AREAL GEOLOGY AND CONTACT RELATIONS OF THE BASEMENT COMPLEX AND LATER SEDIMENTS, WEST END OF THE SAN GABRIEL MOUNTAINS, CALIFORNIA

A Thesis

by

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ABSTRACT

The west end of the San Gabriel Mountains is a relatively small block of pre-Cretaceous metamorphic complex faulted from the main mass of the San Gabriel Mountains by the San Gabriel fault. This core of metamorphic rocks is flanked on three sides by Tertiary sediments represented by Eocene, Pliocene, and Pleistocene formations. The Eocene and Pliocene are characteristic off-shore and littoral marine deposits. The Pleistocene is principally of terrestrial origin.

The area is one of structural complexity. This can be accounted for, in part, by assuming that this end of the mountain block acted as a centre of rotation for north-south compressional forces that were active to the west.

The San Gabriel Range is believed to be a fault block, raised to its present elevation principally by movements along faults which parallel the north and south margins. The faulting is not restricted to the extreme margins, but often is located within the range itself.

The west slope of the range is characterized by depositional relations between the sediments and the underlying mountain mass. If any faulting has occurred, it is thought to be farther west than the contact between the sediments and the basement complex and to be concealed beneath the younger sediments.

INTRODUCTION

Purpose of the Work:

The thesis presented in the following pages is offered in partial fulfilment of requirements for the degree of Master of Science at the California Institute of Technology, Pasadena, California.

The primary purpose of this study was to determine the nature of the contact between the basement complex of the San Gabriel Mountains and the later sedimentary formations which flank it on three sides. The sedimentary rocks were mapped in some detail to supplement the study.

Location:

The area includes the extreme western end of the San Gabriel Mountains, and is located a short distance east of San Fernando Pass which separates the San Gabriel Mountains from the Santa Susanna Mountains to the west.

The area mapped comprises the west-central portion of Sylmar Quadrangle and is bounded by latitudes N. 34° 19' - 34° 20' and longitudes W. 118° 27' - 118° 30'. The area covers approximately 13 square miles, is bounded on the north by Placerita Canyon, on the west by San Fernando Pass, and extends east to the Olive View Sanitorium. The locality is readily accessible by car via Foothill Boulevard, a distance of about twenty-five miles from Pasadena. (See figure 1.)

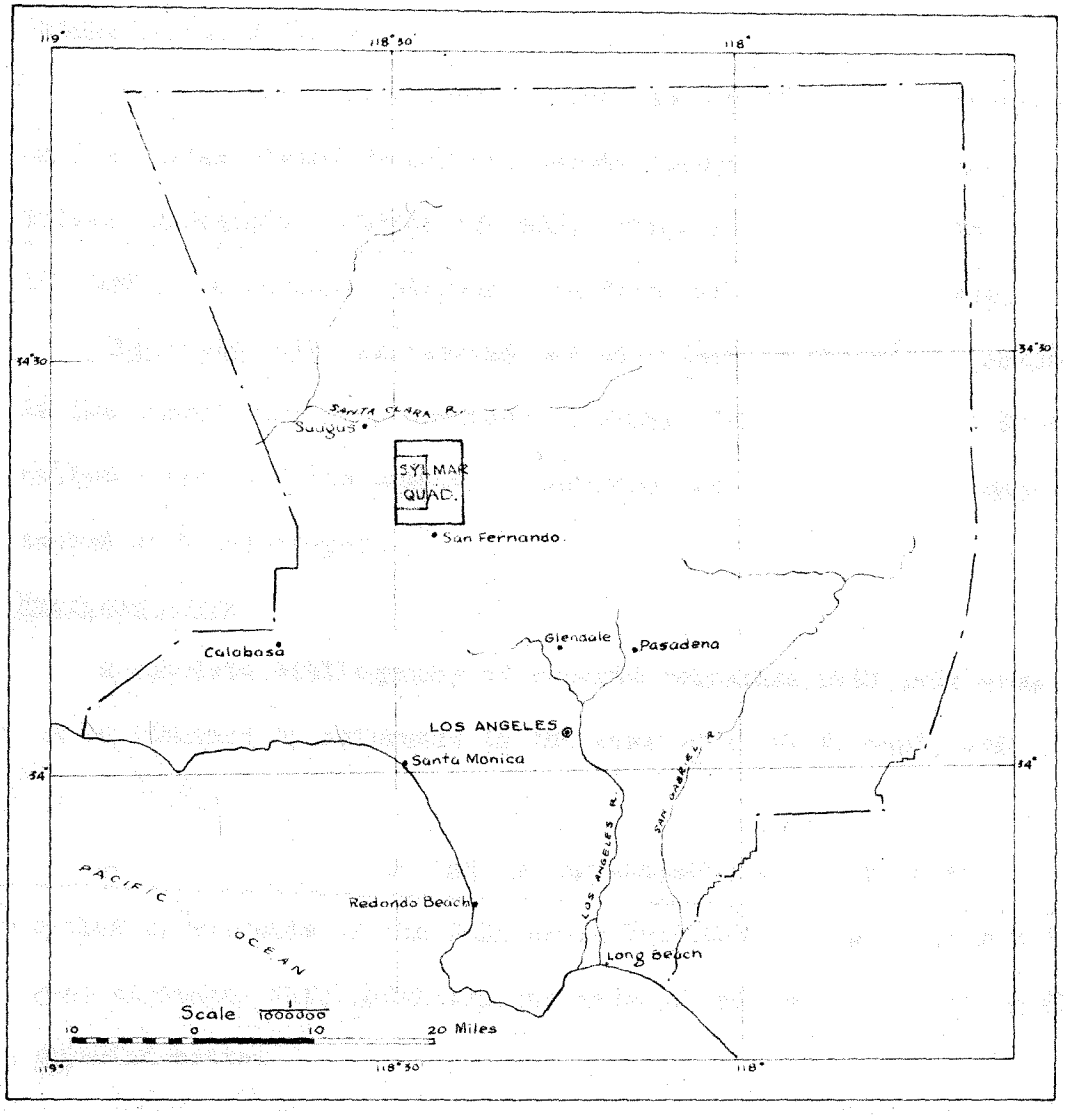

FIG. 1

INDEX MAP
OF
LOS ANGELES COUNTY
SHOWING LOCATION OF MAPPED AREA.

Method of Field Work:

The method of investigation used was Brunton compass mapping on the United States Geological Survey topographic map of the Sylmar Quadrangle, edition of 1935. The horizontal scale is 1":2000', and contour intervals are five and twenty-five feet.

The field work was carried out at intervals during the course of the school year from November to April 1939-1940. Robert B. Hoy collaborated with the author in carrying out the field work connected with this paper.

Previous Work:

A complete bibliography of reports concerned with this area can be obtained by reference to the work of W. S. W. Kew[1], and M. L. Hill[5].

Several senior theses and other Master's theses have been written by students of the California Institute of Technology on areas adjoining this locality, but none of this work has been published.

Acknowledgments:

At this point the writer wishes to acknowledge the help and interest shown by Doctors F. D. Bode and J. H. Maxson, in the progress of the work. The problem was the result of their suggestion and proved an excellent introduction to this type of geologic work.

The writer is grateful for the capable assistance of Robert B. Hoy, also a student at California Institute of Technology, in carrying out the mapping of the area with which this discussion is concerned.

An acknowledgment is due to Dr. W. S. W. Kew of the Standard Oil Company who kindly discussed some of the problems of the area and by whose courtesy access was obtained to certain roads.

Appreciation is also expressed to the residents in the vicinity whose cooperation facilitated the mapping of the area.

Topography, Vegetation and Climate:

The western end of the San Gabriel Mountains, although not reaching elevations equal to those found further east, stands out boldly above the surrounding country. The surface is rugged, the mountain mass being dissected by many V-shaped canyons. Elevations of this particular section range from 1400 feet to 3500 feet.

Chaparral, sage and juniper form a heavy brush which covers the hill sides. Cacti are common; yuccas being the most plentiful. In canyons, along the streams, and in other sheltered environments, cottonwood, sycamore and live oak trees are found.

The region is semi-arid, the annual rainfall being approximately seventeen inches. Practically all the rain falls between the months of November to March, and, with few exceptions, the streams are intermittent. The average annual temperature ranges around 60° F. but during the hottest months, August and September, temperatures rise to over 90°.

The character of the topography of this area made detailed mapping difficult in places. Rock exposures were found for the most part in the steep walled canyons, and the soft nature of the rocks encountered made climbing precarious. The covering of brush

in some places reached such thickness as to present an almost impassable barrier.

STRATIGRAPHY

General Statement:

The rocks of the area are composed of a central uplifted mass of old metamorphic rocks flanked by sediments principally of Pliocene and Pleistocene age. A small area of Eocene sediments is exposed in the western part of the area by uplift along a north-south fault. Thicknesses and general lithologic characters are indicated in the accompanying stratigraphic column. (Fig. 2.)

The Basement Complex:

The San Gabriel Mountains are composed of a complex assemblage of metamorphic and igneous rocks. In general the rocks are foliated, although some massive igneous intrusives were observed. A sedimentary origin is assigned to some of the metamorphic complex[2] because of the occurrence of bands of crystalline limestone and adjacent metamorphic rocks characteristic of metamorphosed sediments.

The foliation of the metamorphic rocks is sometimes straight and regular but in other places the banding is extremely irregular and offers evidence of intense deformation. The many faults occurring in the rocks of the basement complex result in a mosaic of small blocks.

The general complexity of the basement rocks is increased by the occurrence of later dikes--usually dioritic in composition.

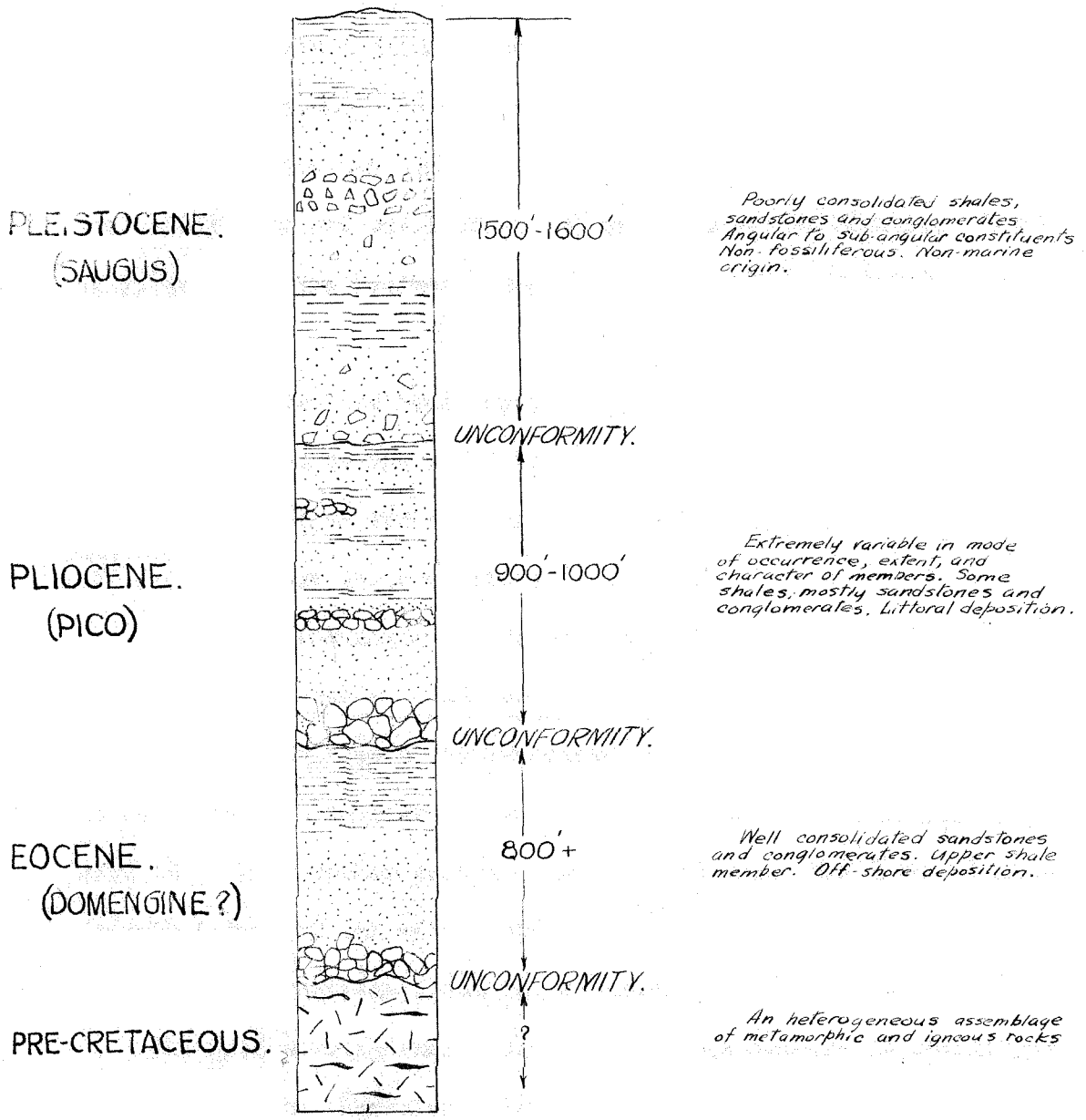

FIG. 2.

GENERALISED STRATIGRAPHIC COLUMN.

Miller[2] divided the basement complex into units ranging in age from Pre-Cambrian to Middle Miocene. The oldest rocks are those of the Placerita metasediments, so called because of their occurrence in Placerita Canyon, and dated Pre-Cambrian because of the lack of fossils. The greater portion of the rocks was emplaced before Cretaceous time but small dikes are dated as Middle Miocene. Generally, however, the basement complex is referred to as pre-Cretaceous.

The Eocene:

Eocene rocks are found only at one locality in this area. Excellent exposures are found in Elsmere Canyon. The occurrence, which is bounded on the east by a north-south fault, extends south for approximately three-quarters of a mile.

The rocks composing the Eocene range from conglomerates to sandstones and shales. The lowest member of the formation is a conglomerate composed of well-rounded boulders. The conglomerate is overlain by a massive light-colored sandstone which grades upward to a shaly member carring limy concretions. The entire series is well indurated and noticeably more resistant than the other sedimentary formations found in the area.

The good sorting exhibited by the Eocene members is thought by the author to be characteristic of off-shore deposition in a rapidly subsiding basin. The materials for the most part appear to have been derived from the San Gabriel Mountain mass.

The Eocene as measured here has a minimum thickness of eight hundred feet. The lower contact is at no place visible. The

Eocene underlies the Pico with a marked angular unconformity.

No fossils were found to substantiate the age of these rocks. Their pre-Miocene age is undoubted however and Kew[3] correlates them with the Domengine formation. Similar material is reported to have been cored in drilling in the north-west corner of the quadrangle and it is likely therefore that Eocene rocks underlie most of the later rocks of this vicinity.

Since Eocene rocks yield oil in the Newhall district to the west, their presence in this area is of importance. None of the other formations exposed are favorable oil horizons, and the numerous oil and gas seepages which occur, notably along contacts and fault zones, may have their origin in the underlying Eocene as does the oil found in the Pliocene.

The Pliocene:

No Oligocene or Miocene strata are exposed in the area mapped. The Eocene is overlain unconformably by the Pico formation, the lowest formation of the Fernando group. This formation is named for its excellent exposures in Pico Canyon on the northern side of the Santa Susanna Mountains. The Pico is considered to be Lower Middle Miocene in age.

The Pico is by far the most important Tertiary formation in the area. Exposures extend from a point about one-quarter mile south of Placerita Canyon south through Elsmere Canyon to Grapevine Canyon, and, at places, the Pico attains a thickness of nine hundred to one thousand feet. Immediately to the east of Grapevine Canyon,

faulting limits the Pico to a narrow irregular band which widens north of Rancho Sombrero and the Olive View Sanatorium. The exposures in the southern portion of the area represent a smaller section than those of Elsmere Canyon.

The Pico overlaps all older Tertiary formations to rest unconformably on the basement complex. This corroborates the concept that a considerable amount of diastrophic activity marked the interval between the Miocene and Pliocene epochs. The noticeable overlap, characteristic of the formation throughout the area suggests encroaching Pliocene seas.

The Pico is overlain unconformably by Saugus gravels.

Overlap and irregularities of the surface upon which the Pico was deposited have resulted in a wide lateral variation of the basal members. Generally speaking however, the basal member of the Pico is a conglomerate which is entirely absent in some places but in others attains thicknesses of from ten to twenty feet. The boulders of the conglomerate are extremely variable in size and degree of rounding.

The Pico is extremely variable in nature. Pockets of conglomerate are found within massive sandstone, and shaly beds are found alternating with sandy strata. The extremely irregular relations seem to suggest deposition under rapidly changing environment. Cross bedding, scouring by swift currents, and sudden deposition of coarse material, indicate that Pliocene times may have been

characterised by minor oscillations of the land mass that was probably near by.

A dark sandy shale, containing large limonitic concretions, is a characteristic upper member of the Pico found in this area, as well as in others. It occurs resting unconformably upon the metamorphic complex on the western slope of the San Gabriel Range. It is believed to have been deposited by an advancing Pliocene sea and subsequently lifted to its present elevation by the faulting that elevated the San Gabriel Mountains.

The Pico appears to be coarser and to contain a greater proportion of conglomerate to the south. In Grapevine Canyon, the Pico is characterised by coarse white sandstone and conglomerate. In Elsmere Canyon and vicinity the members are finer grained.

Some of the Pico horizons are stained a dark brown color by oil content. This is particularly true in Elsmere Canyon territory where the Pico is the producing horizon for a few oil wells. The porous nature of the Pico makes it a good reservoir for oil derived from underlying formations.

A rather coarse sandstone found near the base of the Pico is characterised by a high fossil content. Echinodermata, pelecypoda, gastropoda, and brachiopoda are found in abundance. Marine vertebrate remains, such as sharks teeth, the teeth of the sea-cow (Desmostylus?*) and whale bones are found scattered through the Pico in all parts of

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* Personal communication with E. L. Furlong, California Institute of Technology.

the area. Comparison of fossils collected from the Pico, with collections at the California Institute of Technology, substantiate Lower Middle Miocene age for the Pico of this region.

A fossil locality of importance is found in the eastern branch of Elsmere Canyon. The fossils are found in a sandstone cliff-forming bed which contains a number of invertebrate forms. The fossils are in a good state of preservation.

The source of Pico material is probably the San Gabriel Mountain mass. Pebbles and boulders of metamorphics and igneous rocks characteristic of the basement complex form a large percentage of the constituents found in the various members.

Fossil evidence proves the marine origin of the Pico, and the cross-bedding, scouring and lateral variation of the constituent members in this region suggest a rapidly changing littoral environment.

Bluffs are formed in resistant, massive, often heavily iron-stained members of the Pico. On the north-west slope of the range, the Pico forms a remarkable dip slope area approximately three thousand feet wide and one mile long.

The Pleistocene:

The Pico formation is unconformably overlain by the Saugus formation. Kew states[3] that recent work has proved the Saugus to be entirely of Pleistocene age.

In this area the Saugus is terrestrial in origin and is composed of clays, sands, and gravels. The material tends to be coarse and

subangular and differs from the underlying Pico principally in the degree of induration. Characteristically, the Saugus consists of brown sandstone with many thin conglomerate beds containing sub-rounded basement complex pebbles six to eight inches in diameter.

The unconformity between the Saugus and the Pico is not of great magnitude and in places the material is so similar that demarkation of the contact can only be approximate. Lithologic characters were employed in mapping the approximate contact. A green series of sandy shales occurs at the base of the Saugus and this was used as a marker for the base of the Saugus.

Like the Pico some of the Saugus gravels and sandstones are iron stained and saturated with oil. Several oil seeps occur in Saugus gravels in Elsmere Canyon where the Saugus is believed to be the producing horizon for some of the oil in the Elsmere Canyon Field. Like the Pico it is a reservoir rock for oil derived from the underlying sediments.[1]

To the west the Saugus is reported[1] to grade into marine material. It overlies the Pico and, at the north-west corner of the mountain block, overlaps the Pico to lie directly on the basement complex.

The Saugus is overlain by terrace deposits and patches of alluvium. These were not mapped and will not be discussed further than indicating their existence.

STRUCTURE

General Statement

The main structural features of the area under discussion are three in number.

First, the central mountain mass of metamorphic complex which forms the western extremity of the San Gabriel Range. This mass of metamorphic and igneous is broken into a mosaic of blocks by numerous faults. Although it constitutes the major portion of the area mapped, no effort was made to analyze its structural complexity.

The San Gabriel Range is bounded on the north in this area by the San Gabriel fault which lies between the main mountain mass and the small block forming the western extremity of the range. Only a small portion of this fault lies within the boundaries of the area mapped but it is an important structural consideration due to the possible role it played in the geologic history of the area. The San Gabriel fault strikes N 65° W and dips steeply to the north. Movement along this fault has been principally strike-slip[1].

South of the central mountain mass lies the Sierra Madre fault, the third important structural feature to be included in this general discussion. This fault is not found close to the base of the mountains but outcrops in the Tertiary sediments about two thousand feet south of the contact between the Tertiaries and the metamorphic complex. It is the most southerly of the faults mapped in this area.

In short, the geologic picture is a central core of older metamorphic rocks flanked by Tertiary sediments that dip out from

the mountain mass. Faults along which elevation of the mountain range has been effected, lie to the north and south of the central core. The area is one of uplift.

Grapevine Canyon and vicinity is an area of structural perplexity. Geologic structures found in the region west of the canyon can be traced eastward to the canyon, but here they seem to be discontinued and no trace of them may be found east of the canyon. The Santa Susana overthrust which lies only a short distance to the west, is a geologic structure of some extent and yet it finds no expression at Grapevine Canyon or places further east.

Gentle undulatory folds in the sedimentary strata immediately to the west of the mountain block have axes that strike slightly south of east and rotate to a more nearly east-west position as you go from north to south. These flexures probably originated by deposition on an irregular surface and may have suffered further deformation as a result of movement on the Santa Susana fault to the west.

The western extremity of the rigid mountain block acted as a centre of rotation. Faulting in the west in a north-south direction resulted in further flexure of the sedimentary strata deposited around the margin of the mountain and produced drag effects which may explain the almost vertical attitude of the Pico strata that strike into the south-west corner of the range.

If this hypothesis is justified, the extension of the Santa Susana fault found in the southwest corner of the area, is probably

a tear fault bringing relief from compressional forces by the north side moving west.

Faults:

The San Gabriel Mountains are correctly considered as a block bounded on both the north and south sides by faults. It is thought by the writer that the range has been lifted to its present elevation principally by movement along these faults.

The western segment of the San Gabriels, which comprises the central mass of the area mapped, is faulted from the main body of the San Gabriel Mountains by the San Gabriel fault, movement along which has been principally strike slip. The San Gabriel is considered by some to be a branch fault of the San Andreas master system. It strikes N 65° - 70° W and dips steeply to the north.

At the east end of Placerita Canyon a fault occurs about one quarter mile south from and parallel to the San Gabriel fault. This fault was named the Placerita fault by W. S. W. Kew. It is a vertical fault striking N 65° - 70° W, the south side of which has brought metamorphic complex in contact with Saugus gravels. This contact was followed westward from the eastern edge for about four thousand feet, after which it strikes across Saugus gravels. Due to the nature of the Saugus formation, the course of the fault is followed here only with difficulty. Movement has been practically all vertical as no evidence of horizontal displacement was seen. The vertical movement is not thought to have exceeded a few hundred feet.

Immediately north of the Placerita fault, the sediments dip north at 30°-45° and sometimes assume a vertical attitude. This increase in dip is probably the result of drag along the fault since a short distance further north, they assume their normal dip of about N 20°.

The narrow area between the Placerita and San Gabriel faults is a graben, the relative movements on the faults being up on both the north and the south sides. This differential movement has produced a synclinal structure[3] between the two faults.

The Placerita fault is assigned a Post-Saugus age as it has displaced the Saugus gravels.

A minor fault in the Saugus was recognized near the west line of the S.W. ¼ Section 5, T. 3 N., R. 15 W. This fault strikes N 25° E and is vertical. It was traced north for approximately twenty-five hundred feet where it was lost in the alluvium of Placerita Canyon. Movement on the fault was slight, the west side came up bringing the green formation characteristic of basal Saugus into contact with younger Saugus gravels. There is little evidence of drag, as the sediments on both sides of the fault dip N 15° - 20° W. This fault is also post Saugus in age.

An important fault, for which is suggested the name of Grapevine fault, outcrops in Grapevine Canyon and can be traced almost to Placerita Canyon along a strike of N 5° E, a distance of approximately twelve thousand feet. For the most part the fault is vertical, although slight variations in dip were found along the strike.

Vertical displacement of a few hundred feet has raised the western side and exposed underlying Eocene rocks. This fault marks the eastern boundary of the Eocene occurrence. Post Saugus movements have occurred along this fault but there is no evidence to prove that the fault was not active before that time.

The Grapevine fault may extend further south and join other faults which occur at the extreme south-west corner of the San Gabriel Mountains, but the existence of this extension could not be proved.

The sedimentary rocks in the vicinity of the Placerita fault are crushed to a considerable degree--the fault zone sometimes reaching a width of twenty feet or more. Excellent evidence of drag is found on the east side of the fault where dips are reversed from 20° W to 20° E.

The extreme south-west corner of the San Gabriel mountain block is an area of intense deformation. White sandstone members of the Pico formation, with dips ranging from 65°-85° N, strike N 60° E and butt against a fault which lies a short distance out from the contact between the metamorphic complex and the overlying Tertiary sediments.

It is suggested that this fault, which curves around the south-west corner of the San Gabriel Mountains, be known as the Rancho fault. It outcrops in the north end of Grapevine Canyon, strikes south-east around the corner of the metamorphic complex, and then assumes a nearly east-west course along the base of the mountain

block where it brings Pico in contact with the metamorphic complex for about three thousand feet. Continuing on its east-west course it cuts across the Pico formation behind the Rancho Sombrero and then swings slightly south. No surface expression of its existence could be found beyond this point. It is possible that this fault is a branch of the Sierra Madre fault.

At its western extremity, the Rancho fault dips west, but as it approaches the corner of the San Gabriel range it assumes a vertical attitude which it maintains, with local variations, for the rest of its length. There is no means of determining the amount of movement that has taken place along this fault. It appears to have been principally a vertical displacement which has raised the metamorphic complex with respect to the surrounding sediments. The sandstones along this fault are hard and massive and highly fractured as a result of movement along the fault. Dips close to the fault are nearly vertical.

An eastern extension of the Santa Susana fault is found in the Pico formation in the southwest corner of the area. This fault strikes approximately parallel to the sedimentary strata, N 60° E. The plane of the fault is vertical and is traced with difficulty to within a few hundred feet of the fault zone that bounds the southwest corner of the range. Extensive movement on the fault is not evident with the exception of increased dips of the sediments due to drag on the south side of the fault. The north side of the fault was raised with respect to the south.

At this point attention may be drawn to the anomalous occurrence of a hill which lies out in front of the main range between the Rancho Sombrero and Grapevine Canyon. The hill is composed of a central core of metamorphic rocks of the San Gabriel formation which is surrounded by later sediments. The hill is evidently an outlier from the main mountain mass, but the reason for its presence is not apparant.

A fault, thought to be part of the Sierra Madre, cuts across the southern end of this outlier. Evidence for the Sierra Madre fault is slight at this place and its course is mapped with difficulty since it disappears under alluvium a short distance east from the hill and can be traced only a short distance west from the hill. The Sierra Madre fault is relocated north of the Olive View Sanatorium and then traced east to the edge of the area.

A small fault is found in the Pico east of the outlier. This fault strikes S 70° W and crosses the mid-point of the hill. A marked offset of the metamorphic core of the hill along the projected strike of the fault would seem to indicate that the fault cuts across the hill although no evidence of this could be found on the west side. Movement along the fault has moved the north side up and to the east. It is thought likely that this fault is a branch of the previously mentioned Rancho fault.

North from Rancho Sombrero, vertical movement along a high angle fault has brought the Pico in contact with the metamorphic complex. The fault strikes N 20° E and outcrops along the east

side of a ridge that extends back into the mountains. Movement along the fault has resulted in elevation of the older rocks.

Remarkable evidence of recent southward overthrusting is found about five thousand feet due north from a point mid-way between Rancho Sombrero and the Olive View Sanatorium. Here excellent exposures of a fault plane dipping N 40° are afforded by an adit into the metamorphic complex. Old metamorphics of the San Gabriel formation override Pico conglomerates and sandstone.

This fault contact extends east for approximately one thousand feet and then swings to N 25° E for two thousand feet after which it probably continues in the metamorphic complex. A peculiar change in the attitude of this fault occurs after it changes its strike. Over the last two thousand feet of its length the fault is vertical--a profound change from 40° to vertical, in a very short distance.

Two parallel faults lie close to the eastern boundary of the area. Both are high angle faults striking N 25° E. The most westerly of these two faults outcrops entirely within rocks of the metamorphic complex whereas the other brings Pico in contact with the basement rocks. In both cases movement on the faults has elevated the western side.

Small faults occur all through the area but little can be added to the general discussion by a description of such features.

Folds:

In a general way, the sedimentary strata can be thought of as flanking the central core of old metamorphic rocks. Minor undulations

occur as the result of deposition on an irregular surface. More pronounced folds are probably the result of compressional forces.

Insufficient work was done in the sedimentary strata to enable a detailed account of the structures present and so only a few of the more apparent features will be described.

West of Rancho Sombrero the Pico is folded into a small anticline the axis of which is approximately east-west. Dips are steeper on the north flank of the fold, and the fold appears to parallel the small branch of the Rancho fault. The anticline plunges to the west.

A synclinal structure in the Pico formation is found immediately north of where the Los Angeles City boundary crosses the western limit of the area mapped. The syncline lies just within the western boundary of the quadrangle. The fold is comparatively tight, the flanks dipping at angles of from 35^{0}-40^{0}. The axis of the syncline is bent concave to the north.

An important anticline is located in Elsmere Canyon. It is a broad, steeply plunging fold, the axis of which extends in a northwest direction down Elsmere Canyon. Dips range from 15^{0} to 20^{0} on the flanks of the fold. The Standard Oil Company of California has drilled twenty-one wells along this fold. Some of these wells are still producing a small amount of oil.

There are no well-defined folds north of the Elsmere Canyon fold other than the general swing of the sediments around the end of the mountain range.

Contact Relations Between the Basement Complex and Tertiary Sediments

Since the primary purpose of this investigation was to examine the nature of the contact between the basement complex and the later sediments, a brief description of the relations at various points along the contact will be given.

Starting at the north-east corner of the area, the contact between the basement rocks and the sediments is a vertical fault, the Placerita fault. In the vicinity of this fault, the older rocks are badly shattered, and the members of the Saugus are tilted steeply to the north. These contact relations extend west for a distance of four thousand feet to where the Saugus is found in normal depositional contact with the older rocks. Here the Saugus overlaps the Pico and was deposited directly on the basement rocks. This depositional relation continues for a short distance south from Placerita Canyon.

From a point slightly more than one thousand feet south from Placerita Canyon to the south-west corner of the San Gabriel range, the contact relations are those of normal deposition of the Pico on the older rocks of the San Gabriel Mountains. Varying thicknesses of basal conglomerate, composed of well-rounded boulders of typical San Gabriel formation[2] material, rest unconformably upon the older rocks of the basement complex along the greater part of the contact. In places, a sandy shale has been deposited on the

older rocks of the complex. The lower few inches of this shale contain well-rounded pebbles and cobbles of metamorphic rocks.

The covering of conglomerate and shale is thin along the contact. Scouring has exposed windows of the older rocks, and accumulation of the sediments in local basins has resulted in patches of shale isolated in the complex.

At the south-west corner of the San Gabriel Range, a thick basal conglomerate is found deposited directly on the old metamorphic core of the mountains. The conglomerate contains large sub-angular boulders of metamorphic and igneous rocks. Movement along the Rancho fault has caused shattering and brecciation to a marked degree at this location. The fault narrows the strip of basal conglomerate to the east and soon becomes the contact between the sediments and the complex. The fault is vertical and, as with most of the other faults, the older rocks are elevated with respect to the sediments. Few dips can be measured due to the massive nature of the sandstone but close to the fault indications are that dips have been steepened by drag. This fault contact extends east for approximately three thousand feet.

The contact leaves the Rancho fault at this point and swings north-east. For the next four thousand feet or so, the Pico is found deposited on the complex with normal depositional relations.

Fault contact relations between the Pico and the complex core of the San Gabriel Mountains are encountered again directly north of Rancho Sombrero. The fault, thought probably to be a branch

of the Rancho fault, strikes N 10° E, and can be traced north for about four thousand feet, along the length of which Pico sandstones and conglomerate are in contact with the basement. The fault is vertical and movements have elevated the older metamorphics.

North and east from this fault the contact between the sediments and complex is again of a fault nature but it assumes particular significance in that it is the only portion of the contact along which the older rocks are thrust over the adjacent sedimentary formations.

The thrust is a low angle fault dipping N 40° and the fault contact is accordingly somewhat sinuous. In a short distance to the east however it becomes vertical and swings to a N 25° E strike. Pico sandstones are in fault contact with the complex for about two thousand feet, after which the fault strikes off into the basement complex.

In front of the thrusted portion of the basement complex a strip of Pico is deposited on the older rocks with normal depositional relations.

A small fault lies close to the eastern boundary of the area and brings the metamorphic complex in contact with the sediments that lie to the east. The fault is vertical, and the metamorphics have been elevated with respect to the sediments. Dips of the sediments have been increased from the normal value of 25° to 60° in the vicinity of the fault.

Considering, now, the contact relations between the surrounding sediments and the older rocks that form the core of the outlying

hill of complex in front of the main mountain mass: The strikes and dips of the surrounding Pico members are extremely irregular but no evidence of faulting is found at the contact between them and the core of older rocks. It is suggested therefore that originally the hill was an island and that during Pliocene times the sediments were deposited normally upon its slopes. Since then, elevation of the entire region has occurred. Recent faulting has taken place south of the hill, and another fault has cut across the central part of the hill. Such faulting would cause distortion of the surrounding sediments so that their original depositional relations would be obscured.

Summary:

Briefly, the mountain mass of the San Gabriel range is a fault block that has been elevated by fault movements along the north and south sides. In places along the south margin, post-Pleistocene movements have thrust the block of metamorphic complex out over the adjacent sediments, and in others vertical faulting has brought the sediments into fault contact with the older rocks. This faulting is not restricted to the extreme south margin of the range but in places lies back in the hills.

The west end of the range is characterised by depositional relations between sediments and underlying mountain mass. If any faulting has occurred it must be further west than the contact between the sediments and the basement complex and concealed beneath the younger sediments.

Elevation along the north side has taken place along the Placerita fault. The San Gabriel fault which separates this western segment of complex from the main mountain mass, has raised the larger block with reference to the small one.

The general area is one of uplift above the surrounding terrain.

GEOLOGIC HISTORY

1. Pre-Cretaceous: Formation, deformation and metamorphism of the metamorphic complex of the San Gabriel range. Erosion.
2. Eocene: Submergence of area. Deposition of marine sediments. Uplift and erosion.
3. Oligocene and Miocene: Uplift and erosion. Seas of these periods may not have extended this far east or, if sediments of these ages were deposited, they must have been swept off by later erosion.
4. Pliocene: Submergence and deposition of marine sediments around the mountain mass. Sea was advancing east. Minor oscillations occurred during Pliocene.
5. General uplift of the area: Withdrawal of the sea. Slight erosion.
6. Pleistocene: Deposition of Saugus. Probable faulting activity.
7. Quaternary: Further uplift of area, faulting.
8. Recent: Erosion and local deposition.

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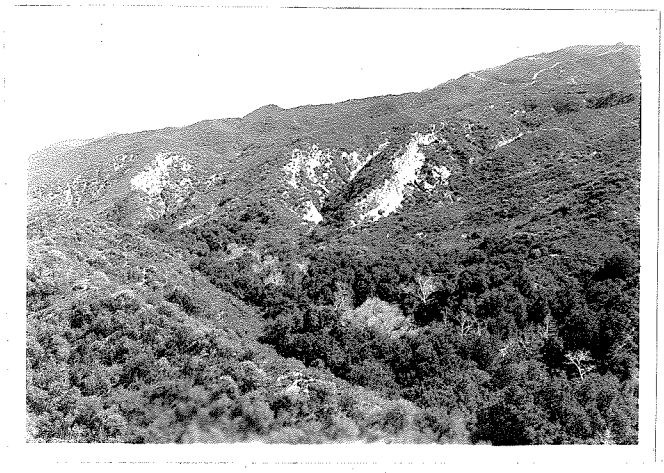
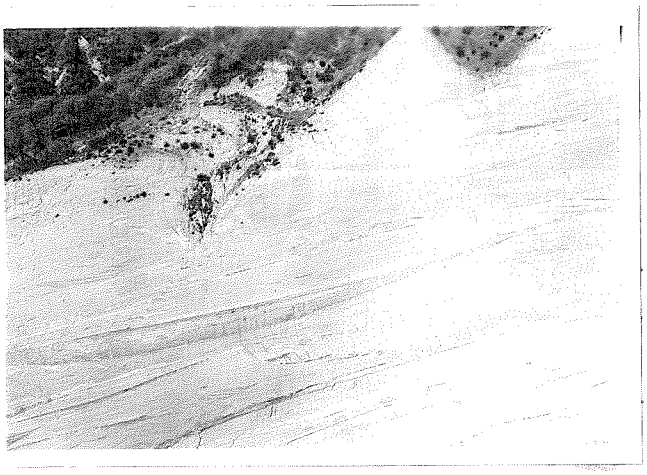
PLATE III

A. West end of the San Gabriel Mountains as seen from the south.

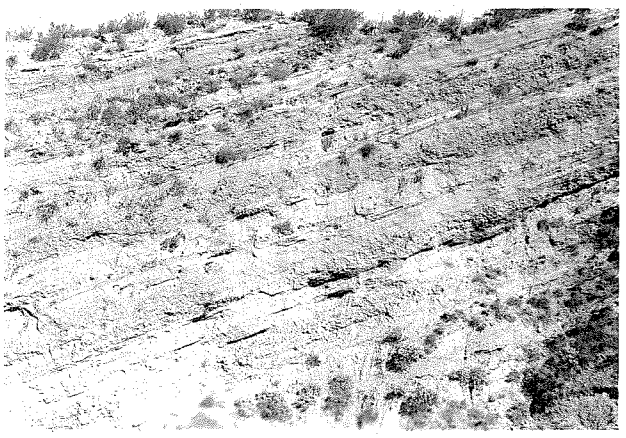


B. Whitney Canyon. Light colored Tertiary sediments flank the older metamorphics and dip north-west.

PLATE IV

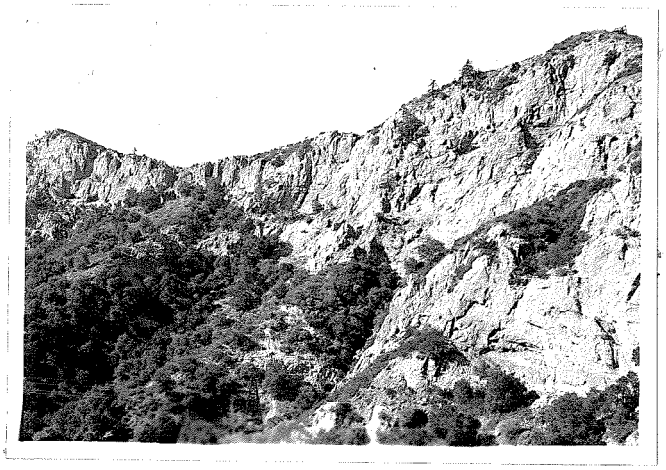


A. Exposure of Pico sandstone in road cut through San Fernando Pass. Note scouring and cross-bedding.



B. Exposure of Pico in Whitney Canyon showing interbedded sandstones and conglomerates.

PLATE V.



A. High ridge of Pico sandstone at the west boundary of the area. Abandoned well in foreground was drilled on the Elsmere anticline.

B. Assymetrical syncline in Pico formation as seen looking west along its axis.