A REPORT ON THE GEOLOGY OF
A PORTION OF THE WHITTIER HILLS
BETWEEN TURNBULL AND LA HABRA CANYONS.

By

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INTRODUCTION

LOCATION AND EXTENT OF AREA

The rocks of the Tertiary described in this report are in the Puente Hills which are just south of the town of Puente, southeast from the town of El Monte, north of the town of Whittier, and approximately thirteen miles in a southeasternly direction from Los Angeles. The area investigated lies between Turnbull Canyon Road on the west and Hudson Avenue on the east.

The maps which cover this district are the Los Angeles County maps, La Habra and Whittier Quadrangles. The scale is 1/2400, and the contour interval is five and twenty-five feet. The maps are accurate and adequate in every detail.

FIELD WORK

The investigation was undertaken as a fulfillment of a requirement for a Bachelor of Science degree at the California Institute of Technology located at Pasadena, California.

The time spent in the field was over fifteen days which extended over the first five months ofthe year 1930. The maps used were Los Angeles County maps. Locations for plotting geologic data were made by intersections with the Brunton compass on prominent topographic and cultural features. The maps are so excellent that in many cases locations can be made by using topography alone, thus allowing all of the geologist's time to be concentrated on the geologic problems, instead of correcting the topographic map.

Due to the numerous oil wells which are located inthe area, traveling over the country is comparatively easy, and becauseof the rolleng nature of the hills,portions which are not connected by roads are readily accessible by foot. Only in the bottom of canyons is the vegetation so thick that one's progress is halted to any great extent because of it.

Beginning the investigation at Turnbull Canyon Road was done with the purpose of continuing the work southward started by S. W. Lohman of the class of 1929. Our work overlaps some, but as Turnbull Canyon Road was the only prominent feature close at hand it was decided that it was the logical starting point.

The work was stopped at Hudson Avenue because of lack of time to continue farther, and it was the logical place to stop.

The investigation was started with the desire to put on the map in detail of all of the geology, both areal and structural, but a two or three days in the field convinced the writer that this was an impossibility because the area is so complicated that the number of exposures is entirely inadequate, although there is a number of good exposures. As is usually the case in almost all kinds of geological work in hills of this type, there are a number of isolated exposures of the formation, and then there will be a rolling hill covered with grasses andseveral feet of overburden and surface creep, making it almost impossible to determine lithologic changes, or the stratigraphic relationships of the materials below. Taking into consideration the complexity of the area and exposures available, only the most evident structural features were mapped with the felling that there is still more that could be mapped, if the hills could be uncovered, exposing what lies beneath their grassy slopes.

PREVIOUS PUBLICATIONS

Dr. W. A. English, Bulletin 768; Geology and Oil Resources of the Puente Hills Region, Southern California.

On page 10 of this report there is a list of the better known publication dealing with this general district.

GEOGRAPHY

GEOGRAPHIC NAMES

The definition of the geographic names are taken from the U. S. G. S. Bulletin 768.

The Puente Hills: The whole group of hills lying between the towns of Pomona, Whittier, and Corona, and a small area directly south of the town of Puente. As there is no other name applicable the larger division, the name should be preferably be used for the group of hills lying between Santa Ana and San Gagriel River. As this defined the hills are triangular in outline, being bounded on the northwest by San Gabriel Valley, on the northeast by the Santa Ana coastal plain, La Habra Valley, and Santa Ana River Canyon.

The Whittier Hills: The part of the Puente Hills directly n north of the city of Whittier and east of La Habra Canyon.

TOPOGRAPHY AND DRAINAGE

The topography is distinctive of the rolling type of hills which are common is this vicinity. The hills are in the majority of cases are dome shaped and the ridges leading to the domes are never sharp, but are convex upward. Many of the canyon walls are steep, and most of the larger canyons have flat bottoms.

The highest mountain in the area is Workman Hill which has an elavation of 1391', and stands approximately 1000 feet above the surrounding country. The majority of the hills are less than a 1000 feet high, and the area investigated is lower than the country to the west, or to the east.

There are no large rivers, or as matter of fact no running water in district at all. In a few of the canyons there is a spring or so, but the water is full of carbonates or sulphur so that it is not fit to drink, and probably exists only during the rainy season. All of the larger canyons have their own drainage lines which finds their own way out of the hills into the valley, there is no large drainage system in the hills.

The area on the north side of the hills drains into a small gulch which skirts the northern edges of the hills, and finally drains into the San Gabriel River to the west. The area to the south of the divide drains into La Habra Valley, and finally reachs the Santa Ana River. The drainage is in the majority of cases, consequent because what there is, is the result of the uplift of the Puente Hills, and there has not been enough time since the uplift for the intermittent streams to become subsequent, although several places along the Whittier fault the canyons follow it, showing that that the streamshave followed these weaker areas.

South of Workman Hill approximately two thousand feet, there is a large basin of interior drainage, or sag pond formed by faulting. It has an area of 1/10 of a square mile, and is 25 to 30 feet deep. This large depression is not a single sag pond, but it has numerous other small sag ponds around its borders, on the south and east, which is indicative of intense faulting. This large depression rests among the top of the hills, and no doubt if it had a lower elevation so that several streams could drain into it, there would be a small lake similar in origin to Lake Elsinore, formed by the continuation of the same fault.

CLIMATE

The climate is typically Southern Californian, semi-arid. It is somewhat coller here than farther south around San Bernadino, Pomona, Corona, and that vicinity because the Whittier Hills has its climate equalized, due to its close proximity to the ocean. In winter there are light frosts, and in the summer a temperature over 95 degees is uncommon. The rainy season is during the winter time, as a result in the late winter the hills are covered by green grasses which dry up before the end of May. The average annual rainfall is around ten to fifteen inches.

NATURAL VEGETATION

The vegetation is typical of the lower hills of Southern California, being covered with wild grasses and flowers. This type of vegetation covers most of the shale and sandstone exposures, but the coarser sediments are covered with brush, not the chaparral, but a variety of sage brush. This brush is very thick in many of the canyons. The wild grasses make excellent pasturage for sheep which graze over the hills during the winter.

CULTURE

Besides the exploitation of the oil in the district it is dominantly agricultural. It is noted for its citrus fruits which are cultivated in the valleys and in the broadest canyons. In the eastern part of the area is the greatest agricultural development, Many of the hills are terraced, on which are grown avocado tress, and on many of the hill slopes are wheat and barely fields.

Many good paved roads traverse the district on all sides; the Valley Boulevard is to the north, and the coast highway is to the south. Two paved roads cross the hills, Turnbull Canyon Road and Hudson Avenue.

EXPOSURES

As pointed out under the heading of field work, the number and quality of exposures are good, but they are inadequate for the complexity of the area. Hills that are formed of shale and sandstone weather very rapidly, and they are covered in the majority of cases with a good crops of grasses, so that it is possible to go for nearly a quarter of a mile, wihtout seeing an exposure of the strata below. If the formations were continuous this would not be harmful, but in a region which has been subjected to a intense folding and faulting, more frequent exposures are needed.

SUMMARY

The region described in this report is a portion of the Whittier Hills south of Turnbull Canyon, extending to the east to Hudson Avenue in La Habra Canyon. The area includes only Miocene and Pliocene sedimentary formations. The maximum thickness of the sediments would be about 12000 feet.

The area described is the most complicated in the Puente Hills and, has been the most active geologically. The region is a mozaic of fault blocks, and the strata in many of these blocks are badly folded and contorted. The hills were uplifted mainly along the Whittier fault, since Post-Fernando time. There are some folds, but they are small and are only local in their occurrence.

Due to the accumulation of oil in the Fernando homocline, but more correctly a limb of an anticline, to the south of the Whittier fault, the region is of much interest economically. The oil fields are among the oldest in the state.

GENERALIZED COLUMNAR SECTION

SYSTEM	PERIOD	FORMATION	SYMBOL	SECTION	THICKNESS	CHARACTER
QUATERNARY	RECENT	QUATERNARY ALLUVIUM	Qal		?	Valley fill.
TERTIARY	PLIOCENE	FERNANDO	Tf		±5500'	Marine buff and gray siltstone and sandstone.
					±1000'	Buff conglomerate.
	UPPER MIOCENE	UPPER PUENTE	Tup		±4000'	Marine white, buff and gray shales, diatomaceous and siliceous shales.
					±2000'	Buff and gray sandstone.
					±75'	Buff and gray conglomerate.

STRATIGRAPHY

GENERAL CONSIDERATIONS

The names of the different formations and their ages will be taken from Dr. English's U.S. G. S. bulletin 768.

There are only three formations in the area investigated, the undifferentiated Fernando (Pliocene) consisting of marine shales, sandstones, and conglomerates; the Puente formations (Middle and Upper Miocene) which are siliceous shales, shales q sandstones, and conglomerates,; and Quaternary Alluvium. The first two formations are marine and the last is continental. The sediments in the first two formations are very similar lithologically, therefore the question just where to draw the contact is very difficult to answer in absence of any diagnostic fossils.

The Puente formation as mapped is divided into Upper Puente shale and Upper Puente sandstone. The contact between the two divisions is gradatonal.

The writer found that one of the most characteristic features of the Puente shale, was beds of brecciated tawny yellow hard siliceous sandy shale which had been recemented by silica and calcite, and occurs intermittantly throughout the shale beds. These brecciated shale beds were formed by the intense deformation to which this region was subjected, and being more brittle from the high silica content broke into small pieces while the softer layers were folded. In the course of time they were recemented together by the perculating waters carring silica and calcite in solution. In the exposures of Pliocene shale and sandy shale visited no phenomenon such as this was seen.

This criteria was used to call the shale, sandstone, and conglomerate about station 57 and north of the Whittier fault and south of the next fault northward, Puente instead of Fernando, as determined by English. The conglomerate and sandstone was included in the same age determination as the shale because the contacts are gradational. It is improbable that in two formations of different ages, that two beds of the same composition, as these siliceous beds would be deposited, so that when they were deformed by the same forces a similar result would be obtained. Therefore, in absence of such reliable criteria as organic fossils, one is as safe as can be hoped in using criteria as this to make age determinations.

Only the upper most part of the Tertiary history is recorded here, but farther south according to Dr. English a representative, but by no means a complete record is found.

PUENTE FORMATION (MIDDLE AND UPPER MIOCENE)

Dr. English divides the Puente formation into Lower shale, Middle sandstone, and Upper shale and sandstone. Only the Upper shale and sandstone are represented in the area investigated. The separation of the shale and sandstone can be done, but it is difficult to draw a sharp boundry between the two because there is shale interbedded with the sanstone, and sandstone interbedded with the shales in both of the providences, but only a rough approximation is determinable.

The name was given to the Puente formation by Eldridge in bulletin 309, and was taken from the name of the hills, Puente, where it crops out over nearly their entire extent.

A lithologically similar formation of approximately the same age is found to the west in Ventura and western Los Angeles counties. There it is called the Modelo formation.

The formation crops out on the north side of the Whittier fault and extends almost to the northern edge of the hills, where a small thickness of Fernando lies unconformable above it. It extends farther west and east than what was mapped inthis report. The Puente formation forms the core of the range with a Pliocene formation on either side, and has been faulted up above the younger Fernando.

The age of the Puente is determined by its stratigraphic position, which is between the Topango (Middle Miocene) and Fernando (Pliocene). There has been no diagnostic fossils found in the formation as mapped, Puente. The only fossils found are some foraminifera and diatoms. Dr. English records finding some whale vertebrae in the Middle sandstone member several miles east of Burruel Point which is south of the area covered by this report.

There has been found also a horse tooth identified as premolar 1 of Hipparion mohavense Merriam in the Upper Puente formation of the San Jose Hills. It corresponds very closely to the type specimen of the Ricardo which is regarded now as late Miocene. This agrees admirably well with the way in which English has mapped in the formation, but in view of the fact that he is not sure of his determination of his formation in locality and the age ofthe Ricardo is not settled, the horse's tooth lends very little definite information to the age of the Puente on absence of a more complete specimens.

UPPER SHALE

The upper shale member of the Puente crops out north of Whittier, and is bounded on the north by the Workman fault, named by S. W. Lohman, and a small fault which runs parallel to Turnbull Canyon Road. It continues for a short distance pass Turnbull Canyon on the west, and is cutt off on the east by the most southern portion of the Workman fault. It has a thickness of from 3000 to 4000 feet. A close approximation is impossible because the beds are badly folded and contorted.

The shales are light colored, thinly bedded, and usually soft. They range from white and pinkish to alight gray and buff in color. The white and gray shales are interbedded with a tawny yellow hard silicified brecciated sandy shale layer which varies from a few inches in thickness to ane to three feet in thickness. The light gray shales beds are not continuously gray, but change to buff or a brown color every foot or so. which is probably due to a greater iron content. These shales contain a high percentage of gyysum, and the silica content is much lower than in the white shales. The gray shales are much more abundant than the white diatomaceous shales, and have their greatest thickness south from the Turnbull Canyon. The shales are made up mostly of clayey materials, but varies from a real clayey shale to a sandy shale.

The white diatomaceous shale is found close to the Whittier fault, and is continuous nearly along its entire length in the area mapped. The shale beds are soft thinly bedded, and easily cleavable. There is very little, or no, gypsum in the beds. The strata which contain the diatoms are soft, and have a dry and punky feeling. They are very light in weight. A single diatomaceous bed is only a few inches thick, adjacent to it will be a hard light buff colored, silicified layer, and then some darker colored clayey shale layers before the next deatomaceous bed occurs. The white siliceous shale exposures seem to thicken as one proceeds to the southeast till in La habra Canyon on the Hudson Avenue road cut, nearly the whole exposure is the white siliceous shale, though not all of it diatomite.

The shale beds are badly contorted and folded, and from their nature do not form many outcrops, but thanks to the numerus roads many good exposures are visible.

UPPER SANDSTONE

The sanstone beds have a maximum thickness of a little over 2000 feet, and are found south of the shale exposures. There is hardly any great thickness of sandstone which is not interbedded with some shale. Sometimes the shale is a foot thick other times a stringer ispresent, and as the sandstone is poorly bedded the shale makes a convenient marker for an attitude, but care must be taken because in many places the sandstone beds have been deformed, such as smashing, squezzing and formation of fracture planes, and consequently these shale layers do not give the true attitude of the formation.

The sandstones are buff, brown, gray and white in color. They are soft, and the hardest can easily be smashed by a blow with the pick. The sanstones are mostly quartzose, and many are micaceous. In general fined grained to medium grained, and the grains are rounded. Due to the softness of the sandstone, there are very few extensive exposures, and the weathered portions form similar structures as the shale beds do. The sandstone weathers to a darkerbrown soil.

The sandstones are in general much softer than the Fernando sandstone.

The fineness and homogeneity of the material in the upper member of the Puente indicates that it was deposited in rather deep and quite water, and that there were constant conditions during deposition, as shown by the thick and poorly bedded sandstone.

The conglomerates of the Puente, mapped as a part of the upper member, are very similar to the Fernando conglomerates in many places, both contain well rounded to subangular rocks; and the rocks are very similar in size and composition. They are predominantly granitic, with some quartzites,gneisses, and some felsites which appear to be of intermediate composition, probably an andesite, many of themare porphyritic. In general the Miocene conglomerates are lighter in color than the Pliocene, and the rocks if anything at all, are smaller in size ranging from 1/2 to 3 inches in diameter.

The thickness of the conglomerate is not over 75 feet which occurs in one continuous bed in an E-W direction for approximately one mile in length. It thins out at the west end and is faulted at the east end of its extent. This conglomerate bed does many peculiar things which will be described under the heading of structure on page 24.

The conglomerate beds which occur close to the Whittier fault and the small patches which found near it, are probably fault slices. These beds are found along its entire lenght, and are very helpful in tracing the fault.

The conglomerate bed described above grades into a white sandstone and shale and diatomite which finally grades into a typical buff sandstone of the Upper Puente.

The Puente is of particular importance because it is considered as the origin of the oil which is found in the Puente Hills.

UNDIFFERENTIATED FERNANDO (MIDDLE PLIOCENE)

The Fernando consists of marine shale, sanstone, and conglomerate. The age was determined upon the marine fossils found in it by Dr. English. In the area investigated, there is not a complete section of Fernando. The Fernando which lies south of the Whittier fault is mostly a very soft, massive, dull brown, usually micaceous brown sandstone and siltstone with occasional beds of hard limy concretions which frequently contain a few fossils. These concretions are usually the only indication of any bedding. The fossils are small gastropods, and lamellibranchs which were in such a poor stage of preservation that no collections were made. These beds dip to the south with an average dip of 40 degrees. It was originally thought that they fromed a homocline, but the present idea is that these beds are a limb of an anticline which has been cut off by the Whittier fault, and if traced to the southwest they would form a syncline and then pass into anticline forming the Santa Fe Springsanticline. The remarkable feature about these beds is their lack of deformation. Beds to the north just as competent, or even more so, show the result of extensive deformation while these beds are only tilted. They have a maximum thickness of approximately 5500 feet. In some places the sandstone grades into a fine gravel of well rounded pebbles of uniform size, but it is only a local condition. The sandstone weathers into a soil very similar to the original sandstone of siltstone.

The Pliocene material which is north of the Puente formation consists mostly of the coarser clastics, coarser sandstone and conglomerates. The greatest thickness of the conglomerates in the area investigated is along the road cut on Hudson Avenue in La

Habra Canyon where there is less than a 1000 feet. There is a much greater thickness of conglomerate north of Turnbull Canyon.

The conglomerate by Turnbull Canyon is dominantly brown in color, and varies in degree of sorting and induration. The rocks are mostly granitic with a few quartzites and felsites. The rocks are well rounded, and have an average diameter of three inches which is a little larger than the Puente conglomerates. The matrix of this conglomerate is a coarse sandstone while that of the Miocene is much finer. A peculiar feature of this conglomerate, is that it overlies a soft gray quartzose micaceous sandstone which is medium to coarse grained which grades into the great thickness of Pliocene conglomerates. At another locality station 43 this same sequence occurs, and is a good indication that they are of the same age.

There are two conglomerates in the Fernando, the buff colored conglomerate which has the larger rocks, and over lies the soft gray sandstone, and the conglomerate od small thickness which is between station 43 and Hudson Avenue. The first conglomerate is with reasonable amonnt of assurance Pliocne, while the second is no doubt Pliocene also, but it casts a shade of doubt as to whether the Puente conglomerate is Pliocene or Miocene. In thickness it is thinner than the Mionene, but in size, shape, and composition of materials very similar; the only difference being that the matrix is more sandy and coarser than the Miocene conglomerates. The Fernando conglomerate here (between station43 and Hudson Avenue) does not rest on the soft gray sandstone as the other conglomerate does, but is conformable with the folded Puente shale from all evidence available.

The ages of the Miocene conglomerate was determined mostly by the finer sediments into which it graded. The Miocene ,or Puente conglomerate grades into a white sandstone and shale and a diatomaceous shale which has the hard yellow brecciated shale bed, and the Pliocene conglomerate grades into a soft medium grained quartzose sandstone.

The conglomerate being harder than the other formations forms the high hills and ridges.

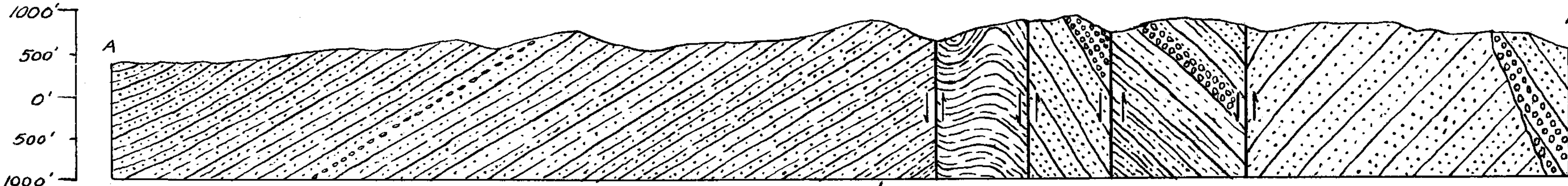
The sandstone north of the Puente formation is decidely different from that to the south. The sandstone to the north is coarser, mostly quartz, sometimes well stratified with brown and gray layers, and does not have any hard limy concretions.

There is a very small amount of Pliocene shale south of Turnbull Canyon, but it is always soft and is not siliceous.

QUATERNARY ALLUVIUM

This formation consists mostly of weathered sandstone and shale from the two older formations. It is of terrestrial origin. There are great thicknesses of it in the San gabriel Valley to the north and in the La Habra Valley to the south.

STRUCTURE SECTION



Scale 1/24000

TERTIARY

PLIOCENE	UPPER MIOCENE
Tf	Tup
FERNANDO	UPPER PUENTE
Marine buff and gray shales, silt-stone, sandstone, and conglomerate.	Marine white, buff, and gray shales, siliceous and diatomaceous shales. Buff and gray sandstones and conglomerates.

STRUCTURE

GENERAL CONSIDERATIONS

A conspicuous fact in the deformation of these hills is the absence of any folds of large size, and the great number of faults, especially in the Puente formation. All of the deformation is the result of faulting. There are many small folds beautifully exposed in the road cut of Hudson Avenue, and many similar folds are found in the shale and sandstone beds farther north. A syncline is beauti-is exposed in Turnbull Canyon on the west side of the road on the Whittier side of the canyon, just east of the Workman fault. It was no doubt formed as the result drag from faulting, and is only a local affair because no trace of it can be found onthe east side of the road for any distance at all.

From the attitudes of the Fernando formation on each side of the Puente, and the fact that an old formation has been elevated between a younger is good evidence that at one time in the forma-tion of these hills, there was an anticline formed, and due to further compression and uplift, the relief was found easier by faulting rather than by folding. This idea is more plausible when we realize that there exist a folded structure south of the Whit-tier fault, and that the southward dipping beds south of the Whittier fault are a part of the clinorium, which the Santa Fe Springs is a part. As yet there has been no evidence, that there exists a series of folds under the alluvium of the San Gabriel Valley.

It is very difficult to understand how a folded structure would with more compression result in vertical faults. The normal pro-ceedure would be an overthrust, or at least not a steep series of faults. This would lead one to believe that at first there was form-ed by compression, or may be by some local causes in the sediments, such as change of volume, due to overloading or crystalization of gypsum, a series of folds, and later due to entirely different set of forces, the faulting occurred causing the formation of the Whittier Hills. An argument against this view would be that the faulting and folding would have to take plcae in comparatively recent times, in Post-Fernando or after Middle Pliocne time, and has there been enough time for such a change of forces, and time to produce these results. It must be realized that the folds existing between t the Whittier fault and Santa Fe Springs are not very small, though not large when compared with the Appalachian folds, and there would be consumed considerable time in their formation. The amount of faulting also has been great, so that there is some doubt as to whether there has been enough time available for such results.

From the above discussions it will be seen that there is only one fact known for sure, which is, the faulting occurred later than the folding, and the fault planes are very steep making faulting due to compression alone hard to realize. As yet, it can only be said that here is another fascinating problem which shows how little is known about the mechanics of the deformation of the earth.

The faulting has been very intense in this region with no one direction for the faults. Roughly, there seems to be two directions for the traces of the faults, one in an E-W direction, and the other in an N-S direction. The faults in an E-W direction are the largest and the most recent while those in the N-S are practically inactive faults.

All of the faults planes have been assumed to be vertical because the traces of faults have cut across canyons and ridges in practically a straight line. Due to the similarity of the formations, it is practically impossible to trace a fault plane across the various differences in elevation. Only different isolated exposures of attitudes are encountered, and no faults planes have been visible. Many of the faults were traced in on physiographic evidence which gives one very little information, as to the actual attitude of the fault plane.

WHITTIER FAULT

The Whittier fault is the most important structural feature in the region, and has been largely resposible for the formation of the Puente Hills. It forms the contact between the Fernando and Puente on the south. The fault has been traced farther south, and is found to be the extension of the Elsinore fault system. The Elsinore fault is thought to branch at the east end of the Puente Hills into two faults, the Whittier fault which follows the south side of the Puente Hills and the Chico on the north side of the Hills. The trace of the Chico fault has not been found, but it is inferred from similar evidence as is used in placing the San Gabriel fault approximately at the foot of the San Gabriel Mountains, which is the abrupt change of elevation at the edge of the Perris Peneplain.

The Whittier fault in the area infestigated is fairly easy to trace, through out its extent. It is marked by conglomerate beds which crop out along its course.

The beds south of the fault dip to the south while those to the north general dip to the north. The fault zone in many places is over 200 feet wide, so that a sharp lithologic change is not noticable, especially when the materials on each side of the fault closely resemble each other.

On ridges which the fault crosses there are usually many good saddles, so that physiographic evidence is very useful.

The throw on the Whittier fault has been considerable, but there is no definite way to determine the amount. No doubt there has been a good deal of Horizontal movement also, but as there is no offset of structural features which can be measured, no quantative measure can be obtained. It is a probably a normal fault, although with a fault which has a vertical plane, whether the fault is a normal or a reverse fault is a hard question to solve. Some good exposures will be found at stations 17 and near 15.

WORKMAN FAULT

The Workman fault was named by K.E. Lohman in his report, on the Geology of a Portion of the Whittier Hills. It intersects with the Whittier fault just south of the east end of the large basin, south of Workman Hill, extends just west of the Workman Hill, crosses Turnbull Canyon Road, and finally dies out in the center of the Hills to the northwest. The fault was located largely on physiographic evidence, and also on the lithologic change of sediments, and a change of attitude of the formations on each side of the fault. Along its length there are several good saddles, and at the north side of the sag pond south of Workman Hill, the western portion of the hill which forms the northern side of the pond has been moved to the south a distance of nearly 300 feet. Close to where the fault intersects the Whittier fault, the sandstone beds are terminated. The northern portion of the fault forms the contact between the Fernando conglomerates and the Upper Puente shales.

The fault is also termed a vertical fault, with the west side moving upward with respect to the east. The total upward movement is not known, but it could hardly be expected to be anything that would equal that of the Whittier fault. The horizontal movement would be nearly 300 feet, with the west block moving to the south with respect to the east, if the end of the hill on the north side of the sag pond is to be taken as a measure.

A small fault which runs in an E-W direction south of Workman Hill was determined largely on physiographic evidence. Along its trace there are large saddles on spurrs, and it is hard to understand how they would be formed other than by faulting when the lithologic change in the formations is between shale and soft sandstone. There is also a change of attitude between the formations, but due to the thick growth of brush the numberof attitudes available are not as plentiful as are really needed.

It is not entirely clear whether or not, this fault does not continue along the northern edge of these hills forming the contact between the Pliocene and the Miocene formations, and does not extend out into the valley. Further to the south the Fernando conglomerate beds are very thin, and in some places grade into a sandstone. Where attitudes are available they show a discordance, with Puente but at no place is there a fault plane visible,and there is very little physiographic evidence for faulting. Because of the meager physiographic evidence of faulting, the contact was called an unconformity, but with more information it might turn out to be a fault. In La Habra Canyon the contact between the white Puente shales and the Fernando conglomerate, appear to be one of no angular discordance. It is true the shales are badly contorted, but they grade into a sandstone then to a fine conglomerate, then finally to the typical Fernando conglomerate.

In the first large canyon south of the Pliocene-Miocene contact in the middle of the area, a minor fault is present. Its existence was determined by a change of attitude on each side of the fault, the sandstone beds to the south dip to the north, and the beds to the north dip to the south.

In the canyon there are several saddles, and at the eastern end the west side of the canyon has been elevated, so that the canyon has been forced to extend its course to the east, instead of turning to the north, as one would expect it normally to do, because a small canyon has started to eat its way south to intersect it at its normal exit to the valley. At station 43 the fault is beautifully exposed with north dipping conglomerates and sandstone beds at 25 to 30 degrees intersecting vertical sandstone and conglomerate beds.

The fault extends to the west and intersects with the Whittier fault and cuts off the Workman fault, or it is cut off by the Workman fault. The true relationship between the three faults is not known because the intersections are in a canyon and no attitudes are visible.

To the south of this fault there is a conglomerate bed described lithologically on page 14. It begins with a N. 75 W. strike and a vertical dip, and changes the dip to the north farther to the east. At station 37 there is a break in the conglomer-bed in which the east part moves southward approximately 200 feet The dip here is approximately 40 degrees N. About 1/8 of a mile farther east, another break occurs although not large. From here the conglomerate bed keeps its N. 40 degree dip, but the strike begins to change from N. 80 W. to N. 75 E. strike. There can be hardly any question, that two minor faults are the cause of these displacements, and are cut off by the Whittier fault which is just to the south, but to trace the faults to the north is practically impossible because of the canyon for one, and series of rounded hills on the other which has a thick growth of grasses. From the deformation of the conglomerate, it seems as though there was some force trying to bend the conglomerate bed in the center, pushing it to the south, but most probably the deformation was the result of the movements on the Whittier fault.

South of the conglomerate bed described above is a hill capped with a conglomerate bed. Some time wassspentin trying to figure out the relationships between the two conglomerate beds. Whether the two formations are/the same bed, or whether one is Fernando in age, or Puente in age. If they are of the same bed, there is a discordance in attitude, so that the one to the north, if projected southward, would be more than a hundred feet above the southern conglomerate bed. In other words the conglomerate which tops the hill dips below the northern conglomerate. The northern conglomerate bed is considered as Miocene in age, and whether or not, the conglomerate which caps the hill is of the same age or younger, there must be a fault in the canyon to account for the relationships between the two beds. The conglomerate bed capping the hill cannot be older than the other conglomerate because the bed is only of small size, and it is not probable that such a small bed could be faulted above the rest of the hills. any great distance.

There is some indication that the two conglomerate beds could be limbs of an overturned anticline because the sandstone beds immediately below the conglomerate capping the hill is similar lithologically to the sandstone above the other conglomerate, but differences being that it is thinner, not so well bedded, and does not grade into shale as rapidly. The conglomerate beds are very similar in composition, but the one to the south has on the whole larger rocks. It has been decided that the most logical solution is to consider the conglomerate beds of the same age, and that there is a fault relationship between them. The fault has been dotted because no trace of it was found.

At the northern side of the hill the conglomerate bed is cut off by a fault which is north of the Whittier fault and parallel to it. Here, it turns to the north and continues through the saddle where farther north it intersects the fault to the west which is nearly parallel to the Whittier fault.

South of the hill capped by conglomerate, the faults were drawn in on the bases of a pronounced change of attitude. Although the change of attitudes is a frequent occurrence, and usually not a very safe evidence for faulting in this district, but here they are more or less constant in certain areas, so as to lead to the conclusion of faulting when a marked change of attitude is discovered.

The movements on all of theses minorfaults are very difficult to determine because they are in the same formation, so that the amount of horizontal or vertical displacements cannot be measured. It is very clear that they are not very important structurally, but are very interesting for determining the amount of geologic activity.

PHYSIOGRAPHY

The physiography is very important as a criteria for determining the structure, and is very beautifully developed. The hills are all rolling with steep walls at the bottom 2/3 of their heighth . Many of them have the shape of an inflated parachute. This would indicate that the country before uplifting was rolling plains country, but there has been considerable erosion, so that most likely none of the old land forms are retained.

In the southern part of the area, there is an excellent fault scharp exposed; formed due to the uplift along the Whittier fault. The top of the fault scharp is a sloping hillside on which is grown barley and wheat, and at its lower edge is a shear drop of two hundred feet or so.

Many of the saddles, swales, and canyons are of subsequent origin, due to the ease with which the softer brecciate materials were eroded with respect to the harder formations.

ECONOMIC RESOURCES

The region is of extreme interest economically because of its oil and gas resources. The Puente Hills is one of the oldest producing fields in the state, but the production has never been large. The oil and gas has accumulated in the limb of the anticline south of the Whittier fault, and has been trapped by the fault because of the impervious layer gauge formed by the faulting and the Puente shales. The district is still considered as an oil producing area because many oil compaoies are still looking for more favorable drilling locations,and one at the present time is drilling a test well about a mile and a half west of the Haciendo Country Club.

GEOLOGIC HISTORY

Only the later part of the Tertiary and the Quaternary history is here recorded. There has been no volcanic or intrusive activity, and th only rocks are of sedimentary origin.

In Upper Miocene time there was a large shallow sea into which was deposited the Puente shales and sandstones. The sea became deeper during the deposition of the shale. The next event was the recession of the sea, and the western portion of thearea was exposed to erosion and some deformation. There was next the transgression of the Pliocene sea into which was deposited the great thicknesses of conglomerates. Later the sea deepened and conditions were maintained more or less constant during which the great thicknesses of Fernando sandstone and siltstones were deposited. The sea then receded, and in Post-Fernando time, the region has been subjected to intense deforming stresses resulting in the uplift of the Puente Hills. At the same time erosion has been filling the valleys with Quaternary Alluvium. During this period of erosion the present topography was formed.