STRATIGRAPHY OF THE WEST SIDE SOUTHERN SAN JOAQUIN VALLEY[1]

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Many of the topics that will be discussed are controversial, but the stratigraphic units selected are believed to be in the most use by geologists studying the west side of the San Joaquin Valley. The various units are described chronologically from youngest to oldest, as has been done in some previous guidebooks. For ease of reference, each formation is described under the following topics in the same order: 1) type locality, 2) characteristics and lithology, 3) fauna and age, 4) stratigraphic relationships, 5) divisions, and 6) oil and gas. The fauna and age section has been written by Robert Blaisdell.

TYPE LOCALITY AND ACCEPTANCE

Under type locality it will be found that some of the names are informal without a definitely described type section. Also, some of the stratigraphic units are mainly faunal zones without a characteristic lithology. Many of the names were probably used by petroleum geologists before they appeared in print. Equivalent names to the stratigraphic unit discussed are considered under 5) divisions.

The degree of acceptance of the formations and members named is placed in three categories: 1) formal units accepted by the U.S.G.S. in the Lexicon (1966), such as: Tulare, San Joaquin, Etchegoin, etc., 2) informal units listed in the Lexicon (1966), such as: Antelope shale, McDonald shale, Devilwater siltstone, etc., 3) units not listed by the U.S.G.S., but used locally and informally are placed in quotation marks, such as: "Button bed," "Phacoides sand," "Salt Creek shale," "Oceanic sand," etc.

STRATIGRAPHIC NOMENCLATURE

Since the units picked are not all accepted as formations, a brief mention of the stratigraphic nomenclature may be in order. The Pleistocene and Pliocene units used: the Tulare, San Joaquin, and Etchegoin, have all been accepted as formal formation names. The Miocene units used, on the other hand, are members, or smaller stratigraphic units, that are mostly informal. The Miocene has been divided into two formal formations: 1) the Monterey Formation replacing the term Maricopa shale, which has been abandoned, and 2) the Temblor Formation.

The Monterey Formation is mostly shale in the type section of its members: Reef Ridge, Antelope, McDonald, Devilwater, and Gould. Lithologically, these members can be separated in their typical areas, but they are carried beyond their lithologic limits by micro faunal assemblages. Beyond the limits of the faunal zones, new member names are given. As an example, typically the Reef Ridge is a blue shale or a diatomaceous shale, the Antelope is a gray-brown rhythmically bedded siliceous to cherty shale, the McDonald a massive chocolate brown siltstone, the Devilwater a grayish siltstone, and the Gould is a massive siliceous shale. To the north, the Antelope and the McDonald members are included in the McLure brown shale member because they cannot be separated by either lithology or fauna.

The Temblor Formation is mostly sand with some shale in the type section of the Temblor Ranch. The members and beds included under it are: the "Button bed"; Media shale member; Carnerous sandstone member; Santos shale member, which includes the "Upper Santos," Agua sandstone, and "Lower Santos"; the "Phacoides"; and "Salt Creek shale." The Vaqueros in the Salinas Valley is the approximate equivalent to the Temblor in the San Joaquin Valley. However, when both the terms are used in the San Joaquin Valley, the Temblor refers to the Turritella ocoyana zone or the Saucesian and younger beds, whereas the Vaqueros refers to the Turritella inezana zone or the Zemorrian beds. It will be found that the type locality for all Miocene units listed, except the Reef Ridge, is in the Chico Martinez area which will be visited on the field trip.

It is believed the Oligocene Tumey should be treated as a formation, although in places north of Devils Den it has been considered as a member of the Kreyenhagen Formation.

The Upper Eocene consists of two formations that interfinger into each other: 1) Kreyenhagen Shale in the Coalinga district in the north, and 2) The Tejon Formation of mostly sands and some shale at the south end of the valley. The Point of Rocks sandstone is a tongue of the Tejon Formation in the Kreyenhagen Shale that extends as far north as Pyramid Hills. On the other hand, the Welcome formation (Upper Kreyenhagen) and the Canoas shale are tongues of the Kreyenhagen above and below the Point of Rocks.

SEQUENCES

Unfortunately, some formations like the Temblor have unconformities within them, or some formations are a part of all of a certain succession of lithologies between unconformities. For this reason, and also to attempt to formulate a stratigraphic pattern for this area, the concept of sequences is introduced for the westside, although its application is somewhat speculative. Since this term has not been used previously in the literature on the West Side, it is explained more fully below. A sequence is defined as the beds between the more important unconformities and their continuation into conformable beds. The term sequence was used by Sloss, Krumbein, and Dapples (1949) for strata

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between major regional unconformities in the interior of North America. Compared to that, the sequences referred to here are local and of short duration, but possibly contain equivalent thickness of strata.

The sequences have a certain tectonic and depositional succession. On the West Side there seems to be two types of sequences: 1) a thin sequence with a thin erratic post unconformity sand, a middle shale, and a thick but truncated upper pre-unconformity sand; 2) the thick sequence is thicker, but otherwise similar with the addition of a middle sand incased in an upper and lower shale, and the upper pre-unconformity sand is thin or absent.

The stratigraphy of the West Side is tentatively divided into 9 sequences listed below:

1. Tulare thick sequence—Tulare Formation.
2. Pliocene thick sequence — San Joaquin and Etchegoin Formations.
3. Feed Ridge thin sequence — Reef Ridge.
4. Monterey thick sequence—Antelope, McDonald, Devilwater and Gould members of the Monterey Formation, and the "Button bed" unit of the Temblor Formation.
5. Saucesian thick sequence—Media, Carneros, "Upper" Santos.
6. Lower Santos thin sequence—Agua and "Lower" Santos.
7. Salt Creek thin sequence — "Phacoides" and "Salt Creek."
8. Oligocene thin sequence — Tumey and "Oceanic."
9. Kreyenhagen thick sequence — Kreyenhagen, Point of Rocks, and Canaos.

The names are temporary and, if the concept is usable, more formal names may be presented.

Thick sequences are characterized by a thick middle sand incased in shale. Examples of a thick sequence are as follows: The Kreyenhagen sequence has the erratic post unconformity sand, the Mabury; and the thick midle sand, the Point of Rocks, incased in the Canoas and Kreyenhagen shales. There is no pre-unconformity sand. The Saucesian sequence is similar with the middle sand, the Carneros, incased in the "Upper" Santos and Media shales. The Monterey sequence has the post unconformity sand, the "Button bed" and, in places, the numerous overlapping Devilwater sands. The middle sand, the Stevens, is incased in the Antelope shale. There is no pre-unconformity sand. In the Pliocene sequence the Bates and other sands are the post unconformity sands. The middle sandy section, the Upper Etchegoin, is incased in the Lower Etchegoin and San Joaquin clayey sections. The Tulare sequence consists of fluvial sands between the upper and lower lacustrine beds.

The significance of the middle sands is that they were deposited when the West Side and the Temblors were a deeply sinking basin and the sands were derived from uplifts elsewhere.

The thin sequences, except for the Oligocene sequence, are characterized by a thick and rapidly truncated pre-unconformity sand. Examples of a thin sequence are as follows: The Salt Creek sequence has the erratic basal post unconformity "grit" followed by the "Salt Creek shale," and the thick pre-unconformity sand, the "Phacoides" or "Belridge 64." The Lower Santos sequence is similar with the basal sand, the "Bloemer" followed by the "Lower" Santos shale and the pre-unconformity sand, the Agua. The Reef Ridge sequence also has basal sands followed by shale and the pre-unconformity sand, the Olig-Potter. On the crest of the Temblor the probably correlative fine Santa Margarita Sand is overlain by the pre-unconformity granite conglomerate. In the case of the Oligocene sequence, the basal post unconformity sand, the "Oceanic" is the most prominent. This is followed by the Tumey shale, but the pre-unconformity sand is missing.

The significance of thin sequence sands is that they are derived from the uplifts of the Temblor Range that produced the unconformities.

UNCONFORMITIES

Since the principle unconformities are the basis for separating the sequences, a brief mention will be made of them.

The Eocene unconformity is the most prominent in the south where it is on basement and disappears to the north of Coalinga where the beds are more or less conformable. This unconformity is a result of uplift in the Transverse Range. The base of the Oligocene unconformity is also more prominent in the south as at Belgin Anticline and disappears north of Devil's Den where it is conformable on the Upper Eocene Kreyenhagen Shale.

Most of the Miocene unconformities, on the other hand, are more prominent in the north and disappear in the southern portion of the Temblor Range where the Miocene is conformable, except for the Reef Ridge. The general tendency is for the progressively younger Miocene unconformities between sequences to migrate southward, closing off the seaway across the southern portion of the Temblor Range. The various Miocene unconformities truncate each other so their original distribution is altered.

The base of the Miocene unconformity is a transitional type, being present in both the Transverse Range at the south end of the valley and in the central Temblor Range.

The base of the Lower Santos, base of the Saucesian unconformities, are present in the central Temblor Range and adjacent areas. The most prominent one is the base of the Upper and Middle Miocene unconformity which shows prominent overlapping and truncation in the central Temblor Range area. The base of the Reef Ridge unconformity is present mainly in the southern Temblor Range.

The base of the Pliocene unconformity is present on the flanks of the southern and central Temblor Range, but it is especially prominent in the Cymric Field. North of Devil's Den it is represented by conformable beds.

The base of the Tulare unconformity is present mostly around the flanks of the valley and such uplifts as Lost Hills and South Belridge.

TYPES OF SAND BODIES

In summary, it appears there are mainly three types of sand, each with its particular type of geometry: 1) the post unconformity sand is either overlapping or erratic, 2) the pre-unconformity sand is wedge shape, often becoming coarser at the top, 3) the middle sand is a thick series of sands that interfingers into shale.

CORRELATION PROBLEMS

Correlation still remains the biggest problem. This makes the discussion of stratigraphic relationships somewhat speculative and subject to different interpretations. For instance, do the Potter, Olig, and Fitzgerald sands belong in the top of the Reef Ridge Miocene, in the basal Pliocene, or both? A choice has had to be made in order to synthesize the stratigraphy and to know which unit to describe them under.

FORMAT

An outline of the items discussed under the various stratigraphic units follows. However, not all items are discussed under each unit.

STRATIGRAPHIC UNIT (AGE)

TYPE LOCALITY.

Type area, type section, or type well. Formal, informal, or local use. What named after, named by whom, subsequent revisions, and references.

CHARACTERISTICS AND LITHOLOGY.

What distinguishes the formation. Boundaries, internal markers. Lithology at the type section, lithology in general, and lithofacies.

FAUNA AND AGE.

Discussion of megafossil zones and microfossil zones with age determination.

STRATIGRAPHIC RELATIONSHIPS.

Distribution. Position in sequence. The area of maximum thickness and thick axis with the conformably overlying and underlying stratigraphic units and those it grades into laterally. Toward the edges, wedging, onlapping unconformably, amount of onlapping or duration of the unconformity, and beds truncated. Where unit is truncated by an overlying unconformity. Outcrops.

DIVISIONS.

Equivalent names for the same unit. Subdivisions of the unit. Facies names. Named oil sands.

OIL AND GAS.

Trends and gravity variations.

TULARE FORMATION

PLEISTOCENE

TYPE AREA: East Flank of Kettleman Hills adjacent to Tulare Lake. F. M. Anderson (1905) p. 181. Type section suggested as La Ceja in Section 35-21S/17E by Woodring, Stewart & Richards (1940) pp. 13-26. Formally accepted.

CHARACTERISTICS AND LITHOLOGY: The main characteristics are buff colored sediments and fragments of older sediments. The type area consists of 1000 feet of gypsiferous sands and clays. In general, it consists of fluvial sands which are silty, pebbly, and conglomeratic and, in the upper and lower portions, are lacustrine clay, silt, fine grained sandstones, tuff, limestones, gypsum, and diatomite. Near the front of the Temblor Range it consists of fragments of older sediments.

FAUNA AND AGE: The Tulare Formation is non-marine in origin and considered Pleistocene in age from stratigraphic position and contained Mollusca. In some places the Tulare contains abundant, well preserved, re-cycled Eocene and Miocene foraminifera.

The boundary with the underlying San Joaquin Formation in the Kettleman Hills area, which has been regarded as the type region, has been placed at the top of the "Upper Mya" molluscan assemblage of the San Joaquin and below the "Lower" Amnicola Molluscan assemblage of the Tulare.

Beds of the Tulare contain a goodly number of Mollusca representing fresh water snails and mussels and a few brackish water clams. Fresh water diatoms are also present. The fauna have been divisible in the Kettleman Hills area into an "Upper" and a "Lower" Amnicola assemblage, both assemblages characterized by an abundance of fresh water gastropods, belonging to the Amnicolidae (Flumincola, Pyrgulopsis, Calipyrgula, Littoridina, Amnicola, Hydrobia and Brannerillas). For a listing of the mollusks and the diatoms, the reader is referred to Woodring, et al (1940) listing opposite page 78, and to Arnold (1909) on pages 91 to 101.

STRATIGRAPHIC RELATIONSHIPS: This formation includes the entire Tulare sequence. It occurs mainly on the west side of the San Joaquin Valley with the thick axis of around 4500 feet extending from San Emgidio Nose through the Kettleman Hills, along which it is conformably overlain by the Alluvium and underlain by the San Joaquin Formation. Eastward, it grades into the Kern River Formation. To the west, the Tulare unconformably overlaps formations as old as the Eocene. It outcrops in the Temblor foothills, Kettleman Hills, at North Belridge, Elk Hills, etc.

DIVISIONS:

CORCORAN CLAY MEMBER. Upper Tulare lacustrine member. Type well is a test hole in Section 15-15S/14E. It is 50-120 feet thick and covers 4000 square miles. Frink and Krues (1954), pp. 2357-2371.

"AMNICOLA SAND" is an important oil sand named after the numerous small gastropods that are found in this sand.

OIL AND GAS: 12 to 15° gravity oil is found in a belt extending from the South Lost Hills, S. E. North Belridge, South Belridge, Cymric, McKittrick to Midway Sunset. The oil is principally in the lacustrine beds of the lower Tulare where it overlaps San Joaquin, Etchegoin, Reef Ridge, and Antelope oil bearing sands. Possibly it is a lake shore line accumulation.

Gas is trapped by the pinch out of thin gas sands in the Dudley Ridge Field.

SAN JOAQUIN FORMATION

UPPER PLIOCENE

TYPE AREA: Eastside of the north dome of Kettleman Hills Section 23-22S/18E. Named by F. M. Anderson (1905) p. 181. It was further defined by Barbat & Galloway (1934) pp. 476-499. Formally accepted.

CHARACTERISTICS AND LITHOLOGY: Characterized by blue and green fine grained rocks that are more persistent than the overlying or underlying formations. Principally fine grained silty sands, silt, and clay. Somewhat rhythmic, green, barren, varved clays; blue Mya-Elphidium clays; and the brown Pecten clays.

FAUNA AND AGE: The San Joaquin Formation is predominantly marine in origin and many of the coarser grained beds contain marine molluscan fossils. Some of the finer grained beds appear to be non-marine in origin; at least marine fossils have not been found in many of them, and the remains and land plants and fresh water shells are present in some. The San Joaquin is considered late Pliocene and, possibly, early Pleistocene in age from stratigraphic position and contained Mollusca.

The largest marine faunas are generally found in sand, sandstone and conglomerate. These beds are distinctive by the fossil and lithic components, but most of these show stratigraphic change along strike and, therefore, the only member recognized is the Cascajo Conglomerate at the base of the formation.

Contact with the overlying Tulare is placed above an "Upper Mya" molluscan assemblage. There are several other faunule zones within the San Joaquin characterized by species of Pecten, Acila, Anadara, Mya, Trachycardium, Dendrasters (sand dollars) and numerous representative gastropods. Some of the more characteristic species are: *Pecten coalingensis, Ostrea vespertina* and *Dendraster coalingensis.* For a more complete listing of the mollusks the reader is referred to

Woodring, et al (1940) listing opposite page 78. A listing of diatoms recorded from the formation may be found on page 41 of Woodring.

STRATIGRAPHIC RELATIONSHIPS: This formation is the upper shaley part of the Pliocene sequence. It occurs mainly on the West Side of the San Joaquin Valley, with the thick axis of around 4200 feet extending from San Emigdio nose northward through the Coalinga District along which it is conformably overlain by the Tulare and underlain by the Etchegoin. Eastward, it grades into the Kern River Formation. It wedges to the west and, in places, overlaps on to the Miocene. Also to the west, it is truncated by the basal Tulare unconformity.

DIVISIONS:

CASCAJO CONGLOMERATE Member occurs in the Kettleman Hills. Woodring, et al (1940).

OIL AND GAS: The oil is heavy on the west and grades to gas in the center of the basin. It is 15-23° gravity at Midway Sunset, 18-36° at Buena Vista Hills, 18-39° at Elk Hills with a gas cap. The center of the valley has gas sands from Semitropic to Paloma. Possibly these are shore line sands and sands on the flanks of growing structures.

ETCHEGOIN FORMATION

LOWER PLIOCENE

TYPE AREA: Etchegoin Ranch and vicinity, NW/4 Section 1-19S/15E at the north end of the Coalinga Field. Named by F. M. Anderson (1905) pp. 178-181. Barbat & Galloway (1934) restricted the Etchegoin. Formally accepted.

CHARACTERISTICS AND LITHOLOGY: Massive blue and brown sandstones, poorly sorted blue or bluish gray shales, and pebble conglomerates. In places variable, making correlations difficult. The Lower Etchegoin (Jacalitos) is more shaley and it has a basal sand, also some diatomite and punky shale.

FAUNA AND AGE: The Etchegoin Formation is predominantly marine in origin and strata of the formation contain marine Molluscan faunal assemblages that lend themselves to faunule zonation. However, some of the beds within the formation do contain fresh water mollusks or a mixture of marine and fresh water mollusks. The Etchegoin is considered early Pliocene in age from stratigraphic position and contained Mollusca.

At Kettleman Hills Woodring, et al (1949) have delineated nine molluscan faunule zones within the Etchegoin. The most satisfactory horizon is these is the Littorina faunule assemblage which is near the top of the formation. This faunule assemblage is used to help delineate the Etchegoin from the overlying San Joaquin.

Some of the more characteristic molluscan fossils found in the Etchegoin are: *Arca trilineata, Mytilis Coalingensis, Littorina mariana, Pseudocardium gabbi, Pseudocardium densatum* and *Siphonalia kettlemanensis.* For a more complete listing of the mollusks the reader is referred to Woodring, et al (1940) listing opposite page 78. A listing of diatoms recorded from the formation may be found on pages 67, 75 and 78 of Woodring (1940).

STRATIGRAPHIC RELATIONSHIPS: This formation includes the middle sand, the lower shale, and the basal sand part of the Pliocene sequence. It occurs mainly on the westside of the San Joaquin Valley with the thick axis in the center of the valley, reaching a maximum thickness of 4730 feet at North Dome Kettleman Hills. Northward, the thick section trends between Pyramid Hills and Coalinga, indicating a probable connection with the sea. In this central area it is conformably overlain by the San Joaquin and underlain by the Reef Ridge. Eastward it grades into the Kern River Formation. It wedges to the west and, in places, is overlapped by the San Joaquin. Also to the west, it truncates beds as old as the Cretaceous (Coalinga) and, in turn, it is truncated by the basal Tulare unconformity.

DIVISIONS:

JACALITOS FORMATION named from Jacalitos Creek, 21S/15E, south of Coalinga, by Arnold and Anderson (1908). It is considered equivalent to the Lower Etchegoin.

"BITTERWATER CREEK FORMATION" named from Bitterwater Creek (Section 32, 33-11N/24W) by Dibblee (1962). It is a semi-siliceous shale facies up to 3000 feet thick, grading northwest into marine sandstones.

"PANORAMA HILLS FORMATION." Non-marine pebble gravel in lower part grades southeast through marine sandstone into the Bitterwater shale. It is adjacent to the San Andreas fault. Dibble (1962) S.J.G.S. Guidebook "Geology of The Carrizo Plains & San Andreas Fault."

OIL SANDS in the Upper Etchegoin are the Bitumen, Wilhelm, and Gusher sands; and in the Lower Etchegoin, Calitroleum, etc.

BATES SAND, the basal Etchegoin sand on the east flank of Devil's Den.

FITZGERALD SAND is the basal Etchegoin sand in the Cymric area.

OIL AND GAS: Lower gravity (13-18°) oil is found near the truncation and shore lines, and higher gravity (18-40°) oil basinward. Gas is found in the center of the basin. Oil and gas trends are similar to the San Joaquin.

MONTEREY FORMATION

REEF RIDGE SHALE MEMBER UPPER MIOCENE DELMONTIAN

TYPE LOCALITY: At the base of the Reef Ridge north of the Pyramid Hills Field. Named by Barbat and Johnson (1933), Gester and Galloway (1933) pp. 1174-1176. It outcrops on the flanks of the Diablo and Temblor Ranges. Restricted by Siegfus (1939). Formally accepted as a formation, informally as a member of the Monterey.

CHARACTERISTICS AND LITHOLOGY: Blue shale in the vicinity of the type section. White, gray, or brown diatomaceous sandy, thin bedded shale with poorly sorted granitic sands and conglomerate to the south.

FAUNA AND AGE: The foraminifer, *Bolivina obliqua,* found in the Reef Ridge, is an index fossil for Kleinpell's (1938) Delmontian stage of the Upper Miocene. Some other foraminifers reported from the Reef Ridge Shale in the Belridge and Kettleman Hills area are: *Nonion belridgensis, Nonionella miocenica, Buliminella elegantissima, Buliminella dubia, Bulimina pseudotora, Virgulina californiensis, Virgulina subplana, Bolivina brevoir* and *Eponides exigua.*

The Chico Martinez (Belridge) diatomite of the Chico Martinez Creek area is of Mio-Pliocene age by lithologic correlation with the Belridge diatomite in the subsurface at South Belridge where *Elphidium hughesi,* which is common in the Pliocene, has been found in the upper part of the diatomite and *Bolivina obliqua* is abundant in the lower part.

STRATIGRAPHIC RELATIONSHIPS: This represents the entire Reef Ridge sequence. The thickest section is probably 2200 feet in the Midway

Sunset area. In its axial area it is conformably overlain by the Etchegoin and underlain by the Antelope Shale. Eastward, it grades into the Chanac. Toward its periphery it is essentially regressive with shale at the base with an overlying pre-unconformity sand becoming increasingly coarse toward the top, such as the Olig, Potter, etc. It is truncated by the basal Pliocene and the basal Tulare unconformities to the west.

DIVISIONS:

BELRIDGE DIATOMITE is a facies of the Reef Ridge. Siegfus (1939).

OIL SANDS are the Olig, Potter, Lakeview, and Marvic sands.

OIL AND GAS: Oil in this formation has been found mainly in the McKittrick-Midway Sunset area.

ANTELOPE SHALE MEMBER UPPER MIOCENE-UPPER MOHNIAN

TYPE LOCALITY: Probably informally named by petroleum geologists from outcrops in the Temblor Hills adjacent to the Antelope Valley. First appeared in print in an article by E. B. Noble (1940) on the Rio Brova Field p. 1332 (fig. 1), and by Simonson and Grueger (1942) p. 1611 (fig. 2) p. 1617. Informal

CHARACTERISTICS AND LITHOLOGY: This is a member of the Monterey Shale and grades into the McLure Shale Member to the north. The lower Antelope is mainly cherty and siliceous shale; whereas, the Upper Antelope has a brown shale facies, a cherty and siliceous shale facies (Chico Martinez) and a sand and shale facies (Stevens).

FAUNA AND AGE: The Antelope is probably Upper Miocene, Upper Mohnian by stratigraphic position. The foraminifers *Buliminella elegantissima, Bolivina seminuda, Nonionella miocenica, Nonion* sp., *Uvigerina subperegrina, Virgulina* sp. and *Globigerina bulloides* are found in the lower part of the Antelope along with the mud pecten *Pecten peckami. Pecten peckami* is an important subsurface fossil.

The Chico Martinez cherts (McLure of Prof. Paper 195) contain relatively non-diagnostic arenaceous foraminifers, including Cyclamminas and Trochamminas. These beds are Delmontian or Upper Mohnian by stratigraphic position.

STRATIGRAPHIC RELATIONSHIPS: This formation is in the upper part of the Monterey sequence. It contains the middle sand of the sequence, the Stevens and the siliceous shale portion. The thickest section is probably in the outcrop section adjacent to the Midway Sunset Field, where it is conformably overlain by Reef Ridge and underlain by the McDonald shale. Eastward, it grades into the upper Fruitvale shale and Santa Margarita sands. It is possibly locally unconformable with the overlying and underlying formations. It outcrops on the eastern flank of the Temblor Range.

DIVISIONS:

UPPER AND MIDDLE McLURE. The Antelope grades into the upper brown shale and the middle siliceous and cherty shales of the McLure.

CHICO MARTINEZ apparently first appeared in print in the S.J.G.S. Guidebook on Chico Martinez Creek (1959). It is apparently equivalent to the Upper Antelope Haplophragmoides arenaceous zone. Some geologists consider it in part Reef Ridge. This formation changes from siliceous shale and chert at the type locality (Section 11-29S/20E) to brown shale to the north.

STEVENS SAND was named after the Stevens Station on the Sunset Railroad as an informal subsurface name. It first appeared in print in Hoots (1938) pp. 701-718. The central valley Stevens sand is an interfingering blanket sand with a cementation barrier adjacent to the Coles Levee and Paloma Fields, possibly due to commingling of the eastern and western waters.

The westside sands equivalent to the Stevens sand are composed of off structure linear sand bodies. The northern one goes under various names such as the McKittrick Stevens sand, Asphalto sands, "555" sand at Buena Vista Hills, and the Elk Hills Stevens sands. In the Midway Sunset area, these sands may be roughly divided into: 1) upper Antelope Monarch, Contact, Gibson, Hoyt, Beverly, 10-10, and Essex sands; 2) upper middle Antelope Webster, Signal, Exeter and 29-D sands; 3) lower middle Antelope Moco, Uvigerina C, Obispo, and Metson sands; and 4) lower Antelope Republic, Williams, and Leutholtz sands.

OIL AND GAS: Oil is found in the Stevens and related sands. It is higher gravity basinward. Oil is also found in the fractured shales. It is more prolific in the fractured chert facies adjacent to Stevens sand production.

McDONALD SHALE MEMBER UPPER MIOCENE-LOWER MOHNIAN

TYPE LOCALITY: Probably informally named by petroleum geologists from outcrops southwest of the present McDonald Field. First appeared in print as equivalent to the Pulvinulinella gyroidinaformis zone in an article by Cushman and Goudkoff (1930) p. 1. This unit is within the Monterey Shale, and grades into the basal portion of the McLure Shale Member. It is described as a member of the Monterey Shale in Simonson and Krueger (1942) pp. 1616-1617. Informal.

CHARACTERISTICS AND LITHOLOGY: In Temblor Range the McDonald shale is characterized as a massive chocolate brown silty shale in contrast to the buff and tan Devilwater-Gould and the siliceous well-bedded light brown shale of the Antelope. In places, it has a cherty and siliceous shale member, and a sand member often basal.

FAUNA AND AGE: The McDonald is considered to be Lower Mohnian in age on the basis of its stratigraphic position and contained microfauna.

Upper McDonald shales are representative of Kleinpell's (1938) *Bulimina uvigerinaformis* zone of the late Lower Mohnian stage age. Some of the foraminifers found in these upper shales are *Pulvinulinella gyroidinaformis, Bolivina sinuata sinuata alisoensis, Uvigerina hootsi.* In the Chico Martinez Creek area, the uppermost McDonald carries rare occurrences of *Uvigerina segundoensis.*

Cassidulina monicana, Eponides keenani, Gyroidina montereyana (obesa), Bolivina californica, Bolivina parva and *Uvigerina joaquinensis* are some of the foraminifers found in the lower McDonald shales. The assemblages place these shales in the *Bolivina modeloensis* zone of early Lower Mohnian stage age. Lower McDonald shales that were laid down in deep water carry a fauna characterized by *Pullenia moorei* and *Rotalia becki* (see discussion by C. H. Rudel in the guidebook).

STRATIGRAPHIC RELATIONSHIPS: This formation is in the middle part of the Monterey sequence. It is the shale below the middle sand of the sequence. The thickest section is probably in the outcrops in the Temblor Hills adjacent to the Midway Sunset Field (2250 feet) where it is conformably overlain by the Antelope Shale and underlain by the Devilwater siltstone. Eastward, it grades into the Lower Fruitvale shale and northward, into the lower McLure shale. In the northern part of the area adjacent to the Temblor Range, the McDonald forms the basal member of the sequence with the Packwood as the basal sand, truncating beds as old as the Eocene Point of Rocks. The McDonald outcrops along the front of the Temblor Range.

DIVISIONS:

LOWER MCLURE. The McDonald grades into this portion of the McLure.

TWISSELMAN SAND type section on the Twisselman Ranch in Section 14-27S/18E. Heikkila and MacLeod (1951) p. 12.

PACKWOOD SAND is in the vicinity of the North Antelope Field and is named after Packwood Creek.

OIL AND GAS: A small amount of oil has been produced from the Packwood sand and fractured shales.

DEVILWATER SILT MEMBER MIDDLE MIOCENE-LUISIAN

TYPE LOCALITY: Probably informally named by petroleum geologists from outcrops in Devilwater Creek west of the Antelope Hills Field. First appeared in print Bailey (1939) pp. 66-71. Informal.

CHARACTERISTICS AND LITHOLOGY: It is a buff to dark gray sandy siltstone with a greenish cast. In the vicinity of the McDonald and Antelope Hills Field it has numerous sands.

FAUNA AND AGE: The Devilwater silt contains foraminifers typical of the Luisian stage of the Middle Miocene.

The late Luisian *Siphogenerina collomi* zone of Kleinpell (1938) is not represented in the Devilwater in the Chico Martinez Creek area but, elsewhere, in the subsurface it is characterized by the foraminifers: *Valvulineria californica* ss., *Siphogenerina collomi, Baggina californica, Bolivina advena striatella, Anomalina salinasensis* and *Pullenia miocenica.*

The upper portions of the Devilwater silt in the Chico Martinez Creek area contain foraminifers indicative of the *Siphogenerina nuciformis* zone of the Luisian. Some of these are: *Baggina californica, Bolivina advena striatella, Bolivina imbricata, Anomalina salinasensis, Dentalina quadrulata, Hemicristellaria beali, Pullenia miocenica, Siphogenerina nuciformis, Valvulineria californica.*

Foraminifers in the lower portions of the formation in the Chico Martinez Creek area are representative of the early *Luisian, Siphogenerina reedi* zone. Some of these are: *Bolivina advena ornata, Bolivina californica, Valvulineria californica* ss and var. *obesa, Siphogenerina reedi* and *Siphogenerina nuciformis.*

STRATIGRAPHIC RELATIONSHIPS: This formation is in the upper lower part of the Monterey sequence. The thickest section, up to 1500 feet, is probably the one west of the Midway Sunset Field, where it is conformably overlain by the McDonald shale and underlain by the Gould Shale Member. Eastward, it grades into the Round Mountain silt and northward, into non-marine beds. The thick interval of overlapping sands in the McDonald-Antelope Hills area indicates the rather long duration of the base of the upper and middle Miocene unconformity. It outcrops in the Temblor Hills.

DIVISIONS:

ALFERITZ FORMATION (informal) named by Van Couvering and Allen (1943) pp. 496-500. This is equvalent to the Devilwater. In spite of this being the first description of the surface beds, it is little used. Devil's Den District.

OIL SANDS in the McDonald Anticline Field are the "Theta" or "2nd Devilwater Sand" and the "Tolco" or "7th Devilwater Sand."

OIL AND GAS: The oil production is mostly limited to the sands mentioned above in the McDonald Field. There is some gas at Antelope Hills and oil in the Foraminite zone at Railroad Gap.

GOULD SHALE MEMBER MIDDLE MIOCENE-RELIZIAN

TYPE LOCALITY: Probably informally named by petroleum geologists from Gould Hill south of Chico Martinez Creek. The type locality extends from center W/2 Section 14-29S/20E to southeast side of Chico Martinez Creek. Cunningham and Barbat (1932) pp. 417-421.

CHARACTERISTICS AND LITHOLOGY: The most characteristic lithology is hard, silicified, locally cherty and resistant platy tan shale. In some places, it is more massive and siliceous. The siliceous shales distinguish it from the Devilwater. At Belgian Anticline it is brown siltstone. Where it is a clay shale or siltstone, its presence is determined by paleo or electric log correlations. The thicker sections have the siliceous shale facies.

FAUNA AND AGE: The Gould Shale is placed in the late Relizian stage of the Middle Miocene, both by the contained foraminifers and stratigraphic position.

Such foraminifers as *Baggina robusta, Bolivina imgricata, Gyroidina reliziana, Nonion costiferum, Siphogenerina branneri* and *Valvulineria californica* vars. *obesa* and *appressa* found in the Gould are representative of the Kleinpell's (1938) *Siphogenerina branneri* zone of the Relizian.

STRATIGRAPHIC RELATIONSHIPS: This formation is in the lower part of the Monterey sequence. The thickest section of up to 1500 feet is probably west of the Midway Sunset Field. It is conformably overlain by the Devilwater and underlain by the "Button bed." Eastward, it grades into the Round Mountain silt.

SUBDIVISIONS:

LAYMAN 2 SAND is productive at the McDonald Field.

OIL AND GAS: Oil production is limited to the above sand.

TEMBLOR FORMATION

"BUTTON BED" MEMBER BASAL MIDDLE MIOCENE

TYPE LOCALITY: Carneros Creek is given by Heikkila and MacLeod (1951) p. 10, as the type locality. It was first mentioned in print by F. M. Anderson (1905) p. 170, who said it was the top member of the Temblor. It is named after the button-like sea urchins *Scutella merriami.*

CHARACTERISTICS AND LITHOLOGY: The fossil mentioned above is the most characteristic feature at the type locality, but these are not present in many places. It is a medium gray to brown massive sand.

FAUNA AND AGE: Abundant specimens of the small, "button-like" echinoid, *Scutella merriami,* as well as the characteristic *Pecten estrellanus* and *Pecten andersoni,* occur in the Button Bed sands. The Molluscan assemblages, referable to the Molluscan *"Turritellaocoyana"* zone, as well as some of the microfossils found in the siltier parts of the stratigraphic unit, place the unit in the early Middle Miocene.

Some of the foraminifers found in the stratigraphic unit are: *Bolivina advena striatella, Nonion costi-*

ferum, Nonionella miocenica, Valvulineria miocenica, Siphogenerina branneri and *Siphogenerina hughesi.* The foraminifers are characteristic of the *Siphogenerina hughesi* zone of Kleinpell (1938). Abundant Sporbo (phosphatic oolites) are also found in the siltier parts of the stratigraphic unit.

STRATIGRAPHIC RELATIONSHIPS: This is the basal portion of the Monterey sequence. The thickest section is probably 800 feet in the outcrops in Sections 17, 20, 21-27S/18E. It is conformably overlain by the Gould Shale and underlain by the Media Shale, and grades into Gould Shale. It onlaps beds as old as the Eocene Point of Rocks. In the outcrop it is an erratic sandstone varying from zero to 800 feet from 26S/17E to 29S/20E. In the subsurface it appears to consist of several basal transgressive sandstones.

DIVISIONS:
None.

OIL AND GAS: Oil is produced in the North Antelope and Antelope Fields where it truncates and overlaps the Agua sand. Oil is also found at the McDonald Field.

MEDIA SHALE MEMBER LOWER MIOCENE-UPPER SAUCESIAN

TYPE LOCALITY: First mentioned by Cunningham and Barbat (1932) pp. 417-421. Probably named after Media Agua Creek west of the McDonald Field. Informal.

CHARACTERISTICS AND LITHOLOGY: It ranges from a platy tan silty shale to a light colored siliceous shale. The most characteristic feature in outcrop is the presence of numerous 3 foot buff colored limestone beds.

FAUNA AND AGE: The foraminifers of the Media shales are representative of Kleinpell's *Uvigerinella obesa* zone of the late Lower Miocene Saucesian stage. Some of the more characteristic foraminifers are: *Bulimina inflata alligata, Cibicides floridanus, Eponides mansfieldi, Nodogenerina koina, Nodosaria parexilis, Nonion costiferum, Plectofrondicularia miocenica directa, Planulina appressa, Robulus simplex, Uvigerinella obesa impolita* and *Siphogenerina transversa.*

In the Chico Martinez Creek area the first 50 feet of a sandy silt interval referred to as Media, which underlies the Button Bed sand in the area, contains Lower Relizian *Siphogenerina hughesi* zone foraminifers. Some of the species noted are: *Anomalina salinasensis, Uvigerinella californica, Valvulineria miocencia* and *Siphogenerina branneri.* No *Siphogenerina hughesi* were found.

STRATIGRAPHIC RELATIONSHIPS: This is the upper part of the Saucesian sequence. The Media is thickest in the Temblor Range where Carneros is thin or absent and it rests directly on the "Upper" Santos shale. In Cedar Canyon, it is 2300 feet thick. In the axial area it is conformably overlain by the "Button bed" and underlain by either the Carneros sand or "Upper" Santos shale. It grades into the Carneros sand and, on the eastside, into the Freeman silt. It is unconformably truncated by the "Button bed" in the Antelope Hills and other areas. It outcrops on the flanks of the Temblor Hills.

DIVISIONS:
None.
OIL AND GAS: None.

CARNEROS SANDSTONE MEMBER LOWER MIOCENE SAUCESIAN

TYPE LOCALITY: Carneros Creek west of the Chico Martinez Oil Field. Cunningham and Barbat (1932) pp. 417-421. Probably first named by H. G. Schenck, May and Gilboe (1931). Informal.

CHARACTERISTICS AND LITHOLOGY: The lithology varies from a very hard lumpy calcareous sandstone to a well-bedded platy calcareous sandstone to a buff colored friable sandstone.

FAUNA AND AGE: *Pecten miguelensis* and *Scutella merriami* are some of the more characteristic mollusks found in Carneros sands. The Mollus assemblage is relatable to the Molluscan *"Turritella ocoyana"* zone and perhaps within the "Vaqueros-Temblor Transition" of Loel and Corey. Stratigraphic relationship of the Carneros (lying between the two Saucesian stage age shales — the Media and the Upper Santos) places the unit in the Lower Miocene Saucesian stage.

STRATIGRAPHIC RELATIONSHIPS: This is the middle sand in the Saucesian sequence. It is incased by Media and "Upper" Santos shale. There are three bodies of Carneros sand: 1) a northern one extending as far south as North Belridge with a maximum thickness of 2390 feet in the Bates area; 2) the middle or main Carneros sand body extending from the type section to Elk Hills, with a maximum thickness of 2000 feet; 3) the southern one in the Temblor Hills west of Midway Sunset, extending from Crocker Canyon to the Pioneer area, with a maximum thickness of 5000 feet. The Carneros is overlain and grades into the Media shale, and it is underlain and grades into the "Upper" Santos shale. It outcrops in the Temblor Range.

DIVISIONS:

ANDERSON SAND in the Welport area is probably equivalent to the 1st and 2nd Carneros to the south.

WESTON 3 SAND in the Welport area is probably equivalent to the 3rd Carneros sand to the south.

OIL AND GAS: The middle or main Carneros sand body has the bulk of the oil from fields such as Salt Creek, Welport, Railroad Gap, and Elk Hills. Railroad Gap has the largest gas cap. The southern sand body in the Temblor Hills has the thickest sands but only small fields with 20-30° oil. Also the northern sand body has only small accumulations of 12-23° oil.

"UPPER" SANTOS SHALE MEMBER LOWER MIOCENE-LOWER SAUCESIAN

TYPE LOCALITY: Santos Creek, Gester and Galloway (1933) and May and Gilboe (1931). The term "Upper" Santos shale was mentioned by Goudkoff (1934). Santos informal. "Upper" Santos local usage.

CHARACTERISTIC AND LITHOLOGY: Light gray shales with thin sand lenses, and tan, platy, siliceous and calcareous shales with lenticular limestones and sandstones. Usually less silty than the Media shale.

FAUNA AND AGE: The microfauna of the "Upper" Santos shales represent Kleinpell's (1938) *Siphogenerina transversa* and *Plectofrondicularia miocenica* zones of the Lower Saucesian stage of the Lower Miocene.

Bolivina marginata adelaidana, Cibicides americanus, Siphogenerina transversa, Siphogenerina tenua, Siphogenerina mayi, Baggina robusta var., abundant Sporbo (phosphatic oolites) and fish remains are some of the microfauna normally found in these shales.

STRATIGRAPHIC RELATIONSHIPS: This is the lower shale of the Saucesian sequence. The maximum thickness of 1500 feet occurs in the Bitterwater Creek outcrop area where little, if any, Carneros is present. It is conformably overlain and grades into the Carneros sandstone. In places, it is overlain by the Media shale. In the axial area it is underlain conformably by the Agua sand.

It also unconformably overlaps beds as old as the Tumey shale. It outcrops in the Temblor Hills.

DIVISION:

None.

OIL AND GAS: None.

AGUA SANDSTONE MEMBER LOWER MIOCENE-UPPER ZEMORRIAN

TYPE LOCALITY: Named informally in an abstract by Clark and Clark (1935) p. 137, with no type section given, but that it occurred between Carneros Creek and Cedar Canyon. Named after Media Agua Creek. Heikkila and MacLeod (1951). Informal.

CHARACTERISTICS AND LITHOLOGY: This sandstone is medium to coarse grained and gritty with muscovite and glauconite.

FAUNA AND AGE: *Bulimina carnerosensis, Buliminella subfusiformis, Siphogenerina transversa, Siphogenerina mayi* and *Uvigerinella sparsicostata* are found in the shale and silt interbeds in a sand body in the Chico Martinez Creek in the approximate stratigraphic position of the Agua sand of Media Agua Creek. This fauna is representative of the *Uvigerinella sparsicostata* zone of Kleinpell, which is the upper division of the Zemorrian stage of the Lower Miocene.

STRATIGRAPHIC RELATIONSHIPS: This is the pre-unconformity sand in the Lower Santos sequence. The maximum thickness is around 400 feet in the Antelope Hills area. It is conformably and unconformably overlain by the "Upper" Santos shale and underlain by and probably grades into the "Lower" Santos shale. It is truncated by the base of the Saucesian unconformity in the Beer Nose area. To the south, in the Antelope Hills Field, it is truncated by the base of the "Button bed" unconformity. It has small outcrops in the Temblor Hills, but it is mainly subsurface.

DIVISIONS:

None.

OIL AND GAS: North Antelope 15° oil, Antelope Williams 17° oil, McDonald 25° oil, and North Belridge 45° oil.

"LOWER" SANTOS SHALE MEMBER LOWER MIOCENE ZEMORRIAN

TYPE LOCALITY: Santos Creek, Gester and Galloway (1933) and Gilboe (1931). The term "Lower" Santos shale was mentioned by Goudkoff (1943). Santos informal, "Lower" Santos local usage.

CHARACTERISTICS AND LITHOLOGY: Dark brown to gray brown shale and gray brown silt with interbedded shale.

FAUNA AND AGE: Foraminifers contained in the upper shales of the "Lower" Santos are representative of Kleinpell's (1938) upper division of the Lower Miocene Zemorrian stage, the *Uvigerinella sparsicostata* zone. Some of the species reported by Kleinpell in the Zemorra Creek section are: *Bulimina carnerosensis, Gyroidina soldanii, Saracenaria schencki, Siphogenerina mayi* and *Uvigerinella sparsicostata.*

Uvigerina gallowayi, Uvigerina kernensis, Uvigerina "pseudoatwilli" and *Pseudoglandulina gallowayi* are found in the lower shales of the "Lower" Santos. The foraminifers place these lower shales in the lower division of the Zemorrian stage, the *Uvigerina gallowayi* zone.

STRATIGRAPHIC RELATIONSHIPS: The Lower Santos sequence has an erratic basal sand, the "Bloemer," the "Lower" Santos shale and, finally, the massive Agua sand which, in places is truncated by an unconformity. The maximum thickness of the "Lower" Santos shale is probably 375 feet at N. E. McKittrick. It is conformably overlain by the Agua sand and underlain conformably and unconformably by the "Phacoides sand." In the vicinity of uplifts, it is unconformably overlain by the "Upper" Santos shale and by the "Button bed." It outcrops in the Temblor Range, but it is overlapped northward by the "Upper" Santos shale.

DIVISIONS:

BLOEMER SAND named after the Ohio Bloemer Lease, Section 36-27S/20E. It is a basal Lower Santos sand found at North Belridge and elsewhere. There is a correlation difficulty in that the Bloemer probably correlates with the thin "Phacoides" in the Antelope Hills area. Unfortunately, the type "Phacoides" may belong here rather than with the "Phacoides" described subsequently.

OIL AND GAS: Bloemer sand at North Belridge and possibly the thin "Phacoides" sands elsewhere.

"PHACOIDES SAND" MEMBER LOWER MIOCENE-LOWER ZEMORRIAN

TYPE LOCALITY: Kleinpell (1938) p. 107, Goudkoff (1943) p. 250, mentions that the "Phacoides" Reef is exposed in Salt Creek and in Chico Martinez Creek. However, the name "Phacoides" is now used for a sand that is probably underneath this one. Local usage.

CHARACTERISTICS AND LITHOLOGY: Light gray sandy siltstones at the base, grading to massive sand with thin hard gray lenses becoming coarser and having glauconite at the top.

FAUNA AND AGE: Molluscan assemblages containing *Pecten (Chlamys) sespeensis, Pecten branneri, Bruclarkia (Agasoma) barkeriana, Lucina acutilineatus, Amantus mathewsoni, Clementia pertenuis* and *Ostrea* sp. found in the Phacoides "reefs" are relatable to the molluscan *"Turritella inezana"* zone and placed in the Zemorrian stage of the Lower Miocene by Kleinpell (1938). The Phacoides stratigraphic relationship would further place the Phacoides in the lower division of the Zemorrian stage.

In the calcareous and glauconitic Phacoides sand in the vicinity of Chico Martinez-Zemorra Creek area, the following microfossils were found: *Cibicides floridanus, Robulus inoratus, Uvigerinella obesa impolita, Elphidium* sp. and Sporbo and sponge spicules.

STRATIGRAPHIC RELATIONSHIPS: This is the pre-unconformity sand in the Salt Creek sequence. The maximum thickness is in excess of 400 feet. It is conformably and unconformably overlain by the "Lower" Santos shale and underlain and interfingers into the "Salt Creek shale." It is unconformably truncated by the incompletely known base of the Lower Santos unconformity.

DIVISIONS:

BELRIDGE "64" SAND is named after the Belridge #64 well in Section 27-27S/20E. The type Phacoides may correlate with Bloemer in the previously described unit.

OIL AND GAS: The principle areas of production are the North Belridge and N. E. McKittrick-Railroad Gap area.

"SALT CREEK SHALE" MEMBER LOWER MIOCENE-LOWER ZEMORRIAN

TYPE LOCALITY: Mentioned by Goudkoff (1943) in the subsurface. Presumably named after Salt Creek southwest of the Cymric Field. Named by J. R. Williams (1936) in Div. Oil & Gas. Calif. Oil Fields Vol. 21, No. 4 called the "Salt Creek"—shale between the Bloemer and Belridge "64" sand. Local usage.

Characteristics and Lithology: Greenish black to black sandy silts with thin sands and an erratic basal sand. Also a massive brown shale.

Fauna and Age: The microfossil assemblage contained in the Salt Creek shales have a high percentage of arenaceous foraminifers. The foraminiferal assemblages are considered to be Lower Miocene, Lower Zemorrian in age. Some of the foraminifers found in these shales are: *Buliminella curta, Glandulina laevigata, Globigerina bulloides, Gyroidina soldanii, Plectofrondicularia vaughani, Cyclammina incisa, Haplophragmoides translucens, Ammobaculites* sp. and coarse *Trochammina* spp.

Stratigraphic Relationships: This is the basil portion of the Salt Creek sequence consisting of a shale and an erratic basal sand. Maximum thickness of the Salt Creek is probably 825 feet on the east flank of the Devil's Den area. It is conformably overlain and grades into the "Phacoides sand," and underlain by the Tumey shale. It unconformably overlaps formations from the Tumey to as old as the Eocene. It outcrops in the central portion of the Temblor Range.

Divisions:

Gibson sand is named after the Union Gibson lease in Section 36-27S/20E. This name conflicts with the Gibson sand of Upper Antelope age in the Midway Sunset area.

Oil and Gas: Very little production. Shows in the Gibson sand. Some production in the basal grit.

TUMEY FORMATION

TUMEY SHALE MEMBER

OLIGOCENE-REFUGIAN

Type Locality: Tumey Gulch, S/2 Section 16-16S/13E, north of Coalinga, by Atwill (1935) pp. 1192-1204. A more complete section is found just south of the type area in the Arroyo Ciervo, 16S/13E. Cushman and Simonson (1944). Informal. The Lexicon (1966) treats it as a member of the Kreyenhagen Formation.

Characteristics and Lithology: Lithofacies in the south end of the valley (Tecuya) are non-marine beds consisting of red and green silts, coarse granular sandstone, massive conglomerates. In the Devil's Den district (Wagonwheel formation) it consists of fossiliferous sandstone with an overlying siltstone. Northward to Tumey Gulch it consists of thick shale with lenticular sands.

Fauna and Age: Characteristic foraminifers of the Tumey, exclusive of the Leda and Transition zones of Cushman and Simonson (1944), are: *Plectofrondicularia packardi* and var. *multilineata, Plectofrondicularia garzaensis, Bolivina jacksonensis, Cibicides hodgei, Uvigerina garzaensis, Uvigerina atwilli, Uvigerina cocoaensis, Bulimina* cf. *schwageri* and *Guttulina irregularis.* These foraminifers are indicative of the Oligocene Refugian stage.

Stratigraphic Relationships: This is the upper part of the Oligocene sequence. The maximum thickness of 1600 feet extends from the east flank of Devil's Den north to the type section. Southward it is 500 feet or less. It is conformably and unconformably overlain by the "Salt Creek shale" and conformably underlain by the "Oceanic sand" and the Kreyenhagen shale. It is unconformably truncated by the base of the Miocene unconformity and the base of the Saucesian unconformity. The Tumey outcrops at the type section, and in the Devil's Den area, and at the south end of the valley.

Divisions:

Wagonwheel formation is used in the Devil's Den district as the equivalent to the Tumey shale. Named by H. R. Johnston (1909), Smith (1956). Although this name predates the Tumey and is closer to the oilfields, it is little used.

Tecuya formation, Stock. Univ. Calif. Geol. Dept. Bull. Vol. 12 (1920) pp. 267-276. Named after Tecuya Creek near the Grapevine.

Oil and Gas: Heavy oil occurs in the fractured shales of the Tumey in the Welcome Valley Field. Some lenticular sands on the east flank of Devil's Den also have small accumulations.

"OCEANIS SAND" MEMBER

OLIGOCENE

Type Locality: The "Oceanic sand" (subsurface only) was named after the Oceanic lease in the Cymric Welport area, Section 22-29S/21E. Local usage.

Characteristics and Lithology: Light brown, fine to medium grained sand with some kaolin.

Fauna and Age: Only molluscan fragments have been recorded from the Oceanic sands. Stratigraphic position (lying between the Refugian Tumey shales and uppermost Narizian age Kreyenhagen shales) places the Oceanic sands as probable Lower Refugian Oligocene in age.

Stratigraphic Relationships: The "Oceanic sand" is the basal portion of the Oligocene sequence. It extends from the Belgian Anticline-N. E. McKittrick area to the North Belridge - Blackwells Corner area. The maximum thickness is probably less than 200 feet. It is conformably overlain by and grades into the Tumey shale; and it is conformably and unconformably underlain by the Kreyenhagen shale. It has no outcrops because it is always truncated by the base of the Miocene and other unconformities before reaching the surface.

Divisions:

None.

Oil and Gas: 32-36° oil is produced from the northeast flank of Belgian Anticline, NW end of N. E. McKittrick, McKittrick Front, Cymric Welport and Sheep Springs areas, and the north end of North Belridge. Also a small amount of 20° oil was produced at the Bacon Hills area of the McDonald Field.

KREYENHAGEN FORMATION

EOCENE

Type Locality: It was named by F. M. Anderson (1905) p. 163, from the Kreyenhagen wells located in Sections 32, 33-22S/16E, south of Coalinga. Formal. In local usage the Kreyenhagen shale is used also as a member of the Kreyenhagen Formation overlying the Point of Rocks.

Characteristics and Lithology: Dark brown to medium gray fissile shale with fish remains, sponge spicules and radiolaria. Typically lavender brown siliceous splintery siltstone and shale with some sands and limestones.

Fauna and Age: "Restricted" Kreyenhagen (drawn at the Refugian-Narizian contact) encompasses the *Bulimina corrugata* and *Amphimorphina jenkensi* zones of the Upper Eocene Narizian stage of Mallory (1959). Some of the foraminifers reported from the "restricted" Kreyenhagen shale are: *Amphimorphina jenkensi, Bulimina corrugata, Anomalina garzaensis, Asterigerina crassiformis, Bulimina microcostata, Eponides umbonata, Planularia markleyana, Gyroidina soldanii octocamerata, Robulus welchi, Uvigerina garzaensis* and *Uvigerina churchi.*

Stratigraphic Relationships: It is the upper shale member of the Kreyenhagen sequence, the maximum thickness of which is about 1500 feet. It is conformably and unconformably overlain by the Tumey and the "Oceanic," and underlain and grades into the Point of Rocks sandstone. It is truncated on top by the base of the Miocene, base of the Saucesian, base of the Upper and Middle Miocene, and base of the Tulare unconformities. The main outcrops of the Kreyenhagen shale are north of the Pyramid Hills Field.

DIVISIONS:

WELCOME MEMBER of the Kreyenhagen Formation was named by Van Couvering and Allen (1943) p. 496. This is a tongue of the Kreyenhagen shale where it overlies the Point of Rocks sandstone in the Devil's Den district. Although it is little used, according to the Code (1961) and Lexicon (1966) it should be used in preference to Kreyenhagen shale member.

REED CANYON SILT. Probably equivalent to the Kreyenhagen at the south end of the valley.

OIL AND GAS: Small amounts of oil were produced from fractured shale in the Middle Dome Kettleman Hills.

POINT OF ROCKS SANDSTONE MEMBER EOCENE

TYPE LOCALITY: The Point of Rocks was originally designated as a unit of the Tejon Formation, but is here discussed under the Kreyenhagen Formation. Named by Reed and Hollister (1936) p. 1566, on a columnar section from the Point of Rocks northwest of the Welcome Valley Field, Section 2-26S/18E. Informal.

CHARACTERISTICS AND LITHLOLGY: Massive, coarse to medium grained arkosic sandstone with "cannonball" concretions.

FAUNA AND AGE: The Point of Rocks sandstones encompass most, if not all, of the Upper Eocene *Bulimina microcostata* zone of the Lower Narizian and extend through the *Amphimorphina californica* zone and at least down into the *Vaginulinopsis mexicana* zone; both of these latter zones are of Middle Eocene age and belong to Mallory's (1959) Ulatisian stage. Shale and silt interbeds in the Point of Rocks sands contain such forms as: *Uvigerina churchi, Bulimina corrugata, Dorothia principensis, Gyroidina orbicularis planata* and *Cibicides "pygmaea."*

STRATIGRAPHIC RELATIONSHIPS: This is the middle sand of the Kreyenhagen sequence. The maximum thickness is in excess of 5000 feet. It is conformably overlain and grades into the Kreyenhagen shale and conformably underlain and grades into the Canoas shale. It outcrops in the Temblor Range from the Cymric Field northward.

DIVISIONS:

None, but it is divided into several separate sands at Belgian Anticline and Pyramid Hills.

OIL AND GAS: Belgian Anticline, Cymric Welport (30°), Antelope Hills (17°), Shale Point South, Devil's Den Alferitz (37°) and Pyramid Hills Field (16-17°). The heavy oils are associated with unconformities.

CANOAS SILTSTONE MEMBER EOCENE

TYPE SECTION: Named after Canoas Creek about 20 miles south of Coalinga. Mentioned in Calif. Div. of Mines. Bull. 118 by Clark, p. 187, and Chambers, p. 487; and by Cushman and Siegfus (1942). Type locality is Garza Creek, Kings County. Formal. Basal member of the Kreyenhagen.

CHARACTERISTICS AND LITHOLOGY: Gray claystone locally silty with some thin glauconitic sandstone. The basal lenticular Mabury sand is a massive, medium to coarse grained to pebbly sand with glauconite near the base.

FAUNA AND AGE: The siltstones in the basal Kreyenhagen in the Coal Mine Canyon and Cantua Creek area develop locally into a unit referred to as the Canoas siltstone. The foraminifers contained in these siltstones are Middle Eocene in age and are placed by Mallory (1959) in the *Amphimorphina californica* zone of the Upper Ulatisian. Some of the foraminifers characteristic of the Canos are: *Vaginulinopsis asperuliformis, Martinotiella* cf. *petrosa, Bifarina nuttalli, Pleurostomella nuttalli* and *Anomalina dorri aragonensis.*

STRATIGRAPHIC RELATIONSHIPS: This is the lower shale and basal sand if the Kreyenhagen sequence. It is conformably overlain and grades into the Point of Rocks sand. It is underlain conformably and unconformably by the Domengine and older beds. It outcrops west of the Chico Martinez area, at Devil's Den, and further north.

DIVISIONS:

The correlation and the possible equivalents need further study because of the confusion in the literature. Tentatively, these units are considered as part of the Canoas horizon.

"MUD PIT SHALE" is an equivalent name for the Canoas Siltstone now no longer used.

GREDAL. Van Couvering and Allen (1943) Devil's Den district. Equivalent to the Canoas silt. D.O.G. Sum. Oper., Vol. 43, No. 1 (1957). Variegated, green-red claystone containing occasional sandstone beds and considerable glauconite. Mallory (1959) refers to the Gredal as a member of the Lodo formation.

MABURY SAND is the basal sand member of the Canoas. There are also other sands in the Canoas. Van Couvering and Allen (1943) pp. 496-500. Named after the Mabury Hills where it outcrops in Sections 10, 11-26S/18E. Coarse tan sandstone with black chert pebbles, containing *Spiroglyphus tejonensis.*

OIL AND GAS: Gas occurs in the Mabury sand at Shale Point, Shale Flat and Bolton areas in 27S/19E. Oil occurs in lenticular sands in the Norris area and the Orchard area of 24S/18E. The traps are near the pinch outs of the sands.

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(Editor's note: The Bibliography is presented in this form to show the chronology of the stratigraphic nomenclature.)

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SOME SOLUTIONS TO LOGGING PROBLEMS ON THE WEST SIDE OF CALIFORNIA'S SAN JOAQUIN VALLEY[1]

ARMOUR KANE[2]

Production on the west side of the southern San Joaquin Valley is from shaly sands. While the degree of shaliness varies, truly clean sands are rarely encountered. Further characterization of the producing formations requires classification by depth. In the deeper producing sands the formation waters are brackish to salty; in the shallow zones the waters are fresh. Porosities are generally higher in the shallower unconsolidated sands. Log evaluation of the shallow sands, already made difficult by shaliness, fresh water, and lack of compaction, is further complicated by the common occurrence of low-gravity, high-viscosity crude oils. The special interpretation methods for these shallow zones will be covered following discussion of the more common methods used for the deeper sands.

LOG EVALUATION OF THE DEEPER HORIZONS

The minimum logging program for the deeper sands consists of an Induction-Electrical Survey and either a Sonic Log or a Formation Density Log. The Induction-Electrical Survey (IES) provides correlation control for subsurface mapping and structural studies. In addition, the resistivity values from the IES are used with porosity data to find and evaluate oil- and gas-bearing zones.

While either sonic or density logs provide porosity control to augment the IES, the choice of which to use depends on the primary problem to be solved. The IES-Sonic combination provides the most reliable identification of hydrocarbon-bearing shaly sands. The pessimistic effect of shaliness on resistivity measurements is offset by an optimistic effect on sonic-derived porosities. However, if accuracy of porosity measurements is the more important, the better combination

[1]Manuscript submitted Feb. 1968.
[2]Schlumberger Well Services,
Bakersfield, California.