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SECOND ANNUAL
FALL FIELD FROLIC

OF THE

DEPARTMENT OF GEOLOGICAL SCIENCES

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

SEPTEMBER, 1984

A FIELD GUIDE TO THE NORTH-CENTRAL VENTURA BASIN

COMPILED BY

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HIGHLIGHTS OF FIRST DAY

Discussion of some oil fields in the area

Pliocene turbidity current deposition around a seamount

A look at some naturally burned oil shale

Santa Paula Oil Museum

Sulphur Mountain oil seeps

The Matilija overturn

A Cretaceous-Eocene unconformity

The Santa Ynez fault

Materials presented here to guide you on day one are from:

Geologic Guide No. 2 of the California Division of Mines and Geology Bulletin 170

Part 2 of the California Division of Oil and Gas' 1961 edition of California Oil and Gas Fields Maps and Data Sheets

Guidebook for Field Trip 1 of the 1967 Cordilleran Section meeting of the Geological Society of America

INTRODUCTION TO A FIELD TRIP ALONG UPPER SESPE CREEK, VENTURA COUNTY, CALIFORNIA, WITH COMMENTS ON TERTIARY STRATIGRAPHY OF THE AREA

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INTRODUCTION

The depositional environment and paleogeographic setting of some Tertiary rocks in the vicinity of upper Sespe Creek have been interpreted through use of sedimentary structures and fossils. The purpose of the field trips described in this guidebook is to give the participant the opportunity to observe the structures and fossils on which these interpretations are based. The area investigated is between Pine Mountain and the Topatopa Mountains in northern Ventura County, California (Fig. 1 of Reid, this guidebook).

Two one-day field trips are described (see Field Trip Guide of Fritsche, this guidebook). The first is to the Piedra Blanca area where a transgressive sequence of the Vaqueros Formation of late Oligocene and/or early Miocene age is exposed. The sequence from bottom to top includes deposits of a muddy beach that had a low tidal range, a shallow grassy bay, a shallow open bay that was inlet influenced in places, a sand sheet on which were scattered several submarine dune fields, an open shelf on which submarine debris flows occurred, and finally an environment of low sedimentation rate on the outer edge of the shelf. Possible marine rocks of the Oligocene Sespe Formation, turbidites of the Eocene Matilija Sandstone, and Pleistocene stream terraces are also studied on this trip.

The second trip is to the Chorro Grande-Godwin Canyon area where a regressive sequence of the Santa Margarita Formation of late Miocene age is exposed. This sequence from bottom to top includes deposits of a phosphate-rich shelf, an offshore bar that had a well-developed tidal inlet, a gypsum-rich saline lagoon, a mudflat, and deltaic floodplain deposits on which paleosols developed. Turbidites of the Miocene Monterey Formation can also be seen on this trip.

Articles in this guidebook include a summary of Tertiary stratigraphy of the area (this article), a description of Miocene macrofossils in the area (Squires and Fritsche), an interpretation of the Vaqueros (Reid) and Santa Margarita (Thor) depositional environments, a description and interpretation of stream terraces in the area (Gutowski), and a field trip guide (Fritsche). These articles represent part of the results of work done in the area by faculty and students at California State University, Northridge and by Shmitka (1970) at the University of California, Davis. Since 1964, eleven CSUN field classes have mapped in the area and three master's theses have been completed (Shmitka, 1970; Thor, 1977; and Reid, 1978).

The authors of this guidebook are indebted to those who went before them and prepared the way with geologic maps and stratigraphic studies. Field classes and graduate students from the University of California, Los Angeles were the pioneers (Dreyer, 1935; Badger, 1957; Hagen, 1957; Gross, 1958; Larson, 1958; and Jestes, 1963). Students and faculty from Stanford University followed and provided additional details and ideas (Dickinson and Lowe, 1966; and Dickinson, 1969a). The interested reader is encouraged to consult the works of Dickinson (1969b and 1969c), Ingle (1969), Lowe (1969), and McCracken (1969) for further insights into the rocks of this area.

STRUCTURAL SETTING

Rocks described in this guidebook are exposed in a synclinal graben that occurs between the Pine Mountain fault and the Tule Creek and Santa Ynez faults (Fig. 1). Structures within this area generally trend east-west. Most folds are inclined and overturned and some are fan folds. Most faults are high-angle reverse faults that occur on or near the hinge surfaces of large folds. Other faults in the area are left-slip faults. Folding preceded faulting and produced structural patterns along which later reverse faulting occurred. The folds and reverse faults probably formed in a single post-middle-Miocene period of deformation. The left-slip faults most likely formed later, after the major deformation.

STRATIGRAPHY

A generalized stratigraphic column of rocks in the area is shown in Figure 2.

EOCENE ROCKS

JUNCAL FORMATION

Page and others (1951) applied the name Juncal Formation to rocks in the crestal region of the Agua Caliente anticline in Santa Barbara County. Along Sespe Creek, similar rocks occur in the cores of anticlines in the southwestern part of the area. Jestes (1963) informally referred the lower portion of these rocks to his Ortega Hill sandstone and the upper portion to the Cozy Dell Shale, but Vedder and others (1973) have since correlated them to the Juncal Formation.

The Juncal Formation is a series of alternating shale and sandstone beds, with sandstone being dominant in the lower half and shale in the upper half. The shale portion is nonresistant, light olive gray in color, and resembles the Cozy Dell Shale members described below. Interbedded with the shale are

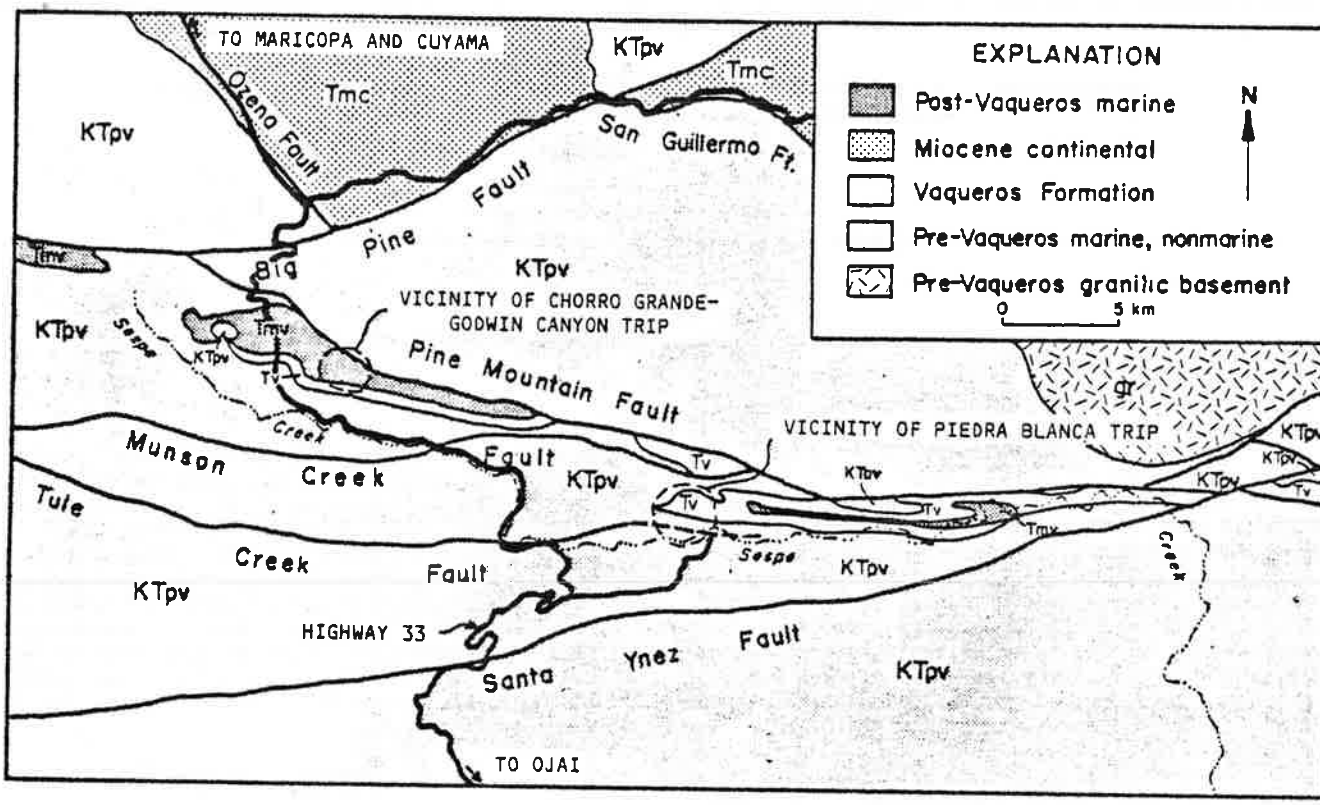

Figure 1. Index to major faults and gross rock unit distribution in the vicinity of upper Sespe Creek (adapted from Jennings and Strand, 1969).

thin sandstone beds composed of moderately resistant, yellowish-gray and light olive-gray, fine-grained arkose. Cross bedding and parting lineation occur in the sandstone beds, but only rarely. Porosity and permeability are low, and macrofossils are rare. Work by Jestes (1963) supplements the brief lithologic description included here.

MATILIJA SANDSTONE

Rocks at Matilija Springs in Ventura County were first referred to as the Matilija Sandstone by Kerr and Schenck (1928). Rocks of similar age and appearance occur south of Sespe Creek from the west end of the area eastward to Lion Canyon. Good exposures at Derrydale Canyon prompted Jestes (1963) to name the rocks the Derrydale sandstone. Correlation of these rocks to the Matilija Sandstone was made by Vedder and others (1973).

The Matilija Sandstone in the Sespe Creek area is a resistant, greenish-gray to gray-brown, fine- to medium-grained, moderately sorted, micaceous arkose. Beds are from 0.5 to 2 m thick and are separated by shaly partings and thin mudstone interbeds 5 to 10 cm thick. The shale and mudstone make up less than 10 percent of the unit. The sandstone beds commonly are graded and contain convolute and cross bedding in the upper portions of the beds (see Fritsche, this guidebook, Stop 16). Ripple marks and scour channels also occur. The rock has low porosity and permeability. Body fossils are rare, but the trace fossil *Ophiomorpha* is common. Additional details on lithology and distribution are in Jestes (1963).

COZY DELL FORMATION

Overlying the Matilija Sandstone in Cozy Dell Canyon on the east side of the Ventura River in Ventura County is a sequence of rocks which Kerr and Schenck (1928) named the Cozy Dell Formation. Rocks of similar lithology occur throughout the Sespe Creek area except for within a 4- to 5-km-wide zone on the south side of the Pine Mountain fault. Along Sespe Creek, this formation can be divided into three members, a lower and an upper shale unit and an intervening sandstone unit which Jestes (1963) called the Circle B sandstone.

The shale members are predominantly nonresistant, brown to greenish-gray, silty mud-shale with up to 20 percent fine-grained sandstone interbeds. The shale commonly is massive, but in places is thin bedded. Mica flakes, carbonaceous matter, and concretions from 15 to 60 cm in diameter are common. The sandstone member and the sandstone interbeds consist of moderately resistant, yellow-brown to greenish-brown, fine-grained, moderately sorted, micaceous arkose. Beds are 0.1 to 1 m thick and generally are internally massive. Cross bedding, convolute bedding, and ripple marks occur, but less commonly than in the Matilija Sandstone. Porosity and permeability in the formation are poor. Few macrofossils occur in the unit, but they are more common than in the Matilija. The interested reader will find more information on the unit in Jestes (1963).

COLDWATER SANDSTONE

The name Coldwater Sandstone was first used by Kew (1924) for rocks on Coldwater Creek, a tributary of lower Sespe Creek in Ventura County. Along upper Sespe Creek, rocks of the same lithology occur in a narrow band about 4 to 5 km south of the Pine Mountain fault and in another narrow band just north of the Santa Ynez fault and east of Highway 33. These rocks have been called the Coldwater Sandstone by all

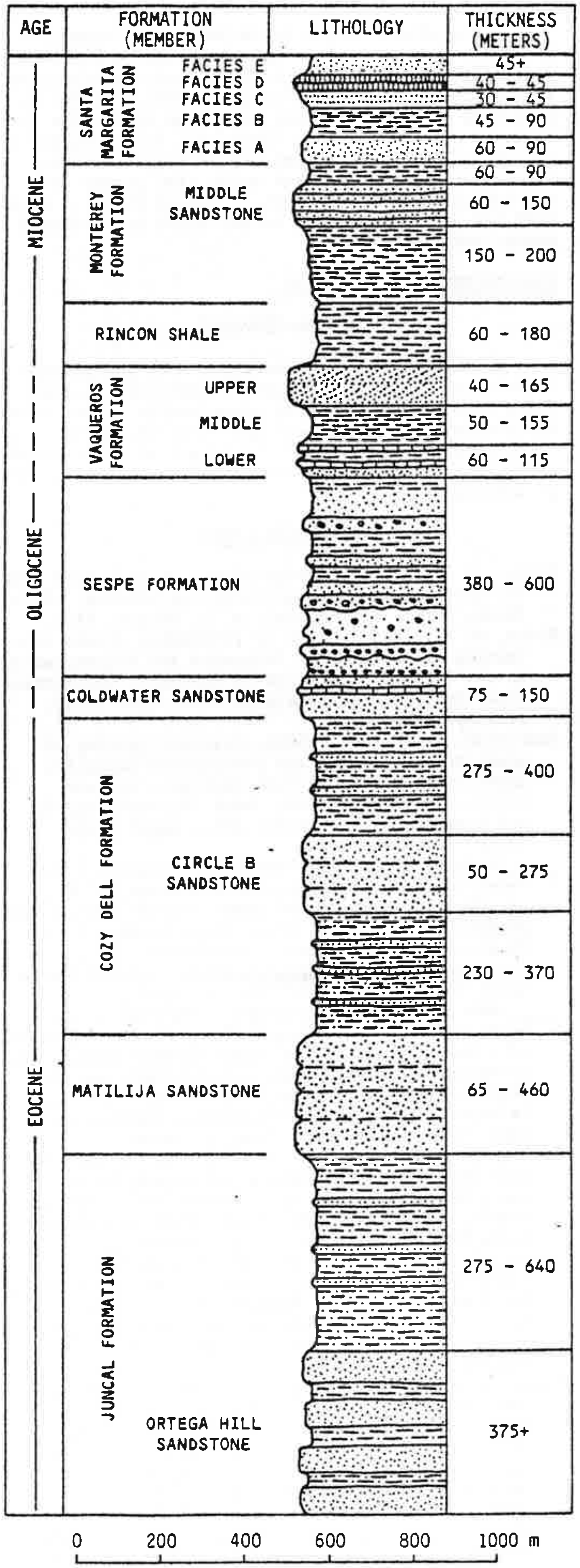

Figure 2. Generalized stratigraphic column of rocks exposed along upper Sespe Creek. Thicknesses are compiled from Jestes (1963), Shmitka (1970), Thor (1977), and Reid (1978).

previous workers.

The Coldwater Sandstone is about 85 percent sandstone and 15 percent siltstone and limestone which are mostly confined to the uppermost part of the unit. The sandstone is a moderately resistant, gray to yellow-brown, medium- to fine-grained, moderately sorted, micaceous arkose, which tends to be more friable than the sandstone in older units. Beds are from 0.2 to 1 m thick and commonly are internally massive, although parallel laminations and low-angle cross bedding occur in places. The rock is moderately porous and permeable. Macrofossils, especially oysters, are moderately common and specimens from several localities are in the CSUN collections. Limestone beds in the unit are gray and generally are the most fossiliferous layers. Siltstone sequences are brown and massive and contain 30- to 60-cm-thick, irregularly spaced, discontinuous, calcareous concretionary layers.

OLIGOCENE ROCKS

SESPE FORMATION

Watts (1897) first used the name Sespe Formation for red, continental rocks along the lower portions of Sespe Creek. Lateral equivalents of these rocks can be traced into the upper Sespe Creek area where they occur in a narrow band just below the Vaqueros Formation (Fig. 1). All workers in this area have called these rocks the Sespe Formation.

The formation is composed of a mixture of 75 percent sandstone, 15 percent conglomerate, and 10 percent siltstone, with the conglomerate tending to be concentrated in the lower portions of the formation. Most of the sandstone and conglomerate beds are moderately resistant, but a range exists from nonresistant beds to very resistant cliff formers. The sandstone and conglomerate are yellow brown to red-brown, moderately to poorly sorted, moderately friable, and arkosic in composition. Individual strata range from fine-grained sandstone layers to conglomerate layers that contain boulders of about 30 cm diameter. Beds range from 0.5 to 3 m in thickness, commonly contain internal bedding planes, and are graded in some places. Primary structures include cross bedding, scour channels, rip-up clasts, and some parting lineation. Conglomerate clasts are mostly sedimentary, volcanic, and granitic. The rock is moderately porous and permeable and is unfossiliferous, except for trace fossils of marine-like burrows which occur in some places (see Fritsche, this guidebook, Stop 9). Siltstone is mostly red or green and occurs in interbeds from 2 cm to 3 m thick. Details on the lithology and petrology of the unit in the upper Sespe Creek area are in McCracken (1969).

OLIGOCENE AND/OR MIOCENE ROCKS

VAQUEROS FORMATION

The Vaqueros Formation in the Sespe Creek area crops out on the south side of and within about 3 km of the Pine Mountain fault (Fig. 1). The nomenclatural history and lithology of the three members of the Vaqueros that are recognized in this area are discussed by Reid (this guidebook). Macrofossils from the formation are described by Squires and Fritsche (this guidebook, Tables 1, 2, and 3). Throughout the area, the top of the formation is marked by a glauconitic sandstone bed which was reported by Patet (pers. comm., 1972) as being of regional distribution. This glauconitic sandstone is the oldest of three beds in the area that can be used as markers in making lithologic correlations; the other two are in the Rincon and Santa Margarita Formations described below.

MIOCENE ROCKS

RINCON SHALE

The name Rincon Shale was first used by Kerr (1931) to describe a siltstone unit on the east side of Rincon Mountain in Ventura County. A similar siltstone unit occurs immediately above the Vaqueros Formation in most of the upper Sespe Creek area (Fig. 1), but in the west an unconformity occurs above the Vaqueros and the Rincon is missing. Vedder and others (1973) refer this unit to the Monterey Shale and use the name Rincon Shale for what is herein called the middle member of the Vaqueros Formation.

The Rincon Shale is a nonresistant, dark gray to dark brown siltstone that weathers to light brown, reddish brown, and yellow brown. Organic matter and pyrite are common constituents of the rock. Bedding is rare in the unit, which tends to be mostly massive throughout. Layers of yellow-brown, ovoid, calcitic and dolomitic concretions are common, some of them being septarian concretions. Porosity and permeability are low. Except for foraminifera, which are common, fossils are rare (see Squires and Fritsche, this guidebook, Table 4).

The contact between the Rincon Shale and the overlying Monterey Shale is marked by a regionally extensive bentonite bed which occurs at this stratigraphic horizon throughout the Ventura basin. This bentonite bed is the second of the three marker beds in the area that is available for making lithologic correlations.

MONTEREY SHALE

The type section of the Monterey Shale (Blake, 1856) at Monterey, California, is a long way from upper Sespe Creek, but the similarity of the rocks is sufficient to allow use of the name here. The unit is exposed along the southwest side of the Pine Mountain fault and has been called the Monterey Shale by all previous workers in the area.

The rock is a moderately resistant, grayish-yellow, siliceous shale. Beds are very thin and fissile. Porosity and permeability are poor to moderate, depending on the amount of fracturing. Foraminifera are the only fossils and they are abundant in some places. In the middle of the shale unit is a sandstone member which is composed of resistant, yellowish-gray, medium-grained, moderately sorted, locally conglomeratic arkose. Beds are 15 to 50 cm thick and internally are either graded, parallel laminated, or locally cross bedded. Fossils are common, but most are abraded and apparently have been transported. A more extensive discussion of this unit can be found in Dickinson (1969c).

SANTA MARGARITA FORMATION

Immediately south of the Pine Mountain fault and only in the western part of the area is a thin band of exposures of the Santa Margarita Formation. The nomenclatural history and lithology of the five facies of this unit found in this area are discussed in the article by Thor (this guidebook). Macrofossils from the formation are described by Squires and Fritsche (this guidebook, Table 5). In the middle of facies B (Thor, this guidebook) is a distinctive, light gray, vitric tuff bed which also occurs at the same stratigraphic level in Cuyama Valley. This tuff bed is the uppermost of the three lithological marker beds in the area.

PLEISTOCENE-HOLOCENE ROCKS

STREAM TERRACES

Stream terrace deposits are common along Sespe Creek in the central and eastern parts of the area where they lie with angular unconformity on all rock units except for the Juncal and Santa Margarita Formations. The lithology and origin of these terrace deposits is described in the article by Gutowski (this guidebook).

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MAP 22

Continue through Simi Valley toward Santa Susana Pass at the east end of the valley. This valley is a synclinal depression, and formations ranging in age from Cretaceous to Pleistocene are exposed on its margins. At Oil Canyon, on the north side of the valley, active oil seepages occur on outcrops of oil-saturated sandstone.

At Santa Susana Pass the road traverses a thick section of Cretaceous strata. Cuts east of the top of the grade (Stop 25) provide good exposures of structures, attributable to turbidity flow, that are similar to those in the Pliocene strata at Santa Paula Creek. Here can be seen convolute bedding, pull-aparts, flow clasts, and graded bedding, which are attributable to formation in deep water by submarine landsliding.

Cretaceous rocks in Santa Susana Pass

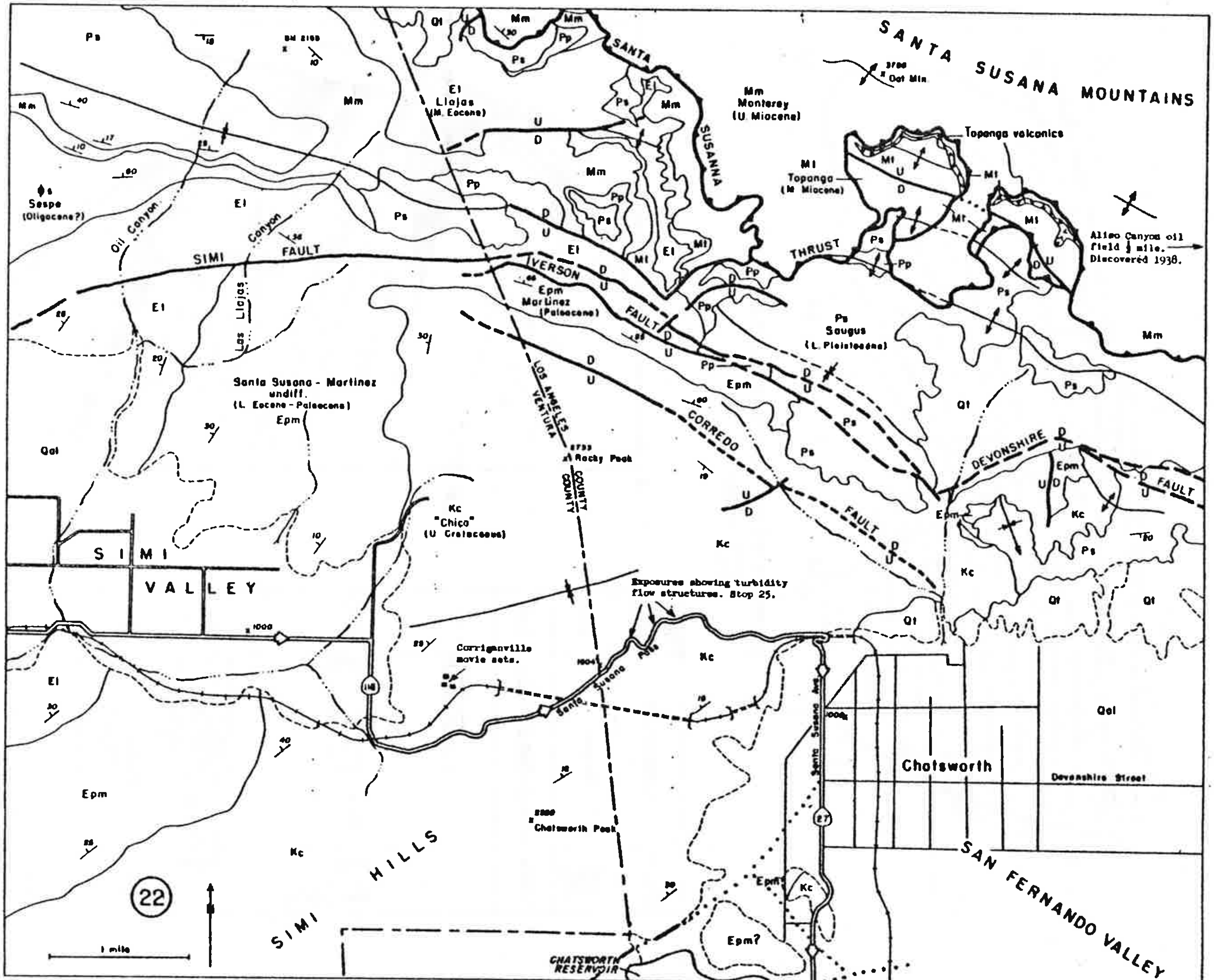
The silver-colored tanks and derricks visible on top of the Santa Susana Mountains to the northeast, and overlooking San Fernando Valley, mark the location of the Aliso Canyon oil field. This field, structurally one of the most complex in California, has oil accumulated in both structural and stratigraphic traps that are contained within a graben concealed beneath the Santa Susana thrust fault. The Santa Susana thrust, one of the most significant faults in these mountains, extends for several miles beyond this area. Because the fault dips gently near the surface, has been recently folded, and is offset locally by tear faults, its trace is very sinuous. The northern block has been thrust southward on the Santa Susana fault for 18 miles along the southern side of the Santa Susana Mountains, and the fault has a minimum vertical displacement estimated to be about 8,000 feet. The fault is nearly flat near the surface, but steepens to almost vertical at depth. It is believed by some geologists to have been steep during its early history and to have later developed a flat segment that roughly followed an erosion surface. It was active as recently as Pleistocene time, as terrace deposits of that age are overridden by the thrust.

Aliso Canyon oil field and Santa Susana thrust

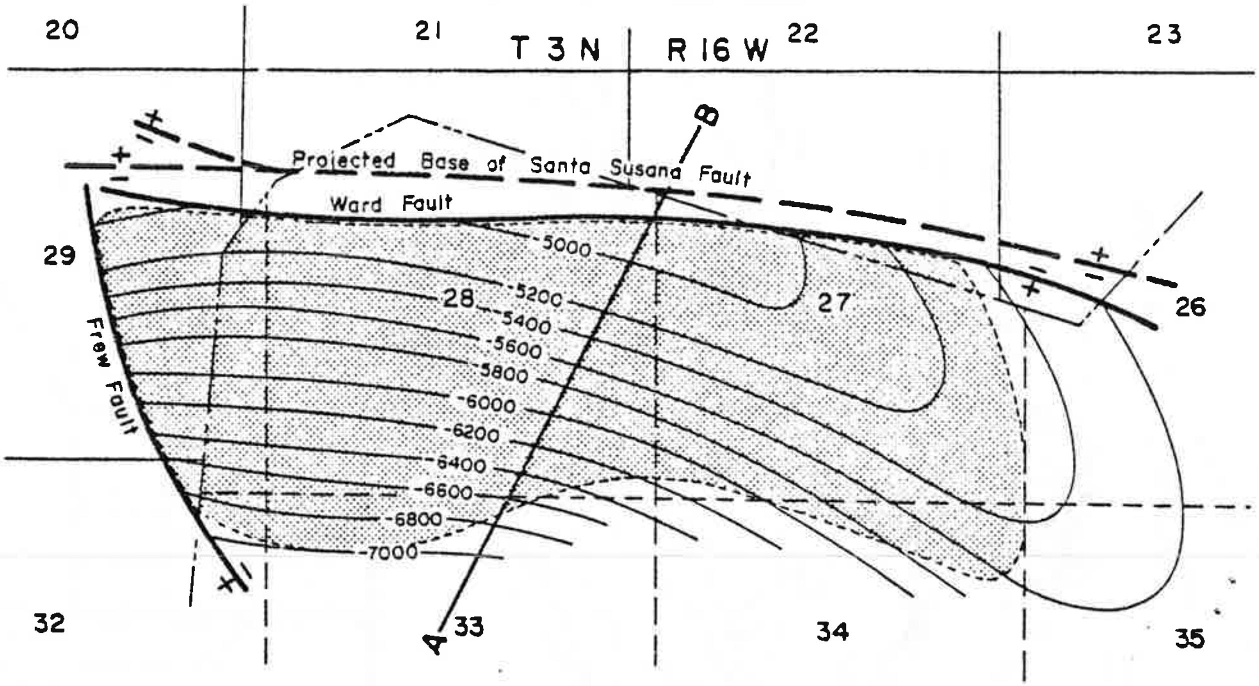
Another feature that demonstrates the recency of deformation in this area can be seen from Stop 25. This is a Pleistocene terrace deposit that is visible along the south flank of the Santa Susana Mountains at a distance of several miles due east. Faulting along the north edge of the valley has caused this terrace deposit to be tilted about 15 degrees northward, toward the mountains from which the sediments were derived.

The rocks exposed in the Santa Susana Mountains, ranging in age from Cretaceous through Pleistocene, are shown in the following generalized columnar section:

Terrace deposits (nonmarine upper Pleistocene)
Saugus (nonmarine Plio-Pleistocene)
Pico (marine upper and lower Pliocene)
Monterey (marine upper and middle Miocene)
Topanga (marine middle Miocene)
Llajas (marine middle Eocene)
Santa Susana (marine lower Eocene)
Martinez (marine Paleocene)
Chico (marine Upper Cretaceous)


SANTA SUSANA MOUNTAINS
Mm
Monterey
(U. Miocene)
Ml
Topanga
(M. Miocene)
Topanga volcanics
Aliso Canyon oil field ½ mile. Discovered 1938.
El
Llajas
(M. Eocene)
Φs
Sespe
(Oligocene?)
Oil Canyon
Las Llajas Canyon
SIMI FAULT
SANTA SUSANNA THRUST
IVERSON FAULT
Epm
Martinez
(Paleocene)
Ps
Saugus
(L. Pleistocene)
CORREDO FAULT
DEVONSHIRE FAULT
Santa Susana - Martinez undiff.
(L. Eocene - Paleocene)
Kc
"Chico"
(U. Cretaceous)
LOS ANGELES COUNTY
VENTURA COUNTY
Rocky Peak
Exposures showing turbidity flow structures. Stop 25.
Corriganville movie sets.
Santa Susana Pass
SIMI VALLEY
SIMI HILLS
Chatsworth Peak
CHATSWORTH RESERVOIR
Santa Susana Ave
Devonshire Street
Chatsworth
SAN FERNANDO VALLEY
Qal
22
1 mile

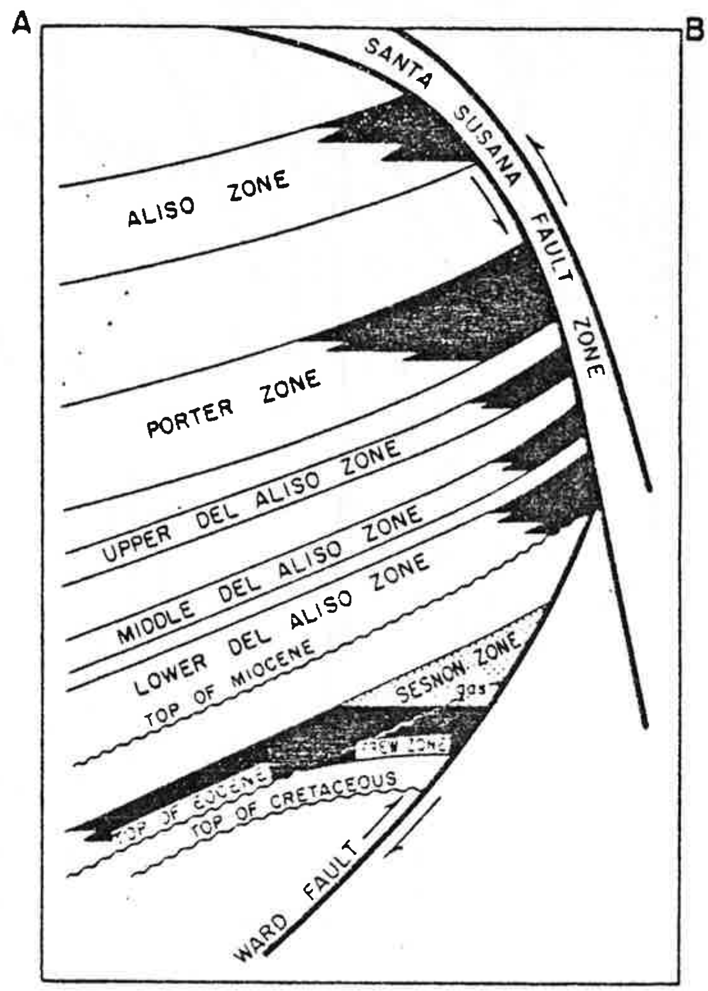
ALISO CANYON OIL FIELD



CONTOURS ON TOP OF SESNON ZONE

PRODUCTIVE AREA

EPOCH		FORMATION	Thick-ness (Feet)
MIO-CENE		Modelo	3500
SANTA SUSANA THRUST FAULT			650
PLIOCENE	Upper	Pico (Aliso; Porter; Upper Del Aliso)	3000
	Lower	"Repetto" (Middle Del Aliso; Lower Del Aliso)	600
MIO-CENE		Modelo (Sesnon)	650
EOCENE		Llajas (Frew)	500
CRETA-CEOUS		undifferentiated	?



CALIFORNIA DIVISION OF OIL AND GAS

FIELD DATA SHEET

ALISO CANYON OIL FIELD
Los Angeles County

LOCATION 5 miles southwest of Newhall.

DISCOVERY DATA Tidewater Associated Oil Co. (now Tidewater Oil Co.) well No. "Porter" 1, Sec. 27, T. 3 N., R. 16 W., S.B.B.& M. Completed October 25, 1938. I.P. 700 b/d 22.1-degree gravity oil.

STRUCTURE Faulted, plunging anticline.

ELEVATION 1,680-3,330 BASE OF FRESH WATERS 100-800 SPACING ACT APPLIES Yes

PRODUCING ZONES

Name of Zone or E. Log Marker	Average Depth (feet)	Average Thickness (feet)	Geologic Age	Geologic Formation	Gravity or B.t.u.	Salinity of Zone Water Gr./Gal.
Aliso	4,300	100	U. Pliocene	Pico	12-17	1,000
Porter	5,050	150	U. Pliocene	Pico	21-25	1,000
Del Aliso	6,500	200	U. & L. Pliocene	Pico & "Repetto"	17-27	1,000
Sesnon	8,100	110	M. Miocene	Modelo	20-53	700
Frew	8,650	190	U. Eocene	Llajas	20-23	900

DEEPEST WELL DATA Tidewater Associated Oil Co. (now Tidewater Oil Co., Operator) well No. "Standard-Sesnon 1" 17, Sec. 28, T. 3 N., R. 16 W. T.D. 12,417 in Cretaceous. Redrilled and completed in Sesnon zone.

PRODUCTION DATA—JANUARY 1, 1961

Cumulative Oil (bbl.)	35,092,940	Total Wells Drilled	187
Cumulative Gas (Mcf.)	47,098,964	Total Wells Completed	143
1960 Average Oil (b/d)	4,701	Producing Wells (1960 Aver.)	116
1960 Average Gas (Mcf/d)	9,617	Maximum Proved Acreage	1,085
Peak Production (1955) (bbl.)	2,906,872		

USUAL CASING PROGRAM
13-3/8" cem. 500
7" cem. over zone
5-1/2" perforated liner

BOP EQUIPMENT Required

MISCELLANEOUS Since June 22, 1953, the oil field has been operated under a court order limiting gas production of each well producing from the Sesnon zone to 4,500 cubic feet per barrel of oil.

REFERENCES Calif. Div. of Oil and Gas "Summary of Operations" Vol. 29, No. 1 (1943) and Vol. 45, No. 1 (1959).

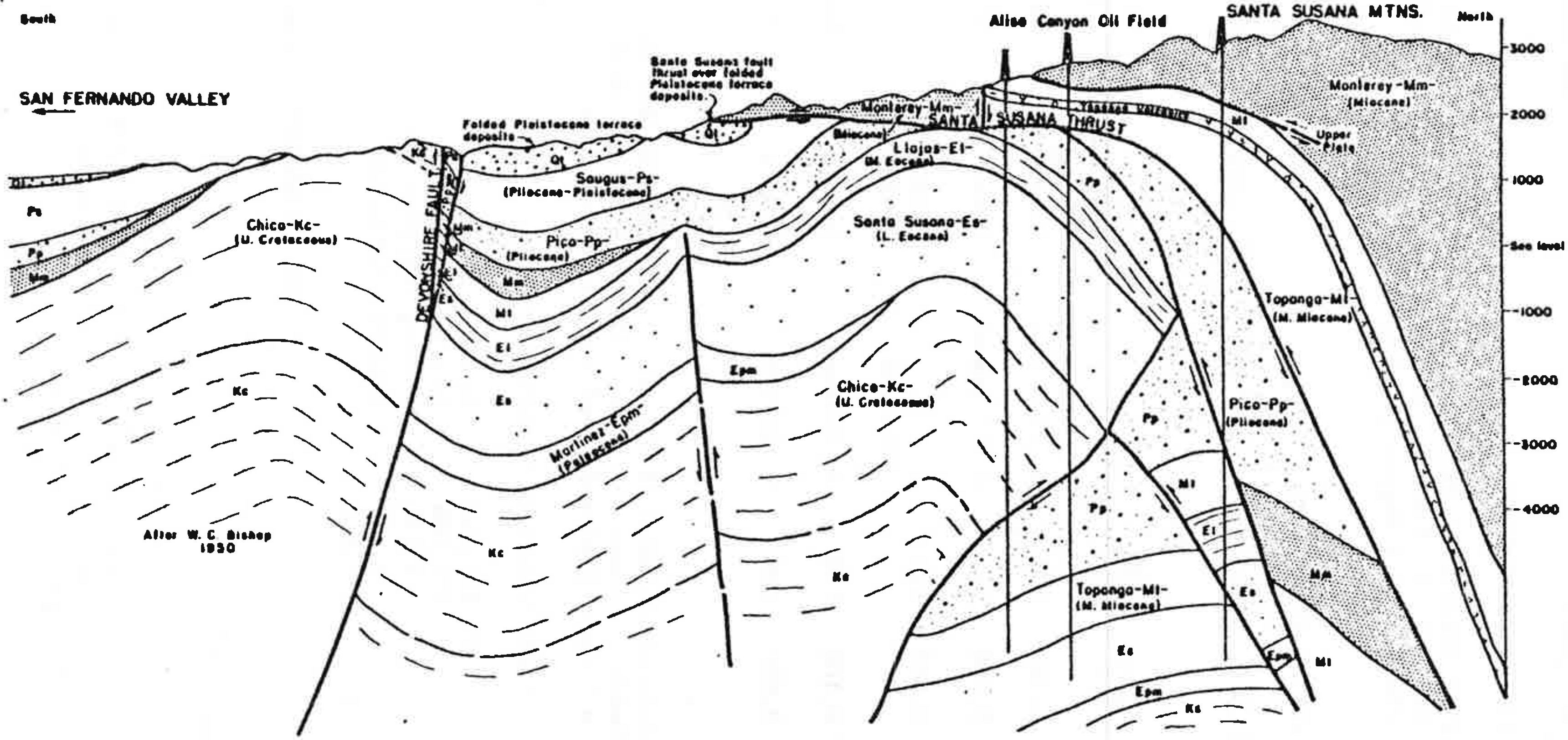
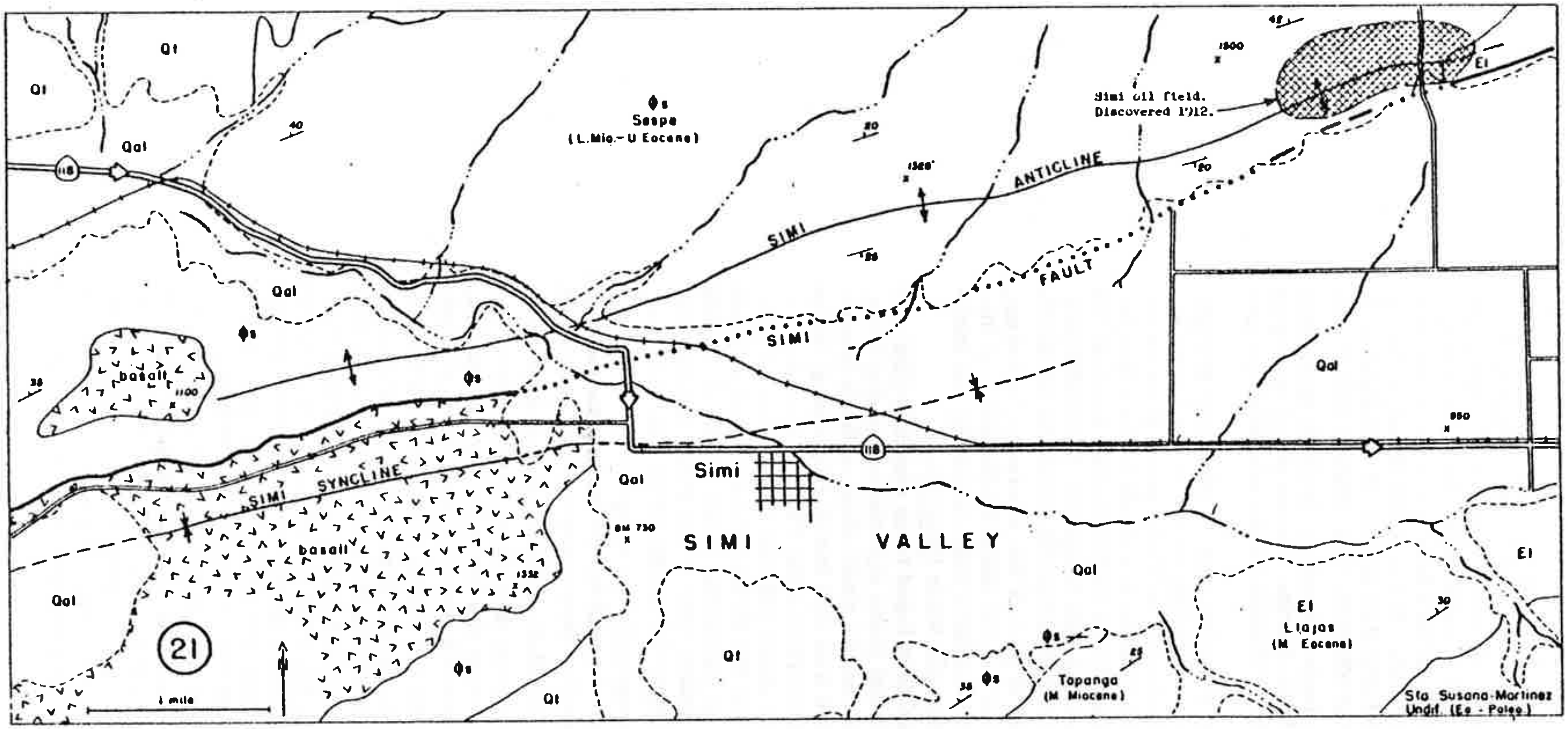


Fig. 28. Cross section through Aliso Canyon oil field.



MAP 21

In a steep roadcut, about 3.7 miles east of Moorpark, red and white sandstone and siltstone of the Sespe formation are exposed. The hilltop on the right (south) of the road is capped by a Miocene basalt flow. An even more extensive mass of basalt covers the hill that is just west of the town of Simi.

The Simi oil field lies on the Simi anticline, which closely parallels the north side of the valley. The axis of this fold crosses the highway about 29 miles northwest of the town of Simi. South of the anticline, and roughly parallel to it, is a prominent fault that follows the foot of the hills. This fault, or others related to it, have modified the structure of the anticline and may have influenced the accumulation of petroleum in the oil field. The oil wells pass through the Sespe red beds near the surface, and most of the production is obtained from the upper part of the underlying Llajas (middle Eocene) formation. The production is small, but the oil, unlike typical California Miocene and Pliocene oils, contains a high percentage of paraffin. Approximately 50 wells are being pumped, and each yields about $2\frac{1}{2}$ barrels per day. The total output of oil from the Simi field is more than $2\frac{1}{2}$ million barrels.

Simi oil field

The basal beds of the Sespe formation and the Llajas formation (middle Eocene) are exposed east of the field. This is the area in which the lower part of the Sespe formation has been dated as upper Eocene on the basis of a meagre vertebrate fauna. The Llajas beds are highly fossiliferous.

MAP 20

From South Mountain the route continues east through the Bardsdale oil field at the mouth of Grimes Canyon. This is another of the anticlinal fields that lie en echelon along the north slopes of Oak Ridge. It is notable for its early discovery (1891) and for a very low rate of decline in production. Some of the oldest wells in this field are still active, or are capable of further production. The original output was obtained solely from the Sespe formation. In 1936, additional production was obtained from marine Eocene strata at depths greater than 5,000 feet. Upper Eocene rocks are several thousand feet thick at depth.

Bardsdale oil field

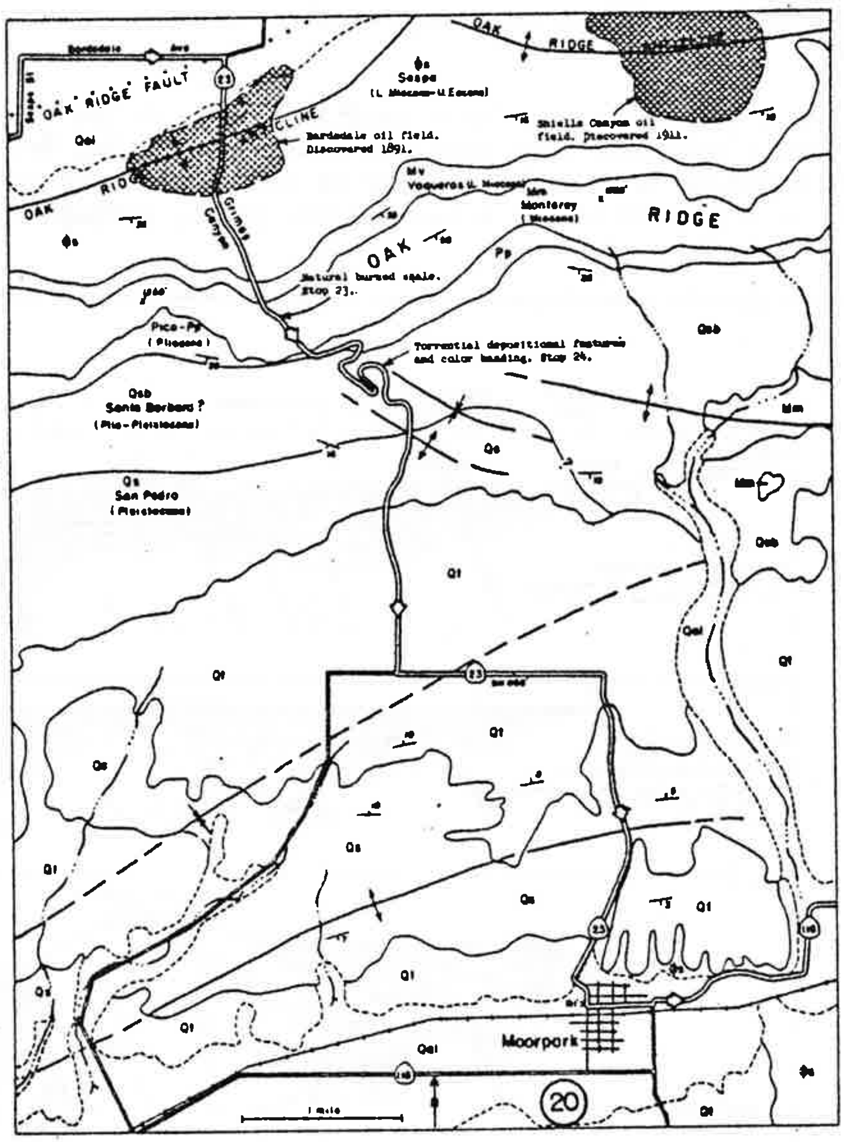
The Grimes Canyon road displays an excellent section of Tertiary and Quaternary rocks that range in age from Oligocene at the mouth of the canyon to Pleistocene at the crest of Oak Ridge. Here the formations are much thinner than in the Santa Clara River Valley to the north. During much of the Tertiary period the area along Oak Ridge was intermittently uplifted, or did not subside as rapidly as the terrain to the north.

The bright red color of part of the Monterey formation, so conspicuous in Grimes Canyon about a mile south of the Bardsdale field, is believed to have been caused by the burning of organic layers within the shale (Stop 23).

Locally the rock has been fused to an obsidian-like material. Until recent years hot gases and smoke issuing from a fissure in Miocene shale on the south slope of South Mountain indicated that the shale was still burning in places. Higher on the grade, the road traverses the Pico (Pliocene) formation, which here is only about 500 feet thick. This formation thickens westward along the strike, and pinches out to the east. The Pico formation is 14,000 feet thick on the north side of the Santa Clara River Valley near Santa Paula Creek, just a few miles from here (Map 10)! Cross-bedded sandstones, stratigraphically above the Pico formation, are exposed still higher on the grade (Stop 24). Here the coarse nature of the sediments, the prominent cross-bedding, and other structural features typical of torrential deposition are very well displayed. A few miles to the west the Santa Barbara formation, of nearly equivalent age, consists mostly of blue-gray silt that grades into the coarse sand and gravel seen here. Such shallow-water features are in marked contrast to the deep-sea, turbidity-flow features shown in the Pliocene sediments at Santa Paula Creek and in the Cretaceous rocks at Santa Susana Pass, San Fernando Valley (Map 23). Note the peculiar, rusty brown color banding in the prominent roadcut on the second hair-pin turn. This banding commonly lies athwart the bedding, and is attributable to the effects of percolating ground waters.

Grimes Canyon

From the top of the grade southeastward to Moorpark the road crosses a broad plain or terrace covered with a deposit of late Pleistocene sand and gravel. Just north of Moorpark the road passes through a canyon cut into loosely consolidated sand and gravel of the San Pedro (Pleistocene) formation. Turn left at Moorpark and proceed eastward into Simi Valley.


OAK RIDGE FAULT
Qal
RIDGE
OAK
Sespe
Bardsdale oil field. Discovered 1891.
Shiells Canyon oil field. Discovered 1911.
OAK
RIDGE
Mv
Monterey
RIDGE
OAK
Pp
Grimes Canyon
Natural burned shale. Stop 23.
Pico-Pp
(Pliocene)
Torrential depositional features and color banding. Stop 24.
Qsb
Santa Barbara ?
Qsb
Mm
Qs
San Pedro
(Pleistocene)
Qt
Qal
Qs
Moorpark
20

Mileage 67.9 - STOP 1. Pico sandstones and conglomerates with repeated graded bedding, flame structure and shale clasts, features generally attributed to turbidity-current deposition. This outcrop is representative of the Pico from this point downsection to the Miocene. Directional features and basement clasts indicate an eastern source. Although present-day uplands east of here (Simi Hills, Santa Susana Mountains), are composed of mainly pre-Pliocene sedimentary rocks, the clast types in these conglomerates are almost entirely crystalline. Occasional clasts of anorthosite and norite suggest a source in the San Gabriel Mountains.

Walk up the road past a thin mudstone section to cross-bedded sandstone and conglomerates which appear to be of shallow-water origin. Clast types in the conglomerates are similar to those in the deep-water sediments.

As a general rule, the turbidite facies of the Pico is separated both vertically and laterally from the shallow-water San Pedro-Saugus facies by a thick mudstone unit. The absence of the mudstone at Grimes Canyon is attributed to its position in a basin entry point, perhaps filling a submarine canyon.

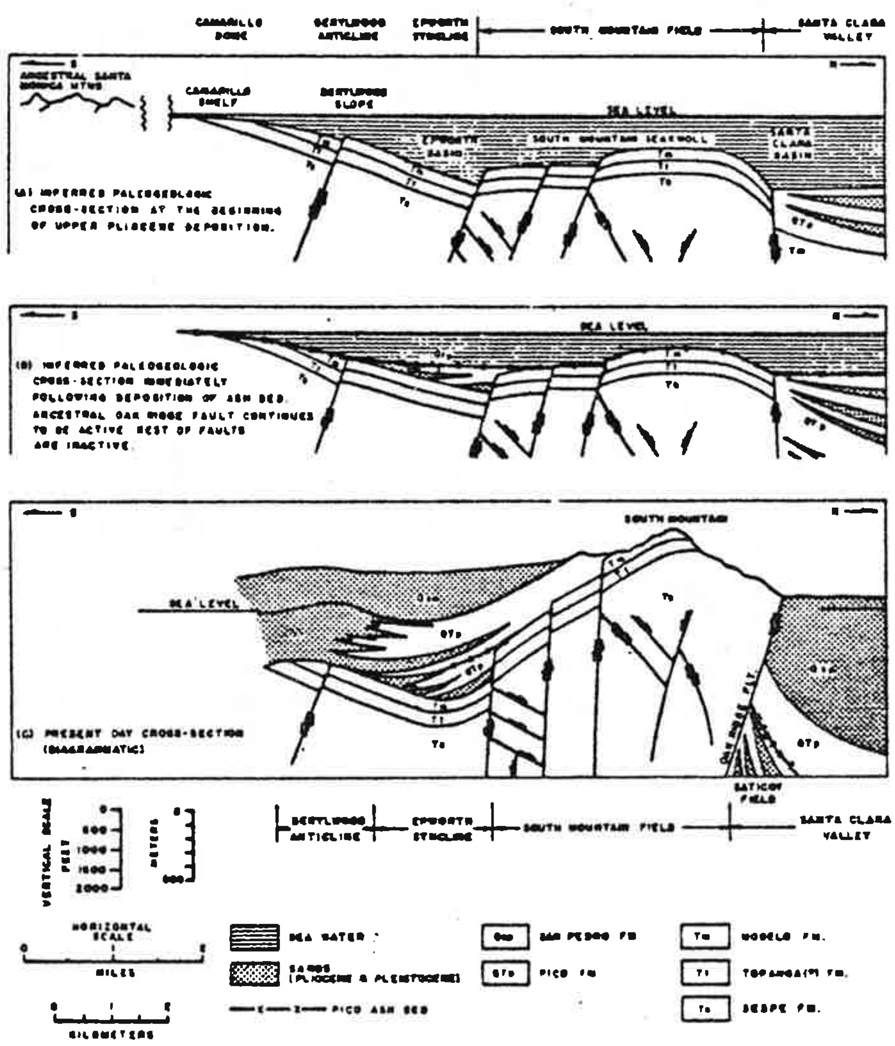
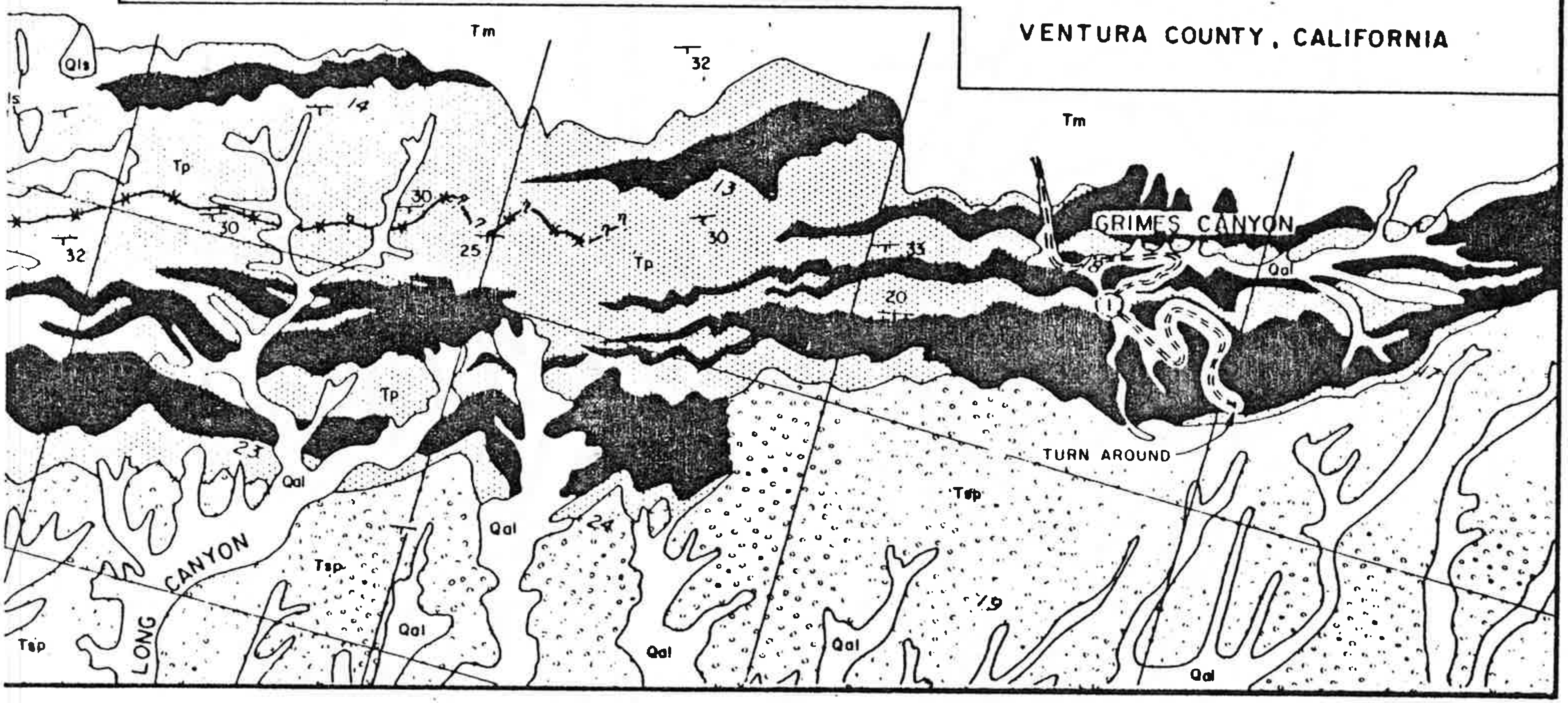


Fig. 4

GEOLOGY OF PART OF

SOUTH MOUNTAIN — OAK RIDGE AREA

VENTURA COUNTY, CALIFORNIA



Relationship of buried Modelo Fault scarps to intra-Pico ash bed, which continues unfaulted over the tops of the scarps in Section 19. Within the Pico Formation, sands are shown in black and fine-grained sediments in fine stipple pattern. Sands are abundant east of Balcom Canyon, shale out westward in the direction of South Mountain. Base map Moorpark and Santa Paula 7 1/2 minute quadrangles, U.S. Geological Survey 1951

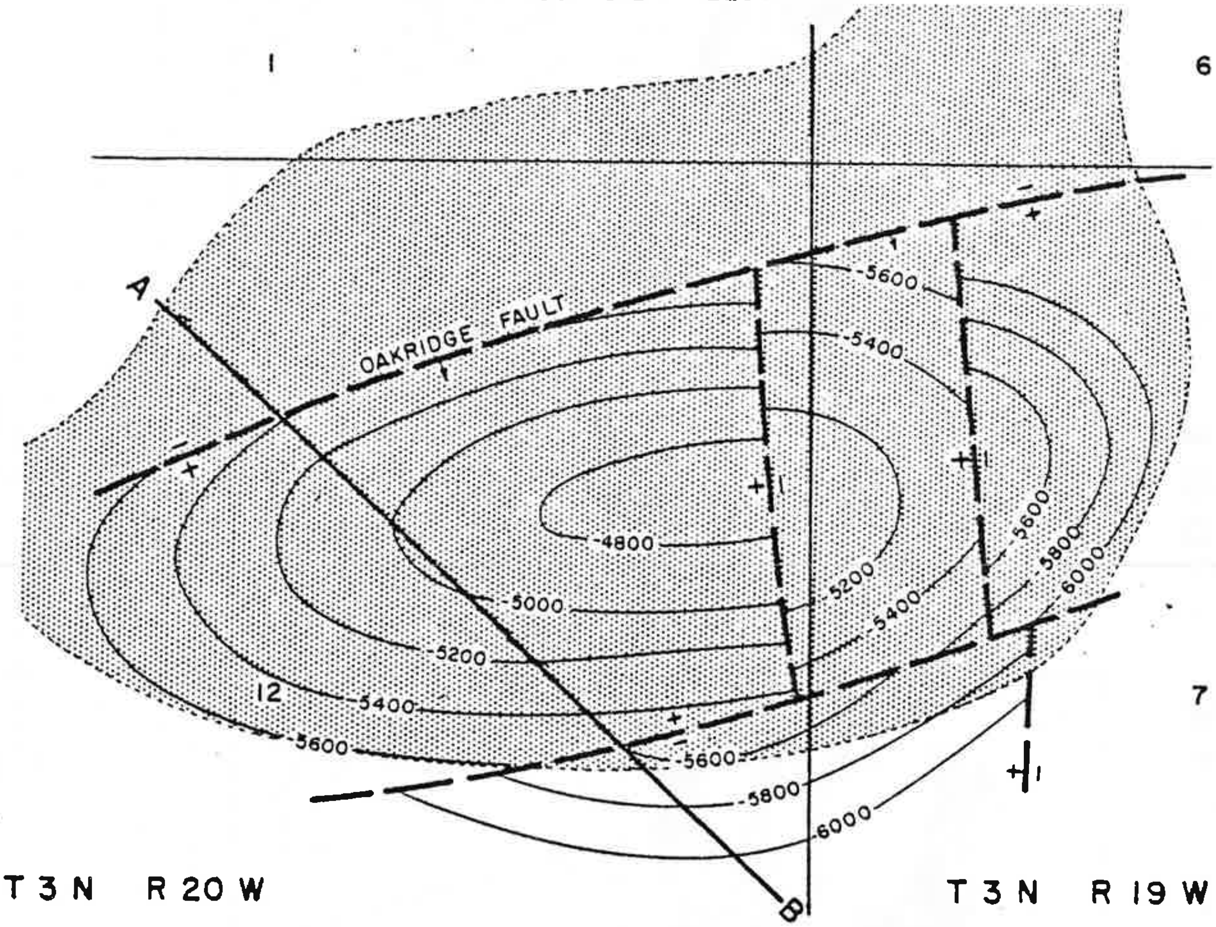
= = = FIELD TRIP ROUTE

(1) FIELD TRIP STOP

LEGEND

Qal	ALLUVIUM AND TERRACE	Tp	PICO FM.	Ta	ANDESITE SILL
Qls	LANDSLIDE MATERIAL	Tm	MODELO FM.	Ts	SESPE FM.
Tsp	SAN PEDRO FM.	Tms	MIOCENE SANDSTONE	—✕—✕—	ASH BED
				———	FAULT

BARDSDALE OIL FIELD



CONTOURS ON TOP OF THE E_{12} MARKER

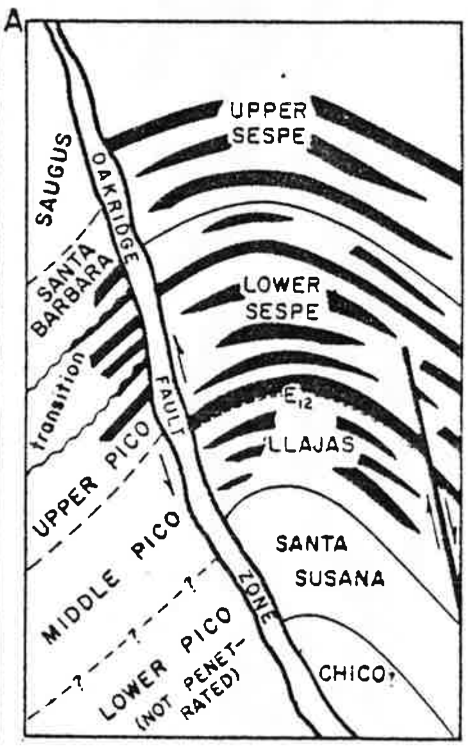
Scale

0 1000 2000 FT

PRODUCTIVE AREA

North of Oakridge Fault

EPOCH	FORMATION		Thickness (Feet)
PLEISTOCENE	Saugus		2000
	Santa Barbara		2000
Transition			600
PLIOCENE	Pico	Upper	6000
		? Middle	364+
		Lower	not penetrated



South of Oakridge Fault

EPOCH	FORMATION		Thickness (Feet)
OLIGOCENE	Sespe	Upper	2750
		Lower	2800
EOCENE	E_{12} Llajas		2500
	Santa Susana		2000
CRETACEOUS	Chico ?		300+

CALIFORNIA DIVISION OF OIL AND GAS

FIELD DATA SHEET

BARDSDALE OIL FIELD
Ventura County

LOCATION 2 miles south of Fillmore

DISCOVERY DATA Union Oil Co. of Calif. well No. "Robertson" 2, Sec. 12, T. 3 N., R. 20 W., S.B.B.& M. Completed March 24, 1892. I.P. 25 b/d.

STRUCTURE An elongated dome truncated by the Oakridge fault

ELEVATION 725± BASE OF FRESH WATERS * SPACING ACT APPLIES No

PRODUCING ZONES

Name of Zone or E. Log Marker	Average Depth (feet)	Average Thickness (feet)	Geologic Age	Geologic Formation	Gravity or B.t.u.	Salinity of Zone Water Gr./Gal.
Irwin	5,580	660	(Pleistocene	Santa Barbara	29	300
			(Pliocene	U. Pico	29	300
S Series	(2,230	1,300	Oligocene	U. Sespe	25	1,950
	(4,175	2,100		L. Sespe	25	2,000
E Series	6,620	2,450	Eocene	Llajas	33	1,900

DEEPEST WELL DATA Union Oil Co. of Calif. well No. "Irwin-Berylwood" 5, Sec. 1, T. 3 N., R. 20 W. T.D. 16,457 in M. Pico (Pliocene).

PRODUCTION DATA—JANUARY 1, 1961

Cumulative Oil (bbl.)	9,271,358	Total Wells Drilled	237
Cumulative Gas (Mcf.)	60,722,869	Total Wells Completed	192
1960 Average Oil (b/d)	1,624	Producing Wells (1960 Aver.)	130
1960 Average Gas (Mcf/d)	3,555	Maximum Proved Acreage	590
Peak Production (1951) (bbl.)	715,285		

USUAL CASING PROGRAM BOP EQUIPMENT Required

11-3/4" cem. 350
7" cem. above zone
5-1/2" perforated liner hung through zone or a combination string cemented through ports above the zone with perforations below the ports

MISCELLANEOUS *None above the Oakridge fault
Production was rejuvenated by the discovery of the Eocene zones in 1936 and again in 1956 with discovery of the Pleistocene-Pliocene zone. Both discoveries were made by the Union Oil Co. of Calif.

REFERENCES Calif. Div. of Oil and Gas "Summary of Operations" Vol. 10, No. 5 (1924) Vol. 22, No. 3 (1937), Vol. 31, No. 2 (1945), Vol. 43, No. 2 (1957)

MAP 19

At Santa Paula, turn right (south) onto Riverside Drive, cross the Santa Clara River, and proceed eastward following the river road to South Mountain. The oil field on the precipitous slopes of South Mountain, is one of a chain of fields along the Oak Ridge uplift, which is marked by a series of en echelon anticlines. The north flank of the South Mountain anticline is cut by the Oak Ridge thrust fault, here concealed by alluvium, which has brought rocks of Oligocene and Miocene age northward over strata as young as Pleistocene. The road on the north side of South Mountain crosses steeply dipping and overturned red beds of the Sespe formation. Wells here penetrate the thrust fault at depth, and show that it has a dip of 55 degrees or more to the south; the displacement is measurable in thousands of feet.

South Mountain oil field

The South Mountain oil field is picturesque because of the deep erosion that has beautifully exposed the variegated rocks of the Sespe formation. Some of the derrick locations are so inaccessible that drilling equipment had to be transported to them by way of specially constructed inclined railways. The first producing well on South Mountain, completed in April 1916, recovered oil from zones in the Sespe formation. Since then some wells have reached the top of marine sedimentary rocks of Eocene age, and some have pierced the Oak Ridge fault and passed into younger sediments below. This is illustrated in the cross section shown in fig. 26

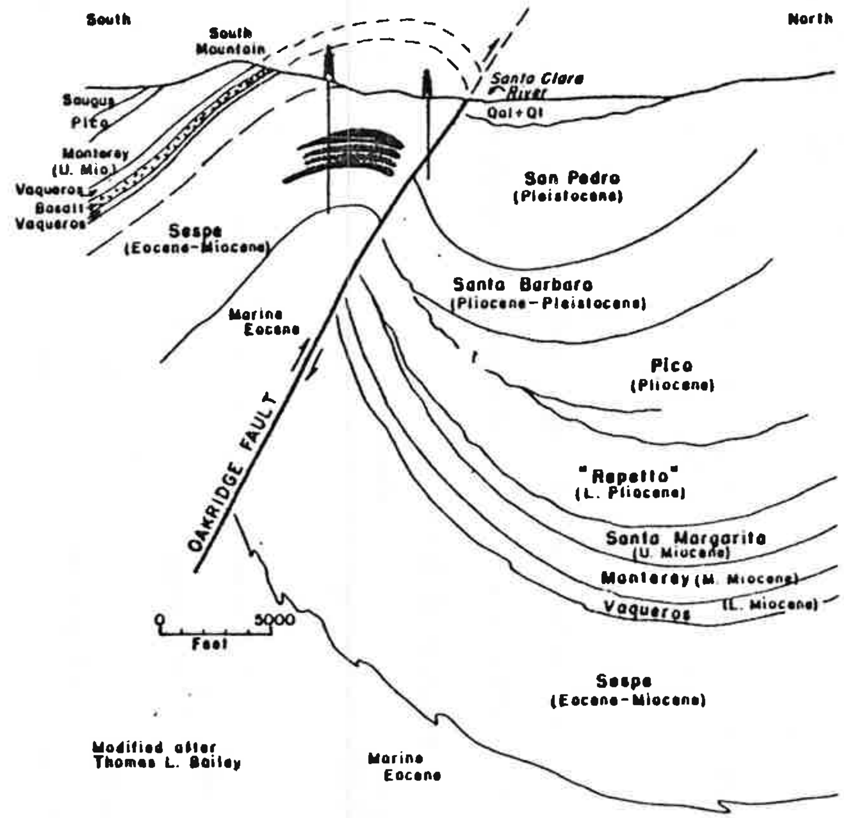
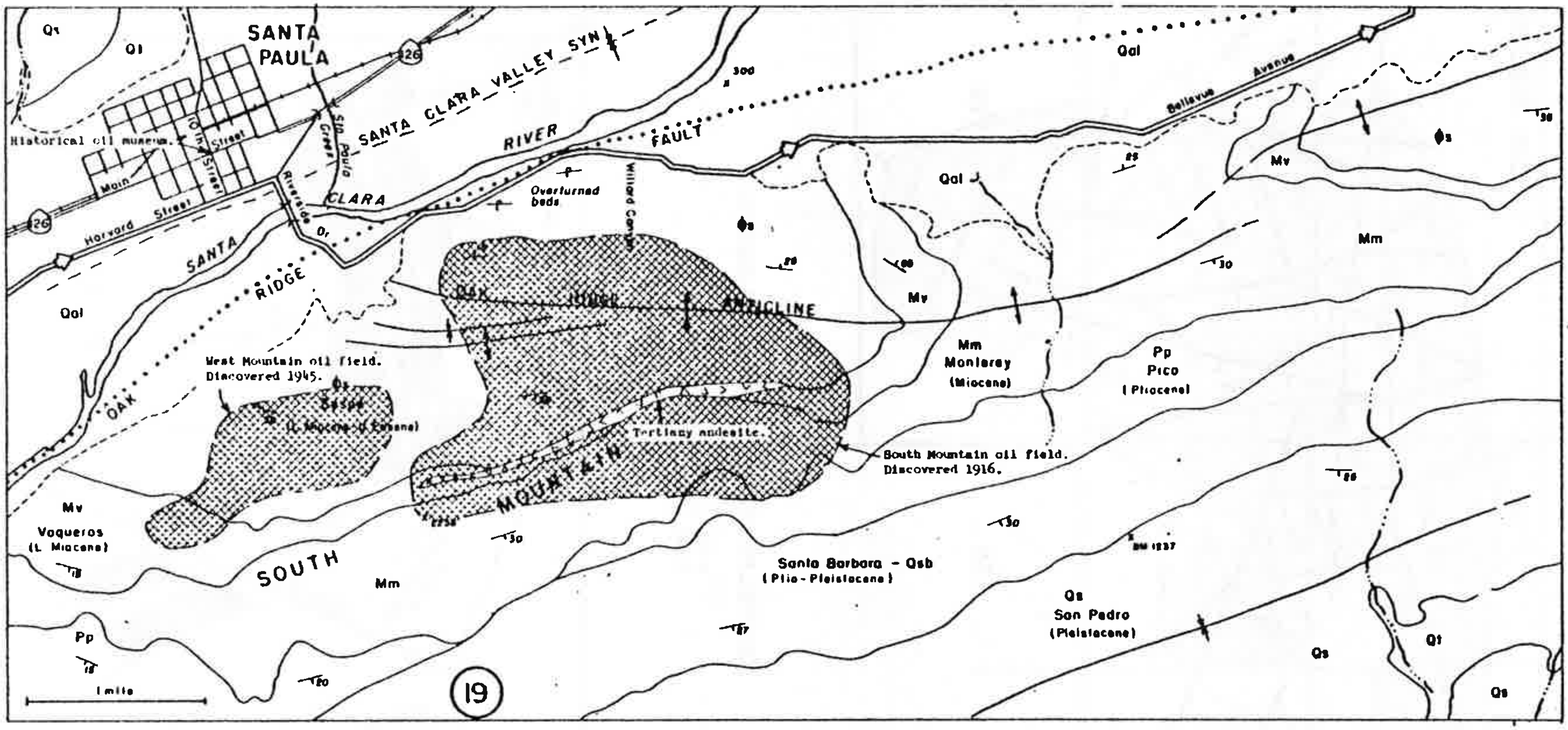


Fig. 26. Cross section through South Mountain oil field.

Origin of oil from Sespe formation

The origin of the oil being produced from these rocks poses a difficult problem. The oil generally is believed to have originated in marine sediments, and to have migrated into nonmarine strata; some geologists, however, believe the oil might be indigenous to the Sespe formation. If the oil migrated from petroliferous marine strata, it may have been derived from the marine shales of Eocene age that underlie the Sespe (mainly Oligocene) formation beneath South Mountain. Some of the oil may have migrated laterally from marine Eocene rocks that lie beneath the Santa Clara syncline (see fig. 26), and some may have migrated upward from Miocene or Pliocene rocks that lie below and on the north side of the Oak Ridge fault. Countless tiny cracks and joints in the shale beds between the source rocks and res-



ervoir rock may have acted as channels for upward migration.

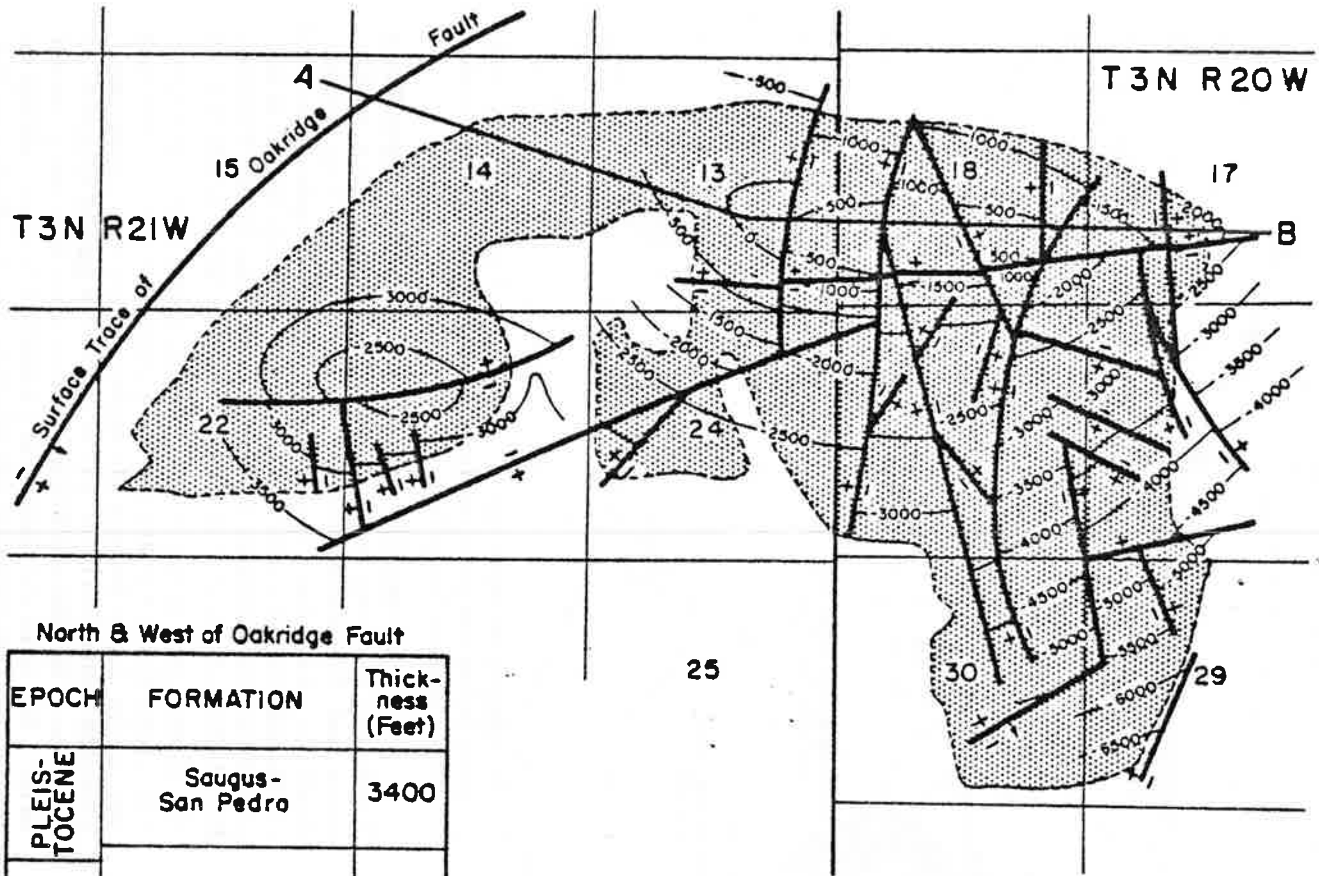
On clear days, a side trip to the top of South Mountain affords a magnificent view of the Santa Clara River Valley and the Santa Ynez Mountains. On exceptionally clear days, generally following rainstorms, it is possible to see all four of the Channel Islands and one or two of the Catalina group to the south and west. On the distant skyline to the east, one can

View from South Mountain

see the San Gabriel Mountains dominated by San Antonio Peak, more than 80 miles away. Directly north across the Santa Clara River Valley rises the Santa Paula Ridge, composed of Eocene sedimentary rocks. An extremely thick section of Pliocene rocks is exposed on its lower slopes, and the two units are separated by the San Cayetano thrust, which dips steeply northward. The trace of the fault is clearly shown by differences in rock types in the underlying Pliocene and overlying Eocene rocks, by a break in slope, and by differences in vegetation. The Timber Canyon alluvial fan, directly below the San Cayetano thrust, is clearly observable from this side of the valley.

Along the banks of Santa Paula Creek, west of Santa Paula Ridge, lies an intact section, nearly 20,000 feet thick, of Pliocene and Pleistocene rocks. West of the creek is Sulphur Mountain, a long, narrow ridge topped by a flat upland surface and flanked on the south by a steep escarpment. North of Sulphur Mountain and Santa Paula Ridge are the higher Topatopa Mountains, culminating in Hines Peak, elevation 6,700 feet, at the eastern end of the range. Looking to the south, one sees the broad Oxnard Plain and the abruptly terminated western end of the Santa Monica Mountains. In the near foreground rises the Camarillo Hills, which express a gentle anticline on the edge of the Oxnard Plain. The flexure is of very recent origin, for even the Quaternary alluvium is bowed gently on the flanks of this anticline and the strata of the San Pedro formation generally dip parallel to the surface of the hills.

SOUTH MOUNTAIN OIL FIELD



CONTOURS ON BASE OF CONGLOMERATE

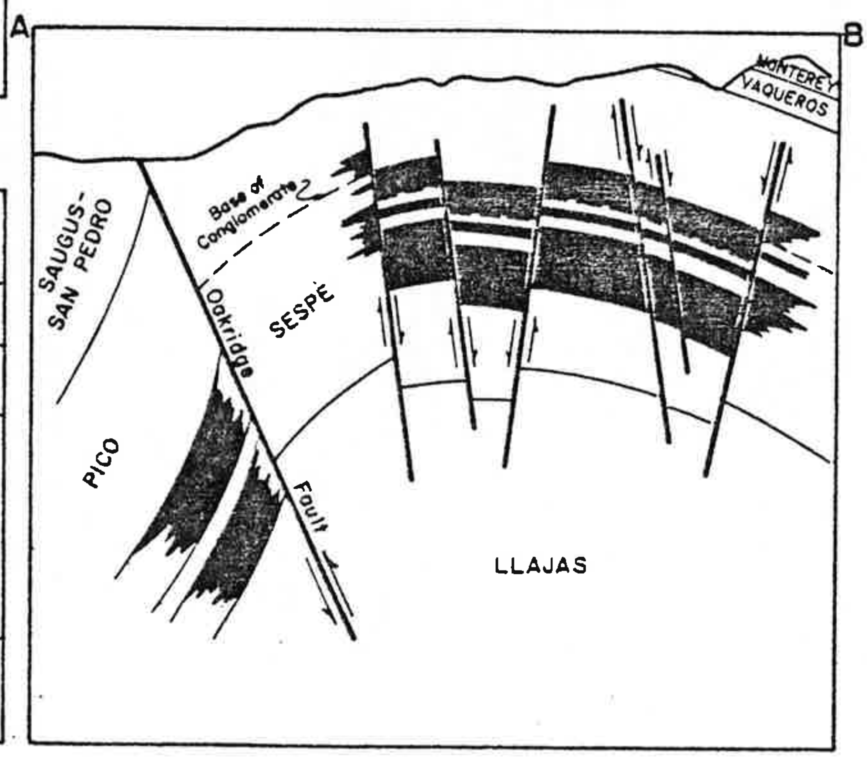
PRODUCTIVE AREA

North & West of Oakridge Fault

EPOCH	FORMATION	Thickness (Feet)
PLEISTOCENE	Saugus-San Pedro	3400
PLIOCENE	Pico	8650+

South & East of Oakridge Fault

EPOCH	FORMATION	Thickness (Feet)
MIOCENE	Monterey	0 to 1200
	Vaqueros	0 to 1100
OLIGOCENE	Base Conglomerate--- Sespe	7000
EOCENE	Llajas	2600 (drilled)



CALIFORNIA DIVISION OF OIL AND GAS
FIELD DATA SHEET

SOUTH MOUNTAIN OIL FIELD
Ventura County

LOCATION One mile south of Santa Paula

DISCOVERY DATA Oakridge Oil Co. (now Texaco Inc.) well No. "South Mountain" 1, Sec. 13, T. 3 N., R. 21 W., S.B.B.& M. Completed April 5, 1916. I.P. 25 b/d 25-degree gravity oil.

STRUCTURE Faulted dome above, stratigraphic and fault traps below Oakridge fault zone

ELEVATION 250-2,200 BASE OF FRESH WATERS * SPACING ACT APPLIES No

PRODUCING ZONES

Name of Zone or E. Log Marker	Average Depth (feet)	Average Thickness (feet)	Geologic Age	Geologic Formation	Gravity or B.t.u.	Salinity of Zone Water Gr./Gal.
Sespe	1,250-) 7,000)	2,000	Oligocene	Sespe	22	(915- (2,090
Bridge	7,200	1,250	Pliocene	Pico	33	525

*No fresh waters except near outer boundary of field

DEEPEST WELL DATA Texaco Inc. well No. "T-U Norman Richardson Heirs" 1, Sec. 14, T. 3 N., R. 21 W. T.D. 13,412 in Pico (Pliocene).

PRODUCTION DATA—JANUARY 1, 1961

Cumulative Oil (bbl.)	89,548,378	Total Wells Drilled	591
Cumulative Gas (Mcf.)	174,645,499	Total Wells Completed	552
1960 Average Oil (b/d)	18,407	Producing Wells (1960 Aver.)	130
1960 Average Gas (Mcf/d)	43,180	Maximum Proved Acreage	590
Peak Production (1959) (bbl.)	7,436,184		

USUAL CASING PROGRAM BOP EQUIPMENT Required

Shallow Sespe: 8-5/8" cem. over zone; 5-1/2" perf. liner
Deeper Sespe: 11-3/4" cem. 315; 5-1/2" cem. through zone, selectively perforated
Bridge Pool: 10-3/4" cem. 750; 7" combination string through zone, c.p. over zone and c.p. below productive Sespe sands

MISCELLANEOUS Texaco Inc. initiated a pilot water flood in the Sespe sands on July 1, 1956. Humble Oil & Refining Co. has one gas injection well. Union Oil Co. of Calif. injects waste water in well No. "C & H" 1

REFERENCES
Calif. Div. of Oil and Gas "Summary of Operations" Vol. 10, No. 5 (1924) and Vol. 29, No. 2 (1943) or Reprint No. 4 (1957)
AAPG-SEPM Guidebook Joint Ann. Mtg., Los Angeles, 1958
Calif. Div. of Mines Bull. 170 (1954) Map Sheet No. 29

MAP 10

Several Quaternary terraces are clearly discernible along the mountain slopes bordering the Santa Clara River Valley, as is the well developed alluvial fan at the mouth of Timber Canyon. Timber Canyon has been filled with detrital material derived from the steep scarp of the San Cayetano thrust that rises above it. This fan deposit is best observed from points on the opposite side of the valley, where it can be seen in its entirety.

Timber Canyon fan

The California Oil Museum, on the corner of 10th and Main Streets in Santa Paula, is housed in the building where the Union Oil Company was founded in 1890. The museum contains equipment used in the early days of oil development in the region.

Oil Museum

For 4 miles north along Santa Paula Creek, Highway 150 traverses, at right angles to the strike, an uninterrupted homoclinal section of Pliocene and Pleistocene deposits. The total thickness of this section is approximately 17,000 feet, of which about 12,000 feet comprises Pliocene strata. In Adams Canyon, 2 miles to the west, these sediments approach 20,000 feet in thickness, and are believed to form the thickest section of marine Pliocene and Pleistocene rocks in California, and one of the thickest in the world.

Santa Paula Creek Pliocene section

The Pliocene sediments contain many structural features that have been attributed to deposition in deep water by turbidity currents. Such subsurface currents contain sediments in suspension, and when once initiated flow along the floor beneath a body of still water owing to the greater density of the mixture of water and solid material. Turbidity-current structures are particularly well exposed in the banks of Santa Paula Creek at Stop 14. Sandstones, in thin layers interbedded with shale, are believed to have been first deposited in a deep marine basin several miles from the shore, and then later transported into the central and deeper parts of the basin by means of turbidity currents. Ecological studies of Foraminifera in the Pliocene Pico formation indicate that these beds were deposited in marine waters several thousand feet deep, certainly out of reach of near-shore sedimentation, and for this reason the turbidity-current origin for these beds appears most attractive. Examples of most turbidity-current structures such as graded bedding, load casts, pull-aparts, slump structures, convolute bedding, and current bedding can be observed in the banks of Santa Paula Creek.

Turbidity-current structures

Sulphur Mountain north of Stop 14, is essentially a south-dipping homocline of Miocene sediments locally overturned to the north. These structural relations are shown in figure 14. The bold escarpment on the south side of Sulphur Mountain, first interpreted as a fault scarp, is now thought to be an effect of differential erosion between resistant shale of the Monterey formation and the softer underlying shale of the 'Santa Margarita' formation.

Sulphur Mountain

On each side of Highway 150 are conspicuous alluvial terraces formed by the ancestral Santa Paula Creek, which flowed southward. The various levels reflect periodic rejuvenations of the stream, which now is actively cutting downwards.

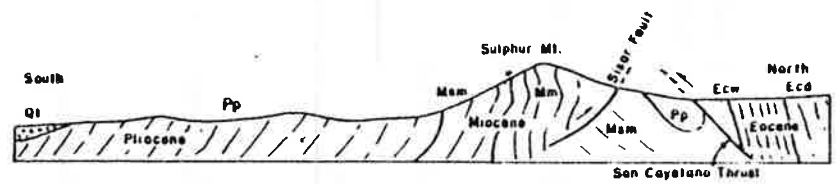
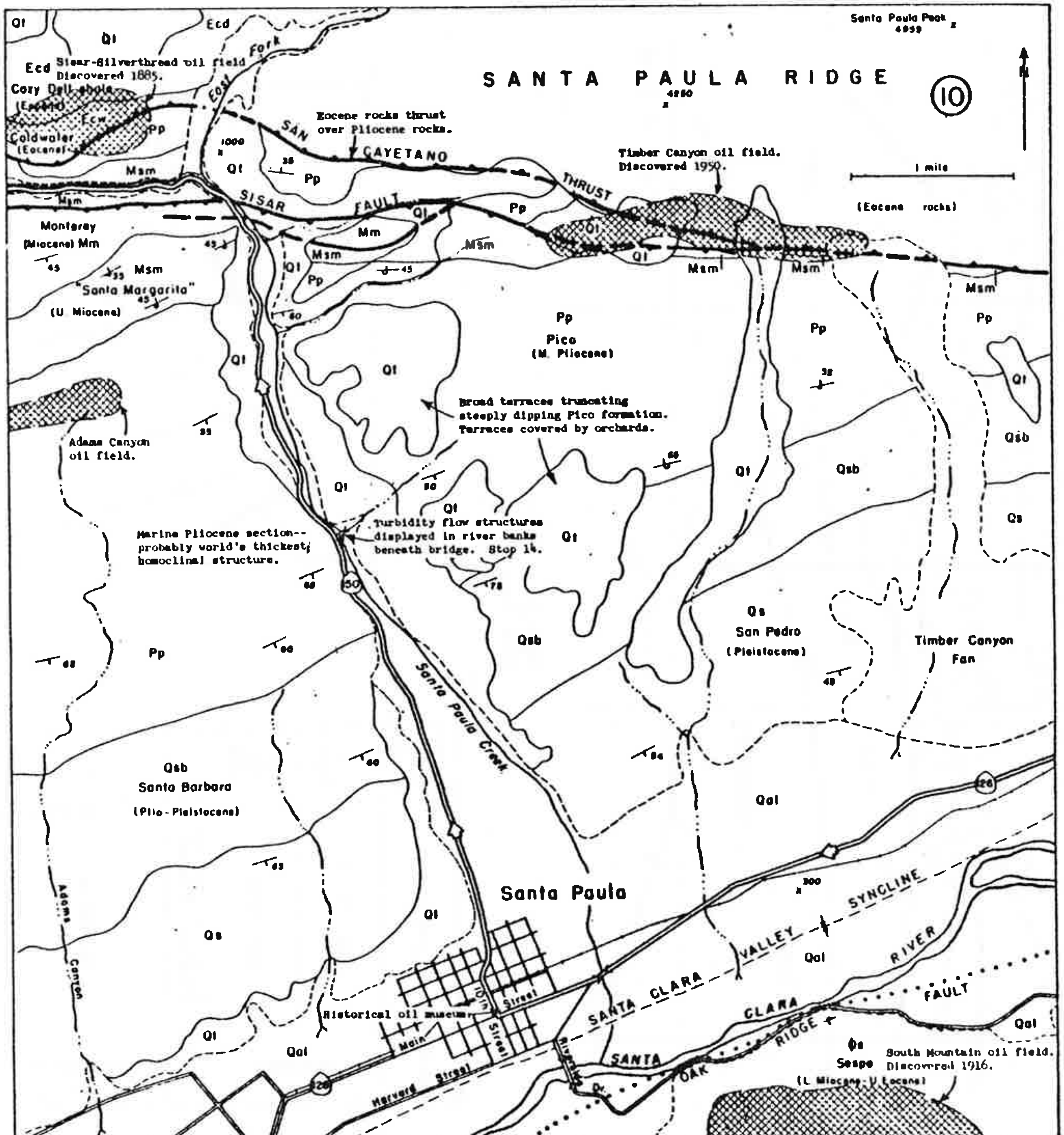


Fig. 14. North-south cross section through Sulphur Mountain.

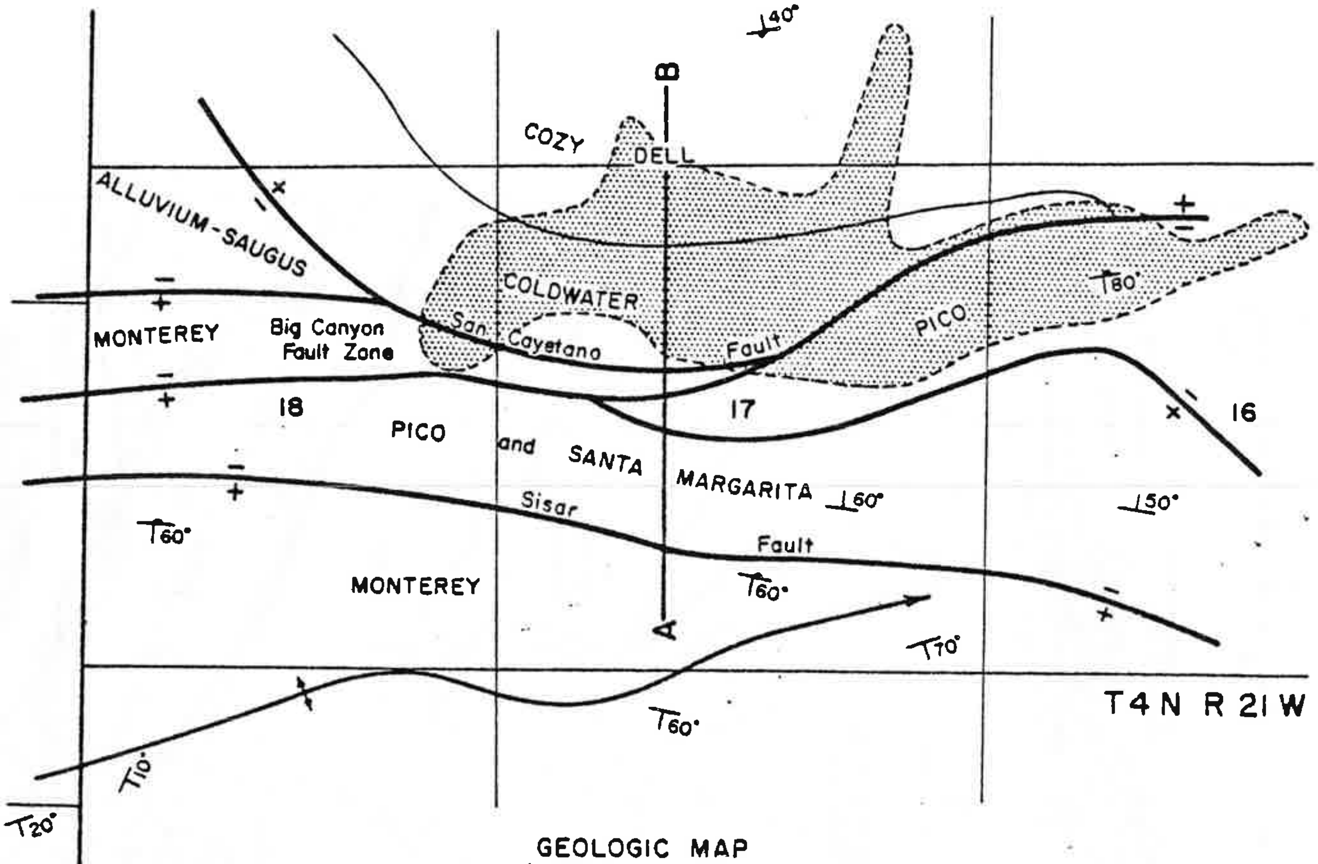
The south-dipping Sisar fault, well exposed in the road-cut at the junction of the east fork of Santa Paula Creek and Sisar Creek, cuts the north slope of Sulphur Mountain, where it brings the Monterey formation in contact with the 'Santa Margarita' formation (fig. 14).

The San Cayetano thrust, traceable on the surface for more than 30 miles, enters the region east of Timber Canyon, crosses Santa Paula Ridge, and disappears beneath the alluvium of Ojai Valley. It probably dies out in the south slopes of Santa Paula Ridge, where hard Eocene (Matilija) sandstone of the upper plate forms a 2,000-foot scarp above the softer 'Santa Margarita' (Miocene) and Pico (Pliocene) shales at the base of the ridge. The Timber Canyon oil field is adjacent to the thrust west of the Timber Canyon fan. Within the field the fault dips approximately 55 degrees north, and has a minimum vertical displacement of about 8,000 feet. That the San Cayetano thrust probably is still active is shown by deposits of late Quaternary terrace gravels which have been faulted and back-tilted toward their source.

San Cayetano thrust


SANTA PAULA RIDGE
10
Santa Paula Peak 4959
4250
1 mile
(Eocene rocks)
Sisar-Silverthread oil field
Discovered 1885.
Cozy Dell shale (Eocene)
Coldwater (Eocene)
Ecd
Ecw
East Fork
Eocene rocks thrust over Pliocene rocks.
SAN CAYETANO THRUST
SISAR FAULT
Timber Canyon oil field.
Discovered 1950.
Monterey (Miocene) Mm
Msm
"Santa Margarita"
(U. Miocene)
Pp
Pico
(M. Pliocene)
Adams Canyon oil field.
Broad terraces truncating steeply dipping Pico formation. Terraces covered by orchards.
Turbidity flow structures displayed in river banks beneath bridge. Stop 14.
Marine Pliocene section--probably world's thickest; homoclinal structure.
Qt
Qsb
Qs
San Pedro
(Pleistocene)
Timber Canyon Fan
Santa Paula Creek
Qsb
Santa Barbara
(Plio-Pleistocene)
Santa Paula
Qal
Adams Canyon
Historical oil museum
10th Street
Main
Harvard Street
Riverside Dr.
SANTA CLARA VALLEY SYNCLINE
SANTA CLARA RIVER
SANTA CLARA FAULT
OAK RIDGE
SANTA
Φs
Sespe
(L. Miocene-U. Eocene)
South Mountain oil field.
Discovered 1916.
150
126
300
1000

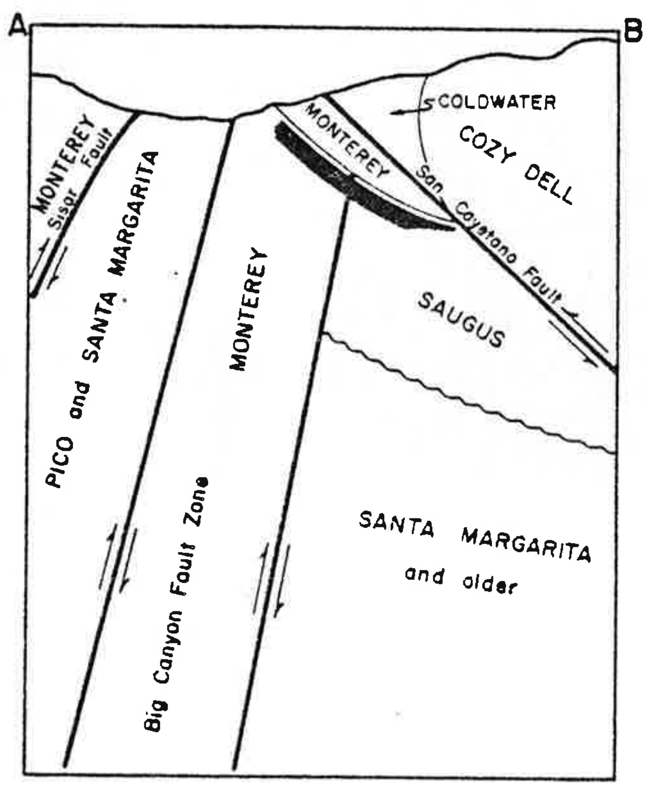
OJAI OIL FIELD
SILVERTHREAD AREA



GEOLOGIC MAP
(After Spencer F. Fine)

PRODUCTIVE AREA

EPOCH	FORMATION	Thickness (Feet)
EOCENE	Cozy Dell	0 to 600
EOCENE	Coldwater	0 to 500
San Cayetano Thrust Fault		
MIOCENE	Monterey	700
PLIOCENE	Saugus	1000



CALIFORNIA DIVISION OF OIL AND GAS
FIELD DATA SHEET

OJAI OIL FIELD
Silverthread Area
Ventura County

LOCATION 8 miles east of Ojai

DISCOVERY DATA Philadelphia Calif. Petroleum Co. well No. "Ojai" 6, Sec. 18, T. 4 N., R. 21 W., S.B.B.& M. Completed 1867, I.P. 15 to 20 b/d. This well is considered to be the first commercial oil well in California.

STRUCTURE Homocline with tar seal affected by faults

ELEVATION 1,560 BASE OF FRESH WATERS 600 SPACING ACT APPLIES No

PRODUCING ZONES

Name of Zone or E. Log Marker	Average Depth (feet)	Average Thickness (feet)	Geologic Age	Geologic Formation	Gravity or B.t.u.	Salinity of Zone Water Gr./Gal.
Unnamed	420	295	Pliocene and Miocene	Saugus and Monterey	22	*

DEEPEST WELL DATA Richfield Oil Corp. well No. "Hillside" 1, Sec. 8, T. 4 N., R. 21 W., T.D. 9,221 in Rincon (Lower Miocene).

PRODUCTION DATA—JANUARY 1, 1961

Cumulative Oil (bbl.)	1,683,497	Total Wells Drilled	79
Cumulative Gas (Mcf.)	368,000	Total Wells Completed	72
1960 Average Oil (b/d)	42	Producing Wells (1960 Aver.)	39
1960 Average Gas (Mcf/d)	0	Maximum Proved Acreage	270
Peak Production (1911) (bbl.)	41,800		

USUAL CASING PROGRAM BOP EQUIPMENT Not required

Almost all of the wells in this area were drilled by cable tools with many variations in sizes of casing and depths landed or cemented.

MISCELLANEOUS * Water is reported to be fresh. Used to water cattle.

REFERENCES Calif. Div. of Mines Bull. 170 (1954) Map Sheet 28
Calif. State Mining Bureau Bull. 63 (1913)

MAP 11

Oil seepages occur on the north side of Sulphur Mountain and along the base of the Topatopa Mountains. The seep at Stop 15 is reported to be the largest in California. Here heavy oil, accompanied by sulphurous water, flows down the side of the mountain from outcrops of fractured Miocene shales between the Sisar and San Cayetano faults. In the early 1860's several tunnels driven into the steep south slopes of Sulphur Mountain penetrated oil sands below the surface. This marked the first successful 'oil mining' in the western hemisphere.

Oil 'mining'

It is estimated that more than 30 tunnels with a combined length of about $2\frac{1}{2}$ miles were driven into the mountain. All the work was done by hand, and the tunnels were aligned and lighted by the use of mirrors and reflected sunlight. Caving ground and petroleum gases caused the deaths of several workers. Individual tunnels generally were less than 1,000 feet long, and a foot-board and a track ran their entire length. Also on the floor was a gutter in which the oil and water flowed down to a separating tank. It is reported that one of these oil tunnels yielded 900 barrels of oil per month when it was completed in 1889. A little oil still is being obtained from some of these tunnels today.

The top of the grade west of Stop 15 provides an excellent view of the precipitous ranges of the Santa Ynez Mountains and the geologically complex area between this range and Sulphur Mountain. In the towering cliff-front of the Santa Ynez Mountains bordering Ojai Valley, the beds have been folded and overturned so that they dip north. This structural feature has been named the Matilija overturn, and is part of the south limb of the intricately faulted anticlinal fold, nearly 40 miles long, that lies on the southern slopes of the Santa Ynez Mountains. West of the Ventura River the beds again have a normal southern dip. Eocene formations are involved in the Matilija overturn.

Matilija overturn

The prominent white ledge exposed at the base of the mountains is the Coldwater sandstone; it is bordered on the north by the older Cozy Dell shale (see cross-section). The Cozy Dell shale is in turn bordered on the north by the still older Matilija sandstone. Higher in the mountains, above the Matilija sandstone, the Juncal formation is locally upthrust along the Bear Canyon fault. Near Sisar Creek, the Matilija structure is broken by the San Cayetano thrust. The San Cayetano and Sisar faults converge still farther to the east, and several faults between them separate wedges of Miocene and Pliocene rocks.

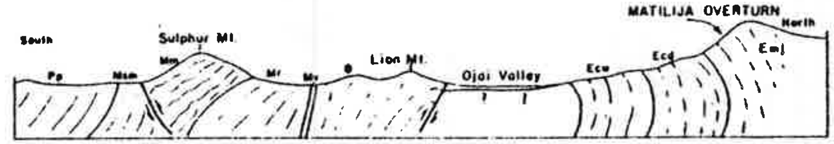


Fig. 16. North-south section showing overturned Eocene section and its relationship to rest of area.

At the east end of Upper Ojai Valley a fine example of Recent stream capture is displayed in the Santa Paula Creek-Sisar Creek-Lion Creek drainage system.

Sisar Creek stream capture

High terraces suggest that the waters of what today is the East Fork of Santa Paula Creek once flowed westward (see fig. 17, I). Santa Paula Creek, eroding headward, captured first the East Fork (II), and then Sisar Creek (III).

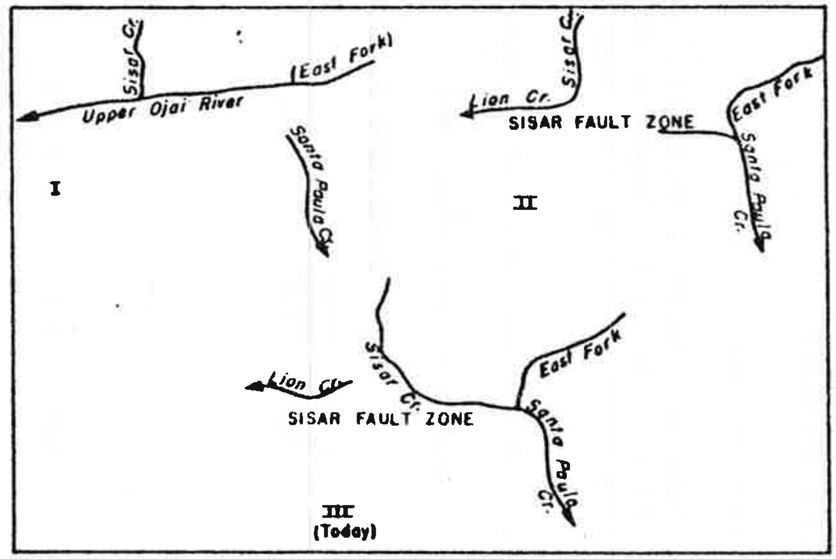
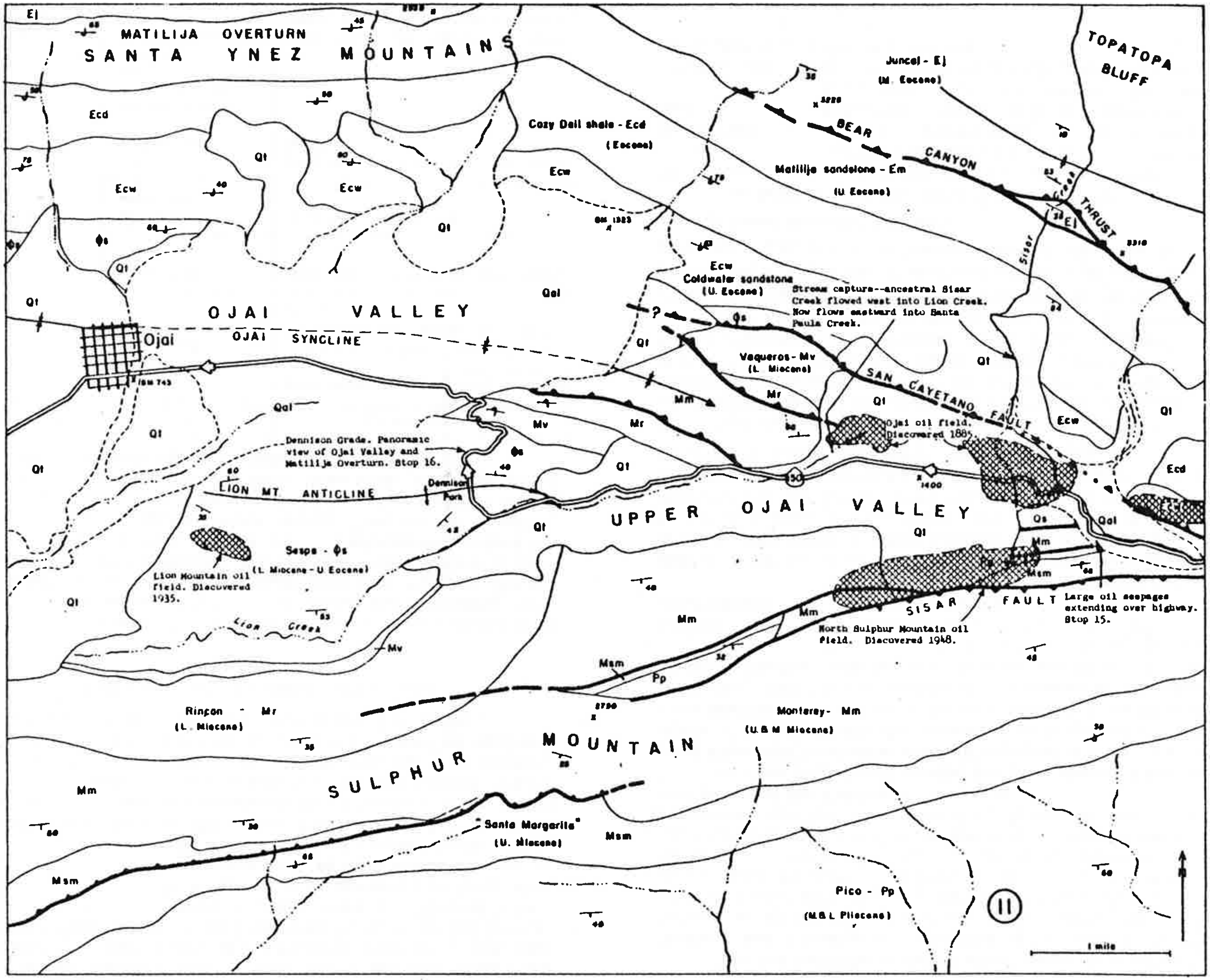


Fig. 17. Stages in capture of Sisar Creek by Santa Paula Creek.

The structure of the rocks beneath Upper Ojai Valley is obscured by terrace gravels, alluvial fans, and stream deposits, but well data indicate that it is essentially an east-plunging faulted anticline that is bounded on the north and south by thrust faults. At Dennison Park, near Stop 16, the highway crosses the axis of the Lion Mountain anticline (also known as Black Mountain anticline), the exposed core of which consists of red beds of the Sespe (mainly Oligocene) formation.


MATILIJA OVERTURN
SANTA YNEZ MOUNTAINS
TOPATOPA BLUFF
Juncal - El
(M. Eocene)
BEAR CANYON THRUST
Cozy Dell shale - Ecd
(Eocene)
Matilija sandstone - Em
(U. Eocene)
Ecw
Coldwater sandstone
(U. Eocene)
Stream capture--ancestral Sisar Creek flowed west into Lion Creek. Now flows eastward into Santa Paula Creek.
OJAI VALLEY
OJAI SYNCLINE
Ojai
Vaqueros - Mv
(L. Miocene)
SAN CAYETANO FAULT
Ojai oil field. Discovered 188
Dennison Grade. Panoramic view of Ojai Valley and Matilija Overturn. Stop 16.
LION MT ANTICLINE
Dennison Park
UPPER OJAI VALLEY
Sespe - Φs
(L. Miocene - U. Eocene)
Lion Mountain oil field. Discovered 1935.
Lion Creek
SISAR FAULT
Large oil seepages extending over highway. Stop 15.
North Sulphur Mountain oil field. Discovered 1948.
Rincon - Mr
(L. Miocene)
Monterey - Mm
(U. & M. Miocene)
SULPHUR MOUNTAIN
"Santa Margarita"
(U. Miocene)
Pico - Pp
(M. & L. Pliocene)
11
1 mile

Stop 16, on one of the turn-outs on Dennison Grade, provides an excellent view of Ojai Valley and the Santa Ynez Mountains. Ojai Valley is a structural depression, and, like Upper Ojai Valley, it is filled with Pleistocene and Recent stream alluvium more than 700 feet thick.

Ojai Valley

Its structure is essentially synclinal, with overturned beds on each limb. The north side of the valley is bounded by the steep wall of the Santa Ynez Mountains. The overturned strata in the mountains can be traced westward to the Ventura River, where they are nearly vertical, and thence to points beyond where they revert to a normal south-dipping attitude. The alluvial fans emerging from the large canyons are excellent aquifers, and furnish most of the water supply for Ojai Valley.

WHEELER HOT SPRINGS - VENTURA

MAP 12

From Dennison grade the road passes through the town of Ojai (pronounced 'Oh-hi', an Indian word meaning 'the Moon'). West of Ojai turn right onto U.S. Highway 399 and proceed north to Wheeler Hot Springs. This 5-mile trip passes through a steep canyon whose walls permit a close inspection of the upper Eocene section. This section is mostly overturned as far north as the third tunnel in Wheeler Gorge, where the road crosses the Santa Ynez fault. The rocks to the north lie in their normal stratigraphic position.

Series	Formation	Lithology
Oligocene	Sespe	Pink sandstone and conglomerate.
Eocene	Coldwater sandstone	Light-colored hard sandstone; fossiliferous; green and red shale.
	Cozy Dell shale	Gray shale with some sandstone.
	Matilija sandstone	Gray hard sandstone.
	Juncal formation	Gray shale with minor sandstone layers.
	Sierra Blanca limestone member.	
Upper Cretaceous	Undifferentiated	Hard shale and sandstone, thin beds, with conglomerate layers.

The low foothills at the mouth of the canyon, whence the Ventura River issues, are underlain by red beds of the Sespe formation. On the west side of the highway these beds extend over the higher hills up to the skyline. The bold white outcrops at and near the skyline are beds of the Coldwater (Eocene) sandstone in normal stratigraphic position. Quaternary terrace gravels along the highway mask the contact of the Sespe formation with the light-colored sandstone and interbedded red shales of the Coldwater formation.

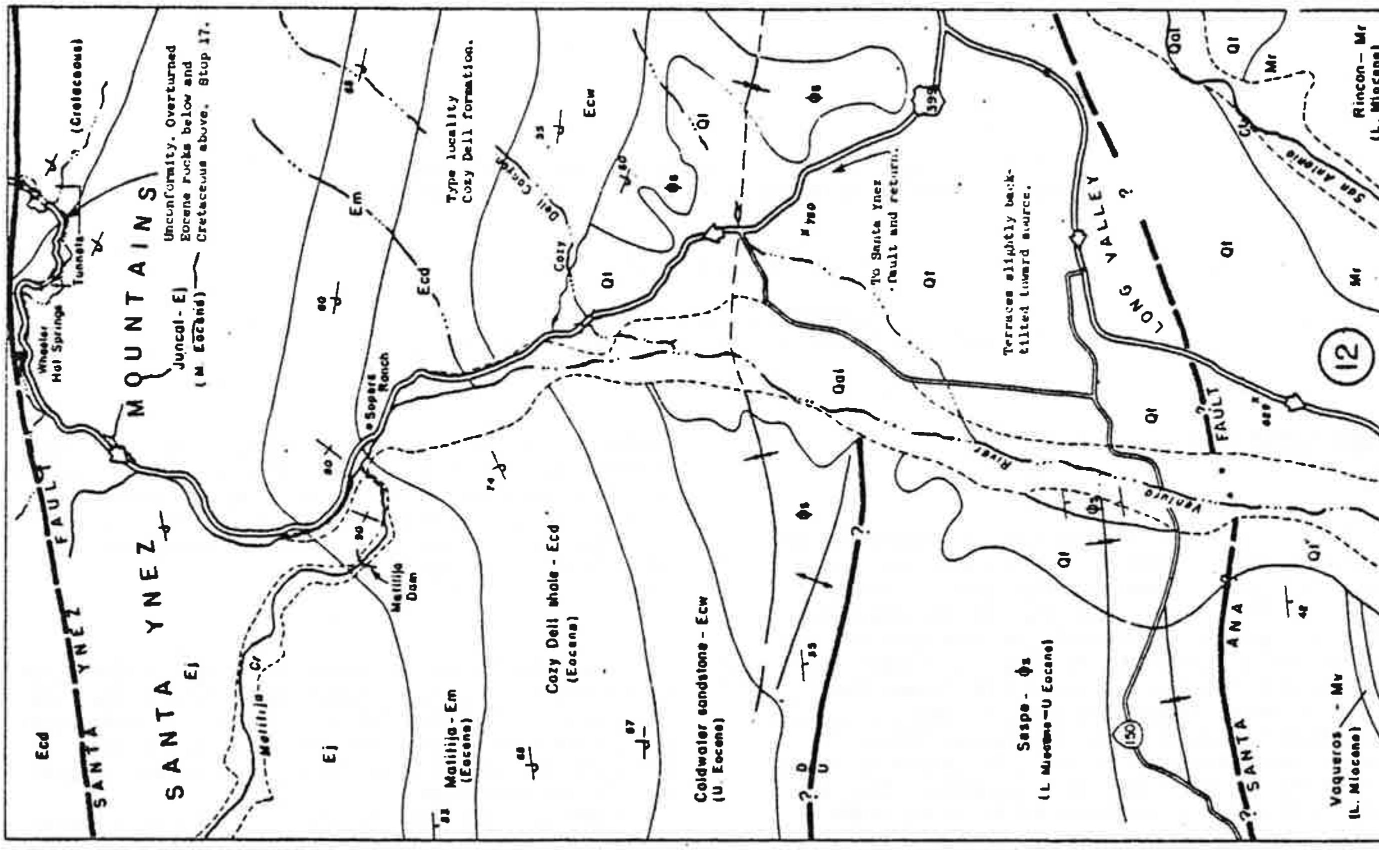
At Cozy Dell Creek bridge, the gray shales of the Eocene Cozy Dell formation are well exposed. A tenth of a mile north of Soper's Ranch this formation is in contact with Eocene Matilija beds. This is the type locality of the Matilija formation. Note the narrowness and steepness of the canyon where it cuts the more resistant Matilija sandstone. The lowest unit of the overturned section, the Juncal (middle Eocene) formation, consists mainly of dark gray shale that contains thin layers of hard sandstone. The exposures of the Juncal formation extend from a point about three-quarters of a mile northwest of Soper's Ranch, past Wheeler Springs, to a point a short distance beyond the north portal of the first tunnel in Wheeler Gorge. Here the disconformable base of the Eocene section is marked by dark limy shale (Sierra Blanca member) in contact with Cretaceous shale (Stop 17).

Eocene stratigraphy

Cretaceous conglomerate and interbedded dark shale are exposed between the south portal of the second tunnel and the third tunnel ahead. Note the rectilinear course of the creek at the tunnels, where strong control has been exercised by bedding and jointing in the resistant rocks. Large loadclasts and very thick graded beds are characteristic of the Cretaceous strata. Excellent current bedding is exhibited by the thin sandstone layers within the Cretaceous shales just north of the northern tunnel, and a Cretaceous ammonite has been uncovered in these hard black shales.

The Santa Ynez fault, which is traceable for more than 60 miles, crosses the highway a short distance north of the northern tunnel. Here overturned to the vertical, Cretaceous conglomerate and underlying black shale lie in fault contact with the Cozy Dell (Eocene) formation. The stratigraphic separation on the Santa Ynez fault at this locality is estimated to be 8,000 to 9,000 feet.

Santa Ynez fault



Proceed north on Highway 33 to Rose Valley to make camp. If there is time we will look at the geology around Rose Valley Falls.

HIGHLIGHTS OF SECOND DAY

An all-day hike in the Piedra Blanca area to:

See faults

Study Miocene stratigraphy, sedimentary structures, and depositional environments

Study development of stream terraces

Collect fossils

Materials presented here to guide you on day two are from:

Fall, 1978, Field Trip Guidebook of the Pacific Section of the Society of Economic Paleontologists and Mineralogists

FIELD TRIP GUIDE TO THE PIEDRA BLANCA AND CHORRO GRANDE-GODWIN CANYON AREAS OF NORTHERN VENTURA COUNTY, CALIFORNIA

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PIEDRA BLANCA TRIP

INTRODUCTION

This trip begins at Lion Canyon Campground and follows the route shown on the vertical air photo mosaic in Figure 1 (photos taken by U. S. Forest Service in May, 1968). The trip can be completed either as a 10-km (6-mi) circular hike with the end at Lion Canyon Campground or as a 7-km (4-mi) one-way hike with the end at Circle B Boy Scout Ranch.

Lion Canyon Campground (Fig. 1, Stop 1; labeled Piedra Blanca Camp on U. S. Geological Survey 7½-minute topographic maps of the Lion Canyon quadrangle, see Squires and Fritsche, this guidebook, Fig. 2) is north of Ventura and Ojai and is along Sespe Creek in the Los Padres National Forest in northern Ventura County, California. It is reached by way of Highway 33 and the Rose Valley Road (see Reid, this guidebook, Fig. 1). All access roads are paved, but the U. S. Forest Service gate above the campground is sometimes locked.

To make the 10-km circular trip requires no prior arrangements unless before starting you wish to check with the U. S. Forest Service office in Ojai, California, for information on access to Lion Canyon Campground and on the condition of Sespe Creek. To make the 7-km one-way trip requires a shuttle car and prior permission from the Great Western Council Boy Scout office in Van Nuys, California. Those attempting the trip without notifying the Boy Scout office will find locked gates and German shepherd patrol dogs at Circle B Ranch.

Elevation at Lion Canyon Campground is 915 m (3,000 ft). The highest point along the trail is 1,080 m (3,540 ft) and this elevation is achieved by two moderately easy and gradual climbs of 75 and 90 m (250 and 300 ft). After heavy rains in the winter and on into the spring it is impossible to cross Sespe Creek at the start of the trip and in the summer the weather is very hot. Late spring and fall are the best times to take this trip. There is commonly water in Piedra Blanca Creek at the lunch stop, but it should not be relied on for drinking because of campgrounds upstream.

FIELD TRIP LOG

STOP 1

In the gully along the south side of the road and on the south side of Lion Canyon Campground can be seen the trace of the Tule Creek fault. At this point the Sespe Formation (red sandstone to the west and on the north side of the fault) is juxtaposed against the lowermost beds of the Cozy Dell Shale (olive shale to the east and on the south side of the fault).

Cross Sespe Creek and proceed north on the Piedra Blanca Trail. After a short climb, the trail crosses the surface of stream terrace level 3 (Gutowski, this guidebook), and after a second climb to a junction with an abandoned road, is at the elevation of stream terrace level 4. Continue north into a small, shallow valley.

STOP 2

This shallow valley marks the trace of the Piedra Blanca fault (Fig. 1), a fault that offsets the Tule Creek fault with about 730 m (2,400 ft) of left slip. The Piedra Blanca fault has the same strike and slip direction as the Big Pine fault and possibly originated at the same time.

Continue north on the trail, go around a corner toward the east, and at the point where the trail turns once again to the north, continue eastward cross country into the shallow canyon shown on Figure 1.

STOP 3

Exposures in this canyon are of the upper member of the Vaqueros Formation (Fig. 2) as described by Reid (this guidebook). Rocks of the middle part of the member are not well exposed, but this is the only place on this trip where rocks of the lower and upper parts of the member can be seen.

Walk south along the canyon until you see the exposure shown in Figure 3. This is at the base of the upper member and belongs to Reid's (this guidebook) plane-bedded sandstone lithosome. Near the upper part of this exposure are a few layers of medium-scale cross bedding.

Figure 4 is a view northward along the canyon from the above exposure. Outcrops at A and D in the photograph belong to the cross-bedded lithosome and outcrops B and C to the massive and bioturbated unit. Between C and D in the canyon can be found one of the conglomerate beds. North of the last sandstone knob (east side of the canyon) and exposed in the sides of the canyon is the glauconitic sandstone lithosome. Environmental significance of each of these lithosomes is discussed by Reid (this guidebook).

Fossils from this area include a few shark's teeth, most common in the conglomerate lithosome, and some brachiopods from near the top of the glauconitic sandstone, occasionally occurring in small cannonball-like concretions.

At this locality, one should make a mental note of the lack of well-defined cross bedding as compared to the amount that will be seen at Stop 5.

Return to the trail (west) and head north on the trail. Note the conglomerate bed just beyond where the trail makes a turn to the west. This same conglomerate bed can be traced to the north side of the Tule Creek syncline (Fig. 1) where similar beds will be seen at the next stop.

Continue north to the point where the conglomer-

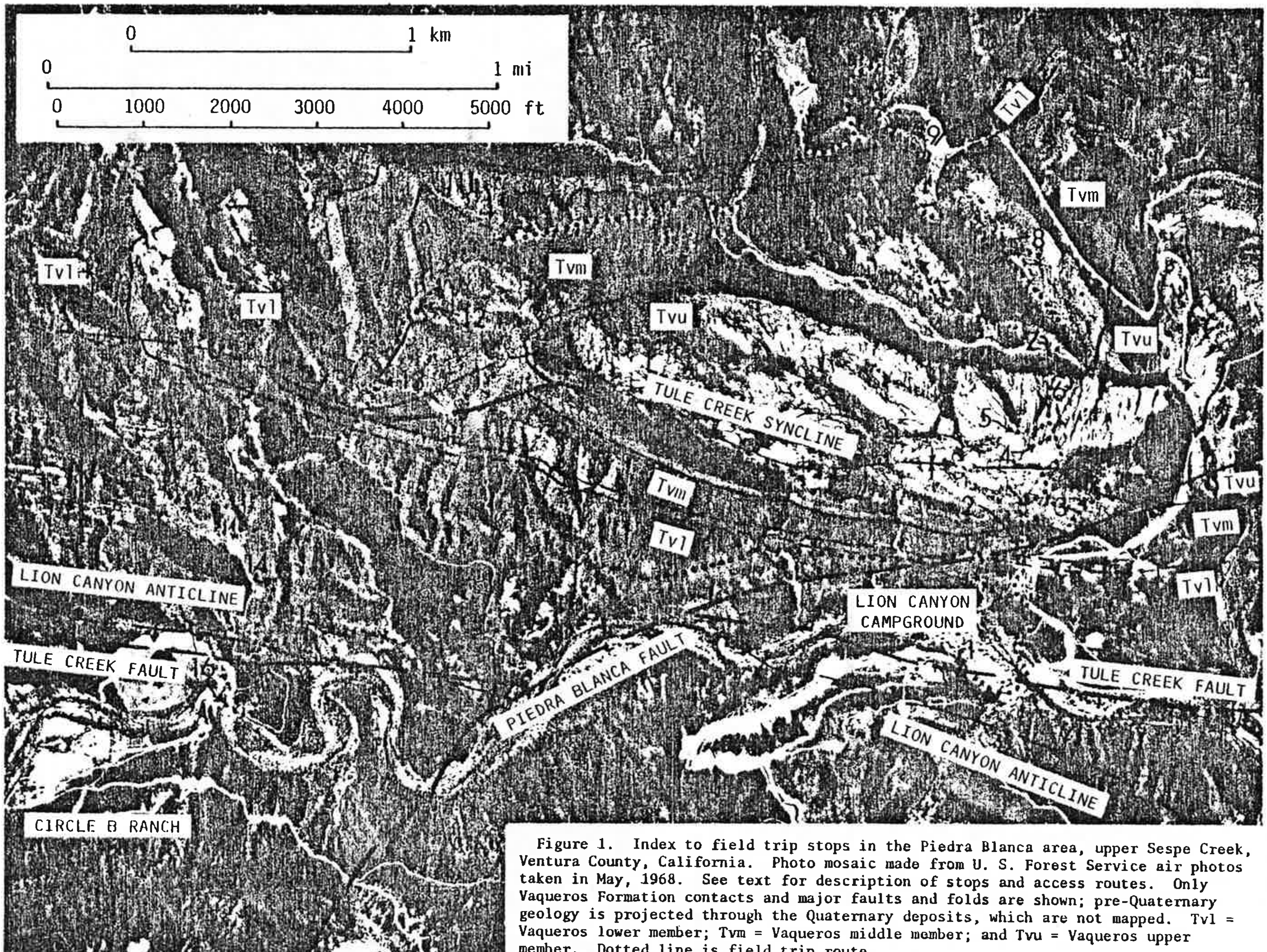

Figure 1. Index to field trip stops in the Piedra Blanca area, upper Sespe Creek, Ventura County, California. Photo mosaic made from U. S. Forest Service air photos taken in May, 1968. See text for description of stops and access routes. Only Vaqueros Formation contacts and major faults and folds are shown; pre-Quaternary geology is projected through the Quaternary deposits, which are not mapped. Tvl = Vaqueros lower member; Tvm = Vaqueros middle member; and Tvu = Vaqueros upper member. Dotted line is field trip route.

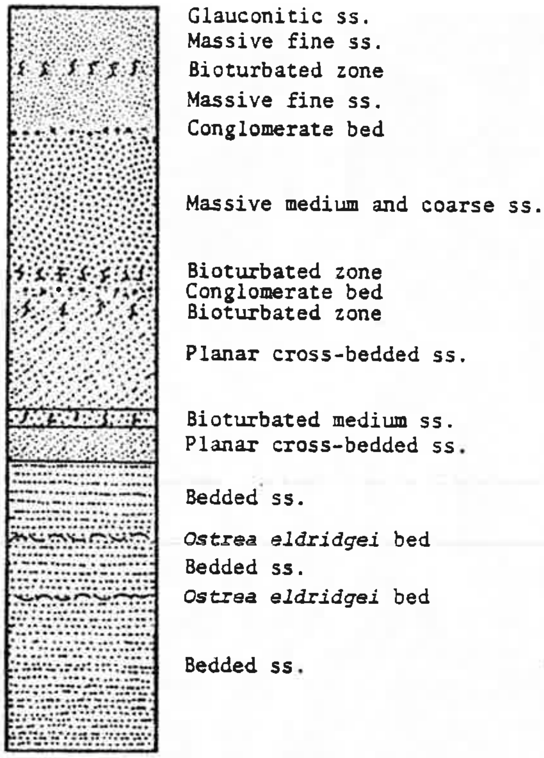

Figure 2. Stratigraphic column of the upper member of the Vaqueros Formation at Stop 3. Total thickness is 127 m.

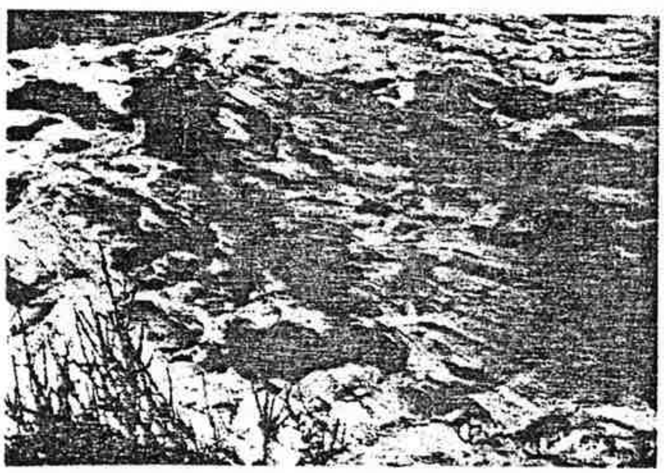

Figure 3. Outcrop at Stop 3 of plane-bedded sandstone exposed at the base of the upper member of the Vaqueros Formation.

ate beds cross the trail on the north side of the syncline.

STOP 4

Follow the conglomerate beds westward about 30 m to where they can be viewed easily. Note the texture, sorting, and composition of the beds. Discussion of their origin is in Reid (this guidebook). Note the truncated burrows (Fig. 5) at the base of the beds and the bulbous load(?) features (Fig. 6) at the base of the lowermost thin bed.

Return to the trail and continue to the point from which the view in Figure 7 can be seen.

Figure 4. View northward up the canyon at Stop 3 taken from the outcrop shown in Figure 3. Sandstone exposures are in the upper member of the Vaqueros Formation; outcrops labeled A and D are cross-bedded sandstone and outcrops B and C are massive and bioturbated sandstone.

Figure 5. Truncation of burrows by conglomerate bed in the upper member of the Vaqueros Formation as seen at Stop 4.

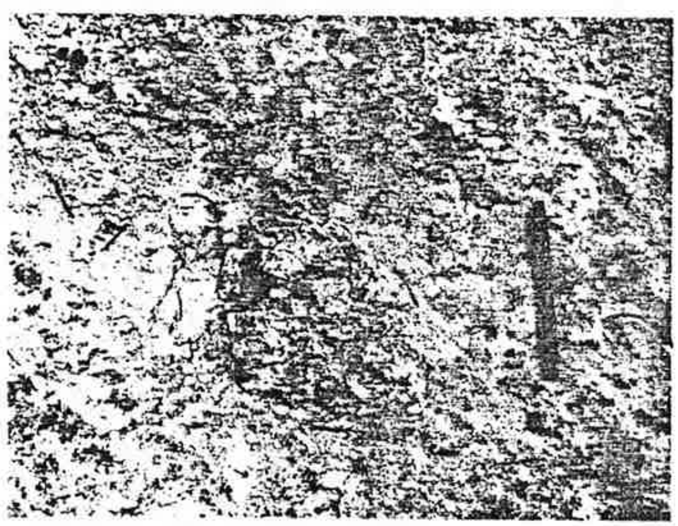

Figure 6. Bulbous load(?) feature at base of conglomerate bed in the upper member of the Vaqueros Formation as seen at Stop 4.

Figure 7. Cliff of upper member of the Vaqueros Formation exposed at Stop 5 in Piedra Blanca.

Figure 8. Close-up of cliff in Figure 7, showing planar cross bedding that is interpreted to have been deposited by straight-crested megaripples in a submarine dune field.

STOP 5

In the cliff to the west (Figs. 7 and 8) are the large-scale, planar cross beds that Reid (this guidebook) has interpreted as being submarine, straight-crested megaripples or dunes. Note the thickness of the cross-bedded sequence as compared to what was seen previously at Stop 3 (Fig. 9). Walk cross country to the south end of the cliff for a close examination of these cross-bedded features.

Return to the trail and continue north to the top of the hill.

STOP 6

At this point the trail is at the same elevation as terrace level 4 (Fig. 10). Terrace level 5 can be seen higher and to the northeast. Note the thickness, clast size, composition, and sorting of the terraces in slope exposures along Piedra Blanca Creek. Discussion of the nature and origin of the terraces is in Gutowski (this guidebook).

Also from this vantage point can be seen to the northeast the folded nature of the Vaqueros Formation (Fig. 10).

In the trail just over the crest to the north is a bed of scattered *Ostrea eldridgei* which is common at this stratigraphic horizon low in the upper member (see Squires and Fritsche, this guidebook).

Continue down the trail to the north into the canyon at the bottom of the hill. Keep a sharp look-

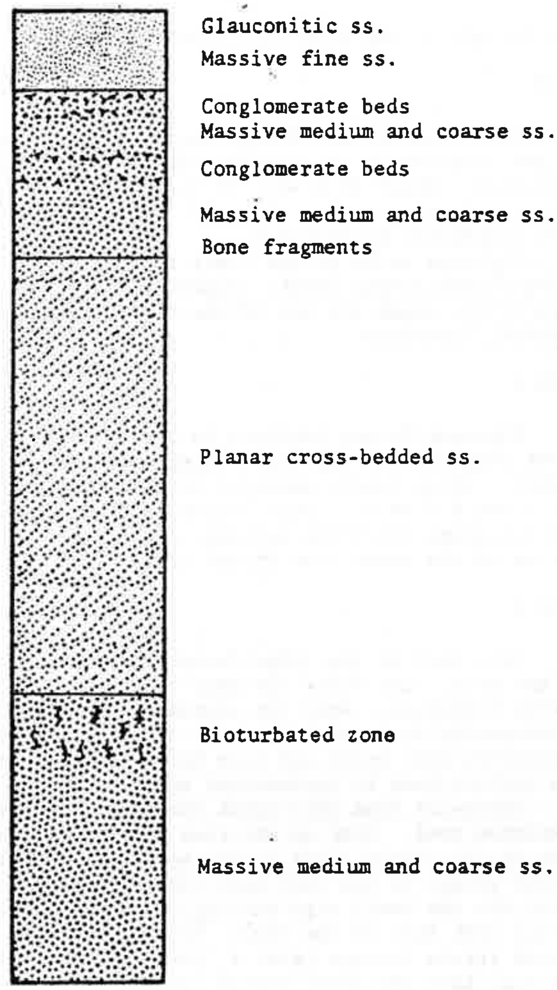

Figure 9. Stratigraphic column of the upper member of the Vaqueros Formation at Stop 5. Note abundance of cross bedding compared with amount shown in Figure 2. Total thickness is 165 m.

Figure 10. View northeastward from Stop 6. Terrace levels 4 and 5 shown in center. Behind terraces on the right is a syncline in the sandstone of the upper member of the Vaqueros Formation.

out for poison oak from this point on.

STOP 7

Along the bottom of the canyon are good exposures of the mudstone of the middle member of the Vaqueros Formation. About 30 m west of the trail is a bed of large concretions which show that the mudstone has been moderately bioturbated.

Continue north on the trail to Stop 8 for lunch along Piedra Blanca Creek. Exposures along the east bank of the creek are all of the middle member of the Vaqueros Formation.

STOP 8

Numerous Eocene boulders in the creek at the lunch stop contain the trace fossil *Ophiomorpha nodosa*. After lunch, continue north along the trail for about 0.5 km to a bold stream-cut exposure of the red and green sandstone and mudstone of the Sespe Formation on the south side of the trail.

STOP 9

This part of the Sespe Formation is near the top of the unit, just below the base of the marine Vaqueros Formation. Note the abundance of burrows and bioturbation features. Do these deposits represent supratidal back beach and salt marsh deposits or were the burrows made by terrestrial animals?

Northward from this point the trail follows an abandoned road. Stay on the road as it turns left and goes up the canyon slope to the west. As the road swings around to the west near the top of the hill, watch for the trail sign marking an unmaintained trail on the left side of the road. Follow this trail across stream terrace level 4, down the west side of the hill into the first stream canyon, then across a low ridge into a second canyon (see Fig. 1 to keep located). Follow this second stream canyon north to Stop 10.

STOP 10

On the east side of the canyon is a good exposure of the transition from the Sespe Formation (to the north) into the lower member of the Vaqueros Formation (to the south). Check the article by Reid (this guidebook) to see environmental interpretations he has made for the lower member, then make your own interpretation of the transitional series of beds exposed here. Can you recognize bioturbated supratidal mudflats, sandy beach, grassy lagoon, and shallow open bay deposits? The sandstone bed that occurs low in the section here is atypical of most Sespe-Vaqueros transitions in this area.

About 50 m south of the Sespe-Vaqueros contact, one of the *Kewia*-bearing limestone beds stands out abruptly in the creek bed. Is this a storm-lag deposit or does the bed represent merely the normal current-sorted accumulation of sand dollars on the bottom of the bay?

Return to where you left the trail in the stream canyon and continue west on the trail. At the intersection of the trail with the first small canyon to the north, turn north and walk a short distance up the canyon to some fossil beds.

STOP 11

The most abundant fossil in this area is *Ostrea howelli* which occurs in a bed about 5 m north of the trail. This bed is near the base of Fritsche's (this guidebook) middle member of the Vaqueros and near the top of Reid's (this guidebook) lower member. These oysters probably were living in a crowded oyster bed in a shallow, open bay or lagoon. Abundance of the oysters may be due to influence of a nearby inlet.

A little farther north in the canyon are beds of *Turritella* and other fossils.

Washing down the slopes in the canyon on the south side of the trail are a few specimens of *Ostrea eldridgei ynezana* which occur in beds in the upper part of the middle member.

Continue on the trail westward up the canyon. The last side canyon on the north before reaching the crest of the trail (Stop 11B) is another good canyon for fossil collecting.

Cross over the crest of the trail (highest point on the trip) and go down the other side until you again cross the bed of *Ostrea howelli*. A little distance below this on the trail watch for the first resistant, sandy, *Turritella*-hash limestone bed to cross the trail. This bed would be the top of Fritsche's (this guidebook) lower member of the Vaqueros. From here to where the trail reaches the canyon bottom is Stop 12.

STOP 12

The resistant fossil beds of the lower member of the Vaqueros Formation are well exposed along this part of the trail. Proceed down the trail and watch closely for a greenish-brown sandstone bed on the south side of the trail. This bed is full of crab claws and presumably other crab parts.

Continuing on down the trail, look at the fossiliferous sandstone and limestone beds, especially those containing *Kewia*, *Anomia*, and *Potamides* (Squires and Fritsche, this guidebook), and note that these beds are separate and different from the intervening mudstone units. This difference is the basis for the interpretation that these fossil beds are swell-lag, storm-lag, or mass extinction deposits, rather than just beds of normal deposition.

The *Turritella* and *Kewia* beds are higher in the section and probably are shallow, open-bay deposits, with *Kewia* representing the shallowest of the two. Below them are very shallow deposits represented by *Anomia* and *Potamides* beds, the *Potamides* indicating a grassy bay environment. The environment of the crab-claw bed is not clear, but it is suggested that it might represent a supratidal shoal.

Note that there are no beds which might be interpreted as sandy beach deposits. The lack of such beds indicates a coastline of low tidal range and low waves where only muddy and silty strandlines existed (Reid, this guidebook).

Continue southwestward along the trail and parallel to exposures of the fossiliferous beds of the lower Vaqueros. Note that the trail now goes back up section through the beds. The crab-claw bed is well exposed again at the place where the trail is in the canyon. Stop 13 is where the trail once again crosses the uppermost *Turritella* beds of Fritsche's (this guidebook) lower member.

STOP 13

A resistant, sandy, *Turritella* limestone bed exposed here in the stream canyon illustrates well a bipolar orientation pattern for the fossils (Fig. 11). Such a bipolar orientation of elongate conical shells is here interpreted to be the result of orientation by bimodal oscillating currents, either wave or tide induced, which moved perpendicular to the orientation direction.

A little south of this point, the trail crosses for the second time the hinge trace of the Tule Creek

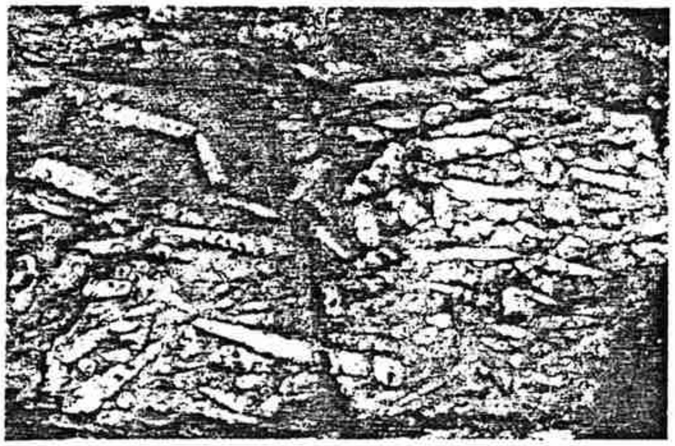

Figure 11. Bipolar orientation of *Turritella* shells in limestone bed of the lower member of the Vaqueros Formation as seen at Stop 13.

syncline. Note the steepness of the Vaqueros and Sespe Formations on the south limb of the fold.

Follow the trail southwestward up onto the terrace surfaces.

STOP 14

At this point the trail is on terrace level 5 of Gutowski's (this guidebook) "central terrace sequence". Note the extreme size of the boulders here compared with those seen at other places on the trip. The boulder size, coupled with the distance of the boulders from the slope break on Pine Mountain, is the main evidence for assuming that the terraces were in part deposited by debris flows.

Continue southwestward on the trail to a trail junction. Turn left and follow the trail to the east until it overlooks a meander of Sespe Creek.

STOP 15

The trace of the Tule Creek fault can be seen from here as it crosses the east bank of the meander (Fig. 1). The near-horizontal beds on the south side of the fault are the uppermost parts of the Matilija Sandstone; the steep-dipping beds on the north side of the fault are in the middle of the Cozy Dell Shale (Circle B sandstone of Jestes, 1963; see Fritsche and Shmitka, this guidebook, for reference). This portion of the Tule Creek fault is farther south than the portion previously seen at Stop 1 due to offset by the younger Piedra Blanca fault (Fig. 1). The Piedra Blanca fault (Rose Valley fault of Shmitka, 1970; see Fritsche and Shmitka, this guidebook, for reference), after offsetting the Tule Creek fault with 730 m (2,400 ft) of left slip, passes westward through the saddle on the skyline to the south where the Circle B Ranch road comes through.

If you are returning to Lion Canyon Campground, continue east on this trail for about 3 km. If you are going to Circle B Ranch, retrace your steps to the trail junction and take the south trail down the hill and across the terrace to Sespe Creek.

STOP 16

On the east side of Sespe Creek are near-horizontal beds of the uppermost part of the Matilija Sandstone. These medium to thick, fine sandstone beds contain vertical and horizontal *Ophiomorpha nodosa*, cross bedding, convolute bedding, and ripples (Fig. 12).

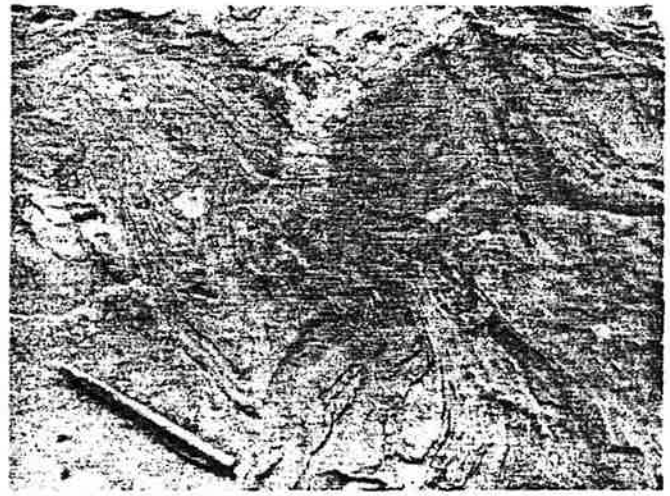

Figure 12. Convolute bedding and the trace fossil *Ophiomorpha nodosa* (burrow in upper right) in the Matilija Sandstone as seen at Stop 16.

These "bc" Bouma sequence beds probably were deposited in a "proximal" turbidite environment. The facies relationships of the Eocene sandstone units in this area were studied by Jestes (1963; see Fritsche and Shmitka, this guidebook, for reference), but detailed stratigraphic analyses of each of the sandstone units have not been done and would be fascinating research projects.

HIGHLIGHTS OF THIRD DAY

Study of stratigraphy, sedimentary structures, and depositional environments of the:

Cretaceous rocks of Wheeler Gorge

Eocene Matilija Sandstone

Miocene Vaqueros Formation

Oligocene Sespe Formation

Eocene Sierra Blanca Limestone (if time permits)

Materials presented here to guide you on day three are from:

Spring, 1972, Field Trip Guidebook of the Pacific Section of the American Association of Petroleum Geologists

Spring, 1979, Field Trip Guidebook of the Pacific Section of the American Association of Petroleum Geologists

Guidebook for Field Trip 2 of the 1967 Cordilleran Section meeting of the Geological Society of America

UPPER CRETACEOUS RESEDIMENTED CONGLOMERATES AT WHEELER GORGE, CALIFORNIA: DESCRIPTION AND FIELD GUIDE[1]

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ABSTRACT: A field map and measured stratigraphic sections revise the geology of Wheeler Gorge. There are three layers of conglomerate, each of which passes upward into massive sandstones, classical turbidites, and/or dark mudstones with thin distal turbidites. Clast long axis orientation on conglomerate layers 1 and 3 gives vector means of 282 and 287 degrees respectively. This agrees closely with flutes (285) and grooves (279) on layer 1, and hence gives a paleocurrent direction for layer 3 for the first time.

The conglomerates do not contain as much inverse grading as has previously been suggested, and none of the conglomerates is stratified. Inverse grading was measured in one bed, indicating a continuous upward coarsening of both the smaller and larger clasts in the population. The Wheeler Gorge conglomerates do not fit precisely with the three generalized models of conglomerates recently proposed by Walker, but are closest to the "disorganized-bed" model.

OBJECTIVES

The section of Upper Cretaceous conglomerates and sandstones at Wheeler Gorge, Ventura County, California, has become one of the classic locations for detailed examination of the features of deep-water, resedimented conglomerates and coarse sandstones. This is because of the clean three-dimensional outcrops, easy accessibility, and two excellent published descriptions by Rust (1966) and Fisher and Mattinson (1968).

One purpose of this paper is to present a sketch map of the gorge, together with revised measured sections that indicate fault repetition within the section published by Fisher and Mattinson (1968). I am indebted to Fisher for his help in examining my field sketch map (Fig. 1). He pointed out (personal communication, 1973) that the area near C (Fig. 1) "had a heavy cover of brush and was partly covered with alluvium" in 1967, hence obscuring the stratigraphic relationships. This part of the gorge is now (1974) clean and well exposed.

Another objective is to check the usefulness of clast orientation studies in the determination of paleoflow direction—this is particularly easy because the base of the lowest conglomerate displays flute casts, groove casts, and a well-developed clast orientation. The internal details of the conglomerates—fabric, grading and stratification—are compared with the generalized conglomerate models set up by Davies and Walker (in press) and Walker (in press), and a method for quantifying inverse grading is investigated.

MAP AND MEASURED SECTIONS

A map of Wheeler Gorge is shown in Figure 1. The northern tunnel is 21.2 miles north of the Ventura Freeway exit on California Highway 33, and 7.7 miles north of the intersection of Highways 33 and 150 in Ojai. There is space for parking about one hundred yards north of the northern tunnel, and one can scramble down into the gorge at the parking area, or at the access points shown on the map. Most of the walls of the gorge are nearly vertical, and rise for several hundred feet above the Ventura River. The river is normally little more than a trickle, and all the patterned areas of the map are accessible except in the gorge at the location F. Here, one can either wade, or use the path to the west.

The rest of the map is self-explanatory, except at B, where the 40 degree dip of the fault carries it beneath the overhanging nose of conglomerate.

[1] Manuscript received, May 16, 1974; revised September 4, 1974.

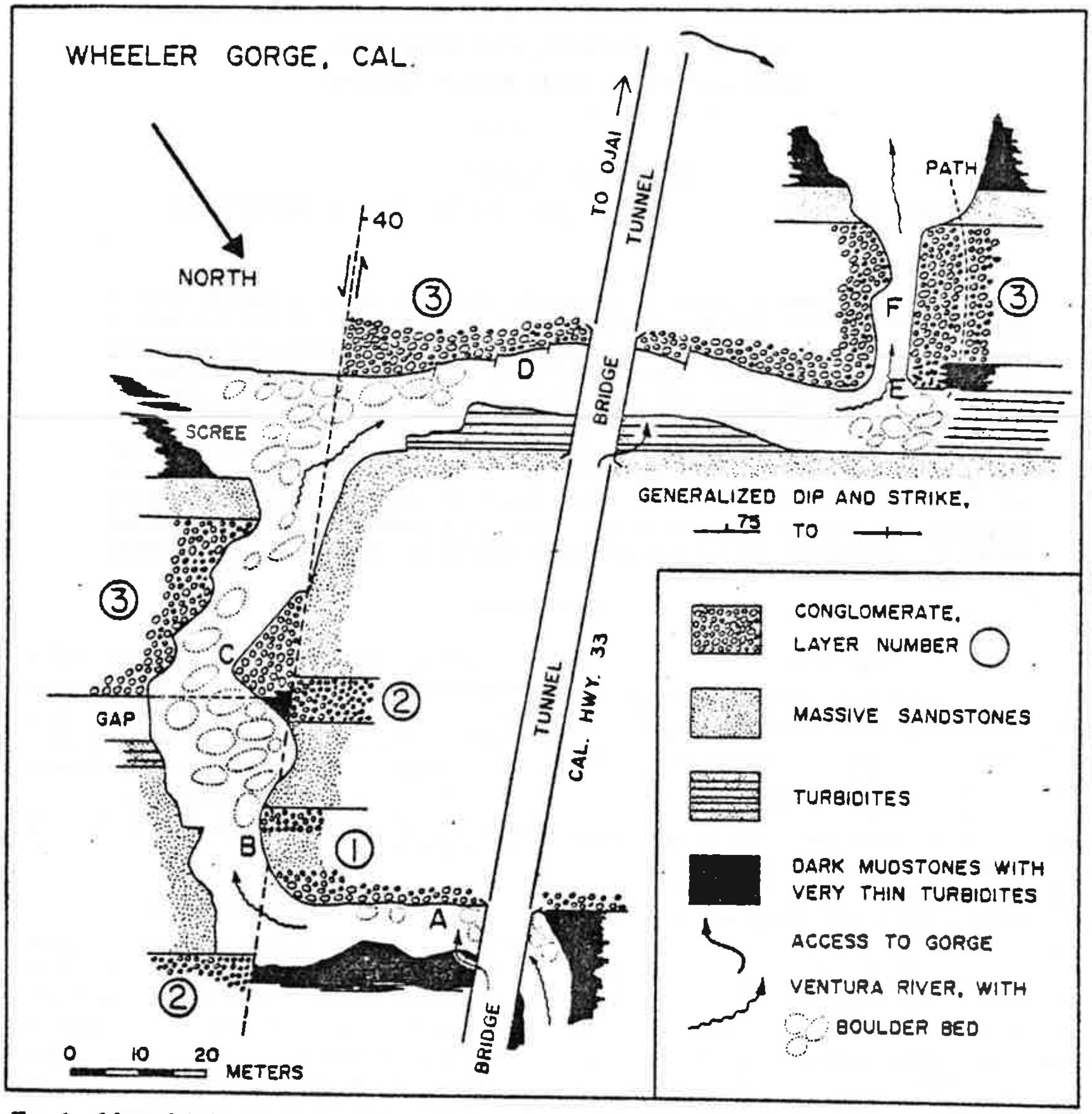

FIG. 1.—Map of Wheeler Gorge, Ventura County, California. Note orientation of map, presented this way for ease of use in the field. Letters and numbers explained in text. At D, base of conglomerate layer 3 is offset by many small faults that trend roughly parallel to the large fault 40 m east of the highway.

Stratigraphic sections were measured wherever possible, and are shown in Figure 2. The long column was measured in the easternmost stretch of the gorge, meters 1–32 on the west bank (B on map), and meters 32–105 on the east bank, from the stream corner at layer 2 to the scree shown on the map. The shorter column was measured below the southern bridge (45–70 m), and along the path south of letter E (70–105 m).

My conglomerate layer 1 is exactly equivalent to Fisher and Mattinson's (1968, Fig. 3) units 1 and 2a. My layer 2 was not recognized by Fisher and Mattinson, and my layer 3 is equivalent to Fisher and Mattinson's unit 4a and b, and also to their unit 6. It is now clear from excellent exposures in the gorge that their unit 6 is a fault repeat of units 4a and b.

The conglomerates appear abruptly as an unnamed 100 m unit within some 700 m of dark mudstones containing distal turbidites. These mudstones are bounded to the north by the Santa Ynez fault, and are overlain unconformably by middle Eocene rocks to the south. The

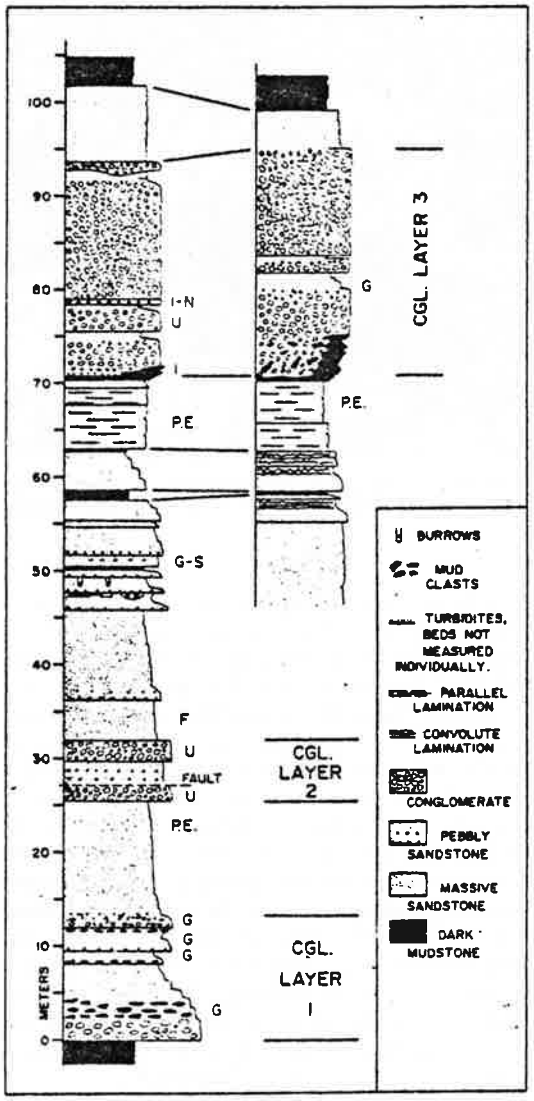

FIG. 2.—Measured sections of the conglomerate-turbidite series in Wheeler Gorge. See text for exact locations of sections. I-N, inverse to normally graded; U, ungraded; I, inverse grading; P.E., poorly exposed; G-S, graded and stratified; F, fractured; G, normally graded.

area has been mapped by Rust (1966), who discusses earlier work in the area.

FACIES

The map and measured sections depict four main facies; conglomerates, coarse massive sandstones, turbidites (alternations of fine sandstones and mudstones), and dark mudstones containing thin graded siltstones (distal turbidites).

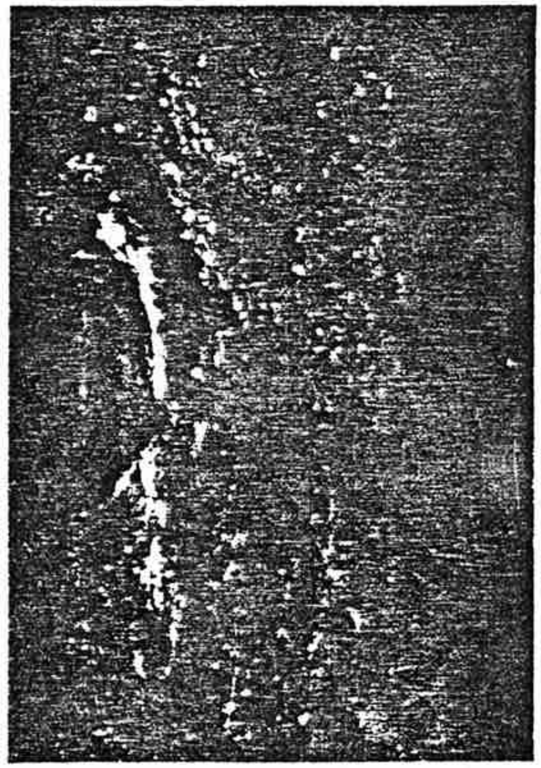

FIG. 3.—Basal portion of first bed in conglomerate layer 1, near location A on map (Fig. 1). Note absence of inverse grading. Top to left.

Conglomerates

Conglomerates are essentially restricted to the three layers shown on the map. Layer 1 is composed of four main "beds," but because of amalgamation of units, and abundance of large mudstone clasts, defining "beds" is somewhat subjective. In the beds of layer 1 sketched in Figure 2, there appears to be neither inverse grading, nor stratification other than the sub-horizontal orientation of the mudstone clasts. The basal portion of the lowest bed near A (Fig. 1) is shown in Figure 3. In this part of the gorge, the base can be seen to cut at least 2.25 m into the underlying dark mudstones.

The observation that there is no inverse grading differs from that of Fisher and Mattinson (1968, p. 1014), who note that "each conglomerate bed is inversely graded, starting at the base with a thin basal zone of sandstone or pebbly sandstone which abruptly grades upward to "conglomerate." The difference of opinion may derive from differing definitions of "beds" within the sequence, and differing interpretations of contacts that "abruptly grade

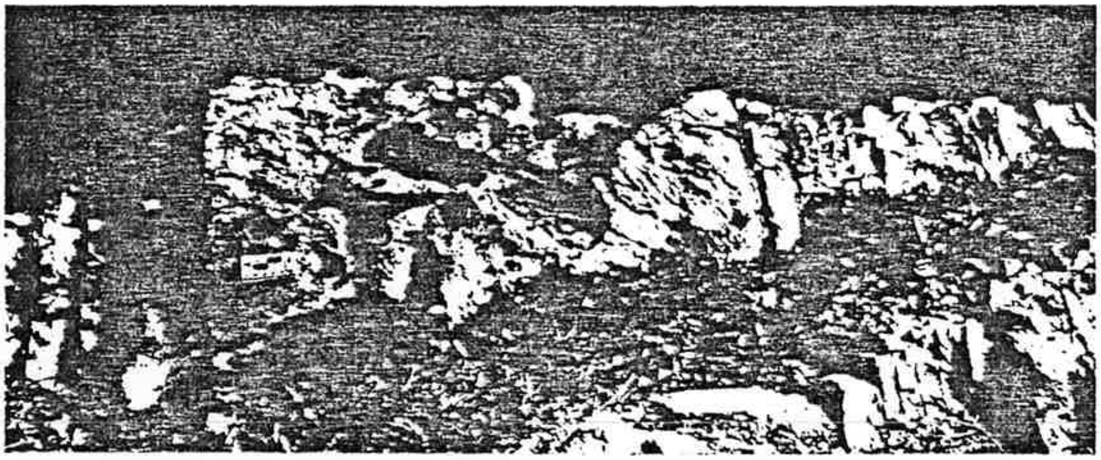

FIG. 4.—Base of conglomerate layer 3 at location E on map (Fig. 1), showing large incorporated mudstone clasts. Photo is taken immediately adjacent to the erosional channel margin (partly under vegetated cover). Top to right.

upward." The problem of inverse grading is discussed in a separate section below.

The conglomerates of layer 2 are not very well exposed. The lower bed (at 26 m, Fig. 2) is brecciated by a small bedding plane fault, and contains rather dispersed, well-rounded clasts, without any sign of inverse or normal grading. The upper conglomerate bed is not graded, except at the very top where there is a rapid passage into coarse sandstones.

Layer 3 contains the thickest conglomerate beds in the section. The base of the layer cuts at least 3 m downward into dark mudstones (71–74 m, Fig. 2), breaking large (1.9 × 0.65 m) mudstone clasts from the wall (Fig. 4), and injecting conglomerate into bedding planes in the mudstone (E, Fig. 1). This contact was excellently described by Fisher and Mattinson (1968, p. 1016–7); the same contact, with at least 1 m of erosion, can be seen near location C, Fig. 1. At this point, inverse grading is well developed and will be discussed below. The layer is 25–30 m thick, but is composite (see Fig. 2). This can be seen along the path (west of F, Fig. 1), and on both sides of the stream at location C. Impersistent sandstone layers at about 78 m can be seen to be eroded by overlying conglomerates. Inverse grading is restricted to the base at location C, and to the layer at 79 m (Fig. 5). Because of poor, mud and slime-covered outcrop, it is not certain whether the conglomerate from 82 to 90 m (long stratigraphic section, Fig. 2) is a single bed. In the short section, the bed from 84 to 95 m appears to be a single bed, without any overall grading.

These three conglomerate layers do not fit very well with the generalized models for resedimented conglomerates recently proposed by Walker (in press) and Davies and Walker (in press). These three models are (a) *disorganized-bed* (no grading, no stratification, normally no strongly preferred fabric); (b) *inverse-to-normally graded*, characterized by inverse and normal grading, without stratification; and (c) *graded-stratified*, characterized by absence of inverse grading, and presence of normal grading and stratification. The Wheeler Gorge conglomerates are not stratified, and in my opinion, only two individual beds have unequivocal inverse grading. The dominant structure is normal grading without stratification, or disorganized-bed (lacking normal and inverse grading, and stratification).

Coarse Massive Sandstones

Above the three conglomerate layers are sequences of coarse, massive sandstone. The conglomerate at 12 m (Fig. 2) grades up into a 7-m thick sandstone—the lower 2 m contains pebble- and granule-grade material, but the upper 5 m is an ungraded medium sandstone. The whole 7 m appears to be one bed, without evident sedimentary structures.

The sandstones immediately above conglomerate 2 are fractured, but the 9-m sandstone from 37 to 46 m is not fractured and appears to be a single bed. The basal 30 cm of the bed contains pebbles up to 2 cm; the bulk of the bed is coarse and medium sandstone without sedimentary structures. The best exposures of

FIG. 5.—Inverse to normally graded bed (with notebook) at 79 meters in Figure 2. Face is cut roughly parallel to flow direction—note absence of imbrication. In bed below the inverse to normally graded one, note chaotic fabric with large clasts almost on end.

thick sandstones with sedimentary structures are between 46 and 58 m. These pebbly sandstones are graded, and variously contain parallel lamination, convolute lamination, dubious dish structure, burrows and layers of mudstone clasts. There are no shales between individual sandstones.

The sandstones above conglomerate 3 consist of several individual beds, with well-developed thick zones of parallel lamination (path west of location F). Below the scree (Fig. 1), the same sandstones are in beds 0.60 to 1.50 m thick, and display both parallel and convolute lamination.

Turbidites

The only exposures of "classical" turbidites—alternating graded sandstones and shales—occur between 63 and 70 m, in the stream bed below the southern bridge, and in the steep gully northwest of location E. Individual beds approach 1 m in thickness although most beds are thinner than 0.5 m. Most are graded, and many display parallel and convolute lamination. Grooves oriented 102–282 degrees were observed on the base of one bed.

Dark Mudstones

Dark gray to black thinly laminated mudstones characterize the section above and below the 100-m sandstone-conglomerate sequence, and occur uncommonly within the sequence (Fig. 2). The mudstones contain thin (1–10 cm, average about 2–5 cm) siltstone layers which have sharp bases, and may be either massive and sharp topped, or ripple cross-laminated. The ripples invariably suggest a westward flow direction. The siltstones are extensively bioturbated, with both vertical burrows and horizontal trails and/or burrows. The dark mudstones with thin siltstones are interpreted as a classical distal turbidite facies (Walker and Mutti, 1973).

FINING- AND THINNING-UPWARD SEQUENCES

The entire 100-m interval can be divided into three overall fining- and thinning-upward sequences, 0–25.50 m, 25.50–70.50 m, and 70.50 to 105 m. The first sequence grades from conglomerates to medium sandstone, and although the grain size becomes finer upward, individual beds do not become thinner upward. The second sequence (25.50–70.50 m) is the best developed, with a progressive change from conglomerates upward into thick massive sandstones, thinner massive sandstones, classical turbidites with interbedded shales, and finally into dark mudstones. The third sequence grades from massive conglomerates abruptly into thickbedded massive sandstones, and then abruptly into dark mudstones.

Progressive sequences that thin and fine upward have been noted in other turbidite formations, (Wood and Smith, 1959; Warren, 1963, 1964; Kimura, 1966). The most detailed work has been done in Italy, notably by Curcio, Pranzini and Sestini (1968), Sestini (1970), Mutti and Ricci Lucchi (1972) and Mutti and Ghibaudo (1972). The Italian workers, particularly Ricci Lucchi (personal communication, 1974), emphasize that the fining- and thinning-upward sequences can be seen to occupy broad channels up to 1 km wide, and they relate the sequences to progressive abandonment of channels in the mid-fan areas of submarine fans (Mutti and Ghibaudo, 1972; Walker and Mutti, 1973). Mutti and Ghibaudo (1972, Table II) go as far as comparing the turbidite fining-

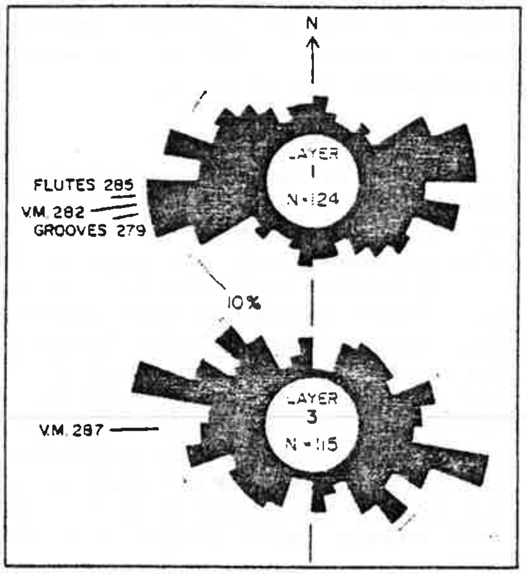

FIG. 6.—Clast long axis orientations on bases of layers 1 and 3. Note the close relationship between clast vector mean and flute and groove directions on layer 1.

upward sequence with that of alluvial and delta-plain environments, but I believe this comparison to be misleading. In the fluvial channel, the best developed fining-upward sequences are developed in active channels (as opposed to neck cut-offs), in which progressive lateral migration of point bars, or progressive reduction in flow (chute cut-off) give rise to the sequences. By contrast, on a submarine fan, there is no continuous flow of turbidity currents down the channels, and hence no strong theoretical reason why successive currents using a channel should deposit finer materials in thinner beds. The grain size and current volume will be strongly influenced by events in the source area rather than in the channel.

In the present example, exposures along the Santa Ynez Fault are essentially two-dimensional, and there is no outcrop evidence that the Wheeler Gorge conglomerates are channelized. I do not believe that the turbidite fining-upward sequence is sufficiently well understood to assign the Wheeler Gorge deposits to a channel—the fining-upward could equally well reflect gradual diminution of supply in the hinterland, giving rise to progressively finer-grained and smaller flows.

PALEOCURRENT DIRECTIONS

Rust (1966, p. 1396) has shown that the principal paleoflow direction for the conglomerates (Wheeler Gorge and the area stretching 10 miles to the east) was toward the west and northwest. The base of layer 1 above the northernmost tunnel bears large (up to 1 m long) flute casts indicating flow toward 285 degrees. At location A on the map, grooves with pebbles in the ends indicate flow toward 279 degrees, and in the gully northwest of location E, grooves indicate flow toward 282 degrees.

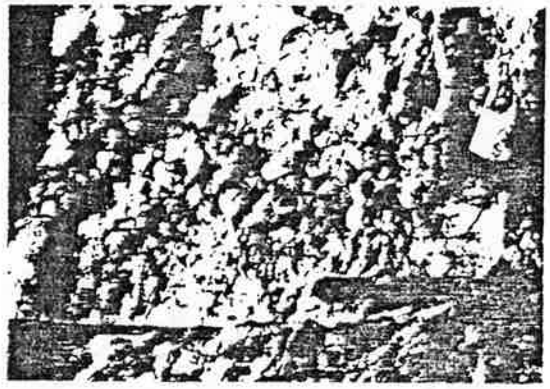

FIG. 7.—Base of layer 3 at location C, Figure 1. Note conglomerate cutting down to left (below note book) and inverse grading (measured in Figure 8).

It has been demonstrated by Davies and Walker (in press) and Walker (in press) that in some resedimented conglomerates, the clasts show a strong preferred orientation, with long axes parallel to paleoflow direction. To check the fabrics on the bases of layers 1 and 3, a series of photographs was taken, and the long axis orientations of clasts were measured. Because of the limited number of clasts showing on the base of layer 1, they could not be measured on traverse lines across the photographs (see Davies and Walker, in press). Instead, the prints were divided into one-inch squares, and each square was carefully searched for *all* elongate clasts.

The results are shown in Figure 6. The vector mean for layer 1 (282 degrees, standard deviation 23 degrees) is very close to the flutes and grooves on the base of the bed, confirming that the clasts are aligned dominantly parallel to flow. Using this evidence, the vector mean of 287 degrees (standard deviation 30 degrees) for layer 3 is interpreted as indicating flow toward 287 degrees for this layer. It is unfortunate that there are no surfaces exposed in the gorge parallel to this flow direction, on which imbrication might have been investigated. The surfaces closest to the ideal orientation are

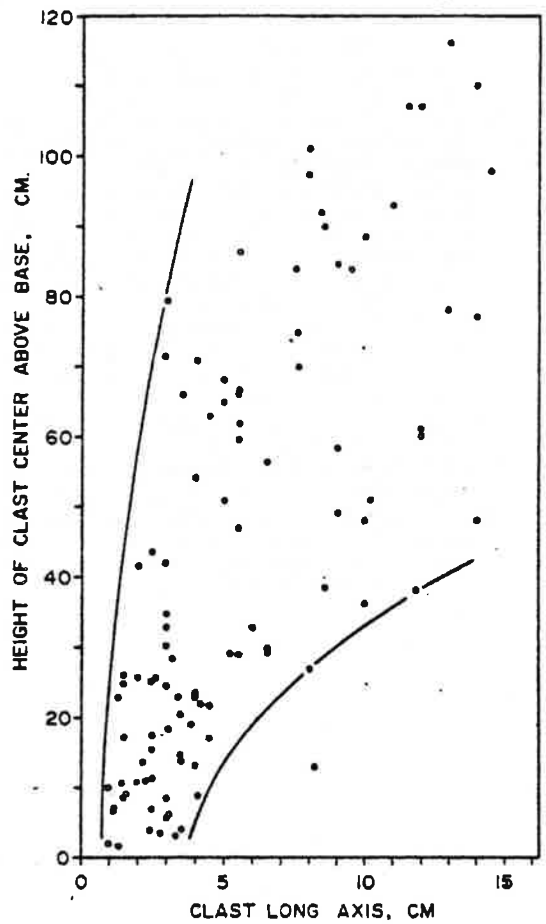

FIG. 8.—Graph of clast long axis (cm) against height of clast center above base of bed, for base of layer 3 at location C (Fig. 1)—see Figure 7. Graph is explained in text.

in layer 3 north of the scree (Fig. 1), but they show no preferred fabric—indeed, many clasts appear to stand sub-vertically (Fig. 5).

The only other orientation observed in Wheeler Gorge was a groove on a turbidite at about 68 m (N.W. of location E). It trended 102–282 degrees, very close to the vector mean clast orientation for conglomerate layer 3 (287 degrees).

INVERSE GRADING

Fisher and Mattinson (1968, p. 1014) noted that "each conglomerate bed is inversely graded, starting at the base with a thin basal zone of sandstone or pebbly sandstone which abruptly grades upward to conglomerate." In my opinion, inverse grading is not as abundant as this statement implies; the difference of opinion may depend upon how "grading" is defined. Grading ideally implies a *progressive* change of size upward from the base of the bed. If there are *abrupt* changes of size, the "grading" may not imply continuous deposition from one flow, but amalgamation of different flows. The interpretation of grading in these two cases would be very different.

It has recently been stressed (Walker, in press) that quantification of grading and inverse grading is important, and an example was given from the Wheeler Gorge conglomerates. Inverse grading was measured at location C, in the lower 1.20 m of layer 3 (Fig. 7), and the results of clast size versus distance of the clast center above the base are shown in Figure 8. The two curves show that inverse grading is present in both the small and large clasts: the use of such a diagram in basin analysis is discussed fully by Walker (in press).

In terms of flow mechanics, the scarcity of inverse grading at Wheeler Gorge implies that flows were not highly concentrated, and that dispersive pressure between the clasts was not important during the last stages of transport (Walker, in press). The implication is that slopes were not very steep at the Wheeler Gorge location, and the prediction is that if the conglomerates could be traced eastward, more beds with inverse grading would appear, and the sandy portions of the section would disappear. This prediction cannot be tested, because the closest Upper Cretaceous outcrops are about 35 miles to the east, in the Simi Hills, where massive sandstones and pebbly sandstones (probably unrelated to the Wheeler Gorge rocks) crop out.

ACKNOWLEDGMENTS

I am indebted to Dick Fisher for examining my field map, and Don McCubbin for helping record the inverse grading data. The work was done whilst I was on sabbatical leave as Visiting Scientist at the Denver Research Center, Marathon Oil Company, and I thank the Company for making their facilities available to me. The work was funded by the National Research Council of Canada, and the manuscript was improved by the comments of Don McCubbin and David MacKenzie.

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MATILIJA SANDSTONE: A TRANSITION FROM DEEP-WATER FLYSCH TO SHALLOW-MARINE DEPOSITION

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Introduction

The Matilija Sandstone of Eocene age is an excellent unit in which to study the transition from deep-water flysch to shallow-marine deposition and, in particular, thick-bedded (proximal) turbidites. Jestes (1963) and Stauffer (1967b) recognized the lower thick-bedded turbidite and the upper shallow-marine divisions in the Matilija Sandstone. The Matilija Sandstone is potentially productive in the offshore Santa Barbara Basin. Thick-bedded turbidites, such as those found in the Matilija Sandstone, are economically important because they are commonly major reservoir rocks in many of the local petroliferous provinces. The purpose of this paper is to describe the Matilija Sandstone and present conclusions on its source area, its environments of deposition, and its displacement on the Santa Ynez fault.

The Matilija Sandstone crops out along strike and forms prominent, resistant ridges in the Santa Ynez Mountains for over 50 miles from west of Gaviota to northeast of Ojai (Fig. 1). It is exposed on both sides of the Santa Ynez fault, thinning both westward and eastward from its maximum exposed thickness of 2,750 feet (838 meters) at the type section, Matilija Springs. This paper describes the "eastern" part of the Matilija Sandstone (Stauffer, 1967b; Dibblee, 1966), and includes all rocks called Matilija Sandstone east of San Marcos Pass (Fig. 1).

Kerr and Schenck (1928) originally defined the Matilija Sandstone at Matilija Springs as the lower resistant sandstone member of the Tejon formation (Kew, 1919). Tejon formation was used in a time-stratigraphic sense and subsequently has been dropped from local stratigraphic nomenclature. Matilija Sandstone, a lighologic term, has been raised from the member to formation status.

General Stratigraphy

At its type locality, Matilija Springs (Fig. 2), the lower part of the section is transitional with the underlying Juncal formation. Foraminifera from the type Matilija indicate a middle Eocene (Ulatisian) age for at least the lower half of the unit (Blaisdell, 1955; Natland, 1957). Mollusks in the upper Matilija indicate a late Eocene (Narizian) age (Jestes, 1963). Lithologically, the Matilija Sandstone consists of a thick-bedded sandstone sequence at the base that is overlain by cross-bedded sandstone beds, and, in turn, by interbedded gray to red siltstone and cross-bedded sandstone. Within the siltstone section are thin limestone and gypsum beds, beds with mud cracks, and abundant mollusks. The siltstone and cross-bedded sandstone unit passes upward into laminated sandstone and siltstone beds which are transitional to the overlying

Cozy Dell Shale.

Faunal data indicate a shallowing trend from bathyal depths at the base of the Matilija to neritic in the cross-bedded sandstone and siltstone beds, followed by deepening toward the top of the formation (Blaisdell, 1955; Natland, 1957; Jestes, 1963). This trend is consistent with the trends of sedimentary and biogenic features observed. The Matilija Sandstone here represents a major regressive event (van de Kamp and Harper, 1969).

Petrology and Source Area

The Matilija Sandstone consists of submature arkoses, ranging from very fine- to coarse-grained sandstone. The average sandstone is medium grained, contains mica, numerous rock fragments, and calcite cement. Petrographic data indicate that the Matilija Sandstone was primarily derived from granitic and metamorphic rocks with minor contributions of volcanic and sedimentary rocks, and rocks possibly of Franciscan origin.

Paleocurrent, thickness, and provenance studies (Link, 1971) suggest that the Matilija Sandstone was deposited in an east-west trending basin or trough (Ventura Basin), with the source being to the east. The sequence is probably time-transgressive with older rocks to the east and younger rocks to the west. The present-day outcrops of the Matilija Sandstone that are exposed in the Santa Ynez Mountains display only a diagonal cross-section of the formation (Fig.3).

Environments of Deposition and Basin Model

The Matilija Sandstone records a major regression in the Eocene Ventura Basin, in which thick-bedded turbidites were deposited on the floor, slope, and possibly on the shelf of the basin. These turbidites were subsequently covered by progradational delta complexes. The transition between these turbidites and delta complexes is gradational and laterally continuous, suggesting that they are closely related.

The lowermost sandstone beds of the Matilija Sandstone are interpreted as laid down by density underflows on a submarine-fan complex. Thin-bedded (distal) and thick-bedded (proximal) turbidites are recognized. They display graded bedding; have sharp lower bedding contacts commonly with directional sole marks and load features; and contain mudstone clasts, amalagamation features, and a deep-water fauna. The proximal and distal turbidites differ in that the former have an extremely thick "a" interval (Bouma, 1962) and contain faint wavy laminae and distinctive dish structures (Stauffer, 1967a).

The uppermost beds of the Matilija Sandstone are interpreted as laid down by various types of traction currents in shallow-marine environments. The vertical sequence of sedimentary and biogenic features, the facies, and the aerial distribution of these beds suggest that they were deposited as a progradational deltaic complex (Link, 1971) in which three main environments are recognized -- shelf, coastal, and restricted-coastal lithofacies (Fig. 3).

The transition between the turbidite and deltaic intervals is marked by a thickening of beds and a slight coarsening of the average grain size, an increase in bioturbation, and an increase in large channel-like features upward in the vertical sequence of beds. Directly overlying and gradational with this interval are units containing a shallow-marine fauna and current-derived primary features. No evidence of an unconformity or hiatus was observed.

The basin model presented here (Fig. 4) associates shallow-marine deltaic deposition, the submarine-fan complex, and turbidity currents together in a single explanation of sedimentation, that of deep- and shallow-marine deltaic deposition. Proximal turbidite deposition is postulated to be directly related to deltaic deposition and generated by slumping and sliding of sediment toward deeper water as high-concentration density underflows on the front and flanks of a prograding delta. As flows of unconsolidated sediment deposit material and move farther from the source, they change into lower-concentration density underflows which later form distal turbidites. The resultant submarine-fan complexes form at the front and flanks of the prograding delta, which provides a likely source of sediment which under the influence of gravity slumped or slid into deeper water. As the delta progrades and fills the basin, the turbidites derived from it are covered by shallow-marine deposits of traction-current origin. Continued progradation, subsidence, and delta switching may explain the highly variable, thick shallow-marine sequences of the uppermost Matilija Sandstone.

Displacement on the Santa Ynez Fault

In comparing the Matilija Sandstone across the Santa Ynez fault, offset of less than a mile or two is suggested by (1) similar section thicknesses on both sides of the fault (see Fig. 3), and (2) similar vertical lithofacies sequences on both sides of the fault with only minor variations. All these features suggest that the Eocene basin in which the Matilija Sandstone was deposited has had little lateral displacement.

Conclusions

The Matilija Sandstone (middle-late Eocene), exposed in the Santa Ynez Mountains, records a major regressive event and a transition from deep-water flysch to shallow-marine deposition in the Eocene Ventura Basin. The Matilija Sandstone is underlain by the Juncal formation and overlain by the Cozy Dell Shale. The Juncal formation - - a flysch or distal turbidite sequence - - grades upward into a proximal turbidite sequence in the lower part of the Matilija Sandstone. This proximal turbidite sequence is overlain by a shallow-marine complex which is divisible into shelf, coastal, and restricted-coastal lithofacies.

Matilija Sandstone deposition documents shoaling from outer neritic to bathyal depths in the Juncal formation and basal Matilija Sandstone to neritic and littoral depths in the upper Matilija. It closed in a rapid transgression which culminated in the deposition of the Cozy Dell Shale (neritic to bathyal depths).

The Matilija Sandstone was deposited by a westward prograding deltaic system that extended from the shelf into the basin, which it gradually filled. The source area was to the east, and petrographic data indicate that the Matilija Sandstone was derived primarily from granitic and metamorphic rocks. Comparison of sections of the Matilija Sandstone across the Santa Ynez fault suggest little lateral displacement along this fault since Eocene time.

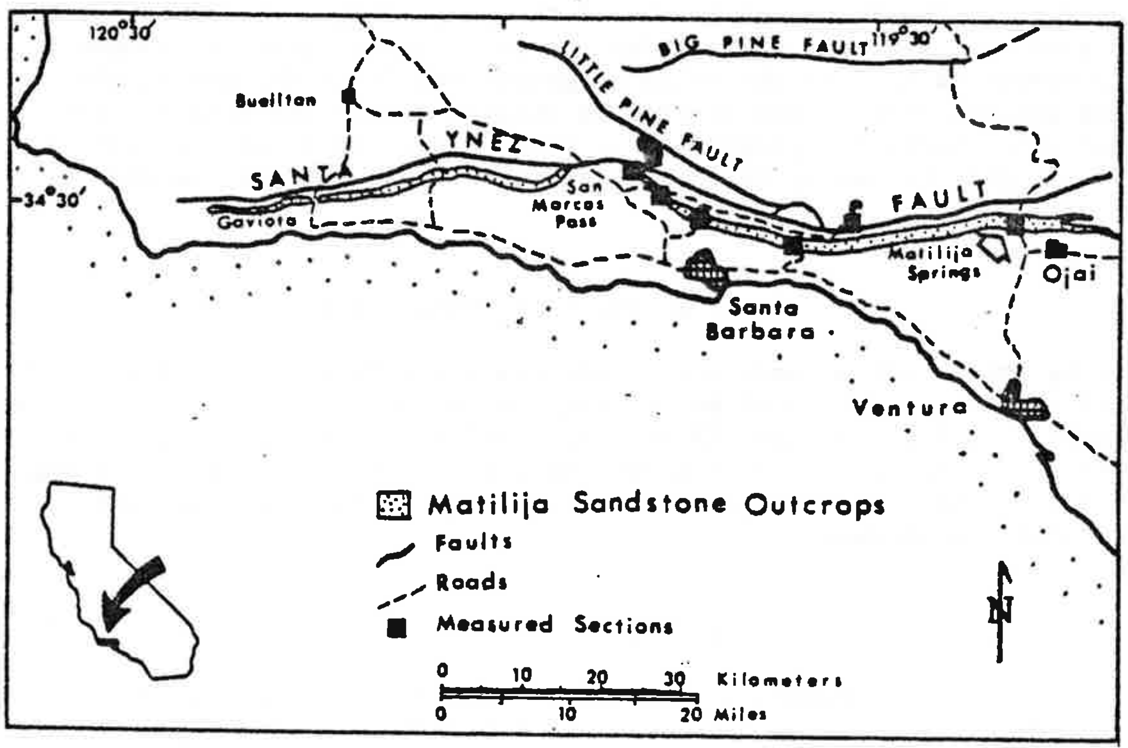


Figure 1. Index map showing the Matilija Sandstone outcrops, measured section localities, major faults, and roads in the Santa Ynez Mountains, California.

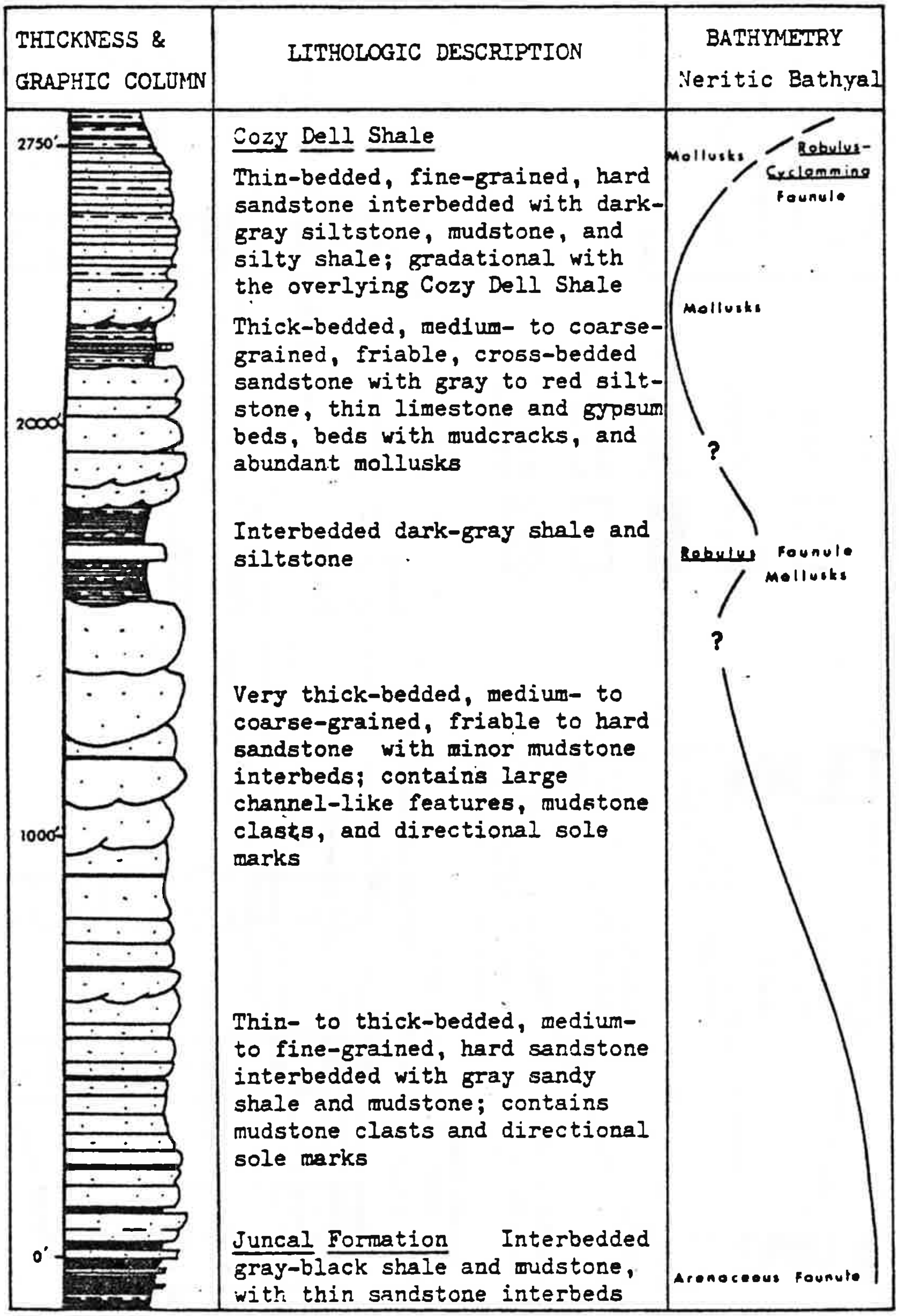


Figure 2. Stratigraphy and bathymetric interpretation for the Matilija Sandstone - - type locality, Matilija Springs.

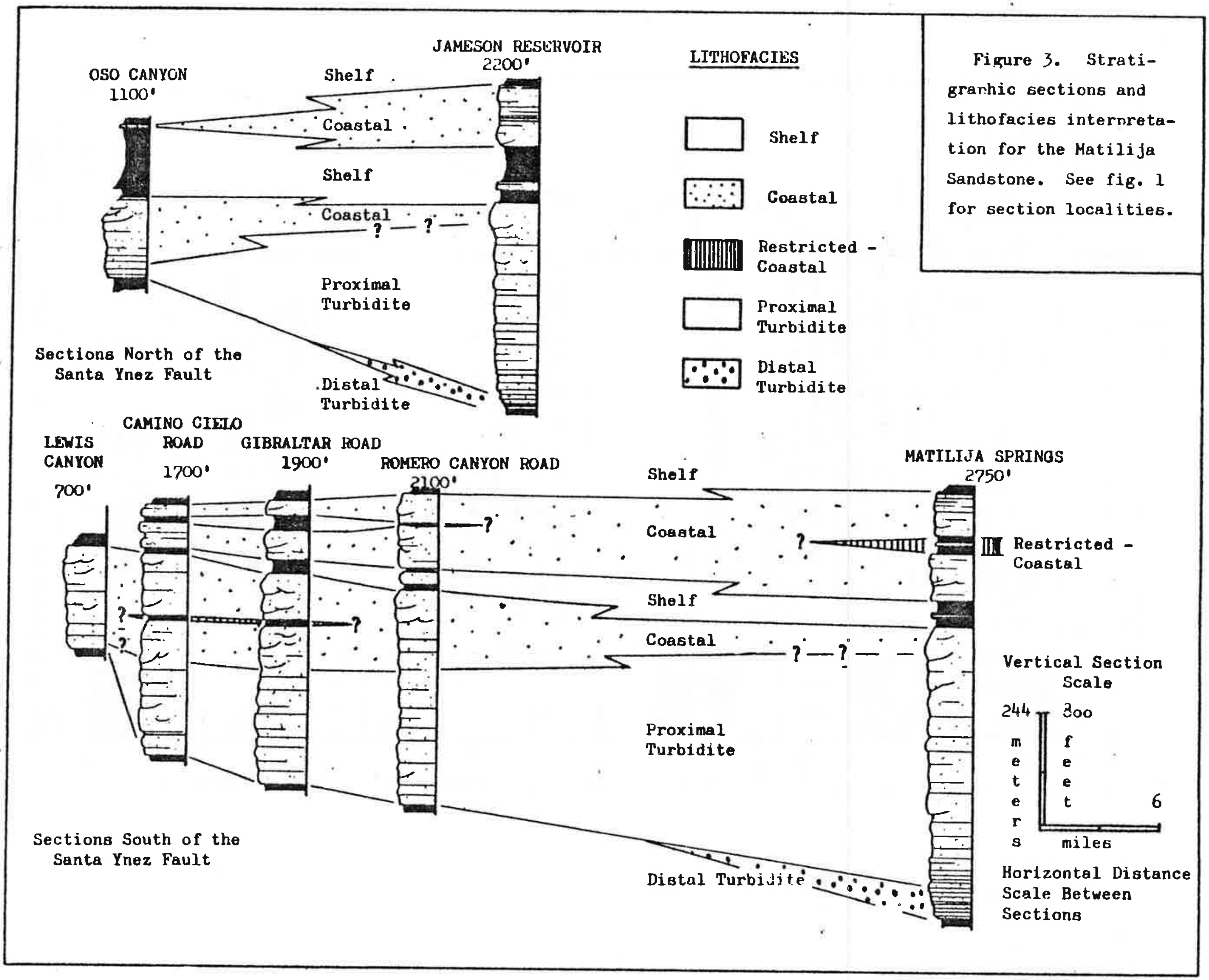


Figure 3. Stratigraphic sections and lithofacies interpretation for the Matilija Sandstone. See fig. 1 for section localities.

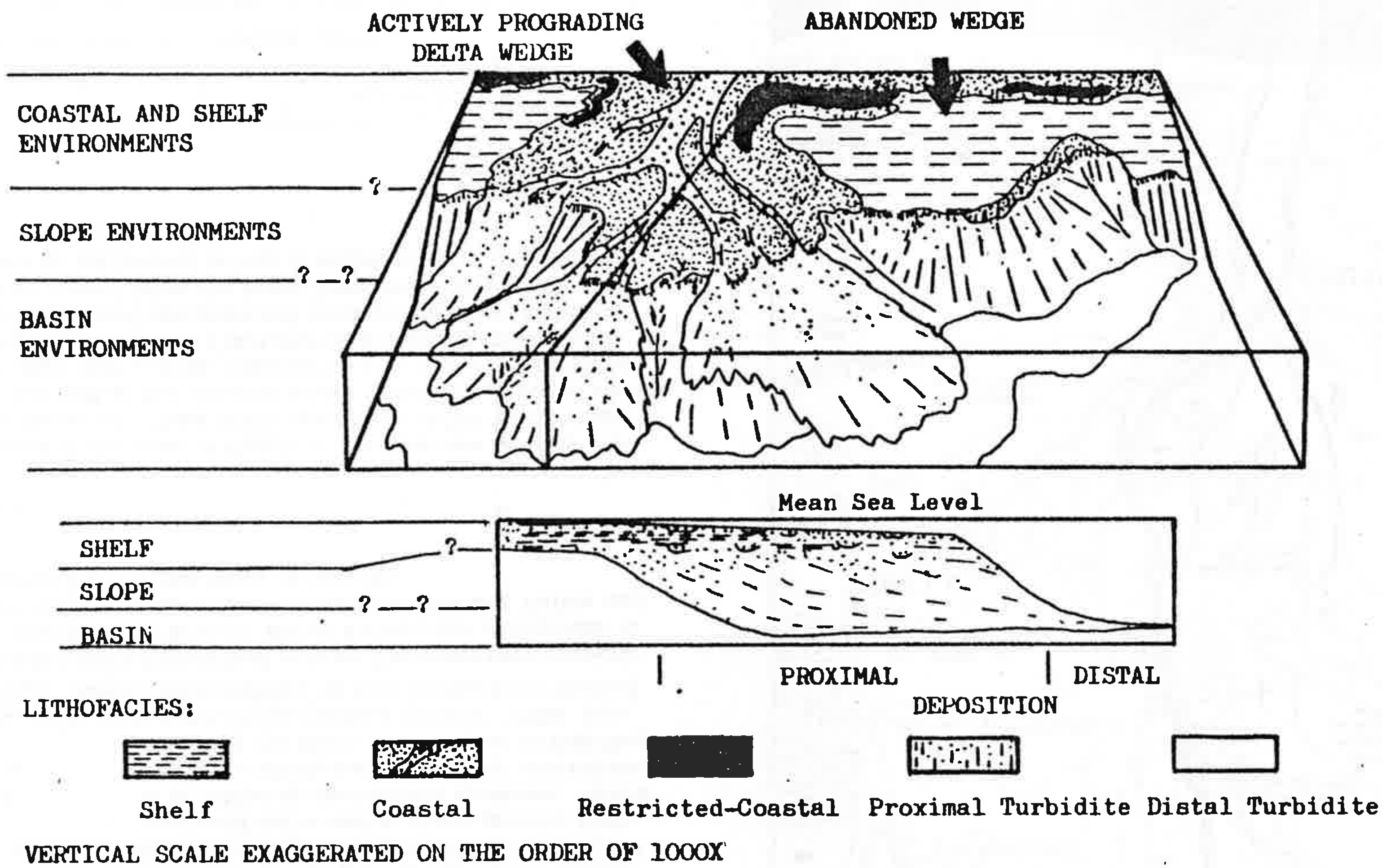


Figure 4. Depositional model for the Matilija Sandstone and associated environments. Based on a prograding delta system extending from the shelf into the basin with lateral shifts of delta lobes and shoaling of the basin with continued progradation (modified after Ferm, 1970).

Return to the mouth of the canyon of the upper Ventura River and follow Highway 399 south through the valley of the Ventura River to the coast. In this part of the route, conclusive evidence of intermittent uplift in Quaternary time and of continued deformation to the present time is provided by Quaternary terraces. These terraces, which may be seen at several levels along the river, are warped so that they are now inclined in a direction opposite to their initial seaward slope. Recent diastrophism is also indicated by faulted terraces and some Recent fault scarps. Terraces exist throughout the length of the Ventura River Valley, and a sequence of seven terraces is present in the area between Long Valley and San Antonio Creek (see Maps 12 and 13).

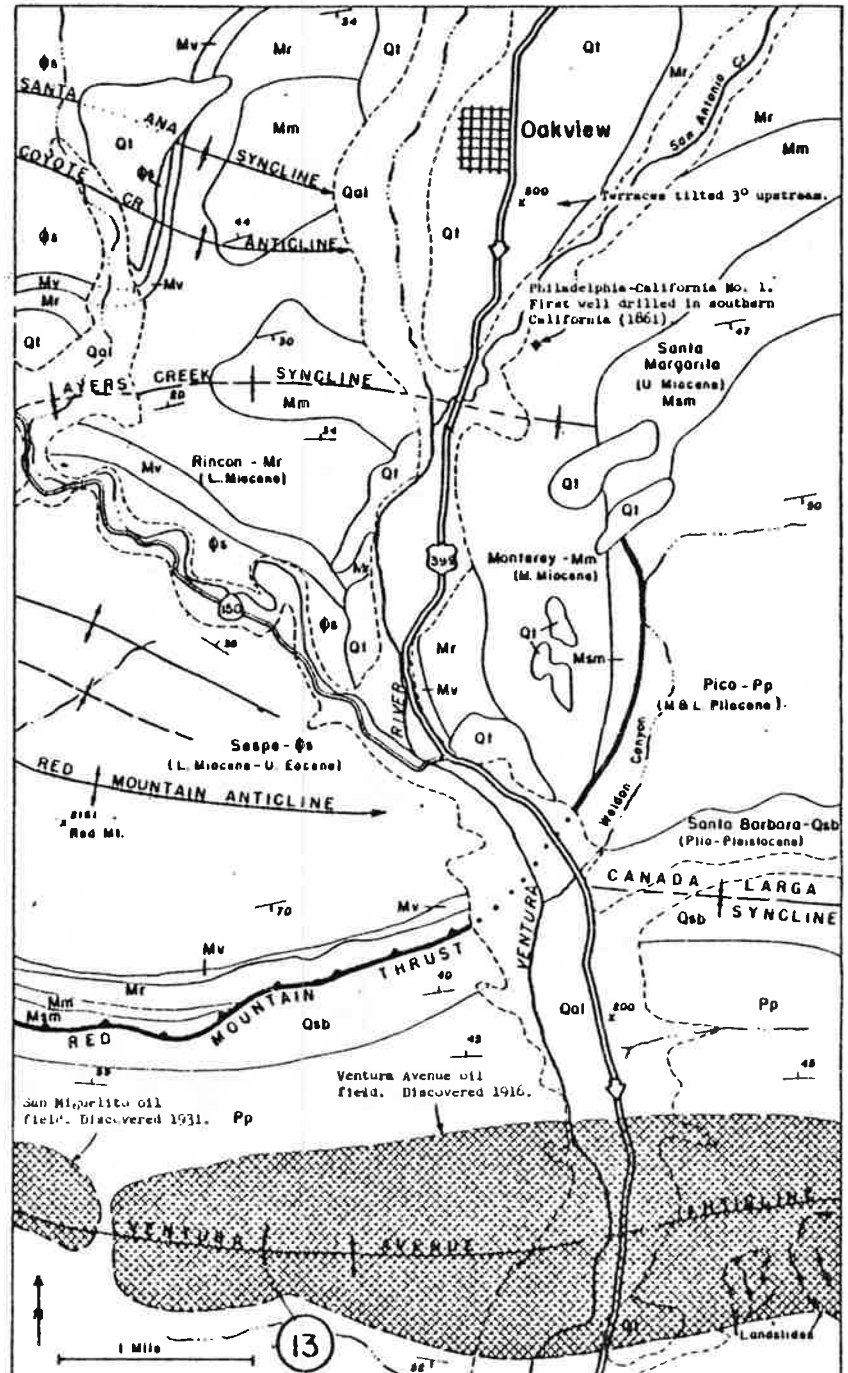
Warped terraces

MAP 13

South of the town of Oakview, the Oakview terrace widens to a mesa, and rises from an altitude of 500 feet at Oakview to 550 feet at San Antonio Creek within a horizontal distance of less than a mile. This terrace is clearly back-tilted and continues to rise for a distance of 2 miles farther south. It can be recognized upstream and downstream from Oakview, and can be traced from the Santa Ynez Mountains to the sea. The creek is antecedent in that it maintained its course during the warping.

Fig. 19. Profile of Oakview terrace.

To the east, across San Antonio Creek, is the site of Philadelphia-California No. 1, considered to be the first well drilled in search of oil in southern California. This hole was drilled in the 1860's by the Scott interests of Pennsylvania (see Map 13).



ROAD LOG

NOTE: ALL DRIVING INSTRUCTIONS ARE PRINTED IN CAPITAL LETTERS

DISTANCE BETWEEN POINTS	COMMENTS
0.6*	LEAVE HWY. 33 ON RIGHT, exit road. TURN RIGHT. CROSS BRIDGE. Red Mountain Fault cuts across road, trending north-south to westerly. Trace is on south side prominant skyline. Due south are Sespe beds dipping 40 to 60 degrees southeast. The change in strike from east dipping Monterey to the southeast dipping Sespe reflects the southeasterly plunge of the Red Mountain Anticlinal trend.
0.6	Junction with Santa Ana Road on right. CONTINUE STRAIGHT TO CASITAS DAM VISTA POINT.
1.8	STOP #1. Casitas Dam overview. Refer to Field Trip Map (Plate IV) and Plates V & VI for remainder of trip. Looking east across the dam to the shoreface north of the dam are seen sandstones of the Vaqueros Formation exposed along ths shoreline and continuing east holding up the ridge that intersects the dam abutment on the far (east) shore. North of the dam (on the east) the rolling, subdued topography is composed of Rincon Formation north to the tree covered ridge in the middle-foreground. At the base of this ridge, the Vaqueros outcrops and north of this is Sespe Formation, continuing north into the Topatopa Mountains (upheld by Sespe Formation low on the slopes, and Eocene rocks higher up and north). Swinging to the west, viewing the island due north of the vista point is a small, very poorly exposed Vaqueros outcrop crossing the southern tip of the island. The remainder of the island to the north is composed of Sespe Formation. Swing further west, in the near background is a steep road cut within the Sespe Formation. This exposure is just south of Field Trip Stop #7. Continuing the pan to the west, in the near foreground, on the ridge immediately across the southern arm of the lake is seen a resistant outcrop of Vaqueros sandstones holding up the ridge. This is along the south limb of the Ayers Creek Syncline shown on the map (Plate IV).

Structurally, the lake is traversed by the east-west trending Coyote Creek Anticline and several subsurvient folds. Just north of the lake is the east-west trending Arroyo Parida Fault, down thrown on the north, with Sespe beds on both sides. This fault will be seen later between Lunch Stop #5 and Stop #6.

LEAVE STOP #1. RETURN TO SANTA ANA ROAD.

Just south of dam, note good exposure of Sespe beds. Immediately to the left across the Canyon bounded to the north by the dam are resistant ledges of Vaqueros sandstone outcrops which continue east under the power poles.

1.8 TURN NORTH ONTO SANTA ANA ROAD.

0.2 Resistant upper Sespe sandstones exposed on left side of road.

0.4 On left, beneath the power poles are good exposures of Vaqueros Formation (continuious outcrop with that seen at Stop #1). Because of the poor location on the road, the buses will not stop here. A similar outcrop will be viewed at Stop #4. The contact with Rincon Formation is seen immediately to the north.

0.2 Terrace cobble conglomerates exposed on both sides of the road.

0.1 Rincon Formation on left. Note the contact with Terrace material overlying the Rincon high on the hill.

0.2 STOP #2 Rincon Formation. These exposures are very typical of the Rincon throughout the Ventura Basin.

Here the northeast dipping beds are exposed on the south flank of the Ayers Creek Syncline.

East, across the Ventura River are highly contorted beds of the Monterey Shale. The steep regional plunge to the east projects the Rincon into the sub-surface across the river.

> Rincon Siltstone is composed of olive-grey to blue-grey siltstone and light tan to orange siltstone concretion beds. The siltstone is medium bedded (1" to 3" thick) and well indurated with calcareous cement. Beds are very thinly stratified. Joints are closely spaced (½" to 10" apart) and cut bedding planes at nearly right angles. Gypsum occurs on bedding and joint surfaces. The siltstone is composed

of approximately 40 percent quartz, 15 to 20 percent feldspar, 10 percent oxides, 7 percent organic material and 3 percent dolomite and calcareous cement. Minor sandstone intercalations occur throughout the section.

DEPOSITIONAL ENVIRONMENTS

The thin stratification within the siltstone beds may be taken to indicate an absence of benthonic organisms that would mix the sediments by burrowing. This suggests enviroments such as lagoons, stagnant marine basins, or undisturbed non-marine. This transgressive sequence between the marginal marine Vaqueros rocks and deep water deposits of the Monterey Formation, indicates a lagoonal environment of deposition is unlikely.

SYNTHESIS

Rock of the Rincon Siltstone is indicative of moderately deep, stagnent marine basin environments. Source of the sediments cannot be determined, but was probably granitic, as in the underlying units, mixed with hemipelitic clays.

LEAVE STOP #2. CONTINUE NORTH.

0.2 Very poorly exposed contact of Rincon/Basal Monterey in gulley on left. Proceeding north, we view poorly exposed Monterey Shales.

0.4 STOP #3. Hwy. turnout on right side of road. Monterey Formation.

Monterey Formation is typically composed of dark brown to light grey shales, weathering yellowish to tan. The shale is thin to medium bedded (½" to 2" thick), locally microlaminated and has good fissility. Siliceous, calcareous, and diatamaceous beds are common, with occassional chert nodules. Shales are composed of clays and mica with siliceous and calcareous cement.

Note the terrace boulder conglomerate cutting down into the Monterey on the curve of the road. Here, the strong contortions within the shales result in 90 degree kink-bends that exposed bedding planes parallel and perpendicular to the outcrop.

This highly deformed section is within the axis of the Ayer's Creek Syncline. The lack of a distinct axial roll over in the fold, but rather a zone of contorted, alternately north, south, and east (down plunge) dipping beds is common to many folds of the Ventura Basin and suggests a mixture of passive slip and flexural sip folding.

LEAVE STOP #3. CONTINUE NORTH.

0.6 Axis of Coyote Creek Anticline. Here, above, to the left of the road, four wells were drilled in the 1950's. Refer to the paper by John Curran (this guidebook) for a discussion of the wells.

Swinging northwest around the curve in the road, burnt shales of the Monterey are exposed on the left (west).

0.2 Stone building of the Two Lazy Two Ranch on right side of road. Light grey diatomaceous shales of the Monterey on left, below the burnt shales.

0.6 Intersection with Santa Ana Road. Exposures of Monterey on rolling hills west of road.

0.1 Intersection of Burham Road on right. East dipping Monterey north of intersection.

0.3 East, across Ventura River, note the extremely thick, tilted terraces.

0.1 Road curves left (west). North of the road are very poor exposures of Rincon silt and clay.

0.3 Lake Casitas, Wadleigh Arm on left (best bass fishing in California). The ridge to the right (north) of the road is held up by the south dipping Vaqueros Formation which will be viewed at the next stop.

0.4 Contact of top of Vaqueros Formation at curve in road.

0.1 STOP #4. Vaqueros Formation in road cut. Sespe contact at west end of road cut. Refer to the paper by Eastes and Fritsche (this guidebook) for a measured section and interpretation of this sequence.

LEAVE STOP #4. Proceeding west around lake, from here on we remain in Sespe Formation for the remainder of the field trip.

0.2 Brown Sespe sandstones in road cut to right (north). South dipping, planar slopes on island to the left (southwest) are a reflection of dip slopes in the Sespe Formation.

0.9 TURN INTO ENTRANCE TO LAKE CASITAS RECREATIONAL AREA. PARK IN FRONT PARKING AREA. LUNCH STOP #5. Eat lunch, drink beer.

LEAVE LUNCH STOP. TURN LEFT (NORTH) BACK ONTO ROAD. PROCEED TO HWY. 150.

0.2 Intersection with Hwy. 150. TURN LEFT (WEST). Panorama of Topatopa Mountains to north. Reddish flat irons on lower slopes are Sespe. Light grey Eocene exposed higher on slopes.

Traveling west on Hwy. 150, the tree covered ridge on the left (south) is held up by the east-west trending Arroyo Parida Fault. The fault traverses the Sespe Formation and is downthrown on the north.

1.0 Well exposed joint sets within Sespe. The road here traverses along the axis of a minor syncline north of the Arroyo Parida Fault.

0.2 Arroyo Parida Fault scarp exposed immediately south of road (on left).

0.1 STOP #6. DANGEROUS CURVE. USE EXTREME CAUTION ALONG ROAD! Excellent exposures of sedimentary structures within the Sespe.

Notice the strong butress scoured erosional channel edges on some of the conglomerates where the channel axis swings out normal to the outcrop. Across on the west side of road, notice the strong jointing which is accentuated by differential weathering.

The outcrop in this roadcut represents the lower unit of the Sespe Formation, being made up primarily of sandstones and conglomerates. Note the high flow regimes, parallel bedding, graded beds, and disorganized beds. Also note the sole markings, flute casts, and other tool markings indicative of turbulent flow.

In a broad regional sense the Sespe Formation is a time transgressive sequence of rocks ranging in age from late Eocene to early Miocene.

This non-marine sedimentary sequence is associated with the Ynezian regression (Fisher, 1972) or referred to earlier (Dibblee, 1950) as the Ynezian Orogeny. The first evidence of this regression is reflected in the eastern Santa Ynez Mountains by the development of a shallow water facies of the Matilija (early to middle Eocene) (Link, 1972) and the development over most of the area of the paralic deltaic sediments of the Coldwater Formation. The termination of the Ynezian regression is reflected in marine transgression as recorded by the Vaqueros Formation. The maximum thickness for the Sespe in the area is 7000 feet in the eastern Santa Clara Trough, with a thickness of 5000 feet in the Ojai-Casitas area (Fisher, 1972). Directional feature

STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS OF THE VAQUEROS FORMATION NEAR LAKE CASITAS, VENTURA COUNTY, CALIFORNIA

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INTRODUCTION

Two sections of the late Oligocene and/or early Miocene Vaqueros Formation were measured and described in the vicinity of Lake Casitas, Ventura County, California, for the purpose of determining the depositional environment history of the unit. The first section is at the east end of Lake Casitas dam and the second is along Santa Ana Road on the northeast shore of the lake (Fig. 1). The Casitas Dam section (Fig. 2) can be seen from a distance at Stop 1 on the field trip; the Santa Ana Road section (Fig. 3) is the topic of study at Stop 4.

The two sections were measured by tape and compass methods and described by Eastes. Environmental analysis and writing were the joint efforts of both authors. Because thin sections were not available, analysis of the two sections is based solely on field observations. The authors are indebted to S. A. Reid, Getty Oil Company, for his field assistance and helpful comments during the project.

Stratigraphy and lithology of the two sections are presented in tabular form in Figures 2 and 3. In the following discussion of depositional environments, only the rocks at the Santa Ana Road location (Fig. 3, Stop 4) will be referred to specifically, but rocks at Casitas Dam (Fig. 2) indicate similar depositional environments.

Environmental subdivisions of the coastal zone as used herein are defined by Reineck and Singh (1975, p. 285). The backshore is that part of the beach which is above the mean high water line; foreshore is between the mean high water and low water lines; shoreface is between mean low water line and wave base; and the transition zone and offshore environments are below wave base.

The Vaqueros Formation exposed in this area is a transgressive marine sequence which is underlain by the continental Sespe Formation and overlain by the marine Rincon Formation. The environments represented range from salt marsh to offshore and indicate a marine coast of low energy.

Red and green chert are common in all the Vaqueros sandstones around Lake Casitas, thus indicating at least a partial Franciscan source rock for the Vaqueros.

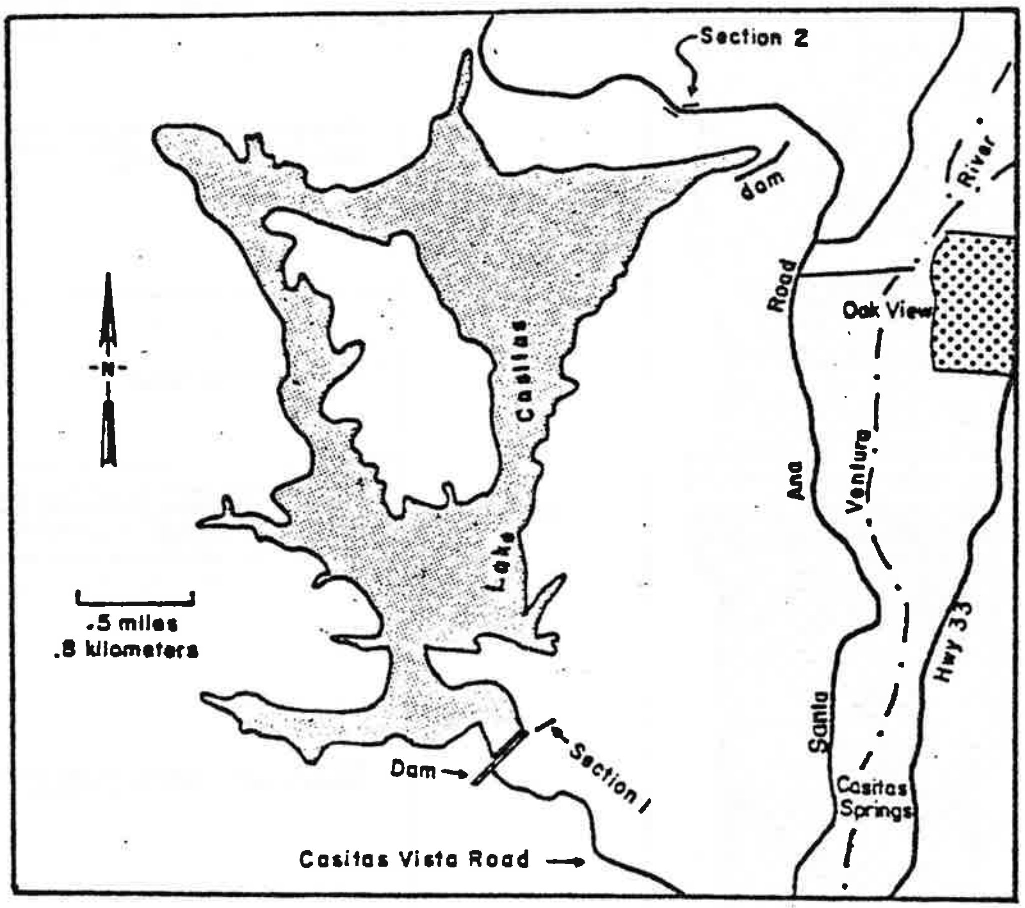

Figure 1. Location of stratigraphic sections measured in the Lake Casitas area.

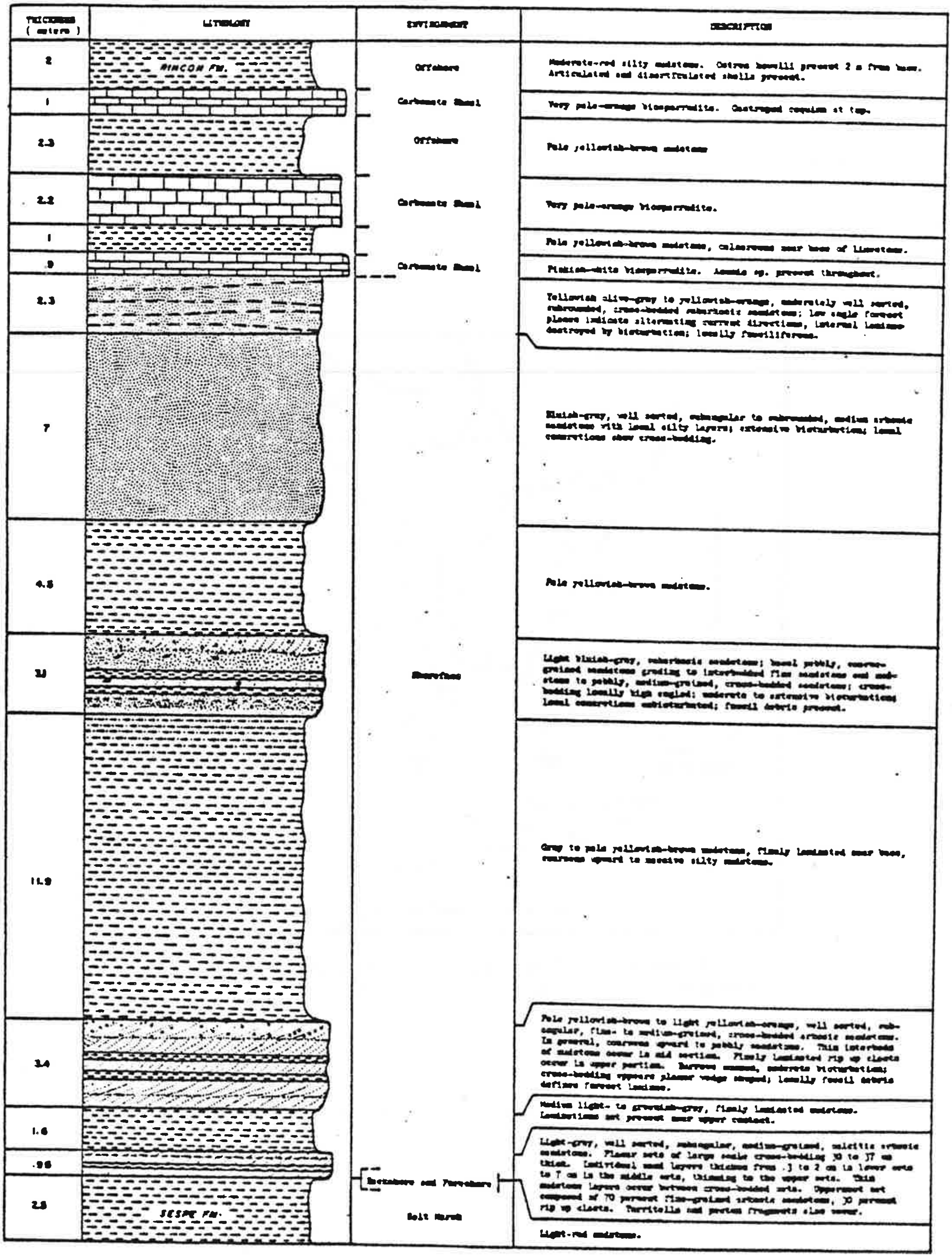

Figure 2. Section 1 measured in Vaqueros Formation west of Casitas Dam.

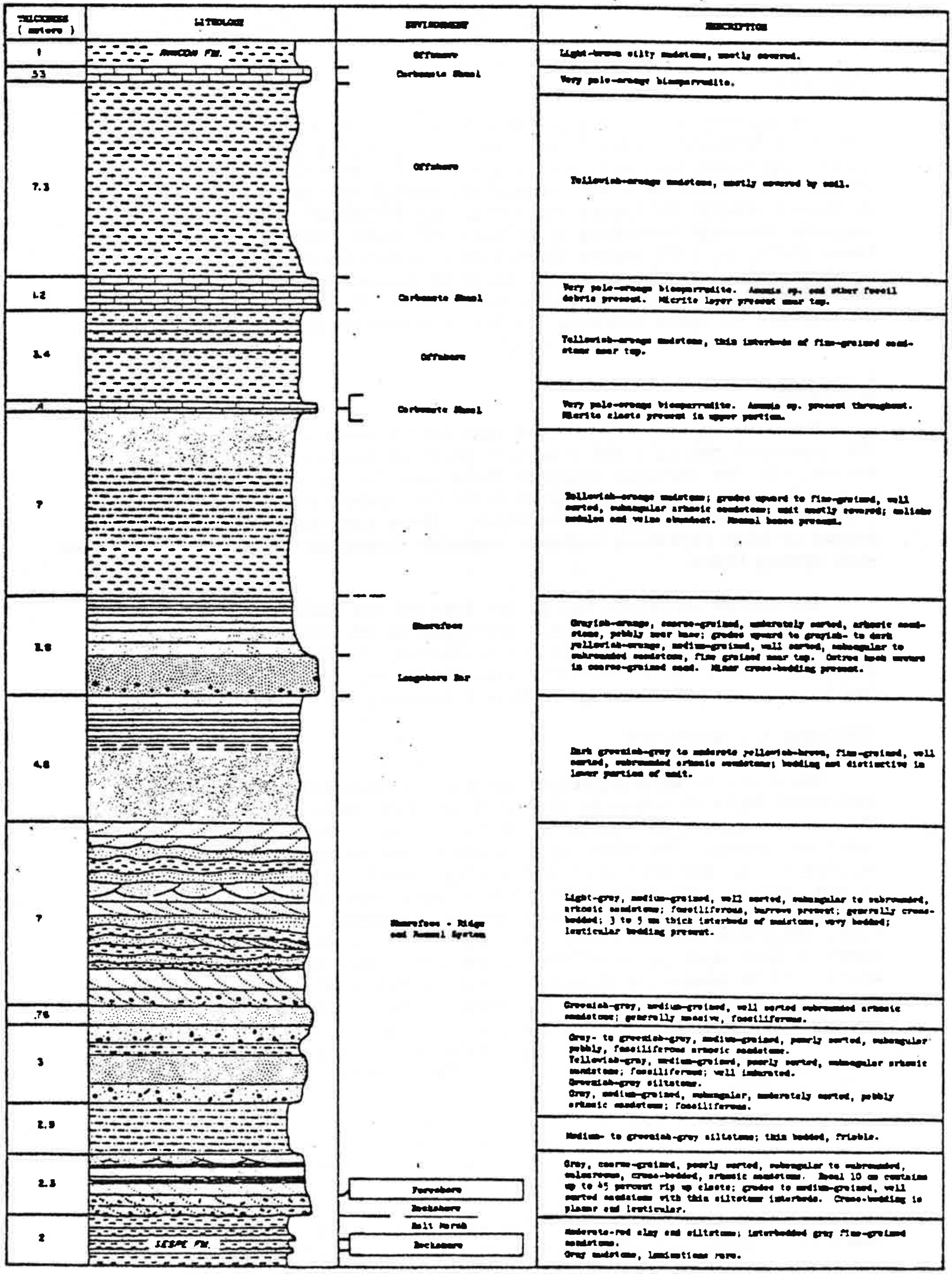

Figure 3. Section 2 measured in Vaqueros Formation north of Lake Casitas.

DEPOSITIONAL ENVIRONMENTS AT STOP 4

SALT MARSH

The uppermost red to gray, generally massive mudstone deposits of the Sespe Formation, because of their stratigraphic position between underlying floodplain and overlying backshore environments, are interpreted as deposits of a well-vegetated coastal salt marsh. Although no fossil remains or traces are found, the rarity of laminations suggests thorough reworking by animals and plant roots. Frey and Basan (1978, p. 123) report that in many modern southern California marshes, relatively little plant material becomes incorporated into the substrate. If plant root bioturbation is the reason for the massive nature of these deposits, then a slow deposition rate and slightly oxidizing conditions are indicated.

BACKSHORE

Two thin, gray, fine-grained sand layers occur interbedded with the uppermost red silt and clay salt marsh deposits of the Sespe Formation. In the vertical sequence these sand layers occur within rocks of marsh environment, which indicates short-term deposition of a new environment on top of the marsh. These sand layers are interpreted as high backshore washover deposits formed during storms associated with spring tides.

The coarse sandstone bed at the base of the Vaqueros Formation represents a storm ridge deposit developed on the seaward edge of the salt marsh. The coarseness of the sandstone, the abundant rip-up clasts derived from the mudstone directly below, and the stratigrahic position of the bed all support this interpretation.

FORESHORE AND SHOREFACE

The fine- to medium-grained sandstone immediately above the thin backshore deposits contains 10- to 20-cm-thick tabular crossbed sets that are interlayered with parallel-bedded units that contain thin mudstone lenses. The cross bedding was formed by moderate strength, unidirectional currents that were moving toward the northwest. Currents in the coastal zone that could produce such cross bedding include oscillating wave-induced currents that are perpendicular to the shoreline, longshore currents that are parallel to the shoreline, and rip currents that move in an offshore direction. Because longshore currents would tend to produce a climbing ripple pattern that is different from the pattern here, and because rip currents would not occur in the rock record until higher in the section, it is suggested that these deposits were formed by landward advancing ridges or bars similar to those described by Davis (1978, Fig. 33) and Davidson-Arnott and Greenwood (1976, p. 157).

Becuase these landward-advancing ridges which occur in the shoreface zone are immediately overlying the backshore deposits, it follows that the beach or foreshore zone was geographically very thin and thus accumulated few or no deposits. This implies a low-energy coastline which had low waves and a low tidal range. A similar low-energy muddy beach environment has also been propsed for the Vaqueros Formation in the Sespe Creek area (Reid, 1978, p. 30).

Overlying the lowermost cross-bedded ridge deposit is a series of tabular and lenticular cross-bedded sandstone units which are interbedded with mudstone sequences that in places contain wavy bedding. This series of deposits suggests the development of an extensive ridge and runnel system in the shoreface zone. The sandstone layers in the column represent deposits formed on the ridges or bars and the intervening mudstone units represent deposition in the runnels or troughs. The uppermost coarse-grained sandstone unit in the column would represent the outermost and usually largest of the bars, referred to as the longshore bar by Harms and others (1975, p. 82). The intervening cross-bedded sandstone beds preserve portions of both landward and seaward migrating bars.

In a similar modern beach area studied by Davidson-Arnott and Greenwood (1976) the waves average about 1.5 m in height and the bars are up to 2.5 m high, with their crests as much as 3.5 m below the surface and as much as 300 m offshore. Under these conditions both the ridge and runnel deposits are sand, but the runnel deposits contain a "distinct fine component which is not present in the bar sands". It is suggested on this basis that average wave height during deposition of the Vaqueros Formation was even lower than 1.5 m, thus allowing mud to be the most common deposit in the runnels where only very weak longshore currents existed.

The generally massive nature of some of the sandstone beds within this ridge and runnel system indicates extensive bioturbation and thus a low to moderate sedimentation rate. Fossiliferous pebbly sandstone beds that occur in the section perhaps represent lag deposits formed by winnowing during a storm. Small oyster fragments in the coarse-grained sandstone of the outermost longshore bar deposit indicate a nearby bioherm, and the relative lack of bioturbation features in this bed and the coarseness of the sand indicate a relatively high sedimentation rate and current strength compared with the more landward bar deposits.

TRANSITION ZONE AND OFFSHORE

Above the coarse sandstone bed that marks the outermost longshore bar is a section of fine sandstone, siltstone, and mudstone beds that contains three intervening limestone beds. Somewhere between the longshore bar deposit and the first limestone in the section are the rocks that mark the transition zone. Because tides and wave-induced currents were small in this area, the transition zone was most likely very thin and is not clearly recognizable, but it must occur in the section somewhere below the first limstone bed.

The limestone beds, because they have a meager terrigenous clastic component and because they are between mudstone units, probably were deposited in the offshore zone and represent a continuation of the ridge and runnel topography that occurred in the underlying shoreface zone. The limestones represent shallow water shoals that were conducive to the formation of marine bioherms. Because the fauna of the Vaqueros Formation is considered to be subtropical in nature (Loel and Corey, 1932, p. 163) the presence of limestone in the section should not seem too unlikely.

The limestone beds contain fossil fragments, micrite, and micrite intraclasts among other things. The micrite could only become a dominant deposit in the absence of a terrigenous influx, thus offshore, and could only be ripped up to form intraclasts in the presence of occasional strong currents.

Nelson (1978, p. 766), in a study of temperate shelf carbonates of New Zealand, concluded that the major mode of origin of micrite in the New Zealand carbonates was by abrasion of faunal tests by natural and biological processes.

The picture that develops from the above statements is that the carbonate shoals or banks of the Vaqueros Formation were perhaps near mean wave base level and just slightly raised above adjacent troughs. Slight agitation and oxidizing conditions during periods free of storms produced an optimum environment for biological communities and the production of micrite by abrasion. During storm periods, agitation increased and ripped up recently formed micrite layers to form intraclasts that became incorporated in the deposit.

The silty mudstone of the overlying Rincon Shale represents the offshore zone beyond the carbonate shoals. Exposures of this unit are poor due to extensive erosion. In the Casitas Dam section the silty mudstone of the Rincon contains an Ostrea howelli life assemblage, which suggests a water depth of less that 40 m (Keen, 1963, p. 106).

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measurements and clast types indicate northern source areas of Franciscan and granitic terrain (McCrackin, 1972) and a southern volcanic-granitic source terrain (Fisher, 1972).

Minerologically, 85 percent of the detrital material is feldspar and quartz at a 1:1 ratio. Biotite is the only abundant ferromagnesian mineral in more than trace amounts. Montmorillonite and illite are the dominate clay minerals, with illite being subordinate and only trace amounts of kaolinite and chlorite found. Also present are smaller amounts of calcite (in the form of cement, bedded, and nodular limestones and marls), gypsum, and borates (Flemel, 1966).

The Sespe is generally divided into four units reflecting a decrease in clast size and flow regime (Fisher, 1972).

- BASAL UNIT: (only locally developed) Conglomerate facies-alluvial fan deposits.
- LOWER UNIT: Conglomerate and sandstone facies - sand and conglomerate filled channels, parallel laminated sands and silts.
- MIDDLE UNIT: Sandstone facies - lesser amounts of silt and mud. Channel fill sand sequences.
- UPPER UNIT: Siltstone and mudstone facies - Low energy small scale cross bedding and ripples.

Sedimentary features present in the Sespe Formation consist of both high and low flow regime generated structures. Planar beds with lineation partings are the most common high flow regime structure. However, large scale dunes and antidunes have been observed. Low flow regime features such as ripples, trough cross-bedding, and forsets have also been observed. "Turbidite" like features such as flute casts, sole markings, load casts, and graded bedding are also present. These features represent torrential flooding with high sediment load and high flow regimes (McCracken, 1972).

LEAVE STOP #6. Continue south around Lake Casitas. Proceeding around this northern arm of the lake on the large curve of the road we are travelling along strike of the south dipping beds to the axis of the Santa Ana Syncline (which intersects the road at the Ranger Station). Turning back to the east, we continue along strike on the south flank of the syncline into overturned beds.

1.0 "Las Padres National Forest, Casitas Station" sign. Axis of Santa Ana Syncline crosses road here.

0.4 Slickensided Sespe on left side of road. Probably a reflection of the unnamed fault that intersects the Coyote Creek Anticline to the east.

0.2 STOP #7. PARK AT ROAD TURNOUT AND WALK BACK (NORTHWEST) ALONG ROAD. Overturned beds of the Sespe Formation. "Dunshee #1" well is approximately ¼ mile to the south (refer to paper by Curran--this guidebook). Outcrops in the middle unit of Sespe displaying cross-bedding and channel-fill sequences in addition to graded bedding. Cross-bedding, graded beds, and channel scours demonstrate that these beds are overturned.

Continue on Highways 150 and 101 to Santa Barbara.

Watch for Summerland oil field and Summerland offshore platforms, which are described on the next four pages.

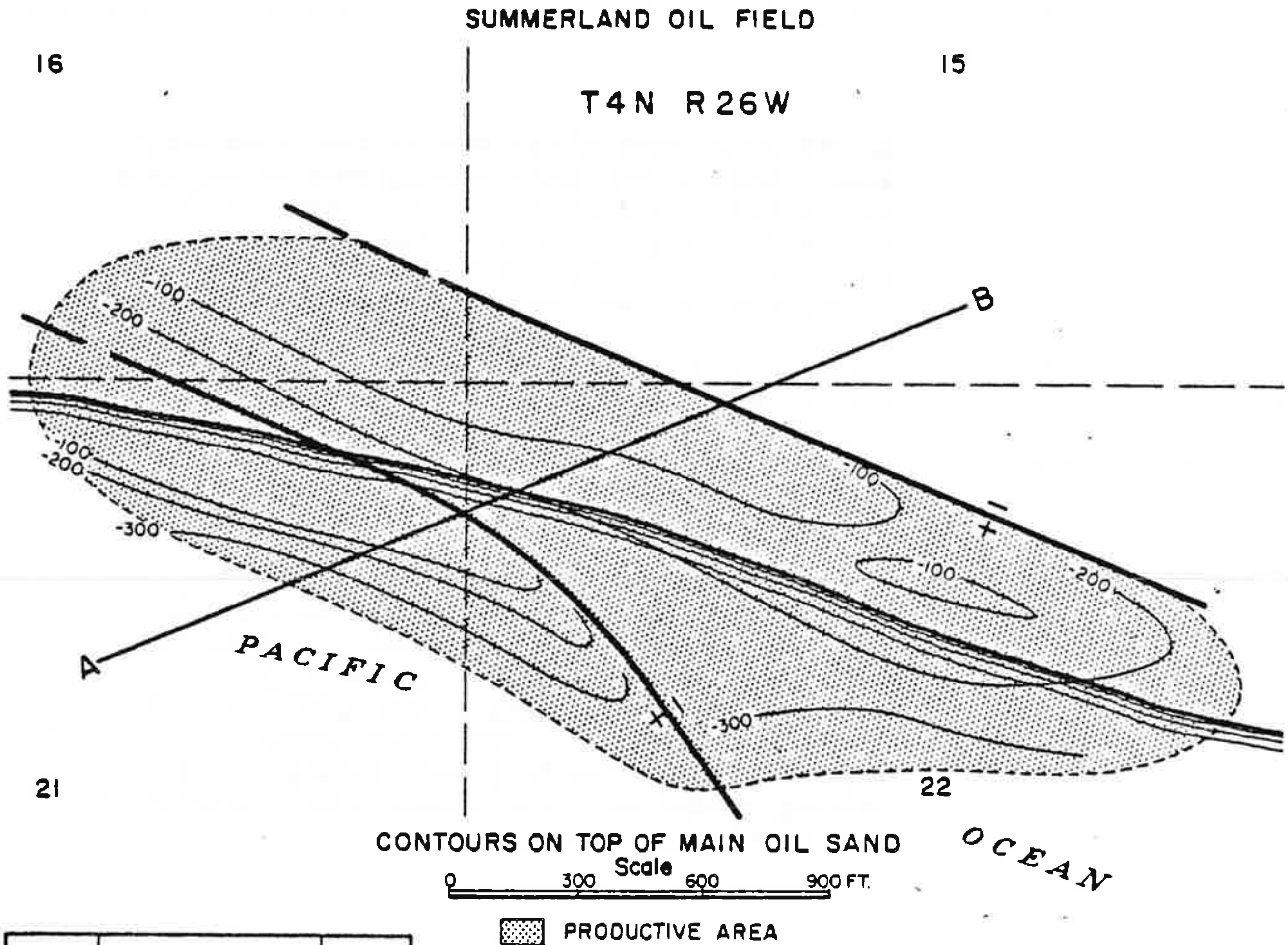
In Santa Barbara exit the freeway on Salinas Street and proceed northwest.

Turn right on Sycamore Canyon Road.

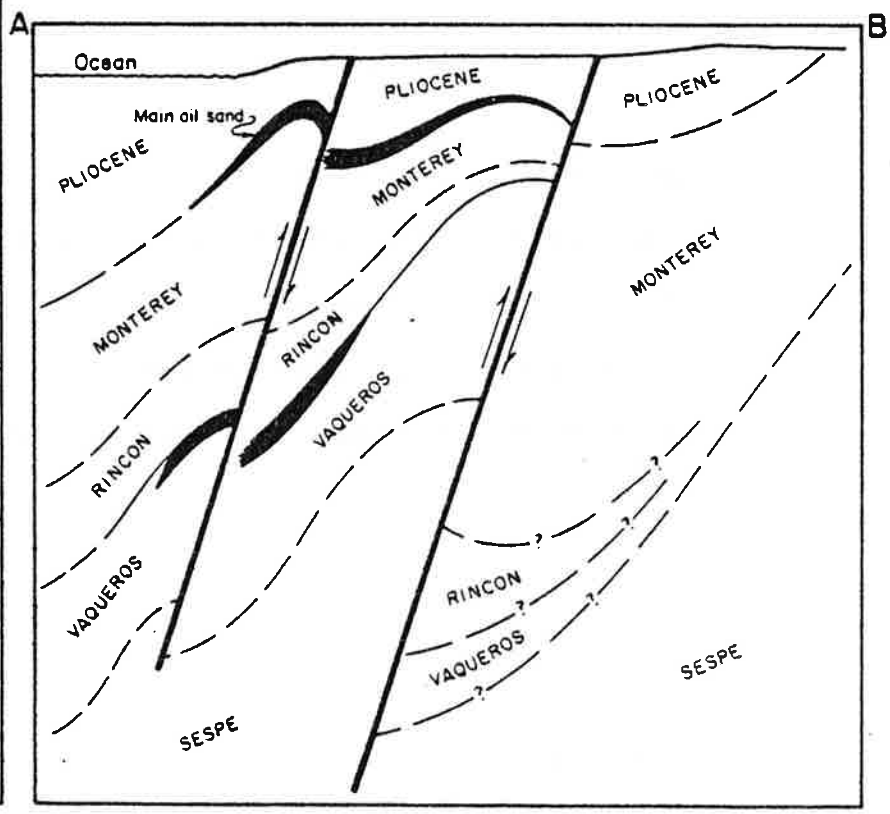
Turn left on Stanwood Drive.

Turn right on El Cielito Road.

Turn right on Gibraltar Road and proceed with next portion of road log.



EPOCH		FORMATION	Thickness (Feet)
PLIOCENE		Santa Barbara Main Oil sand	600
MIOCENE	Upper	Monterey	300 to 700
	Middle	Rincon	200 to 400
	Lower	Vaqueros	200 to 600
OLIGOCENE		Sespe	?



CALIFORNIA DIVISION OF OIL AND GAS
FIELD DATA SHEET

SUMMERLAND OIL FIELD
Santa Barbara County

LOCATION 5 miles east of Santa Barbara

DISCOVERY DATA Discovery well drilled and completed prior to 1894. No data are available regarding well history or production.

STRUCTURE Faulted anticline.

ELEVATION 20 BASE OF FRESH WATERS 40 SPACING ACT APPLIES No

PRODUCING ZONES

Name of Zone or E. Log Marker	Average Depth (feet)	Average Thickness (feet)	Geologic Age	Geologic Formation	Gravity or B.t.u.	Salinity of Zone Water Gr./Gal.
Main	140	100	Basal Pliocene	Santa Barbara	7	-
Vaqueros	1,400	300	L. Miocene	Vaqueros (?)	16	-

DEEPEST WELL DATA Tidewater Oil Co. well No. "Seaside-State" 1, Proj. Sec. 22, T. 4 N., R. 26 W., S.B.B.& M. T.D. 6,191 in Oligocene.

PRODUCTION DATA—JANUARY 1, 1961

Cumulative Oil (bbl.)	3,224,458
Cumulative Gas (Mcf.)	0
1960 Average Oil (b/d)	0
1960 Average Gas (Mcf/d)	0
Peak Production (1929) (bbl.)	80,830
Total Wells Drilled	402
Total Wells Completed	396
Producing Wells (1960 Aver.)	0
Maximum Proved Acreage	260

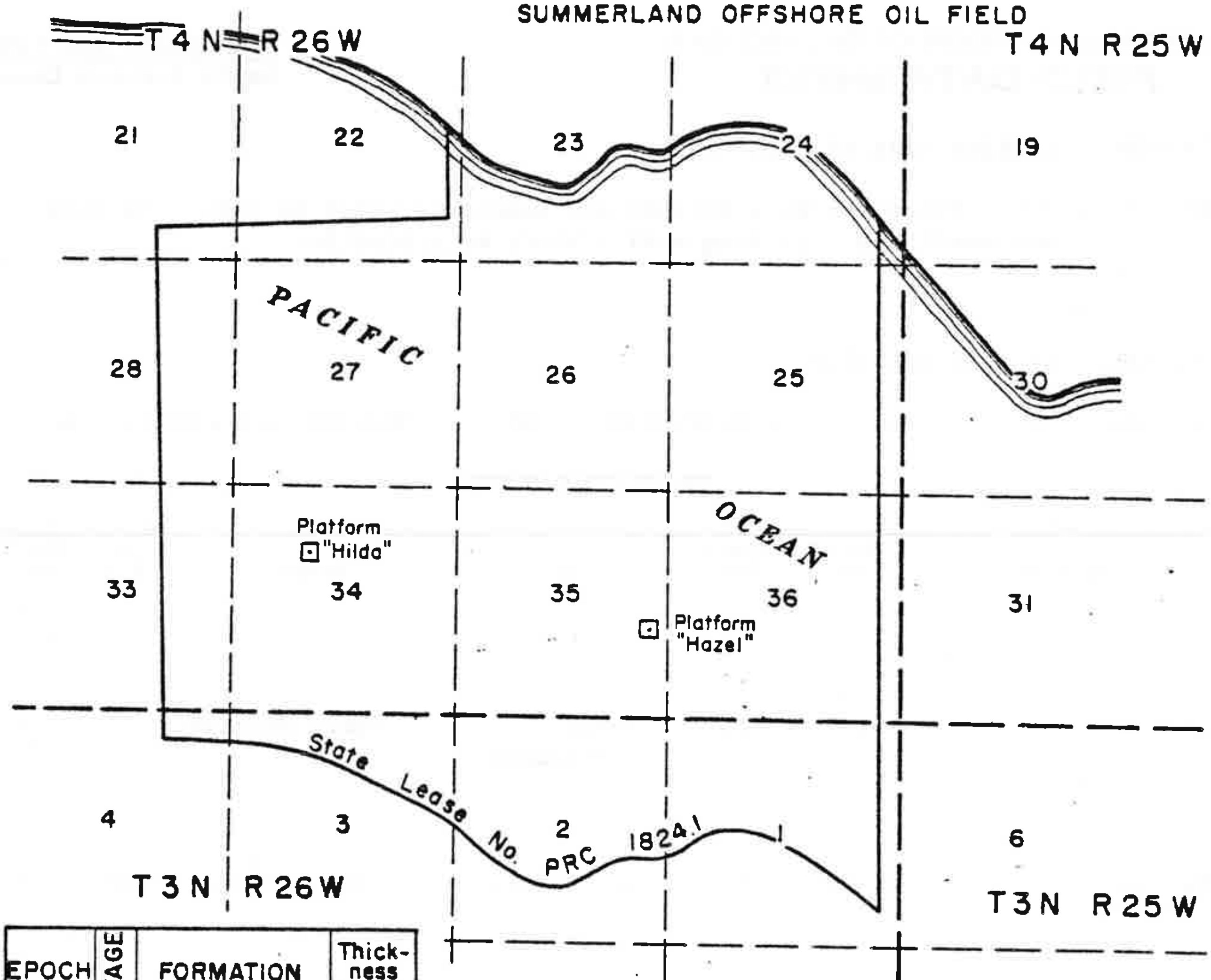
USUAL CASING PROGRAM
12-1/4" or 11-3/4" cem. above zone
8-5/8" liner landed through zone

BOP EQUIPMENT Not required

MISCELLANEOUS Nine wells are completed-idle, 387 wells completed and abandoned. Oil well piers extending into Pacific Ocean have been removed by storms and/or demolished. Some wells were dug by hand.

REFERENCES -

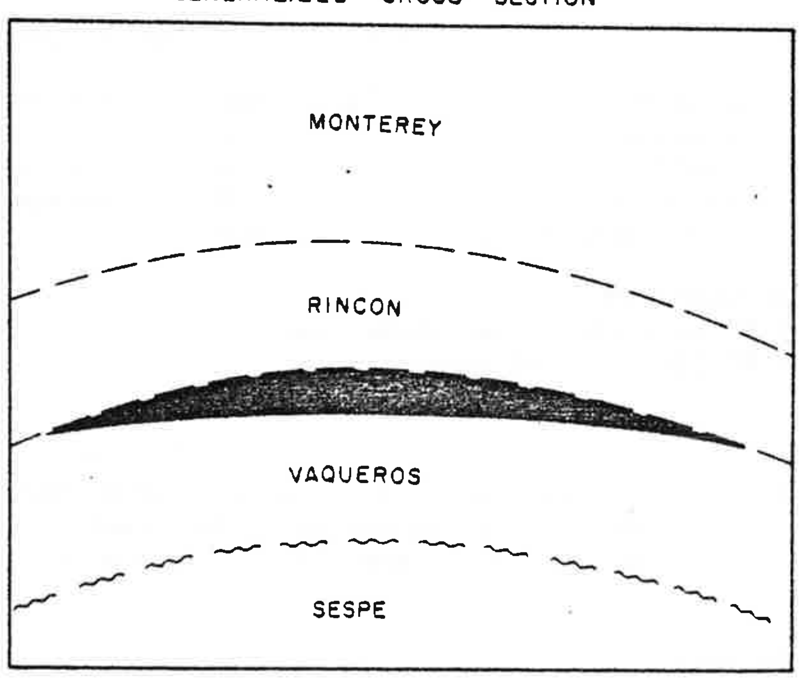
SUMMERLAND OFFSHORE OIL FIELD



EPOCH		STAGE	FORMATION	Thickness (Feet)
MIOCENE	Middle	Relizian - Luisian	Monterey	*
MIOCENE	Lower	Saucesian	Rincon	*
MIOCENE	Lower	Zemorrian	Vaqueros	*
OLIGOCENE			Sespe	*

* Data not available

GENERALIZED CROSS SECTION



CALIFORNIA DIVISION OF OIL AND GAS
FIELD DATA SHEET

SUMMERLAND OFFSHORE OIL FIELD
Santa Barbara County

LOCATION Offshore from the town of Summerland

DISCOVERY DATA Standard Oil Co. of Calif. well No. "Standard-Humble Core Hole" 1, (now "SHSS 1824 Core Hole" 1) Proj. Sec. 27, T. 4 N., R. 26 W., S.B.B.& M., drilled from a mobile barge, never produced; abandoned May 9, 1957. Development of the field began in September 1958, after installation of Platform Hazel.

STRUCTURE *

ELEVATION 78 BASE OF FRESH WATERS None SPACING ACT APPLIES Yes

PRODUCING ZONES

Name of Zone or E. Log Marker	Average Depth (feet)	Average Thickness (feet)	Geologic Age	Geologic Formation	Gravity or B.t.u.	Salinity of Zone Water Gr./Gal.
Undesignated	*	*	Miocene	Vaqueros	36-38	1,300

DEEPEST WELL DATA *

* Omitted at request of operator

PRODUCTION DATA—JANUARY 1, 1961

Cumulative Oil (bbl.)	854,417	Total Wells Drilled	20
Cumulative Gas (Mcf.)	1,766,882	Total Wells Completed	17
1960 Average Oil (b/d)	2,120	Producing Wells (1960 Aver.)	10
1960 Average Gas (Mcf/d)	4,680	Maximum Proved Acreage	*
Peak Production (1960) (bbl.)	775,516		

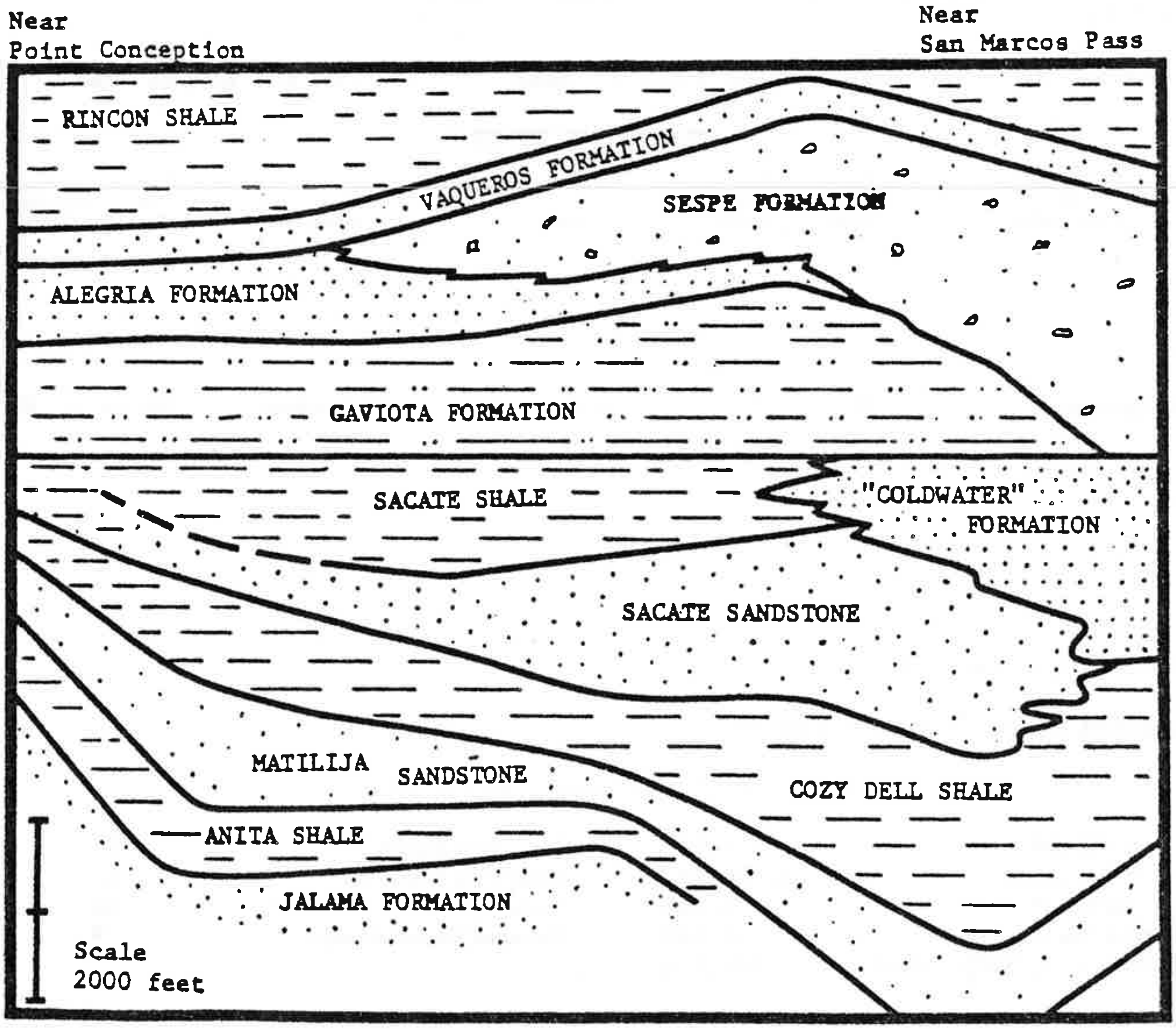
USUAL CASING PROGRAM
10-3/4" cem. 1,800
7" cem. through zone and gun-perforated

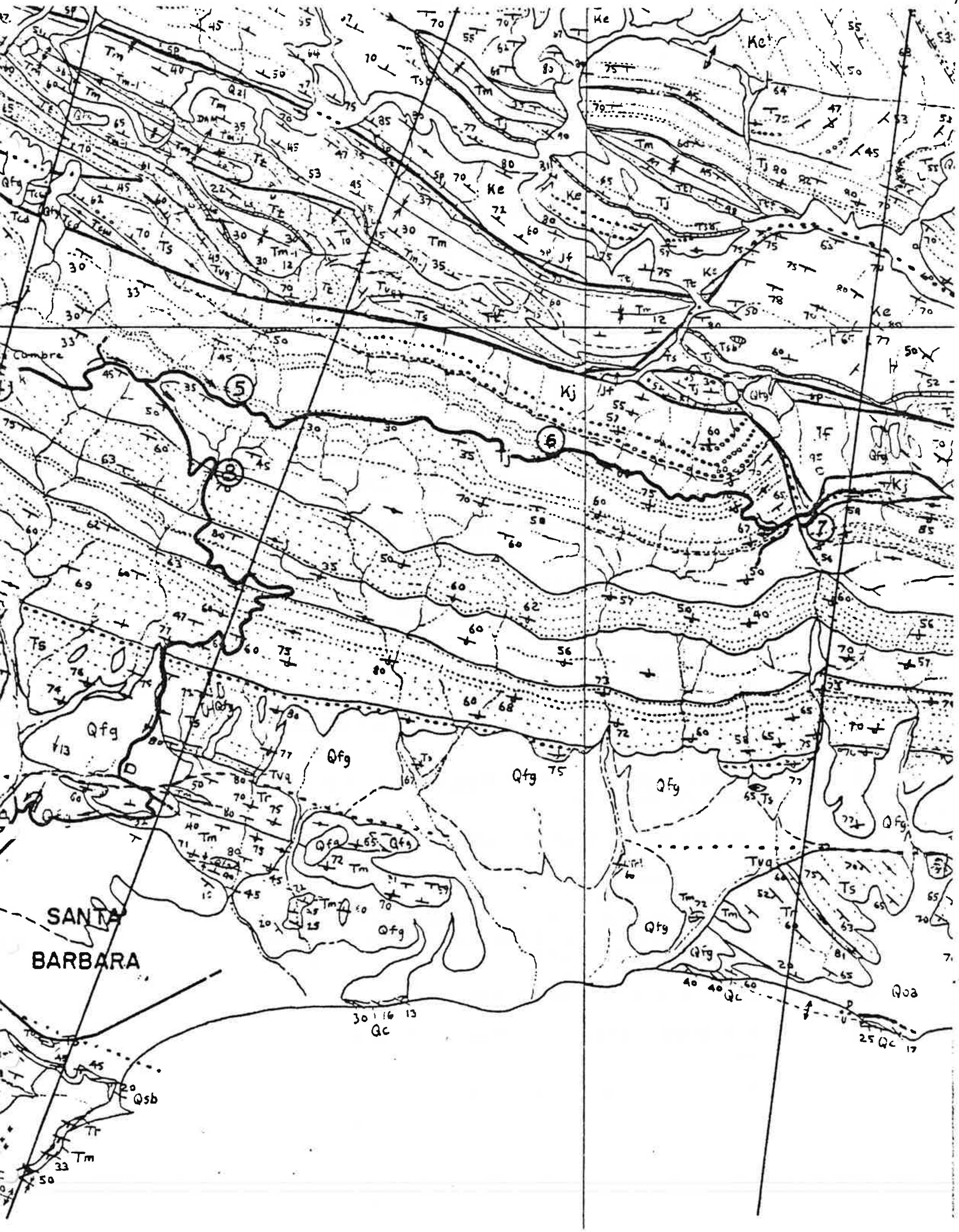
BOP EQUIPMENT Required

MISCELLANEOUS Drilling is conducted from two platforms approximately two miles apart, situated about 2.2 miles offshore and in about 100 feet of water.

REFERENCES -

STRATIGRAPHIC DIAGRAM FOR AREA WEST OF SAN MARCOS PASS HIGHWAY



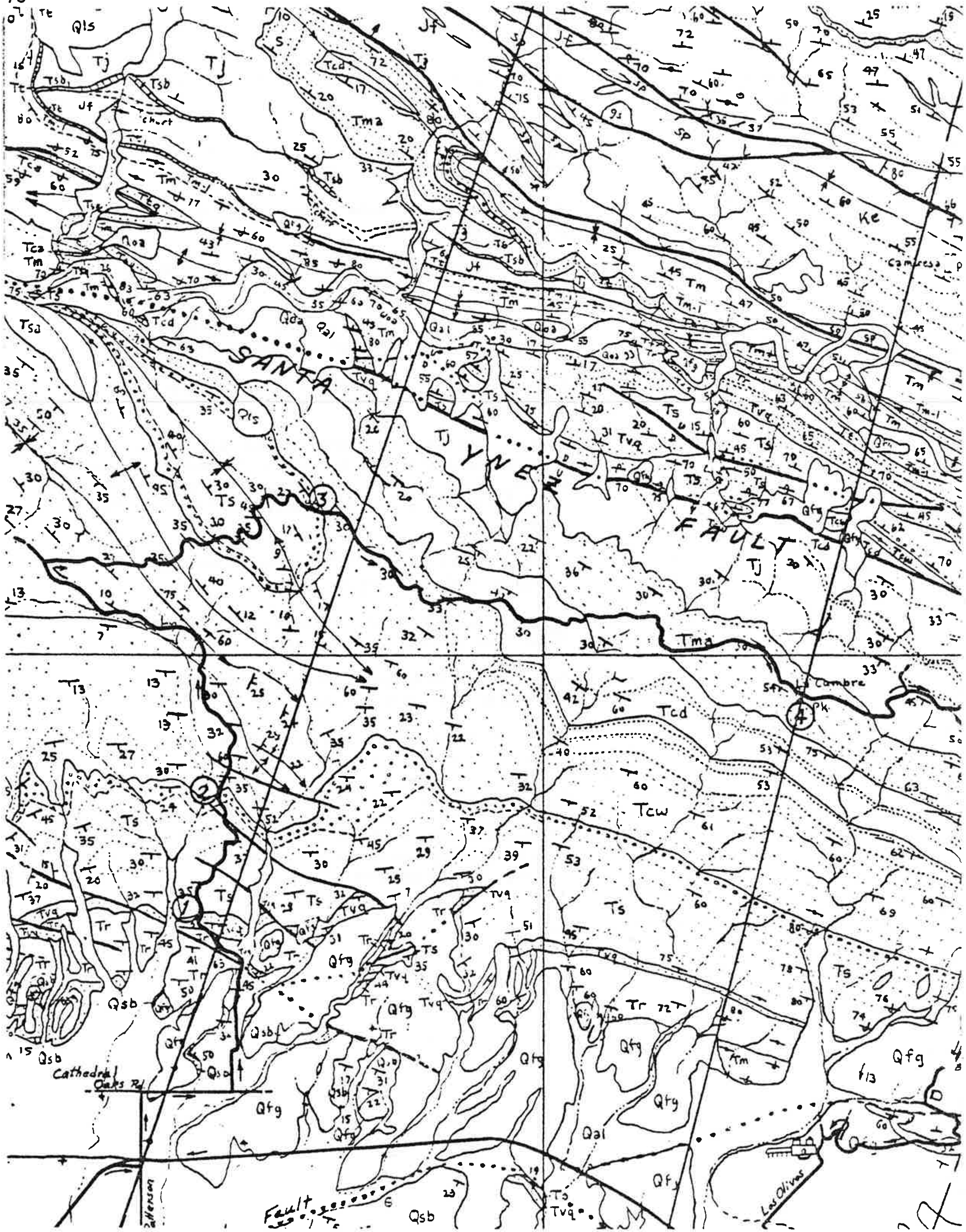

SANTA
BARBARA
Qfg
Qoa
Qsb
Qc
Kj
Ke
Tm
Ts
Tvq
Tr
Tj

Follow this road log from near the bottom of the page to the top.

0.1	STOP 8. Contact of the Juncal Formation with the Matilija Sandstone is exposed in cut on left side of road. W. R. Dickinson will discuss sedimentary structures and their interpretation at this stop.
0.5	Contact of the Matilija Sandstone with the overlying Cozy Dell Shale. Just below the contact, ripple marks are well exposed on bedding surfaces of the Matilija Sandstone.
0.2	Sandstone interbeds within the Cozy Dell Shale.
0.6	Base of the Coldwater Sandstone.
0.7	Road crosses back into the Cozy Dell Shale.
0.3	Contact of the Cozy Dell Shale with the Coldwater Sandstone.
0.5	Beds in the Coldwater Sandstone are overturned here.
1.2 & 0.1	Oyster beds are exposed in the upper part of the Coldwater Sandstone.
0.1	Contact of the Coldwater Sandstone with the Sespe Formation, which is conglomeratic and displays channeling near the base.
0.1	Pleistocene fanglomerate, which overlies the Sespe Formation here, is exposed on right side of road.
0.6	Continue straight on Gibraltar Road; road becomes Mountain Drive.
0.6	At stop sign, turn left on Mission Ridge Road past Sheffield Reservoir.
0.6	Continue to the right on Mission Ridge Road.
0.3	Monterey Shale is exposed on right side of the road.
0.3	Pleistocene fanglomerate is exposed here, where it has been uplifted along the Mission Ridge fault and tilted toward the south.
0.8	Continue on Mission Ridge Road.
0.3	Make sharp left turn onto Mountain Drive and continue downhill.
0.1	Turn left on Los Olivos Street.

Stops 5, 6, and 7 will be visited in order before returning to see stop 4.

0.1	Contact between the basal Sespe and the Coldwater Sandstone.
2.1	Contact of the Coldwater Sandstone with the Cozy Dell Shale.
1.3	Contact between the Cozy Dell Shale and the Matilija Sandstone.
2.2	STOP 4. La Cumbre Peak Lookout. Panoramic view with discussion of the geology by Dibblee.
0.8	Contact between the Matilija Sandstone and the Juncal Formation.
0.4	Road to Gibraltar Dam turns off to left; continue straight on Camino Cielo. The Santa Barbara water tunnel, which carries water from Gibraltar Dam to the city of Santa Barbara, passes through the range here.
0.7	Depression Drive turns off to right; continue straight on Camino Cielo.
0.8	STOP 5. View to north of Gibraltar Dam with discussion of geology by Dibblee.
3.5	Camino Cielo Sandstone with mudstone clasts is exposed on left side of road.
2.0	STOP 6 in Camino Cielo Sandstone with good view to north of Blue Canyon.
0.7	STOP 7 at turnout just beyond Romero Canyon Road turnoff. Walk to see conglomerates of Cretaceous age along a branch of the Santa Ynez fault and to collect glaucophane schist from the Franciscan Formation, if time permits.


SANTA YNEZ FAULT
La Cumbre Pk
Cathedral Oaks Rd
Los Olivos
Fault
Camuesa
Tma
Tcd
Tcw
Ts
Tvq
Tr
Tj
Tm
Tsb
Jf
Sp
Ke
Qfg
Qsb
Qal
Qls
Tsa
chert

Follow this road log from the bottom of the page to the top.

0.2	Rincon Shale is exposed in cut on left side of the road, where it is overlain by a fanglomerate.
0.7	Approximate location of the Rincon Shale-Vaqueros Sandstone contact.
0.2	Vaqueros Sandstone-Sespe Formation contact.
0.1	STOP 1 in the Sespe Formation, which is about 2,800 feet thick here.
1.2	STOP 2 to observe basal Sespe and Sespe-Gaviota facies relationships.
0.3	Oyster bed exposed in the Coldwater Sandstone.
0.2	Red interbeds within the Coldwater Sandstone are exposed on the right side of the road.
0.4	Continue straight.
0.1	San Marcos Road joins San Marcos Hwy. Ripple marks are well exposed in the Coldwater Sandstone across highway. Turn left at stop sign--BE CAREFUL!
1.8	Approximate location of the axis of the Brush Peak anticline, which plunges to the southeast.
0.5	Turn right onto Camino Cielo.
1.1	View looking northwest along the axis of the Los Laureles syncline in the Coldwater Sandstone.
0.6	Crossing axis of syncline in the Coldwater Sandstone.
0.2	Basal conglomerate of the Sespe Formation, overlying the Coldwater Sandstone, is exposed on the south side of the road. Here this conglomerate contains numerous diorite clasts, which are rare in the basal Sespe along San Marcos Pass. Similar diorite clasts are present in the Cozy Dell Shale to the west of San Marcos Pass.
1.2	Axis of syncline in the Sespe Formation coincides with this saddle.
0.7	Basal conglomerate of the Sespe is again exposed on the left side of the road.
0.1	STOP 3. View of the geology to the north across the Santa Ynez drainage.

LOCAL PALEOGEOGRAPHY OF THE SIERRA BLANCA LIMESTONE (EOCENE)

(A Preliminary Report)

Charles Elling Schroeter, University of California at Santa Barbara

Introduction

The local paleogeography of the Sierra Blanca Limestone (Eocene) was worked out by the writer in the central Santa Ynez Mountains about 10 kilometers northeast of Santa Barbara, California (Fig. 1). The study was done in conjunction with mapping of a 9.1 square kilometer (3.5 square mile) fault slice bounded by the Santa Ynez and Juncal Camp faults. The most important problem concerned with this study is its local nature. Therefore, major paleogeographic extrapolations will be avoided, and inferred displacement along major structures, namely the Santa Ynez fault, will be carefully qualified.

Local Sierra Blanca paleogeography was determined by petrographic, paleoecologic, and stratigraphic studies. Sedimentary facies were then delineated, and their respective sedimentary environments inferred. Paleogeography was ultimately determined by studying the vertical stacking and lateral distribution of these sedimentary environments.

The Sierra Blanca Limestone was first described by Nelson (1925) at its type locality about 16 kilometers north of the study area. Keenan (1932) described in detail the 68-meter section at the type locality, and Walker (1950) discussed its geochemistry and economic potential. Page, Marks, and Walker (1951) and Dibblee (1966) mapped the Sierra Blanca regionally throughout Santa Barbara County. Johnson (1968) made some paleogeographic interpretations on the limestone based on relationships of regionally mapped lateral facies.

Paleontology and Age

Larger invertebrates in the Sierra Blanca Limestone were described by Nelson (1925), Woodring (1930), Keenan (1932), and Howe (1934); Page, Marks, and Walker (1951, p. 1748) compiled a faunal list. The joint occurrence of two important orbitoid Foraminifera, *Pseudophragmina psila* (Woodring), and *Discocyclina (Aktinocyclina) aster* Woodring, in the limy sediments of the Sierra Blanca Limestone suggest a late Penutian Age (earliest Eocene) for this unit (Mallory, 1959).

Foraminifera described by the writer in the red shale subfacies of the Sierra Blanca also indicate a Penutian Age. The presence of *Anomalina tennesseensis* W. Berry, whose last known occurrence is upper Penutian (Mallory, 1959), and the combined presence of *Anomalina garzaensis* Cushman and Siefgus, *Cibicides felix* Martin, *Cibicides pseudowuellorstorffi* Cole (?), *Marginulina regularis*

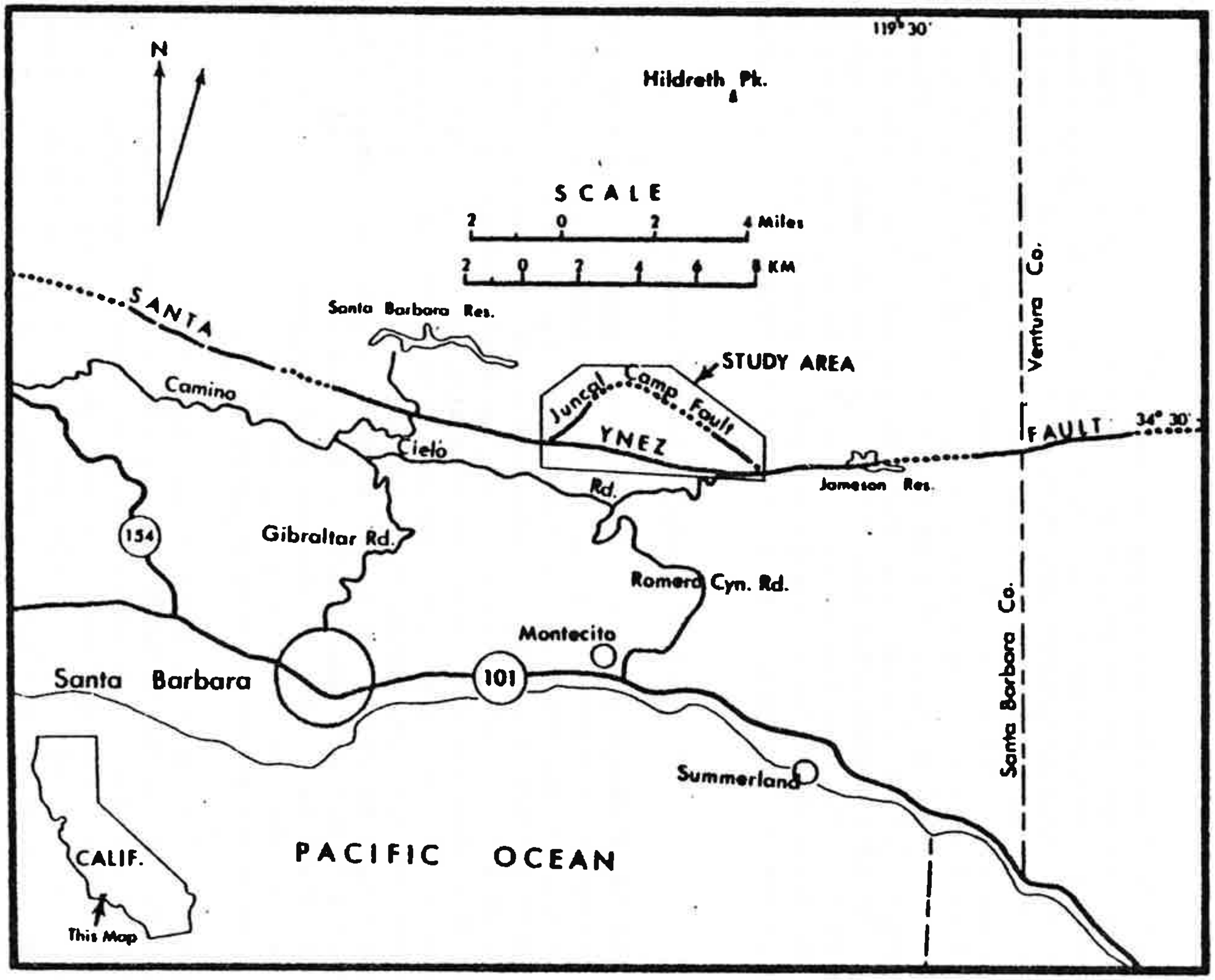


Figure 1. Index map.

d'Orbigny, and Planularia truncana (Gumbel) (?), whose first known occurrence is in the lower Penutian (Mallory, 1959) support this age. A nannoplankton sample collected from this red shale unit by the writer, and analyzed by Frank R. Sullivan (1972) also suggests a Penutian Age.

Sedimentary Facies and Environments

Description of sedimentary facies delineated in the Sierra Blanca Limestone, and their interpreted sedimentary environments, are given in Table 1. Lateral and vertical distribution of the sedimentary environments represented by these facies (e.g. paleogeography) are shown in Figures 2 and 3 respectively. Six facies have been defined: (1) bedded calcirudite, (2) massive algal calcirudite, (3) calcarenite, (4) shelf, (5) clean sand, and (6) transgressive sand. The first five facies are associated with fairly stable carbonate deposition, and represent the following respective sedimentary environments (from seaward to landward): (1) talus slope, (2) shelf margin algal bank, (3) shoal skeletal sands, (4) narrow shelf with open ocean circulation, and (5) high-energy near-shore sands. The thin transgressive sand facies often stratigraphically overlies the first three facies mentioned, and it probably represents a destructive phase during the subsequent Penutian north-northeastward transgression.

Paleogeographic Reconstruction

The main depositional setting of the Sierra Blanca Limestone in the study area is illustrated in Figures 2 and 3. Here, sedimentary environments associated with an algal bank, which probably existed along at least 7 kilometers of west-northwest-trending shelf margin, are shown (Schroeter, unpubl. Master's Thesis, 1972). A local topographic high probably existed along this margin during this time and throughout the remaining Eocene, as suggested by the great thinning of the remaining Eocene section from 7,000 feet (2 kilometers to the northeast) to 400 feet around the inferred shelf margin. The bulk of algal and other biologic material, which once lived as organisms along the shelf margin, was eroded by currents and/or wave action, and accumulated as talus downslope from the algal bank. Most of the material trapped on the landward side of this bank was reworked by currents in shallow water (inner shelf depths), and eventually deposited as well-sorted skeletal sands.

A narrow shelf existed landward of the algal bank in an area of open ocean circulation and normal salinity. Here, lime mud and red shale containing a rich pelagic fauna were deposited in quiet water. Outer-shelf water depths (100-200 meters) probably existed over much of this area, as suggested by the common occurrence of both uniserial and coiled lagenid foraminifers. Moreover, an abundant braarudosphaerid nannoplankton fauna associated with these foraminifers suggests an inshore (neritic) environment (Sullivan, 1965; and Sullivan, 1972, written communication).

Shallow-water deposition at inner-shelf depths (0 to 100 meters) existed on the landward edge of the shelf. Here, terrigenous material mixed with carbonate sediment probably was reworked and sorted by current and wave action. An intertidal environment with restricted circulation may have locally existed,

Table 1

SEDIMENTARY FACIES AND ENVIRONMENTS OF THE SIERRA BLANCA LIMESTONE

Facies	Max. Thickness (meters)	Sedimentology	Fauna	Environment
Bedded Calcirudite	26 m.	Pebbly packstone beds 30-90 cm. thick with occasional gray marl interbeds (5-10 cm. thick). Sandy skeletal grainstone present where unit locally thins.	Abundant pebble-size fragmented algae. Mixed foraminiferal fauna (orbitoids and miliolids with lagenids).	Talus slope.
Massive Calcirudite	3 m.	Massive algal grainstone containing up to 90% pebble-size algal clusters.	Mainly calcareous red algae, few solitary corals and forams.	Algal bank
Calcarenite	8 m.	Massive grainstone, packstone, and some wackestone containing sand-size skeletal material.	Calcareous red algae, orbitoid and miliolid Foraminifera.	Skeletal shoal sands.
Shelf	12 m.	Calcareous red shale and gray wackestone.	Rich in planktonic foraminifers and nannoplankton. Common shelf benthonic foraminifers.	Narrow quiet shelf.
Clean Sand	5 m.	Calcareous sandstone at base. Grades upward into sandy grainstone.	Whole non-abraded oysters at base. Few miliolids.	High energy near-shore sand.
Transgressive Sand	3 m.	Sandy intraclastic grainstone.	Unfossiliferous.	Shallow water transgressive unit.

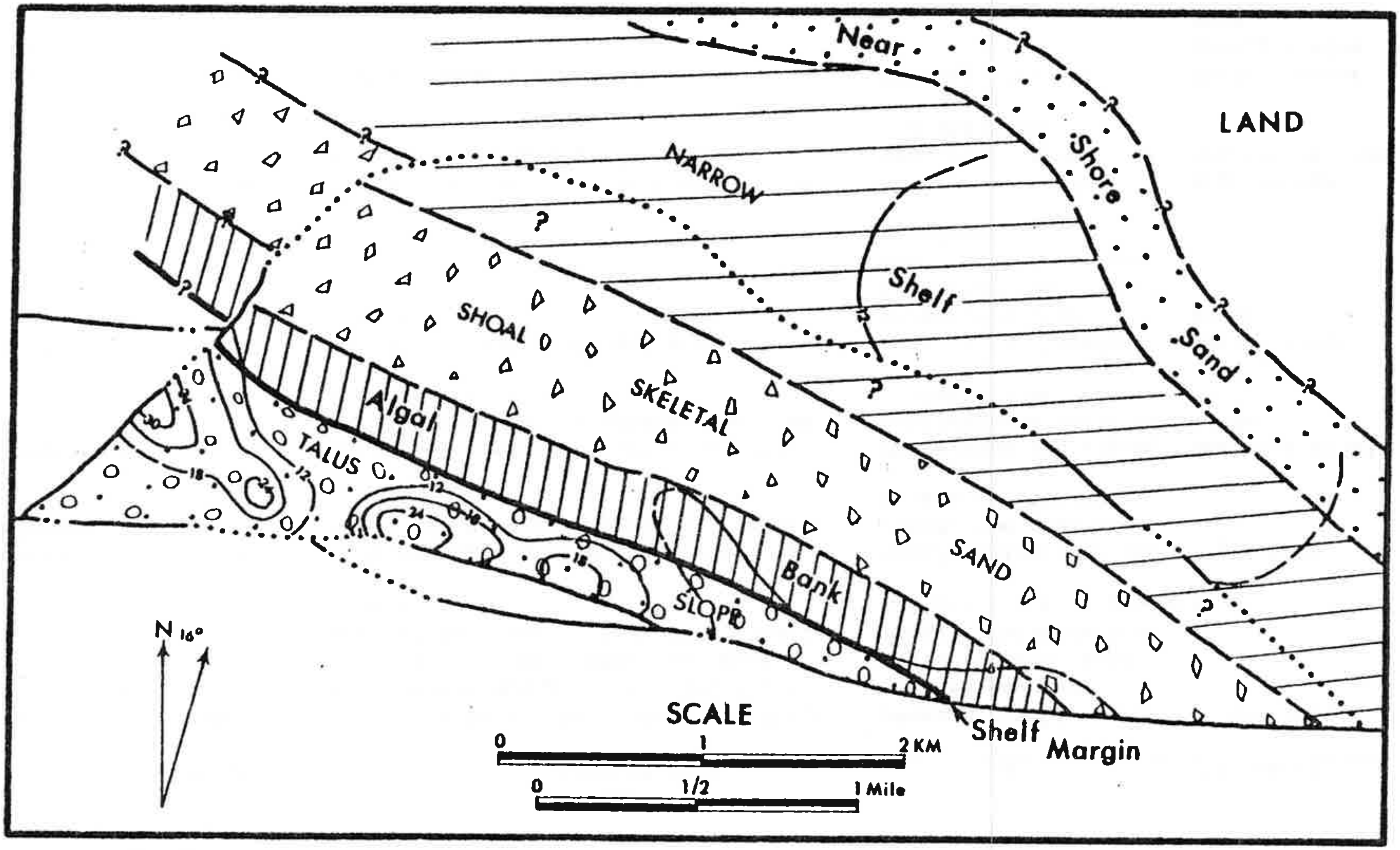


Figure 2. Paleogeographic reconstruction of the Sierra Blanca Limestone showing present distribution of sedimentary environments (inferred from analysis of sedimentary facies) superimposed on an isopach map (contour interval 6 meters).

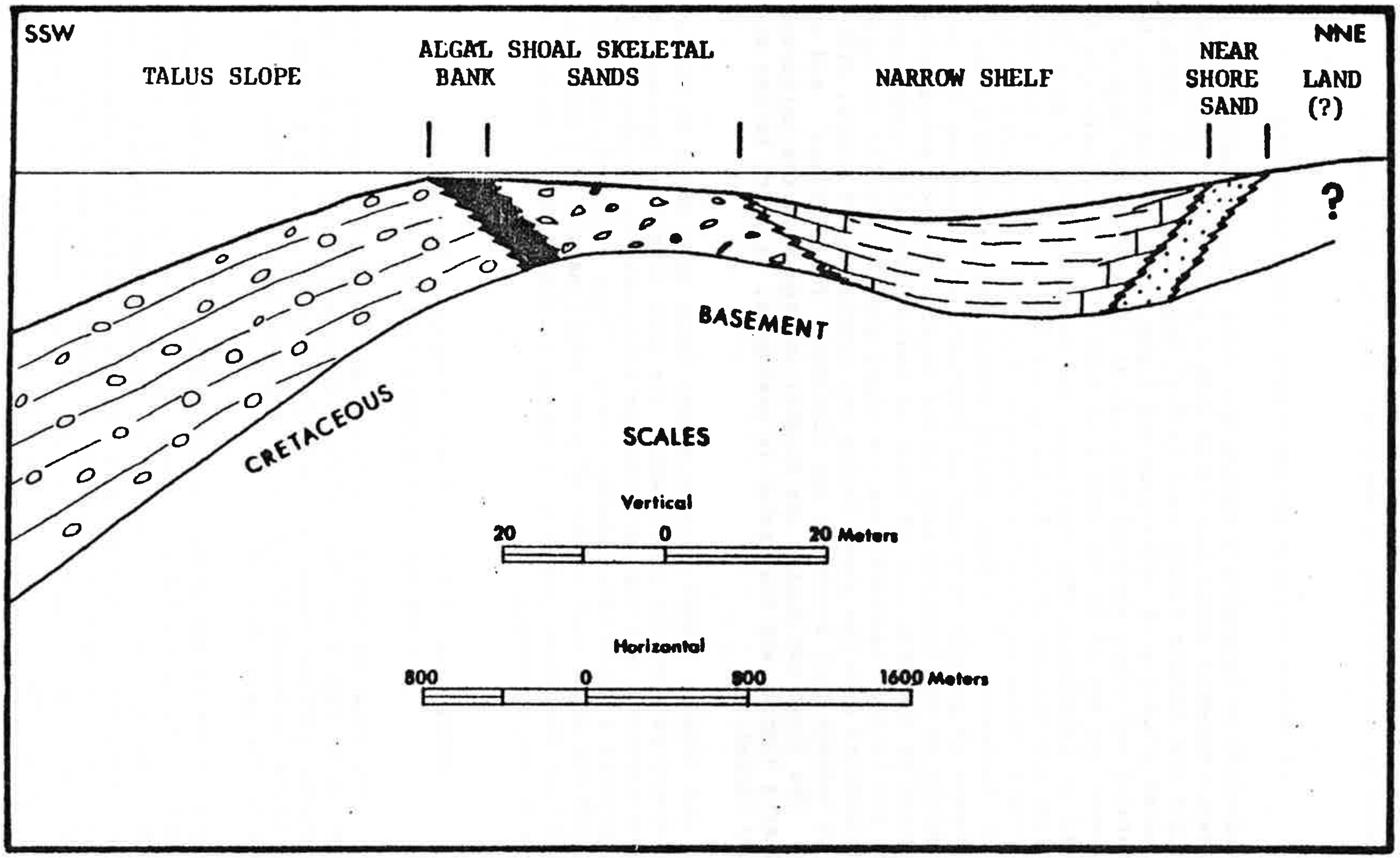


Figure 3. Generalized palinspastic cross section (perpendicular to depositional strike) of Sierra Blanca Limestone paleogeography showing vertical distribution of sedimentary environments. Water depth shown is relative, and not drawn to scale.

as suggested by the abundance of whole non-abraded oysters.

A Modern Analogue to the Sierra Blanca Limestone

The distribution of sedimentary facies and their related sedimentary environments closely resemble those associated with a present-day algal bank studied by Schlanger and Johnson (1969) near La Paz, Baja California. Here, an algal bank composed primarily of calcareous red algae, some foraminifers, button-shaped corals, and other skeletal material is located on the edge of a shallow shelf between the Bay of La Paz (Bahia La Paz) and a deep Basin (La Paz Basin) in the Gulf of California (See Schlanger and Johnson, 1969, Figure 3). The distribution and content of the facies associated with this algal bank have striking similarities to those of the Sierra Blanca in the area studied. These include the following: (1) algal-gravel facies characterized by the abundance of coarse-sand to granule-size rounded fragments of calcareous red algae, and located mainly on the landward side of the algal bank; (2) calcarenite facies characterized by the dominance of fine- to coarse-sand size carbonate skeletal material, and located landward from the algal gravel; and (3) terrigenous facies situated landward from the above facies and consisting of clays, silts, and sand which contain rich benthonic and planktonic Foraminifera and other skeletal material. The first two facies are roughly analogous to the calcarenite facies of the Sierra Blanca, and the latter is analogous, in part, to the shelf and clean-sand facies.

Schlanger and Johnson (1969) studied a core taken at a depth of 660 meters directly downslope from the algal bank. The core contained predominately terrigenous material, but was also rich in subrounded to rounded algal fragments, and it contained a mixed invertebrate fauna. These sediments were probably derived from the algal bank on the adjacent shelf margin (Schlanger and Johnson, 1969), and they therefore probably represent a talus deposit similar to that of the Sierra Blanca Limestone.

Correlation of Sierra Blanca Limestone Sedimentary Facies Across the Santa Ynez Fault

Suggested correlation of Sierra Blanca sedimentary facies across the Santa Ynez fault is shown on Figure 4. The vertical distribution of facies in three Sierra Blanca sections just northeast of the fault slice is similar to that of a section which the writer measured at a locality south of the Santa Ynez fault and 15 kilometers to the east (Fig. 4).

Piercing points are formed along the north side of the Santa Ynez fault where lines formed at the approximate boundary of the various facies intersect the fault plane (Fig. 2). The line formed at the boundary between the shelf and clean-sand facies intersects the Santa Ynez fault about 1 kilometer east of the fault slice. A matching piercing point is tentatively established on the south side of the fault, and 15 kilometers east of the former point, where a line formed by the same facies intersects the fault plane (Fig. 4). Therefore, 15 kilometers of left-slip is tentatively suggested for this portion of the Santa Ynez fault.

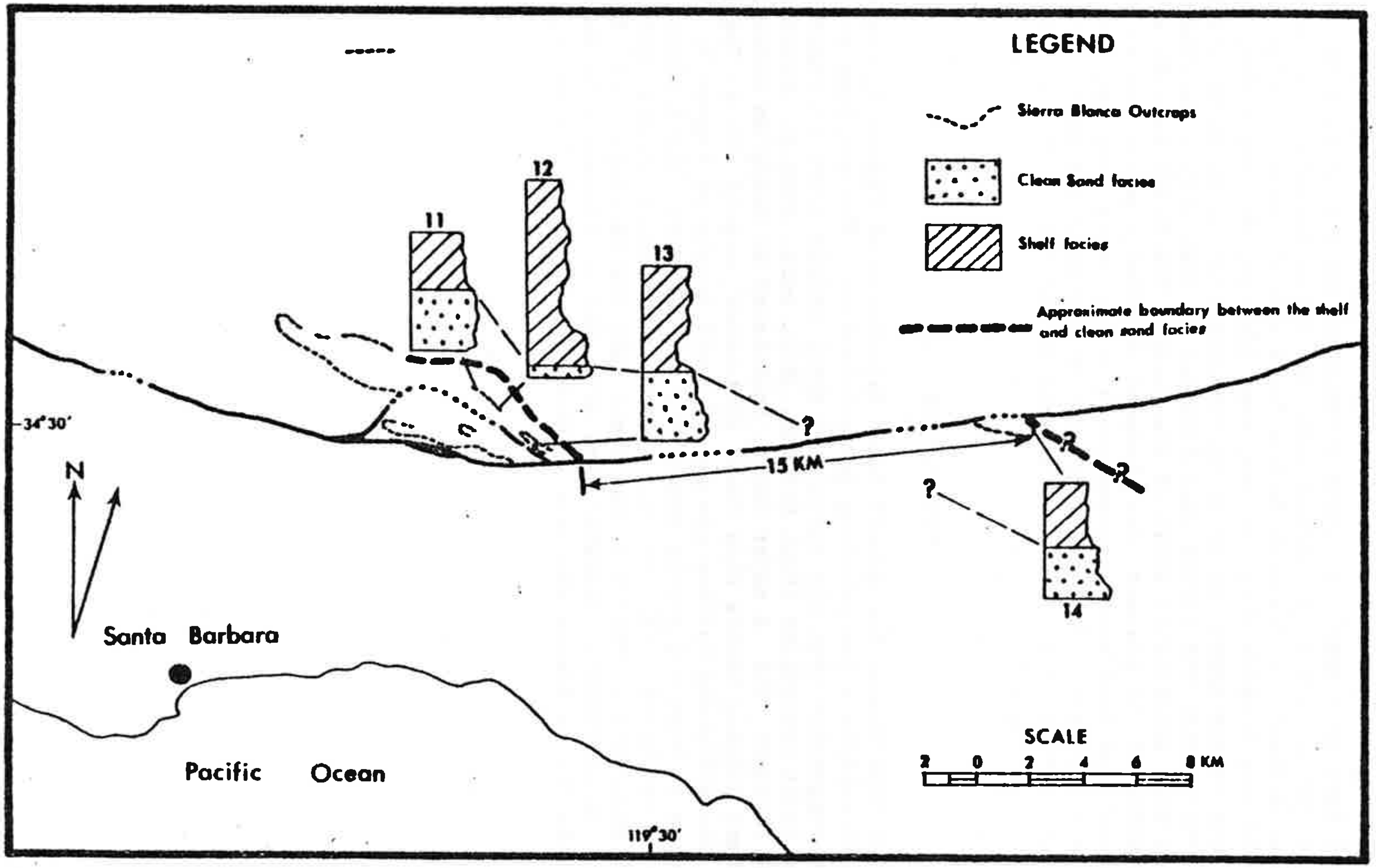


Figure 4. Map showing regional distribution of Sierra Blanca Limestone outcrops as mapped by Dibblee (1966) and Merrill (1954) north and south of the Santa Ynez fault respectively. Similarities in the vertical distribution and trend of facies are shown on both sides of the fault.

Three important qualifications must be made for the above conclusions: (1) facies trends would have to intersect the fault plane at a sufficient angle (at least 20 degrees); (2) facies trends on the south side of the Santa Ynez fault would have to subparallel those established on the north side; and (3) these facies would have to be unique (non-repetitive perpendicular to the depositional strike). A drawback to the first qualification is that these trends could vary considerably, and may even parallel the Santa Ynez fault, although they do not appear to do so in the area studied north of the fault. The main problem with the second qualification is that only a two-dimensional picture has been established south of the fault. The third qualification seems plausible at the present time, because no other similar Sierra Blanca Limestone sections have been reported south of the Santa Ynez fault or northeast of the study area. More detailed work on the Sierra Blanca paleogeography will have to be done in these areas, as well as its entire extent, in order to verify the foregoing conclusions.

Post Script

An alternate hypothesis, the growth fault hypothesis of Figure 5, has been developed to explain a few existing inconsistencies. The new idea evolved around the suggestion that the postulated shelf margin shown in Figures 2 and 3 might be fault controlled (Paul Hoffman, 1972, pers. comm.). Evidence for this is as follows: (1) A major fault, postulated as being an extension of the northeast dipping Little Pine Fault (Schroeter, unpubl. M. A. Thesis, 1972, Plate 1), conspicuously follows the mapped shelf margin of Figure 2; (2) this fault appears to have a dip-slip component, the northeast block rising relative to the southwest block; (3) the talus slope environment should underlie the algal-bank according to Figure 3, but these data are lacking; (4) the talus environment is distinctly separated from all other environments by this fault; and (5) the Sierra Blanca abruptly thickens southwest of the fault.

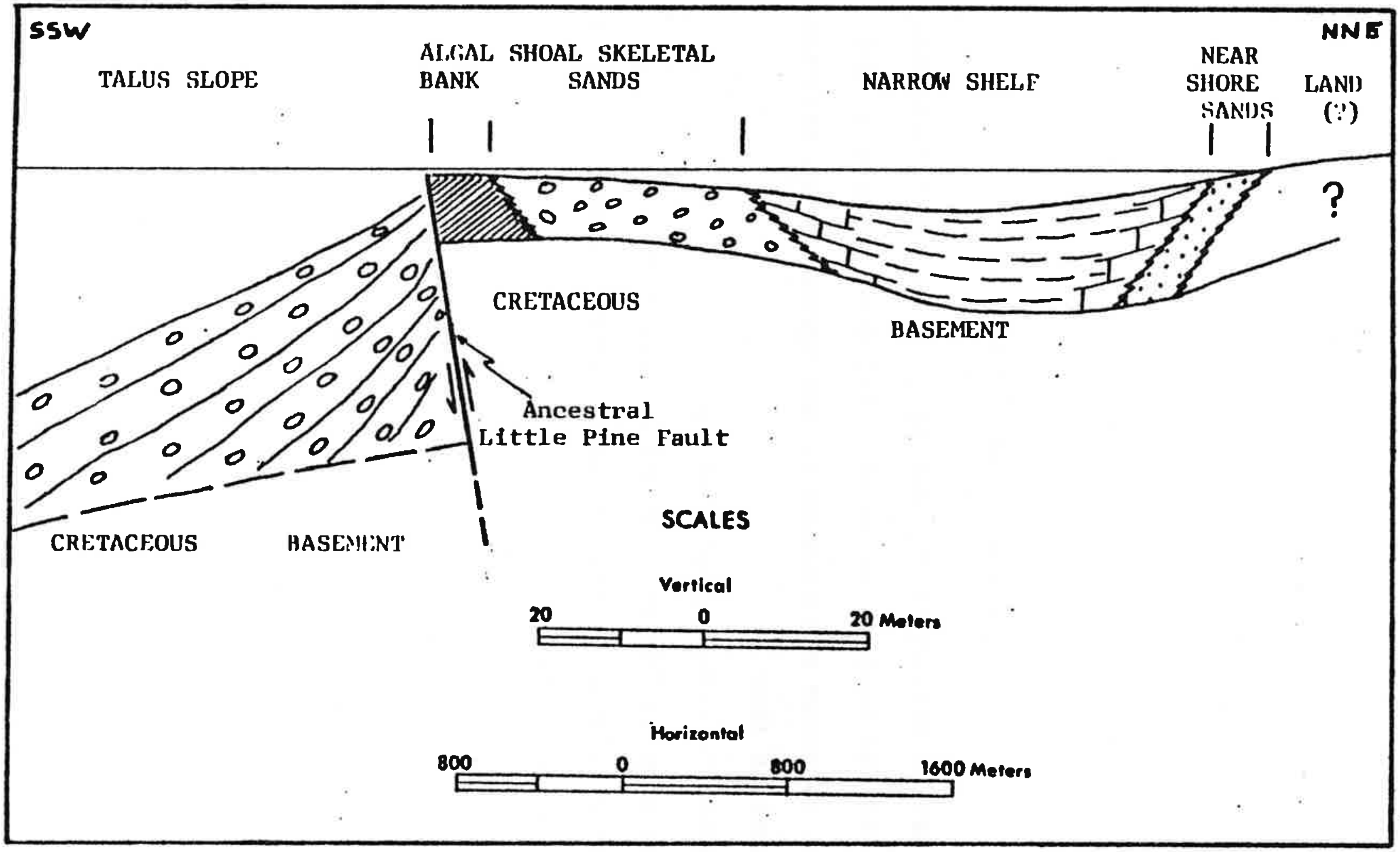


Figure 5. Palinspastic cross section of Sierra Blanca Limestone paleogeography. Here, accumulation of algal material at the shelf margin is related to movement along a growth fault (ancestral Little Pine Fault) which defined the shelf margin. Water depth is not drawn to scale.

HIGHLIGHTS OF FOURTH DAY

There are no guides to the geology of the Santa Ynez River area near Oso Canyon, so we will explore the area on our own. We will continue the studies of day three and in addition we will look at the:

"Temblor" Formation of Dibblee

some special "Sespe" Formation occurrences

Also we will discuss the tectonic significance of this area along the Santa Ynez River.