W.M. Cagen   SW San [illegible]

Contents

Summary:

The region is in the southwestern portion of the San Gabriel Mountains, north of Los Angeles, California.

Stratigraphically it is composed of a section of Neogene rocks with some up-faulted older rock. The normal sequence as represented here is: Upper Modelo, unconformity; Pico, conformity; Saugus, angular unconformity; Quaternary terraces. The basement rock, composed largely of para-gneiss, schist and intrusive granite, has been faulted up from below. Its age is pre-Miocene, possibly pre-Jurassic.

The structure of the region is characterized by faults of the dip-slip vertical or steeply normal type.

Geologically the history of the region is: invasion of the sea during Miocene time, deposition of the Modelo formation, broad uplift and subsequent denudation; faulting at the opening of the Pliocene, a second incursion of the sea, deposition of the Pico formation; orogenesis north of the region here described followed by withdrawal of the sea in Upper-Pliocene time, deposition of the Saugus formation (Piedmont Deposit); active faulting and orogenesis at the close of the Pliocene; continuous erosion with short resting stages during the Quaternary.

Geology of a Part of the Southwestern Portion of the San Gabriel Mountains

Introduction

Location:

The region which will be described in this report lies in Los Angeles County, southern California. It is a part of the southwestern portion of the San Gabriel Mountains. The area lies in the southwestern quarter of R14W, T3N and overlaps into sections five and six of R14W, T2N. Physiographically it is bounded on the south by San Fernando Valley, on the east by Little Tujunga Canyon, and on the north and west by Buck and Lopez Canyons respectively.

Previous Work:

In recent years this region has been investigated by several geologists, namely W. S. W. Kew[1], W. J. Miller[2], and M. L. Hill.[3] The writer became interested in this area while pursuing undergraduate studies at the California Institute of Technology and elected to continue working there as a problem for a senior thesis. The earlier work was executed in a region east of and adjacent to the one here described.

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1. U.S.G.S. Bull. 753 - Geology and Oil Resources of a Part of Los Angeles and Ventura Counties, Cal. (1924)

2. Geomorphology of the Southwestern San Gabriel Mountains of California Univ. of Cal. Bull No. 6 - Vol 17, pp. 193-240 (1928)

3. Structure of the San Gabriel Mountains, North of Los Angeles, California Univ. of Cal. Bull. No. 6 - Vol. 19, pp. 137-170 (1930)

Physiography

In order to classify the area as to its stage in the cycle of erosion it is necessary to divide it into two divisions according to whether it is made up of Tertiary or pre-Tertiary rocks. The Tertiary division is now in the stage of middle to late maturity. No remnants of an old land surface are evident on any of the ridges. A possible exception is the ridge that lies between Kagel and Lopez Canyons which is shown on the map to be covered with terrace material. Dissection is well advanced.

West of Little Tujunga Canyon the drainage pattern has been made very largely by consequent streams, only one subsequent channel of prominence having been incised between the Pico and Saugus formations. East of Little Tujunga Canyon a strong subsequent pattern has already been cut. The major streams of the region, four in number, are of consequent origin. Their channels lie incised across the strike of the formations in Little Tujunga, Herrick, Kagel, and Lopez Canyons. North of the basement-complex Buck Canyon and Gold Creek make up the subsequent drainage pattern.

The second division is made up of pre-Tertiary rocks consisting of para-gneisses and schists with igneous intrusives. It is much harder than the Tertiary division and has been exposed to erosion comparatively recently by up faulting. The topographic features formed by these older rocks represent a stage of late youth in the erosion cycle. Seen from a high elevation, the mountains to the east of Little Tujunga Canyon present large flat areas sloping toward the northwest. These areas give to the mountains the aspect of a tilted fault block which has suffered uplift along its southeastern edge and this has really been the case. The flat areas represent remnants of an exhumed land surface of post-Pico age. In consequence of faulting activity and upheaval of this block, Gold Creek, which once cut through Saugus sediments, has been superimposed upon the basement rocks and now runs parallel to Little Tujunga Creek through non-faulted, hard rocks rather than cutting its way along the easier path of the Saugus-basement complex contact. It is corroborative of the fact that the Saugus formation once extended upon the slope of the basement in the vicinity of Gold Creek.

Stratigraphy

Introduction:

Stratigraphically the region may be divided into five distinct units, starting with pre-Miocene gneisses and schists and passing successively through Upper Miocene beds (Modelo), Pliocene beds of the Fernando Group comprised of the Pico and Saugus formations, and Quaternary beds. The Quaternary beds have been subdivided by the writer into three divisions largely on topographic evidence and will be discussed under Quaternary stratigraphy.

Basement-Complex:

The oldest rocks in the area are to be found in the basement-complex. Petrologically, the basement-complex is made up of para-gneisses, biotite and biotite-talc schists, graphite schists and marble intruded by granite and hornblendite. Graphite schists are not common; the writer found them on the south slope of the basement east of Herrick Canyon. They occur in bands between contorted gneisses and are approximately from four to six inches thick. Other evidence which establishes the author's belief in the sedimentary origin of the gneisses is the occurrence of marble. Patches of marble occur at the head of Herrick Canyon at station #47 and in Marble Canyon.[1] Granite is the most important intrusive of the region and outcrops over extensive areas. From Kagel Canyon extending west to Pacoima Wash, the basement consists of the outcrop of a large intruded mass of coarse grained hornblendite which may possibly represent the complementary rock to the granite.

It was not the writer's purpose to investigate

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1. The author has applied the name Marble Canyon to a canyon formerly without a name and in which large lenses of marble occur. The mouth of Marble Canyon opens into Little Tujunga Canyon about 100 yards north of the mouth of Gold Creek.

the basement-complex in detail and the aforementioned rocks have not been mapped separately but have been lumped together under the general term of basement-complex and mapped as such.

Age of the Basement:

The writer has assigned a pre-Miocene age to the rocks of the basement because the Miocene shales (Modelo) of this region show no evidence of metamorphism. Other writers have assigned different ages to these rocks. W. S. W. Kew[1] has mapped them as pre-Jurassic and the intrusive granite as Jurassic (?) although no rocks of Jurassic age are found in contact with these metamorphics. M. L. Hill[2] gives to these rocks a pre-Cretaceous age on the basis of Cretaceous (?) or Eocene (?) sediments which occur in unmetamorphosed condition faulted against them.

Modelo:

The oldest unmetamorphosed sediments that occur in the region are of Upper-Miocene age. Marine invertebrate fossils gathered from this formation by the field class of the California Institute of Technology were identified by W. Popenoe as of Upper-Miocene age. These fossils occurred in upfaulted blocks, adjacent to the basement, in the area just east of the one here being described.

1. U.S.G.S Bull. 753
2. Structure of the San Gabriel Mountains, North of Los Angeles, Cal.

Lithologically this formation is composed chiefly of brownish gray sandy shale, calcareous and siliceous in parts, intercalated with beds of medium grained, yellowish, arkosic sandstone. On the east side of Little Tujunga Canyon thin beds of silicified sandstone occur along with thick beds of yellow sandstone. These beds of sandstone are in the form of lenses and were not traceable west of the cayon.

The author has concluded on the basis of the irregular contact between the Modelo and the overlying Pico that the relationship between these two formations is one of erosional unconformity. There is no accordance between the strike of the beds and the contact trace. This discordance is not explicable by faults or attitude of beds. No angular unconformity was visible anywhere; if one exists it is very slight. In contrast to this irregular contact is the remarkably straight one between the Pico and Saugus formations.

In general lithology, age, and relations of unconformity with the overlying Fernando Group, these beds conform with W. S. W. Kew's[1] and G. H. Eldridge's[2] descriptions and definitions for the upper Modelo.

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1. U.S.G.S. Bull 753
2. U.S.G.S. Bull 309

The writer is unable to give a thickness for this formation because its lower contact is concealed in this region. The maximum thickness here exposed was computed to be approximately two thousand feet.

Pico:

Unconformably overlying the Modelo is the Pico formation comprising a maximum thickness of 1500 feet of marine sediments. At its base is a coarse, rusty conglomerate which is succeeded by about 50 to 100 feet of soft, gray, earthy shales intercalated with thin beds of conglomerate and sandstone. This is followed by massive, buff colored sandstone beds at the top. Bedding is well developed; cementation is good in the basal conglomerate, elsewhere it is poor; consolidation is good.

No fossils were found in this formation but the writer has followed W. S. W. Kew[1] in calling it Pico largely because it is separated below by an unconformity and because stratigraphically it lies between formations that have been determined as Upper Miocene and Upper Pliocene in age respectively. The Pico is therefore assumed to be of Lower Pliocene age.

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1. U. S. G. S. Bull. 753

Saugus:

Conformable upon the Pico lies the Saugus formation forming the upper member of the Fernando group. A maximum thickness of 5000 feet is exposed in this region. This formation represents a piedmont deposit. It is composed chiefly of soft beds of coarse, arkosic sandstone, white in color. The material shows extremely poor sorting and poor stratification. Cross-bedding occurs characteristically. Intercalated in the beds of sandstone are conglomeratic strata which are characterized by a striking abundance of anorthosite cobbles. These are absent from the Pico formation. The anorthosite is bluish in color, coarsely crystalline and is composed almost totally of plagioclase feldspar (labradorite?) with some olivine. The presence of the anorthosite made the tracing of the Saugus beds a comparatively easy matter and offered a key for unravelling their geologic history. North of the Merrick Syncline the occurrence of reddish brown earthy looking beds is common. These beds are composed chiefly of small flakes of biotite and angular fragments of feldspar. It is the preponderance of biotite that gives them their brownish color.

The age of the Saugus has been determined as Upper-Pliocene on the basis of a horse tooth which the author found and which was identified by Doctor Chester Stock as being that of a Pliohippus of Middle to Upper-Pliocene age. The tooth was found in the Saugus formation east of the area here mapped. The stratigraphic position of the Saugus beds also lends support to the belief that they are of the Upper-Pliocene epoch.

uaternary Terraces:

The Quaternary deposits present a problem which still remains unsatisfactorily settled in the author's mind. In this paper the Quaternary terraces have been divided into three divisions on the basis of discordant topography.

Everywhere the terraces unconformably ~~overly~~ overlie the formations beneath them but chiefly they are found on the upturned edges of the Saugus beds. Kagel Canyon offers one of the most striking examples of discordant terrace surfaces. The floor of Kagel Canyon is made up of alluvium that is just beginning to be dissected. The average grade of the valley floor is 9 per cent. Lying between Lopez and Kagel Canyons is a high ridge at an elevation of 2050 feet covered with a maximum thickness of about fifty feet of alluvium. The floor of Kagel Canyon which is right at the base of this ridge is at an elevation of 1750 feet. There is a change in elevation of 300 feet in about a quarter of a mile between the alluvium on the ridge and that in Kagel Canyon. Obviously there are two independent surfaces represented here and a considerable length of time must have elapsed during which the earlier surface was dissected and a second one formed.

In Little Tujunga Canyon, the anomalous elevations and physiographic features of the terraces have led to a threefold division. The most pronounced terraces in this canyon occur on the east side, capping the Saugus beds. They are quite flat and are almost completely under cultivation. On the west side of Little Tujunga Canyon, just south of the Lopez fault is a large flat alluviated surface in the early stages of dissection and sloping toward Little Tujunga Canyon with an approximate grade of 20 per cent. This latter surface would meet the present stream channel about thirty feet below the terraces on the east side. It is inexplicable to the author how a flat surface and a comparatively steep sloped one could have been formed adjacent to one another contemporaneously.

Near the mouth of Little Tujunga Canyon on the east side, there occur two maturely dissected terraces. Their elevation lies slightly above that of the flat surfaces which cap the Saugus beds. If the drainage direction through the canyon has not changed since Pleistocene time it is natural to expect that the terraces near the mouth of the stream should be lower than those farther upstream. The anomalous discordance of these surfaces with those on the Saugus formation coupled with their mature dissection has led the author to correlate them with the terrace capping on the high ridge west of Kagel Canyon.

The terrace relations which I have tried to describe are not confined to single canyons and cannot be successfully explained by local conditions. They are of comparatively wide extent and represent conditions that were active over broad areas.

On the basis of the aforestated evidence, the author has divided the terraces into three divisions, Quaternary terrace #1 being the oldest, Quaternary terrace #2 intermediate, and Quaternary terrace #3 youngest.

Lithologically there is practically no difference between Qt_1 and Qt_2. Both are composed of large to medium subangular boulders of gneiss and granite. The general color is reddish brown. The Qt_3 terrace material is gray in color and is less coarse than that of the older terraces. The attitude of the terraces indicates that no folding or tilting has occurred in the region since their deposition.

Of general interest is the fast that the alluviated surfaces marked Qt_1, lying between Herrick and Little Tujunga Canyons have been cut into by old meandering streams. The airplane photographs show the old meanders clearly.

Structure

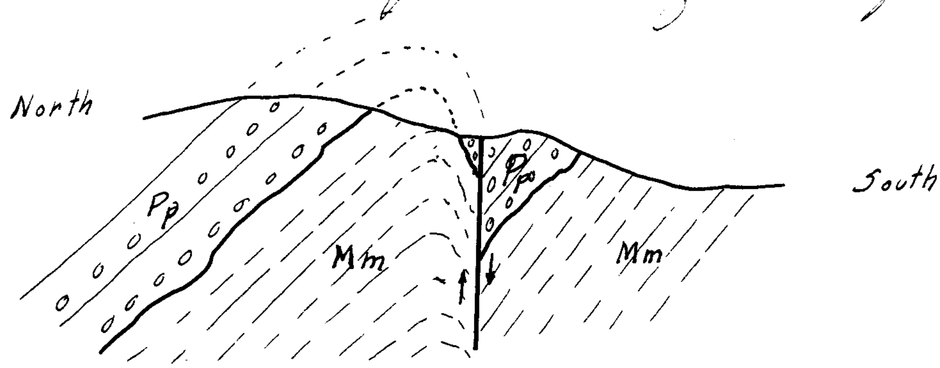
Introduction:

The region is remarkable for the number of faults that occur in it. Aside from the faults there is only one significant syncline that traverses the area; otherwise the structure of the beds is homoclinal with the dip toward the north. The age of the faulting dates from earliest Pliocene to the close of the Pliocene. No evidence of Quaternary faulting activity has been observed. The existing elevations and tilt of the strata are the result of the latest faulting which occurred at the close of Saugus time. It is the belief of the writer that the syncline represents in a large measure the result of drag phenomena along a nearby fault.

aults in the Modelo Formation:

In the Modelo formation the author has recognized three faults which are indicated on the geologic map. Two of these faults have been responsible for the small anticlinal structure that runs transversely into Kagel Canyon. The third fault is shown as a probable one on the geologic map. There has been little displacement along it. A series of lined up saddles and slight deformation in the shale mark its course. The type exposure for the other two faults and the enclosed anticline is in Kagel Canyon. The fault planes are not actually visible but the anticline, composed of Pico beds and surrounded by Modelo shale, is only explicable by faults. Section A-A' on the geologic map shows the relationships that exist.

In the assumption that the fault planes are vertical the southern block has suffered a maximum downward displacement of 900 feet.



Generalized Sketch of a Section in the Modelo 800 feet East of Section A-A'

The age of these faults is post-Pico and more than likely post-Saugus judging from the attitude of the beds on either side of the fault.

Merrick Syncline:

The Merrick Syncline as it has been named by M.L. Hill[1] is one of the most persistant structures of the region. It trends in a northwesterly direction, striking through the Saugus formation and extending across the entire area. East of Herrick Canyon it is an open fold and can be traced without great difficulty. In Little Tujunga Canyon it is excellently exposed. On the north

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Structure of the San Gabriel Mountains, North of Los Angeles, Cal.

limb of the syncline just east of Herrick Canyon, the first tendency to become an overturned fold is visible. As one walks north from the axial plane from station #59 to #61 the beds dip to the south more and more steeply until they pass through the vertical plane and dip to the north as overturned beds. West of Herrick Canyon the fold is closed and overturned; the beds of both limbs dip toward the north. Section A-A' shows this structure. The writer believes that the fold is chiefly a drag phenomenon, especially in the region between Lopez and Herrick Canyons where it is closely folded, and that its extension farther east is an expression of the fold gradually dying out. A minor anticline north of the Merrick Syncline in the vicinity of Little Tujunga Canyon precludes the possibility of drag effects acting in that region. However it is the author's belief that the fold is directly related to the faulting that occurs north of it and that any compressional forces that may have been involved were activated by the faulting.

The folding occurred at the close of Saugus time and was not continued into the Pleistocene.

Lopez Fault:

The Lopez fault extends southeastward from Pacoima Wash almost to Little Tujunga Canyon where it bends sharply to the northeast. W. S. W. Kew called it the Sierra Madre[1] fault. M.L. Hill renamed it the Lopez[2] fault to distinguish it from the fault east of Little Tujunga Canyon and because it is so well exposed at the head of Lopez Canyon. In Mason Hill's paper it is described as a steep reverse fault whereas W.S.W. Kew mapped it originally as a normal fault. The writer has seen the fault exposed in several places. No where is it a sharp distinct plane. In Lopez Canyon the zone of brecciation is at least twenty feet wide; elsewhere the breadth varies from five to ten feet. Exposures were seen in no less than five canyons indicated on the geologic map as stations along the fault. In the portion that parallels Little Tujunga Canyon, it is vertical. Good exposures occur at stations #8 and #72. On the section of the fault that trends southeastward, the dip also was found to be vertical in Lopez Canyon and at station #46. The writer therefore classifies it as a dip-slip vertical fault. The sharp bend that it makes near Little Tujunga Canyon precludes possible lateral movement.

Assuming that the Saugus overlaps the Pico toward the north in about the vicinity of the Lopez Fault, the minimum displacement on the fault would be equal to the thickness of the Saugus (The Saugus Formation once extended

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1. U.S.G.S. Bull. 753

2. Structure of the San Gabriel Mountains, North of Los Angeles, Cal.

over the basement) plus the difference in elevation between the summit of the scarp and the Saugus beds at the foot. Accordingly the throw would be equal to 3900 feet plus 500 feet or a total of 4400 feet. This is the minimum calculated value for the throw where section A-A' intersects the fault. The thickness of material that has been eroded from the basement-complex proper has been neglected. If the Pico beds extended over the basement at this point the estimate is likely to be 500 to 1500 feet too low.

Little Tujunga Fault:

The Little Tujunga Fault trends southeast from a point in Little Tujunga Canyon on the contact between the basement-complex and the Saugus formation. It has been given this name by the writer because it is well exposed in the road cut in Little Tujunga Canyon near the mouth of Gold Creek. Here the fault plane is marked by a thin band of gouge which dips to the southwest 20°. Northward in Little Tujunga Canyon, the fault disappears and is replaced by a depositional contact of Saugus on basement. On the southwestern face of the scarp, it is traceable by the Saugus beds which dip into the basement. About 1500 feet east of Little Tujunga Canyon the fault branches and bounds a slice of the Modelo formation which has been thrust up. A marine, invertebrate fauna in a very poor state of preservation was found in this Modelo. The attitude of the fault was clearly seen only in the road cut in Little Tujunga Canyon where it was normal.

In the opinion of the writer, the fault can be classified as normal and rotational with the axis of rotation running through Little Tujunga Canyon. The amplitude of the throw increases toward the east.

Landslide:

At the head of Herrick Canyon, as a result of the steep scarp that once must have existed, is a huge landslide mass. When looked at from close proximity in Herrick Canyon, it appears to be a more or less solid block. Looked at from a distant point south of the scarp, the evidence of landsliding is striking. The mass looks more or less rounded, too rounded to have been formed purely by erosional processes. At its crest is a huge scar marking what must have been its former position. The airplane photographs show this unusually smooth topography as well as the landslide scar. The Lopez Fault cannot be traced across this landslide but exposures of the fault on opposite sides of the mass fall remarkably well into line.

Geologic History

The geologic history of the region is complex but can be worked out with reasonable certainty starting from late Miocene time.

During the deposition of the Modelo formation the sea lay over the region covering it completely and extending north over the present basement-complex. The land was of low relief and probably lay to the north. At the close of Miocene time broad uplift was initiated with consequent withdrawal of the sea and subsequent erosion of the land. No folding or tilting occurred.

The opening of Pliocene time witnessed faulting along the Lopez and Little Tujunga Faults which resulted in high scarps that closed the region off from the north. An incursion of the sea occurred. The highlands were worn down and the resulting Pico sediments were deposited. By the close of Pico time the Lopez and Little Tujunga highlands had been reduced to low relief.

The abundance of anorthosite in the Saugus formation offers a key to the geologic history of Upper-Pliocene time. According to W. J. Miller the only occurrence of anorthosite on the Pacific coast thus far known is in the western portion of the San Gabriel Mountains. "The anorthosite, together with the anorthosite-gabbro facies, occupies an almost unbroken area comprising much of the western portion of the San Gabriel Mountains. The greatest length of the area is eighteen miles extending from the Monte Cristo Mines on the east to Coyote Canyon and Lang on the west." 1.

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1. (Abstract) Bull. of Geol. Soc. of Amer. Vol. 39 - pt. 1., pp 164-165

Saugus time was initiated by mountain forming to the north of the region here described. The effects in this area were reflected by a a withdrawal of the sea. Piedmont deposits began to sweep down from the northern mountains and soon the remnants of the Lopez and Little Tujunga highlands were buried under the sea of waste. The topography was probably a grand one. Looking from the south one would have seen an imposing range with a great bajada sloping away from its base.

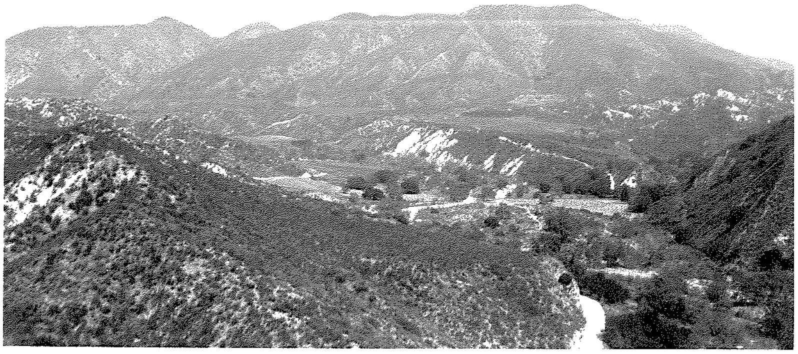
The close of the Pliocene was marked by great orogenic activity. Mountain blocks were pushed up along the Lopez and Little Tujunga Faults. Minor faulting occurred in other parts of the region. The Tertiary beds were tilted steeply to the north. Erosion became active; the Saugus beds were planed off of the highlands and the Tertiary formations to the south were well dissected.

Pleistocene history is not so clear. In aspect the region looked much as it does today with the exception that the canyons were not cut so deeply and the mountains were higher and bolder. From the terrace deposits that now remain, it appears that the region passed through three successive resting stages during which alluviation took place. The causes for these stages and their interruption have not been determined.

The region today is being actively eroded and the topography is a rugged one although the elevations are not very great.

APPENDIX

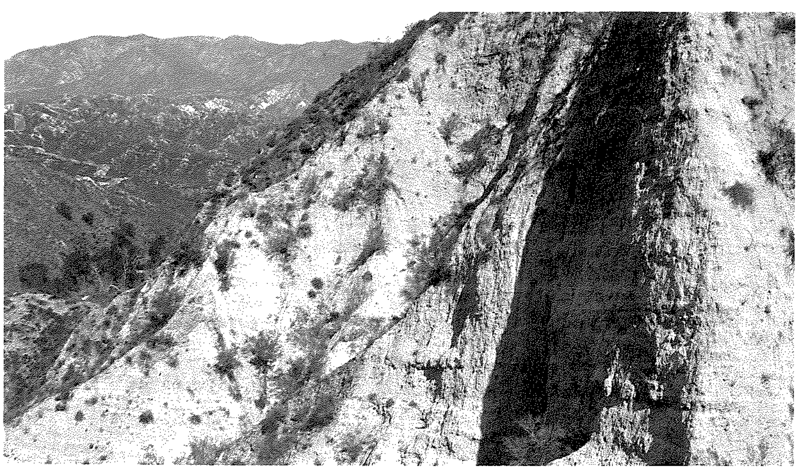
Exposure of Little Tujunga Fault in road cut in Little Tujunga Canyon



View looking NE. into Little Tujunga Canyon.
Terraces on the right.

steep sloping Qt_3 terrace west of
Little Tujunga Canyon

Exposure of Pico in Little Tujunga Canyon showing crossbedding

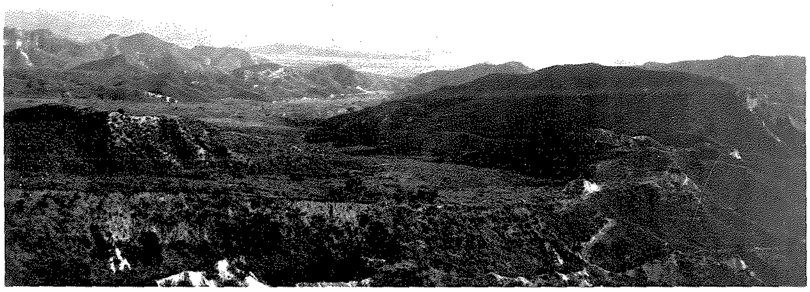


Exposure in the Pico near Sta. #1

Looking north in Herrick Canyon at landslide

View looking NW. across Saugus beds toward Pacoima Wash

Qt_2 terrace unconformably capping Saugus in Little Tujunga Canyon



View looking SE. across Kagel Canyon in the foreground. The Verdugo Hills form the left background.

Period	Epoch	Formation	Columnar Section	Thickness	Description of Formations
Neogene	Pleistocene	Quaternary Terrace		Qt_3 50'± Qt_2 30'± Qt_1 50'±	Qt_3 - Gray, coarse, rounded stream gravel Qt_2 - Dark, coarse fanglomerate Qt_3 - Rusty, coarse fanglomerate
		unconformity			
	Pliocene	Fernando Series: Saugus P_s		5000'+	White colored terrigenous or shallow water deposits, greatly crossbedded, composed of arkosic sandstone intercalated with beds of conglomerate and gravel.
		Fernando Series: Pico P_p		1500'±	Shallow marine deposits. Coarse conglomerate on the south grading into massive, brown sandstone toward the north. Beds are well consolidated. Conglomerate is rust colored.
		unconformity			
	Miocene	Modelo M_m		2000'+	Gray marine shales of sandy composition, intercalated with beds of light brown colored sandstone. Shales silicified in parts.
		Sequence Concealed	Sequence Concealed		
Eogene	Pre-Miocene	Basement Complex bc		Thickness ?	Para-gneisses, biotite and graphite schists, marble, intruded by granite and hornblendite.