A REPORT ON THE GEOLOGY OF A PORTION OF THE WHITTIER HILLS, SOUTHERN CALIFORNIA

By

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

Area covered

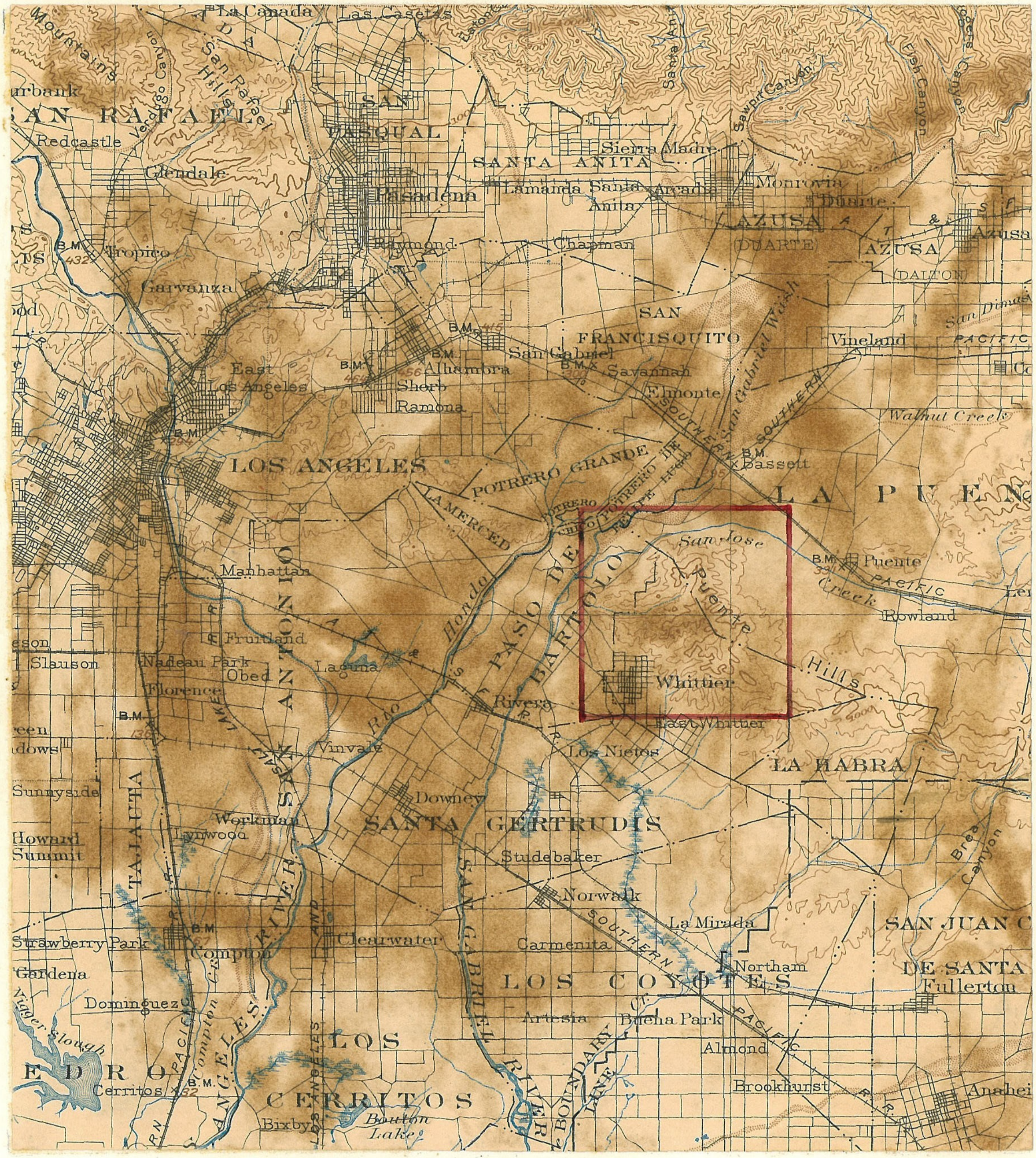
The area described in this report occupies a block of approximately 20 square miles, the northwest corner of which is 10 miles east of the center of Los Angeles. (See Figure 1) The southwest corner of the area is occupied by the city of Whittier. The area is situated at the intersection of four quadrangles, including the southeast corner of the El Monte Quadrangle, the southwest corner of the Puente Quadrangle, the northwest corner of the La Habra Quadrangle, and the northeast corner of the Whittier Quadrangle. Most of the area is occupied by the Whittier Hills which form the northwest corner of the Puente Hills. The rest includes portions of the San Gabriel Valley and the coastal plain.

Purpose and Scope of Examination

This piece of work was undertaken as a thesis problem at the California Institute of Technology in partial fulfillment of the requirements for the degree of Bachelor of Science. It was originally intended to be highly detailed, but because of the size and complexity of the area it was found necessary to confine most of the attention to the broader geological features.

Character and Methods of Field Work

Twenty-five days were spent in the field during the period from early January to June, 1929. A small fraction of this time was devoted to general reconnaissance, but most of the time was spent in mapping areal geology. This amount of time was quite inadequate for a thorough understanding of the problem, for many of the conditions encountered are subject to more than one interpretation



Scale $\frac{1}{250000}$

2 0 2 4 6 Miles

Contour interval 250 feet

Figure 1. Map showing the location of the area described in this report.

The field map used was made from portions of four U.S.G.S. topographic maps covering the above mentioned quadrangles . Fortunately all of these maps have a scale of 1/24000, with 5 and 25 foot contour intervals. This made location by topography relatively easy, for the maps are very accurately made. Locations for plotting data were determined by Brunton Compass sights, by aneroid barometer readings, and by topography- in varied combinations.

PREVIOUS PUBLICATIONS

The only work used for reference was:

English, Walter A., Geology and oil resources of the Puente Hills region, southern California : U.S.G.S. Bull. 768, pp. 1-110, 1926.

Many other works deal with the geology of this region, but as the list is quite long, it can be obtained from page 10 of the above paper.

GEOGRAPHY

Topography and Drainage

The highest point in the Whittier Hills is Workman Hill (1387 feet), which rises about 1000 feet above the surrounding plains. Numerous ridges rise above 1100 feet in altitude, but the average elevation is not much over 750 feet. A persistent ridge running nearly North and South forms the backbone of the hills. Rising rather abruptly to an altitude of 1200 feet at the North, this ridge continues Southward at elevations always above 1000 feet, culminating with Workman Hill. As this ridge divides the drainage from East to West, Most of the canyons and ridges run East and West.

The area to the North of Workman Hill has greater relief and more rugged topography than that to the South. (See Figure 2)

Figure 2

Looking North
across Turnbull Canyon

Figure 4

Cliff of Siltstone

Figure 3

Erosian in Siltstone

The hills are usually well rounded, but many of the canyons are deeply incised- often having nearly vertical walls. Such a canyon is shown in Figure 3. Figure 4 shows the nearly verticalcliff which forms the north rim of this canyon. The east-west ridges have gently sloping north flanks but drop quite precipitously to the South. They follow the strike of the strata in most places, and the north flanks are merely modified dip slopes. This relation is well brought out in Figure 16 which also shows the main ridge in the background.

Most of the streams contain water only during and immediately after rains, but several of the canyons have small springs - usually of sulphur water. The eastern, northern, and northwestern drainage empties into San Jose Creek- a permanent stream which joins the San Gabriel River.

There are but two undrained areas, one small pond at the northern end, and a good sized basin in the southern end - about $\frac{1}{2}$ mile South of Workman Hill . The latter has a minimum depth of about 25 feet. (See Figure 19)

Climate

The climate of the region is quite mild due to the proximity of the ocean. This is substantiated by the fact that avacados are grown of some of the highest parts of the hills. In winter light frosts occur occasionally , necessitating the use of smudge pots in the surrounding citrus and avacado groves. The rainfall is small and comes almost entirely in the winter - as is typical of semi-arid regions.

Vegetation

Fortunately for the geologist this region has only a sparse growth of natural vegetation. Areas of shale or siltstone are grass covered, while the sandstones and conglomerates favor the growth of brush. In places the brush is quite dense, especially in the canyon bottoms. The canyons and many of the slopes contain large sycamores and live-oaks.

Exposures

The greater part of the area is favored with good exposures. Natural exposures are most numerous in the harder rocks- especially in the Fernando conglomerate which forms cliffs in many places. The softer rocks are often unexposed over large areas- yet the largest single exposure in the area occurs in soft siltstone. (See Figures 3 and 4.) Road cuts and excavations are numerous in the oil fields and in the vicinity of Turnbull Canyon.

Culture

Citrus and avacado groves surround the hills on all sides, and extend up into them at the eastern end of Turnbull Canyon. Numerous houses line the flanks of the hills at the eastern and western ends. The summit of Turnbull Canyon has been subdivided, but fortunately most of the lots are still unsold. Most of the hilly portion is used for cattle and sheep grazing to which purpose they are admirably adapted. The Whittier oil field lies just to the East of Whittier, And the Sycamore Canyon Rock and Gravel Co. operates in that canyon North of Whittier.

The coast highway passes just to the South, and the inland highway is but a short distance North. Numerous roads traverse the area the best of which is paved- connecting the towns of Whittier and Puente through Turnbull Canyon. Although much of the area cannot be reached by automobile, all parts are readily accessible on foot. The hills abound with cattle trails which have proven very valuable.

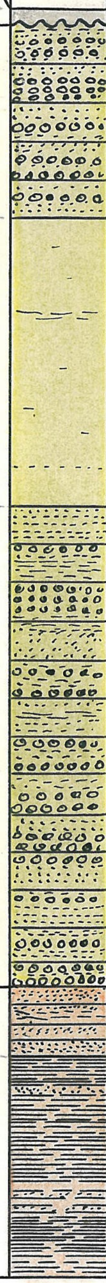
Figure 5

Northwest corner of the hills.

Figure 6

Sycamore Canyon Rock and Gravel Company.

APPROXIMATE COLUMNAR SECTION



SYSTEM	SERIES	FORMATION	SYMBOL	SECTION	THICKNESS	CHARACTER
Quaternary	Recent	Alluvium	Qal		?	Valley fill
Tertiary	Pliocene	Fernando Group	Tf		1000 + -	Sandstones and conglomerates with some shale and siltstone
					1500 + -	Massive siltstone. Occasionally shale. Very little coarse material.
					2500 + -	Alternate sandstones and conglomerates with some shale and siltstone.
	Upper Miocene	Upper Puente	Tp		350+-	Buff-yellow ss.
					? fault	Shale (clay, sandy, siliceous, diatomaceous). Little sandstone

Scale 1"=1000'

BRIEF SUMMARY OF THE GEOLOGY

The northern part of the Whittier Hills contains but two formations, upper Puente (upper Miocene) and the Fernando Group (Pliocene). The Fernando (consisting of conglomerates, sandstones, siltstone, and shale) is apparently conformable on the Puente(consisting of sandstone, and siliceous, diatomaceous, sandy, and clay shales).

The hills appear to be warped up from all sides, with the oldest rock (Puente) faulted up to the surface in a mosaic of fault blocks; with both faulting and warping playing important roles.

The topography is of moderately low relief and is usually related to the underground structures by differential erosian.

The region is of economic importance because of the Whittier oil field, whose oil is trapped between one limb of a faulted anticlineand an adjoining impervious shale block. This fault is regional - being a continuation of the distant Elsinore Fault.

STRATIGRAPHY AND PETROGRAPHY

General considerations

The area described contains only three formations, two of which are sedimentary marine formations of the upper Tertiary, the other is alluvium. The oldest- the Puente formation - is limited to the upper Miocene in this area, but the middle Miocene portion is not far to the South. The other formation is the Fernando group- Pliocene in age.

Names and ages of formations are taken from U.S.G.S. Bull. 768.

Upper Puente formation (Upper Miocene)

In this area the Puente formation occurs in three adjacent fault blocks surrounded by the Fernando. Only the top of the Puente is represented - the lower portion being cut off by faults.

This formation is represented by two facies - a lower shale member and an upper sandstone member. They were not differentiated on the map because the change is gradual and the one is always present to some extent in the other.

The Puente shale varies considerably from place to place both as to character and composition. Most of the shale is buff to dark brown in color, thinly laminated, and easily cleavable. In hardness it varies from soft clay shale, sandy shale, and diatomaceous shale to an extremely hard siliceous shale which breaks with a smooth fracture. In general it weathers to a lighter color- gray, yellow, or white. The soft shale often contains inumerable fractures which are sometimes filled with gypsum. The siliceous shale often shows very delicate banding, but is sometimes quite uniform- merging into a very fine grained sandstone. Figure 7 shows a typical example of the soft shale.

Interbedded with these hard and soft shales are thin beds (2"-12") of a most peculiar type of rock. Originally it was a very hard, extremely fine grained sandstone or sandy shale. Being thus hard and brittle it was fractured in every direction by the folding and crumpling of the shales. Then the sharp fragments- held in their original positions - were cemented into a very hard rock by silica. Many of the cracks remain open up to $\frac{1}{4}$ of an inch- others are filled with quartz crystals or with chalcedony. The result is a very unique type of breccia, usually bright yellow in color- occasionally reddish or buff. Figure 8 shows a contorted layer of this breccia in typical Puente shale in which the hard layers show up as white bands.

Beds of sandstone are often interbedded in the shales, especially near the contact between the shale and sandstone facies. One small patch of conglomerate was in the shale just to the North of the Whittier Fault (Station 162), but due to its proximity to the fault it may belong to the Fernando.

Diatomaceous shale was encountered at only one locality (See stations 166 & 167 North of the Whittier Fault in the oil field) The rock is pure white, very light in weight, and is nearly pure diatomite. Mr. K. E. Lohman determined the flora to be of distinctly marine origin.

The Puente shale covers the greater part of the two Puente fault blocks. The nature of the rock does not allow frequent exposures - nevertheless there are several large natural exposures and numerous road cuts. It is usually quite free from brush, being covered only with wild grasses and mustard. Figure 9 shows an anticlinal fold in a shale outcrop. The change of vegetation between shale and sandstone can be seen in the background, also the low, rolling hills typical of the shale areas.

Figure 7

Puente shale

Figure 8

Brecciated sandstone reef in Puente shale

A small spring near the eastern end of Turnbull Canyon has deposited considerable travertine on the shale. The water was tested with citric acid and found to contain a considerable amount of dissolved carbonates.

Figure 9

Puente shale showing anticline

Figure 10

Puente sandstone

overlying the shale is a sandstone member varying in thickness from about 200 t0 500 feet in the western block to a somewhat greater thickness in the eastern block. The sandstone occurs alone in both massive and laminated types, and interbedded with shale. The predominant color is orange-yellow, but buff, grey, and white sandstones occur . The orange-yellow color (due to iron) weathers to a darker color - usually brown. In hardness it varies from a soft rock to an extremely hard one, and in general is somewhat harder than the overlying Fernando.

The cement is usually silica or iron. The composition is variable, but clean grains of arkosic sand with trifling amounts of muscovite predominates. The sandstone is usually fine to medium in grain, consisting nearly always of well rounded to sub angular grains.

The sandstone member being much harder than the shales is better exposed, and forms steeper topographic forms. A reef of this hard - yellow sandstone is shown in Figure 10.

The absence of coarse materials in the upper Puente suggests a low-lying continent or slow, deep water deposition.

Age

No diagnostic fossils have been found in the Puente of the Whittier Hills. Dr. English determines the age by its position midway between the middle Miocene Topanga and the Pliocene Fernando, and by its lithologic similarity to the Monterey Group. The only fossils found in this area were diatoms, foraminifera, reed imprints, and fish scales.

The Fernando Group undifferentiated (Pliocene)

Overlying the upper sandstone member of the Puente is the Fernando Group. North of Whittier a north dipping monoclinal section of Fernando about 5000 feet thick overlies the upper Puente sandstone with apparently complete conformity. The contact was placed at the first conglomerate encountered above the Puente sandstone, for the rocks grade into one-another with apparently continuous deposition. Figure 11 shows a geology pick

Figure 11

Puente- Fernando contact

pointing toward the contact - here somewhat obscured by soil. The contact South of the Whittier Fault is also apparently conformable. Elsewhere the two formations are in fault contact, with the possible exception of the long narrow strip of Fernando $\frac{1}{2}$ mile East of Workman Hill. (See structure) Dr. English considers that the regional relation is an unconformable one.

The most striking lithologic differences exist between the two formations. Whereas the Puente consisted exclusively of fine grained rocks (with one minor exception), the Fernando contains conglomerates and coarse grained sandstones in great abundance. Most of the fine grained material of the Fernando is deposited in the form of massive siltstone rather than shale.

The Fernando contains every gradation of rock from extremely coarse conglomerate containing boulders up to 4 feet in diameter , to fine grained siltstone and shale. These different types occur in all possible combinations. It is not uncommon to find coarse conglomerate, fine sandstone, siltstone, etc., all interbedded with sharp separation. Figure 12 illustrates sharp lithologic changes of this sort.

Figure 12

Fernando sandstone and conglomerate

Figure 13

Fernando conglomerate

Conglomerate

The Fernando conglomerate varies greatly as to sorting, degree of induration, and size of particles, but is rather uniform in composition. The particles are all of igneous origin, chiefly granitic, but with various combinations of felsitic and basaltic lavas, quartz, gabbros, and exceptionally- anorthosite. They are usually well rounded, occasionally sub angular, never angular. the matrix consists of smaller well-washed pebbles and sand grains. Much of it is so poorly sorted that its bedding cannot be distinguished from nearby. There are occasional beds of conglomerate which show nearly perfect sorting through several feet. Perhaps the most distinctive feature of Fernando conglomerate is its predominant red-brown color due to limonite. A typical Fernando conglomerate is shown in Figure 13.

Two types of conglomerate have been encountered which do not fall under the above description. Just below the Whittier Fault (Station 191) occurs a bed of well sorted conglomerate about three inches in thickness, containing very well rounded pebbles; which is saturated with oil- trapped by the underlying siltstone. At Stations 67 and 70 on the north rim of Turnbull Canyon occurs the hardest conglomerate in the area. It owes its hardness to the fact that the fault which passes near it has carried silica bearing water - cementing the rocks to a monolithic mass which breaks through pebbles.

The conglomerates are the best exposed rocks in the area, forming cliffs and reefs throughout the

Fernando section. Several of these hard strata are shown in Figure 14 . This rock is responsible for most of the rugged topography of the region, for it occurs with great frequency throughout all of the Fernando blocks.

Figure 14

Fernando on the north rim of Sycamore Canyon

Sandstone

The fernando sandstones are quite variable in character. Several occurences of exceedingly hard sandstone were noted, but in general it is poorly consolidated- usually softer than Puente sandstone. Some sandstones are quite well washed- others contain much silt. The particle size is quite variable, but medium grained sandstones predominate. Many of the coarser sandstones are arkosic with minor quanities of biotite and other femic minerals- suggesting a granitic derivation. Occasionally the sandstone contains great quanities of mica- chiefly muscovite. White, grey, buff, brown, and reddish brown are the usual colors- buff being the most common. Here as in the conglomerates, limonite stain is very common. Some of the brown sandstones closely resemble those of the Puente, a fact which often made it difficult to separate the two formations. Hard sandstone concretions are not uncommon in the sandstone - usually quite small, but South of east Turnbull Canyon (Sta. 97) two perfectly spherical concretions of sandstone measured 2 feet in diameter. Marked cross bedding was seen in only two localities.

The sandstone is not as well exposed as the conglomerate, but is often exposed with it . The sandstone weathers more rapidly than the conglomerates forming depressions between conglomerates outcrops.

Siltstone and Shale

The most unique rock in the area is the Fernando siltstone. Occasionally it is bedded to form shale, but often occurs hundreds of feet thick without a trace of bedding and without any indication of attitude. A cliff of this material is shown in Figure 4. The material consists of clay with more or less sand, and is always quite fine grained. When dry, the material is light buff in color, but is quite dark when damp. Innumerable joints occur in the siltstone, usually in every direction, but on one occasion the joints were so evenly spaced that they were at first mistaken for bedding. In Figure 15 the true bedding dips

Figure 15

False bedded siltstone

down to the left and the false bedding due to jointing dips down to the right. The jointing was apparently caused by thorough drying out for a depth of 4 - 5 feet.

The siltstone occurs in greater single beds than any other rock. Its maximum thickness is around 1500 feet, although it occurs in smaller amounts quite frequently. The deposition of the material must have taken place under remarkably constant conditions - to form such thicknesses without interruption. It forms a marked contrast to the rapidly deposited conglomerate in this respect.

very little shale occurs, but when it does it is much lighter in color than the Puente shale, and never siliceous.

Although the largest single exposure of the region is in siltstone, the rest of it is very poorly exposed. It weathers rapidly, giving rise to well rounded topography.

Age

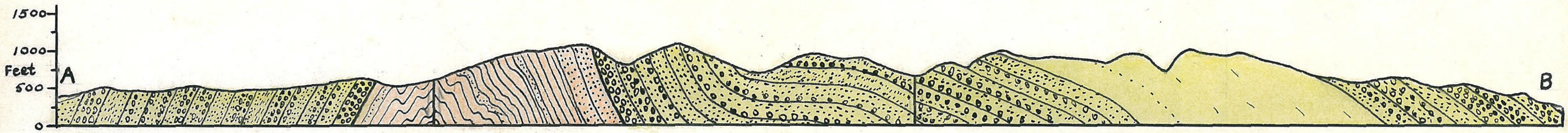
The only fossils found in the Fernando were foraminifera and mollusc fragments. At Station 7 in the northern end a siltstone member about 1" thick contains poorly preserved mollusc shells - nothing of any value. Foraminifera were found at station 17 in the northern end. The Fernando farther to the South yields an abundance of fossils which are middle Pliocene in age, according to Dr. English.

Quaternary Alluvium

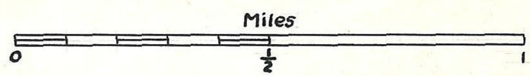
Both the San Gabriel Valley to the North and the coastal plain to the South are covered with a considerable thickness of alluvium.

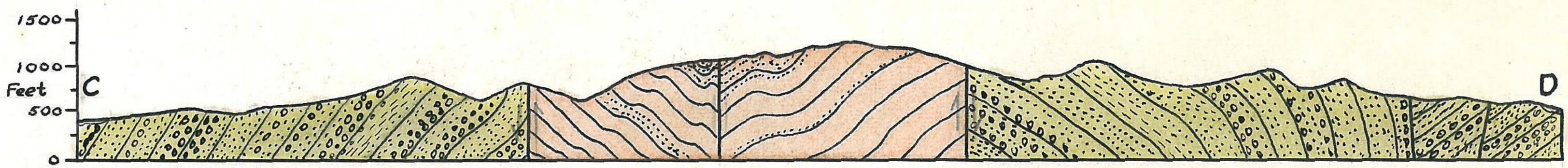
STRUCTURE SECTIONS

Scale 1/24000



Section along line A-B





Section along line C-D

Tertiary		Quaternary
U. Miocene	Pliocene	Recent
Tp	Tf	Qal
Puente Formation Siliceous shale, diatomaceous shale, sandy shale, buff sandstone, local conglomerate..	Fernando Group Conglomerate, sandstone, sandy shale, siltstone.	Alluvium and Valley fill

STRUCTURE

The structure of this region is exceedingly complex, and is related to both faulting and folding. Faults- both major and minor-are quite numerous. Beds dipping 60,70, or 80 degrees are frequent ,while a number of vertical dips have been recorded. Dr. English, in dealing with the structure of the Puente hills makes the following comment regarding the Whittier Hills.

"The Whittier Hills, comprising the area west of La Habra Canyon, show some of the most complicated structure to be found within the district. Steep irregular dips, numerous faults, unconformities, and lithologic variations in the different formations and members make the structure as well as the stratigraphy, difficult to work out. The writer has seen several maps of the area South of Workman Hill that were not in agreement with his own map or with one another."

In attempting to work out the structure of this region, many difficulties were encountered. Certain parts, such as the area North of Workman Hill are complicated with numerous minor faults and folds. The area South of Workman Hill is fittingly described above by Dr. English. The structure of this section owes its complexity to the great number of major faults which intersect- producing a mosaic of formations. Despite these facts, the area North of Whittier and the area South of the Whittier Fault have rather simple structures.

The structure of greatest regional significance is the Whittier Fault - passing just to the North of Whittier. This great fault can be tied up with the Elsinore Fault farther to the South. The beds in the block South of the fault are seen to dip steeply down into the coastal plain. Four miles to the Southwest occurs the great dome beneath the Santa Fe Springs oil field indicating that the region just South of the Whittier Fault may not be a simple monocline but may be the eastern limb of a syncline. As can be seen on the map, this block has Puente shale in the center and Fernando on both sides with dips diverging toward the Southwest- thus forming an anticline. It is not unreasonable to suppose that this is a recurrence of the same anticlinal structure encountered at Santa Fe Springs- certainly the two structures are in direct line. This structural correlation was suggested to the writer by Dr. R. D. Reed.

It will be noted that the Whittier Fault (as well as several other faults) appears on the map as a straight line. this is due to the fact that one can rarely ever be sure of its exact whereabouts, and because known points fall on a straight line. It appears to be a fault of considerable throw in which the northern block of hills rose with respect to the southern coastal plain. Since the points on this fault fall on a straight line it appears to be a rather steep (if not vertical) fault. Although no direct evidence is at hand, the fault appears to be normal in character because of the way in which the coastal plain is warped up. The greater amount of underlying Puente exposed in the northern block points to its being stratigraphically lower but structurely higher. The fact that the boundaries of the two Puente blocks do not line up on both sides of the the fault may be due to horizontal displacement , hinge faulting , reversal in throw, etc. Dr. English (whose Puente-Fernando is differantly placed than the one on the accompanying map) explains the discrepancy by reversal of throw- but no direct evidence for this was encounterd.

The region North of Whittier is a rather simple monocline dipping steeply down under the San Gabriel Valley. The monocline occasionally flattens out as seen in the structure section A-B. The dips are as high as 80 degrees near the Puente-Fernando contact .- which is apparently conformable.

The Workman Fault (here named) cuts off this structure in a northwesterly direction. This fault follows a somewhat sinuous course. At a number of places it has to be shown dotted, but its direction is checked by numerous certain points. One of these points is shown in Figure 16, where the steep wall of conglomerate to the left is suddenly cut off. This same thing happens in the background on a branch fault which intersects the Workman Fault at Turnbull Canyon. This branch fault is better shown in Figure 17 . Here the

Figure 16

Workman Fault

Figure 17

Branch fault

cut off conglomerates have been cemented into a very hard rock by silica bearing water in the fault plane. The fault appears to dip steeply to the East, but no structures have been deffinitely tied up on both sides, so that the nature of the movement is not deffinitely known. It is soon lost in the soil to the North. The Workman Fault is lost in the soil to the North , but can be traced for three miles to the South. Three tenths of a mile from its southern end it passes through a deppressed area(See Figure 18) which is about 20 feet deep. It was first though to be a sag pond due to the fault, but is now thought to be due to landsliding in the soft shales. The nature of the movement may only be inferred from the stratigraphic position of the Puente block and the Fernando, which indicates that the Puente has been brought up with respect to the Fernando.

The eastern half of the map North of Turnbull Canyon is a region where one may expect anything , In the vicinity of east Turnbull Canyon dozens of minor faults were recorded, but only a few could be traced, and much time was wasted in trying to correlate isolated points. Anticlines and synclines occur in several places. Figure 19 shows a striking syncline crossing Turnbull Canyon in which the bedding is parallel to the surface. The longest fault shown in this corner appears to demarcate part of the hills from the plains, but as it was put in on the basis of conflicting dips and lithologic differences, no statement will be made regarding the movement.

Figure 18

Depression on

Workman Fault

Figure 19

Syncline crossing

Turnbull Canyon

The southeastern corner of the map shows the region of greatest uncertainty. The best description of it is quoted above from Dr. Englishes report, and it may be said that this map can be added to the list of disagreeing maps. The fault running East from Workman Hill can be rather deffinitely traced by the lithology, but it is nowhere exposed in cross section . Its straightness and the stratigraphic break suggest that the Puente has moved upward along a nearly vertical fault. The northwest fault to the East is still in doubt. It was first mapped as a depositional contact as shown by Dr. English, and may well be. If the contact is depositional it represents a profound unconformity as shown by the dip and strike marks, and by the fact that it intersects the shale and sandstone facies of the Puente. This is in marked contrast to the Puente-Fernando contact to the Northwest- but one should not reason what the contact should or should not be. If it is a fault, it is a normal dip slip strike fault in which the Puente has come up, but here again the fault? is not exposed in cross section. The evidence for a depositional unconformity is equally strong so the matter will be left in doubt.

The southeastern Puente block is apparently bounded on all sides by faults. Its southern boundary can be readily placed near its center but the two ends are somewhat obscured by soil and lithologic similarities . The short fault cutting off the block to the Southeast cuts off the conglomerate bed shown on the map. The nature of the movement along the latter two faults can only be inferred , for this entire region South of Workman Hill has low relief , considerable soil, and poor exposures, but apparently the Puente block was faulted up.

The Puente blocks are badly folded and crumpled in most places.

The slice of Fernando between the Whittier Fault and the Puente block dips steeply to the North and is vertical in places (see Figure 20).

Evidently the Whittier Hills have been bulged up from below exposing the underlying Puente in the center, and forming a mosaic of fault blocks.

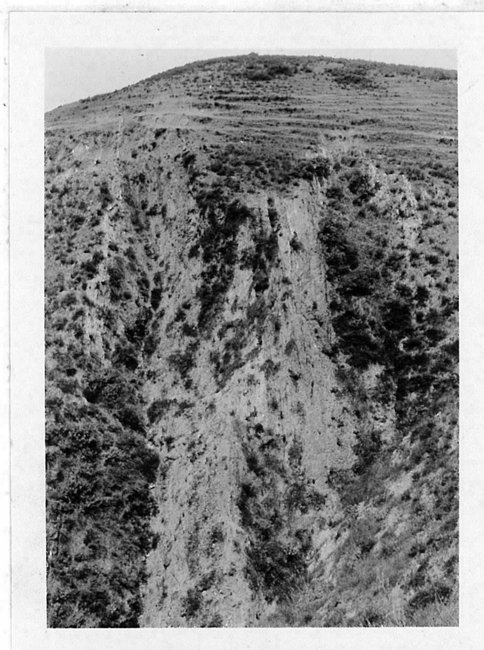


Figure 20

Vertical Fernando

PHYSIOGRAPHY AND BRIEF GEOLOGIC HISTORY

Only the later chapters of geologic history are unfolded in the Whittier Hills. No basement rocks or sediments older than upper Miocene are exposed but are known to exist farther to the South. It will thus be necessary to begin with the deposition of the upper Puente shale in the upper Miocene

1. Deposition of the Puente shale on the underlying rocks- probably far off shore.

2. Change of conditions by regression of sea or elevation of the continent causing the deposition of the Puente sandstone member.

3. At this point there seems to have been an interruption in some parts of the Puente Hills causing an unconformity, but North of Whittier the conditions were:

3'. Either marked regression of the sea or marked uplift causing deposits of coarse conglomerates.

4. Continuation of this apparently high lying continent with slight variations in conditions causing the alternations of sandstone, conglomerate, shale, etc.

5. Change to very uniform conditions of slow deposition producing great thicknesses of massive siltstone.

6. Resumption of conglomerate and sandstone deposition.

7. Complete regression of sea and elevation of the continent followed or accompanied by marked folding and faulting, in post Fernando time - possibly Quaternary- producing a mosaic of Pliocene and upper Miocene rocks

rising above the surounding country.

8. Differential erosian of hard and soft strata causing ridges and canyons to develop -many of them following the strikes of the beds.and weathering into dip slopes. The eroded material was carried out and deposited on the surrounding plains. Masses of soft shale which had steep edges gave way at certain places, causing landslides and producing undrained regions.

ECONOMIC RESOURCES

That part of the Whittier Hills traversed by the Whitier Fault is one of the oldest oil fields in the State. This field has been pumped for about 40 years and is still producing. This is a very interesting occurence of oil, for the fields situated along the fault are probably the largest fields in the world whose structural trap is due entirely to a fault. The steeply dipping Fernando traps the oil against the impervious Puente shale. There are still (according to Dr. English) about 53 producing wells in the Whittier Hills, and about 35 dry or abondoned wells.

The only other economic resourse is the rock and gravel obtained from Fernando conglomerate in Sycamore Canyon by the Sycamore Canyon Rock and Gravel Company. This is an ideal sourse of rock and gravel, since the cliffs can be undermined, yielding huge piles of easily handled material. A view of this plant is seen in figure 6.