STRUCTURE AND STRATIGRAPHY OF A PORTION OF SAN GABRIEL FOOTHILLS IN THE NORTHERN THIRD OF THE SUNLAND QUADRANGLE, LOS ANGELES COUNTY, CALIFORNIA.

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INTRODUCTION

LOCATION

The area is located in San Fernando Valley, California, north-west of the small town of Sunland. The area extends 2½ miles eastward from Little Tujunga Canyon to Ebbie Canyon along the north side of Tujunga Wash and thence northward one mile up Ebbie Canyon to the basement complex; it extends 1½ miles north-eastward from Tujunga Wash up Little Tujunga Canyon.

To reach the area from Pasadena, drive 20 miles west from the center of town along Foothill Blvd. The center of the south side of the area lies at the point where Foothill Blvd. resumes its east-west direction after crossing Tujunga Wash, about 2 miles beyond Sunland.

SHAPE AND SIZE--

The area is a trapezium with the east side trending N 13° E for 6000' from the mouth of Ebbie Canyon, the north side trends 10,000' N 56° W, to Little Tujunga Canyon. The western side extends for 11,500' S 50° W, while the south side runs 16,000' S 80 E back to Ebbie Canyon.

The area of the trapezium is 2568 acres or 4.06 square miles.

There is very little human culture in the region. Along the south side there is a fringe of orange groves with a road up Oliver and Schwartz Canyons to small ranches. In the north-west corner there is a ranch on the large Q.O.Al. terrace. A road runs up Ebbie Canyon to the granite complex. The Forestry Service is building a road near the northern boundary to extend westward from the upper end of Doan Canyon.

PURPOSE--

The mapping of the area to determine stratigraphy and structure was undertaken as the basis of a Senior Thesis, to obtain a Bachelor's

Degree in Science from the California Institute of Technology, Pasadena, California.

FIELD METHODS AND ACCURACY--

The survey was conducted with aid of a Brunton compass for determining dips and strikes and locations in the field. The mapping was done on a Fairchild Aerial Photograph of the region, scale 1" = 1630'. The information was later transferred to an Advance Sheet of the Sunland Quandrangle of the U.S.G.S. Topographic Sheet, scale 1"= 2000'.

The contacts indicated as a very closely spaced series of dots are within 150' of the correct position. When the contacts are indicated by a dashed line (formed again with dots), it is in approximately the correct position, while if the dashed line is qualified with question marks the author is not certain of either the location or existence of the contact. The same general statements apply to the indications of faults (a solid line instead of a dotted one being used) and the axes of folds.

The central point refered to in all azimuth and distance locations, B.M. 1198, is located on the north west corner of the most northerly of two bridges over which Foothill Blvd. crosses Tujunga Wash approximately two miles west of Sunland.

ACKNOWLEDGEMENTS--

The author is indebted to the following: Dr. Bode, who assisted in the choice of the area and made valuable suggestions from time to time, R. Hayward, who worked out some of the invertebrate fossil material, L. Schombel and W. White who are working in adjoining areas and contributed useful information found in their work, M. Peet for

stenographic work, and W. J. Smith who assisted in the photography. Mason Hill published a report, including in it, this area; this paper, entitled "Structure of the San Gabriel Mountains North of Los Angeles, California". U. of Cal. Publication in Geology, Vol. 19, no. 6, pp. 137-170, 1930, is referred to from time to time in the text.

RELIEF AND DRAINAGE--

Along the southern boundary, the drainage, composed of consequent streams, flows toward the south into Tujunga Wash. The relief is low until the Pico conglomerates are reached which have very bold cliffs on the southern side.

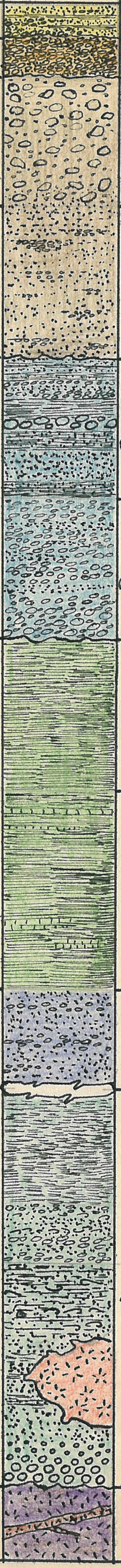
From the Pico beds north, the consequent streams from the flanks of the hills drain into the subsequent streams running east or west in valleys developed by the differential erosion. Here the relief is low and more rolling until one reaches the foot of the San Gabriel Mountains themselves which are steep and rugged with a consequent drainage pattern.

OUTCROPS--

In general the outcrops are abundant and good on the south slopes of the hills, but the north sides are usually covered by vegetation and soil; moreover, the beds dip to the north for the most part.

Specifically, the outcrops are the best in the southern group of Miocene beds and in the Pico Formation (on the south slope). The best outcrops will be found on the steeper walls and deep in some canyons where the streams have begun side-cutting.

The Saugus beds and the Fascination Series both have extensive outcrops, but they do not exhibit much in the way of attitudes. This is particularly true of the Saugus.



		Formation	Series	Symbol	Thickness	Rock Types
Cenozoic	Quaternary	Alluvium		QAl		Gravel, sand, silt, and landslide debris
		Old Alluvium		QOAl	75'+	Terrace Gravels
		Unconformity				
	Pliocene	Saugus	Coarse	Tsc	500'+	Coarse, poorly bedded and loosely consolidated cgl.
			Sandy	Tsc	600'	Coarse sandstone and fine cgl. Poorly bedded and consolidated.
		Disconformity				
		Pico	Coates	Tps	600' (to 1200')	Fourth sandy-shale and sandstone Medium conglomerate and sandstone Third shale Boulder bed Second sandy-shale Coarse white sandstone First sandy shale
			Conglomerate	Tpc	600' (to 1000')	Grey cgl and sandstone Red cgl.
		Disconformity				
	Miocene	Modelo	Muddy Shale	Tmsi	650'	Finely laminated, muddy shale, white and yellow solution minerals.
			Shale	Tmsh	850'	Siliceous, chalky, cherty shale.
			Sand-stone & Cgl.	Tmc	420'+	Micaceous, arkosic, coarse s.s. with cgl beds of acid-igneous cobbles and gravel.
		Unknown				
		Fascination		Tmf Tmb Tmf	1580'	Silty-shale Cgl and arkosic s.s. fossiliferous Silty sandstone, fossiliferous Olivine-diabase Basal conglomerate
		Unconformity				
Meso	Jur. (?)	Basement-Complex		Jbc	?	Granodiorite(?) with dikes.

PETROGRAPHY

With the exception of the diabase, all work upon the rocks was megascopic. The thicknesses of the beds were, with a few minor exceptions, calculated from the extent of the outcrops on the map and the magnitude of the dips.

-MIOCENE-

TOPANGO FORMATION

I. Fascination Series

A. Contacts

1. Lower-depositional upon basement complex, in igneous contact with basement complex.
2. Upper-fault contact with sandy series of Saugus Formation.

B. Composition

1. Basal Conglomerate

   Very well rounded pebbles of acid igneous rock, $\frac{1}{8}$"-1" in diam.

2. Olivine-Diabase intrusive sheet*.

   Labradorite Plagioclase

   Olivine

   Augite

   Magnetite

   Iddingsite } Secondary
   Calcite }

3. Silty Sandstone

   Fine grained quartz sandstone.

*Mason Hill suggested the material was a basalt flow. Thin sections have shown it to be diabase and field evidence proves its intrusive character. Intrusive structures. Ibid., page 142.

4. Conglomerate and Sandstone

Interbedded medium sized, 2"-4", acid igneous cobbles with white arkosic sandstone.

5. Silty Shale

Fine-grained

C. Lithology

1. Basal Conglomerate

a. Poorly consolidated, iron stained, slightly weathered.

2. Olivine-Diabase

a. Dark red to grey or black.
Vesicular top and bottom.
Apophyses on the upper surface.

b. Successive layers of which the younger penetrate the older.

c. Usually badly weathered.

3. Silty Sandstone

a. Light tan to yellow.

b. Well bedded and poorly consolidated.

c. Fossiliferous.

4. Conglomerate and Sandstone

a. White, tan and greenish-yellow.

b. Well bedded and sorted. Hard to friable.

c. Very fossiliferous.

5. Silty-Shale.

a. Tan color with local patches of some yellow solution-mineral (?) in bedding planes.

b. Friable to fairly hard. Closely bedded, well sorted. Grades upward to finer material.

c. Scattered fossils similar to those in No. 4.

D. Large and small areas of this series appear to the north and the south of the Sunland Fault along the north side of the area near the Basement Complex.

E. Representative outcrops.

1. Basal Conglomerate
   9000' N 14^{o} E BM 1198 (Page 2)
2. Olivine-Diabase
   7500' N 21^{o} E BM 1198 (Page 2)
3. Silty Sandstone
   8000' N 37^{o} E BM 1198 (Page 2)
4. Conglomerate and Sandstone
   8400' N 52^{o} E BM 1198 (Page 2)
5. Silty Shale
   7600' N 54^{o} E BM 1198 (Page 2)

F. Thickness and Variations

1. Basal Conglomerate.
   a. 100' (?) thick.
   b. Only appears locally where sediments lie in depositional contact upon Basement Complex.
2. Olivine Diabase
   a. From 50' to 500' thick.
   b. Not present in all of Fascination Series but does outcrop for 5400' trending N 70^{o} W from head of Doan Canyon.
3. Silty Sandstone
   a. 210' thick, discontinuously.
   b. Extends from Doan Canyon roughly N 60^{o} W (though

the whole series bends more northward to the west) to the northern boundary of the area. The outcrops are interrupted by fault blocks.

4. Conglomerate and Sandstone
   a. 260' thick.
   b. Outcrops the same as No. 3 above.
5. Silty Shale.
   a. 520' known thickness, remainder cut off by Sunland Fault.
   b. Outcrops the same as No. 3 above.

G. Age

These beds were determined as Upper Topango (Upper Middle-Miocene) by R. Hayward; see the last section of this report for a list of the fossils. Mason Hill* reports the following fossils as determined by Dr. A. J. Tieje:

Amiantis cf. communis Nomland
Pecten raymondi cf. brionianus Trask
Solen perrini Clark
Chione cf. semiplicata Nomland

Tieje suggested a possible age of upper Miocene. The diabase is believed to be of only slightly later age since flows formed by a quite similar magma were found by R. B. Lockwood** to be associated with Lower Modelo sediments three or four miles to the south of this area.

* Ibid., page 143

** Lockwood, R. B. Senior Thesis, 1936-1937

MODELO (?) FORMATION

I. Sandstone and Conglomerate Series

A. Contacts

1. Basal--unknown

2. Upper--overlain by siliceous shales with small angular discordance, 8-10°

B. Composition

1. Sandstone:

CONSTITUENTS	%	SIZE	SHAPE	WEATHERING	COLOR
Quartz	40-80	0.5 m.m.	angular	none	clear
Feldspars	10-40	1-3 m.m.	rounded	one half	white to pink
Biotite	0-5(?)	1 m.m.	angular	none to complete	black
Muscovite	5-10	2 m.m.	angular	none	clear

2. Conglomerate

(a) Igneous constituents

(1) Granites (with and without femags)

Size--Sand to cobbles.

Lesser amounts of gneisses and porphries.

Abundant, 90-95%

(2) Felsites

Average size 2-3 inches

Vesicular and porphyritic

Colors are blue, grey, and red.

Not abundant, 3-5%

(b) Sedimentary

Occasional fragments of white to brown shale.

C. Lithology

1. Sandstone

Color--White to brown

Hardness--Very friable to hard

Texture

Beds are thick and very well sorted.

Some irregular color banding about concretions may be seen occasionaly.

2. Conglomerate

Color--Usually tan to brown

(Fresh exposures rare)

Weathers to grey gravely soil.

Hardness--Consolidation is very poor.

Texture--Beds are massive and poorly sorted.

Weathering--Quite rapid and almost universal.

D. The series is exposed for 8625 feet trending N 72° W along the north side of Tujunga Wash, between Little Tujunga Canyon on the west and Bridge Canyon on the east. The maximum width is about 600'.

E. Representative exposures

Sandstone: 250' N of B.M. 1198 (See page 2 for location of B.M. 1198) and 5100' N 61° W of B.M. 1198.

Conglomerate:

6450 feet N 66° W of B.M. 1198 (See page 2) near the shale-conglomerate contact on the south side of the Gully located by above azimuth.

F. Variations and Thickness

The size and composition varies laterally and vertically in no specific manner, beds lense out and reappear. The whole series is covered by a residual mantle of Q.O.Al. which obscures the contacts, exposures and attitudes to a marked degree. The average strike is N 72° W, the average dip is 25° N.

The beds are not completely exposed, but 420 feet are known.

G. Mason Hill* calls these beds Miocene because they underlie the Pico and are of Miocene character.

II. Shale (siliceous to chalky, and cherty) series.

A. Contacts:

1. Lower--overlies conglomerate with 8-10° discordance. (Contact obscured in most places by remnants of Q.O.Al.)

2. Upper--conformably overlain by muddy siltstone.

B. Composition

1. Siliceous shales, varying to chalky shales laterally and changing to silty shale vertically. Cherty layers are abundant in silty shale.

2. Mineral species

Gypsum--present in the siliceous shales and more abundantly present in the silty shale. (Platy and fibrous growths between bedding planes and in joints.)

Micas--present in small quantities.

3. Particles are very fine, though locally the silty shale may be arenaceous. All are well weathered.

* Ibid., page 143

C. Lithology

1. Color--Siliceous shales are white, the silty shales yellow to tan.
2. Hardness--Silty and siliceous shales are usually well consolidated. The diatomaceous is very friable and tends to spall off. The chert layers are very resistant and stand in sharp relief as result of differential erosion.
3. Texture; etc.

   The stratification is usually excellent, as is the sorting. One clearly defined bluish-white arkosic sandstone bed extending 1000' east of a point 7000' N 60° W of B.M. 1198 (See page 2) was used as a marker bed. The beds are crumpled and folded in an irregular manner due to soil-creep and forces initiated during uplift. Cleavage due to shearing and tensional forces is universal and usually lies perpendicular to the bedding.
4. Weathering:

   The siliceous shale weathers to a dark grey to black adobe, while the silty shale becomes a dark brown adobe with angular pebbles and blocks of chert. Gypsum fragments are occasionally found in both weathered rocks.

D. Distribution:

The series is exposed for 9600' east of Little Tujunga Canyon, trending N 68° W about 600' north of Tujunga Wash and has a maximum width of 1200'.

E. Representative exposures:

1. Chalky shale

   a. 900' N 52° E of B.M. 1198 (Page 2)

   b. 1800' N 19° W of B.M. 1198 (Page 2)

2. Siliceous Shale

   5850' N 63° W of B.M. 1198 (Page 2)

3. Silty Shale

   4650' N 53° W of B.M. 1198 (Page 2)

F. Variations and thickness.

The siliceous shale locally and laterally changes chalky shale, while the silty shale does not vary appreciably in composition.

The sharp distinction seen on the west end between the silty and siliceous shales gradually diminishes so that east of Cactus Canyon the silty shale is the predominate type with the siliceous or chalky variety only occasionally present.

The known thickness varies from 200 feet to 850 feet.

G. Age

Mason Hill* considered these beds, Miocene on the basis of their position below Pico and their general character.

III. Muddy Shale Series

A. Contacts

1. Lower--conformably over lies the Silty Shales.

2. Upper--west of Bridge Canyon, unconformably overlain by Pico conglomerates, but east of Bridge Canyon the shales and Pico conglomerates interfinger.

* Ibid., page 143

B. Composition

1. Muddy shales with streaks of yellow and white solution minerals and abundant plates of gypsum. Biotite (?) and muscovite are abundant. Locally the layers are arenaceous.

2. The grain size is usually very fine, though the particles may be as large as o.2 m.m..

C. Lithology

1. Color--Usually a dark brown with light-tan sandy lenses or yellow solution stains.

2. Hardness--Varies from compact to quite friable.

3. Texture, etc.

The stratification and sorting are excellent. The laminae are thin, usually 10 m.m.. The shale exhibits considerable twisting and jumbling, particularly near the upper contact, which is probably due to soil creep, landslide drag-effects, forces traceable to regional uplift, and to the burden of the overlying, relatively ridgid conglomerate beds. Tensional and shear cleavage is universal and lies perpendicular to the bedding surface.

4. Weathering:

The Muddy Shales do not weather as readily as the Silty Shales and consequently form, in some places, more bold relief. The weathering product is a sticky, dark-brown to black soil.

D. Distribution:

The series is exposed for 6300' east of Cactus Canyon and trending about N 65^{o} W. The beds lie 1550' north of the mouth of Cactus Canyon. The maximum width of the exposure is 750' (the eastern end).

E. Representative exposures.

1. 4500' N 42° W of B.M. 1198 (See page 2)

2. 1450' N $43\frac{1}{2}^{\circ}$ E of B.M. 1198 (See page 2)

F. Variations and Thickness

The composition is fairly consistent laterally and vertically. The thickness increases from 100' on the western to 650' on the eastern end. From Little Tujunga Canyon to Cactus Canyon, the Q.O.Al. probably covers most of the series, though small patches of the Muddy Shale appear locally.

On the eastern end, stringers of conglomerate which eventually connect with the Pico Formation begin to appear in the shale and eventually pinch it out.

G. Age

Mason Hill* considered these beds to be Miocene on the basis of their position below the Pico and their general character.

-PLIOCENE-

PICO FORMATION

I. Conglomerate Series

A. Contacts

1. Lower--west of Bridge C. lies unconformably upon Muddy Shale series.

East of Bridge C., interfingers with Muddy Shale series.

2. Upper--conformably overlain by the Coates Series.

* Ibid., page 143

B. Composition

1. Two divisions of series are:

   Older--Red Conglomerates

   Younger--Grey Conglomerates and Sandstones.

2. Both divisions contain:

   a. Igneous

      Plutonic, 85-95% $\pm$

      Sub-angular to subrounded pebbles, cobbles and boulders of granites, monzonites (?), and diorites. Some gneissic and porphritic types.

   b. Eruptives 5-15% $\pm$

      Felsites and porphyritic basalts.

      Red, black, and grey.

   c. Sediments--Some few fragments of tan and white shale.

3. Most of the material is about one-third weathered, but the amount is quite variable.

C. Lithology

1. Color

   a. Reddish brown in lower division.

   b. Light to dark grey in upper division.

2. Most of the conglomerates are well compacted and cemented. The material will stand to form cliffs with an angle as high as 80-85^{o} from horizontal. Average angle of cliffs is 40-45^{o}.

3. Texture, etc.

   The sorting is usually fair but quite variable;

the stratification surfaces are not sharply marked; the beds grade one into the other. Lensing of beds is frequent, and the lenses vary from a few feet to thousands of feet in extent.

4. The rocks do not weather readily; the result of the process yields gravel talus beds at the bases of the cliffs.

D. Distribution

The series is exposed for 11,250 feet from the mouth of Ebbie canyon, west, to Little Tujunga Canyon, trending about N 64° W. The maximum width of exposure is 1400 feet.

The Red Conglomerate Division is present only from Schwartz Canyon west, to a point 1200 feet east of Little Tujunga Canyon.

E. Representative exposures.

1. Red conglomerate
   3000 feet N 24° W of B.M. 1198 (page 2)
2. Grey Conglomerate
   2700 feet N 6° W of B.M. 1198 (page 2)

F. Since the beds are resistant to erosion and weathering and will stand well, the exposure constitutes a line of steep cliffs from 150 to 500 feet high.

G. The composition and thickness vary both laterally and vertically. The thickness diminishes eastward from 1000' to 200' . The underlying shale lenses into the Grey Conglomerate Division near Bridge and Terrace Canyons.

H. Age

Mason Hill* cites the occurence of distinctive

*Ibid., page 143

Pico fossils in these beds at another locality.

II. COATES SERIES

A. Contacts

1. Lower--conformably overlies the Conglomerate Series.

2. Upper--overlain by the Saugus Formation with local angular discordance.

B. Composition

1. The Coates Series consists of:

a. Four sandy shale divisions

b. Two prominent sandstone divisions

c. One thin boulder bed

C. Lithology

1. Sandy Shales

Usually dark brown, friable, well bedded and sorted, finegrained to coarse, silty shales, contain a little gypsum and considerable quantities of mica.

2. Sandstones

Usually coarse-grained, of angular to sub-angular fragments, arkosic, usually white or grey, from very hard to very punky.

3. The boulder bed

Composed of very large (1 to 3 feet in diameter) cobbles and boulders of granitic material with sand and pebbles intermixed. The boulders are sub-round in shape.

D. Distribution

The series is exposed from the mouth of Ebbie Canyon for 11,250 feet west to Little Tujunga Canyon, trending N 64° W. The broadest exposure is 1500 feet wide.

E. Representative exposures, by divisions (oldest on top).

1. First Sandy Shale

   3000 feet N 74° E of B.M. 1198 (See page 2)

2. Coarse White Sandstone

   3150 feet N 9° W of B.M. 1198 (See page 2)

3. Second Sandy Shale

   3300 feet N 8° W of B.M. 1198 (See page 2)

4. Boulder Bed

   3000 feet N 14° W of B.M. 1198 (See page 2)

5. Third Shale

   3475 feet N 4° W of B.M. 1198 (See page 2)

6. Medium Conglomerate and Sandstone

   3600 feet N 1° E of B.M. 1198 (See page 2)

7. Sandy Shale and Sandstone

   3750 feet N 3½° E of B.M. 1198 (See page 2)

F. Variations and thickness

To attempt a detailed account of all variations in thicknesses and composition would be prohibitive by nature of its size. Suffice it to say the divisions chosen are fairly consistent in thickness and composition taken in the broader aspects. As a whole, the series diminishes in thickness from 1200 feet at the western end to 600 at the eastern.

G. Age

Mason Hill* cites the occurence of distinctive Pico fossils in these beds at another locality.

*Ibid., page 143

SAUGUS FORMATION

I. Sandy Series

A. Contacts

1. Lower--overlies the Coates Series of the Pico Formation with local angular discordance.

2. Upper--conformably (?) overlain by Coarse Series (contact too vague to map.)

B. Composition

1. Coarse sandstone and fine conglomerate.

a. Sandstone

White and pink feldspars, and quartz.

b. Conglomerate

Pebbles of acidic igneous rocks with some gneisses. Black or greenish pebbles of very basic character.

Pyroxene or amphibole bearing pebbles are distinctive.

C. Lithology

1. Sandstone

a. White to pale tan, very friable, partially sorted but poorly bedded.

b. Cross bedding and scour channels.

2. Fine Conglomerate

a. White, very friable, pebbles sub-round to sub-angular, badly weathered.

b. Usually occurs as scour-fillings.

3. No fossils found in the Sandy Series.

D. The series is exposed in two bands 11,000' long trending N 60° W from two regions, one 2000' and one 4000' north of the mouth of Ebbie Canyon.

E. A representative exposure may be seen on the west side of Ebbie Canyon 6000' N 64 E of B.M. 1198 (See page 2)

F. Since the upper contact is obscure, no definite statements as to thickness or variation may be accurately made, but an approximation of the thickness would be 600' ± 150 feet.

G. Age

These beds are Saugus according to Mason Hill.*

II. Coarse Series

A. Contacts

1. Lower--conformably (?) overlies the Sandy Series.

2. Upper--unknown.

B. Composition

1. Coarse Conglomerate

a. Schist; gneiss; porphyrtic, grey granitic; felsites (black and red); and vesicular lava pebbles and cobbles.

b. Distinctly two sizes of constituents

(1) 1/8" to 1", mostly ¼"-3/8".

(2) 3" to 10", mostly 6"-8".

c. Sub-angular

C. Lithology

1. Light grey, very friable.

2. Poorly sorted and consolidated.

- 3. Attitude is rarely determinable.

4. No fossils located, though horse-teeth reported.

D. This series lies between the two bands of the Sandy Series, that is in a strip trending 5000', possibly more, N 60° W

* Ibid., page 144

from a region about 3000' north of the mouth of Ebbie Canyon.

E. Satisfactory outcrops may be seen along the ridge 6000' N 51° E of B.M. 1198 (See page 2)

F. The thickness is unknown but probably 500' ± are here exposed.

G. Age

Saugus, according to Mason Hill.*

QUATERNARY

Quaternary Old Alluvium

A. Contact

1. Lower contact with Miocene and Pliocene sediments, usually unconformably.

B. Composed of varying detritus depending upon the location and the source of the material. Usually coarse sand and conglomerate.

C. Poorly bedded, soft, undisturbed, and in some places cross-bedded.

D. Thickness varies from a few feet to 75 feet or more.

E. Widespread in the north-west and south-east portions of the area and present locally in other places.

F. Nature--conglomerate material forming terraces near or along the margins of the larger canyons.

Quaternary Alluvium

The gravel, sand, and silt to be found in the stream channels and small flood-plains of the area. Also to be included are the land-slides in the southern section. Variable in character, composition, extent, and thickness.

* Ibid., page 144

GEOLOGIC STRUCTURE

Broadly speaking, the average strike and dip of the sedimentary rocks is N 60° W, 40° N. In the Miocene shales there is frequent and extensive deviation from this attitude, while the sandstones of all the formations follow the strike, at least, quite closely.

--FOLDED STRUCTURES--

The major folding has been the result of drag effects on either side of the Sunland Fault along the base of the Complex. The folds are inclined so that one flank has been overturned. Elsewhere throughout the region the only folding is that present in the shales as contortion and some other minor anticlines and synclines, with one, long strip of acute flexing paralleling Tujunga Wash in the southern exposure of the Miocene shales.

<u>Merrick Syncline</u>

The Merrick Syncline is, by far, the most outstanding fold in the area. The axis extends for 11,000' N 60° W through the Saugus beds, about 500 to 1000 feet south of the Sunland Fault.

This syncline appears to represent the drag-fold formed by the uplift of the San Gabriel Range. The axial surface of the fold dips 50° northward, which means that the northern portion of the north flank is overturned. This overturning may be traced continuously from Ebbie Canyon to the north-west corner of the area. Proof of the overturned character of the sediments may be shown in three ways, (a) the appearance of the lower beds of the Saugus Formation on the north and south sides of the axis, (b) the dips, with a southern inclination, increase on the north side of the axis to the vertical and then gradually decrease in magnitude with a northern inclination, and (c) on the face of a cut on the fire-control road 6650' N 27° E of B.M. 1198 (Page 2) scour-channels may be seen which clearly illustrate the position of the beds. The flexing has been so intense that the two limbs are approximately parallel.

The Syncline gradually approaches the Sunland Fault from west to east so that east of Ebbie Canyon the overturned beds do not appear.

Sunland Anticline

The Sunland Anticline, which lies on the north side of the Sunland Fault and parallel to it, lies in the Miocene beds (Fascination Series). This fold is also a drag feature of the Sunland Fault. Most of the beds in which it once lay have been eroded away so that only in one place may it be clearly seen. If one stands upon a point ~~4000~~ 8,000' N 30° E of B.M. 1198 (See page 2) and looks N 80° W, two portions of the Silty Sandstone of the Fascination Series will clearly indicate its presence. This is shown in the section B-B'. See, also, figure 1.

Figure 1
The Sunland Anticline

The axial plane of the anticline dips 60°-70° toward the north. As a consequence, the beds on the southern flank have all been overturned. There is additional evidence for overturning. (a) By systematic counts made over outcrops of shell-bearing rocks in the Fascination Series, it has been determined that 74% of the individual valves of pelecypods over two inches in diameter lay in the beds with the convex side downward where the beds are overturned. This result was compared with a similar count made in the Pleistocene beds near Second and Beacon Streets in San Pedro, California, where it was found that 81% of the valves over 2" in diameter lay with the convex side upwards (shells less than 2" in diameter were not found to be reliable indicators). (b) On the west wall of Doan Canyon 8400' N 52° E of B.M. 1198 (page 2) it was found that an arkosic sandstone, apparently lying below a conglomerate composed of small pebbles, contained fragments of this conglomerate.

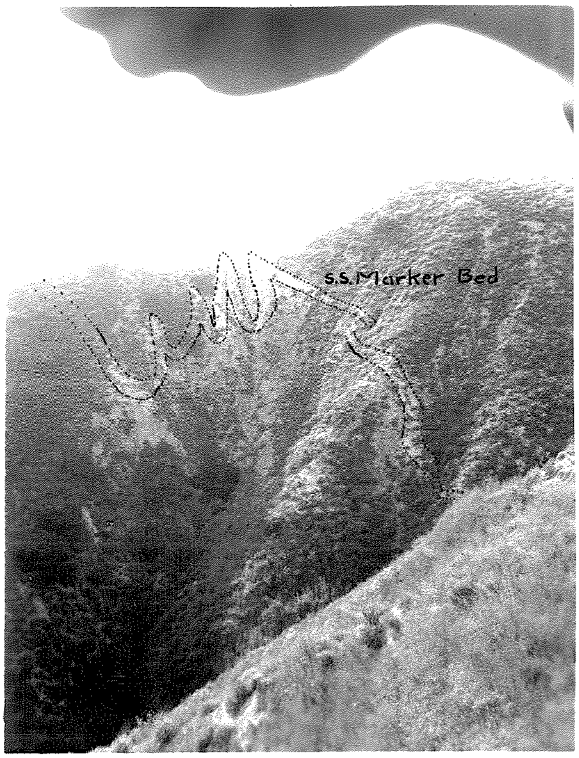


Figure 2.
Flexure in the Tmsh division of the Modelo

(c) The whole Fascination Series grades from coarse on the north to fine on the south while the attitude is nearly vertical on the north and dips to the north on the south side.

A syncline trending N 75° W for 2000' and thence N 40° E for about 2000' begins about 4600' N 82° E B.M. 1198 (page 2). The fold is of minor character and appears only in the southern Miocene beds and the Pliocene beds. Its significance is not known.

7650' N 63° W of B.M. 1198 (page 2) may be seen a flexure consisting of from 5 to 7 isoclinal folds striking about N 75° W and dipping 70° N. At the location cited, the width of the flexure is about 100', figure 2. On the south side of the flexure the regional dip in the Miocene Shale Series is 28°, while on the north, the dips are 40° to 60° toward the north. This bending, with usually fewer folds visible, may be traced intermittently S 75° E for 8000'. Mason Hill* and Kew** mapped this flexure, at the location cited, as a small fault, but careful investigation by the author has shown that beds are continuous across the supposed fault.

The flexure roughly parallels the Merrick Syncline and the Sunland Fault in dip and almost exactly in strike. It is possible that the same orogenic forces which produced the Sunland Fault may also be responsible for this flexing. The relative ages of the flexure and the small faults which traverse it (Cactus Fault and Oliver Fault) are not known. No displacement is indicated on the map where the faults and flexure intersect; however, the flexure could not be traced sufficiently accurately to warrant any such relationship. The author presumes all these faults to be related to the Herreres Fault and therefore older than the Sunland Fault and the flexure.

--FAULT STRUCTURES--

Faults in this area are far more numerous than folds. There are two major and two minor folds, but there are two large faults, one medium fault, and eight known small faults, some of which branch, besides. These range in size from a displacement of 50 feet and a known length of 200' to a displacement of about 4000'.and a known length of more than 9000'.

I. Sunland Fault

This reverse fault lies near the north side of the area extending 9000'± approximately N 55° W from a point 7400' N 53° E of B.M. 1198 (page 2). The fault dips to the north 50° to 70°. The fault surface is exposed on the fire-control road 7000' N 40° E of B.M. 1198 (page 2).

* Ibid., Map opposite page 142.
**Kew, W.S. Geology and Oil Resources of part of Los Angeles and Ventura Counties, California.
U. S. Geol. Surv. Bull. 753, map. 1924 a.

Figures 3 and 4, sections A-A' and B-B'. However, in most other places, soil or talus effectively covers the actual fault. Nevertheless, from the trace of the fault on the surface, one can see that the Basement Complex and in some places the Fascination Series have ridden up and out over the younger Saugus beds.

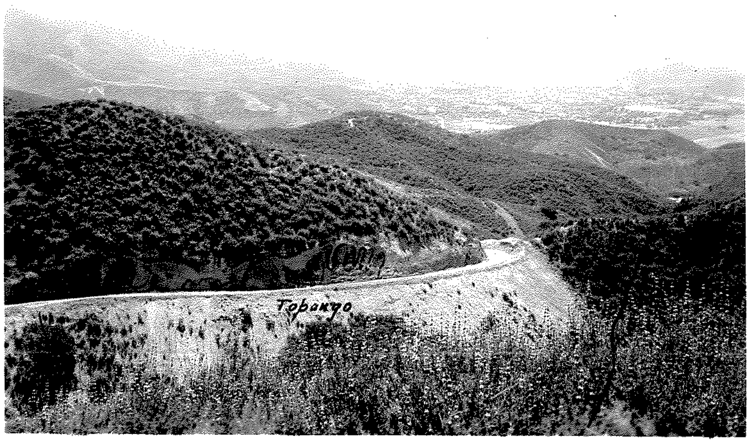


Figure 3.
Wrinkling in the Fascination Shale. The Sunland Fault

The stratiagraphic throw must be at least 3800 fee and perhaps more. This may be determined by the fact that at a point 800' above the top of the youngest Saugus beds lies the Basal Conglomerate of the Miocene beds and 3000' of sediments have been removed from above the Basal Conglomerate. The maximum figure would probably be a throw of 5500'.

The Sunland Fault Scarp forms the southern slope of the San Gabriel Mountains in this region as shown in figure 4. The fault is responsible for the raising of the Fascination Series as well as the development of the Merrick Syncline and the Sunland Anticline. Farther to the west, this same (?) fault is known as the Lopez Fault, Mason Hill.*

* Ibid., page 149 and map opposite page 142

II. Herreres Fault

This is an oblique strike-slip fault trending for a known 4000' N 85° E from 8700' N 3° E B.M. 1198 (page 2), and a possible 4000', or more, S 85° W therefrom. The fault surface, which passes through the Saugus, separates the Fascination Series from the Saugus, passes through the Basement Complex, separates the Complex from the Fascination Series and then passes into the Complex again, is probably vertical.

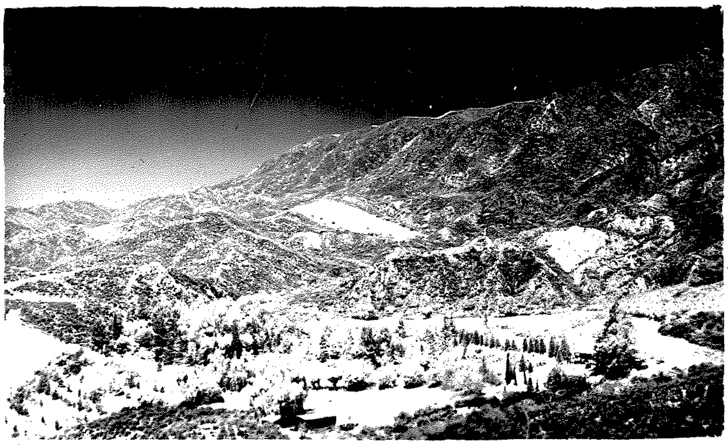


Figure 4.
General View of the Northern Part of the Area.
In the foreground, a Q.O.Al. Terrace along Big Tujunga C. In the middle, the Pico and Topango formations. Sunland Scarp in the background. (Infra-red photo by Legge.)

The surface is not clearly exposed at any point. There have been two known movements on the fault, one before and one after the Sunland Fault. In the second movement, the dip-slip was 200' and the strike slip was 425' with a total slip of 485'. The south block moved east and down at an angle of 28° (in the plane of the fault). The magnitude of the first movement is not accurately known but is estimated at a total slip of 900' to 1100' in the same direction.

A deep, steep-walled canyon follows the course of the fault through the Basement Complex. To the west, the fault disappears under the Q.O.Al. Terrace and the Little Tujunga Canyon. W. White who studied the area west of Little Tujunga Canyon, found a fault which appears directionally, to be the continuation of the Herreres Fault. This is merely stated as a possibility since further work would be required to determine the relationship, if any exists.

III. Red Gulch Fault

Probably related in age and originating forces to the Herreres Fault is the Red Gulch Fault which trends N 76° E for a known 2000' from 7800' N 18° E B.M. 1198 (page 2). The surface of the fault is no-where exposed but is probably vertical as may be seen by the trace on the topography. The fault brings together the Miocene Diabase of the Fascination Series and the Basement Complex; farther eastward, it runs into the Basement Complex. To the west, in the Saugus, the fault cannot be certainly traced; very likely it dies out rapidly in these sediments.

Red Gulch Fault, like the Herreres Fault, is believed to be oblique strike-slip with about a 20° departure of the direction of movement from the horizontal, dipping toward the east. The total slip on the fault is not less than 1490' with the south side moving eastward and down slightly.

If the direction of this fault curved slightly to the south as it were extended westward, it would pass through an offset of a red marker bed in the Saugus and finally join the East Branch of the Oliver Fault. No absolute evidence for this may be cited but the three factors line up to a certain degree, though the displacement on the Oliver Fault is less than that on the Red Gulch Fault. Both are strike-slip, the Red Gulch about vertical, while the Oliver dips 70° NW.

IV. Cactus, Oliver, and Lane Faults

All these faults are approximately parallel, and have similar attitudes and displacements. They are all best developed in the Pico beds though some may be traced into the Miocene and Saugus. The general trend is N 35° E for the Cactus and the Oliver, while the Lane trends N-S on the southern end, then turns and runs about N 30' east. The Oliver and the Lane branch at their northern ends. The whole group are strike-slip.

A. Cactus Fault

The dip varies from 90° to 70° NW. It may be traced continuously from the mouth of Cactus Canyon 6000' N 70° W B.M. 1198 (page 2) to a point within 500' of the Pico-Saugus contact. The total slip on the fault is 550'. This may be measured by the offset of the Tmc and Tmsh divisions of the Miocene near the mouth of Cactus Canyon. A definite bend occurs in the fault 800' north of the mouth of Cactus Canyon. In direct line with this southern portion, at 9000' N 64° W B.M. 1198 (page 2), is a considerable amount of shattering with the slippage surfaces parallel to the trend of the southern end of the Cactus Fault. Because of landslides and a Q.O.Al. terrace, definite evidence is not available, but the evidence above coupled with the disappearance of two marker-beds in the Tmsh division of the Miocene makes the possibility of a fault continuing up Cactus Canyon through the above cited point and into Little Tujunga Canyon plausible. Further detailed work would be necessary to settle this question.

B. Oliver Fault

The dip is vertical (?). The fault may be clearly traced north-eastward 2200' from the Pico-Miocene contact at 4000' N 34° W B.M. 1198 (page 2). Near the crest of the ridge, it branches. The Eastern Branch appears to pass through an offset in the Pico-Saugus contact though this has not been definitely proved because of the hinderance of brush and a heavy soil mantle. South of the location cited, the offset, which appears in the marker beds of the Miocene, suggests the probability of the continuation of the Oliver; land-sliding masks the definite proof. The total slip is about 400' as measured by the definite offset of the Pico beds. The west side moved southward relative to the eastside. Slickensides occur 4400' N 20° W B.M. 1198 (page 2).

Figure 5
Lane Fault in the Pico beds.

C. Lane Fault

This fault may be clearly seen at 3100' N 17° W B.M. 1198 (page 2), figure 5. From this point the fault is readily traced northward for 1000' at which point it branches and each branch continues another thousand feet. Beyond these points, soil mantle and brush obscure any traces. South of the location cited, in and about Schwartz Canyon, there is some evidence for contination in the offsetting of the Tmsh and Tmsi beds of the Miocene. The Pico-Miocene contact is offset in the wrong direction, but this may well be due to another of those ubiquitous landslides. The fault does not reach the Tmc-Tmsh contact in Miocene, however. The fault dips 70° W; the total slip is 230' with the east side moving south.

These three faults appear to be older than the Sunland Fault because the flexure described above does not seem to be offset by them. They may well be related to the Herreres and the Red Gulch faults as their attitudes and direction of motion seems to indicate.

V. <u>The Relief Faults</u>

In the middle of the north boundary of the area, east of Herreres Ranch, there are three faults all trending north and south and dipping westward from 50 to 70°. The author believes they represent relief faults for the Sunland Fault. All three are normal. The western fault is hardly more than a few tens of feet of slippage on a well developed joint. The middle fault has a heave of 200' and a throw of 150'. It divides the remnant of the Fascination Basal Conglomerate into three portions. The fault may be clearly traced through the Basement Complex lying to the north. It has been offset by the movement of the Herreres Fault. The eastern fault has a heave of over 600' and a throw greater than 450 to 500 feet. This fault, too, has been offset by the Herreres Fault. On the northern wall of Herreres Canyon, all three faults offset leucocratic and melanocratic divisions of the Basement Complex.

--INTRUSIVE STRUCTURES--

Along the eastern half of the northern boundary of the area lies a mass of basic volcanic material with a known length of over 7000' and a width varying from 100' to 1500'. It lies between the

Basement Complex on the north, and the Fascination sediments on the south.

Mason Hill* suggested that the mass was a basalt flow. Thin sections of the material have shown both holocrystalline and percrystalline textures, but mainly the former. There are three stages of plagioclase in the percrystalline type and two stages in the holocrystalline. The minerals present are listed in detail in a later section. The author has seen frequent examples of baking and chilling on the northern contact (with the Basement Complex). On the southern contact (the top of the body, it dips southward approximately 19° and strikes N 70° W) good indications of baking or chilling are not readily found except at 8000' N 24° E B.M. 1198 (page 2), where the sediments, which lap over because of the Sunland Anticline, have not been entirely removed from the igneous body. At this point small offshoots run into the sandstone from the underlying diabase. They penatrate several inches in some places where they are under an inch in diameter and several feet if they are larger. The sandstone is very white, which might indicate bleaching, figure 6. At 7850' N 25° E B.M. 1198 (page 2), there is an elliptical patch of diabase about

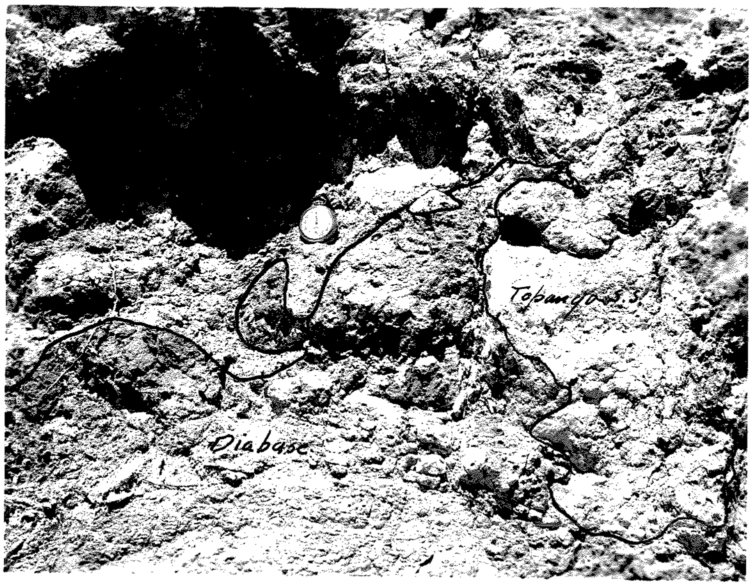


Figure 6.
Apophyses of diabase in Topango Sandstone.

* Ibid., page 142

50 feet long. A narrow tongue 3 to 5 feet wide extends intermittantly from the patch to the main mass. The whole body sharply transects the beds which are frequently of a fine-grained character and have nearly vertical dips. Occasional basalt boulders appear in some of the conglomerates, 150', stratigraphically, above the diabase, but a thin-section of one of these showed the boulder was not even similar to the diabase, but consisted of a quartz-latite. At 7875' N 26° E B.M. 1198 (page 2) was found a boulder of fossiliferous Miocene sandstone in the diabasic soil material on the ridge.

On the other hand, the igneous material is quite vesicular near the top contact. These vesicles are frequently filled with well crystallized calcite. No definite baking is present to any great extent. Iddingsite appears around the Olivine in some of the diabase.

With the mass of data pointing toward an intrusive body, the author feels that the diabase may safely be called an intrusive sheet, shallow probably, but never the less, intrusive.

--ANOMALOUS STRUCTURES--

On the Pico-Miocene contact, 2050' N 14° E of B.M. 1198 (page2) a peculiar feature may be observed. The Pico conglomerate bed in contact with the Miocene Silty Shale below, abruptly terminates. Vertical joints trending at right-angles to the strike of the beds are developed in the stub-end of the conglomerate. The shale beds, apparently uninterruptedly, continue with their usual attitude around this stub-end and extend over the top of the conglomerate in line with the fracturing, beds may be traced uninterruptedly, thus excluding the possibility of any extensive faulting.

The author cannot explain the abrupt termination, but believes the appearance of the tongue of conglomerate surrounded by shale is due to interfingering of the two members. That is, the conglomerate represents fans dumped into a shallow water body at the same time the shales were deposited. This interfingering is repeated east of the location cited.

There is a small patch of Pico conglomerate perched upon the crest of a hill composed of Miocene shales, 6000' N 55° W B.M. 1198 (page 2). The patch is removed from the Pico beds by several hundred feet and should not appear on the hill according to the dip of the Pico. This probably represents the remnant of an ancient landslide; such features, though not so old are very common in that vicinity.

HISTORICAL GEOLOGY

I. The first step was the formation of the Basement Complex. This was not investigated by the author.

II. Deposition of the Topango Series. The fossil material would indicate that at least a portion was marine. The increasingly finer sediments indicate a gradually decreasing relief in the source region.

III. The intrusion of the diabase. The time is conjectural, but was probably during, or just before the deposition of the Lower Modelo beds a few miles to the south.

IV. The deposition of the Modelo Formation followed, or was coincident with the diabase intrusion.

V. Renewed uplift of the source region as shown by the coarse Pico conglomerate. Westward, the sediments below may have tilted somewhat, but not toward the east, for the fingering is evident.

VI. Deposition of the Pico beds, partly fluviatile or lacustrine and partly marine. The highlands were gradually worn down and were renewed several times as shown by the interbedded conglomerate and shale.

VII. The Basin was tilted again, particularly toward the west. The highlands rose and the fluviatile deposition of the Saugus beds began.

VIII. During this time the Herreres, Red Gulch, Oliver, Lane, and Cactus faults are thought to have developed. The time cannot be placed much more accurately than this, for it is possible that they had their origin at an earlier date.

IX. Further uplift of the highlands and then the deposition of the upper part of the Saugus beds proceeded.

X. A general regional uplift and tilting was followed by the development of the Sunland Fault which formed the Sunland Anticline and the Merrick Syncline as well as this particular portion of the San Gabriel

Mountains. The relief faults also developed during this period.

XI. Regional erosion and dissection took place, at which time activity was renewed upon the Herreres Fault.

XII. The land-laid Q.O.Al. Terraces were formed in Tujunga Wash and Little Tujunga Canyon.

XIII. A slight uplift produced renewed activity in the streams which began to dissect these terraces.

XIV. Present-day erosion and deposition of Q.Al. in stream channels.

SPECIAL INVESTIGATIONS

DETAILED PETROGRAPHY

Section B.

Microscopic

1. Texture

    Docrystalline

    Fine-grained

    fabric

    Feldspars-subhedral (3 phases)

    Femags- subhedral

    Porphyritic-dopatic

    Hyloplitic

2. Minerals

    Essential

    Labradorite

Larger phenocrysts	An 51
Medium phenocrysts	An 63
Ground Mass	An 67

    Varietal

    Olivine (alterations to iddingsite)

    Accessory

    Augite

    Magnetite

    Calcite (Secondary)

    Alterations

    Iddingsite on Augite (almost complete)

3. Remarks

    The section appears quite dark because of the high percentage of iddingsite, magnetite, and some dark glass. The ground-mass feldspars are quite distinct in shape and have definite optical effects.

Section C.

Microscopic

1. Texture

Holocrystalline to per-crystalline

Fine-grained

Fabric

All crystals are subhedral

Pilotaxitic

Porphyritic, sempatic

2. Minerals

Essential

Labrodorite	An 58	(2 phases)

Varietal

Olivine	(altered to iddingsite)

Accessories

Augite	
Magnetite	
Calcite	(Secondary)

Alterations

Iddingsite	(very fine pseudomorphs after Olivine)

3. Remarks

This section is lighter than "B" since it contains less magnetite. It has practically no glass. The ground-mass feldspars are much more closely packed. The feldspar phenocrysts exhibit a strange phenomenon which looks like a "graphic intergrowth of glass and feldspar" though this is probably not the actual case. Dr. Ian Campbell suggested the possibility of weathering effects. The author suggests that the "glass" may be some sort of a zeolite.

4. Illustration

Magnification 72 x

Plane-Polarized Light

A= Augite

Id= Iddingsite

Mag= Magnetite

F.G.= Anhedral feldspar

F= Subhedral feldspar

Paleontological Evidence

The following species from the Fascination Series have been tentatively identified. The weight of evidence indicates Upper Topango.

PELECYPODA

Nuculana, sp	
Saxidomus nuttalli Conrad	Topango
Cryptomya, sp	
Chione temblorensis Anderson	Topango
Pecten(Plagioctenium) discus Conrad	Miocene

Pecten (*Plagioctenium*) *pabloensis* Conrad — San Pablo (U. Miocene)

Phacoides (*Lucinoma*) *acutilineatus* Conrad — Topango

Clementia, sp

Mya, sp

Clementia / *Phacoides* — This specimen may possibly be either.

GASTROPODA

Neverita cf. *reculuziana* Petit	Topango
Drillia sp. *wilsoni* Anderson and Martin?	Topango
Oliva californica Anderson	Topango
Natica multipunctata	Topango
Cancellaria dalliana Anderson	Topango
Turitella, sp	
Lunatia, sp	

NOTE. Where Topango is given as the age determination of a particular form, the word means only that the form was identified by comparison with a Topango specimen, but it does not necessarily mean that the newly identified fossil is restricted to the Topango.

Work of Russell Hayward

--BIBLIOGRAPHY--

Hill, M. L.

1930 Structure of San Gabriel Mountains North of Los Angeles U. of Cal. Pub. in Geol., Vol. 19, No. 6, pp. 137-170.

Kew, W. S.

1924a. Geology and Oil Resources of part of Los Angeles and Ventura counties, California, U. S. Geol. Surv. Bull. 753, 197 pp, map and sections.

Johnson, H. R., and Warren, V. C.

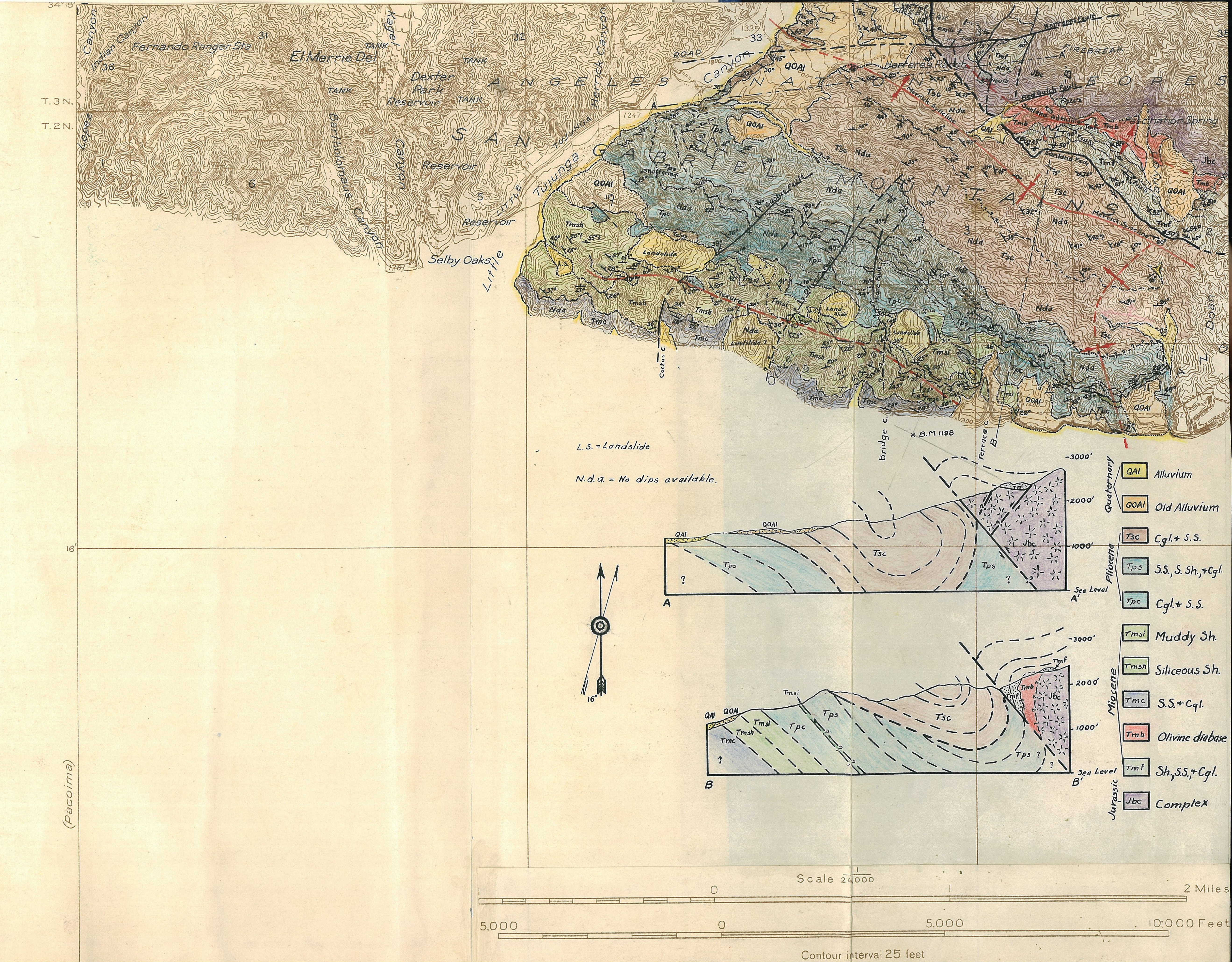
1927 San Gabriel investigation, Calif. Dept. Pub. Works, Div. of Water Rights, Bull. 5 73-101

Mendenhall, W. C.

1908 Foothill Belt, Southern Calif., U. S. Geol. Surv., Water Supply Paper 219

Trask, J. B.

1855 Report on geology of Coast Mountains. Calif. Sen. Doc. 14, 95 pp.



34°18'
T.3N.
T.2N.
16'
(Pacoima)
Fernando Ranger Sta.
El Merrie Del
Dexter Park Reservoir
Reservoir
Reservoir
Selby Oaks
Little Tujunga Canyon
ANGELES
SAN GABRIEL MOUNTAINS
Cactus C.
Bridge C.
Terrace C.
× B.M. 1198
Landslide
L.S. = Landslide
N.d.a. = No dips available.
A
A'
B
B'
Sea Level
1000'
2000'
3000'
Quaternary
QAl Alluvium
QOAl Old Alluvium
Pliocene
Tsc Cgl. + S.S.
Tps S.S., S. Sh., + Cgl.
Tpc Cgl. + S.S.
Miocene
Tmsi Muddy Sh.
Tmsh Siliceous Sh.
Tmc S.S. + Cgl.
Tmb Olivine diabase
Tmf Sh., S.S., + Cgl.
Jurassic
Jbc Complex
Scale 1/24000
0
1
2 Miles
5,000
0
5,000
10,000 Feet
Contour interval 25 feet