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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 un-faulted older rock. The normal sequence as represented here is: Upper Mioceo, unconformity; Pico, conformity; Sanga, 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 Mioceo 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 Sanga formation (Pleistocene 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 R 14 W, T 3 N and overlaps into sections five and six of R 14 W, T 3 N. 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. H. Kent, W. J. Miller, and M. L. Hill. 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.

U.S.G.S. Bull 753 - Geology and Resources of a Part of Los Angeles and Ventura Counties, Cal. (1929)

Bibliography:

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 Kazel 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 Tanguy 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, Kazel, 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 Tauga 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 Tauga-Basement complex contact. It is corroborative of the fact that the Tauga formation once extended upon the slope of the basement in the vicinity of Gold Creek.

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), Pleistocene beds of the Fernando Group comprised of the Foothills and Fanga 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 gneiss, schist, and hornblende talc schist, graphite schists, and marble intruded by granite and hornblende. Graphite schists are not common; the writer found them in 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 marbles. Patches of marble occur at the head of Herrick Canyon at station #47 and in Marble Canyon. 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 hornblende which may possibly represent the complementary rock to the granite.

It was not the writer's purpose to investigate

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.

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. F. W. Kawi 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 gives to these rocks a pre-Cretaceous age on the basis of Cretaceous (?) or Eocene (?) sediments which occur in unmetamorphosed condition faulted below:

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. Popinco as of Upper-Miocene age. These fossils occurred in unfaulted blocks adjacent to the basement in the area just east of the one here being described.

U.S. Geol. Bull. 783
Structure of the San Gabriel Mountains, North of Los Angeles, Cal.
Lithologically this formation is composed chiefly of browny gray 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 siliceous 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 Canyon.

The author has concluded on the basis of the irregular contact between the Models 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 Sanque formations.

In general lithology, age, and relations of unconformity with the overlying Fernando Group, these beds conform with W. S. H. Kerr's and G. H. Eldridge's descriptions and definitions for the upper Models.

1. U.S.G.S. Bull 753
2. U.S.G.S. Bull 959
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.

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 shale 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 local conglomerate, elsewhere it is poor; consolidation is good.

No fossils were found in this formation but the writer has followed W.S.W. Key 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.

U.S.G.S. Bull. 753
Conformable upon the Pico lies the Sanguis formation forming the upper member of the Fernando group. Its maximum thickness of 5000 feet is exposed in the 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 Sanguis beds a comparatively easy matter and offered a key for unraveling their geologic history. North of the Merrick Syncline its 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 Sanguis 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 Pliothippus of Middle
to upper-Pliocene age. The tooth was found in the Sanguis formation east of the area here mapped. The stratigraphic position of the Sanguis beds also lends support to the belief that they are of the upper-Pliocene epoch.

Water认证 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 overlie the formations beneath them but chiefly they are found on the upturned edges of the Sanguis 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 Saugee 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 mostly dissected terraces. Their elevation lies slightly above that of the flat surfaces which cap the Saugee 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
anomalies, discordance of these surfaces with those on the
Laugus formation, coupled with their mature dissection
has led the author to correlate them with the terrace
capping 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 aforesaid evidence, the
author has divided the terraces into three divisions,
Quaternary terrace #1 being the oldest, Quaternary
terrace #2 intermediate, and Quaternary terrace #3
younger.

Lithologically there is practically no difference
between Qt1 and Qt2. Both are composed of large to
medium subangular boulders of gneiss and granite.
The general color is reddish brown. The Qt3
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 fact that the alluviated
surfaces marked Qt1, 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 homolined 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 Tertiary time. It is the belief of the writer that the syncline represents in a large measure the result of drop phenomena along a nearby fault.

Faults 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
13.

antcline, composed of Pico beds and surrounded by Modelo shale, is only explicable by faults. Section H-H' 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 960 feet.

![Diagram of geological section]

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-Saukian, 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, is one of the most persistent structures of the region. It trends in a north-westerly direction, striking through the Saukian 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

structure of the San Gabriel Mountains, North of Los Angeles, Cal.
Lamps on 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 51 to 61, the beds dip to the southeast more and more steeply until they pass through the horizontal plane and dip to the north as overturned folds. West of Herrick Canyon the fold is closed and overturned; the beds of both limbs dip toward the north. Section 47-47' 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 Herrick 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 southeasterly from Pacoima Wash almost to Little Tujunga Canyon where it bends sharply to the northeast.
15.
calve of the Sierra Nevada range. W. L. Hill renamed it
the Lopez Fault to distinguish it from the fault east
of Little Tujiunga 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. Keen mapped it originally as
a normal fault. The writer has seen the fault expos-
ed 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 Tujiunga Canyon, it
is vertical. Good exposures occur at stations #8
and #72. On the section of the fault that trends
southwestward 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 Tujiunga
Canyon precludes possible lateral movement.
Assuming that the Sangus 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 Sangus (The Sangus Formation was extended
over the basement) plus the difference in elevation between
the summit of the scarp and the Tuenango beds at the foot.
If economics the throw would be equal to 3700 feet plus
500 feet or a total of 4200 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 1000 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 Tuenango
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 Tuenango on basement. On
the southwestern side of the scarp, it is traceable by
the Tuenango beds which dip into the basement. Further
1500 feet east of Little Tujunga Canyon the
fault reappears and bounds a slice of the Modelo
formation which has been thrust up. A marine, inverte-
brate fauna in a very poor state of preservation was
found in this Modelo. The attitude of the fault was
In the opinion of the writer, the fault can be classified as normal and rotational with the axis of rotation running through Little Su ingenia Canyon. The amplitude of the throw increases toward the east.

The head of Herrick Canyon, as a result of the deeply scarped fault, must have existed as 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 landsiding is striking. The mass looks more or less rounded, so rounded to have been formed purely by erosional processes. At its crest is a high scar marking what must have been its former position. The airplane photographs show the 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 fail 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, mass 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 Tuftunga Faults which resulted in high scarp bays that closed the region off from the north. An incursion of the sea occurred. The highlands were worn down and the resulting Poco sediments were deposited. By the close of Pico time, the Lopez and Little Tuftunga highlands had been reduced to low relief.

The abundance of anorthosite in the Tuftunga 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 Prieto Mines on the east to Coyote Canyon and Lang on the west."
Quartzite time was initiated by mountain forming to the north of the region here described. The effects on this area were reflected by 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 the 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 Tertiary beds were planed off of the highlands and the Tertiary formations to the south were well dissected.

Pliocene 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 bold. 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 N.E. into Little Tujunga Canyon. Terraces on the right.

Steep sloping Qtz 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
Qtz terrace unconformably capping Sagus in Little Tujunga Canyon

View looking SE. across Kagel Canyon in the foreground. The Verdugo Hills form the left background.
<table>
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<th>Period</th>
<th>Epoch</th>
<th>Formation</th>
<th>Columnar Section</th>
<th>Thickness</th>
<th>Description of Formations</th>
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<tr>
<td>Neogene</td>
<td>Pliocene</td>
<td>Saugus P&lt;sub&gt;s&lt;/sub&gt;</td>
<td>Quaternary Terrace</td>
<td>5000' +</td>
<td>White colored terrigenous or shallow water deposits, greatly crossed, composed of arkosic sandstone intercalated with beds of conglomerate and gravel.</td>
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<tr>
<td></td>
<td></td>
<td>Ferdinando Series</td>
<td>Unconformity</td>
<td>1500' +</td>
<td>Shallow marine deposits. Coarse conglomerate on the south grading into massive, brown sandstone toward the north. Beds are well consolidated. Conglomerate is rust-colored.</td>
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<td></td>
<td>Pre-Miocene</td>
<td>Concealed Basement Complex</td>
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<td>Paragneisses, biotite and graphite schists, marble, intruded by granite and hornblendite.</td>
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