GEOLOGY OF A PORTION OF THE SANTA MONICA MOUNTAINS

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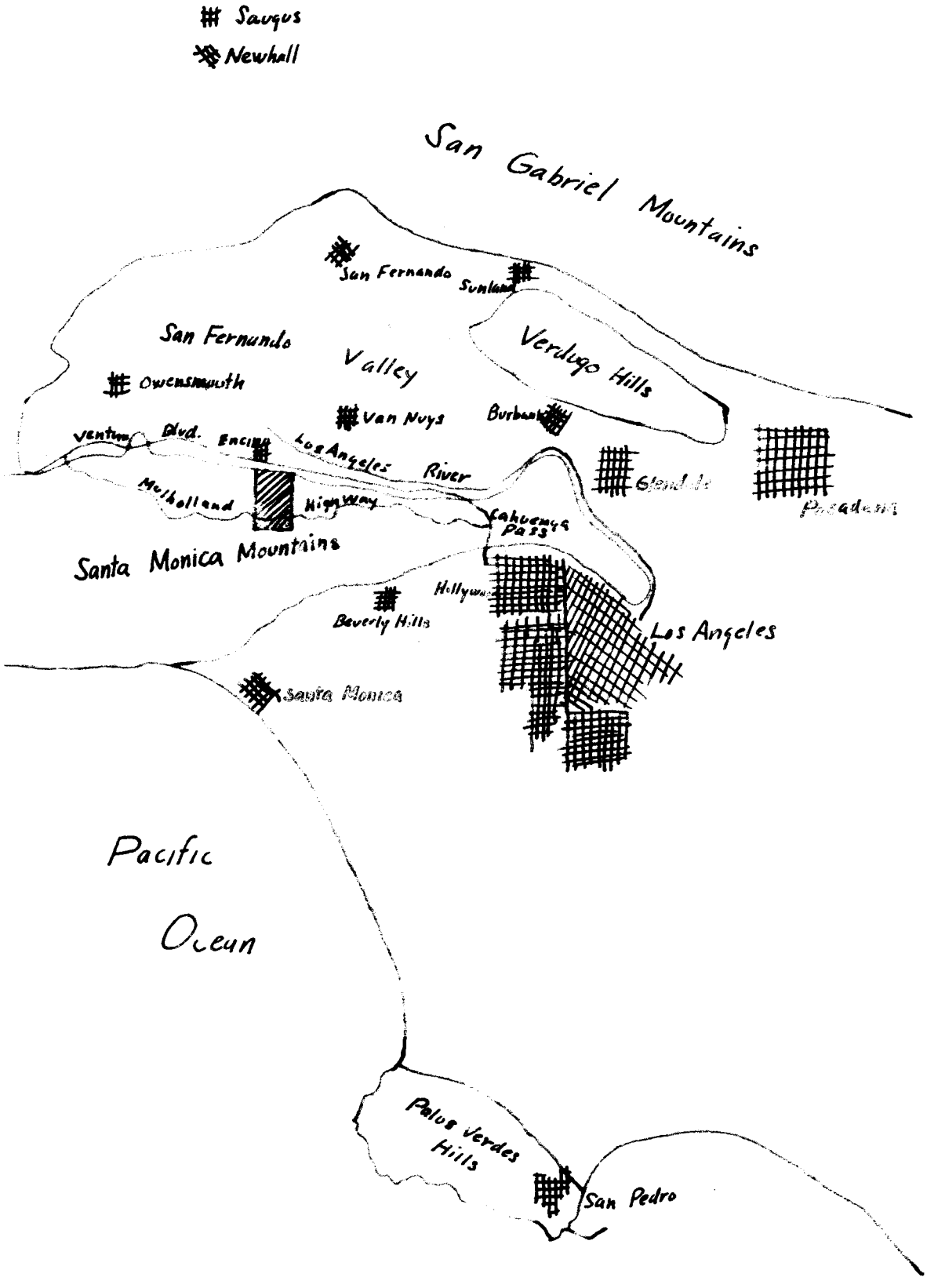


Rough sketch map of Southern California showing the location of the area of this report.

INTRODUCTION

The area discussed in this report lies on the north side of the Santa Monica Mountains, bordering on the San Fernando Valley. It includes the region around the Encino Country Club and Encino Reservoir, and extends from Ventura Boulevard on the North to a short distance south of Mulholland Highway. The accompanying sketch map shows the location of the area, and its relation to the major features of Southern California. It is easily accessible from Los Angeles or Pasadena by Ventura Boulevard or Mulholland Highway.

Very excellent Los Angeles County maps (2,000 feet to the the inch, 25 ft. C.I.) are available for the region, in the form of the U.S.G.S. Van Nuys and Reseda quadrangles. Fairchild Aerial Surveys of Los Angeles have also made a mosaic aerial map of this locality and the remainder of the Santa Monica Mountains. The mapping for this report was done entirely on the aerial map, which proved highly satisfactory, allowing contacts and other features to be located very accurately. The scale used was 1500 feet to the inch.

Mapping was made difficult by several features. Most of the region is covered by very heavy brush, which is all but impassable. Accurate mapping is very slow and laborious. In the valley north of the Encino Country Club, contacts and exposures are largely covered by alluvium, making exact mapping impossible. Also this fact coupled with the similarity in lithology between parts of the Modelo and Topanga formations makes it difficult to find the Modelo-Topanga contact. One helpful feature is that the Modelo is usually free from brush

and covered by grass, which greatly facilitates mapping. An attempt was made to map a small area accurately rather than a larger one roughly. Hence the map represents only an area about three miles square, and of this the mapping west of the the eastern border of the Encino Reservoir ~~is~~ by Holzman. Also the mapping of the Modelo-Topanga contact was done jointly with Holzman.

Part of this area was included in Kew's report, U.S.G.S. Bul. 753. Also the area is included in Hoot's report on the Santa Monica Mountains, now in press as a U.S.G.S. bulletin. The mapping of this report seems to agree in larger details with that of Hoots, but differs slightly from that of Kew as brought out later. This area overlaps in part that covered in Scharf's Senior Thesis. The area to the west has been mapped by Holzman, and that south by Crossman.

SUMMARY

This region was selected for study because it gives a gives a good idea of the geology and structure of the Santa Monica Mountains, and also a certain amount of familiarity with two important Tertiary formations of Southern California, namely the Topanga and the Modelo. Although the structure and geology are fairly simple, they involve the relation of folding and faulting, and throw some light on the geologic history of Southern California.

PHYSIOGRAPHY

The Santa Monica Mountains consists essentially of an anticline, striking east and west and plunging eastward. Hence they are about nine miles wide at Santa Monica and pinch out to about two miles width at Hollywood. Also the maximum elevation at the western part is about 2000 feet, while it is only 1500 feet in the eastern part. The crest of the ridge corresponds roughly to the crest of the anticline. Also the tops of the ridges are at corresponding elevations as though they represent the remnants of an old erosion surface. This surface would necessarily be pre-uplift, that is Upper Pliocene or Lower Pleistocene probably.

The region is of moderate relief and in the stage of late youth in the erosional cycle. The San Fernando Valley to the north is at about 700 feet elevation, the crest of the mountains from 1500 to 2000 feet , and the plain to the south at about 500 feet at the base of the mountains. The streams are all of the consequent type, running about north and south, and are as a rule straight and short. Except during the rainy season, there is no water in them. There is one unusual feature, namely that the drainage divide does not correspond to the crest oof the range. The Mulholland Highway, about one or two miles north of the central axis and crest, marks quite accurately the boundary between the drainage of the streams to the north and to the south.. This discordance is probably partly due to the fact that the streams flowing south have a greater gradient since they flow to sea level, while those flowing north empty into the San Fernando Valley at about 700 feet elevation.

The streams flowing south have cut deep canyons while t hose flowing north have cut relatively shallow valleys. Another interesting fact is that the Los Angeles River, instead of flowing down the center of the San Fernando Valley, has been pushed south against the Santa Monica Mountains by the alluvium washed down from the high San Gabriels to the north. The streams on the north side of the Santa Monica Mountains have been unable to deposit alluvium rapidly enough to keep the river out in the Valley.

The Physiography is not greatly effcted by the structure or distribution of rocks. The fault between the Modelo and the slates is usually marked by a valley, due to the differences in hardness of the rocks. However major valleys cross the fault without regard to its direction. The Modelo usually gives more rounded topography than the other rocks, due to its softness.

STRATIGRAPHY AND LITHOLOGY

The stratigraphic column in the region studied is quite simple, consisting of only three formations, The oldest one forms the core of the anticline in this part of the mountains, and consists mainly of slates and other rocks, probably of Pre-Jurassic age. The exact age is unknown. Farther to the west, these rocks are overlain by Chico beds of upper Cretaceous age. However they are intruded in places by granites, thought to be of Jurassic age. Hence they are probably Pre-Jurassic. They consist mainly of dark-gray, finegrained, fairly hard rocks, intermediate in characters between fine grained sediments and slates. There has been a little recrystalliztion of minerals,

but the typical slaty cleavage has not been developed to any great degree. The rocks are traversed by numerous joint planes, but do not cleave like slates. They are evidently derived by partial metamorhism of finegrained sediments. They weather red and give very characteristic exposures. The bedding is difficult to make out on account of the many joints, and can best be observed on a large scale from a distance. Besides the slates, there are lenses of sandstone, local intrusions of granitic rock, and quartz veins.

The slates are unconformably overlain by the middle Miocene Topanga formation. This unconformity represents quite a gap, since all formations from the Chico to lower Miocene are missing. Farther west in the Santa Monica mountains, Chico, Eocene, and Sespe beds are found, but here they have been removed by erosion if they were ever present. The bedding in both the slates and the Topanga is so obscure that it is impossible to tell exactly how great the angular discordance is between them, but from what field evidence that is available, the discordance does not seem to be more than ten to twenty degrees, if that much. The formation consists mainly of coarse sandstones and conglomerates, with irregular pockets of intrusive and extrusive rocks. The sandstones are massive, medium to coarse grained with some larger pebbles and boulders included, composed mainly of subangular quartz grains and feldspar(weathered to kaolin),with enough limonite to give the rock a brown color. The exposures are brown or reddish brown, and usually show no bedding.

In the vicinity of Encino Reservoir, the rocks consist mainly of very coarse conglomerates, with sub-angular to rounded

boulders of gneiss, schist, granite, and quartzite, from one to six inches in diameter. The material is poorly sorted and shows very little bedding.

Included in these sedimentary rocks are irregular bodies of igneous rocks, partly intrusive and partly extrusive. The rocks are fine grained, and under hand lens examination can not be determined exactly, but seem to range from trachytes to andesites and basalts. There is no quartz phenocrysts present, but numerous crystals of feldspar. The irregularity of the contacts seem to indicate intrusive origin. Also the sandstones around these pockets are often ~~bredde~~ brecciated and highly silicified for some distance from the contact. On the other hand these rocks are very fine grained and must have cooled very quickly. Also associated with them are vesicular lavas and tuffs, indicative of extrusion. Undoubtedly both types of phenomona took place.

The Topanga formation is probably largely of marine origin, but probably represents at least in part a near shore stage, as indicated by the coarse conglomerates. However the medium grained massive sandstones probably represent a somewhat deeper water phase. The source of materials is problematical. It seems to have been a mountain mass of granitic and metamorhic rocks. The distribution of Topanga beds in the Santa Monica Mountains seems to indicate that this source was to the west or to the north-west.

In this area, the Topanga is an isolated patch. Kew mapped it as Vaqueros, but Hoots considered it to be Topanga. This latter view is confirmed by fossils found in the basal

Topanga, about 75 feet above the slate contact. The fossils were in medium grained sandstone, and badly preserved. Many could not be identified, but the following were identified by Mr. Popenoe and myself by comparison with Maitland's collection from the Topanga farther to the west:

Turritella ocoyana Conrad
Neverita cf. recluziana Petit
Cardium (Trachycardium) cf. Vaquerosensis Arnold

These indicate middle Miocene age.

The Topanga formation in this locality is about 1800 feet thick, as nearly as could be judged.

Lying unconformably above the Topanga formation is the Modelo formation. In many places it overlaps the Topanga and lies directly on the slates. The unconformity represents an erosional interval with uplift of the slates and Topanga, but the angular discordance between the Modelo and Topanga does not seem to be very great as far as can be determined.

The Modelo consists mainly of well laminated silicious, diatomaceous, and sandy shales, interbedded with finegrained sandstones of varying thicknesses, from several inches up to some feet. The bedding is very regular and consistant, and the exposures are very characteristic. They are usually light yellowish brown in color.

Where the Modelo lies directly on the slates, it is characterized by a distinctive basal member. This member consists of a massive bed of bluish-gray, coarse to medium grained sandstone, composed of material derived from the weathering of the slates. It is about 35 to 50 feet thick, is very consistent, and is a

great aid in mapping the contact.

Where the Modelo lies on the Topanga, this basal member is missing, and the series starts immediately with shales and fine grained sandstones. However, about 150 feet above the contact is a layer of very coarse conglomerates, quite similar to the Topanga, and easily confused with it. This layer is of variable thickness, from 50 feet up to several hundred, but above it again are shales and sandstones.

The upper part of the Modelo section is characterized by thick massive beds of fine-grained sandstones, interbedded with shales. Kew mapped this as Pico, while Hoots divided it as upper Modelo. In this report, the upper and lower Modelo are not separated, as the time for field work was limited.

No fossil evidence was found as to the age of the formation. A few plant remains were found in the shales. However, because of the characteristic lithology, and the stratigraphic position above the Topanga, it is quite safe to call the formation Modelo, at least the lower half. The upper half is getting near the Pico and may be Pico in part.

The maximum thickness in this region is about 4000 feet.

The youngest formation is the recent alluvium filling the San Fernando Valley. The Pico and Saugus formations are apparently missing. The valley alluvium is composed of unconsolidated sediments, derived from the weathering of the rocks in the Santa Monica Mountains. The thickness is estimated at several hundred feet, probably being quite thick in the middle of the valley.

STRUCTURE

The structure is relatively simple. As previously described, the Santa Monica Mountains consist of a low, broad anticline, striking east and west and plunging gently eastward. The area under discussion is on the north limb of the fold. The structure consists essentially of beds dipping northward from 10 to 25 degrees. The fold is not entirely simple, the limbs being marked by minor folding and faulting, so that in places the beds stand nearly vertical. The general structural trend is about N 80 E. at this locality.

The rocks are traversed by a fault striking roughly north-east. Exposures in road cuts, and the trace of the fault indicate that it dips about 55 degrees south-east. The slates have been uplifted relatively. Hence it is a normal fault, probably due to tension, combined with some vertical forces. This is the type of fault to be expected from tensional forces in the upper beds above the neutral plane, and compressional forces in the core. If the core is in the zone of flow, the compressional stresses could most easily be relieved by upward flow of material. Together with tensional forces in the upper layers, there would result the type of fault found here. The movement has been largely vertical. It could not have been very great horizontally, for if the rocks were "unfaulted" by horizontal movement until the base of the Modelo coincided on each side of the fault, there would be 1800 feet of Topanga on one side of the fault, and none exposed on the other side. By projection of the base of the Modelo in the structure section, it will be seen that

~~a throw~~

the throw of the fault is about 1500 to 2000 feet (assuming that the Modelo was deposited on a plane erosional surface). Any irregularities in this surface would make the above estimate a corresponding amount in error.

The Topanga-Modelo contact is disrupted by a minor fault parallel to the main fault. An exposure of this fault was not found because of the alluvial covering, but the abrubt disruption of the contact justifies the assumption of a fault. The displacement on this fault is probably only a few hundred feet.

The Santa Monica Mountains probably owe their origin to compressive stresses in a north-south direction. The relationship of the folding and faulting to the major structures suggest that it was pure compression, and not induced compression from shearing forces in a north-westerly direction.

The age of the folding is definitely post-Modelo, since these beds are the last involved in the warping. Pico and Saugus beds if ever present have been completely removed. However it seems improbable that they could have been completely removed in post-Saugus time. It seems probable that the Pico and Saugus were never deposited in the Santa Monica Mountains, but that while these beds were being deposited in the basin to the north, the Santa Monica Mountains were uplifted and partially peneplained during Pliocene time. In the section on Physiography, it was suggested that remnants of such a surface are still to be found.

In early Pleistocene time, a great deal of mountain-making activity was initiated. At this time the San Gabries of today began to rise. It is probable that the same forces that acted there also effected the Santa Monica Mountains, since they are

but a few miles away. It is probable then that the Santa Monica were further deformed at that time, the beds and the peneplane being warped into something like the present shape. As in the case of the San Gabriels, the deformation probably continued slowly through the Quaternary and may be going on at the present time.

GEOLOGIC HISTORY

Briefly, the history of the Santa Monica Mountains is probably something like the following:

Deposition of fine-grained marine sediments in Pre-Jurassic time.

Metamorphism of sediments into slates during Jurassic or Pre-Jurassic time.

Intrusion of granits during Jurassic time.

Deposition of Chico, Eocene, and Sespe beds with period of erosion after each.

Deposition of Topanga formation.

Intrusion and extrusion of volcanic rocks.

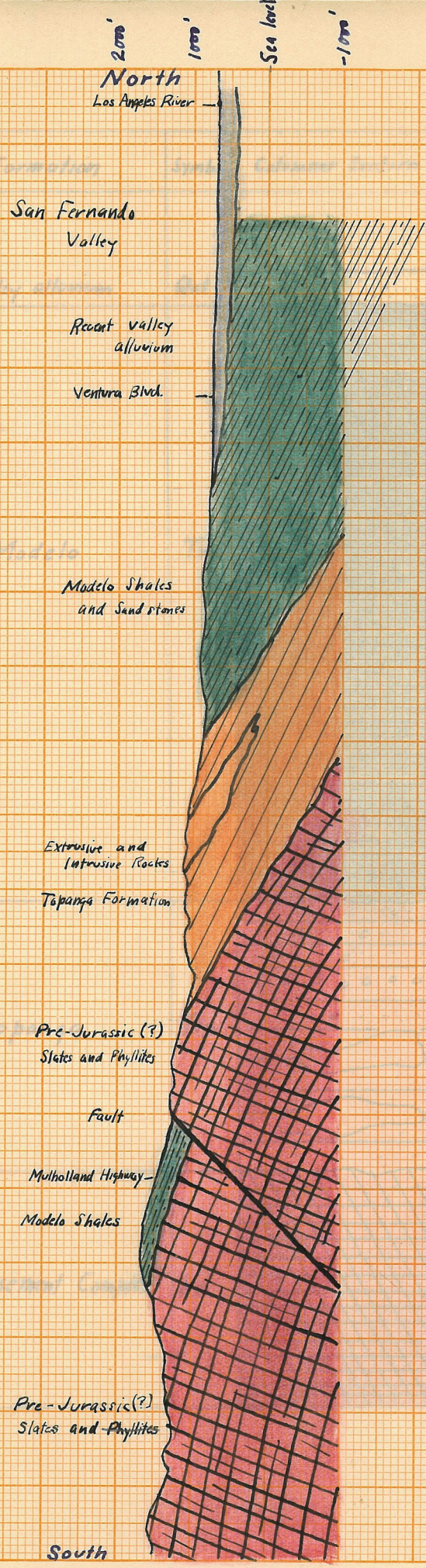
Uplift and erosion.

Deposition of Modelo formation.

Uplift and erosion during Pliocene.

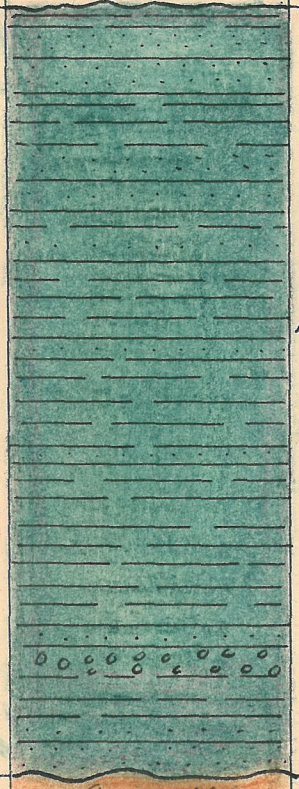
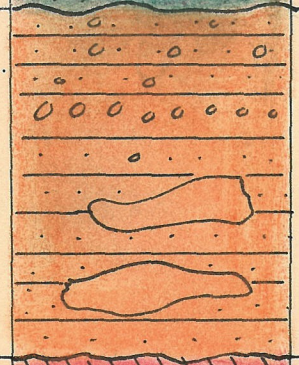
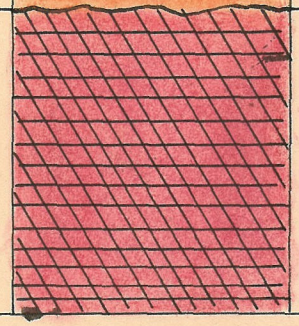
Folding and faulting.

Further warping and erosion during Quaternary.



Structure Section

Taken in direction N21°E, about perpendicular to the general structural trend of the area. Vertical Scale = Horizontal scale = 2,000 feet to the inch.

Age	Formation	Symbol	Columnar Section	Maximum thickness	Characteristics and description
Quaternary	Valley alluvium	Qal		360'+	Consists of sand, fragments of shale, angular slate fragments, etc., derived from Santa Monica Mountains, and deposited in valley.
Upper Miocene	Modelo	Tm		4000'+	Consists mainly of well laminated silicious, diatomaceous, and sandy shales, interbedded with beds of fine grained sandstones from several inches to five or six feet thick. In the west half of the map, the basal members are shales, but with a thick bed (75'-100' thick) of coarse conglomerates about 150' above the Topanga-Modelo contact. In the eastern part of the map, the basal member is a consistant bed of dark colored, coarse grained sand stone. The upper beds of the Modelo consist of thick beds of fine grained sand stones, interbedded with shales.
Middle Miocene	Topanga	Ttp		1800'±	Composed mainly of brownish coarse grained sandstones, and coarse conglomerates. Usually massive and poorly bedded. Included irregular bodies of intrusive rocks, with some vesicular lavas and extrusive rocks.
Pre-Jurassic (?)	Basement Complex	bc			Composed of slates ~~and phyllites~~, weathering red, and badly fractured by numerous joints. Form core of the S.M. Mnt. anticlinal. Intruded by Jurassic (?) granites.