STRUCTURE OF THE NORTHWESTERN PUENTE HILLS
LOS ANGELES COUNTY, CALIFORNIA

Thesis

by

Charles W. Allen

In Partial Fulfillment of the Requirements

For the Degree

of

Master of Science

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Plate I - Frontispiece

Aerial photograph of the central part of the area discussed in this report.

Scale is approximately: 1" = 2,000'


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ABSTRACT

The structure of a part of the northwestern Puente Hills, about four miles east of Whittier, California, is characterized by north dipping marine sandstone, conglomerate, and shale of Upper Miocene and Lower Pliocene ages. These sediments form the north limb of a broad regional anticline that has been faulted by the high-angle Whittier thrust fault, which is located just south of the mapped area. The compressive forces that formed the Whittier fault are responsible for additional minor faulting and folding of the area covered in this report.

There are two main fault systems in the area, the Rowland fault system and the English fault system. The Rowland fault system consists of a main high-angle thrust fault with two spur faults. This system has produced some minor folding, some of which shows overturning, and some just reversal in dip. Many of the folds have been due wholly to the drag effects of the faults, others due to compressional forces, while still others represent a combination of the two forces. The English fault system

marks a change in the general strike of the formations. To the east of this system the formations trend east-northeast, and to the west of the system the trend is west-northwest.

The only flexure that is not apparently connected with faulting is a broad plunging nose or anticline called the Repetto nose. Small anticlinal folds in the southern part of the area may reflect buckling north of the Whittier fault.

INTRODUCTION

Background of investigation

This report and the accompanying geologic map have been prepared in partial fulfillment of the requirements for the Degree of Master of Science in Geology at the California Institute of Technology, Pasadena, California. The area has been selected because it contains the combination of moderately complex surface geology, and subsurface information from core data and electric logs. This area has been selected because it also has structural relationships relating to oil possibilities. Before field work was started no large scale map had been published. However, within one week after the completion of the field work the United States Geological Survey released an Oil and Gas Investigation map (Daviess and Woodford, 1949) on a scale of 1,000 feet to the inch. This is the same scale that the author used. No additional field work was done by the writer after publication of Daviess and Woodford's map, but in the preparation of this report the author has taken into consideration this recent work, and has endeavored to discuss various differences between the two maps.

The field mapping was done on a scale of 1,000 feet to the inch. Two enlargements of aerial photographs gave a complete coverage of the area and made it possible to locate points in the field accurately. At intervals from September, 1948 to May, 1949, approximately fifty days were spent on this project, twenty-five days for the field, and the remainder for the office work. Because much of the area is moderately populated, a great deal of time was spent gaining permission from land owners for access to their property.

Where possible the location of contacts were "walked out", or mapped by float. This method was not possible in most areas of no outcrop or float. The geology of the Puente Hills is often indicated by the topography and vegetation, and in many instances these features had to be used for the tracing of geologic units. Attitudes were plotted wherever possible in order to obtain all available data.

The geology was transferred from the aerial photographs to the office map, which was on the same scale. The base map was enlarged from the La Habra and Puente quadrangles of the United States Geological Survey. The original scale of these maps was 2,000 feet to the inch. The base map had a few intrinsic errors in the location of some of the topographic features, but no attempt was made to correct the base map for topography or for culture. The transferring was within mapable errors of accuracy. A grid has been placed on the map for a convenient method of referrence to specific locations.

The data from 15 wells were used in the subsurface mapping. This data consists of electric logs and/or core descriptions. The degree of quality of this information ranged from very poor to excellent. Many of the logs contain micro-paleontological information, and others contain little more than the driller's "idea" of the formation he was drilling. The author found no diagnostic mega-fossils and made no microfossil determinations.

Acknowledgments

It is a pleasure to acknowledge the cooperation given by the several land owners in the area, Messers. J. B. Cypher, F. Pellkofer, Elwin Pool, A. E. Svenson, J. P. Ferrero, and J. Uniak; Dr. F. Toland; and Mrs. L. Dribble all made the field work possible and took a notable interest in the results. Special acknowledgment should be made to Mr. Richard Ten Eyck of the Continental Oil Company, who aided a great deal in the accumulation of well data, and contributed valuable information concerning the general field relations of the area. Mr. Ten Eyck also furnished the author with micro-paleontological data. Mr. P. H. Gardett of the General Petroleum Corporation first suggested the Puente Hills as a good mapping problem, and assisted in obtaining much

well data. Additional data from Messers. Coleman Morton of Morton and Sons Oil Company, Robert Lily of the General Petroleum Corporation, E. H. Radar of Standard Oil Company, and from the consulting firm of Wm. Ross Cabeen and Associates, helped the author immeasurably in the preparation of this report.

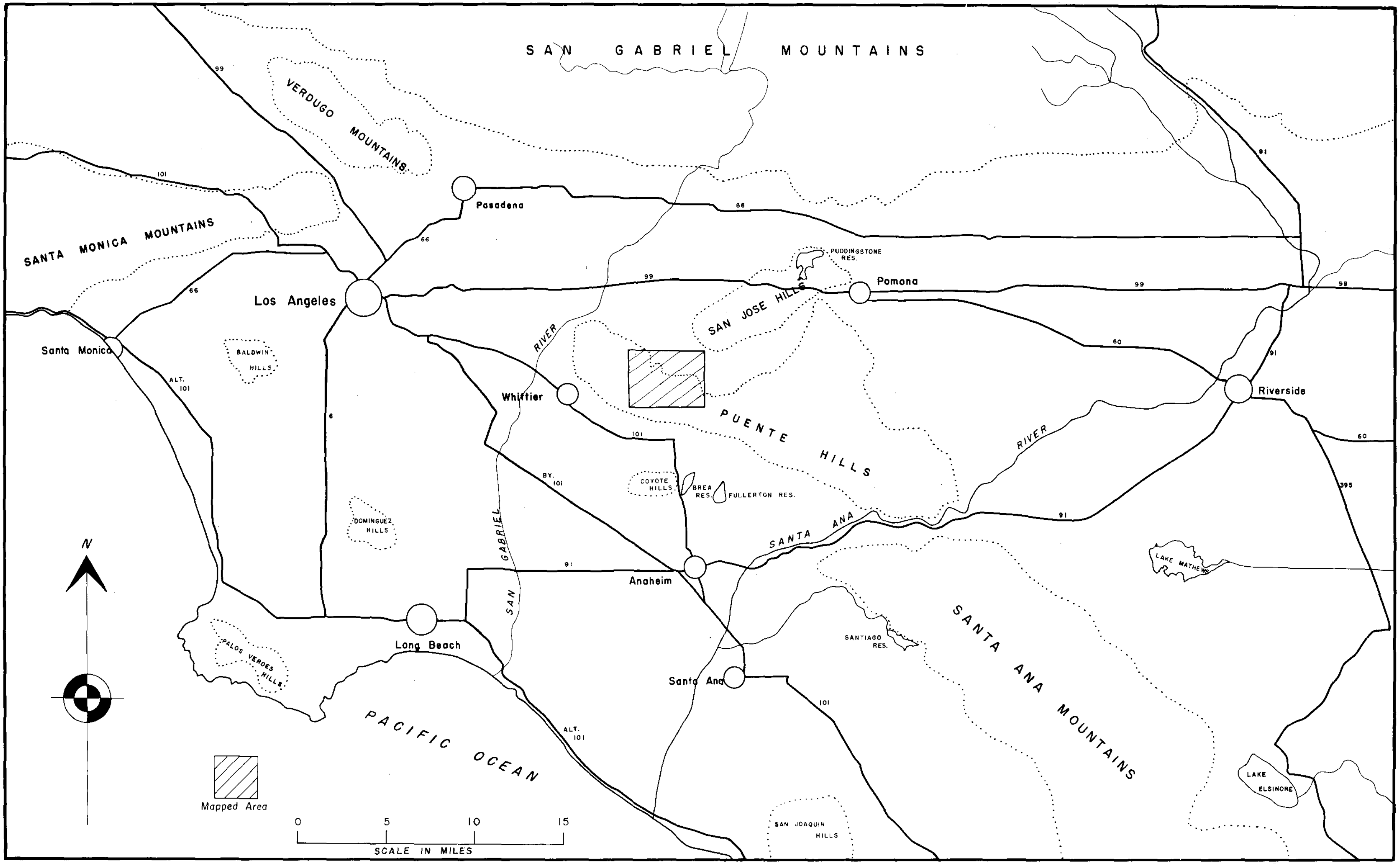
Mr. Hoyt S. Gale, consulting geologist, spent many hours with the author, both in the field and in the office, giving much assistance in all phases of the work. Dr. A. O. Woodford of Pomona College graciously gave much time in discussing the possible interpretations of the field relations. Dr. C. W. Merriam of the California Institute of Technology determined the few megafossils found in the area, and Mr. Merle C. Israelsky of the United States Geological Survey discussed the boundary problems by the use of micro-fossils. The author wishes to express his gratitude to Dr. Richard H. Jahns for the excellent instruction, and for much valuable advice concerning field techniques. The writer is also indebted to Dr. Jahns for his helpful criticism of the first draft of this manuscript.

Previous publications

The first published geologic map of the general area was included in a report by Eldridge and Arnold on the western portion of the Puente Hills (Eldridge and Arnold, 1907). It contains detailed descriptions of the geology and of the productive oil fields at that time. Eldridge's map is a reconnaissance map on a scale of 1 mile to the inch. English mapped the entire Puente Hills region and a part of the Santa Ana Mountain area in 1926 (English, 1926). This work was done also on a scale of 1 mile to the inch. In the English report there is a list of older reports that dealt with the Puente Hills area.

It was not until 1944 that any additional publications appeared. At that time however, a geologic map and report by Woodford, Shelton, and Moran was published on a scale of 1 mile to the inch. More subsurface data were available, more surface work had been done in local areas, and consequently a generalized, but detailed map was prepared. More recently an excellent and detailed map was added to the record (Daviess and Woodford, 1949). The scale of this map is 1,000 feet to the inch, and the mapped area extends over the northwestern part of the Puente Hills.

Numerous special papers on the oil production,



INDEX MAP

Plate II

origin of conglomerates, naming of the formations, and paleontology have been written upon the area. For a complete list of reports, the reader is referred to the bibliography.

Location and physical features

The area described in this report is a part of a physiographic unit about 50 square miles in area called the Puente Hills. The northwest portion of the hills is approximately 15 miles east of the Civic Center of the City of Los Angeles, California. The Puente Hills are about 25 miles long in a west-northwest direction and are 2 to 12 miles wide. The map area is approximately 13 square miles, but alluvium covers about one-quarter of the area. The boundaries of the area are the Range line of 10 West on the west, Fullerton Road on the east, Southern Pacific Railroad on the north, and the 33° 58' line of Latitude on the south. (See Plate II - Index Map).

The relief of the area is moderate, with altitudes ranging from 400 feet to slightly more than 1,400 feet. The nearly complete dissection indicates that the stage in the cycle of erosion is probably middle maturity. The low relief of the foothills in many places appears to be nearing old age in the cycle of erosion. The alluvial cover is 550 feet in elevation on the east, and

400 feet on the north.

Many conglomerate beds form cliffs, and overhanging ledges commonly are developed by sapping of the siltstone beneath. The northern slopes are dipping very gentle, but the southern slopes are extremely steep, with deep, narrow canyons dissecting them.

The drainage system is largely controlled by the northward dipping formations. Near the southern margin of the area a drainage divide trends nearly east-west. North of this divide the drainage pattern is a normal dentridic system, but just south of the divide a major valley trends west-east with its small streams flowing westward. The area contains numerous intermittent springs. Their intermittency is due in part to a limited area of outcrops, and in part to the semi-arid climate of southern California. Most of the seasonal rains are absorbed rapidly with only the excessive precipitation flowing off into streams. The northward flowing streams eventually drain into San Jose Creek, which in turn joins the San Gabriel River west of the area.

The eastern and northern parts of the hills are cultivated farm land or pasture land, both of which make geologic investigations difficult. The heavy cover of wild grass and wild oats occupies the shale or siltstone areas, but the conglomerate formations are covered by the heavier brush, shrubs, and trees. Also the conglomerate and sandstone support a growth of cactii and poison oak. In the southern section avocado and orange groves cover the area, and it is nearly impossible to find any outcrops in this area. In general, the chaparral, greasewood, cactus, and perennial grass that mantle the slopes, and the segregation of the large California oak trees in the larger ravines are a reflection of the semi-arid climate.

GENERAL GEOLOGY

Introduction

The Puente Hills region, plus the Santa Ana Mountains, contains unmetamorphosed marine sedimentary formations ranging in age from Cretaceous to Quaternary (English, p. 11, 1926). Both intrusive and extrusive volcanic rocks are also in the area. The long axis of the hills is paralleled by the Whittier fault, which has been described by many workers as a high-angle thrust with a throw ranging from tens of feet to thousands of feet (Daviess and Woodford, 1949). North of the Whittier fault the marine sedimentary formations are Tertiary or younger in age. The volcanic rocks crop out in the San Jose Hills near Pomona, and in one very small area in the central part of the Puente Hills. In general the geologic grain of the area trends east-west. Not only do the axes of the folds and the strikes of the formations trend in this direction, but the numerous normal faults and thrust fault also trend in an east-west direction.

Nowhere in the Puente Hills themselves does the Basement Complex crop out, but just 15 miles southeast of the Puente Hills, in the Santa Ana Mountains the bulk of the eastern portion is made up of igneous rocks. North of the Whittier fault the Upper Miocene Puente formation crops out more than any other formation. The Lower Pliocene Repetto formation occupies only local areas, and the Pleistocene terrace gravels occur sparsely along the foothills.

In the area covered in this report only a part of the Puente Formation crops out. Daviess and Woodford divide the Puente formation into four members, Lower Siltstone member, Middle Sandstone member; Upper Siltstone member, and a Sycamore Canyon Conglomerate member (Daviess and Woodford, 1949). This division was first suggested by Krueger, who recognized the conglomerate-siltstone sequence as wedging in between the Upper Puente Shale of Eldridge and the overlying Repetto formation (Krueger, 1936). In this report the writer has raised the Sycamore Canyon member to formation rank, the reasons for which are explained in the section on the Sycamore Canyon formation.

The Middle Sandstone member of the Puente formation and all overlying units crop out in the mapped area. These units are the Upper Siltstone member of the Puente formation, the Sycamore Canyon formation, the Repetto formation, some terrace gravels, and alluvium. The Pico formation has been recognized only in the northwestern part of the Puente Hills (Daviess and Woodford, 1949). Fortunately one of the wells (9), which is located about one-half mile north of the northern foothills, penetrated the entire column and supposedly 67 feet into the basement complex. From the core data of this well the section that underlies the region comprises 300 feet of the Middle Sandstone member, the Lower Siltstone member of the Puente Formation, a diabase body that may be a sill, the Topanga formation, some diabase flows(?), and the basement complex.

COLUMNAR SECTION

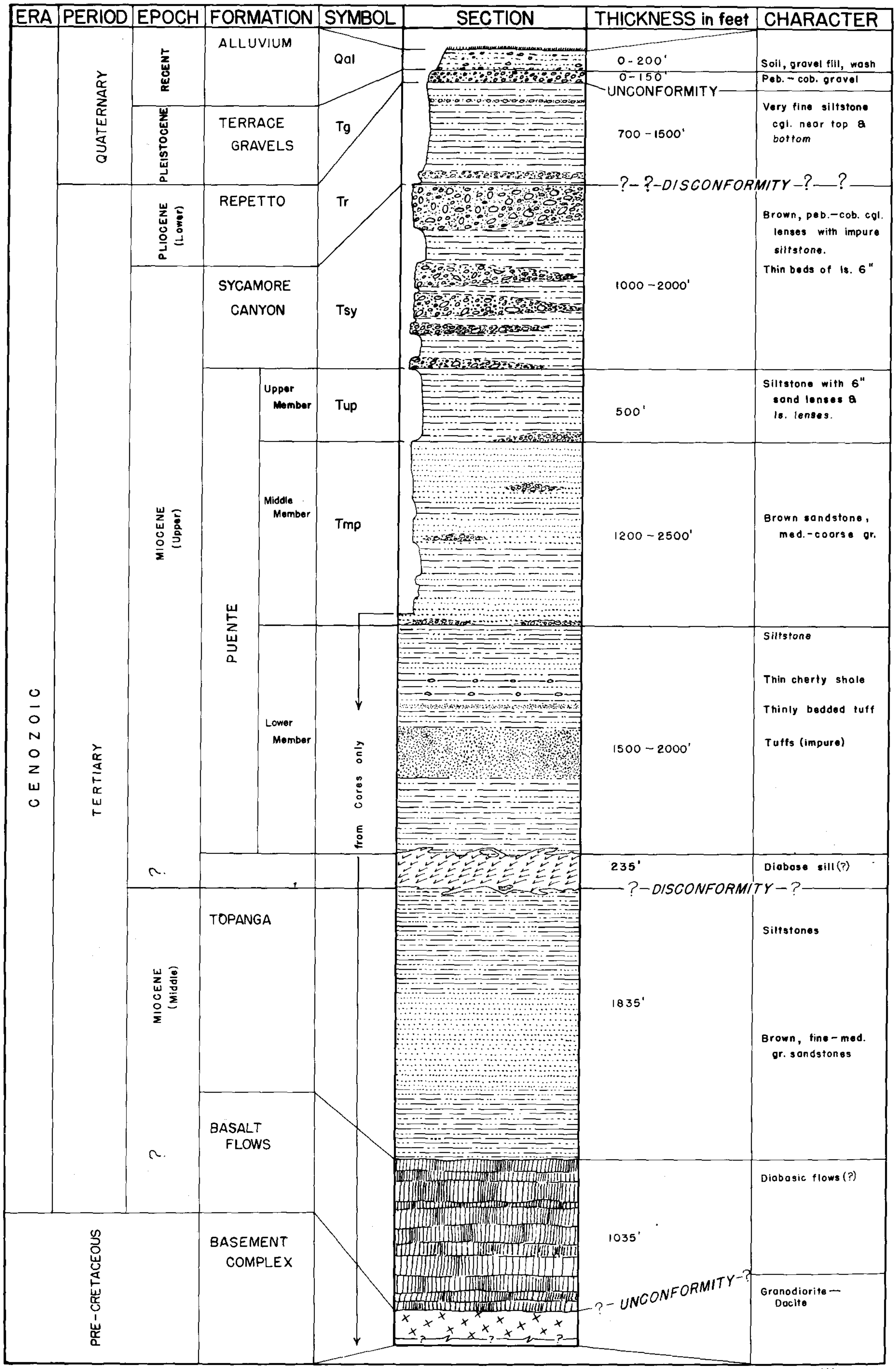


Plate III

Stratigraphy

Igneous Rocks

Basement complex: The basement complex of crystalline rocks that underlies the Puente Hills is nowhere exposed at the surface. It is known only from the few wells that have penetrated it. The Morton and Sons' Rowland 3-1 (9) is the only well in the present mapped area that is believed to have encountered the basement rocks. According to the driller's log the ditch samples were characterized by dull pinkish chips. Woodford made about 17 thin sections of these chips and found them to include quartz-feldspar porphyries, a few feldspar prophyries, and some aplitic or alaskitic rocks (Daviess and Woodford, 1949). He states that all were possibly of granodiorite-dacite composition, and some of the chips were similiar to those from one of the sills(?) encountered in a well about nine miles northeast of the Rowland well. Unfortunately the Rowland well was drilled only 67 feet into the basement complex, and the electric log was run only to 8,100 feet with the top of the basement complex at approximately the 8,600 feet depth.

Volcanic rocks: Many wells have penetrated various sills and flows of volcanic rock, however, the above mentioned well is the only one in the area dealt with in this report from which any description of volcanic rock was obtained. More than 1,000 feet of diabasic rock, probably diabasic Basalt or calcic Andesite, occur above the basement complex found in the Rowland 3-1 well (9) (Daviess and Woodford, 1949). The interpretation from the log seems to favor calling this rock a series of flows lying on the basement of crystalline rocks. Both the self-potential curve and the resistance curve look as though there is a variance in the composition of the rock. This could well be moderately weathered flows. Nearly 500 feet of the flows are not electric logged, so that it is not certain whether they continue down to the basement complex. Neither is it certain that the so-called "basement" is not just another variation in the flows. No direct evidence bears on the age of these lower volcanic rocks; however, Upper Luisian fish scales occur in the core at the 7,242 foot depth in the Rowland 3-1 well (9). This core was taken from about 1,000 feet above the Basalt. Even the inference here is extremely uncertain as the flow nature of the Basalt is not a proven fact. The Basalt may be pre-Middle Miocene in age.

At the 5,495 foot level in the Rowland well (9) is another 235 feet of diabasic rock which may or may not represent a sill. It lies between the Puente formation and the Topanga formation. The reason that this body is called a sill is that Daviess and Woodford found one or two diabase sills 100-200 feet thick near the base of the Puente formation in the eastern part of the Puente Hills area, as shown by well cores (Daviess and Woodford, 1949). If the nature of this diabase is accepted as a sill, the age could be anything younger than Middle Miocene. It is the feeling of the author that this sill is at least middle Upper Miocene in age.

Sedimentary rocks

Topanga formation: The Middle Miocene Topanga formation is a wholly marine unit characterized by a brown, fine to medium-grained, arkosic sandstone, but with variations near the top and bottom. Siltstone and shale, cherty shale, and conglomeratic sandstone are some of the variations. These sediments are known only from well cores. Probably the most complete section of the Topanga formation is in the Rowland 3-1 well (9) mentioned above. Whether the formation is conformable upon the basalt flows is not known. Elsewhere the Topanga formation is assumed to be conformable upon the Vaqueros (English, p. 24, 1926).

Puente formation: The Puente formation was named by Eldridge from the Puente Hills, over which the greater part of this unit crops out (Eldridge and Arnold, p. 103, 1907). It is assigned to the Upper Miocene, and is lithologically similar to the Modelo formation. English states that the Puente formation rests unconformably on Topanga beds in the Santiago Canyon area to the southeast (English, p. 24, 1926). He considered the Puente formation to consist of three units, a lower shale, a middle sandstone, and an upper member comprising several zones of shale, sandstone, and conglomerate. At the suggestion of Krueger (Krueger, 1936), Daviess and Woodford restricted the upper shale member to the shale and siltstone lying immediately above the middle sandstone (Daviess and Woodford, 1949). The fourth, or top member, then was termed the Sycamore Canyon Conglomerate member. In this report the same units are recognized, but the Puente formation is restricted to the shale, the sandstone, and the upper shale section. The alternating siltstone and conglomerate of the Sycamore Canyon member of Daviess and Woodford are called the Sycamore Canyon Formation.

Lower Shale member: The Lower Shale member is known only from well cores in the immediate vicinity covered in this report; however, it crops out just south of the mapped area. It consists of very fine-grained impure shales, thin to moderately massive siltstones, and thin sandstones, all of which interfinger along their strike. The cores from some of the wells show 200-500 feet of an impure ash or tuff. The core at the 4716 foot level in the Rowland well (9) contained ash. The ash was massive, hard, was dark dirty-gray in color, was fine to medium-grained, and contained small brown and black micaceous flakes. A few thin cherty shales near the top of the member also have been recognized. The fresh shale is a light-gray to white in color, but weathers readily to a light-brown or buff color. In the area to the south, the Lower member is in places badly contorted. According to Mr. Ten Eyck of the Continental Oil Company, this member contains foraminifera of Kleimpell's Bulimina uvigerinaformis zone of the Lower Mohnian stage (Kleimpell, p. 129-131, 1936). The maximum thickness is probably a little more than 2,000 feet in the northern foothill region of the mapped area. However, Daviess and Woodford state that the thickness may be as much as 4,000 feet about 3 miles east of this area (Daviess and Woodford, 1949). Locally the member appears to thin to the south, and to again thicken somewhat immediately to the north before it reaches San Jose Creek.

Middle Sandstone member: The Middle Sandstone member occupies all of the southeast and eastern portions of the outcrops. It is characterized by a brown color, and is medium to coarse-grained. Locally it is arkosic.

In many places the sandstone is very conglomeratic, and in places grades into thick, short lenses of conglomerate. These conglomerate lenses probably represent submarine scour and fill. They are far too thick to be raft deposits. These lenses contain numerous blocks of the sandstone, coarse siltstone, and some fragments of impure limestone.

All but about 300 feet of this member crops out, but well cores indicate that the base of the Middle member contains more, and longer, lenses of poorly sorted pebble to cobble conglomerate. Immediately above, and interfingered with the conglomerate is about 300 feet of thinly bedded, poorly consolidated medium to coarse-grained sandstone. These sandstones alternate with thinly bedded siliceous siltstones, and shales upward in the section. The center of the member is marked by a moderately massive, hard, brown, medium to coarse-grained sandstone in which occur some of the aforementioned short conglomerate lenses. Above this massive sandstone lie interbedded thin shales and siltstones, which grade into the top part of the member. The top of the Middle member of the Puente formation is marked by about 300 feet of massive, coarse to pebbly sandstone, with a few short lenses of conglomerate in the lower 200 feet.

The Middle Sandstone-Upper Shale contact is gradational, and the location of the contact in this gradational zone is arbitrary. A conglomerate, which occurs locally near the contact, appears to be different from the scour and fills feature lower in the sandstone. Daviess and Woodford considers this as marking the top of the Middle member (Daviess and Woodford, 1949); however, the writer has placed the contact approximately 50 feet below these conglomerates. Below the conglomerate there is more than 30 feet of siltstone with only occasional sandstone beds present. It is in this eastern area that the Middle member reaches its maximum thickness of about 2,500 feet.

A number of papers have been written on the various conglomerates of the Puente and San Jose Hills concerning the type, source, and mode of deposition of the conglomerates. The author has made no additional study of these problems, except to confirm the lithologic types that have been described in the area. Bellemin's pebble locality number 2, in the Middle member of the Puente formation, contains abundant volcanic pebbles and cobbles (Bellemin, p. 655, 1940). This locality is to the west of the area described in this report. The volcanic pebbles are also abundant in the present mapped area; however, there are numerous cobble-size fragments of granite which Bellemin did not report. Woodford has identified these as tourmaline-actinolite granite and quartz monzonite, and has suggested derivation from a source to the northeast (Woodford, Moran, and Shelton, p. 526-528, 1946).

Upper Shale member: The Upper Shale member of the Puente formation, delineated in this investigation, consists wholly of thinly bedded siltstone and shale, with a few thin lenses of fine to medium-grained soft sandstone, and local 6 inch beds of impure limestone. As stated above, the base of the member in the eastern portion of the area is marked by a chain of thin conglomerate lenses. The limestone contains Pecten pseudomuseum which is characteristic of the entire Monterey group. This Pecten is a pelagic form with a very large vertical range, and consequently it is not diagnostic in locally dating the formation. However, the relative abundance of these Pectens in certain limestone beds has aided greatly in tracing the Upper member across the area.

A soft, white, impure diatomite bed occurs in the northeastern section of the area, where it grades laterally and vertically into diatomaceous siltstones and sandy shales. Near the base of the Upper member the siltstone is very hard and siliceous. Locally secondary gypsum occurs in the siltstone. The cherty sections seem to be absent from this upper member. The maximum thickness of the Upper Shale member is probably in the south-central portion of the area, where it is about 1,250 feet thick. In the area just north of the Rowland Fault this member appears to thicken considerably; however, the writer's impression is that there is a certain degree of thickening, but by no means the extent that is indicated by the exposure. These beds are much contorted, which may very well account for the anomaly. The data from well cores indicate the Upper Shale member of the Puente formation thins to the northeast.

Sycamore Canyon formation: From the type locality, Turnbull Canyon, to the area covered in this paper, and in the vicinity of San Jose Creek, the Sycamore Canyon formation is definitely a mappable unit. It consists of alternating conglomerates and siltstones. The conglomerate fragments are pebbles and boulders, and are poorly sorted. The rock is fairly to well consolidated, and typically forms long, thick lenses. There are four such lenses which extend nearly across the mapped area. They are thin near the southwestern margin of the map, then thicken rapidly and again thin on farther northeast. Most of them, as seen on the map, thin out completely, or are cut off by the Rowland fault in the central portion of the area. Structure section G-A-B shows the pinching out of the lenses, and the occurrance of more lenses at different stratigraphic positions.

In the Rowland well (9) there are at least five such conglomerates. The conglomerate just north of the Rowland fault is thought to be correlative with the second lowest conglomerate of the Sycamore Canyon formation. This is apparent also in the Axis well (3). This conglomerate appears to thicken abruptly to the north and with depth.

According to Bellemin and Woodford, all of the Sycamore Canyon conglomerates were derived from the northeast (Bellemin, 1940) (Woodford, Moran, and Shelton, 1946). Edwards states that most of the conglomerates were derived from the northwestern section of the Peris block, and that the San Gabriel Mountains contributed very little material to the conglomerates (Edwards, p. 800-802, 1934).

The Sycamore conglomerates are very poorly sorted, and have a large range of size distribution. The matrix is very sandy, and contains numerous thin shale and siltstone lenses. The conglomerates range in angularity from sub-angular to sub-rounded, few of them are well rounded.

The shales and siltstone that are between the conglomerates are buff-brown in color, thinly bedded, and are fine to medium-grained. Lithologically these shales and siltstones are similar to those of the Upper member of the Puente formation. Locally thin, laminated, impure limestone beds occur. However, no samples were found to contain any of the numerous pectens that were found in the Puente formation.

Repetto formation: The Repetto formation occupies only a small portion of the outcrop area (map coordinates B-2). The name was proposed in 1930, by a committee of the Pacific section of the Society of Economic Paleontologists and Mineralogists, but it was first used in the literature by Reed in 1932 (Reed, p. 31, 1932). The type locality is in the Repetto Hills, where the formation attains a thickness of more than 2,000 feet. English considered this formation, which he placed in the Fernando group after Eldridge, to lie unconformably above the Puente formation, but on his map he considered the Sycamore Canyon formation of this report as being part of the Repetto. Thus the unconformity would be above the present Middle Sandstone member of the Puente formation (English, p. 40, 1926). Other workers in the area have been in disagreement, not only as to the conformable or unconformable relations, but more fundamentally, on the location of the base of the Repetto itself. Of the geologists who have worked in the area, the disagreement was whether to include in the Repetto formation a lenticular conglomerate bed near the base of the formation. In this report the contact has been drawn to include the conglomerate in the Repetto formation. On the basis of very limited information gained in the field, the writer views this contact as a very slight unconformity. This view is based on a 10° to 15° change in dip. As seen in the B-2 area on the map this change does not occur below the conglomerate, but rather about 100 feet above it. The micro-fossil record of the Continental Oil Company shows no time lapse present in this area. Thus the old question of the Repetto-Sycamore Canyon contact is still very much open to debate.

The Repetto formation consists of a conglomerate at its base, a thick section of silty shale and siltstone, and a thin conglomerate near the top of the formation. The top conglomerate is known only from the Rowland well (9). The absence of stratification, cherty beds, limestone lenses, and siliceous shales distinguishes the Repetto formation from the shales and siltstones that underlie it. The siltstone is generally a white to buff color with much of it resembling clay, and elsewhere it grades into fine sandstone. Most of the foraminifera are arenaceous forms (Reed, p. 230, 1932).

It was in this area that Hoyt S. Gale drilled several 36 inch bore holes in order to determine attitudes of the beds. In the vicinity of C-2 on the map, the contact indicated with queries is based wholly on lithologic information from these holes. Woodford considers this wedge between the two faults as being of questionable Repetto age (Daviess and Woodford, 1949). However, geologists of the Continental Oil Company may have identified Sycamore Canyon forams near the Axis well (3). The siltstone encountered in two of the bore holes look like the Sycamore Canyon siltstones, and that in the hole north of the queried contact appears to be like the Repetto.

In the Rowland well (9) the Repetto formation is 700 feet thick, but at the outcrop it approaches a thickness of 1,500 feet. The age of the Repetto formation is considered as Lower Pliocene (Daviess and Woodford, 1949), although the conglomerate at its base may be of Miocene age.

Terrace gravels and alluvium: The terrace gravels occur along the northwestern and northcentral edges of the foothills. These older alluvial deposits are tilted gently to the north. The terrace gravels, where seen, always occupy the lowlands, and thus are probably late-Pleistocene terrace gravels. The gravels consist of reddish-brown poorly sorted, poorly consolidated, pebble to cobble fanglomerate with an abundant earthy matrix. North of the Rowland fault the lower foothills and valleys are completely masked by this thin layer of gravels which grades up dip into a dark brown soil.

The other valley mouths and the plain areas are filled with river wash, detritus, and soil. The soil contains a large amount of gravel. The thickness of the alluvium in the north is approximately 250 feet.

Summary

The Basement complex has a granodiorite composition and is probably overlain unconformably by a thick section of diabasic basalts of mid-Tertiary age. On top of the basalts is the Middle Miocene Topanga formation, which is characterized by sandy, cherty siltstones, and a very thick section of sandstones. Possibly intruded between the Topanga and the Puente formations is a diabase sill of undetermined age. The overlying Puente formation is divided into three members, the Lower Shale member, Middle Sandstone member, and the Upper Siltstone member. Overlying this sequence is a series of alternating shale beds, siltstone beds, and conglomerate lenses termed the Sycamore Canyon formation. These rocks are Upper Miocene in age. The Repetto formation overlies the Sycamore Canyon formation. The contact is provisionally considered a disconformity. The Repetto formation, essentially a section of sandy shales and siltstones, is marked at its base by a lenticular conglomerate. Pleistocene terrace gravels lie locally on both the Sycamore Canyon formation and the Lower Pliocene Repetto formation. The gravelly alluvium cover is approximately 250 feet thick.

Physiography

General description

The Puente Hills topographically express the geology to an excellent degree. The most interesting feature is the fault-line scarp, probably a composite scarp (Billings, p. 163, 1946), of the Rowland fault. The aerial photographs clearly shows this scarp, which also is marked by a change in the nature of the vegetation. (See Plate I - Frontispiece).

The shales and siltstones of all the formations tend to slide and slump readily. This has been so pronounced that on the geologic map a separate set of symbols has been used to indicate these areas of slide and slump. During March, 1949, a slide occurred which produced scarps 50-75 feet in height. The residents of the area reported that the slide moved intermittently during a period of approximately five days. Loud rumbling noises accompanied the movement. The area of the slide is more than 80,000 square feet. The base of the slide shows a prominant nose or tongue-like structure.

The normal sliding is easily conceived to occur on moderate to steep shale slopes, but the slump, which the writer has called "slump by under sapping", is not readily apparent. In the C-3 area, just west of the triangulation station 1415, two isolated masses of the lower conglomerate unit of the Sycamore Canyon formation have been let down on the underlying shales to the vertical extent of 30 to 50 feet. The sapping of the shales would adequately account for this feature. Daviess and Woodford mapped these conglomerate masses as connected with the main conglomerate bed, but examination of the strikes and dips will immediately indicate that a continuous contact would be impossible unless faulting or some other feature not shown on the map is present (Daviess and Woodford, 1949).

Most of the sharp ridges of the entire area are upheld by the conglomerate lenses of the Sycamore Canyon formation. The conglomerate also is largely responsible for the sharpness of the east-west drainage divide. The Repetto and Sycamore Canyon shales and siltstones offer little resistence to erosion, and thus they form lowlands or rolling hills.

STRUCTURE

General description

The characteristic strike of the formations in the mapped area is east-northeast, with dips generally ranging from 10 to 45 degrees northwest, increasing in steepness south to the drainage divide. This gradual increase in dips south of the northern foothills is broken by faulting, which in turn has resulted in reverse dips on drag folds, some overturning, and small anticlinal flexing in the vicinity near the southern margin of the mapped area.

Most of the main faults of the area are high-angle thrust faults. The Rowland, Vejar, and Spur faults form one fault system, with the Vejar and Spur faults considered as offshoots from the main Rowland fault. These faults are indicated on the geologic map with a dashed line, as their locations are in doubt. It is along the Rowland fault system that many drag effects are present. Other faults occur in the area, and have been lettered rather than named on the map.

The English fault system, B-3 on the map, marks the apex of a moderately sharp change in the trend of the formations. The change is from a west-southwest trend east of the fault system to a west-northwest trend west of the fault system. This is the most broad structural pattern in the area.

Although not in the mapped area, the Whittier fault plays an important role in the structure of the southern most portion of the area. The flexure, or anticline, on the south end of structure section A-B is the first in a general series of three anticlines that lie north of the Whittier fault (Daviess and Woodford, sect. S-T, 1949). Actually this is a highly generalized view as the shales are much contorted in this vicinity. Also a vast amount of sliding and slumping is present, so that the present attitudes of many beds are not meaningful. Nevertheless, it does show that the thrusting against the Whittier fault has caused buckling of the incompetent shales. The only flexure that is not apparently connected with faulting is the plunging nose or anticline in the Repetto formation, A-2 coordinates.

Faulting

Rowland fault system

The ruptures that constitute the Rowland fault system are the main Rowland fault, and the two branches or spurs, the Vejar and Spur faults. English first mapped the main Rowland Fault as passing across the entire area (English, map, 1926). Daviess and Woodford's 1949 map shows the Vejar as being the main part of the Rowland fault.

As seen on the structure section A-B, both the Rowland and Vejar branches have about the same throw, both are high-angle thrust faults, and the hanging and foot-walls of both show drag effects. This structure section conforms with the strikes and dips of the formations at the surface. This section is approximately along the same line as section U-V of Daviess and Woodford (Daviess and Woodford, 1949). A comparison and discussion of the evidence might be in order at this time. On Daviess and Woodford's section the central wedge-like block is considered as a down-dropped mass; but the formations are dipping in the same direction as the movement along the fault. Just east of the Vejar fault, or the north branch, the shales and the conglomerates are dipping in the opposite direction of the supposed movement. The overturning south of the west branch is more pronounced than that shown in the earlier 1949 map. The relations of the Spur fault are approximately the same as those mentioned above, except that the throw is about one-half that of the Vejar and Rowland faults. It seems to follow, then, that these three faults belong to one system of forces, compressional in nature.

The fact that the scarp is on the downthrown side is not of major concern. The formations present the necessary conditions for such a fault-line composite scarp.

The conglomerates south of the Rowland fault are more resistent than the soft siltstones and shales of the upthrown block. The conglomerate east of the Vejar spur has been exposed only recently in geologic time, and the old overlying fine-grained sediments have been eroded away, thus the formation of the present fault-line scarp.

The question of possible recurrent movement on these faults in opposing directions has been considered. No direct evidence that this has not taken place has been seen by the author. The outcrops near the Rowland fault do not appear as contorted as they surely would be if opposing movements had been present. It is only in the soft shales along the Spur fault that this may have been the case, but here too, the soft shales are easily contorted, and their present structure could be due to one fault movement alone.

The Upper-Middle Puente contact, D-3 on the map, shows about 400 feet of offset, but in section the throw is approximately 100 feet. This indicates that the throw of the Rowland fault increases westward. The Rowland fault could not be traced farther westward from where it disappears under the terrace gravels, A-2 coordinates. It is possible that the fault may continue westward along the gravel covered valley, or it may cut across the ridge just north of the Anchor well (2). The latter view is considered very unlikely by the author.

The eastern end of the fault has not been located by the writer, but several geologists have reported that they have located the Rowland fault a mile or so farther east of the area covered in this report.

<u>English fault system</u>

The English fault and faults A through K are included in the English fault system; fault B is an exception, however. The recognition of fault B was made wholly on contorted strikes and dips, and the relative movement of the fault was not determined. The exact sequence in the faulting of this system is very complex, but suggestions can be made as to the cause of faulting. The Whittier Heights fault, in the Turnbull Canyon region on Daviess and Woodford's map (Daviess and Woodford, 1949), has about 3,000 feet of offset according to Ten Eyck of the Continental Oil Company. The movements in the English fault system may represent the absorbtion of this displacement on the Whittier Heights fault.

The relative movement on each of the faults is indicated on the map, and there is no further description here. Fault K could possibly be extended to connect with the main English fault, but there was no direct field evidence seen to confirm this connection. The absence of the conglomerates adjacent to this fault system is not wholly due to faulting, but rapid thining of the conglomerates probably contributes a great deal to the present pattern. The shales and siltstones in this vicinity are highly contorted where exposed in road cuts and foundation trenches. The change of the general trend of the formations, the contorted soft sediments, and the complex faulting suggest that this is a zone of intense deformation.

<u>Other faults</u>

Faults L, M, N, and Q represent minor ruptures, with the common feature of dominantly strike-slip movement. Fault L has formed a ten-foot gouge zone where it crosses the crest of the hills, and here the few slickensides that were seen had a plunge of only 25 to 30 degrees. The location of fault M is indefinite and the exact slip component is also indefinite, but by the offset in small sandstone lenses it appears to be strike slip. It is well to mention here that all of these faults are relatively small in the amount of displacement each of them posesses.

The exact relationship of fault N is difficult to ascertain because of the alluvial cover. A gouge zone of more than 6 feet in thickness marks the location of the fault, and the outlier of conglomerate immediately to the northeast indicates to a certain degree the possible displacement. Some of the shale fragments in the gouge zone show slickensides nearly horizontal, but others also occur in all directions. Fault O was first located immediately south of the Rowland fault on the east slope of the small ravine. Here the conglomerate was offset about 100 feet. Farther south the trace was mapped on the basis of discordant strikes and dips. The apparent offset indicated on the top of the Middle member of the Puente formation may be due to the change in facies instead of being a fault contact. It was impossible to trace fault O into the Rowland fault. It is felt that all of these faults represent differential movement due to compressional forces applied to the area. Their pattern, as well as the patterns of the other fault systems are in accordance with such a conclusion.

Folding

General descriptions

All folding in the area covered in this report seems to be the direct result of faulting, with the exception of the Repetto nose (B-2). The general methods by which the flexures were formed were the warping on the upthrown block as a result of compressional forces, or warping combined with drag effects. A possible exception to the above statement is present along the southern margin of the mapped area (B-3). Many reverse dips are present in this area. No anticlinal symbols have been put in this portion of the area because the writer did not believe that adequate evidence was present to distinguish what may have been folding, from sliding and slumping. Farther east (C-3) the evidence of true folding is more reliable; however, the evidence does not wholly preclude the consideration that the apparent dip reversals are the result of sliding and slumping.

Drag folds

In the limited sense drag folds are only those folds which are formed by a competent bed sliding past an incompetent bed (Billings, p. 42, 1946). However, in this report the term drag fold is used as a flexure formed by the drag effect against a fault. Immediately north of the western branch of the main Rowland fault is a perfect example of this type of fold. The beds have been dragged downward as the block moved up, and on the south side of the fault the opposite situation occurred. The drag effect was upward, dragging the beds upward. On the south side, however, compression was also a prime factor in the overturning of the sediments (See structure section A-B). It is the belief of the author that the evidence of this particular feature is reliable.

The anticline that lies just to the east of the Vejar fault probably owes its origin to at least two forces, compression and drag on the Vejar fault. The one dip symbol in the Sycamore Canyon shale follows the drag conception, but the axis of the anticline does not. A possible explanation may be that the main anticline and accompanying syncline are due wholly to compression, except near the fault. Adjacent to the fault, on the east, thinning of the conglomerate combined with the apparent drag effect have produced the unusual pattern. An attempt was made to establish an additional fault normal to the Vejar fault, but contact between the shale and the conglomerate seems to be a normal sedimentary one.

In the Upper Shale member of the Puente formation (D-2) farther east, another set of folds is shown. Examination of the strikes and dips in this vicinity will show that many other such folds could have been indicated, and all of them with different trends and plunges. These soft incompetent shales and siltstones have offered little resistance to the forces of the area. They are badly contorted and fractured. Numerous symbols have been placed on the map to give some general indication of the nature of these beds. However, the drag effect along the Spur fault is also evident. This evidence is stronger on the north than on the south side of the fault.

<u>Repetto nose</u>

The Repetto Nose is located in the B-2 section, and forms most of the outcrops of the Repetto formation. As the name implies, it is a nose-like feature jutting out into the alluvium on the northwestern flank of the hills. The establishment of this structure was made by the use of bore holes, 36 inches in diameter, drilled through the soil and gravel cover. These holes were drilled in 1948 by an independent geologist Hoyt S. Gale. Because the holes were capped with wooden planks, access to them was fairly easy. Some of them were as deep as 30 feet. The dips and strikes obtained in this manner were extremely reliable.

This northward plunging nose presents more of a problem than the determination of its structure. Why does a soft rock like the Repetto formation jut out into the alluvium? It is definitely known that a basin-like depression exists on the west side of the nose, but on the northeast side the depression is not very great. It is possible that the Vejar fault may extend northwest and form the northeast front of the Repetto nose. The writer did not have enough evidence on hand to postulate further on the possible significance of this feature.

Summary of structure

The Rowland fault system comprises the main structural feature of the area in contrast to the general northward dipping formations. Also a change in trend of the formations is marked by the English fault system. East of this system the formations trend approximately east-northeast, and west of the faults the formations trend west-northwest. Minor folding has accompanied the faulting. Some of the folds have been due wholly to drag effects of the faults, some due to compressional forces, while others represent a combination of the two forces. The Repetto nose plunges out into the alluvium and its northeastern front may represent the northwestward extension of the Vejar fault.

Geologic history

The time interval between the Middle Miocene formations and pre-Cretaceous basement complex has not left any evidence as to the events that were occurring. If an effusive origin for the overlying basalts is accepted, it would require the exposing of the basement surface to erosion and subsequent covering by the basalt flows of pre-Topanga age. These flows may or may not be a terrestrial feature; however, the similar Glendora Volcanics to the northeast are regarded as both terrestrial and submarine flows (Woodford, Shelton, and Moran, 1944). If, as with the Glendora flows, the age is accepted as Middle Miocene, the immediate subsidence of the land mass during Middle Miocene time would be required. Thus, the first transgressing sea was shallow, and the offshore deposition of the Topanga beds was contemporaneous with sinking of the basin. Woodford's work on the conglomerates seems to bear out this conclusion (Woodford, Moran, and Shelton, p. 552-559, 1946). Woodford and his co-authors also state that the source of the Topanga conglomerates was from the north and northeast, while the shoreline lay not far distant. The Topanga in the area covered in this report contains little or no conglomerates; thus it would seem that the conglomerates to the northeast grade southeastward into sandstones and shales, which is in accordance with the concept of the enviormental conditions.

Subsidence continued throughout Middle Miocene time, but was finally brought to a close at the beginning of Upper Miocene time. The thick section of siltstone and siliceous shales of the Lower Shale member of the Puente formation adds evidence to such a conclusion. A quiet, warm sea made it possible for the accumulation of the vast number of foraminifera and fish scales. The source area was apparently in a state of quiescence; thus, the fine-grained sediments were possible to form. Before the deposition of the Lower Puente member there was a very short interval of non-deposition and continued subsidence, causing a minor unconformity.

The Upper Miocene quiesence continued throughout the deposition of the Middle and Upper members of the Puente formation, with irregularities occurring in the source area to the north and northeast. Strong current action, aided by climatic cycles, formed local scour and fill features in the sandstone.

Rapid uplift of the source area and pronounced weather cycles during the deposition of the Sycamore Canyon conglomerates were interspersed with periods of quiescence contemporaneous with the accumulation of the shales and siltstones. Marine life was only locally abundant, and then only during the deposition of the shales. The siliceous foraminifera probably were less abundant than those lower in the column. According to English, minor folding and continued deposition of the sediments took place during this time. The folding reached its maximum at the close of the epoch. This would account for the local disconformities reported along the Repetto-Sycamore Canyon contact.

The shoreline during Repetto time was farther north-east than it had been throughout the deposition of the Sycamore Canyon formation. The absence of conglomerates from the section confirms this interpretation. The absence of cherty shales, siliceous siltstones, in addition to the absence of the conglomerates tend to indicate that the enviormental conditions were quite different than during previous time. The rapid currents, abundant coarse sediments, and the oscillating shoreline of Sycamore Canyon deposition apparently killed most of the siliceous warm water organisms. Reed reports an abundance of arenaceous forms in the Repetto formation (Reed, p. 230, 1932), which would tend to confirm this assumption.

Uplifting of the basin of deposition with combined folding and some faulting, took place during late Pliocene and early Pleistocene time. This exhuming of the sediments, combined with a cool climate (Reed, p. 254. 1932), essentially marked the close of the period of deposition in the Puente Hills region. Erosion during Pleistocene time probably was not extensive, and the present mature topography represents the end product of a long, slow period of continued erosion. The terrace gravels, probably middle Pleistocene in age, indicate the amount of deformation before their deposition. These terraces were subsequently tilted.

The main structural features now visible are relatively recent in age. At the most, they were formed during middle to late Pleistocene. The contorted shales, overturned sections, and sharp folds owe their existence to this period of strong deformation. It is believed that all of the faults mapped in this area were formed during Pleistocene time. It is difficult to correlate the direction of forces, but a compression from the north would account for nearly all of the known displacements. The Whittier fault to the south has had numerous earthquake epicenters on it during the last 20 years of seismic records (Wood, map, 1947). The period of deformation is apparently still in progress.

OIL AND GAS POSSIBILITIES

History of operations

General descriptions

This discussion of oil and gas possibilities is confined in general to the area north of the Whittier fault, and the detailed discussion to the immediate area covered in this report. Production and conspicuous oil showings extend along the north side of the Whittier fault in a broad belt including areas around the town of Puente. The oil shows a remarkably, consistent distribution within a definite zone in the Upper Miocene Puente formation. The earliest producing wells east of Los Angeles City seem to have been in the old Puente field, one and one-half miles southeast of the lower-right-hand corner of the map, where two operators by the name of Lacy & Rowland drilled two wells prior to 1882 and by 1887 had six wells producing. The wells ranged from 800 to 1,000 feet deep and were producing from the fractured Lower Shale member of the Puente formation. The gravity of the oil was $30^{\circ}$to 32°B., and the initial production was about 100 barrels per day. By 1893 there were 25 wells in the Puente Field with an average production per well of 11 barrels per day (McLaughlin, and Waring, p. 308, 1915).

This old Puente field in the only area that has obtained very much commercial production from the lower shale, all other production has come from the Middle member of the Puente formation.

Another producing area is the Turnbull Canyon field, about one mile west of the Repetto nose, in which there are five producing wells. Here the production is from four zones called the Clevenger zones, which is probably equivalent to the upper 765 feet of the Middle Sandstone member of the Puente formation. This production was discovered in 1941 by the Continental Oil Company. The accumulation is against the Whittier Heights fault.

Production developed by the Capital Oil Company on the Baldwin-Pellissier ranch one and one-half miles west of the northwest corner of the geologic map has also produced from the Middle Sandstone member. In this area a major fault also controls the accumulation. In each case the structure is not a complete trap fold.

On the San Jose anticline, located a mile and one-half north of the area on the geologic map, there are only a few producing wells. The outcropping formation in the southwestern San Jose Hills is the Middle member of the Puente formation. Production from the Topanga formation and the Lower Shale member of the Puente formation has been from those areas in which the accumulation has been against a fault and in a highly fractured shale zone.

The only production from the area of detailed mapping is located in the northeastern area. Three wells, numbers (4), (6), and (7) on the map, have produced an average of about 15 barrels per day for the average life of 7 to 8 years before going completely to water. The producing zone is reported to be from the lower Middle Puente and upper Lower Puente members.

At least 150 wildcat wells have been drilled north of the Whittier fault, in the Puente Hills, since the year 1880. Unfortunately most of the wells were drilled without adequate geologic information. In the area covered by this report only those wells drilled since 1927 have been used, 15 in number. The pre-1927 wells were extremely shallow and little or no reliable subsurface information could be obtained.

Description of selected areas

Rowland Estate Ranch: The area termed as the Rowland Estate Ranch is located in the map coordinates B-2 and C-2. It extends from the Union Pacific Railroad tracks on the north, to the crest line of the hills on the south. The first well drilled in this vicinity since 1926 was by the Axis Petroleum Company to a total depth of 2,468 feet. The axis well (2) (B-2) was spudded in the early part of 1942. This well encountered a strong flow rated as "fresh" water between 700 and 800 feet, where the formation seems to be shale with streaks of sand and conglomerate. There may be minor faulting at this depth. According to the operators, shows of gas were reported from 2,310 feet to the total depth. The well was abandoned because of lack of capital. No electric log was run, and the core and shaker descriptions do not appear to be very reliable.

The Axis well was bottomed in the Middle Sandstone member of the Puente formation. The wedge-like structural position of this well (see structure section A-B) would be favorable if there was any area from which accumulation could come. A near commercial well may have been obtained had it been deepened about 500 to 700 feet, thus penetrating the Clevenger zone sands.

The Steele (Horace Steele-Kenwood No. 1) (14) well was drilled to a total depth of 4,272 in the latter part of 1943. The well is situated about 1,000 feet north of the foothills on the gentle sloping surface of the alluvial outwash plain that leads down into San Jose Creek. There is no surface evidence of the geological structure by which this location could have been determined. However, the Steele well obtained sufficient oil and gas to make small production. According to the history filed with the Division of Oil and Gas of the State of California, the well pumped for about two months with an approximate daily rate of 125 barrels per day of which only 5 percent was 13° B. gravity oil. This well penetrated approximately 340 feet of the Lower member of the Puente formation. The oil sands described were grading to spotted showings and to gray sands. Each sand was capped by a tight shale. The evidence that some trap characteristics exist seems fairly definite, but perhaps the Steele well is too far down structure to have been a commercial well. Schlumberger oriented dipmeter readings at 3 depths in the Steele hole showed the dip to be approximately north in each case, and with an average value of 6 to 10 degrees.

Morton and Sons' Rowland 3-1 well (9) was drilled 100 feet southeast from the Steele well in 1945. According to Ted Baer of Stanley and Stoltz Consulting Geologists, this well was a deep test on a conjectural fold closed on the west by the northwest projection of the Vejar fault. Because the Steele well had flat dips as contrasted with 25 degree dips of adjacent surface outcrops, the operators thought that a possible reversal was indicated. This well did not core any until passing the total depth of the Steele well, and they obtained no oil shows below the depth of the Steele well. The Morton and Sons' well, combined with the Steele well, have given an excellent section for the area. Because the Rowland 3-1 well was drilled all the way to basement complex, its record was used in the preparation of the Columnar Section included in this report. The well also appears on the structural section A-B. The top of the basement complex is estimated to be at 8,600 feet and the total depth of the well is 8,667 feet.

A second test was made by the Morton and Sons Oil Company in 1946. This well was apparently drilled without the aid of any geologist, and was located 2,000 feet north of the first Morton well. It was drilled to a total depth of 7,522 feet, which is probably the lower part of the Topanga formation, Upper or Middle Luisian in age. No cores were taken in this well, nor were the cuttings recorded, but electric log correlation with the first test indicate that this well was about 500 feet farther down structure. Very faint indications of gas were reported from this well, and no shows of oil were reported.

A recent well drilled by the Standard Oil Company of California was spudded in January 30, 1949. The map location is marked by (13) and is located in area C-2. This well was located on a conjectural fault wedge. The Sycamore Canyon conglomerate-Upper Puente shale contact was thought to be in fault contact. The evidence for this fault is indeed meager. The well was bottomed at 4,340 feet, which is in the Lower Puente, Lower Mohnian in age. At 1,500 foot depth, the first core was exceedingly "wet", and this was the only indication of any kind of fluid for the entirity of the hole. Very light-brown cut was at the 3,267 foot depth, which is the Middle Puente Sandstone. Since the section was "gray all the way" the well was abandoned March 19, 1949.

Fullerton Road Area: In map area E-3 there are three wells, which were drilled in an attempt to obtained production from the Lower Puente Shale. These wells are located a few hundred feet west of Fullerton Road, and are north of the Rowland fault. It was hoped by the operators that a similiar condition existed near the Rowland fault as in the old Puente Oil Field farther southeast, near the Whittier fault.

The first well was drilled by Rucker, Smith, and Croul Oil Company, number (11) on the map. In 1929 this well was spudded in the Middle Puente Sandstone, and was bottomed in diabase at the 3,644 foot depth. This diabase is possibly the same diabase sill encountered in the Morton and Sons' Rowland 3-1 well at 5,495 feet. The well (11) had poor showings of oil in the lower part of the Middle Puente formation, and also in the upper section of the Lower Puente member. The well was abandoned because of unrecoverable drill pipe. At the time of abandoning, water was flowing into the well. It was later converted to a water well.

A second well in this area was drilled in 1930 by two of the original three operators of the first well. The

Rucker & Croul Grazide number 2 was drilled about 2,000 feet north of the Rowland fault. This well gave the same oil showings as the first well, but there was no commercial zone encountered.

A third well was drilled as late as 1945, by the Troy Oil Company, in a position intermediate between the first two holes. It was bottomed at a depth of 2,952 feet in the Lower Puente Shale. It was abandoned without any sign of commercial production.

Repetto nose area: Only one well has been drilled in this vicinity, the Anchor Petroleum Company's Hudson number 1 (2), which was drilled in 1927 to a total depth of 4,824 feet. After penetrating 770 feet of Repetto siltstone, the hole encountered all of the Sycamore Canyon and Puente Formations. It is very possible that the well would have penetrated diabase in another 100 feet. There were spotted oil shows throughout the entire section, including the Repetto, but none of it was of commercial value.

Pomona Boulevard area: It is in this area that the only semi-sustained production has occurred. Six wells have been drilled on what appears to be a very small, local anticline, with no appreciable closure. The three wells that obtained production lie on the crest of the fold. There are the Barry Oil Company's W. Y. Rowland number 1, Dietzel Oil Company's W. Y. Rowland number 1, and Dietzel's W. Y. Rowland number 2. These wells are probably producing from the equivalent horizons of the lower Middle Puente formation, and the upper part of the Lower Puente formation. They were abandoned because of water encroachment. The other wells drilled in the area were all edge-water locations. Two of the wells have penetrated the diabase at the base of the Lower Puente Shale.

It is believed by the author, that this area has been exhausted of all possible production. There does not appear to be enough closure of the structure to allow any additional development.

Future production

In general it may be said that any trap sufficient to retain accumulation within this area may be looked upon as a good possible prospect for commercial production. As has been stated, nearly all of the wildcat wells drilled in the area have had a certain degree of showings of oil and gas. It is the opinion of the author that the only location in the area of detailed mapping which may have suitable trap characteristics for the commercial production of oil and gas, is in the Repetto nose.

The Repetto nose is a broad, gentle, plunging nose. This supposed closure, however, has not been proved, nor is there any good evidence that it will be proved by additional field mapping. Whether there is closure on this nose depends wholly upon whether or not the Rowland fault cuts across the southern part of the structure. If the fault dies out before reaching the nose, the chances of any production are very slim. Assuming that the Rowland fault does cut the structure, does not eliminate the projection of the Vejar fault along the northeast front of the Repetto nose. If there is true, the chance of production is all the more questionable.

Summary and conclusions

In summarizing the oil and gas possibilities of this area, it is sufficient to state that at least one wildcat well has been drilled in nearly every square mile. The only areas which have not had a test is the Repetto nose and the wedge between the Rowland Vejar faults, of which perhaps the Repetto nose is a part. This of course is excluding the area south of the Rowland fault, where the outcrops show no evidence of a favorable structure.

APPENDIX

Wells drilled for oil and used in the preparation of this report (Part I)

No. on map	Operator	Well	Location
1	Alleghany Pet. Corp.	W.Y. Rowland No. 1	E-1
2	Anchor Pet. Co.	Hudson No. 1	A-2
3	Axis Pet. Co.	W.R. Rowland No. 1	C-2
4	Barry Oil Co.	W.Y. Rowland No. 1	E-2
5	Butler, C. R.	Butler No. 1	E-1
6	Dietzel, J. W.	W.Y. Rowland No. 1	E-1
7	Dietzel, J. W.	W.Y. Rowland No. 2	E-1
8	Honolulu Oil Co.	Butler No. 1	E-1
9	Morton and Sons	Rowland Est. No. 3-1	C-2
10	Morton and Sons	Rowland Est. No. 3-2	C-2
11	Rucker, Smith, & Croul	Grazide No. 1	E-3
12	Rucker, and Smith	Grazide No. 2	E-3
13	Standard Oil Co.	Rowland Est. No. 1	C-2
14	Steele, Horace	Kenwood No. 1	C-2
15	Troy Pet. Co.	Troy No. 1	E-3

APPENDIX

Wells drilled for oil and used in the preparation of this report (Part II)

Year begun	Status	Elevation	Total Depth	Remarks
1944	Aband.	460	?	No record
1927	Aband.	725	4824	
1942	Aband.	620	2468	Sect. G-A-B
1942	Aband.	438	2423	
1935	Aband.	430	4133	
1930	Aband.	433	4908	
1931	Aband.	450	2520	
1936	Aband.	425	3768	Sect. C-D
1945	Aband.	482	8667	Sect. G-A-B
1946	Aband.	415	7552	Sect. G-A-B
1929	Aband.	575	3644	Sect. C-D
1930	Aband.	575	2188	Sect. C-D
1949	Aband.	675	4340	
1943	Aband.	482	4272	
1945	Aband.	584	2952	Sect. C-D

APPENDIX

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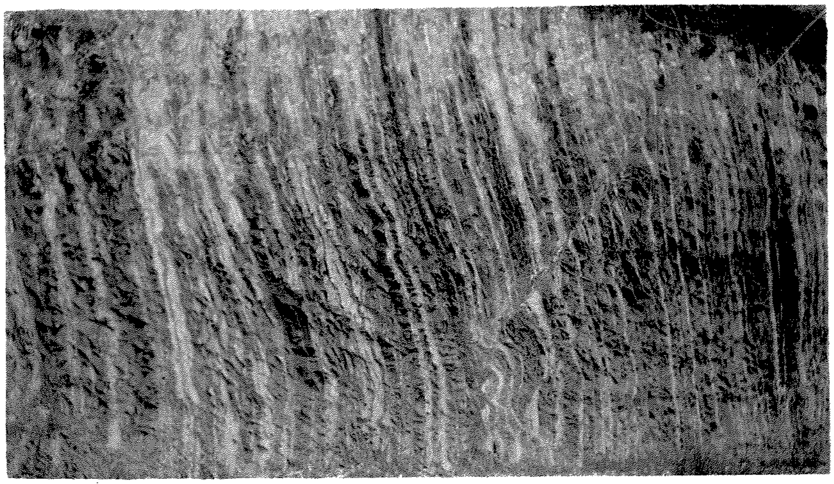

PLATE VI

Top ------Terrace gravels that cover the low-
lands, east of the Repetto nose. The
Repetto nose is in the background.

Bottom ---Lower Siltstone member of the Puente
formation. Location is one-half mile
southeast of the mapped area. Dips
are nearly vertical, and the height
is 15 feet.

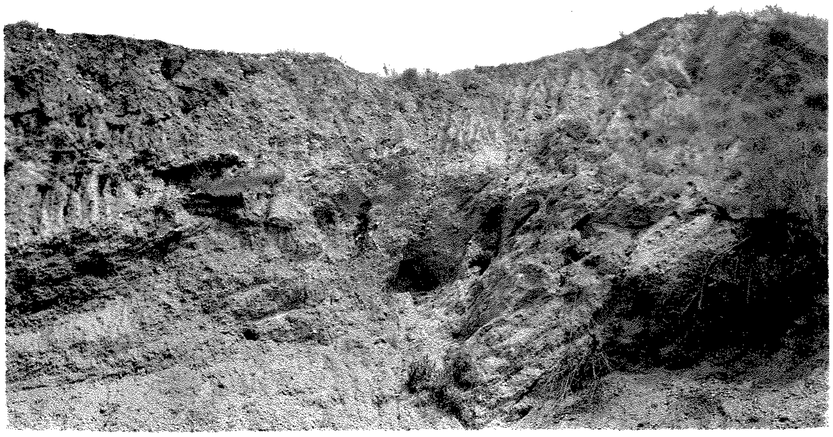

PLATE VII

Top ----- View showing rapid change of dip along the Vejar fault. Picture is taken from the hill north of the Axis Petroleum well. The shale is located just to the right of the picture.

Bottom -- A typical cliff formed by the Sycamore Canyon Conglomerate.

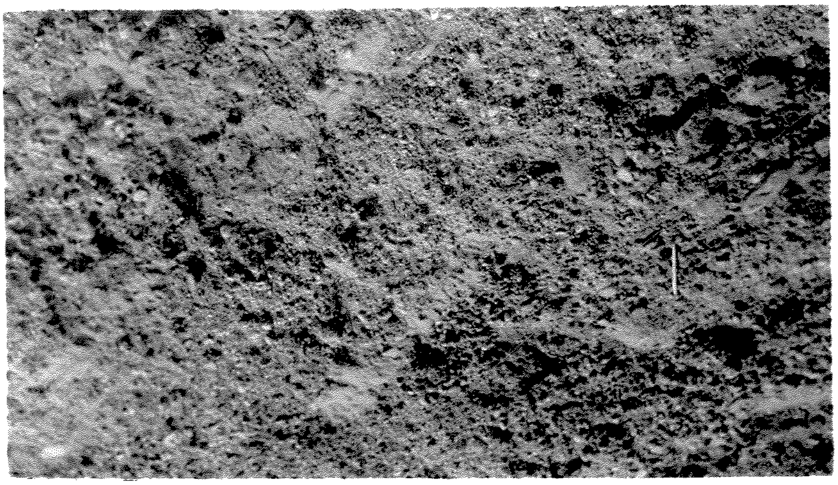

PLATE VIII

Two views of Sycamore Canyon Conglomerate.
Pencil is for scale.

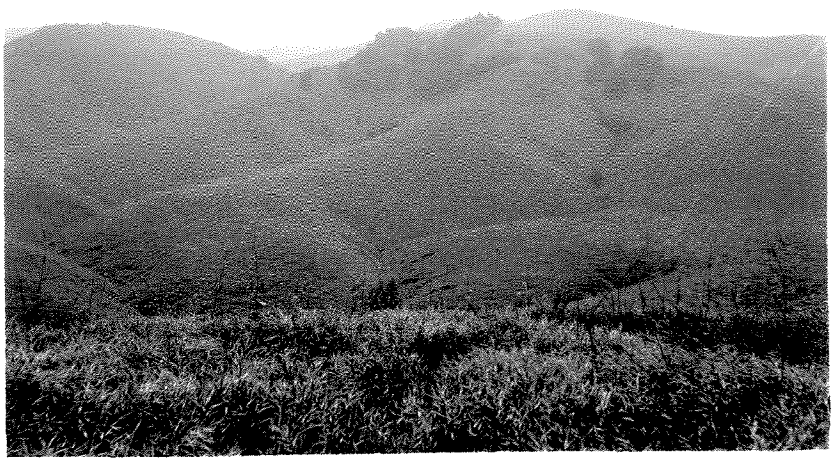

PLATE IX

Top ------ Rowland fault trace. Picture was taken facing the west, along the trace. The beds on the north and south are dipping into the fault. Hills in the upper right are called the Repetto nose.

Bottom -- Same as above, but facing south.

PLATE X

Top ----- Gradational contact of the Upper Shale and Middle Sandstone members of the Puente formation. Location is along Fullerton Road, which is in the northeast corner of the area. Pencil is for scale.

Bottom -- Typical conglomerate-shale contact. Picture was taken facing northeast, from a location 200 feet southeast of Standard Oil Company's Rowland Estate No. 1 well.

PLATE XI

Two views of recent landslides in the Upper Shale member of the Puente formation. Location of the slides is 2,000 feet southeast of Triangulation Station 1415. Scarps are 50 to 75 feet high. (Note in foreground the slide scars which were made in 1948)