GEOLOGY OF THE WHITTIER HILLS, CALIFORNIA

Thesis

by

David B. Ericson

In Partial Fulfillment of the Requirements

for the Degree of

Master of Science

California Institute of Technology,

Pasadena, California

1 9 3 3

CONTENTS

ILLUSTRATIONS

Acknowledgments

The writer wishes to express his thanks for several valuable suggestions received from Dr. John H. Maxson during the preparation of this thesis.

Introduction

Area Covered

The area of 16.3 square miles described in this thesis lies to the northeast of the town of Whittier in the southeast corner of Los Angeles County, California.

It is bounded by the Alluvium which surrounds the area on all sides except in La Habra Canyon where Hudson Road has been taken as the boundary. The form thus outlined is somewhat elongated in a northwest-southeast direction. Its maximum length is about six and a half miles.

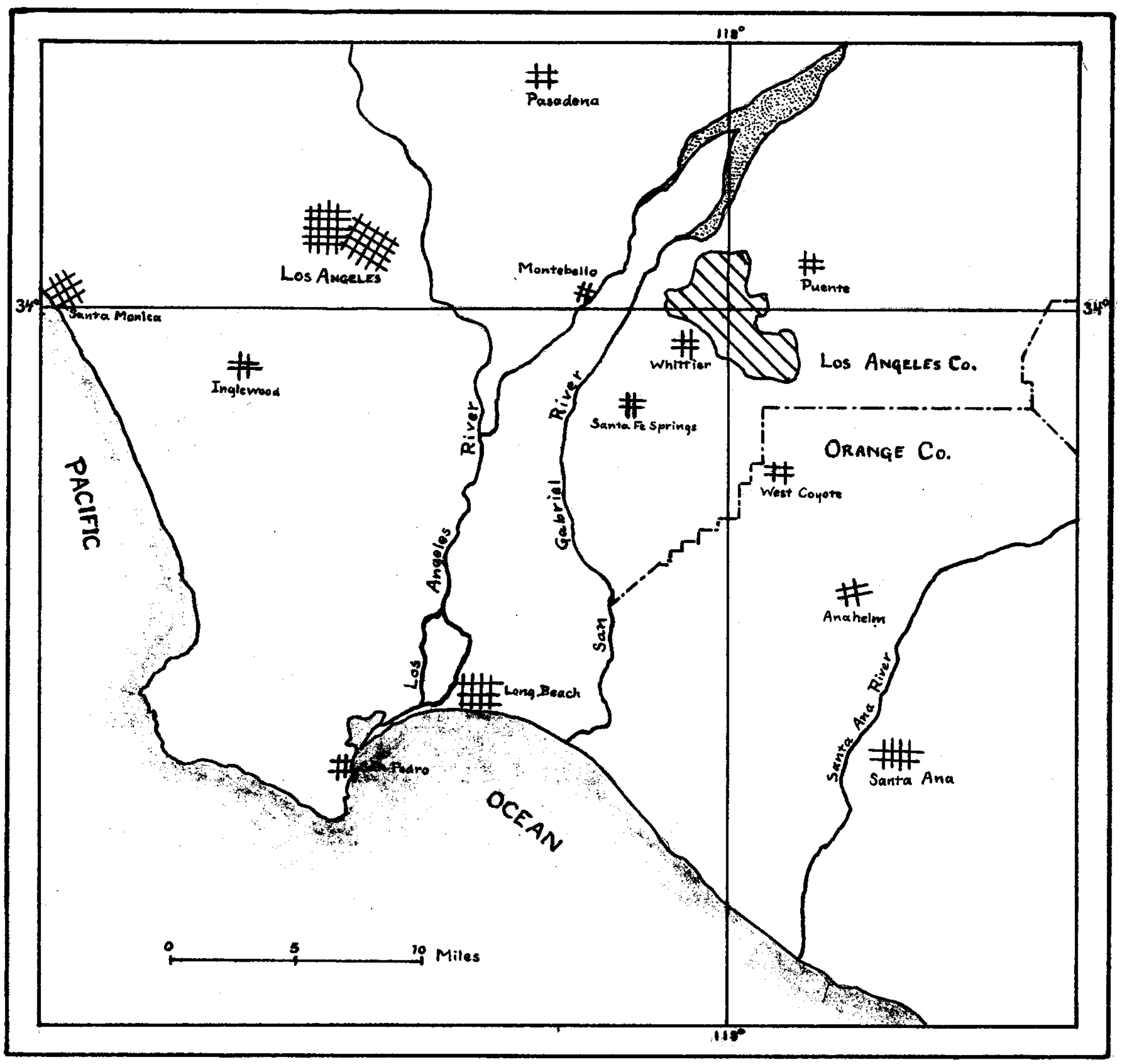
Purpose of the Examination

The work described in this paper was done in partial fulfillment of the requirements for the degree of Master of Science. The area was chosen as one which would afford a large amount of practice in field methods and at the same time familiarize the writer with certain phases of Californian geology.

Character and Method of Field Work

The field work was done during the college year of 1932-1933, in which time the writer spent about ten hours per week in the field. United States Geological Survey topographic maps on a scale of one twenty-four thousandth were used as a base upon which points were located, usually by reference to the topography or in a few cases by Brunton sights to prominent points.

Plate I



Area mapped and discussed in this thesis

Index Map of the Whittier Hills

Topography and Drainage

The area may be separated into two divisions on the basis of topography. The first, which lies to the north of Turnbull Canyon, is characterized by northeast-southwest trending ridges, whose northern slopes are steep and often concave upward. The intervening canyons are from two to three hundred feet deep. A large part of the drainage is into the San Jose Creek, which in turn flows into the San Gabriel River.

The second division lies to the south of Turnbull Canyon. It displays a topography of very irregular pattern, and with no definite trend. For the most part, the forms are more rounded and the slopes almost all convex upward, altho it is in this part of the hills, just south of the head of Turnbull Canyon, that the highest point in the area, Workman Hill, is found. It has an altitude of 1,387 feet above sea level, and therefore stands about 1,000 feet above the alluvial plain surrounding the area. Most of the intermittent streams draining this part of the hills lose themselves in the alluvium.

Climate

Due to the proximity of the sea, there are no extremes of temperature either in winter or summer. Except for a few rainy days, the writer was able to carry on field work during the entire winter without the slightest inconvenience.

The average annual rainfall at Anaheim, a few miles to the south of the Whittier Hills, has been 11.5 inches for a number of years. The rainfall in the Hills is probably close to this figure since their relief is hardly sufficient to alter their climate.

Vegetation

The rounded hills of shale support little else than grass, which is, however, enough to greatly reduce the velocity of erosion. On the sandstone and conglomerate outcrops there is usually a fairly dense underbrush, which considerably impedes geological investigation. In many of the small canyons there is an abundance of Rhus diversiloba, or "Poison Oak." This is especially troublesome in the early spring. In some of the large canyons, such as Sycamore Canyon and Turnbull Canyon, there are a few fairly large trees. In general the rather sparse vegetation is that typical of a semi-arid climate.

Definition of Geographic Name

Standard Oil Canyon

The canyon extending to the north from the Standard Oil camp, 1.95 miles southeast of Whittier, will be referred to several times in discussing the structure of the area. It will therefore be convenient to call it the Standard Oil Canyon hereafter.

Stratigraphy

English, in his report on the Puente Hills (U.S.G.S. Bull. 768), recognized the following stratigraphic units in the region described in this thesis: The Middle and Upper Miocene Puente formation of which only the upper sandstone member, the upper shale member, and the middle sandstone occur in the Whittier Hills, and the Fernando Group of Pliocene age. No igneous rocks were found.

Altho a good deal of shale is interbedded with the upper sandstone member of the Puente formation, and a good deal of sandstone with the upper shale member, still the units are sufficiently distinct that there is no difficulty in following the contacts. Since this division of the Puente formation gives a sequence of beds useful in interpreting the structure, it has been retained without change in this thesis.

Puente Formation: According to English, the Puente formation is probably equivalent to the Modelo formation of Ventura and western Los Angeles counties, and also to the Salinas shale and Maricopa shale in the central part of the state. The formation derives its name from the Puente Hills, where it is particularly well exposed. English, lacking fossil evidence, determined its age on the basis of its stratigraphic position between the Middle Miocene Topanga formation and the Pliocene Fernando beds. In the Whittier Hills, the only evidence pertaining to its age is that it underlies the Fernando group. English's age determination is therefore accepted as being the most satisfactory one under the circumstances.

<u>Puente Formation</u>

<u>Middle Sandstone member</u>: The only occurrence is a small triangular patch about 3,000 feet long lying just north of the Whittier fault a little more than a mile west of Hudson road. It is a red to buff, fairly coarse-grained sandstone containing numerous thin shale beds. The bedding, thanks to the shale, is quite distinct. For the most part the rock is very friable. No crossbedding was observed. It closely resembles the upper sandstone member except that no hard concretionary beds with plant remains were found in it. Since it conformably underlies 930 feet of diatomaceous shale, which in turn underlies Fernando conglomerate, its stratigraphic position is in no doubt. Altho there seems to be a good deal of disturbance at its contact with the upper shale member, there is certainly no faulting and the dips and strikes above and below the contact are in fairly good accord. The thickness exposed is about 1,120 feet.

<u>Upper Shale Member</u>: The best exposures occur south of the Turnbull Canyon road, and north of the Whittier Fault, extending in an irregular and somewhat broken belt from a point just north of the town of Whittier to the southeast as far as the boundary of the area at Hudson road.

The northern exposures along Turnbull Canyon show a fissile, rather thin bedded shale with many intercalated sandstone beds, generally no more than two or three feet thick, tho rarely as much as ten feet thick. Where freshly exposed by road cuts, these sandstone beds have a peculiar violet tint. The normal color of the shale is gray or buff but in many places there are numerous white beds only a few millimeters thick. The white color is not due to the presence of diatoms however. Some of the white material is impure chalk which dissolves readily in acid; elsewhere it appears to be a clayey material. Hardly more than traces of diatoms are to be found in Turnbull Canyon, altho fish scales and bones are not very rare. Gypsum occurring in the bedding planes and along joints is quite abundant thruout the shale.

These northern shale exposures are characterized by the presence of many buff colored, very limey beds, from two to three feet thick, showing very fine bedding but with little fissility. Their brittleness is evident from the fact that where the ordinary shales above and below have yielded to folding, the limey beds have been highly brecciated. Gypsum, small quartz crystals, milky chalcedony, and rarely asphalt, are present in the cavities of these breccias. In the northern part of the fault block south of Workman Hill, the limey beds form almost the only outcrops, the softer shale manifesting itself only as small whitish chips scattered thru the soil mantle. However, most of these outcrops are of no value as indications of structure, since most are composed of rock so thoroly brecciated that there is no possibility of obtaining reliable dips and strikes. When the writer first came across these outcrops, he was convinced that they gave evidence of faulting. Further investigation shows that they are probably due to folding fairly near to the surface. If they are due to faulting, they ought to occur along definite lines, but as a matter of fact they occur pretty much all over the northern part of the fault block. In addition, similar breccias are exposed in many of the road cuts in Turnbull Canyon, where there has been much folding but no faulting. In the southern part of the area the brittle limey beds are absent.

At the head of Standard Oil Canyon, and especially just north of the Whittier Fault on the western side of the canyon, there are some highly diatomaceous shale beds, containing layers several centimeters thick which are almost wholly composed of diatom tests and sponge spicules. Among the diatoms the genus Coscinodiscus is prominent. Associated with the diatomite are light gray, rather indistinctly bedded, gypsiferous shales, which are quite free from diatoms. Here and there the shale contains thin layers of sandstone showing miniature cross-bedding. Similar diatomaceous shale is found about a mile to the east on both limbs of the syncline to the north of the Whittier Fault. Fish scales are plentiful in the diatomaceous beds.

Along Hudson road at the southeastern boundary of the area there are some magnificent exposures of the upper shale member. The facies here is rather deceptive. At a little distance parts of the member appear to be highly diatomaceous. Closer inspection shows such beds to be really composed of fine white sand containing only extremely thin beds of diatoms, most of which are beautifully preserved and are plainly visible with a ten-power lens. The sand beds are generally thin, from a few millimeters to two or three centimeters, but they are so numerous that some outcrops are more sand than shale.

Several oil seeps occur in outcrops of this member. The most important are close to the Whittier Fault on the north side and about 1,200 feet west of Hudson road. Another is on the overturned limb of the syncline east of Standard Oil Canyon.

There are about 930 feet of this shale on the southern limb of the syncline just mentioned. On account of faulting and complex folding this is the only section that can be measured with any degree of accuracy.

<u>Upper Sandstone Member</u>: This member outcrops along two belts, one of which is 1.3 miles long and lies north of and parallel to Turnbull Canyon, while the other extends from a point seven-tenths of a mile south of Workman Hill to the east for 1.3 miles.

Altho the rock probably does not contain sufficient feldspar to be called an arkose, it certainly contains enough to be classed as an arkosic sandstone. In addition to the feldspar some beds contain an abundance of dark mica. The

Plate II

A. Oil seep near the Whittier fault and 1,200 feet west of Hudson Road

B. Oil seep just to the north of the Whittier fault and 400 feet east of Hudson Road in La Habra Canyon sand grains are for the most part fairly coarse, and even become conglomeratic towards the top of the member. In many places the bedding is so indistinct that it is difficult to take dips and strikes. On the other hand some outcrops have very distinct bedding, due to the presence of very thin shale beds. These shale beds are perhaps evidence of temporary climatic changes during the deposition of the sandstone which permitted the kaolinization of the feldspar. No cross-bedding was observed. The ordinary color is red or buff. There are, however, a few beds containing calcareous concretions up to one foot in diameter, which are light gray or even slightly greenish in color. As such beds are replete with fragments of leaves, plant stems, and bits of charcoal, it seems reasonable to suppose that the change of color is due to a reduction of iron by the organic material.

The thickness north of Turnbull Canyon is about 400 feet.

Fernando Group Undifferentiated: The rocks of this group are best represented north of Turnbull Canyon and the North Whittier Boulevard. They are also well exposed south of the Whittier fault and to the east of the town of Whittier.

North of Turnbull Canyon the Fernando beds rest conformably on the upper sandstone member of the Puente formation. Along Hudson road north of the Whittier fault there are some Fernando beds that rest conformably on Puente upper shales. On the other hand, on the overturned limb of the syncline east of Standard Oil Canyon, a short erosion interval following the deposition of the Miocene shales is shown in the presence of a thin basal conglomerate of shale fragments along the contact. At the head of Standard Oil Canyon just to the north of the Whittier fault the Fernando rests on the eroded and steeply dipping shales of the Puente formation with a foot or two of conglomerate composed of partly rounded fragments of diatomaceous shale at its base.

The rocks of the Fernando group consist of shales, sandstones, and conglomerates. The commonest type of shale is a gray sandy clay shale, very poorly bedded, and usually so soft that it can be crumbled in the fingers. Its slight resistance to erosion, its tendency to slump, and lack of bedding make the taking of reliable dips and strikes difficult. The only mineral distinguishable with a hand lens is a dark mica. In many localities the shale contains abundant and well preserved foraminifera. A few outcrops carry a fauna of oysters, pectens, bryozoa, dentalia, solens, arcas, cancellarias, and various other small pelecypods and gastropods. However, the pelecypod shells are usually so much dissolved and crushed as to be very difficult to collect. One of the best fossil localities is at the extreme northeast corner of the area, where the Union Pacific Railroad makes a cut in these shales. Another is nine-tenths of a mile southeast of the center of Whittier in a road cut on Sixth Street. Farther south in the vicinity of La Habra Canyon fossils are to be found in a number of horizons in the shales. Not far above the base of the formation there are some well bedded harder shales usually intercalated with thin sandy layers.

The sandstone beds of the Fernando group are quite variable in character. There are all gradations between silt beds little removed from clays in texture, and coarse-grained stones on the border line between sandstones and conglomerates. The common colors are buff and red, altho some of the fine-grained rocks are grey or almost white. There are a few thin beds that are firmly bound with calcareous cement, but for the most part the sandstones, like almost all the rest of the Fernando group, are very slightly consolidated. Some of the coarse-grained stones on weathering yield hard lenticular concretions as much as two feet in diameter. At only one point near the mouth of Standard Oil Canyon was some rather obscure cross bedding observed.

Heavy conglomerates of great heterogeneity both as to size and kind of constituents make up an important part of the Fernando beds. The well rounded pebbles and boulders up to two feet in diameter are predominately composed of granite, gneiss, schist, and quartzite. In the vicinity of faults and in a very few thin beds elsewhere the matrix of fine sand may be so well consolidated that the rock breaks across the contained pebbles. Generally, however, the beds are no more consolidated that the associated sandstones.

The most striking feature of the Fernando beds is their abrupt lateral and vertical variation. Vertically, thin bedded shales alternate with conglomerates containing large boulders within a few feet, while horizontally, conglomerates lense out and give place to shales within a few tens of feet. Needless to say the working out of structure is considerably more difficult on this account.

The Fernando beds are approximately 5,500 feet thick northwest of Turnbull Canyon.

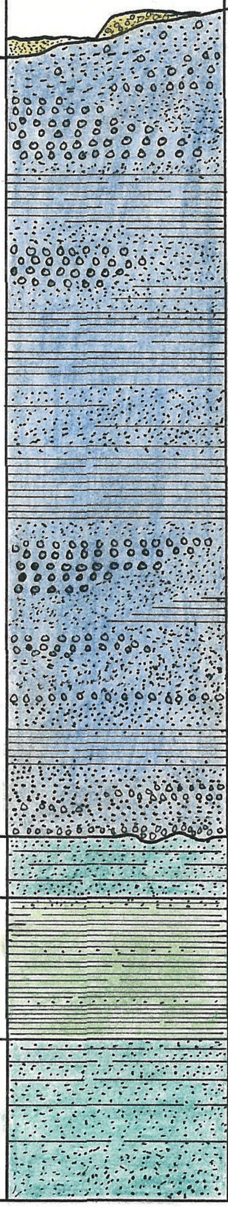
The Middle Pliocene age of these beds was determined by English(1) from a list of fossils collected by Eldridge in the vicinity of Brea and Olinda Canyons.

Terrace Deposits: These beds are well developed in the southeastern part of the area, especially in the vicinity of the Murphy Ranch about two and three-quarter miles from Whittier. The stream on the eastern side of the Standard Oil Camp is flowing in a channel twenty-five feet below the top of horizontal beds composed of gravel washed down from the Fernando conglomerates to the north.

In La Habra Canyon at the southeast boundary of the area there are more terrace deposits, altho these are not so strikingly shown on the topographic sheet as those near the Murphy Ranch. At the mouth of Sycamore Canyon and also along the San Jose Creek on the northern margin of the areaare some terraces of limited extent.

(1) Walter A. English,
Geology and Oil Resources of the Puente Hill Region, Southern California. U. S. Geological Survey Bulletin 768

Plate III

Age	Formation	Symbol	Columnar Section	Thickness in Feet	Character
Recent	Terrace Deposits and Alluvium				Horizontally bedded gravels and clays.
Pliocene	Fernando Group	Tf		5,500±	Interbedded conglomerates, sandstones, and shales. Generally only slightly consolidated.
	Local Unconformity				
Middle and Upper Miocene	Puente Formation — Upper Sandstone Member	Tpuss		400±	Buff arkosic sandstone.
	Puente Formation — Upper Shale Member	Tpush		930±	Thin-bedded shale, partly diatomaceous.
	Puente Formation — Middle Sandstone Member	Tpmss		1,120+	Buff arkosic sandstone.

Columnar section of the Whittier Hills

None of these beds has been distinguished from the recent valley fill with which they merge as they are followed away from the hills.

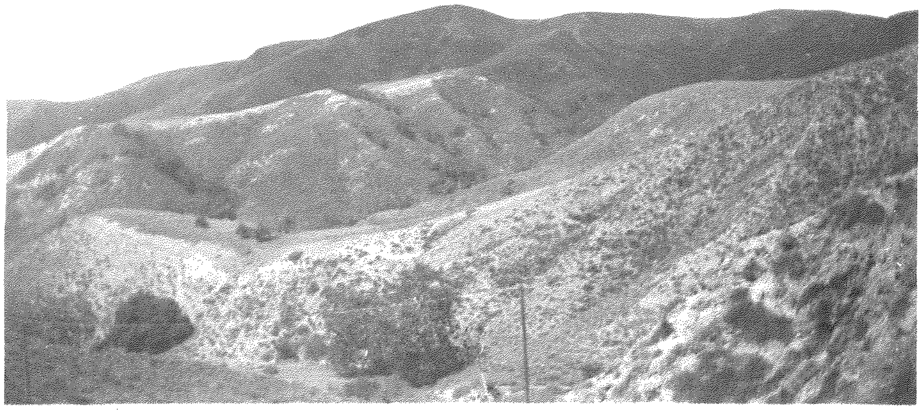
Structure

The Whittier Hills may be divided into the following three structural divisions: (1) The region of Fernando beds north of the Turnbull Canyon road, (2) The Fernando region south of the Whittier fault, and (3) an intermediate region north of the Whittier fault extending from Turnbull Canyon to La Habra Canyon.

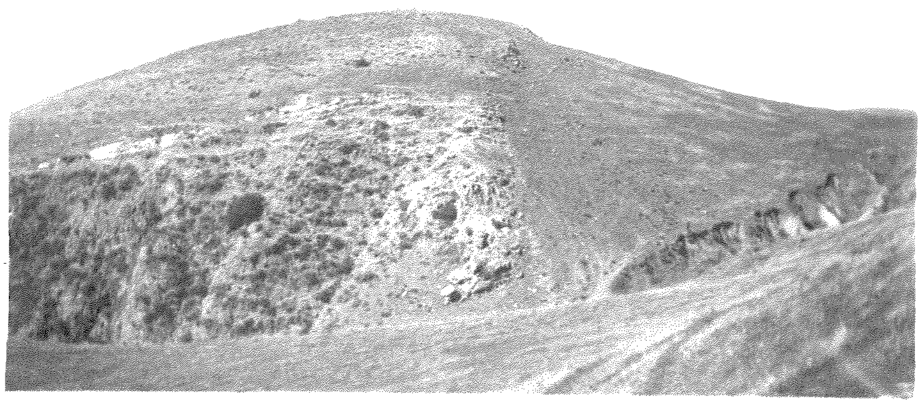
The first of these divisions is essentially a monocline having an average strike of N60°W and a dip of about 35°N. South of the mouth of Sycamore Canyon, however, the structure is complicated by vertical and even overturned beds dipping steeply to the south. Some folding has also taken place along the eastern margin of the region, and also in the area to the north and northeast of Workman Hill. Just to the north of Workman Hill Turnbull Canyon cuts at right angles across the axes of a small syncline and somewhat larger anticline. These structures pitch a little west of north at an angle of about 20°.

The fault which crosses Turnbull Canyon west of the syncline is well marked by the change from thin bedded shale to heavy conglomerate as one goes east along the Turnbull Canyon road. Farther to the Northwest where it crosses the ridge to the south of Sycamore Canyon the fault plane is fairly

Plate IV



A. Small syncline to the north of Workman Hill in Turnbull Canyon



B. Conglomerate faulted against shale in the Fernando beds 1 mile N 55°W from Workman Hill

Plate V

A.

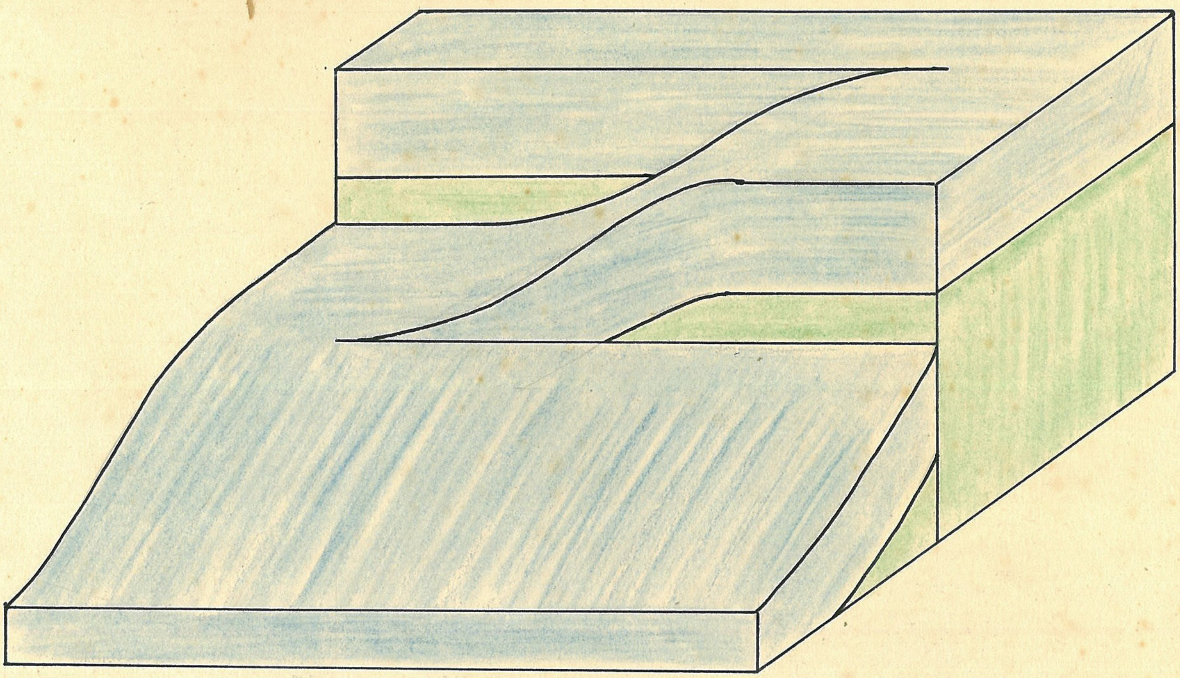
B.

A. and B. Folded and faulted Puente shale and interbedded sandstones in a road-cut in Turnbull Canyon $\frac{3}{4}$ mile from the mouth of the Canyon well exposed and shows a slight hade to the east. The apparent vertical displacement at this point is not less than 200 feet judging from the thickness of a shale bed on the east side which has moved down with respect to conglomerates on the west.

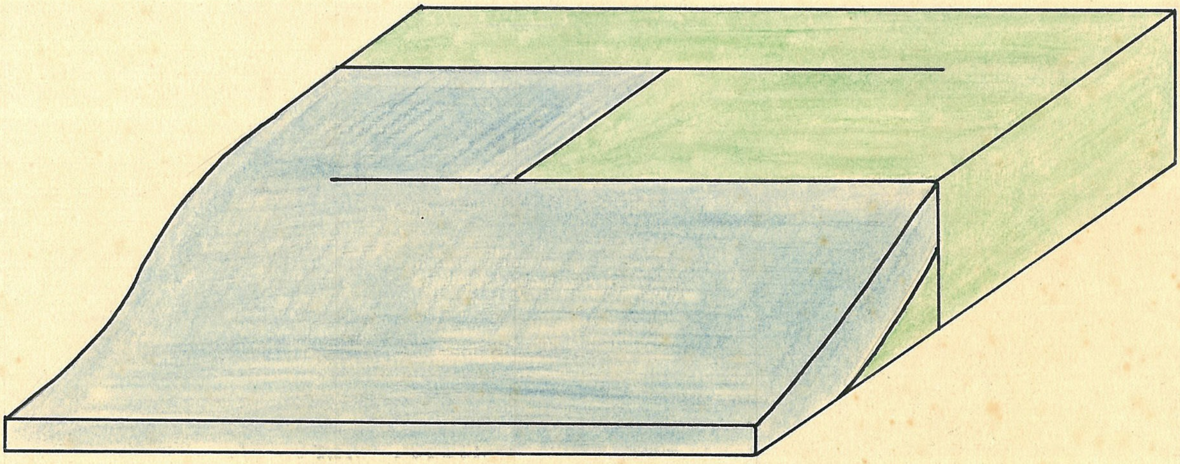
Of the two other faults shown in this region, the one to the west is hardly traceable in its southern part where it passes thru shale. However, it is very well expressed farther to the north. Rather indistinct drag indicates that the upthrow side is to the east. The hade is small and to the east. The plane of the other fault about a thousand feet to the east is practically vertical. According to the drag the upthrow side is to the west. Evidently the block between the faults is a small horst.

The second structural region is dominated by the Whittier fault. According to English's report the total length of this fault is 32 miles. To the southeast it joins the Elsinore fault, while to the northwest it disappears under the alluvium about a mile and a half northwest of the town of Whittier. Actually the true Whittier fault seems to die out about three quarters of a mile east of Turnbull Canyon, and another fault approximately 1,000 feet to the north takes up the displacement. It is possible that the true Whittier fault curves to the north and joins the northern fault. However, the faults as mapped accord strictly with the evidence obtained in the field, and since this entails no structural

Block Diagrams Illustrating Faulting in the Vicinity of Standard Oil Canyon

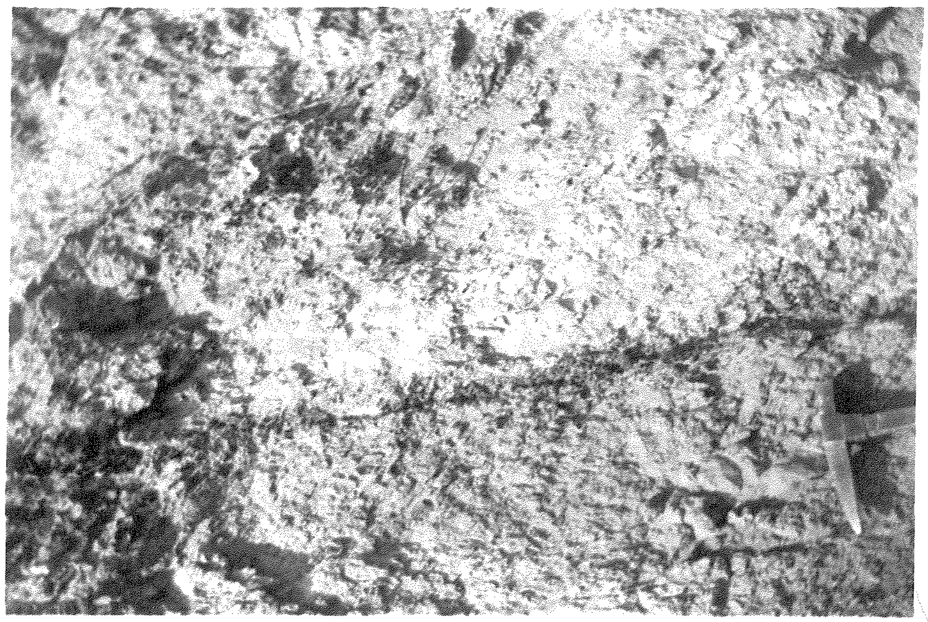


Before Erosion



After Erosion

Plate VII



Trace of the Whittier Fault exposed in a road-cut on the western side of Standard Oil Canyon. On the left is gray shale of the Fernando group and on the right, diatomaceous shale of the Puente formation impossibility, it is probably better to leave the map free of any unnecessary assumption.

About midway between the faults and some 600 feet northwest of the Miocene-Fernando depositional contact there is, thanks to active erosion, a small "window" in which the highly nonconformable contact reappears. This "window" is nearly 125 feet lower topographically than the southeastern outcrop of the contact, which indicates that the contact is dipping to the northwest. This lends some support to the idea that the structure is what might be called a "stratigraphic fault ramp" rather than a fault block between two branches of the Whittier fault. The accompanying block diagram will make any further explanation unnecessary.

From an inspection of the map it is evident that the direction of throw on the northern fault of the two just discussed reverses as the fault is followed across Turnbull Canyon. East of the canyon the older formation lies to the north of the fault, while west of Turnbull Canyon the opposite is true. Farther west the displacement appears to die out rapidly until it becomes almost impossible to trace the fault.

The plane of the true Whittier fault is exposed on both sides of the Standard Oil Canyon. On the western side the exposure is in a road cut. Since the hade, which is very slight, is to the northeast, and the older formation is to the north, the fault is reverse. The Fernando beds here consist of rather poorly bedded gray gypsiferous shales which contrast well with the finely bedded diatomaceous Miocene shale. There is remarkably little gouge present in the fault. The eastern exposure is in a cut made to accommodate the iron building of a pumping engine. It is practically the same as the western exposure.

A very rough estimate of the vertical displacement on this part of the fault may be made by taking the average dip, 45°S, of the Fernando monocline to the south of the fault, and measuring the distance perpendicular to the Fernando strike, from the depositional contact at the mouth of Turnbull Canyon to a line drawn parallel to the strike and thru the depositional contact on the "fault ramp" north of the fault. This method gives a vertical displacement of about 4,000 feet.

Generally speaking, the region south of the Whittier fault and its western extension is simple in structure. To the west of Turnbull Canyon there is a narrow strip of Miocene shale about three quarters of a mile long. The contacts at both ends of the strip are apparently depositional. The structure may therefore be interpreted as that of an anticline steeply pitching to the southwest and truncated to the north by faulting.

To the southeast of the mouth of Turnbull Canyon as far as La Habra Canyon the Whittier fault is flanked by a monocline of Fernando beds. Northwest of the Standard Oil Canyon the strike is east-west and the dip about 50°S. Just east of the

Plate VIII

Some complicated structure in the Puente shales exposed in a road-cut in La Habra Canyon four-tenths of a mile north of the Whittier Fault.

same canyon some minor faults are exposed, and the dips and strikes of the beds in the southern part of the canyon suggest an anticlinal nose. The fault planes are practically vertical. At least one of these faults shows excellent slickensides which dip down to the south at an angle of 73°. No doubt this faulting and folding is a continuation southward of the disturbance which produced the faulting north of the head of the Standard Oil Canyon.

Toward the southeastern end of this Fernando belt the strike of the monocline more nearly parallels the Whittier fault.

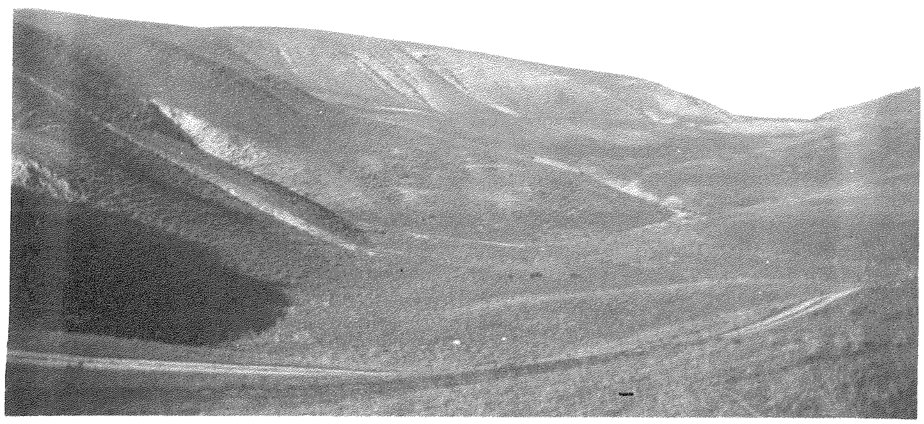
The third region includes practically all of the Miocene exposures. In spite of considerable confusion in the structure of the beds immediately to the southeast of Turnbull Canyon, it is possible to discern a general dip to the south. On the other hand the dip is to the northwest on the other side of the canyon, and conforms fairly closely to that of the Fernando beds. This reversal of dip together with the minor faulting and contortion of the shales along the Turnbull Canyon road suggests faulting. Unfortunately no other evidence was found to confirm this.

The fault extending from the head of Standard Oil Canyon had already been sufficiently described in dealing with the structure of the northern Fernando monocline. To the east of this fault and south of Workman Hill there is an irregularly shaped fault block. The fault forming its north and northeastern boundary is not well exposed in the vicinity of Workman Hill, and could only be followed approximately. However, to the southeast where it passes close to the alluvial contact it is well defined and the Fernando conglomerates dipping 70°S. are truncated along the strike in such a way as to preclude all possibility of a depositional contact. Several small springs occur along the trace of this fault, much to the advantage of the nearby sheep raisers. The water is probably carried by sandstone beds intercalated with the Miocene shales.

The southern edge of the block is bounded by a rather obscure east-west trending fault, which has dropped the Upper Sandstone member of the Puente formation against diatomaceous shales lying to the south. Evidence in support of faulting lies in the oblique truncation of the Fernando beds near the western end of the contact, in the cutting off of the Fernando-Miocene contact south of the fault and 1,400 feet from the fault's western end, and in the rather steeply south dipping (50°-40°) sandstone beds along the eastern half of the fault.

A half mile south of Workman Hill in this same fault block there is a peculiar undrained depression some thirty feet deep, and 1,000 feet long. It is rather dificult to see how this depression could be due to landsliding. It appears more likely that it is the result of very recent movement on a fault which branches from the main fault forming

Plate IX



Depressed area at the head of Standard Oil Canyon the western margin of the block. This fault is well marked near the western end of the depression where shale to the west has been faulted up against the overlying sandstone to the east, and again a short distance to the south where a thin shale bed overlying the sandstone is cut off along the fault. Before the faulting the depressed area probably drained to the south into the Standard Oil Canyon. Deep trenching of hillsides by drainage channels and the presence of miniature terraces in many of the small valleys in the vicinity of the depression is further evidence of recent movement. A thousand feet northeast of the depression there is a small anticline overturned to the south, which has a low angle thrust fault along its crest.

To the south of the previously described fault block there is another roughly triangular block bounded to the southwest by the Whittier fault and to the east by a rather sinuous fault extending from the alluvium on the north, southward to the Whittier fault. The block is essentially a closely folded syncline, the northern limb of which is overturned. The axis, which plunges to the west is rather strongly concave to the north. The two limbs dip at nearly the same angle, a fact which probably lead W. A. English, in his report on the Puente Hills, to map the block as a simple monocline dipping to the north. The evidence for a Syncline, however, appears to be quite conclusive. In the first place the fault defining the eastern margin of the block does not truncate the Fernando conglomerates at the eastern end. On the contrary these beds can be followed completely around the synclinal bow. It is also to be remarked that the beds of the northern limb are practically vertical for a short distance just before curving around the bow. A simple paper model will show that in the case of such a curved surface as the conglomerate probably represents the point at which the surface must become vertical is about where the steep dips are mapped.

Along the north limb good exposures of the contact between the Miocene shale and the conglomerate leave no doubt that the contact is depositional. No fossils were found in the conglomerate, but in physical character it differs in no way from typical Fernando conglomerate. The shales to the north are certainly Miocene since they are composed of almost pure diatomite a short distance from the contact and contain numerous fish scales and bones.

But the best evidence that the underlying conglomerate is younger than the shale is found in the presence of a thin basal conglomerate composed of angular fragments of a shale similar to that which outcrops immediately north of the contact. Since there is no shale in the conglomerate to the south which might have supplied these fragments it is reasonable to conclude that the basal conglomerate was deposited on the shale beds which now lie to the north.

There are several small faults cutting across the contact along the northern limb, but the apparent horizontal displacement of all excepting one is too small to plot on a map of the scale used.

To the southeast of this synclinal fault block there is a large area of Miocene shale flanked to the northeast by conglomerates and shales of typical Fernando character. The Miocene shales show a much confused structure where they are exposed in cuts along Hudson road. The general dip is to the north. The Miocene-Fernando contact, which is well exposed in a cut, is depositional and strictly conformable. For some distance north of the contact the Fernando beds consist of shales and sandstones which are almost as much contorted as the Miocene beds. There is nevertheless a gradual diminution in the disturbance until near the alluvium the beds are tilted but little folded.

Near the northwestern end of the Fernando-Miocene contact exposures are poor. What dips and strikes could be taken near the contact show that there too considerable folding and overturning has taken place since the deposition of the lower Fernando beds.

Physiography

In the northern Fernando region the drainage to a large extent has followed the more easily eroded shale and sandstone beds exposed by the regional dip to the northwest. A few slightly better consolidated conglomerate beds determine hogbacks trending parallel to the regional strike. Of these the best developed is north of Sycamore Canyon. The northern slope of this ridge, as well as that of the majority of ridges in the region, is gentle, while the southern slope is steep and even vertical in some places.

In the two southern structural regions very little relation between topography and structure appears. This is strikingly the case with the Whittier fault, which has no noticeable topographic expression at any point along its trace within the area mapped.

Physiographically the most interesting part of the area is south of Workman Hill, where recent uplift and faulting are shown by the small depression described under Structure, and the very active erosion which is cutting deep channels in the soil mantle.

Still farther south in the vicinity of the Standard Oil Camp and the Murphy Ranch there is beautiful evidence of recent uplift in the well developed terraces, which are well shown on the United States Geologic Survey topographic sheet of the area.

The last uplift is indicated by the vertically walled channels 25 to 30 feet deep cut by intermittent streams in horizontally bedded terrace material. These channels are best shown north of the Murphy Ranch.

A. Looking east along the Whittier Fault with the mouth of Turnbull Canyon in the foreground. The well-rounded hills on the left are composed of Puente shale, while the bush-covered hill to the right is composed of Pliocene sandstones and conglomerates.

B. Typical topography in the Pliocene region north of Turnbull Canyon

The Whittier Oil Field

Location: From the northern end of the field, which is about half a mile south of the mouth of Sycamore canyon, the field extends along the southern side of the Whittier fault for about four miles in a S.65°E. direction. The greatest width, about three-quarters of a mile, is in the vicinity of Standard Oil Canyon.

Occurrence of Oil: Commercial production is practically confined to the Fernando Series. According to one theory the oil originated in the Miocene diatomaceous shales, while the other theory maintains that the oil originated in clay shale beds of the lower part of the Fernando group.

Undoubtedly the Miocene shales contained a large quantity of organic material at one time, as is evidenced not only by the diatom tests, but also by the plentiful fish bones in certain horizons. It seems therefore entirely probable that such oil as occurs in these shales is indigenous to them. However, the migration of the oil into the Fernando beds appears somewhat doubtful when one takes into consideration the nonconformity in the region about the head of Standard Oil Canyon. Obviously here the diatomaceous shales were folded and eroded before the deposition of the Fernando beds. It seems reasonable to suppose that the oil, which they no doubt contained, migrated into the anticlines and was lost in great measure when these structures were planed off by erosion, rather than that it remained in the folded shales, and only migrated after the Pliocene beds were ready to receive it.

To believe that the oil is indigenous to the Pliocene beds in spite of their scanty traces of organisms is not difficult since there are many forms of life, which would leave no record of themselves since they lack any kind of skeleton. In fact, that such nonskeleton animals have contributed to the organic material of certain formations is the most satisfactory explanation for the oil occurrences in the Rocky Mountain and eastern oil fields.

Therefore, while admitting that there is no very cogent evidence for either theory, the writer inclines to think that the oil originated in the lower part of the Fernando group.

Structure: The oil occurs thruout a thickness of 3,000 feet of the lower part of the Fernando according to W. A. English (U. S. G. S. Bull. 768). There are five productive zones. The lowest, which has a thickness of about 1,000 feet, lies in the west end of the field, while the highest zone, which is of little importance as a producer, is found only in the eastern part of the field. The second zone lies from 500 to 600 feet below the top of the first and is not over 300 feet thick. The third is 600 to 700 feet below the second and has a thickness of 100 to 250 feet, and the fourth zone lies nearly 1000 feet below the third.

Apparently these horizons are dependent upon the contact of the various sandy and conglomeratic beds of the Fernando with the relatively impervious shales of the Puente formation north of the fault, and the steep south dip of the Fernando beds up which the oil has migrated.

Most of the wells producing oil in commercial quantities have been located far enough south of the fault to tap the oil strata at depths ranging from 800 to 2,500 feet, where oil of from 15° to 22° B. is obtained. Several wells have been drilled north of the fault. These obtained a little oil from the sandstone beds in the Puente series, but they have now been abandoned.

Bibliography

As far as the writer knows, the two publications listed below are the only ones that have appeared dealing with the geology of the Whittier Hills.

Eldridge, G. H.,
The Puente Hills Oil District, Southern California:
U. S. Geol. Survey Bull. 309, 1907

English, Walter A.,
Geology and Oil Resources of the Puente Hills Region,
Southern California:
U. S. Geol. Survey Bull. 768, 1926

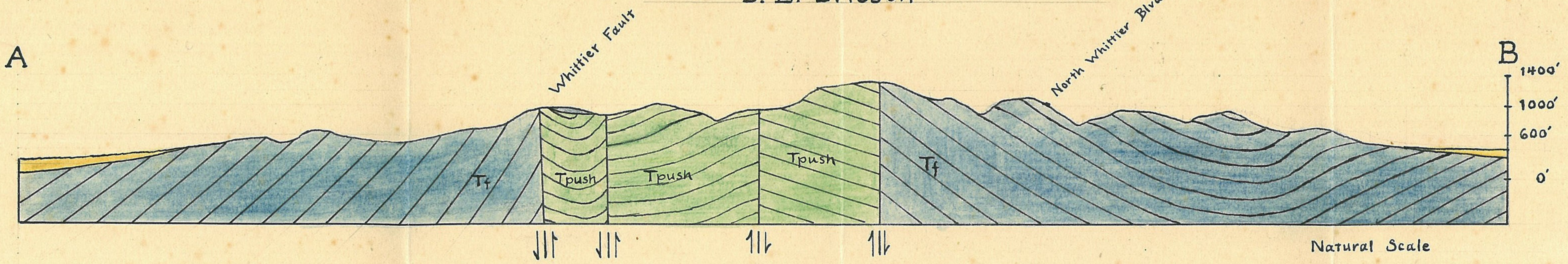
Ericson-dh-1933

Plate XII

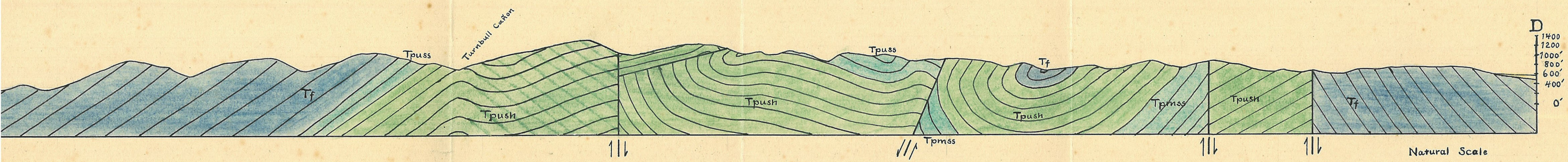
MS

Geology of the Whittier Hills

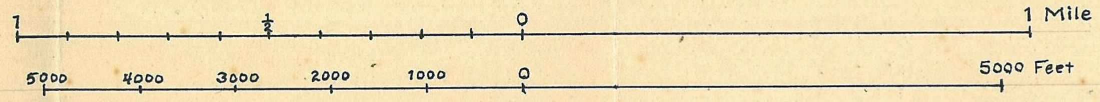
D. B. Ericson



Section along Line A-B



Section along Line C-D



Scale $\frac{1}{24,000}$

Natural Scale