THE GEOLOGY OF A PORTION OF EASTERN VENTURA BASIN, CALIFORNIA

Thesis by

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In Partial Fulfillment of the Requirements

For the Degree of

Master of Science

California Institute of Technology

Pasadena, California

1948

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THE GEOLOGY OF A PORTION OF EASTERN VENTURA BASIN, CALIFORNIA

INTRODUCTION

The eastern part of the Ventura Basin has aroused the interest of geologists, professionals and amateurs alike, for almost one hundred years. Much of this attention has stemmed from the discovery of small deposits of gold, and the completion of a few producing oil wells within the area. Of more academic interest are some problems presented by the stratigraphy and paleontology of the region. These questions have been debated at length by Stirton, Maxson, Kew, Jahns, and others. References to these discussions are provided in the bibliography.

The Ventura Basin is a structural trough lying in the Transverse Range division of the Coast Range province of California. As shown in Figure 1, the specific part of the Ventura Basin discussed in this report lies somewhat east of the center of the valley, and northeast of the town of Newhall. The area is well within the boundaries of Los Angeles County, and is easily accessible by US Highway 6, as well as by numerous state and county roads. It lies 30 miles from the Los Angeles Civic Center.

This report deals with an area of approximately twenty-six square miles, comprising parts of the Saugus, Newhall, Sylmar and Humphries quadrangles mapped by the United States Geological Survey. It is essentially bounded by Bouquet, Placerita, Soledad, and Mint Canyons. The settlements of Saugus-Pardee, Honby, Solamint, St. Johns, and Forest Park are included within these boundaries.

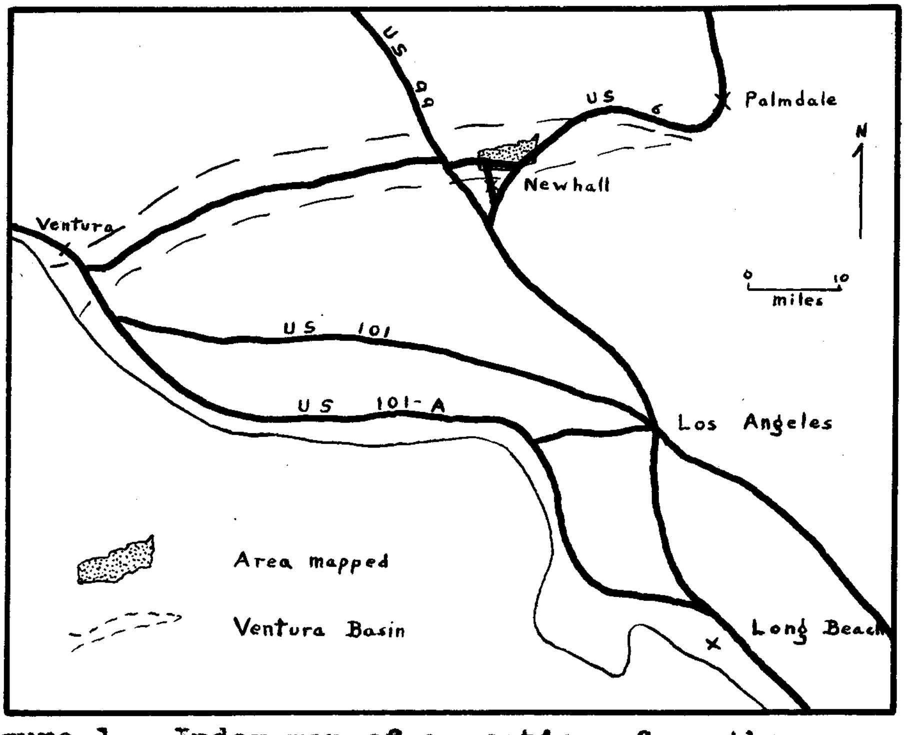


Figure 1 - Index map of a portion of southern California, showing relations of area of this report to local geography and the Ventura Basin.

The position of the northern border of the map was determined by the position of the southern border of an area mapped by Jahns in 1938, and published in a report of the Carnegie Institute of Washington as noted in the bibliography. The remainder of the cartographic border was located in areas of alluvium wherever possible, forming a natural geologic boundary, or on the physical boundary of a state highway.

The geology of the area herein discussed is made especially interesting by the presence of a representative section extending from the Upper Miocene to the present, and by the absence of two formations, the Modelo and Pico, from certains parts of the area. A large series of river terraces, numerous examples of stream piracy, and the presence of several types of mass movements are of considerable geomorphic interest. The possibility of commercial production of petroleum, gold, and ilmenite adds economic importance to the investigations.

The northern two-thirds of the territory examined was mapped during twenty-two field days in the winter of 1946-47 as an exercise in geologic mapping for the California Institute of Technology. An additional fifteen field days were spent during the following winter in re-examination of the northern part, and in mapping the additional southern third of the resulting area. This report is submitted in partial fulfillment of the requirements for the degree of Master of Science at the California Institute of Technology.

The climate of the eastern portion of the Ventura Basin is of the semi-arid type. The mean annual rainfall at Newhall is approximately 17 inches, and the mean annual temperature is slightly higher than 61° Fahrenheit. Even the Santa Clara River, which flows through the center of the area, is an intermittent stream. Live water is present only after cloudbursts or prolonged heavy rains.

The vegetation is of the Sonoran type, consisting almost entirely of sage and greasewood with cacti and decidedly sharp-pointed yuccas scattered about. A few trees grow along the valley bottoms, or in other relatively moist places.

The vegetation is relatively thick on the north-facing slopes, where evaporation of the scanty supply of moisture is not as rapid as it is on the southerly slopes which suffer the full impact of the sun. The flat-surfaced terraces are capped by a soil cover that is excellent for cultivation.

ACKNOWLEDGMENTS

The writer is greatly indebted to Professors Richard H. Jahns and Robert P. Sharp of the California Institute of Technology for their help and counsel given in the office, and on several trips into the field. Much benefit was derived from discussions with associated students, especially R.J. MacNeill and J.F. Lance. So many debates concerning the geomorphic features displayed in the region were held with E.M. Shoemaker that, despite every effort to the contrary, it has been impossible to divorce his ideas entirely from those of the writer.

STRATIGRAPHY

Four sedimentary formations of Tertiary age occur within the area mapped, as shown in Plate I. These are the Miocene Mint Canyon and Modelo formations, the Pliocene Pico formation, and the Plio-Pleistocene Saugus formation. Also present are Quaternary terrace deposits and valley-bottom alluvium. No igneous rocks are exposed at the surface within the area of the map.

Any lithologic criterion formulated to differentiate between the strata in the mapped area is almost certain to fail at one or more places. In fact, certain horizons within the four bedrock formations are commonly so similar that spot identification is impossible, and recourse must be had to an analysis of the regional distribution and relations of the units. The over-all lithologic characteristics of the stratigraphic series must be coupled with data from the few fossil localities, or with the scattered exposures of angular unconformities to permit certain identifications.

The lack of broadly applicable lithologic characteristics, as well as the scarcity of good exposures in many parts of the area, make an accurate determination of stratigraphic columns impossible. It also makes some highway and railroad excavations extremely difficult to interpret in terms of lithology.

The diagrammatic section, Figure 2, shows the general relations existing between the four sedimentary formations as known from exposures within or near the mapped area.

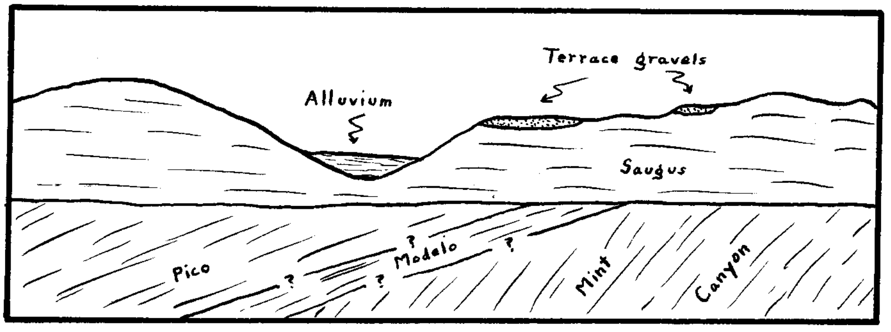


Figure 2 - Diagrammatic section showing the general relations between the formations.

Mint Canyon Formation

The eastern third of the area is underlain by strata of the Mint Canyon formation. To the west these rocks dip unconformably beneath younger horizons.

The lack of extensive exposures throughout much of the area immediately underlain by Mint Canyon rocks leaves the details of structure and stratigraphy but vaguely known. The extensive area of cliffs and badland exposures on the northern side of Puckett Mesa enabled Jahns to recognize twenty-seven time subdivisions within the formation. (1 Some of these subdivisions could be traced southward from the mesa, but only for short distances.

Computations made in an area of homoclinal dip between Mint Canyon and Soledad Canyon show that at least 1,600 feet of Mint Canyon strata are present there. A comparable result was obtained from measurements along the northern border of the map through another homoclinal section. These columns cannot be correlated with assurance, nor can they be matched with beds exposed in the extreme northeastern corner of the map. However, it is thought that the last named beds are older, and that the true thickness of Mint Canyon beds exposed within the area mapped is not less than 2,000 feet.

The top of this column is the approximate equivalent of the top of Jahns' column, (2 and the bottom lies near his Member 10. The estimate of thickness stated above is nearly equal to his measured column between these two points.

(1 - R.H. Jahns, Carnegie Institution of Washington, Publication No. 514, Paper IX, pp 145-194, 1940.

(2 - R.H. Jahns, op. cit.

In general, the Mint Canyon strata are characterized by a light gray color, locally tinged with light tan. The beds vary from coarse boulder conglomerates to fine-grained sandstones and siltstones. The bedding is known to be irregular, with large-scale lensing and cross-bedding in many parts of the section. The formation is commonly better indurated than the younger formations in the region.

In the northeastern corner, where the oldest strata are exposed as they rise to the east, the sediments tend to be finer grained, thinner and more evenly bedded, and darker in color. Reddish brown to medium gray mudstones and siltstones are abundant, and a few thin beds of volcanic tuff and tufaceous sandstones are exposed here and there.

Fresh-water lacustrine fossils have been reported from similar strata north and west of Puckett Mesa. (3 On the basis of a southward appearance of coarser fluviatile sediments, Jahns drew a lacustrine-fluviatile facies line north of the mesa. However, based on the finding of scattered outcrops of a similar nature south and east of the mesa, it is suggested that these conglomerates interrupting the finer lake sediments may represent the deposits of a low lakehead

(3 - R.H. Jahns, op. cit.

delta that pushed forward into the shallow water, and was prolonged by a mid-basin channel where the swifter currents of floods would drop their coarse debris. These relations are shown in Figure 3. Puckett Mesa thus would occupy the mid-basin channelway, and lacustrine sediments could be expected to occur both north and south of this zone.

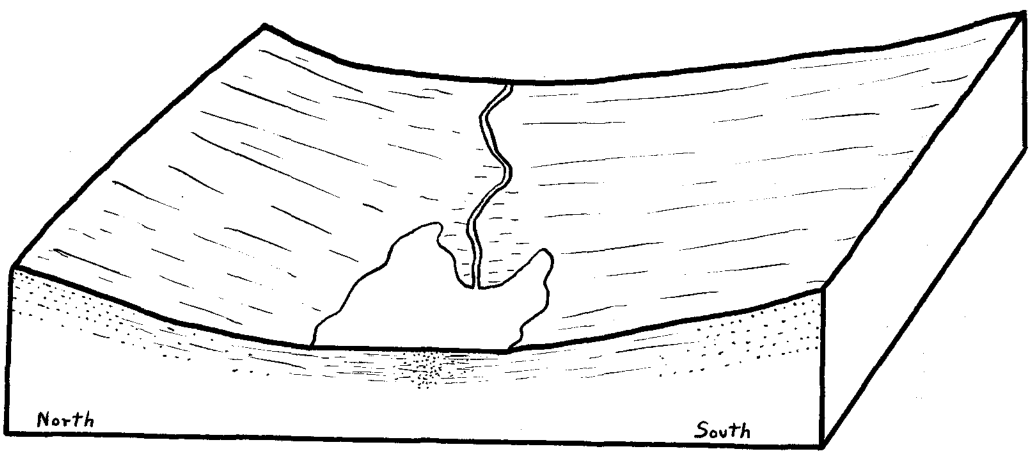


Figure 3 - Diagram showing the suggested distribution of lacustrine sediments within the Mint Canyon formation.

The disappearance of lacustrine strata to the west is not surprising. It is probable that the Mint Canyon beds were deposited in a broad valley flanked by great bajada surfaces that sloped gently upward toward the bases of high, rugged mountains to the north and south. During periods of sufficient rainfall, an intersequent stream undoubtedly flowed seaward between the opposing fans. Any lakes resulting from the fan-daming of this stream would lead a very tenuous existence, subject to sudden encroachment, or even complete filling by the coarse debris carried by cloudburst waters.

At the point Sec. 2 (45-29) (3 a small cliff exposes drag-folded Mint Canyon sediments. These minor flexures represent a type of contemporaneous deformation which occurred before the beds had been consolidated. This locality lies along the southern edge of the deltaic zone suggested on the previous page.

Although an incomplete vertebrate fauna has been collected from several localities immediately adjoining the mapped area to the northeast and north, no fossils were found in Mint Canyon rocks within the territory under discussion here. However, there can be

(4 - To facilitate the accurate location of points on the base map, the coordinate system in common use by the armed forces is here superimposed on the already-existing land office grid of section lines. This method subdivides the vertical and horizontal lines of a grid square into hundredths. Measurement is made from a zero point corresponding to the lower lefthand corner of the grid square. The notation in parentheses lists first the distance horizontally to the right of this zero point, and then the distance vertically upward to the location desired.

Because all points thus listed in this report will lie within the confines of the area mapped, township or range designations will preceded the section number only when necessary to prevent any misinterpretation.

no doubt as to the identification of these beds owing to their observable continuity with fossiliferous parts of the type section to the north and east.

Modelo Formation

In the north-central portion of the area are a few small outcrops of a formation designated as Modelo (?) by Kew. [5] This designation was based on lithologic similarity to known Modelo strata farther west in the Ventura Basin, and on their unconformable relationship to the underlying Mint Canyon beds, as observed on the northern flank of the Bouquet Canyon-Plum Canyon divide.

Paleontological evidence obtained since Kew's work has shown these strata to be the equivalent of the upper part of the type Modelo of Hudson and Craig. Therefore, Jahns used the designation "Modelo". [6] Further study has shown these strata to be uppermost Miocene Neroly in age. However, for the purposes of this report, the name Modelo will be used without modifying marks or symbols.

Within the area discussed herein, the actual contact between the Modelo and Mint Canyon strata is

(5 - W.S.W. Kew, United States Geological Survey, Bulletin 753, 1924

(6 - R.H. Jahns. op. cit.

everywhere obscured by slope detritus, or lies along a fault. From exposures slightly to the north, in the area mapped by Jahns, it is known that the Modelo is present as a thin wedge between Mint Canyon and Saugus strata, narrowing and disappearing to the east. The same relationship is known to exist toward the south.

Along the south side of Plum Canyon, the lowest Modelo horizon visible is a hard, brown cobble conglomerate. This probably corresponds to the persistent basal conglomerate mentioned by Jahns,(7 and is therefore interpreted as representing the base of the Modelo in that area. It is overlain by thin layers of well-bedded gray to tan siltstone and fine-grained sandstone with a few persistent horizons of a tougher, dark brown sandstone. Scattered grains and anhedral masses of gypsum occur in the finer beds.

The exposures further west, on the northern side of Plum Canyon, show bedded gray sandstones and pebble conglomerates with some conspicuous layers of brown sandstone. These gray beds closely resemble some exposures of Mint Canyon strata, but the brown sandstone is distinctive, and the series can be traced northward into the area mapped by Jahns where it overlies the Mint Canyon formation with a visible unconformity.

(7 - R.H. Jahns, op. cit.

It is though that these strata lie stratigraphically above those seen on the southern side of Plum Canyon.

About two hundred feet of Modelo rocks is clearly demonstrable. A total of three hundred feet may be more accurate if the distances between outcrops and the lack of data on the attitude of the bedding are taken into account. The contact with the overlying Saugus strata is not clearly exposed at any locality within the area, but can be inferred within a few feet by changes in lithology. It is undoubtedly also an angular unconformity, thus accounting for the thinning of the Modelo eastward and southward. These relations are clearly shown in Section B-B of Plate III.

One highly fossiliferous bed of hard brown sandstone about a foot thick was found in the Modelo section south of Plum Canyon. Unfortunately, most of the remains are of worm tubes, or are too highly broken to be readily identifiable. A few fragments of shell were also found on the detrital slopes directly opposite on the northern side of the canyon. Such organisms as could be identified are listed in Appendix C.

The entire Modelo formation was deposited under marine conditions, probably in a broad, shallow estuary formed by the drowning of the subaerial valley of Mint Canyon time. From the somewhat finer nature of the debris deposited, it may be inferred that the mountains surrounding the basin had less elevation than during the preceding period of deposition.

<u>Age of the Mint Canyon and Modelo Formations</u>

Merriam and Matthew early proposed that the beginning of the Pliocene epoch could be reognized by the first appearance of <u>Hipparion</u>. Difficulty was encountered when <u>Hipparion</u> remains were discovered in the Mint Canyon formation, because Miocene marine fossils occur in the overlying Modelo rocks. This started a debate which is still in progress.

The type section of the Modelo, as described by Hudson and Craig, contains marine fossils extending in age from Middle Miocene Temblor time to uppermost Miocene San Pablo time. The Modelo found directly overlying Mint Canyon strata contains marine fossils dates as late Upper Miocene Neroly age. After the deposition of the Mint Canyon strata there was a time lapse sufficient for the deformation and erosion of these beds before the deposition of the Modelo. Even if it is considered that the upper part of the Mint Canyon is the time equivalent of the lower part of the Modelo, due to the overlap of a marine transgression from the west, the Mint Canyon formation still must be dated as approx--imately middle Upper Miocene according to the time scale of the invertebrate paleontologists.

Among the group of vertebrate paleontologists, Stirton stands by the designation of a Lower Pliocene age as inferred from the presence of Hipparion. He admits that the beds may be in part transitional from the Miocene. McGrew and Meade agree with this statement.

On the other hand, Lewis, Maxson, Jahns, and Eaton who quoted Stock, suggest that Hipparion originated in the New World, and first appears in the Mint Canyon strata. The form would thereby be of an older age than remains found in other localities in North America, Europe or Asia. An uppermost Miocene or trans--itional Mio-Pliocene age is then possible for the Mint Canyon formation.

However, even this accession on the part of the vertebrate paleontologists is not sufficient to bring the two age views into accord. The final solution awaits arbitration between the two groups, with consequent modification of one or both time scales. Nevertheless, it disrupts existing time zones less, and agrees with known facts better if the Mint Canyon is considered to be of middle Upper Miocene age, and the Modelo uppermost Miocene in age. (8

Pico Formation

In the central part of the area, the Soledad anticline exposes beds of the Pico formation within a small area immediately south of Soledad Canyon. Pico strata also are visible in narrow belts along the bottoms of Placerita Canyon and Hidden Valley.

The Pico strata vary in lithology from coarse conglomerates to fine-grained sandstones and siltstones. The beds are commonly light to medium brown, and are characterized by limonitic stains as well as by concretions and veinlets of iron oxide. Yellow sands and thinly well-bedded gray siltstones also are present.

(8 - O.H. Hershey, Univ. Calif. Pub., Bull. Dept. Geol., Vol. 3, No. 1, pp 1-30, 1902-04.
F.S. Hudson and E.K. Craig, Bull. A.A.P.G., Vol. XIII, pp 509-518, 1929.
J.H. Maxson, Carnegie Inst. of Wash., Pub. No. 404, Paper VII, pp 79-112, 1930.
R.A. Stirton, AM. Jour. Sci., Vol. 26, pp 569-576, 1933.
R.A. Stirton, Am. Jour. Sci., Vol. 32, pp 161-206, 1936.
T. Clements, Bull. A.A.P.G., Vol. XXI, pp 212-232, 1937.
P.O. McGrew and G.E. Meade, Am. Jour. Sci., Vol. 36, pp 197-207, 1938.
G.E. Lewis, Am. Jour. Sci., Vol. 26, pp 208-211, 1938.
J.H. Maxson, Bull. A.A.P.G., Vol. XXII, pp 1716-1717, 1938
J.H. Maxson, Bull. G.S.A., Vol. 49, pp 1916-1917, 1938.
J.E. Eaton, Bull. A.A.P.G., Vol. XXIII, pp 517-558, 1939.
R.H. Jahns, op. cit.

Most of the strata show small-scale cross-bedding to an extreme degree. Anhedral to subhedral masses of gypsum are very abundant in the finer-grained beds.

The Pico is a marine formation, numerous Lower Pliocene fossils being found in other localities. However, only in the railroad cut at point Sec. 20 (50-18) were any organic remains found within the area mapped. These were scattered fragments of marine shells, with very few complete individuals obtainable.

The bottom of the Pico strata is nowhere visible within the area of the present mapping. It is thought that the Pico beds unconformably overlie the Mint Canyon formation, from evidence in exposures a short distance beyond the eastern border, where the intervening Modelo formation is seen to lens out. (9

Along the northern walls of both Placerita Canyon and Hidden Valley the Pico-Saugus contact can be traced without difficulty. It is an angular unconformity. Figure 4 shows this unconformity at the point Sec. 31 (30-12) on the north side of Placerita Canyon. This same contact can be seen, though not as clearly, at one point on a hilltop in the northern area of Pico exposures.

(9 - R.H. Jahns, personal communication.

Figure 4 - Angular unconformity between Pico strata and overlying Saugus beds at the point Sec. 31 (30-12) in Placerita Canyon.

The northern exposure of Pico strata would represent a thickness of more than 2,000 feet if there were no repetition by faulting. No faults can be clearly demonstrated, but, as indicated in a later sectional sketch, Plate III, A-A, at least one fault is thought to be present. However, it is probable that a thickness of no less than 1,500 feet of Pico beds is present.

The section of Pico strata represents the record of further marine deposition in the Ventura Basin estuary that was occupied by the sea during Modelo time.

Saugus Formation

Strata of the Saugus formation are present over approximately two-thirds of the area mapped. These rocks are clearly divisible into two facies that interfinger in a transitional zone.

The northeastern part of the Saugus formation is characterized by tan to medium brown strata varying from coarse boulder conglomerates to fine sandstones and siltstones. The bedding is irregular and lenticular to a marker degree.

As the formation is traced westward along the divide between Bouquet-Plum Canyon and Soledad Canyon, a few horizons of a coarse-grained gray sandstone appear within the column of brown strata. South of Soledad Canyon these gray beds are very abundant. They constitute as much as half of the total thickness of the formation, and increase in number to the San Gabriel fault. Here the gray beds are abruptly cut off, only tan and brown strata appearing south of the fault. These two facies may be referred to as the Banded Saugus and the Brown Saugus for convenience.

The gray beds of the Banded Saugus are much more indurated than adjacent brown horizons, and in many instances uphold low cliffs, or even hogback ridges in areas of steep dip. Where the gray beds are most numerous, there is an almost uniform alternation between the brown and the gray, each being about ten feet in thickness. The outlying interfingering gray horizons further north retain this nearly constant thickness, the brown between increasing in thickness as some of the gray beds disappear. The lensing process can be observed both on the western end of the divide between Soledad and Bouquet Canyons, and in the widest part of the area between the San Gabriel fault and Soledad Canyon.

This should not be interpreted as meaning that no gray-colored horizons are present within the Brown Saugus facies. However, those gray to light tan beds that are present do not show the marked induration of the Banded Saugus gray beds.

Figure 5, at the point Range 16 west, Sec. 14 (60-05) on the Bouquet-Soledad divide, shows a prominent cliff upheld by a gray horizon within the Banded Saugus. A similar, higher bed upholds smaller cliffs near the top of the slope.

These gray beds in the Banded Saugus, it is believed, represent a marine, or at least estuarine

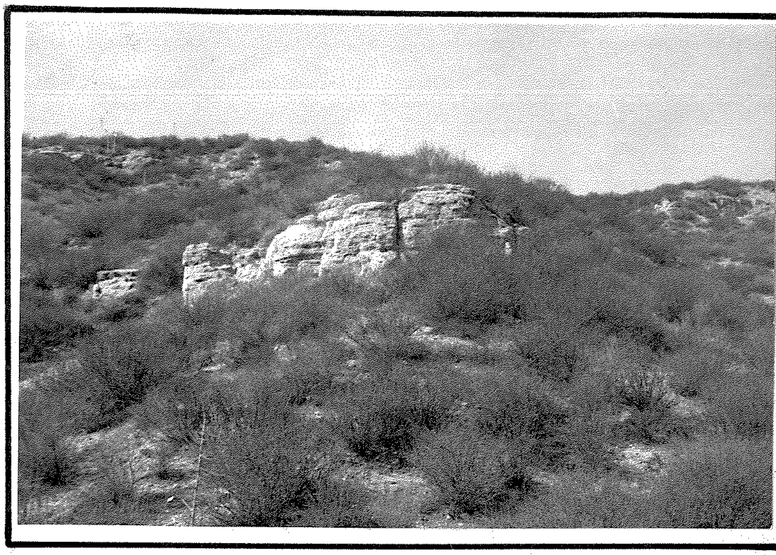


Figure 5 - Cliffs of Banded Saugus graybeds in Section 14.

facies of deposition. Kew states that west of Placerita and Ellsmere Canyons the eastern terrestrial Saugus formation becomes marine in part, the beds becoming lighter colored and better developed. [10] The bedding is much more uniform in the area of the Banded Saugus than in the Brown Saugus, suggesting more stable conditions of deposition. This would be compatible with the change from terrestrial to marine environment, where more complete sorting would be expected than on the bajada slopes.

Fossil records from other localities indicate that the Saugus varies in age from Upper Pliocene to Lower Pleistocene. No fossils were found in Saugus strata in this area.

(10 - W.S.W. Kew, op. cit.

Because the majority of the Saugus formation is essentially flat-lying, a fairly accurate estimation of the thickness can be made. North of the San Gabriel fault there is about 800 feet of strata, and south of the fault there is an additional 300 feet. The exact relationship existing between the strata on the two sides of the fault is not known. However, drag effects resulting from the last period of movement along the fault suggest that the horizons to the south are younger than those to the north. The magnitude of the interval is not known. It is estimated that not less than 1,400 feet of Saugus strata is present within the area. Figure 6 shows diagrammatically the supposed intra-Saugus relations.

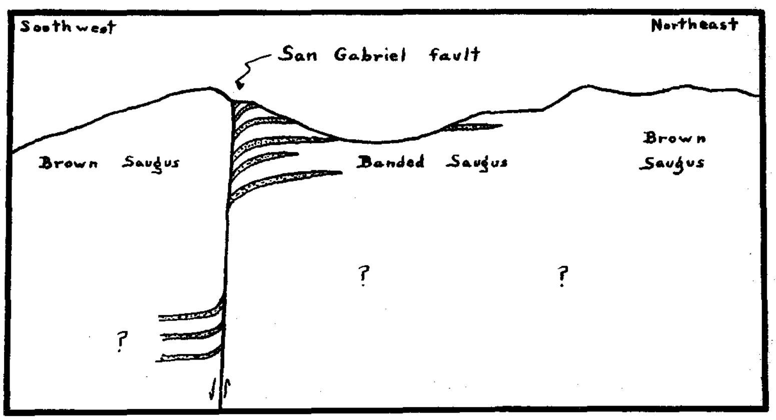


Figure 6 - Diagrammatic representation of the relation between the Saugus facies across the San Gabriel fault.

The contact between the Mint Canyon and the Saugus formations is well exposed along both sides of Corner Canyon, and in other canyons in the same vicinity. Unconformable relationships are clearly demonstrable. The Saugus strata also can be shown to lie unconformably upon the Pico strata wherever the older formation is present. Relations with the Modelo are not as clear. but the presence of an unconformity is inferred, as previously noted.

The strata of the Saugus formation record the final period of deposition occurring throughout the eastern end of the Ventura Basin. Alluviation again took place on great bajada slopes inclined gently basinward from the foot of high mountains similar to those of Mint Canyon time. The sea had retreated westward since the deposition of the marine Modelo and Pico strata.

Quaternary Deposits

Quaternary terrace deposits younger than Saugus strata are found in some localities, and exhibit unconformable or disconformable relations to the underlying strata. Much of the evidence for this post-Saugus deposition has been removed by subsequent dissection, and there is extreme difficulty in differentiating the scattered terrace gravels from the underlying Saugus conglomerates in many localities. In as much as time made it necessary to limit the mapping in some direction, no attempt was made to delineate these terrace deposits. Notable exposures of terrace gravels are present on the

Soledad-Mint Canyon divide at the point Range 15 west, Sec. 15 (80-10), and south of the Bermite Powder Company at the point Range 16 west, Sec. 23 (78-00). This phase of the geological problems of the area will be discussed, at least in part, in a paper now being prepared by E.M. Shoemaker.

Quaternary alluvium is present as stream fill, and as alluvial fans and cones. All forms of alluvium were grouped as a single unit for the purpose of this report. It is expected that Shoemaker will subdivide these forms.

STRUCTURE

Detailed struotural interpretations are necessarily limited to the few areas of good exposures. Only generalized statements can be made concerning the remaining portions of the mapped area.

Folds

In a zone of excellent exposures in the vicnity of Corner Canyon, the Mint Canyon strata are warped into two small anticlines and two small synlcines. The axes of these folds are essentially parallel, and trend northeast-southwest. The wave lengths vary between 500 and 2,000 feet. The anticlines plunge to the southwest, the synclines to the northeast at a low angle. These folds are not identifiable farther to the northeast, in the region underlain by Mint Canyon strata.

Several rather extreme vagaries of dip and strike are present along the base of Puckett Mesa in the northeastern corner of the area. Although it was thought that many of these discrepancies are due to block slumping off the scarp of the mesa, the presence of such mass movements could not be proven. It is possible that several minor folds and/or faults are present.

Another sharp discordance in strike is prominent along a line oriented in an easterly direction from the mesa front. It is not known whether this line of change of strike marks the presence of a fault, or the sharp nose of an anticline plunging in a westerly direction. The hypothetical presence of a fault is favored.

In general, the Mint Canyon strata show a homoclinal dip to the southwest in the northern part of the area, and a homoclinal dip to the northwest in the southern portion. These may be interpreted as marking the trough and the lower south flank of a broad syncline, which probably corresponds within narrow limits to the basin of deposition that existed in Mint Canyon time.

The Modelo rocks exhibit a gentle homoclinal dip to the south. There is a slight drag visible along a small fault that cuts the formation on the south side of Plum Canyon.

As previously stated, the Pico formation is mainly exposed near the core of an anticline known as the Soledad anticline. (11 This fold plunges gently to the northwest, where Saugus beds are also affected. Its axis trends northwest. This is perhaps the major fold of the area, as it is known to continue to the southeast.

(11 - W.S.W. Kew, op. cit.

The Pico strata themselves are highly deformed, being thrown into steep dips, which approach the vertical and are even overturned at two exposures. The presence of one fault is known from evidence outside of the mapped area to the east. The steepest dips and overturning are inferred to mark the location of this break.

The limited exposures of Pico strata in Placerita Canyon and Hidden Valley show only a homoclinal dip to the northwest.

The Saugus formation is, in most places, flat lying, but it has been bent into very small folds at several localities, and has been extensively deformed by drag within the zone of the San Gabriel fault. An area of divergent dip and strike in Section 13 may be due to mass movements.

Faults

One small fault is exposed on the southern side of Plum Canyon, where it cuts Modelo strata. The fault plane is vertical, and the dislocation is a matter of only about fifteen feet. This fault continues across the canyon in a direction slightly west of north, as can be shown by the juxtaposition of Mint Canyon and Modelo strata.

The presenc of a second fault, probably of similar attitude, is inferred a thousand feet farther up the canyon, where the Modelo strat abruptly disappear. Both of these faults vanish where Saugus beds are encountered, and probably represent pre-Saugus movements.

Five minor breaks are recognizable in the Corner Canyon area, each offsetting the Saugus-Mint Canyon contact a few tens of feet. The latest movement along these faults is therefore post-Saugus in age. Three of these breaks trend nearly east, whereas the other two strike more north of east. In all places these faults are present in very poor exposures, and their exact attitudes cannot be obtained.

By extension of positive evidence from points east of the mapped area, at least one fault is known to cut the Pico strata near the northern edge of Section 29. This fault is responsible for the overturning of the beds, a characteristic present to the east as well. Certain increases in dip of the Pico strata north and south of the supposed location of this fault permit the very tentative insertion of two other faults, as shown in Section A-A of Plate III. The existence of these faults is not wholly demonstrable, but the presence of vertical or steeply-dipping strata seems best explained by a fault, as no tight folds are known to exist in the mapped area. The known fault trends slightly north of west. Drag shows that the northern side moved downward relative to the southerly side.

The major structural feature of the area is the San Gabriel fault, which cuts across the southern portion of the map. The fault trace trends slightly north of west. The fault plane is apparently essentially vertical, as evidenced by the lack of control exerted by topography on the trace. Although the San Gabriel is reported to be essentially a strike-slip fault, drag indicates that during the last phase of dislocation, the northern block moved relatively upward. The magnitude of this movement is not determinable within the area, but is probably in excess of one hundred feet, and may be as great as several hundreds of feet.

Evidence for the fault trace includes the abrupt termination of the Banded Saugus gray-beds; the steepening of strata in drag to the trace of the fault, and then their gentling to horizontal again in the other block; and the presence of such features as fault-line valleys, a fault-line scarp, minor sag areas, and springs. These features are further discussed in the section on geomorphology.

A major subsidiary of the San Gabriel fault has been postulated to the north, in the western part of the area. This is based on the evidence of topographic features and the local steepening of the strata, suggesting further drag effects not related to the San Gabriel fault itself. Once in the center of Soledad Canyon, it is thought that this fault bends southward to parallel the San Gabriel fault, as suggested by the strike of Saugus strata supposedly affected by drag forces north of the canyon.

The presence of another minor break subsidiary to the San Gabriel fault is clearly indicated by fault-line topography in the extreme western part of the area.

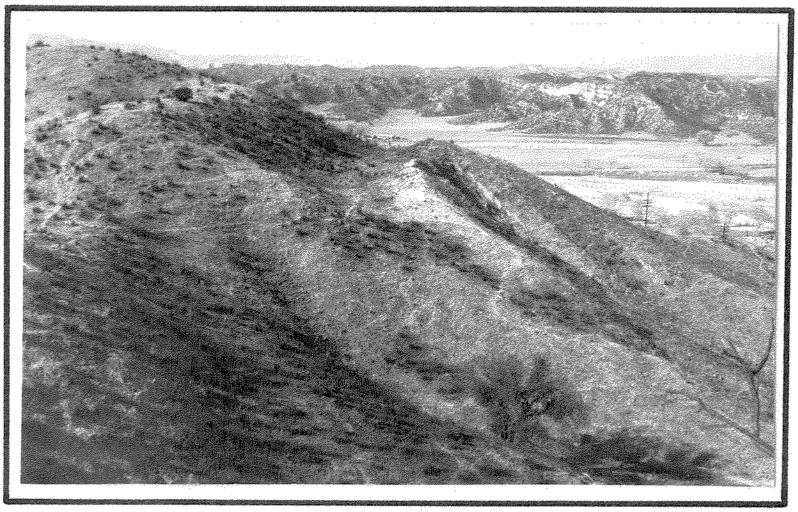


Figure 7 - Fault-line trough of a spur of the San Gabriel fault at the point Sec. 23 (04-66) south of the Santa Clara River.

Here, an anomalous topographic trough, apparently formed by differential weathering along a fault trace, cuts across one flank of a small hill, as shown in Figure 7.

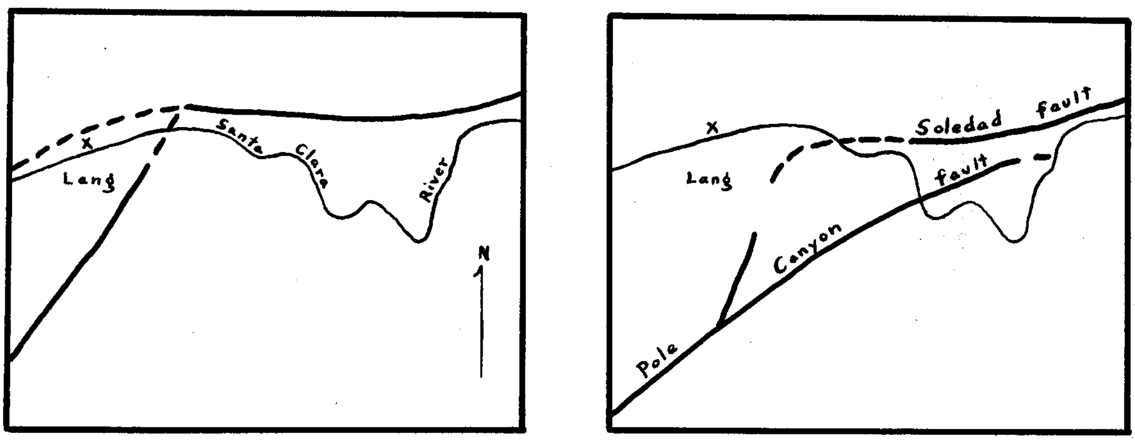
Lack of outcrops prevents a positive location of the westernmost half mile of the San Gabriel fault trace. The indicated bend to the south, shown on the map, is strongly suggested by the change in strike of the Saugus strata as exposed in cuts along the railroad north of the fault. This interpretation is further supported by evidence afforded by changes in soil color, and color banding as seen from an airplane flying over the area.

The Soledad Fault Problem

On his geologic map, Kew (12 shows a fault (the Soledad fault) trending in a westerly direction down Soledad Canyon to a point just east of the village of Lang. From this spot further prolongation is by a dotted line, indicating concealment of the fault trace. He mapped a second fault, the Pole Canyon fault, extending in a southwesterly direction from the westernmost exposure of the Soledad Canyon fault, as shown in Figure 8A.

(12 - W.S.W. Kew, op. cit.

As a result of later study, Oakeshott [13] showed that the Soledad fault actually curves south to trend almost normal to its orientation further east. It supposedly intersects the Pole Canyon fault, which would have an almost asymptotic relation to the more easterly portion of the Soledad break. These relations are shown in Figure 8B. By this means Oakeshott made it possible for the Pole Canyon fault to take up all of the movement that occurred along the Soledad Canyon fault further east.



A. B.

Figure 8 - Relations between the Soledad and Pole Canyon faults as mapped by Kew (A) and by Oakeshott (B).

This interpretation has been received with some reservations by Jahns and others, who still wonder whether the Soledad fault might not actually extend westward along Soledad Canyon beyond its last exposure.

(13 - G.B. Oakeshott, 33rd Report of the State Mineralogist, Calif. Jour. Mines & Geol., pp 215-249, 1937

The area under discussion in this paper did not yield conclusive evidence in either direction. However, it is estimated that a minimum of 1,500 feet of Pico strata are present immediately south of Soledad Canyon in Sections 20 and 29, whereas there are no recognized members of the Pico formation present north of the canyon, less than 3,000 feet away. Lensing sufficiently sharp to remove such a thickness of strata in this short distance does not appear credible under the conditions of deposition that supposedly existed during Pico time. Neither is post-Pico channeling an acceptable explanation, in view of the absence of any record of other than small-scale channeling elsewhere. The most logical interpretation of the disappearance of the Pico beds is by post-Pico, pre-Saugus faulting.

The exact location of a hypothetical extension of the Soledad fault is indeterminate, owing to cover by Saugus beds or alluvial debris. It is possible that some of tha variations in dip in Sections 20 and 29 may be due to drag along such a fault. Furthermore, the pattern formed by the subsidiary breaks on the north side of the San Gabriel fault suggests that they may be link faults between the San Gabriel and another major fault lying slightly to the north and converging with it westward. This may or may not be a continuation of the Soledad fault.

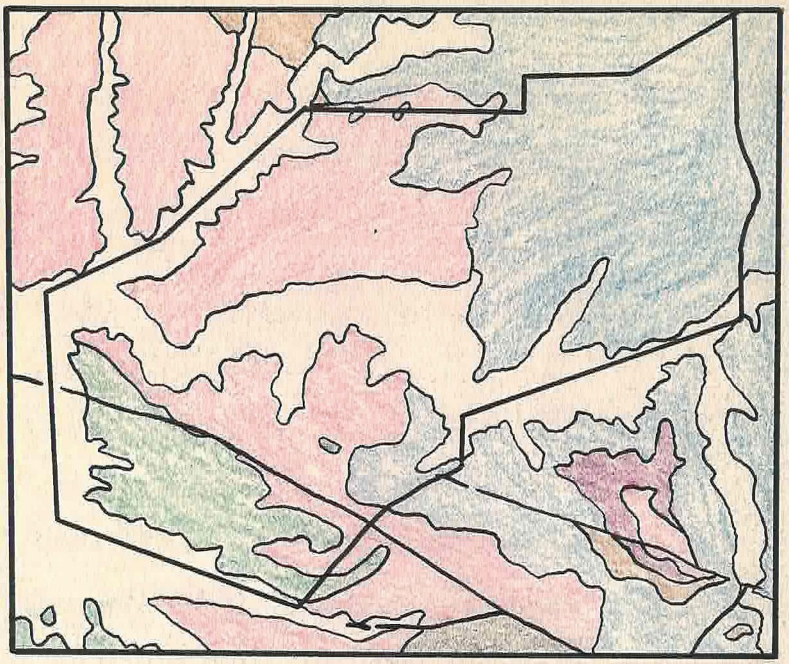
COMPARISON WITH MAP OF W.S.W. KEW

Although the present map agrees in general with that made by Kew during the period 1917-1919, (14 there are several disagreements in detail, as shown in Plate IV.

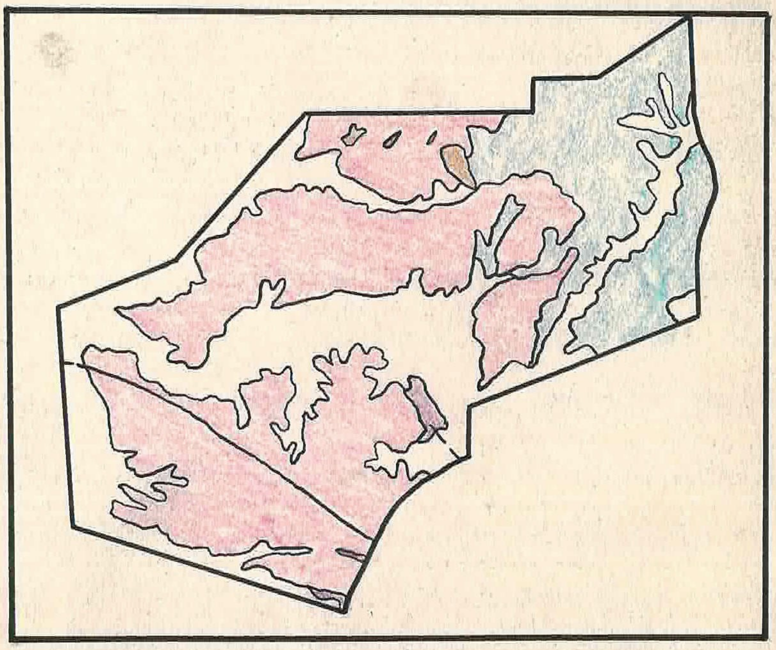
The contact between the Saugus and Mint Canyon formations appears to have a much more intricate pattern than that shown by Kew, and the Saugus strata extend farther southeast. There can be little doubt concerning this extension, as the angular unconformity is distinctly visible in numerous cliffs along Corner Canyon and its tributaries as well as in one locality overlooking Mint Canyon. The change in color between the brown Saugus and the gray Mint Canyon strata shows on the slopes even where good outcrops do not exist.

Both lithologic and paleontologic evidence demonstrate the presence of a large patch of Modelo strata crossing Plum Canyon. Detailed mapping of the trace of the Mint Canyon-Saugus unconformity shows that the Mint Canyon beds do not extend as far west in Plum Canyon as shown on Kew's map.

(14 - W.S.W. Kew, op. cit.



A.



B.

Terrace gravels — Saugus fm. — Pico fm.

Modelo fm. — Mint Canyon fm. — "Basement complex"

Plate IV. A comparison between the geologic map of Kew in U.S.G.S. Bulletin 753 (A), and the geologic map of this report (B).

Continuous exposures from the area mapped by Jahns to the north, where unquestionable Modelo strata are clearly exposed, make it certain that the small patches of a formation underlying the Saugus and exposed in valleys cutting the divide between Plum and Bouquet Canyons, is Modelo and not Mint Canyon, as shown by Kew.

Fossils, lithology, and evidence from exposures east of the area mapped, make it certain that the strata exposed in the Soledad anticline are Pico rather than Mint Canyon. However, Mint Canyon beds probably are exposed immediately east of the edge of the map.

Kew's interpretation of the strata exposed south of the San Gabriel fault and east of Placerita Flats as Quaternary terrace deposits seems open to question. Almost every exposure in this area shows light brown to tan, well bedded sands and gravels that are not at all characteristic of the undoubted terrace deposits. Such terrace deposits include both those north of Soledad Canyon, and those overlying the questionable terrace deposit on the divide overlooking the Bermite Powder Company plant. Kew may well have interpreted the Saugus-Pico contact as one between terrace deposits and Saugus strata.

Disagreements in the location of the boundary of the alluvial deposits are insignificant, owing to the great disparity in the scales of the two maps. Likewise, the minor faults and folds shown on the present map would not be shown on one of much smaller scale. The trace of the San Gabriel fault has been changed slightly on the basis of lines of evidence, which, although not positive, are thought to be sufficiently sure to warrant such alterations.

GEOMORPHOLOGY

The region considered in this paper holds special interest for the geomorphologist. There is a large assemblage of the erosional and depositional features common to landscapes in semi-arid regions underlain by poorly-consolidated rocks. The value of geomorphic study in this area is increased by the fact that features of several geomorphic cycles are present. This complexity is in itself worthy of study, but the limitations of working time made it possible only to recognize and describe some of the more obvious geomorphic features without giving due consideration to their origin, or to the history that they reveal. It is expected that the paper being prepared by Shoemaker will elaborate upon the omissions of this study.

Soils

Mature soil is lacking from a large part of the area mapped. On the steep, youthful slopes, at angles as great as 45°, rainwash, rillwash and creep carry off all of the fine material as fast as it is loosed by the disintegration of the bedrock. This leaves an accumulation of coarse lag gravels on the ridge tops, and a thin veneer of gravels in transit down the slopes. The few low-angled mature slopes remaining from a previous cycle of erosion exhibit some soil development, as do the various stream terraces. The parts of the alluvial stream bottoms well removed from the main channels have a covering of sandy silt overlying the older stream gravels. In all places the characteristics of the soil reflect the local variations in the sandy, silty, or conglomeratic composition of the underlying bedrock.

Youthful calcareous caliche is present in most of the soils underlying remnants of mature surfaces, and in the upper portions of fine-grained bedrock underlying more youthful surfaces in many localities. This caliche is present as stringers, thin layers, and small masses scattered throughout the soils, and is especially abundant along joints or fractures, such as the deeply-cut, anastomosing desiccation cracks common in fine-grained debris. The caliche is also common along planes of higher permeability in the upper parts of the bedrock beneath the mature surfaces. This is especially true for fine-grained siltstones and sandy shales.

An occurrence of caliche unique for this area was found at the junction of two headwater tributaries of Corner Canyon at the point Sec. 10 (25-04). Here a small outcrop of a coarse boulder conglomerate of the Mint Canyon formation is entirely cemented by a porous caliche, or travertine deposit. It is thought that this occurrence marks the location where a lime-rich spring at one time bubbled to the surface, removing some of the fines from the bedrock, and filling the resulting spaces with a calcareous deposit.

Weathering Features

Examples of cavernous weathering are present on a few cliff faces. The most outstanding of these are on a southerly-facing cliff of the Pico formation south of Soledad Canyon at the point Sec. 29 (65-84). The sheer cliff slopes at an oblique angle to the direction of dip of the near-vertical beds, but at a greater inclination, thus truncating the strata at an acute angle in both plan and vertical section. The strata are also broken by two joint planes inclined at a moderate angle in the opposite direction.

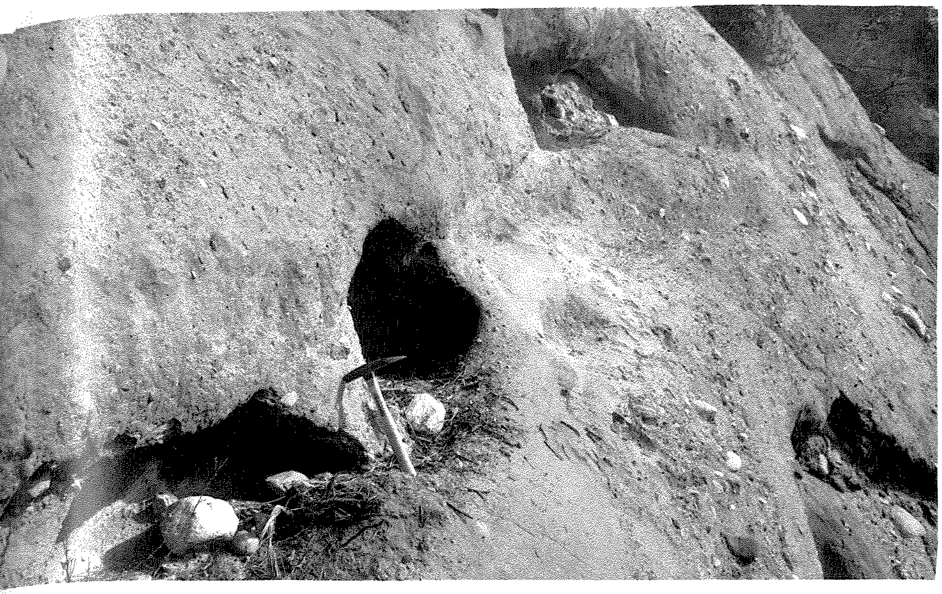
The processes of weathering, such as solution of cementing material, raindrop impact, and freezing and thawing, first opened small recesses on the cliff face at the intersections of joint planes and bedding planes. The initial openings were then enlarged, and some of them coalesced along stratigraphic horizons especially susceptible to disintegration. Most of these weak zones are composed of coarser grains than the average surrounding material. However, some factor such as degree and strength of cementation exerted more control as mere grain size, as the openings are localized within certain zones in a stratum composed of particles of only one order of size.

Photograph A in Plate V shows that the floors of these cavities slope either at the steep gradient of the dipping strata, or the more gentle angle formed by the intersection of the controlling joints with the cliff face. In every place, however, there is ample opportunity for wind-driven rainwater or seeping groundwater to run out at the lower ends in as much as there is no raised sill. Debris formed by the disintegration of the bedrock may thus be removed. Miniature spillways at the lower sides of the cavities show that this has happened.

Enlargement of the openings has proceeded upward as well as inward and sideward, so that in some places a large excavation lies behind the more resistant rock of the cliff face, and is reached by a relatively small opening, as suggested in photograph B of Plate V. This outer face may be more resistant owing to greater original cementation, or its strength may have been increased by the secondary cementation provided by a process of case hardening.

It is thought that groundwater percolating through the rocks has been of prime importance in bringing about their disintegration both by its own active cutting, and by promoting chemical weathering of susceptible parts of the rock. This water is probably present only after moderate to heavy rains, and undoubtedly enters the rock from points not far distant on the ridge above. As this moisture percolates through the bedrock it leaches out the cement at points of greatest inherent permeability. The pebbles and grains of sand thus loosened are removed by gravity, groundwater, and rainwash. Larger pebbles and cobbles are loosened by the removal of supporting sand grains until they fall free and roll out of the openings at the lower end. It is not apparent that wind has produced any great effect in the formation of the cavities at this location. Pack rats have used some of the deeper openings as burrows, and may have aided in the removal of debris to a slight degree.

Two small openings are present in a northerly-facing cliff bordering the San Gabriel fault farther west. These recesses developed in a conglomeratic sandstone of the Saugus formation, and are also localized along a joint plane. However, the stratification of this bedrock is too coarse to control the shape of the cavern. Here also it is believed that the removal of cement by groundwater is the main process by which the



Photograph A

Photograph B

Plate V. Cavernous weathering of Pico strata at the point Sec. 29 (65-84).

disintegration of the bedrock proceeds. However, wind action is of prime importance in the removal of the resulting debris. These openings have cup-shaped floors, the lowest portions of which are two to three inches below the outer sill. There are no spillways by which the accumulated water could escape with any load of detrital material.

At the time of observation, a strong wind was blowing almost directly against the cliff face. Turbulence was set up within the two recesses, the fine debris was swirled about, and some was being blown out of the cavities. This moving debris also must have contributed to the enlargement of the openings by active corrasion, as indicated by absence of weathering scales on the walls and roof. No animals inhabited these caverns.

In various places throughout the area, there are limited regions of badland topography formed by the intricate dissection of fine-grained sedimentary strata. Numerous earth pillars are displayed. This also has occurred in coarser-grained rocks, but to a more limited extent. The resulting forms are well shown in a small, vertical-walled, steeply-sloping gully that has been cut into the side of a tributary to Hidden Valley at the point Sec. 31 (19-78). At this locality the bedrock is a coarse cobble-conglomerate of the Saugus formation. Many "earth" pillars have been isolated by erosion, but no pedestal rocks could be found. The lack of such pedestals appears noteworthy. Although the uneven grain necessary for the formation of pedestal rocks is present, some other important factor is lacking. There seems to be no doubt that these features were formed by water moving either along the surface of the ground, or seeping from subsurface channelways of minute dimensions. The wind appears to have had no part in their formation, and the rock appears to be too well cemented to be greatly affected by raindrop impact.

Mass Movements [15]

Although considered by many workers to be a very minor agent in the formation of landscapes, mass movements occupy a position of considerable importance in the Ventura Basin. These dislocations of the earth's surface disrupt drainage, lower total relief, and increase local inequalities of the surface to a marked degree.

Mass movements of several types occur within the area mapped, and are of all age from those virtually obliterated by dissecting gullies, to slumps which have taken place within the past decade. The most common of these movements is soil creep, which is active on all of the steeper slopes. This process is the slow transfer of

(15 - The terminology employed in this section is based on that outlined by C.F.S. Sharpe in Landslides and Related Phenomena, Columbia U. Press, New York, 1938.

soil and rock particles down slope under the influence of gravity, with the aid of lubrication by rainwash and groundwater.

A most noteworthy area of soil creep lies along the southern side of the railroad in the south-central part of Section 20. Here a steep, northward-facing slope, originally covered with a thick growth of vegetation, has been denuded by a recent brush fire which destroyed the root network that held the soil cover in place. As a result, the entire soil cover has begun to creep downhill, forming a surface with innumerable small wrinkles and discontinuous hummocks.

Among other types of mass movements, are all gradations from slumps to earthflows. Composite earthflow-slump areas are especially numerous around the northwesterly-plunging nose of the Soledad anticline in Sections 19 and 30. In general, each zone of movement can be divided into an upper part that has slumped along definite planes of movement, and a lower part within which the earth and bedrock material have actually flowed downslope in a disorganized manner. The zone of slump is characterized by nearly vertical breakaway scarps, many of which are discontinuous, and sections of the original land surface which have dropped down intact along these scarps to various levels and now lie at various attitudes. In some localities, miniature horsts and grabens have been developed by the differential movements of the separate blocks. The zone of flowage forms a complex terrain characterized by a lobate outline, the interior of which is broken into innumerable hummocks and closed basins. Small gullies cut into the pre-movement surface have been interrupted and dislocated in a very complex manner.

Because this zone of concentrated mass movement roughly parallels the curve of the Saugus beds around the nose of the Soledad anticline, it is assumed that a horizon especially susceptible to deformation by sliding is present. The strata which are visible in the slump areas are fine-grained silts and sands, but it is likely that the principal horizon of weakness lies under these strata and is not visible in the slump scarps.

The weakness of the strata and their susceptibility to movement are enhanced by a localization of groundwater near the surface. A well and springhouse lie in the small valley in the southeastern corner of Section 19, and a small reservoir has been constructed further up the same valley in the northeastern corner of Section 30. This reservoir appears to maintain a constant level of water without benefit of pumping. Moisture-loving vegetation in many of the valleyheads within the arc of mass movements indicates concentrations of water at all of these points.

The source of this water, and the reason for its concentration are not known. It may be the result of groundwater rising along the San Gabriel fault zone, as suggested by the presence of one running spring at the point Sec. 30 (48-26), and thence moving northward along the inclined Saugus strata to appear in the lower valleys.

The best example of slump without attendant earthflow occurs in the headwater region of a tributary of Corner Canyon in the southwest corner of Section 9. Both flanks of the valley have been affected. On the eastern side, a block of ground four hundred feet wide and a thousand feet long as measured parallel to the stream course has slumped as a single unit. The vertical displacement was about twenty feet at the scarp.

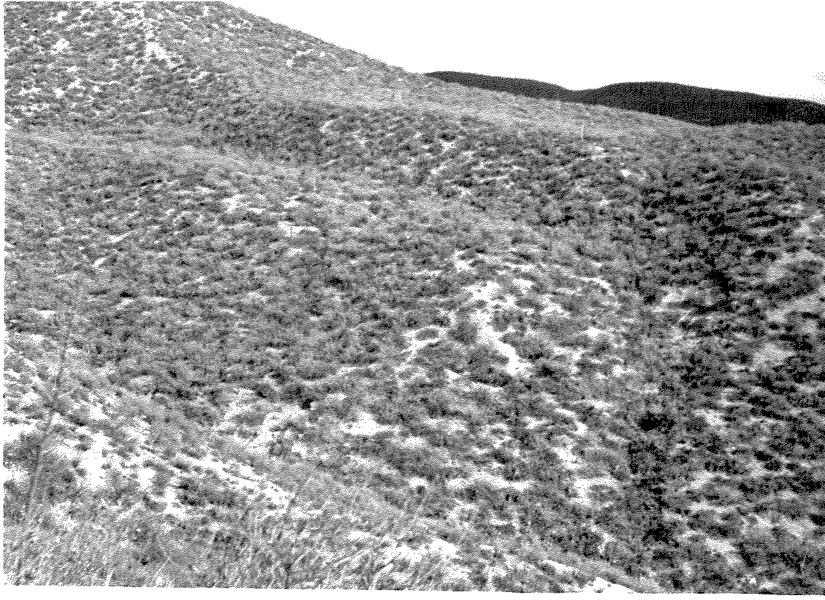
Directly opposite, on the western side of the valley, a similar area also suffered dislocation. However, this sector broke into a number of minor slices and blocks, each of which moved on its own slip plane to a degree different from the adjacent blocks. The resulting terrain is broken by numerous scarps and tension cracks.

Plate VI. Slump phenomena in Section 9.

Photograph A shows a single slump unit on the eastern side of the valley. The one break-away scarp is clearly discernable. The upper, nearly-horizontal surface is an old erosion surface unconnected with the slumping.

Photograph B shows the surface of the single slump unit in the foreground, a sector of multiple slumping in the left rear, and an old planated slump to the right rear

Photograph C shows the detail of features on the western side of the valley.



Photograph A

Plate VI. Slump phenomena in Section 9.

Photograph B

Photograph C

Upstream, on the same side of the valley, is a flat area that probably represents the surface of an older slump. It has been considerably modified by subsequent stream dissection. The photographs of Plate VI illustrate the features of this general area of slump.

A mudflow differs from an earthflow in that the moving mass of debris contains more water, and consequently moves at a faster rate, and possibly down inclines of less slope. The resulting form is also slightly different, closely resembling the bulbous snout of a viscous lava flow. Only one recognizable mudflow form was seen within the area mapped. This flow lies near the transmission line in the west-central portion of Section 30. The side of a small hill evidently became saturated with water, which formed mud from the fine-grained Saugus sediments present there. The resulting fluid material flowed down the adjacent stream valley for several hundred feet.

Multiple small-scale slumps known as sheeptracks or terracettes, are present on the steeper slopes that have only a sparse cover of vegetation and are underlain by fine-grained rocks or debris. This form is especially well represented over the southwestern part of the area. The form is dependent on bedrock structure only in as much as that structure brings favorable horizons to the surface.

Minor Erosional Features

The region immediately west of the Saugus-Pico contact in the southwestern corner of Section 20 is underlain by fine-grained debris and bedrock that are very susceptible to small-scale gullying. A typical vertical-sided barranca has been incised into the gently-curved floor of the main valley. Upstream are tributary barrancas, or gullies, also with vertical sides and vertical headwalls, as illustrated by Figure 9. Further upstream, the sod-covered valley floor acts as the bed of the stream.

Figure 9 - Gullying in the southwest corner of Section 20.

The steep headwalls of these minor gullies may have been cut primarily by the turbulence created at the bottom of the small waterfalls from the sod-covered upper channel. Such action is of course possible only after heavy rains have formed flowing streams. A more continuous process that aids the formation of these sharp breaks is the slow sapping accomplished by groundwater where it seeps out of the soil into the deeper channels.

Of interest in the same area are small features that might be termed perched gullies. Three of these are visible in Figure 9. In general, the floors of the minor valleys are covered by a smooth, unbroken sod. In some places, however, this sod cover has been broken by any of several means, including animal burrows, stock trails, and slumping. The break has permitted surface water to cut actively into the underlying soil, and a gully is quickly developed by headward cutting. Such a minor gully is completely isolated from the integrated gully system eating headward from the main valley barranca. A small alluvial fan or cone built of the debris formed from the headward cutting often bases these gullies.

Also of note in this area are the miniature natural bridges and subterranean channelways formed where minor, intermittent brooklets flow under the sod cover for short distances. Some of these channels are undoubtedly localized by the presence of animal burrows, whereas others probably owe their origin to the formation of a passageway by desiccation cracking.

Box or steephead canyons have been formed on a small scale at scattered points throughout the area. One of these has been mentioned in connection with "earth" pillars. Several others occur along the base of Puckett Mesa in Sections 3 and 10. Figure 10 illustrates the scalloping of the edge of the mesa by coalescing steepheads.

Figure 10 - Scalloped edge of Puckett Mesa.

In some places it can be clearly demonstrated that these box canyons are essentially plunge-pool features cut by running water dropping over the rim of a cliff or steep slope. In others, however, it is just as clear that no water whatsoever flowed over the rim, and the steep face is due to sapping of its lower portions by groundwater.

A typical saw-cut valley in miniature lies on the northern side of Hidden Valley just west of the main highway. Rainwater was concentrated in the rut of an old road. The downcutting was localized and proceeded rapidly through the soft sediments. Lateral cutting was virtually non-existant, so that the resulting gully is essentially the width of the stream which cut it, eight to twelve inches, yet several feet deep.

<u>Streams and Valleys</u>

Streams of several types occur within the area. The courses of most of them show no apparent relation to any discernable bedrock structure, and may therefore be termed insequent.

Many subsequent streams have developed their valleys by working headward along the strike of easily-eroded strata, leaving the more resistant rock as ridges. The outstanding examples of this type of stream are found in the region immediately north of the San Gabriel fault, where the Banded Saugus has been bent into steep dips by drag. Many streams working headward from the Santa Clara River have cut valleys along zones underlain by the softer brown beds. The resistant gray horizons are thus left in relief to form hogbacks. Not every brown layer has been thus singled out, but certain weaker or thicker ones have been etched out by stream action.

Where underlain by rocks of the Saugus formation, Plum Canyon is essentially a subsequent valley. Further east, its course lies down the dip of the Mint Canyon strata, forming a pseudo-consequent stream.

Minor obsequent and resequent gullies are cut on hogbacks along the San Gabriel fault zone. Equally minor streams that flow over the surface of their own alluvial fan or cone are of the autoconsequent type.

The phenomenon of monoclinal shifting characterizes the subsequent streams in the area. Because the stream can cut its valley deeper most easily in the belt of weak strata, it tends to shift its course down the dip of such favorable horizons, and away from the more resistant rocks directly below its channel. This movement results in the development of a comparatively steep valley wall toward which the stream is shifting, and a more gentle dip-slope wall on the opposite side.

Evidence of monoclinal shifting, and the resultant valley cross-section, are exceedingly well displayed in the western half of Plum Canyon, illustrated in Figure 11. The gently-sloping northern side of the valley is a dip-slope down which the stream has shifted its course as it degraded the valley floor. It is probable that this valley center has shifted as much as 3,000 feet to the south.

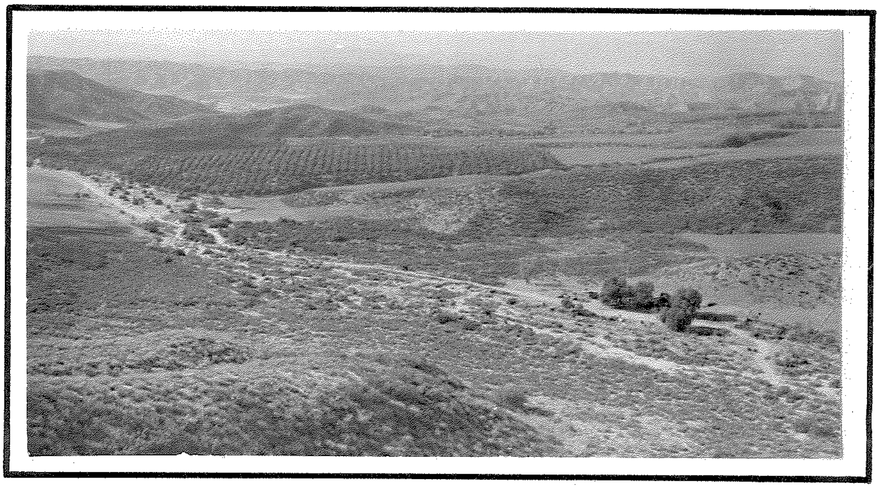


Figure 11 - View west in Plum Canyon, showing the northern side dip-slope resulting from a monoclinal shifting towards the south.

Stream Piracy

Stream piracy has been common within the boundaries of the area mapped. Examples of three major types of capture are recognizable.

Capture by headward working, the classical method of stream piracy, is well shown at many points.

The major tributary of the valley occupied by the Bermite Powder Company in the southeastern corner of Section 23, had a short course to the Santa Clara River. It was able to work rapidly headward into the soft Saugus sediments south of the San Gabriel fault. Not long ago, even by human time standards, this valley intersected the shallow, mature valley of a stream which flowed some distance westward to Placerita Flats. The headwaters of this latter stream were then captured.

Capture by the lateral planation of a major stream, known as intercision, is imminent at two localities along Placerita Canyon near the point of abrupt change in direction into Placerita Flats. Here, the northern side of the canyon has worked progressively further north as the creek actively impinges against this slope. The result has been to practically destroy the divide between Placerita Creek and a small creek running parallel to it and slightly to the north. Intercision is imminent along this divide in Section 35 at the points (48-90) and (63-73). In the latter locality, the capture of the minor stream is being aided by its own lateral cutting on a bend convex to Placerita Canyon.

Autopiracy, in which a tributary of the original main stream captures the headwaters of its parent, has taken place south of the San Gabriel fault zone and along it in Sections 25 and 30. The major stream, which is a tributary of Hidden Valley, originally had a long headwater reach oriented in a nearly east-west direction, and extending north of the fault zone. A small tributary worked headward from this stream, and entered the fault zone where its erosive power became considerably greater than that of the headwater portion of the main stream. This increase in power may have been due to the intersection of a large source of groundwater along the fault zone, or to the superposition of the main stream on more resistant strata. In any case, the small tributary was able to extend itself rapidly eastward along the fault zone until it intersected the headwaters of the parent stream, as shown in Figure 12. The captor then

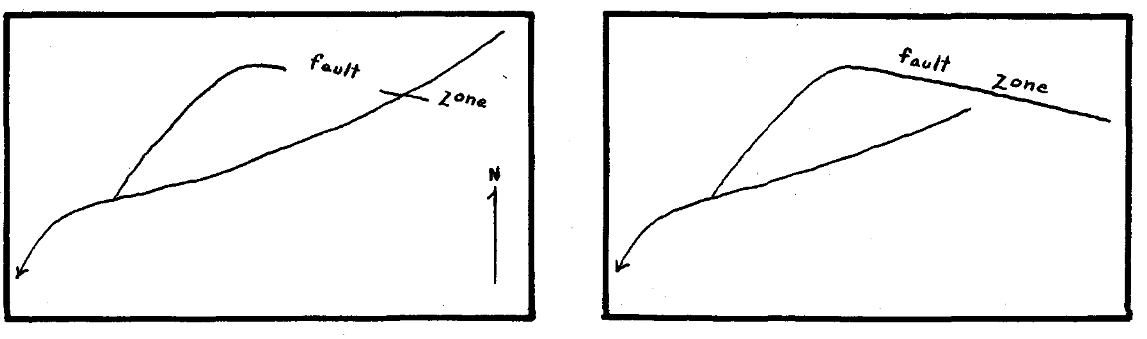


Figure 12 - Diagram of autopiratic stream capture along the San Gabriel fault zone.

continued to work eastward, becoming much more powerful than its beheaded parent by finding more sources of water along the fault zone. It was thus able to cut its valley considerably below the level of the beheaded parent stream, even at their point of intersection. Since then, rejuvenation has begun to work headward along the parent valley, forming a two-cycle valley where the steep-sided youthful gully has been incised into the older, broadly mature valley floor (see Figure 13).

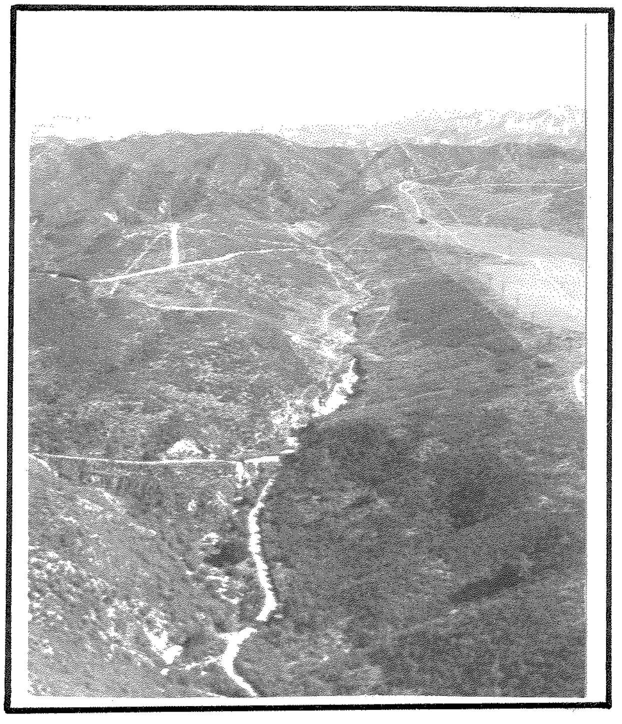


Figure 13 - Two-cycle valley of rejuvenation in Sections 25 and 30.

Although no actual stream capture in the usual sense has taken place, the monoclinal shifting of Plum Canyon has removed the headwater basins of several streams that drain southward into Soledad Canyon. The beheaded valleys of these streams, one of which is clearly visible in Figure 14, are clear evidence of the history of that region.

Figure 14 - Beheaded valley south of Plum Canyon. Dip-slope plane of monoclinal shifting is visible in the foreground.

A shifting of drainage by the process of basin filling has occurred or is imminent at several localities. The best example of this process is in Section 29 at the point (75-80). Debris from the cliffs of the Pico formation has entirely filled the larger valley-basin to the south, so that the divide on its northern side has been topped by the alluvium in one spot, shown in Figure 15. Continuance of the cliff erosion and aggradation of the basin will result in the movement of water and debris across the divide at this spot, instead of around the end of the spur farther east. This process of basin filling is notably active along the eastern side of the large valley in the western portion of Section 19.

Drainage lines have also been shifted, sometimes to a radical degree, by the numerous slumps and earthflows occurring throughout Sections 19 and 30. In many places, former stream valleys now stand high and dry, cut off at each end by slump scarps, or blocked by earthflow debris.

Figure 15 - Basin fill topping spur divide in Section 29.

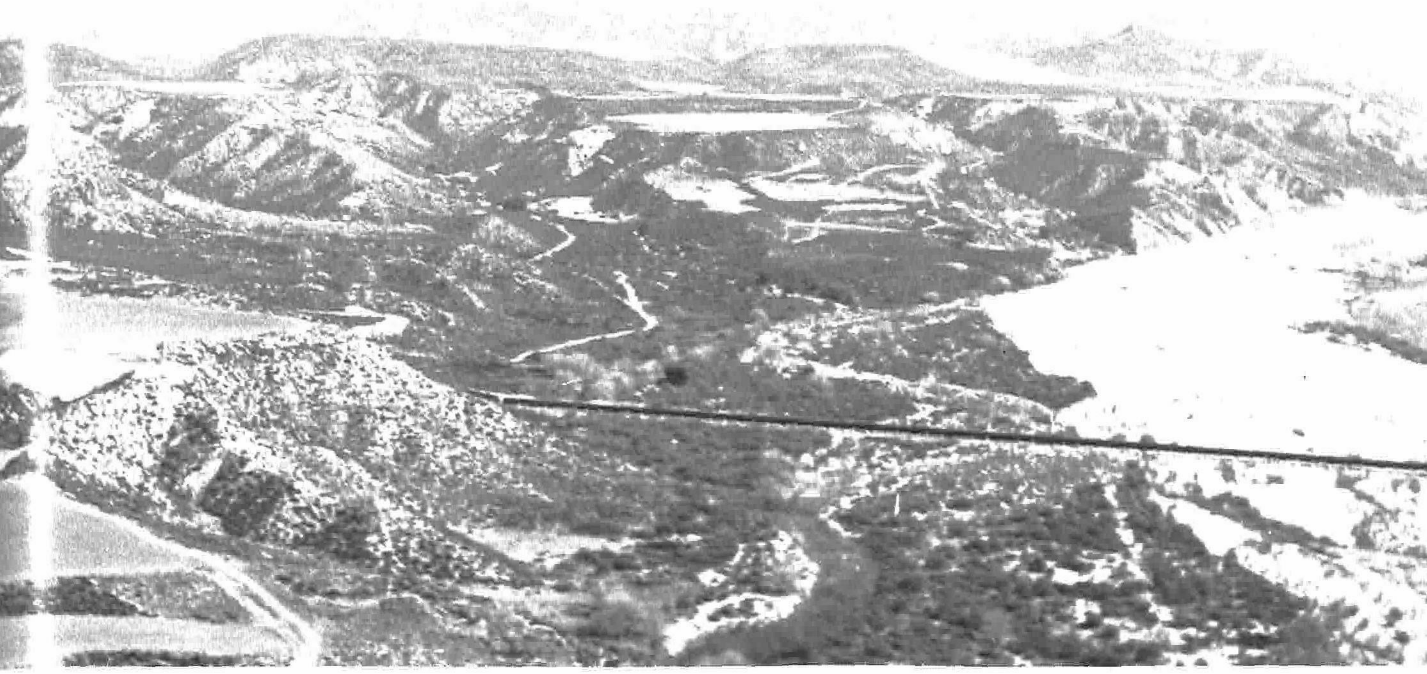
Stream Terraces

As shown in the photographs of Plate VII, outstanding topographical features of the area are the stream-cut surfaces that occur singly or in groups along the northern side of Soledad Canyon. These are the remnants of ancient flood plains of the Santa Clara River, which were later dissected by further downcutting. As such they may be designated by the term berm as proposed by Bascom. (16 Likewise, if it considered that the inter-bench risers were cut during rejuvenation of the river. Bucher's term strath terrace (17 could be applied. However, it is thought that at least the majority of these features were dependent for their distribution simply on the lateral swinging of the river from one side of its valley to the other during relatively continuous degradation. This is not rejuvenation in the usual sense, and therefore, the term strath is not applicable. In as much as the term berm has not come into general usage, it appears to be an unnecessary complication of the nomenclature, and the term stream terrace seems sufficient.

It is possible that some of these terraces are related to higher stands of the ocean to the west as indicated by marine terraces along the coast. In such an event, renewed downcutting would be caused by rejuvenation by a lowering of sealevel, and might conceivably have been able to work headward from the ocean to the area here under consideration. The term strath would then be applicable. However, there is no means of local discrimination between terraces formed by the two means.

(16 - F. Bascom, Science, Vol. 47, No. 1911, pp 172-3, 19

(17 - W.H. Bucher, Science, Vol. 75, 1935, pp 130-1, 1932



Photograph A

Photograph B

Plate VII. Stream terraces on the northern side of Soledad Canyon, looking toward the east (A), and toward the west (B).

As shown on Plate II, the geomorphic map, some of the largest terraces north of Soledad Canyon may be correlated in time or river-stage groups, indicating that they were cut during nearly if not exactly the same interval of planation. Others, cut by a local swing of the river, bear no close relation to individuals on either side.

A few excellent terraces are also present along the northern side of Placerita Canyon. The relation of these levels to those on the northern side of Soledad Canyon cannot be accurately determined.

Other Topographic Surfaces

Many notable surfaces within the area are not classifiable as stream terraces. Gently sloping surfaces east of Placerita Flats, south of the intersection of Corner Canyon with Soledad Canyon, and along the northern side of Plum Canyon were not completely understood in the brief time available for their examination. The Corner Canyon surfaces are illustrated in Figure 16.

As previously stated, it is probable that the surface north of Plum Canyon represents the dip-slope floor cut on the Saugus formation by the monoclinal shifting of Plum Creek. This explanation is not adequate for the area east of Placerita Flats, where the strata are flat lying, but it may be at least a part of the explanation for the surfaces in the vicinity of Corner Canyon. It is expected that the paper now being prepared by Shoemaker will deal adequately with the genesis of these erosion surfaces.

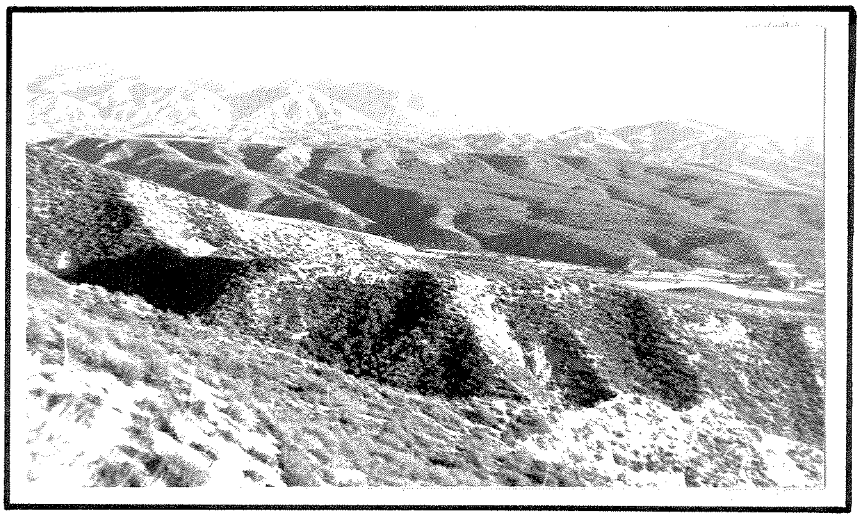


Figure 16 - Dissected sloping surface near Corner Canyon.

Fault Forms

It is not likely that there are any true fault forms within the area mapped, as there has apparently been no recent movement on any of the faults. However, fault-line forms are common along the trace of the San Gabriel fault.

Fault-line valleys have been etched out along the fault zone from the east and from the west in Section 30.

Minor fault-line gullies are recognizable farther to the west. A fault-line scarp, shown in Figure 17, borders the central portion of the fault zone in Section 25. This is an obsequent fault-line scarp, its relief being opposed to that of the last movement along the fault plane. The relief of this scarp is noteworthy, as it is the reverse of that which would normally be expected. To the south of the fault lie relatively weak Brown Saugus strata of relatively fine grain. To the north are the resistant, cliff-building horizons of the Banded Saugus. Yet the resistant strata, which moved relatively upward, now stand topographically lower.

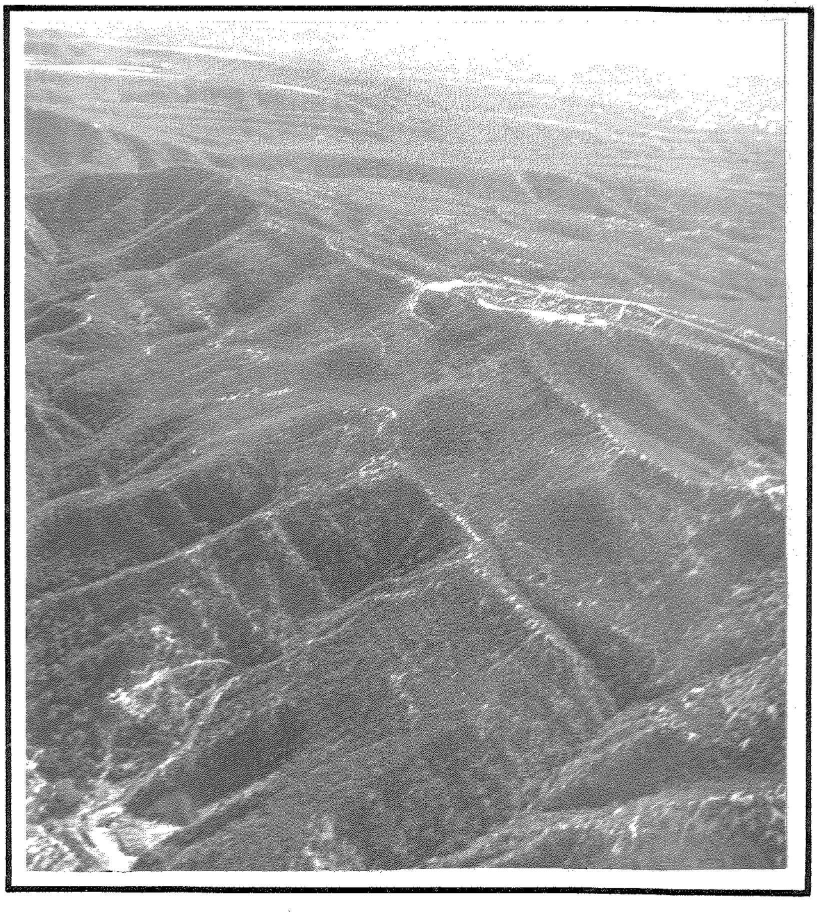


Figure 17 - Obsequent fault-line scarp of the San Gabriel fault. Inclined erosion surface in the background.

Because this relation cannot be directly explained by movement along the fault plane in relatively recent time, it is thought that the relief is due to retardation of erosion of the weaker rocks by their greater permeability. If the rainwater is permitted to sink into a rock rapidly it can produce little erosion, even though the rock may be relatively very weak. Another factor in this instance may be the presence, in at least part of this specific area, of gravels capping the weak Saugus strata. Such a capping will form a protective cover for the bedrock, as noted by Rich in a study of the erosion of arid and semi-arid terrains. (18

(18 - J.L. Rich, Jour. Geol., Vol. XIX, pp 492-506, 1911

GEOLOGIC HISTORY

In Early Tertiary time, perhaps during the latter part of the Eocene epoch, faulting and attendant deformation took place in the area of the present Transverse Ranges of Southern California. The uplift of the ancestral San Gabriel Mountains and the Sierra Pelona to the north left a topographic low, the Ventura Basin, between them. Fanglomerate debris was dumped from the mountain scarps into this basin, accompanied by the extrusion of igneous material to the east. Faulting and folding deformed the resulting strata, which comprise the Vasquez and Tick Canyon formations. (19 They are now exposed east and north of the area mapped.

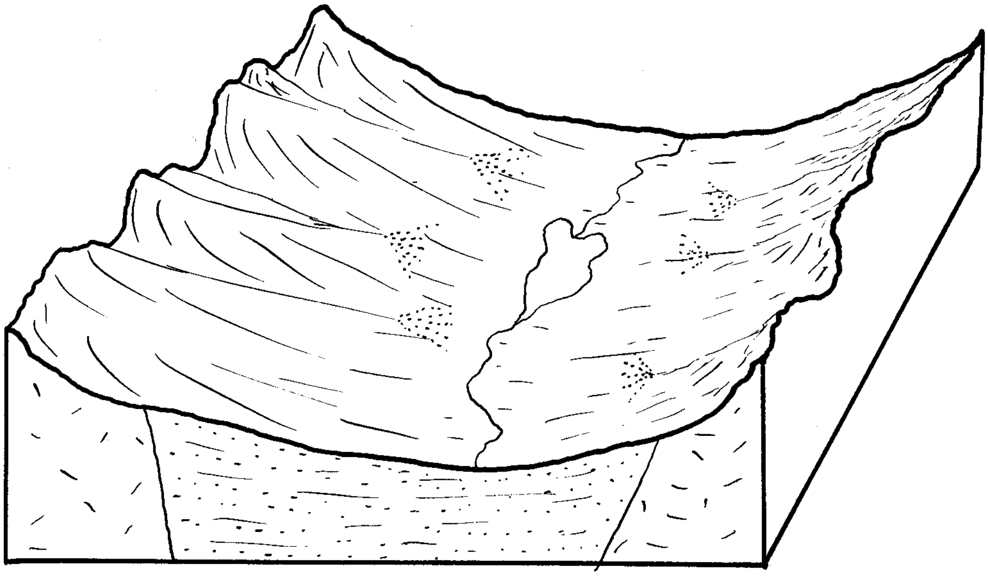
Continued supplies of debris from the mountain masses formed fanglomerates and finer sedimentary rocks of the Mint Canyon formation, probably in middle Upper Miocene time. The basin floor was occupied by local ephemeral lakes subject to rapid filling by the shifting bajada slopes. Volcanic debris from sources outside the area settled to form tuffs and tufaceous sandstones. The climate was probably semi-arid, although some vegetation existed, as shown by the presence of fossil herbivores.

(19 - R.H. Jahns, op. cit.

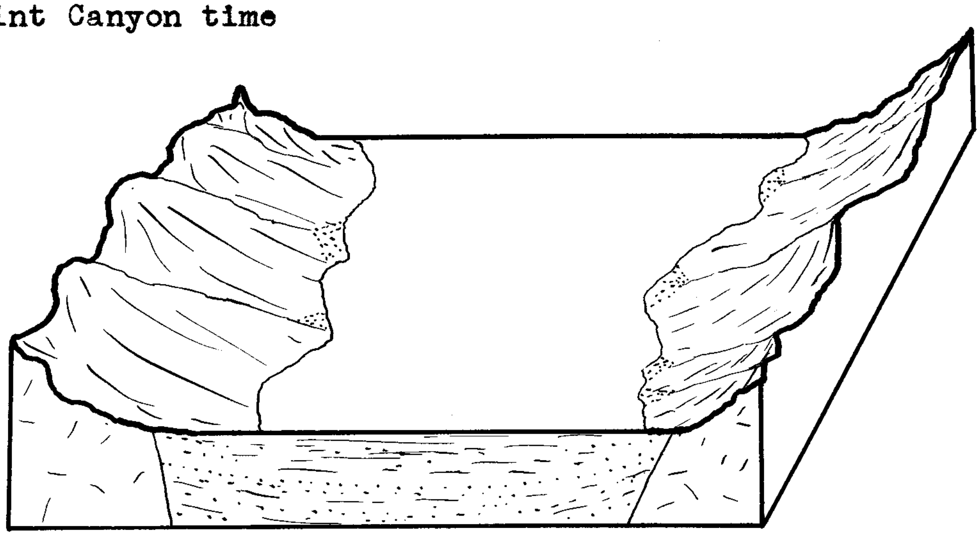
As Upper Miocene time progressed there was a lowering of the basin floor and consequent invasion by marine waters. There may have been some deformation of the Mint Canyon strata before this relative lowering of sealevel. However, such a movement would in itself effect rejuvenation of the streams, causing downcutting and truncation of strata that already possessed the primary dip of the bajada slopes.

It is possible that the entire region underwent tectonic lowering to a certain extent, as the fine-grained sediments of the subsequent Modelo formation suggest low relief of the neighboring mountain masses, such as would be expected following the active erosion of Mint Canyon time. In any case, the Modelo embayment or estuary was probably of fairly shallow depth, as indicated by the thick shells of the marine organisms found as fossils.

There is no evidence within the area mapped that bears on events that occurred after the deposition of the Modelo strata and before deposition of the overlying Pico beds. It may be inferred that there was slight uplift of the basin to permit removal of the uppermost Modelo strata, followed by lowering and a second marine invasion. It is certain that there was considerable relief of the mountain borders, so that fanglomeratic debris could be supplied once more, during Lower Pliocene time.



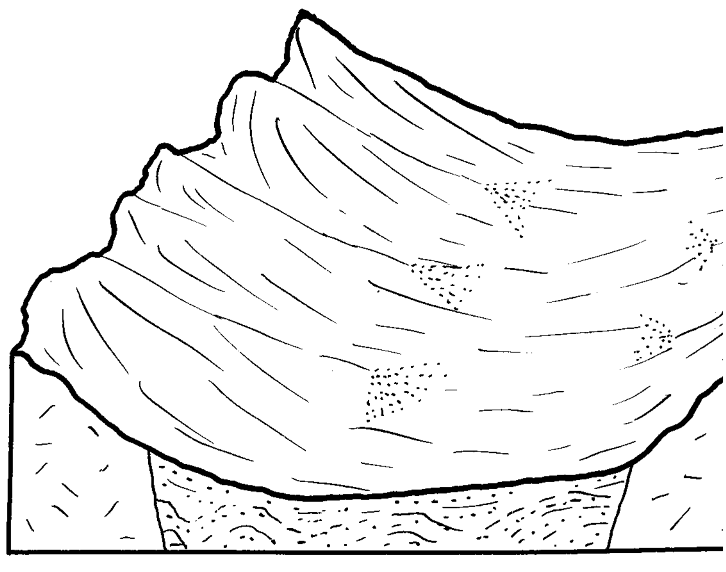
Mint Canyon time



Modelo-Pico time

Plate VIII.

Diagrammatic representations of the landscapes of the major time intervals, looking towards the east.



Saugus time

Again there was uplift, with coincident faulting and folding, and a considerable interval of Pliocene time is without record. In Upper Pliocene time, however, conditions again became favorable for deposition, and fanglomeratic debris from the mountains formed the Saugus strata. Deposition was continuous into the Pleistocene epoch, but was finally brought to a close by minor faulting and folding. The historical sequence is illustrated by the diagrams of Plate VIII.

The remaining portion of Pleistocene and Recent time witnessed numerous minor changes in the topography of the eastern Ventura Basin. Small thickness of terrace gravels overlie the Saugus beds in some localities. It is noteworthy in this connection that such gravels on the Soledad-Placerita divide south of the Bermite Powder Company contain large proportions of schist fragments. The only known source of such material is in the mass of the Sierra Pelona directly to the north, and separated from this locality by the present valleys of Bouquet Canyon and the Santa Clara River. If this is the actual source of the schist pebbles, it means that the course of the Santa Clara River lay to the south, somewhere near the present valley of Placerita Canyon. It is impossible to prove this hypothesis from evidence present within the limited confines of the area mapped.

It may be that some of the major post-Saugus fault movements, such as those along the San Gabriel fault, forced the Santa Clara river to shift its channel northward to its present position in Soledad Canyon.

When the Santa Clara channel first became located in approximately its present position, a mature topography existed. Remnants of this surface can still be found on the higher slopes. As the river cut down in its valley, it swung from side to side, cutting wide floodplains, that were then left as terraces by the next swing of the current. At the same time Plum Canyon was shifting its channel southward along the dip of the Saugus beds. Many other minor changes in landscape were also being effected.

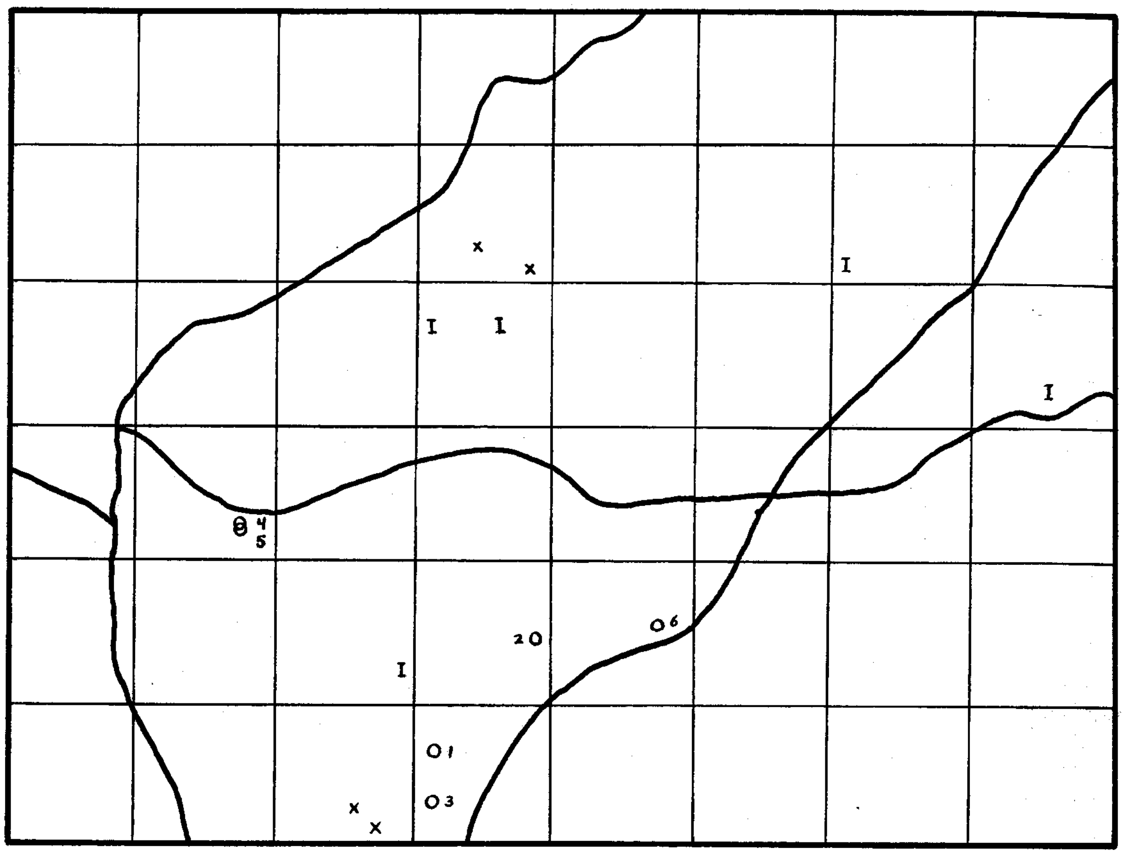
ECONOMIC GEOLOGY

Owing to the central position in the interest of southern California which petroleum occupies, its production has been attempted at various localities throughout the Venture Basin, including the area mapped. Similar interest was aroused by the discovery of gold in Placerita Canyon, and attempts have also been made to concentrate ilmenite at a profit. The available supply of groundwater is of considerable economic importance in the semi-arid climate.

Petroleum and Natural Gas

There is no production of either petroleum or natural gas within the area mapped. However, at least five wells were drilled in the past, in attempts to find commercial production. A sixth hole is now being drilled by a private operator.

The deepest of the old wells was Stabler #4, drilled by the General Petroleum Corporation between August, 1919 and August, 1920. It was extended to a depth of 3,506 feet, with several showings of tar, oil, and gas. No production was obtained, however, and the



Oil wells
Gold or ilmenite prospects
Ilmenite deposits

Highways

Plate IX. Index map of oil, gold, and ilmenite prospects.

Grid is the Land Office survey of townships and ranges, subdivided into sections.

<u>Oil wells</u>

1. General Petroleum Corporation, Stabler #3
2. General Petroleum Corporation, Stabler #4
3. Occidental Petroleum Corporation, #1
4. Community Oil Producers of California, #1
5. Community Oil Producers of California, #2
6. McCain wildcat well

project was abandoned. The well is near the northeast corner of the southeast quarter of Section 30, and is shown on the index map of economic prospects, Plate IX.

At approximately the same time, General Petroleum sank their 2,640-foot Stabler #3 in the northwest quarter of Section 31. This well also yielded showings of gas and oil, but not in commercial quantities.

The Occidental Petroleum Corporation drilled their Number 1 well in Hidden Valley, in the western part of Section 31. The 605-foot hole showed a little gas and tar near the bottom before drilling was interrupted. It was the intention of the company to continue this well, but the plan failed. Drilling was done in the summer of 1922.

These operations were all seeking an extension of the Ellsmere Canyon field which lies to the south of the area. The wells were drilled on small structures, or even where no structures appear to exist, in the hope of encountering small traps at depth. The nearest production was from two wells on the ridge south of Placerita Canyon, where oil was obtained from Pico strata at a depth of 1,200 feet.

General Petroleum's Stabler #4 was aimed at possible oil accumulations along the crest of the Soledad anticline. The southeastern end of this fold, in eastern Placerita Canyon, supported eight producing wells in the early part of the 1900's.

Possibly interpreting the steep dips on beds dragged up along the San Gabriel fault as a closed anticline, the Community Oil Producers of California chose a rather unusual location for drilling. In the summer of 1920 they began drilling for oil in the southeastern quarter of Section 23m on the southern edge of the Santa Clara River valley. So much water was struck that the well was converted to a water well after reaching a depth of only slightly over two hundred feet. Impressed by the showing of oil, and a high gas pressure in this first well, however, the company began drilling a second well eighteen feet away. It was intended that this should be solely a producer of oil. Drilling records cease at a depth of 255 feet, but petroleum maps show this well as having a depth of 3,560 feet. Presumably no production was obtained. (20

The McCain well is now being drilled by a private operator near the center of Section 29. This location is believed to be on the crest of the Soledad

(20 - The preceding information about oil wells was obtained from the California Oil and Gas Bureau.

anticline, which was apparently missed by General Petroleum's Stabler #4 well. This well has been drilled only a few hundred feet at this time, and has produced no showings of interest. In all probability, no production will be found, although evidence of oil, gas, and tar may lead the driller into extending to considerable depth.

Driller's logs were recorded during the sinking of the two General Petroleum wells. These logs were obtained through the courtesy of Mr. F.L. Wadsworth, Chief Petroleum Engineer of the General Petroleum Corporation. Howeverm any interpretations of the stratigraphy of these logs is extremely tenuous, owing to the great lithologic similarity between members of the stratigraphic column, and the lack of accurate discrimination on the part of the recorders.

It is apparent from the surface mapping that both wells spudded in in the Saugus formation, in each locality apparently underlain by Pico strata. The log of Stabler #3 suggests that the bottom of the Saugus-Pico group was reached at a depth of 225 feet. The log of Stabler #4 suggests that this boundary lies only 35 feet below the surface of the ground. Indications from the McCain well give a comparable figure to this latter record. Each of these depths is entirely possible. Beyond this little can be said about the logs. The Modelo strata lens out a short distance east, and hence are probably not represented in Stabler #4. They may have been present in Stabler #3, as considerable thicknesses are reported farther south.

It is the opinion of petroleum geologists that in the Ventura Basin the diatomaceous beds of the Modelo formation acted as the source of the petroleum, which was subsequently trapped in the coarser beds of the overlying Pico and Saugus formations. This hypothesis is clearly stated by Kew. [21] Where the fine-grained beds of the Modelo formation are overlain with angular unconformity by younger strata, it was an easy process for the petroleum to migrate upward into such porous zones.

The showings of petroleum in undoubted Mint Canyon strata, as recorded in Stabler #4, would appear to indicate sources within that formation. This hypothesis is not necessary as petroleum can easily have migrated into the Mint Canyon traps from Modelo strata that stand stratigraphically higher, but topographically lower to the south.

The position of the San Gabriel fault between the two Stabler wells makes it possible that Stabler #3, south of the fault, may lie in a considerable thickness

(21 - W.S.W. Kew, op. cit.

of Modelo strata that are absent north of the fault. It is not known if any post-Modelo movement along that fault occurred which would be adequate to cause such possible differences in thickness of Modelo strata on the two sides of the break.

Gold

In March of 1842 Francisco Lopez Y Arballo was pulling up wild onions in the eastern reaches of Placerita Canyon when he found grains of gold adhering to the roots. This started a miniature gold rush that sent men scurrying into the neighboring hills in search of the precious metal.

It is said that when the Southern Pacific Railroad completed construction of the Saugus and San Gabriel Divisions, Chinese laborers attempted to work placer gold deposits in the Ventura Basin. No matter who actually did the work, placer operations certain were attempted at several localities within the area mapped. Even though the exactness of some of the tales of huge nuggets is discounted, there clearly was some production. However, the lack of adequate supplies of water for wet placer operation made all of the projects economically infeasible, and they have since been abandoned.

The probable source of this placer gold lies in the northeastern part of the Ventura Basin, where a few hard-rock mines are yielding small quantities of the metal today.

Ilmenite

The iron-titanium oxide, ilmenite, has frequently been looked upon as a possible source of titanium for commercial purposes. Natural concentrations of ilmenite sand occur in thin layers in the Saugus and Mint Canyon formations. Probably there are similar occurrences in the Modelo and Pico formations, although the depositional environment may have precluded such concentration.

In several localities placer operations have been aimed at concentration of this ilmenite sand, and also cobbles of the mineral. Considerable quantities of the concentrate were actually recovered in some places. However, there was no market available at the time, and the concentrates are still lying at the abandoned locations. It is to be suspected that many of these operations were merely promotional schemes, abandoned when the credible investors had donated their funds.

Cobbles of pure ilmenite as much as six inches in diameter lie on the surface of the ground, and are contained in the upper few inches of the mantle rock in certain areas. It is noteworthy that fragments larger than coarse sand have never been seen actually in place in any of the bedrock formations exposed within the area mapped. Coupled with this is the fact that all occurrences of the cobbles lie in stream valleys associated with remnants of the mature upland surface, indicating a relation with the streams of that stage.

The probable source of this ilmenite lies within the San Gabriel Mountains south of the southeastern corner of the Ventura Basin.

Groundwater

Surface water is present in the major stream valleys only after prolonged heavy rains. The water of the small brooklets formed in the hills after each rain quickly sinks into the alluvium on reaching the debris-filled valleys. Homes and farms of the area therefore depend almost entirely on supplies of pumped groundwater.

Full consideration of the groundwater problems is beyond the scope of this report, but it can be pointed out that the parched surfaces of alluvium-floored valleys present a somewhat erroneous conception of the supply of water available. As reported by Mr. Willaday, the county librarian at Forest Park, it is only necessary to drill a short distance in the center of the main valleys to obtain supplies of water as great as 800 gallons per minute.

The narrowing of Soledad Canyon along the western edge of Section 24 forms a natural dam that forces the groundwater toward the surface of the alluvium. Surface water is present in a channel of the Santa Clara River for a few hundred yards, and a small pond lies against the outward-curving flank of the valley on the northern side.

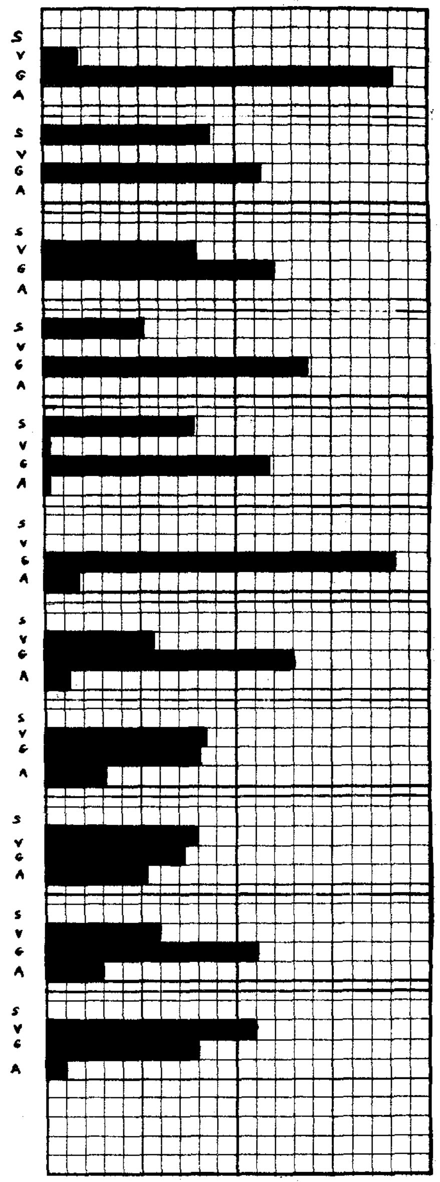
An interesting by-product of groundwater investigations was the demonstration by drillers' logs that Mint Canyon just south of Forest Park is filled with alluvial debris to depths greater than 70 feet, and perahps as much as 100 feet. The cause of such aggradation arouses considerable speculation.

APPENDICES

APPENDIX A. Pebble Counts In Conglomerates

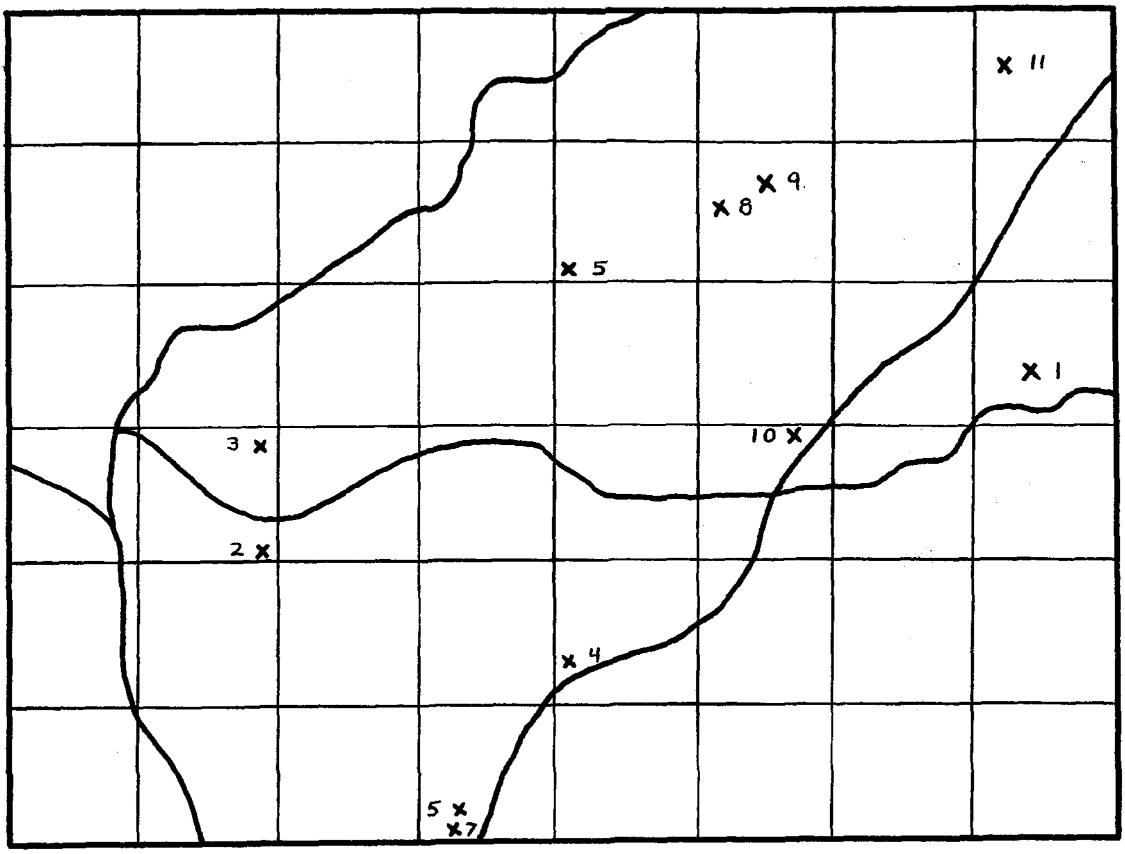
1. Terrace gravels
2. Terrace gravels
3. Banded Saugus
4. Banded Saugus
5. Brown Saugus
6. Brown Saugus
7. Pico
8. Modelo
9. Mint Canyon
10. Mint Canyon
11. Mint Canyon

(Locations are shown on index map on page following.)



S - schist
V - volcanics
G - granitic rocks
A - anorthosite

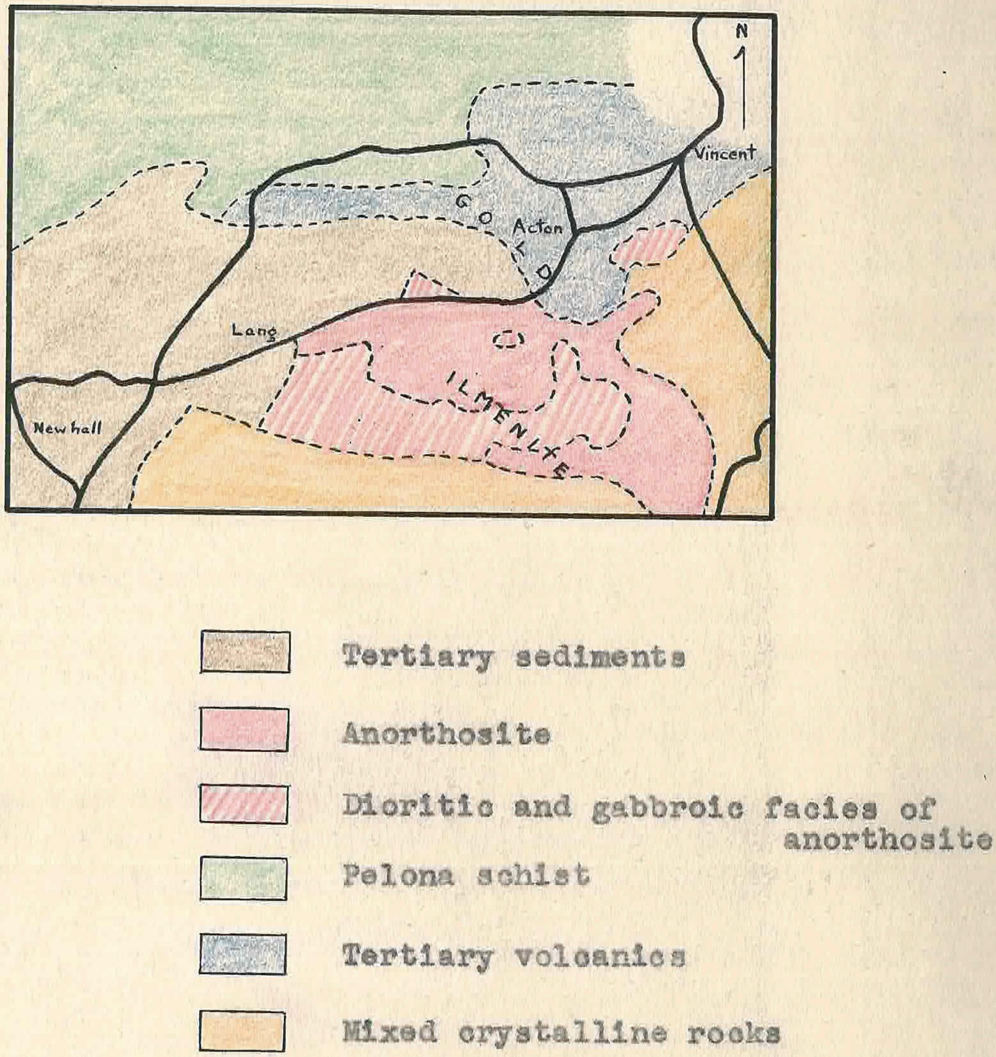
The noteworthy occurrence is that of the schist in the terrace gravels of the second category. In order to reach this position (south of Soledad Canyon) the pebbles must have traversed the present position of the Santa Clara River Valley, indicating a drainage differing from the present pattern.



3 x Location of pebble counts. (Numbers correspond to those used on the Distribution Graph.)

~ Highways

1. Terrace gravels
2. Terrace gravels
3. Banded Saugus graybed
4. Banded Saugus graybed
5. Brown Saugus
6. Brown Saugus
7. Pico formation
8. Modelo formation
9. Mint Canyon formation
10. Mint Canyon formation
11. Mint Canyon formation



Possible source areas of the distinctive rocks represented within the conglomerates of the Mint Canyon, Modelo, Pico, and Saugus formations and the Quaternary deposits of the eastern Ventura Basin. (22

(22 - Data was obtained from W.S.W. Kew in USGS Bulletin 753, from W.J. Miller, Jour. Geol., Vol. XXXIX, pp 331-344, and from R.H. Jahns by personal communication.

APPENDIX B.

General Petroleum Corporation Well - Stabler #3

Township 4 North, Range 15 West, Section 31

870 feet north and 482 feet east of west ¼ corner

Elevation of derrick floor - 1,450 feet above sealevel

Depth - 2,640

Drilled between May 25, 1919 and July 15, 1920

Driller's Log

	thickness	depth
Yellow sand and clay	60	60
Yellow sand	70	130
Yellow sand and clay	40	170
Gray sand	20	190
Yellow sand	35	225
Blue clay and sand	10	235
Fine gray sand	10	245
Sandy blue shale	20	265
Hard shell	10	275
Water sand	25	300
Hard sand	15	315
Water sand	30	345
Blue shale	6	351
Sand	29	380
Sticky blue shale	8	388
Sand and blue shale	10	398
Sand and boulders	9	407
Blue shale	12	419
Hard sand	44	463
Sand and blue shale	50	513
Sticky blue clay	10	523
Sticky blue shale	16	539
Conglomerate	7	546
Blue clay	7	553
Blue shale	31	584

Hard sand	28	612
Blue shale	7	619
Blue clay	7	626
Sand	14	640
Blue clay	27	667
Blue shale	10	677
Water sand	5	682
Blue shale	108	790
Conglomerate	7	797
Blue shale	53	850
Sticky blue shale	8	858
Sandy shale	22	880
Sand	16	896
Sand and boulders	4	900
Blue shale and shells	14	914
Sand	36	950
Sandy shale	20	970
Blue shale	63	1033
Loose sand	29	1062
Blue shale	5	1067
Sand and boulders	9	1076
Sand	32	1108
Blue shale	26	1134
Sand	29	1163
Shale	7	1170
Water sand	10	1180
Blue shale	15	1195
Sand	72	1267
Blue shale	20	1287
Sand	66	1353
Sticky blue shale	55	1408
Sand	9	1417
Brown shale	23	1440
Hard sand	8	1448
Brown shale	10	1458
Hard shell	11	1469
Brown shale	10	1479
Coarse gravel	7	1486
Brown shale	24	1510
Sticky blue shale	20	1530
Blue shale	30	1560
Sticky blue clay	12	1572
Sticky blue shale	20	1592
Hard shell	8	1600
Blue shale	40	1640
Sand	6	1646
Sandy blue shale	12	1658
Sticky blue shale	8	1666
Blue shale	8	1674
Sand - <u>containing gas</u>	8	1682
Blue shale	26	1708
Sand	7	1715
Sandy blue shale	43	1758

Sand	35	1793
Sticky blue shale	17	1810
Sandy blue shale	10	1820
Blue shale	10	1830
Sand - containing oil and gas	14	1844
Blue shale	8	1852
Soft blue shale	7	1859
Blue shale	6	1865
Sand - containing gas	10	1875
Hard sand	20	1895
Shell	14	1909
Hard blue sand	8	1917
Sand	97	2014
Blue shale	11	2025
Hard sand	34	2059
Blue shale	5	2064
Hard shell	21	2085
Hard rock	7	2092
Hard sand - containing oil and gas	9	2101
Hard sand	78	2179
Shale	46	2225
Shell	2	2227
Shale	96	2323
Shell	7	2330
Shale	22	2352
Sand	12	2364
Shale	5	2369
Sand	6	2375
Shale	77	2452
Hard sand	8	2460
Shale	6	2466
Hard shell	46	2512
Shale	7	2519
Hard sand	8	2527
Hard shell	23	2550
Hard shale	6	2556
Hard sand	7	2563
Hard shale	21	2584
Sand rock	22	2606
Sand	17	2623
Sandy shale	6	2629
Sand	11	2640

Interpretations

The well is known to have spudded in in the Saugus-Pico strata. The bottom of this group was apparently passed at a depth of 225 feet. It is not known what the underlying formation was, but the alternating brown shale at depths of 1440-1479 suggest Modelo lithology.

General Petroleum Corporation Well - Stabler #4

Township 4 North, Range 15 West, Section 30

1,927 feet north and 259 feet west of section lines

Elevation of derrick floor - 1,605 feet above sealevel

Depth - 3,506 feet

Drilled between August 28, 1919 and August 31, 1920

Driller's Log

	thickness	depth
Yellow sand	35	35
Blue shale	45	80
Sandy blue shale	40	120
Gray water sand	39	159
Shale and boulders	16	175
Sand	6	181
Sandy shale and boulders	3	184
Sandy shale	1	185
Sand and shale	17	202
Sticky blue shale	5	207
Shale	20	227
Sand and boulders	14	241
Sand	8	249
Shell	4	253
Sand	26	279
Sand and boulders	9	288
Sand	32	320
Blue shale	5	325
Sand and shale	20	345
Sand	49	394
Brown shale	18	412
Sand	15	427
Hard sand	28	455
Shell	1	456
Sand	12	468
Hard pan	1	469
Shell	8	477
Brown shale	7	484
Shale	18	502
Sandy shale	133	635
Sand - <u>containing tar</u>	2	637
Sandy shale	1	638
Sand - <u>containing tar</u>	10	648

Shale	38	686
Blue shale	19	705
Shale	3	708
Blue shale	27	735
Shale - containing gas	50	785
Blue shale	30	815
Shale - containing gas	32	847
Shale and shell	3	850
Shale	114	964
Shale - containing oil	10	974
Shale	16	990
Shale - containing gas	38	1028
Shale	39	1067
Sand	3	1070
Shale	52	1122
Shale - containing gas	68	1190
Shale	74	1264
Shale - containing oil	25	1289
Shell	2	1291
Shale	51	1342
Hard shale	18	1360
Shale	51	1411
Sticky shale	17	1428
Shale	32	1460
Sticky shale	38	1498
Shale	12	1510
Hard shell - containing gas	2	1512
Shale	4	1516
Hard shale	12	1528
Shale	17	1545
Shell	4	1549
Shale	14	1563
Hard shale	11	1574
Blue shale	16	1590
Blue shale - containing gas	22	1612
Blue shale	8	1620
Shale	19	1639
Hard shale	15	1654
Blue shale	41	1695
Shale	55	1740
Shale and shell - containing gas	15	1755
Shale - containing gas	18	1773
Shale	306	2079
Blue shale	56	2135
Shale	107	2242
Blue shale	12	2254
Shale	101	2355
Gray shale	10	2365
Blue shale	2	2367
Black shale	3	2370
Shale	9	2379
Blue shale	6	2385
Shale	5	2390
Brown shale	7	2397
Hard blue shale	13	2410
Blue shale	45	2455

Shale	5	2460
Blue shale	10	2470
White shale	5	2475
Blue shale	5	2480
Hard blue shale	5	2485
Shale	5	2490
Hard blue shale	5	2495
Blue shale	3	2498
Hard blue shale	4	2502
Blue shale	45	2547
Soft blue shale	2	2549
Hard blue shale	3	2552
Light blue shale	3	2555
Hard blue shale	1	2556
Blue shale	17	2573
Hard white shale	5	2578
Hard gray shale	13	2591
Hard blue shale	29	2620
Hard white shale	5	2625
Hard shell	6	2631
Blue shale	95	2726
Blue shale - <u>containing gas</u>	10	2736
Blue shale	24	2760
Blue shale - <u>containing gas</u>	26	2786
Blue shale	25	2811
Shale	19	2830
Blue shale	17	2847
Hard sand	12	2859
Blue shale	44	2903
Shale	53	2956
Blue shale	26	2982
Shale	9	2991
Blue shale	33	3024
Shale	171	3195
Blue shale	5	3200
Shale	24	3224
Hard shell	1	3225
Hard sand	3	3228
Shale	1	3229
Fine sand	1	3230
Sand - <u>containing oil</u>	32	3262
Sand	2	3264
Sandy shale	5	3269
Hard sand	10	3279
Sand and shale	12	3291
Shale	13	3304
Shale - <u>containing gas</u>	4	3308
Shale	5	3313
Hard shell	2	3315
Shale	26	3341
Shale and shell	2	3343
Shale	32	3375
Sandy shale	3	3378
Shale	8	3386
Shale - <u>containing gas</u>	4	3390

Shale	7	3397
Hard shale	2	3399
Shale	2	3401
Blue and brown shale	2	3403
Shale	7	3410
Hard shale	3	3413
Shale - <u>containing gas</u>	3	3416
Shale	2	3418
Shale - <u>containing gas</u>	3	3421
Shale	3	3424
Shell	4	3428
Hard shell - <u>containing gas</u>	2	3430
Hard shale	7	3437
Brown shale	2	3439
Shale	2	3441
Shale - <u>containing gas</u>	6	3447
Shale	4	3451
Shale - <u>containing gas</u>	5	3456
Shale	5	3461
Shale - <u>containing gas</u>	7	3468
Shale	4	3472
Shale - <u>containing gas</u>	4	3476
Hard shale	4	3480
Shale and boulders	4	3484
Shale	10	3494
Shale - <u>containing gas</u>	3	3497
Shale	9	3506

Interpretations

The well is known to have spudded in in the Saugus-Pico strata. This group was apparently very thin, the bottom being passed at a depth of only 35 feet. It is probable that the remainder of the column was Mint Canyon strata, with the possibility of some older formations being encountered at depth. The thin brown horizons are known to occur locally in the Mint Canyon formation, and when found singly do not indicate Modelo lithology.

Occidental Petroleum Corporation Well - #1

Township 4 North, Range 15 West, Section 31

100 feet west of aqueduct line, 100 feet north of canyon road.

Elevation of derrick floor - 1,375 feet above sealevel

Depth - 605 feet

Drilled between March 9, 1922 and August 9, 1922

Estimated first production of oil or gas at 1,400 feet.

Driller's Log

Very hard formation of largé boulders, gravel and blue shale.

Little showing of gas and tar at 585 feet.

Intend to continue drilling sometime in future.

Community Oil Producers of California Well - #1

Township 4 North, Range 16 West, Section 23

250 feet south and 50 feet east from first bridge east of first tunnel north of Saugus on the Southern Pacific Railroad. Bridge or opening being #448E.

Elevation of derrick floor - 1214 feet above sealevel

Depth - 227 feet (or more)

Drilled between July and September, 1920

Estimated depth to oil sand as 1,500 feet.

Driller's Log

	thickness	depth
Clay and boulders	160	160
Water at 1 gallon per minute		39
Water at 1 gallon per minute		105
Hard conglomerate	47	207
Water at 2 gallons per minute ran over top of casing.		
Some oil.		
Heavy gas pressure.		
End of record		227

Intend to use as water well.

Community Oil Producers of California Well - #2

Township 4 North, Range 16 West, Section 23

18 feet north of Well #1

Elevation of derrick floor - 1,214 feet above sealevel

Depth - unknown

Estimated depth to oil sand 800 feet

Driller's Log

	thickness	depth
Clay	110	110
Flowing water		110
Conglomerate	17	127
Soft conglomerate	128	255
End of record		255

Maps list well as being 3,560 feet deep.

APPENDIX C.

Modelo Fossils

The following fossil individuals were identified in Modelo strata on the southern side of Plum Canyon at the point Sec. 9 (17-51). Identifications are by courtesy of Dr. C.R. Stauffer of the California Institute of Technology.

Ostrea titan

Lunatia sp.

Diplodonta sp.

Leda sp.

Lyropecten sp.

Teredo sp.

Corbula (?) sp.

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