# Paleontology Report

State of California

Business, Transportation and Housing Agency

# Memorandum

To: Cheryl Sinopoli
Environmental Planning-District 12

Date: November 8, 2006

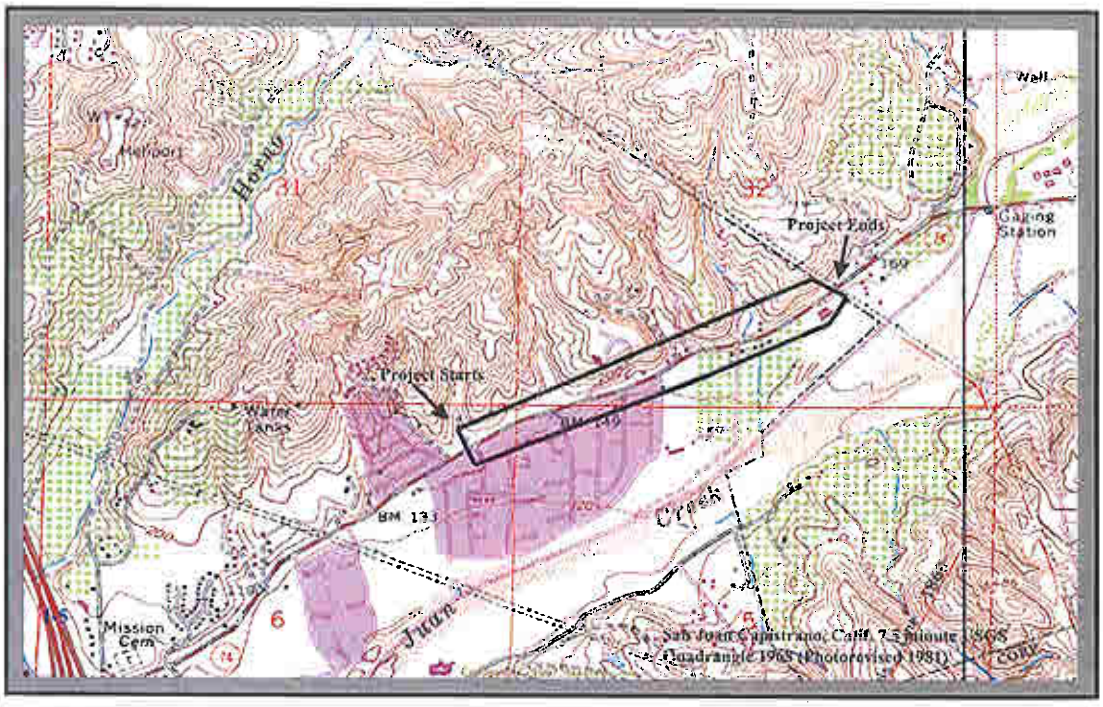
File No.: Or-74—KP 1.6/3.0
(PM 1.0/1.9)
Widen Highway
12-086900

From: **DEPARTMENT OF TRANSPORTATION/District 5**
Central Coast Technical Studies Branch
Environmental Engineering Section
Wayne W. Mills

Subject: **PALEONTOLOGY REPORT**

## Introduction

This is the paleontology report for a proposed project that would widen Highway 74 northeast of the City of San Juan Capistrano in Orange County. The highway would be widened from 2 to 4 lanes between just west of Calle Entradero and the City of San Juan Capistrano/County of Orange boundary. The project would widen the existing two-lane highway to 4-lanes with a 3.6-meter (11.8-foot) wide, striped median.




**Project Location**

District 12
EA 086900
PM 1.0/1.9 KP 1.6/3.0

**Figure 1—Portion of the San Juan Capistrano and Canada Gobernadora Quadrangles**

## Regulatory Setting

Paleontology is the study of life from past geologic ages. The current geologic age is called the Holocene, and it began about 10,000 years ago. Archaeology is the recovery and study of evidence of man from past (historic) ages. Several laws regulate impacts to both archaeological and paleontological resources. Some of these regulations are:

-**The Antiquities Act of 1906**- requires permission for collecting 'objects of antiquity" on public lands.

-**The National Environmental Policy Act (NEPA)** requires protection of environmental resources when a project is built on public lands.

-**The California Environmental Quality Act (CEQA)** requires selection of the most feasible alignment with the least potential for damaging the environment.

-**Public Resource Code 5097.5** requires permission from the regulating agency to "excavate upon, remove, destroy, injure or deface…" paleontological or archaeological remains on public land. Section 5097 also makes provisions for a site survey by State Parks and Recreation Department if it is suspected that there are fossils on a proposed project.

Fossils (especially vertebrate fossils) recovered in situ by qualified paleontologists are our only source of important information about the history and changing environments of the land we now inhabit.

## Affected Environment

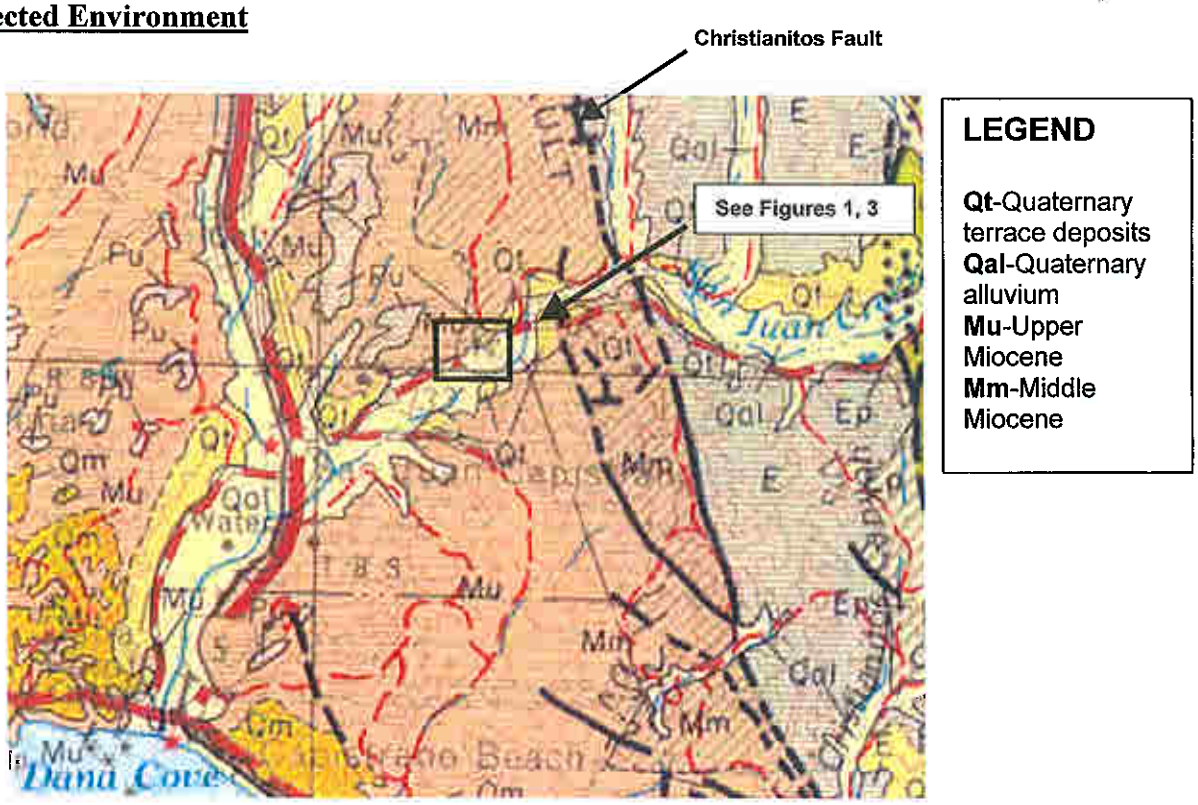



**Figure 2—Portion of the Geologic Map of California—Santa Ana Sheet Showing the Project Geologic Setting**

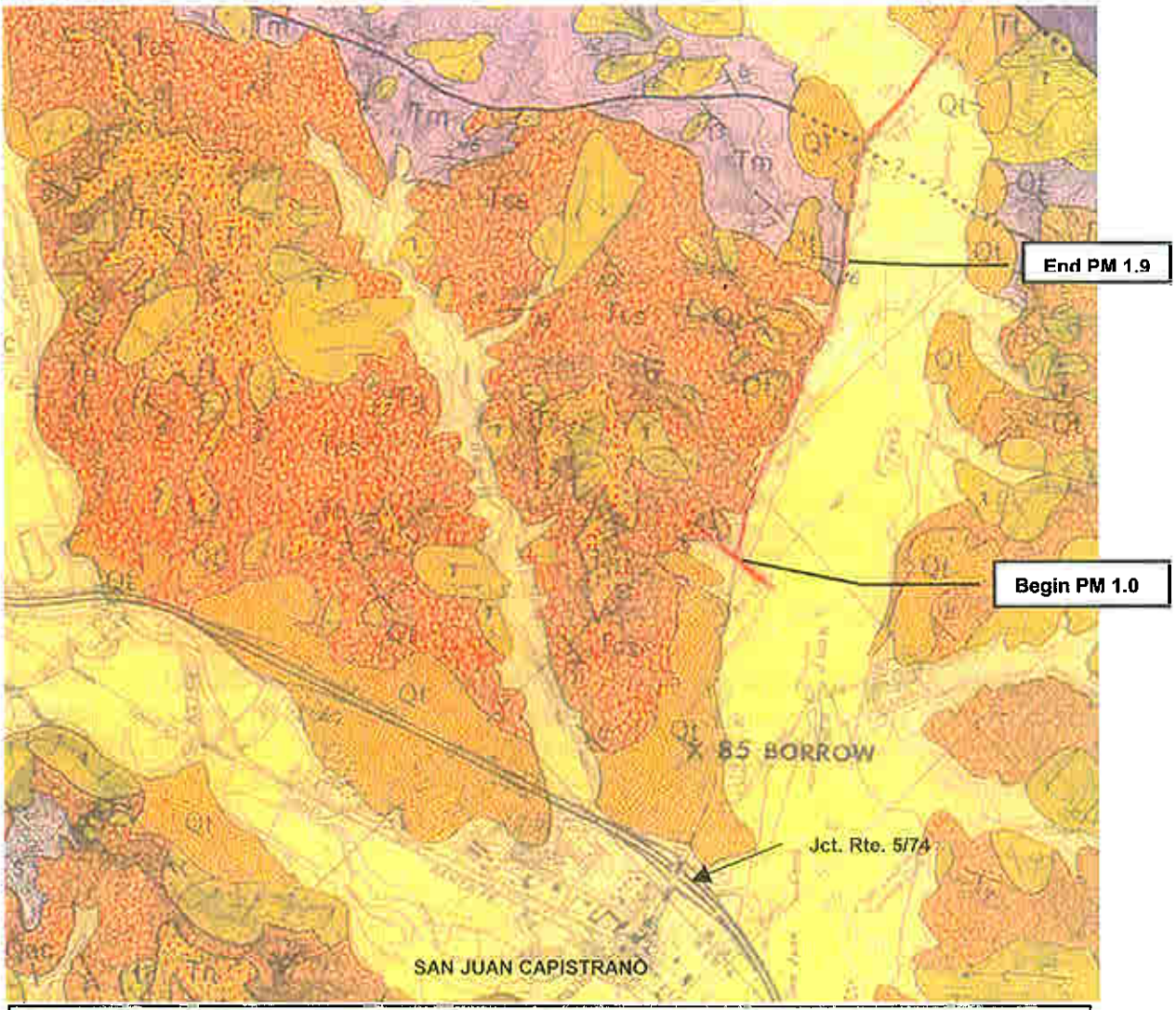



**Figure 3—Portion of Geologic Map of Orange County (Morton, PK and Miller, RV, 1981) Showing the Project Vicinity**

The project is set in San Juan Canyon, a northeast, southwest trending canyon[1] formed by the meandering San Juan Creek. The highway in the project area is set against the hills that border the canyon to the north. The range in elevation from one end of the project to the other is 45 to 53 meters (149 to 162 feet). Figure 1 shows that nearly one-third of the area bordering the project to the east is in or adjacent to existing orchards, and that the east side of the southern half of the project is in a developed section of the canyon bottom. These facts suggest that much of the land

[1] The major difference between a valley and a canyon is that a canyon has steep sides. Both are formed by the down-cutting action of a river or a stream, and both are bordered by hills or mountains.

underlying and bordering the highway to the east has been previously disturbed. They also provide the reason why most of the widening for the project will be done by cutting into the hillside west of the highway.

According to the *Geologic Map of Orange County, California-Showing Mines and Mineral Deposits* (Morton and Miller, 1981), the project area is underlain by the following formations. Table 1 lists the formations, and their assigned sensitivities for paleontological resources.

**TABLE 1—FORMATIONS IN THE PROJECT AREA ACCORDING TO GEOLOGIC MAP OF ORANGE COUNTY, CALIFORNIA**

| Post miles | Formation | Potential for sensitive resources |
|---|---|---|
| | Quaternary alluvium and Colluvium (eastern project boundary) (Qal) | Low |
| | Non-marine terrace deposits (Qt) | Low |
| | Upper Miocene Capistrano Formation (siltstone facies) (Tcs) | High |
| | Miocene Monterey formation (Mm) | High |

**The Quaternary alluvium and colluvium** were mostly deposited within the last 10,000 years. These formations are composed of soil and slope wash, as well as sand and gravel from the creek beds. They may occasionally contain fossil float material derived from older bedrock. However, since in situ fossils have not been found in these formations in the project area, they are considered to have a low potential to contain sensitive paleontological resources.

**The Quaternary Terrace Deposits** are composed of poorly consolidated sand and gravel. These deposits are quite common in the project area. Typically they are poorly fossiliferous, but if they contain fossil remains, these remains can be very important. A nearby survey conducted for the Rancho Mission Viejo Ranch Plan found no sensitive paleontological resources in the terrace deposit formations, so in the project area, Quaternary Terrace Deposits are considered to have a low potential to contain sensitive paleontological resources.

**The Capistrano Formation** is described as Pliocene to Upper Miocene marine rocks, consisting of siltsone, fine sandstone, and shale with local limestone concretions. The University of California at Berekeley Museum of Paleontology (UCMP) database shows that bird and mammal bones have been found in the Capistrano Formation at other locations in Orange County.

**The Monterey Formation** of Middle Miocene age is one of the most wide spread formations in California. This formation reflects a large-scale inundation of what is now the California coast by seas during the Middle Miocene period. This inundation covered most of the state. Rocks of the Monterey formation are diatomaceous and siliceous shales, and often contain microfossils, and the bones and scales of fish. Marine vertebrate fossils and even algae (seaweed) have been found at some Monterey Formation locations.

The preliminary Geo-technical report for the project (Christopher Harris, July 2001) notes that the entire project is underlain by alluvium. The depth to bedrock has not yet been determined, but will be at a later date.

**Minimization Measures**

Because of the potential for excavations in the Capistrano and Monterey Formation where sensitive fossils could occur, monitoring by a qualified paleontologic monitor will be required when excavations in these formations will take place. A review of the geotechnical boring logs should determine when or if these formations may be encountered especially in the large cuts between Stations 26 and 34.

This determination does not apply to future iterations of the project that may broaden its scope from the current plans. If project plans change significantly, Environmental Engineering will be given an opportunity to reassess the issue of potential to discover sensitive paleontological resources.

Because sensitive paleontological resources may be discovered during construction, the Environmental Generalist is requested to place the following statement in the project conditions memo. If any vertebrate of plant fossils are discovered during construction, work shall be halted in the immediate vicinity of the discovery (33 foot radius), until the District Archaeologist, District Paleontology Coordinator, or the designated paleontological monitor have the opportunity to review the discovery. Contact names and telephone numbers are:

| | | | |
|---|---|---|---|
| District 12 | Archaeologist | Cheryl Sinopoli | (949) 724-2855 |
| District 5 | Paleontology Coordinator | Wayne Mills | (805) 549-3193 |

Remediation of any sensitive resources encountered before or during construction can include removal, preparation and curation of any significant remains. The most logical curation facility for fossils discovered on this project would be the Orange County Curation facility on Chestnut Avenue. However, recently some controversy over the continued use of that facility for archaeological and fossil storage has risen, and it is possible that significant finds from this project could be sent to the San Diego Museum of Natural history, or the UCMP.

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# APPENDIX

# UCMP Vertebrates (All ages)-Orange County

This list is compiled from the Vertebrate database of the University of California at Berkeley Museum of Paleontology. It ostensibly contains all the vertebrate and plant fossils in the museum collection from Orange County.

| Section | Class | Taxon | Period | Epoch | Locality |
|---|---|---|---|---|---|
| 43588 | Vertebrates | Reptilia | Cretaceous | Late Cretaceous | Harding Cr, (Ladd Fm.) |
| 123279 | Vertebrates | Aves | Quaternary | Pleistocene | Newport Bay E 1 (Palos Verdes Sand) |
| 39979 | Vertebrates | Aves- Oceanodroma hubbsi | Tertiary | Miocene | Petrel (Capistrano Fm.) |
| 137417 | Vertebrates | Osteichthyes-Paralichthys sp. | Tertiary | Miocene | LACM 7136, Moulton Parkway (Monterey Fm) |
| 32695 | Vertebrates | Mammalia Desmostylus Hesperus | Tertiary | Miocene | Santiago Canyon Road, (Topanga Fm) |
| 60103 | Vertebrates | Chondrichthyes-Isurus tumulus | Tertiary | Miocene | Santiago Canyon Rd. |
| 60104 | Vertebrates | Chondrichthyes-Carcharodon tembloris | Tertiary | Miocene | Santiago Canyon Rd. |
| 63384 | Vertebrates | Chondrichthyes, Isurus tumulus, | Tertiary, | Miocene, | Santiago Canyon Rd. |
| 82676 | Vertebrates | Osteichthyes | Tertiary | Miocene | Aliso Creek (Puente Fm) |
| 94322 | Vertebrates | Osteichthyes | Tertiary | Miocene | El Toro 1, (Monterey Fm) |
| 94323 | Vertebrates | Chondrichthyes Isurus hastalis | Tertiary | Miocene | El Toro 1, |
| 94324 | Vertebrates | Chondrichthyes Isurus planus | Tertiary | Miocene | El Toro 1, |
| 94325 | Vertebrates | Chondrichthyes Isurus sp. | Tertiary | Miocene | El Toro 1, |
| 94326 | Vertebrates | Chondrichthyes Galeocerdo aduncus p. | Tertiary | Miocene | El Toro 1, |
| 94327 | Vertebrates | Chondrichthyes Carcharhinus sp. | Tertiary | Miocene | El Toro 1 |
| 10015 | Vertebrates | Mammalia Desmostylus hesperus | Tertiary | Miocene | Santiago Canyon Rd. (Topanga Fm) |
| 94328 | Vertebrates | Chondrichthyes Myliobatis sp. | Tertiary | Miocene | El Toro 1 |
| 137419 | Vertebrates | Aves | Tertiary | Miocene | LACM 7136, Moulton Parkway (Monterey Fm) |
| 94329 | Vertebrates | Mammalia | Tertiary | Miocene | El Toro 1 |
| 94330 | Vertebrates | Mammalia Allodesmus kernensis | Tertiary | Miocene | El Toro 1 |
| 94331 | Vertebrates | Mammalia | Tertiary | Miocene | El Toro 1 |
| 94332 | Vertebrates | Mammalia | Tertiary | Miocene | El Toro 1 |
| 94333 | Vertebrates | Mammalia | Tertiary | Miocene | El Toro 1 |
| 94334 | Vertebrates | Mammalia- Dusisiren jordani | Tertiary | Miocene | El Toro 1 |
| 94335 | Vertebrates | Mammalia- Dusisiren jordani | Tertiary | Miocene | El Toro 1 |
| 98192 | Vertebrates | Mammalia-Dioplotherium allisoni | Tertiary | Miocene | Top Of The World, (Topanga Fm.) |
| 101005 | Vertebrates | Mammalia | Tertiary | Miocene | Sulpher Creek Reservoir (Capistrano Fm.) |
| 111612 | Vertebrates | Chondrichthyes | Tertiary | Miocene | El Toro 1 |
| 137418 | Vertebrates | Reptilia-Psephophorus sp | Tertiary | Miocene | LACM 7136, Moulton Parkway (Monterey Fm) |
| 130380 | Vertebrates | Aves | Tertiary | Miocene | El Toro 2 Capistrano Fm.) |
| 130381 | Vertebrates | Aves | Tertiary | Miocene | El Toro 2 |
| 58042 | Vertebrates | Mammalia | Tertiary | Oligocene | Bolero Lookout (? Fm) |
| 58070 | Vertebrates | Mammalia | Tertiary | Oligocene | Bolero Lookout |

# THE GEOLOGIC HISTORY OF ORANGE COUNTY

**(modified from "Orange County Geology - Teachers Guide", by Carol J. Stadum, Chapman College, for the Orange County Department of Education)**

## The Triassic-Jurassic Bedford Canyon Formation (Jbc)

The backbone of Orange County is the Santa Ana Mountain Range that extends from the Puente Hills near Prado Dam southeast beyond the county limits. The highest, northern-most peaks in the range are composed of Triassic-Jurassic Period meta-sedimentary rocks of the Bedford Canyon Formation. This formation contains the oldest exposed rocks in Orange County that were formed during the earliest part of the great "Age of Reptiles", about 225 million years ago. These rocks include argillite, quartzite, slate, and small exposures of shale and limestone that contain poorly preserved mollusk fossils.
Underlying the Bedford Canyon Formation and exposed to the southeast of Santiago Peak, is the granitic core of the mountains. The large, round, white, granodiorite boulders are easily seen from the Lower San Juan Creek Campground, over the summit of the Ortega Highway, and along the eastern flank of the mountains above Lake Elsinore.

The Bedford Canyon Formation was subjected to long periods of erosion, then it was submerged and younger sediments were deposited upon it. The formation was exposed again and this old erosional surface may be seen today where it is in contact with the Santiago Peak Volcanics of the Jurassic Period. The silver, lead, tin, and zinc mines in the Santa Ana Mountains are located in the Bedford Canyon Formation, and limited quantities of ore have been recovered since 1870. Mining in the Santa Ana Mountains has had little success because the formation has been so greatly fractured and faulted that the ore veins are offset and impossible to trace. A promising vein will appear for a few hundred feet then disappear. The boom days of the silver mines in the late 1800's and the search for tin by the Borden Company (tin to make cans for their milk) at the turn of the century provide excellent study for county historians. Limestone has been quarried in some parts of the mountains, but the mines are presently inactive. Some deposits of gypsum have also been mined.

## The Jurassic Santiago Peak Volcanics (Jsp)

Lavas flowed across the Bedford Canyon Formation during the Jurassic Period plucking pieces of the metasedimentary rocks from the erosional surface as they passed. The lava cooled quickly and chunks of Bedford Canyon rocks can be seen included in the lava at the contact between the two formations. These angular chunks of argillite and quartzite in the lava look like raisins in raisin bread.
The volcanic vent is gone and much of the volcanics have eroded from above the Bedford Canyon Formation. The latter formation is about 20,000 feet thick whereas the overlying Santiago Peak Volcanics are about 2,300 feet thick. The volcanics exposed in Silverado Canyon consist of hornblende andesite.

## The Early Cretaceous Trabuco Formation (Kt)

The county landscape during the Mesozoic Era appeared as vast stretches of an old erosional surface that was created by a fluctuating marine and continental environment. Then the land was partly covered by extruded volcanics. Unconformably overlying the volcanics is the easy-to-identify Trabuco Formation. This formation consists of rounded cobbles and boulders which accumulate in a semi-arid environment. The red binding clays in the Trabuco Formation conglomerate are indicative of continental deposits and the size and shape of the cobbles suggest that the formation may have consisted of ancient coalesced alluvial fans.

## The Middle Cretaceous Baker Canyon Conglomerate Member of the Ladd Formation (klb)

The Trabuco Formation is the earliest Cretaceous Period formation to be found in Orange County. It is exciting to study the rocks of this period because we see, as we enter this period, continental deposits and a semi-arid land, which then begins to subside as shallow seas slowly cover the alluvial fans with marine sandstone, beach cobbles, and sea shells. This Middle Cretaceous marine formation is called the Baker Canyon Conglomerate Member of the Ladd Formation. Shallow water clams and snails may be observed as fossils in this fairly resistant sandstone.

## The Middle Cretaceous Holz Shale Member of the Ladd Formation (Klh)

The seas continued to occupy a subsiding basin. The sediment deposited in the deep-seas was composed of fine, clay-sized particles. It drifted far before sinking to the sea bottom to be mixed with a variety of invertebrate fossils and bits of wood which have become carbonized (charcoal-like). The deep-sea shale is the upper member of the Ladd Formation and is called the Holz Shale. The most unusual fossil found in this shale is the ammonite, an extinct octopus-like mollusk which had a coiled, wavy, chambered shell.

## The Late Cretaceous Williams Formation (Pleasants Silty Sandstone (Kwp) and Schulz Ranch Sandstone Members (Kws))

Land emergence began near the end of the Mesozoic Era, and the last of the "Age of Reptiles" saw the county covered by a shallow, warm sea. The Williams Formation of the Late Cretaceous is divided into two members, the Pleasants Silty Sandstone and the Schulz Ranch Sandstone. This latter member contains wavy bands of sandstone and beach (lag) cobbles indicating that it may have been an ancient shoreline.

## The Tertiary (Paleocene) Silverado Formation (Tsi)

The Silverado Formation which overlies the Williams Formation contains coal seams and commercial clay deposits. It marks the beginning of the Cenozoic Era, called the "Age of Mammals", 70 million years ago. The county was then covered with swampy sea-marshes and lagoons. The coal deposits are in thin seams and are low quality lignite. They were mined during the turn of the century and the town of Carbondale near the mouth of Silverado Canyon was established as a coal mining town. The town has since disappeared. Mollusk fossils found in the Silverado formation indicate that it was deposited during the Paleocene Epoch of the Tertiary Period. Pisoltitc (pea-shaped) aluminum-rich clays are sporadically found at the base of this formation.

## The Tertiary (Eocene) Santiago Formation (Tsa)

The Santiago Formation is Eocene in age and consists of yellow-marine sandstone, siltstone, and cobble conglomerate. The formation has a gradational contact with the underlying Silverado Formation. The yellow sandstone has weathered into caves and irregular cliffs which provided a "hide-out" for banditos during the last century. A good place to see the sandstone caves is near the junction of Santiago Canyon with Fremont Canyon behind Irvine Park.

## The Tertiary (Late Eocene to Early Miocene) Vaqueros/Sespe Undifferentiated (Tv/Ts)

Locally it is difficult to designate rocks as being Oligocene in age or to place them anywhere in the same time scale between the Late Eocene and the Early Miocene. Elsewhere in California, Oligocene rocks have been differentiated but generally in the Orange County area the Vaqueros-Sespe Formations are interbedded and almost impossible to separate. Where a differentiation can be made, the red-colored Sespe Formation is a continental deposit and the buff-colored Vaqueros Formation is marine and contains marine invertebrate fossils. The formations represent a period of transition from a nonmarine to a marine depositional environment. The sediments may have accumulated along the shore of a subsiding or fluctuating sea basin, or deposition occurred in desert bolsas (bays) alternating with shallow sea incursions. These undifferentiated sediments are spectacular and can be distinguished as red, maroon, buff, and gray, highly-eroded sandstones. They are poorly consolidated and present problems to land developers. "The Sinks" area near Bolero Lookout in the Santa Ana Mountains is an example of the brightly-colored, highly-eroded formations. More accessible sites are exposed along the west flank of Santiago Creek near Silverado Canyon and in the Santa Ana Canyon near Gypsum Canyon.

## The Miocene Epoch "Smorgashbord"

The Miocene Epoch represents a "smorgasbord" of rock types, minerals, fossils, and structural activity. Miocene formations contribute a great thickness of marine sediments. Faulting was widespread during the Late Miocene, and these "fossil" faults are commonly observed in offset beds. Although researchers are not completely in agreement about the sequence of geologic events in the Miocene, the following interpretation is probably the most acceptable.

## The Early-Middle Miocene Topanga Formation (Tt)

The Topanga Formation is present throughout the Los Angeles Basin (of which Orange County is a part) and contains abundant marine fossils ranging from sharks teeth to sea shells and microfossils. It was deposited during the Early-Middle Miocene in a shallow, warm sea. Near Lake Forest, a reef of pectens and other fossil mollusks is exposed in a dry wash. It was through this widespread formation that volcanics pushed their way. The El Modeno Volcanics, the first row of hills east of Orange, represent a series of lava flows and ash flows that accumulated in a shallow sea. In the San Joaquin Hills, Miocene volcanics intruded finger-like projections (diabase) through the overlying marine sediments. Mercury deposits (cinnabarite) in the Red Hill area of Tustin are apparently from this volcanic activity that occurred throughout the Los Angeles Basin fifteen million years ago

## The Early-Middle Miocene San Onofre Breccia (Tso)

Concurrent with or immediately after the formation of the Topanga Sandstone, great landslides fell down the slopes of a large landmass west of our present coastline. Catalina Island is a remnant of that landmass and crystalline Catalina-type rocks were eroded to form the San Onofre Breccia. The breccia formation has been uplifted by faulting and forms the headland of Dana Point. An estimate is that the speed of the landslides must have at times exceeded 100 miles an hour to create such a large boulder breccia. The rocks and minerals include asbestos, serpentine, actinolite, fuchsite, epidote, chlorite, glaucophane, pyrite, magnetite, and quartzite.

## The Middle Miocene Monterey Shale (Tm)

In the Middle Miocene Epoch a great sea inundation, associated with the development of deep

basins, resulted in massive accumulations of diatomite, an almost pure deposit of one-celled, glassy, plant shells which are commercially mined for use as swimming pool filters. The white (diatomaceous) cliffs of Newport Back Bay are formed by the Monterey Shale Formation and contain fish scales and fish bones as well as microfossils.

## The Late Miocene Puente Formation (La Vida (Tplv), Soquel (Tps), Yorba (Tpy), Sycamore Canyon (Tpsc) Members)

The area again changed as the deep basins filled and the sea began to retreat. The Puente Formation was deposited in the Late Miocene and is composed of four members. From oldest to youngest the members are as follows: The La Vida Member consists of laminated diatomaceous siltstone with thin interbedded sandstone and coincides in depositional time with the top of the Monterey Formation; the Soquel member is sandstone with some interbedded siltstone and local conglomerate beds; the Yorba Member has thin-bedded siltstone and local beds of sandstone and conglomerate; and the Sycamore Canyon Member consists of inter-bedded conglomerate, sandstone, and siltstone. This may be confusing to the layman; for the purposes of this Guide the entire formation is composed of Late Miocene marine sediments containing some fossils and is found in the northern and northeastern part of Orange County. Sandstone provides a good reservoir rock for oil which has been trapped by faulting and folding. Sandstone of the Puente Formation composes most of the Puente Hills. The Burruel Hills are also cloaked by the Puente Formation which has a maximum thickness of 5,400 feet.

## The Late Miocene to Early Pliocene Capistrano Formation (Tcs, Tct, Tcs)

The marine Capistrano Formation is found in the southern part of the county. It ranges from Late Miocene to Early Pliocene in age and consists of poorly consolidated, fossiliferous, sandy-siltstone and mudstone. Sediment failures have caused extensive landsliding in San Juan Capistrano and San Clemente areas. Turbidite deposits may be seen in the sea cliffs between Dana Point and San Onofre. Turbidites are deposits of marine sediment formed by undersea mud slides or turbidity currents that dump sediment into graded layers: the larger-sized gravel falls first, followed upward by progressively finer sediment grains. The base of the turbidite is a sharp accumulation of the coarse gravels. The top of a turbidite deposit is often difficult to define because the fine-grained, last to settle sediments, blend with the natural "grain-size" of marine sediments.

## The Pliocene Niguel Formation (Tn)

The Niguel Formation is a shallow, marine deposit that overlies the Capistrano Formation in the Mission Viejo area. It is Pliocene in age and has a maximum thickness of 350 feet. This gray, Silty sandstone contains abundant fossil sea shells and is unconsolidated.

## The Pliocene Fernando Formation (Repetto Sandstone (Tfl), Pico Sandstone (tfu) Members)

The 5,000-feet thick Fernando Formation is composed of two members which have been considered by many geologists to be separate formations. The lower unit is the Repetto Sandstone and the upper unit is the Pico Sandstone. You may observe folded Repetto Sandstone along the east side of the Newport Freeway-cut through the toe of Burruel hills near the town of Olive. These marine sediments were also laid down during the Pliocene Epoch.

## The Late Pliocene Unnamed Formation

A Late Pliocene unnamed sandstone formation deposited in the Newport Beach area contains a wealth of vertebrate and invertebrate fossils but is on private property and inaccessible. This formation has produced fossils of marine mammals, sea birds and a variety of sea shells.

## Uplift and River Down-Cutting in the Pliocene

The seas continued to withdraw as the land was uplifted. The Santa Ana River, which drains the San Bernadino Mountains, flowed across the land's surface in its present position before the Santa Ana Mountains were elevated. As the mountains rose during the Pliocene, the persistent river continued cutting in its channel, eroding , steep narrows known as the Santa Ana Canyon. A stream or river which continues in its channel instead of being rerouted by an uplifting landmass is called an antecedent stream. The river deposited great quantities of alluvial material upon the land that is now Orange County, providing the basis for an excellent soil for our agricultural industries. The heavily populated, areas of the county are built upon this ancient flood plain. The San Gabriel River is also, an antecedent river and continued to cut across the Puente Hills as they were uplifting.

## The Pliocene La Habra (Qlh) and Coyote Hills (Qch) Formations

The La Habra Formation is found in the Coyote Hills and along the southern flank of the Puente Hills. It is a non-marine deposit and appears to have been an old flood plain. Diatomaceous shale chunks or clasts occur near the basal contact with the underlying Coyote Hills Formation. These clasts were probably washed from the Puente Hills area onto the growing flood plain in the Late Pleistocene Epoch. The Coyote Hills Formation is limited only to the Coyote Hills and is a lagoonal deposit.

## The Cutting of Marine Terraces (Qt, Qtm) in the Plio-Pleistocene

During the end of the Pliocene and into the Pleistocene Epoch, the seas receded slowly. Each successive shoreline is represented today by a marine terrace. Three marine terraces are seen north of Corona del Mar. These flat terraces may be crossed by driving toward the beach on MacArthur Boulevard.

## The Pleistocene San Pedro Sandstone (Qsp), Timms Point Silt, Lomita Marl, Palos Verdes Sand

Although the Pleistocene Epoch is called the "Ice Age", no glacial ice covered the county or southland area. A heavily vegetated, marshy area extended inland beyond the shoreline, and a great variety of vertebrate "Ice Age", animals lived in southern California. The tar seeps (La Brea Tar Pits in Los Angeles) entombed many of those species. Peat bogs in the coastal area near Huntington Beach were covered with sand and have become peat beds. San Pedro Sandstone, which contains marine fossils; Timms Point Silt; and Lomita Marl, a calcareous clay found near Palos Verdes, were all deposited in the Pleistocene and underlie beach-terrace sands. The Palos Verdes Sand (terrace) with abundant Pleistocene sea shells can be seen from Coast Highway #l in the Newport Mesa cliffs.

## Faults and Earthquake Activity

Marine sediment in the Los Angeles Basin is greater than 10,000 feet thick. Near the Coyote Hills in the northwest part of Orange County the sediment thins to 50 to 200 feet thick. When an earthquake occurs, the movement of the tremors through the sediment tends to amplify the motion; the effect is similar to shaking a bowl of jelly.

There are many faults and fault zones throughout southern California. Certainly there has been no activity

along most faults for millions of years. Other fault systems have been active since the Pleistocene Epoch but not in the last two hundred years, or within the recorded history of Orange County. Scientists are presently developing new methods for measuring the potential threat of earthquake activity along Pleistocene faults. Two large fault zones in Orange County which have not been active in recorded history are the Norwalk fault zone which trends northwest-southeast near Anaheim and the Cristianitos fault zone which trends north-south across the Ortega Highway east of San Juan Capistrano.
The three active and large fault zones that have been active in this century are the Whittier fault zone, the Elsinore fault zone, and the Newport-Inglewood fault zone. The Whittier fault zone extends along the southwestern base of the Puente Hills and has trapped migrating oil. The zone may be observed by driving into the Puente Hills from Brea on Brea Boulevard. One mile north of Brea the road turns east along the foot of the hills (the fault zone), then turns north again. The road was built along a stream coarse which was offset by the Whittier fault. The Whittier fault joins the Chino fault near Prado Dam, and they merge into the Elsinore fault zone which trends along the eastern base of the Santa Ana Mountains.

**Brief Perspective on the Fossils of Orange county**

The Miocene Epoch was a dramatic time globally, especially in western North America. Major reorganization of lithospheric plates, particularly along the Pacific margin of North America, produced mountain uplifts, initiated movement on the nascent San Andreas fault system, and formed numerous coastal marine basins, such as the Los Angeles Basin, of which most of Orange County is a part. Today the Los Angeles Basin is a topographic basin, but during the Miocene, it was a tectonically active, subsiding marine depositional basin that accommodated a vertical thickness of up to six miles! of **Neogene** sediments, one of the thickest Neogene stratigraphic successions in the world. One of the initial deposits of the early Los Angeles Basin is the ***Topanga Formation***, a shallow to moderately deep marine deposit of sandstone and siltstone. The Topanga has produced an abundance of fossils, including invertebrates, plants, and vertebrates such as shark teeth, whales, sea cows, sea lions, and sharks. Locally interstratified with the Topanga deposits are ***the El Modeno Volcanics***, which, owing to their igneous origin, have produced no fossils; however, some of the associated volcanic ash deposits have produced fossils, perhaps preserved as mass die-offs during volcanic eruptions. Stratigraphically overlying the Topanga Formation are deeper marine deposits of the late **Miocene** ***Puente Formation***. These deposits have produced marine invertebrate and vertebrate fossils. Along fringing parts of the foothill belt of the northern Santa Ana Mountains, particularly in the Mission Viejo area, is a white sandstone deposit called the ***Oso Sand*** member of the ***Capistrano Formation***. The Oso Sand is late Miocene to early Pliocene in age and represents deposition in a large shallow-marine embayment. This is one of the most prolific fossil-bearing units in the entire county, having produced fish, shark (some teeth up to 6" long belonging to the voracious scourge of Miocene seas, *Carcharodon*), whale, sea lion, and other marine mammals from scores of localities. This embayment may have been an ancient calving ground for whales, and hence a "killing field" for sharks. Many of the jacketed specimens at the County warehouse were collected from Mission Viejo Planning areas and Lake Forest from the Capistrano Formation during the late 1970s-early 1980s. The Capistrano Formation is overlain by shallow-marine deposits, including the ***Niguel*** and ***Fernando*** formations of **Pliocene** age, which have produced invertebrate and vertebrate fossils. Capping the Tertiary formations, mostly along drainage courses, are surficial deposits of stream terrace origin that are **Pleistocene** in age. These late ice-age deposits have produced important land vertebrate fossils from a few scattered localities. Geologically recent **(Holocene)** deposits are unfossiliferous, but may contain archaeological bone and shells.

**THE ORANGE COUNTY ARCHAEOLOGICAL/PALEONTOLOGICAL CURATION PROJECT**

http://anthro.fullerton.edu/orangecocuration

In July, a front and hind flipper assembly of an *Imagotaria*, a primitive walrus, was entered into competition by the Orange County Natural History Museum and put on display at the Orange County Fair. This exhibit garnered a first place blue ribbon and trophy in the rocks, mineral, and fossils division. The specimen, from the upper **Monterey Formation** (late Miocene) in the Laguna Niguel area, was prepared at the warehouse by Leah Hahn, Patty Hatfield, and Carla Sawyer. This well preserved, but disarticulated specimen, had to be salvaged bone-by-bone and reconstructed into a partial skeleton over a six-month period; it became the subject of Leah's senior thesis project at CSUF, and was published in Dimensions, the journal of undergraduate research in the College of Natural Science and Mathematics, CSUF.

In August, the warehouse received two jackets containing a whale skeleton from the upper Miocene **Capistrano Formation** from the Prima Deschecca Landfill in south Orange County. This balinopterid whale specimen was jacketed in two parts: the lower vertebral column in one jacket (see photo) and portion of skull, humerus, radius/ulna, ribs, and upper vertebral column in the other. It was donated by the Orange County Waste Management Agency. Work began immediately upon delivery, and initial analysis suggests it may well be a new species, perhaps even a new genus. Volunteers Leah Hahn, Patty Hatfield, Carla Sawyer, Jacki Hanson, Muffy Mendelson, Debbie and Jennifer Marsing, and Brian Kussman have worked hard to get these jackets prepped.