G E O L O G Y O F
T H E S T. F R A N C I S D A M A R E A,
L O S A N G E L E S C O U N T Y, C A L I F O R N I A.

Thesis by

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LIST OF ILLUSTRATIONS

FIGURE: PAGE

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ABSTRACT

About 5000 feet of Tertiary sediments is exposed in the general vicinity of the old St. Francis Dam Reservoir, in San Francisquito Canyon, Los Angeles County, California. The area where these sediments occur is located in the easternmost part of the Ventura Basin.

At least 500 feet of well bedded red siltstones, shales, sandstones and conglomerates of continental origin is overlain by 2700 feet of piedmont deposits made up of coarse conglomerates, fanglomerates, and associated finer grained clastic rocks. No specific age can be assigned to these deposits, but to the north they are unconformably underlain by marine strata of Eocene age. These are thick bedded to massive arkoses. To the west, south and southwest the piedmont deposits are unconformably overlain by non-marine conglomerates and massive sandstones of the Upper Miocene Mint Canyon formation. The evidence prevails that the sediments in the area studied become progressively younger to the south and to the west, as happens everywhere else in the easternmost part of the Ventura Basin. Fossiliferous beds of the uppermost Miocene Modelo formation unconformably overlie the Mint Canyon beds to the south and to the west.

Pre-Cretaceous rocks composed of gray, quartz-muscovite, schist crop out in the northeasternmost part of the area. Metaquartzites and quartz veins are minor parts of this terrane. This group of rocks is known as Pelona Schists.

Pre- and post-Mint Canyon dip-slip reverse faulting seems to

form the dominant structural feature of the area. A possibility of normal faulting exists in the northwestern part of the area, between Eocene(?)-Miocene(?) rocks and the Mint Canyon formation, and is fully considered in the text.

The sedimentary formations are folded, and the axes follow a northwest-southeast direction in the northern part of the area, and are probably related to a first stage of deformation in pre-Mint Canyon times; to the south, the fold axes trend north-south, and seem to be related to a second stage of deformation that probably took place in post-late Miocene time.

The area is in its late youth to early mature state of topographic development. The stream along San Francisquito Canyon cuts across the structure of the Pelona schists indiscriminately for at least one mile, reflecting inheritance of a drainage system established under different conditions. Cavernous weathering is largely confined to many beds of hard, massive, conglomeratic sandstone of Eocene(?)-Miocene(?) age, in the north central part of the area.

INTRODUCTION

Location and Physical Features.

The area discussed in this report is located in the easternmost part of the Ventura Basin, in Los Angeles County, California, and covers about 14 square miles. The southernmost part of the area is 5 miles airline distance north of Saugus, which in turn is 45 miles northwest of Los Angeles. The entire area is crossed by a narrow, paved road, which extends along much of San Francisquito Canyon and connects the town of Saugus with Hughes Lake, 29 miles to the north. Excellent rock exposures are present on both walls of the canyon, and can be reached easily from this road.

A tractor road extends westward from the site of the St. Francis Reservoir, and gives access to the western and northwestern parts of the area, in the vicinity of Charlie Canyon. To the southeast, well maintained dirt and gravel roads serve the area north of Dry Canyon Reservoir. (See Index Map, Fig. 1)

Both Charlie and Dry Canyons can be traversed along good trails for reasonable distances up stream from the southern end of the area. In addition, several firebreaks and trails, maintained by the U.S. Forest Service, cut irregularly across hilly country throughout the whole area.

The lowest point in the area is in San Francisquito Canyon, west of the Dry Canyon Reservoir, and is 1317 feet above sea level; it is situated in a wide span of alluvium which separates hills 300 to 400 feet high. The highest point in the map area is on the west side

INDEX MAP

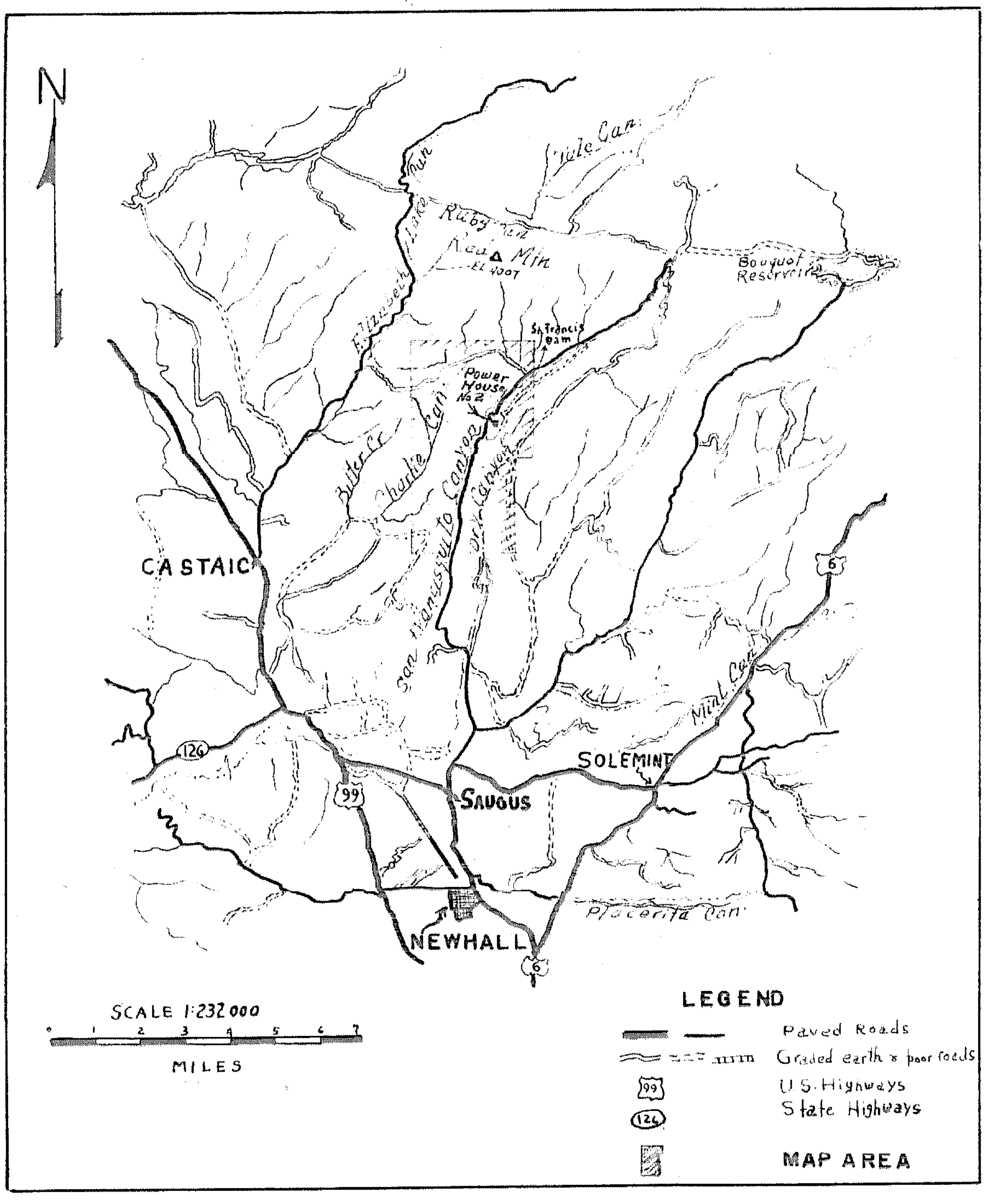
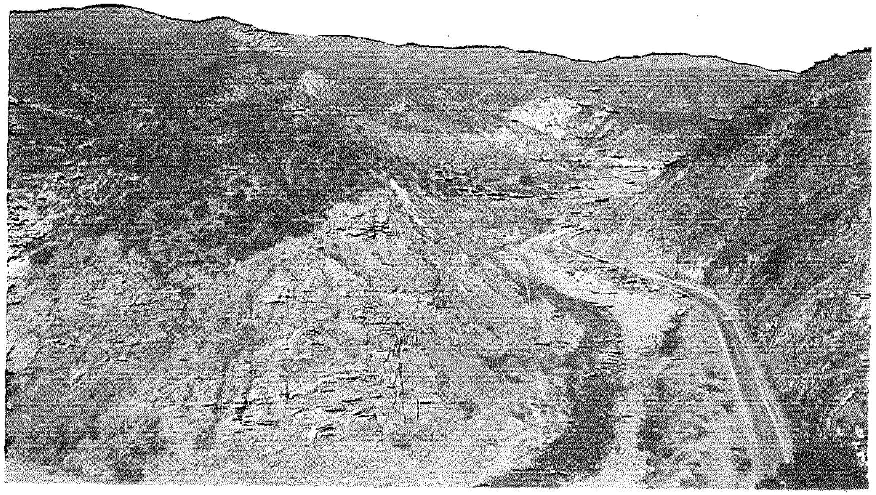


FIG 1



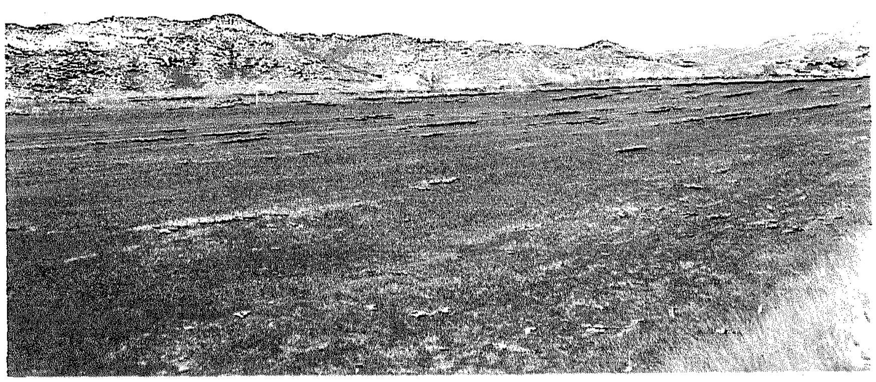


Plate I. Above: General view along San Francisquito Canyon illustrating winding pattern of the stream.
Below: View looking north from the paved road of San Francisquito Canyon, several miles south of the area.

of Charlie Canyon and is the summit of an isolated, cone-shaped, steep sided ridge; its crest is 2356 feet above sea level. Considerable altitude is rapidly gained beyond the northern limits of the map area. For example, the geographic points known as Sierra Pelona lookout, Red Mountain, and Jupiter Mountain are 4850, 4047, and 4496 feet above sea level, respectively.

Most of the canyons and arroyos are narrow and steep sided, specially in the north central part of the area, where the general relief is high. Here the backwearing of slopes is slow in comparison to downward, vertical cutting. A badland topography is clearly shown in the same part: extensive mechanical disintegration of coarse sandstone and bouldery conglomerates has left an irregular distribution of more resistant bodies, which in general are most abundant on the top of the hills.

North and northeast of Dry Canyon the relief is low; gently rolling country characterizes a topography developed on an old series of rocks, known as Pelona schists, which cropout in this part of the area. Here the Pelona schists form a tongue projected from the southern flank of the Pelona anticline, a structural feature lay several miles to the northeast.

Very narrow and winding paths along part of San Francisquito Canyon are present: the road in the canyon bottom makes many sharp turns in following the abrupt bends carved by San Francisquito Creek.

The main direction of drainage is northeast-southwest. During the wet season, usually in winter time, the main streams flow into the Santa Clara River; precipitation varies from one year to another; the mean annual value is approximately 15 inches. The climate is semi-arid, and is very dry for almost four fifths of the year. It is expected, therefore, that rapid evaporation and percolation impede superficial flow of streams during a reasonable amount of time. Local cloudbursts, however, do occur occasionally, and result in very high run-off along those streams that drain the areas of precipitation.

The most common type of vegetation is represented by a thick growth of several kinds of a medium sized bush. Several slopes are practically covered with it, and make the field work slow and difficult. In some parts, where protection from sun, precipitation and prevailing winds is achieved, an evergreen variety of tree grows, adding to the strong hilly landscape a contrast of life and color.

Population.

The Canyon is sparsely populated; the inhabitants are owners of several acres of land, and concentrate on cultivating the terraces and floodplain areas of the stream and its major tributaries.

Power House No. 2, 10 miles north of Saugus, holds several men working for the maintenance and continuous supervision of the turbines and their related equipment; under 530 feet of head of water, coming down from a reservoir located on top of the adjacent eastern hills, the energy delivered to Los Angeles County is 43,600 kilowatts.

Gold-quartz veins in the Pelona schists have been worked on a very small scale, and there has been some search for copper in breccia-like material that occurs on a ridge between San Francisquito and Charlie Canyons. Flagstone from certain layers of the Pelona schist has been quarried to a limited extent.

Scope of this work.

The purpose of the present study was to determine, in detail, the stratigraphy and structure of the area in the general vicinity of the old St. Francis Reservoir.

Field and Office work.

45 days were spent in the field. Point elevations and magnetic north directions were plotted in a good, 1/12000 scale U.S.G.S. topographic map with the aid of a Brunton Compass; short distances on the ground were measured by pacing.

The office work covered three and a half weeks. Drafting, and the preparation of illustrations as well as writing and typewriting of the manuscript took two and a half weeks. Six days were necessary for the examination of thin sections under the petrographic microscope; a rapid review of vertebrate fossils of the Mint Canyon formation was given during this interval at California Institute of Technology.

Previous work.

The investigations which followed the failure of the dam in 1928 included several geological studies in connection with engineering problems in the Old St. Francis Dam Site 1/.

1/ See, for example, publications by F.L. Ransome on the "Geology of the St. Francis Dam Site", Economic Geology, Vol. 23 No. 5, pp. 553-563, 1928, and Bailey Willis, on the "Report on the Geology of the St. Francis Dam Site, Los Angeles County, California", Western Construction News, Vol. 3 No. 12, pp. 409-413, 1928.

Kew 2/ investigated the geology of a large area to the south,

2/ Kew, W.S.W. "Geology and Oil Resources of a part of Los Angeles and Ventura Counties, California". U.S.G.S. Bull. No. 753, 1924.

emphasizing the fault relations between basement rocks and upper Miocene formations.

An important collection of vertebrate fossils, attributed to the Mint Canyon formation, was made under the direction of the late paleontologist and stratigrapher, Chester Stock, but these have not been classified thus far. Maxson 3/, and Jahns 4/, likewise

3/ Maxson, John H. "A Tertiary Mammalian Fauna from the Mint Canyon formation of Southern California", Carnegie Inst. of Washington, Publ. No. 404, pp. 77-112, 1928.

4/ Jahns, Richard H. "Stratigraphy of the Southernmost part of Ventura Basin, Cal., with a description of a new Lower Miocene Mammalian Fauna in the Tick Canyon Formation", Carnegie Inst. of Washington, Pub. No. 514, pp. 145-194, 1938.

collected and studied some fossils from near-by areas.

Clements 5/ described the features of the area, mainly

5/ Clements, Thomas. "Structure of Southeastern part of Tejon Quadrangle, California". A.A.P.G. Bull., Vol. 21 No. 2, pp. 212-232, 1937.

in general structural and stratigraphic terms. Other authors, including Miller (1952), Hill (1939) and Halloway (1940), have made contributions that directly or indirectly have some connection with the work performed by the writer.

Acknowledgments.

This work could not have been carried to its completion without the invaluable help of several persons. Dr. Richard H. Jahns, from California Institute of Technology, gave advice on the general nature of the problem, and took the writer to northeastern localities, where evidences of special flow and sedimentological processes occur in rocks that probably are related in age to sediments thereafter encountered by the writer in his own area. Fruitful talks with Mr. William R. Muehlberger, of California Institute of Technology, substantiated some of the conclusions set forth in this report.

Of special aid to the writer was the tentative classification, made by Dr. George Edward Lewis, of the United States Geological Survey, of some vertebrate fossils from the Mint Canyon formation.

The field work was considerably stimulated by the generosity, hospitality and courtesy of Mrs. and Mr. Louis Raggio who, for six weeks during the summer of 1952, were hosts to the author in their home, on the San Francisquito Canyon Road, 8 miles north of Saugus. The permission given by Mr. H. Brown, of Brook's ranch, 7 miles north of the dam, for going through the gate of the earth road connecting St. Francis Dam with Charlie Canyon, is greatly appreciated.

Several persons of the community of Power House No. 2 aided the author in different ways during the time spent in the field.

The laboratory and library facilities at California Institute of Technology were of great assistance in the preparation of the manuscript.

STRATIGRAPHY

Metamorphic and clastic sedimentary rocks are distributed extensively in the map area. About 5000 feet of sediments, ranging in age from Eocene to Recent, were deposited in an area underlain by granitic and metamorphic rocks. The sediments are younger to the west and to the south, indicating that the area studied represents the margin of a large basin.

Basement rocks.

The northeasternmost part of the area studied is represented by 3.2 square miles of metamorphic rocks named by Hershey 6/ Pelona schists. It forms part of a tongue projected to the southwest from the southern flank of the Sierra Pelona anticline.

A thrust fault separates the Pelona schists from Eocene(?)-Miocene(?) red beds on the west, whereas a non-conformable depositional contact with upper Miocene Mint Canyon formation is clearly indicated

6/ Hershey, O.H. "Quaternary of Southern California". The American Geologist, Vol. 29, 1902a, Legend of map Pl. I.

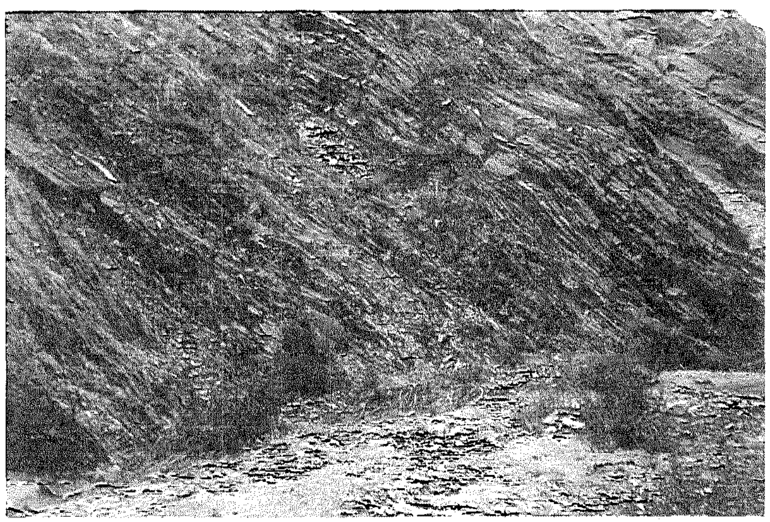


Plate II. Above: Contact relations between Pelona schists and overlying thin red beds and light yellow conglomerates of the Mint Canyon formation.

Below: A good exposure of Pelona schists; view looking west from paved road in San Francisquito Canyon .

on the south and southwest. (See Fig. 2, or section F-G, Fig. 5).

Despite the metamorphic character of the Pelona schists a distinct gross bedding is recognized where the outcrops are well exposed (Pl. II, lower picture); in general the beds are split into thin to thick bedded units, composed by an alternation of gray, fine to medium grained, quartz-muscovite, schists, and white metaquartzites. Veins of quartz, probably of hydrothermal origin, cross-cut the schists in several places.

From the few schist samples collected in the area, the following summary of petrographic features was obtained:

I.

1. Mineral grains: 60 per cent of rock.	Optical Properties:
Quartz: 40-50 per cent grains	Conchoidal fracture Wavy extintion Inclusions Irregular outlines Fractured Low positive relief Uniaxial positive
Muscovite: 40 per cent grains (partly sericite)	High birefringence Parallel extintion Strain shadows Twisting of grains Biaxial negative
Biotite (rare)	Parallel extintion Opaque Small 2V
Magnetite	Opaque Euhedral forms
Chlorite	Green, micaceous, alteration from biotite

	Optical properties
Limonite	Massive Yellow-red color
Hematite	Opaque Produced by weathering of magnetite.

2. Matrix: 40 per cent rock.

Composed of an almost colorless, slightly opaque, assemblage of minerals, among which recrystallized quartz is conspicuous.

II. Texture and Structure.

Fine grained in general. Isolated grains of medium-grained quartz are present.

Schistosity has been accompanied by segregation of quartz-feldspathic and micaceous minerals into alternating lamellae.

Mica plates commonly inclose or surround quartz grains.

Few of the feldspar grains are twisted.

Muscovite is so strained that different interference colors, red-rose, blue and green, are shown in thin section.

Some grains show replacement of feldspar by muscovite.

Mica plates and c-axis of quartz are oriented parallel to the main direction of bedding.

In regard to the origin of these rocks, it is possible to accept that previously to metamorphism the mineral composition was characterized by being that of clay, silt and sand, with a high quartz-feldspar content.

The absence of calcium bearing metamorphic minerals evidences an environment of deposition through non-carbonated, probably marine waters.

High temperature metamorphic minerals are absent in the Pelona schists, and abundance of low temperature hydrous minerals such as micas, suggests formation at lowest metamorphic temperatures. It is evident, therefore, that metamorphism occurred at no great depth, probably less than 10 kilometers. The source of static pressure was achieved by the weight of overlying sediments, as strongly suggested by the slate cleavage developed parallel to bedding. Contemporaneous and post-metamorphic folding, generally broad and in a large scale, facilitated the opening into which several quartz veins were deposited. It was responsible, too, for the bending of micaceous minerals.

The thickness of the metamorphic rocks has been measured outside the limits of the area, in one of the limbs of Pelona anticline. 8,300 feet were recorded. The age of these beds is probably pre-Cretaceous, taking into consideration that metamorphism and batholith intrusions occurred elsewhere in California during the Jurassic, and also during the Cretaceous.

Eocene rocks.

The northernmost part of the map area includes rocks of probable Eocene age. No fossil evidence was found by the writer, but Clements 7/ indicates that farther north invertebrate fossils, characteristic of marine Eocene faunas, have been collected.

7/ Clements, Thomas. op. cit. p. 214, 1937.

Eocene(?)-Miocene(?) red beds in the north are faulted against the Eocene rocks and are overlain unconformably a short distance to the southwest by non-marine Miocene Mint Canyon beds.

The Eocene stratigraphic section is several hundred feet thick and the beds extend well beyond the limits of the map area.

In general, it consists of light yellow, medium to coarse grained, thick bedded to massive biotite-bearing arkoses, interbedded with thin to medium-thick layers of conglomerate. Thin beds (about one foot in maximum thickness) of drab-brown shales are found more rarely.

Several patches of coarse, yellow conglomerates of the Eocene section are well exposed along the road in San Francisquito Canyon, 2.2 miles north of St. Francis Dam. In general, they are 15-20 feet thick, and consist of 75-90 per cent of pebbles, cobbles and boulders very well rounded, the nature of which is largely that of monzonites, diorites, quartz-diorites and porphyry andesites; a few cobbles are made up of quartzites and perhaps gray crystalline limestone. The subordinate matrix is quartz-feldspathic. These conglomerates are overlain by a thick series of yellow, massive arkoses, and are faulted against Eocene(?)-Miocene(?) red beds.

There is little change in lithologic facies among the Eocene rocks, both laterally and vertically; their predominant composition, great thickness and the areal extent, suggest formation on a subsiding area of deposition adjacent to rapidly rising granitic ranges which perhaps lay to the north and northwest. The origin of the volcanic constituents occurring in the conglomerates is unknown.

Eocene(?)-Miocene(?) rocks.

Continental deposits of Eocene(?)-Miocene(?) age are extensively distributed in the area mapped. They cover approximately 5 square miles, are separated from older formations by faults to the north and northeast, and are overlain by younger beds to the west and to the south. A detailed discussion of the faults is prepared under the heading of "Structural Geology". The thickness of the section is variable. A maximum of 3500 feet was measured.

The character of the sediments is not uniform; variation in lithology, texture, and bedding are common throughout. Clastic rocks like mudstones, shales, silts, sandstones and conglomerates occur with consistent, rapid changes in thickness and lithofacies, both laterally and vertically.

Age of the sediments.

Sharp 8/ applied the name Vazquez to a series of sediments

8/ Sharp, R.P. "Geology of Ravena Quadrangle", Pan American Geologist Bull., Vol. 63, p. 314, 1935.

that have some resemblance to the ones studied by the writer.....

"18 miles east of Saugus, apparently 9000 feet of early Tertic fanglomerates, and 4000 feet of curiously interbedded basalts are exposed. They lie unconformably on a pre-Tertic basement, and unconformably under the Mint Canyon formation (upper Miocene)" ... "The fanglomerates of the Vazquez section are composed of angular fragments of anorthosite, quartz-diorite, granite and gneiss, commonly a foot or two on diameter, though larger fragments are abundant".

No basalts are present in the map area, and anorthosite fragments are extremely rare in the sedimentary rocks. On the other hand, Stock 9/ determined the range in age of beds which have great

9/ Stock, Chester. "Sespe Faunas", Pan American Geologist Bull., Vol. 63, p. 314, 1935.

similarity in lithology with the lowermost section of the sediments under discussion. Quoted from his report is the following: ....

".. Vertebrate faunas have been obtained in the Sespe formation of Southern California... north of Simi Valley, Las Posas hill, and South Mountain. At least four stages in the history of North American mammal life are known in the stratigraphic record of the Sespe section, and these range in age from upper Eocene to lower Miocene".

The writer is compelled to assign an Eocene(?)-Miocene(?) age to the section present in the map area; it is probably younger than Eocene rocks on account of the rounded clasts of arkosic rocks, probably derived from the Eocene section that are present in some conglomeratic beds of the section under study. It certainly antedates the overlying Mint Canyon series, which has been found to contain vertebrate fossils of Upper Miocene.

For purposes of facilitating the study, two main bodies of sediments are considered:

a) The highly red, maroon and pink colored beds, which occur in the lowest part of the stratigraphic section.

b) The sandstones and coarse conglomerates that overlie the lower beds and in general are of different color, texture, bedding, and composition.

In the geological map (Fig. 2) the boundary between those two main bodies was traced. Careful observation in the north disclosed that one is transitional into the other. In this part of the area, therefore, the boundary traced is purely tentative.

Hills of low or moderate relief are formed by the lower beds. On the map the beds appear as irregular patches. In front of Power House No. 2 their thickness is 470 feet, but it increases rapidly to the north and northwest, to 1000 feet or more.

The lower beds are made up of medium to coarse grained feldspathic sandstones and arkoses, intercalated with poorly consolidated conglomerates, mudstones, and silty shales. The major constituents of the conglomerates vary in size and composition from place to place. Near St. Francis Dam the ratio of sedimentary pebbles and cobbles to igneous clasts is roughly 4 to 1. The fragments of igneous rocks consist of unidentified dark volcanics, and some coarse grained diorites, much altered. Metamorphic rocks fragments, made up of schist and gneiss, are rare. A shining luster is peculiar in some of them, even after having been broken.

The sedimentary major constituents of the conglomerates, at the same locality, consist of feldspathic sandstone, fine to medium grained in general; grains of quartz and feldspar are poorly rounded; the degree of sorting is poor to moderate. In thin section, it is observed that the matrix forms between 15 and 20 per cent of the total rock, and it is occasionally associated with biotite flakes.

The source of the red coloring agent is unknown. Many sand grains are merely coated with thin films of hematite. The association, at least in part, of biotite and hematite leads to the belief that biotite contributed to the formation of hematite after deposition. However, most of the facts previously established suggest that these beds were red-colored before deposition. According to Krumbein 10/ ...

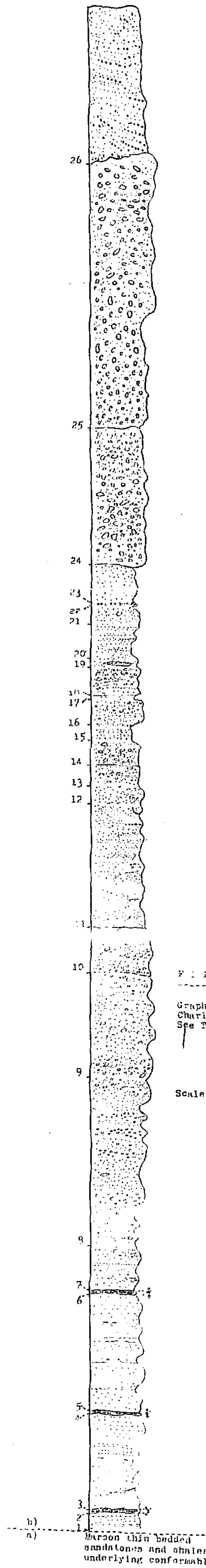
10/ Krumbein, W.C. and Sloss, L.L., "Stratigraphy and Sedimentation" p. 371, 1951.

"Primary red beds form in the piedmont and upper reaches of alluvial planes and are characterized by conglomerate, coarse sandstone and red silty shale. The climate of the source area is postulated as sufficiently warm and humid to produce red soil on the interfluves. Erosion of the rapidly rising source area provides red clay from the soil and unaltered feldspar from the rapidly incising valleys. The depositional conditions may include almost any climatic factors. The essential feature is preservation of the red color accomplished by rapid burial in an oxydizing environment".

The larger concentration of hematite occurs in the lowermost deep-marooned beds. Up section they change into brown. The line marking this difference in color may be mapped only in some places. In the north, where that contact is no longer traceable, its indication on the map is approximate. Generally the fine clastics predominate towards the south, but *inclosed boulders 1-2 feet thick are far from rare.*

In the northwesternmost part of the area, resistant, thick-bedded conglomerates can be traced for about 1/2 mile in a direction west-east (see Fig. 2 and picture on Plate VI). They are overlain by a body of white-weathering sandstones and thin bedded conglomerates, which apparently wedge out within a short distance towards the east. They probably are tuffaceous, and are well exposed in the road connecting St. Francis Dam and Elizabeth Lake. (An abrupt change in structural attitude in regard to the adjacent beds is indicative of cross faulting.) A peculiar thin lamination is present; annual sedimentation of clay and fine grained sand is indicated by an alternation of fissile shales and sandstones. The environment responsible for such kinds of texture and lithology was that of a lake, with a fluctuating annual ground water supply.

The upper section of beds has a maximum thickness of 2700 feet.



F I G U R E 3.

Graphic presentation of Charlie Canyon Section; See Table I on text P.22.

Scale: 1 inch = 100 feet.

Badlands are formed by it at different places. A rugged country occurs for most of the parts where it is present.

The upper section of beds is characterized by heterogeneous composition and texture; bedding is rarely continuous. Individual beds intergrade one into another. Therefore, it may be seen that key beds indicated either by time or lithologic units cannot be followed and mapped within reasonable distances in such a great thickness of clastic sediments.

For purposes of illustration a detailed stratigraphic section is described. Figure 3 is the graphic presentation of it.

TABLE I.

Charlie Canyon Section, Los Angeles County.

Section of Eocene(?)-Miocene(?) rocks, measured along Charlie Canyon, approximately 3 miles west airline distance from St. Francis Dam. Section extends from outcrops 800 feet immediately south of tractor road to canyon outcrops 1.5 miles southwest. (Sec. 2, R 16 W, T 5 N). Red Mountain Quadrangle.

Unit		Thickness (feet)
26	Massive sandstone, weathers light red, made up of granitic igneous rock grains. Interfingers with thin to medium bedded layers of conglomerate....	250?
25	Conglomerate, weathers buff-gray. Major constituents vary from pebble size to several feet large, mainly made up of diorites and granodiorites. Forms resistant ridge on highest hill of west wall of Charlie Canyon........................	560

Unit		Thickness (feet)
24	Coarse conglomerate, about 90 per cent large cobbles of coarse grained, light gray granodiorites; and 10 per cent of sandy matrix of same composition. Yellow, feldspathic quartzite cobbles become subordinate at bottom; they are in general coarse grained..	231
23	Quartzose sandstone, red, medium to thick bedded, coarse grained in general; thin pockets of conglomerate in between...............................	63
22	Conglomeratic pocket containing large cobbles, mainly of coarse grained granitic rock, and brown weathering quartzitic sandstones....................	4
21	Sandstone, red and green, medium to thick bedded, medium to coarse grained, composed of 70 per cent feldspar and 20 per cent quartz, with 10 per cent silt and clay. Contains isolated, poorly rounded pebbles and cobbles of granitic rocks...............	31
20	Silty sandstones and shales, interbedded with pockets of conglomerate 1-2 feet thick, which contain light colored granitic and granodioritic pebbles. Few unconformities between those beds................	52
19	Sandstone, red, coarse grained, quartzose, interbedded with red silty shales........................	16
18	Sandstone, red, coarse grained, quartzitic, interlensed with cobbly conglomerate, which contains 50 per cent of fragments of igneous rocks, light colored and coarse grained, and 50 per cent of sandstone fragments, brown, coarse grained, quartzose..	47
17	Silty shale, red.......................................	4
16	Conglomerate, sandy, poorly sorted. Medium to well rounded pebbles and cobbles up to 6 inches across, made up of coarse grained granite and brown quartzose sandstone..........................	36

Unit		Thickness (feet)
15	Quartzose sandstone, brown to red, coarse grained, pebbly, well stratified; it graduates into silty shale at the top....................	21
14	Pebbly conglomerate, with few boulders up to 2 feet long. About 60 per cent of total major fragments are composed of brown, limonitic, quartzose sandstone, medium to coarse grained...	36
13	Sandstone, conglomeratic, red. Few boulders, poorly rounded, up to 1.5 feet long, mainly made up of light colored coarse grained granitic rocks......................................	37
12	Same as 13, but with a larger content of boulders......................................	32
11	Feldspathic sandstone, red generally lense shaped, not resistant to erosion. Few pebbles at bottom, with a considerable increase in size and number at the top. Fragments predominate in coarse grained igneous rocks, with coarse fine-grained, brown quartzites. In this body of rocks, pebbles and cobbles form about 35 per cent of total. Sandstones are fine to coarse, and are cross bedded..........................	239
10	Coarse conglomerate, in tight pockets; cobbles and boulders of granitic and quartz-dioritic composition, in general mediumly rounded. Brown, fine to very fine grained quartzitic arkose cobbles, well rounded, form about 1/3 of total major constituents at the top....................	78
9	Sandy conglomerate; sand becomes subordinate up section, pebbles at bottom. Considerable increase in size and amount of pebbles up section. The composition of them ranges between coarse grained quartz-diorites, diorites and granites, some of which have pink phenocrysts of orthoclase feldspar 1 to 2 inches long. Few pebbles of black, fine grained igneous rock, perhaps norite....................................	172

Unit		Thickness (feet)
8	Sandstone, red in general, quartzose, medium to coarse grained, subrounded grains, conglomeratic. Pebbles are composed of yellow to brown quartzites, feldspathic sandstone, and silty arkoses. Individual layers of conglomerate, up to 10 feet thick. Few black and red pebbles, much rounded, probably volcanic..................	286
7	Sandstone, medium to coarse grained, in ledges varying from 2-8 feet thick, light-brown red. Subordinate ledges of conglomeratic sandstone in between. Igneous boulders, weather pink are up to 1 foot across, and composed of quartz diorite, poorly rounded. Fine grained brown quartzites in general poorly rounded. Few pebbles of pinkish red, much altered volcanic rocks. (A fossiliferous, grey limestone pebble with gasteropods up to one inch long is present.)	78
6	Conglomerate, 90 per cent of which is composed of fairly rounded pebbles and cobbles. About 50 per cent are granodiorites and anorthosite, very well rounded. The other clasts are composed of coarse grained, yellow quartzite and arkoses...............	4
5	Feldspathic sandstones, very coarse grained, thick bedded to massive, brown to dark brown, weather pink, occasional arkosic pebbles interlayered with brown shales, thin bedded...........................	197
4	Conglemerate; melanocratic, red pebbles and cobbles of igneous rock, fairly rounded. Few coarse grained granitic............................	2
3	Sandstone, biotitic, feldspathic, thick bedded to massive, brown in fresh surface. Weathers pink; crumply, loose, fine to coarse grained, with thin interbeds of brown chocolate shale which contain nodules of silty mud............	161
2	Brown conglomerate, mainly sandstone pebbles. Occasional quartz chunks and fine grained red igneous rock fragments, many of which are very altered..	16

Unit		Thickness (feet)
1	Sandstone, arkosic, fine grained, purple pink weathered surface, interbedded with layers 1 inch to 1.5 inches thick, of brown shale.......	26
	TOTAL THICKNESS	2699
	ROAD	

The decreasing order of abundance of igneous pebbles, cobbles and boulders, as far as rock classification is concerned, is as follows:

1. Porphyry quartz-diorite.

2. Micro-leuco quartz-diorite.

3. Porphyry diorite.

4. Light-grey, pinkish granite. (Coarse hollocrystalline texture, pegmatitic, in several places.)

The following appear much more rarely:

Purplish-red, banded, porphyry andesite.

Anorthosite.

Red aphanitic, fine grained, unidentified volcanics.

Black, fine grained norite (?).

Analogously, for the sedimentary major constituents of the conglomerates the order of abundance is as follows:

1. Fine grained, feldspathic sandstone, yellow to brown.

2. Very coarse grained quartzitic arkose, gray to pale yellow.

3. Medium to coarse grained, light yellow arkose.

4. Conglomeratic arkose. (Same as 3, but 10-15 per cent

of grains are made up of feldspar and quartz particles larger than 4mm.)

More rarely:

Clayey arkose.

Sub-graywacke?

Field evidence discloses an absolute increase in the amount of pebbles, cobbles and boulders of igneous composition to the west, but mainly to the south and southwest, as well as their rapid increase of size; the sand members show a larger content of igneous grains in those general trends. In some parts of Charlie Canyon, near the contact with upper Miocene beds, and in the west wall of San Francisquito Canyon, in front of Power House No. 2, unusual associations of igneous materials occur, shaping peculiarly the rough topography of a badland country. Tight consolidation and monomineralic character are features which can easily conceal their clastic origin. In some places it is possible to outline large boulders, thanks to a thin film of silt, which has been partly weathered to limonite. In others, the clastic origin is inferred when angular debris, of variable sizes, accumulate at the foot of steep slopes, thereby demonstrating, not mechanical disintegration from an igneous body, but, rather disaggregation from a clastic body previously consolidated.

The sedimentological processes responsible for such kind of deposits are suggestive of transportation under conditions of very low water content within a high proportion of solids. The almost solid mass would flow down slope from high parts by gravity, but it is believable that on parts of lower relief movement could continue for one, or perhaps, two miles, due to the inertia already gained and the plastic yielding of materials.

An original piedmont environment is indicated by the wide range of the deposits, from clays and silts to blocks of large dimension, and the general imperfection of rounding. According to Lawson 11/a fan-

11/ Lawson, A.C. "The petrographic designation of alluvial fan formations", Univ. California Publ. Dept. Geol., 7 (1925), pp. 325-334.

glomerate will result when lithification occurs; it is composed of a more or less heterogeneous association of units of conglomerate, sandstone, arkose, siltstone and claystone to form such a deposit. All variations of clastic sediments dovetail with each other, and there is much "cut and fill" structure. Sands and the finer gravels are likely to be cross laminated.

The sections of shales recorded in the stratigraphic column may be explained as deposition of clay and silt in basins formed between the fans.

The great thickness suggests the presence of an upland in process of elevation, which continuously yielded a supply of sediments to an area of deposition in process of subsidence. This upland, probably a granitic range, lay to the west, south and southwest, because, as previously established, igneous fragments in the sedimentary beds are more abundant in those directions. Likewise, the source of the sedimentary materials lay to the north. Coalescence of fans on the area of deposition and a renewal of elevation from time to time in the source areas is evident. A semiarid to arid climate is postulated.

Volcanic rocks.

Patches of volcanic rocks cap high parts of the ridge between Charlie and San Francisquito Canyons. They are extremely weathered, but their general characteristics may be outlined as follows:

1. The color varies from pale-brown to red ochre.

2. Some voids where feldspar phenocrysts were lodged are still traceable.

3. Quartz phenocrysts present, sub-angular and angular.

4. Contamination with foreign coarse material, igneous, gray, of heterogeneous size, much fractured and weathered is existent.

5. The matrix is much corroded, becoming soft, mud-like.

6. Partly vesicular and partly amygdaloidal.

7. Thickness about 15-25 feet.

8. Name: Breccia-like, porphyry-rhyolite.

These rocks may be considered to be, at least partly, of a volcanic flow breccia type. (Reason: point No. 4; fragments up to 10 inches size.)

Age: The stratigraphic position of the volcanic rocks and general characters suggest an Eocene(?)-Miocene(?) age. The writer does not have any clues as to locate them more precisely in the Tertiary geological column.—Their origin is unknown.

An unusual body of poorly sorted quartzitic schist, schist, and gneissic debris, heterogeneously mixed with minor amounts of quartz fragments, and loose sand, intergrates a few of the hills in Charlie

Canyon, and covers a small area southwardly. It lies unconformably upon the Eocene(?)-Miocene(?) rocks so far described under (b), and its maximum thickness is certainly 500 feet, but probably 600 feet or more. (See cross section F-G, Fig. 5.) The sandy matrix forms in general about 15-20 per cent and is largely composed of schist particles. and quartz fragments. No stratification or bedding are present, but the overall structural attitude has a component of dip of few degrees to the southwest. It apparently represents a flow of debris.

A patch of debris-like material, designated on the map as "brown breccia" caps a hill between Charlie and San Francisquito Canyons, east of the fault contact with upper Miocene beds, and overlies the schistic material previously mentioned.

Its character is probably tectonic. Thin sections made of it have shown intense fracturing of individual components, like a mesh, in some cases. Veinlets of secondary calcite and spherulitic quartz have filled the fractures. Heterogeneous assemblage of rocks is predominant but angular fragments of quartz are rather common. Cuprite and malachite minerals are present in minor amounts, weathering in the characteristic green and blue colors. They were probably deposited from percolating ground waters which in part had those minerals in solution. However, their primary origin is not known.

<u>Age</u>: The schistic materials antedate the upper Miocene, because they are not found overlying the Mint Canyon series. They certainly are post-volcanic in age, because they lie unconformably on one of the patches of breccia-like porphyry rhyolite. Their range in age is therefore Eocene(?)-Miocene(?).

Taking into consideration the bulk lithological composition and the broad textural and structural patterns, the source area appears to be the Pelona Schist mountains to the northeast.

Thickness	Eocene(?)-Miocene(?) rocks:
(a)	470 feet
(b)	2699
Volcanics	20
Schistic materials	500
Total Thickness	3689 feet

Mint Canyon formation.

Hershey named the Mint Canyon formation 12 /, a series of

12 / Hershey, O.H. "Some Tertiary formations of Southern California", The American Geologist, Vol. 29, No. 6, pp. 349-372, 1902.

units composed of upper Miocene conglomerates, sands, and gravels which cropout several miles east of Saugus.

Light colored sediments wedge out into a narrow strip in San Francisquito Canyon. Evidence based on vertebrate fossils found in the lower beds, as well as lithologic characteristics, has shown their equivalence to those first described by Hershey in Mint Canyon.

The land forms of the map area on which the Mint Canyon beds occur, display a topography of moderate relief. In general, the relief is less to the south, near the contact with massive Miocene beds of the Modelo formation.

Several types of clastic sediments interfinger with one another. Neither the conglomerates nor the sandstone and silt layers that compose the Mint Canyon beds are sufficiently uniform to be traced for great distances. Cut-and-fill structure is common. Striking differences in color and in texture were used to differentiate the units described in the following terms:

Basal gray conglomerate: This conglomerate attains a maximum thickness of 40-60 feet, and unconformably overlies the Pelona schist rocks; the exposures occur south of Power House No. 2 along a distance of 1/2 to 3/4 mile, forming isolated patches. Flat slabs, of variable size, poorly to well rounded and made up of gray schist, make up the coarse constituents of the conglomerate. A sandy unsorted matrix, with fragments of quartz and igneous rocks are intermingled throughout. The degree of consolidation is high.

1/3 mile southwest from Power House No. 2, west of the paved road, a white calcareous body overlies the gray conglomerate. It is 7-8 feet thick, and composed of very compact, hard, fine grained silty, tuffaceous, caliche(?), much contaminated with medium to coarse grain size schist particles and angular fragments of quartz (derived from it). The origin of the calcareous body is not certain. It probably represents an stage in which leaching out of calcium from overlying conglomeratic beds took place the constituents of which were mainly calcium plagioclases of igneous rocks, such as diorites and granodiorites.

Orange yellow conglomerate: The gray conglomerate gives way to poorly bedded conglomerates that contain a low amount of schistic fragments, and are mainly formed by pebbles and cobbles of light colored granitic igneous rocks; well rounded, dark colored, vesicular volcanics are present in about 5-10 per cent, and yellow quartzose sandstones are of minor importance. The matrix is unsorted and coarse grained; fragments of quartz are irregularly distributed. This bed grades laterally into light brown, to more sandy thick bedded facies. Its thickness varies from place to place; it is 45-50 feet thick in front of Power House No. 2.

In the area between San Francisquito Canyon and the east side of Dry Canyon, the contact of the Pelona schist and Mint Canyon formations is very irregular. The lower beds have a minor amount of schist fragments; apparently the sediments came from southern and southeast sources, stream transported, and were laid down on a surface very rugged of the basement complex, which was subjected to considerable erosion before sedimentation occurred. The conglomerates, generally light orange-yellow in color (near the basement contact) are composed chiefly of pebbles and cobbles of igneous rock, with a few boulders as well. A common variety of igneous rock among the pebbles is a porphyry diorite, light brown in color, with euhedral phenocrysts of zoned plagioclase. The matrix is quartz-feldspathic sand.

Light brown conglomerates, sand and siltstone: Southwardly, along Dry Canyon, the orange conglomerate changes laterally and rapidly up section into a series of light brown to light gray sandstones, generally thick bedded to massive with an apparent increase of silt in that general direction. The amount of conglomerate becomes entirely subordinate near the contact with the Modelo formation.

Downstream in San Francisquito Canyon, east of the road, the yellow beds grade into dark-green weathering ones, with a noticeable increase in pebbles and cobbles of sedimentary rocks, whose composition varies from impure arkose to feldspathic sandstone.

A detailed stratigraphic description at one locality is as follows:

TABLE II

Section of upper Miocene beds measured on the east side of San Francisquito Canyon. Section extends from outcrops immediately east of paved road going along the canyon, 2.5 miles airline distance downstream from the old site of St. Francis dam, to top hill outcrops SE above gully, about 1/4 mile east. Sec. 14, Red Mountain Quadrangle, Los Angeles County, California. R. 16 WT5N.

QUATERNARY GRAVELS. THIN VENEER.

Unit		Thickness (feet)
10	Light brown sandstone, massive, loose, coarse grained, made up of quartz and sand grains in about equal proportion................................	21
9	Conglomeratic sandstones and siltstones, interbedded. Well rounded pebbles of igneous rocks, light brown in color............................	78
8	Sandstones, light gray and light brown, in general coarse grained, thick bedded to massive, mostly arkosic. Some minor conglomerates, with well rounded igneous pebbles. Isolated cobbles, poorly rounded, mainly igneous rocks.............	432
7	Sandstone, arkosic, thick bedded; some thin layers of pebbles and cobbles. Mudballs and clayballs rarely present. Weathers to light brown. Color is yellow brownish. Feldspar grains commonly kaolinized......................	26

Unit		Thickness (feet)
6	Yellow orange, coarse grained, arkosic sandstone and siltstones, interlensing with each other. Scattered pebbles and cobbles, igneous and sedimentary. Angular unconformities between individual members. Uppermost 10 feet covered............	52
5	Arkoses, light brown, loose, fine to coarse grained. Isolated cobbles and boulders, poorly rounded, mainly of igneous composition.............	10
4	Series of sandstones, arkosic, light brown, with cobbles and pebbles of arkosic rocks, well rounded and of same color.................................	10
3	Conglomeratic pocket; with igneous and sedimentary cobbles and boulders, medium rounded, up to 1-1/2' in diameter. Grades up section into sandstone.....	13
2	Sand, arkosic, light buff, coarse grained. Contains scattered igneous and sedimentary pebbles throughout...	15
1	Conglomerate, light buff to dark green in color. Cliff-forming near Raggios' ranch. Interfingered with lenses of arkosic sandstone. Cobbles and boulders, very well rounded, mainly of coarse grained igneous composition. Few are made up of light brown, medium to coarse grained biotite arkose, and some others of schist, occurring mainly at base. General decrease of grain size to the top of the unit..............................	24
	covered	
	Road Total Thickness	651 feet

The light buff-green conglomerates in the west wall of San Francisquito Canyon grade north and northwest into a series of thick-bedded sandstones of quartz-feldspathic composition and light gray to red in color, which in turn gives way to a body of pink to orange, poorly sorted, massive conglomerate. This conglomerate is characterized by its large cobbles and boulders of granitic rocks, and by interlensing of shaly sandstone within the lower beds. Its boundary with Eocene(?)-Miocene(?) beds is a fault. It extends to the west through Charlie Canyon, where thick bedded, light buff arkosic sandstones predominate over minor conglomerates. It is observed that in general to the south, the Mint Canyon series get gradually less and less conglomeratic and the amount of silt increases correspondingly. Thick to massive biotite arkoses predominate. The marine environment of the Modelo formation is gradually approached through an almost imperceptible change.

A thin body of red sandstone overlies the Pelona schist unconformably (see Pl II). It is extended from the easternmost part of the contact between the Eocene(?)-Miocene beds and the Mint Canyon formation southward for a short distance. It contains minor conglomerates and gray-schistic debris, finely grained. Yellow conglomerates overlie it conformably.

Age: An Upper Miocene age has been assigned to the Mint Canyon formation. Maxson (1928) has described a faunal assemblage composed mainly of Camelidae, Rhinocerotidae and Equidae; the Merychippus and Hipparion species of the Equidae are considered to be of decisive importance for the assignment of an Upper Miocene age to the formation. Lewis 13/

13/ Lewis, G.E. "A new Siwalik correlation", American Jour. of Science Vol XXXIII. March, 1937.

considers that the Mint Canyon formation belongs to the upper half of the Upper Miocene. However, a brief inspection given to the C.I.T. fossils collected from San Francisquito Canyon was simply referred by him as to "Typically Upper Miocene".

Jahns 14/ assigns an Upper Miocene age to the Mint Canyon

14/ Jahns, R.H. op. cit. 1940, p. 172.

formation, on the basis of vertebrate fossils found in areas to the east.

Modelo formation.

Shales and sandstones deposited under brackish water and marine conditions were tentatively correlated by Kew 15/ with the Modelo

15/ Kew, W.S.W. U.S.G.S. Bull., 753, pp. 67-69, 1924.

formation. As stated by Jahns (1940) they represent the only marine beds in the easternmost Ventura Basin north of the Santa Clara Valley.

This formation lies unconformably on the Mint Canyon series. The angle of unconformity is of the order of 8 to 10 degrees in Dry Canyon, where a dark yellow basal conglomerate, 6 to 8 feet thick of the Modelo formation occurs, overlapping the underlying light colored massive sandstones of Mint Canyon. Reworked igneous pebbles of this formation are definitely encountered in Modelo basal conglomerate. In this part of the area such conglomerate is overlain by light brown to yellow, poorly sorted, coarse grained silty biotite arkose, that includes 8 per cent to 10 per cent of igneous rock granules; it contains fossils less than 1/4" across: some are gastropods, a few probably are brachiopods, and most are pelecypods, with arenaceous shells difficult to identify. Other authors have described the following list of invertebrates:

Tegula varistriata Nonland

Trophon cf, Ponderosum Cobb

Turritella sp

Pecten cf. estrellanus Conrad.

In the west wall of San Francisquito Canyon Ostrea titan is found. This pelecypod is characteristic of the Upper Miocene. Of large size (up to 40 centimeters in length) its shells are thick and massive, suggesting an environment of strong wave action.

Gray and brown arkosic conglomerate and feldspathic quartzose sandstone, 1 - 3 feet thick, occasionally fossiliferous, mark the boundary between the Modelo formation and Mint Canyon series in that part of the area. The sandstone represents stable conditions of sedimentation, with very mild subsidence during accumulation, and with considerable transport and winowing action before final accumulation. As pointed out by Krumbein (1951, p. 130) it is typical of basal sands developed by encroaching seas, and occurs commonly in association with widespread unconformities.

The position of the contact between Modelo formation and Mint Canyon series is rather uncertain to the north and northwest. Apparently there is a transitional lithologic change between nonmarine and marine sediments.

No attempt was made to describe a detailed stratigraphic section of the Modelo formation, because its lithology is very uniform. A thickness of 240 feet was estimated between the north end of Dry Canyon Reservoir upstream to the contact with Mint Canyon beds. Brown silty shales are more abundant to the south, but, so far as the map area is concerned, they remain subordinate to thick and massive beds of fine to medium grained silty arkose.

Age: The stratigraphic position of the Modelo formation and its invertebrate faunal content are diagnostic of an uppermost Miocene age.

Pliocene(?) rocks.

A body of brown unsorted sands, silts and gravels has been tentatively mapped as Pliocene?, between San Francisquito and Charlie Canyons. It lies unconformably on the Modelo formation. Its thickness is variable, but a maximum of 25 feet was recorded.

Pleistocene Terraces.

East of Dry Canyon a terrace, composed of poorly sorted, well rounded schistic materials, rests unconformably at a low angle on the Mint Canyon formation. Its maximum thickness is 60 feet; it represents alluvial fan material swept out from the Sierra Pelona, on the north, over the Pleistocene valleys of Santa Clara River, to the south. Several other patches of Pleistocene materials were mapped. Tilting in all cases is very moderate, never exceeding 3-4 degrees.

Alluvium.

Alluvium is present in all the canyons. A maximum thickness of 120 feet was recorded from a recently drilled water well near the southernmost end of the map area. It is composed chiefly of gravels, with fragments that include several kinds of igneous, metamorphic and sedimentary materials.

STRUCTURAL GEOLOGY

The area studied is structurally complex. Added to this fact is the lacking of good exposures in critical points, rendering, therefore, an overall complicated picture. However, the broad structural features could be mapped with a good degree of accuracy.

The block of sedimentary units of Eocene(?)-Miocene(?) rocks is bounded on all sides by faults. In the north, Eocene rocks are thrusted up at an angle of 35 degrees against soft, dark maroon shales, poorly sorted conglomerates, and silts. This structural relation is clearly exposed a short distance north of the road connecting St. Francis Dam and Elizabeth Lake Canyons (see Fig. 2 and structural section C-D, Fig. 4). The reverse fault is continuous in the northern part of the area, with minor breaks and changes from its general northeast-southwest trend; the throw is unknown. It is definitely post-Eocene in age, but it may be as young as post-late Miocene, which is the probable age of the major San Gabriel fault situated several miles farther south. The latter fault trends northwesternly and is typically strike-slip, with a south-

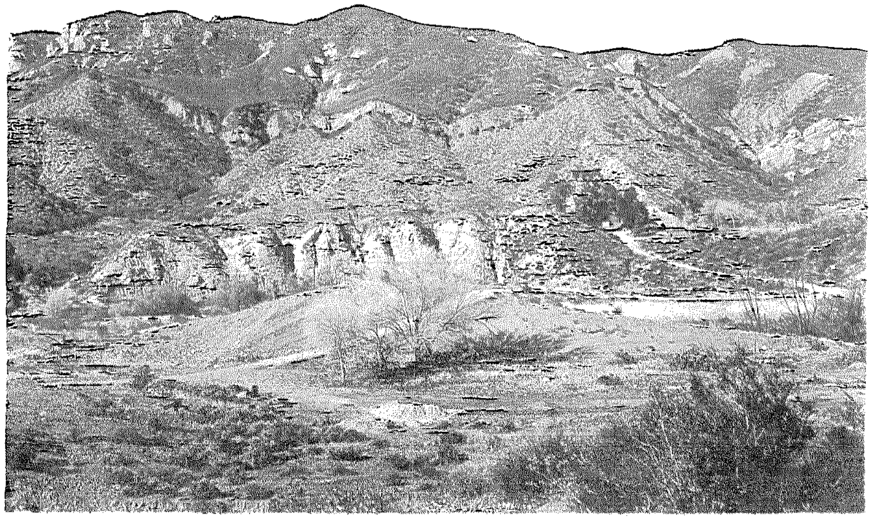
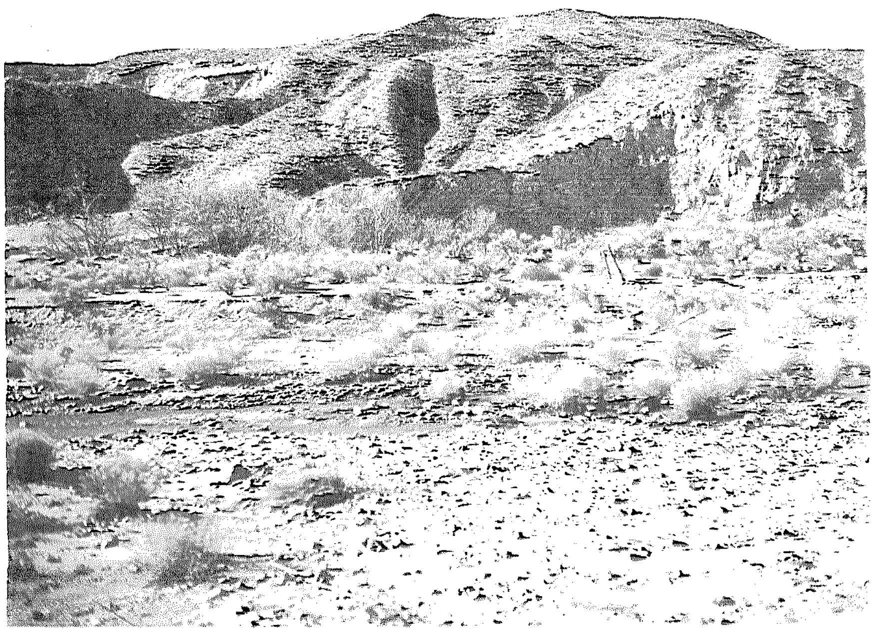


Plate III. View from paved road, looking to the west wall of San Francisquito Canyon, illustrating: Above: Scarp faces occurring on Eocene(?)-Miocene(?) rocks. Below: Near southern end of map area, folding of Modelo formation.

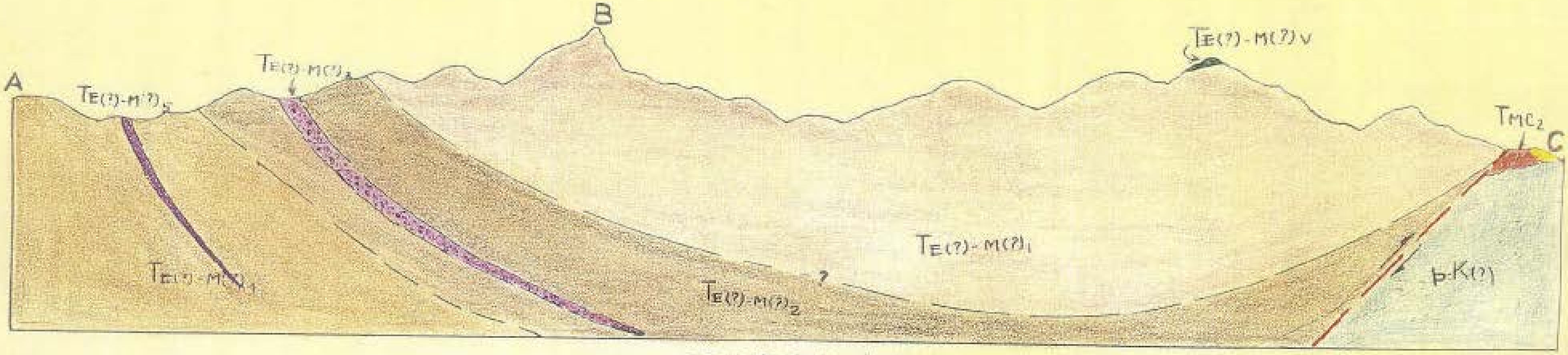


eastward displacement on the east side. It is conceivable, therefore, that the dip-slip, reverse fault described on the northern part of the area bears a gash relationship in regard to the San Gabriel Fault, in which case its age would be post-late Miocene.

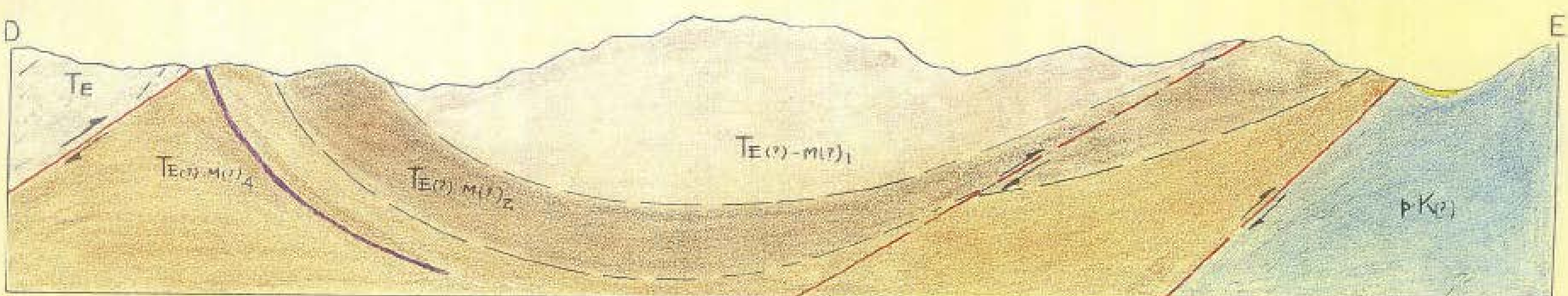
Another high-angle thrust fault shoves up Eocene(?)-Miocene(?) red beds against basement complex of the Pelona schists; it trends 65 northeast and dips 45 west at the site of the St. Francis Dam. Of unknown vertical and horizontal displacement, this structural feature has been named the San Francisquito fault. It is clearly traceable along the western wall of the canyon, a short distance west of the paved road, and may be unmistakably followed at least 1.5 miles south-southwest from the old St. Francis Dam site.

The more or less straight trend of the San Francisquito fault is lost a short distance to the northwest of Power House No. 2; it follows a sinuous pattern where yellow and gray conglomerates of Mint Canyon wedge out into the Canyon. In that place red beds of the Eocene(?)-Miocene(?) are thrusted on them. To the southwest the character of the fault is obscure; in the ridge, before it crosses to Charlie Canyon, it is normal: beds of the Mint Canyon dip 40 to the south, and apparently become the footwall in respect to the Eocene(?)-Miocene(?) rocks. At this point a breccia overlies the latter rocks, and its formation is suggested as being genetically related to pre-Mint Canyon fault scarps.

After crossing the ridge, the fault continues to be normal,



SECTION A-B-C



SECTION D-E

Feet

500 0 500 1000

FIG. 4

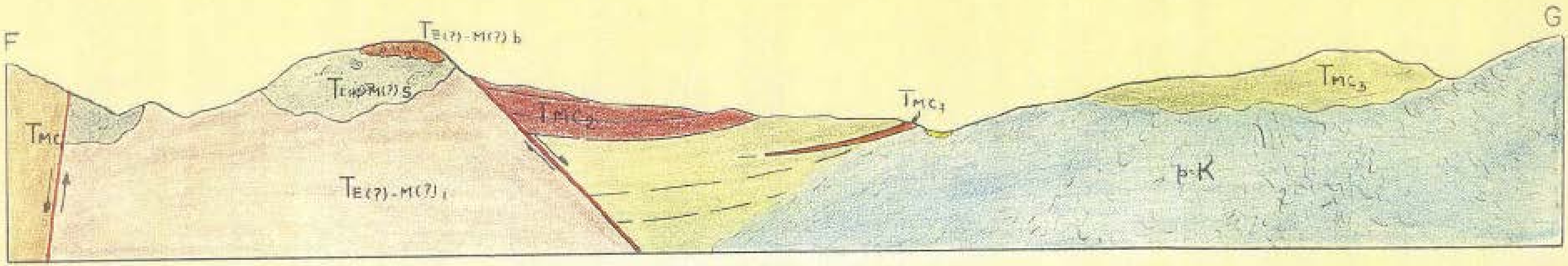
and it may be seen along the west fork of Charlie Canyon for at least 1.5 miles, where topographic saddles occur in several hills associated with the fault. It apparently ends in the north, where it contacts the west-east trending reverse fault previously cited (see section F-G, Fig. 5). The vertical displacement is unknown. It is post-Mint Canyon formation in age.

In 1928 the St. Francis Dam collapsed, and the resulting flood caused human and material destruction on a great scale. The San Francisquito fault, which extends along the canyon and passes through the site of the old dam, often has been claimed to be responsible for the failure of the dam. Studies of the foundation made by civil engineers, however, disclosed the phenomenon of "roof" and "piping" as the main cause of the failure: backward erosion of seepage, caused by local irregularities existing in the bearing pressures on the foundation because of inevitable local variations in soil properties, started points of channels of flow, which grew to ough length from the exit backwards, leading to considerable weakening and thus to the collapse of the dam.

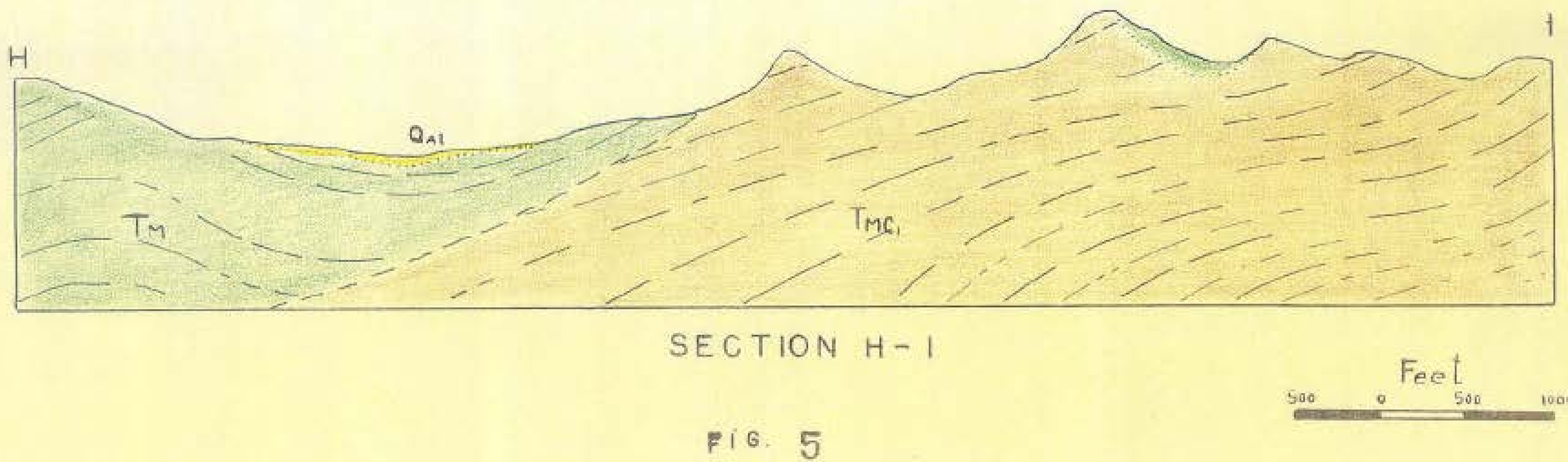
Several other faults of minor displacements occur throughout the area: their trend varies from one place to another. They are dip-slip fractures.

Intricate and close folding is displayed in the northern part of the area on shales and silty shales of red beds. The axes of the flexures are differently orientated within rather short distances.

To the south, folding is broad and open in the massive beds



SECTION F-G



SECTION H-I

FIG. 5

of the Mint Canyon and Modelo formations. A minor fold with an east-west axis is indicated on plate III. It shows thin bedded shales over-riding more compact massive sandstones of the Modelo formation.

SUMMARY OF HISTORICAL GEOLOGY

1. A basement complex, formed by igneous and metamorphic rocks occupied the entire area in pre-Eocene times.

2. During the Eocene, a marine basin situated to the north of the area, received a thick body of arkosic sediments derived from adjacent areas of granitic rocks that were rapidly rising.

3. A basin of deposition was formed to the south during Eocene-Miocene times and red beds and fanglomerates were laid down. Old granitic ranges, situated to the west and southwest probably were faulted against the rapidly subsiding basin.

4. Orogenic movements were followed by extravasation of lava flows. Channel filling of metamorphic debris from the east and northeast was rather common.

5. Cessation of deposition, erosion of granitic ranges and uplift of sedimentary basin took place. North-south compression forces originated folding, and later on, dip-slip reverse faulting took place, perhaps in Middle Miocene times.

6. Cessation of uplift and erosion were followed by deposition of Upper Miocene Mint Canyon continental sediments on lowland, basement complex terrains adjacent to the Eocene-Miocene area of sedimentation.

Plate IV. Above: View from paved road, north of St. Francis Dam, looking west to low hills of Eocene(?)-Miocene(?) red beds. Below: View looking south, taken from Charlie Canyon.

7. After deposition of the Mint Canyon beds, a slight orogenic disturbance was followed by the advance of a sea from the west, and by deposition of uppermost Miocene Modelo sandstones and shales.

8. General uplift and east-west compression forces gave way to folding in a north-south direction, and to dip-slip reverse faults between Eocene(?)-Miocene red beds and Pelona schists as well as upper Miocene Mint Canyon yellow conglomerates.

9. Release of accumulated stress along old sites of fault scarps in the western part of the area developed normal faulting.

10. In the southern part of the area inundation during Pliocene(?) and Pleistocene times was followed by the formation of terraces made up of coarse materials.

11. The last stage in the geological history of San Francisquito Canyon area is represented by uplift, dissection, and tilting of terraces, and by recent alluviation.

The structural features of the area possible may bear some connection with the San Andreas fault, which lies several miles to the northeast of the map area and whose nature is that of a strike-slip fault.

GEOMORPHOLOGY

The evolution of land forms in the map area to its present state has been reached through the modelling and sculpturing during the Quaternary of structural bodies formed during Tertiary times, when

Plate V. Above : View looking to the southwest from Charlie Canyon illustrating cavernous weathering.
Below: View north, from Charlie Canyon. Cavernous weathering on south face of highest cliff in the area.

intense deformation of the country rock by folding and faulting was produced. Lithology has been a decisive factor in the control of relief: resistant buffers of well consolidated conglomerates stand high in the hills in the north central part of the area, being generally steep sided and rugged, whereas gently rolling country appears in the areas where dominantly soft and poorly consolidated materials occur (see, for example, plate IV).

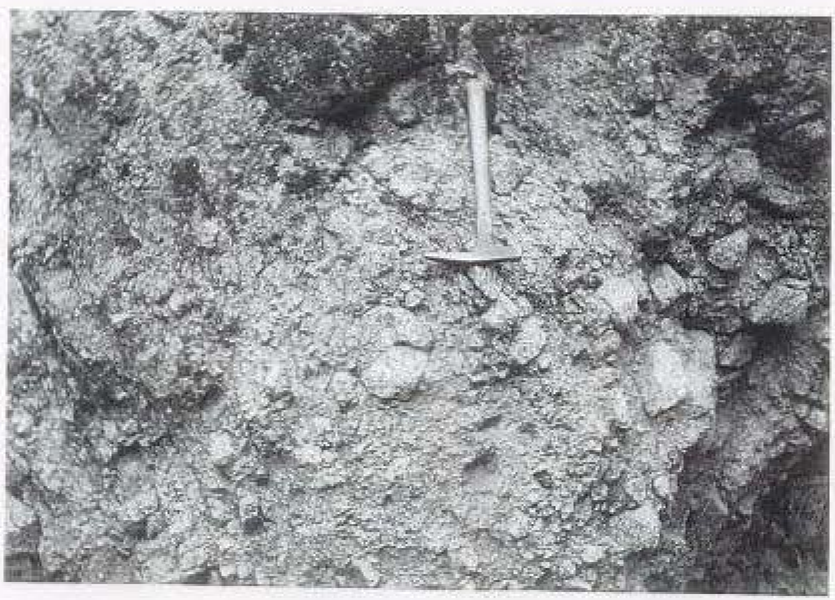
All the streams are dissecting their channels downward in a rather vigorous way. The area is in its late youth to early mature state of topographic development. The stream along San Francisquito Canyon cuts across the structure of the Pelona schists indiscriminately for at least 1 mile, reflecting perhaps inheritance of a drainage system established under different conditions.

To the south, after leaving the schists, the stream is consequent with the structure of Mint Canyon and Modelo formations; numerous subsequent tributaries joint to it along its downstream course.

The winding pattern of the stream in the northernmost part of the area, following a west-east direction, is the result of change in lithology and the influence of underlying rock structure. The axes of anticlines and synclines are subparallel to the course of the stream.

Well exposed scarp faces run subparallel to San Francisquito road one fourth of a mile west of it. They are clearly shown in the airphotograph, and probably mark the site of an old fault. Moreover, they separate brown and red silts, sands and conglomerates, from over-

Plate VI. Above: View taken from truck trail between site of St. Francis Dam and Elizabeth Lake, and looking northeast. It illustrates conglomerates traced on the map and indicated as T E(?) -M(?)3.
Below: On Charlie Canyon, approximately one mile southwest from same road illustrating detailed close-packing of igneous fragments occurring in fanglomerates of the Eocene(?)-Miocene(?).



lying gray coarse conglomerates, both bodies being of Eocene(?)-Miocene(?) age. As illustrated in plate IIIa, the topographic expression is indicative of a fault. The change in attitude of overlying and underlying beds corroborates that fact, as may be noticed in the structural section D-E, Fig. 4. Such a fault is reverse and of short vertical displacement. It fades out to the south, near the houses of Power House No. 2; to the north it ends after a distance of 1.9 miles.

Cavernous weathering (see Pl. V) is largely confined to many beds of hard, massive conglomeratic sandstones of the north central part of the area. In some places it shows "honeycomb" structure. In Charlie Canyon it is particularly noticeable.

Granular disintegration occurs in the north and northcentral parts of the area, where igneous cobbles and boulders constitute a large part of the coarse conglomerates.

Plate VII. View from paved road in San Francisquito Canyon, looking west into Modelo hills, taken at:
Above: near south end of the area.
Below: hills a short distance north from Santa Clara River.

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