SURFACE AND SUBSURFACE GEOLOGY

OF MONTEBELLO HILLS

CALIFORNIA

BY

RUHOLLAH Y. KARUBIAN

THESIS PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA

AUGUST 1939

CONTENTS

ABSTRACT

In the following paper a report of both surface and subsurface geology of the Montebello oil field is given.

First a general survey of this area was made and then a geologic map with all field data plotted was prepared. Subsurface correlations were made by use of the electrical logs (Schlumberger) and the subsurface structure was studied. Also data from previous publications and from the core samples of the older drilled oil wells in this area was utilized in preparing a structure contour map.

This area, because of its large oil fields, has been of economical importance for the last twenty years. Recently two new fileds were brought in and it is estimated that these fields are going to make a new record for oil production in the state of California.

One of these new fields is on the east and somewhat to the south of the old field and the second new field is located on the southwest corner of the old field. Both of these fields are of different horizones and much deeper than the older pool.

The older field known as Montebello field is an anticline, with its axis running in an east and westerly direction. There is a major unconformity below this anticline beneath which appears the oil sands of the lower

horizons of the newly discovered pools.

The nature of rocks is highly complicated and shoreline deposites are well recognized in this area. Most of these sediments are sandstones of different characters. These sandstones get coarser and grade into conglomerates from one side and change to silt and at some instances to a thin layer of shale.

There is a big fault in this area which cuts the upper most sediments and for which there are some surface evidences. It is shown (by use of Schlumberger methods) also that there exists another fault which cuts the axis of the new eastern filed and of which there is no surface evidences.

INTRODUCTION

Purpose of Investigation

This study was made in partial fulfilment of the requirements for the Degree of Master of Science at the California Institute of Technology.

The field work was carried on in the months of June and July, 1939, following which this report was prepared.

Method of Investigation

The topographic map prepared by the United States Geological survey was enlarged two times, and used as a base map. The Brunton compass was used for determination of dips and strikes.

In the study of the subsurface structure, records prepared by the Schlumberger Corporation were studied. These are the electrical logs, resistivity against porosity, of the drilled wells.

Acknowledgments

The author wishes to acknowledge his indebtedness to Dr. John H. Maxson of the California Institute for his numerous useful suggestions and his supervision . Dr. Maxson also helped the study and interpretation of the Schlumberger electrical logs.

Dr. Smith of the Geological Department of the Texas Company at Los Angeles has been kind in lending the electrical logs of the new field to the southeast

for the preparation of this report.

The base map used in this report was prepared by Messers. C. A. Ecklund, T. H. Moncure, and C. W. H. Hessley of the United States Geological Survey.

Much help has been derived from the United States Geological Survey publication Bulletin 768, "Geology and Oil Resources of the Puente Hills Region, Southern California." by Mr. Walter A. English.

Also the summary of operations of the California Oil Fields (Vol. 5 - No. 11), issued by the California State Mining Bureau, was used in the study of the old upper zone (Pliocene) oil pool in this region.

GEOGRAPHY

Location

This report includes that portion of Montebello Hills which is located between latitudes 34 01' and 34 03.5' and longitudes 118 04' and 118 08.5'. They are in the Alhambra And El Monte quadrangles, Los-Angeles County.

These hills are some twelve miles southeast of the city of Pasadena and some five miles east of the c city of Los Angeles.

Size of the Area Studied

Field work was carried on in the Montebello Hills, covering a territory some 23,000 feet long and about 16,000 feet wide.

Relief and Elevation

The elevation of the highest points in this area is about 632 feet above sea level. The relief is rather low and does not exceed 450 feet.

Drainage

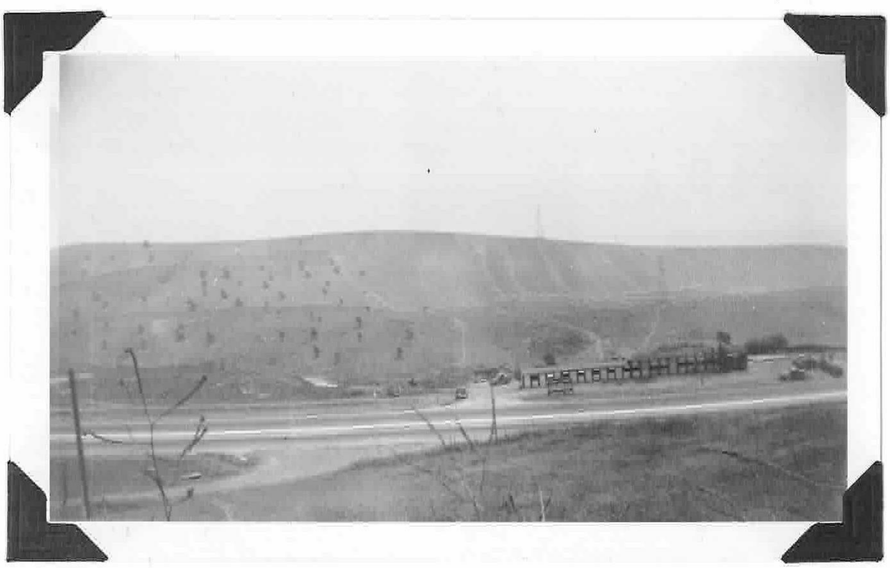
There is one large stream, the Rio Hondo, running from north to south and located on the east side of the hills. The drainage is south-ward and all the canyons eventually get together and form one larger stream.

On the north side the gullies seem to run north for a short distance after which they all go east-ward to unite and join the Rio Hondo.

Vegetation

There are two main types of vegetation cover- the hills which are roughly related to the type of the soil and the underlying rock.

On the conglomerate beds cactus plants have formed large cactus gardens, while the shaly area is covered with grass.



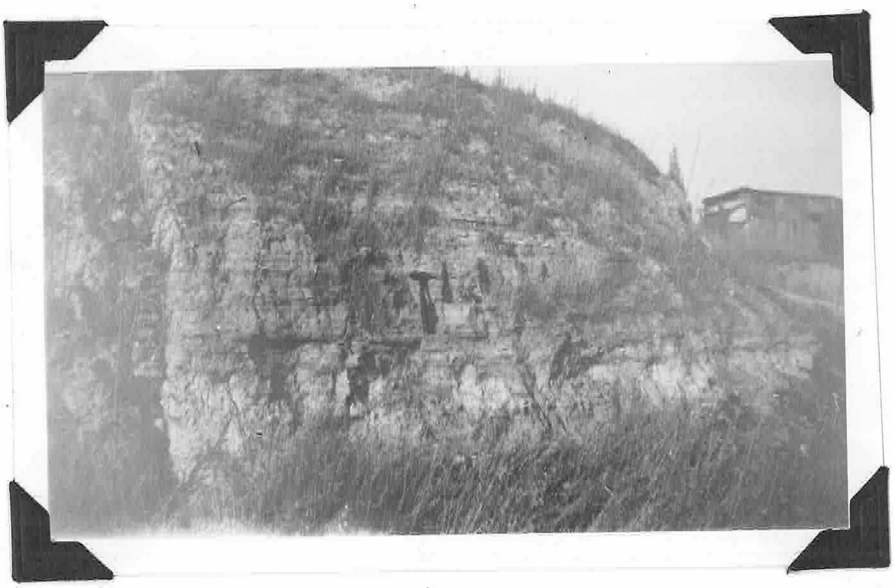
A general view of the north-westerly part of the area, showing the rounded hill tops and the area covered with grass. The terrace on the opposite side has been developed by the action of the stream during uplift of the hills.

Most of the northwest hills in the shaly area are used for raising oats,etc. On the lower lands and on the alluvium beds citrus groves and fruit trees are numerous.

Rock Exposures

The exposures here are extremely poor. A thick mantle of soil has covered almost all of the hills. Except some gullies and road cuts, there are no exposures available.

There are three quarries where rock is taken out for commercial uses. At these stations the cross bedding of the recent deposits is well shown.

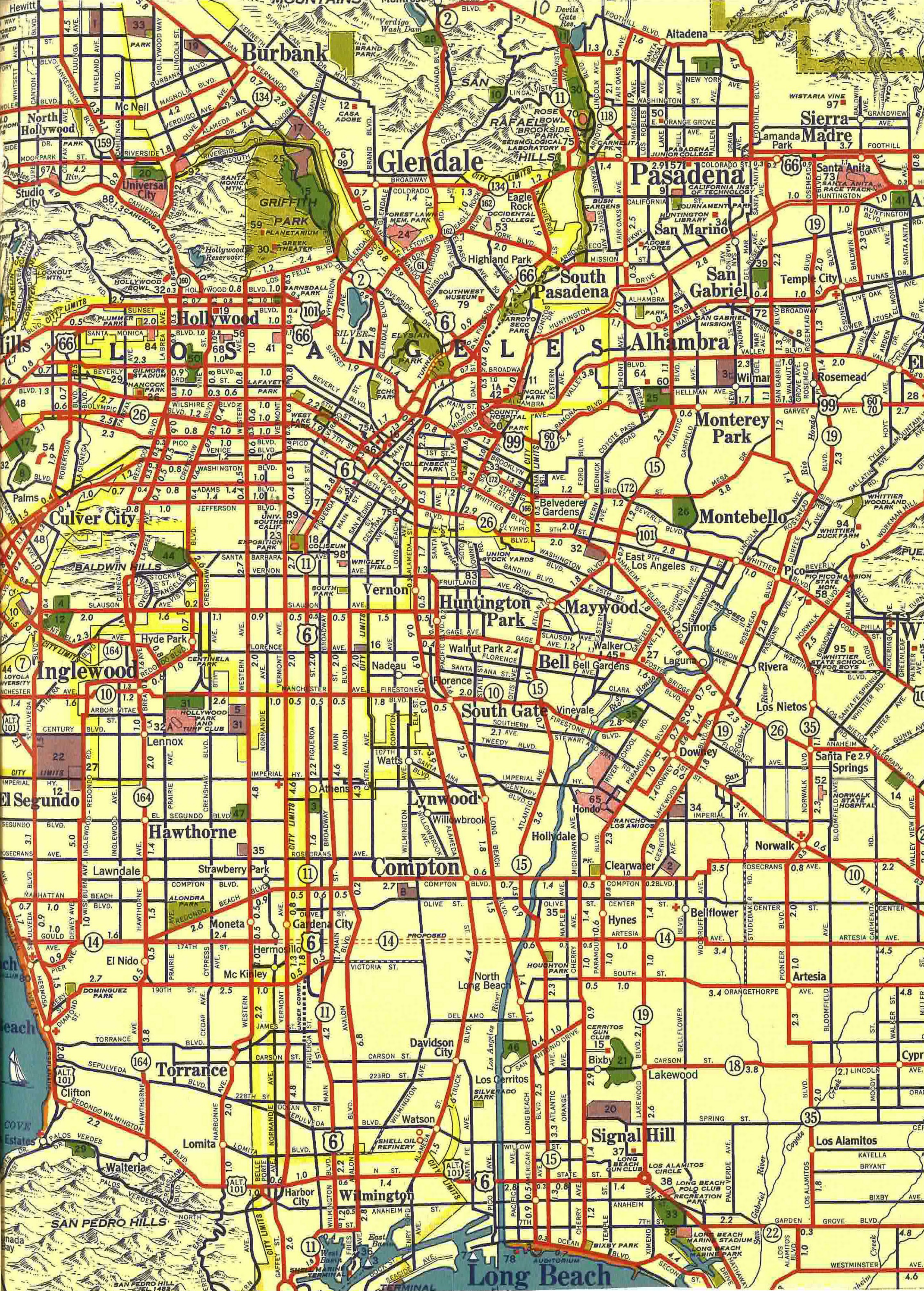


A view showing the thin strata of intermediate sandstone and silt beds, almost horizontal. Located at 11-C , and is of Lower Pico formation.

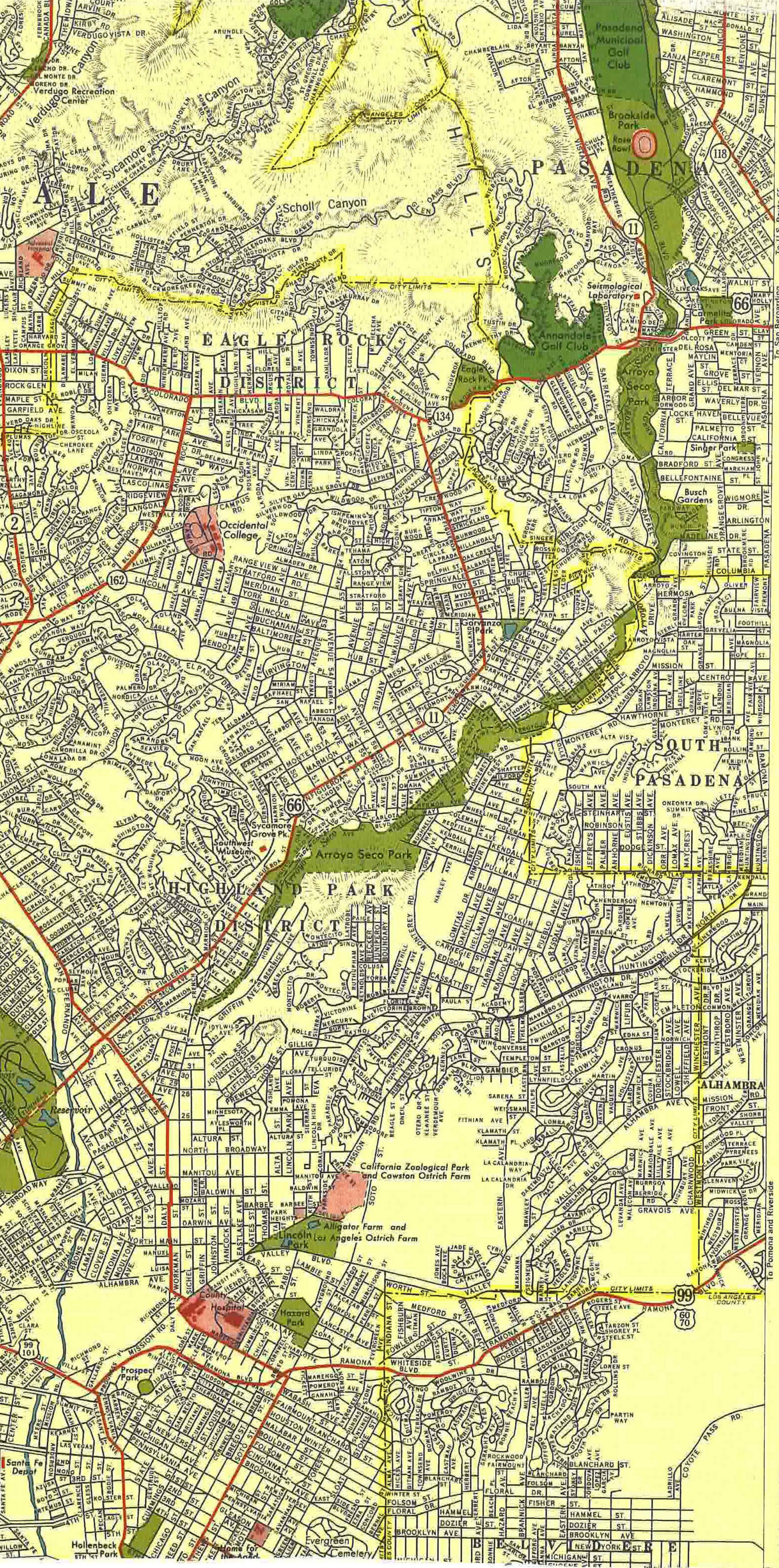
Culture

There are good roads surrounding the area on all four sides. On account of the presence of oil wells easy access can be had to almost any point by driving in the southern portion of the area. However, there are not many roads or paths in the north part, but it is not difficult to get to all points.

These hills are surrounded by towns whose outlying districts are in the foothills. Most of the lower lands and plains are used by the farmers for growing vegetables and fruit gardens.



Burbank
Glendale
Pasadena
Altadena
Sierra Madre
Lamanda Park
Santa Anita
North Hollywood
Studio City
Universal City
Griffith Park
Eagle Rock
Highland Park
San Marino
South Pasadena
San Gabriel
Temple City
Hollywood
LOS ANGELES
Alhambra
Rosemead
Wilmar
Monterey Park
Montebello
Culver City
Palms
Baldwin Hills
Belvedere Gardens
East Los Angeles
Pico
Vernon
Huntington Park
Maywood
Bell
Bell Gardens
Walnut Park
Hyde Park
Inglewood
Nadeau
Florence
South Gate
Rivera
Los Nietos
Downey
Santa Fe Springs
Lennox
Watts
El Segundo
Lynwood
Willowbrook
Hawthorne
Hollydale
Hondo
Norwalk
Lawndale
Strawberry Park
Compton
Clearwater
Bellflower
Moneta
Gardena City
Hynes
Hermosillo
El Nido
Mc Kinley
North Long Beach
Artesia
Torrance
Davidson City
Bixby
Lakewood
Clifton
Los Cerritos
Watson
Signal Hill
Los Alamitos
Lomita
Walteria
Harbor City
Wilmington
San Pedro Hills
Long Beach


PASADENA
SOUTH PASADENA
ALHAMBRA
EAGLE ROCK DISTRICT
HIGHLAND PARK DISTRICT
Pasadena Municipal Golf Club
Brookside Park
Rose Bowl
Seismological Laboratory
Annandale Golf Club
Eagle Rock Pk.
Arroyo Seco Park
Carmelita Park
Singer Park
Busch Gardens
Occidental College
Garvanza Park
Sycamore Grove Pk.
Southwest Museum
Verdugo Recreation Center
Scholl Canyon
California Zoological Park and Cawston Ostrich Farm
Alligator Farm and Los Angeles Ostrich Farm
Lincoln Park
Hazard Park
County Hospital
Hollenbeck Park
Santa Fe Depot
Reservoir
Evergreen Cemetery
CITY LIMITS
LOS ANGELES COUNTY
To U.S. Route 66
To San Bernardino
To Pomona and Riverside

However, not much use is made of the conglomerate areas.

There are a number of power lines and a booster station in the area, Also.

STRATIGRAPHY AND PETRAGRAPHY

There are no igneous or metamorphic rocks in the area surveyed. Various types of sedimintary rocks are present, The conglomerates grade into sandstone, silt, and shale.

Recent Alluvium and Terrace

This area is mostly covered by a thick mantle of soil, its thickness varying from a few inches up to three or even four feet on the side of less steep hills. It is dark gray to almost black in color, due to the presence of decayed organic materials in it. All such areas covered with this soil are used for raising oats, wheat, etc.

Alluvium has covered has covered most of the area and is specially noticeable at the mouth of the canyons and at the foot of the hills.

The alluvium has originated from the older conglomerate and shale beds. Much cross bedding and a brown to red color with very little or no sorting are its characteristics. The size of the pebbles does not exceed four inches and as a rule they are under two inches in diameter. The alluvium grades from coarse and sandy types at the foot of the hills to much finer and clayey deposits away from the hills and in the plains where the slope is not so great.

Beneath the soil and merging with it is this alluvium and valley fill which is the accumulated Quaternary outwash from the adjacent hills. Mr. English in his paper states, for this region that the valley fill merges with the San Pedro (?) formation, which in turn merges with the Fernando. And thus in the outlying oil fields it is difficult to determine from drill records the thickness of the several Post-Fernando formations.

Pleistocene Gravels

These flank the hills on all sides, lapping unconformably upon the Fernando formation, which is exposed in the center and the east end of the range.

The Pleistocene is characterized by low dips showing recent uplift. These gravels are brown in color and are mostly of — syenite —, highly weathered and almost perfectly rounded. The largest ones are about five inches in diameter while the majority of them is about three inches in diameter.

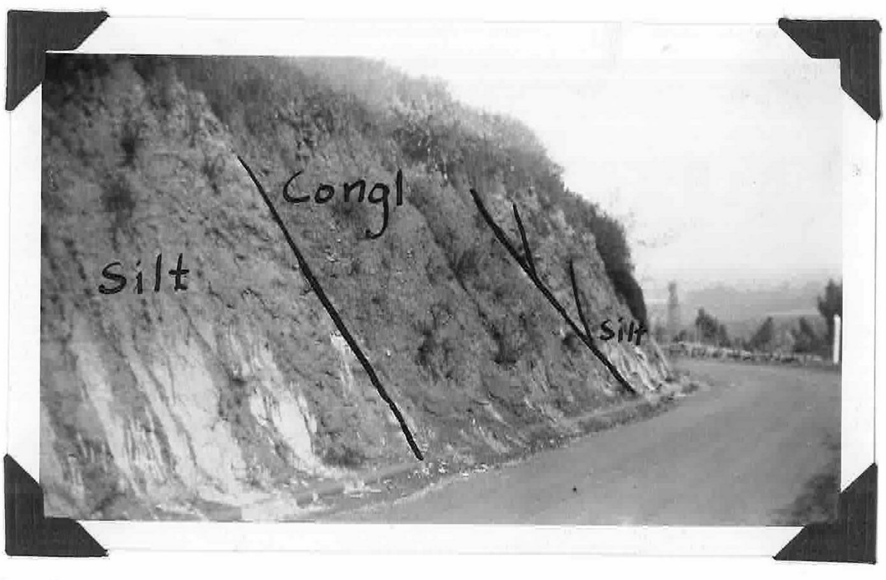
Fernando Formation

This is of Pliocene age. They are undifferentiated beds of gravel, sandstone, and silty shales. Eliminating the surface gravels, the wells in this field penetrate about 1500 feet of shales and sandy shales, showing greyish brown in outcrop and logged by drillers as blue shale. Beneath this series are strata of hard conglomerates or gravel from 50 to 200 feet in thickness. Beneath this bed of conglomerate lie strata of brown shale or sandy shale with occasional beds of sandstone. This formation is approximately 200 feet thick and forms the cap beneath which lie the oil formations. The productive formations consist of sands separated by several hundred feet of brown shale or sandy shale similar in character to the shales immediately below the conglomerate.

This formation, the Fernando group, is laid unconformably above the Puente and is named by Eldridge from San Fernando Valley, northwest of Los Angeles, where the group is well developed. It is taken to be of Pliocene age because it carries a distinctive fauna of marine shells of that age.

Its lithological difference from the immediate underlying formation, the Puente, is in the general absence of siliceous shales, a greater abundance of conglomerates, and slightly less in-duration. Despite these general differences, there are several localities where it is difficult to decide whether the beds belong to one formation or the other.

The base of this Fernando group is marked by an abrupt change from fine-grained sandstone to a coarse conglomerate.



This is a good example of the unconformities which are present in these formations. Note how the silt beds, with much shale in them, change to conglomerate. Above this conglomerate bed is another strata of silt and that again grades into conglomerate. This shows a typical shore sediments which is characteristic of these sediments in this area.

From the basal beds of the Fernando to the edge of the hills there is a succession of lenticular conglomerates separating beds of sandstone, shaly sandstone, and sandy clay shale, of which the clay shale is the most abundant. Thus it is evident that on account of the lenticularity character of these beds their thickness is much subject to change in different localities. In this work only two types of beds are recognized: first, the conglomerate, including sandstone beds; and next, the shale beds, including the silty shale beds.

The following figures show the approximate thickness of the beds of shale and conglomerate, shown on the map. These are directly measured from the field map and are correct within plus or minus ten percent: shale (including light-grey siltstone which weathers yellow; several six to eight inch calcareous layers; fine grey siltstone, which weathers to impure clay soil.)

4.5 x 1000 = 4500 feet

$\frac{x}{a} = \cos 30°$; $x = a \cos 30°$

$\cos 30° = .86603$; $a = 4500$

Thus $x = 4500 \times .86603$

$x = 3900$ feet

0.75 x 1000 = 750'

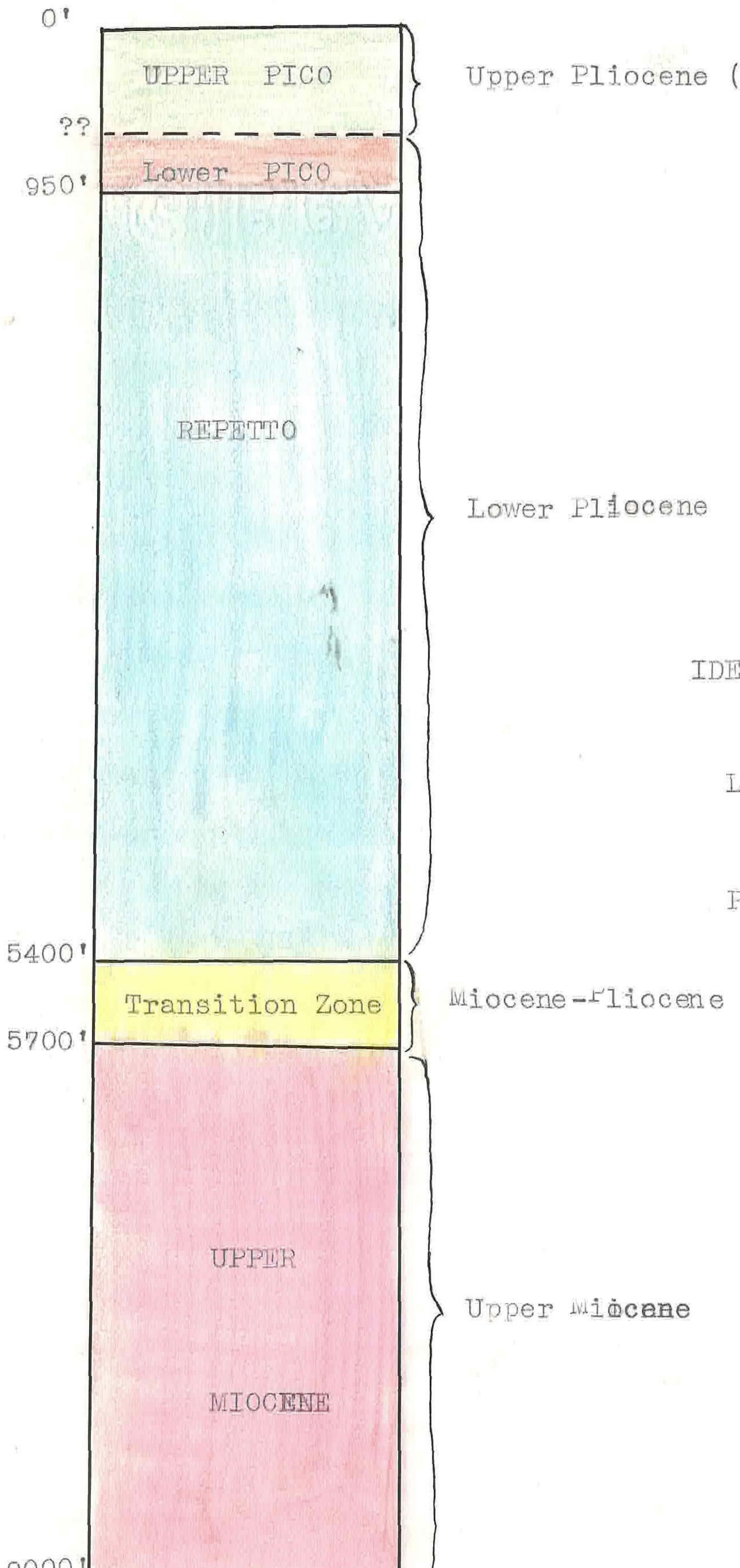
$\frac{y}{b} = \cos 30°$; $y = b \times \cos 30$

$y = 750 \times .86603$ or $y = 649$

or about 650 feet.

and the total thickness is: 3900 + 650 = 4550'

conglomerate (including sandstone, buff to red conglomerate with many boulders of syenite, yellow conglomerate, massive nearly white sandstone, buff coarse and firm sandstone and conglomerate.) There is no way to measure directly these beds off the map, but from the study of the map it is evident that they should exceed some 1500 feet.



IDEAL GRAPHIC COLUMN OF THE

MONTEBELLO FIELD

Los Angeles Co. California

Courtesy of the TEXAS Co.

Prepared by R.Y.Karubian
August 1939.

A general statement might be made that the shale beds and the silt beds are on both top and bottom bordered by conglomerate beds. In the shale beds on the northwest corner concretion beds are seen. Some concretions are as much as two to three feet in diameter.

"The lithologic character of this Fernando suggests that it was deposited near shore," wrote Mr. English. "Rather definite proof of this conclusion is presented by a collection of marine shells from the vicinity of San Gorgonio Pass, some 40 miles east of the Puente Hills. These shells are of approximately the same age as those found in the Fernando, though they are all Gulf of California species and entirely different from those of the same age found on the Pacific Coast. This difference indicates that a land barrier existed between the SanGorgonio Pass region and the area of deposition of the Fernando. This barrier probably occupied most of the area between the Chino-Elsinore fault and the San Jacinto fault. The lack of terraces of Fernando beds within this area and the physiographic history of the area confirm the conclusion based on Paleontology that this was a land area during Fernando time."

For the study and character of the fossils of the area the writer suggests the paper by W. A. English, The Fernando Group near New Hall, California, University of California Bulletin dept-partment of Geology, Vol. 8, pp. 203 - 218, 1914; and the paper by Mr. Eldridge on fossils of Brea and Olinda Canyons.

Fernando used to be considered the most important geologic formation in this area, but now the Puente formation is considered most important. Most of the oil is produced from these Puente sands and some from sands in the upper part of the Puente formation. The oilbearing sands are of both fine sandstone and conglomerate. However, the oil is usually found in the coarser beds in the lower thousand feet of Fernando according to the information gathered from the printed literature.

PUENTE FORMATION (MIDDLE AND UPPER MIOCENE)°

General Character

This formation is similar in age and lithology to the Modelo formation of Los Angeles and Ventura Counties and is of the same age as the Salinas shale and Maricopa shale in the central part of the State. The formation outcrops all over the Puente Hills north of the Whittier fault and in a belt along Burruel Ridge south of Santa Ana River. The formation is subject to muchslumping and surface creep. The formation consists of alternating coarse and fine grained beds. The sandstone members locally contain conglomerate in such a way as to suggest deposition at the mouth of a river, the boulders being dropped at the mouth while the sand was carried farther out. The shales consist of fine quartz grains, siliceous mud, and clay, with which is mixed more or less diatomaceous material. The hardness of the shale varies between wide limits. Davis, who studied the Franciscan cherts, believes the variation in hardness to be due in the main to the relative amounts of colloidal silica deposited as an original constituent of the bed. Analyses show that less clay was present in the sediment thatformed chert than in the one which formed a softer variety of shale. The so called "diatomaceous shales" may carry up to 10% of material of organic origin. Some observers believe some of the shales to be of predominantly organic origin. Howevery, the character and thickness of the shales prove them to be not at all similar to the diatomaceous oozes now accumulating deep in the ocean, and the perfect preservation of a few diatom remains and organic skeletons makes impossible the assumption that the shale is made up of crushed and unrecognisable organic remains. The author believes the shales to be the result of direct chemical precipitation from silica-rich marine waters. The entire formation is divisible in general into a lower shale, a middles sandstone, and an upper mixed shale and sandstone zone.

Lower Shale

The shale is apparently unconformable on the Topanga formation, and since it consecutively rests on different phases of the Topanga, the formation was evidently encroaching on a previous land area. The shale is noticeably white. The main lithologic type is a fine elastic shale, grading into a fine siltstone and with some interbeded sand stone. Southwest of Pomona this member is lacking. The thickness varies from 0' to 4000'.

Middle Sandstone

This member is predominantly a yellow sandstone. There is a conspicuous concretionary bed and an oil seep bed in this member, which run across the entire region. In some places granite boulders 10' in diameter have weathered out of the pure, fine, sandstone. The thickness of the member is not known, although it may reach 4000'. Where it reaches the latter thickness, however, there may be repetition due to faulting.

Upper Member

This member is a mixture of shale, sandstone, and conglomerate which can not be correlated in different parts of the area. Some of this member may belong to the overlying Fernando formation, but in the absence of an unconformity, the author puts the doubtful beds with the Puente formation. Outcrops are poor, and the structure is not worked out between outcrops. In some places the overlying Fernando formation is clearly unconformable, while in other places the relationship is not evident.

Age

Since no diagnostic fossils are found, the age is given as middle and upper Miocene on the basis of lithology and stratigraphic position.

Oil

There are some oil seeps and a few tar seeps in the middle member throughout the region.

° English, Walter; Geology and Oil Resources of the Puente Hills Region, Southern California; USGS Bull 768; 1926. Parts abstracted from this paper are within pp. 26-39.

FERNANDO GROUP UNDIFFERENTIATED*

Unconformably above the Puente is the Fernando group, named by Eldridge from the San Fernando Valley, NW of Los Angeles, where the group is well developed. It carries a distinctive fauna of marine shells of Pliocene age. It differs from the Puente in the general absence of siliceous shales, a greater abundance of conglomerates, and slightly less induration. The chief outcrop areas are in a strip directly south of the Whittier fault, between Whittier and Yorba Linda, in the vicinity of the Santa Ana Canyon oil field, in the Coyote Hills at Burruel Point, and on the north side of the Whittier Hills.

At the west end of the Whittier Hills there is a well exposed section of the Fernando. An abrupt change from the fine-grained sandstone to a coarse conglomerate marks the base of the Fernando group. The section consists of alternating conglomerates and sandstones with some siltstones and clays. It shows a general prevalence of fine-grained material in the upper part of the section and of glomerate and sandstone in the lower part and also at the top. This section is about 5000 feet thick.

Just east of Whittier there is about 6000 feet of Fernando, a yellow sandstone being considered the base of the group.

Along the outer edge of the hills between Whittier and La Habra Canyon there are some beds of pink to red gravel that dip toward the valley at a slightly smaller angle than the underlying part of the Fernando. They may belong to the San Pedro Formation, but in the absence of definite evidence of unconformity they have been included with the Fernando.

On the ridge between Brea and Olinda Canyons possibly 90% of the Fernando is fine-grained impure sandy clay shale or siltstone with interbedded fine sandstone. The rest is conglomerate. East of Olinda the beds dip at steep angles, and a nearly full section of 5000-6000 feet of Fernando is exposed. The beds are somewhat coarse grained and conglomerates are more prominent than to the west of Olinda.

In the vicinity of the Santa Ana Canyon oil field the lower 1000 feet of the Fernando includes massive beds of white sandstone that are not seen in other parts of the Puente Hills. Above this zone there is softer sandy shale similar to that found above the basal coarse zone elsewhere.

In the West Coyote Hills only the outcrops at the west end of the hills certainly belong to the Fernando. At that point soft gray and yellow fine sand and sandy shale are interbedded with minor amounts of conglomerate. The rest of the west Coyote Hills is covered with gently dipping beds of yellow gravel which probably belongs to the San Pedro formation.

In the Burruel Point region the Fernando is well exposed and its unconformable relation to the underlying Puente is well shown. Very little coarse material is here present in the Fernando; it consists of soft sandy shale and siltstone, gray when fresh and yellow after weathering.

The lithologic character of the Fernando suggests that it was deposited near shore. In the vicinity of San Gorgonio Pass marine shells of approximately the same age but all of which were Gulf of California species and entirely different from those of the same age found in the Pacific Coast. This difference is taken as indicative of a land barrier existing at that time between the San Gorgonio Pass region and the area of deposition of the Fernando. This barrier probably occupied most of the area between the Chino-Elsinore fault and the San Jacinto fault.

The fauna in general seems to indicate an age of the beds less that that of the basal part of the Fernando in NW Los Angeles County studied by the writer and greater than that of the beds in the vicinity of the city of Los Angeles studied by Moody. On this basis and in accordance with the correlations made for the above mentioned faunas with the standard time scale, the fauna of the Fernando in the Puente Hills should be considered Middle Pliocene.

The Fernando of the district in question is the most important terrane in relation oil production, as most of the production sands are within it. The oil sands include both fine grained sandstone and also conglomerate. The oil is usually found in the lower 1000 feet of the Fernando.

*English, Walter; <u>Geology and Oil Resources of the Puente Hills Region, Southern California</u>; USGS Bull 768; 1926

Part abstracted: pp. 39-44

GEOLOGY OF CALIFORNIA*

Arrangement of Pliocene Formations and Faunas in So. Calif.

Group	Formation	Faunal zones: Foraminifera	Mollusca
Fernando	Pico	Cibicides lobatus (D'Orbigny)	Pecten caurinus (Gould)
		Uvigerina n. sp.	Pecten hemphilli (Dall
		Cibicides mckannai Galloway and Wissler	
		Uvigerina peregrina Cushman	
		Bulimina subacuminata Cushman and Stewart	Trophoseyon nodiferum (Gabb)
	Repetto	Plectofrondicularia californica Cushman and Stewart	Argobuccinum, n. sp.
		Arenaceous forms	

Southern California Pliocene Formations

Kew	Eaton	Compromise	
Pico	Pico	(Restricted Pico) 6,200	Pico group
	Santa Paula	Santa Paula 7,500	
		(Repetto) 1,750	

*By Ralph Reed

GEOLOGIC STRUCTURE

This oil productive area, known as the Montebello field, occupies the crest and flanks of an anticline in the La Merced Hills, which lie about one mile north of the town of Montebello and about five miles east of Los Angeles.

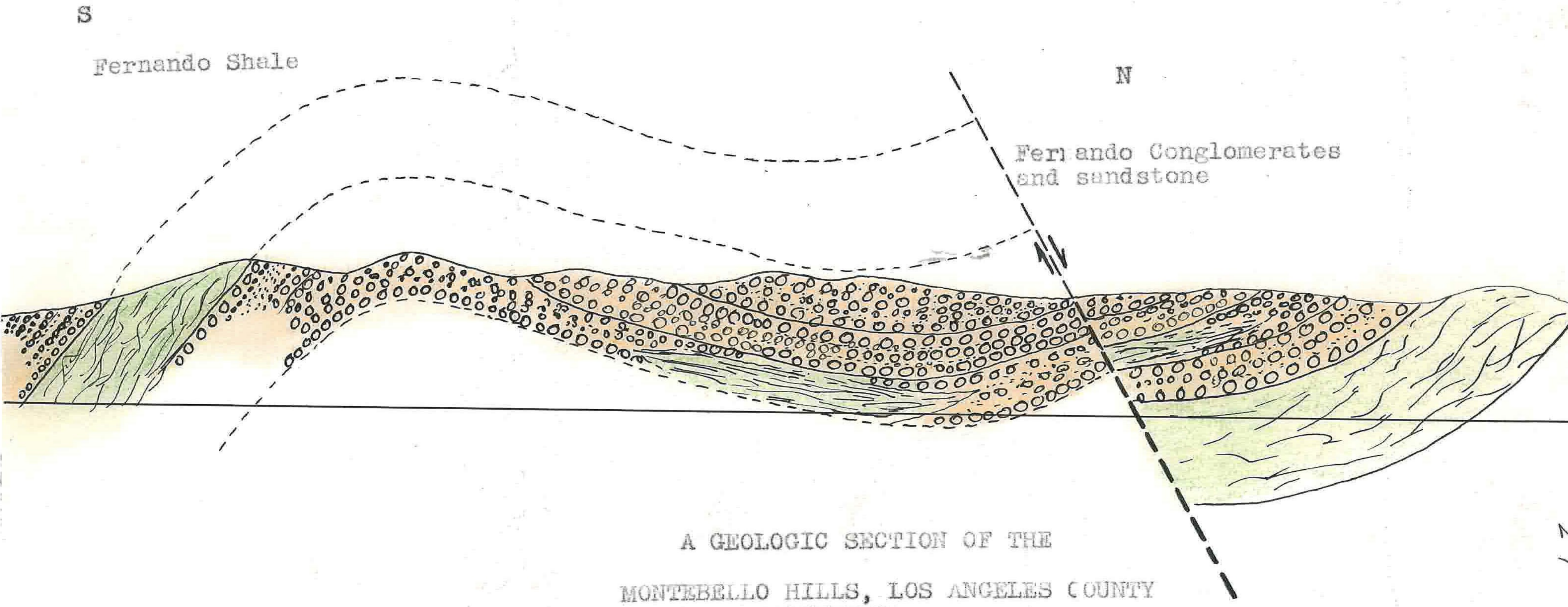
From a study of the field map of this area one can easily detect a major syncline and anticline running almost east and west, the anticline being situated on the south side of the syncline.

Topographically the La Merced Hills form a spur at the eastern extremity of the Repotto Hills, which extend westward to Los Angeles and disappear eastward under the Rio Hondo and San Gabriel rivers.

The axis of the anticline follows in a general way the east and west trend of the hills, which terminate in rather an abrupt slope at the east end and slope more gently toward the west where they merge with the valley floor.

Since the deposition of the Pleistocene, minor faulting has occurred on the south side and east end of the hills, giving dips of 50 to 60 degrees in Fernando shales, which are faulted against shallow dipping Pleistocene sand and gravels. This feature was at first thought to limit the productivity of the anticline on the south side, but subsequent developments indicate that the surface faulting does not extend to the oil measures, which show uniform and gradual dips on both north and south flanks.

These surface faults are detected in this area only by the disarranged dips and strikes. There is no other means, such as slickensides or displacement of strata, available to detect them.



A GEOLOGIC SECTION OF THE

MONTEBELLO HILLS, LOS ANGELES COUNTY
CALIFORNIA.

Prepared by R. Y. Karubian, August 1939.

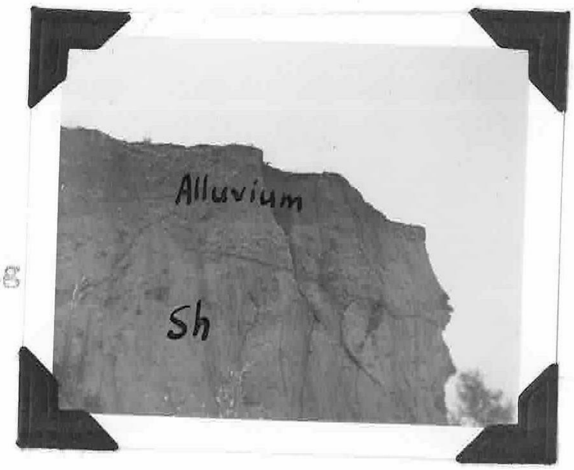
California Institute of Technology
PASADENA, California.
Vertical Scale(Exagerated) 1 inch = 500 feet.
Horizontal Scale 1 inch = 1000 feet.

Beside the two major folds there are several small local folds that might be noticed by the dips and strikes. From the study of these dips and strikes on the field map we note that there is a small fold running almost north and south at about L-M and 5.

There are three small folds, forming two small anticlines, and a small syncline in between them almost in the middle of the map, at H-J and 9-11.

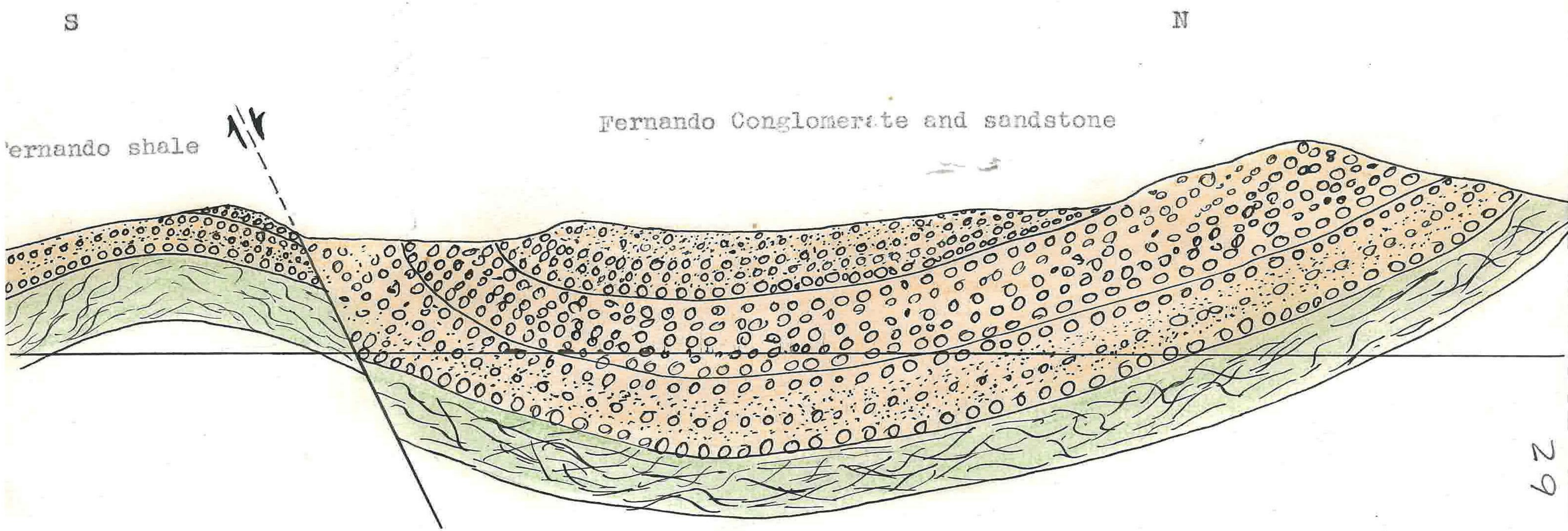
At those points many dips and strikes were taken. There is also good evidences of the presence of these folds in the south side of the wash. At this point a number of layers grading from conglomerate to silt and eventually to shale are exposed.

This shows another unconformity between the shale beds and the recent alluvium in one of the shale quarries in this area. The conglomerate or the sandstone beds are missing, and this thus shows a missing member of the group.



Also at B-D and 11-12 there are two folds running almost east and west. Their presence was also detected by the dips and strikes obtained in the field.

At K-8 and 7.9 in the conglomerate beds a number of slabs of conglomerate were noticed all having a north dip of about 60 and a strike of almost N 75° E. After following this point towards the west another place was noticed showing definite signs of fault-



A GEOLOGIC SECTION OF THE

MONTEBELLO HILLS, LOS ANGELES COUNTY, CALIFORNIA.

Prepared by R. Y. Karubian, August 1939.

CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIFORNIA

Scale: Vertical (exagerated twice) 1"=500'

Horizontal 1"= 1000'

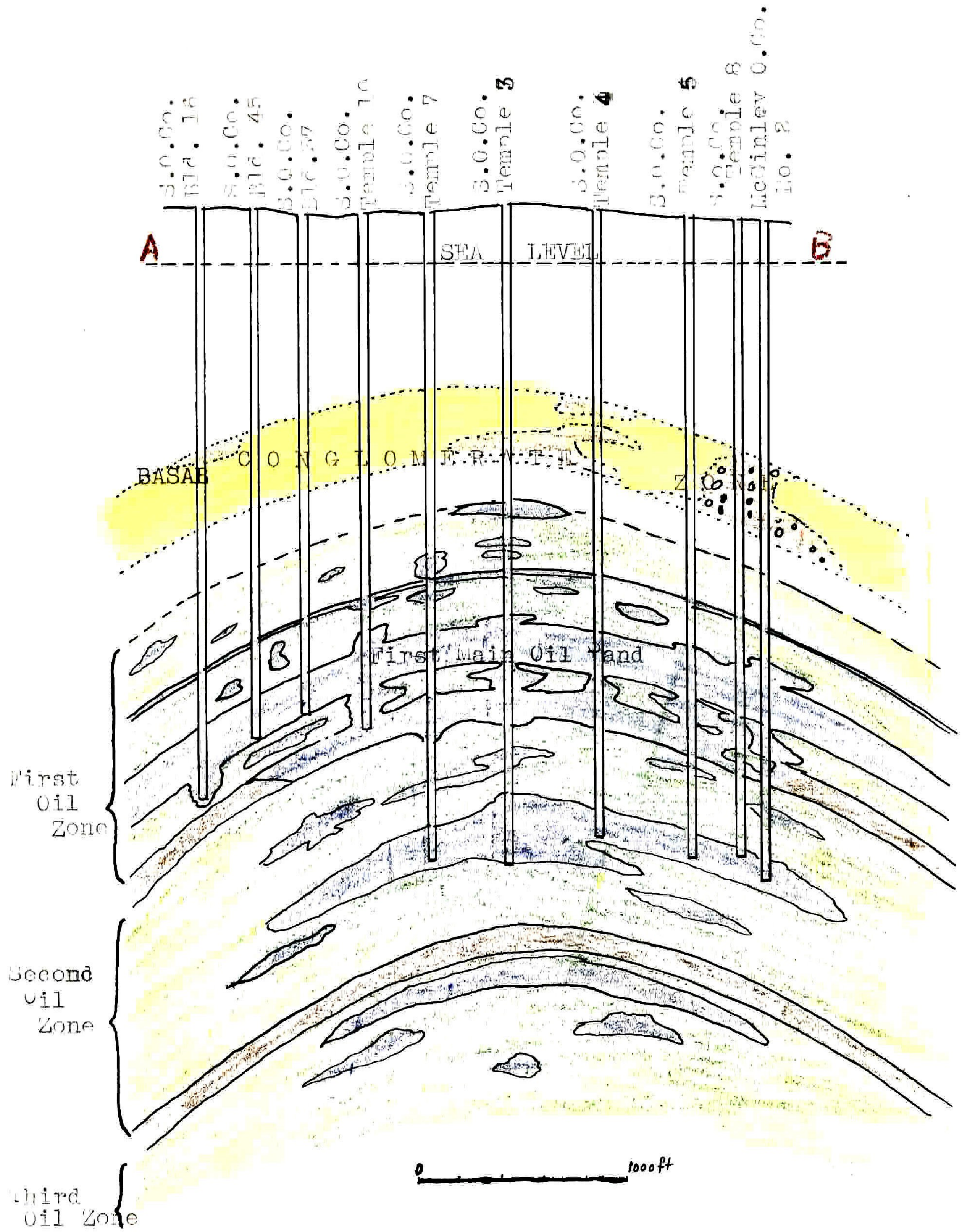
ing. At L.5 and 6.7 on the road cut there is a thin layer of shale about two or three feet thick and almost horizontal next to a dipping bed of conglomerate. Following this further west

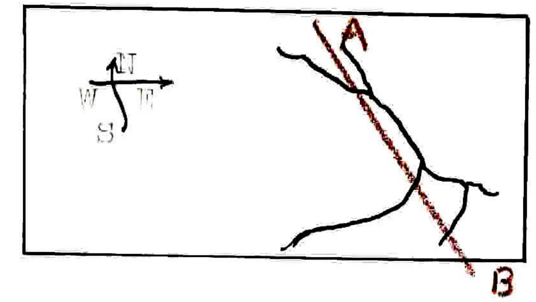
A typical view of the conglomeratic area.

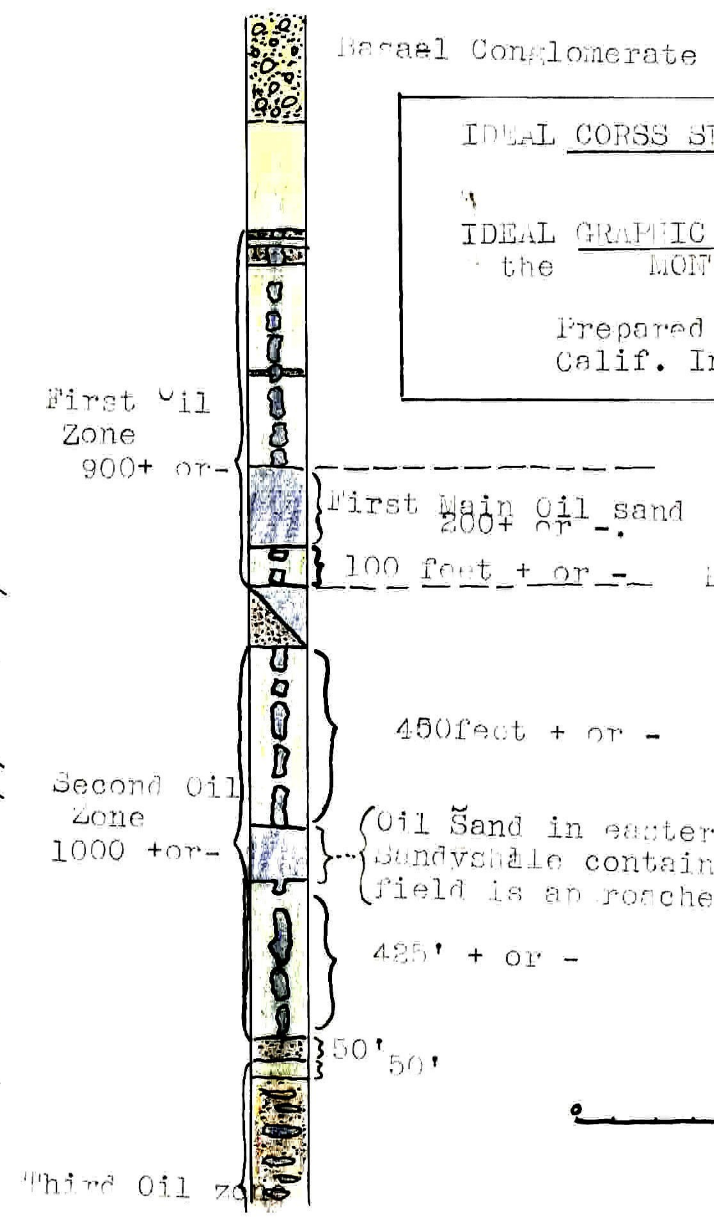
a zone of weakness is recognized to be present in between the two hill tops. Presence of slickensides in the conglomerate beds also confirms the presence of a fault zone. From the study of the sections prepared in this report the presence of this fault is confirmed, otherwise there is hardly any other explanation for the structures as they appear on the map.

However, the exact path of this fault towards the east after line 8-8 and west after line 5-5 is not known. By the use of geophysical surveying one might be able to locate it more exactly.

There is no direct way to measure the amount or the direction of displacement caused by this fault, except it is well evident (Note the sections prepared) that the north side has gone down and the south side up. This fault is post-folding--see sections. There are a number of other small folds and drag folds especially in the shale beds that are not of any importance and thus are neglected here.







IDEAL CORSS SECTION Transverse to the axis of MONTEBELLO ANTICLINE
&
IDEAL GRAPHIC LOG showing GEOLOGICAL FORMATION the MONTEBELLO FIELD, California

Prepared by R.Y.KARUBIAN. August 1939.
Calif. Institute of Tech., Pasadena, Cal.

Copied from the Summary of operations of the California Oil Fields (Vol. 5 No. 11).

Subsurface structure

A very interesting problem and at the same time of much economic importance is the subsurface structure of this area. From the study of the Schlumberger records available and their comparison with the field data and core logs the following subsurface structures are suggested:

After the deposition of Miocene sediments some folding occured and at least two major anticlines were formed (The new south-east and south-west fields.)

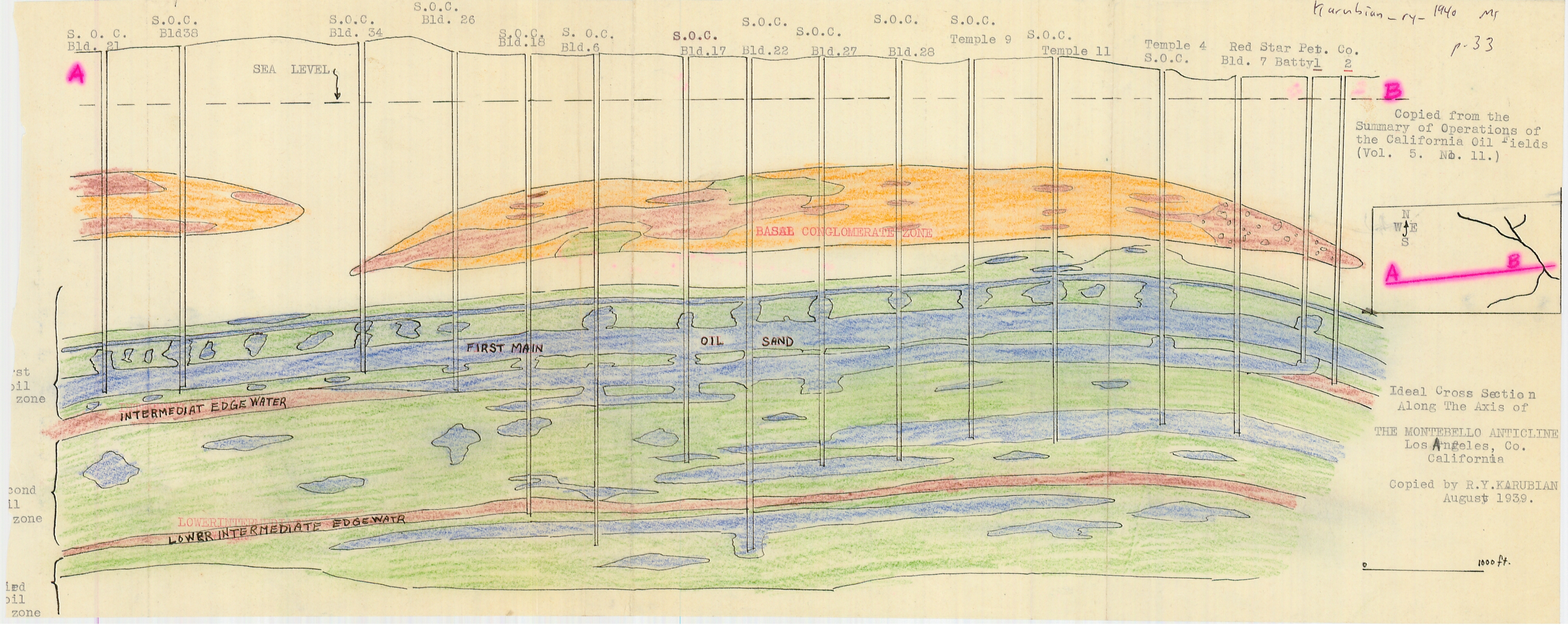
Some time after this folding -post Miocene and pre-Pliocene- a fault was produced and it cut the axis of the anticline of the new field on the southeast side of the old field. Then erosion, and deposition evidently caused an unconformity here between the Miocene and what followed it later (that is the Lower Pliocene). Deposition was carried on and beds of shale, silt, sandstone, and conglomerates were interchangeably deposited . This deposition of sediments is not by all means conformable within itself but due to raise and fall of the shore line many unconformities were produced.

It is noted that no other important structural deformations were brought about until the Saugus beds were laid, after which time a second series of foldings took place and the upper anticline was developed. This then was followed by the fault discovered by Schlumberger methods.

The recency of last folding is well shown by the tilting of the Saugus formations.

Karubian_ry-1940 ms

p-33



Copied from the Summary of Operations of the California Oil Fields (Vol. 5. No. 11.)

Ideal Cross Section Along The Axis of

THE MONTEBELLO ANTICLINE
Los Angeles, Co.
California

Copied by R.Y.KARUBIAN
August 1939.

Thus one going down from the most recent deposits will pass thru Pleistocene and upper Pliocene (Upper Pico). This is unconformable on top of the lower Pico or the uppermost portion of Lower Pliocene. These two beds form a thickness of about 950 feet. Then follows the Repetto (or the lowest portion of Lower Pliocene) and next is the Transition zone between upper Miocene and Lower Pliocene which is some 300 feet thick. Then on the Miocene beds are encountered.

Thus it is easy to see why the structure contours of the new and the old fields do not agree. The new oil producing horizons in the fields southeast and southwest of the old field are producing from the upper Miocene. The upshot of it is that there must have been important folding following the deposition ofthe Miocene beds which was followed by erosion, and development of the unconformity above which the Pliocene beds were deposited. It is also observed that the axis of the new field (the older folds) is located to the south of the Montebello anticline.

From the above discussion the interesting and import conclusion is drawn that in this locality different epochs of deformation have produced reserviors which are only slightly separated from one another.

<u>Unconformities</u>

By far the most important unconformity of them all is the one between the Miocene and the Lower Pliocene beds. But this is totally covered up and there is no surface evidence of it.

There are numerous unconformities in this area. However, the best one exposed is the one separating the conglomerate beds from the underlying shale. This is well noticed at the road cut at F.8 and 5.4, also at N.1 and 12.8 by the road cut. On account of lensing out of many of the sandstone and conglomerate beds numerous other unconformities are present.

Miscellaneous Structural Features

On the very east side of the hills on account of numerous small and local faults in the upper sedimentary beds a number of dips and strikes running in all directions are present.

At points 9.5 and I.9 the Fernando conglomerate beds are unconformably in contact with the recent unconsolidated conglomerate.

This picture is taken at F.8 and 5.3. on the map. This shows the conglomerate beds grading into silt with large concretions. Also it shows a local unconformity. Note the small anticline.

PHYSIOGRAPHY AND GEOMORPHOLOGY

In this section the land forms of this area will be considered and surface features discussed. There is no direct evidence of the character of the land area from which these sediments were derived, except that portion which might have been preserved in the present land forms, and that is insufficient for any positive suggestion. We quote Mr. English,

"The physiographic history of Southern California of which there is good record dates from a time near the end of the Fernando epoch. During Fernando time an extensive surface of low relief was developed over nearly all of the southern part of the state."

A general view showing the rolling, and rounded hill tops of this area.

"The physiographic development of the coastal plain is of great economic interest, as it affords the only direct evidence available for predicting the possible position of domes other than those already known... The coastal plain includes two divisions: one, which will be called the La Habra terrace...the other division, to the south of this line, is a low slope toward the coast occupied by alluvial fans of the Santa Ana and San Gabriel Rivers. Coyote Creek follows the trough between the fans of these two rivers."

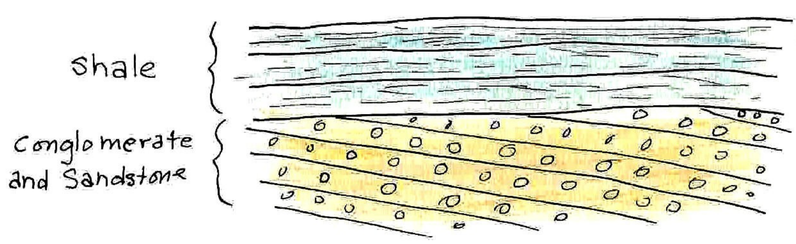
"Where the La Habra terrace joins the hills it has an altitude of 400 to 500 feet. The lower side of the terrace is only 100 feet above sea level close to Mirada, but it becomes higher toward the east. Several groups of low hills occupy the central and southern parts of the terrace for most of its length. Of these the most prominent are the East Coyote and West Coyote hills. The former reach an altitude of 561 feet, and the latter of 610 feet, both being from 150 to 200 feet above the level of adjacent parts of the terrace. During the formation of the La Habra terraces these hills acted as dams and caused the streams flowing southward from the Puente Hills to build up an alluvial apron on La Habra Valley. As the alluvial slope was built up it extended tongues between gaps in the hills and may even have buried some hills completely. Recently the La Habra terrace has been dissected by the principal streams to a maximum depth of about 100 feet. This erosion was probably caused by a climatic change to greater humidity, as evidence of similar recent cutting is found all over southern and central California. The most prominent of the streams that cut La Habra terrace are La Brea and Coyote creeks, along both of which good exposures of the La Habra terrace deposits may be found."

"The position of the East and West Coyote hills was determined by geologic structure. In each group there is an eastward-trending anticlinal axis passing almost exactly through the highest point. The Fernando beds, which are present at the surface over most of the hills, dip at considerably steeper angles than the present surface slope. In the West Coyote Hills the San Pedro (?) formation arches over the crest of the hills in almost exact conformity with their present form, if the recent gullies are disregarded. Evidently these hills owe their height largely to uplift after San Pedro time. Their present form, however, departs considerably from that of the dome produced by this uplift. Most of the erosion that affected the hills probably took place very soon after the uplift and before the formation of the La Habra terrace was very far advanced, for the La Habra epoch must have been one of deposition rather than of erosion. The East Coyote Hills, particularly, were modified in form. Almost the whole of the eastern dome of these hills was cut down below the level of the present terrace, and of the western dome only the southeastern part remains. In the West Coyote Hills the north side was considerably cut away, and Coyote Creek evidently followed its present course prior to the Post-San Pedro uplift, as it cuts off a small hill to the west of the main range of hills."

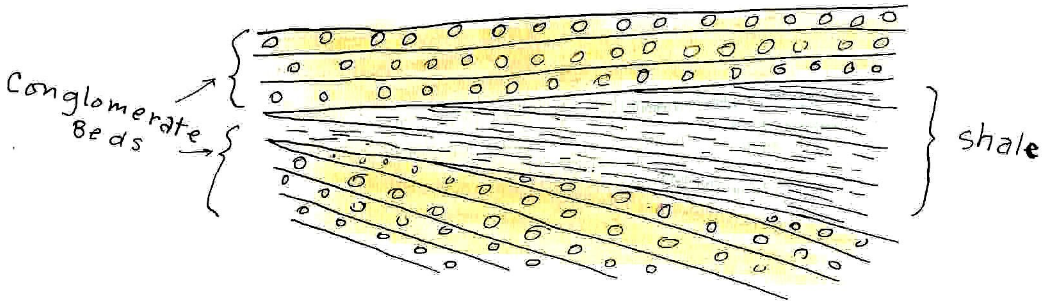
Geomorphologically this area, being mostly of recent age and sedimentary in character, can not be much discussed. However, it is clear that after the Perris peneplain there was a deposition and following this deposition of sediments a syncline and an anticline were formed. Thus the area was given a new start for erosion and wearing off the higher points. At the present time, the rounded hill tops, the wide U-shaped valleys and the well developed drainage system of the area suggests maturity to old age for this area.

GEOLOGIC HISTORY

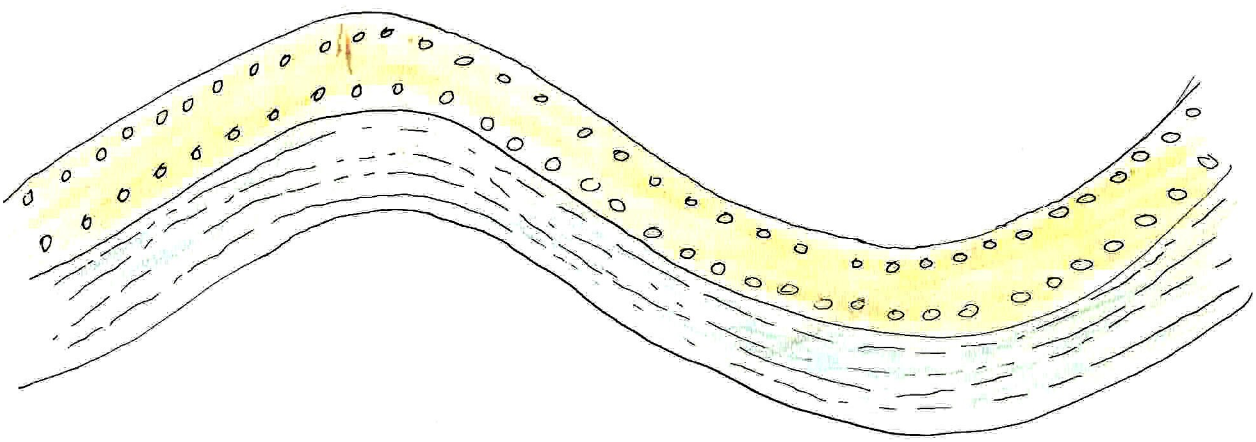
On top of the Puente formation, middle to upper Miocene in age, was laid unconformably on the siltstone, sandstone, and conglomerate beds of the Fernando group. These beds are very inconsistent and seem to lense out in different directions. However, from the survey of this area, it is evident that on top of the Puente layers thin beds of the Fernando group were laid. Before the formation got a chance to get thicker the area was tilted one way or the other and the shore line was shifted around and consequently the type of the sediments were changed from fine to coarse or vice-versa. And as a result a number of unconformities were produced. The siltstone grading into shale of the Fernando group was laid on top of the Puente conglomerate.



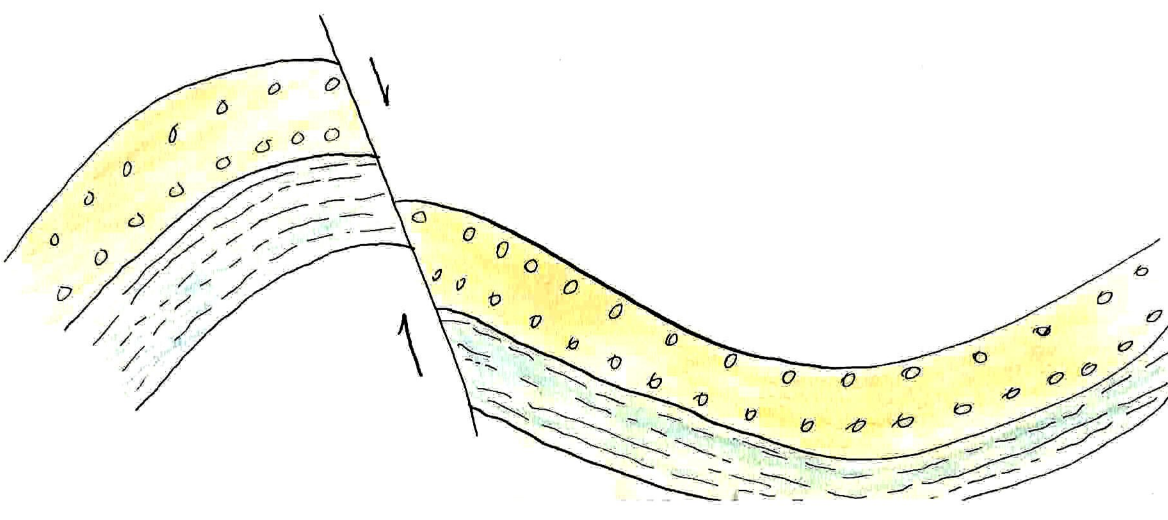
Then this shale was covered by conglomerate and sandstone, this contact being unconformable.



At this time due to some external forces the layers were under a compressive force and they yielded by forming an anticline and syncline.



After this anticline and syncline were formed, due to some other or probably the same forces, the area yielded by breaking and thus forming a fault with an almost east and west direction.



After the fault the northern block was dropped down and the southern block was pushed up, thus forming the present form for this area as seen in the prepared sections in this report.

ECONOMIC CONSIDERATIONS

This area is of great economic importance. It has been producing for over twenty years and is expected to do so for many years to come.

The anticline described above has been the first productive field brought in in this region. It is well surveyed for the oil companies by geophysical means and rather a good record of electrical logs and cores is kept for most of the wells by them.

There are a number of producing horizons in this area. The uppermost, being in the most recent sediments, was the oldest productive field of this region. In the recent years, however, other new fields are being located in the deeper horizons.

According to the sections prepared by the different oil companies' search, it is evident that there are three fields definitely separate from one another. The first is the old field on the uppermost zone. The second field is the new one located on the eastern side of the area and just south of the nose of the hills. And the third field is out of this area and just on the south and west corner of these hills.

The farthest down they have drilled (about 9000 feet) at present, is in the upper Miocene beds which are from 5700 feet on down. The logical places to drill for oil would be on any one of the three fields mentioned.

By the use of Schlumberger logging it is shown that there is a fault under the upper sediments running almost N 30 W and dipping east. This fault on the -5000 feet contour will be running some 4500 feet east of the most eastern corner of these hills. Thus on drilling for oil in this eastern field one should locate the exact path of this fault and avoid that path as long as possible.

There are a number of sand and shale quarries that seem to be of economical importance. There are many more points that might be quarried in case of demand.

BIBLIOGRAPHY

Moody, C. L. , Fuana of the Fernando of Los Angeles. U. C. Pubs., Bull. Dept. of Geol., vol. 10, No. 4, pp. 59 - 62.

Eldridge, G. H., and Arnold, Ralph, the Santa Clara Valley, Puente Hills, and Los Angeles Oil Fields. USGS Bull. 309.

Stlader, W., The Petroleum Industry in California. California State Mining Bureau, Bull 69, p. 449.

English, W. A., The Fernando group near Newhall, California. U. C. Publication Bull Dept. Geol., vol., 8 No. 8, pp. 203 - 218, 1914.

Soper, E. K., And Grant, U. S. , The geolgy and Paleontology of a portion of Los Angeles County, California. , G. S. A.Bull, Vol. 43, pp. 1041-1068.

Arnold Ralph, The Paleontology and stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California. California Academy of Science, Memories vol. 4.

C. and M. Schlumberger and E. G. Leonardon, Paris, France, Electrical Coring; a method of Determining Bottom-hole Data by Electrical Measurements. A.I.M.E. Transactions, volume 110. New York meeting, Feb. 1932 pp 237 - 272.

C. and M. Schlumberger and E. G. Leonardon, Paris, France, Electrical Coring; a method of Determining Bottom-hole Data by Electrical Measurements, and a new contribution to subsurface studies by means of Electrical measurements in Drill Holes. A.I.M.E., vol. 110. pp. 273- 288.

Schlumberger Electrical well logging by schlumberger well surveying corporation. Houston Texas. 16 pages.

Summary of Operations. California Oil Filds. California State Mining Bureau Vol. 5 No. 11. May 1920.