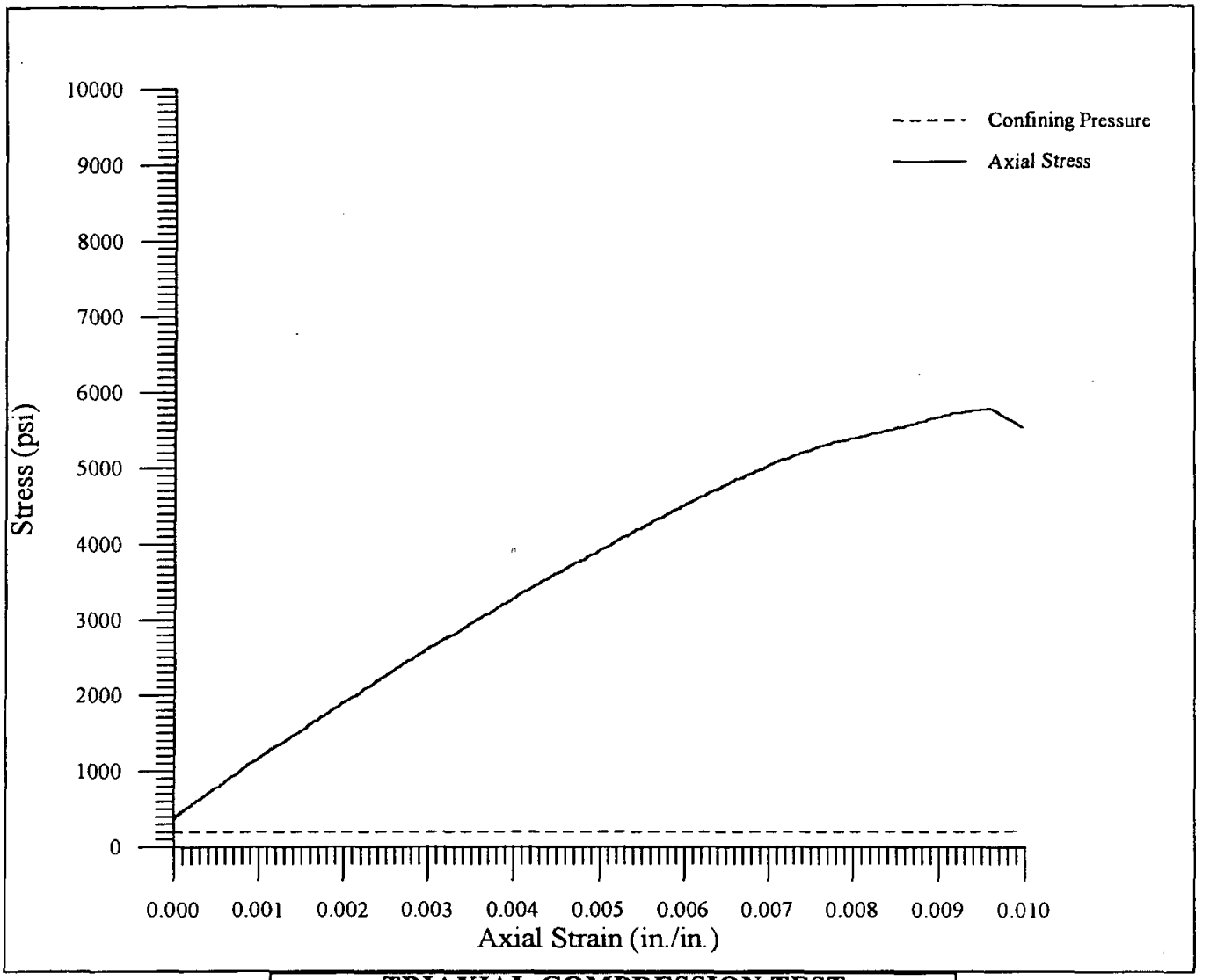


TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 11A-479
Boring: 02-11A
Depth: 479.8-480.2'
Density: 166.3 pcf

DESCRIPTION
Dark gray shale interbedded with medium gray siltstone.

Conf. Pressure (psi)	*Strength* (psi)
206	5779

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

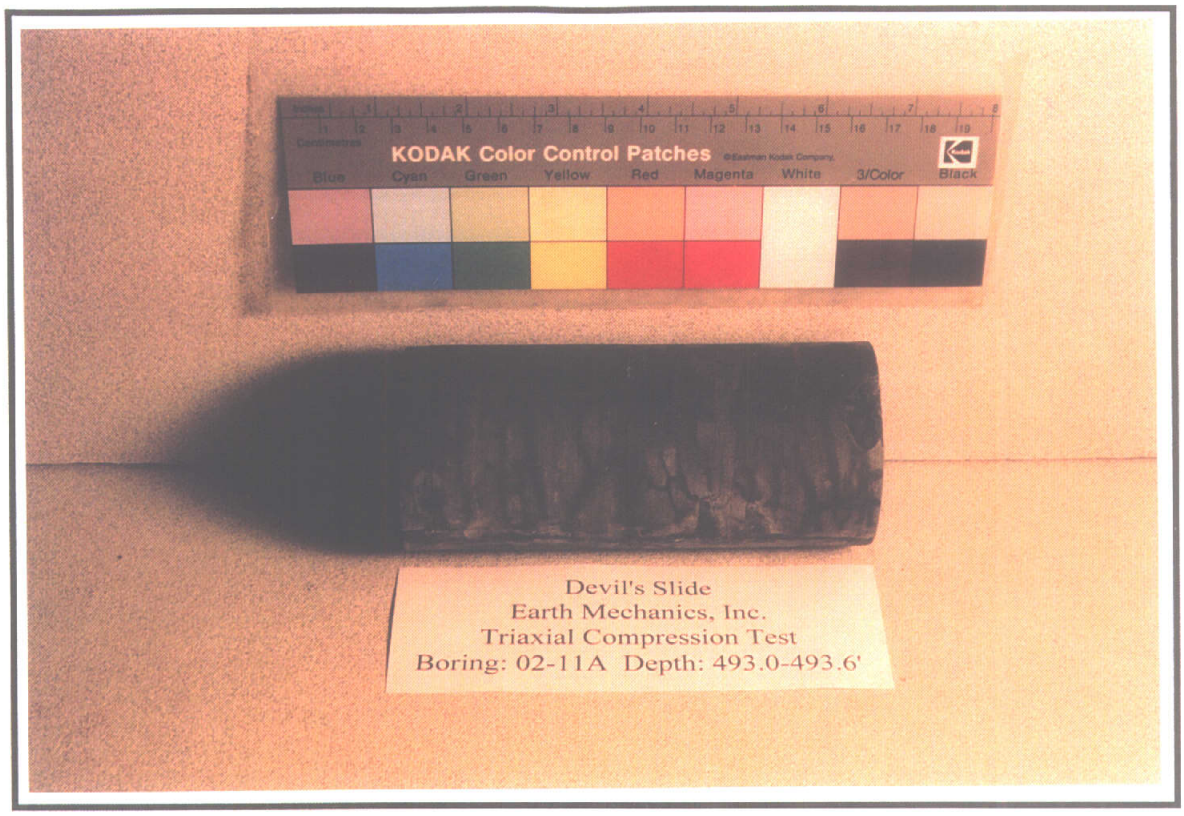
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

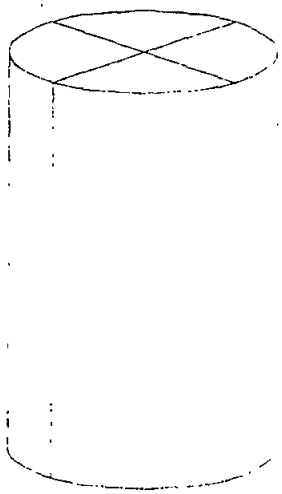
Date: 10/23/02
Technician: A. Bro

Client: EMS
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray highly Fractured shale - several fractures healed with CA glue.

Sample Depth: 493.0 - 493.6' Sample Condition: received & tested moist

d_1	d_2
2.404	2.394
2.402	2.400
2.402	2.399
2.399	2.400
2.399	2.396

l_1	l_2
+.0048	+.0055
+.0021	+.0026
±.0002	±.0002
-.0008	-.0005
-.0005	-.0010



Avg. diameter : 2.400 Avg. length : 5.366
Sample area : 4.524 l/d ratio : 2.24
Sample volume(in^3) : 24.275
Sample weight (g) : 1042.78
Density : 42.95 g/in^3 = 163.6 pcf (1 g/in^3=3.8095lb/ft^3)

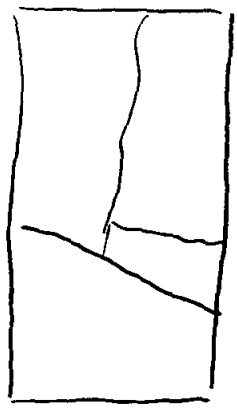
Test Confining Pressures (psi)

200		

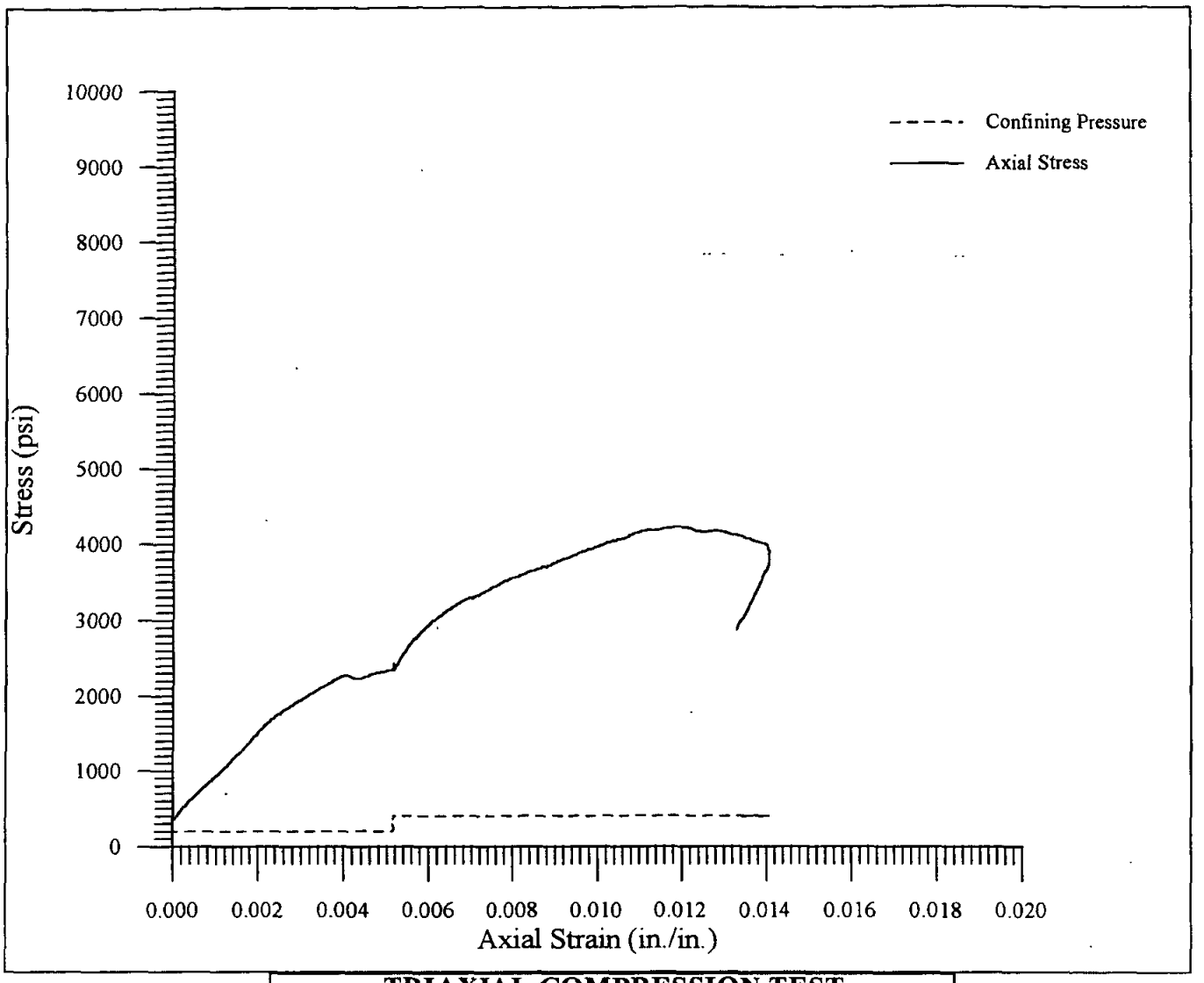
904 = Fax

Comments:

JOINT CONTROLLED FAILURE - Failed by axial splitting & shear



27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@saber.net



TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 11A-493
Boring: 02-11A
Depth: 493.0-493.6'
Density: 163.6 pcf

DESCRIPTION
Dark gray highly fractured shale.

Conf. Pressure (psi)	Strength (psi)
201	2276
411	4226

Geo Test G T U *Unlimited*

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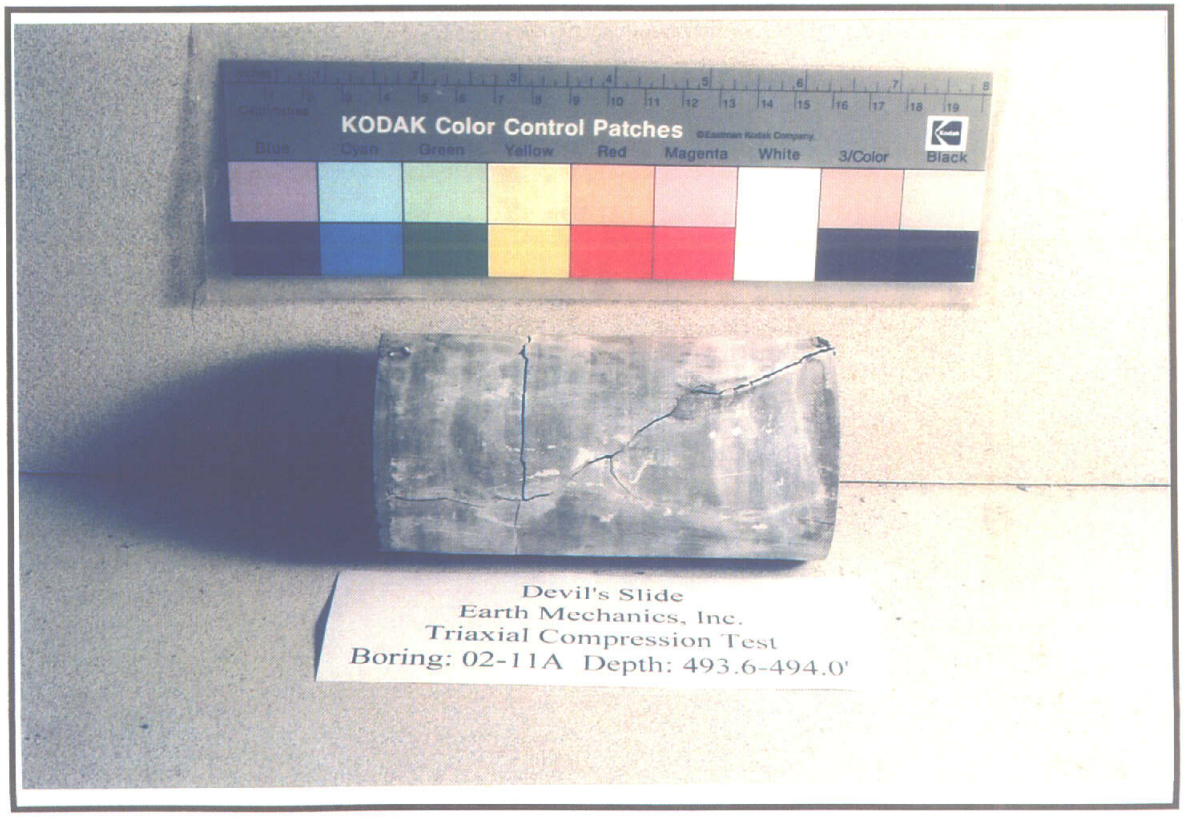
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

DATA SHEET
Triaxial Compression Test of Rock (ASTM D2664)

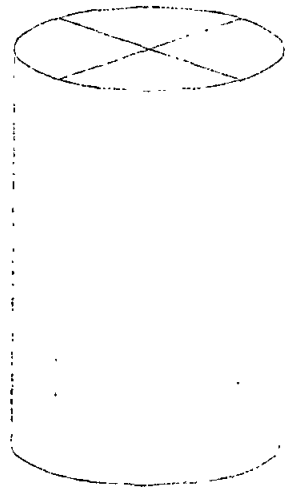
Date: 10/23/02
Technician: A.Bro

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11A
Sample Description: Dark gray interbedded shale with medium gray siltstone with sedimental fractures.

Sample Depth: 493.6-494.0' Sample Condition: received & tested moist

d_1	d_2
2.396	2.388
2.395	2.390
2.391	2.393
2.394	2.390
2.393	2.393

l_1	l_2
+.0009	+.0003
+.0005	+.0001
±.0001	±.0002
-.0003	-.0003
-.0008	-.0002



Avg. diameter : 2.393 Avg. length : 4.687
Sample area : 4.498 l/d ratio : 1.96
Sample volume(in^3) : 21.080
Sample weight (g) : 912.6g
Density : 43.29 g/in^3 = 164.9 pcf (1 g/in^3=3.8095lb/ft^3)

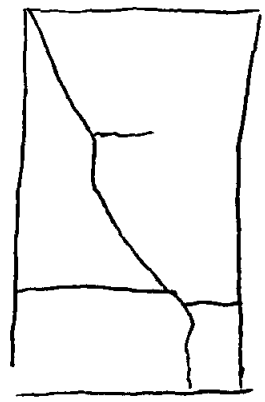
Test Confining Pressures (psi)

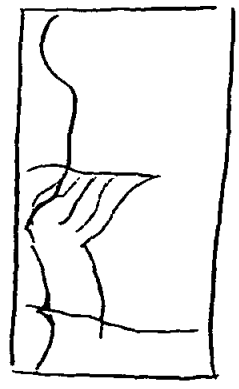
200		

900 = Fail

Comments:

INTACT FAILURE? - failed by shear





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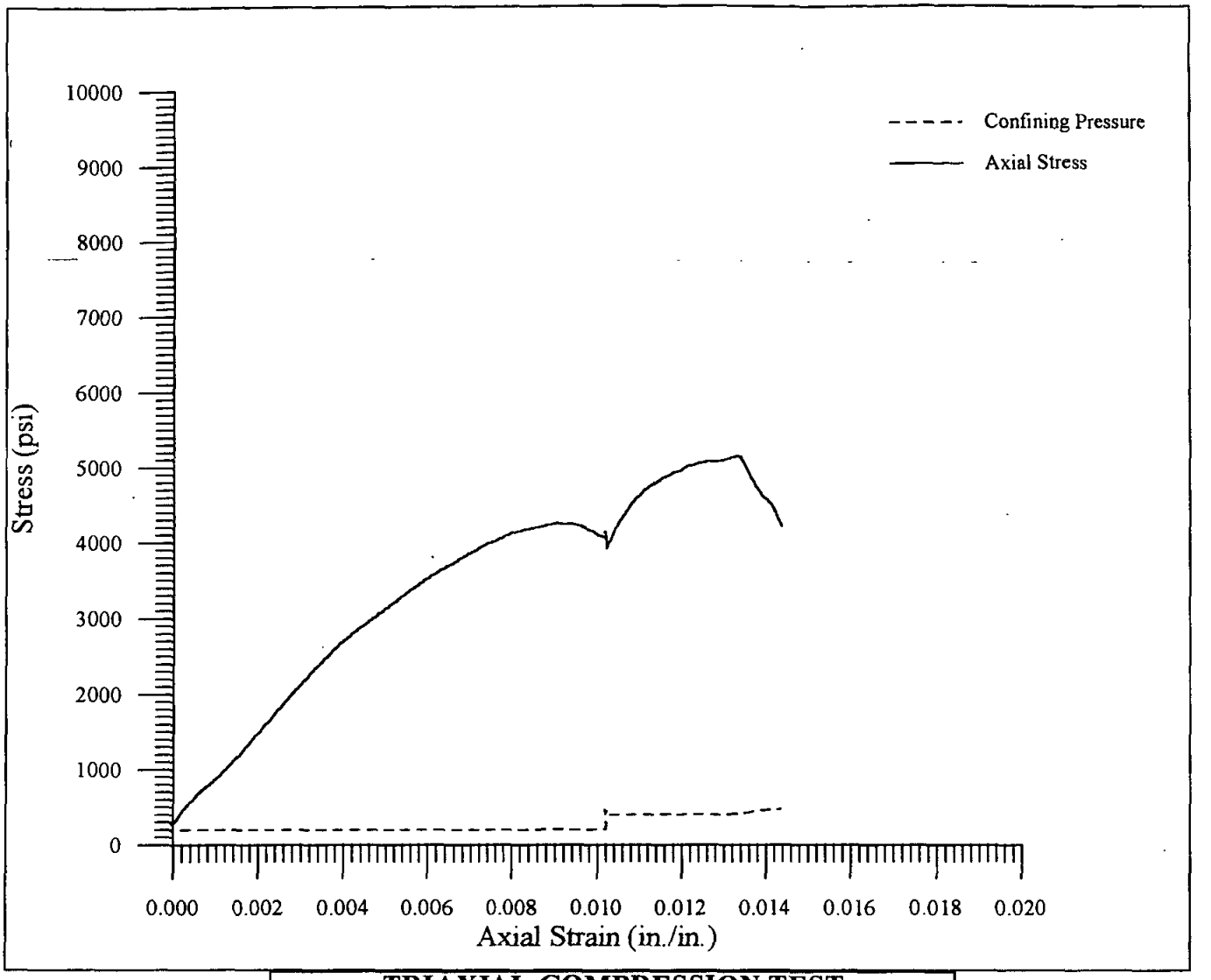

TRIAXIAL COMPRESSION TEST
Axial Stress & Confining Pressure vs. Axial Strain

Sample: 11A-493B
Boring: 02-11A
Depth: 493.6-494.0'
Density: 164.9 pcf

DESCRIPTION
Interbedded dark gray shale and medium gray siltstone with several fractures.

Conf. Pressure (psi)	Strength (psi)
206	4265
414	5160

Geo Test GTU *Unlimited*

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Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

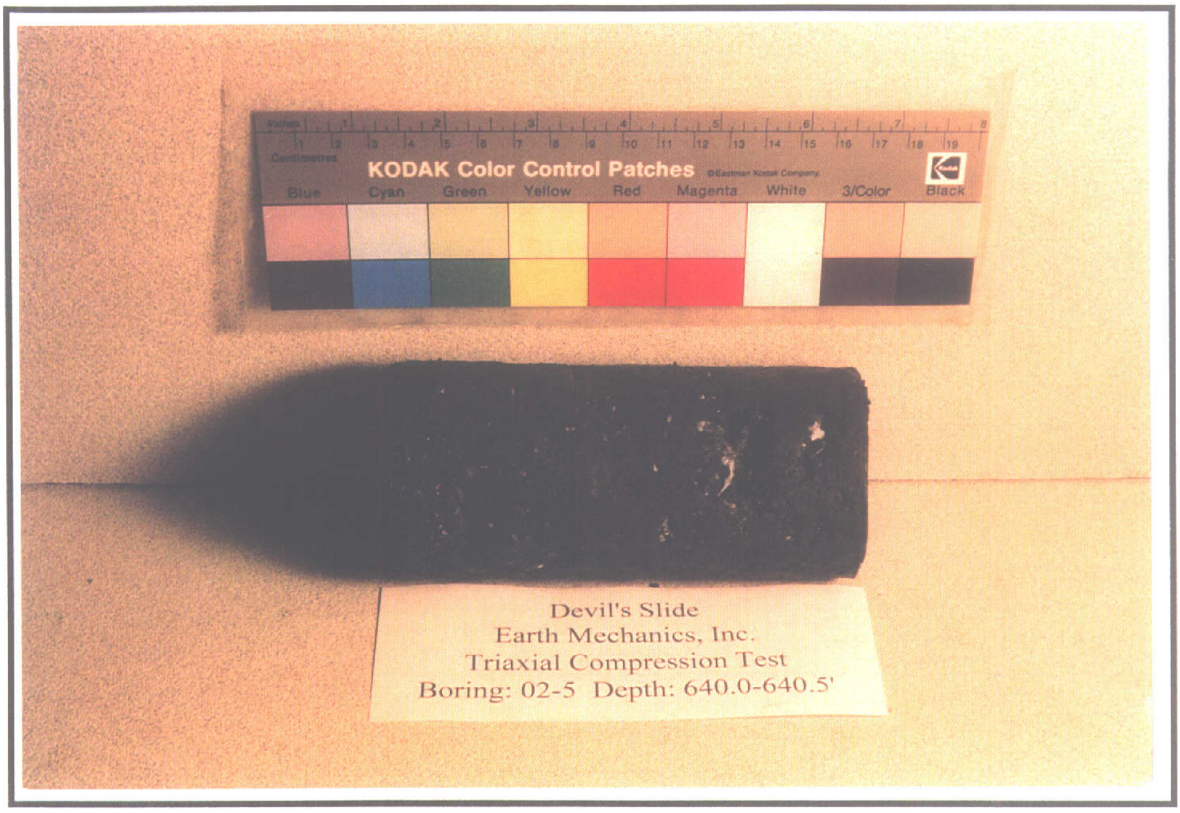
Project Number: none

Test Date: October 23, 2002

APPENDIX C

MULTI-STAGE TRIAXIAL TESTS

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

DATA SHEET

Triaxial Compression Test of Rock w/ Pore Pressure Measurement

(A procedure developed at GTU following the guidelines of ASTM D4767)

Date: 10/24/02

Technician: ABD

Client: EMI

Job: #151 - Devil's Slide

Sample ID: Boring 02-5

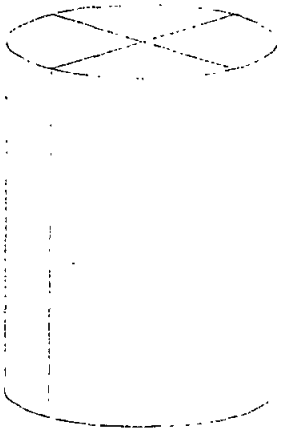
Sample Description: Dark gray sheared shale gouge w/ granitic clasts

Sample Depth: 640.0-640.5' Sample Condition: received & tested moist

d_1	d_2
2.403	2.384
2.411	2.392
2.407	2.406
2.422	2.421
2.393	2.385

NOT MEASURED - TOO SOFT

l_1	l_2



Avg. diameter : 2.402 Avg. length : 5.288

Sample area : 4.531 l/d ratio : 2.20

Sample volume(in^3) : 23.962

Sample weight (g) : 983.1 g (w/ plastic cover)

Density : 41.03 g/in^3 = 156.3 pcf (1 g/in^3=3.8095lb/ft^3)

Initial Cell Pressure (psi) σ_{ci}	Final Cell Pressure (psi) σ_{cf}	Inititial Eff. Confining Pressure (psi) σ'_{ci}	Final Eff. Confining Pressure (psi) σ'_{cf}	$1-\frac{\Delta\sigma'_c}{\Delta\sigma_c}$ B
100	125.4	50	50.7	.97
100	132.2	50	51.4	

$1-\frac{.7}{25.1}=.97$

$1-\frac{1.4}{52.2}=.96$ Adjustment

Comments: σ_3' = 50, 100, 195 psi 200 psi - limit of diff pressure gauge

reset LVDT 2x, once during 2nd consol. and 2 times during 3rd plastic loading phase ~1000lb overload. During the 2nd reset portion the loading ram stopped. The sample relaxed, the LVDT was reset, and loading was continued.

Barrelling Failure

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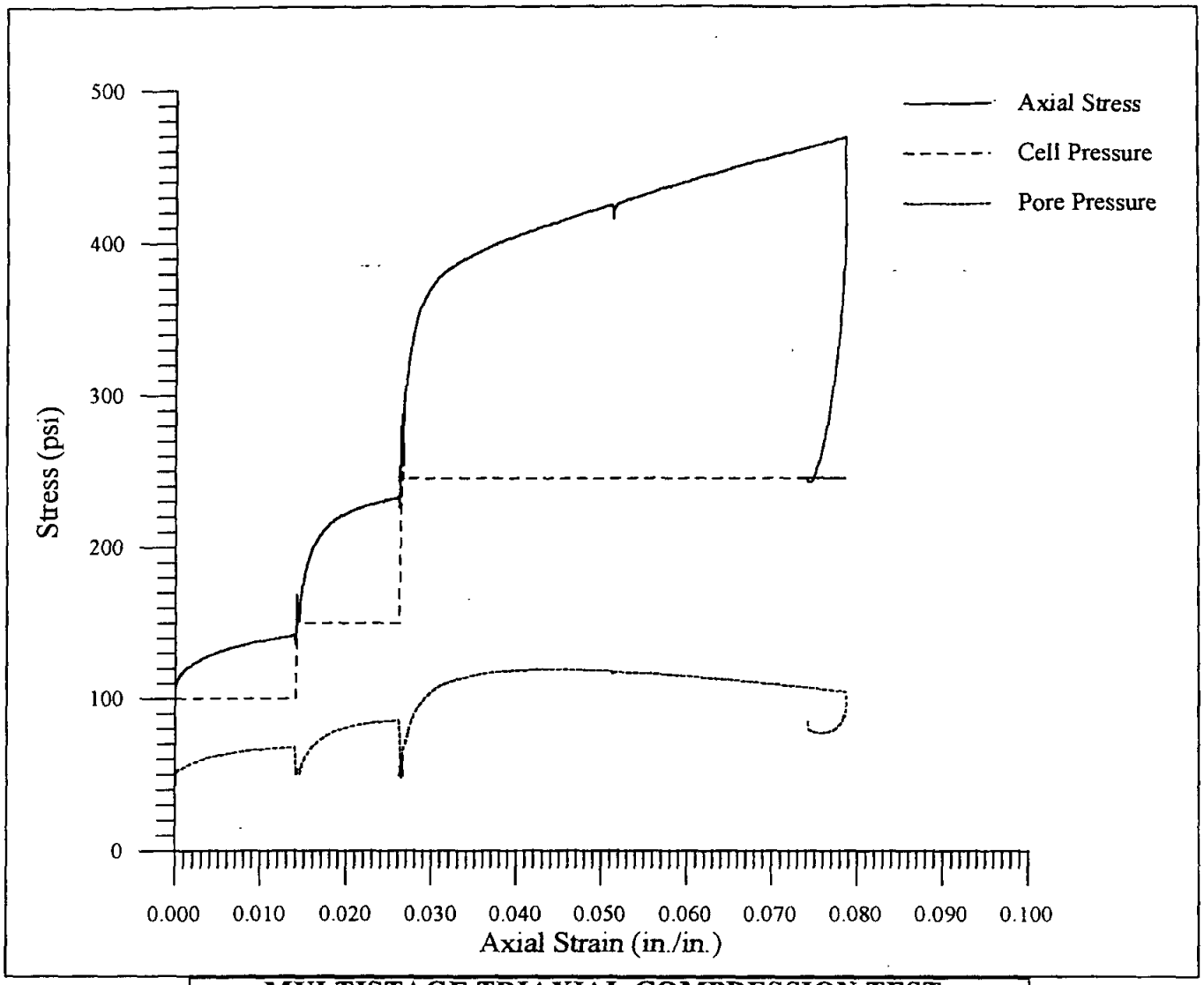

MULTISTAGE TRIAXIAL COMPRESSION TEST
Axial Stress, Cell Pressure, & Pore Pressure vs. Axial Strain

Sample: 5-640
Boring: 02-5
Depth: 640.0-640.5'
Density: 156.3 pcf

DESCRIPTION
Dark gray sheared shale gouge.

Strain (in./in.)	Cell Pres. (psi)	Pore Pres. (psi)	Strength (psi)
.016	100	69	145
.016	151	84	219
.030	151	84	236
.030	245	119	390

Geo Test Unlimited G T U
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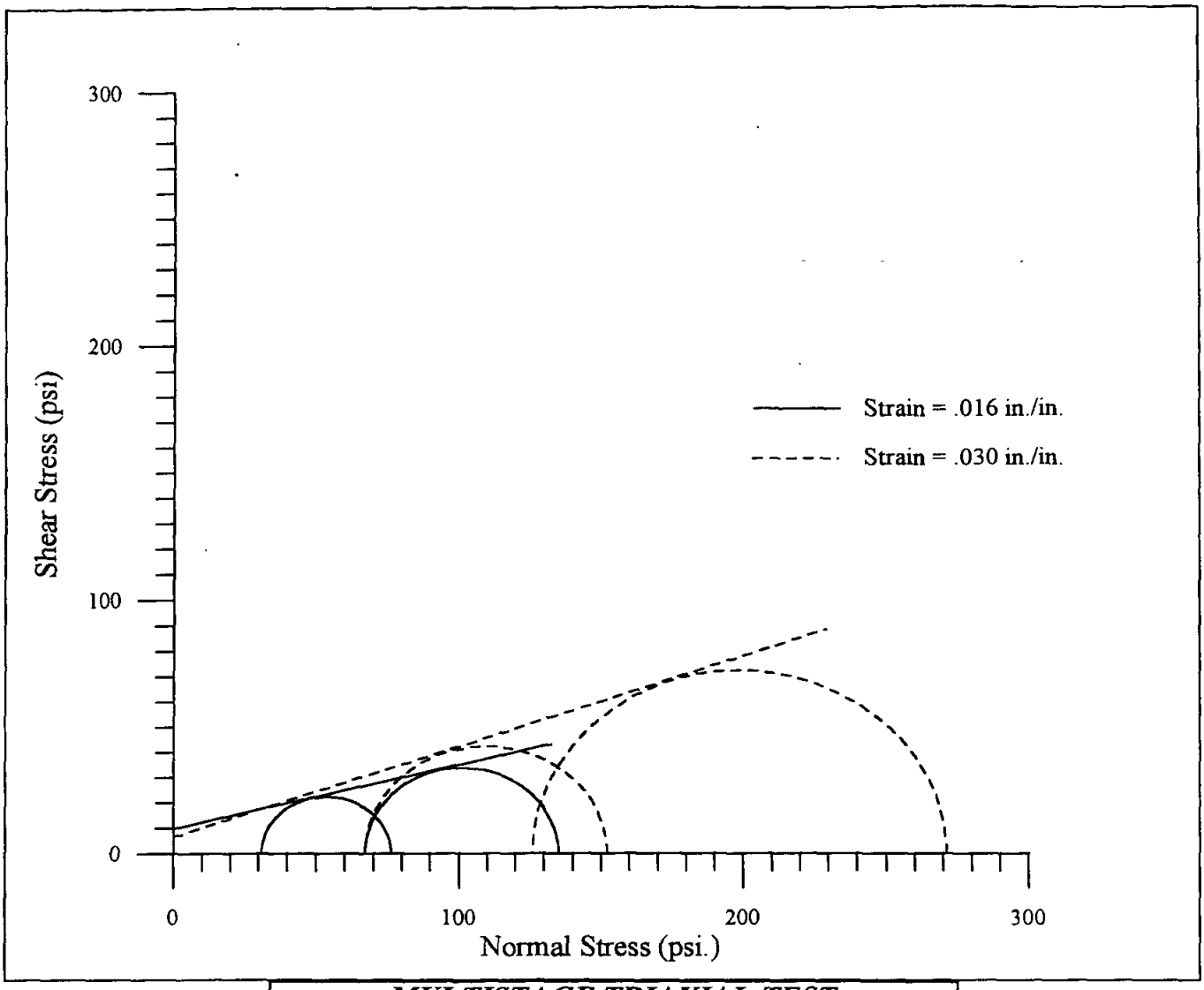
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 24, 2002



MULTISTAGE TRIAXIAL TEST
Effectve Stress Mohr Failure Circles

Sample: 5-640
Boring: 02-5
Depth: 640.0-640.5'
Density: 156.3 pcf

DESCRIPTION
Dark gray sheared shale gouge.

Strain (in./in.)	C' (psi.)	ϕ' (degrees)
0.016	10	13
0.030	6	18

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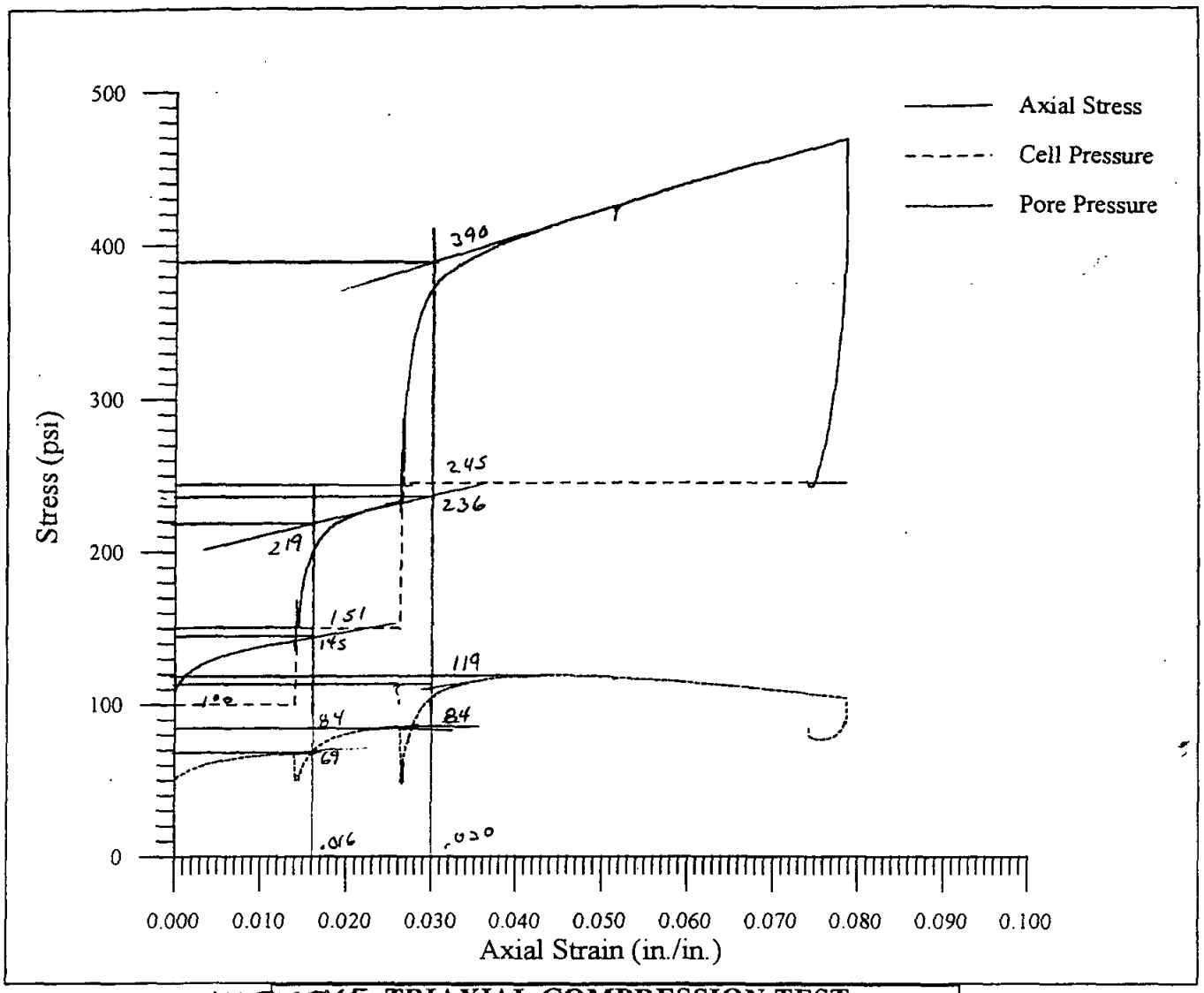
Project Number: none

Test Date: October 24, 2002



MULTISTAGE **TRIAXIAL COMPRESSION TEST**
Axial Stress & Confining Pressure vs. Axial Strain
Cell & Pore Pressure

Sample: 5-640
Boring: 02-5
Depth: 640.0-640.5'
Density: 156.3 pcf

DESCRIPTION
Dark gray sheared shale gouge.

Axial Strain (in/in)	Cell pressure Conf. Pressure (psi)	Pore press Strength (psi)
	206	4265
	414	5160

Geo Test Unlimited
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Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

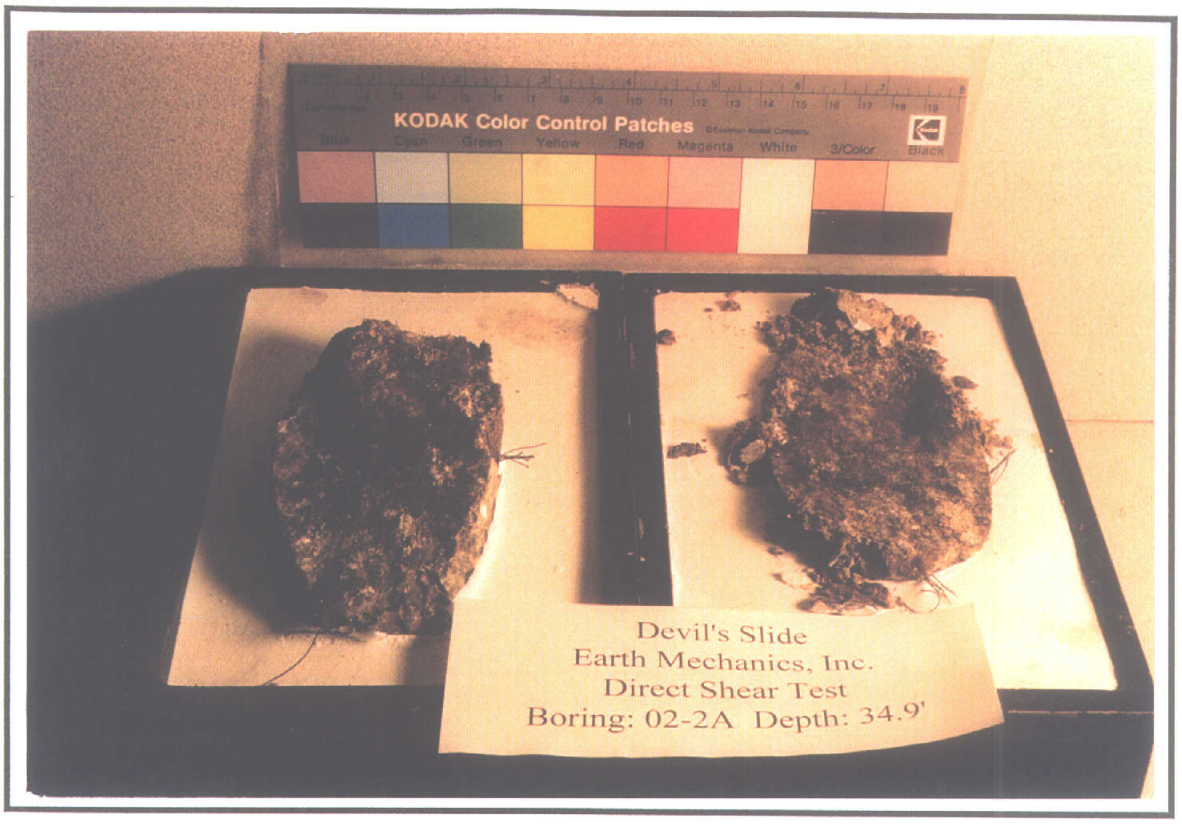
Project Number: none

Test Date: October 24, 2002

APPENDIX D

DIRECT SHEAR TESTS

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

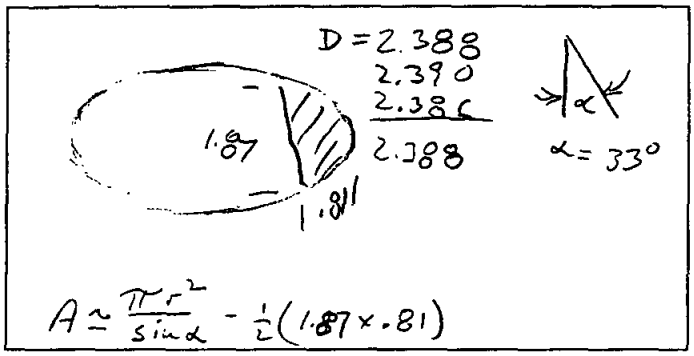
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2A
SampleDescription: Rough joint in moderately altered granodiorite.

Date: 10-17-02
Tester: A. Bro

Sample Depth: 34.9 Sample Condition: received dry - tested moist

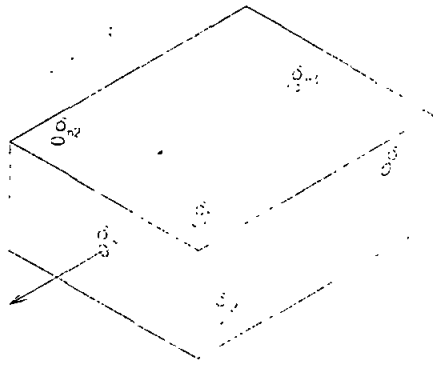
Sketch of Shear Surface



Sample area : 7.47 in²

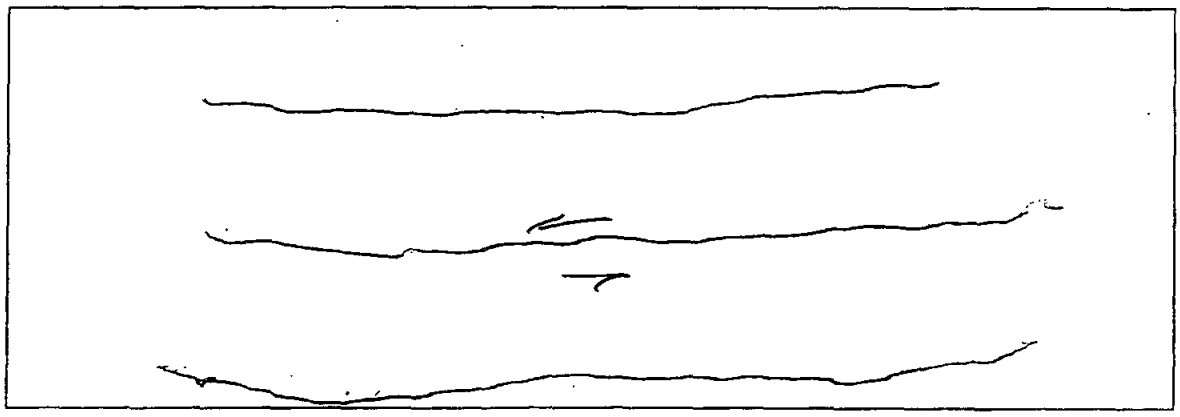
σ_n	25	50	100	psi
F_n	187	374	748	lb
$F_n - W_b$	172	359	733	lb

Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 14.9 lb

Joint Profiles



Comments:

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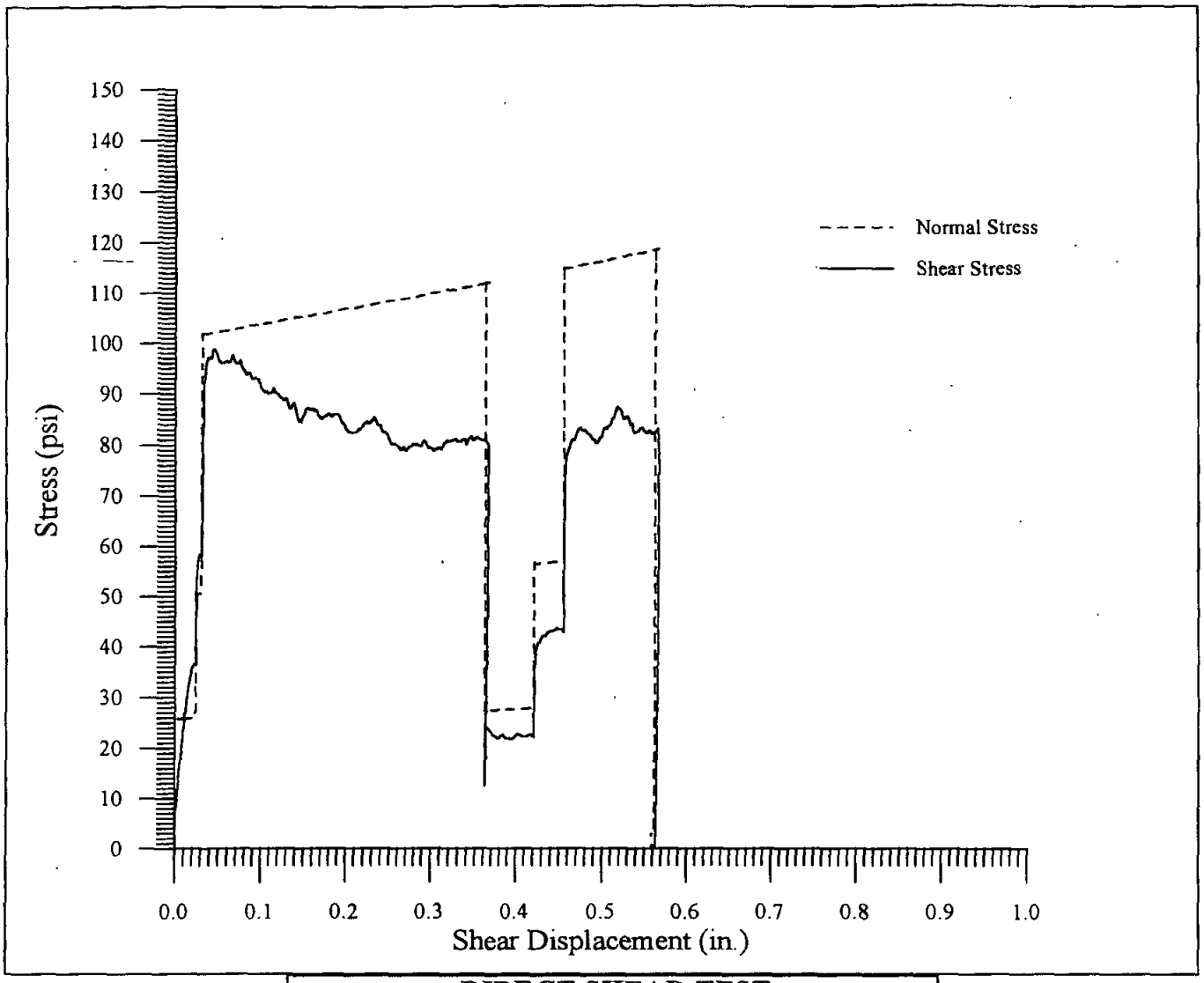

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2A
Sample: 2A-34
Depth: 34.9'

DESCRIPTION

Rough joint in moderately altered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Initial	26	36.5
	50.5	58
	102	97
Final	27.5	22
	56.5	43
	116	82

Geo Test Unlimited
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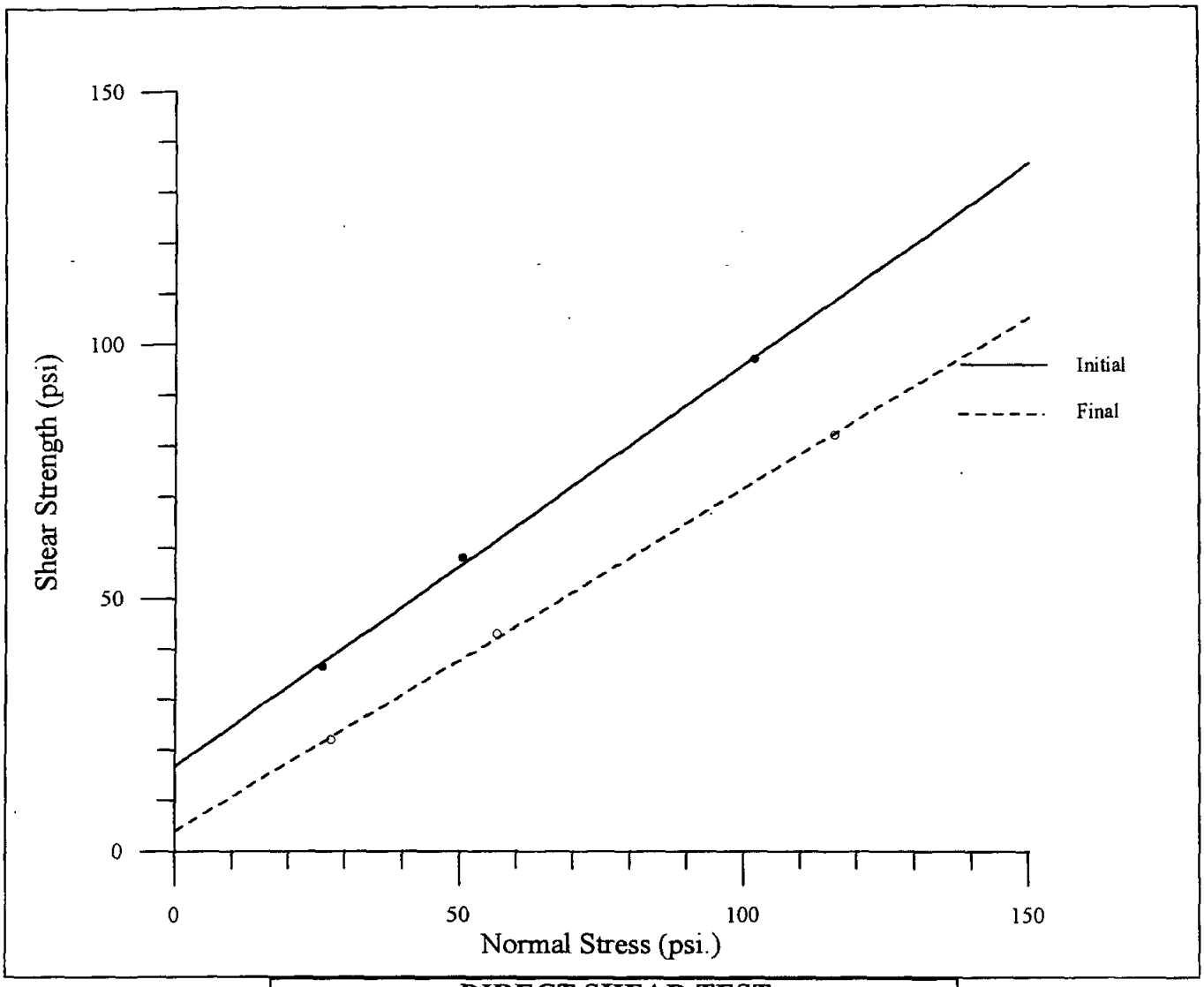
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 17, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2A
Sample: 2A-34
Depth: 34.9'

DESCRIPTION
Rough joint in moderately altered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	16.8	38.3
Final	4.0	34.0

Geo Test G T U *Unlimited*
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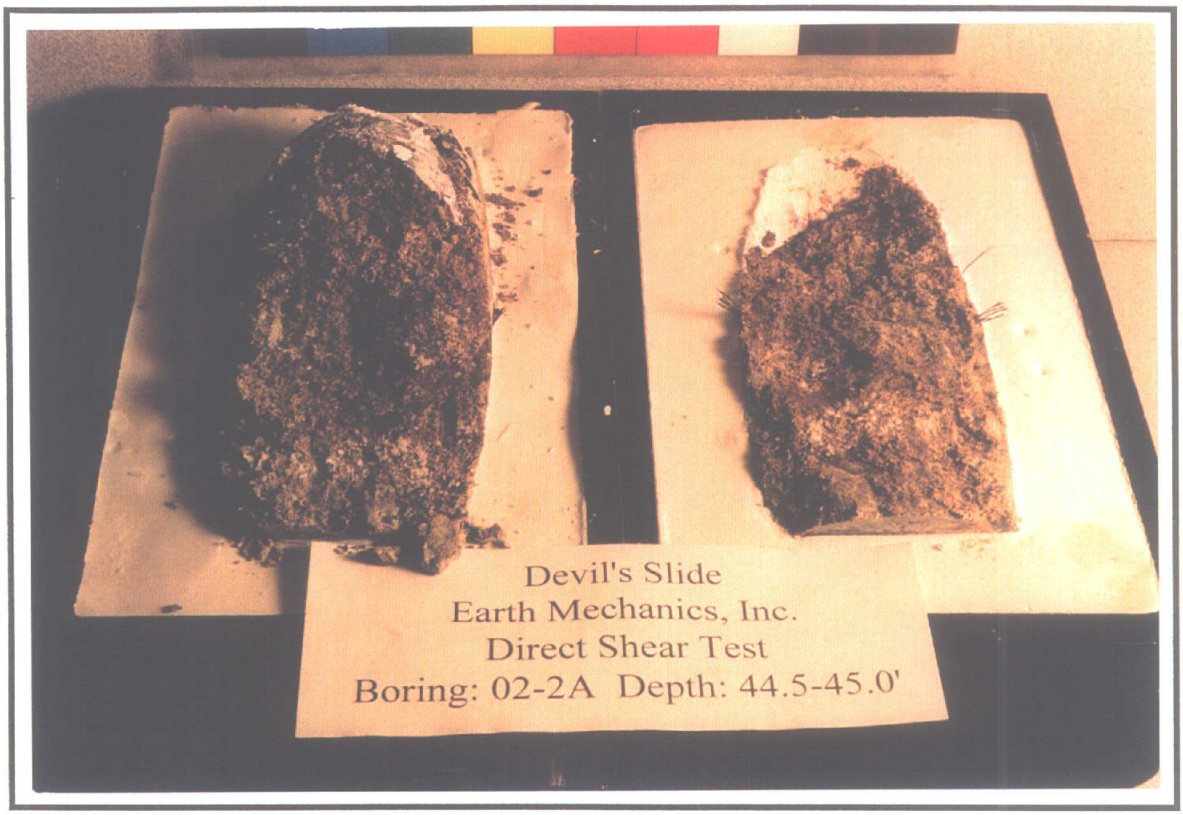
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 17, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo GTU Test Unlimited

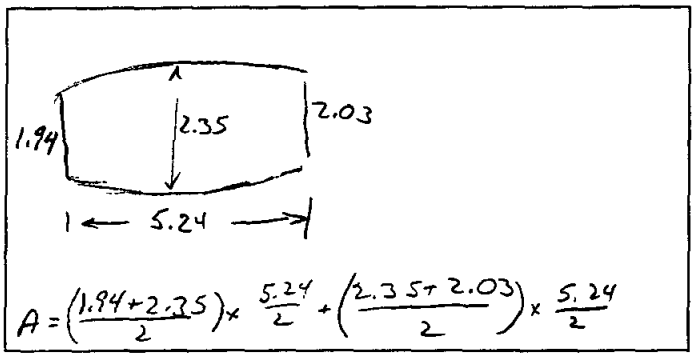
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-2A
SampleDescription: Rough oxide coated joint in altered granodiorite

Date: 10-17-02
Tester: A.Bro

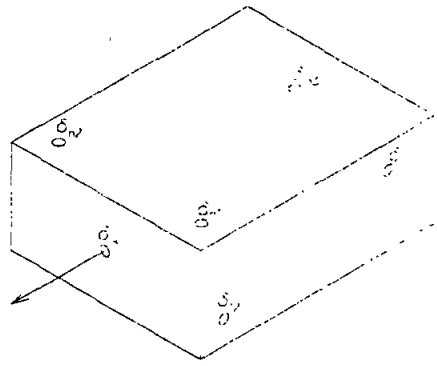
Sample Depth: 44.5 - 45.0 Sample Condition: received dry - tested moist

Sketch of Shear Surface



Sample area : 11.36 in²

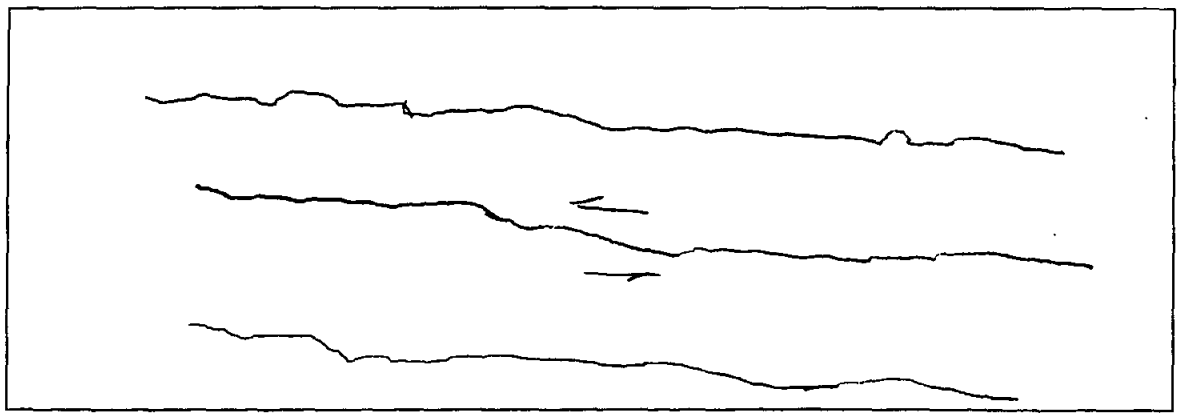
Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 14.3 lb

σ_n	25	50	100	psi
F_n	284	568	1136	lb
F_n-W_b	269	553	1121	lb

Joint Profiles



Comments: "Final" test sequence was performed prior to reaching a low plateau after 13 + cycles since the box was rotating so much that it may not otherwise have been possible to do the "final" test suite.

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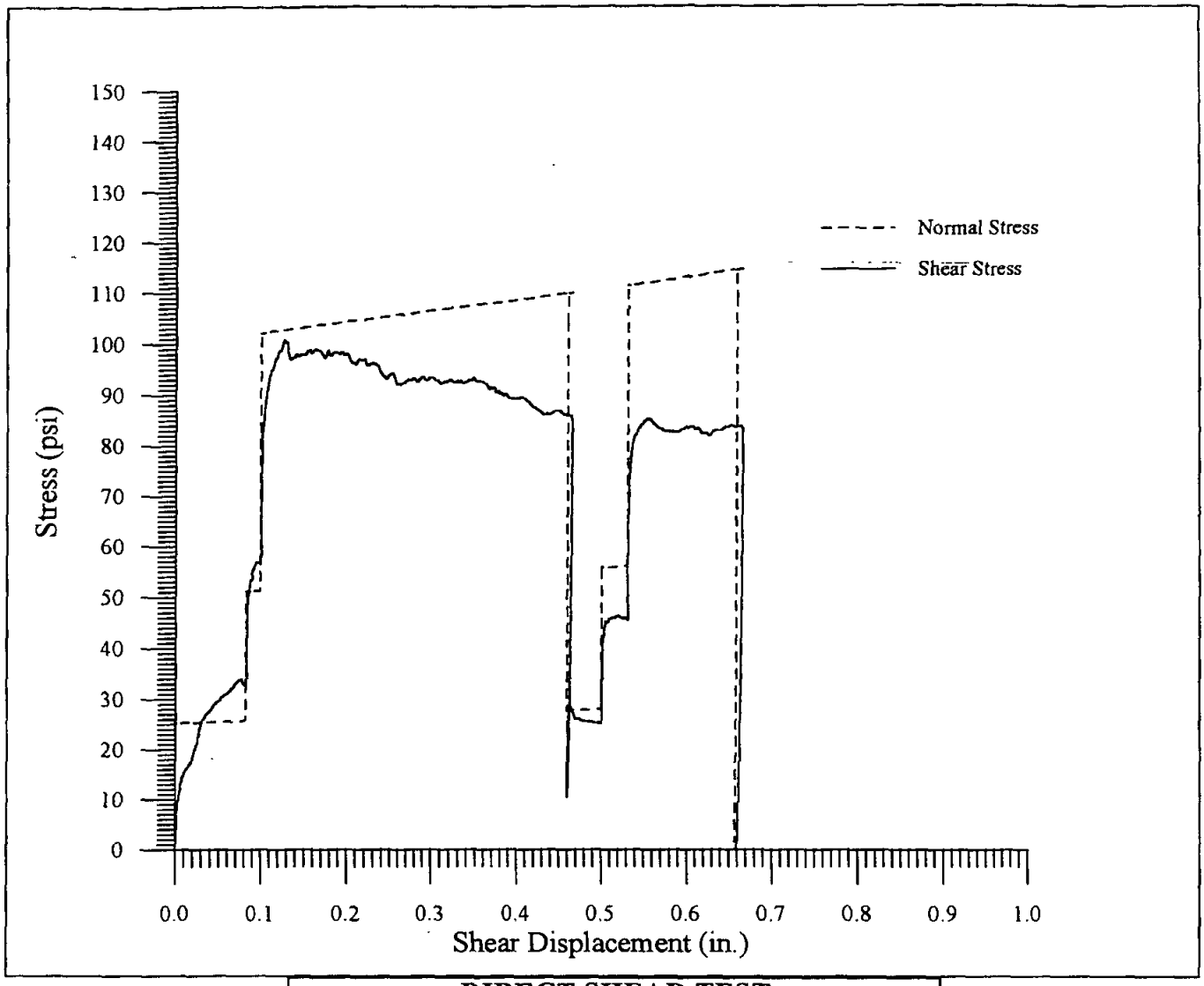

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2A
Sample: 2A-44
Depth: 44.5-45.0'

DESCRIPTION

Rough oxide coated joint in altered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Initial	25.5	34
	51	56.5
	103	100
Final	28	25
	56	46
	113	84

Geo Test G T U *Unlimited*
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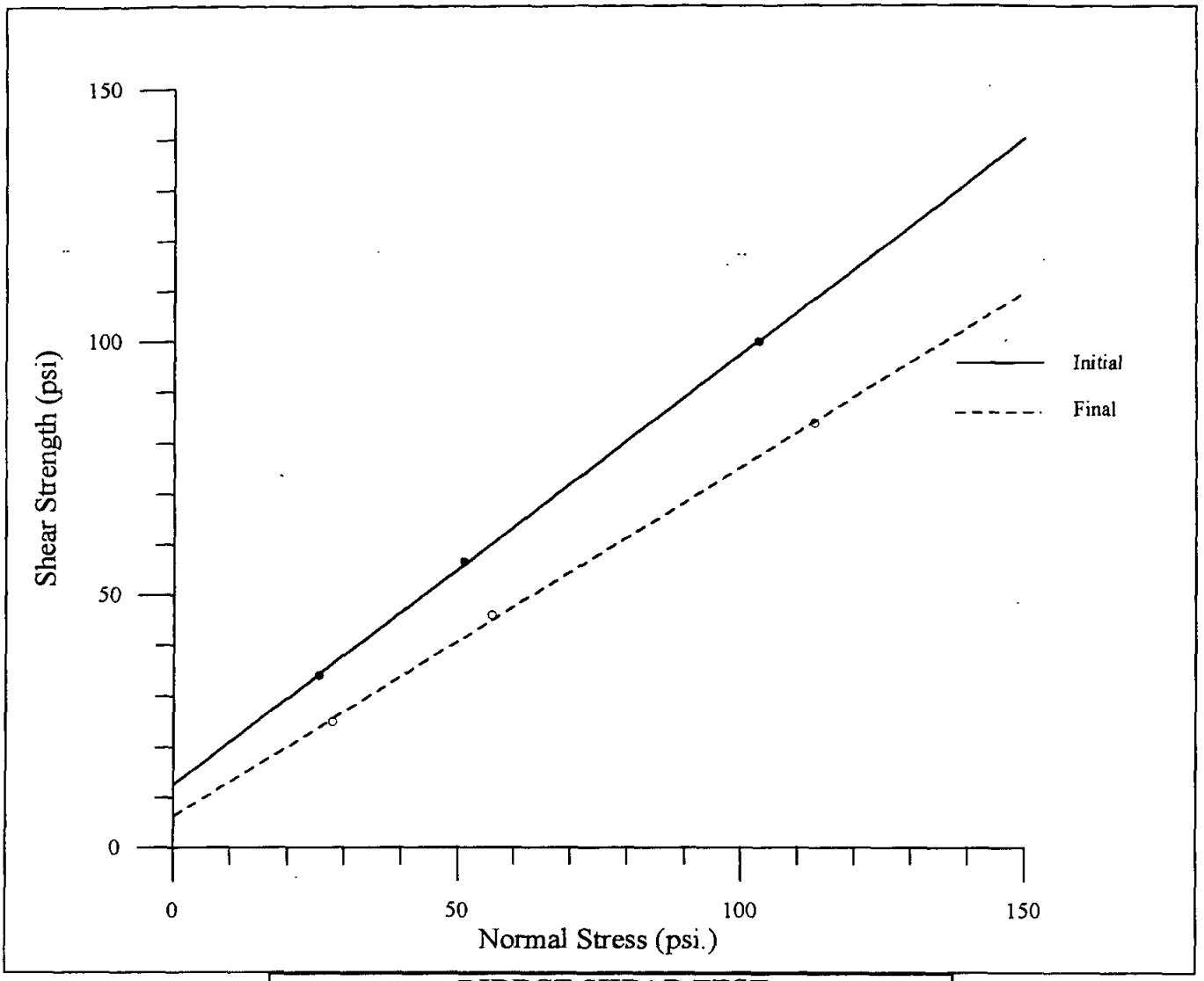
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: *none*

Test Date: October 17, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2A
Sample: 2A-44
Depth: 44.5-45.0'

DESCRIPTION
Rough oxide coated joint in altered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	12.7	40.3
Final	6.4	34.6

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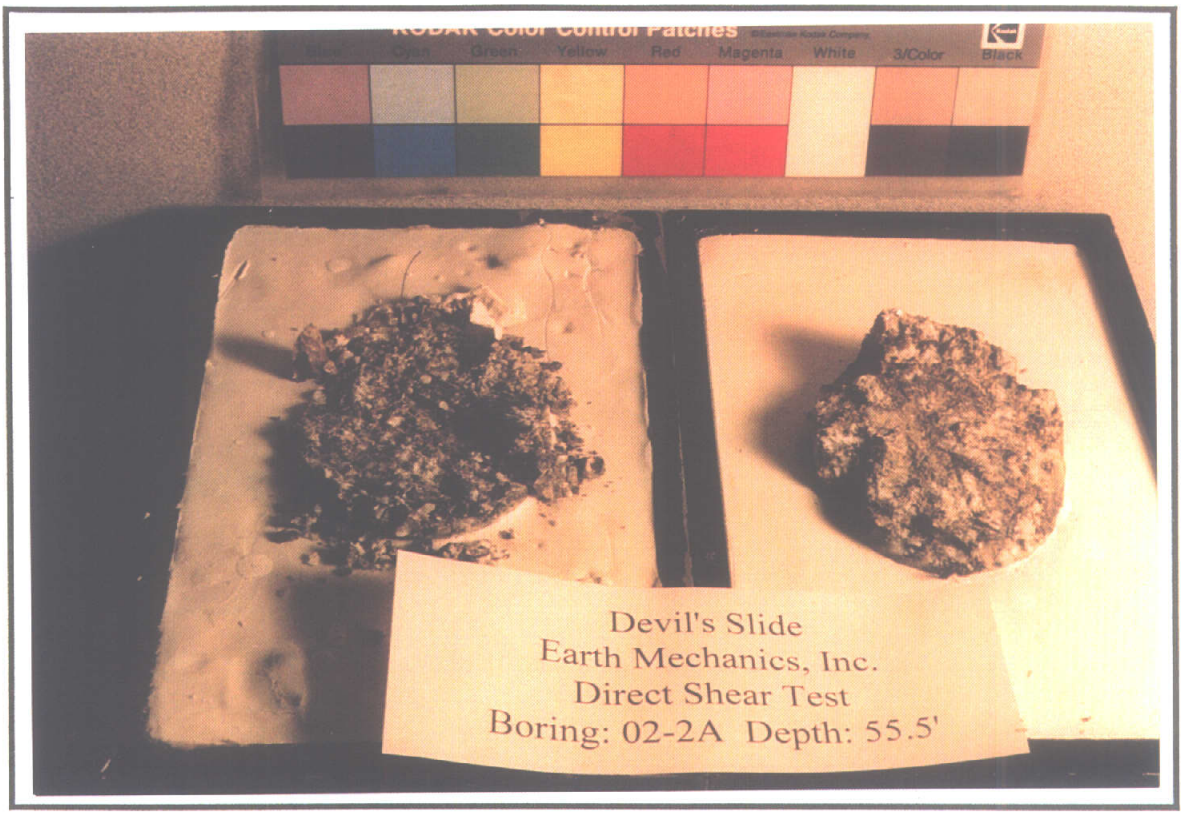
Project: Devil's Slide

Project Number: none

Test Date: October 17, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

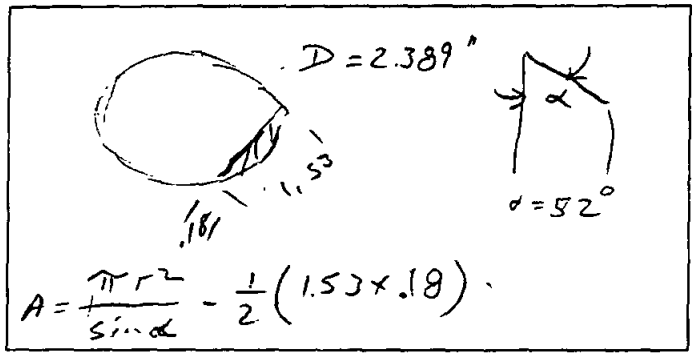
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2A
SampleDescription: Planar joint in unaltered granodiorite

Date: 10-18-02
Tester: ABro

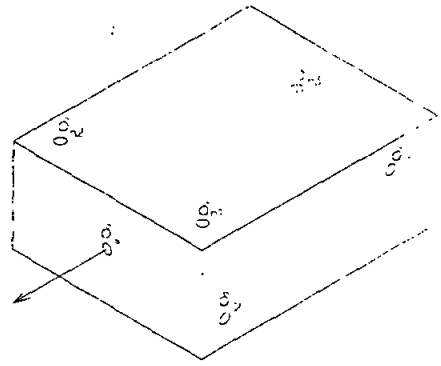
Sample Depth: 55.0'
Sample Condition: received dry - tested moist

Sketch of Shear Surface



Sample area : 5.55

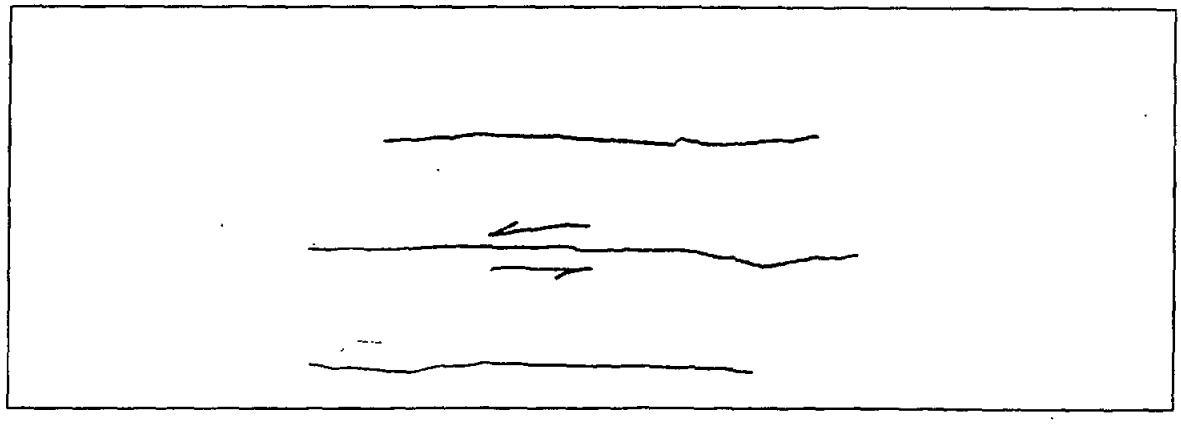
Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 14.9 lb

σ_n	25	50	100	psi
F_n	139	278	556	lb
F_n-W_b	124	263	541	lb

Joint Profiles



Comments: Odd strain hardening behavior - possibly due to impressions matched joint? Smooth joint - probably due to asperities wearing through surface coating.

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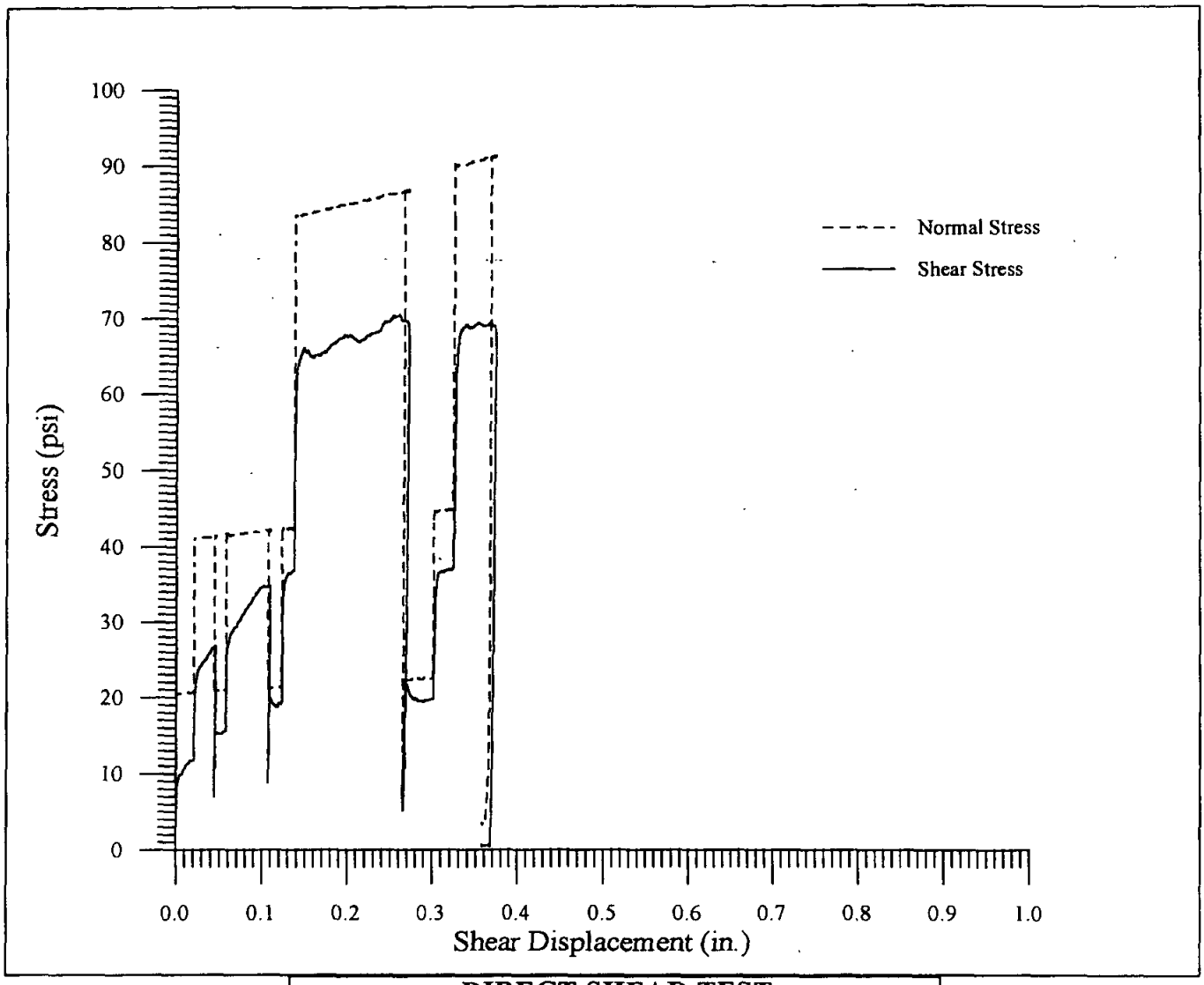


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2A
Sample: 2A-55A
Depth: 55.0'

DESCRIPTION

Planar joint in unaltered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Initial	21	19
	42.5	36.5
	84	66
Final	22.5	19.5
	44.5	37
	90.5	69

Geo Test Unlimited GTU

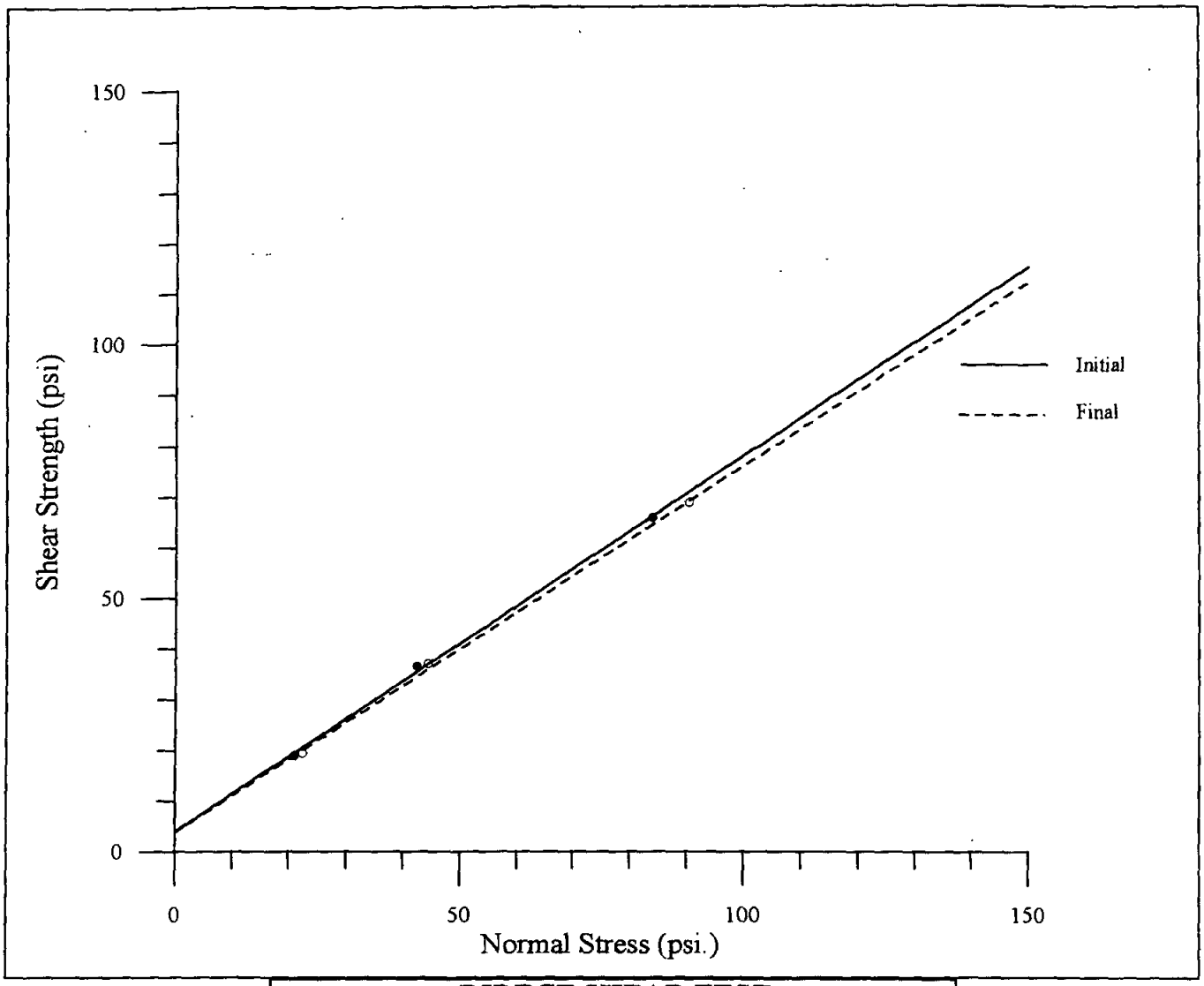
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2A
Sample: 2A-55A
Depth: 55.0'

DESCRIPTION
Planar joint in unaltered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	4.1	36.5
Final	3.9	35.9

Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

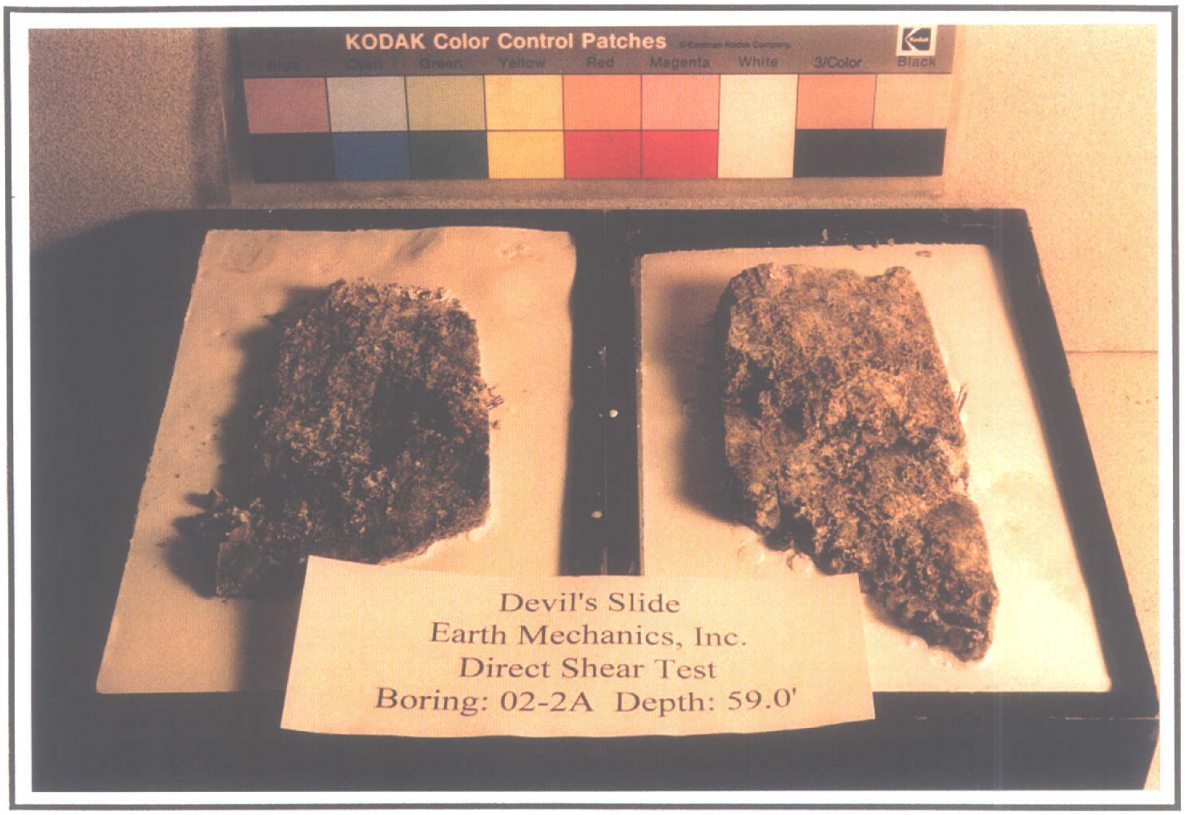
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

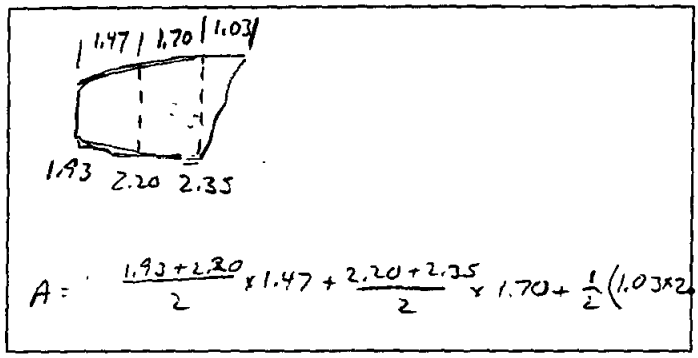
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Bory 02-2A
SampleDescription: Rough joint in altered granodiorite

Date: 10-17-02
Tester: A. Bro

Sample Depth: 59.0' Sample Condition: received dry - tested moist

Sketch of Shear Surface

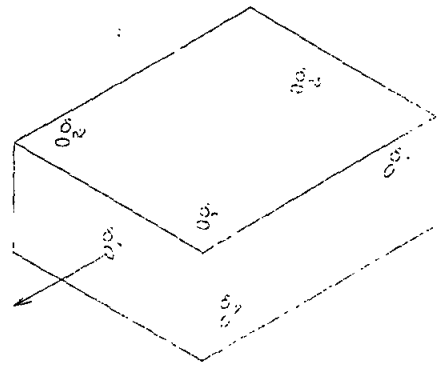


$$A = \frac{1.93+2.20}{2} \times 1.47 + \frac{2.20+2.35}{2} \times 1.70 + \frac{1}{2}(1.03 \times 2.35)$$

Sample area : 8.11 in²

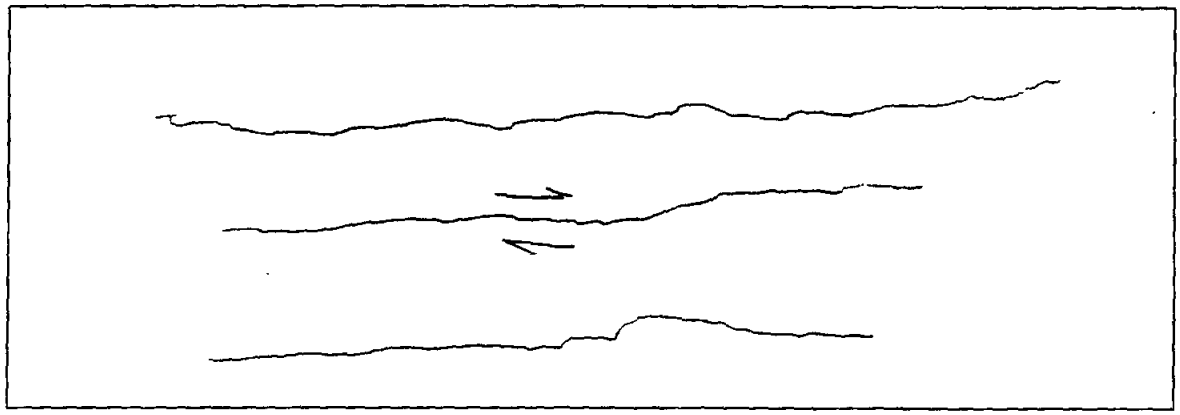
σ_n	25	50	100	psi
F_n	203	406	812	lb
F_n-W_b	188	391	797	lb

Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 14.9 lb

Joint Profiles



Comments:

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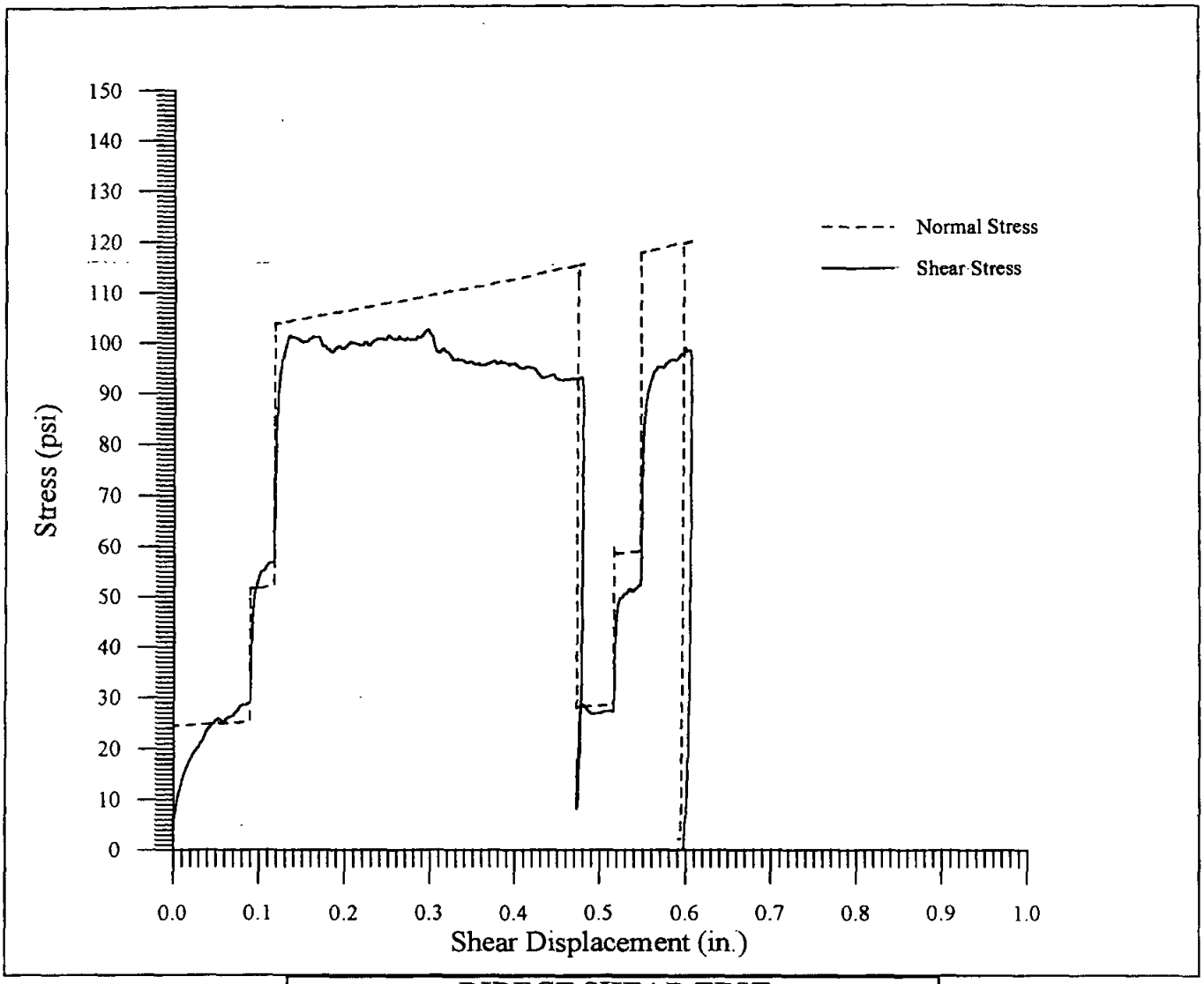


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2A
Sample: 2A-59
Depth: 59.0'

DESCRIPTION

Rough joint in altered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Initial	25	30
	52	57
	105	101
Final	29	27
	59	52
	118	96

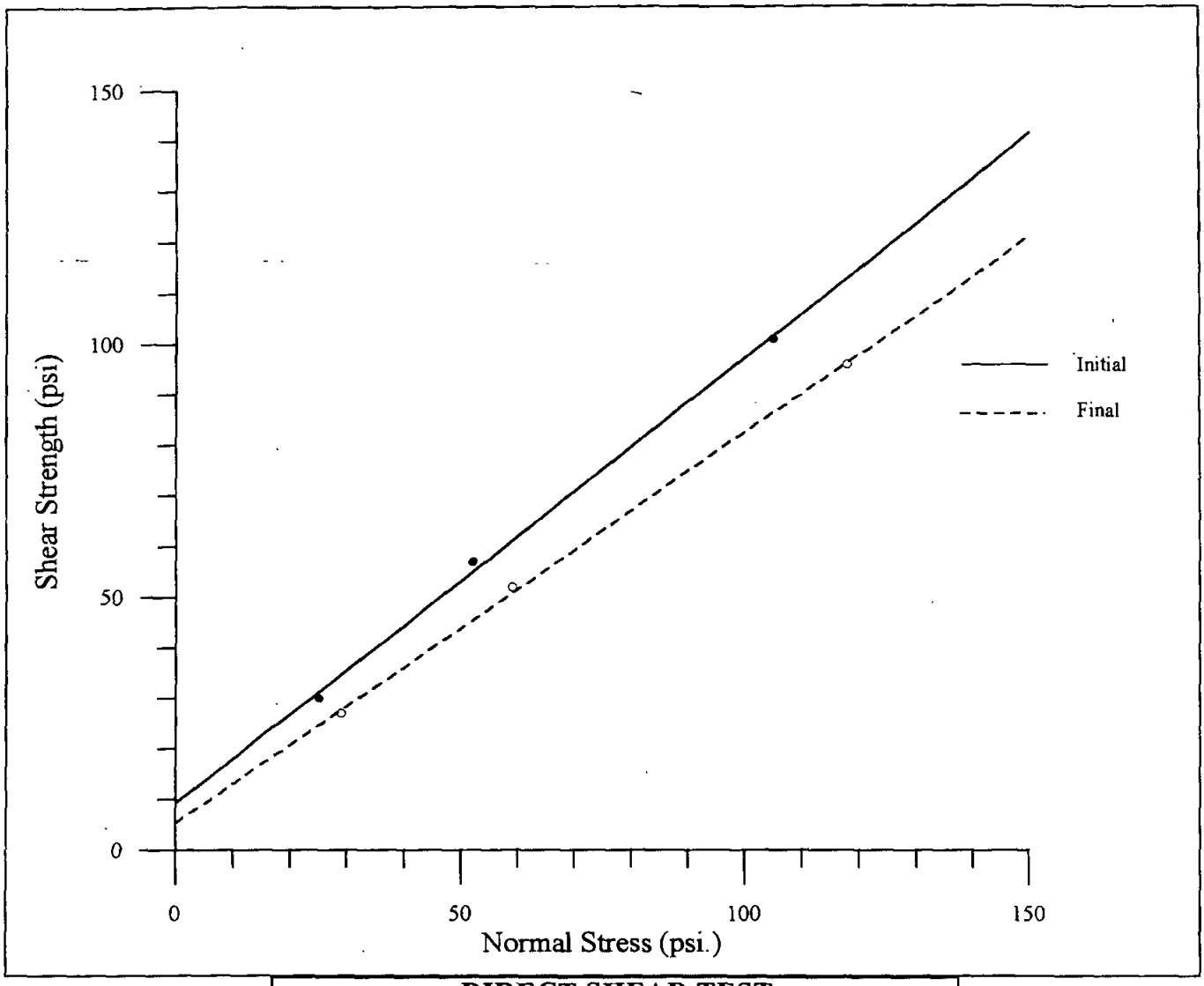
Geo Test Unlimited G T U
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 17, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2A
Sample: 2A-59
Depth: 59.0'

DESCRIPTION
Rough joint in altered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	9.3	41.3
Final	5.4	37.6

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 17, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

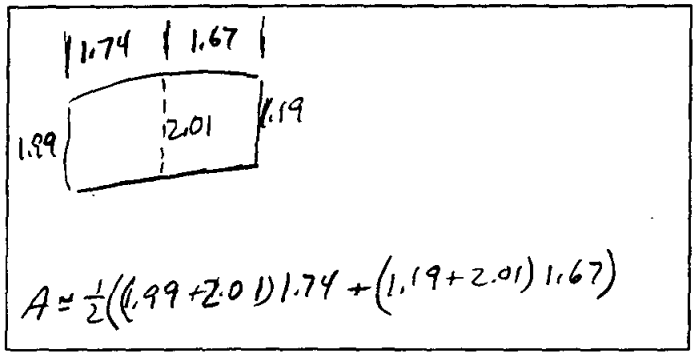
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2A
SampleDescription: Planar joint in altered granodiorite

Date: 10-18-02
Tester: ABro

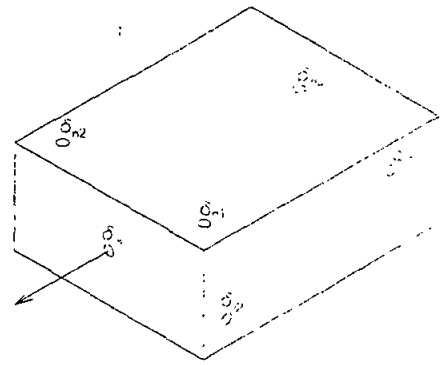
Sample Depth: 60.4' Sample Condition: received dry - tested moist

Sketch of Shear Surface



Sample area : 6.15 in²

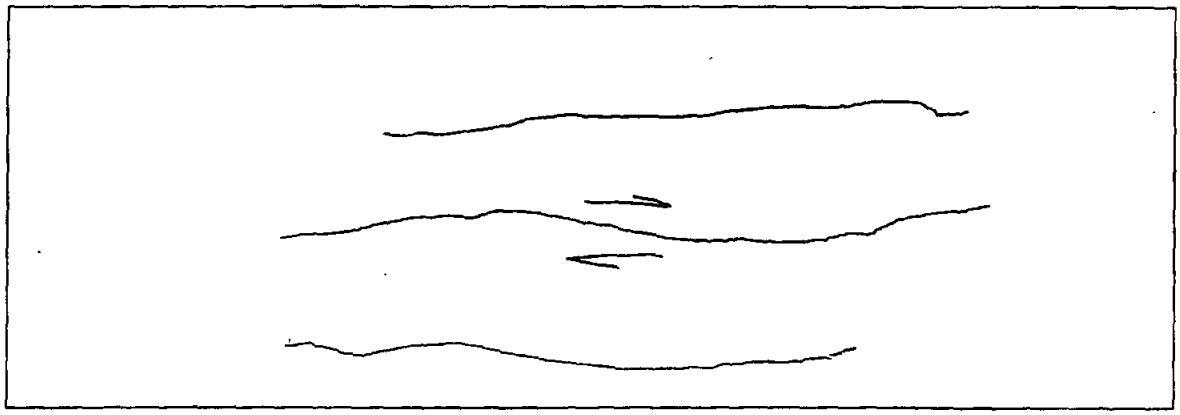
Location of LVDTs on top shear box



σ_n	25	50	100	psi
F_n	154	308	616	lb
$F_n - W_b$	139	293	601	lb

Estimated top box weight: 15 lb
Measured top box weight: 14.8 lb

Joint Profiles



Comments:

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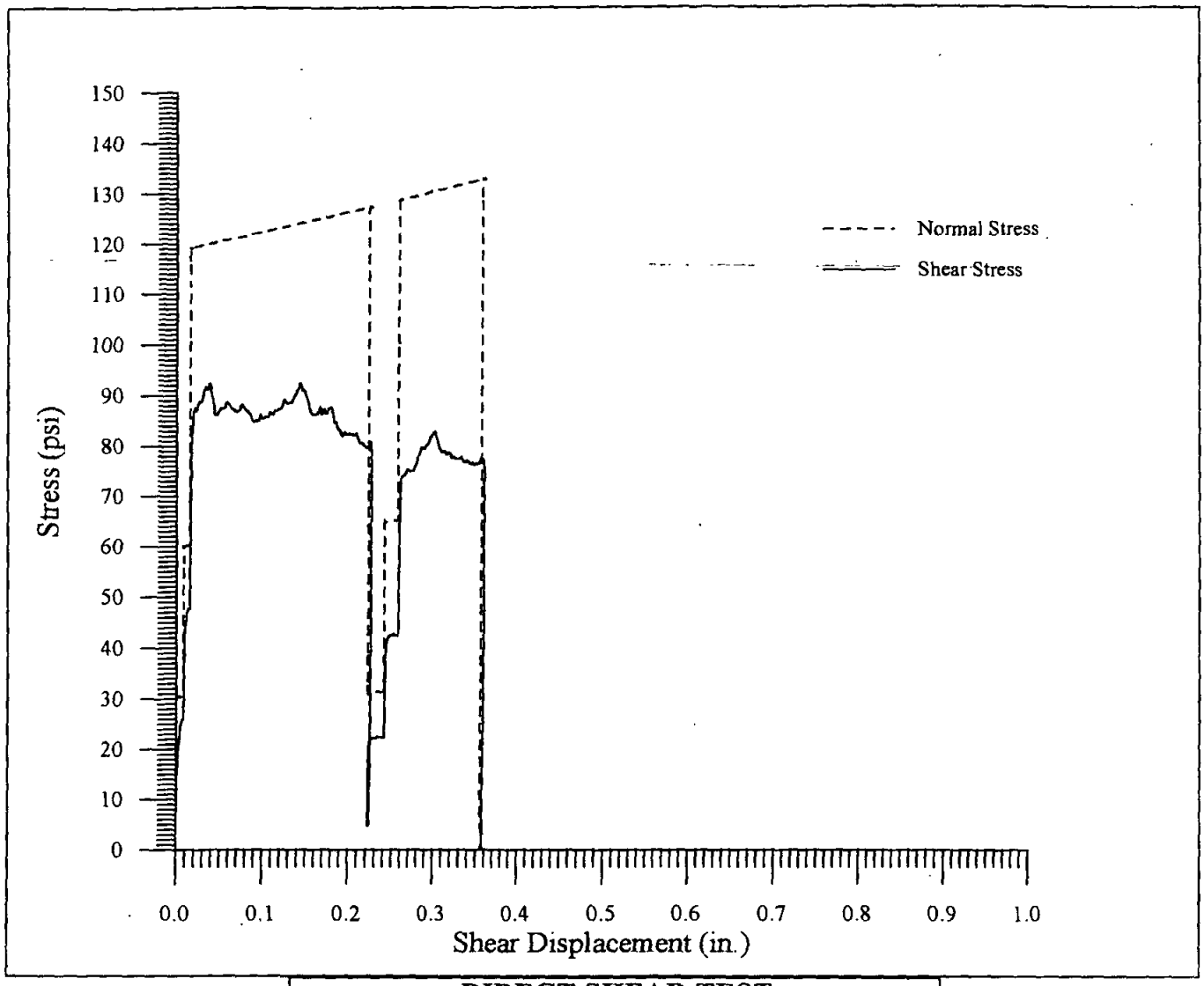


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2A
Sample: 2A-60
Depth: 60.4'

DESCRIPTION

Planar joint in altered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Initial	30.5	26
	60	48
	120	88.5
Final	31.5	22.5
	65	42.5
	129	75.5

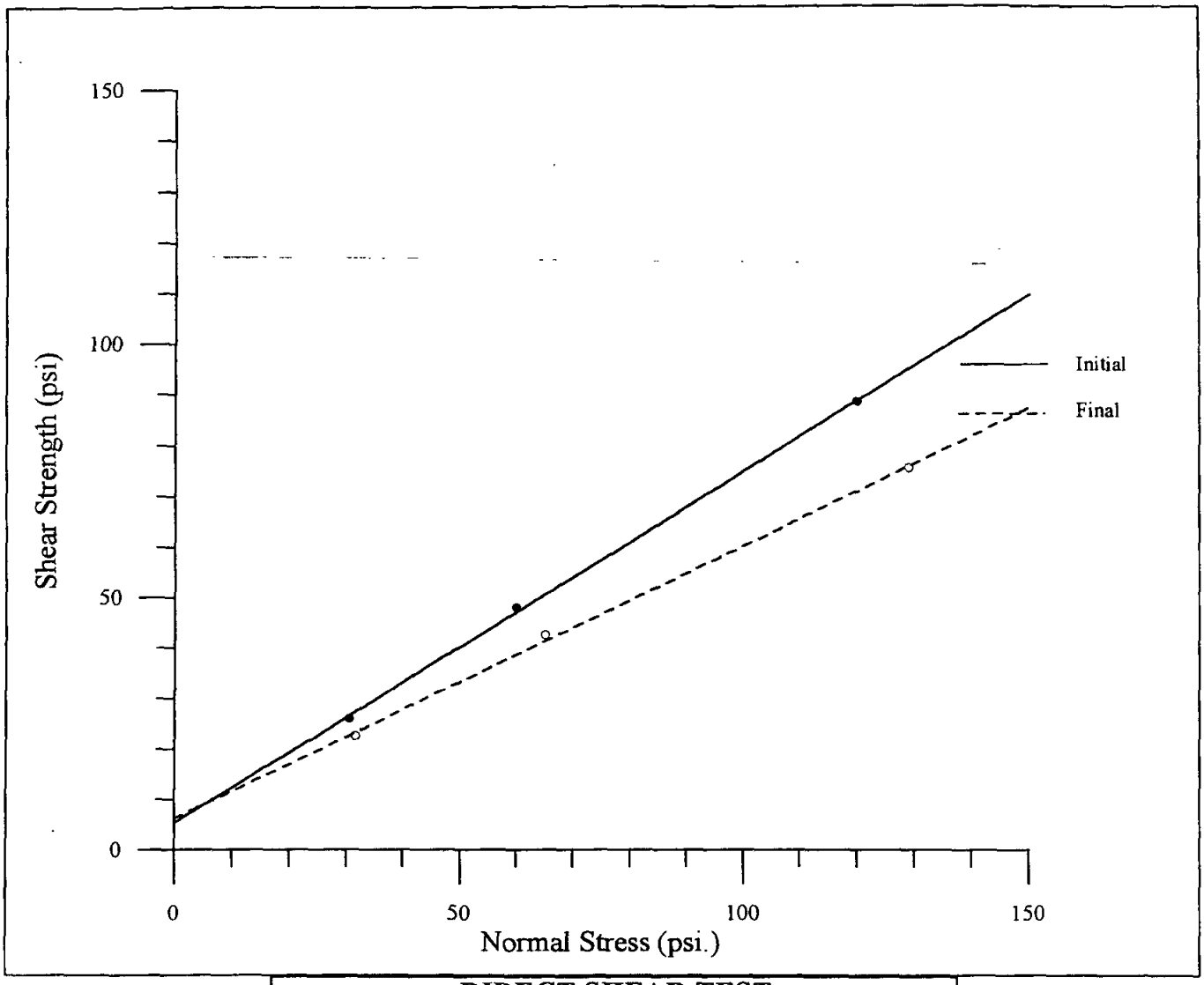
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2A
Sample: 2A-60
Depth: 60.4'

DESCRIPTION
Planar joint in altered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	5.4	34.8
Final	6.3	28.4

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

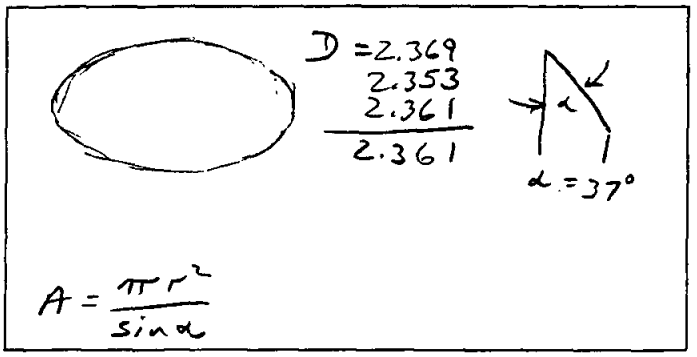
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2B
SampleDescription: undulating joint in altered granodiorite

Date: 10-18-02
Tester: A. Bro

Sample Depth: 41'
Sample Condition: received dry - tested moist

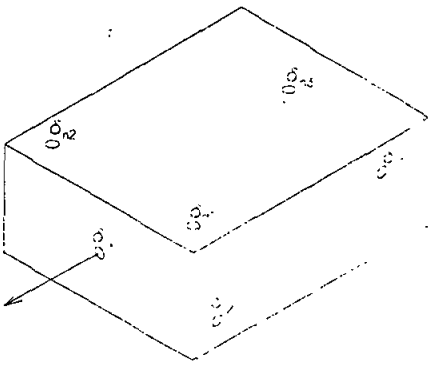
Sketch of Shear Surface



Sample area : 7.27

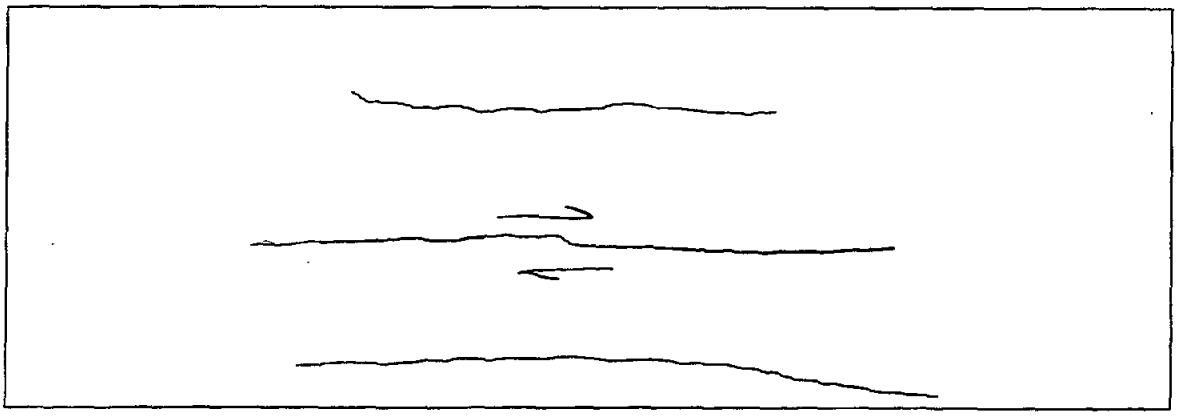
σ_n	25	50	100 psi
F_n	182	364	728 lb
F_n-W_b	167	349	713 lb

Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 14.7 lb

Joint Profiles



Comments:

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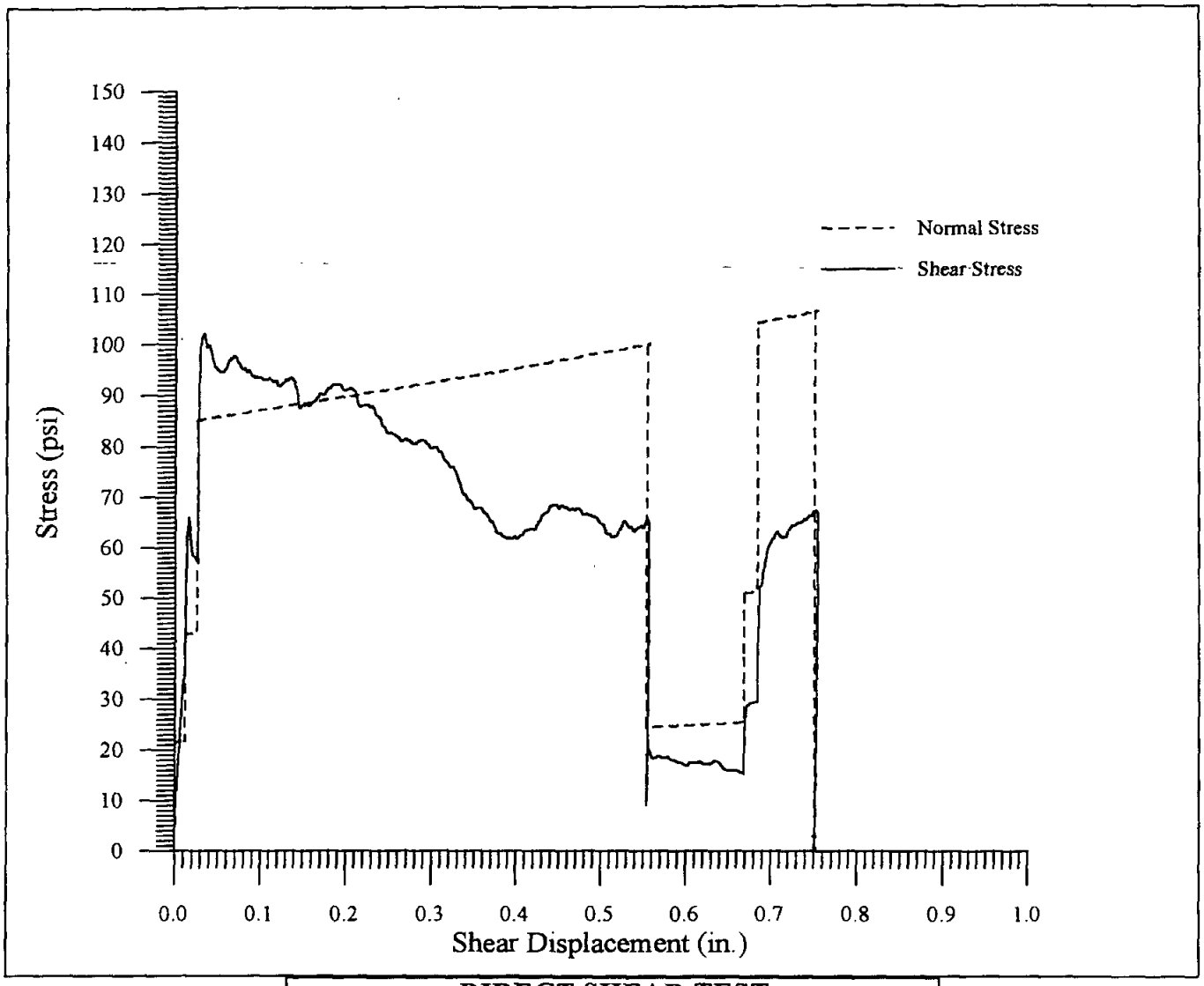


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2B
Sample: 2B-41
Depth: 41.0'

DESCRIPTION

Undulating joint in altered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Initial	21.5	36.5
	43	66
	85.5	102
Final	25	16
	51	29.5
	105	64

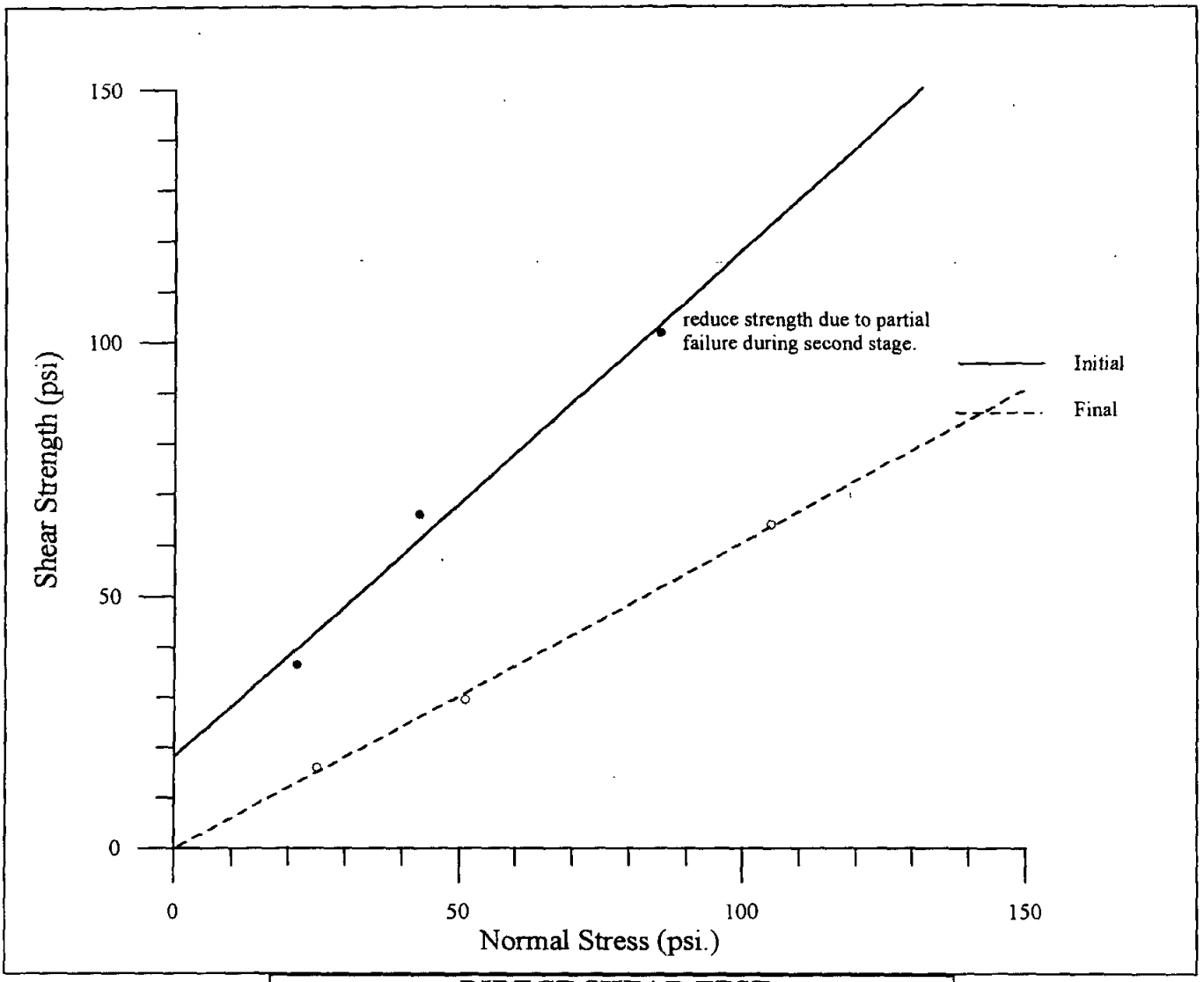
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2B
Sample: 2B-41
Depth: 41.0'

DESCRIPTION
Undulating joint in altered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	18.2	45.0
Final	0.0	31.2

Geo Test G T U Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

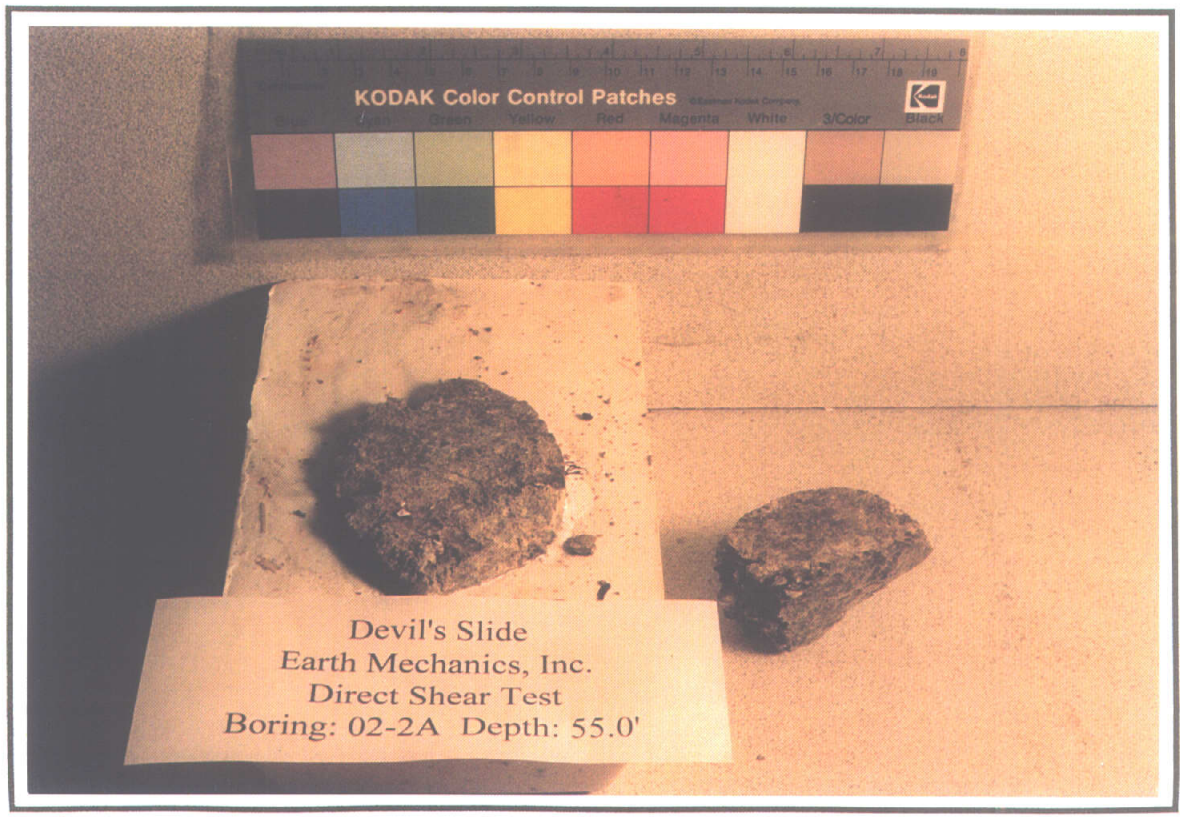
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited — GTU

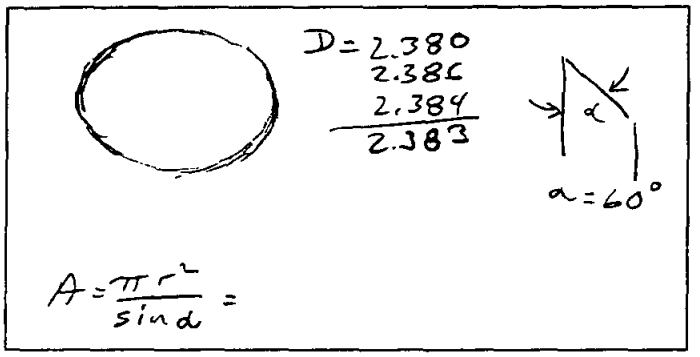
DATA SHEET
Direct Shear of Rock (ISRM)

Client: ERI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2A
SampleDescription: Rough joint in altered granodiorite - not through-going

Date: 10-17-02
Tester: A. Bro

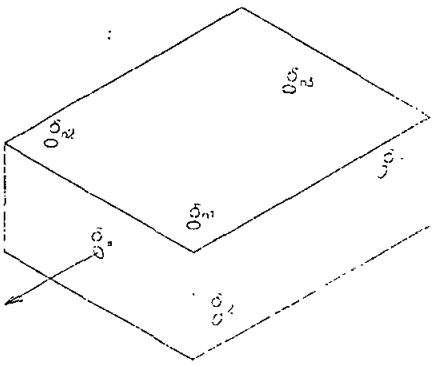
Sample Depth: 55.5 . Sample Condition: received dry - tested moist

Sketch of Shear Surface



Sample area : 5.15 in²

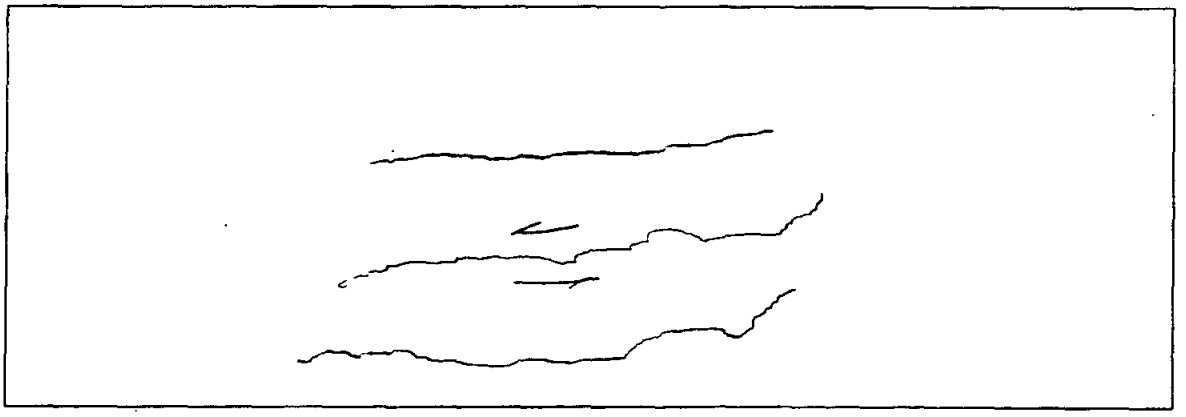
Location of LVDTs on top shear box



σ_n	25	50	100	psi
F_n	129	258	516	lb
F_n-W_b	114	243	501	lb

Estimated top box weight: 15 lb
Measured top box weight: 14.7

Joint Profiles



Comments: 1st Failure @ 114 F_n is due to rotation of block end of box. Increased F_n to 501 to fail the sample. Probably a bumpy type of shear (indicated by increase of shear load when the normal load increased.)

lots of crushed granodiorite on sheared joint.

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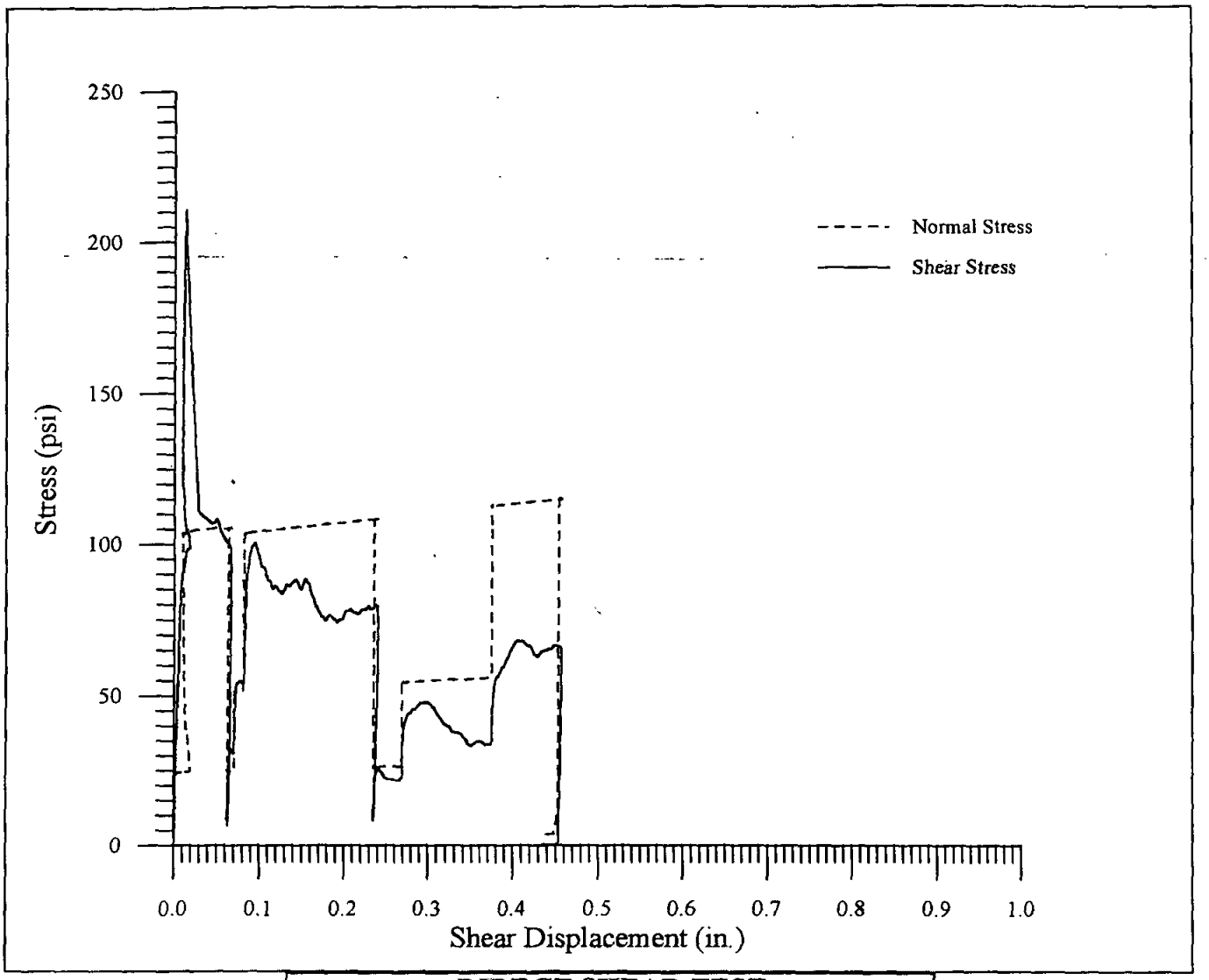


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2A
Sample: 2A-55B
Depth: 55.5'

DESCRIPTION

Rough non-through-going joint in altered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Peak	105	210
Initial	26	32
	52	55
	102	100
Final	26	22
	55	45
	109	79

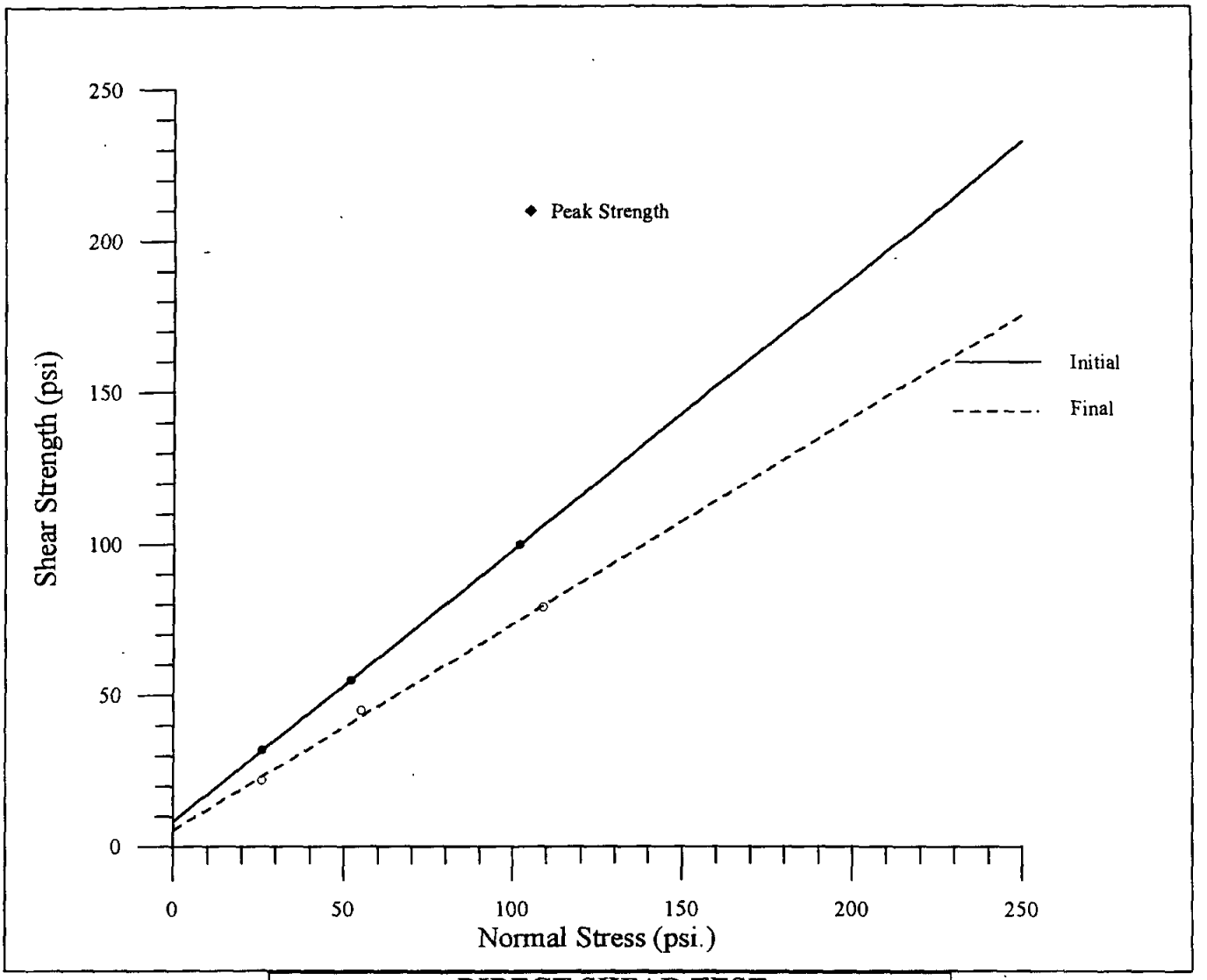
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 17, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2A
Sample: 2A-55B
Depth: 55.5'

DESCRIPTION
Rough non-through-going joint
in altered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	8.6	41.8
Final	5.6	34.2

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: **Earth Mechanics, Inc.**
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: **Devil's Slide**

Project Number: none

Test Date: **October 17, 2002**

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

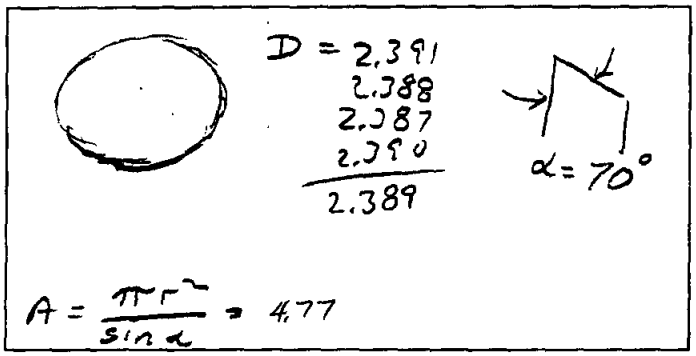
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2B
SampleDescription: Slightly rough joint in altered granodiorite

Date: 10-18-02
Tester: A. Bro

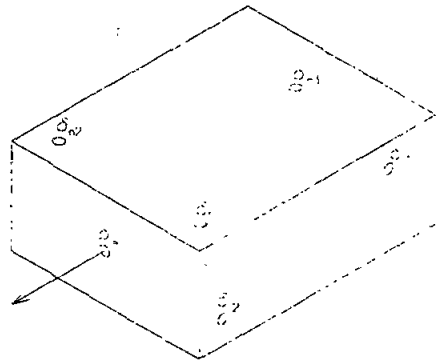
Sample Depth: 95.4'
Sample Condition: received dry - tested moist

Sketch of Shear Surface



Sample area : 4.77 in²

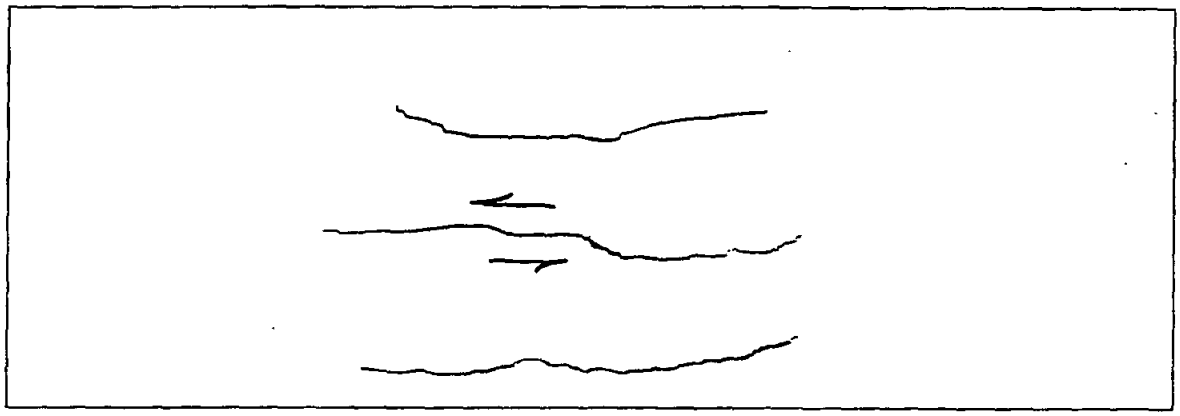
Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 14.7 lb

σ_n	25	50	100	psi
F_n	119	238	476	lb
$F_n - W_b$	104	223	471	lb

Joint Profiles



Comments:

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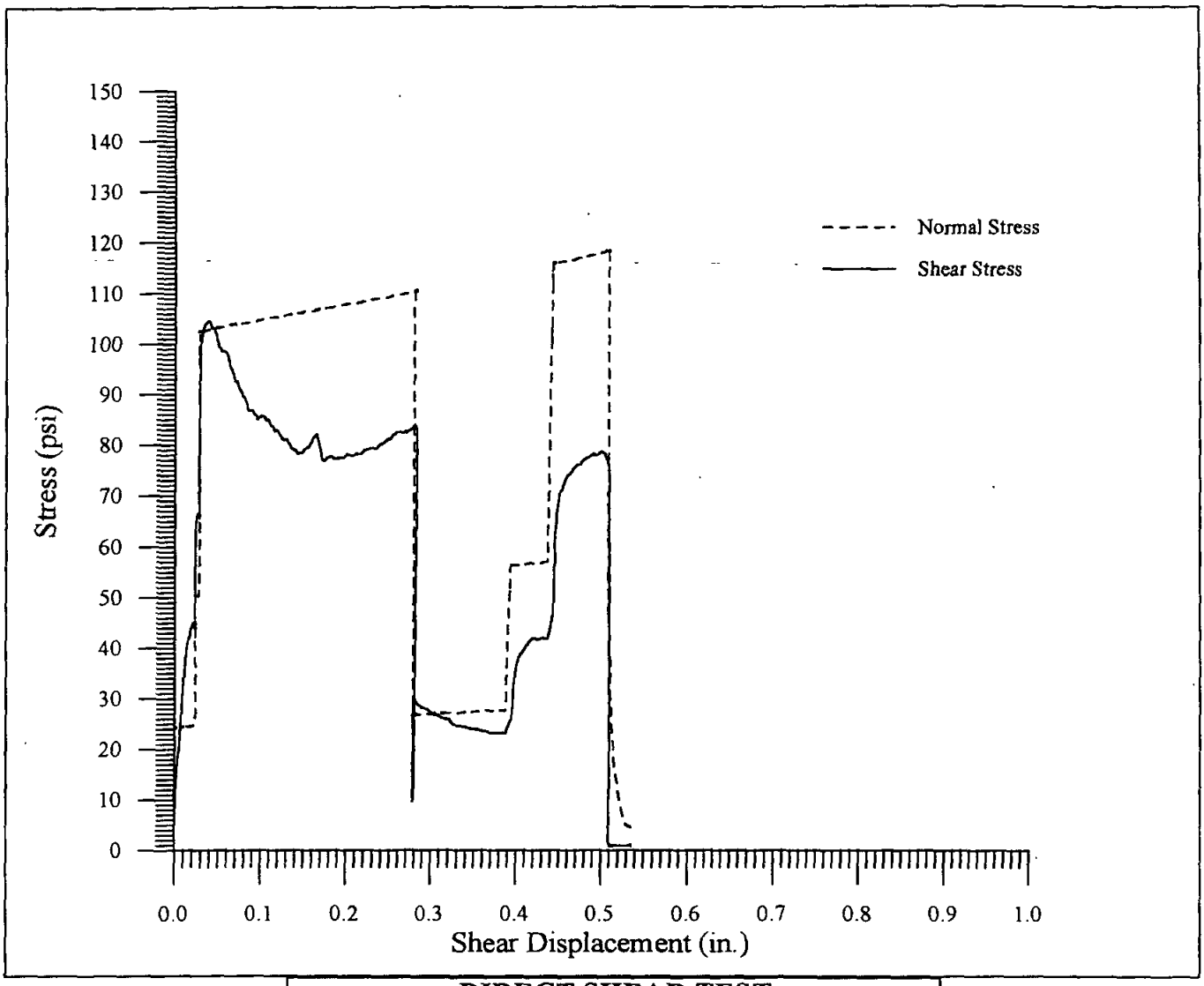


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2B
Sample: 2B-95
Depth: 95.4'

DESCRIPTION

Slightly rough joint in altered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Initial	24	45
	50.5	66.5
	103	104.5
Final	27.5	23
	57	42
	118	78.5

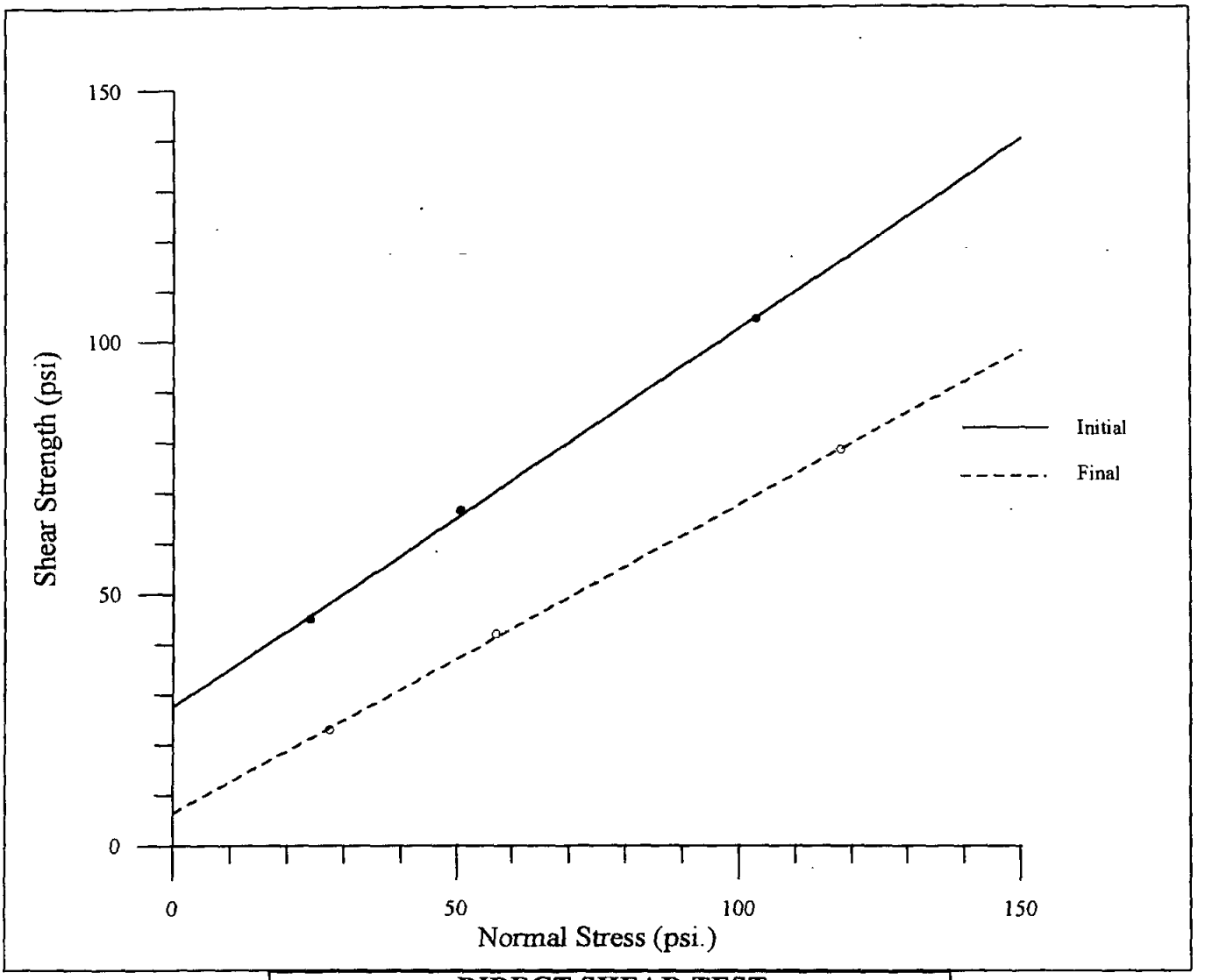
Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2B
Sample: 2B-95
Depth: 95.4'

DESCRIPTION
Slightly rough joint in altered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	27.7	36.8
Final	6.6	31.4

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

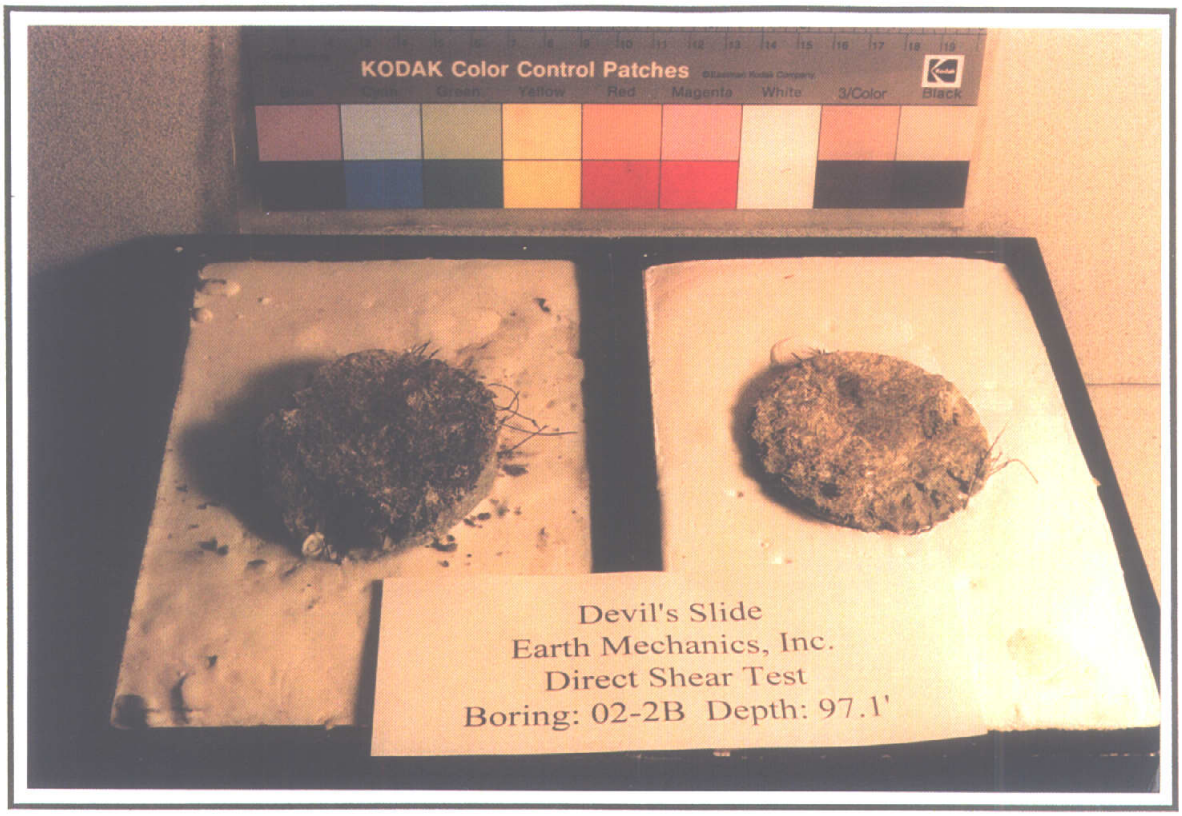
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited

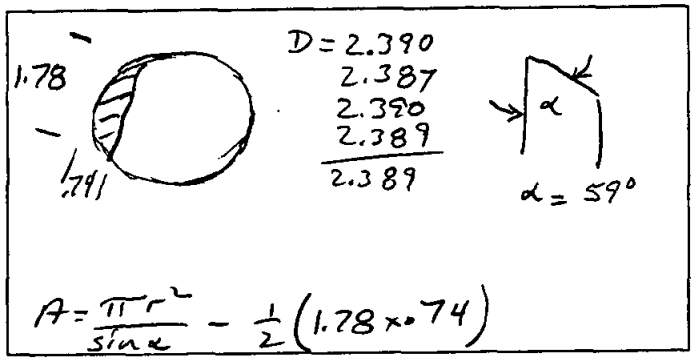
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2B
SampleDescription: Planar joint in altered granodiorite

Date: 10-18-02
Tester: A. Bro

Sample Depth: 97.1' Sample Condition: received dry - tested moist

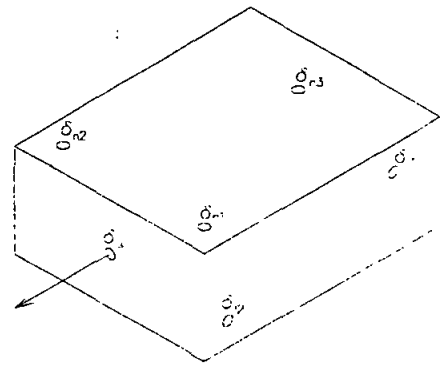
Sketch of Shear Surface



Sample area : 4.57 in²

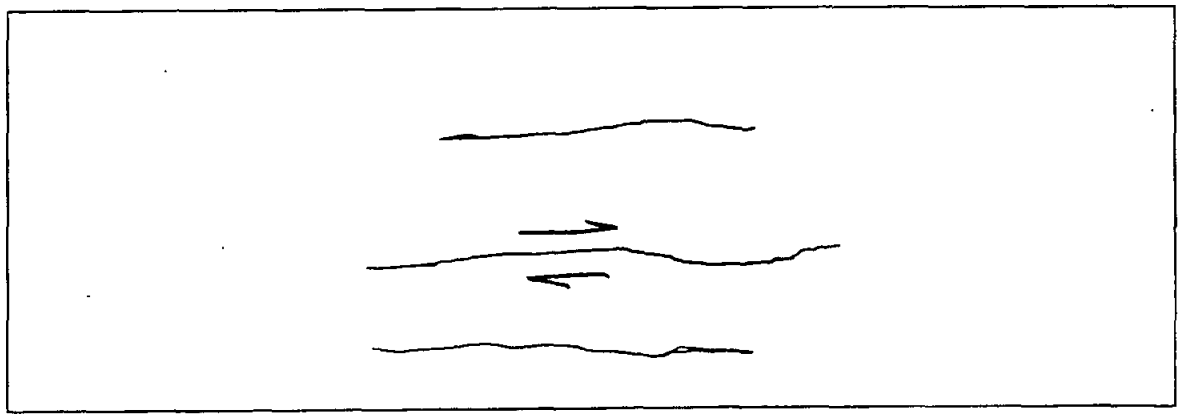
σ_n	25	50	100	psi
F_n	114	228	456	lb
F_n-W_b	99	213	441	lb

Location of LVDTs on top shear box



Estimated top box weight: 15 lb
Measured top box weight: 15.0 lb

Joint Profiles



Comments:

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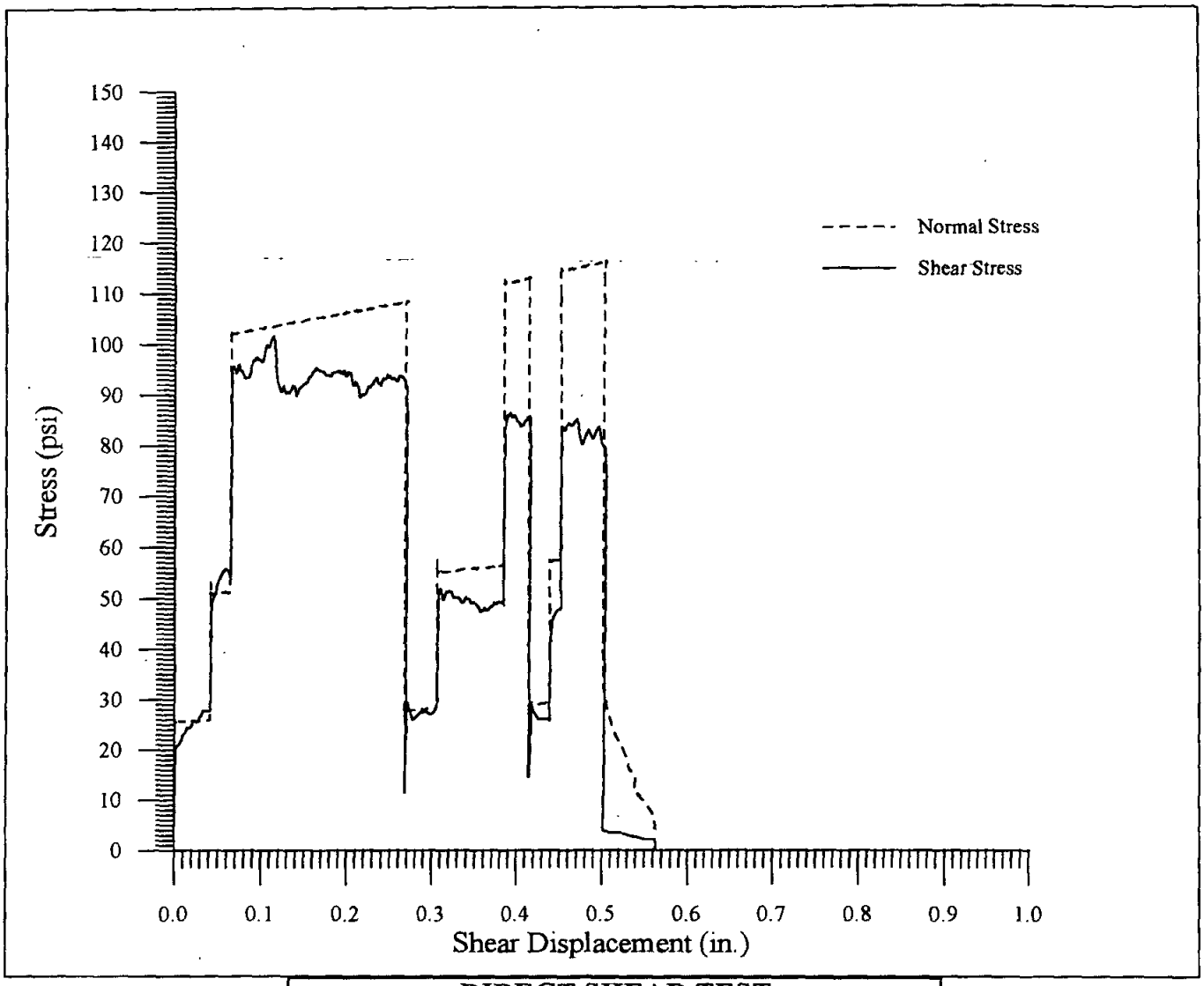


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2B
Sample: 2B-97
Depth: 97.1'

DESCRIPTION

Planar joint in altered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Initial	25.5	28
	51	55.5
	102	95.5
Final	29	26
	57.5	48
	115	84

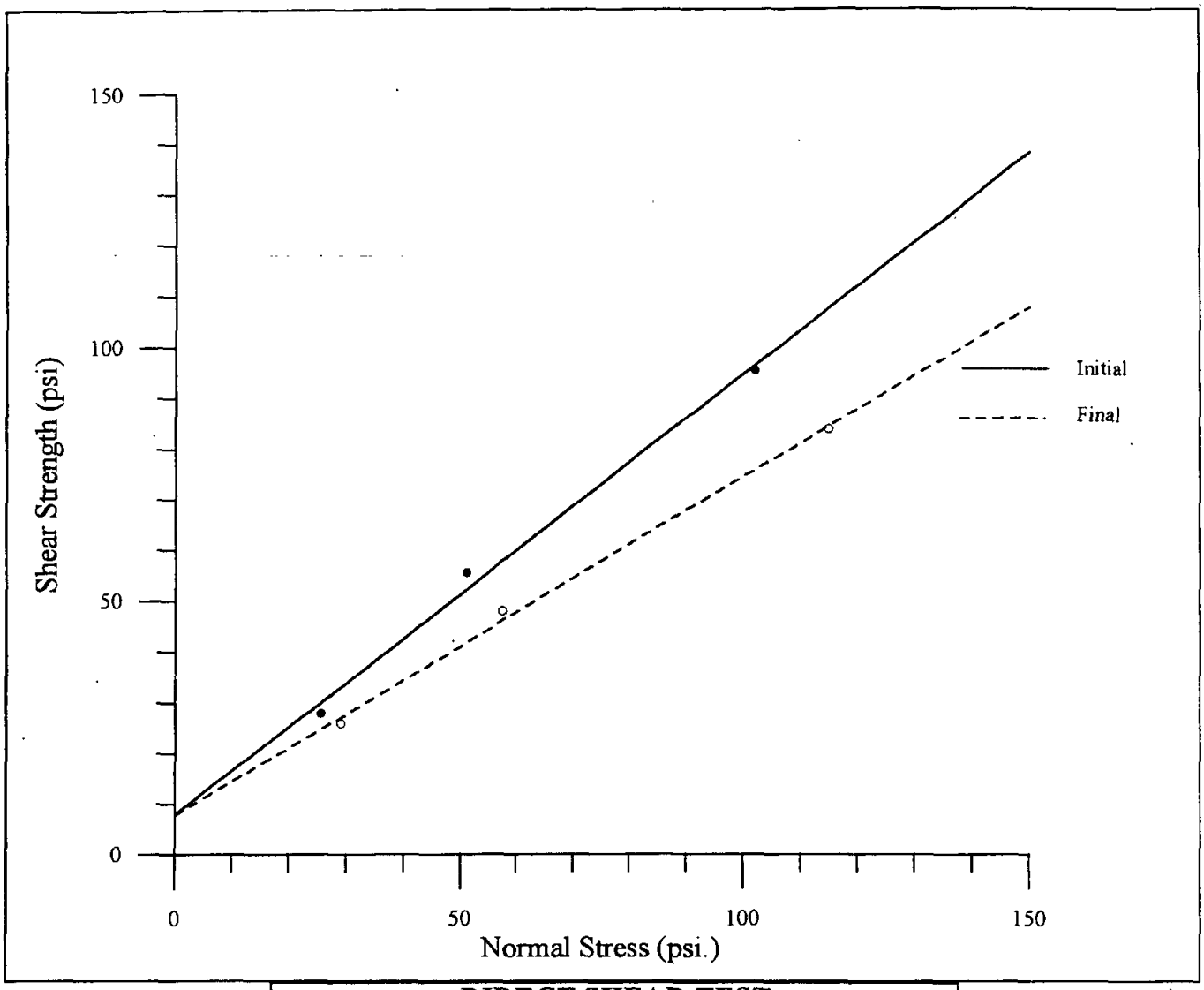
Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2B
Sample: 2B-97
Depth: 97.1'

DESCRIPTION
Planar joint in altered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	8.0	41.0
Final	7.8	33.7

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

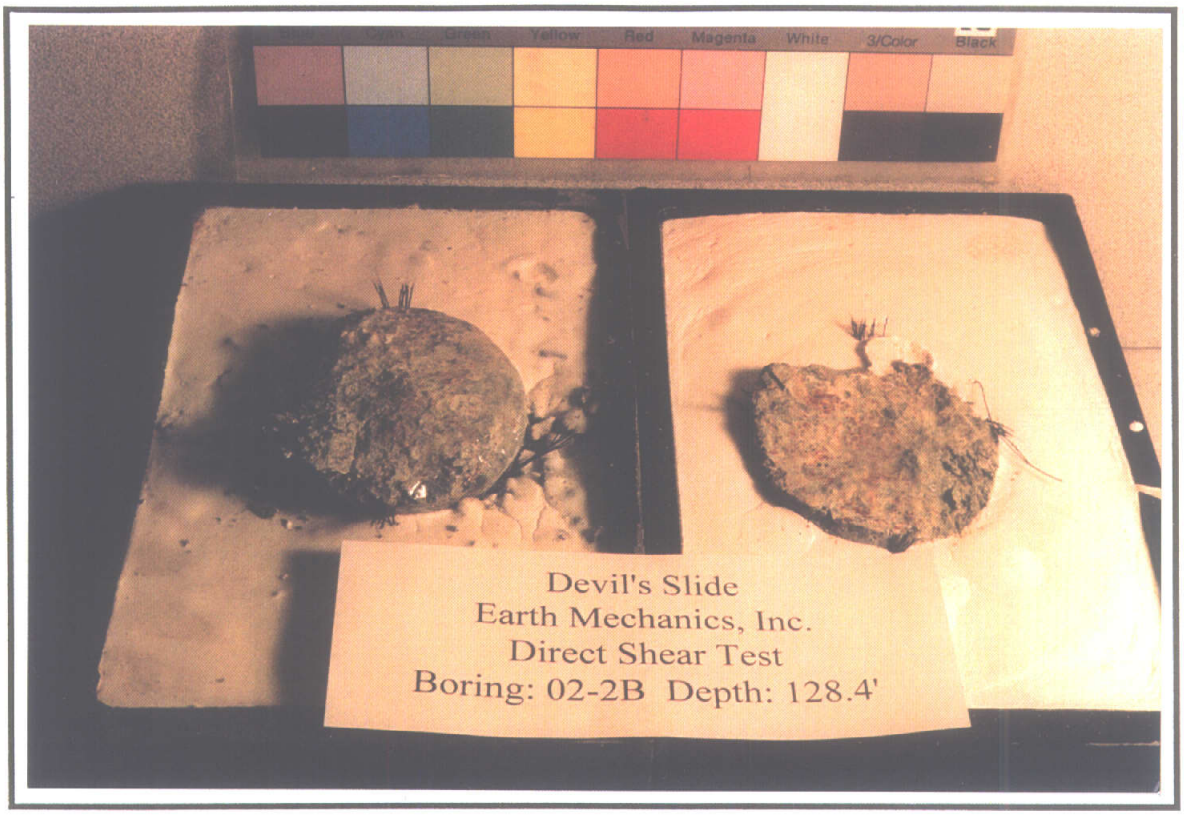
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

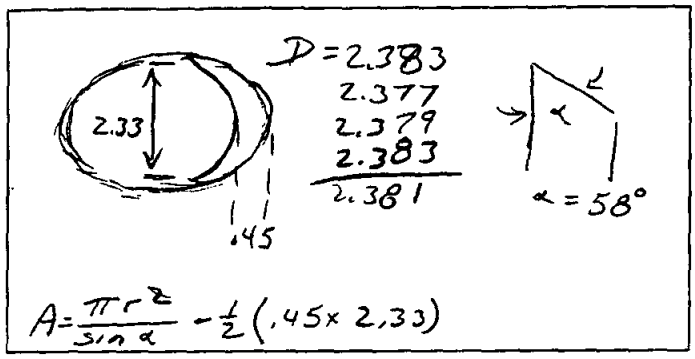
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-2B
SampleDescription: Undulating joint in altered granodiorite

Date: 10-18-02
Tester: A. Bro

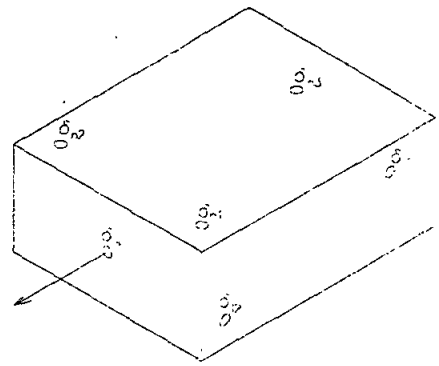
Sample Depth: 128.4' Sample Condition: received dry - tested moist

Sketch of Shear Surface



Sample area : 4.73 in²

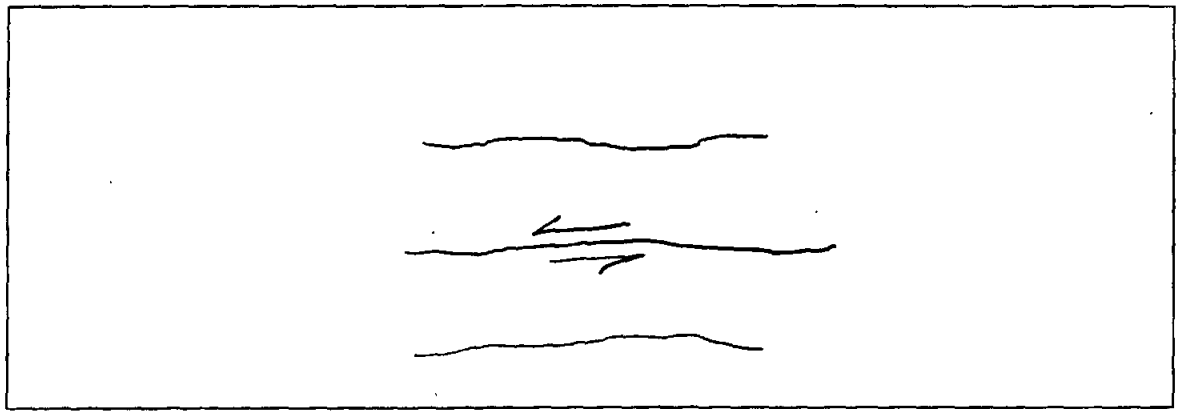
Location of LVDTs on top shear box



σ_n	25	50	100	psi
F_n	118	236	472	lb
F_n-W_b	103	221	457	lb

Estimated top box weight: 15 lb
Measured top box weight: 14.8 lb

Joint Profiles



Comments:

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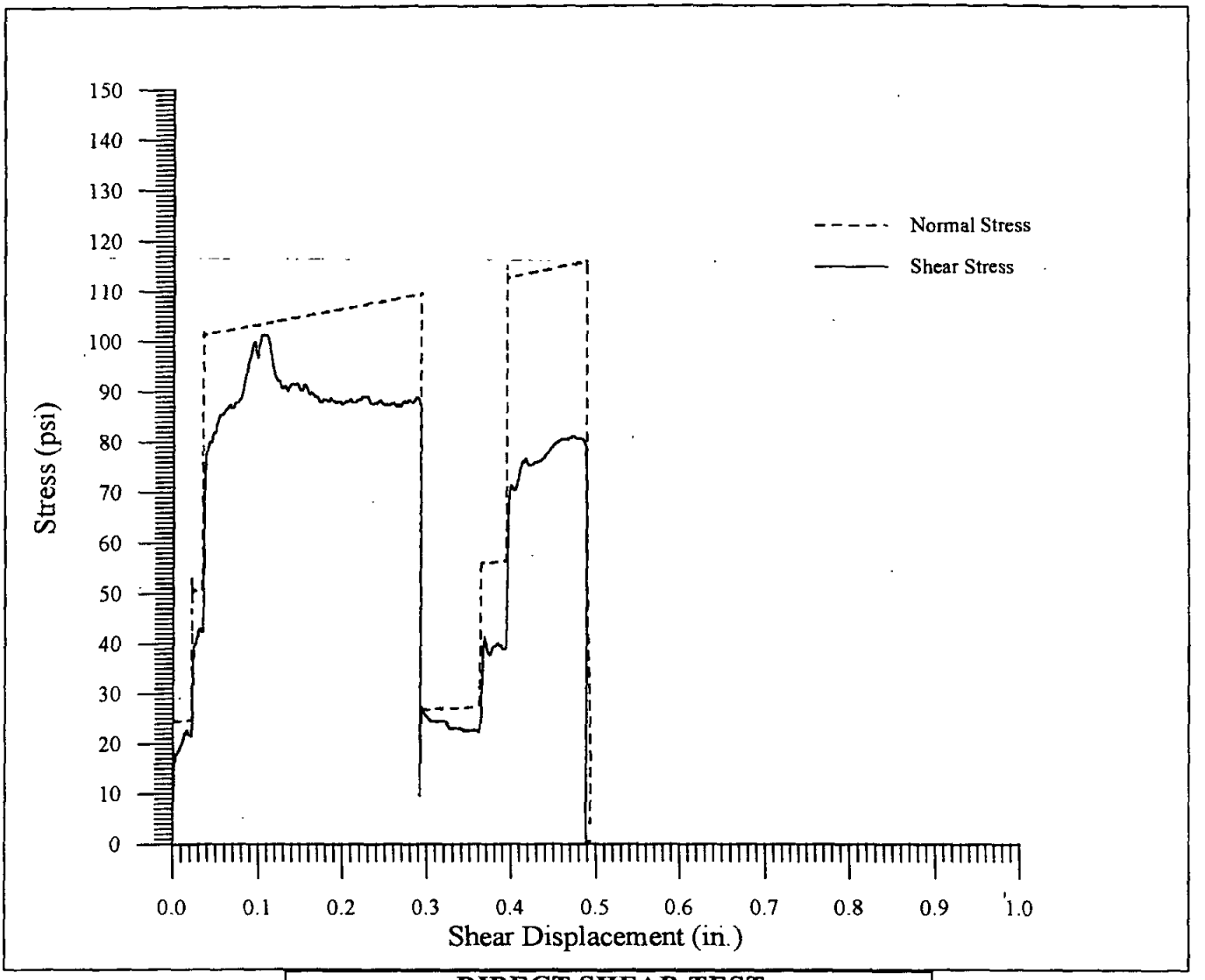


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-2B
Sample: 2B-128
Depth: 128.4'

DESCRIPTION

Undulating joint in altered granodiorite.

	Normal Stress (psi)	Shear Strength (psi)
Initial	24.5	22.5
	51	43
	102.5	88
Final	27	22.5
	56.5	39.5
	103.5	75

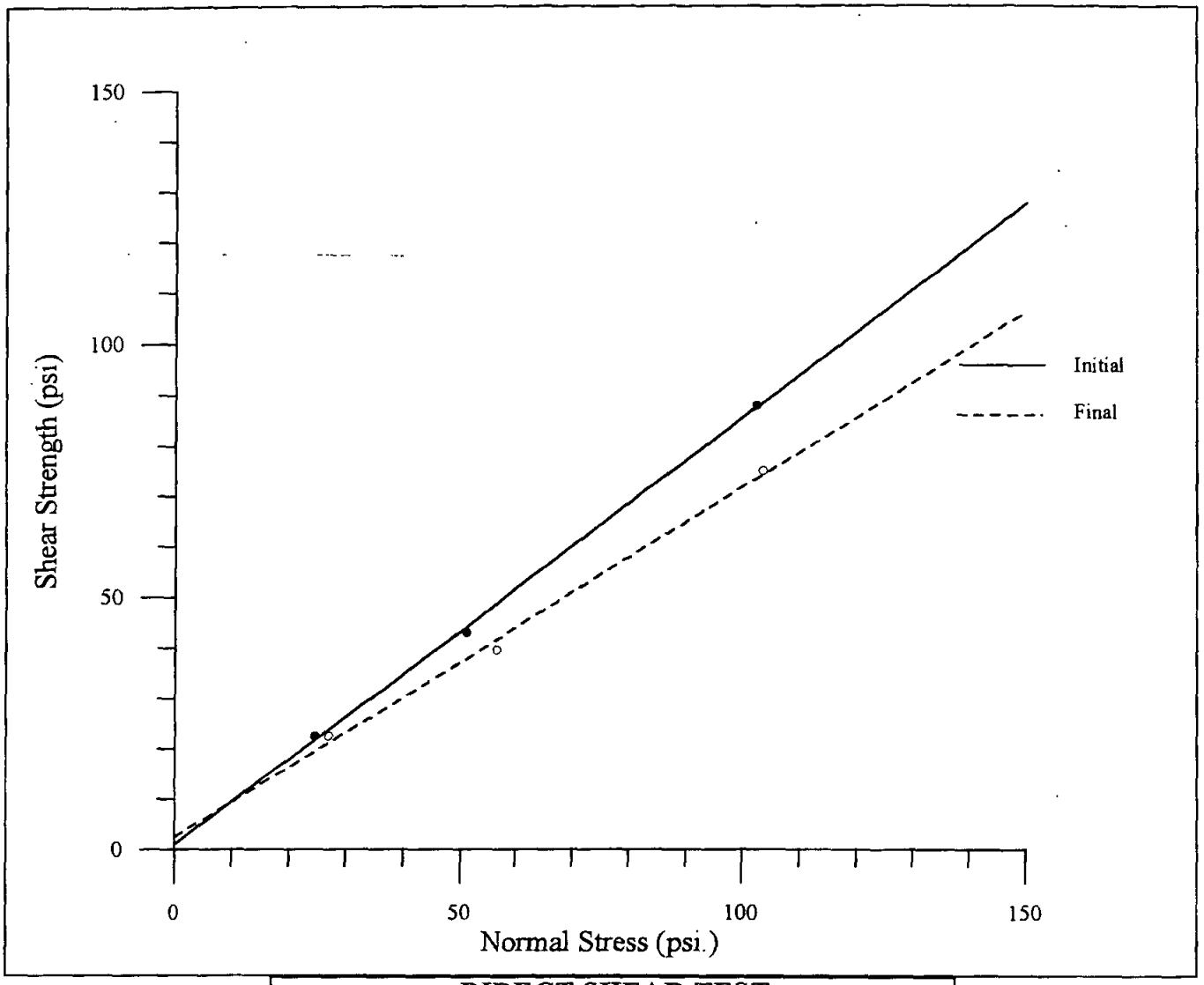
Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-2B
Sample: 2B-128
Depth: 128.4'

DESCRIPTION
Undulating joint in altered granodiorite.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	1.1	40.2
Final	2.5	34.7

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: October 18, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

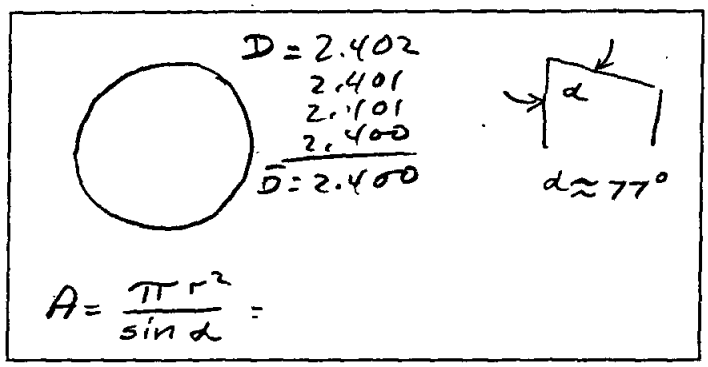
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
SampleDescription: clean planar shale bedding parting - appears to be a fresh mechanical break

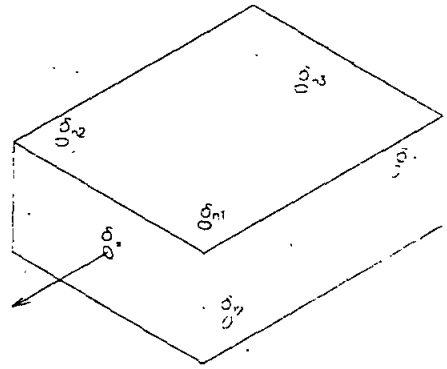
Date: 9/25/02
Tester: A. Bro

Sample Depth: 317.6' Sample Condition: received dry - tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box

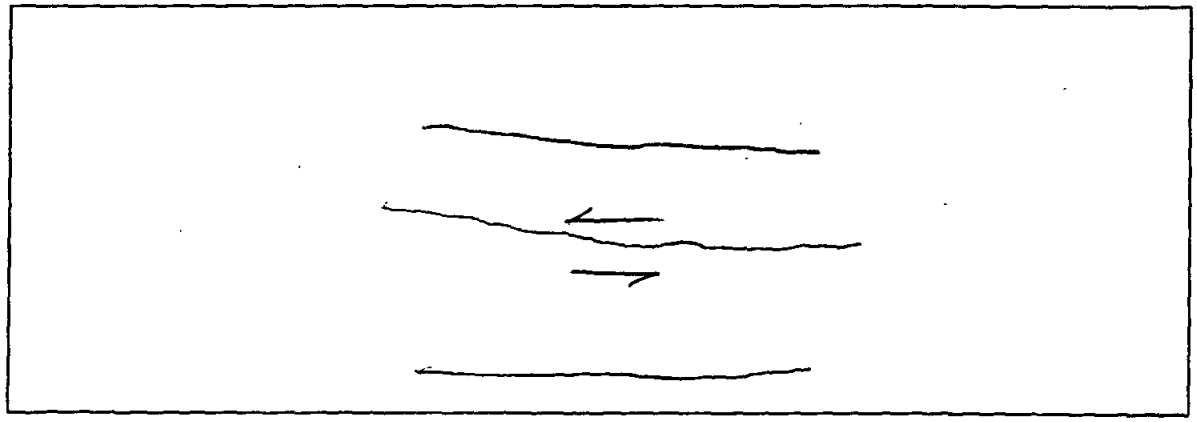


Sample area : 4.64 in²

σ_n	60	120	240	psi
F_n	278	557	1114	lb
F_n-W_b	263	542	1099	lb

Estimated top box weight: 15.5 lb
Measured top box weight: 14.8 lb

Joint Profiles



Comments:

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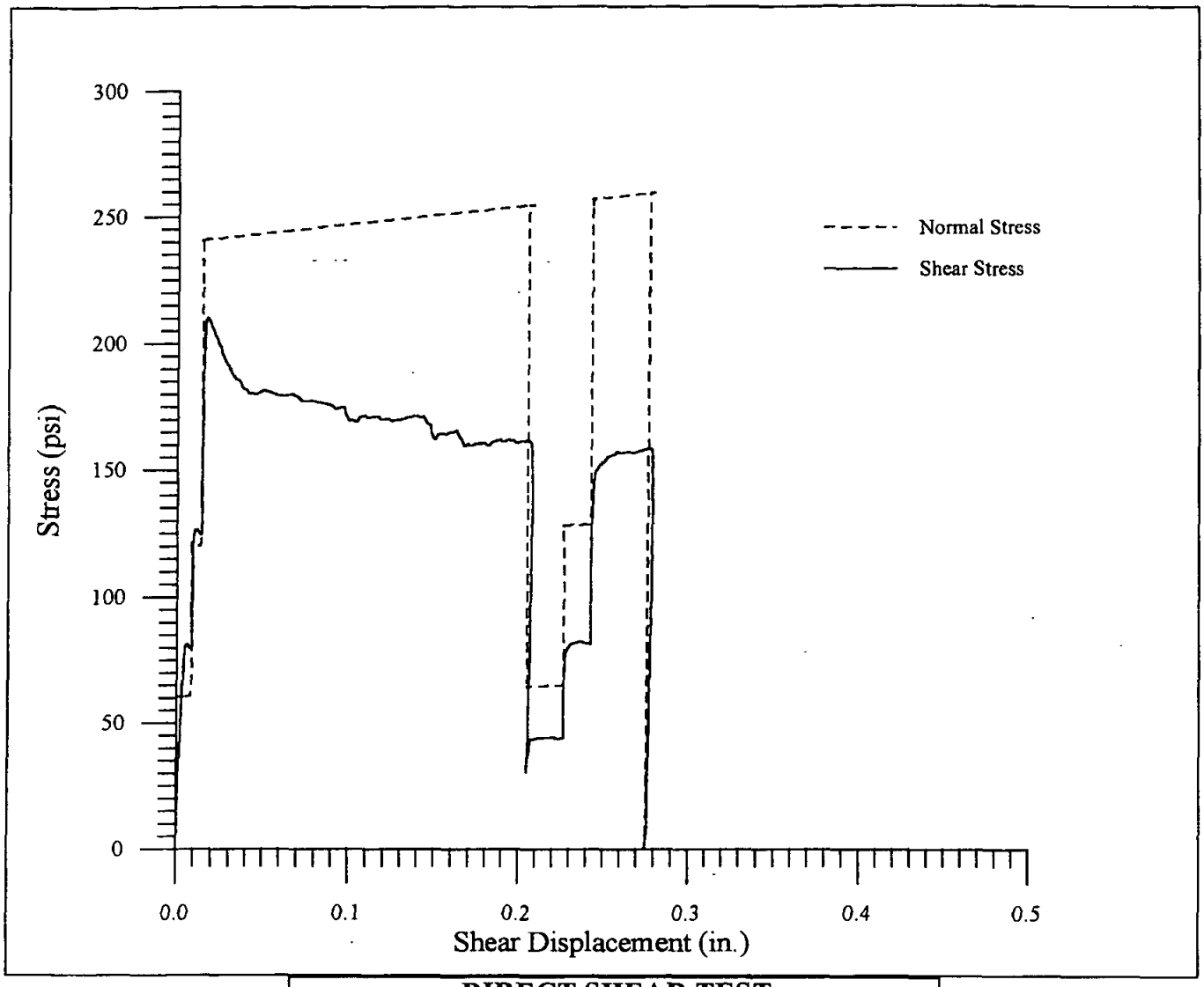


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-317
Depth: 317.6'

DESCRIPTION

Clean planar bedding plane in shale possibly a mechanical fracture.

	Normal Stress (psi)	Shear Strength (psi)
Initial	60	72
	120	126
	241	210
Final	65	45
	128	83
	259	157

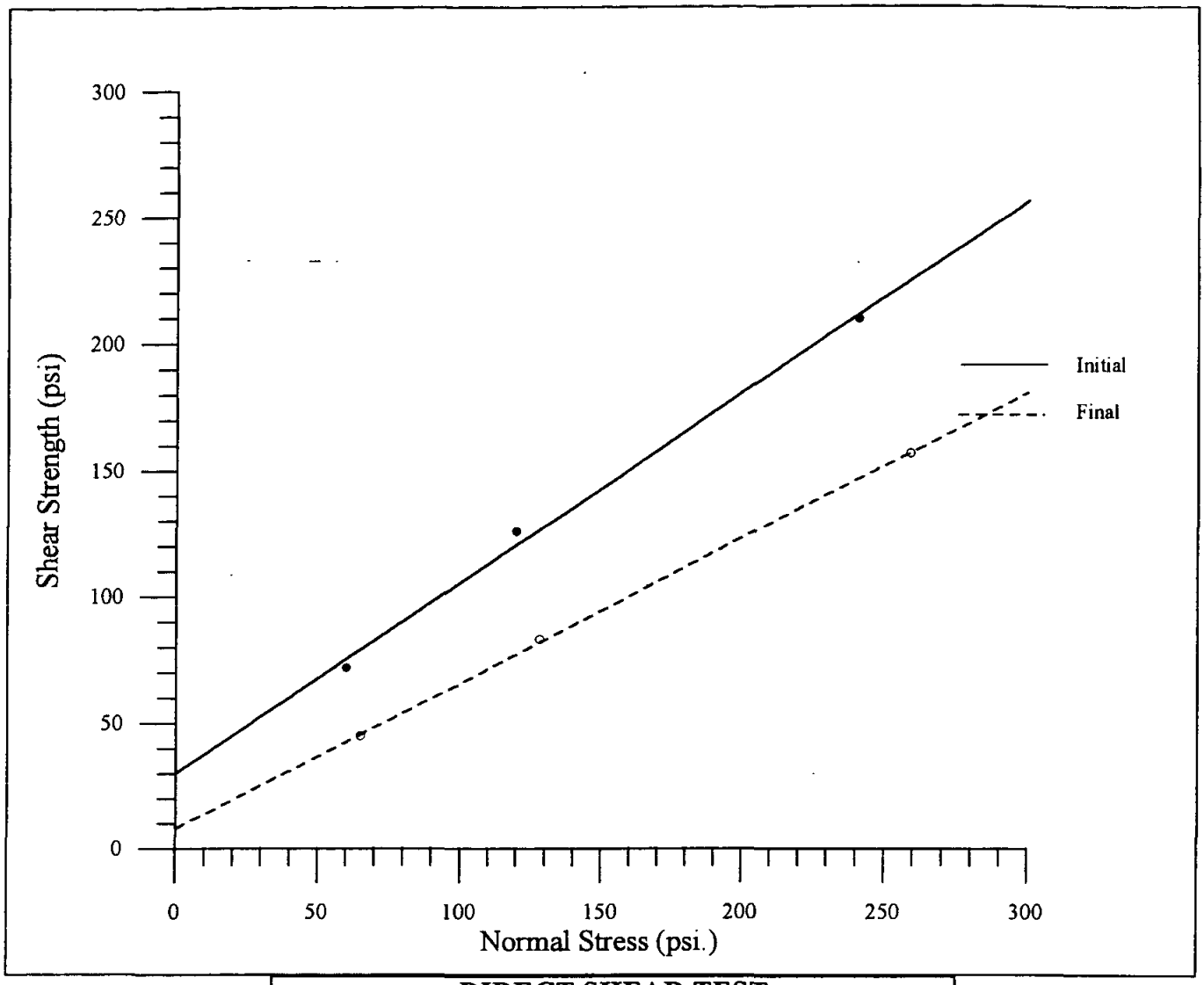
Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-11
Sample: 11-317
Depth: 317.6'

DESCRIPTION
Clean planar bedding plane in shale, possibly a mechanical fracture.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	30.4	37.0
Final	8.3	29.9

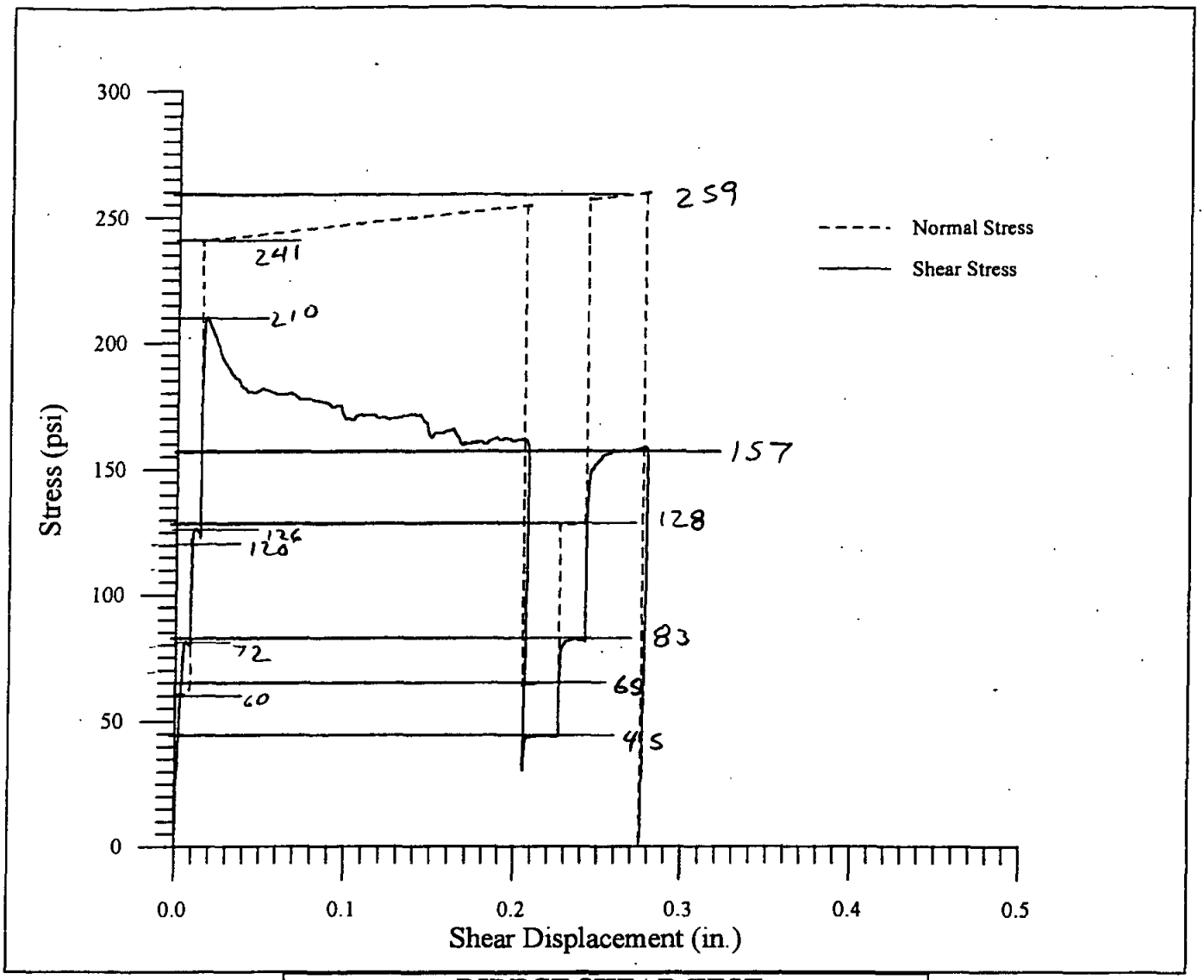
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-317
Depth: 317.6'

DESCRIPTION

Clean planar shale bedding plane in shale *possibly a mechanical fracture.*

	Normal Stress (psi)	Shear Strength (psi)
Initial	15.5	20.0
	30.5	35.0
	60.5	59.0
Final	16.0	10.5
	33.5	20.0
	67.0	36.5

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

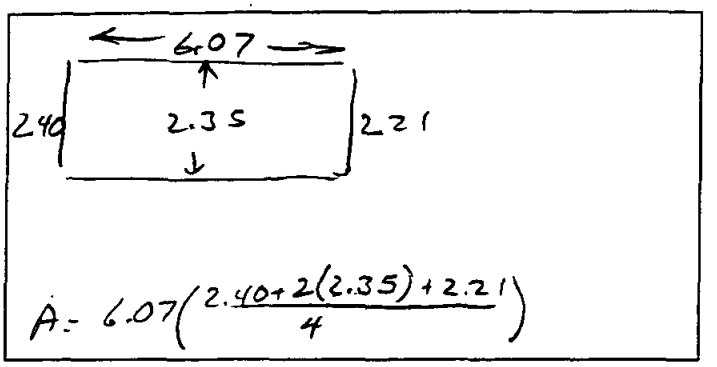
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
SampleDescription: Contact between sheared shale gouge and shale ~10° to core axis. INTACT SAMPLE

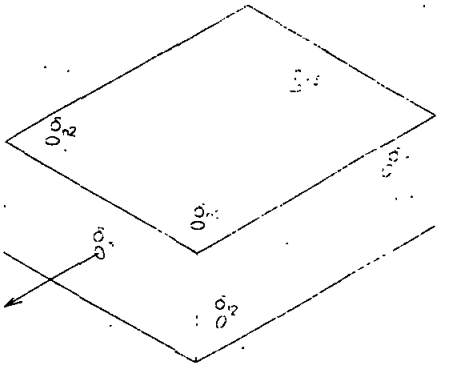
Date: 9/25/02
Tester: A. Bro

Sample Depth: 233.7-234.2' Sample Condition: received moist - tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box



Sample area : 14.13 in²

s/b	40	80	160	psi
σ_n*	15	30	60	psi
F_n	212	424	848	lb
F_n-W_b	197	409	833	lb

Estimated top box weight: 15.5 lb
Measured top box weight: ~15 lb

Joint Profiles

NO JOINT PROFILE - SOFT CLAY FILLING

Comments: *estimated gouge strength ≈ 60 psi
Strain hardening behavior
4th stage i-curved relatively long normal compression
FAILED by shear along shear zone - clay was squeezed into inter-box void.

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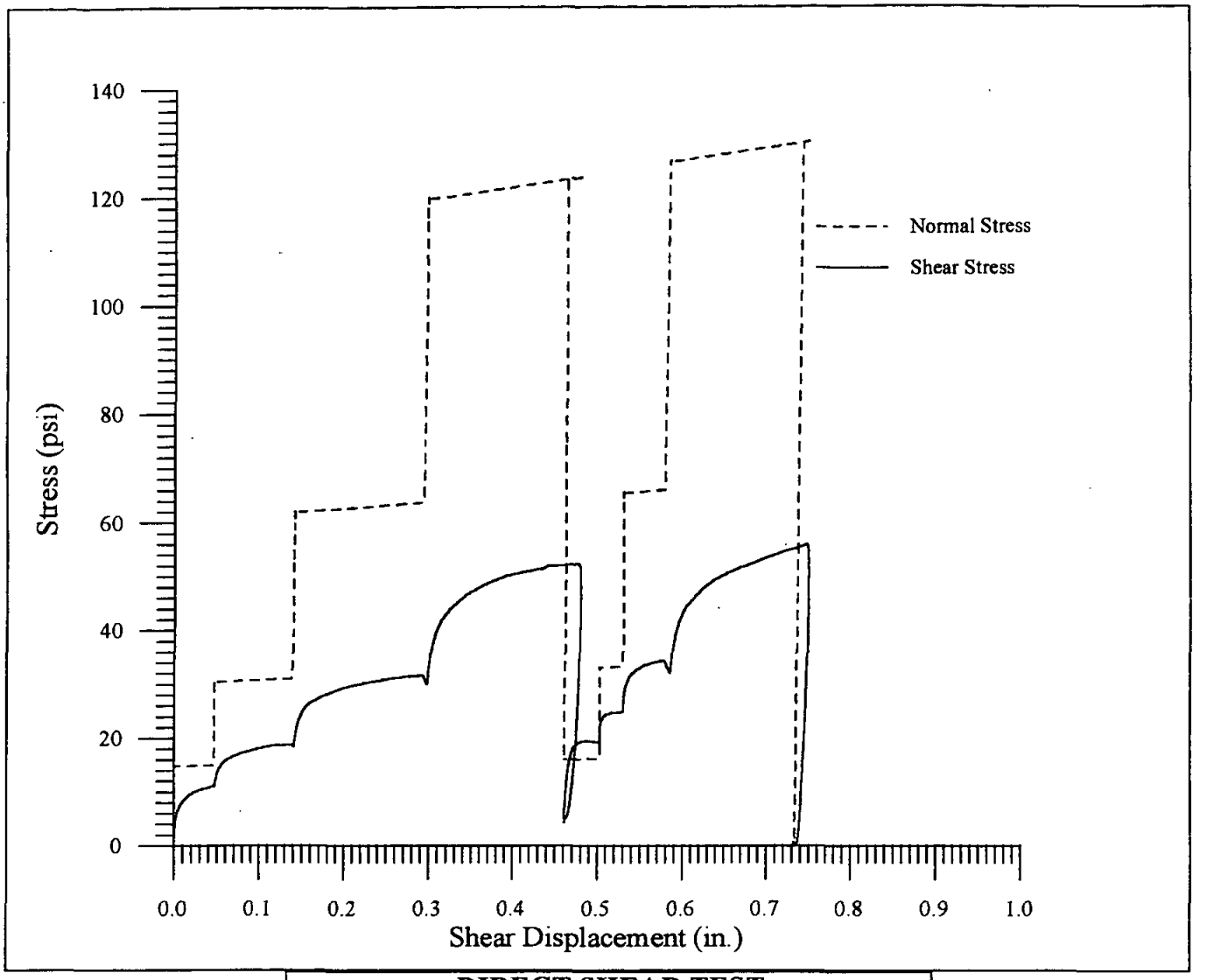


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-233
Depth: 233.7-234.2'

DESCRIPTION

Intact interface between sheared clayey shale gouge and shale.

	Normal Stress (psi)	Shear Strength (psi)
Initial	15	12
	31	19
	64	32
	125	53
Final	16	19
	33	25
	66	34

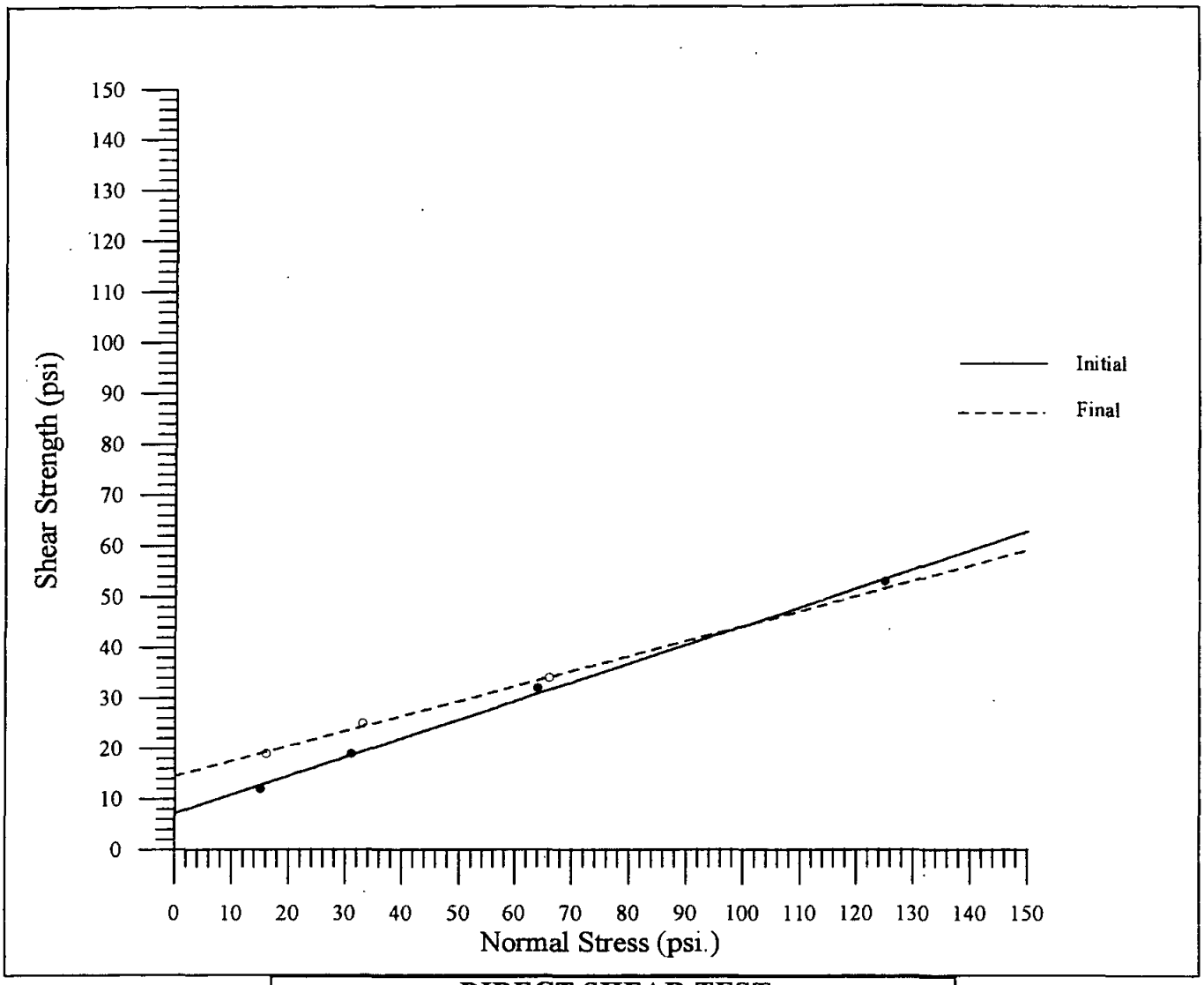
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-11
Sample: 11-233
Depth: 233.7-234.2'

DESCRIPTION
Intact interface between sheared clayey shale gouge and shale.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	7.3	20.3
Final	14.6	16.5

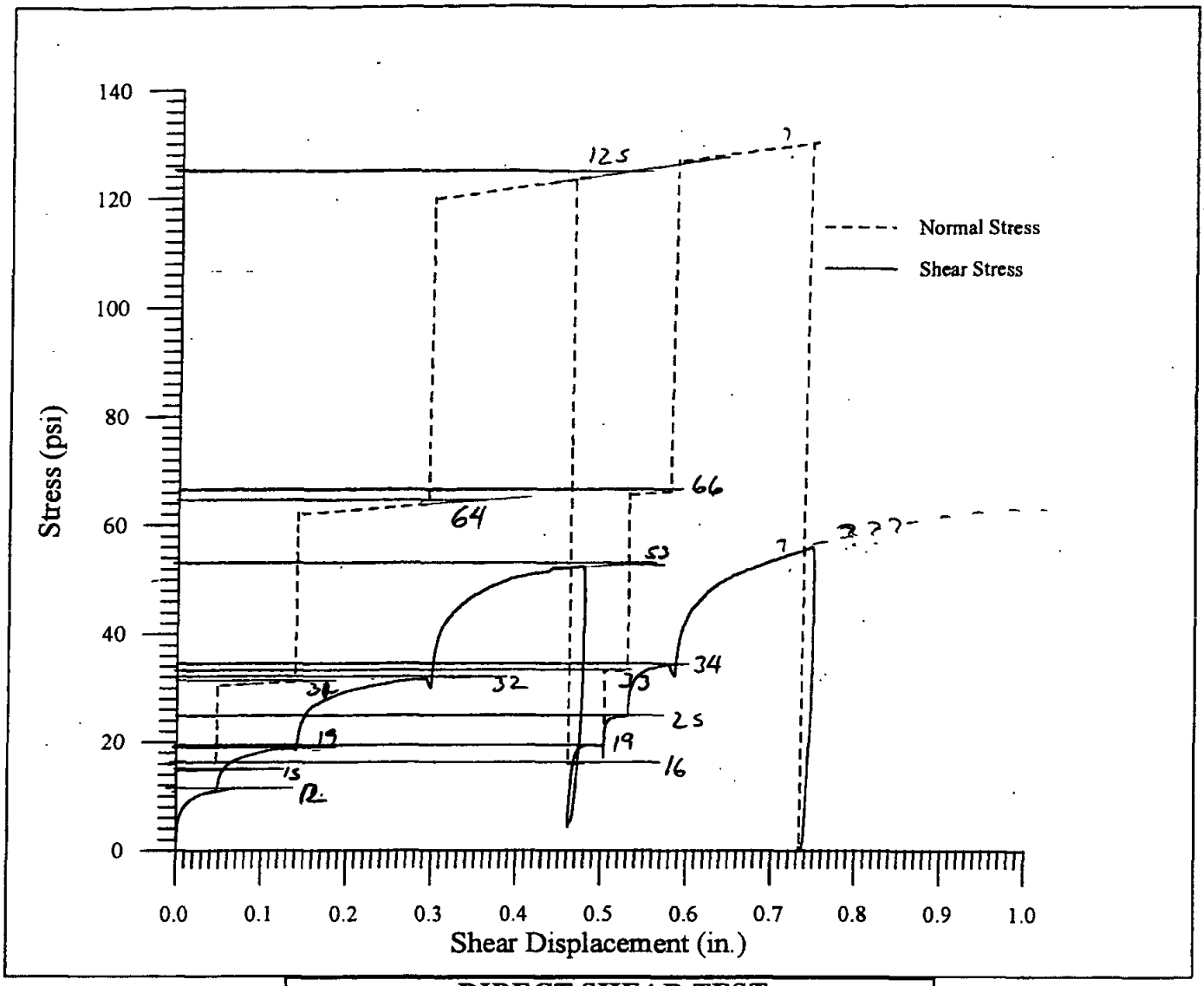
Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-233
Depth: 233.7-234.2'

DESCRIPTION

Intact interface between sheared clayey shale gouge and shale.

	Normal Stress (psi)	Shear Strength (psi)
Initial	15.5	20.0
	30.5	35.0
	60.5	59.0
Final	16.0	10.5
	33.5	20.0
	67.0	36.5

Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

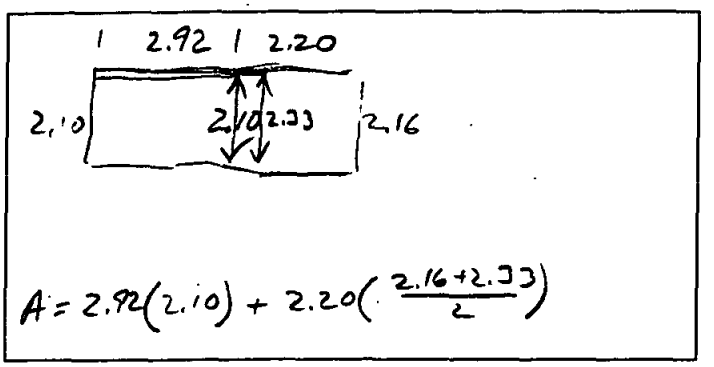
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-11
SampleDescription: Partially healed axial joint passing through shale and grey sandstone - oxide coated

Date: 9/25/02
Tester: A.Bro

Sample Depth: 122.8-123.2' Sample Condition: received dry - tested - wet

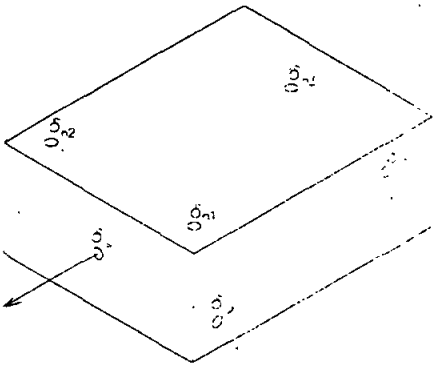
Sketch of Shear Surface



Sample area : 11.07 in²

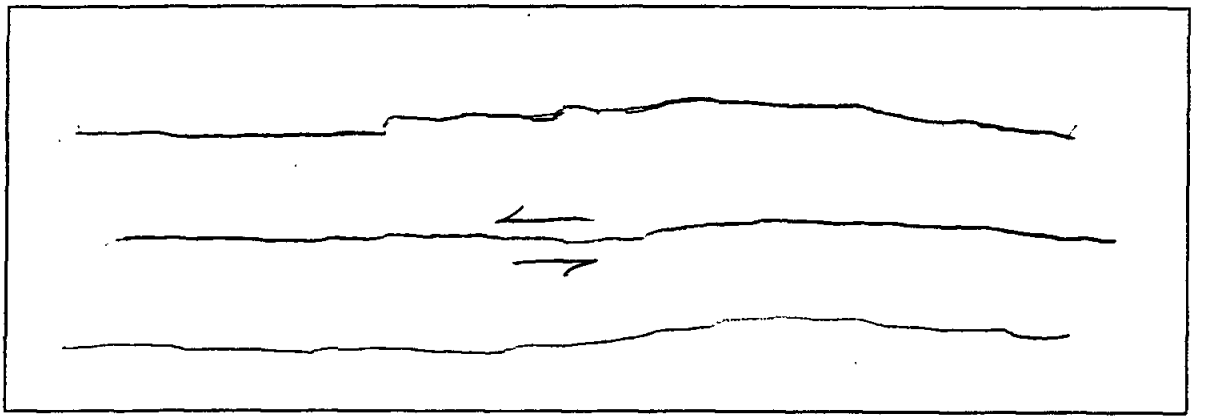
σ_n	15	30	60	psi
F_n	166	332	664	lb
F_n-W_b	151	317	649	lb

Location of LVDTs on top shear box



Estimated top box weight: 15.5 lb
Measured top box weight: 14.7 lb

Joint Profiles



Comments: Excellent sample & test

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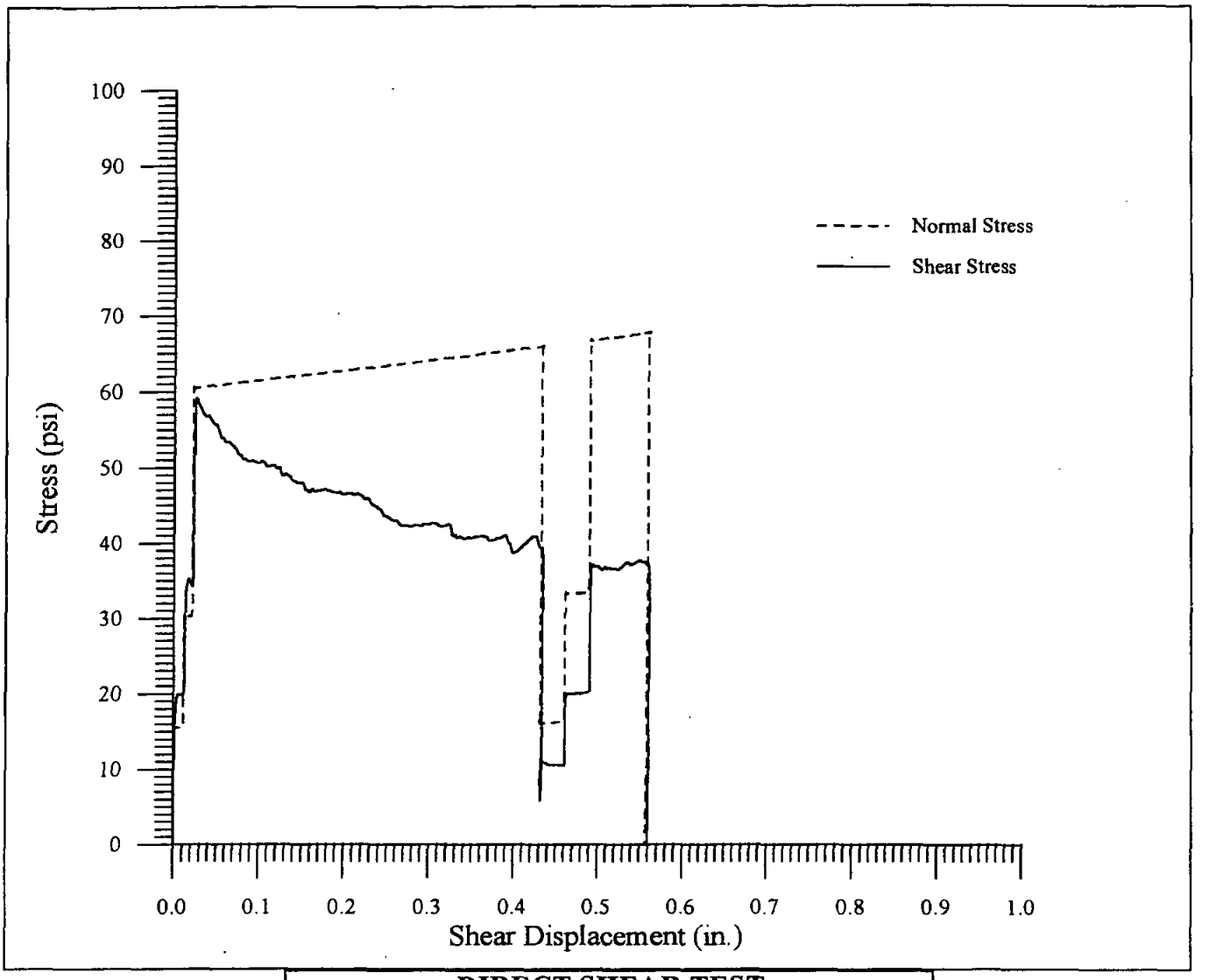


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-122
Depth: 122.8-123.2'

DESCRIPTION

Partially healed axial oxide coated joint passing through shale and gray sandstone

	Normal Stress (psi)	Shear Strength (psi)
Initial	15.5	20.0
	30.5	35.0
	60.5	59.0
Final	16.0	10.5
	33.5	20.0
	67.0	36.5

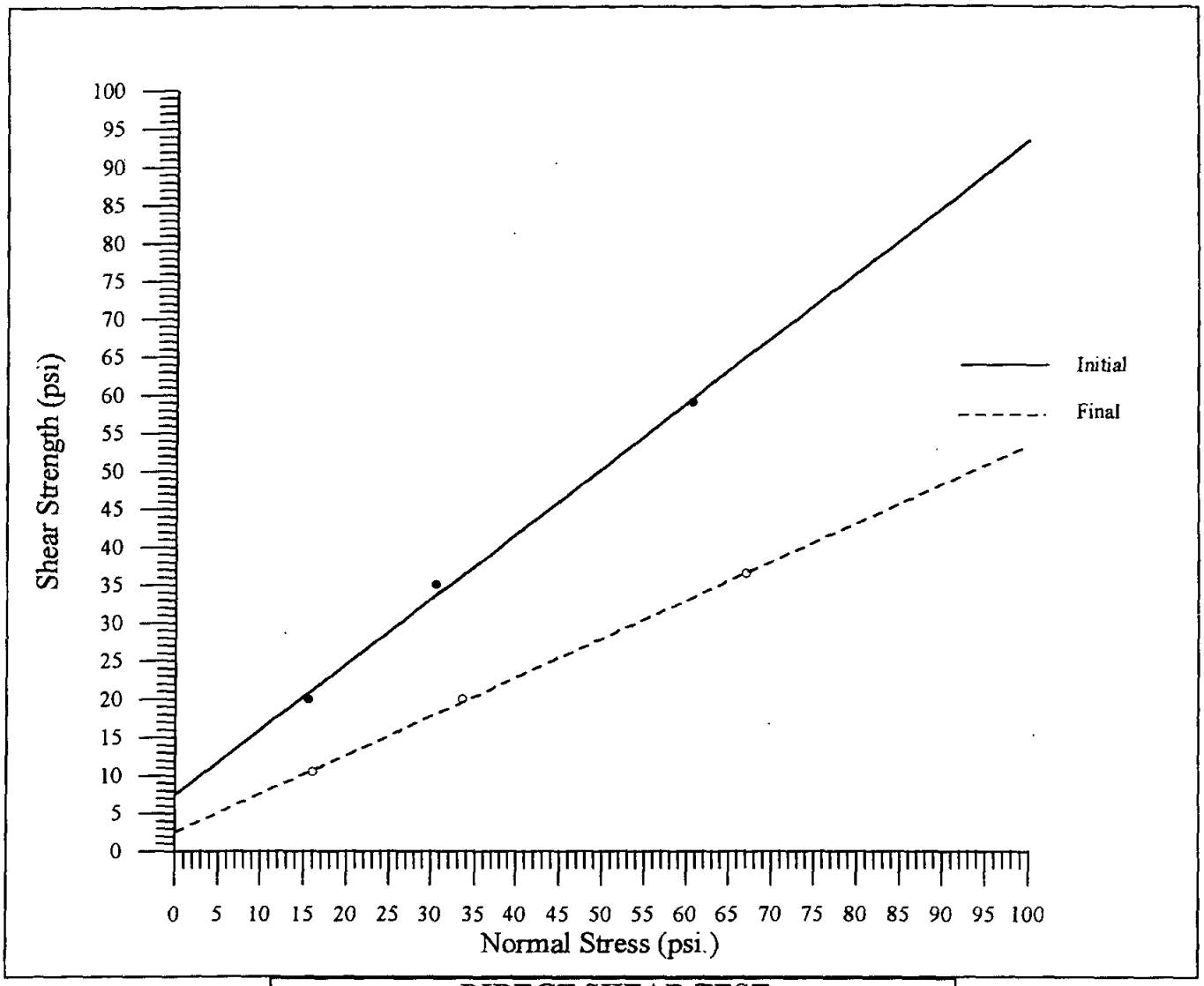
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-11
Sample: 11-122
Depth: 122.8-123.2'

DESCRIPTION
Partially healed axial oxide coated joint passing through shale and gray sandstone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	7.6	40.6
Final	2.6	26.9

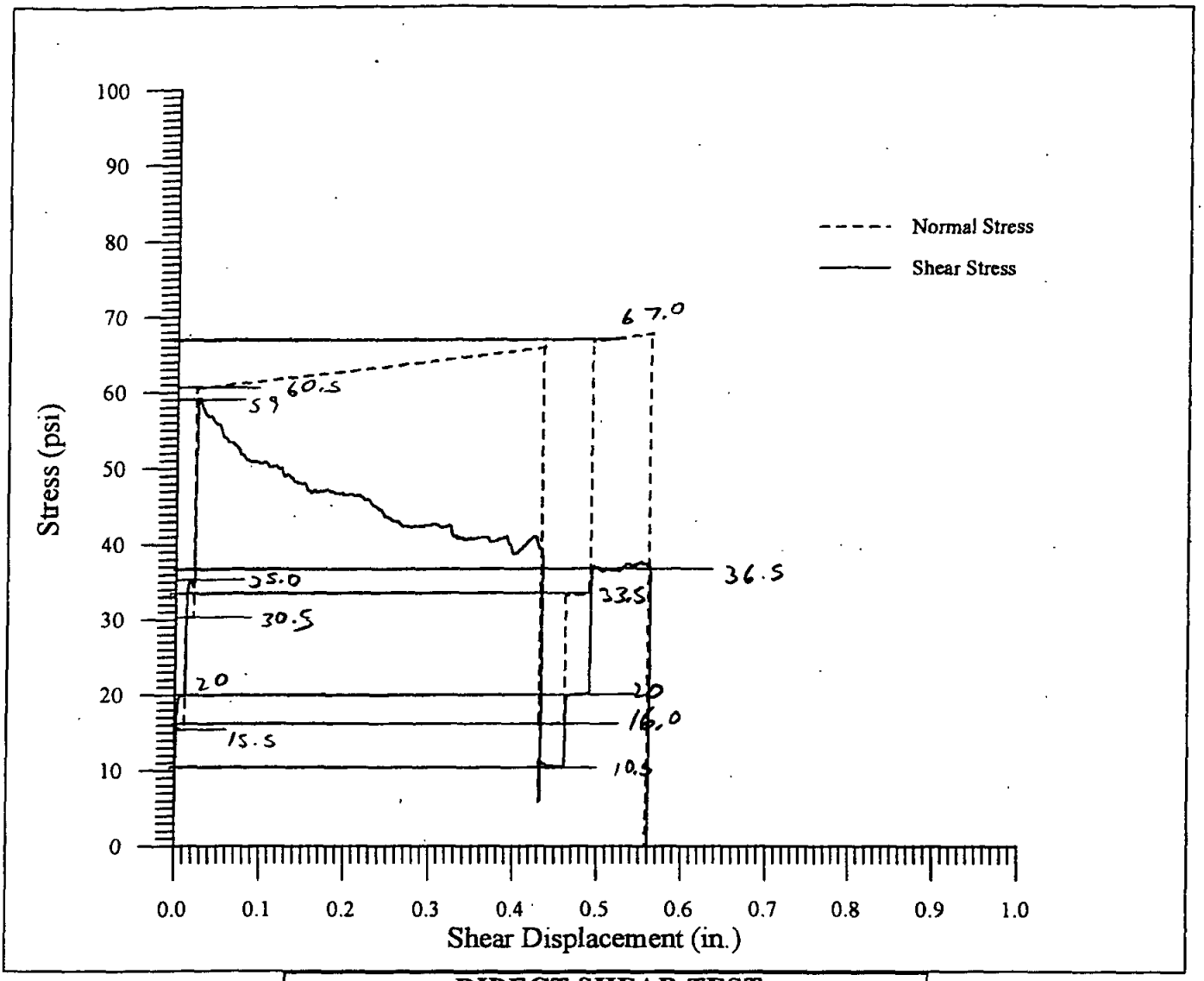
Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-122
Depth: 122.8-123.2'

DESCRIPTION

Partially healed axial oxide coated joint passing through shale and gray sandstone

	Normal Stress (psi)	Shear Strength (psi)
Initial	4.7	3.9
	10.8	8.5
	21.2	14.7
Final	4.9	3.9
	11.4	7.9
	24.5	14.1

Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

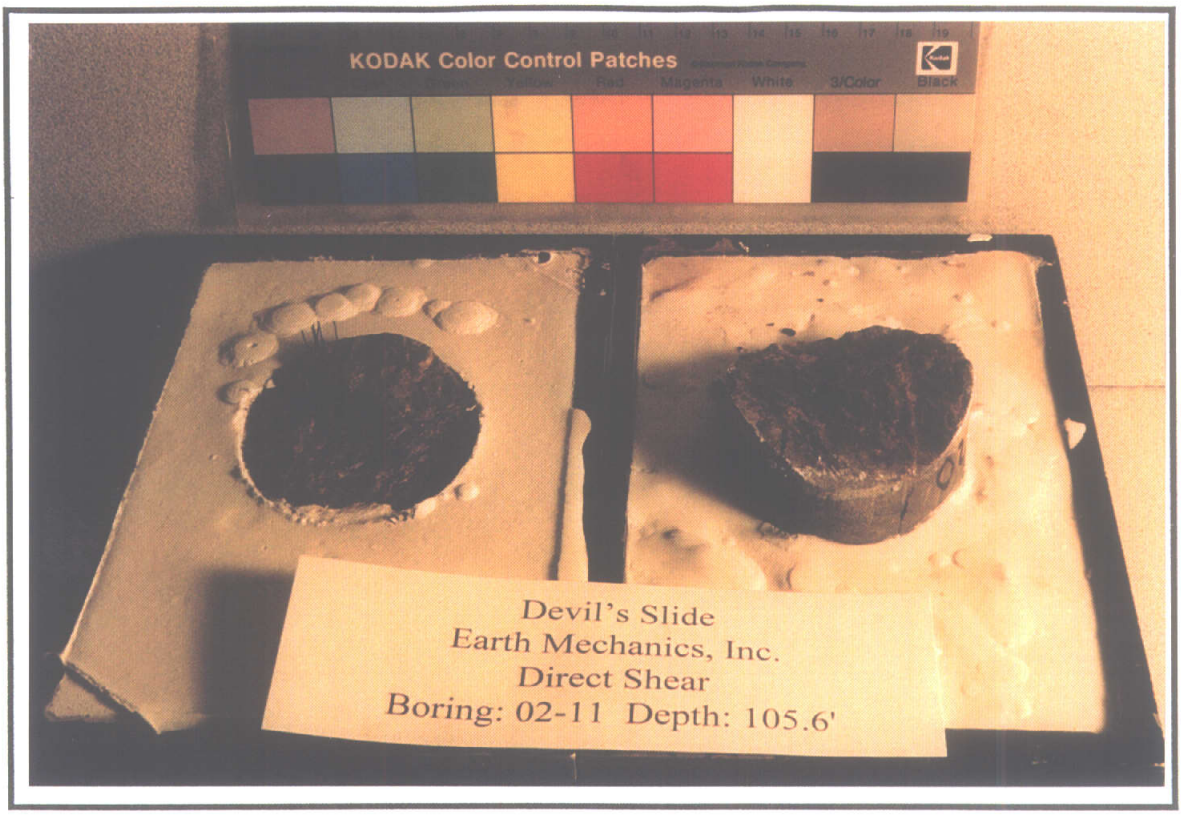
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited — GTU

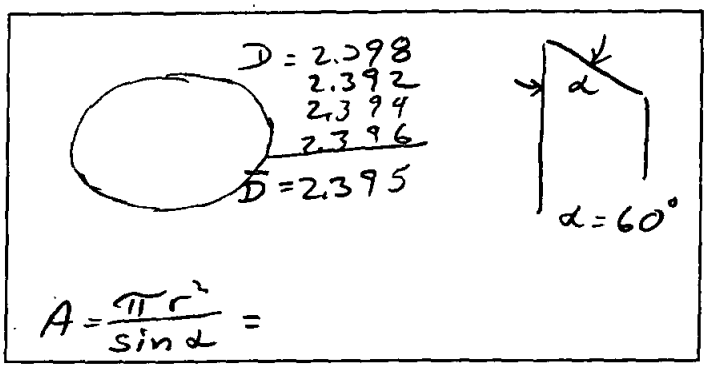
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
SampleDescription: Wavy oxide stained bedding plane contact between shale and tan sandstone.

Date: 9/25/02
Tester: A.Bro

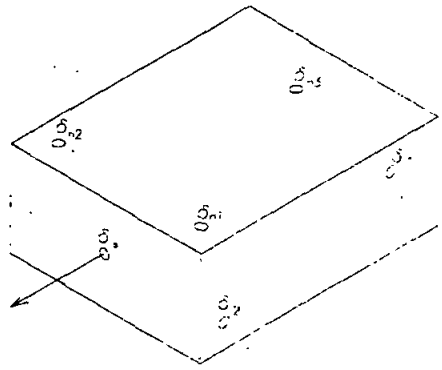
Sample Depth: 105.6 Sample Condition: received dry - tested moist

Sketch of Shear Surface



Sample area : 5.20 in²

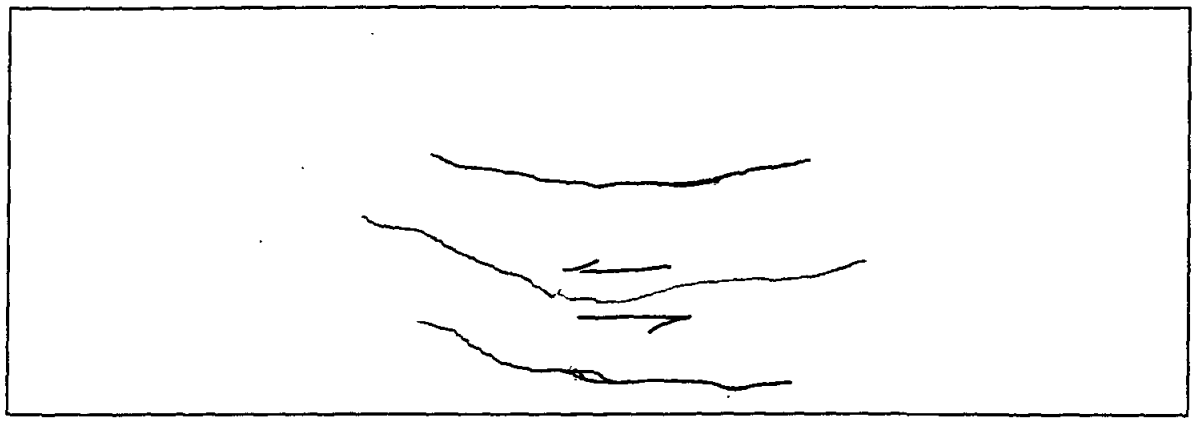
Location of LVDTs on top shear box



σ_n	10	20	40	psi
F_n	52	104	208	lb
$F_n - W_b$	37	89	193	lb

Estimated top box weight: 15.5 lb
Measured top box weight: 14.7 lb

Joint Profiles



Comments: at about .2" shear displacement - the box rocked enough for the edges to make contact. - Box reset & tested a second time.
On retest started to touch out about .227" ie just prior to last stage

PLOTTED w/o area correction

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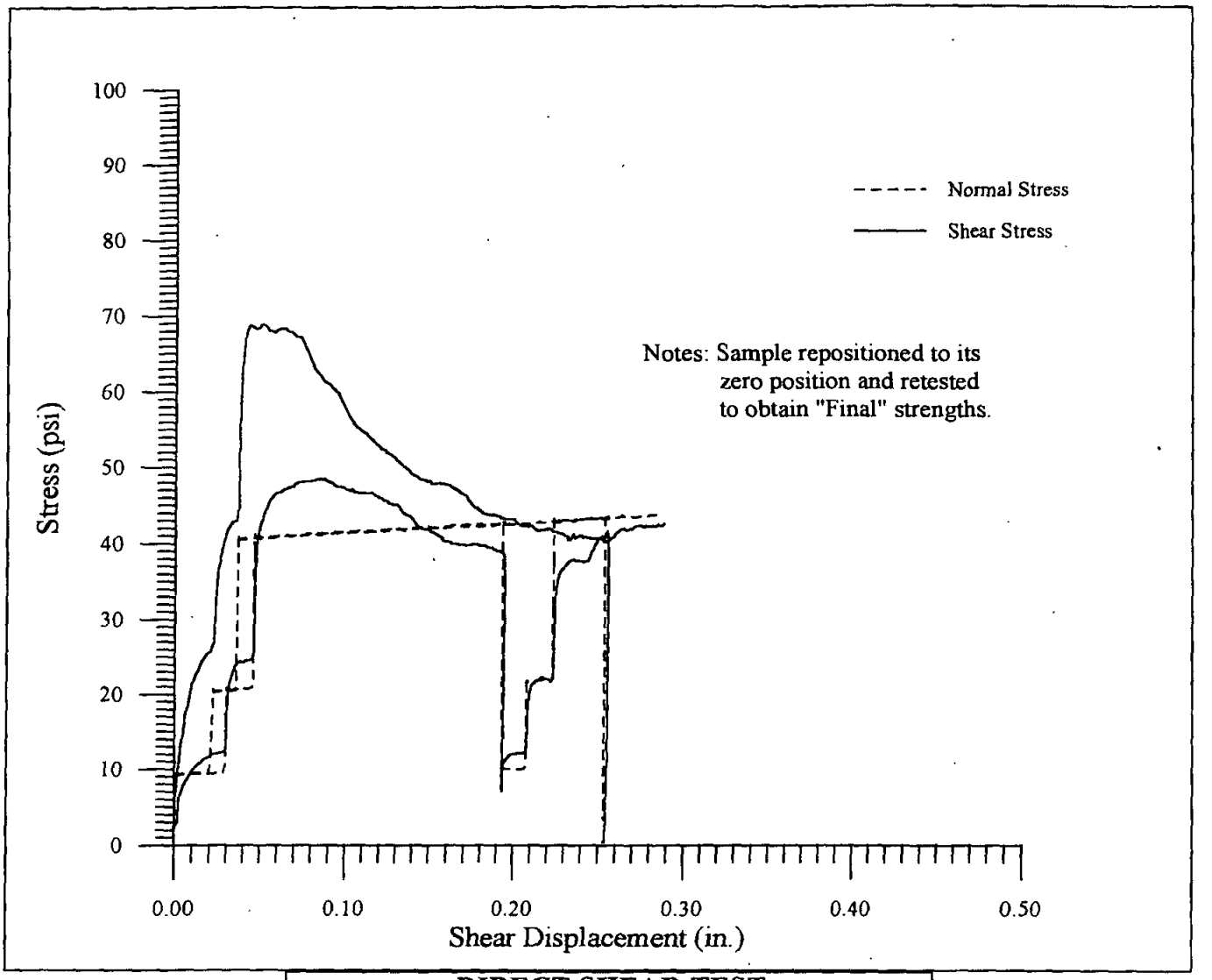


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-105
Depth: 105.6'

DESCRIPTION

Wavy oxide stained bedding contact between shale and tan sandstone.

	Normal Stress (psi)	Shear Strength (psi)
Initial	9.2	26.5
	20.5	43.0
	40.8	68.5
Final	10.0	12.0
	22.0	22.0
	43.0	37.8

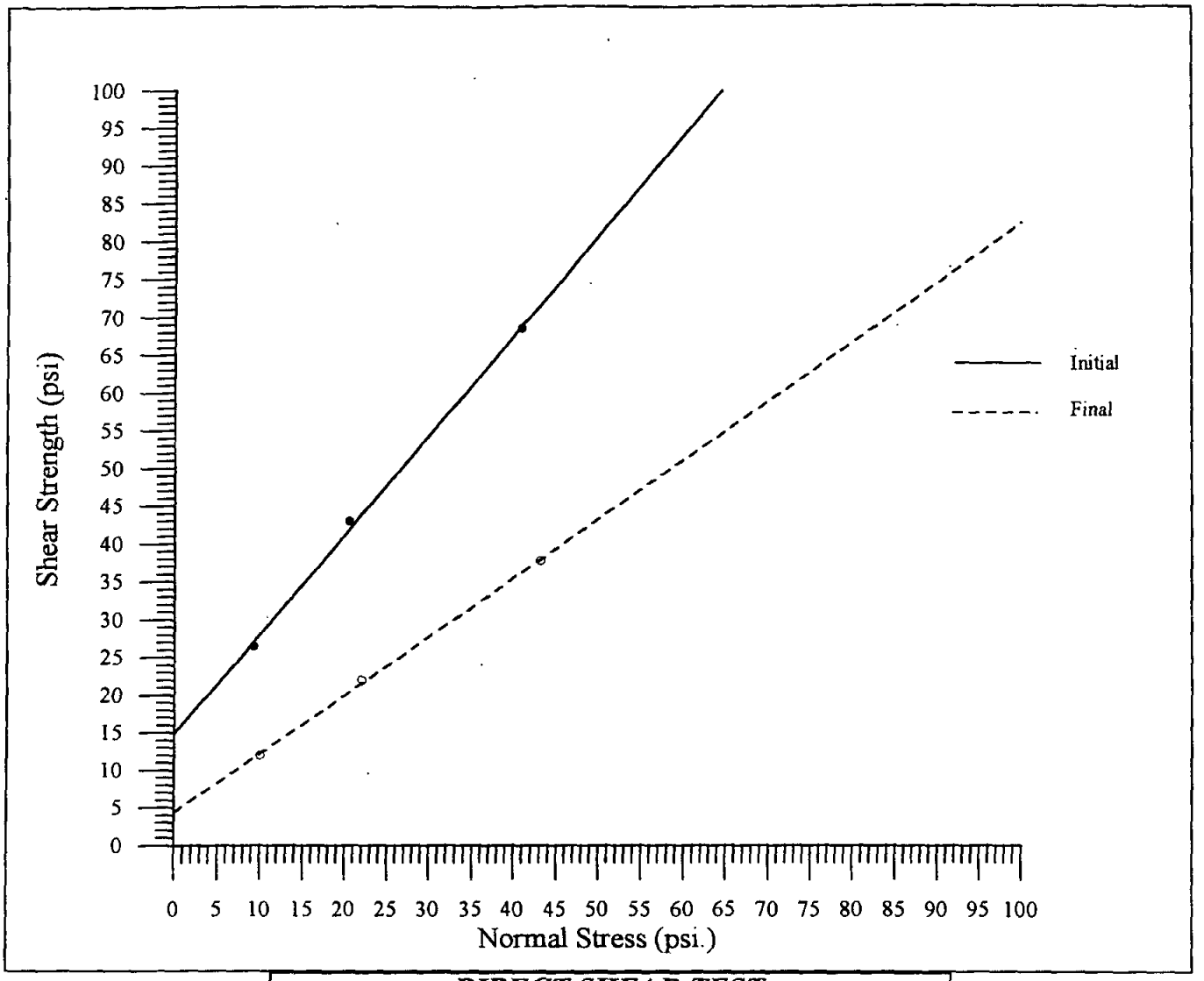
Geo Test GTU *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-11
Sample: 11-105
Depth: 105.6'

DESCRIPTION
Wavy oxide stained bedding contact between shale and tan sandstone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	15.0	52.9
Final	4.5	37.9

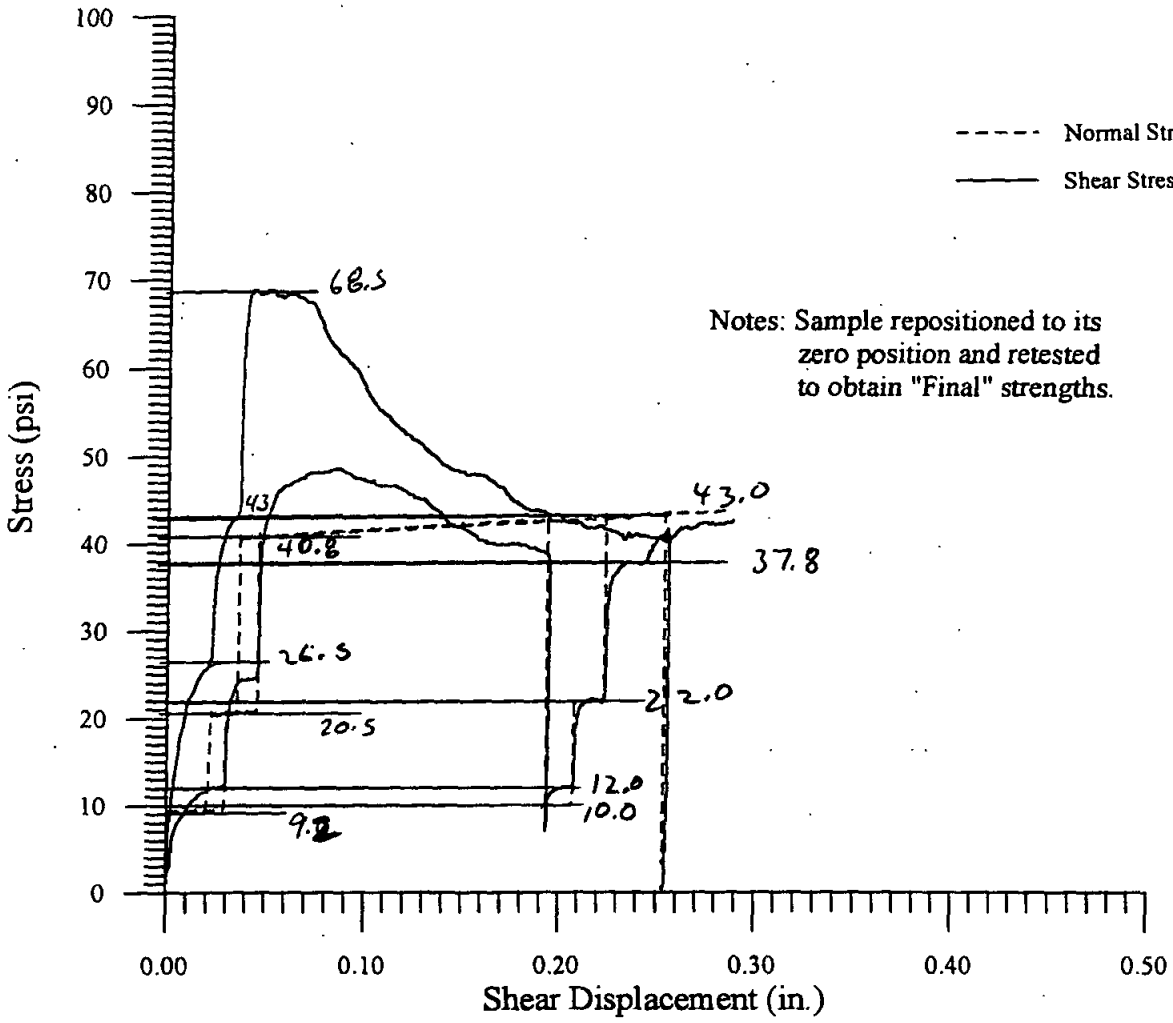
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-105
Depth: 105.6'

DESCRIPTION

Wavy oxide stained bedding contact between shale and tan sandstone.

	Normal Stress (psi)	Shear Strength (psi)
Initial	9.5	26.2
	20.3	42.8
	40.0	68.0
Final	9.5	11.7
	20.5	20.5
	40.5	35.5

Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 25, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

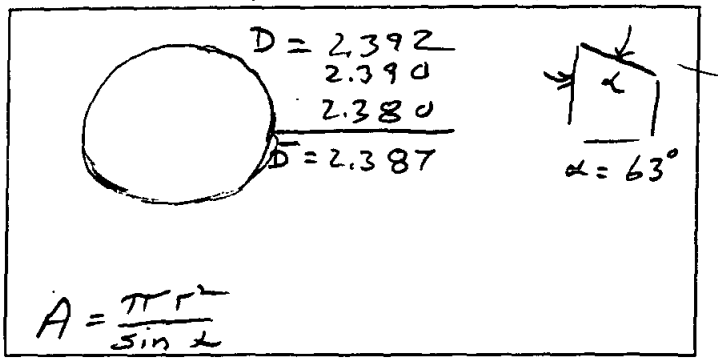
DATA SHEET
Direct Shear of Rock (ISRM)

Client: ERI
Job: #151-Devil's Slide
Sample ID: Boring: 02-11
SampleDescription: Bedding contact between shale gouge and shale (planar) - slickensided surface

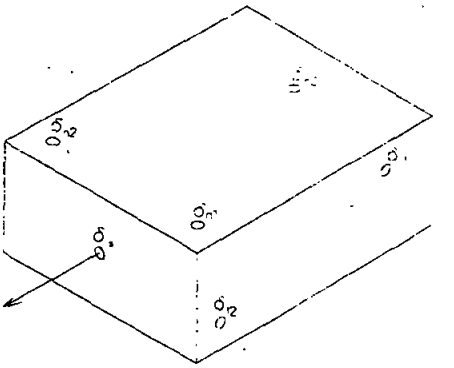
Date: 9/24/02
Tester: A. Bro

Sample Depth: 93.6' Sample Condition: received moist - tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box

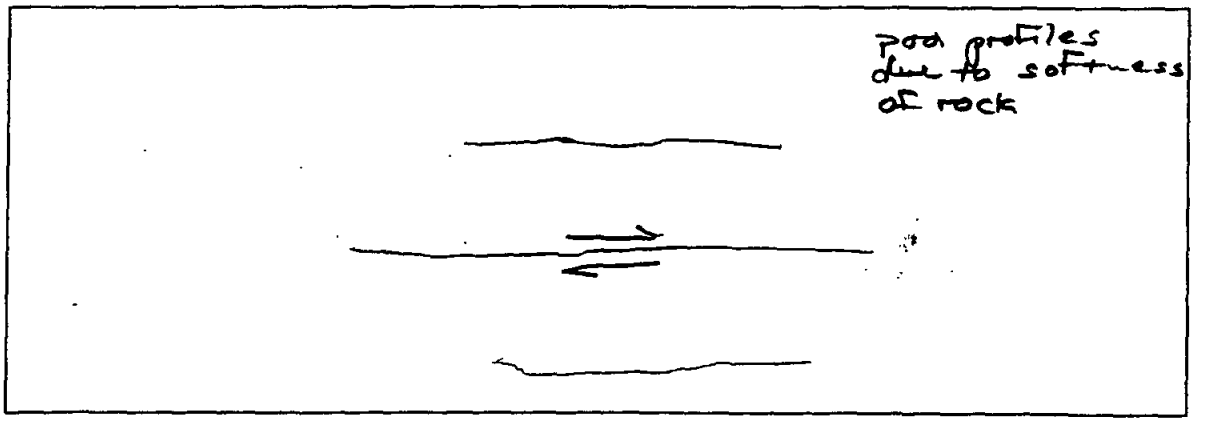


Sample area : 5.02 in²

σ_n	5	10	20	psi
F_n	25	50	100	lb
$F_n - W_b$	10	35	85	lb

Estimated top box weight: 15.5 lb
Measured top box weight: 14.8 lb

Joint Profiles



Comments: See DS sample @ 93.4' for interface at the other side of this shear zone. This sample appears to characterize the intact strength and the other sample characterizes the "residual" strength?

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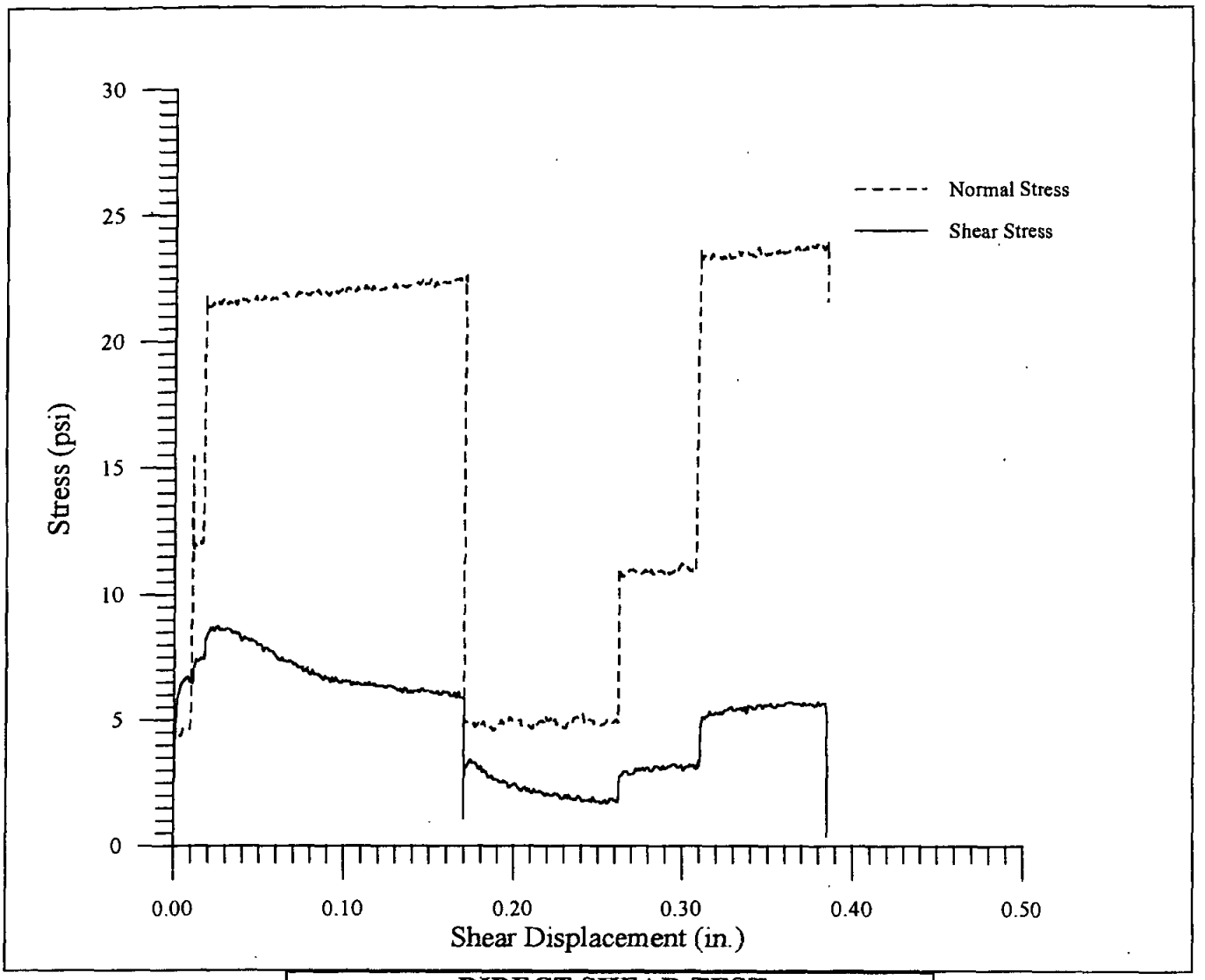


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-93B
Depth: 93.6'

DESCRIPTION

Bedding contact between shale gouge (sheared soft & clayey) and shale with a slickensided surface.

	Normal Stress (psi)	Shear Strength (psi)
Initial	4.6	6.6
	12.0	7.5
	21.5	8.7
Final	4.9	1.8
	11.0	3.2
	23.6	5.6

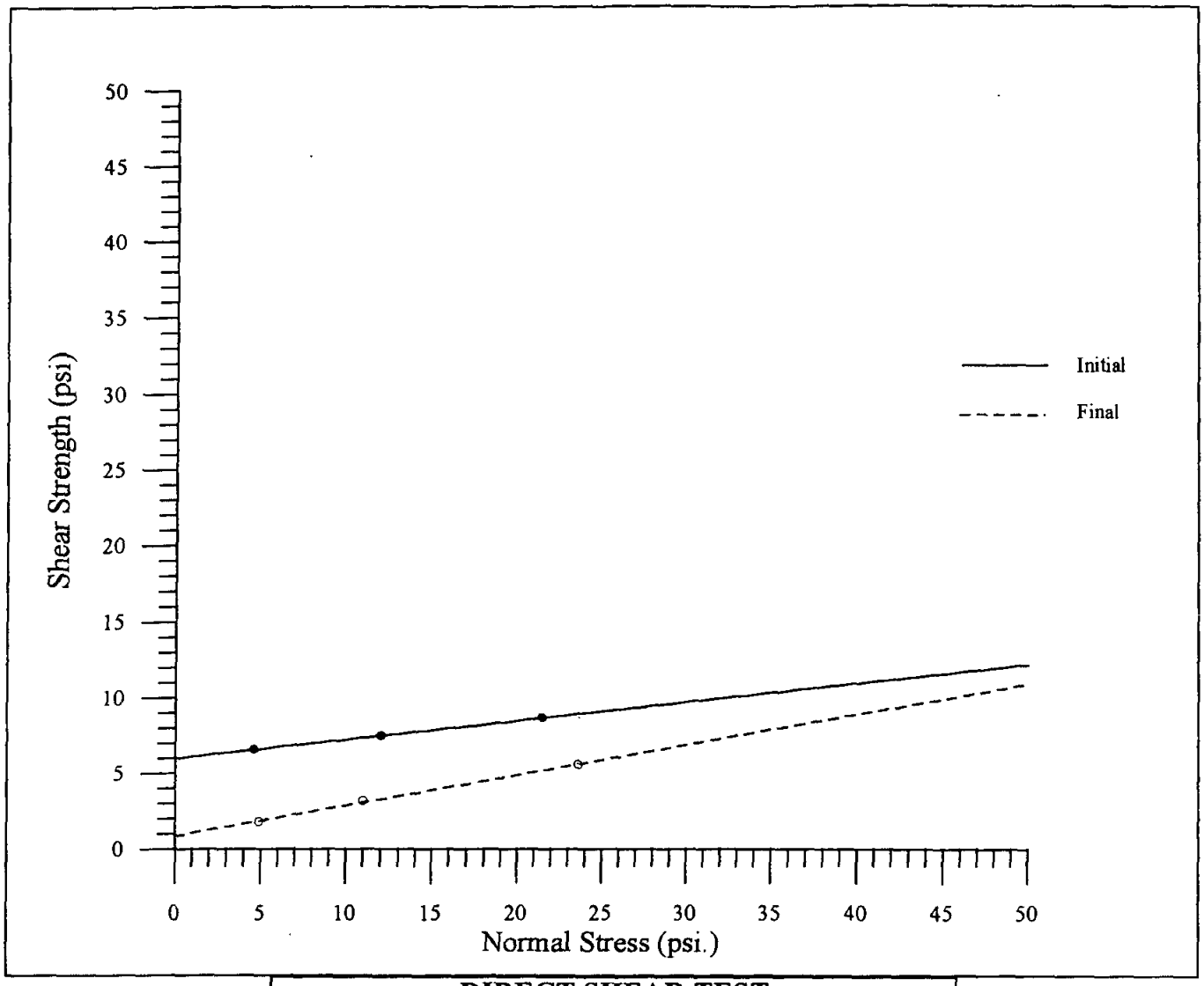
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 24, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-11
Sample: 11-93B
Depth: 93.6'

DESCRIPTION
Bedding plane contact between shale gouge (sheared soft & clayey) and shale with a slickensided surface.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	6.0	7.1
Final	0.9	11.4

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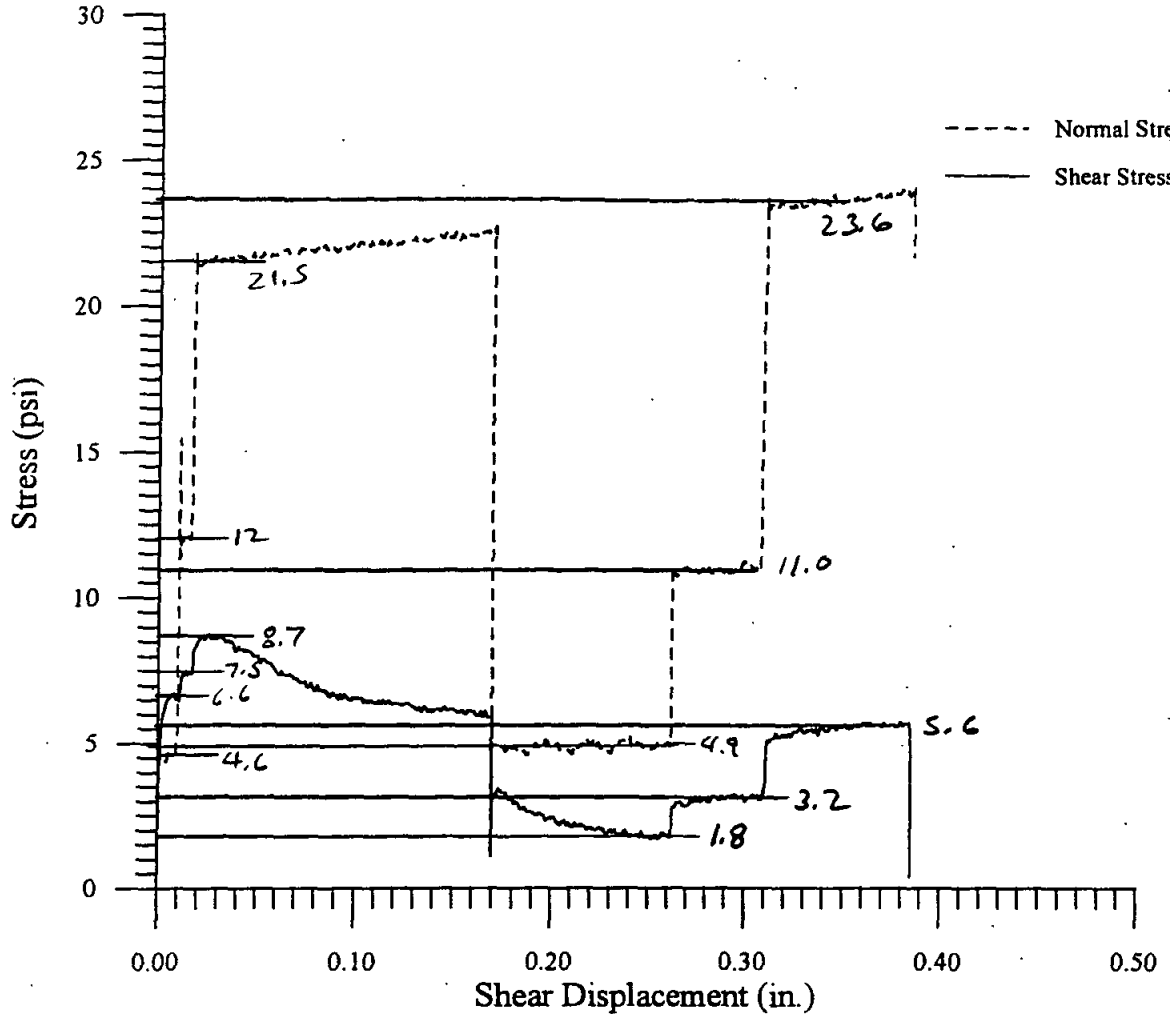
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 24, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-93B
Depth: 93.6'

DESCRIPTION

Bedding contact between shale gouge (sheared soft & clayey) and shale with a slickensided surface.

	Normal Stress (psi)	Shear Strength (psi)
Initial	4.5	1.6
	10.2	2.5
	20.4	4.2
Final	none	none

Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

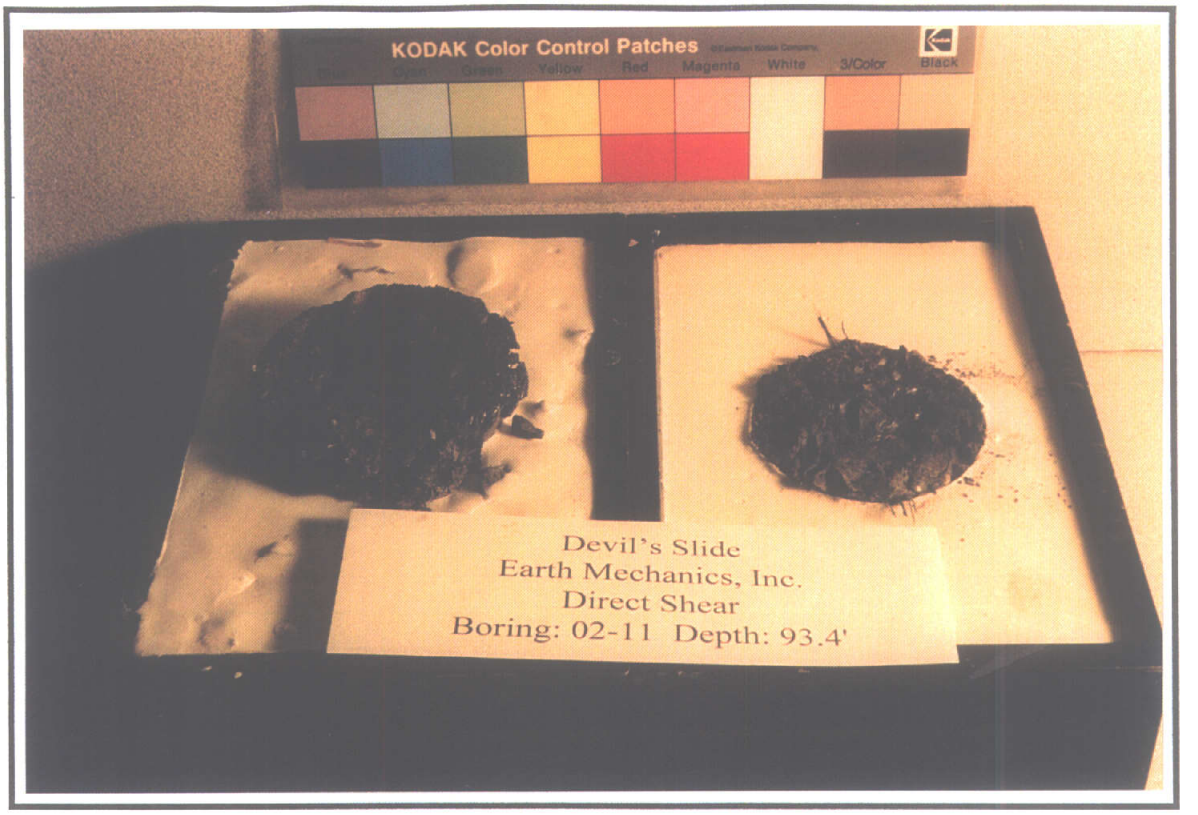
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 24, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited GTU

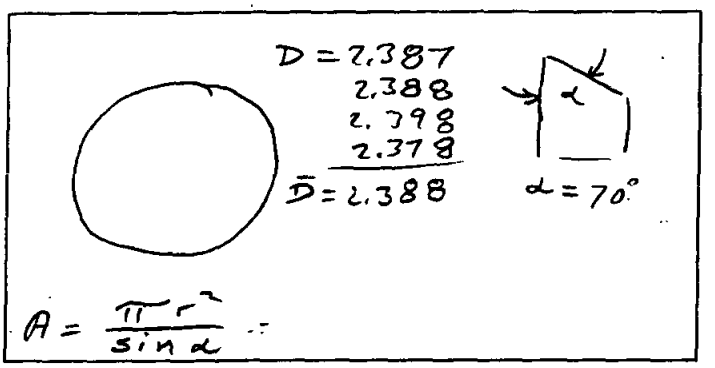
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
SampleDescription: Bedding contact between shale gouge and tan sandstone - sheared soft clayey shale gouge

Date: 9/24/02
Tester: A. Bro

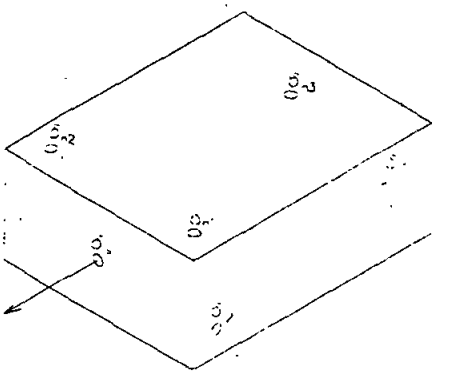
Sample Depth: 93.4'
Sample Condition: received moist - tested moist

Sketch of Shear Surface



Sample area : 4.77 in²

Location of LVDTs on top shear box

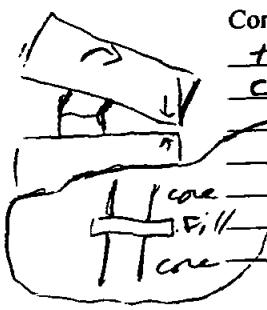


σ_n	5	10	20	psi
F_n	24	48	96	lb
$F_n - W_b$	9	33	81	lb

Estimated top box weight: 15.5 lb
Measured top box weight: 14.3 lb

Joint Profiles

highly deformed clay - not receiving fill



Comments: Last stage of 1st suite may be somewhat "stronger" than 4 appropriate. Box rotated and seated in box-to-box contact - possible cause for "hardening" influence.
Lots of fill-spreading

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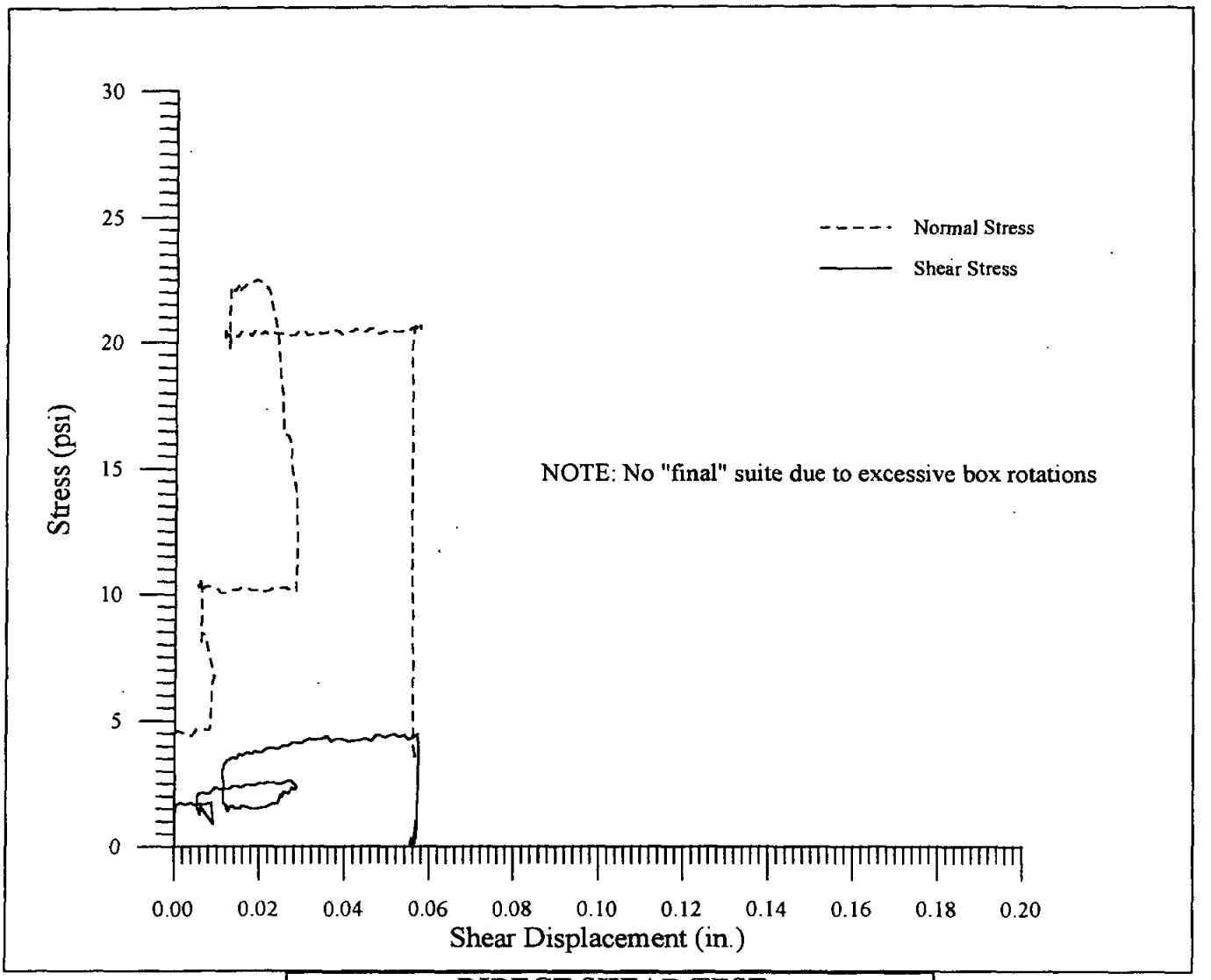

DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-93
Depth: 93.4'

DESCRIPTION

Bedding contact between shale gouge (sheared soft & clayey) and tan sandstone.

	Normal Stress (psi)	Shear Strength (psi)
Initial	4.5	1.6
	10.2	2.5
	20.4	4.2
Final	none	none

Geo Test Unlimited
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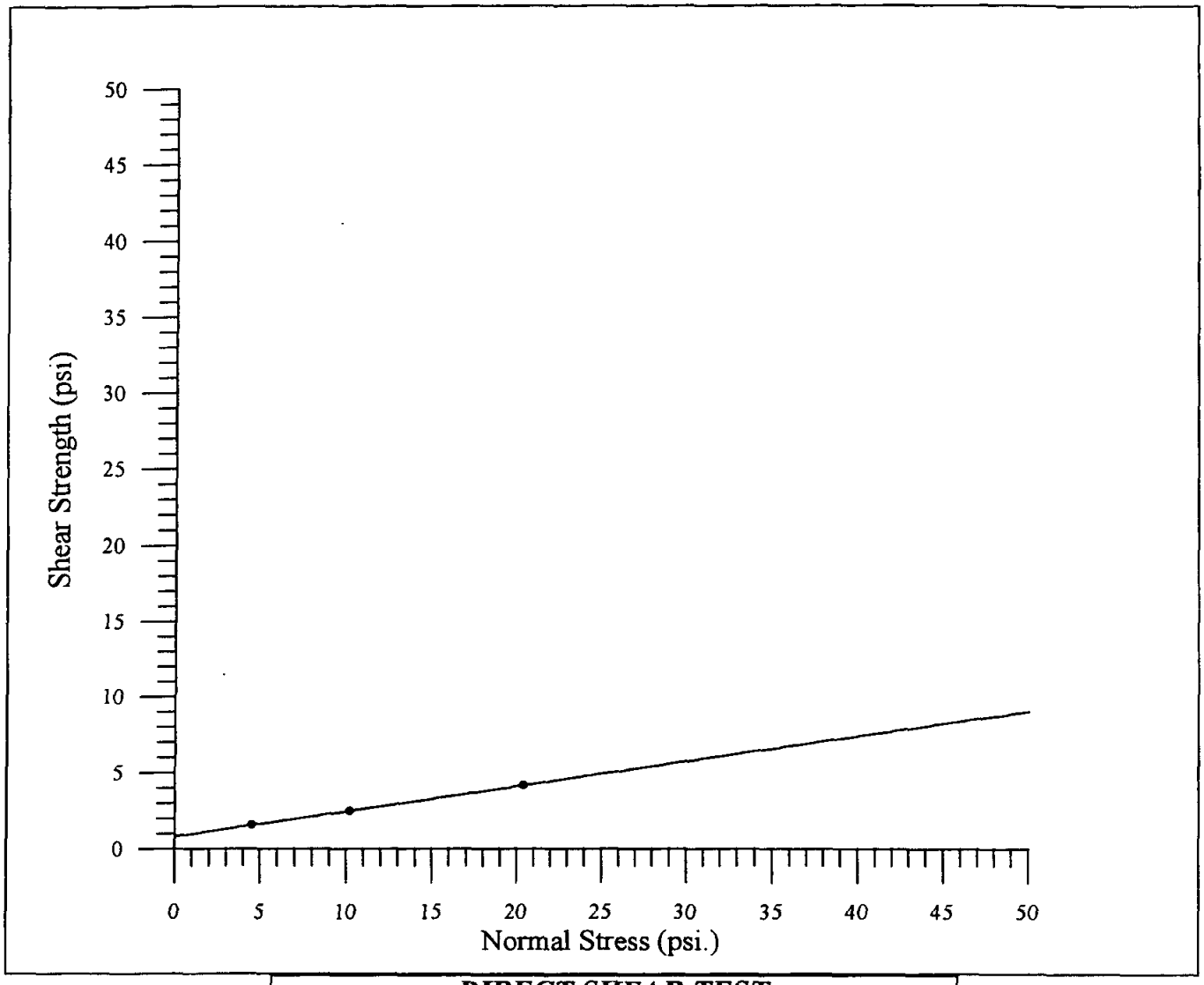
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 24, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-11
Sample: 11-93
Depth: 93.4'

DESCRIPTION
Bedding contact between shale gouge (sheared soft & clayey) and tan sandstone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	0.8	9.3
Final	na	na

Geo Test Unlimited
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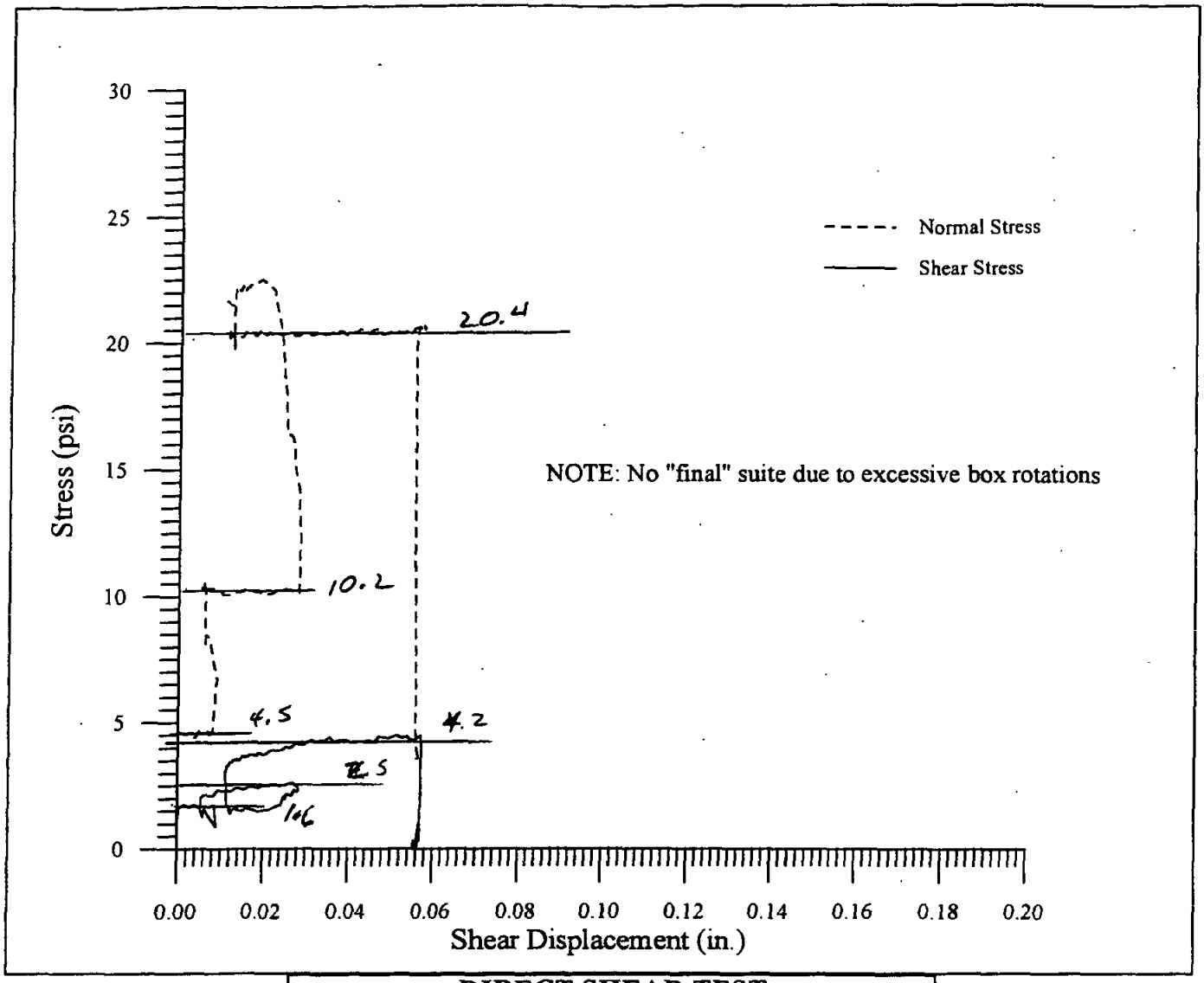
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 24, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-93
Depth: 93.4'

DESCRIPTION

Bedding contact between shale gouge (sheared soft & clayey) and tan sandstone.

	Normal Stress (psi)	Shear Strength (psi)
Initial	4.7	3.9
	10.8	8.5
	21.2	14.7
Final	4.9	3.9
	11.4	7.9
	24.5	14.1

Geo Test Unlimited GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

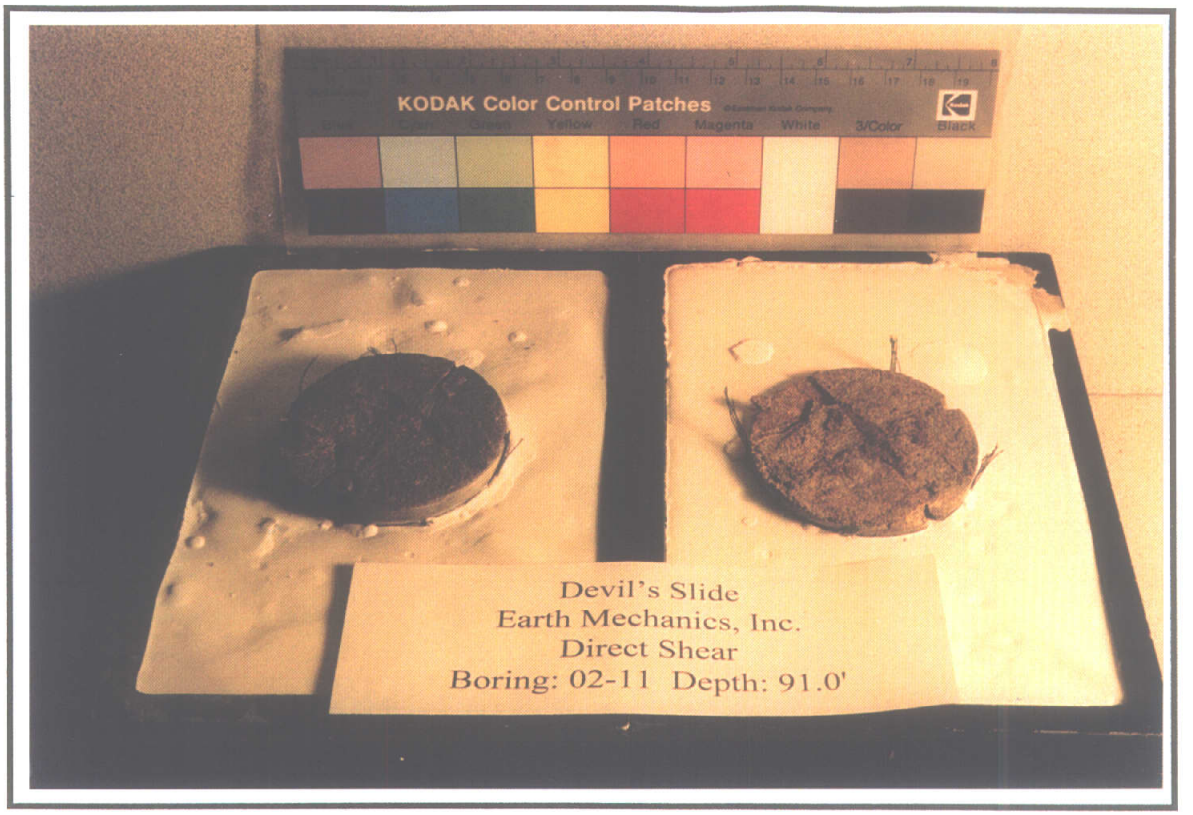
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 24, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

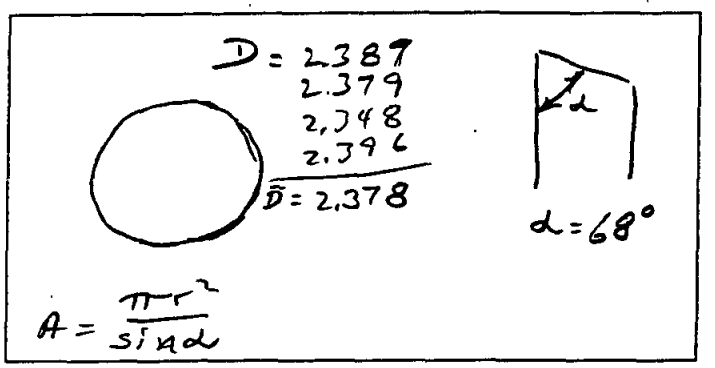
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMT
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
SampleDescription: Planar bedding joint in tan sandstone

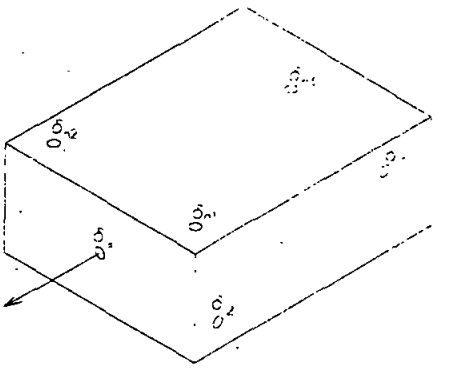
Date: 9/24/02
Tester: A. Bro

Sample Depth: 91.0'
Sample Condition: received dry - tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box

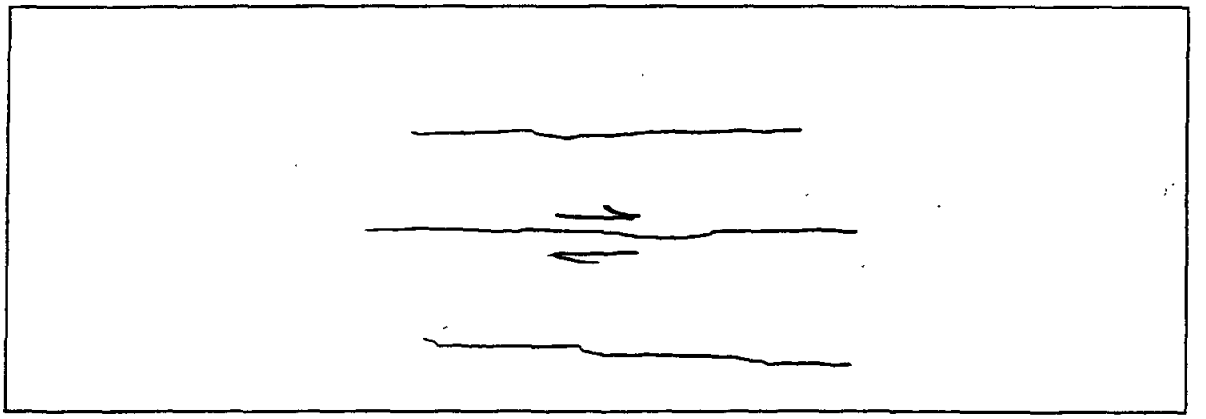


Sample area : 4.79 in²

σ_n	5	10	20	psi
F_n	24	48	96	lb
$F_n - W_b$	9	33	81	lb

Estimated top box weight: 15.5 lb
Measured top box weight: 14.8 lb

Joint Profiles



Comments: strain hardening in validated 1st multi stage set

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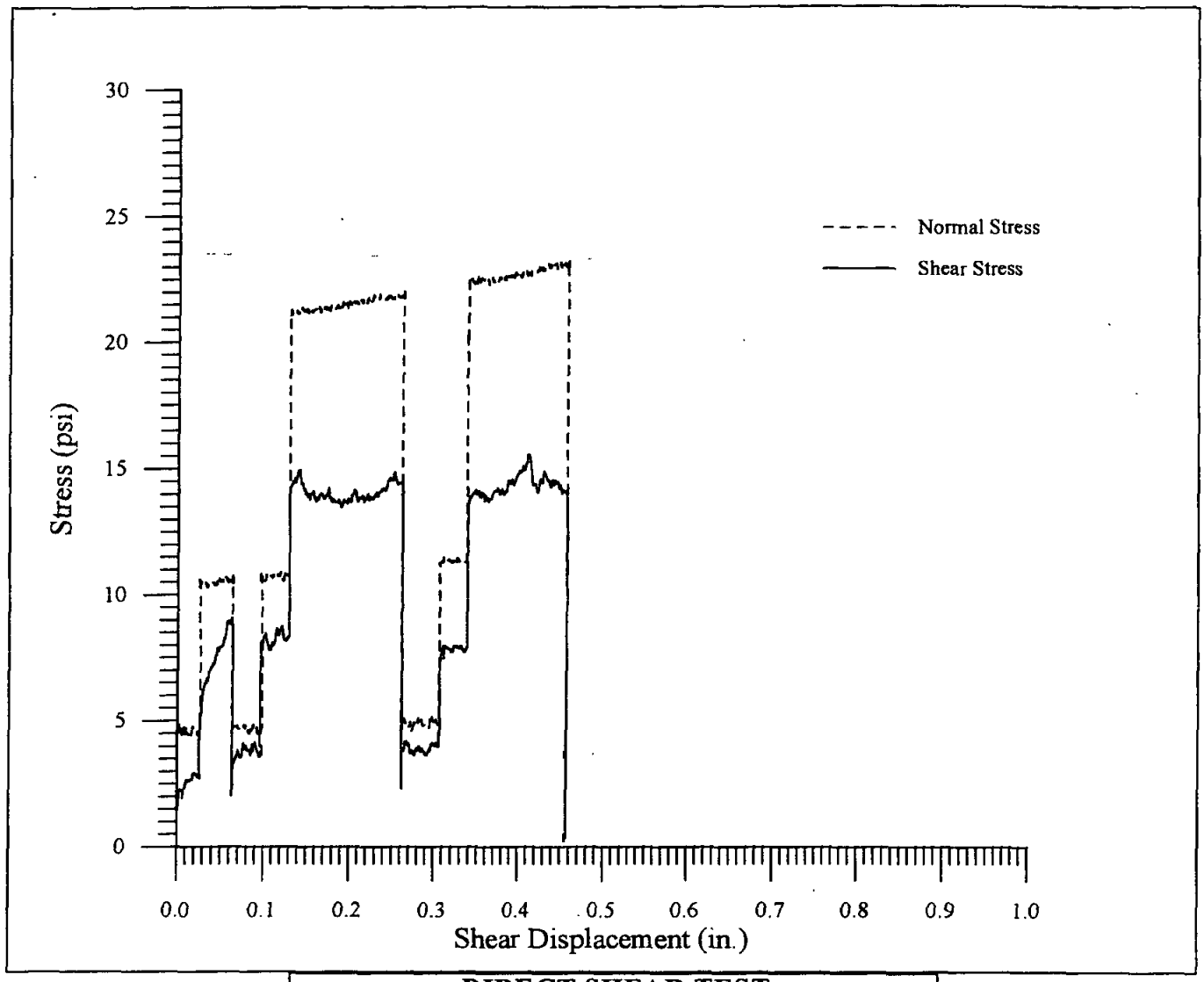


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-91
Depth: 91.0'

DESCRIPTION

Planar bedding joint in tan sandstone.

	Normal Stress (psi)	Shear Strength (psi)
Initial	4.7	3.9
	10.8	8.5
	21.2	14.7
Final	4.9	3.9
	11.4	7.9
	24.5	14.1

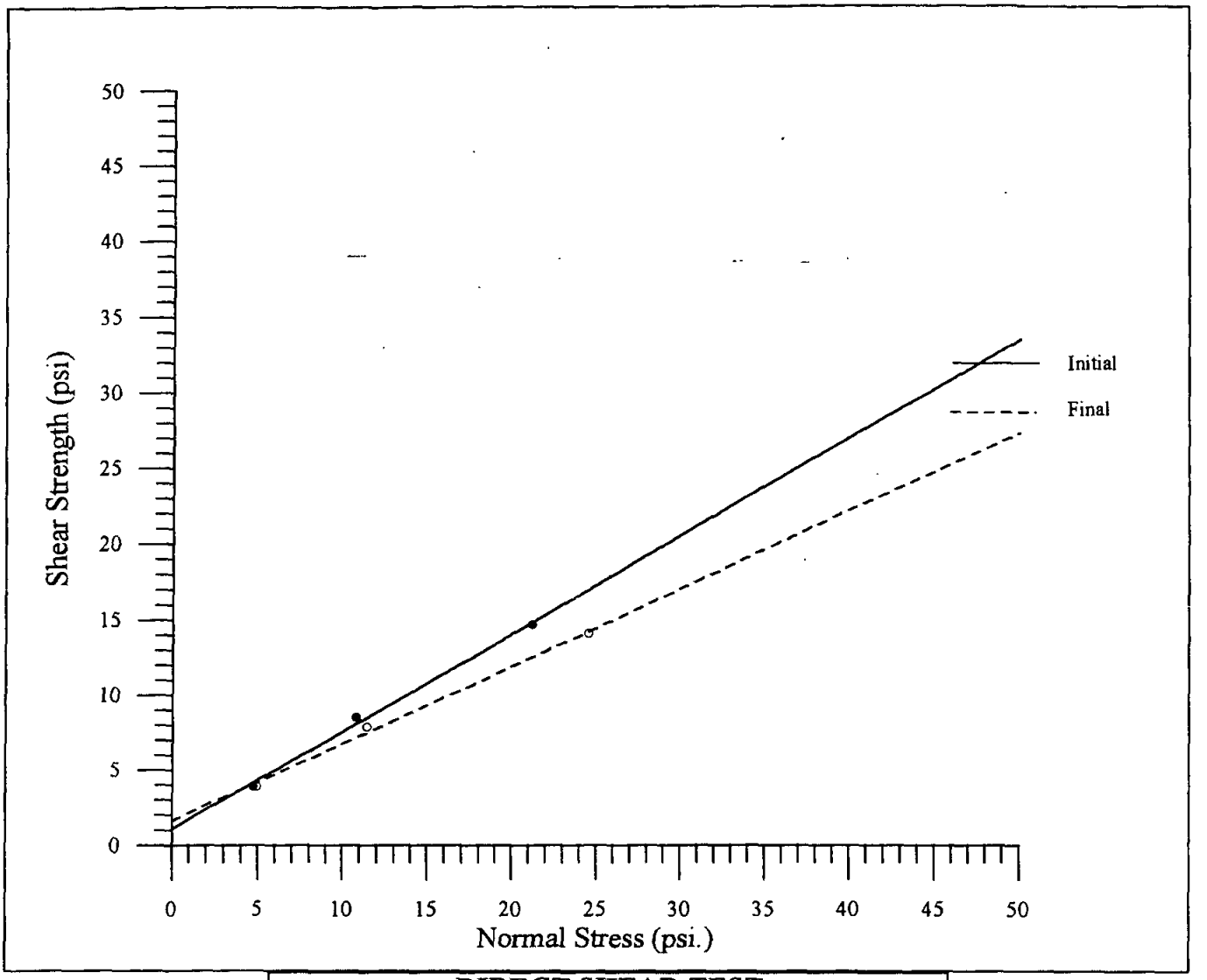
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 24, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-11
Sample: 11-91
Depth: 91.0'

DESCRIPTION
Planar bedding joint in tan sandstone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	1.1	33.0
Final	1.6	27.2

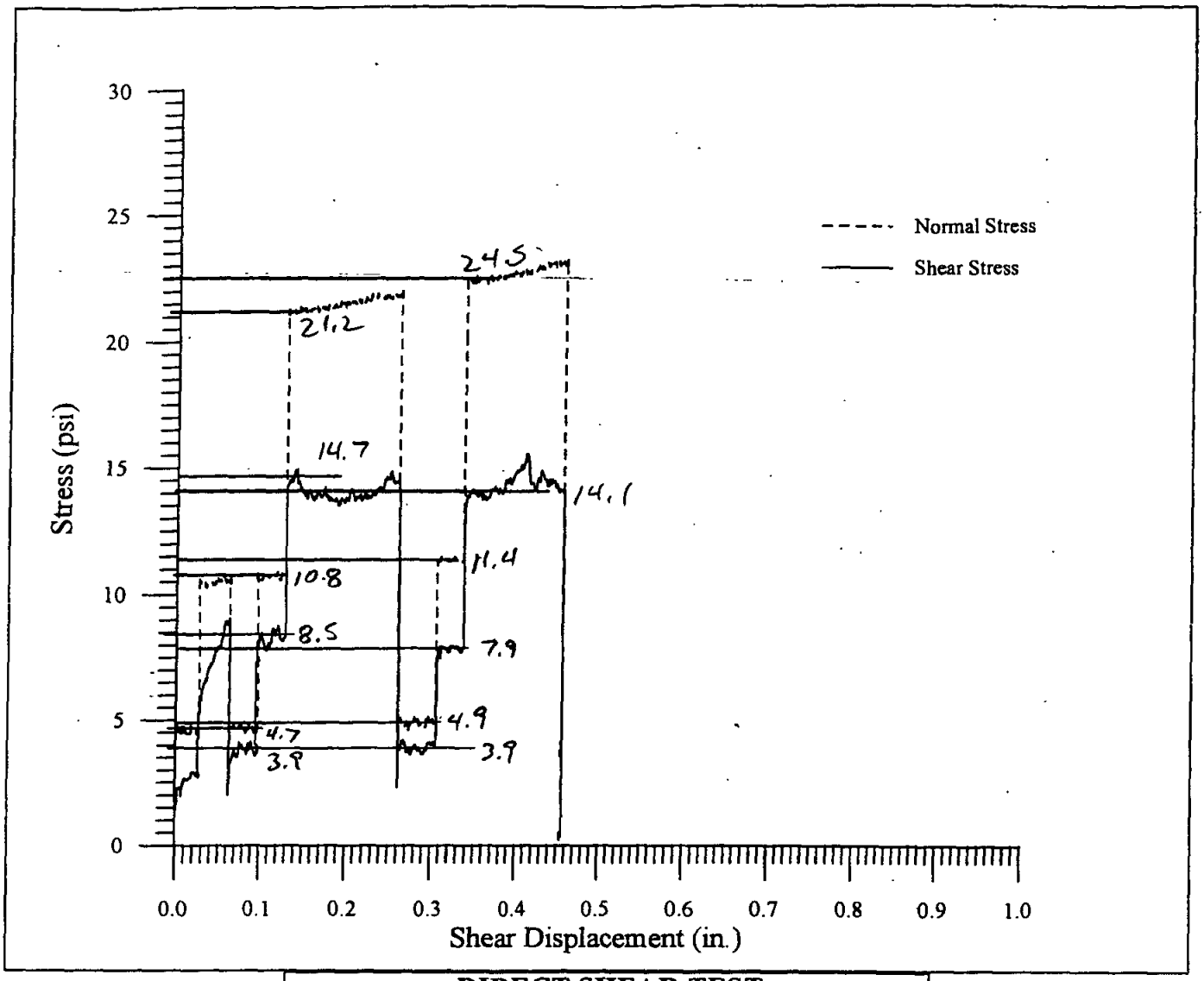
Geo Test G T U Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 24, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-91
Depth: 91.0'

DESCRIPTION

Planar bedding joint in tan sandstone.

	Normal Stress (psi)	Shear Strength (psi)
Initial	5.1	4.2
	10.6	7.5
	20.6	15.0
Final	5.6	5.3
	11.6	9.5
	22.5	16.6

Geo Test Unlimited
GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 24, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo GTU Test Unlimited

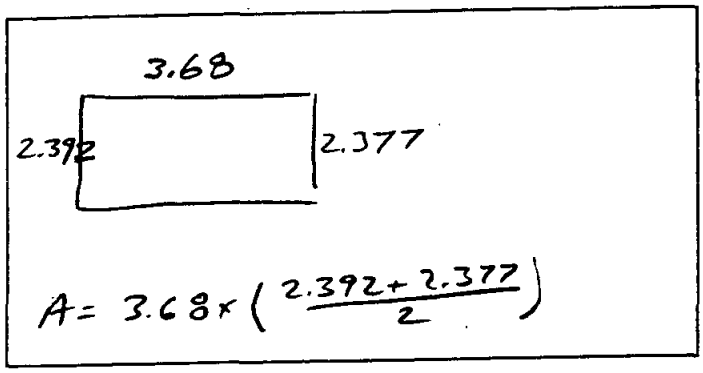
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMT
Job: #151-Devil's Slide
Sample ID: Boring 02-11
SampleDescription: Axial clay slightly wavey Filled joint (with oxide coating) in tamaish gray sandstone.

Date: 9/23/02
Tester: A.Bro

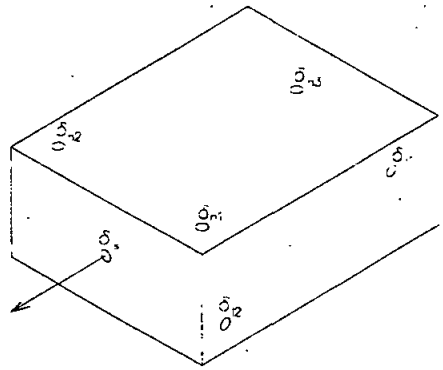
Sample Depth: 90.7-90.9' Sample Condition: received dry - tested moist

Sketch of Shear Surface



Sample area : 8.77 in²

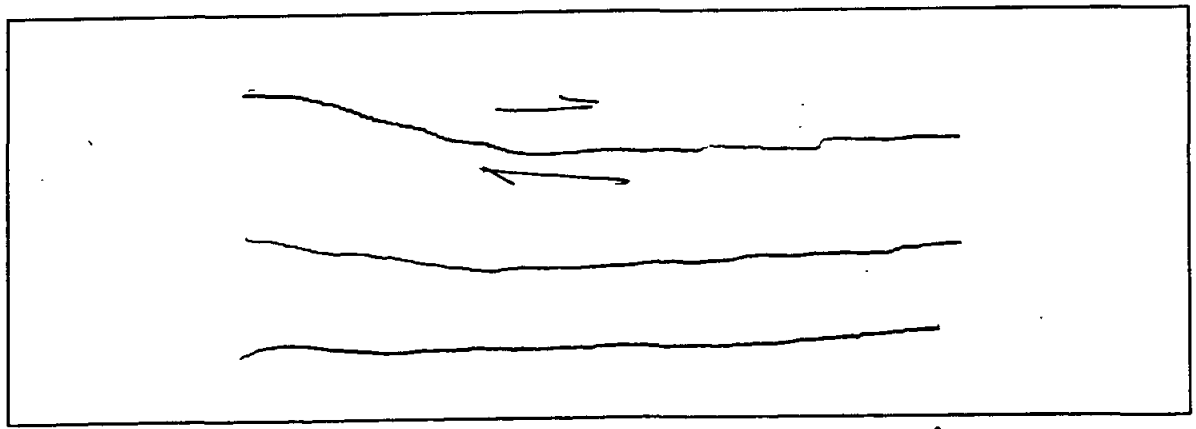
Location of LVDTs on top shear box



σ_n	5	10	20	psi
F_n	43.9	87.7	174.4	lb
F_n-W_b	28	72	159	lb

Estimated top box weight: 15.5 lb
Measured top box weight: 15.0 lb

Joint Profiles



Comments: During 1st suite, 1st stage & 1st part of 2nd stage probably governed by coating. Later part of 2nd stage & subsequent stages probably are governed by host rock. Final behavior may also be due to asperities as indicated by sample post-peak traces.
Lots of block rotation ⇒ tried to finish test within a short displacement.
Small slicks & overriding evident after test

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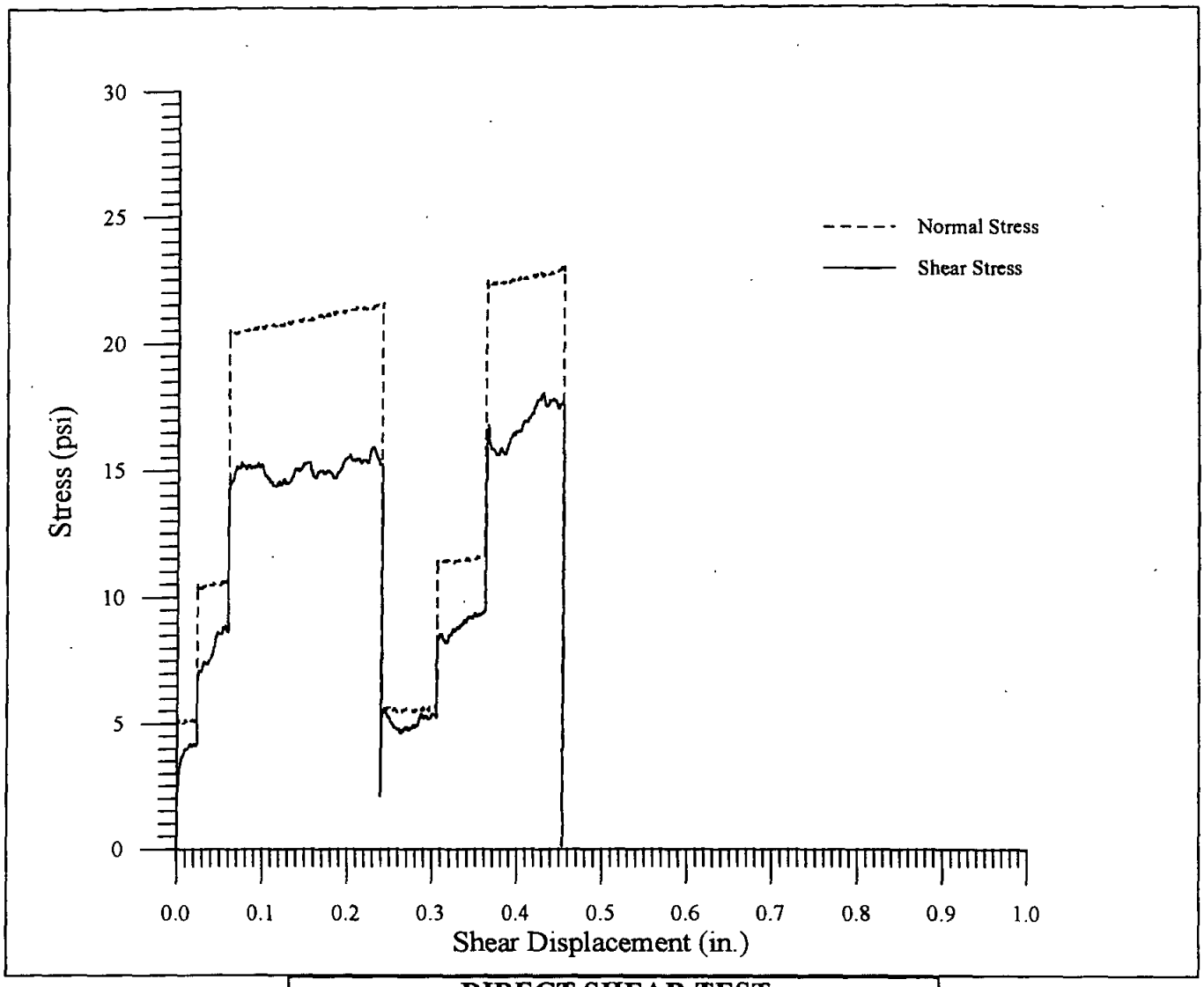


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-90
Depth: 90.7-90.9'

DESCRIPTION

Slightly wavy clay filled joint with oxide coating in tannish gray sandstone.

	Normal Stress (psi)	Shear Strength (psi)
Initial	5.1	4.2
	10.6	7.5
	20.6	15.0
Final	5.6	5.3
	11.6	9.5
	22.5	16.6

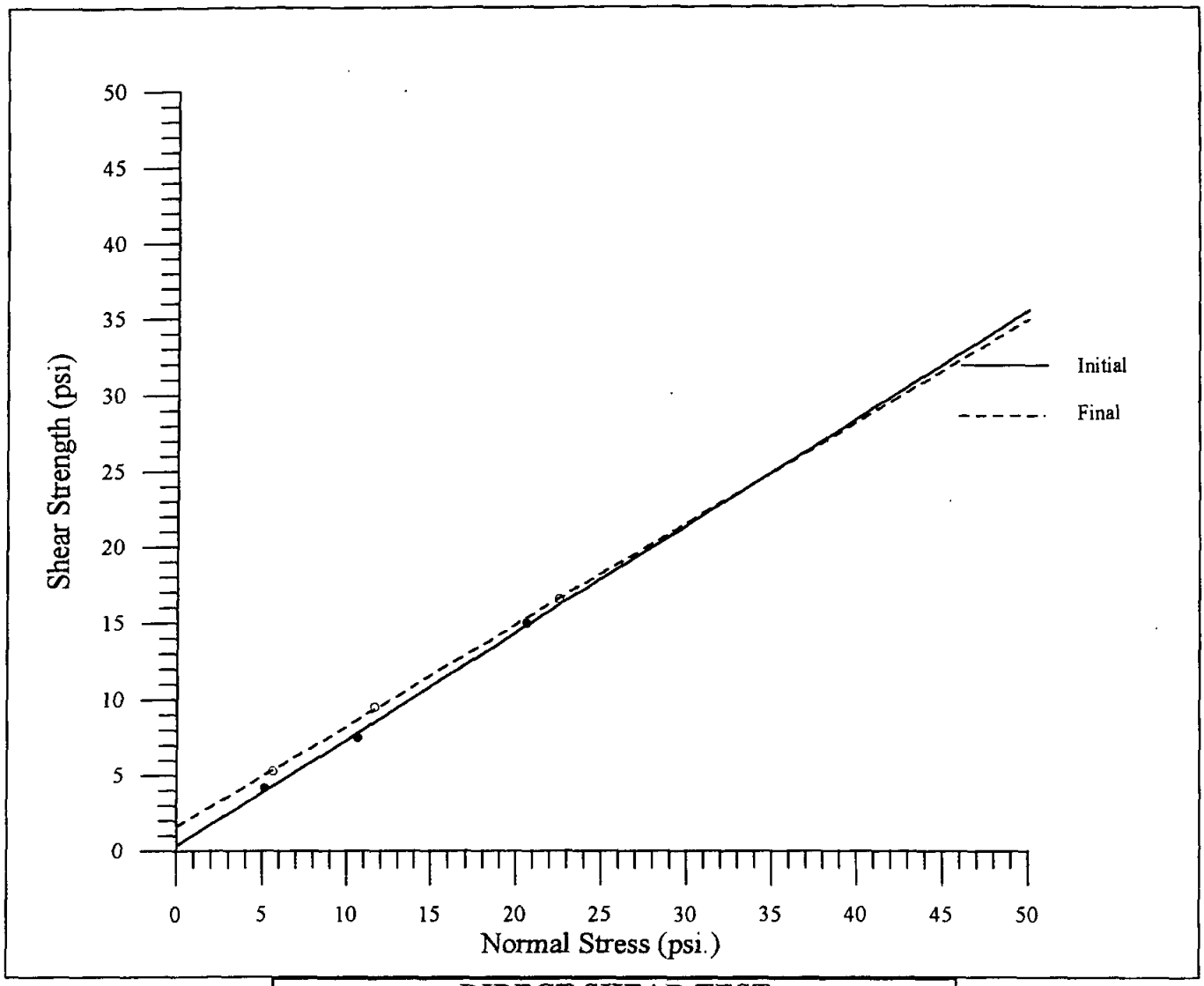
Geo Test G T U *Unlimited*
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 23, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-11
Sample: 11-90
Depth: 90.7-90.9'

DESCRIPTION
Slightly wavy clay filled joint with oxide coating in tannish gray sandstone.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	0.4	35.1
Final	1.6	33.7

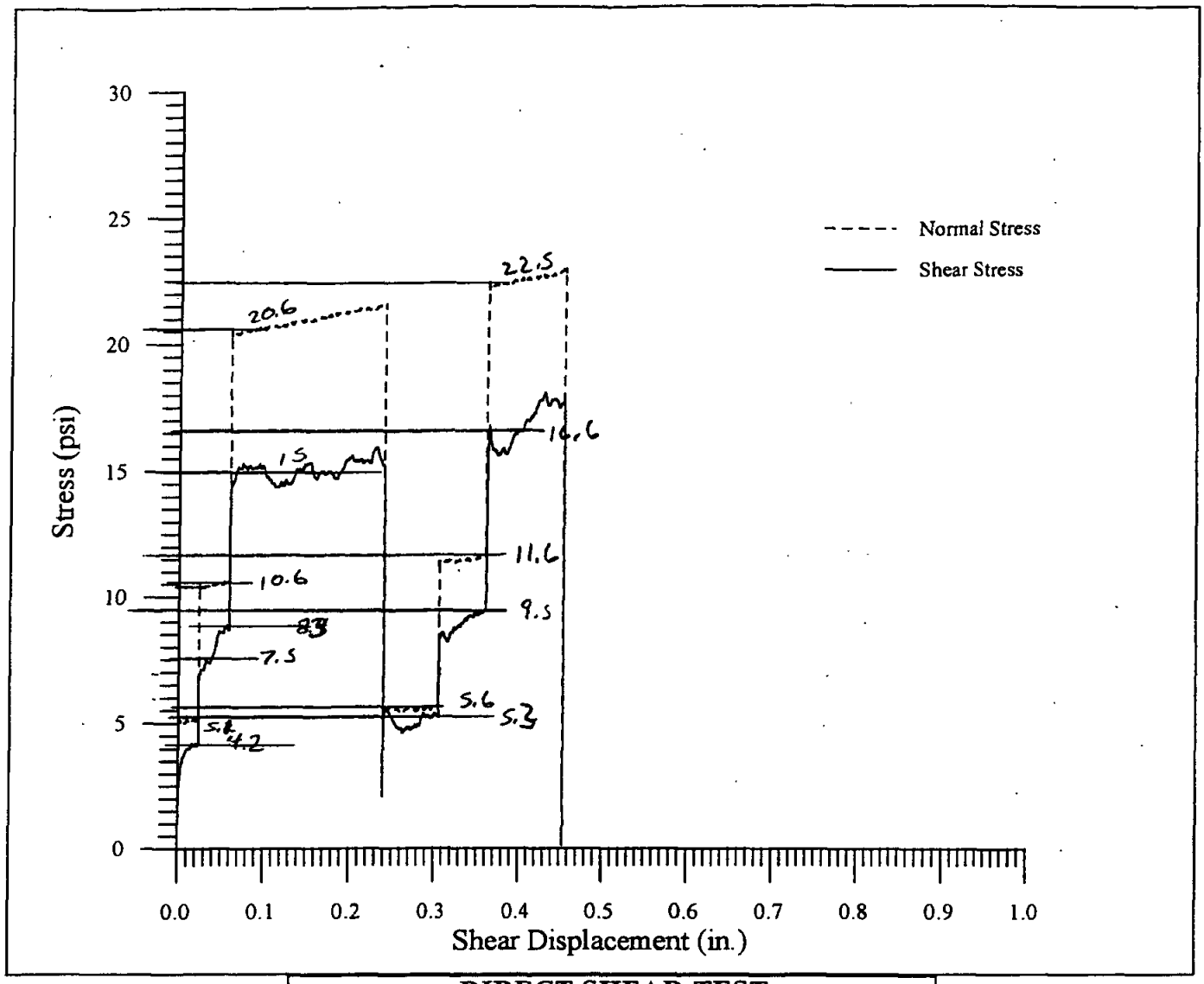
Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 23, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-90
Depth: 90.7-90.9'

DESCRIPTION

Slightly wavy clay filled joint with oxide coating in tannish gray sandstone.

	Normal Stress (psi)	Shear Strength (psi)
Initial	6.0	3.7
	9.6	7.2
	20.5	15.0
Final	8.0	5.0
	12.2	7.0
	24.5	12.7

Geo Test Unlimited
GTU
27069 N. Bloomfield Rd.
Nevada City, CA 95959

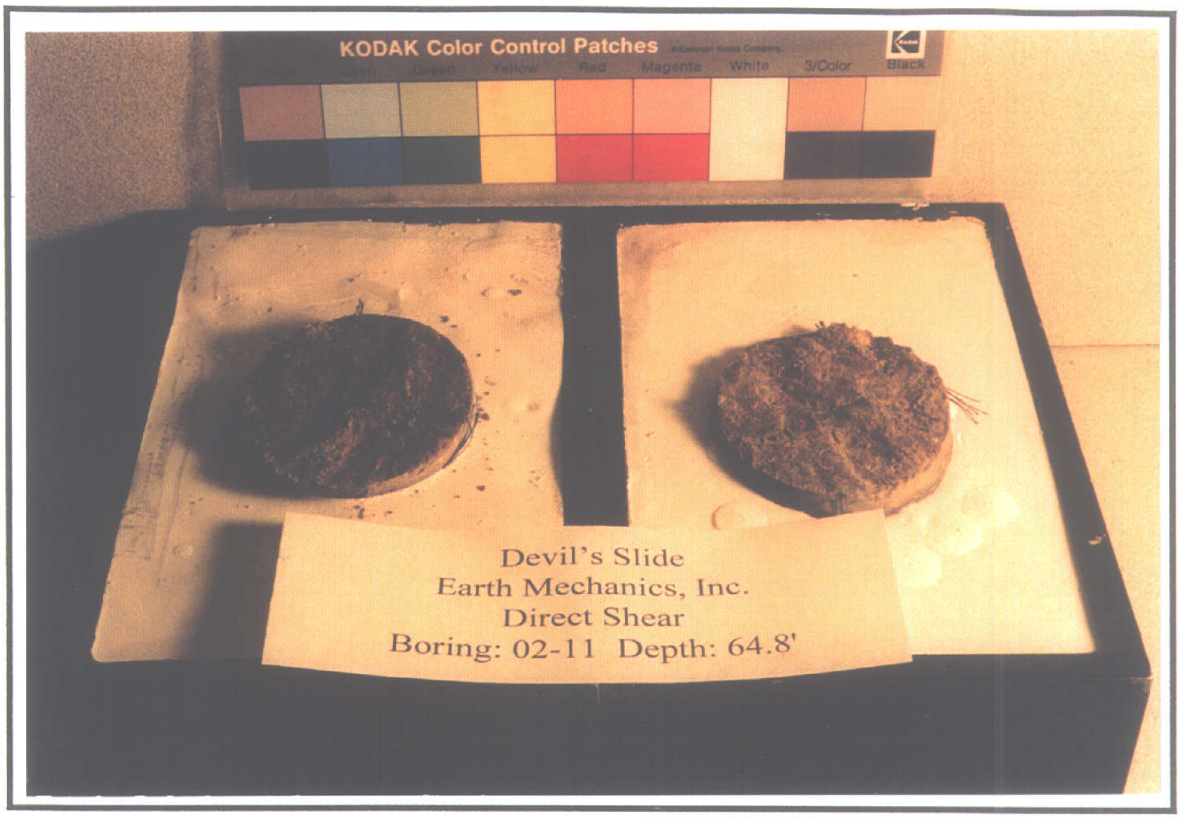
Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION



Geo Test Unlimited (GTU)

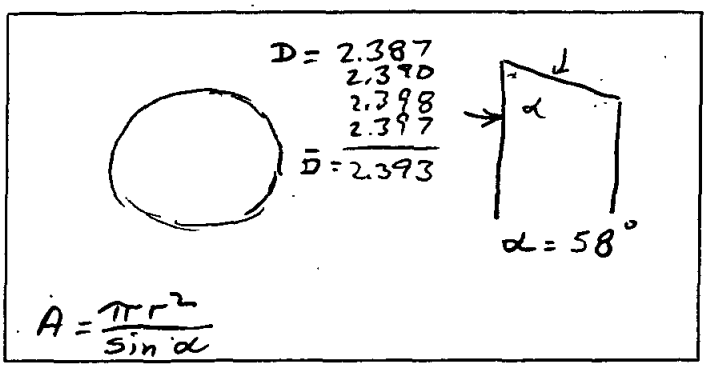
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151 - Devil's Slide
Sample ID: Boring 02-11
Sample Description: Planar, slightly rough bedding joint at shale/tan sandstone interface - interface mostly in shale. Joint coated with tan silt(?)

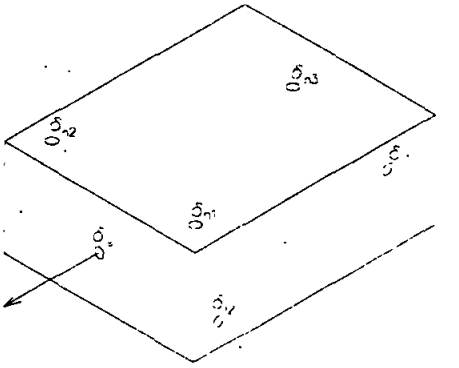
Date: 9/23/02
Tester: ABro

Sample Depth: 64.8' Sample Condition: received dry - tested moist

Sketch of Shear Surface



Location of LVDTs on top shear box

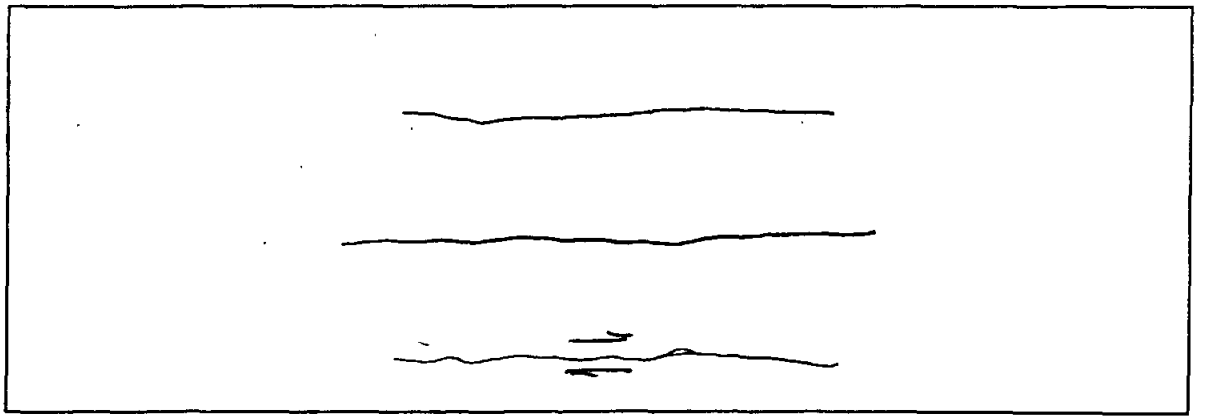


Sample area : 5.30 in²

σ_n	5	10	20	psi
F_n	26.5	53.0	106	lb
$F_n - W_b$	11	38	91	lb

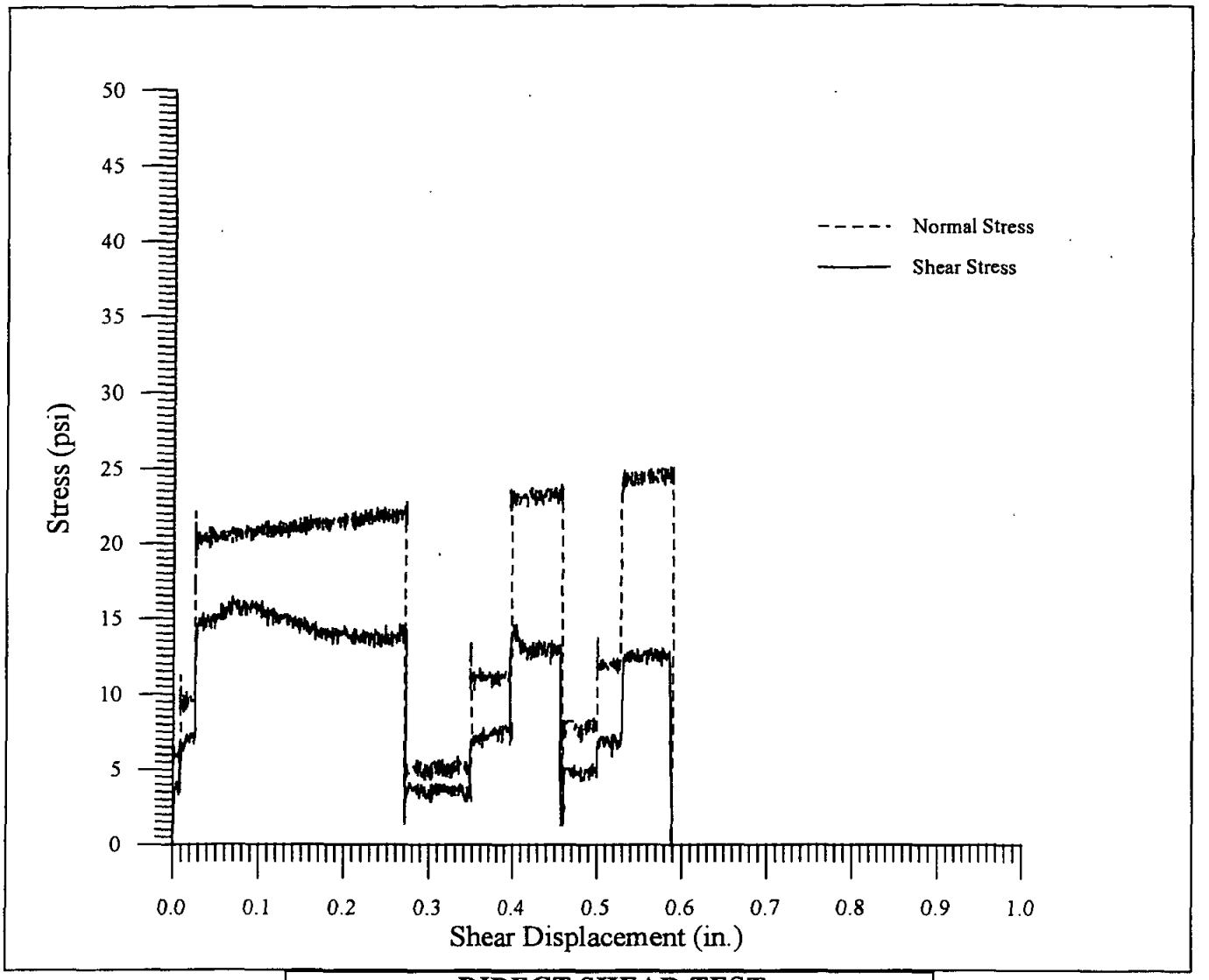
Estimated top box weight: 15.5 lb
Measured top box weight: 14.8 lb

Joint Profiles



Comments: 10 kip load cells - need to change to 2 kip cells

27069 N. Bloomfield Rd., Nevada City, CA 95959 Tel/Fax (530)470-0583 email: abro@mindspring.com



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-64
Depth: 64.8'

DESCRIPTION

Planar slightly rough bedding joint at shale/sandstone interface. Joint is mostly contained in the shale.

	Normal Stress (psi)	Shear Strength (psi)
Initial	6.0	3.7
	9.6	7.2
	20.5	15.0
Final	8.0	5.0
	12.2	7.0
	24.5	12.7

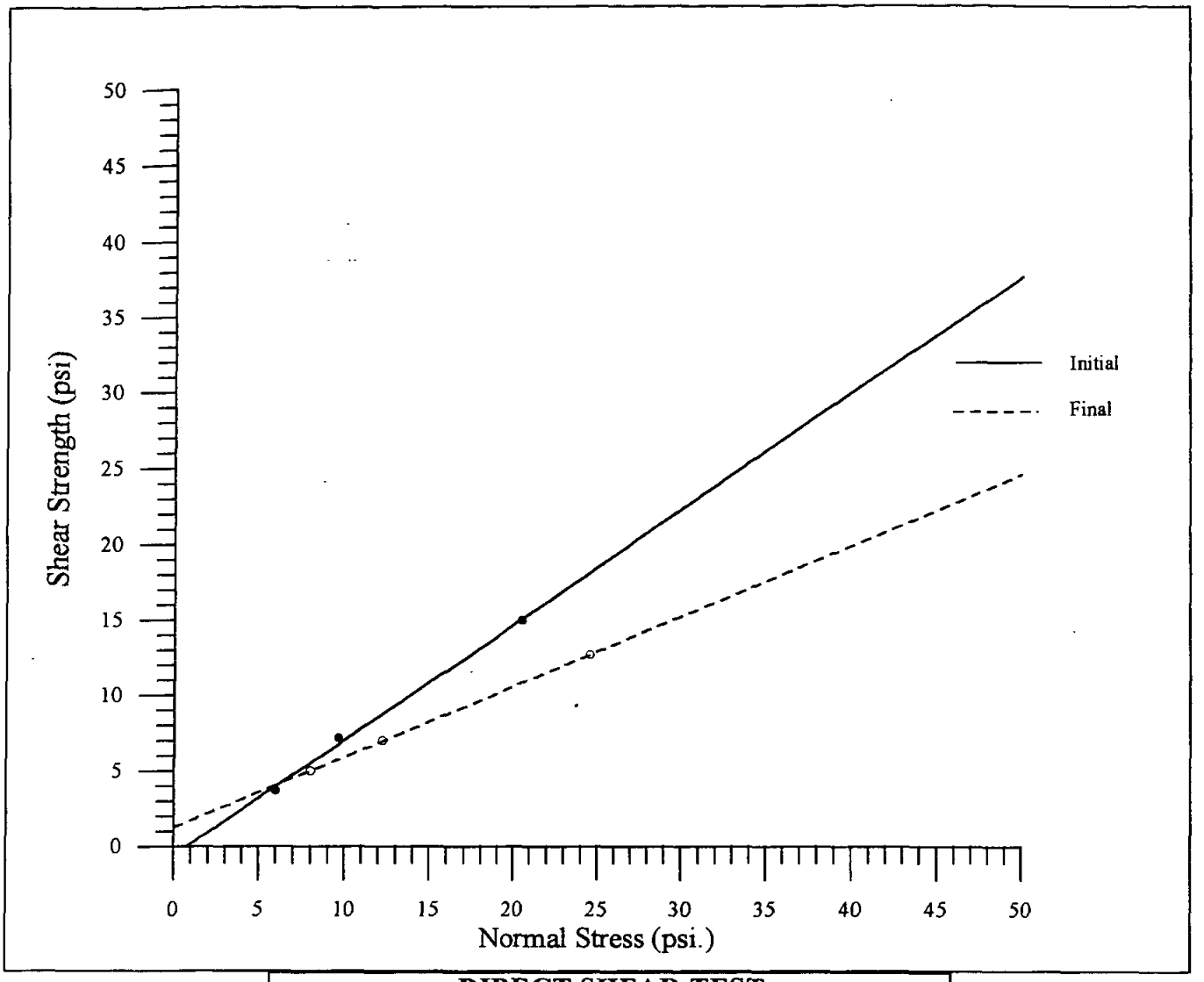
Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 23, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-11
Sample: 11-64
Depth: 64.8'

DESCRIPTION
Planar slightly rough bedding joint at shale/sandstone interface. Joint is mostly contained in the shale.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	NA (-0.6)	37.4
Final	1.3	25.0

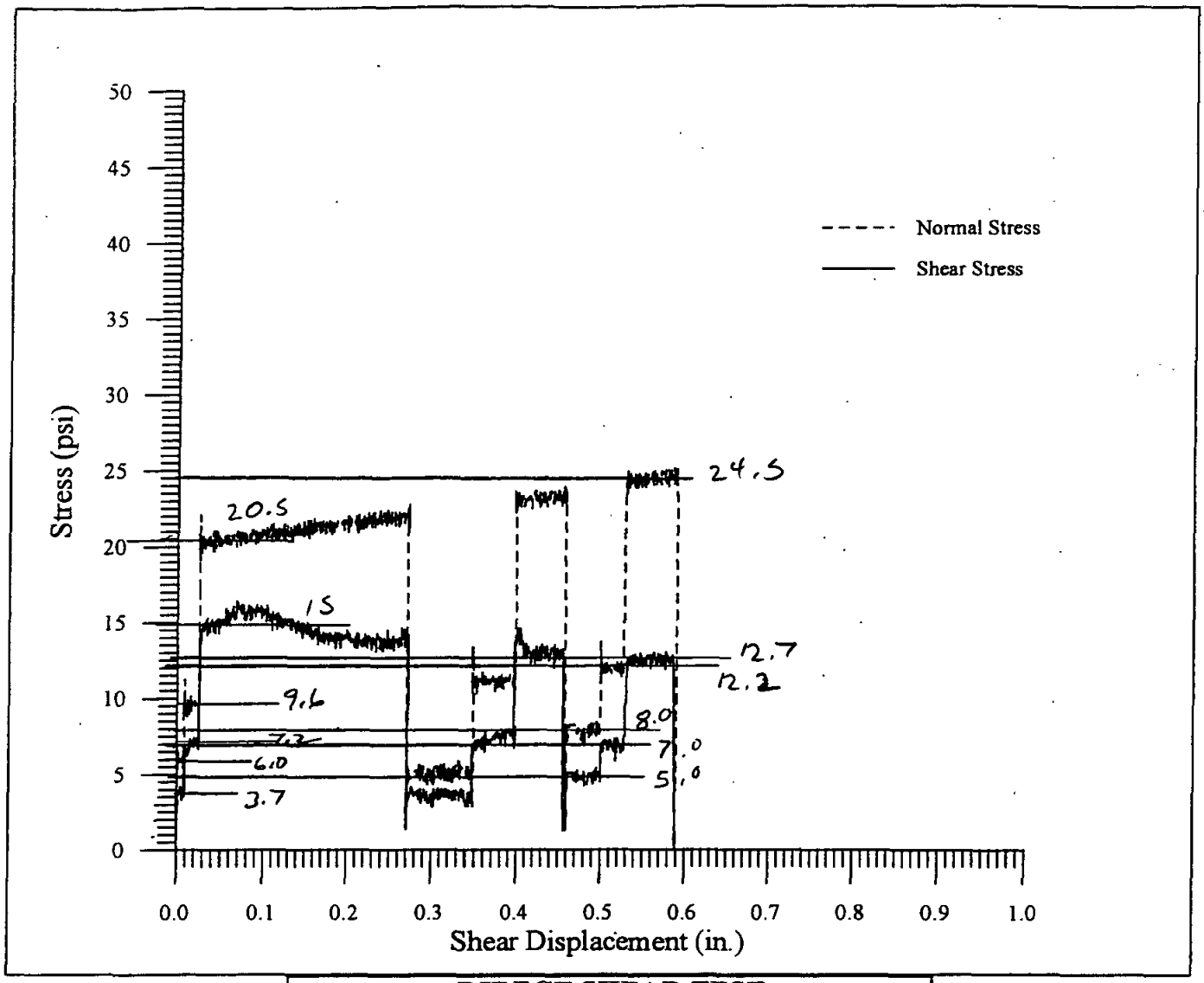
Geo Test Unlimited G T U
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 23, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-11
Sample: 11-64
Depth: 64.8'

DESCRIPTION

Planar slightly rough bedding joint at shale/sandstone interface. Joint is mostly contained in the shale.

	Normal Stress (psi)	Shear Strength (psi)
Initial	16	14
	31	20
	65	34
Final	17.5	12.5
	36.5	21
	72.5	33

Geo Test Unlimited (GTU)
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 23, 2002

LABORATORY ROCK TEST SAMPLES
2002 PHASE 2B FIELD EXPLORATION

Geo Test Unlimited (GTU)

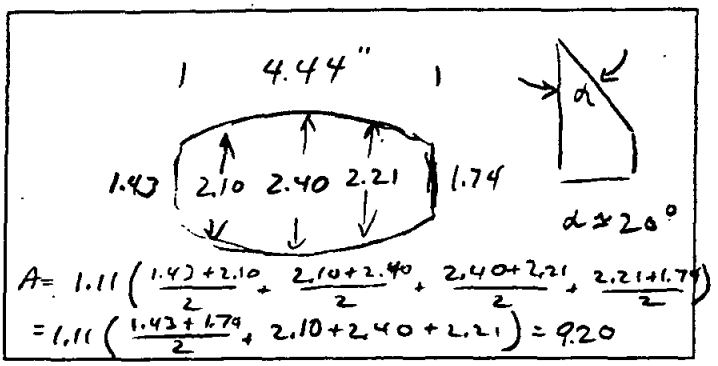
DATA SHEET
Direct Shear of Rock (ISRM)

Client: EMI
Job: #151-Devil's Slide
Sample ID: Boring 02-6
SampleDescription: Gray clayey silty Fine sand Filled joint in Gray sandstone - Filling up to 1/8" thick. Sheared on Felt gray clay surface.

Date: 9/23/02
Tester: A.Bro

Sample Depth: 435.0 Sample Condition: received moist - tested moist

Sketch of Shear Surface



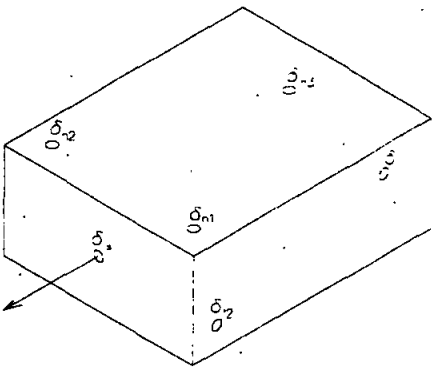
$A = 1.11\left(\frac{1.43+2.10}{2} + \frac{2.10+2.40}{2} + \frac{2.40+2.21}{2} + \frac{2.21+1.74}{2}\right)$

$= 1.11\left(\frac{1.43+1.74}{2} + 2.10+2.40+2.21\right) = 9.20$

Sample area : 9.20 in²

s/b	200	400	800 psi – too high
σ_n*	15	30	60 psi
F_n	138	276	552 lb
$F_n - W_b$	123	261	537 lb

Location of LVDTs on top shear box



Estimated top box weight: 15.5 lb
Measured top box weight: 14.9 lb

Joint Profiles

planar - clay filling invalidates profiles - too soft

Comments: *Filling strength ≈ 50 psi = max σ_n ⇒ say 60 psi
reset δ_{n3} @ about .56" shear displ. (it fell off the box)
used 10 kip load cells

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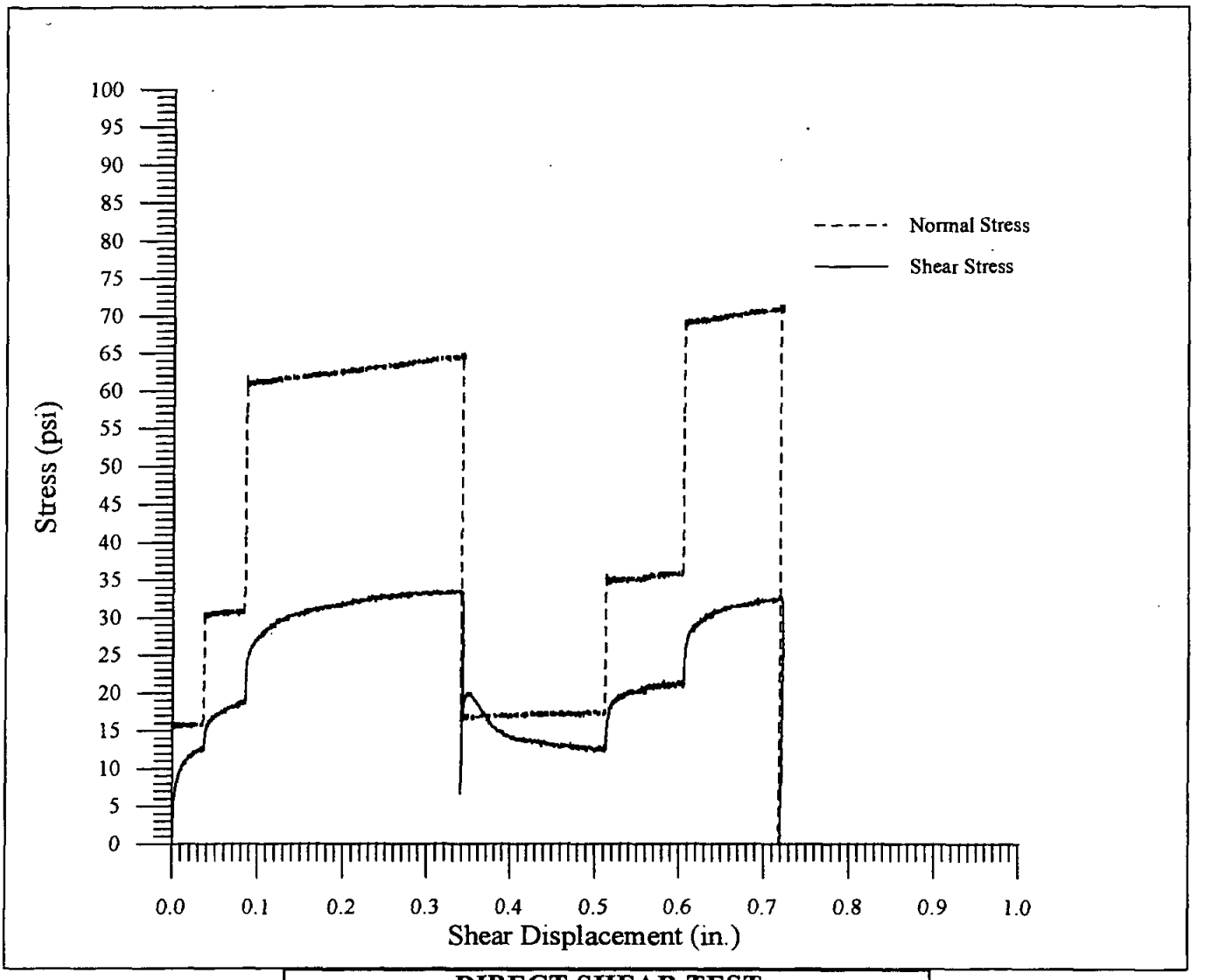


DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-6
Sample: 6-435
Depth: 435.0'

DESCRIPTION

Gray sandy clay gouge filled joint in gray sandstone. Filling up to about 1/8 inch thick.

	Normal Stress (psi)	Shear Strength (psi)
Initial	16	14
	31	20
	65	34
Final	17.5	12.5
	36.5	21
	72.5	33

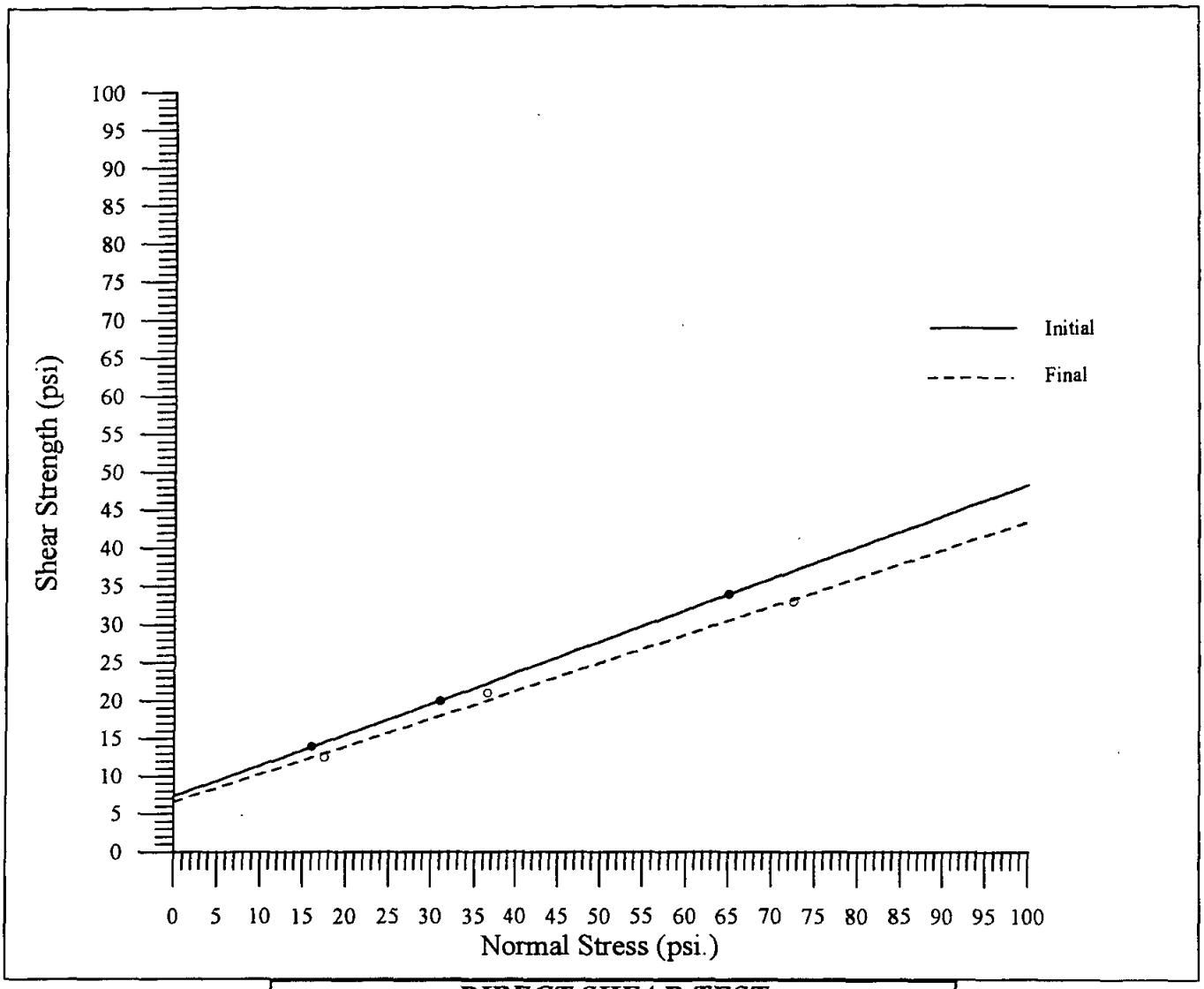
Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 23, 2002



DIRECT SHEAR TEST
Failure Envelope Normal Stress vs. Shear Strength

Boring: 02-6
Sample: 6-435
Depth: 435.0'

DESCRIPTION
Gray sandy clay gouge filled joint in gray sandstone. Filling up to about 1/8 inch thick.

	Shear Intercept (psi)	Friction Angle (degrees)
Initial	7.4	22.2
Final	6.7	20.2

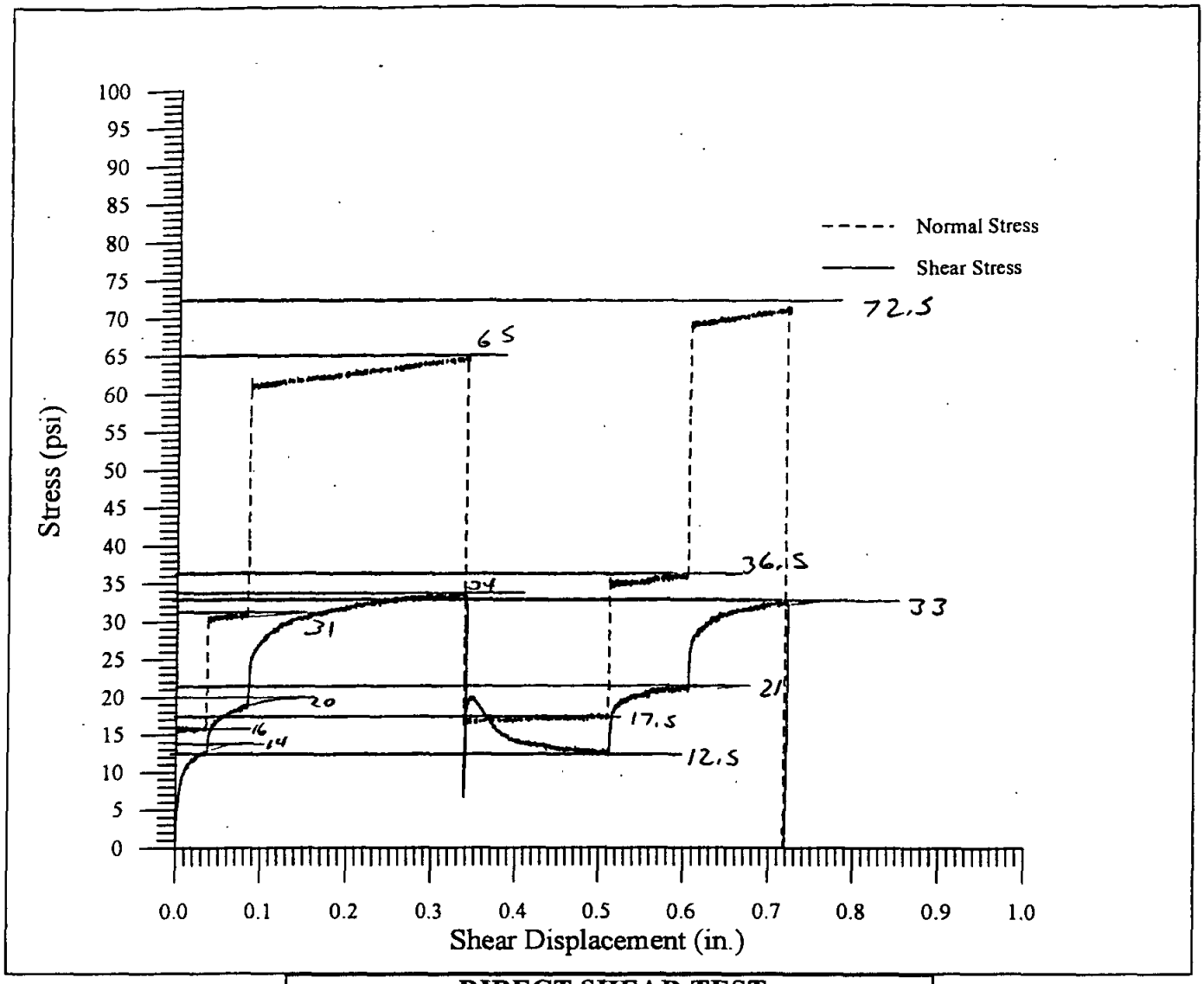
Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 23, 2002



DIRECT SHEAR TEST
Shear and Normal Stress vs. Shear Displacement

Boring: 02-6
Sample: 6-435
Depth: 435.0'

DESCRIPTION

Gray sandy clay gouge filled joint in gray sandstone. Filling up to about 1/8 inch thick.

Normal Stress (psi)	Shear Strength (psi)
16	17
29	25
60	46

Geo Test Unlimited
27069 N. Bloomfield Rd.
Nevada City, CA 95959

Client: Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Project: Devil's Slide

Project Number: none

Test Date: September 23, 2002

APPENDIX C-4

PETROGRAPHIC ANALYSIS BY SPECTRUM PETROGRAPHICS

Summary of Petrographic Tests

Boring / Site	*Depth Interval (ft)*	*Description*
02-2B	225.8	Altered quartz diorite, cross-cutting vein
02-6	380	Conglomeratic sandstone
02-11	111.7-112.5	Fine grained sandstone
	123.2-123.7	Dark-gray claystone
	228.5	Dark-gray silty claystone, with trim bedding laminae
02-11A	480.7-481.0	Dark-gray silty claystone
	520.0	Dark-gray silty claystone, with parallel shear surfaces
	529.1-529.4	Altered silty claystone
	543.5	Altered claystone
02-13	90.2-90.8	Relatively fresh quartz diorite
02-21	297.5-298	Medium-grained cataclasite from quartz diorite protolith (2 sections)
02-21 (?)	443.4-443.9	Medium-grained cataclasite from quartz diorite protolith
? (X)	282.1-282.3	Medium grained sandstone
? (Y)	286	Cataclasite from sandstone or conglomerate protolith
02-T2A	-	Altered claystone
Note: 1 ft = 0.305 m		

DEVIL'S SLIDE TUNNEL PROJECT

Petrographic Report #NQT

November 25, 2002

for

Douglas H. Hamilton
2 Bassett Lane
Atherton, CA 94027

by

Michael DePangher, Ph.D.
Spectrum Petrographics, Inc.

Key to Petrographic and Photomicrographic Descriptions

Clay minerals common in altered rocks must often be identified by X-ray diffraction either because their optic properties are not diagnostic or because they are too fine grained to be reliably identified by optical methods. The term "clay" is used herein to denote fine grained phyllosilicates in general. Under ideal conditions, it is often possible to optically discriminate between 4 major groups: kaolinite, smectite, mica (including illite), and chlorite. This is done whenever conditions permit.

The term "sericite" is applied to fine grained colorless phyllosilicates that show upper 2nd order maximum interference colors. These could include muscovite, illite, paragonite, lepidolite, margarite, clintonite, pyrophyllite, and talc. The term "intermediate clay" is applied to fine grained very pale or colorless phyllosilicates that show upper 1st order maximum interference colors. These are probably dominated by chlorite, smectite, and mixed-layer illite/smectite.

The term "opaques" is used to refer to all materials opaque (and sometimes semi-opaque) to transmitted light. The term "FEOH" is herein used to indicate fine grained, yellowish to reddish brown, earthy materials of varying opacity in transmitted light. FEOH is probably mostly Fe oxy-hydroxides but may sometimes include sphalerite, realgar, orpiment, jarosite, a number of Mn oxy-hydroxides, and organic matter.

Particle size distributions are given as (A-B-C μm), where A, B, and C are the smallest, median, and largest particle sizes, respectively, in microns. A question mark (?) in the position of A, B, or C indicates that the value of A, B, or C was indeterminate, probably because of excessively large or small particle size or statistically insignificant numbers of particles.

Mineral abundances are visual estimates. For multi-lithologic materials (cuttings, etc...), mineralogy, textures, and alteration are described only for the dominant lithology.

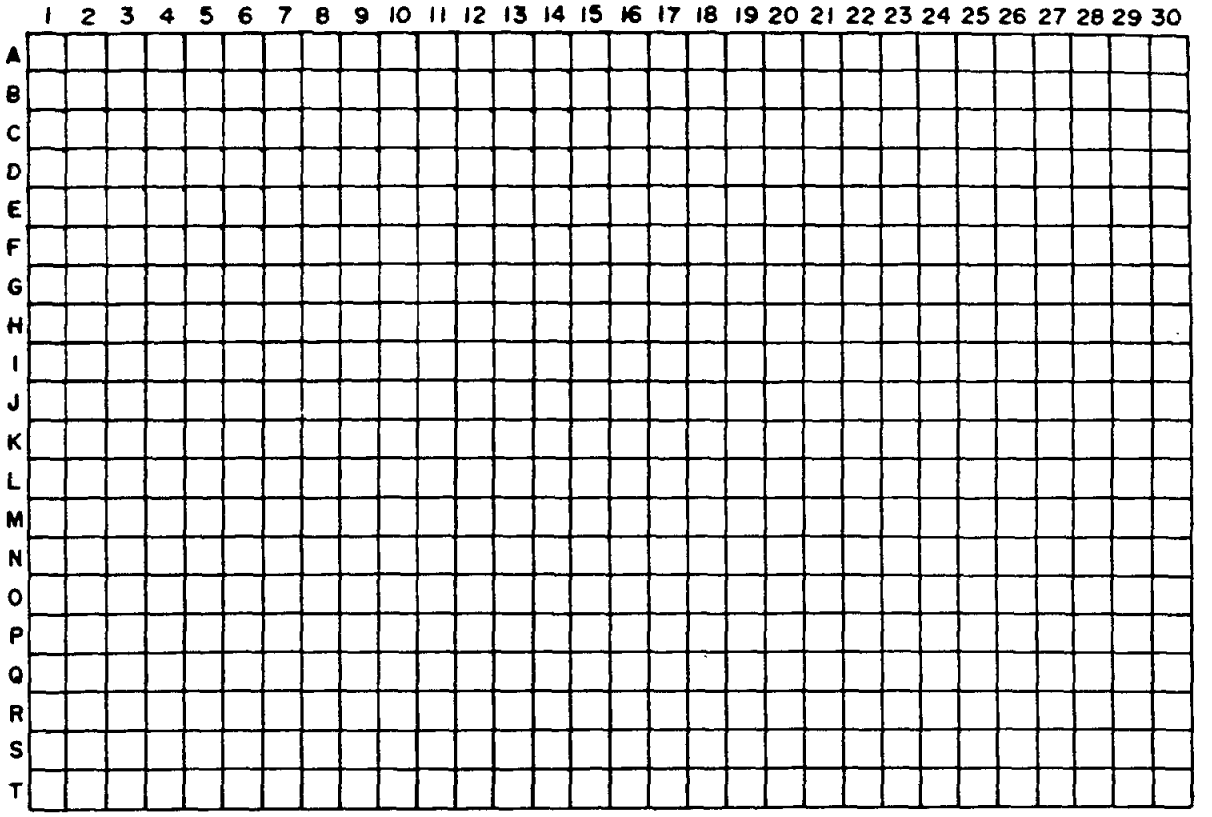
Section preparation codes are as follows: (1) Format: 27 x 46 mm, 51 x 76 mm, or 1" round; (2) Finish: standard lapping (STD) or polished (POL); (3) Stains: sodium cobaltinitrite (SCN), alizarin red S (ARS), potassium ferricyanide (PF), and barium chloride + potassium rhodizonate (BCPR); and (4) Cover: none, permanent Loctite acrylic (PLA), or removable Canada Balsam (RCB).

Photomicrograph captions/labels contain the following items of information in consecutive order separated by forward slashes: (1) sample identification, (2) film roll number, (3) frame number, (4) type of illumination, (5) field of view (FOV) or the magnification on the color print, which is given as the number of times actual size (ie., 32X), and (6) the job identification number. "PPL" indicates plane-polarized light; "XPL indicates cross-polarized light. "R" indicates reflected light. "550" means that a 550 nanometer wavelength plate was inserted in the light path. "C" indicates that the substage condenser was in (sometimes used for Fe-oxides). "O" indicates substage condenser in an oblique position. These various illuminations can be combined. "CON" indicates conoscopic illumination. For normal photography of hand specimens, the focal length of the lens used is given rather than the magnification. POL means that a polarizing filter was used with the lens, and DAY means the sample was photographed in diffused daylight.

Features on photomicrographs can be located by overlaying the accompanying orthogonal plastic grid. A block of squares is marked by referencing the uppermost left and lowermost right corners of the block, ie. A6-E15. Linear features are marked by designating the extent of the feature from beginning to ending points, ie. B6 to L19.

A question mark after a rock or mineral name in a petrographic description means that there is some degree of uncertainty about the identification of that rock or mineral.

The size of an alteration selvege around a vein is given as a half-width (the width of a selvege on one side of the vein) expressed as a fraction of the associated vein width (vw).



For proper photo grid registration, align the top and left sides of the grid with the top and left sides of the photo.

SAMPLE # **02-2B 225.8** November 25, 2002

ROCK NAME ALTERED GRANODIORITE -- probably formed by cataclasis and hydrothermal alteration (secondary clinozoisite + ferroan [calcite + dolomite] + chlorite + FEOH) of a medium granodiorite plutonic rock.

MINERALS Plagioclase (32%) + quartz (32%) + clinozoisite (18%) + K-feldspar (7%) + ferroan [calcite + dolomite] (7%)+ chlorite (2%) + FEOH (2%).

TEXTURES Phaneritic, holocrystalline, equigranular, hypidiomorphic, medium grained. Cataclasis has produced a weakly directed fabric.

ALTERATION Alteration features in relative chronological order from oldest to youngest are: (1) cataclasis; (2) veins and mineralized cataclastic structures of clinozoisite; (3) cataclasis; and (4) veins of ferroan [calcite + dolomite]. The following alteration features are also present but of indeterminate relative ages: (1) plagioclase weakly altered to clinozoisite; and (2) biotite completely altered to chlorite + clinozoisite + FEOH.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-2B 225.8/02029/11/DAY/3X/NQT ALTERED GRANODIORITE showing typical appearance of hand specimen with a well defined cataclastic structure (C11 to R16)

B 02-2B 225.8/02030/23/XPL/28X/NQT ALTERED GRANODIORITE showing typical appearance of fractured granodiorite (A1-J10) adjacent to a well developed cataclastic zone (T9 to A21) cut at a low angle by veins (T5-A16; T15 to A24) of ferroan [calcite + dolomite]..

C 02-2B 225.8/02030/24/XPL/28X/NQT ALTERED GRANODIORITE showing typical appearance of fractured granodiorite cut by a vein (F1 to T12) of ferroan [calcite + dolomite].

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

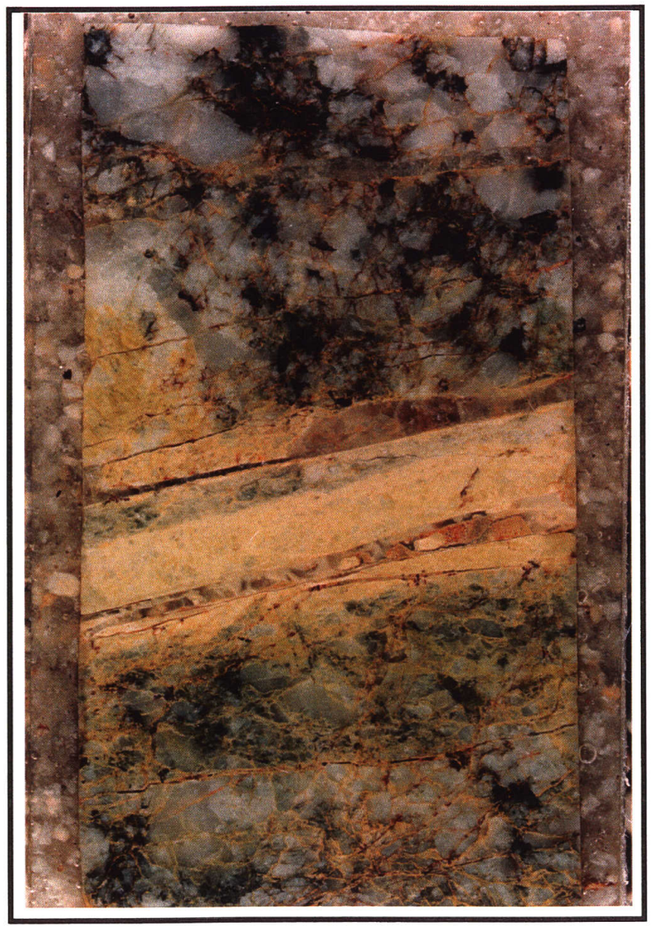


PHOTO A

PHOTO B

PHOTO C

SAMPLE # **02-6 380** November 25, 2002

ROCK NAME ALTERED SANDSTONE -- probably formed by cataclasis and hydrothermal alteration (secondary sericite + opaques + chlorite + clinozoisite + [calcite + ferroan calcite] + leucoxene + FEOH) of a medium to coarse lithic arkose (McBride, 1963) protolith.

MINERALS K-feldspar (30%) + quartz (28%) + plagioclase (28%) + sericite (5%) + opaques (3%) + chlorite (2%) + clinozoisite (2%) + [calcite + ferroan calcite] (2%) ± biotite (<1%) + zircon (<1%) + leucoxene (<1%) + FEOH (<1%).

TEXTURES Clastic sedimentary, non-directed fabric.

Detrital Framework Grains (90%) are angular to subangular, ?-500-10,000 μm, K-feldspar (20%) + quartz (20%) + plagioclase (20%) + lithic fragments (30%) of brecciated granodiorite + chlorite schist + quartz diorite + dacite porphyry. Contacts between grains are curved.

Matrix/Cement (10%) is composed of sericite-rich lithic fragments.

ALTERATION Alteration features in relative chronological order from oldest to youngest are: (1) weak cataclasis; and (2) cataclastic structures mineralized by calcite + ferroan calcite. The following alteration features are present but of indeterminate relative ages: (1) plagioclase weakly altered to clinozoisite or [sericite + K-feldspar]; and (2) biotite strongly altered to chlorite.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-6 380/02029/12/DAY/3X/NQT ALTERED SANDSTONE showing typical appearance of hand specimen with large lithic grains cut by a late cataclastic structure (O3 TO E26) mineralized by calcite + ferroan calcite.

B 02-6 380/02031/0/XPL/28X/NQT ALTERED SANDSTONE showing typical appearance of large lithic grains.

C 02-6 380/02031/01/XPL/28X/NQT ALTERED SANDSTONE showing typical appearance of large lithic grains.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

PHOTO A

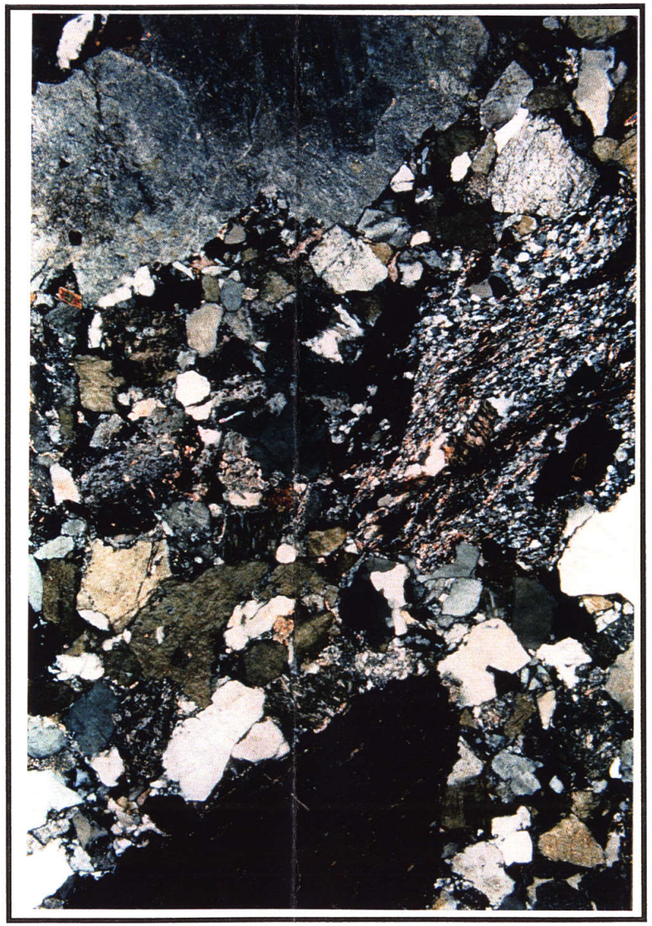


PHOTO B

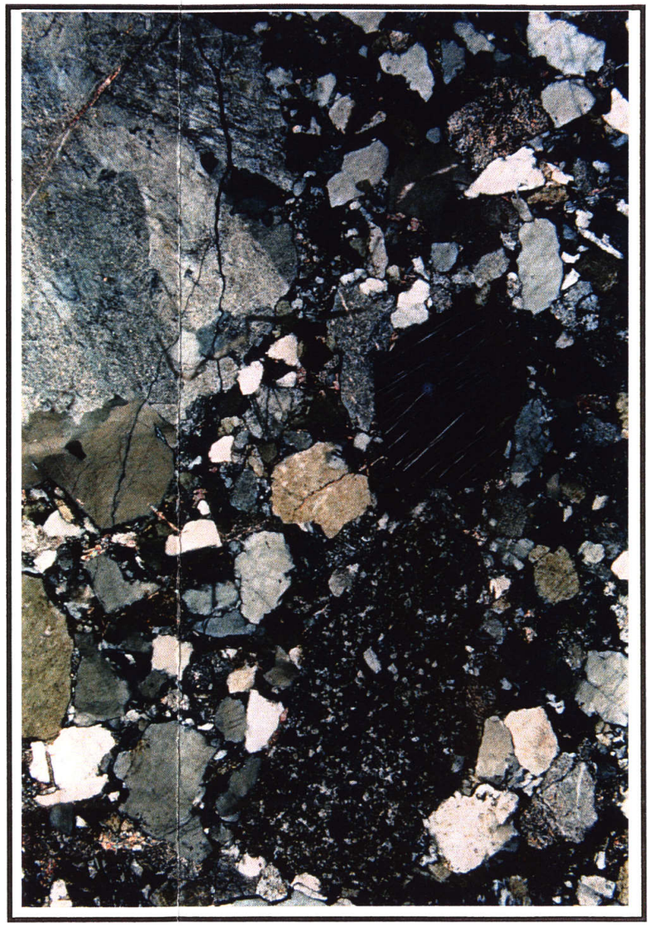


PHOTO C

SAMPLE # **02-11 111.7-112.5** November 25, 2002

ROCK NAME ALTERED SANDSTONE -- probably formed by cataclasis and hydrothermal alteration (secondary K-feldspar + sericite + clinozoisite + ferroan dolomite + FEOH) of a medium arkose (McBride, 1963) protolith.

MINERALS Quartz (30%) + plagioclase (20%) + K-feldspar (15%) + sericite (15%) + clinozoisite (10%) + ferroan dolomite (7%) + biotite (2%) + FEOH (1%) + opaques (<1%).

TEXTURES Clastic sedimentary. Preferentially oriented long axes of elongate grains defines a weakly directed fabric.

Detrital Framework Grains (95%) are subangular, ?-400-1280 μm, quartz (40%) + plagioclase (40%) + K-feldspar (10%) + biotite (3%) + lithic fragments (2%) of altered granodiorite. Contacts between grains are curved.

Matrix/Cement (5%) is composed of sericite-rich lithic fragments.

ALTERATION The following alteration features are also present but of indeterminate relative ages: (1) (1) veins of ferroan dolomite + FEOH; (2) plagioclase moderately altered to [sericite + clinozoisite + K-feldspar + ferroan dolomite]; and (3) biotite moderately altered to sericite + FEOH.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-11 111.7-112.5/02029/13/DAY/3X/NQT ALTERED SANDSTONE showing typical appearance of hand specimen.

B 02-11 111.7-112.5/02031/02/XPL/28X/NQT ALTERED SANDSTONE showing typical appearance of angular grains.

C 02-11 111.7-112.5/02031/03/PPL/28X/NQT ALTERED SANDSTONE showing typical appearance of angular grains cut by a vein of ferroan dolomite (D2, D15, G25) + FEOH.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

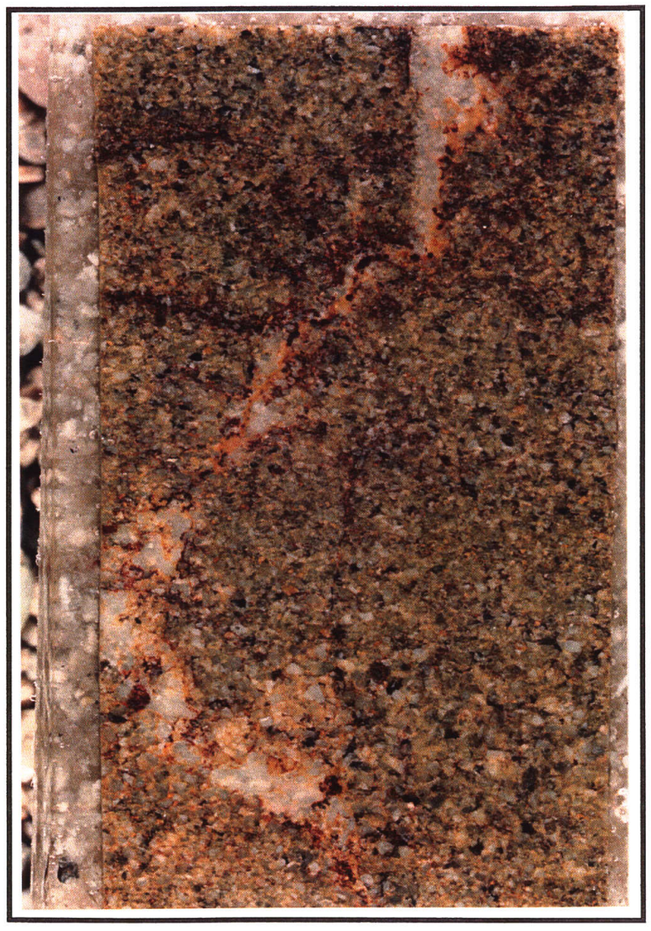


PHOTO A

PHOTO B

PHOTO C

SAMPLE # **02-11 123.2-123.7** November 25, 2002

ROCK NAME ALTERED CLAYSTONE -- probably formed by alteration (secondary ferroan dolomite + sericite + chlorite) of a claystone protolith.

MINERALS Clay (illite ?) (70%) + quartz (15%) + opaques (5%) + carbonaceous matter (5%) + ferroan dolomite (1%) + plagioclase (1%) + sericite (1%) + biotite (1%) + chlorite (1%).

TEXTURES Clastic sedimentary. Very fine bedding defines a moderately directed fabric.

Detrital Framework Grains (20%) are angular, ?-25-400 μm quartz (15%) + biotite (3%) + plagioclase (2%). Contacts between grains are floating.

Matrix/Cement (80%) is composed of clay + carbonaceous matter + opaques.

ALTERATION The following alteration features are present but of indeterminate relative ages: (1) Plagioclase moderately altered to sericite + ferroan dolomite; and (2) biotite moderately altered to chlorite.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-11 123.2-123.7/02029/14/DAY/3X/NQT ALTERED CLAYSTONE showing typical dark fine grained appearance of hand specimen.

B 02-11 123.2-123.7/02031/04/XPL/28X/NQT ALTERED CLAYSTONE showing typical fine grained appearance (A1-I9; L23-T30) with a coarser silty layer (I20).

C 02-11 123.2-123.7/02031/05/XPL/114X/NQT ALTERED CLAYSTONE showing typical closeup appearance of fine grained claystone (A12-T30) with a coarser silty layer (A1-G7).

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

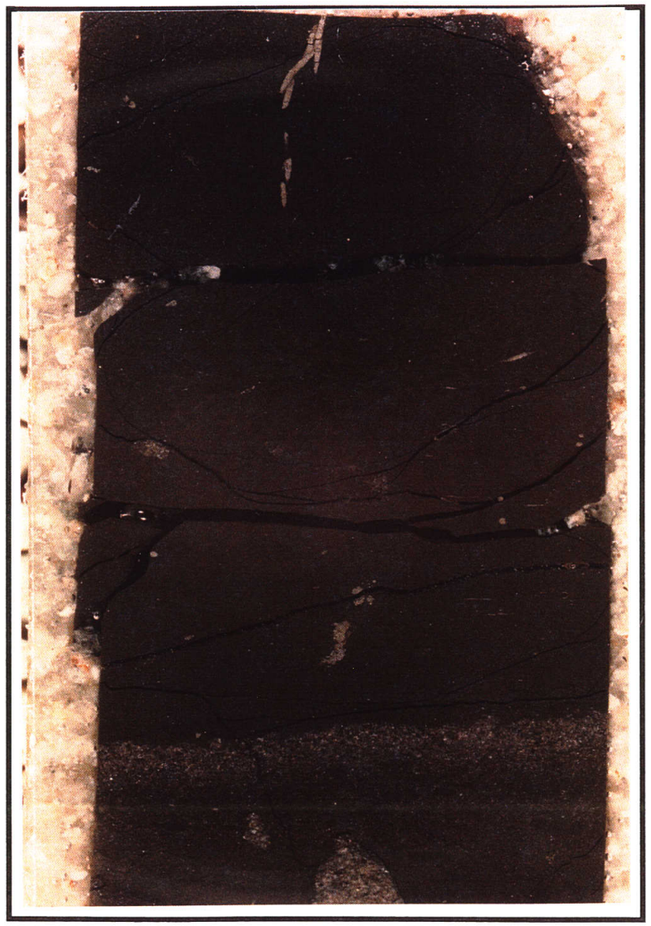


PHOTO A

PHOTO B

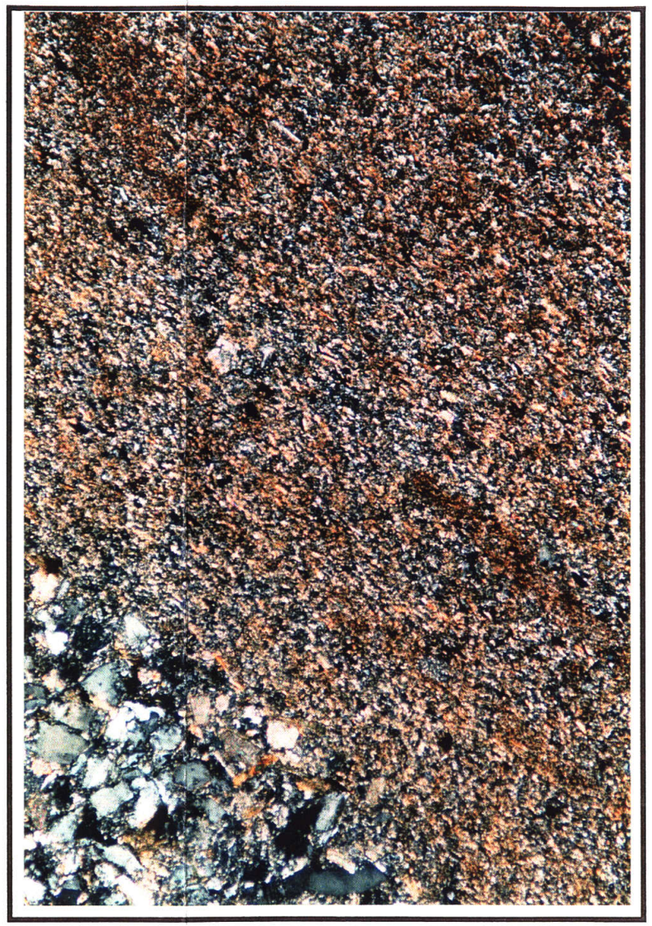


PHOTO C

SAMPLE # **02-11 228.5** November 25, 2002

ROCK NAME ALTERED SILTY CLAYSTONE -- probably formed by alteration (secondary ferroan dolomite + sericite) of a silty claystone protolith.

MINERALS Clay (illite ?) (62%) + quartz (20%) + opaques (5%) + carbonaceous matter (3%) + ferroan dolomite (3%) + plagioclase (3%) + biotite (2%) + sericite (2%).

TEXTURES Clastic sedimentary. Very fine bedding defines a moderately directed fabric.

Detrital Framework Grains (25%) are angular, ?-30-360 μm quartz (20%) + plagioclase (3%) + biotite (2%). Contacts between grains are floating.

Matrix (72%) is composed of clay + carbonaceous matter + opaques.

Cement (3%) is composed of ferroan dolomite.

ALTERATION The following alteration features are present but of indeterminate relative ages: (1) veinlets of ferroan dolomite; and (2) plagioclase weakly altered to sericite + ferroan dolomite.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS A 02-11 228.5/02029/15/DAY/3X/NQT ALTERED SILTY CLAYSTONE showing typical appearance of hand specimen.

B 02-11 228.5/02031/06/XPL/28X/NQT ALTERED SILTY CLAYSTONE showing typical fine grained appearance.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

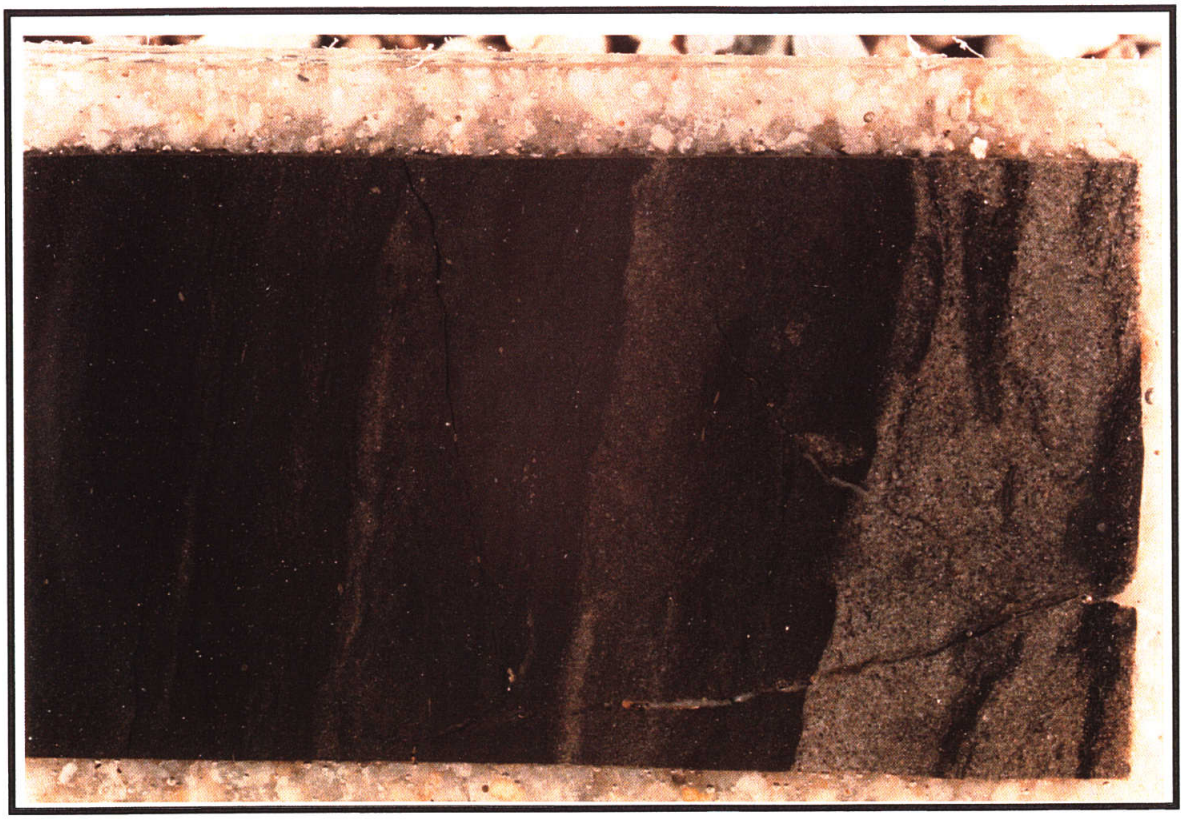


PHOTO A

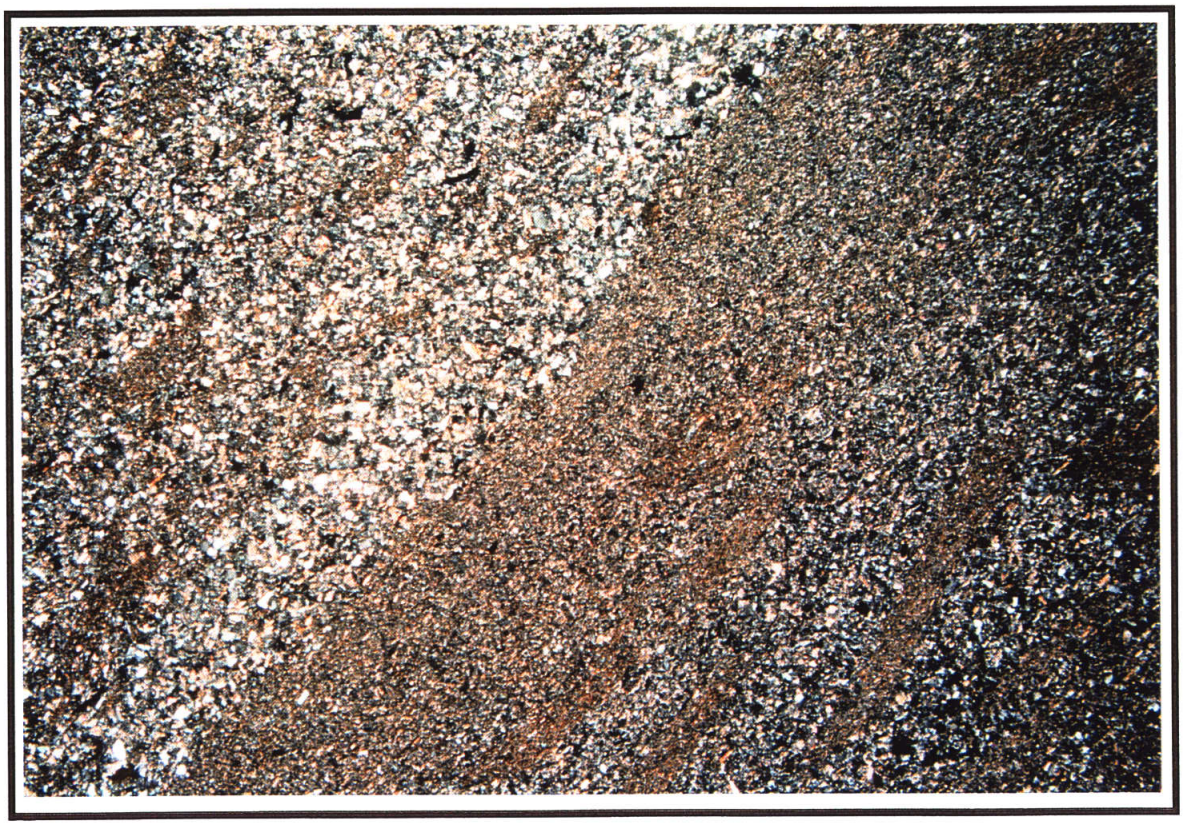


PHOTO B

SAMPLE # **02-11A 480.7-481.0** November 25, 2002

ROCK NAME ALTERED SILTY CLAYSTONE -- probably formed by alteration (secondary ferroan dolomite + sericite) of a silty claystone protolith.

MINERALS Clay (illite ?) (52%) + quartz (19%) + ferroan dolomite (15%) + opaques (4%) + carbonaceous matter (3%) + plagioclase (3%) + biotite (3%) + sericite (2%).

TEXTURES Clastic sedimentary. Very fine bedding defines a moderately directed fabric.

Detrital Framework Grains (25%) are angular, ?-30-170 μm quartz (19%) + plagioclase (3%) + biotite (3%). Contacts between grains are floating.

Matrix (60%) is composed of clay + carbonaceous matter + opaques.

Cement (15%) is composed of ferroan dolomite.

ALTERATION The following alteration features are present but of indeterminate relative ages: (1) veinlets of ferroan dolomite; and (2) plagioclase weakly altered to sericite + ferroan dolomite. Minor bioturbation seems to have been caused by rootlets.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-11A 480.7-481.0/02029/16/DAY/3X/NQT ALTERED SILTY CLAYSTONE showing typical appearance of hand specimen.

B 02-11A 480.7-481.0/02031/07/XPL/28X/NQT ALTERED SILTY CLAYSTONE showing typical fine grained appearance.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

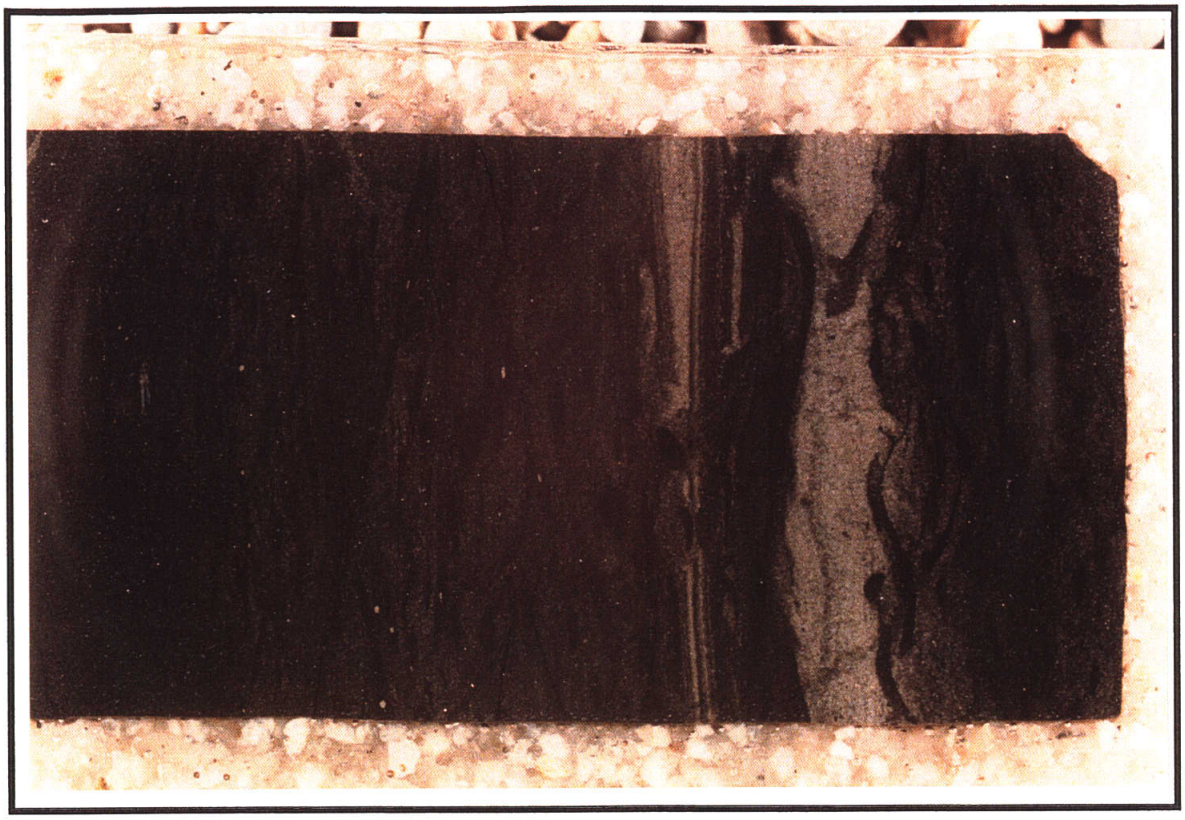


PHOTO A

PHOTO B

SAMPLE # **02-11A 520** November 25, 2002

ROCK NAME ALTERED CLAYSTONE -- probably formed by alteration (secondary ferroan dolomite) of a claystone protolith.

MINERALS Clay (illite ?) (74%) + quartz (13%) + carbonaceous matter (5%) + opaques (4%) + ferroan dolomite (2%) + plagioclase (1%) + biotite (1%).

TEXTURES Clastic sedimentary. Very fine bedding defines a weakly directed fabric.

Detrital Framework Grains (15%) are angular, ?-25-150 μm quartz (13%) + biotite (1%) + plagioclase (1%). Contacts between grains are floating.

Matrix/Cement (85%) is composed of clay + carbonaceous matter + opaques.

ALTERATION The following alteration features are present but of indeterminate relative ages: (1) veinlets of ferroan dolomite.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-11A 520/02029/17/DAY/3X/NQT ALTERED CLAYSTONE showing typical appearance of hand specimen.

B 02-11A 520/02031/08/XPL/28X/NQT ALTERED CLAYSTONE showing typical fine grained appearance.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

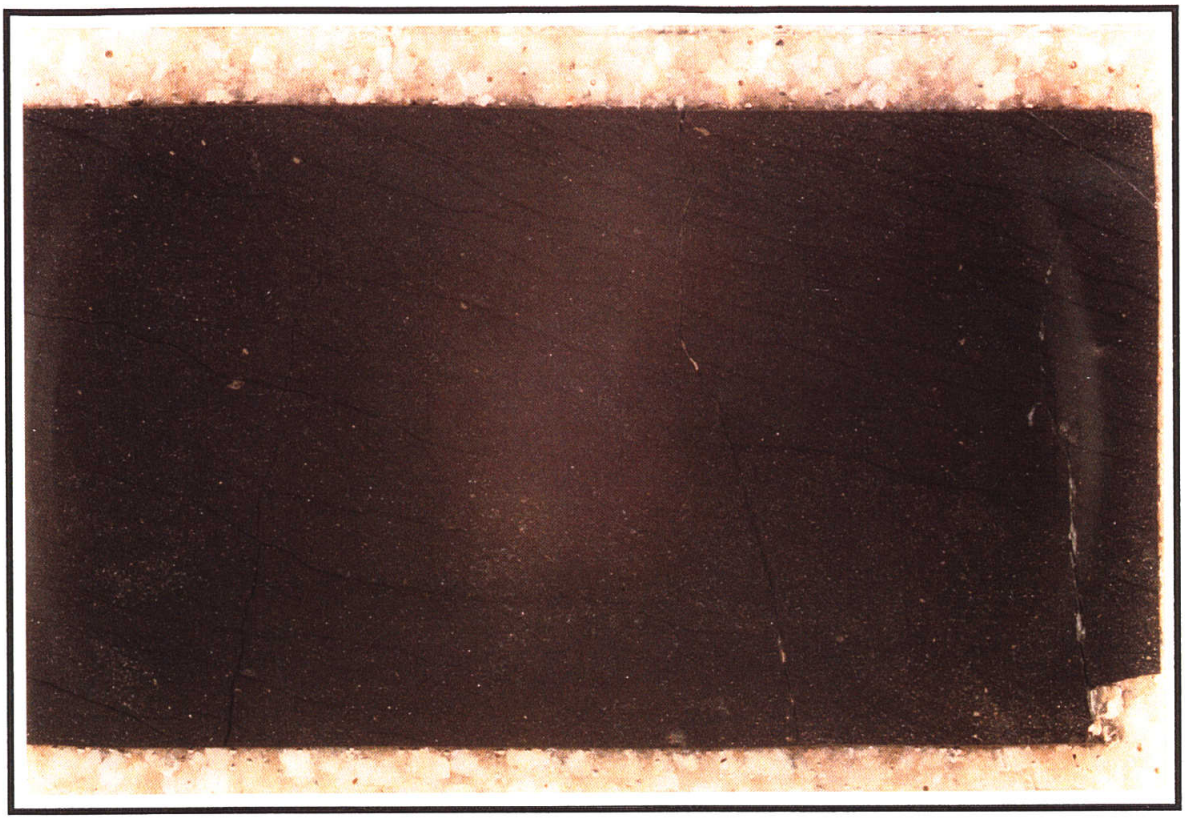


PHOTO A

PHOTO B

SAMPLE # **02-13 90.2-90.8** November 25, 2002

ROCK NAME ALTERED GRANODIORITE -- probably formed by cataclasis and hydrothermal alteration (secondary clinozoisite + K-feldspar + chlorite) of a medium granodiorite plutonic rock.

MINERALS Plagioclase (28%) + quartz (28%) + clinozoisite (28%) + K-feldspar (10%) + chlorite (4%) + opaques (2%) + zircon (<1%).

TEXTURES Phaneritic, holocrystalline, equigranular, hypidiomorphic, medium grained, non-directed fabric.

ALTERATION Alteration features in relative chronological order from oldest to youngest are: (1) cataclasis; (2) veins and mineralized cataclastic structures of clinozoisite; and (3) cataclasis. The following alteration features are also present but of indeterminate relative ages: (1) plagioclase weakly altered to clinozoisite + K-feldspar + chlorite; and (2) biotite completely altered to chlorite.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-13 90.2-90.8/02029/18/DAY/3X/NQT ALTERED GRANODIORITE showing typical brecciated appearance of hand specimen.

B 02-13 90.2-90.8/02031/09/XPL/28X/NQT ALTERED GRANODIORITE showing typical appearance of fractured granodiorite adjacent to cataclastic zone (A1-I10) cut by veins (T9 to A21) of clinozoisite.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

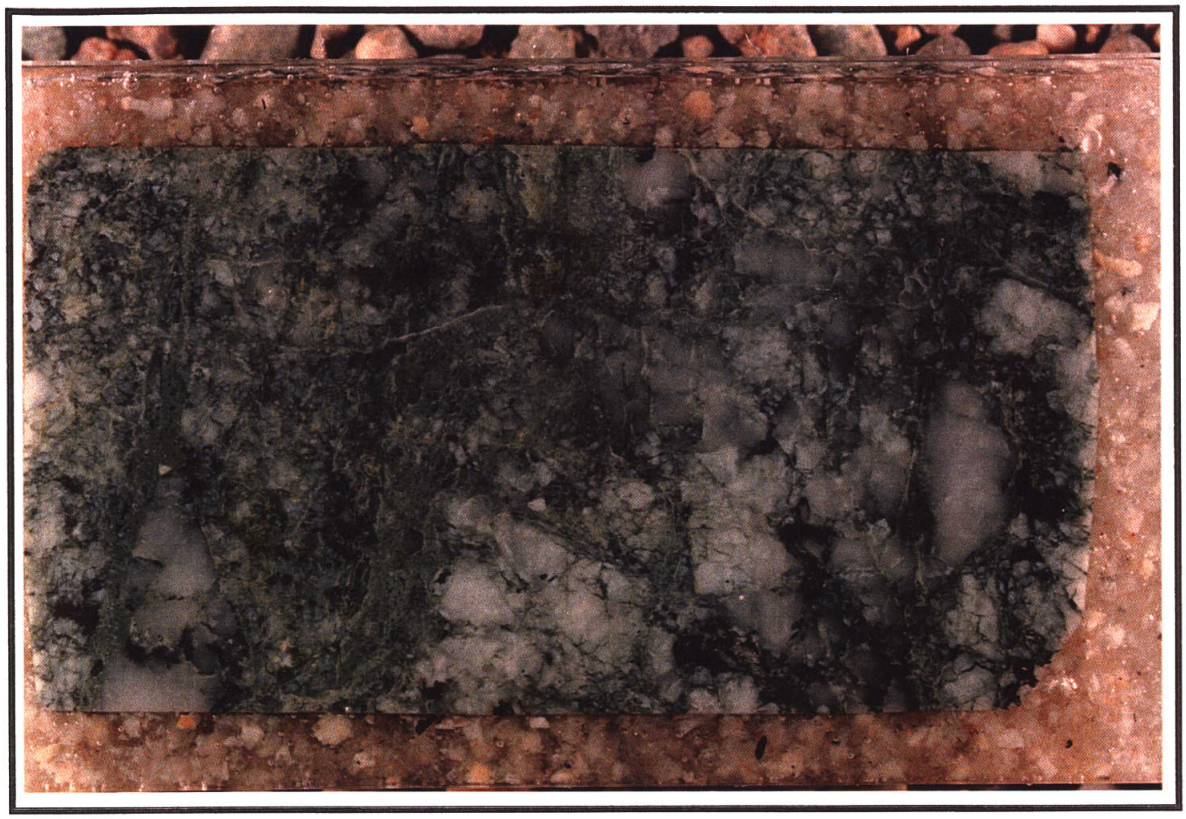


PHOTO A

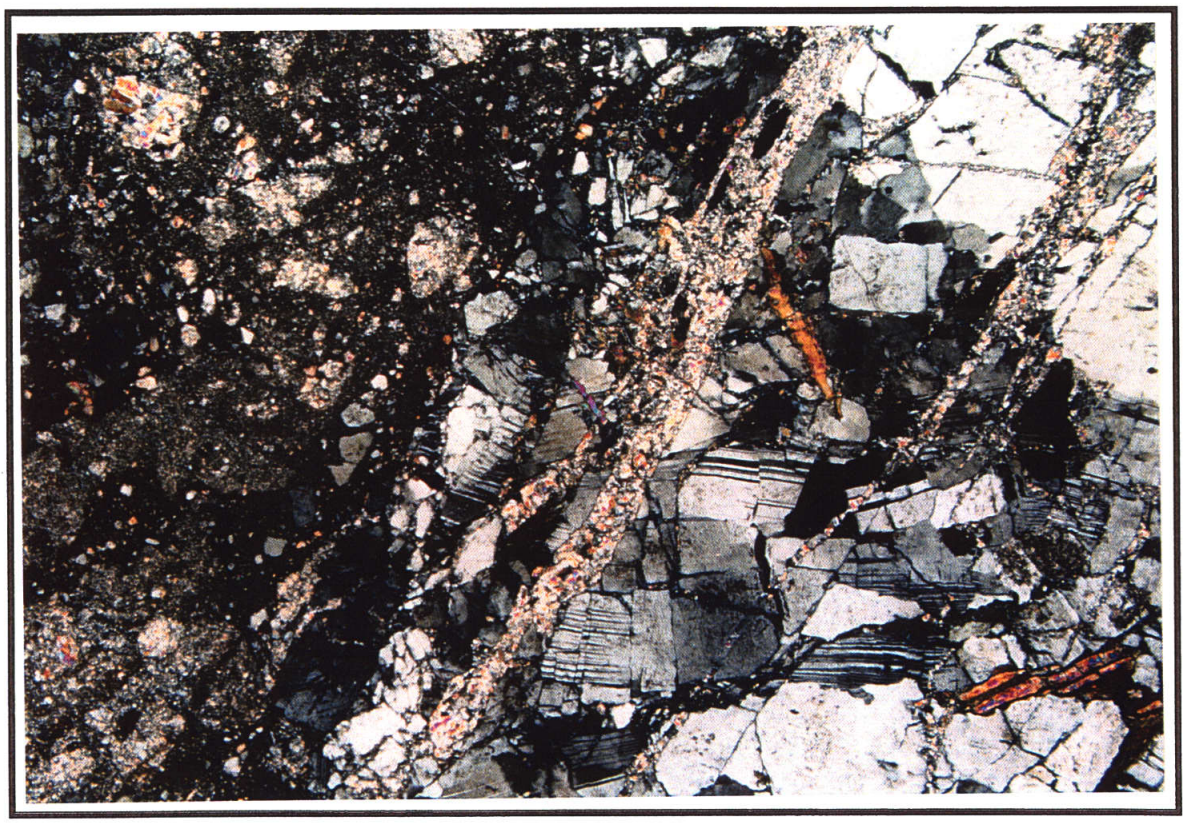


PHOTO B

SAMPLE # **02-21 297.5-298** November 25, 2002

ROCK NAME ALTERED QUARTZ DIORITE -- probably formed by cataclasis and hydrothermal alteration (secondary gypsum + K-feldspar + clinozoisite + sericite + calcite + chlorite) of a medium quartz diorite plutonic rock.

MINERALS Plagioclase (38%) + quartz (38%) + biotite (8%) + gypsum (5%) + K-feldspar (3%) + clinozoisite (3%) + sericite (2%) + calcite (2%) + opaques (1%) + chlorite (<1%).

TEXTURES Phaneritic, holocrystalline, equigranular, hypidiomorphic, medium grained, non-directed fabric.

ALTERATION Alteration features in relative chronological order from oldest to youngest are: (1) cataclasis; (2) veins of gypsum + clinozoisite; and (3) veins of calcite. The following alteration features are present but of indeterminate relative ages: (1) plagioclase weakly altered to sericite + clinozoisite + gypsum + K-feldspar; and (2) biotite moderately altered to sericite + chlorite.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-21 297.5-298/02029/19/DAY/3X/NQT ALTERED QUARTZ DIORITE showing typical appearance of hand specimen.

B 02-21 297.5-298/02031/10/XPL/28X/NQT ALTERED QUARTZ DIORITE showing typical appearance of late veins (Q1 to A17) of calcite.

C 02-21 297.5-298/02031/11/XPL/28X/NQT ALTERED QUARTZ DIORITE showing typical appearance of a vein (A9-T20) of gypsum (J10) + clinozoisite (H18).

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

PHOTO A

PHOTO B

PHOTO C

SAMPLE # **02-21 297.5-298** November 25, 2002

ROCK NAME ALTERED QUARTZ DIORITE -- probably formed by cataclasis and hydrothermal alteration (secondary sericite + clinozoisite + chlorite + calcite + K-feldspar + gypsum) of a medium quartz diorite plutonic rock.

MINERALS Plagioclase (43%) + quartz (25%) + biotite (10%) + sericite (10%) + clinozoisite (3%) + chlorite (2%) + calcite (2%) + opaques (2%) + K-feldspar (1%) + gypsum (1%) + apatite (1%).

TEXTURES Phaneritic, holocrystalline, equigranular, hypidiomorphic, medium grained, non-directed fabric.

ALTERATION Alteration features in relative chronological order from oldest to youngest are: (1) cataclasis; (2) veins of clinozoisite; and (3) veins of calcite. The following alteration features are present but of indeterminate relative ages: (1) plagioclase moderately altered to sericite + K-feldspar; (2) biotite weakly altered to chlorite; (3) veinlets of gypsum; and (4) veinlets of K-feldspar.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS A 02-21 297.5-298/02029/20/DAY/3X/NQT ALTERED QUARTZ DIORITE showing typical appearance of hand specimen.

B 02-21 297.5-298/02031/12/XPL/28X/NQT ALTERED QUARTZ DIORITE showing typical appearance of late veins (T2 to A26) of calcite.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

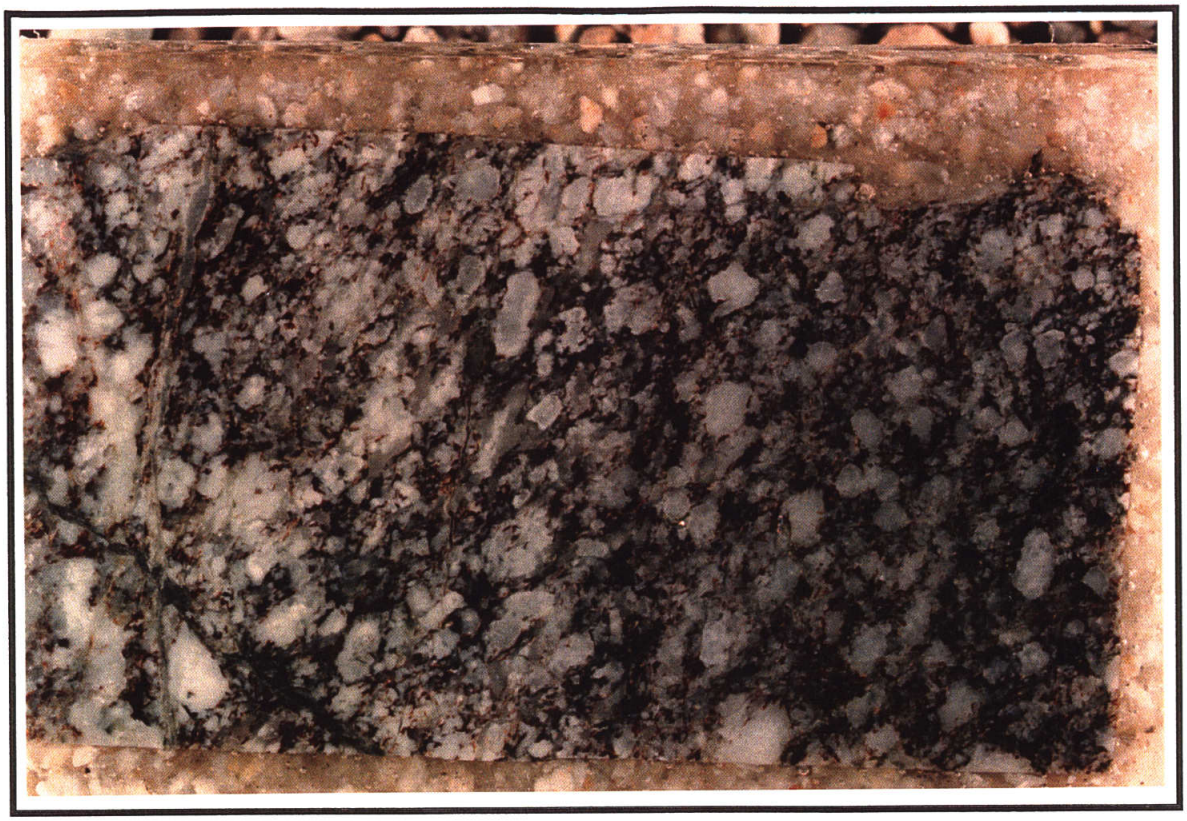


PHOTO A

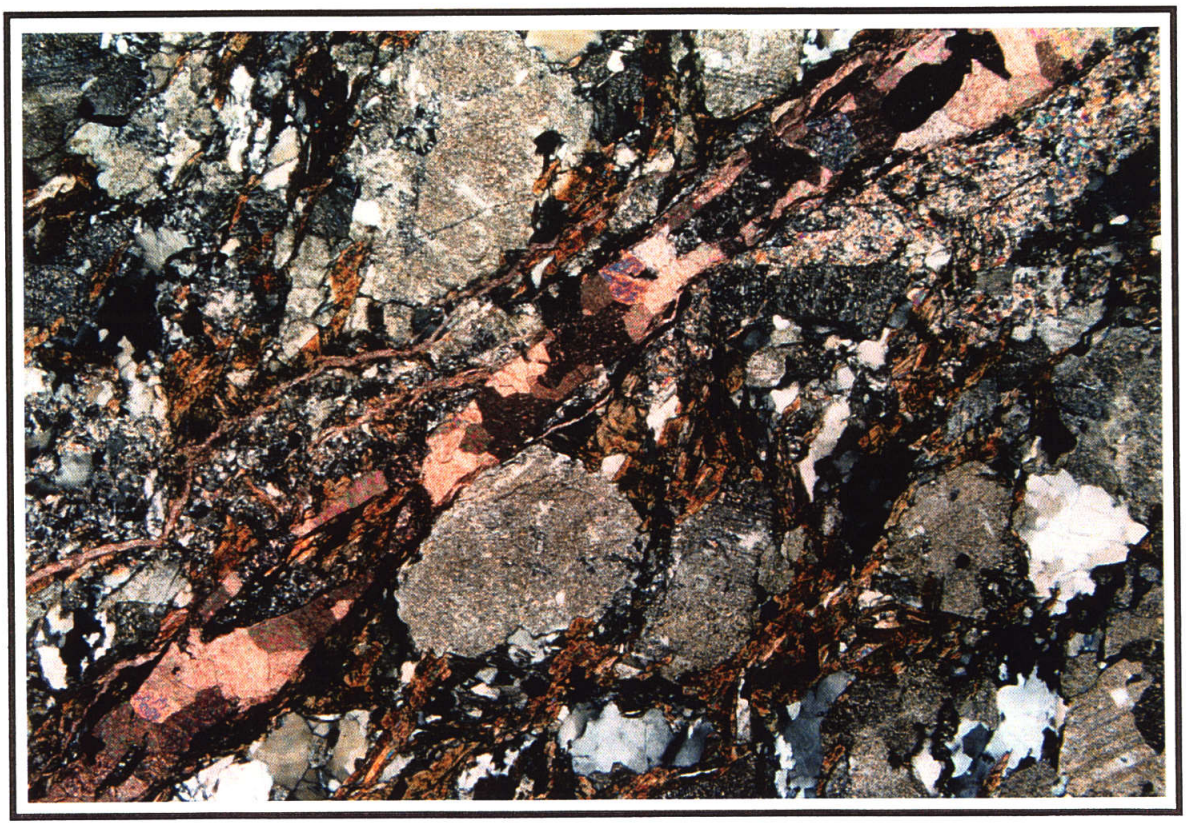


PHOTO B

SAMPLE # **02-21(?) 443.4-443.9** November 25, 2002

ROCK NAME ALTERED QUARTZ DIORITE -- probably formed by cataclasis and hydrothermal alteration (secondary clinozoisite + chlorite + K-feldspar + calcite + sericite + FEOH) of a medium quartz diorite plutonic rock.

MINERALS Plagioclase (50%) + quartz (37%) + clinozoisite (10%) + chlorite (1%) + K-feldspar (1%) + calcite (1%) + sericite (<1%) + FEOH (<1%).

TEXTURES Phaneritic, holocrystalline, equigranular, hypidiomorphic, medium grained, non-directed fabric.

ALTERATION Alteration features in relative chronological order from oldest to youngest are: (1) cataclasis; (2) veins of clinozoisite; (3) cataclasis; and (4) veins of calcite. The following alteration features are present but of indeterminate relative ages: (1) plagioclase weakly altered to clinozoisite + K-feldspar; and (2) biotite moderately altered to chlorite + sericite.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-21(?) 443.4-443.9/02029/21/DAY/3X/NQT ALTERED QUARTZ DIORITE showing typical brecciated appearance of hand specimen.

B 02-21(?) 443.4-443.9/02031/13/XPL/28X/NQT ALTERED QUARTZ DIORITE showing typical appearance of cataclastic texture cut by a late vein (T11 to C18) of calcite.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

PHOTO A

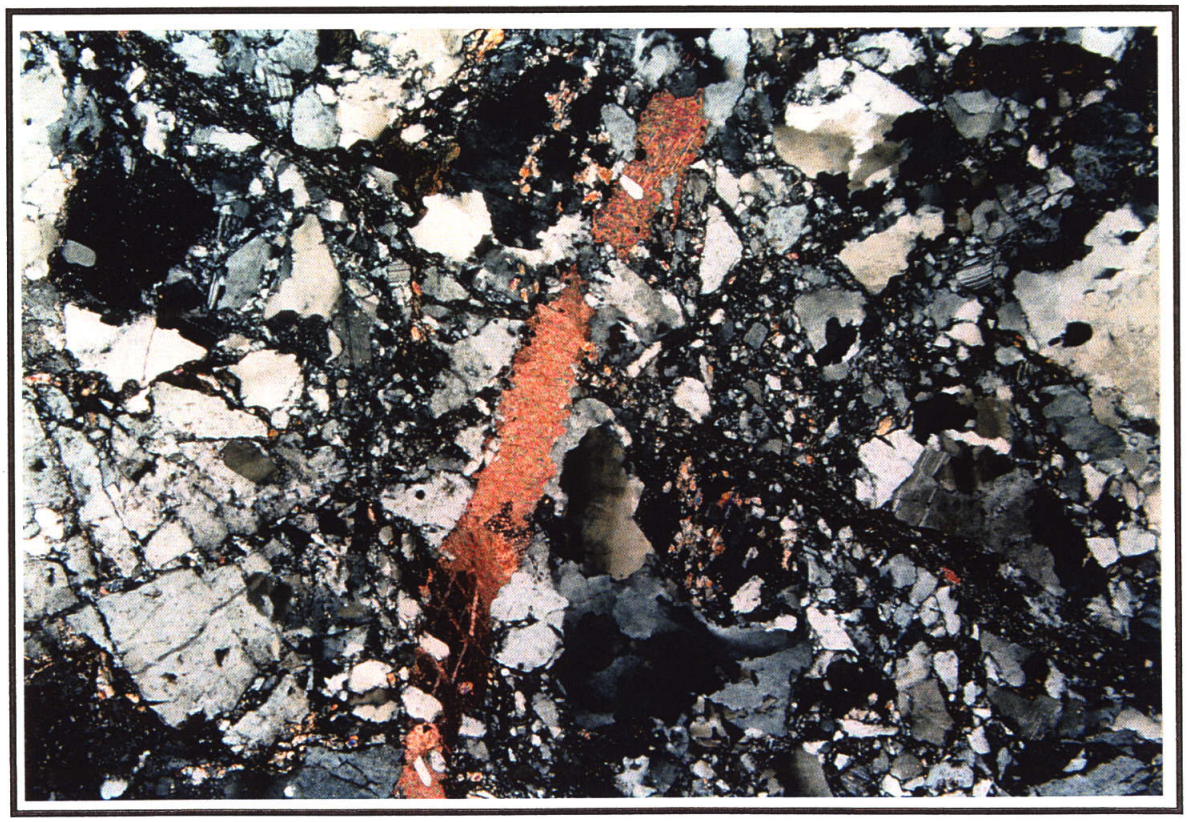


PHOTO B

SAMPLE # **?(x) 282.1-282.3** November 25, 2002

ROCK NAME ALTERED SANDSTONE -- probably formed by cataclasis and hydrothermal alteration (secondary quartz + sericite + [calcite + ferroan calcite] + chlorite) of a coarse arkose (McBride, 1963) protolith.

MINERALS Quartz (26%) + plagioclase (26%) + K-feldspar (26%) + sericite (16%) + opaques (5%) + [calcite + ferroan calcite] (1%) + chlorite (<1%).

TEXTURES Cataclastic overprint on clastic sedimentary; non-directed fabric.

Detrital Framework Grains (80%) are subangular, ?-920-4000 μm, quartz (24%) + plagioclase (23%) + K-feldspar (23%) + lithic fragments (10%) of various altered granodiorites + basalt + carbonaceous chert. Contacts between grains are curved to sutured.

Matrix/Cement (20%) is composed of sericite + opaques.

ALTERATION Alteration features in relative chronological order from oldest to youngest are: (1) cataclasis; (2) veins of calcite; and (3) cataclasis. The following alteration features are also present but of indeterminate relative ages: (1) veins of quartz + sericite + ferroan calcite; and (2) biotite completely altered to chlorite.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A ?(x) 282.1-282.3/02029/22/DAY/3X/NQT ALTERED SANDSTONE showing typical appearance of hand specimen.

B ?(x) 282.1-282.3/02031/14/XPL/28X/NQT ALTERED SANDSTONE showing typical appearance of deformed lithic grains.

C ?(x) 282.1-282.3/02031/15/XPL/28X/NQT ALTERED SANDSTONE showing typical appearance of multiple crosscutting cataclastic structures.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

PHOTO A

PHOTO B

PHOTO C

SAMPLE # **?(y) 286.0** November 25, 2002

ROCK NAME CATACLASITE -- probably formed by cataclasis and hydrothermal alteration (secondary calcite + opaques + sericite + chlorite) of a heterogeneous coarse sandstone or conglomerate protolith.

MINERALS Quartz (40%) + plagioclase (27%) + calcite (15%) + K-feldspar (5%) + sericite (5%)+ opaques (5%) + sericite (2%) + chlorite (1%).

TEXTURES Cataclastic overprint on clastic sedimentary; non-directed fabric.

Porphyroclasts (70%) are ?-30,000 μm lithic fragments of various granodiorite + dacite porphyry + monocrystalline [quartz (10%) + plagioclase (10%) + K-feldspar (<1%)]. Contacts between porphyroclasts are indeterminate.

Matrix (15%) is composed of the comminuted equivalent of the clasts, suggesting a dominantly cataclastic mechanism of brecciation.

Cement (15%) is composed of calcite.

ALTERATION Alteration features in relative chronological order from oldest to youngest are: (1) cataclasis; and (2) veins of calcite. The following alteration features are also present but of indeterminate relative ages: (1) plagioclase weakly altered sericite.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A ?(y) 286.0/02029/23/DAY/3X/NQT CATACLASITE showing typical appearance of hand specimen with large lithic fragments.

B ?(y) 286.0/02031/16/XPL/28X/NQT CATACLASITE showing typical appearance of large lithic grains of granodiorite (N14-T24) and dacite porphyry (A20-J30).

C ?(y) 286.0/02031/17/XPL/28X/NQT CATACLASITE showing typical appearance of a large lithic grain dacite porphyry.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

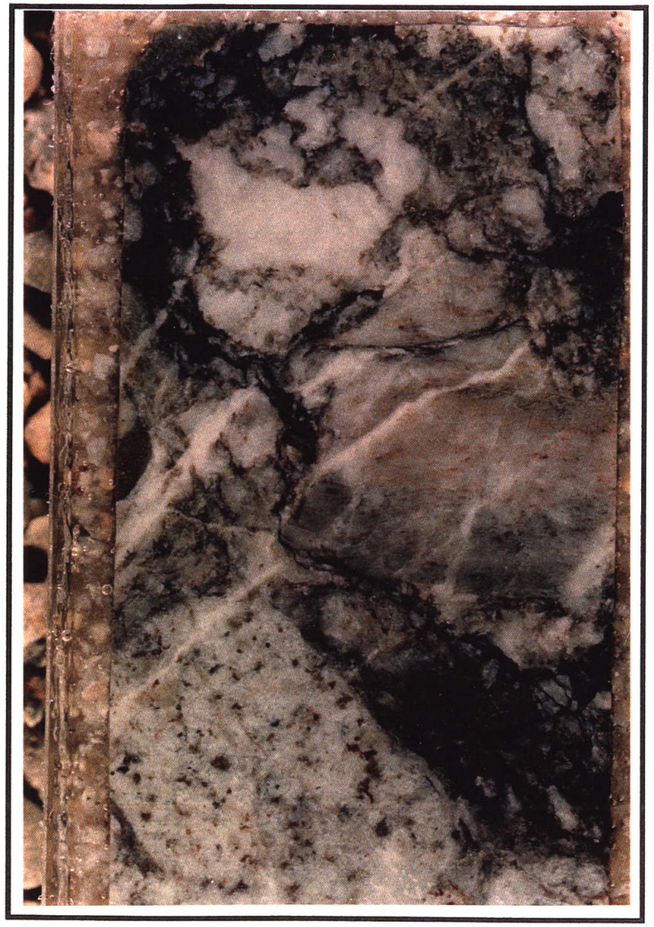


PHOTO A

PHOTO B

PHOTO C

SAMPLE # **TR-2A** November 25, 2002

ROCK NAME ALTERED CLAYSTONE -- probably formed by alteration (secondary opaques) of a claystone protolith.

MINERALS Clay (illite ?) (78%) + quartz (15%) + carbonaceous matter (5%) + opaques (2%).

TEXTURES Clastic sedimentary, non-directed fabric.

Detrital Framework Grains (15%) are angular, 25-150 μm quartz (15%). Contacts between grains are floating.

Matrix/Cement (85%) is composed of clay + carbonaceous matter + opaques.

ALTERATION No other alteration features were observed.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A TR-2A/02029/24/DAY/3X/NQT ALTERED CLAYSTONE showing typical dark fine grained appearance of hand specimen.

B TR-2A/02031/18/XPL/28X/NQT ALTERED CLAYSTONE showing typical fine grained appearance.

C TR-2A/02031/19/XPL/114X/NQT ALTERED CLAYSTONE showing typical closeup appearance.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

PHOTO A

PHOTO B

PHOTO C

SAMPLE # **02-11A 529.1-529.4** November 25, 2002

ROCK NAME ALTERED SILTY CLAYSTONE -- probably formed by alteration (secondary ferroan dolomite + opaques) of a silty claystone protolith.

MINERALS Clay (illite ?) (60%) + quartz (23%) + ferroan dolomite (8%) + carbonaceous matter (5%) + plagioclase (2%) + opaques (2%).

TEXTURES Clastic sedimentary. Very fine bedding defines a moderately directed fabric.

Detrital Framework Grains (25%) are angular, 30-200 μm quartz (23%) + plagioclase (2%) + microfossils (<1%). Contacts between grains are floating.

Matrix (67%) is composed of clay + carbonaceous matter + opaques.

Cement (8%) is composed of ferroan dolomite.

ALTERATION No other alteration features were observed.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-11A 529.1-529.4/02030/01/DAY/3X/NQT ALTERED SILTY CLAYSTONE showing typical dark fine grained appearance of hand specimen.

B 02-11A 529.1-529.4/02031/20/XPL/28X/NQT ALTERED SILTY CLAYSTONE showing typical fine grained appearance.

C 02-11A 529.1-529.4/02031/21/XPL/114X/NQT ALTERED SILTY CLAYSTONE showing typical closeup appearance.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

PHOTO A

PHOTO B

PHOTO C

SAMPLE # **02-11A 543.5** November 25, 2002

ROCK NAME ALTERED CLAYSTONE -- probably formed by alteration (secondary ferroan dolomite + opaques) of a claystone protolith.

MINERALS Clay (illite ?) (70%) + quartz (15%) + ferroan dolomite (5%) + carbonaceous matter (5%) + opaques (3%) + plagioclase (2%).

TEXTURES Clastic sedimentary. Very fine bedding defines a weakly directed fabric.

Detrital Framework Grains (17%) are angular, 30-240 μm quartz (15%) + plagioclase (2%) + microfossils (<1%). Contacts between grains are floating.

Matrix (78%) is composed of clay + carbonaceous matter + opaques.

Cement (5%) is composed of ferroan dolomite.

ALTERATION No other alteration features were observed.

SECTIONING Format: 27 x 46 mm Finish: STD Stains: SCN (all) + [ARS + PF] (right half) Cover: PLA

PHOTOS

A 02-11A 543.5/02030/02/DAY/3X/NQT ALTERED CLAYSTONE showing typical dark fine grained appearance of hand specimen.

B 02-11A 543.5/02031/22/XPL/28X/NQT ALTERED CLAYSTONE showing typical fine grained appearance.

C 02-11A 543.5/02031/23/XPL/114X/NQT ALTERED CLAYSTONE showing typical closeup appearance.

PETROGRAPHICS PHOTOS
2002 PHASE 2B FIELD EXPLORATION

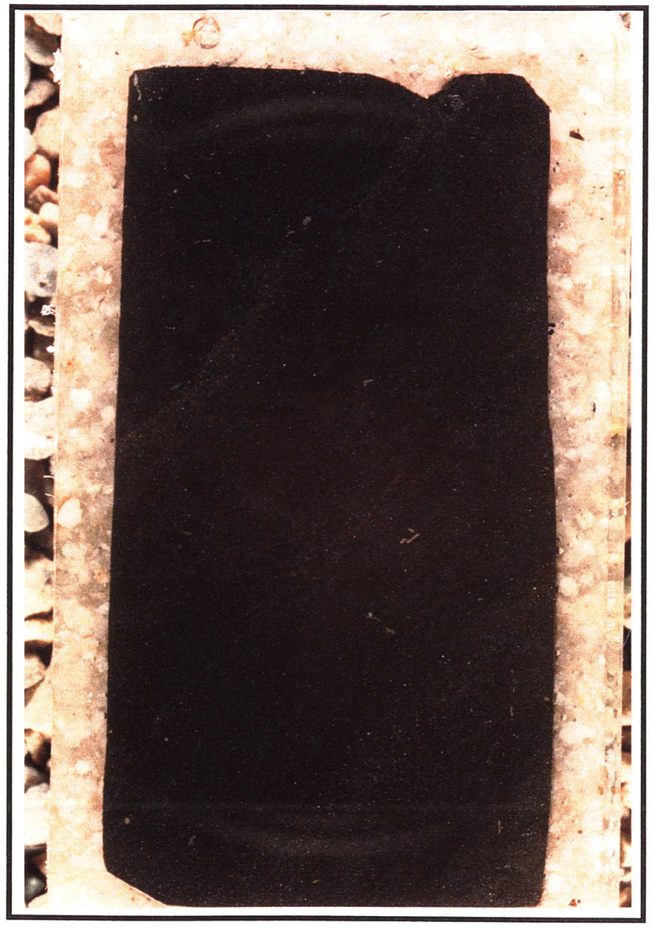


PHOTO A

PHOTO B

PHOTO C

APPENDIX D-4

AGGREGATE POTENTIAL REACTIVITY BY SMITH EMERY

SMITH-EMERY GEOSERVICES
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FAX 213/746-0744

November 4, 2002

SEG File No.: 32411-1
SEG Report No.: G-02-9666

Earth Mechanics, Inc.
Attention: Mr. Hubert K. Law
17660 Newhope Street, Suite E
Fountain Valley, California 92708

RE: Devil's Slide Tunnels Project
CORE SAMPLES

Gentlemen:

Smith-Emery GeoServices has completed testing for the reference material. Test results are as follows:

REPORT OF TEST

Sampled Delivered by Client: 10-28-02 **Date Tested:** 10-30-02

Standard : ASTM C289 Chemical Method

Sample No..	Sample I.D.		Potential Reactivity	
	Borehole	Depth	Dissolved Silica Sc millimoles/1	Alkalinity Reduction Rc millimoles/1
1	02-06	366'- 367'	92.9	100
2	02-07	404.5'- 405.5'	124.9	90

Core Samples is considered potentially deleterious as per C289 fig 2.

Should you have any questions regarding the contents of this report, please call.

Respectfully submitted,
SMITH-EMERY GEOSERVICES

ANGELITO CABANILLA
Geotechnical Laboratory Manager

AC/em
cc: addressee

APPENDIX E-4

WATER SAMPLE TESTING BY SEVERN TRENT LABS

Submission#: 2002-09-0688

October 06, 2002

SEVERN TRENT LABORATORY

STL San Francisco
1220 Quarry Ln
Pleasanton CA 94566

Tel.: (925) 484-1919
Fax: (925) 484-1096
www.stl-inc.com
www.chromalab.com

CA DHS ELAP#:2496

Earth Mechanics, Inc.
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Attn.: Raj Varatharaj
Project#: 02-134 T.02B
Project: Devil's Slide Tunnels

Dear Mr. Varatharaj:

Attached is our report for your samples received on 09/27/2002 17:30
This report has been reviewed and approved for release. Reproduction of this report is permitted only in its entirety.

Please note that any unused portion of the samples will be discarded after 11/11/2002 unless you have requested otherwise.
We appreciate the opportunity to be of service to you. If you have any questions, please call me at (925) 484-1919.
You can also contact me via email. My email address is: tgranicher@chromalab.com

Sincerely,

Tod Granicher
Project Manager

Submission #: 2002-09-0688

Gasoline

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Phone: (650) 738-9359 Fax: (650) 738-9379

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/27/2002 17:30

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www.chromalab.com

CA DHS ELAP# 2496

Samples Reported

Sample Name	Date Sampled	Matrix	Lab #
02-5 WATER	09/27/2002 08:30	Water	1

Submission #: 2002-09-0688

Gasoline

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Attn.: Raj Varatharaj
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Fax: (925) 484-1096
www.stl-inc.com
www.chromalab.com

CA DHS ELAP# 2496

Prep(s): 5030
Test(s): 8015M
Sample ID: **02-5 WATER**
Lab ID: 2002-09-0688 - 1
Sampled: 09/27/2002 08:30
Extracted: 10/4/2002 14:19
Matrix: Water
QC Batch#: 2002/10/04-01.04

Compound	Conc.	RL	Unit	Dilution	Analyzed	Flag
Gasoline	490	50	ug/L	1.00	10/04/2002 14:19	g
Surrogates(s)						
4-Bromofluorobenzene-FID	80.8	50-150	%	1.00	10/04/2002 14:19	

Submission #: 2002-09-0688

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Project: 02-134 T.02B
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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 5030 Test(s): 8015M

Method Blank **Water** **QC Batch # 2002/10/04-01.04**

MB: 2002/10/04-01.04-008 Date Extracted: 10/04/2002 08:40

Compound	Conc.	RL	Unit	Analyzed	Flag
Gasoline	ND	50	ug/L	10/04/2002 08:40	
Surrogates(s)					
4-Bromofluorobenzene-FID	87.8	50-150	%	10/04/2002 08:40	

Submission #: 2002-09-0688

Gasoline

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Project: 02-134 T.02B
Devil's Slide Tunnels

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Fax: (925) 484-1096
www.stl-inc.com
www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 5030

Test(s): 8015M

Laboratory Control Spike **Water** **QC Batch # 2002/10/04-01.04**

LCS 2002/10/04-01.04-006 Extracted: 10/04/2002 Analyzed: 10/04/2002 09:57
LCSD 2002/10/04-01.04-007 Extracted: 10/04/2002 Analyzed: 10/04/2002 10:23

Compound	Conc. ug/L		Exp.Conc.	Recovery		RPD	Ctrl.Limits %		Flags	
	LCS	LCSD		LCS	LCSD	%	Rec.	RPD	LCS	LCSD
Gasoline	506	484	500	101.2	96.8	4.4	75-125	20		
Surrogates(s)										
4-Bromofluorobenzene-FID	444	432	500	88.8	86.4		50-150			

Submission #: 2002-09-0688

Gasoline

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www.chromalab.com

CA DHS ELAP# 2496

Legend and Notes

Result Flag

g

Hydrocarbon reported in the gasoline range does not match our gasoline standard.

Submission #: 2002-09-0688

PNA analysis by 8270C

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Phone: (650) 738-9359 Fax: (650) 738-9379

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/27/2002 17:30

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www.chromalab.com

CA DHS ELAP# 2496

Samples Reported

Sample Name	Date Sampled	Matrix	Lab #
02-5 WATER	09/27/2002 08:30	Water	1

Submission #: 2002-09-0688

PNA analysis by 8270C

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Phone: (650) 738-9359 Fax: (650) 738-9379

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/27/2002 17:30

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www.chromalab.com

CA DHS ELAP# 2496

Prep(s): 3510C/8270C
Test(s): 8270C
Sample ID: **02-5 WATER**
Lab ID: 2002-09-0688 - 1
Sampled: 09/27/2002 08:30
Extracted: 10/1/2002 08:57
Matrix: Water
QC Batch#: 2002/10/01-01.11

Compound	Conc.	RL	Unit	Dilution	Analyzed	Flag
Naphthalene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Acenaphthylene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Acenaphthene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Fluorene	ND	5.0	ug/L	1.00	10/02/2002 13:37	
Phenanthrene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Anthracene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Fluoranthene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Pyrene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Benzo(a)anthracene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Chrysene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Benzo(b)fluoranthene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Benzo(k)fluoranthene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Benzo(a)pyrene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Indeno(1,2,3-c,d)pyrene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Dibenzo(a,h)anthracene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Benzo(g,h,i)perylene	ND	2.0	ug/L	1.00	10/02/2002 13:37	
Surrogates(s)						
Nitrobenzene-d5	44.1	35-114	%	1.00	10/02/2002 13:37	
2-Fluorobiphenyl	38.9	43-116	%	1.00	10/02/2002 13:37	sl
p-Terphenyl-d14	89.9	33-141	%	1.00	10/02/2002 13:37	

Submission #: 2002-09-0688

PNA analysis by 8270C

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Phone: (650) 738-9359 Fax: (650) 738-9379

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/27/2002 17:30

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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 3510C/8270C
Method Blank
MB: 2002/10/01-01.11-001

Water

Test(s): 8270C
QC Batch # 2002/10/01-01.11
Date Extracted: 10/01/2002 08:57

Compound	Conc.	RL	Unit	Analyzed	Flag
Naphthalene	ND	2.0	ug/L	10/01/2002 15:05	
Acenaphthylene	ND	2.0	ug/L	10/01/2002 15:05	
Acenaphthene	ND	2.0	ug/L	10/01/2002 15:05	
Fluorene	ND	2.0	ug/L	10/01/2002 15:05	
Phenanthrene	ND	2.0	ug/L	10/01/2002 15:05	
Anthracene	ND	2.0	ug/L	10/01/2002 15:05	
Fluoranthene	ND	2.0	ug/L	10/01/2002 15:05	
Pyrene	ND	2.0	ug/L	10/01/2002 15:05	
Benzo(a)anthracene	ND	2.0	ug/L	10/01/2002 15:05	
Chrysene	ND	2.0	ug/L	10/01/2002 15:05	
Benzo(b)fluoranthene	ND	2.0	ug/L	10/01/2002 15:05	
Benzo(k)fluoranthene	ND	2.0	ug/L	10/01/2002 15:05	
Benzo(a)pyrene	ND	2.0	ug/L	10/01/2002 15:05	
Indeno(1,2,3-c,d)pyrene	ND	2.0	ug/L	10/01/2002 15:05	
Dibenzo(a,h)anthracene	ND	2.0	ug/L	10/01/2002 15:05	
Benzo(g,h,i)perylene	ND	2.0	ug/L	10/01/2002 15:05	
Surrogates(s)					
Nitrobenzene-d5	72.0	35-114	%	10/01/2002 15:05	
2-Fluorobiphenyl	69.9	43-116	%	10/01/2002 15:05	
p-Terphenyl-d14	88.6	33-141	%	10/01/2002 15:05	

Submission #: 2002-09-0688

PNA analysis by 8270C

Earth Mechanics, Inc.
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CA DHS ELAP# 2496

Batch QC Report

Prep(s): 3510C/8270C

Test(s): 8270C

Laboratory Control Spike **Water** **QC Batch # 2002/10/01-01.11**

LCS 2002/10/01-01.11-002 Extracted: 10/01/2002 Analyzed: 10/01/2002 15:34
LCSD 2002/10/01-01.11-003 Extracted: 10/01/2002 Analyzed: 10/01/2002 16:02

Compound	Conc. ug/L		Exp.Conc.	Recovery		RPD	Ctrl.Limits %		Flags	
	LCS	LCSD		LCS	LCSD	%	Rec.	RPD	LCS	LCSD
Acenaphthene	22.4	22.4	30.0	74.7	74.7	0.0	56-118	30		
Pyrene	23.1	25.6	30.0	77.0	85.3	10.2	52-115	35		
Surrogates(s)										
Nitrobenzene-d5	16.6	19.4	25	66.4	77.6		35-114			
2-Fluorobiphenyl	17.4	16.6	25	69.6	66.4		43-116			
p-Terphenyl-d14	22.2	22.6	25	88.8	90.4		33-141			

Submission #: 2002-09-0688

PNA analysis by 8270C

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Phone: (650) 738-9359 Fax: (650) 738-9379

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/27/2002 17:30

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CA DHS ELAP# 2496

Legend and Notes

Result Flag

sl

Surrogate recoveries were lower than QC limit due to matrix interference, confirmed by reanalysis.

Submission #: 2002-09-0688

Gases by 3810M

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Phone: (650) 738-9359 Fax: (650) 738-9379

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/27/2002 17:30

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www.chromalab.com

CA DHS ELAP# 2496

Samples Reported

Sample Name	Date Sampled	Matrix	Lab #
02-5 WATER	09/27/2002 08:30	Water	1

Submission #: 2002-09-0688

Gases by 3810M

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Phone: (650) 738-9359 Fax: (650) 738-9379

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/27/2002 17:30

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Fax: (925) 484-1096
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www.chromalab.com

CA DHS ELAP# 2496

Prep(s): 3810
Test(s): 3810M
Sample ID: **02-5 WATER**
Lab ID: 2002-09-0688 - 1
Sampled: 09/27/2002 08:30
Extracted: 10/1/2002 16:40
Matrix: Water
QC Batch#: 2002/10/01-01.37

Compound	Conc.	RL	Unit	Dilution	Analyzed	Flag
Methane	ND	0.010	ug/ml	1.00	10/01/2002 16:40	
Ethylene	ND	0.020	ug/ml	1.00	10/01/2002 16:40	
Ethane	ND	0.020	ug/ml	1.00	10/01/2002 16:40	

Submission #: 2002-09-0688

Gases by 3810M

Earth Mechanics, Inc.
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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 3810 Test(s): 3810M

Method Blank **Water** **QC Batch # 2002/10/01-01.37**

MB: 2002/10/01-01.37-001 Date Extracted: 10/01/2002 10:56

Compound	Conc.	RL	Unit	Analyzed	Flag
Methane	ND	0.01	ug/ml	10/01/2002 10:56	
Ethylene	ND	0.02	ug/ml	10/01/2002 10:56	
Ethane	ND	0.02	ug/ml	10/01/2002 10:56	

Submission #: 2002-09-0688

Gases by 3810M

Earth Mechanics, Inc.
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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 3810

Test(s): 3810M

Laboratory Control Spike **Water** **QC Batch # 2002/10/01-01.37**

LCS 2002/10/01-01.37-002 Extracted: 10/01/2002 Analyzed: 10/01/2002 11:34
LCSD 2002/10/01-01.37-003 Extracted: 10/01/2002 Analyzed: 10/01/2002 11:42

Compound	Conc. ug/ml		Exp.Conc.	Recovery		RPD	Ctrl.Limits %		Flags	
	LCS	LCSD		LCS	LCSD	%	Rec.	RPD	LCS	LCSD
Methane	0.0720	0.0704	0.0721	99.9	97.6	2.3	65-135	35		

Submission #: 2002-09-0688

pH

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
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Pacifica, CA 94044
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Project: 02-134 T.02B
Devil's Slide Tunnels

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www.chromalab.com

CA DHS ELAP# 2496

Samples Reported

Sample Name	Date Sampled	Matrix	Lab #
02-5 WATER	09/27/2002 08:30	Water	1

Submission #: 2002-09-0688

pH

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Phone: (650) 738-9359 Fax: (650) 738-9379

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www.chromalab.com

CA DHS ELAP# 2496

Prep(s):	9040B	Test(s):	9040B
Sample ID:	**02-5 WATER**	Lab ID:	2002-09-0688 - 1
Sampled:	09/27/2002 08:30	Extracted:	9/27/2002 18:20
Matrix:	Water	QC Batch#:	2002/09/27-01.22

Compound	Conc.	RL	Unit	Dilution	Analyzed	Flag
pH	6.5	0.0	SU	1.00	09/27/2002 18:20	

Submission #: 2002-09-0688

pH

Earth Mechanics, Inc.
Attn.: Raj Varatharaj
520 San Pedro Avenue, Ste. 10
Pacifica, CA 94044
Phone: (650) 738-9359 Fax: (650) 738-9379

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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 9040B
Method Blank
MB: 2002/09/27-01.22-001

Water

Test(s): 9040B
QC Batch # 2002/09/27-01.22
Date Extracted: 09/27/2002

Compound	Conc.	RL	Unit	Analyzed	Flag
pH	7.01		SU	09/27/2002	

Submission#: 2002-09-0208

September 18, 2002

SEVERN TRENT LABORATORY

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1220 Quarry Ln
Pleasanton CA 94566

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www.stl-inc.com
www.chromalab.com

CA DHS ELAP#:2496

Earth Mechanics, Inc.
17660 Newhope St., #E
Fountain Valley, Ca 92708
Attn.: Hubert Law
Project#: 02-134 T.02B
Project: Devil`s Slide Tunnels

Attached is our report for your samples received on 09/11/2002 15:18
This report has been reviewed and approved for release. Reproduction of this report is permitted only in its entirety.

Please note that any unused portion of the samples will be discarded after 10/26/2002 unless you have requested otherwise.
We appreciate the opportunity to be of service to you. If you have any questions, please call me at (925) 484-1919.
You can also contact me via email. My email address is: tgranicher@chromalab.com

Sincerely,

Tod Granicher
Project Manager

Submission #: 2002-09-0208

Gasoline

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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www.stl-inc.com
www.chromalab.com

CA DHS ELAP# 2496

Samples Reported

Sample Name	Date Sampled	Matrix	Lab #
02-11A	09/11/2002 07:00	Water	1

Submission #: 2002-09-0208

Gasoline

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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Pleasanton, CA 94566

Tel: (925) 484-1919
Fax: (925) 484-1096
www.stl-inc.com
www.chromalab.com

CA DHS ELAP# 2496

Prep(s): 5030
Test(s): 8015M
Sample ID: **02-11A**
Lab ID: 2002-09-0208 - 1
Sampled: 09/11/2002 07:00
Extracted: 9/17/2002 17:55
Matrix: Water
QC Batch#: 2002/09/17-01.01

Compound	Conc.	RL	Unit	Dilution	Analyzed	Flag
Gasoline	250	50	ug/L	1.00	09/17/2002 17:55	g
Surrogates(s)						
4-Bromofluorobenzene-FID	84.9	50-150	%	1.00	09/17/2002 17:55	

Submission #: 2002-09-0208

Gasoline

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

SEVERN TRENT LABORATORY
STL San Francisco
1220 Quarry Lane
Pleasanton, CA 94566

Tel: (925) 484-1919
Fax: (925) 484-1096
www.stl-inc.com
www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 5030 Test(s): 8015M

Method Blank **Water** **QC Batch # 2002/09/17-01.01**

MB: 2002/09/17-01.01-005 Date Extracted: 09/17/2002 09:12

Compound	Conc.	RL	Unit	Analyzed	Flag
Gasoline	ND	50	ug/L	09/17/2002 09:12	
Surrogates(s)					
4-Bromofluorobenzene-FID	61.6	50-150	%	09/17/2002 09:12	

Submission #: 2002-09-0208

Gasoline

Earth Mechanics, Inc.
Attn.: Hubert Law
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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 5030
5030

Test(s): 8015M
8020

Laboratory Control Spike **Water** **QC Batch # 2002/09/17-01.01**

LCS 2002/09/17-01.01-008 Extracted: 09/17/2002 Analyzed: 09/17/2002 10:45
LCSD 2002/09/17-01.01-009 Extracted: 09/17/2002 Analyzed: 09/17/2002 11:16

Compound	Conc. ug/L		Exp.Conc.	Recovery		RPD	Ctrl.Limits %		Flags	
	LCS	LCSD		LCS	LCSD	%	Rec.	RPD	LCS	LCSD
Gasoline	477	447	500	95.4	89.4	6.5	75-125	20		
Surrogates(s)										
4-Bromofluorobenzene-FID	374	370	500	74.8	74.0		50-150			

Submission #: 2002-09-0208

Gasoline

Earth Mechanics, Inc.

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CA DHS ELAP# 2496

Legend and Notes

Result Flag

g

Hydrocarbon reported in the gasoline range does not match our gasoline standard.

Submission #: 2002-09-0208

Gases by 3810M

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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www.chromalab.com

CA DHS ELAP# 2496

Samples Reported

Sample Name	Date Sampled	Matrix	Lab #
02-11A	09/11/2002 07:00	Water	1

Submission #: 2002-09-0208

Gases by 3810M

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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www.chromalab.com

CA DHS ELAP# 2496

Prep(s):	3810	Test(s):	3810M
Sample ID:	**02-11A**	Lab ID:	2002-09-0208 - 1
Sampled:	09/11/2002 07:00	Extracted:	9/18/2002 14:50
Matrix:	Water	QC Batch#:	2002/09/18-01.37

Compound	Conc.	RL	Unit	Dilution	Analyzed	Flag
Methane	ND	0.010	ug/ml	1.00	09/18/2002 14:50	
Carbon Dioxide	39	2.0	ug/ml	1.00	09/18/2002 14:50	
Ethylene	ND	0.02	ug/ml	1.00	09/18/2002 14:50	
Ethane	ND	0.02	ug/ml	1.00	09/18/2002 14:50	

Submission #: 2002-09-0208

Gases by 3810M

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 3810 Test(s): 3810M

Method Blank *Water* **QC Batch # 2002/09/18-01.37**

MB: 2002/09/18-01.37-001 Date Extracted: 09/18/2002 14:08

Compound	Conc.	RL	Unit	Analyzed	Flag
Methane	ND	0.01	ug/ml	09/18/2002 14:08	
Carbon Dioxide	ND	2.0	ug/ml	09/18/2002 14:08	
Ethylene	ND	0.02	ug/ml	09/18/2002 14:08	
Ethane	ND	0.02	ug/ml	09/18/2002 14:08	

Submission #: 2002-09-0208

Gases by 3810M

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 3810

Test(s): 3810M

Laboratory Control Spike **Water** **QC Batch # 2002/09/18-01.37**

LCS 2002/09/18-01.37-002 Extracted: 09/18/2002 Analyzed: 09/18/2002 14:24
LCSD 2002/09/18-01.37-003 Extracted: 09/18/2002 Analyzed: 09/18/2002 14:32

Compound	Conc. ug/ml		Exp.Conc.	Recovery		RPD	Ctrl.Limits %		Flags	
	LCS	LCSD		LCS	LCSD	%	Rec.	RPD	LCS	LCSD
Methane	*0.0658*	*0.0658*	*0.0721*	91.3	91.3	*0.0*	65-135	35		
Ethylene	0.116	0.115	0.126	92.1	91.3	0.9	65-135	35		
Ethane	0.123	0.123	0.135	91.1	91.1	0.0	65-135	35		

Submission #: 2002-09-0208

PNA analysis by 8270C

Earth Mechanics, Inc.

Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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CA DHS ELAP# 2496

Samples Reported

Sample Name	Date Sampled	Matrix	Lab #
02-11A	09/11/2002 07:00	Water	1

Submission #: 2002-09-0208

PNA analysis by 8270C

Earth Mechanics, Inc.

Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 *Fax:* (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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CA DHS ELAP# 2496

Prep(s): 3510C/8270C
Test(s): 8270C
Sample ID: **02-11A**
Lab ID: 2002-09-0208 - 1
Sampled: 09/11/2002 07:00
Extracted: 9/12/2002 09:02
Matrix: Water
QC Batch#: 2002/09/12-02.11

Compound	Conc.	RL	Unit	Dilution	Analyzed	Flag
Naphthalene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Acenaphthylene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Acenaphthene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Fluorene	ND	5.0	ug/L	1.00	09/13/2002 15:33	
Phenanthrene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Anthracene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Fluoranthene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Pyrene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Benzo(a)anthracene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Chrysene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Benzo(b)fluoranthene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Benzo(k)fluoranthene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Benzo(a)pyrene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Indeno(1,2,3-c,d)pyrene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Dibenzo(a,h)anthracene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Benzo(g,h,i)perylene	ND	2.0	ug/L	1.00	09/13/2002 15:33	
Surrogates(s)						
Nitrobenzene-d5	102.6	35-114	%	1.00	09/13/2002 15:33	
2-Fluorobiphenyl	106.0	43-116	%	1.00	09/13/2002 15:33	
p-Terphenyl-d14	113.2	33-141	%	1.00	09/13/2002 15:33	

Submission #: 2002-09-0208

PNA analysis by 8270C

Earth Mechanics, Inc.
Attn.: Hubert Law
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Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 3510C/8270C
Method Blank

Water

Test(s): 8270C
QC Batch # 2002/09/12-02.11

MB: 2002/09/12-02.11-001

Date Extracted: 09/12/2002 09:02

Compound	Conc.	RL	Unit	Analyzed	Flag
Naphthalene	ND	2.0	ug/L	09/12/2002 13:42	
Acenaphthylene	ND	2.0	ug/L	09/12/2002 13:42	
Acenaphthene	ND	2.0	ug/L	09/12/2002 13:42	
Fluorene	ND	2.0	ug/L	09/12/2002 13:42	
Phenanthrene	ND	2.0	ug/L	09/12/2002 13:42	
Anthracene	ND	2.0	ug/L	09/12/2002 13:42	
Fluoranthene	ND	2.0	ug/L	09/12/2002 13:42	
Pyrene	ND	2.0	ug/L	09/12/2002 13:42	
Benzo(a)anthracene	ND	2.0	ug/L	09/12/2002 13:42	
Chrysene	ND	2.0	ug/L	09/12/2002 13:42	
Benzo(b)fluoranthene	ND	2.0	ug/L	09/12/2002 13:42	
Benzo(k)fluoranthene	ND	2.0	ug/L	09/12/2002 13:42	
Benzo(a)pyrene	ND	2.0	ug/L	09/12/2002 13:42	
Indeno(1,2,3-c,d)pyrene	ND	2.0	ug/L	09/12/2002 13:42	
Dibenzo(a,h)anthracene	ND	2.0	ug/L	09/12/2002 13:42	
Benzo(g,h,i)perylene	ND	2.0	ug/L	09/12/2002 13:42	
Surrogates(s)					
Nitrobenzene-d5	82.6	35-114	%	09/12/2002 13:42	
2-Fluorobiphenyl	73.1	43-116	%	09/12/2002 13:42	
p-Terphenyl-d14	104.9	33-141	%	09/12/2002 13:42	

Submission #: 2002-09-0208

PNA analysis by 8270C

Earth Mechanics, Inc.
Attn.: Hubert Law
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Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 3510C/8270C

Test(s): 8270C

Laboratory Control Spike **Water** **QC Batch # 2002/09/12-02.11**

LCS 2002/09/12-02.11-002 Extracted: 09/12/2002 Analyzed: 09/12/2002 14:11
LCSD 2002/09/12-02.11-003 Extracted: 09/12/2002 Analyzed: 09/12/2002 14:40

Compound	Conc. ug/L		Exp.Conc.	Recovery		RPD	Ctrl.Limits %		Flags	
	LCS	LCSD		LCS	LCSD	%	Rec.	RPD	LCS	LCSD
Acenaphthene	20.1	21.9	30.0	67.0	73.0	8.6	56-118	30		
Pyrene	23.4	22.7	30.0	78.0	75.7	3.0	52-115	35		
Surrogates(s)										
Nitrobenzene-d5	22.5	23.4	25	90.0	93.6		35-114			
2-Fluorobiphenyl	21.4	23.2	25	85.6	92.8		43-116			
p-Terphenyl-d14	25.7	25.6	25	102.8	102.4		33-141			

Submission #: 2002-09-0208

pH

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
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Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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CA DHS ELAP# 2496

Samples Reported

Sample Name	Date Sampled	Matrix	Lab #
02-11A	09/11/2002 07:00	Water	1

Submission #: 2002-09-0208

pH

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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www.chromalab.com

CA DHS ELAP# 2496

Prep(s):	9040B	Test(s):	9040B
Sample ID:	**02-11A**	Lab ID:	2002-09-0208 - 1
Sampled:	09/11/2002 07:00	Extracted:	9/12/2002 10:32
Matrix:	Water	QC Batch#:	2002/09/12-01.22

Compound	Conc.	RL	Unit	Dilution	Analyzed	Flag
pH	7.1	0.0	SU	1.00	09/12/2002 10:32	

Submission #: 2002-09-0208

pH

Earth Mechanics, Inc.
Attn.: Hubert Law
17660 Newhope St., #E
Fountain Valley, Ca 92708
Phone: (714) 751-3826 Fax: (714) 751-3826

Project: 02-134 T.02B
Devil's Slide Tunnels

Received: 09/11/2002 15:18

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www.chromalab.com

CA DHS ELAP# 2496

Batch QC Report

Prep(s): 9045C
Method Blank
MB: 2002/09/12-01.22-001

Soil

Test(s): 9045C
QC Batch # 2002/09/12-01.22
Date Extracted: 09/12/2002 06:45

Compound	Conc.	RL	Unit	Analyzed	Flag
pH	7.02	0.1	SU	09/12/2002 06:45	

APPENDIX F-4

AIR SAMPLE TESTING BY AIR TOXIC

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

Air Toxics Ltd. Introduces the Electronic Report

Thank you for choosing Air Toxics Ltd. To better serve our customers, we are providing your report by e-mail. This document is provided in Portable Document Format which can be viewed with Acrobat Reader by Adobe.

This electronic report includes the following:

- Work order Summary;
- Laboratory Narrative;
- Results; and
- Chain of Custody (copy).

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630

(916) 985-1000 .FAX (916) 985-1020
Hours 8:00 A.M to 6:00 P.M. Pacific
E-mail to:samplereceiving@airtoxics.com

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 0208335A

Work Order Summary

CLIENT:	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708	**BILL TO:**	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708
PHONE:	714-751-3826	**P.O. #**	
FAX:	714-751-3928	**PROJECT #**	02-134 T.O 2B Devil's Slide Tunnels
DATE RECEIVED:	8/16/02	**CONTACT:**	Kelly Buettner
DATE COMPLETED:	8/29/02		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	02-6 air	Modified TO-15	Tedlar Bag
02A	02-8A air	Modified TO-15	Tedlar Bag
03A	02-7 air	Modified TO-15	Tedlar Bag
04A	02-18A air	Modified TO-15	Tedlar Bag
05A	Lab Blank	Modified TO-15	NA
06A	LCS	Modified TO-15	NA

CERTIFIED BY: Linda J. Truman DATE: 08/29/02

Laboratory Director

Certfication numbers: CA NELAP - 02110CA, NY NELAP - 11291, UT NELAP - 9166389892, LA NELAP/LELAP- AI 30763
Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 01/01/02, Expiration date: 06/30/02

Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

This report shall not be reproduced, except in full, without the written approval of Air Toxics Ltd.

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LABORATORY NARRATIVE
Modified TO-15
Earth Mechanics Inc.
Workorder# 0208335A

Four 1 Liter Tedlar Bag samples were received on August 16, 2002. The laboratory performed analysis via modified EPA Method TO-15 using GC/MS in the full scan mode. The method involves concentrating to 0.5 liters of air. The concentrated aliquot is then flash vaporized and swept through a water management system to remove water vapor. Following dehumidification, the sample passes directly into the GC/MS for analysis. See the data sheets for the reporting limits for each compound.

During the five point calibration, two low-level standards are used. The low-level standard for TO-15 compounds is spiked at 0.5 ppbv and represents the reporting limit for these compounds. The low-level standard for the non-TO-15 compounds is spiked at 2.0 ppbv and represents the reporting limit for these compounds. The TO-15 compounds are present in both standards but are excluded from reporting in the 2.0 ppbv standard since a lower level is already included in the curve.

Method modifications taken to run these samples include:

Requirement	*TO-15*	*ATL Modifications*
Sampling/concentrator system	Nafion Drier	Multisorbent concentrator
Blank	Humid Air Blank	Humid Nitrogen Blank for standard analysis. Dry Nitrogen Blank for low level analysis.
BFB acceptance criteria	CLP protocol	SW-846 protocol
Concentration of IS spike	10 ppbv	25 ppbv for TO-14;10 ppbv for low level
Dilutions for initial calibration	Dynamic dilutions or static using canisters	Syringe dilutions
ICAL %RSD acceptance criteria	30% or less, 40% or less for up to two compounds	30% or less for standard compounds, 40% or less for non-standard and polar compounds or = 30% pooled RSD of all compounds
IS recoveries	Within 40% of mean over ICAL for blanks, and w/in 40% of daily CCV for samples.	Within 40% of CCV recoveries for blank and samples.
IS RTs	± 0.33 min from most recent calibration (either ICAL or daily)	± 0.33 min of RT in daily CCV
Daily CCV	70 - 130%	Standard compounds:70 - 130% for at least 90%;Non-standard and polar compounds: 60 - 140% for at least 80%
RF for quantitation	From daily CCV	From ICAL
MSD scan range	35 - 300 amu	35 - 350 amu

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

There were no analytical discrepancies.

Definition of Data Qualifying Flags

Seven qualifiers may have been used on the data analysis sheets and indicates as follows:

B - Compound present in laboratory blank greater than reporting limit (background subtraction not performed).

J - Estimated value.

E - Exceeds instrument calibration range.

S - Saturated Peak.

Q - Exceeds quality control limits.

U - Compound analyzed for but not detected above the reporting limit.

N - The identification is based on presumptive evidence.

File extensions may have been used on the data analysis sheets and indicates as follows:

a-File was requantified

b-File was quantified by a second column and detector

r1-File was requantified for the purpose of reissue

AIR TOXICS LTD.

SAMPLE NAME: 02-6 air

ID#: 0208335A-01A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	t081608	Date of Collection: 8/15/02
Dil. Factor:	1.00	Date of Analysis: 8/16/02

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Freon 12	0.50	2.5	0.54	2.7
Freon 114	0.50	3.6	Not Detected	Not Detected
Chloromethane	0.50	1.0	Not Detected	Not Detected
Vinyl Chloride	0.50	1.3	Not Detected	Not Detected
Bromomethane	0.50	2.0	Not Detected	Not Detected
Chloroethane	0.50	1.3	Not Detected	Not Detected
Freon 11	0.50	2.8	Not Detected	Not Detected
1,1-Dichloroethene	0.50	2.0	Not Detected	Not Detected
Freon 113	0.50	3.9	Not Detected	Not Detected
Methylene Chloride	0.50	1.8	1.4	5.0
1,1-Dichloroethane	0.50	2.0	Not Detected	Not Detected
cis-1,2-Dichloroethene	0.50	2.0	Not Detected	Not Detected
Chloroform	0.50	2.5	Not Detected	Not Detected
1,1,1-Trichloroethane	0.50	2.8	Not Detected	Not Detected
Carbon Tetrachloride	0.50	3.2	Not Detected	Not Detected
Benzene	0.50	1.6	Not Detected	Not Detected
1,2-Dichloroethane	0.50	2.0	Not Detected	Not Detected
Trichloroethene	0.50	2.7	Not Detected	Not Detected
1,2-Dichloropropane	0.50	2.3	Not Detected	Not Detected
cis-1,3-Dichloropropene	0.50	2.3	Not Detected	Not Detected
Toluene	0.50	1.9	6.3	24
trans-1,3-Dichloropropene	0.50	2.3	Not Detected	Not Detected
1,1,2-Trichloroethane	0.50	2.8	Not Detected	Not Detected
Tetrachloroethene	0.50	3.4	Not Detected	Not Detected
1,2-Dibromoethane (EDB)	0.50	3.9	Not Detected	Not Detected
Chlorobenzene	0.50	2.3	Not Detected	Not Detected
Ethyl Benzene	0.50	2.2	0.56	2.5
m,p-Xylene	0.50	2.2	1.3	5.6
o-Xylene	0.50	2.2	Not Detected	Not Detected
Styrene	0.50	2.2	0.92	4.0
1,1,2,2-Tetrachloroethane	0.50	3.5	Not Detected	Not Detected
1,3,5-Trimethylbenzene	0.50	2.5	Not Detected	Not Detected
1,2,4-Trimethylbenzene	0.50	2.5	1.0	5.1
1,3-Dichlorobenzene	0.50	3.0	Not Detected	Not Detected
1,4-Dichlorobenzene	0.50	3.0	Not Detected	Not Detected
alpha-Chlorotoluene	0.50	2.6	Not Detected	Not Detected
1,2-Dichlorobenzene	0.50	3.0	Not Detected	Not Detected
1,2,4-Trichlorobenzene	2.0	15	Not Detected	Not Detected
Hexachlorobutadiene	2.0	22	Not Detected	Not Detected
Propylene	2.0	3.5	Not Detected	Not Detected
1,3-Butadiene	2.0	4.5	Not Detected	Not Detected
Acetone	2.0	4.8	43	100

AIR TOXICS LTD.

SAMPLE NAME: 02-6 air

ID#: 0208335A-01A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081608**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Carbon Disulfide	2.0	6.3	5.0	16
2-Propanol	2.0	5.0	3.0	7.6
trans-1,2-Dichloroethene	2.0	8.0	Not Detected	Not Detected
Vinyl Acetate	2.0	7.2	Not Detected	Not Detected
2-Butanone (Methyl Ethyl Ketone)	2.0	6.0	5.4	16
Hexane	2.0	7.2	2.4	8.6
Tetrahydrofuran	2.0	6.0	Not Detected	Not Detected
Cyclohexane	2.0	7.0	Not Detected	Not Detected
1,4-Dioxane	2.0	7.3	Not Detected	Not Detected
Bromodichloromethane	2.0	14	Not Detected	Not Detected
4-Methyl-2-pentanone	2.0	8.3	Not Detected	Not Detected
2-Hexanone	2.0	8.3	Not Detected	Not Detected
Dibromochloromethane	2.0	17	Not Detected	Not Detected
Bromoform	2.0	21	Not Detected	Not Detected
4-Ethyltoluene	2.0	10	Not Detected	Not Detected
Ethanol	2.0	3.8	5.6	11
Methyl tert-Butyl Ether	2.0	7.3	Not Detected	Not Detected
Heptane	2.0	8.3	Not Detected	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	79	70-130
Toluene-d8	106	70-130
4-Bromofluorobenzene	108	70-130

AIR TOXICS LTD.

SAMPLE NAME: 02-8A air

ID#: 0208335A-02A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081609**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**4.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Freon 12	2.0	10	Not Detected	Not Detected
Freon 114	2.0	14	Not Detected	Not Detected
Chloromethane	2.0	4.2	Not Detected	Not Detected
Vinyl Chloride	2.0	5.2	Not Detected	Not Detected
Bromomethane	2.0	7.9	Not Detected	Not Detected
Chloroethane	2.0	5.4	Not Detected	Not Detected
Freon 11	2.0	11	Not Detected	Not Detected
1,1-Dichloroethene	2.0	8.1	Not Detected	Not Detected
Freon 113	2.0	16	Not Detected	Not Detected
Methylene Chloride	2.0	7.1	2.0 J	7.0 J
1,1-Dichloroethane	2.0	8.2	Not Detected	Not Detected
cis-1,2-Dichloroethene	2.0	8.0	Not Detected	Not Detected
Chloroform	2.0	9.9	6.7	33
1,1,1-Trichloroethane	2.0	11	Not Detected	Not Detected
Carbon Tetrachloride	2.0	13	Not Detected	Not Detected
Benzene	2.0	6.5	Not Detected	Not Detected
1,2-Dichloroethane	2.0	8.2	Not Detected	Not Detected
Trichloroethene	2.0	11	Not Detected	Not Detected
1,2-Dichloropropane	2.0	9.4	Not Detected	Not Detected
cis-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
Toluene	2.0	7.6	4.3	16
trans-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
1,1,2-Trichloroethane	2.0	11	Not Detected	Not Detected
Tetrachloroethene	2.0	14	Not Detected	Not Detected
1,2-Dibromoethane (EDB)	2.0	16	Not Detected	Not Detected
Chlorobenzene	2.0	9.4	Not Detected	Not Detected
Ethyl Benzene	2.0	8.8	Not Detected	Not Detected
m,p-Xylene	2.0	8.8	Not Detected	Not Detected
o-Xylene	2.0	8.8	Not Detected	Not Detected
Styrene	2.0	8.6	Not Detected	Not Detected
1,1,2,2-Tetrachloroethane	2.0	14	Not Detected	Not Detected
1,3,5-Trimethylbenzene	2.0	10	Not Detected	Not Detected
1,2,4-Trimethylbenzene	2.0	10	2.2	11
1,3-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,4-Dichlorobenzene	2.0	12	Not Detected	Not Detected
alpha-Chlorotoluene	2.0	10	Not Detected	Not Detected
1,2-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,2,4-Trichlorobenzene	8.0	60	Not Detected	Not Detected
Hexachlorobutadiene	8.0	87	Not Detected	Not Detected
Propylene	8.0	14	Not Detected	Not Detected
1,3-Butadiene	8.0	18	Not Detected	Not Detected
Acetone	8.0	19	22	52

AIR TOXICS LTD.

SAMPLE NAME: 02-8A air

ID#: 0208335A-02A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081609**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**4.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Carbon Disulfide	8.0	25	Not Detected	Not Detected
2-Propanol	8.0	20	Not Detected	Not Detected
trans-1,2-Dichloroethene	8.0	32	Not Detected	Not Detected
Vinyl Acetate	8.0	29	Not Detected	Not Detected
2-Butanone (Methyl Ethyl Ketone)	8.0	24	Not Detected	Not Detected
Hexane	8.0	29	8.6	31
Tetrahydrofuran	8.0	24	Not Detected	Not Detected
Cyclohexane	8.0	28	Not Detected	Not Detected
1,4-Dioxane	8.0	29	Not Detected	Not Detected
Bromodichloromethane	8.0	54	Not Detected	Not Detected
4-Methyl-2-pentanone	8.0	33	Not Detected	Not Detected
2-Hexanone	8.0	33	Not Detected	Not Detected
Dibromochloromethane	8.0	69	Not Detected	Not Detected
Bromoform	8.0	84	Not Detected	Not Detected
4-Ethyltoluene	8.0	40	Not Detected	Not Detected
Ethanol	8.0	15	Not Detected	Not Detected
Methyl tert-Butyl Ether	8.0	29	Not Detected	Not Detected
Heptane	8.0	33	Not Detected	Not Detected

J = Estimated value.

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	99	70-130
Toluene-d8	90	70-130
4-Bromofluorobenzene	114	70-130

AIR TOXICS LTD.

SAMPLE NAME: 02-7 air

ID#: 0208335A-03A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081610**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**4.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Freon 12	2.0	10	Not Detected	Not Detected
Freon 114	2.0	14	Not Detected	Not Detected
Chloromethane	2.0	4.2	Not Detected	Not Detected
Vinyl Chloride	2.0	5.2	Not Detected	Not Detected
Bromomethane	2.0	7.9	Not Detected	Not Detected
Chloroethane	2.0	5.4	Not Detected	Not Detected
Freon 11	2.0	11	Not Detected	Not Detected
1,1-Dichloroethene	2.0	8.1	Not Detected	Not Detected
Freon 113	2.0	16	Not Detected	Not Detected
Methylene Chloride	2.0	7.1	3.5	12
1,1-Dichloroethane	2.0	8.2	Not Detected	Not Detected
cis-1,2-Dichloroethene	2.0	8.0	Not Detected	Not Detected
Chloroform	2.0	9.9	9.6	47
1,1,1-Trichloroethane	2.0	11	Not Detected	Not Detected
Carbon Tetrachloride	2.0	13	Not Detected	Not Detected
Benzene	2.0	6.5	14	47
1,2-Dichloroethane	2.0	8.2	Not Detected	Not Detected
Trichloroethene	2.0	11	Not Detected	Not Detected
1,2-Dichloropropane	2.0	9.4	Not Detected	Not Detected
cis-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
Toluene	2.0	7.6	18	70
trans-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
1,1,2-Trichloroethane	2.0	11	Not Detected	Not Detected
Tetrachloroethene	2.0	14	Not Detected	Not Detected
1,2-Dibromoethane (EDB)	2.0	16	Not Detected	Not Detected
Chlorobenzene	2.0	9.4	Not Detected	Not Detected
Ethyl Benzene	2.0	8.8	5.5	24
m,p-Xylene	2.0	8.8	6.6	29
o-Xylene	2.0	8.8	4.1	18
Styrene	2.0	8.6	3.4	15
1,1,2,2-Tetrachloroethane	2.0	14	Not Detected	Not Detected
1,3,5-Trimethylbenzene	2.0	10	Not Detected	Not Detected
1,2,4-Trimethylbenzene	2.0	10	3.1	15
1,3-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,4-Dichlorobenzene	2.0	12	Not Detected	Not Detected
alpha-Chlorotoluene	2.0	10	Not Detected	Not Detected
1,2-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,2,4-Trichlorobenzene	8.0	60	Not Detected	Not Detected
Hexachlorobutadiene	8.0	87	Not Detected	Not Detected
Propylene	8.0	14	Not Detected	Not Detected
1,3-Butadiene	8.0	18	46	100
Acetone	8.0	19	1200 E	2800 E

AIR TOXICS LTD.

SAMPLE NAME: 02-7 air

ID#: 0208335A-03A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081610**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**4.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Carbon Disulfide	8.0	25	10	33
2-Propanol	8.0	20	9.5	24
trans-1,2-Dichloroethene	8.0	32	Not Detected	Not Detected
Vinyl Acetate	8.0	29	Not Detected	Not Detected
2-Butanone (Methyl Ethyl Ketone)	8.0	24	100	300
Hexane	8.0	29	42	150
Tetrahydrofuran	8.0	24	Not Detected	Not Detected
Cyclohexane	8.0	28	Not Detected	Not Detected
1,4-Dioxane	8.0	29	Not Detected	Not Detected
Bromodichloromethane	8.0	54	Not Detected	Not Detected
4-Methyl-2-pentanone	8.0	33	Not Detected	Not Detected
2-Hexanone	8.0	33	Not Detected	Not Detected
Dibromochloromethane	8.0	69	Not Detected	Not Detected
Bromoform	8.0	84	Not Detected	Not Detected
4-Ethyltoluene	8.0	40	Not Detected	Not Detected
Ethanol	8.0	15	Not Detected	Not Detected
Methyl tert-Butyl Ether	8.0	29	Not Detected	Not Detected
Heptane	8.0	33	12	48

E = Exceeds instrument calibration range.

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	102	70-130
Toluene-d8	88	70-130
4-Bromofluorobenzene	116	70-130

AIR TOXICS LTD.

SAMPLE NAME: 02-18A air

ID#: 0208335A-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081611**	**Date of Collection:**	**8/15/02**
Dil. Factor:	***4.00***	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Freon 12	2.0	10	Not Detected	Not Detected
Freon 114	2.0	14	Not Detected	Not Detected
Chloromethane	2.0	4.2	Not Detected	Not Detected
Vinyl Chloride	2.0	5.2	Not Detected	Not Detected
Bromomethane	2.0	7.9	Not Detected	Not Detected
Chloroethane	2.0	5.4	Not Detected	Not Detected
Freon 11	2.0	11	Not Detected	Not Detected
1,1-Dichloroethene	2.0	8.1	Not Detected	Not Detected
Freon 113	2.0	16	Not Detected	Not Detected
Methylene Chloride	2.0	7.1	2.1	7.5
1,1-Dichloroethane	2.0	8.2	Not Detected	Not Detected
cis-1,2-Dichloroethene	2.0	8.0	Not Detected	Not Detected
Chloroform	2.0	9.9	Not Detected	Not Detected
1,1,1-Trichloroethane	2.0	11	Not Detected	Not Detected
Carbon Tetrachloride	2.0	13	Not Detected	Not Detected
Benzene	2.0	6.5	Not Detected	Not Detected
1,2-Dichloroethane	2.0	8.2	Not Detected	Not Detected
Trichloroethene	2.0	11	Not Detected	Not Detected
1,2-Dichloropropane	2.0	9.4	Not Detected	Not Detected
cis-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
Toluene	2.0	7.6	4.8	18
trans-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
1,1,2-Trichloroethane	2.0	11	Not Detected	Not Detected
Tetrachloroethene	2.0	14	Not Detected	Not Detected
1,2-Dibromoethane (EDB)	2.0	16	Not Detected	Not Detected
Chlorobenzene	2.0	9.4	Not Detected	Not Detected
Ethyl Benzene	2.0	8.8	Not Detected	Not Detected
m,p-Xylene	2.0	8.8	Not Detected	Not Detected
o-Xylene	2.0	8.8	Not Detected	Not Detected
Styrene	2.0	8.6	Not Detected	Not Detected
1,1,2,2-Tetrachloroethane	2.0	14	Not Detected	Not Detected
1,3,5-Trimethylbenzene	2.0	10	Not Detected	Not Detected
1,2,4-Trimethylbenzene	2.0	10	Not Detected	Not Detected
1,3-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,4-Dichlorobenzene	2.0	12	Not Detected	Not Detected
alpha-Chlorotoluene	2.0	10	Not Detected	Not Detected
1,2-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,2,4-Trichlorobenzene	8.0	60	Not Detected	Not Detected
Hexachlorobutadiene	8.0	87	Not Detected	Not Detected
Propylene	8.0	14	Not Detected	Not Detected
1,3-Butadiene	8.0	18	Not Detected	Not Detected
Acetone	8.0	19	20	48

AIR TOXICS LTD.

SAMPLE NAME: 02-18A air

ID#: 0208335A-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081611**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**4.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Carbon Disulfide	8.0	25	Not Detected	Not Detected
2-Propanol	8.0	20	Not Detected	Not Detected
trans-1,2-Dichloroethene	8.0	32	Not Detected	Not Detected
Vinyl Acetate	8.0	29	Not Detected	Not Detected
2-Butanone (Methyl Ethyl Ketone)	8.0	24	Not Detected	Not Detected
Hexane	8.0	29	Not Detected	Not Detected
Tetrahydrofuran	8.0	24	Not Detected	Not Detected
Cyclohexane	8.0	28	Not Detected	Not Detected
1,4-Dioxane	8.0	29	Not Detected	Not Detected
Bromodichloromethane	8.0	54	Not Detected	Not Detected
4-Methyl-2-pentanone	8.0	33	Not Detected	Not Detected
2-Hexanone	8.0	33	Not Detected	Not Detected
Dibromochloromethane	8.0	69	Not Detected	Not Detected
Bromoform	8.0	84	Not Detected	Not Detected
4-Ethyltoluene	8.0	40	Not Detected	Not Detected
Ethanol	8.0	15	Not Detected	Not Detected
Methyl tert-Butyl Ether	8.0	29	Not Detected	Not Detected
Heptane	8.0	33	Not Detected	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	100	70-130
Toluene-d8	90	70-130
4-Bromofluorobenzene	111	70-130

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 0208335A-05A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081607**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/16/02**	

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Freon 12	0.50	2.5	Not Detected	Not Detected
Freon 114	0.50	3.6	Not Detected	Not Detected
Chloromethane	0.50	1.0	Not Detected	Not Detected
Vinyl Chloride	0.50	1.3	Not Detected	Not Detected
Bromomethane	0.50	2.0	Not Detected	Not Detected
Chloroethane	0.50	1.3	Not Detected	Not Detected
Freon 11	0.50	2.8	Not Detected	Not Detected
1,1-Dichloroethene	0.50	2.0	Not Detected	Not Detected
Freon 113	0.50	3.9	Not Detected	Not Detected
Methylene Chloride	0.50	1.8	Not Detected	Not Detected
1,1-Dichloroethane	0.50	2.0	Not Detected	Not Detected
cis-1,2-Dichloroethene	0.50	2.0	Not Detected	Not Detected
Chloroform	0.50	2.5	Not Detected	Not Detected
1,1,1-Trichloroethane	0.50	2.8	Not Detected	Not Detected
Carbon Tetrachloride	0.50	3.2	Not Detected	Not Detected
Benzene	0.50	1.6	Not Detected	Not Detected
1,2-Dichloroethane	0.50	2.0	Not Detected	Not Detected
Trichloroethene	0.50	2.7	Not Detected	Not Detected
1,2-Dichloropropane	0.50	2.3	Not Detected	Not Detected
cis-1,3-Dichloropropene	0.50	2.3	Not Detected	Not Detected
Toluene	0.50	1.9	Not Detected	Not Detected
trans-1,3-Dichloropropene	0.50	2.3	Not Detected	Not Detected
1,1,2-Trichloroethane	0.50	2.8	Not Detected	Not Detected
Tetrachloroethene	0.50	3.4	Not Detected	Not Detected
1,2-Dibromoethane (EDB)	0.50	3.9	Not Detected	Not Detected
Chlorobenzene	0.50	2.3	Not Detected	Not Detected
Ethyl Benzene	0.50	2.2	Not Detected	Not Detected
m,p-Xylene	0.50	2.2	Not Detected	Not Detected
o-Xylene	0.50	2.2	Not Detected	Not Detected
Styrene	0.50	2.2	Not Detected	Not Detected
1,1,2,2-Tetrachloroethane	0.50	3.5	Not Detected	Not Detected
1,3,5-Trimethylbenzene	0.50	2.5	Not Detected	Not Detected
1,2,4-Trimethylbenzene	0.50	2.5	Not Detected	Not Detected
1,3-Dichlorobenzene	0.50	3.0	Not Detected	Not Detected
1,4-Dichlorobenzene	0.50	3.0	Not Detected	Not Detected
alpha-Chlorotoluene	0.50	2.6	Not Detected	Not Detected
1,2-Dichlorobenzene	0.50	3.0	Not Detected	Not Detected
1,2,4-Trichlorobenzene	2.0	15	Not Detected	Not Detected
Hexachlorobutadiene	2.0	22	Not Detected	Not Detected
Propylene	2.0	3.5	Not Detected	Not Detected
1,3-Butadiene	2.0	4.5	Not Detected	Not Detected
Acetone	2.0	4.8	Not Detected	Not Detected

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 0208335A-05A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081607**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/16/02**	

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Carbon Disulfide	2.0	6.3	Not Detected	Not Detected
2-Propanol	2.0	5.0	Not Detected	Not Detected
trans-1,2-Dichloroethene	2.0	8.0	Not Detected	Not Detected
Vinyl Acetate	2.0	7.2	Not Detected	Not Detected
2-Butanone (Methyl Ethyl Ketone)	2.0	6.0	Not Detected	Not Detected
Hexane	2.0	7.2	Not Detected	Not Detected
Tetrahydrofuran	2.0	6.0	Not Detected	Not Detected
Cyclohexane	2.0	7.0	Not Detected	Not Detected
1,4-Dioxane	2.0	7.3	Not Detected	Not Detected
Bromodichloromethane	2.0	14	Not Detected	Not Detected
4-Methyl-2-pentanone	2.0	8.3	Not Detected	Not Detected
2-Hexanone	2.0	8.3	Not Detected	Not Detected
Dibromochloromethane	2.0	17	Not Detected	Not Detected
Bromoform	2.0	21	Not Detected	Not Detected
4-Ethyltoluene	2.0	10	Not Detected	Not Detected
Ethanol	2.0	3.8	Not Detected	Not Detected
Methyl tert-Butyl Ether	2.0	7.3	Not Detected	Not Detected
Heptane	2.0	8.3	Not Detected	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	81	70-130
Toluene-d8	105	70-130
4-Bromofluorobenzene	82	70-130

AIR TOXICS LTD.

SAMPLE NAME: LCS

ID#: 0208335A-06A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**t081606**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/16/02**	

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	%Recovery
Freon 12	0.50	2.5	107
Freon 114	0.50	3.6	105
Chloromethane	0.50	1.0	101
Vinyl Chloride	0.50	1.3	100
Bromomethane	0.50	2.0	103
Chloroethane	0.50	1.3	96
Freon 11	0.50	2.8	91
1,1-Dichloroethene	0.50	2.0	92
Freon 113	0.50	3.9	95
Methylene Chloride	0.50	1.8	86
1,1-Dichloroethane	0.50	2.0	81
cis-1,2-Dichloroethene	0.50	2.0	96
Chloroform	0.50	2.5	88
1,1,1-Trichloroethane	0.50	2.8	83
Carbon Tetrachloride	0.50	3.2	98
Benzene	0.50	1.6	96
1,2-Dichloroethane	0.50	2.0	85
Trichloroethene	0.50	2.7	88
1,2-Dichloropropane	0.50	2.3	74
cis-1,3-Dichloropropene	0.50	2.3	79
Toluene	0.50	1.9	96
trans-1,3-Dichloropropene	0.50	2.3	79
1,1,2-Trichloroethane	0.50	2.8	82
Tetrachloroethene	0.50	3.4	90
1,2-Dibromoethane (EDB)	0.50	3.9	61 Q
Chlorobenzene	0.50	2.3	90
Ethyl Benzene	0.50	2.2	96
m,p-Xylene	0.50	2.2	97
o-Xylene	0.50	2.2	84
Styrene	0.50	2.2	92
1,1,2,2-Tetrachloroethane	0.50	3.5	77
1,3,5-Trimethylbenzene	0.50	2.5	81
1,2,4-Trimethylbenzene	0.50	2.5	76
1,3-Dichlorobenzene	0.50	3.0	95
1,4-Dichlorobenzene	0.50	3.0	90
alpha-Chlorotoluene	0.50	2.6	85
1,2-Dichlorobenzene	0.50	3.0	96
1,2,4-Trichlorobenzene	2.0	15	88
Hexachlorobutadiene	2.0	22	93
Propylene	2.0	3.5	93
1,3-Butadiene	2.0	4.5	92
Acetone	2.0	4.8	100

AIR TOXICS LTD.

SAMPLE NAME: LCS

ID#: 0208335A-06A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	t081606	Date of Collection: NA	
Dil. Factor:	1.00	Date of Analysis: 8/16/02	

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	%Recovery
Carbon Disulfide	2.0	6.3	88
2-Propanol	2.0	5.0	88
trans-1,2-Dichloroethene	2.0	8.0	100
Vinyl Acetate	2.0	7.2	68
2-Butanone (Methyl Ethyl Ketone)	2.0	6.0	85
Hexane	2.0	7.2	97
Tetrahydrofuran	2.0	6.0	86
Cyclohexane	2.0	7.0	93
1,4-Dioxane	2.0	7.3	84
Bromodichloromethane	2.0	14	87
4-Methyl-2-pentanone	2.0	8.3	85
2-Hexanone	2.0	8.3	85
Dibromochloromethane	2.0	17	91
Bromoform	2.0	21	94
4-Ethyltoluene	2.0	10	93
Ethanol	2.0	3.8	92
Methyl tert-Butyl Ether	2.0	7.3	89
Heptane	2.0	8.3	89

Q = Exceeds Quality Control limits.

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	100	70-130
Toluene-d8	102	70-130
4-Bromofluorobenzene	102	70-130

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- Work order Summary;
- Laboratory Narrative;
- Results; and
- Chain of Custody (copy).

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WORK ORDER #: 0208335C

Work Order Summary

CLIENT:	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708	**BILL TO:**	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708
PHONE:	714-751-3826	**P.O. #**	
FAX:	714-751-3928	**PROJECT #**	02-134 T.O 2B Devil's Slide Tunnels
DATE RECEIVED:	8/16/02	**CONTACT:**	Kelly Buettner
DATE COMPLETED:	8/28/02		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	02-6 air	Modified ASTM D-5504	Tedlar Bag
02A	02-8A air	Modified ASTM D-5504	Tedlar Bag
03A	02-7 air	Modified ASTM D-5504	Tedlar Bag
04A	02-18A air	Modified ASTM D-5504	Tedlar Bag
05A	Lab Blank	Modified ASTM D-5504	NA
06A	LCS	Modified ASTM D-5504	NA

CERTIFIED BY: Sondra L. Truman

Laboratory Director

DATE: 08/29/02

Certfication numbers: CA NELAP - 02110CA, NY NELAP - 11291, UT NELAP - 9166389892, LA NELAP/LELAP- AI 30763
Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 01/01/02, Expiration date: 06/30/02

Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

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LABORATORY NARRATIVE
Modified ASTM D-5504
Earth Mechanics Inc.
Workorder# 0208335C

Four 1 Liter Tedlar Bag samples were received on August 16, 2002. The laboratory performed the analysis of sulfur compounds via Modified ASTM D-5504 using GC/SCD. The method involves direct injection of the air sample into the GC via a fixed 1.0 mL sampling loop. See the data sheets for the reporting limits for each compound.

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

There were no analytical discrepancies.

Definition of Data Qualifying Flags

Seven qualifiers may have been used on the data analysis sheets and indicate as follows:
B - Compound present in laboratory blank greater than reporting limit.
J - Estimated value.
E - Exceeds instrument calibration range.
S - Saturated peak.
Q - Exceeds quality control limits.
U - Compound analyzed for but not detected above the detection limit.
M - Reported value may be biased due to apparent matrix interferences.
File extensions may have been used on the data analysis sheets and indicates as follows:
a-File was requantified
b-File was quantified by a second column and detector
r1-File was requantified for the purpose of reissue

AIR TOXICS LTD.

SAMPLE NAME: 02-6 air

ID#: 0208335C-01A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b081616**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Hydrogen Sulfide	4.0	Not Detected

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-8A air

ID#: 0208335C-02A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b081617**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Hydrogen Sulfide	4.0	Not Detected

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-7 air

ID#: 0208335C-03A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b081618**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Hydrogen Sulfide	4.0	Not Detected

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-18A air

ID#: 0208335C-04A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b081619**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Hydrogen Sulfide	4.0	Not Detected

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 0208335C-05A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b081604**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/16/02**	

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Hydrogen Sulfide	4.0	Not Detected

Container Type: NA - Not Applicable

AIR TOXICS LTD.

SAMPLE NAME: LCS

ID#: 0208335C-06A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b081603**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/16/02**	

Compound	Rpt. Limit (ppbv)	%Recovery
Hydrogen Sulfide	4.0	89

Container Type: NA - Not Applicable

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- Results; and
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WORK ORDER #: 0208335B

Work Order Summary

CLIENT:	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708	**BILL TO:**	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708
PHONE:	714-751-3826	**P.O. #**	
FAX:	714-751-3928	**PROJECT #**	02-134 T.O 2B Devil's Slide Tunnels
DATE RECEIVED:	8/16/02	**CONTACT:**	Kelly Buettner
DATE COMPLETED:	8/30/02		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	02-6 air	Modified ASTM D-1946	Tedlar Bag
02A	02-8A air	Modified ASTM D-1946	Tedlar Bag
03A	02-7 air	Modified ASTM D-1946	Tedlar Bag
03AA	02-7 air Duplicate	Modified ASTM D-1946	Tedlar Bag
04A	02-18A air	Modified ASTM D-1946	Tedlar Bag
05A	Lab Blank	Modified ASTM D-1946	NA
06A	LCS	Modified ASTM D-1946	NA

CERTIFIED BY: Linda D. Truman DATE: 08/30/02

Laboratory Director

Certfication numbers: CA NELAP - 02110CA, NY NELAP - 11291, UT NELAP - 9166389892, LA NELAP/LELAP- AI 30763
Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 01/01/02, Expiration date: 06/30/02

Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

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LABORATORY NARRATIVE
Modified ASTM D-1946
Earth Mechanics Inc.
Workorder# 0208335B

Four 1 Liter Tedlar Bag samples were received on August 16, 2002. The laboratory performed analysis via Modified ASTM Method D-1946 for Methane in air using GC/FID. The method involves direct injection of up to 1.0 mL of sample. With the exception of analyses conducted in accordance with AFCEE 3.0, all reported compound quantifications were calculated from response factors derived from the first Continuing Calibration Verification of each relevant analytical batch. See the data sheets for the reporting limit for Methane.

Requirement	*ASTM D-1946*	*ATL Modifications*
Quantification based on average response factor in the Initial Calibration.	NELAC Standard 5.9.4.2.1(c)	With the exception of samples analyzed under AFCEE 3.0 protocol, all quantification based on the response factor derived from the first Continuing Calibration Verification of each relevant analytical batch.

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

There were no analytical discrepancies.

Definition of Data Qualifying Flags

Seven qualifiers may have been used on the data analysis sheets and indicate as follows:
B - Compound present in laboratory blank greater than reporting limit.
J - Estimated value.
E - Exceeds instrument calibration range.
S - Saturated peak.
Q - Exceeds quality control limits.
U - Compound analyzed for but not detected above the detection limit.
M - Reported value may be biased due to apparent matrix interferences.
File extensions may have been used on the data analysis sheets and indicates as follows:
a-File was requantified
b-File was quantified by a second column and detector
r1-File was requantified for the purpose of reissue

AIR TOXICS LTD.

SAMPLE NAME: 02-6 air

ID#: 0208335B-01A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3081616**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	0.00022

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-8A air

ID#: 0208335B-02A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3081617**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	0.0023

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-7 air

ID#: 0208335B-03A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3081618**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	0.0018

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-7 air Duplicate

ID#: 0208335B-03AA

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3081620**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	0.0018

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-18A air

ID#: 0208335B-04A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3081619**	**Date of Collection:**	**8/15/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	0.00026

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 0208335B-05A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3081615**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 8/16/02**	

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	Not Detected

Container Type: NA - Not Applicable

AIR TOXICS LTD.

SAMPLE NAME: LCS

ID#: 0208335B-06A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3081614**	**Date of Collection:**	**NA**
Dil. Factor:	**1.00**	**Date of Analysis:**	**8/16/02**

Compound	Rpt. Limit (%)	%Recovery
Methane	0.00010	102

Container Type: NA - Not Applicable

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Contact Person RAJ or R.J
Company Earth Mechanics Inc.
Address 17660 Newhope st, Ste. E City Fountain Valley State CA Zip 92708
Phone 714-751-3826 FAX 714-751-3928
(714-478-5660 cell)
Collected By: Signature Hamtheng

Project Info:
P.O. #
Project # 02-134 T.O 2B
Project Name Devil's Slide Tunnels

Turn Around Time:
☑ Normal
☐ Rush ____ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
	02-6 air	08/15/02 11:00Pm	T.O 15, ASTM 1946 (methane only), ASTM D5504 (hydrogen sulfide only)			
	02-8A air	08/15/02	T.015, ASTM 1946 methane only, ASTM D5504 (H2S only)			
	02-7 air	08/15/02	same as above "			
	02-18A air	08/15/02	same as above.			

Relinquished By: (Signature) Date/Time: Hamtheng 08/15/02 (9:30Pm)
Received By: (Signature) Date/Time:
Relinquished By: (Signature) Date/Time:
Received By: (Signature) Date/Time:
Relinquished By: (Signature) Date/Time:
Received By: (Signature) Date/Time:

Notes:

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Temp. (°C)	Condition	Custody Seals Intact? Yes No None	Work Order #

Form 1293 rev. 03

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WORK ORDER #: 0210028A

Work Order Summary

CLIENT:	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708	**BILL TO:**	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708
PHONE:	714-751-3826	**P.O. #**	
FAX:	714-751-3928	**PROJECT #**	02-134 TO2B Devil's Slide Tunnels
DATE RECEIVED:	10/2/02	**CONTACT:**	Kelly Buettner
DATE COMPLETED:	10/9/02		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	02-5 Air	Modified TO-15	Tedlar Bag
02A	02-2 Air	Modified TO-15	Tedlar Bag
03A	Lab Blank	Modified TO-15	NA
04A	LCS	Modified TO-15	NA

CERTIFIED BY: Linda J. Truman DATE: 10/14/02

Laboratory Director

Certfication numbers: CA NELAP - 02110CA, NY NELAP - 11291, UT NELAP - 9166389892, LA NELAP/LELAP- AI 30763
Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 07/01/02, Expiration date: 06/30/03

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LABORATORY NARRATIVE
Modified TO-15
Earth Mechanics Inc.
Workorder# 0210028A

Two 1 Liter Tedlar Bag samples were received on October 02, 2002. The laboratory performed analysis via modified EPA Method TO-15 using GC/MS in the full scan mode. The method involves concentrating to 0.5 liters of air. The concentrated aliquot is then flash vaporized and swept through a water management system to remove water vapor. Following dehumidification, the sample passes directly into the GC/MS for analysis. See the data sheets for the reporting limits for each compound.

During the five point calibration, two low-level standards are used. The low-level standard for TO-15 compounds is spiked at 0.5 ppbv and represents the reporting limit for these compounds. The low-level standard for the non-TO-15 compounds is spiked at 2.0 ppbv and represents the reporting limit for these compounds. The TO-15 compounds are present in both standards but are excluded from reporting in the 2.0 ppbv standard since a lower level is already included in the curve.

Method modifications taken to run these samples include:

Requirement	*TO-15*	*ATL Modifications*
Sampling/concentrator system	Nafion Drier	Multisorbent concentrator
Blank	Humid Air Blank	Humid Nitrogen Blank for standard analysis. Dry Nitrogen Blank for low level analysis.
BFB acceptance criteria	CLP protocol	SW-846 protocol
Concentration of IS spike	10 ppbv	25 ppbv for TO-14;10 ppbv for low level
Dilutions for initial calibration	Dynamic dilutions or static using canisters	Syringe dilutions
ICAL %RSD acceptance criteria	30% or less, 40% or less for up to two compounds	30% or less for standard compounds, 40% or less for non-standard and polar compounds or = 30% pooled RSD of all compounds
IS recoveries	Within 40% of mean over ICAL for blanks, and w/in 40% of daily CCV for samples.	Within 40% of CCV recoveries for blank and samples.
IS RTs	± 0.33 min from most recent calibration (either ICAL or daily)	± 0.33 min of RT in daily CCV
Daily CCV	70 - 130%	Standard compounds:70 - 130% for at least 90%;Non-standard and polar compounds: 60 - 140% for at least 80%
RF for quantitation	From daily CCV	From ICAL
MSD scan range	35 - 300 amu	35 - 350 amu

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

There were no analytical discrepancies.

Definition of Data Qualifying Flags

Seven qualifiers may have been used on the data analysis sheets and indicates as follows:

B - Compound present in laboratory blank greater than reporting limit (background subtraction not performed).

J - Estimated value.

E - Exceeds instrument calibration range.

S - Saturated Peak.

Q - Exceeds quality control limits.

U - Compound analyzed for but not detected above the reporting limit.

N - The identification is based on presumptive evidence.

File extensions may have been used on the data analysis sheets and indicates as follows:

a-File was requantified

b-File was quantified by a second column and detector

r1-File was requantified for the purpose of reissue

AIR TOXICS LTD.

SAMPLE NAME: 02-5 Air

ID#: 0210028A-01A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**r100421**	**Date of Collection:**	**10/1/02**
Dil. Factor:	**4.00**	**Date of Analysis:**	**10/4/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Freon 12	2.0	10	Not Detected	Not Detected
Freon 114	2.0	14	Not Detected	Not Detected
Chloromethane	2.0	4.2	Not Detected	Not Detected
Vinyl Chloride	2.0	5.2	Not Detected	Not Detected
Bromomethane	2.0	7.9	Not Detected	Not Detected
Chloroethane	2.0	5.4	Not Detected	Not Detected
Freon 11	2.0	11	Not Detected	Not Detected
1,1-Dichloroethene	2.0	8.1	Not Detected	Not Detected
Freon 113	2.0	16	Not Detected	Not Detected
Methylene Chloride	2.0	7.1	Not Detected	Not Detected
1,1-Dichloroethane	2.0	8.2	Not Detected	Not Detected
cis-1,2-Dichloroethene	2.0	8.0	Not Detected	Not Detected
Chloroform	2.0	9.9	Not Detected	Not Detected
1,1,1-Trichloroethane	2.0	11	Not Detected	Not Detected
Carbon Tetrachloride	2.0	13	Not Detected	Not Detected
Benzene	2.0	6.5	6.1	20
1,2-Dichloroethane	2.0	8.2	Not Detected	Not Detected
Trichloroethene	2.0	11	Not Detected	Not Detected
1,2-Dichloropropane	2.0	9.4	Not Detected	Not Detected
cis-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
Toluene	2.0	7.6	5.9	23
trans-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
1,1,2-Trichloroethane	2.0	11	Not Detected	Not Detected
Tetrachloroethene	2.0	14	Not Detected	Not Detected
1,2-Dibromoethane (EDB)	2.0	16	Not Detected	Not Detected
Chlorobenzene	2.0	9.4	Not Detected	Not Detected
Ethyl Benzene	2.0	8.8	Not Detected	Not Detected
m,p-Xylene	2.0	8.8	Not Detected	Not Detected
o-Xylene	2.0	8.8	Not Detected	Not Detected
Styrene	2.0	8.6	Not Detected	Not Detected
1,1,2,2-Tetrachloroethane	2.0	14	Not Detected	Not Detected
1,3,5-Trimethylbenzene	2.0	10	Not Detected	Not Detected
1,2,4-Trimethylbenzene	2.0	10	Not Detected	Not Detected
1,3-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,4-Dichlorobenzene	2.0	12	Not Detected	Not Detected
alpha-Chlorotoluene	2.0	10	Not Detected	Not Detected
1,2-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,2,4-Trichlorobenzene	8.0	60	Not Detected	Not Detected
Hexachlorobutadiene	8.0	87	Not Detected	Not Detected
Propylene	8.0	14	Not Detected	Not Detected
1,3-Butadiene	8.0	18	Not Detected	Not Detected
Acetone	8.0	19	19	45

AIR TOXICS LTD.

SAMPLE NAME: 02-5 Air

ID#: 0210028A-01A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**r100421**	**Date of Collection:**	**10/1/02**
Dil. Factor:	**4.00**	**Date of Analysis:**	**10/4/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Carbon Disulfide	8.0	25	Not Detected	Not Detected
2-Propanol	8.0	20	Not Detected	Not Detected
trans-1,2-Dichloroethene	8.0	32	Not Detected	Not Detected
Vinyl Acetate	8.0	29	Not Detected	Not Detected
2-Butanone (Methyl Ethyl Ketone)	8.0	24	Not Detected	Not Detected
Hexane	8.0	29	16	59
Tetrahydrofuran	8.0	24	Not Detected	Not Detected
Cyclohexane	8.0	28	Not Detected	Not Detected
1,4-Dioxane	8.0	29	Not Detected	Not Detected
Bromodichloromethane	8.0	54	Not Detected	Not Detected
4-Methyl-2-pentanone	8.0	33	Not Detected	Not Detected
2-Hexanone	8.0	33	Not Detected	Not Detected
Dibromochloromethane	8.0	69	Not Detected	Not Detected
Bromoform	8.0	84	Not Detected	Not Detected
4-Ethyltoluene	8.0	40	Not Detected	Not Detected
Ethanol	8.0	15	20	38
Methyl tert-Butyl Ether	8.0	29	Not Detected	Not Detected
Heptane	8.0	33	Not Detected	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	110	70-130
Toluene-d8	105	70-130
4-Bromofluorobenzene	108	70-130

AIR TOXICS LTD.

SAMPLE NAME: 02-2 Air

ID#: 0210028A-02A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**r100422**	**Date of Collection:**	**10/1/02**
Dil. Factor:	**4.00**	**Date of Analysis:**	**10/4/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Freon 12	2.0	10	Not Detected	Not Detected
Freon 114	2.0	14	Not Detected	Not Detected
Chloromethane	2.0	4.2	Not Detected	Not Detected
Vinyl Chloride	2.0	5.2	Not Detected	Not Detected
Bromomethane	2.0	7.9	Not Detected	Not Detected
Chloroethane	2.0	5.4	Not Detected	Not Detected
Freon 11	2.0	11	Not Detected	Not Detected
1,1-Dichloroethene	2.0	8.1	Not Detected	Not Detected
Freon 113	2.0	16	Not Detected	Not Detected
Methylene Chloride	2.0	7.1	Not Detected	Not Detected
1,1-Dichloroethane	2.0	8.2	Not Detected	Not Detected
cis-1,2-Dichloroethene	2.0	8.0	Not Detected	Not Detected
Chloroform	2.0	9.9	6.7	33
1,1,1-Trichloroethane	2.0	11	Not Detected	Not Detected
Carbon Tetrachloride	2.0	13	Not Detected	Not Detected
Benzene	2.0	6.5	14	44
1,2-Dichloroethane	2.0	8.2	Not Detected	Not Detected
Trichloroethene	2.0	11	Not Detected	Not Detected
1,2-Dichloropropane	2.0	9.4	Not Detected	Not Detected
cis-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
Toluene	2.0	7.6	9.4	36
trans-1,3-Dichloropropene	2.0	9.2	Not Detected	Not Detected
1,1,2-Trichloroethane	2.0	11	Not Detected	Not Detected
Tetrachloroethene	2.0	14	Not Detected	Not Detected
1,2-Dibromoethane (EDB)	2.0	16	Not Detected	Not Detected
Chlorobenzene	2.0	9.4	Not Detected	Not Detected
Ethyl Benzene	2.0	8.8	Not Detected	Not Detected
m,p-Xylene	2.0	8.8	Not Detected	Not Detected
o-Xylene	2.0	8.8	Not Detected	Not Detected
Styrene	2.0	8.6	Not Detected	Not Detected
1,1,2,2-Tetrachloroethane	2.0	14	Not Detected	Not Detected
1,3,5-Trimethylbenzene	2.0	10	Not Detected	Not Detected
1,2,4-Trimethylbenzene	2.0	10	Not Detected	Not Detected
1,3-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,4-Dichlorobenzene	2.0	12	Not Detected	Not Detected
alpha-Chlorotoluene	2.0	10	Not Detected	Not Detected
1,2-Dichlorobenzene	2.0	12	Not Detected	Not Detected
1,2,4-Trichlorobenzene	8.0	60	Not Detected	Not Detected
Hexachlorobutadiene	8.0	87	Not Detected	Not Detected
Propylene	8.0	14	Not Detected	Not Detected
1,3-Butadiene	8.0	18	Not Detected	Not Detected
Acetone	8.0	19	3600 E	8700 E

AIR TOXICS LTD.

SAMPLE NAME: 02-2 Air

ID#: 0210028A-02A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**r100422**	**Date of Collection:**	**10/1/02**
Dil. Factor:	**4.00**	**Date of Analysis:**	**10/4/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Carbon Disulfide	8.0	25	Not Detected	Not Detected
2-Propanol	8.0	20	Not Detected	Not Detected
trans-1,2-Dichloroethene	8.0	32	Not Detected	Not Detected
Vinyl Acetate	8.0	29	Not Detected	Not Detected
2-Butanone (Methyl Ethyl Ketone)	8.0	24	Not Detected	Not Detected
Hexane	8.0	29	50	180
Tetrahydrofuran	8.0	24	Not Detected	Not Detected
Cyclohexane	8.0	28	12	43
1,4-Dioxane	8.0	29	Not Detected	Not Detected
Bromodichloromethane	8.0	54	Not Detected	Not Detected
4-Methyl-2-pentanone	8.0	33	Not Detected	Not Detected
2-Hexanone	8.0	33	Not Detected	Not Detected
Dibromochloromethane	8.0	69	Not Detected	Not Detected
Bromoform	8.0	84	Not Detected	Not Detected
4-Ethyltoluene	8.0	40	Not Detected	Not Detected
Ethanol	8.0	15	Not Detected	Not Detected
Methyl tert-Butyl Ether	8.0	29	Not Detected	Not Detected
Heptane	8.0	33	19	80

E = Exceeds instrument calibration range.

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	105	70-130
Toluene-d8	105	70-130
4-Bromofluorobenzene	107	70-130

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 0210028A-03A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	r100408	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 10/4/02

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Freon 12	0.50	2.5	Not Detected	Not Detected
Freon 114	0.50	3.6	Not Detected	Not Detected
Chloromethane	0.50	1.0	Not Detected	Not Detected
Vinyl Chloride	0.50	1.3	Not Detected	Not Detected
Bromomethane	0.50	2.0	Not Detected	Not Detected
Chloroethane	0.50	1.3	Not Detected	Not Detected
Freon 11	0.50	2.8	Not Detected	Not Detected
1,1-Dichloroethene	0.50	2.0	Not Detected	Not Detected
Freon 113	0.50	3.9	Not Detected	Not Detected
Methylene Chloride	0.50	1.8	Not Detected	Not Detected
1,1-Dichloroethane	0.50	2.0	Not Detected	Not Detected
cis-1,2-Dichloroethene	0.50	2.0	Not Detected	Not Detected
Chloroform	0.50	2.5	Not Detected	Not Detected
1,1,1-Trichloroethane	0.50	2.8	Not Detected	Not Detected
Carbon Tetrachloride	0.50	3.2	Not Detected	Not Detected
Benzene	0.50	1.6	Not Detected	Not Detected
1,2-Dichloroethane	0.50	2.0	Not Detected	Not Detected
Trichloroethene	0.50	2.7	Not Detected	Not Detected
1,2-Dichloropropane	0.50	2.3	Not Detected	Not Detected
cis-1,3-Dichloropropene	0.50	2.3	Not Detected	Not Detected
Toluene	0.50	1.9	Not Detected	Not Detected
trans-1,3-Dichloropropene	0.50	2.3	Not Detected	Not Detected
1,1,2-Trichloroethane	0.50	2.8	Not Detected	Not Detected
Tetrachloroethene	0.50	3.4	Not Detected	Not Detected
1,2-Dibromoethane (EDB)	0.50	3.9	Not Detected	Not Detected
Chlorobenzene	0.50	2.3	Not Detected	Not Detected
Ethyl Benzene	0.50	2.2	Not Detected	Not Detected
m,p-Xylene	0.50	2.2	Not Detected	Not Detected
o-Xylene	0.50	2.2	Not Detected	Not Detected
Styrene	0.50	2.2	Not Detected	Not Detected
1,1,2,2-Tetrachloroethane	0.50	3.5	Not Detected	Not Detected
1,3,5-Trimethylbenzene	0.50	2.5	Not Detected	Not Detected
1,2,4-Trimethylbenzene	0.50	2.5	Not Detected	Not Detected
1,3-Dichlorobenzene	0.50	3.0	Not Detected	Not Detected
1,4-Dichlorobenzene	0.50	3.0	Not Detected	Not Detected
alpha-Chlorotoluene	0.50	2.6	Not Detected	Not Detected
1,2-Dichlorobenzene	0.50	3.0	Not Detected	Not Detected
1,2,4-Trichlorobenzene	2.0	15	Not Detected	Not Detected
Hexachlorobutadiene	2.0	22	Not Detected	Not Detected
Propylene	2.0	3.5	Not Detected	Not Detected
1,3-Butadiene	2.0	4.5	Not Detected	Not Detected
Acetone	2.0	4.8	Not Detected	Not Detected

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 0210028A-03A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	***r100408***	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 10/4/02**	

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	Amount (ppbv)	Amount (uG/m3)
Carbon Disulfide	2.0	6.3	Not Detected	Not Detected
2-Propanol	2.0	5.0	Not Detected	Not Detected
trans-1,2-Dichloroethene	2.0	8.0	Not Detected	Not Detected
Vinyl Acetate	2.0	7.2	Not Detected	Not Detected
2-Butanone (Methyl Ethyl Ketone)	2.0	6.0	Not Detected	Not Detected
Hexane	2.0	7.2	Not Detected	Not Detected
Tetrahydrofuran	2.0	6.0	Not Detected	Not Detected
Cyclohexane	2.0	7.0	Not Detected	Not Detected
1,4-Dioxane	2.0	7.3	Not Detected	Not Detected
Bromodichloromethane	2.0	14	Not Detected	Not Detected
4-Methyl-2-pentanone	2.0	8.3	Not Detected	Not Detected
2-Hexanone	2.0	8.3	Not Detected	Not Detected
Dibromochloromethane	2.0	17	Not Detected	Not Detected
Bromoform	2.0	21	Not Detected	Not Detected
4-Ethyltoluene	2.0	10	Not Detected	Not Detected
Ethanol	2.0	3.8	Not Detected	Not Detected
Methyl tert-Butyl Ether	2.0	7.3	Not Detected	Not Detected
Heptane	2.0	8.3	Not Detected	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	105	70-130
Toluene-d8	103	70-130
4-Bromofluorobenzene	108	70-130

AIR TOXICS LTD.

SAMPLE NAME: LCS

ID#: 0210028A-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**r100407**		**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 10/4/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	%Recovery
Freon 12	0.50	2.5	103
Freon 114	0.50	3.6	102
Chloromethane	0.50	1.0	99
Vinyl Chloride	0.50	1.3	100
Bromomethane	0.50	2.0	100
Chloroethane	0.50	1.3	97
Freon 11	0.50	2.8	97
1,1-Dichloroethene	0.50	2.0	90
Freon 113	0.50	3.9	90
Methylene Chloride	0.50	1.8	83
1,1-Dichloroethane	0.50	2.0	88
cis-1,2-Dichloroethene	0.50	2.0	97
Chloroform	0.50	2.5	91
1,1,1-Trichloroethane	0.50	2.8	91
Carbon Tetrachloride	0.50	3.2	99
Benzene	0.50	1.6	98
1,2-Dichloroethane	0.50	2.0	97
Trichloroethene	0.50	2.7	90
1,2-Dichloropropane	0.50	2.3	92
cis-1,3-Dichloropropene	0.50	2.3	85
Toluene	0.50	1.9	98
trans-1,3-Dichloropropene	0.50	2.3	84
1,1,2-Trichloroethane	0.50	2.8	89
Tetrachloroethene	0.50	3.4	93
1,2-Dibromoethane (EDB)	0.50	3.9	80
Chlorobenzene	0.50	2.3	90
Ethyl Benzene	0.50	2.2	97
m,p-Xylene	0.50	2.2	93
o-Xylene	0.50	2.2	92
Styrene	0.50	2.2	90
1,1,2,2-Tetrachloroethane	0.50	3.5	86
1,3,5-Trimethylbenzene	0.50	2.5	86
1,2,4-Trimethylbenzene	0.50	2.5	79
1,3-Dichlorobenzene	0.50	3.0	84
1,4-Dichlorobenzene	0.50	3.0	79
alpha-Chlorotoluene	0.50	2.6	80
1,2-Dichlorobenzene	0.50	3.0	82
1,2,4-Trichlorobenzene	2.0	15	82
Hexachlorobutadiene	2.0	22	86
Propylene	2.0	3.5	96
1,3-Butadiene	2.0	4.5	103
Acetone	2.0	4.8	126

AIR TOXICS LTD.

SAMPLE NAME: LCS

ID#: 0210028A-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**r100407**		**Date of Collection: NA**
Dil. Factor:	**1.00**		**Date of Analysis: 10/4/02**

Compound	Rpt. Limit (ppbv)	Rpt. Limit (uG/m3)	%Recovery
Carbon Disulfide	2.0	6.3	114
2-Propanol	2.0	5.0	122
trans-1,2-Dichloroethene	2.0	8.0	118
Vinyl Acetate	2.0	7.2	113
2-Butanone (Methyl Ethyl Ketone)	2.0	6.0	102
Hexane	2.0	7.2	105
Tetrahydrofuran	2.0	6.0	106
Cyclohexane	2.0	7.0	99
1,4-Dioxane	2.0	7.3	106
Bromodichloromethane	2.0	14	107
4-Methyl-2-pentanone	2.0	8.3	103
2-Hexanone	2.0	8.3	98
Dibromochloromethane	2.0	17	96
Bromoform	2.0	21	93
4-Ethyltoluene	2.0	10	118
Ethanol	2.0	3.8	107
Methyl tert-Butyl Ether	2.0	7.3	99
Heptane	2.0	8.3	110

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	105	70-130
Toluene-d8	102	70-130
4-Bromofluorobenzene	101	70-130

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

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Thank you for choosing Air Toxics Ltd. To better serve our customers, we are providing your report by e-mail. This document is provided in Portable Document Format which can be viewed with Acrobat Reader by Adobe.

This electronic report includes the following:

- Work order Summary;
- Laboratory Narrative;
- Results; and
- Chain of Custody (copy).

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Hours 8:00 A.M to 6:00 P.M. Pacific
E-mail to:samplereceiving@airtoxics.com

@ **AIR TOXICS LTD.**

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 0210028B

Work Order Summary

CLIENT:	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708	**BILL TO:**	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708
PHONE:	714-751-3826	**P.O. #**	
FAX:	714-751-3928	**PROJECT #**	02-134 TO2B Devil's Slide Tunnels
DATE RECEIVED:	10/2/02	**CONTACT:**	Kelly Buettner
DATE COMPLETED:	10/11/02		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	02-5 Air	Modified ASTM D-5504	Tedlar Bag
02A	02-2 Air	Modified ASTM D-5504	Tedlar Bag
03A	Lab Blank	Modified ASTM D-5504	NA
04A	LCS	Modified ASTM D-5504	NA

CERTIFIED BY: Linda J. Fruman DATE: 10/14/02

Laboratory Director

Certfication numbers: CA NELAP - 02110CA, NY NELAP - 11291, UT NELAP - 9166389892, LA NELAP/LELAP- AI 30763
Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 07/01/02, Expiration date: 06/30/03

Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

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LABORATORY NARRATIVE
Modified ASTM D-5504
Earth Mechanics Inc.
Workorder# 0210028B

Two 1 Liter Tedlar Bag samples were received on October 02, 2002. The laboratory performed the analysis of sulfur compounds via Modified ASTM D-5504 using GC/SCD. The method involves direct injection of the air sample into the GC via a fixed 1.0 mL sampling loop. See the data sheets for the reporting limits for each compound.

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

The acceptance criteria for the calibration curve were met on 10/02/2002. An end check was analyzed to verify the stability of the analytical system after sample analysis. The results for this end check were <70% of the known spiked concentration (57%). This indicates a slight potential low bias for sample results analyzed on 10/02/2002.

Definition of Data Qualifying Flags

Seven qualifiers may have been used on the data analysis sheets and indicate as follows:
B - Compound present in laboratory blank greater than reporting limit.
J - Estimated value.
E - Exceeds instrument calibration range.
S - Saturated peak.
Q - Exceeds quality control limits.
U - Compound analyzed for but not detected above the detection limit.
M - Reported value may be biased due to apparent matrix interferences.
File extensions may have been used on the data analysis sheets and indicates as follows:
a-File was requantified
b-File was quantified by a second column and detector
r1-File was requantified for the purpose of reissue

AIR TOXICS LTD.

SAMPLE NAME: 02-5 Air

ID#: 0210028B-01A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b100208**	**Date of Collection:**	**10/1/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**10/2/02**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Hydrogen Sulfide	4.0	Not Detected

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-2 Air

ID#: 0210028B-02A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b100209**	**Date of Collection:**	**10/1/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**10/2/02**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Hydrogen Sulfide	4.0	Not Detected

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 0210028B-03A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b100204**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 10/2/02**	

Compound	Rpt. Limit (ppbv)	Amount (ppbv)
Hydrogen Sulfide	4.0	Not Detected

Container Type: NA - Not Applicable

AIR TOXICS LTD.

SAMPLE NAME: LCS

ID#: 0210028B-04A

SULFUR GASES BY MODIFIED ASTM D-5504 GC/SCD

File Name:	**b100203**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 10/2/02**	

Compound	Rpt. Limit (ppbv)	%Recovery
Hydrogen Sulfide	4.0	101

Container Type: NA - Not Applicable

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- Work order Summary;
- Laboratory Narrative;
- Results; and
- Chain of Custody (copy).

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WORK ORDER #: 0210028C

Work Order Summary

CLIENT:	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708	**BILL TO:**	Mr. Raj Varatharaj Earth Mechanics Inc. 17660 Newhope Street Suite E Fountain Valley, CA 92708
PHONE:	714-751-3826	**P.O. #**	
FAX:	714-751-3928	**PROJECT #**	02-134 TO2B Devil's Slide Tunnels
DATE RECEIVED:	10/2/02	**CONTACT:**	Kelly Buettner
DATE COMPLETED:	10/16/02		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.
01A	02-5 Air	Modified ASTM D-1946	Tedlar Bag
01AA	02-5 Air Duplicate	Modified ASTM D-1946	Tedlar Bag
02A	02-2 Air	Modified ASTM D-1946	Tedlar Bag
03A	Lab Blank	Modified ASTM D-1946	NA
04A	LCS	Modified ASTM D-1946	NA

CERTIFIED BY: Linda D. Truman DATE: 10/16/02

Laboratory Director

Certfication numbers: CA NELAP - 02110CA, NY NELAP - 11291, UT NELAP - 9166389892, LA NELAP/LELAP- AI 30763
Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 07/01/02, Expiration date: 06/30/03

Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

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LABORATORY NARRATIVE
Modified ASTM D-1946
Earth Mechanics Inc.
Workorder# 0210028C

Two 1 Liter Tedlar Bag samples were received on October 02, 2002. The laboratory performed analysis via Modified ASTM Method D-1946 for Methane in air using GC/FID. The method involves direct injection of up to 1.0 mL of sample. With the exception of analyses conducted in accordance with AFCEE 3.0, all reported compound quantifications were calculated from response factors derived from the first Continuing Calibration Verification of each relevant analytical batch. See the data sheets for the reporting limits for Methane.

Requirement	*ASTM D-1946*	*ATL Modifications*
Quantification based on average response factor in the Initial Calibration.	NELAC Standard 5.9.4.2.1(c)	With the exception of samples analyzed under AFCEE 3.0 protocol, all quantification based on the response factor derived from the first Continuing Calibration Verification of each relevant analytical batch.

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

There were no analytical discrepancies.

Definition of Data Qualifying Flags

Seven qualifiers may have been used on the data analysis sheets and indicate as follows:
B - Compound present in laboratory blank greater than reporting limit.
J - Estimated value.
E - Exceeds instrument calibration range.
S - Saturated peak.
Q - Exceeds quality control limits.
U - Compound analyzed for but not detected above the detection limit.
M - Reported value may be biased due to apparent matrix interferences.
File extensions may have been used on the data analysis sheets and indicates as follows:
a-File was requantified
b-File was quantified by a second column and detector
r1-File was requantified for the purpose of reissue

AIR TOXICS LTD.

SAMPLE NAME: 02-5 Air

ID#: 0210028C-01A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3100310**	**Date of Collection:**	**10/1/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**10/3/02**

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	0.0019

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-5 Air Duplicate

ID#: 0210028C-01AA

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3100311**	**Date of Collection:**	**10/1/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**10/3/02**

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	0.0018

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: 02-2 Air

ID#: 0210028C-02A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3100312**	**Date of Collection:**	**10/1/02**
Dil. Factor:	**1.00**	**Date of Analysis:**	**10/3/02**

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	0.039

Container Type: 1 Liter Tedlar Bag

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 0210028C-03A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3100304**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 10/3/02**	

Compound	Rpt. Limit (%)	Amount (%)
Methane	0.00010	Not Detected

Container Type: NA - Not Applicable

AIR TOXICS LTD.

SAMPLE NAME: LCS

ID#: 0210028C-04A

NATURAL GAS ANALYSIS BY MODIFIED ASTM D-1946

File Name:	**3100302**	**Date of Collection:**	**NA**
Dil. Factor:	**1.00**	**Date of Analysis:**	**10/3/02**

Compound	Rpt. Limit (%)	%Recovery
Methane	0.00010	94

Container Type: NA - Not Applicable

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Contract Person: RJS / Hubert Law
Company: Earth Mechanics Inc.
Address: 6875 Newport St, Ste E City: Fountain Valley State: CA Zip: 92708
Phone: 714-751-3226 (714-478-8660) FAX: 714-751-3228
Collected By: (Signature)

Project Info:
P.O. #:
Project #: 02-13A T.O. 28
Project Name: Devil's Slide Tunnels.

Turn Around Time:
☒ Normal
☐ Rush ___ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum: Initial	Final	Receipt
01A	02-5 air	10/1/02 4:00pm	T.O.15, ASTM 1946 (oxygen only), ASTM D5504 (hydrogen sulfide only)			
02A	02-2 air	10/1/02 3:00pm	Same as above.			
~~02-28 air~~		~~10/1/02~~				

Relinquished By (Signature) Date/Time: 10/1/02 6:00pm
Received By (Signature) Date/Time: 10/2/02 ATC 810
Relinquished By (Signature) Date/Time:
Received By (Signature) Date/Time:
Relinquished By (Signature) Date/Time:
Received By (Signature) Date/Time:

Notes:

Lab Use Only

Shipper Name	Air Bill #	Opened By	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
Fed Ex Overnight	679180014	TB	-	Good	Yes / No / None	0210028A

Geo GTU Test Unlimited

Test Equipment Design & Fabrication
Laboratory & Field Testing
Consulting Services

Dr. Anders Bro

February 10, 2003

Cerchar Testing
Devil's Slide Tunnels

Mike Kapuskar
Earth Mechanics, Inc.
17660 Newhope St., Suite E
Fountain Valley, CA 92708

Dear Mr. Kapuskar;

On February 6-7, 25 Cerchar abrasion tests were performed by GTU. The procedure used for these tests is appended to this short summary of test results along with copies of the raw data sheets. The samples for these tests were selected to be adjacent to those sections of core for which unconfined and triaxial tests have already been performed. In a few cases the abrasion tests were performed on remnants of the compression tests. A summary of the samples and the abrasion test results are presented in the following table:

Boring	Depth (ft.)	Rock Type	Cerchar Index
02-2	196.0-196.5	Medium gray coarse grained altered granodiorite.	4.5
02-2A	277.0-277.3	Greenish gray altered granodiorite.	4.7 (pp1&np1)
02-2B	249.0-249.5	Medium gray altered granodiorite.	4.6 (pp1&np1)
02-5	229.7-230.2	Dark gray clayey siltstone.	0.7
	475.0-475.5	Medium gray conglomerate with hard clasts up to 1 inch.	4.0(pp3&np1)
	611.0-611.4	Dark gray clayey siltstone.	0.1
	683.6-684.0	Light greenish gray altered granodiorite.	4.5(pp1&np1)
	700.5-701.3	Light greenish gray altered granodiorite.	1.8
02-6	335.5-336.0	Medium gray conglomerate with clasts up to 1/4 inch.	4.3(pp4)
	355.1-355.5	Medium gray sheared and recemented fine-grained sandstone.	2.4
	355.8-356.2	Medium gray sheared and recemented fine-grained sandstone.	4.0
	404.3-404.8	Medium gray medium grained sandstone.	4.4 (np3)
	438.5-439.3	Medium gray medium grained sandstone.	4.5(pp1&np1)
	447.0-448.0	Medium gray medium grained sandstone.	4.5(pp1&np3)

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02-6A	433.0-433.5	Medium gray medium grained sandstone.	4.5(pp1)
	606.5-607.2	Medium gray medium grained sandstone.	3.8(np5)
	830.0-830.5	Dark gray fine grained sandstone with several calcite healed fractures.	3.9 (np1)
02-7	315.5-315.75	Medium gray medium grained sandstone.	4.4(pp4&np1)
02-11	181.0-181.5	Dark gray clayey siltstone.	1.3
	247.5-248.2	Dark gray clayey siltstone with a few lighter gray undulating zones of harder siltstone.	1.4
	274.0-274.6	Dark gray thinly bedded clayey siltstone.	0.9
02-11A	295.0-295.4	Dark gray clayey siltstone.	0.9
	565.0-565.5	Dark gray clayey siltstone.	1.7
02-21	417.0-417.3	Greenish gray fine grained altered granodiorite.	4.0
	442.0-442.8	Light greenish gray sheared and relithified granodiorite.	4.1(pp2)

Notes: pp - some of the test pins partially penetrated the rock surface.
np - some of the test pins did not penetrate the rock surface.
The digits after the designation np or pp indicate the number of tests which exhibited this behavior.

This summary table demonstrates that the weaker rock, such as the clayey siltstone exhibited very little pin wear. Although the pin penetrated the rock quite deeply, the rock hardly wore the pin at all. On the other hand, the granodiorite and the sandstone wore the pins significantly and the pins generally penetrated the rock by only small amounts. Often the pins did not penetrate the rock at all, skating over the sawn surface. The conglomerate and the granodiorite were characterized by having hard clasts or crystals in a weaker matrix. Often the pins would ride up and over the hard clasts and then penetrate the matrix.

GeoTest Unlimited

Dr. Anders Bro

Geo Test Unlimited

Cerchar Abrasion Test[1]
(a non-ASTM or ISRM procedure)

Test Equipment

Rock core samples are cut to a 5 cm length using an MK brand brick saw with continuous rim diamond blade. These flat surfaces provide the flat surface that is to be tested.

The Cerchar device (fabricated by GTU) consists of a translating stage on which is mounted a vise for clamping the sample. A parallelepiped pair of arms is located above the vise in such a manner that the axis of the Cerchar pin is positioned perpendicular to the sawn sample surface and yet allows free movement of the pin in the vertical direction. A steel dead-weight provides the axial load (of 7 kg) which presses the point of the pin against the rock surface. The translating stage is displaced relative to the pin with a screw advance mechanism, and a pair of adjustable stops limits the travel of the displacement stage to one cm.

The abrasion of the pin tips is measured with an inverted microscope in which the tip of the sample is viewed on end. This 100x magnification microscope is used to view the tip and a cross-hair reticule is used as a reference for measuring the width of the abraded tip. The pin is mounted to a translating stage which can then be moved sideways by the advancement of a digital micrometer head.

The 12.5 mm diameter pins are fabricated of 4340 steel which has been heat treated to a Rockwell C 41.9. (It is difficult to get an accurate heat treating to exactly RC 40.) The ends of the pins are ground with a conical point with an apex angle of 90 degrees. The conical points are ground with a surface grinder and the side of a fine abrasive wheel. A spin-fixture is used to hold the pin and rotate it about its axis as it is being ground. Water is used during the grinding process to ensure that the pin temper is maintained.

Test Procedure

The Cerchar pins are first all ground so that the conical ends are smooth surfaced conical tips that come to a sharp point. Care needs to be taken to ensure that no flat surfaces develop on the conical surface of the tip. Five pins need to be ground for each test sample.

The samples are then sawn to an appropriate length. For the apparatus used at GTU, an approximate length of two inches is suitable. No special care is required for this operation. In fact some have suggested that unsawn fracture surfaces be used for the rock surface. Only sawn surfaces are used at GTU. This sample preparation removes the possible variability in the test results due to surface texture.

A sample is then clamped into the vise with the flat surface oriented in a horizontal plane. The translating stage is moved against one stop, and a pin is inserted into the device. The position of the pin is adjusted and clamped so that the arms of the parallelepiped are oriented horizontally. This positioning ensures that the shear reaction force vector will not contribute to the vertical force. The dead-weight is then placed on top of the pin. In one single stroke, the sample is then translated under the pin for a displacement of one cm. This displacement takes approximately 10 seconds. The weight and pin are removed, the sample is repositioned to present an unabraded surface to a new pin, a new pin is installed, the weight is reapplied and the procedure is repeated. A total of 5 abrasion tests are performed on each sample.

In most cases a small burr forms on the downstream edge of the pins. This burr is carefully lapped off using a very fine abrasive stone. The conical surface of the pin is positioned against the stone, abrading away the burr while rotating the pin, using the conical surface as a reference edge.

The pin is inserted into the holder on the microscope. The reticule is aligned with one edge of the wear flat. The micrometer is zeroed and then the pin is translated sideways until the other edge of the wear flat is aligned with the reticule. The width of the wear flat is then recorded in units of tenths of millimeters. The wear is measured both parallel to and perpendicular to the orientation of the wear scratches. These ten values are then averaged together to result in the Cerchar Abrasion index.

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Discussion of Test Procedures and Apparatus

The Cerchar system design presented by West essentially consists of a pin that passes through a fixed plate and positioned using a "holder". The sample is then translated underneath the pin using a dead-weight to apply the vertical load. The possible shortcoming with this design is that the friction between the pin and the holder might significantly modify the force between the pin and the sample. Since the tip of the pin is being pushed sideways by the rock sample, a moment develops which must be reacted by the holder. Therefore if the pin tends to ride up or down, shear forces would add or subtract a component of vertical force to that of the dead-weight. This action would probably tend to generally increase the tip wear and result in higher than expected abrasion values.

The metal from which GTU's pins are fabricated is not the same as that used in France or England. The problem is that there are no standard metal equivalents between these countries. The English standard, as used by West was EN24 hardened to a Rockwell 40C. On a new Norton Fine India Oilstone, FB24, this metal results in a Cerchar index of 2.04 to 2.11.

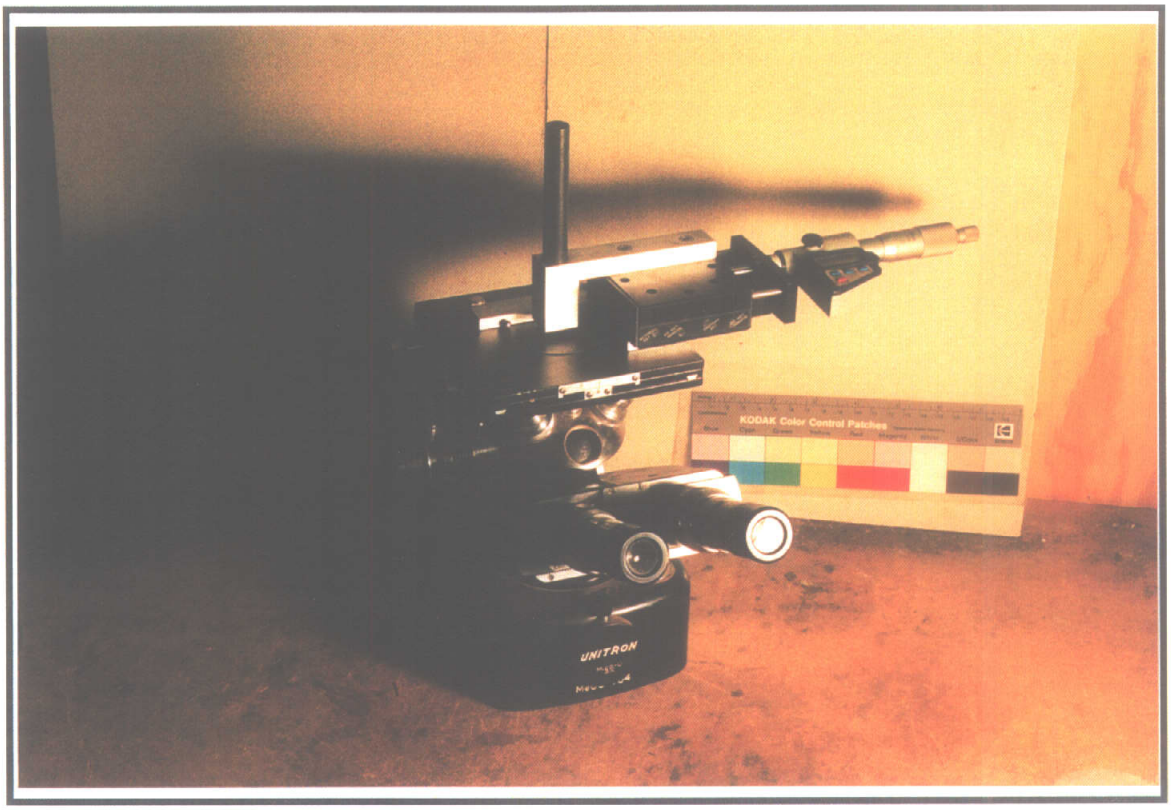
One of the American steels which crosses to the English EN24 is a 4340 steel. As it turns out, the Colorado School of Mines uses this steel in their Cerchar apparatus. They harden their pins to a Rockwell 40C. During the development of GTU's Cerchar device, a set of pins was made with 4340 steel hardened to a Rockwell 40C. When used on the reference Norton Fine India Oilstone FB24, these pins resulted in a Cerchar abrasiveness of 2.1 and 2.2. These values were sufficiently similar to West's results to use this steel and hardness for GTU's standard test configuration.

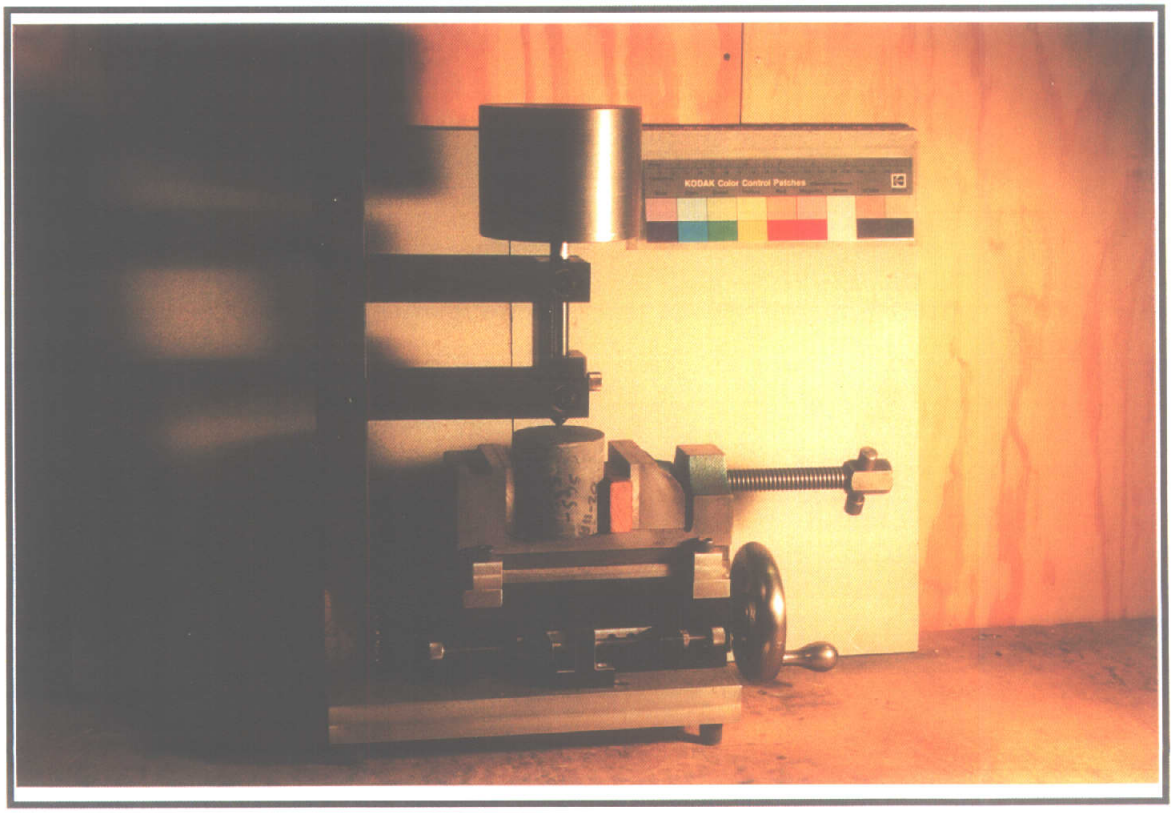
West reports abrasiveness to two decimal places (ie 0.001mm). This precision is not appropriate for any of the measurements taken at GTU. The abrasion surfaces are rough and uneven resulting in uneven edges. Since the edges between the conical surface and the wear surface are not clearly defined, it is hard to justify such precision. Furthermore, for each direction, the width of the wear flat can differ by more than 0.02 mm. Thus GTU does not report the width of the wear flat to any greater precision than 0.01 mm. (or one decimal place in terms of Cerchar index).

It should be noted that there are essentially three modes of wear. One is considered to be invalid, in which the pin skates over the surface of the rock, and does not penetrate the rock. The wear surface of the steel in these cases is quite regular, with very fine abrasions to the steel, resulting in an even circular wear spot on the end of the tip. West considers this wear mode to be invalid, as there is not a proper rock/point interaction. In this case, a fine line of steel particles is deposited on the rock surface.

A valid test, as suggested by West, consists of the point penetrating the rock, creating a groove during the test. There are two steel wear mechanisms for these sorts of interactions. The most common wear mechanism is one in which the rock abrades the steel leaving fine to coarse scratch marks on a flat wear surface. The other mechanism is expressed by small chunks of steel being torn off the steel substrate in an irregular manner, leaving behind a stippled pattern, characteristic of tensile failure. In either type of wear, the wear can occur on the side of the point if the point is imbedded in the rock. These scratch marks which are elevated up the sides of the conical tip make it difficult to accurately estimate the width of the wear flat.

1. West, G., Rock Abrasiveness Testing for Tunnelling. *Int. J. Rock Mech. Min. Sci. & Geomech. Abstr.* Vol. 26, No. 2, pp 151-160, 1989.





CERCHAR TEST DEVICE

Geo Test Unlimited

DATA SHEET
Cerchar Abrasion Index

Client: EMI
Job: #151-Devils Slide

Date: 2/6&7/03
Technician: A.Bro

	Sample ID	Depth (ft.)	Sample Description	Point Hardness (RC)	Wear Width (x0.1mm)		Cerchar Index	
B02-5	5-229	229.7-230.2	Dark gray siltstone (clayey?)	41.9	0.9	0.8	0.7	
					0.6	0.7		
					0.6	1.0		
					0.2	0.4		
					0.6	0.7		
B02-5	5-475	475-475.5	med. gray conglomerate with hard clasts to 1" ø. clasts are quite hard - no penetration	41.9	3.5	3.6	4.0	nope
					3.9	4.0	- part. pen	
					4.4	4.5	- part. pen.	
				(4.2)	2.7-5.7	4.6	- part. pen	
					3.6	4.1		
B02-5	5-611	611-611.4	Dark gray siltstone (clayey?)	41.9	0	0	0.1	
					0	0		
					0	0		
					0.1	0.2		
					0.3	0.5		
B02-5	5-683	683.6-684	Light greenish gray altered granodiorite	41.9	4.3	4.0	4.5	
					3.5	3.7		
					4.4	4.4		
					4.8	4.8	- part. pen.	
					5.2	5.5	- no pen.	
B02-5	5-700	700.5-701.3	Light greenish gray altered granodiorite	41.9	1.4	1.3	1.8	
					1.5	1.4		
					2.3	2.0		
					1.7	1.6		
					2.7	2.4		

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DATA SHEET
Cerchar Abrasion Index

Client: EMI
Job: #151-Devils Slide

Date: 2/7/03
Technician: A. Bro

	Sample ID	Depth (ft.)	Sample Description	Point Hardness (RC)	Wear Width (x0.1mm)		Cerchar Index	
B02-6	6-335	335.5-336	Med. gray conglomerate with clasts to 1/4"	41.9	5.0	5.0	4.3	
					4.3	4.1		- part. pen.
					4.0	3.9		
					4.3	4.1		
					4.0	4.1		
B02-6	6-355	355.1-355.5	med. gray sheared and recemented Fine grained sandstone.	41.9	2.3	2.2	2.4	
					2.2	2.5		
					2.8	3.3		
					2.3	2.6		
					1.6	1.8		
B02-6	6-355B	355.8-356.2	med gray sheared and recemented Fine grained sandstone.	41.9	3.1	3.2	4.0	
					4.6	4.0		
					3.9	4.2		
					4.3	3.9		
					4.2	4.2		
B02-6	6-404	404.3-404.8	med. gray medium grained sandstone.	41.9	4.4	4.3	4.4	
					4.4	4.5		- no pen.
					5.2	4.5		
					4.2	4.1		- no pen.
					4.6	4.1		
B02-6	6-438	438.5-439.3	med. gray medium grained sandstone	41.9	4.0	4.5	4.5	
					4.8	4.7		- partial pen.
					4.3	4.6		- no pen.
					4.7	4.4		
					4.4	4.3		

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Geo Test Unlimited

DATA SHEET
Cerchar Abrasion Index

Client: EMI
Job: #151 - Devils Slide

Date: 2/7/03
Technician: A. Bird

	Sample ID	Depth (ft.)	Sample Description	Point Hardness (RC)	Wear Width (x0.1mm)		Cerchar Index
B02-6	6-447	447-448'	Med. gray medium grained sandstone.	41.9	4.8	4.5	4.5
					4.5	4.2	no pen
					4.2	4.3	no pen
					4.6	4.6	part. pen
					4.5	4.6	no pen
B02-6A	6A-433	433-433.5	Med. gray medium grain sandstone.	41.9	5.0	5.3	4.5
					4.4	4.3	part pen
					4.4	4.6	
					4.0	4.1	
					4.5	4.3	
B02-6A	6A-606	606.5-607.2	Med. gray medium grain sandstone.	41.9	3.6	3.6	3.8
					3.7	3.8	no pen.
					3.8	3.8	
					3.8	3.6	
					4.2	4.0	
B02-6A	6A-830	830-830.5	Dark gray Fine grained sandstone with several calcite healed Fractures.	41.9	3.8	3.9	3.9
					3.7	3.9	
					4.0	4.0	
					4.1	3.9	no pen.
					4.3	3.8	
B02-7	7-315	315.5-315.75	Med. gray medium grain sandstone	41.9	3.8	3.8	4.4
					4.7	4.6	no pen.
					4.4	4.8	part. pen
					4.6	4.4	
					4.2	4.4	

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Geo Test Unlimited

DATA SHEET
Cerchar Abrasion Index

Client: EMI
Job: #151 - Devil's Slide

Date: 2/6/03
Technician: A.Bro

	Sample ID	Depth (ft.)	Sample Description	Point Hardness (RC)	Wear Width (x0.1mm)		Cerchar Index
B02-11	11-181	181-181.5'	Dark gray clayey siltstone	41.9	1.4	1.3	1.3
					1.4	1.4	
					1.3	1.2	
					1.6	1.5	
					0.5	0.9	
B02-11	11-247	247.5-248.2	Dark grey clayey siltstone with a few lighter gray swirls of siltstone (harder than dark gray)	41.9	1.1	1.2	1.4
					1.7	1.8	
					2.0	1.9	
					1.1	1.1	
					0.6	1.1	
B02-11	11-274	274-274.6	Dark gray clayey thinly bedded siltstone	41.9	0.9	0.9	0.9
					1.1	1.8	
					0.4	0.4	
					0.7	1.0	
					0.7	0.8	
B02-11A	11A-295	295.0-295.4	Dark gray clayey siltstone	41.9	0.7	0.5	0.9
					0.8	1.0	
					1.4	1.6	
					0.7	0.8	
					0.7	1.0	
B02-11A	11A-565	565-565.5	Dark gray clayey siltstone	41.9	1.6	1.8	1.7
					1.7	1.9	
					1.6	1.6	
					1.8	1.7	
					1.3	1.7	

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Geo Test Unlimited

DATA SHEET
Cerchar Abrasion Index

Client: EMI
Job: #151-Devil's Slide

Date: 2/6/02
Technician: A.Bro

	Sample ID	Depth (ft.)	Sample Description	Point Hardness (RC)	Wear Width (x0.1mm)		Cerchar Index	
B02-2	2-196	196-196.5'	coarse grained altered granodiorite med. gray	41.9	4.7	4.5	4.5	
					4.4	4.0		
					4.7	4.8		
					4.2	4.9		
					4.6	4.7		
B02-2A	2A-277	277-277.3	Greenish gray altered granodiorite	41.9	4.7	5.2	4.7	
					4.4	4.2		- invalid - no pen.
			No penetration in Feldspars -		4.2	4.2		
					3.8	4.0		- partial pen.
					5.0	4.4		
B02-2B	2B-249	249-249.5	medium gray altered granodiorite	41.9	4.7	5.5	4.6	
					4.3	4.6		
					4.5	4.5		- no pen.
					4.5	4.1		
					4.6	4.5		- partial pen.
B02-21	21-417	417-417.3	greenish gray fine grained altered granodiorite	41.9	2.9	3.1	4.0	
					1.8	1.9		
					5.3	5.0		
					4.5	5.5		
					4.7	5.5		
B02-21	21-442	442-442.8	light greenish gray sheared & schistified granodiorite.	41.9	5.3	4.5	4.1	
					4.6	4.6		- part. pen
					3.1(?)	2.5		
					3.3	3.4		
					4.7	4.5		- part. pen.

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