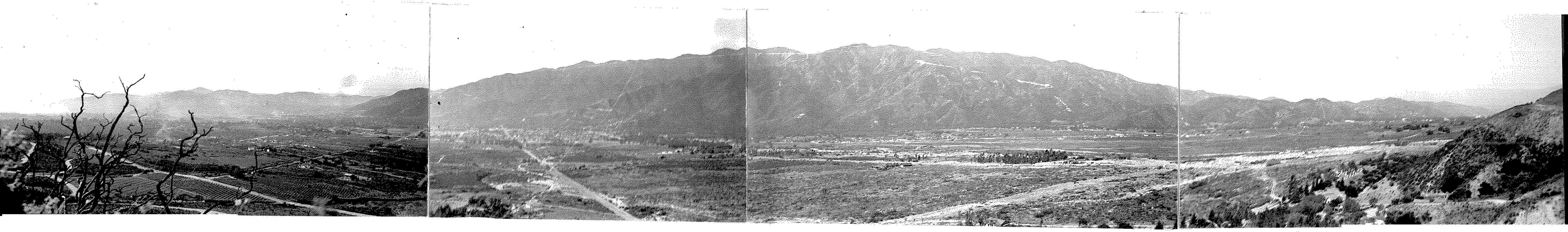
GENERAL GEOLOGY
OF
VERDUGO MOUNTAINS

SENIOR THESIS 1934
J.F. JUDSON



THE VERDUGO MOUNTAINS

OUTLINE OF REPORT.

Local.

Local .

LIST OF ILLUSTRATIONS.

Abstract.

The Verdugo Mountains is a horst bounded on the south and west by reverse faults and on the north by normal faults. These faults are not simple fractures, but are zones including a number of parallel faults. The Verdugo block is not a simple horst, however, but is a composite one, being divided into three main blocks by normal faults which belong to a later period than the reverse faulting. Structurally, the Verdugo Mountains is a part of the San Gabriel Range, and also should include the San Rafael Hills which are only separated from these mountains by Verdugo Canyon.

The western part of these mountains is overlain by Miocene and Pliocene sediments folded into a number of small folds, which, however, are merely flexures on the south limb of an overturned syncline whose axis is across Tujunga Wash. These sediments are largely marine, although fan-glomerates make up a large part of these. The basal conglomerate has a basalt flow intercalated in it.

Introduction.

Location of Area:

The Verdugo Mountains are bounded on the west and south by San Fernando Valley, on the north by the main mass of the San Gabriel Range, and on the east by Verdugo Canyon which separates them from the San Rafael Hills. These mountains are covered by the Sunland, La Crescenta, Glendale and Burbank Quadrangles whose scales are 1:24,000. They are approximately ten miles long by three miles wide and lie between parallels 34° 09' 48" and 34° 16' and meridians 118° 13'40" and 118° 22'20".

The area is readily accessible by means of the many splendid roads which bound it on all sides. The small towns of Montrose, La Crescenta, Tujunga, and Sunland lie along the north side of the Verdugo Mountains; while Glendale and Burbank lie against the southern flanks of these mountains. These towns are all connected by paved highways and make the area accessible from any angle. In addition to these roads along the boundary there are many roads built by the United States Forestry Service which penetrate into all parts of the area. These roads are closed to the general public, but permission is easily obtained to make use of them, also, along the edges of the mountains there are numerous roads built back into the canyons, often as far as a mile, by real estate companies opening up new sub-divisions.

Previous Work:

The Verdugo Mountains have never received a great deal of attention, due chiefly to the fact that they are made up largely of crystalline rocks. The sediments on the west end have, however, received some notice from the oil industry, because the Modelo formation, which outcrops here, often contains oil. They have been mapped in a rough fashion by W.S.W.Kew[1] in 1924, and M.L.Hill[2] in 1930. W. Miller has been the only geologist to work the Verdugo Mountains as a unit, and this he did in connection with the larger problem of the Western San Gabriel Mountains as a whole, paying particular attention to the crystalline rocks and their relationships.

Conditions of Study:

The field work was done in the first half of 1934, in the months January to June, in preparationn of a Senior thesis to fulfil the graduation requirements of the California Institute of Technology. The work was performed under the supervision of J.H.**Maxson**.

The sediments on the west end of the Verdugo Mountains, covering an area of about five square miles, were mapped in detail, the work extending throughout the second term of the school year from January to April. I might add that a part of these sediments immediately south and east of Sunland were mapped in connection with a field course given in the Junior year and are discussed in detail in the report turned in at that time. In the third term, April to June, ~~as~~ a reconnaissance of the rest of the Verdugo Mountains was made with particular attention being paid to the structure

[1] Kew, W.S.W., Geology and Oil Resources of a Part of Los Angeles and Ventura Counties, California, U.S.G.S. Bull., 753, 199 pp. 1924.

[2] Hill, M.L., The Structure of the San Gabriel Mountains North of Los Angeles, California, Univ.Calif. Publ., Bull. Dept. Geol.Sci., vol 19:137-170, 1930.

[3] Miller, W.J., Geomorphology of the Southwestern San Gabriel Mountains of California, Univ. Calif. Publ. Bull. Dept. Geol.Sci., vol 17:193-240, 1928.

Rocks of the Southwestern San Gabriel Mountains, California Geol. Soc. Am. Bull. vol 41: 149, 1930

Geology of the Western San Gabriel Mountains Pub. Univ. Calif. at L.A. in Math. and Phys. Sci. vol 1 114 pp. 1934.

and geomorphology. The total area mapped was about 30 square miles.

The base maps used, i.e., the La Crescenta, Sunland, Burbank, and Glendale quadrangles, had a scale of 1:2400, and a contour interval of five feet and twenty-five feet.

Typical cover of chaparral in the Verdugo Mountains.

Physical Conditions.

Climate:

The annual rain-fall for this part of the country varies from 10 to 20 inches and so this region may be characterized as semi-arid. All except the largest streams are dry for the greatest part of the year, and they often fail to flow during the dry season. The summer temperatures are quite hot, the thermometer often reaching 90-100 and sometimes higher; the nights, however, are cool and very pleasant. In winter the temperature rarely goes below 30°, and although frost is not rare, it is not the usual thing. The surrounding mountains sometimes receive a coating of snow which infrequently reaches down as far as the valleys, but it rarely stays unmelted for as long as a week, except in the canyons.

During the spring months it is quite common to have fogs roll in from the ocean in the mornings, and last until ten or eleven o'clock.

Vegetation:

These mountains support a dense growth of shrubs and bushes, such as is usually found in the semi-arid regions of Southern California. Manzanita Shrub Oak, Greasewood, Yucca, Poison Oak, and California Holly are especially abundant on the hill slopes, where they form a cover so thick that in some places it is almost impossible to get through it. This underbrush varies in height from waist high to seven and eight feet tall, although the averageheight is up to a man's shoulders. The only trees in the region are found in canyons, and include Oak, Elder, Cottonwood, Willow, Sycamore, Mountain Laurel, and Bay. This vegetation becomes very dry in summer and constitutes a grave fire menace.

Surface Relief and Elevation:

The Verdugo Mountains decrease in relief toward the west and finally run under the alluvium a few miles west of Sunland.

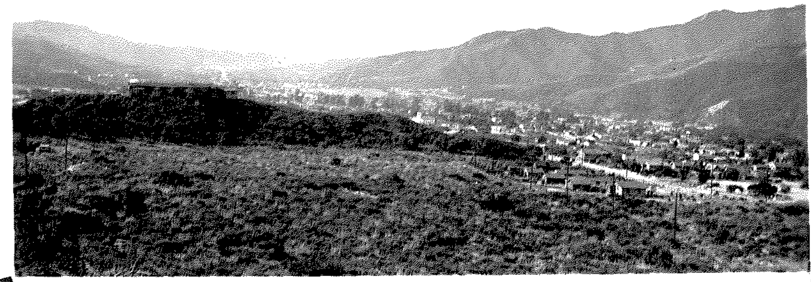
The eastern part of the mountains is very rugged and has a maximum relief of 2500 feet, the highest elevation is 3126 feet. Both the northern and southern scarps are very steep, and have an average slope of about 14°, the canyons being deep and preciptous and ~~are~~ separated by knife ridges. The igneous and metamorphic rock which composes this part of the area is very much decomposed and offers a precarious foothold.

The part of the area west of La Tuna Canyon and east of Sunland Boulavard has a moderate relief of about 800 feet, but the canyons are still quite deep and separated by narrow ridges. East of Sunland Boulavard the relief is very low, not more than a few hundred feet, and the canyons are broad and shallow. The area is made up of low rolling hills. The Verdugo Mountains dip under the alluvium at the Tujunga wash and the only other evidence of them is the appearance of a few low knolls which project above the alluvium a few miles to the west.

Drainage:

The general trend of the Verdugo Mountains is N 50 W, and the major drainage runs perpendicular to this direction;that is,N E - S W. The reason for this is that the so-called mountains are really a long ridge plunging to the west. West of La Tuna Canyon the ridge in very sharp and the canyons run down in long parabolic arcs from this knife edge. The side cutting lateral streams have not developed to any great extent yet, except in those large canyons, such as Verdugo Canyon and La Tuna Canyon. Some of the canyons are fault determined, and have cut their way down along fault planes; La Tuna and Park Canyons are the best examples of this, although many others could be cited. These fault determined canyons are naturally not always parallel to the regular drainage, although they often are.

It is interesting to see how the vegetation effects the drainage. Last ear a forest fire burned off some 5000 acres of brush from the scarp of the



Verdugo Canyon looking south.

View looking out across San Fernando Valley from top of Verdugo Mountains. Santa Monica Mountains shown in distance.

main San Gabriel block, just above La Crescenta. Early in January 1934, this region suffered a cloud-burst during which ten inches of rain fell within three days. The water shed, left bare from the fire, could not hold the water back and the streams became raging torrents. The dirt and rocks on the canyon walls, not having vegetation to hold them, slid down into the canyons, thereby damming up the streams. The water was held back until it developed sufficient pressure to burst these dams, and then it carried all before it, throwing surge upon surge of rocks and debris upon the towns immediately below. It is upon this principle that "booming" is carried on in mining. During this storm a 19 ton boulder was carried three miles and dumped on the highway. This will be referred to again when the origin of the sediments in the west end of the area is discussed. The streams consequent upon the south scarp of the Verdugo Mountains caused little or no damage, although, their water shed is fully as large as the one in the burned off area. This shows that even a cover of chaparral is sufficient to keep erosion at a minimum. In this respect it is interesting to note that, in those canyons running east-west, the north wall is generally steep and more dissected than the south wall due to the fact that the vegetation grows less thick on the north wall. This is particularly well shown in Lunch Canyon, where the underlying rock is about the same on both sides.

Geomorphology.

The one long ridge which constitutes the Verdugo MMunntains is a horst, and is bounded both north and south; and, probably east and west also, by faults. It is not an orthodox horst for on the south side it is bounded by a reverse fault, and on the north side it is bounded by a normal fault. This will taken up more in detail under structure. Since both faults, or rather, since the faults in both shear zones have about a N 60° dip, the effect would be,assuming no erosion had taken place, that of an irregular block, with a parallelogram cross section leaning out toward Glendale at a 60° angle. This block would be tilted toward the west so that it would run under the alluvium at Tujunga Wash. It is not a simple horst, however, but is a composite one composed of numerous fault blocks. Nevertheless, it is possible to distinguish three main blocks which have a different topographic expression with respect to each other. The main block constitutes about two-thirds of the whole and is 1000 feet higher than the other two. The other two blocks have approximately the same height, but are separated from each other by a major fault zone. These blocks have been down dropped with respect to the major block on normal faults. The net effect would roughly be that shown in figure 1.

Kew' speaks of the scarp facing Glendale as a fault-line scarp, although he gives no reason for this statement. A fault line scarp is produced by differential erosion after the original fault scarp has been eroded away. To have this condition brought about, the fault-line scarp must be composed of materials more resistant to erosion than those adjacent to it. The crystalline rock of which the Verdugo Mountains are composed is essentially of the same character as that composing the bed-rock upon which Glendale is built. It is difficult to see how a fault-line scarp could be produced from a homogeneous material. It has been definitely proven that the scarp of the San

kew, W.S.W. XVl International Geological Congress Guide Book 15 pp. 55.

Gabriel Mountains north of Tuhunga wash is a true fault scarp, for a lava bed has been faulted off, and some lava remnants have been found high up on the ridges of the scarp.

One characteristics of a fault-line scarp is that there are little or no materials on the downthrown side.? This condition is true of the eastern and western ends of the scarp, but this can easily be explained. The Tuhunga River flows around the west end of the Verdugo block, and for four or five miles it has cut away all trace of alluvial deposits except those protected by ridges jutting out. The drainage actually flows in towards the base of the scarp in this five mile stretch. Again, west of Verdugo Canyon the alluvial fans have not attained their natural size, because the Verdugo River flows around the point and cuts them off for about a mile. Verdugo River has built up such an enormous alluvial fan that it has crowded the one from the base of the scarp back, due to the fact that the one from the Verdugo River has been built up higher. At present the Verdugo River is flowing on the extreme western part of its fan; but, since it is flowing in a concrete canal, one can not draw any conclusions from this.

In a recent publication Blackwelder[1] lists as an evidence of a fault-line scarp the fact that the trace of the fault crosses lateral spurs instead of limiting their ends. However, this is rather dubious evidence; for ordinarily a block is not thrown up along one fault, but along a series of distributive faults. Nevins[2] mentions the fact that " a series of high angle faults frequently occur so closely spaced as to cut the earth's crust into blocks". He cites the fact that the eastern face of the Sierra Nevada

---

[1] Blackwelder, E. The recognition of Fault Scarps. Jour. Geol., Vol. 36, pp 289-311, 1928.

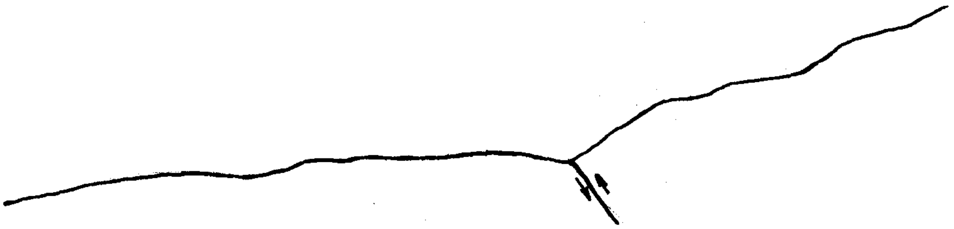
[2] Nevin, C.M., Principles of Structural Geology, pp. 94.

View taken from the Verdugo Mountains showing the front of the San Gabriel Mountains. In the foreground are seen part of the sediments which lie on this portion of the Verdugo Mountains.

Mountains is a place where the drop to Owen's Valley is taken up along a series of steep faults. In the Verdugo Mountains, there are numerous faults running across the ridges of both the north and south scarps;but, as was just seen, this is not evidence that they are fault-line scarps. Blackwelder mentions, also, that super-imposed streams are prima facie~~f~~ evidence of fault-line scarps. The only stream in this area which may be so interpreted is Verdugo River, and this is very probably antecedent, Kew agrees to this. Kew evidently has either a different definition of fault-line scarp than that given above, or else his statement was merely a slip, for he makes it clear that the San Gabriel Mountains are true fault block mountains, and that the Verdugo Mountains are structurally a part of them.

We have received the negative evidence for considering these mountains as an upthrown fault block; now, let us look at the positive evidence.

The actual faults which have produced the uplift on both the north and south blocks have been mapped, and they run along near the base of the scarps, there are undoubtably other faults out in the alluvium which have raised the edges of the block with respect to the valleys. Above Rossmoyne there is splendid physiographic evidence of faulting. A ridge which is sloping back very gradually suddenly changes its shape and goes up very rapidly as in the drawing.



Just at the change of slope a large fault is exposed very clearly is a road cut, this fault can be traced for several miles. The igneous rock on both sides of the fault has practically the same resistivity to erosion. La Tuna and Park Canyon faults also mark a sudden change in relief, about 1000 feet, although in this case the lower blocks were down dropped along normal faults.

In a few places terraces have been preserved. Above Sunland a flat area of about one half acre in extent in cut into the side of a hill. It is cut out of a conglomerate bed, and so one cannot use the criteria of alluvium to prove it a terrace. However, a piece of hornblendite was picked up on it; and since I have never seen this particular kind of rock to occur in the sediments in question, it offers an indication of terrace alluvial. Further, hornblendite of this kind outcrops at the head of Arroyo Seco River, and since Tujunga River also originates up by this outcrop, it is conceivable that, not long ago in geological time, Tujunga River may have cut this present terrace out and deposited the hornblendite there. Hornblendite is not a common rock and occurs in but few localities, and this would lend weight to this theory. There are numerous terraces on the San Gabriel Mountains across Tujunga Wash. Above Burbank there are a couple of terraces that have been preserved on the scarp. On top of one of the ridges there is a level place of about one-half acre in area, and immediately below it there is a terrace which has been cut through in the middle by a stream. It dips gently to the north and shows tilting of the block as it went up.

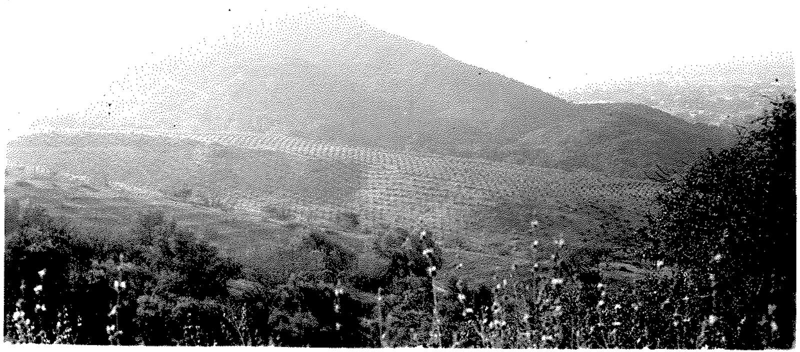
On the scarp above Burbank the ridges, instead of going up in a smooth slope, are benched. Between La Tuna Canyon and Park Canyon there is a distance of about five miles. In a statistical count of the number of correlated bench levels, the following results were obtained.

No. of Bench levels correlated	elevation	total no. of ridges
6	1100	12
7	1200	12
5	1300	12
2	1400	12
3	1500	10

Such figures can not be used to state the number of stages of uplift or anything of the sort, but they show in a rough qualitative way that there are numerous benched ridges, whose levels can be correlated in a rude fashion. These may be due to a number of causes. First, they may be due to differential erosion, and are only correlated accidently. Second, they may be caused by faults which, crossing the scarp face, form a series of steps. Third, they may have been formed by back cutting of the fault scarp in between periods of faulting in the uplift of the block. Such evidence taken alone would not be indicative of faulting, but taken together with other evidence is strongly suggestive.

None of the old land surface is preserved anywhere in the Verdugo Mountains, for the erosion cycle has progressed sufficiently far to oblitrate all traces of it. One reason for this is that the block is relatively long and narrow, and it did not take the streams long to eat headward, and so cut down the divides. The two small down dropped blocks still retain a uniformity of relief, however, which indicates the old land surface must have been of quite low relief, probably similar to that of the present San Fernando Valley, and even the ridge of the main block shows a uniformity of elevation to confirm this idea. The streams flowing south from this ridge have a 1000 foot greater drop than the streams cutting into the north scarp, and in the natural course of stream development this ridge should be pushed more and more to the north; since the streams with the greatest drop have the greatest cutting power. It is interesting to note that, at the present time, the crest of the ridge is one third to one mile closer to the base of the north scarp than it is to the base of the south scarp, notwithstanding the thrusting action of the reverse fault which thrust the block out toward the south. For purposes of description one might say that the mountains are passing from late youth into early maturity in the cycle of stream erosion. Naturally the cycle of erosion goes on at a different rate in unlike rocks. The igneous rock controls the erosion in the greater part of the area, but west of Sunland Boulevard the rocks are en-

Terrace above Oakmont Country Club.



Terrace near Verdugo Woods sub-division.

tirely sedimentary and made up mainly of sandstone, shale, and conglomerates, The lesser resistanceto erosion of the sediments, combined with the low relief has enabled the erosion cycle to advance to the late mature stage.

In many places in the area there are stream terraces or remains of stream terraces. These are shown best in Verdugo Canyon where there are two splended examples of terraces, one above Oakmont Country Club, and the other in the Rossmoyne Tract. These terraces vary from 50 to 75 feet in height and are quite large. In La Tuna Canyon there is a remains of a stream terrace exposed on the road at the end of the canyon. The alluvial is perhaps 30 to 40 feet deep at this place. Along the base of the scarp above Burbank there are some old stream terraces; and in the portion of the area west of Sunland Boulevard there are deposits of alluvium which are remnants of older alluvial deposits, since dissected by streams. These old deposits of alluvial signifies one of three things; i.e.- that the Verdugo Block was uplifted about 50 feet not long ago, thereby rejuvenating the streams; that there was a regional uplift accomplishing the same thing; or that a change of climatic conditions changed the rate of stream erosion. As to the first, there was movement on the main San Gabriel block not very long ago, as evidenced by the young fault block directly in back of Devils Gate Dam. On the other hand the La Tuna Fault is truncated by an alluvial deposit, three feet thick in the upper part of the canyon. The stream has cut down about 10 feet and left the fault and alluvial deposit exposed in a section along the stream bank. La Tuna Fault is a normal fault and there is reason to believe that the normal faulting occured at a later period than the reverse faulting which lifted the block up. If this is so, then the stream terraces are too recent a feature to be caused by an uplift of the block. This would leave then, either a regional uplift or a change in climate as the cause of the stream rejuvenation which dissected these alluvial deposits.

At the present time the streams' to be aggrading instead of degrading, since the mouths of the canyons appear to be filling up with sediments again. This indicates that the streams are against grade and the period of rejuvenation is over.

The Verdugo Canyon offers a nice little problem in physiography. Structurally, the Verdugo Mountains and the San Rafael Hills are one unit, separated only by Verdugo Canyon. There are two possible answers as to its origin. It is an antecedent canyon or else it is a fault determined canyon. As already mentioned,[1] Kew believes it is an antecedent canyon, thereby assuming that the river cut across the Verdugo Block as it was faulted up.[2] Miller on the other hand, draws the Montrose Fault zone down through the canyon. This fault zone was mapped by me almost as far as the Oakmont Country Club, showing that it curves down Verdugo Canyon this far; therefore it is not unlikely that it goes down the center of the valley towards Glendale,. There is no indication that it enters the San Rafael Hills and it is much too big a fault zone to stop.[3] Miller shows no fault in the San Rafael Hills that it could be correlated with. There are numerous road cuts in the canyons neighboring Verdugo Wash, and I made a careful survey of them all, finding no fault planes exposed adjacent to Verdugo Canyon except one with a zone of breccia four inches wide one-quarter of a mile inside the Verdugo Block. This fault was a normal fault and parallel to Verdugo Canyon. Of course if the main fault zone runs down the middle

---

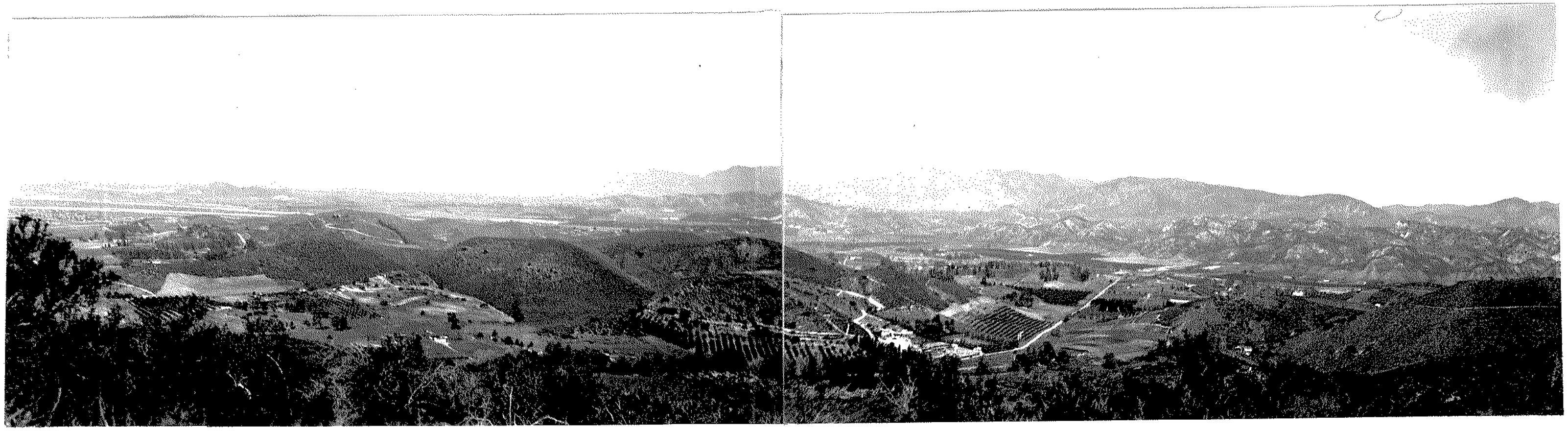
[1] Kew, W.S.W., International Geological Congress Guidebook 15 Southern California, pp 53-54

[2] Miller, W.J. Geology of the Western San Gabriel Mountains, Pub. Univ. Calif. at L.A. in Math., and Phys. sci. Voll, pp114, 1934.

[3] Miller, W.J. Ibid.

of the canyon, the lack of parallel faults in the block itself would not disaprove anything.

From all this one might conclude that the Montrose Fault Zone offered a low resistance to erosion, thereby determining the course of Verdugo River which cut down through the fault block as it arose. As a consequence Verdugo River is probably both antecedent and fault determined.



The extreme western end of the Verdugo Mountains showing Modelo sediments in the middle foreground. In the distant left a small knoll can be seen projecting above the alluvium which is the last trace of the Verdugo Mountains.

Stratigraphy and Petrography.

Regional;

In the western end of the Verdugo Mountains there is an area of about five square miles covered by Miocene and Pliocene sediments, however, the Pliocene sediments cover but a negligible fraction of this area. These sediments rest unconformably on the basement complex, and have a total thickness of perhaps 6000 feet. They are dominantly of marine deposition, although fan-glomerates make up a large part of the total bulk. The lower part of the sedimentary section has a basalt flow embedded in it, although this flow, in part, rests on the basement-complex itself. In one place the fan glomerate is apparently cut by a porphyritic olivine basalt dike which probably was the vent for at least part of the basalt.

The basement complex is made up of some old metamorphosed sediments of Pre-Cretaceous age, which have been intruded and injected a number of times. The petrography of the igneous rocks is very complex, and no attempt will be made in the report to deal with it in other than a cursory fashion, as it constitutes an entire problem in itself.

Local:

Basement-complex:

In the western half of the Verdugo block an old sedimentary series outcrops. These sediments have been greatly metamorphosed and now consist of gneiss, schist, marble, and quartzite beds. Quart-feldspar-biotite- and quartz- feldspar- hornblende gneisses make up the largest part of these rocks, although quartz-mica schists are quite common. In Lunch Canyon one of these quartz-feldspar-biotite gneisses has numerous almandite garnets developed in it. In at least two p;aces in the area graphite schist are present, and indicate the sedimentary origin of the metamorphics. The graphite is present in small flakes, and near

La Crescenta it was abundant enough to be mined. The marble beds, having suffered great metamorphism, have in places developed grossularite garnets vesuvianite, and magnesite. The marble is well crystallized, medium grained, and predominantly white in color. These gneisses and schists have been injected by magmatic material, and as a result there are lenses, stringers, and veins giving rise to a lit-par-lit structure. They are also intruded by pegmatitic and aplitic dikes. These sediments are Pre-Cretaceous in age and are certainly Paleozoic or even Pre-Cambrian in origin. The severe metamorphism suffered by them, and the numerous intrusions of large bodies of diorite, granite, quartz monzonite, and granodiorite have led Miller[1] to incline to the belief that they are Pre-Cambrian in age.

The igneous rock in the sub-basement appears to be fairly uniform. On the upthrown side of the block, adjacent to the fault plane, a quartz monzonite rock is very often found, Specimens have been obtained from Oak Canyon, La Crescenta, Park Canyon, Lunch Canyon, and an old quarry above La Crescenta of this rock, and it has been observed to outcrop in other places, This rock would seem to be the latest intrusion for it is very fresh and intrudes rock very much more weathered. This rock varies from a medium grained phanerite to a porphyritic phanerite with a medium grained ground mass. The phenocrysts are of feldspar. A microscopic examination reveals that the rock is made up of oligoclase (28 an), orthoclase, quartz, biotite, magnetite, apatite and zircon. The rock has suffered extensive alteration; and, consequently the biotite has largely altered to chlorite, The feldspar, both orthoclase and plagioclase, have

[1] Miller, W.J., Geology og the Western San Gabriel Mountains, Publ. Univ. Calif. at L.A. Math. and Phys. Sci. vol. 1, 114pp., 1924.

suffered moderate sericitization, and the othoclase has undergone quite a bit of albitization. A myrmekitic texture has developed between the quartz and orthoclase in some places, indicating a probable simultaneous crystallization between these two constituents.[1] The rock has undergone a moderate strain shown by the unequal extinction of the quartz and orthoclase between crossed nicols. In an old quarry in Park Canyon the intrusive contact between the rock and the metamorphosed sediments is shown.

Much of the main block of the Verdugo Mountains is composed of what Miller[2] calls the Wilson Diorite. Megascopic examination shows the rock to be almost entirely plagioclase and hornblende. This rock has a pronounced banded-gneissic texture, the bands being one to several feet in diameter. Except in the bottoms of the canyons where the streams have laid it bare, it is extremely weathered, and can be broken apart with the fingers.

The dikes of the area are quite numerous and variagated. There are granitic, aplitic, and pegmatitic, dikes constituting the leucocratic phase. Some of the pegmatite dikes are very long, perhaps twenty or thirty feet, and only an inch or so wide. The lamprophyric dikes are also present, as well as numerous diabase dikes.

Basalt:

In middle Miocene time numerous basalt flows were poured out in this region. Just south of Sunland there is a flow which rests partly on the basement and partly on a conglomerate. This lava was not the result of one flow, but was built up by a succession of outpourings of basalt. Just above Sunland there is exposed on a road a zone of breccia, and possibly 50-75 feet above this stratigraphically there is a lense of sandstone in

[1] According to Becke, this may also be due to the albitization of the orthoclase.

[2] Miller, W.J., Ibid.

tercalated in the basalt. This indicates a short interval of time was allowed to elapse, with resultant erosion, between flows. Furthermore, the conglomerate beneath the basalt flow contains numerous boulders of basalt, proving that, before this flow was poured on the surface, another basalt flow was undergoing erosion not far from here. Basalt boulders do not endure stream transportation well, and tend to break up within several miles of tumbling by the water. Near the mouth of Sunland Canyon there is a lenticular outcrop of basalt inside a conglomerate bed resting on the basement. The sediments here dip about 20° N, but the basalt has an apparent dip of about 60° N. by the way it cuts across a ridge. This would indicate it to be a dike Further, a microscopic examination of it shows it to have a groundmass much too coarse for a flow; and, also, it is porphyritic with labradorite crystals one-quarter of an inch long. A microscopic examination of it reveals that it is composed of labradorite (63 an), and olivine. The olivine is almost entirely altered to Iddingsite, Bowlingite, and Magnetite.. In some places the basalt has an amygdaloidal structure in which the amygdules are filled with calcite.

In previous work done in this area, the sediments on the west end of the Verdugo Block have been mapped as undifferentiated Miocene beds. [1]Kew, however, mapped them as Modelo; but no identifiable fossils have ever been found in these sediments. In the course of the field work for this report, a bone embedded in the sandstone containing chert lenses was found. E. Furlong pronounced it an ungulate rib, but said it was too fragmentary to be diagnostic. The only possible correlation left, then, is a lithologic correlation.

[1] Kew, W.S.W., Geology and Oil Resources of a Part of Los Angeles and Ventura Counties, California, U.S.G.S.Bull. 753, pp. 199., 1924

On this basis these beds are similar to those found in the Modelo formation in other parts of the region. In the Santa Monica Mountains the Modelo is separated from the Topango formation by an angular unconformity; though in Santa Clara Valley, where the type section is, the Modelo, as mapped by Kew, represents continuous deposition from Vaqueros to the end of Miocene time. It has had, subsequently, to be divided in a purely artificial manner by F.S.Hudson and E.K.Craig[1]. Somewhat the same situation exists in this area; the sedimentation seems to have gone on, from the time when they were laid down on the basement complex to the base of the Pico formation, without a break. North of Tujunga Wash, the formation lying on the basalt is fossiliferous, and has been tentatively identified as Topanga in age. If the basalt on this side represents the same age as that on the other side; then, the sediments lying on the basement complex are Topanga in age. The only place where it is possible to draw a definite boundary between the Modelo and these sediments, is near the road cut immediately west of Sunland; but, inasmuch, as some beds stratigraphically lower than this contact are undoubtly Modelo in age, this leaves the question up in the air. Nevertheless, the sequence of deposition of these beds has been uninterrupted, and logically they should be mapped as a single unit; since no fossiliferous horizon is present upon which to base a sub-division. This has been done in the map accompanying this report, where Modelo is used in the sense in which Kew used it, and not in the strict sense defined by Hudson and Craig.

In middle Miocene time the land relief was very slow, erosion had stripped away all covering and exposed the basement complex. Upon this

[1] Hudson,E.F..and Craig E.K., Geologic Age of the Modelo Formation California: A. Assoc. Petrolium Geol. Bull. vol. 13, pp. 512-517, 1929.

Basal conglomerate lying on basement complex.

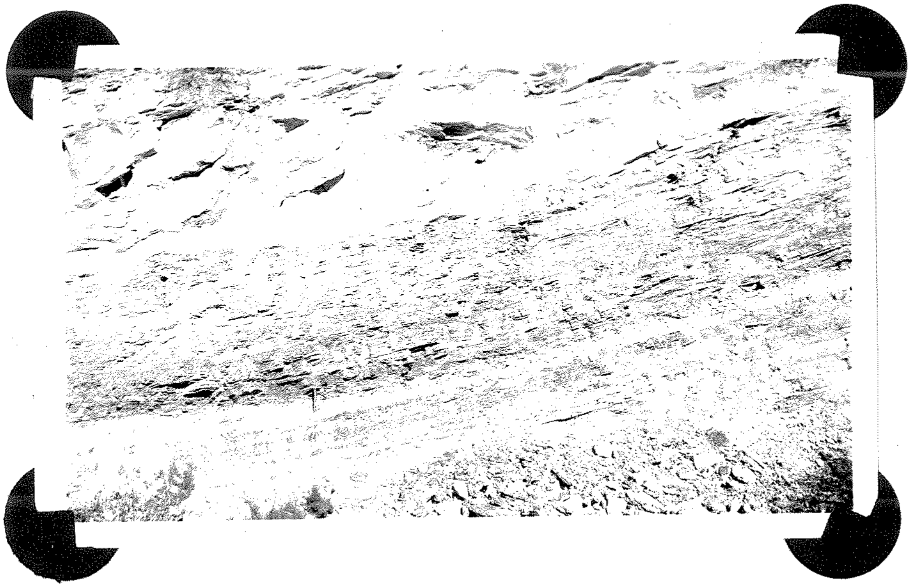
17 ton boulder washed 3 miles from base of mountains by recent cloudburst in La Crescenta.

old land surface a flood of boulders and debris was poured from mountains which had just been raised up. The material lying on the basement is a typical fan-glomerate consisting of sub-rounded boulders of all sizes mixed with shale and sand or arkose. Some of the boulders are twenty feet in diameter and indicate that the mountain source was relatively close. Boulders 1 to 5 feet in diameter are common and those between 6 and 12 inches are very numerous. The boulders are chiefly granitic or felsitic in character and show that the mass undergoing erosion was predominantly of this material. Some metamorphic s are present, chiefly gneisses, and basalt boulders are plentiful. These sediments commonly weather red due to the high iron content which is probably due to the biotite contained in them. The conglomerate does not uniformly cover all the basement complex, for in a few places, it is over lain by sandstone (arkosic) and arenaceous shale. The comglomerate also contains many sandstone and shale beds. The sandstone commonly contains biotite, quartz, and feldspar and averages one mm. in diameter, although there is much variation in size. The shales are buff colored and contain sand, and biotite. In the upper part of the section the conglomerate is often made up of pebbles averaging ¼ to ½ an inch in diameter, they are sub angular and so are more truly a breccia than a conglomerate. It is not uncommon to see isolated boulders 3-4 feet in diameter interbedded in this fine material, and this incongruous situation is found in a number of places. Since this mat rial represents a bajada origin, it can be explained by looking at these deposits forming at the present time. Recently, in La Crescenta a cloud-burst caused a 17 ton boulder to be carried three miles from the base of the mountains and deposited on the highway. In arid or semi-arid regions a sudden cloudburst often causes sheet floods which sweep all before them and carry along boulders many feet in diameter. This is probably what has occured here. This bajada deposit is not of uniform thickness, but has its maximum thickness near

Sunland where it is measured in terms of thousands of feet, near the end of La Tuna Canyon it is measured in terms of hundreds of feet. Evidently the mountain mass was to the east. This is confirmed by the marine deposits which offlap towards the east.

The sea began encroaching just after this, and from now on the sedimentation is dominantly marine, limy marls are found in some places and caliche is very common in the beds. In one of these limestone beds, just above the Barton School for boys, a sample was obtained made up of many foraminifera shells. These have not as yet been determined. Siltstones with fine lamellae are present. Shales are very abundant and are represented by fine paper shales, limy shales, arenaceous shales, diatomaceous shales and silicified shales. These shales are commonly white or grey in color. The sand stone beds are quite thick and vary from 1 to 10' in width. The bulk of these beds are arkosic and contain biotite. The grain size averages about a millimeter. It was in one of these beds that the ungulate rib was found. Just above Tujunga Wash, near the gravel pits, a sandstone was found which contained numerous pockets filled with what appears to be oil residue. This is quite typical of the Modelo which is an oil bearing formation.

One of the most characteristic things about these beds is the silicified shales and cherts which definitely mark them as Modelo. These cherts give a ringing sound when hit with the hammer and break with a conchoidal fracture. They weather brownish or red and break off in right-angled blocks, for the jointing is perpendicular to the bedding. These cherts are white to grey in color, and in some places flint is present which is black in color. The chert beds vary in thickness from 3 to 10 feet and are interbedded in sandstone and ordinary shale beds. The layers in these chert beds have a thickness of from ½ to 6" . In numerous places this chert forms only small lenses in the sandstone layers, measured in terms of



Modelo chert beds exposed in road cut.

View showing wedge of sediments dropped into basement-complex by Lunch fault. Lunch fault is cut off by cross fault.

tens of feet in length and only a foot or so in width. This is notably true in the extreme western part of the area where no continuous chert beds are found. The strange fact about these cherts is that the shales and sandstones above and below them are not silicified. The silicification stops abruptly within a 1/16 of an inch. Paper shales, fine siltstones, sandstones, and pebbled sandstones contact the cherts and, as we said, are not altered. These sandstones are arkosic in composition as are almost all of them in this area. Often there are small lenses of sandstone a few inches in length embedded in the cherts which have suffered no alteration. On the other hand, there are sometimes small chert lenses several feet in length and a few inches in width enclosed within a massive sandstone bed ten feet or more thick. These cherts in places are tremendously contorted and within a distance of a few feet the beds are often at right angles with each other. The beds of soft shale and sandstone between the chert layers often are gouged and brecciated, showing a large differential movement took place between the beds. Above the Barton School for boys the beds have been drag folded due to this differential movement, and show the syncline to lie to the east which is true.

The laminations are very fine and have a width of about 1 mm or even much less. These are marked by small sills of pure quartz or chalcedony. Many dikes of this siliceous material cut through the rock from all angles. These chert beds thicken and thin and occasionly lense out in a few inches which is unusual, for shale beds are more often continuous and lense out slowly. The small dikes and sills of silica running through these cherts would seem to indicate its authigenous nature, but one can not say too much on the origin of chert without a great deal of study. Davis[1] inclines to the belief that they are chemically precipetated by segragation

---

[1] Davis, E.F., The Radiolarium Cherts of the Franciscan Group, Publ. review, Calif. Dept. Geol. Sci. Bull. 11, pp. 235-432, 1918.

of the silica from a colloidal ooze of silica and shale, resulting in the rythmic banding, lensing in and out of the layers and formation of nodules. The type section for these cherts is at station 69 where a ten foot section is exposed for 100 yards along a road cut into a hill.

Higher up in the section soft buff or dun colored shales are found. They are splendidly exposed in a highway cut just west of Sunland. When fresh they are grey colored, but weather to a yellow-orange color. These beds are nearly vertical in this place, and the water running down the bedding plane has altered nearly all of them to this dun color. The consolidation of these shales is poor and their fissility ? facility allows them to be easily broken apart by the fingers. The clay soil which is derived from this shale supports a growth of grass, but is not conducive to the propagation of shrubs and bushes. None of these shales are pure, but contain varying amounts of biotite, quartz and feldspar. Sandstone interbeds are common and range from a few inches to several feet thick. This series of beds is highly incompetent;and , accordingly, where ever they outcrop, they are characteristically involved in drag folding, or otherwise are so distorted that a true attitude is not always easy to obtain. The distinctive character of these beds makes them admirably adapted to serve as marker beds for a key horizon. They are not local in occurance but are regional. For this reason they have been mapped as a key bed in the map accompanying this report and designated as K_1.

These beds are overlain by a conglomerate of which the pebbles are from 1/8 to 1/4 and occasionally 3 inches in diameter. The change from marine deposition to continental is abrupt, but probably represents only a diastem, and not a regional discontinuity of deposition. These continental sediments are characterized by alternating beds of sandstones, conglomerates, and shales, although the shale beds are in the minority. Lenses of conglomerate 15 to 20 feet long and a few feet wide are exposed in the section perpendicular to the strike and would seem to be old stream channels which have been preserved. A few chert nodules are present in these sediments, as well as many concretions which are marked by an encrusting mass of red sandstone, and through which the stratification passes. Many of the conglomerate beds contain boulders averaging about 10 inches in diameter, although at intervals a boulder up to 5 feet in diameter is found. Higher up, ~~in the~~ sandstones become predominant and then shales;, finally, diatomaceous shales are found. These are pure white, fragile and quite fissile. A break in deposition occurs here, and a coarse marine conglomerate of Pico Age is lain over them. It is a disconformity, however, and not an angular unconformity.

Only the lower portion of the Pico Formation is represented in the Verdugo Mountains, although, north of Tujunga Wash, almost the whole thickness of the formation is exposed. The Saugus Formation is also found on the other side of the wash. As far as the stratigraphical record is concerned, this stops with the lower part of the Pico in this area, with the exception of recent alluvial deposits which can be classified into two classes, i.e.- old alluvium and recent alluvium. The old alluvial is preserved in the form of terraces and remnants of earlier deposits of fan-glomerate or bajada breccias are being formed together with considerable thickness of river gravels. In Tujunga Wash the gravel, as exposed in gravel pits, is 60 feet or more deep. The major stream of this region appear to be at grade and are dropping their transported material at the mouths of the canyons and even are filling upp the lower parts of their canyons with stream debris.

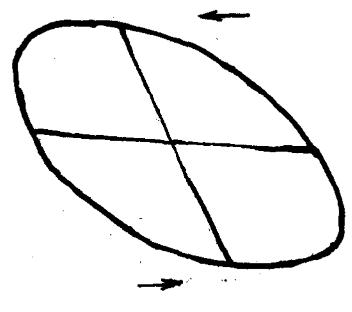
Structure.

Regional:

The structure of the Verdugo Mountains, as has already been indicated under geomorphology, *is* a horst bounded on the south by reverse faults and bounded on the north by normal faults. It is not a single fault block, but is cut into slices on the north and south and is further divided into blocks by normal faulting. This composite block has its maximum relief to the east, adjacent to Verdugo Canyon, and to the west it passes under alluvium, and can be traced only by some low knolls projecting up like islands in a sea of river gravels. Structually, it is a part of the San Gabriel Range and is only a fault slice which has been brought up to the south of the main fault zone of the mountain range. The San Rafael Hills are also structually a part of the Verdugo Mountains, and are separated from the latter only by Verdugo Canyon [illegible]

The sediments on the west end are involved in a series of small folds which, however, are merely flexures on the south limb of an overturned syncline which has its axis north of Tujunga Wash. South-west of Sunland a large wedge of these sediments has been down-dropped into the basement complex.

At the end of the Pliocene time a great crustal deformation took place which folded up the sediments and raised these mountains on high angle thrust faults dipping, on the average, about 60° to the S.W. The compressive forces came from a general N.E.-S.W. direction. Since the easiest relief was upward the strain ellipsoid should be oriented with its long axis up and dipping to the north about 45°, as illustrated.



The reason why the strain ellipsoid is oriented in this position is that shearing forces were active, and not purely compressive forces. The fact that the Merrick syncline is overturned to the south, that is, its axial plane dips north, tends to show that shearing forces were present, further the major faults dip 60° to the north which is a very steep dip for a thrust fault. If the strain ellipsoid was oriented in a vertical position, the thrust planes should dip north at less than 45° angles, since the rock fails as a a brittle body. But it was found that the major fault dipped 60° N, and that numerous minor faults had dips 15° N and even horizontal. The axis of mean strain would be NW-SE and the axis of least strain would be dipping S and the axis of the greatest strain would be dipping N.

After the compressive forces relaxed, gravitation acted on the block, which responded by adjusting itself along normal faults. In this case the strain ellipsoid would have its axis of greatest strain NE-SW, its axis of mean strain NW-SE, and its axis of least strain, vertical.

Local:

Jurassic Cretaceous (?) Intrusion.

The oldest sediments in the area have been intruded many times. The earliest intrusion was the Wilson diorite which subsequently assumed a gneissic texture. Later, it was intruded in turn by granodiorite and quartz monzonite. These latter intrusions were probably coincident with the Sierra Nevada Revolution during which time huge granodiorite batholiths invaded the earth's crust all up and down the Pacific Coast. This intrusion began in Jurassic time and was finished before the end of Cretaceous time, because Chico or upper Cretaceous sediments are unmetamorphosed. These mountains seem to have been a positive block during all Cretaceous and Tertiary time for no Cretaceous or Tertiary sediments seem to have ever been deposited over the site of the mountains, that is speaking of the western part of the San Gabriel Range as a whole. The western end of the Verdugo block, at least, was covered with Miocene sediments, for on top of the ridge, bordering the lower part of La Tuna Canyon on the north, there are some remnants of sediments. Again, at station 129 on a ridge above the end of the highways in La Tuna Canyon there are some lava boulders, although these may have been transported there by stream action.

Faulting in General:

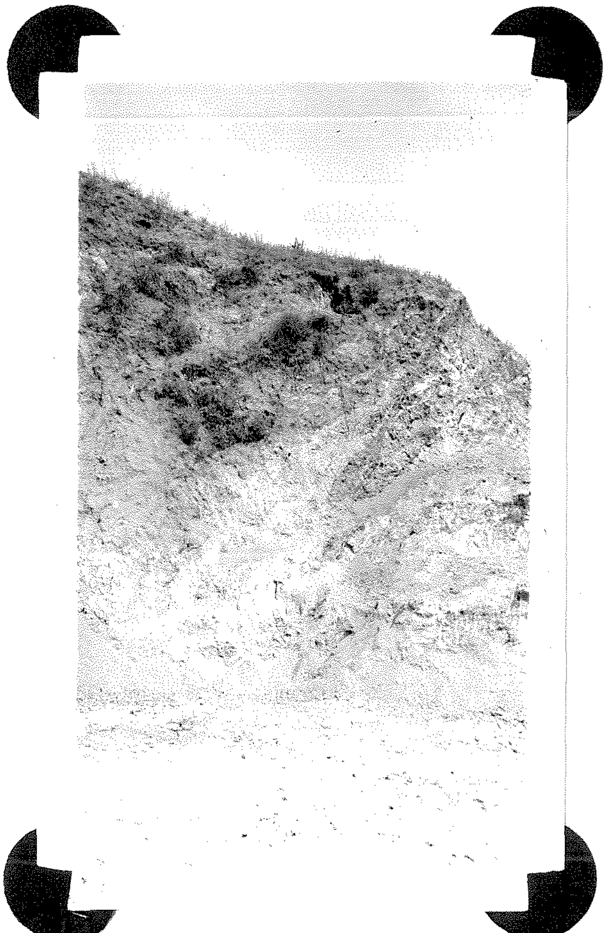
The crustal deformation which has taken place in this region is one predominantly characterized by faulting. The mountains in and near the area are fault block mountains. There seem to have been two distinct periods of faulting. First there was a period of compression during which period the mountains were raised up along high angle reverse faults which bound the front of the San Gabriel Range. After the compressive force had run its course, the crust of the earth relaxed; and, in doing so, adjustments took place which resulted in the down-dropping of blocks along normal faults. As C.R.Longwell pointed out in a lecture made here last year, it is always dangerous to make generalization of this sort; for perhaps the reverse and normal faulting belong both to the same period of time. The fact that the normal faults are expressed topographically would, however, prove that the normal faulting was not prior to the reverse faulting, and would point to the fact that they really are later. Further, the reverse faults are off set in a few places where they are crossed by normal faults.

The numerous roads in these mountains made it possible to pick up

Branch faults curving up to meet the main fault in Burbank fault zone.

Looking south at main fault in Burbank fault zone. Zone of gouge and brecciation is about 40 feet wide.

Large brecciated zone through which one of the large faults in the Burbank fault zone passes. View is looking east.



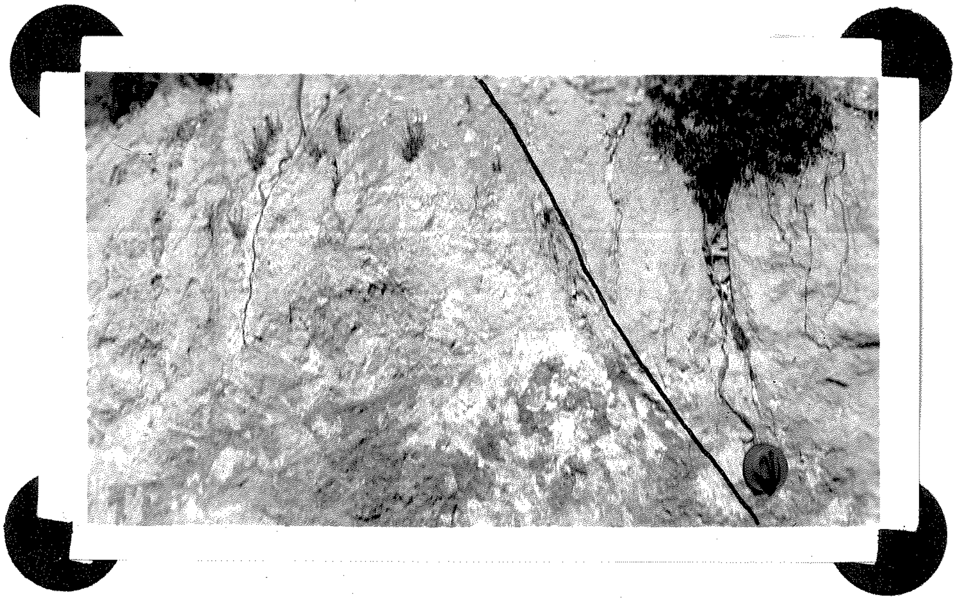
Looking east at one of faults in Burbank fault zone which is exposed in road cut above Rossmoye.

many of these faults in road cuts. The other criteria used to recognize faults was; occurrance of adjacent blocks of large size and of similar rock characters and structure at different elevations, especially if one or both of these blocks has a uniform relief; fault breccia, gouge, and crush zones usually seen cutting across ridges or walls of canyons; long straight canyons, often opposed to the general drainage system; fault gaps and similar phenomena; and the juxtaposition of two dissimilar kinds of rock. The large faults in the area, both reverse and normal, are high angle faults and seldom have a dip lower than 60° or at the least 55°. Some of the branch faults , of course, have a lower dip. The branch faults of the reverse faults often are horizontal, and as they approach the main fault they curve up to meet it as shown in the photograph. This gives them much the appearance of the thrust fault as it is conceived by Willis in his fault range hypothesis. The main faults in this area are not simple fractures, but are rather zones. These faults are distributive in nature and divide up the zone of shear into a number of slices. Branch faults are common, which leave the main faults and go off into the block. It is not uncommon to see faults with zones of breccia and gouge ten feet wide.

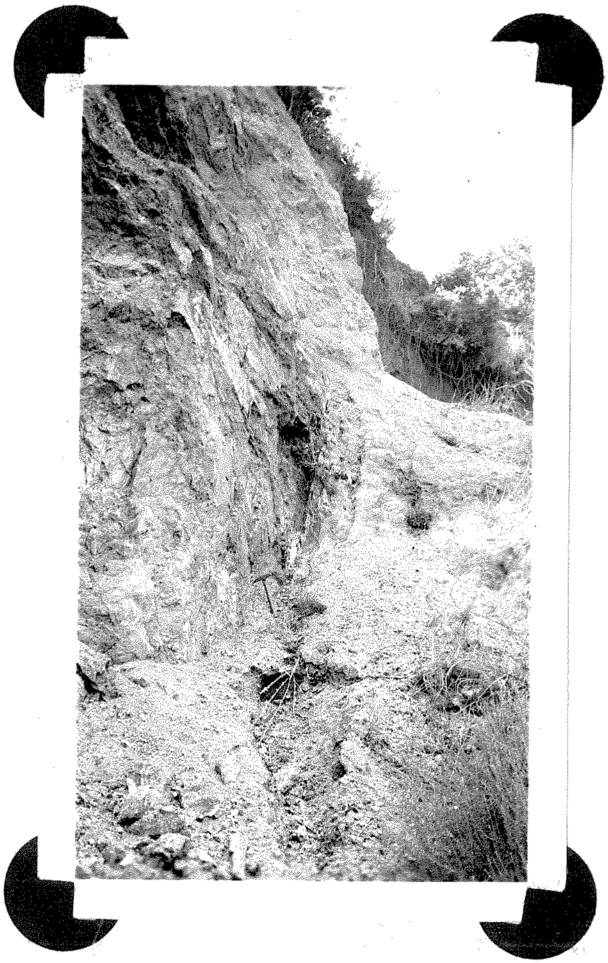
Burbank Fault:

The fault scarp in back of Glendale and Burbank is very striking, from practically a level plain the Verdugo Mountains rise up to over 3000 feet. W.J. Miller[1] claims that the Verdugo Fault is a normal one, because in one place he found some alluvium down-dropped against the igneous rock on a normal fault. In the field work done in connection with report, a number of reverse faults were mapped which cut across the face of this scarp, and in no place was a normal fault observed other than the Park fault.

[1] Miller, W.J., Geology of the Southwestern San Gabriel Mountains, Publ. Univ. Calif. at L.A. in Math. and Phys. Sci. vol. 114 pp. 1934.



Looking west at Montrose fault zone exposed in road cut showing about a 6 foot zone of brecciation.



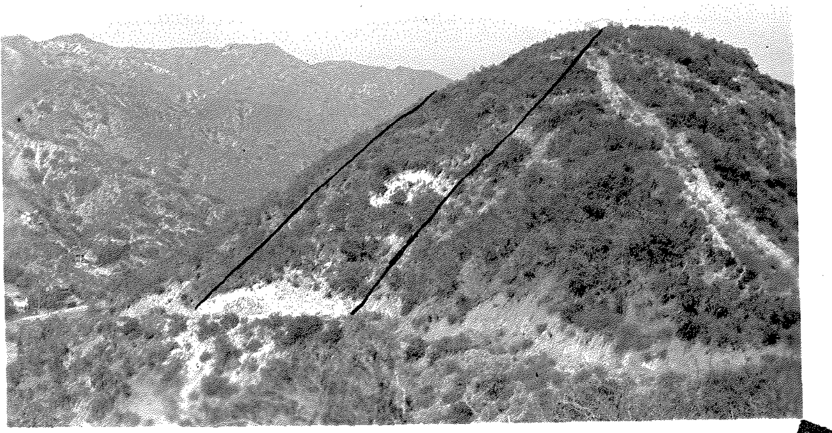
Looking west at one of faults in Montrose fault zone exposed at graphite mine. Graphite can be seen on slickensides where it was dragged down.

The average dip of these faults is about 60° N., except in a few places where faults were observed with a 45° dip. The main fault shown in the photograph has a zone of breccia and gouge about 40 feet wide and a dip of 57° N. The type section for this fault is at station 130 where the picture was taken. The general trend of this fault is about N 65° E. The dominant movement was dip-slip with the older rocks moving up over the younger. On the upthrown side of the block many small branch faults curve out away from the fault to lie in an almost horizontal position. This is probably due to the thrusting action which has taken place. The displacement is not known, since it is not known how much of the movement may have taken place along parallel faults. Undoubtedly the largest part of the movement took place on this fault in ~~lieu of~~ [illegible] its great zone of gouge and brecciation.

Montrose Fault:

There is a question here of whether this fault is due to compression or tension. It dips north and is parallel to the reverse faults which bound the south side of the block; but since the Montrose Valley block is downdropped with respect to the Verdugo block, the Montrose fault must be characterized as a normal dip-slip fault. If, during the period of compression, the Verdugo block was faulted upward at a rate greater than the Montrose Valley block, then the Montrose fault would be due to compression, by reason of the differential movement between the Verdugo and Montrose Valley blocks which allowed the Verdugo block to go up faster. This hypothesis is rather hard to visualize, and the more plausible explanation would seem to be that the Montrose Valley block is a keystone block which was downdropped with respect to the Verdugo Mountains. In the latter case the Montrose fault would be a normal fault and of the same age as La Tuna and Park Canyon Faults. This fault seems to be in line with the La Tuna fault and was joined to it although it may not do so. This fault was also projected down Verdugo Canyon, because no place else was

La Tuna Fault truncated by alluvial deposit in upper part of La Tuna Canyon



La Tuna Fault Zone shown crossing the ridge.

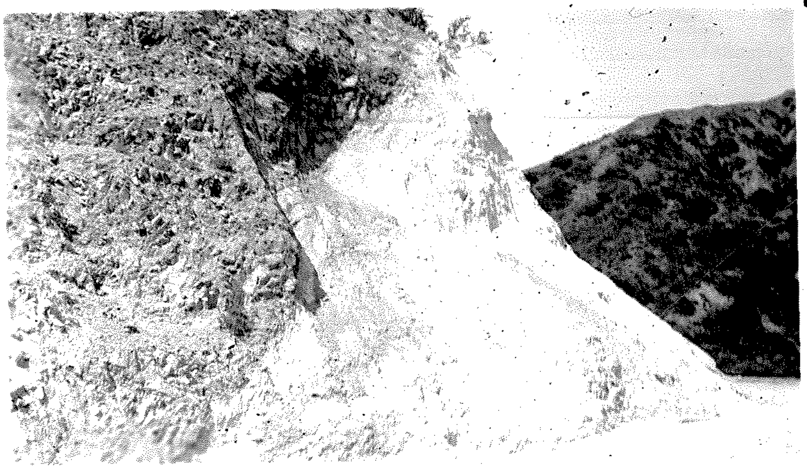
found to put it. There is no sign that it crosses into the San Rafael Hills, and there is no fault mapped there with which to connect it. It certainly does not stop abruptly. In one place this fault cuts across a graphite schist, and the graphite has been dragged down into the fault plane. Some parallel faults can be recognized by the fact that they have dragged down graphite into their fault plane, which is easily recognized where the fault outcrops. This fault varies in dip, at the graphite mine it dips about 80 north while at the Verdugo Woods real-estate tract it dips 50 N. The type section is at station 131 in the Verdugo Woods real-estate sub-division. The displacement can not be made out, other than that the total throw of all the distributive faults is equal to the height of the scarp minus the subsequent erosion.

La Tuna Fault:

This fault runs straight down La Tuna Canyon, and has down dropped the western block 1100 feet with respect to the main Verdugo block. It is dominantly a dip-slip fault and is normal. Its dip varies from 70 to 80 on the average. In the upper part of La Tuna Canyon this fault is truncated by an alluvial deposit which has since been dissected about 10 feet by streams. This shows that there has been no recent movement on the fault, and that, since it is one of the youngest faults in the area, no recent faulting has taken place anywhere in the Verdugo block. Its type-section is at station 132 where it is exposed in a road cut.

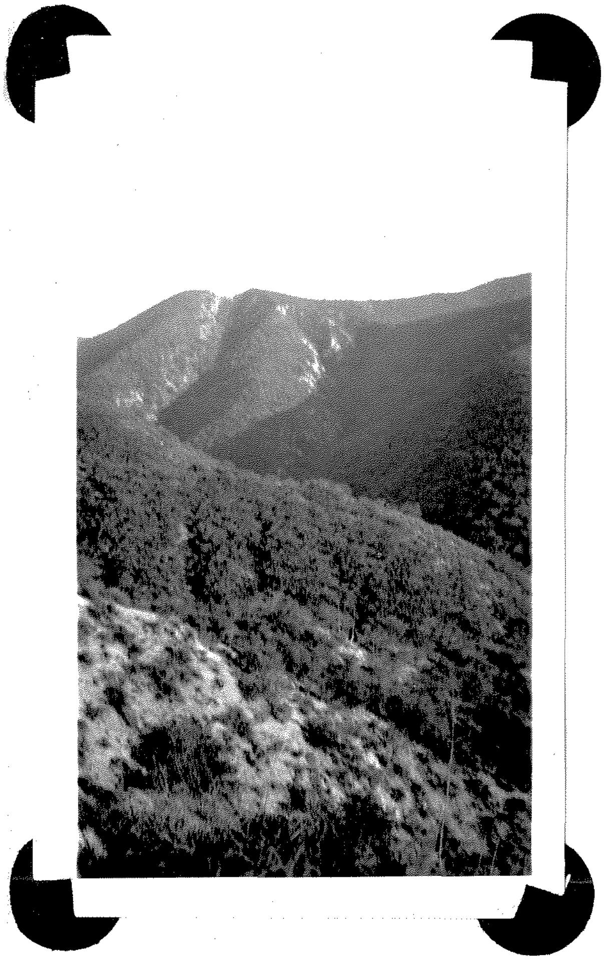
Park Canyon Fault:

This fault is also a normal fault and has downdropped the block, bounded by La Tuna and Park Canyons and the Verdugo fault, about 1000 feet with respect to the Verdugo block. This fault dips about 60 to the west and is dip-slip. This fault is easily traced by means of fault-gaps in which gouge can be picked up from the surface of the ground. In a road-cut near by the fault plane of a small parallel fault has been ex-

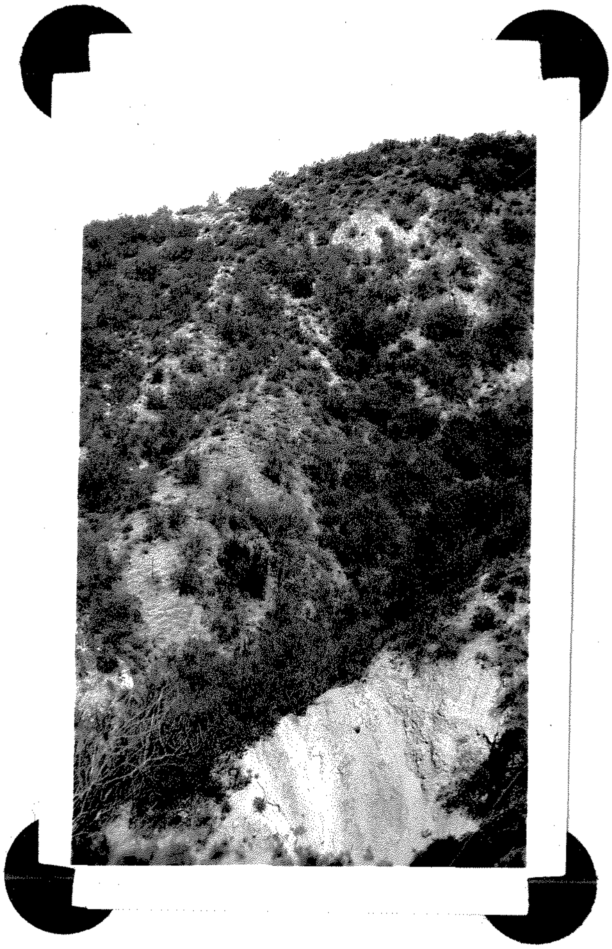


Park Canyon fault shown dipping south. Notice weathered rock dragged down against fresh rock.

Fault exposed by road cut can be traced across road by cracks in earth. Due to rumbling of trucks south side (right) has sunk 2".



View showing fault gap made by Lunch fault as it crosses ridge.



Fault zone of Lunch fault exposed at bottom of canyon.

posed. Where this fault crosses the road a crack has been opened up, and due to the rumbling of trucks the west side has dropped about $2\frac{1}{2}$ inches. It is interesting in that it shows the low resistance offered by a fault to stress. The type section of the Park Canyon fault is at station 133 which is shown in the photograph where very weathered rock is shown downdropped against fresh rock brought up from the basement.

Lunch Canyon Fault:

This fault has downdropped a large wedge of sediments into the igneous rock, and so it is easily traced. Its zone of breccia is 30 feet wide; and, for this reason, where it crosses a high ridge, a splendid example of a fault gap has been made which has a trenched valley on each side of it. At this fault gap the sediments do not come all the way to the fault gap, but detour around it. What has happened is that the fault branches here, one branch going through the gap and the other branch circling around. The result is that a large wedge of igneous rock has been dropped down in the fault plane to form a horse.

The measured dip on this fault in Oak Canyon was 65° NE which is the average dip. The displacement along this fault has been some 2000 feet as near as can be figured, and as the dip is to the north, it is a reverse fault. If it were not for this fact, it may have possibly been considered t the western extension of the Park Canyon Fault which, however, is normal. The Lunch Canyon fault is cut off by a small normal fault which shows the normal faulting to be more recent in point of view of time. The fault cannot be traced from its displacement, for it seems it seems to have dissapeared. The type locality of the Lunch Fault is at station 114.

Barton Fault:

This fault would seem to be an extension of the Lunch Canyon fault were it not for the fact that Lunch Fault is a reverse fault which dips about 60-75° to the north, and the Barton fault- although the fault plane is not exposed, yet by the way it crosses a ridge,- is a normal fault which dips perhaps 60° to the west. If a steep normal fault could change into a steep reverse fault within the space of a mile, then I would say that the Barton fault is an extension of the Lunch Fault, and that the fault up the ridge south of Lunch Canyon was a branch fault. It is certainly strange that a big fault like Lunch fault should disappear all of a sudden. Incidentally, the Barton fault dropped the chert beds down into the sandstone and shale beds lying on the basal conglomerate. This fault could not be reverse for the shales next to the fault plane at the foot of Lunch Canyon abut into the conglomerate beds which lie directly on the basement complex. There is no place below from which these shales could have come.

up,

Sediments:

As has already been said, the sediments are involved in a series of small folds which are not continuous but only a mile more or less in length. They are purely local in character and are flexures of the south limb of a large syncline which has its axis north of Tujunga Wash. The folding is more acute to the east where dips vary from 60° to 50°, in contrast with the western end of the area where the dips vary from 15° to 25°. This may be due to the fact that the thickness of the sediments is greater in the west than in the east, and hence are not as closely folded. This syncline, according to Hill, plunges to the north west, and this is another reason why the dips should tend to flatten toward the west.

There are large thicknesses of sediments in the western end of the block which are not represented in the section adjacent to Sunland at all. This

Hill, M.L., Structure of the San Gabriel Mountains north of Los Angeles California, Univ. Calif. Publ. Bull. Vol. 19, pp. 137-163, 1929-1931.

is probably due to the fact that the Miocene sea covered the west end of the area for a much longer period of time than it did the latter part near Sunland. That this is so may be seen from the fact that the marine sediments near the mouth of La Tuna Canyon are about 2000 feet thick while they are only around 600 feet thick near Sunland. The sea must have reached its maximum extent near here for no marine sediments have ever been found east of Sunland. The off-lap of the sedimentation is shown in the highway cut, just before Michigan Boulevard crosses Tujunga Wash, where conglomerates are laid down over a marine shale.

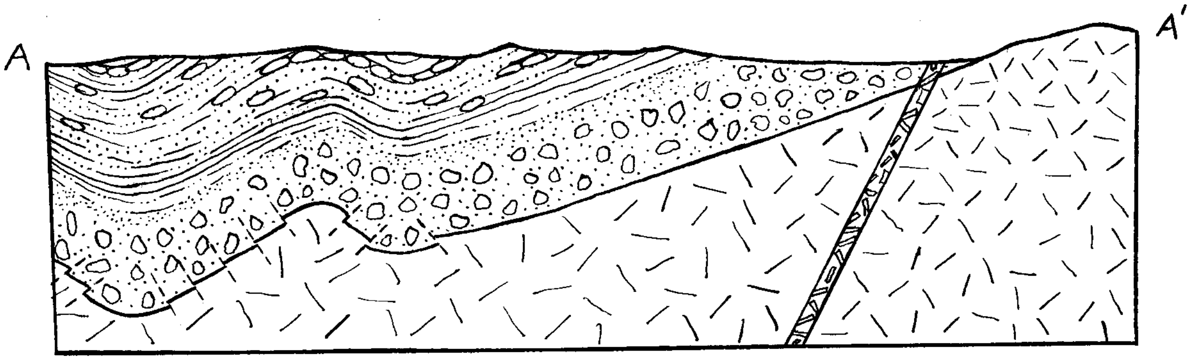
Above Sunland a basalt flow lies partly on the basement, and partly on a conglomerate. The lava is conformable to the sediments, and must be a flow; for it is hard to see how a sill could be injected into a fan-conglomerate. What must have happened is that the igneous mass was undergoing erosion and shedding its debris on an alluvial fan. The basalt was poured out on the igneous rock and flowed down over the fan-conglomerate, thus overlapping both. That the alluvial fan was of good size is attested by the fact that the basalt overlies some 1000 feet of these sediments at the western extension of the flow.

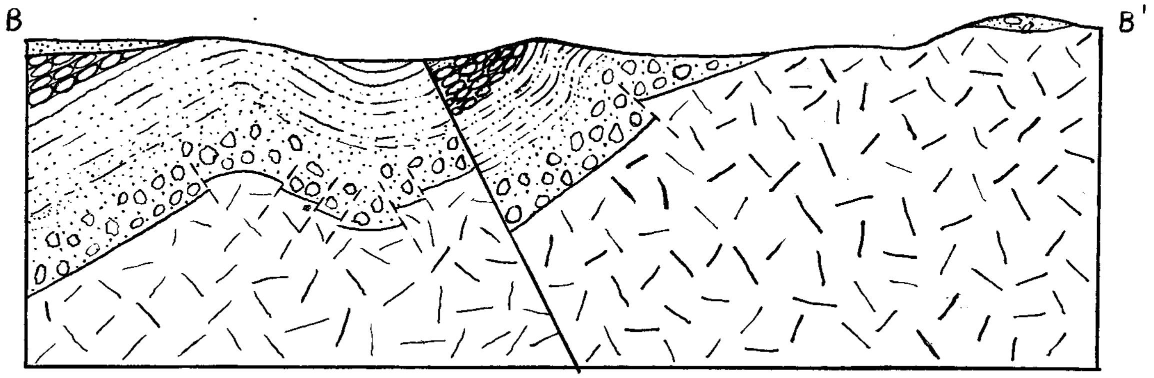
Near the highway cut west of Sunland the Pico contacts the Modelo; however, a fault has dropped down the contact, and, as a result, the contact is duplicated. If one maps the true contact around the hill with the water tower on it, it can be followed down into Tujunga Wash on the right side of a small canyon without a break. Across the canyon is a knoll which overlooks the highway cut, and on this knoll the Pico-Modelo contact can be picked up again. Stratigraphically this contact is about 150 feet below the upper contact, and encircles this small knoll above the highway. On both sides of the knoll the contact has been eroded away and so a fragment of the Pico is left surrounded by the Modelo formation.

Historical Geology.

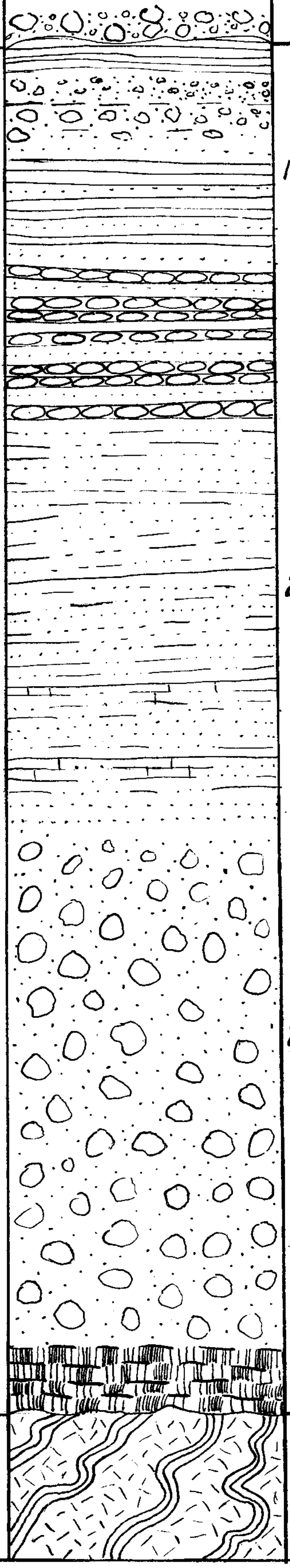
In Paleozoic or Pre-Cambrian time an organic movement took place which shed a large amount of sediments into the sea, which was nearby, for these were marine sediments and not continental. Later these sediments were folded up into mountains and intruded by a diorite batholith. Until Jurassic time this is the only record of the previous history of this area. How many thousands of feet of sediments were laid down and stripped off no one will ever know. In Jurassic time, however, a great batholith of granodiorite intruded this region, and injected itself into these old sediments, later on a large body of quartz monzonite injected itself into this locality The mountains produced at this time were planed off, but, it was not until Miocene time that any sediments were laid down to be preserved until the present day. Pre-Modelo, an orogenic movement took place which was responsible for the pouring forth of a huge mass of sediments. It is likely that the mountain building took place by faulting; for very early in its history, before much accumulation of sediments had taken place, a series of basaltic extrusions took place which covered a large part of this region with basaltic lava. Fan-glomerates then covered up the basalt flows, and about this time the Miocene sea began to indundate the area. A thick series of marine sandstones, shales and a few limestones were laid down. The shore was never very far away for sands formed the most prominent part of the deposition. The arkosic nature of this sandstone as well as the composition of the basal conglomerate indicates that the mass undergoing erosion was granitic in character. Toward the end of Miocene time a series of grey muds and sandstones was laid down. Then the sea receded and continental deposition laid down a cover of conglomerate and sandstones. The sea flowed in again and a thin series of diatomaceous shale was deposited. This is the last record left by the Miocene sea in this area. In the beginning of Pliocene

Time another mountain making movement took place, the sea again flowed in, and a thick series of marine conglomerates was laid down. This is the last record of Pliocene deposition in the Verdugo Mountains. In early quarternary time powerful compressive forces were set up from a general NE-SW direction which took the form of shearing. The sediments were folded, and the folds were overturned to the south west as a result of this shearing; reverse faults were responsible for lifting up a magnificent mountain range. After these shearing forces had spent themselves, gravity reasserted its sway and the earth's crust relaxing from the compression it had just been subjected to, readjusted itself. This adjustment was effected in many cases by movement on normal faults. The fault blocks were dissected by streams and large alluvial fans were built up. Due to a change in climate or to a regional uplift these alluvial fans were dissected and carried away except for small relics inside the mouths of canyons. At the present time the streams seem to be again at grade. This completes the geological history of the Verdugo Mountains up to the present time.





- ▨ Chert
- ☰ Shale
- ⁘ Sandstone
- ⁂ Conglomerate
- ▧ Basement-complex cut by porphyritic basalt dike.

Formation	Symbol	Columnar Section	Thickness	Character and Distribution
Pico Formation	Pc		—	Marine Congl.
Modelo Formation	Md		1000' ±	Diatomaceous sh. Continental deposits of flood plain deposits. Mainly congl. and ss. Incompetent sh. and interbedded ss. sh. are arenaceous and fisile.
			750' ±	Cherts with interbedded ss. and sh. In many places cherts form only small lenses in massive ss. beds.
			2000'-	Marine series of ss. sh. and some ls. in varying proportions of each other.
			2500'-	Fan-glomerate. Also has basalt flow intercalated in it in part. Contains interbedded ss. and sh.
			200' ±	Basalt occurring both as flow and dyke. Interbedded in sed. sometimes.
Basement Complex	Bc			Crystalline Rocks. Para-ortho and injection gneisses and schists. Limestones. Granitic, pegmatitic, aplitic and basic dikes.