DEPOSITION AND DEFORMATION IN THE NORTHERN SOLEDAD BASIN, LOS ANGELES COUNTY, CALIFORNIA

Thesis by

William Rudolf Muehlberger

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ABSTRACT

The Soledad basin is situated north of the San Gabriel Mountains, in Los Angeles County, California, and its center is about 35 miles north of the Los Angeles civic center. Roughly an elongate parallelogram in shape, this basin has dimensions of about ten by thirty miles, with the longer dimension oriented east-west. The Sierra Pelona and the San Gabriel Mountains form the northern and southern boundaries, respectively. The San Andreas fault and the San Gabriel fault, both of which trend northwest in this region, bound the basin on its northeast and southwest borders, respectively. Only the northern part of the basin is discussed in this paper.

The pre-Cretaceous Pelona schist, the oldest unit in the map area, is a thick sequence of muscovite schist, chlorite-muscovite schist and actinolite-chlorite schist with rare layers of quartzite and limestone. This unit underlies the Sierra Pelona, an elongate mountain mass which trends east-west. Granitic intrusive rocks of probable late Jurassic age underlie a complex section of Tertiary rocks in most of the eastern Soledad basin. Gneisses, some of which may represent highly injected Pelona schist, also are present in a belt that in general trends parallel to the Sierra Pelona.

In general, the sedimentary beds exposed at the surface are younger from east to west in the Soledad basin. The marine Martinez formation of Paleocene age is the oldest sedimentary unit in the region.

It is overlain by the Vasquez series which crops out over a wide area, and comprises interlayered fanglomerates and volcanic rocks. Where the Martinez formation has been removed by erosion prior to the deposition of the Vasquez beds, the Vasquez series rests on the pre-Tertiary crystalline rocks. This unit is of doubtful Oligocene age, and has a maximum known thickness of nearly 16,000 feet. The Vasquez beds were deposited in three basins separated by ridges. Late in Vasquez time, these ridges were buried by thick alluvial fans built northward from the San Gabriel Mountains, and the basins thus coalesced into a single broad alluvial apron.

The upper Lower Miocene Tick Canyon formation and the Upper Miocene Mint Canyon formation, which lie above the Vasquez series, also represent nonmarine deposition of dominantly coarse-grained sedimentary material. These units are widespread in the western part of the Soledad basin. Sandstone and siltstone of the "Modelo" formation rest unconformably on the Mint Canyon beds, and reflect an eastward encroachment of marine waters over a part of the basin in late Miocene time. West of the map area, the marine Pliocene Pico formation and the nonmarine Plio-Pleistocene Saugus formation, which grades westward into a marine facies, overlie the older rocks. Terrace deposits of late Pleistocene age are common over much of the area. Recent alluvium is present in all of the major valley bottoms and locally in some of the minor valleys.

The date of the folding and metamorphism of the Pelona schist is not known, but it assuredly is pre-Tertiary. Tertiary rocks have been either tilted or deformed into broad open folds, although locally near the major faults nearly isoclinal folds are found. Almost without exception, these folds plunge to the west or southwest.

The numerous faults are the most prominent structural features of the Soledad basin. Normal faults which trend generally east were formed in post-Martinez, pre-Vasquez time. Displacements occurred throughout Vasquez time and ceased prior to Tick Canyon time. The Pelona fault may have been reactivated just prior to Mint Canyon time. Offsets on these normal faults are as much as 10,000 to 15,000 feet. The normal faults indicate that the minimum compressive stress was oriented nearly north-south. On the other hand, the post-Mint Canyon, pre-Saugus faults indicate a maximum compressive stress oriented north-south, which resulted in a number of northeast-trending left-hand faults with displacements up to 10,000 feet. None of the faults of the Soledad basin have been reactivated in spite of Pleistocene and Recent offsets along the San Andreas fault.

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Location and accessibility

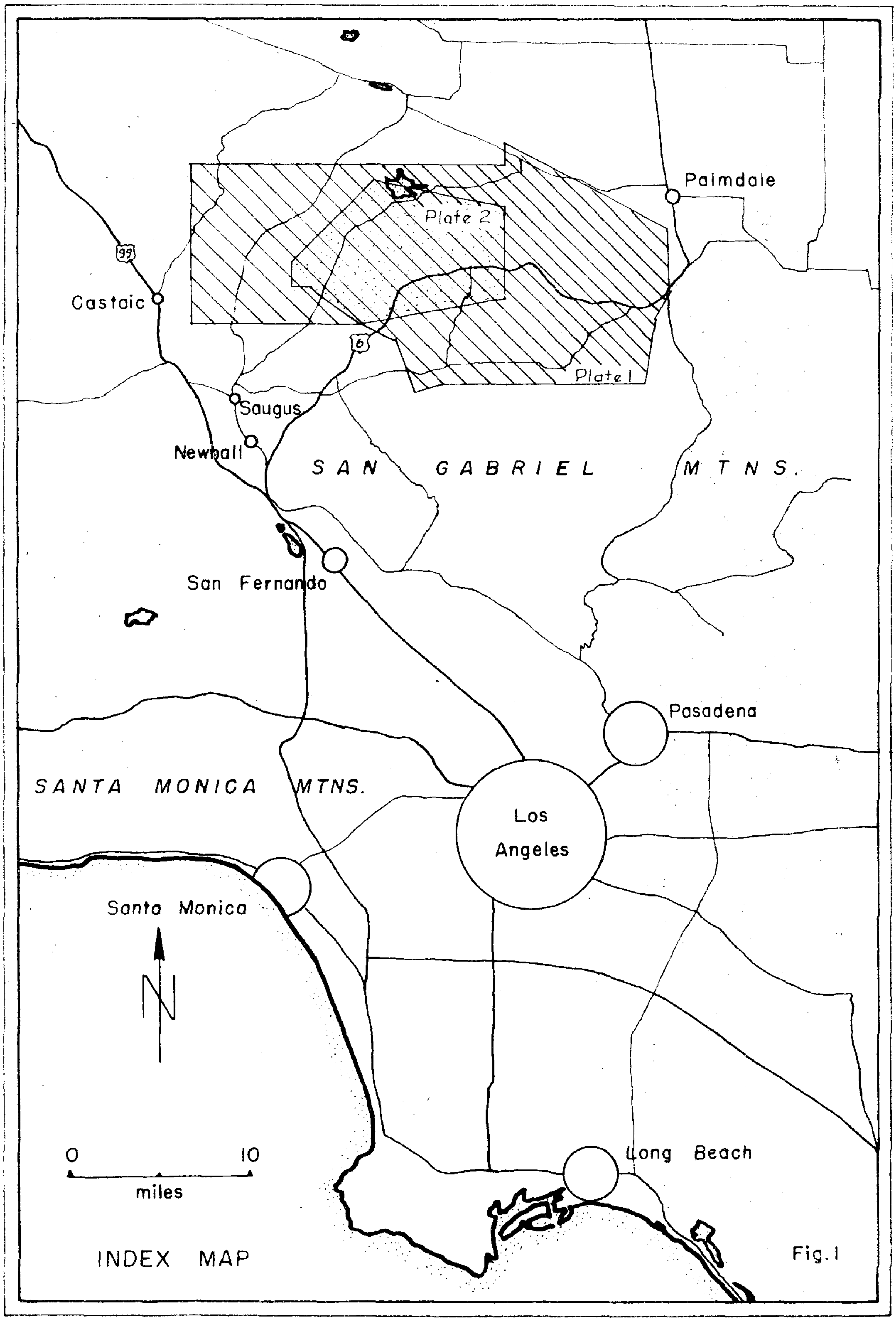
The Soledad basin is situated north of the San Gabriel Mountains, in Los Angeles County, California, and its center is about 35 miles north of the Los Angeles civic center (fig. 1). Roughly an elongate parallelogram in shape, this basin has dimensions of about ten by thirty miles, with the longer dimension oriented east-west.

Paved highways traverse nearly every major canyon, while graded dirt and gravel roads provide easy access to most of the area not served by paved roads. The Sierra Pelona, along the north border of the basin, is the least accessible part of the area. U. S. Highway 6, the Sierra Highway, traverses the basin from Newhall near the south-west margin to Palmdale at the eastern margin.

Small communities are present at intervals along the major highways and along the main line of the Southern Pacific Railroad between Los Angeles and the San Joaquin Valley, via Palmdale and Mojave, which passes along the southern margin of the basin parallel to the Santa Clara River.

Topography and drainage

The Soledad basin is open to the west and is surrounded by highlands on the other three sides. The western San Gabriel Mountains, which form the southern margin of the Soledad basin, are a series of


Palmdale
Plate 2
Castaic
Plate 1
Saugus
Newhall
SAN GABRIEL MTNS.
San Fernando
Pasadena
SANTA MONICA MTNS.
Los Angeles
Santa Monica
0
10
miles
Long Beach
INDEX MAP
Fig. 1

irregular ridges and spurs which attain altitudes of 5, 000 to 7, 000 feet. The Sierra Pelona is an elongate ridge which extends for more than 20 miles in an easterly direction along the northern margin of the basin. Ridge elevations of about 2, 500 feet in the western end increase gradually to 5, 000 feet and more at the eastern end of the range. In the Soledad basin, elevations range from 1, 400 feet to 3, 500 feet with a few peaks in the eastern part rising to altitudes of 4, 000 feet or more.

Local relief varies from 300 feet to 500 feet in the western part of the basin. As the margins of the basin are approached, the country becomes progressively more rugged; the relief locally may be as much as 1, 500 feet in the steep-walled gullies and canyons.

The drainage in the basin is broadly southwestward to the Santa Clara River, which flows westward along the southern margin of the basin. The major tributaries of the Santa Clara River in the Soledad basin are named Agua Dulce, Tick, Mint, Bouquet, San Francisquito, and Elizabeth Lake Canyons, from east to west (pl. 1). The ten mile reach of the Santa Clara River downstream from Acton is a deep, steep-walled gorge known as Soledad Canyon.

Climate and vegetation

This region has a semi-arid climate, with an annual rainfall of about 15 inches. Most of the precipitation falls during the months from November to April, inclusive, and in the higher parts of the Sierra Pelona some is in the form of snow. Palmdale, at the eastern margin of the basin (pl. 1), has an average annual temperature of 61.2° F., the recorded temperatures ranging from 19° F. to 104° F. The average monthly temperatures range from 44.1° F. in January to 81.4° F. in July. These temperatures are believed to be typical of the Soledad basin. The high summertime temperatures are alleviated somewhat by prevailingly low humidity and a daily west wind.

Greasewood, buckthorn, manzanita, yucca, and sage are the most abundant shrubs and are grouped under the term chaparral. Sycamore, cottonwood, and oak are the principal trees, and are locally abundant along the streams and near springs. Brush fires have burned off large areas of the basin. The chaparral on the Sierra Pelona is, in places, so dense that it is almost impossible to penetrate by a geologist.

II. BACKGROUND OF INVESTIGATIONS

Evolution of geological thought on the northern Soledad basin

The Ventura basin is a narrow, elongate trough, which extends from Ventura on the Pacific Coast eastward for nearly 60 miles to the vicinity of Palmdale, which lies along the western margin of the Mojave Desert. Except for the north border, the westward continuation of the basin is, at present, beneath the surface of the Pacific Ocean. During much of Cenozoic time, an arm of the sea, named the Santa Barbara embayment, extended for many miles eastward into the Ventura basin.

Between Newhall and Castaic in the eastern part of the Ventura basin, the San Gabriel fault, one of the major faults of southern California, trends northwest across the basin and marks a significant stratigraphic break between the western and easternmost portions of the basin. This fault marks the eastern limit of both oil production and the thick section of marine sediments. Except for minor amounts of marine sediments, the easternmost Ventura basin is underlain by a thick series of nonmarine sediments and interlayered volcanic rocks. To replace the cumbersome term, easternmost Ventura basin, Bailey and Jahns (1954) have suggested the name Soledad basin, which implies a sharper distinction between the areas on opposite sides of the San Gabriel fault. This study is mainly concerned with the northern and eastern two-thirds of the Soledad basin (pl. 1).

Members of the various railroad, geological and geographical surveys of the middle 19th Century passed through this region and made many scattered geological observations. The first attempts at systematic analysis of this region were made by Hershey (1902a; 1902b), who briefly described the major rock units. He named the Pelona schist, and this designation since has been extended to other areas at some distance from the type area in the Sierra Pelona. He also named several other units, but these designations have been revised by later investigators. Hershey's oldest Tertiary unit, the Escondido series, lies directly on his probable pre-Cambrian Gneiss and Pelona Schist series. His next younger Tertiary unit, the Mellenia series, crops out farther west and unconformably overlies the Escondido series. The Upper Pliocene series crops out still farther to the west, and completes the stratigraphic record as recognized by Hershey. He believed all of these units to be no older than Upper Miocene.

The discovery and development of the oil fields of the Ventura basin greatly stimulated geologic studies in this region. Kew (1924) published the first comprehensive geologic map and report of the eastern Ventura basin and the southwestern Soledad basin. He named and briefly described the Mint Canyon formation, which in part is the Mellenia series of Hershey. He rejected Hershey's term Escondido series, and tentatively correlated those beds with the Oligocene Sespe formation found in the Ventura basin farther west. The northern contact of the Mint Canyon formation against the Pelona schist was mapped as a fault contact by Kew.

Clements (1932) studied the southeastern portion of the Tejon quadrangle which adjoins a part of the north border of the area mapped by Kew. In contrast to Kew, who believed the contact between the Mint Canyon formation and the Pelona schist to be a fault, Clements (1937) mapped the westward continuation as a steeply dipping, depositional contact.

A study of the Elizabeth Lake quadrangle was made by Simpson (1934). The southwestern portion of this 30-minute quadrangle includes the San Francisquito, Bouquet Reservoir, Red Rover, and

Palmdale 6-minute quadrangles (pl. 1). He mapped the entire Pelona fault except for the short segment previously mapped by Kew at the western end of the fault. The Pelona fault was traced by Simpson along the southern base of the Sierra Pelona from the San Andreas fault westward for a distance of nearly 20 miles to the southern edge of the quadrangle, one mile west of Bouquet Canyon (pl. 1). Several southwest-trending branches of the Pelona fault also were mapped. Noting the abundance of Pelona schist fragments in the Quaternary terrace gravels, Simpson dated the earliest movement on the Pelona fault as being either late Tertiary or early Quaternary. He stated that the intrusive rocks have gradational boundaries, and he also believes (1934, p. 384) that an

> "intrusive relationship to Pelona schist series cannot be proved directly, for the only visible contacts are along faults. However, the Pelona schists locally show the effects of superimposed contact metamorphism at several places along the Pelona fault, and one must suppose that the adjacent granitic bodies were the metamorphosing agents."

Simpson retained the name Escondido series for the section described by Hershey, and rejected Kew's correlation with the Sespe formation.

Miller, in 1934, published the results of several years of study of the western San Gabriel Mountains. His reconnaissance map and detailed petrographic descriptions of the rock types still represent the only extensive study of that large area.

A detailed stratigraphic study by Jahns (1939; 1940) enabled him to distinguish an older unit in the basal part of Kew's Mint Canyon formation. He named this older unit the Tick Canyon formation. This distinction between the Tick Canyon and Mint Canyon formations resolved the apparent association of primitive and advanced forms of vertebrate remains within the original Mint Canyon formation as defined by Kew. During the course of his studies, Jahns found that the Vasquez Canyon fault is buried by the Tick Canyon beds; this was the first published suggestion that faults of earlier Tertiary age exist in the Soledad basin.

In an earlier unpublished thesis, Sharp (1935a, p. 66) recognized two distinct periods of faulting farther east in the Ravenna quadrangle (pl. 1). The older east-trending Soledad fault, a normal fault, was found to be offset by younger northeast-trending left-hand faults. He also suggested the name Vasquez (1935b, p. 314) for the unit that was termed Escondido by Hershey; inasmuch as the name Escondido is preoccupied, the more appropriate term Vasquez is used in this paper.

Wallace (1949, pp. 781-806) studied the San Andreas fault between Palmdale and Elizabeth Lake during the period 1940-1942. He provided (1944, pp. 6-18) an excellent discussion of the theories regarding the history and behavior of the San Andreas fault. For a distance of about six miles westward from the San Andreas fault, Simpson had mapped the Pelona fault as separating the Pelona schist from a block of gneissic rocks that lies to the south. Wallace's discussion (1944, p. 95) of the contacts of these two units is quoted here:

> "The borders of the gneissic block southwest of Palmdale reservoir may be fault contacts. No fault zone was observed, no geomorphic evidence of faulting was found, and little other than that the strike of the contacts is parallel to the large branch faults suggested that the contacts are faults. In fact, one road cut near the south contact of the gneissic body exposed numerous granitic dikes intruded into the gneiss thus suggesting that the contact is an intrusive contact."

Thus Wallace casts doubt on the interpretation of the Pelona fault as a branch of the San Andreas fault.

Purpose and nature of study

Reconnaissance studies by Simpson in the northern Soledad basin show a set of southwest-trending faults that branch southward from the east-trending Pelona fault. The Pelona fault, in turn, is shown as branching from the San Andreas fault, which evidently is regarded as the "master fault" of the region. However, recent detailed studies (Jahns, 1940; Wallace, 1944) that have touched on this problem seem to cast doubt on the validity of this concept.

The purpose of this study is twofold:

(1) To decipher the structural features of the northern Soledad basin and to determine the genetic relationships, if any, of the deformations recorded to movements along the nearby San Andreas fault; and

(2) To integrate the general conditions of formation of the Tertiary sediments with structural history of this region.

The investigations have been concerned mainly with the unraveling of the geologic history of the Vasquez series, which provides a large amount of detailed information concerning the early Tertiary history of this region. This study also shows what happens around the fringes of a major sedimentary basin in southern California. These events either may not be recorded or only indirectly recorded in the stratigraphic record in the center of the basin where economic reserves of oil may be found.

Field work

Field work was carried on from April to August in 1952, from May to July in 1953, and intermittently during the intervening period. Mapping was done on a scale of one inch to 1,000 feet on enlarged copies of U. S. Geological Survey maps published at a scale of one inch to 2,000 feet. The results of most of this geological mapping are shown in plate 2. Plate 1 also shows the results of this work, as well as information compiled from the published and unpublished sources that are indicated on the map.

III CRYSTALLINE ROCKS

General statement

Schists, gneisses, and granites compose the "basement" rocks of this region. The Pelona schist, which consists of muscovite schist, chlorite-muscovite schist, and actinolite-chlorite schist, underlies the entire Sierra Pelona and is the oldest rock in the mapped area. Thin beds of quartzite and limestone are present, as are talc-actinolite bodies and quartz veins. The age of the schist is known to be pre-Cretaceous, and is believed to be pre-Cambrian by many previous workers in this region.

Granitic and gneissic rocks crop out to the east and south of the Soledad basin. At least some of the gneisses represent the Pelona schist that has been highly injected by granitic magmas. The granitic rocks range in composition from quartz diorite and quartz monzonite to nearly true granite, and are believed to be correlatives of rocks of the Sierra Nevada batholith.

Andesite and basalt flows of the Vasquez series attain a thickness of nearly 4,000 feet. These volcanic rocks are discussed in connection with the Vasquez series.

Pelona schist

The Pelona schist appears in several widely separated areas of southern California, including the Sierra Pelona (Hershey, 1902a, pp. 274-277), Portal Ridge (Simpson, 1934, p. 318), the eastern San Gabriel Mountains along the south side of the San Andreas fault from Valyermo to San Bernardino (Noble, 1933, pp. 11-12), and in an elongate area between the branches of the Garlock fault in the Tehachapi Mountains (Wiese, 1950, pp. 12-15). All of the above areas lie in a zone that extends for 80 miles along the San Andreas fault and is within 20 miles of the fault zone.

The Rand schist (Hulin, 1925, pp. 23-31; Simpson, 1934, pp. 380-381), identical in lithology and structure and thus believed to be a correlative of the Pelona schist, is exposed near Randsburg, 60 miles northeast of the Sierra Pelona. Miller (1946, p. 528) and Hill and Dibblee (1953, pp. 450-451) have suggested that the Orocopia schist, which is exposed in the vicinity of the Salton Sea 160 miles southeast of the Sierra Pelona, is a correlative of the Pelona schist. Schists that are texturally and mineralogically similar to the Pelona schist form the "basement" rock of the Old Puente oil field, and have led Schoellhamer and Woodford (1951, map sheet) to suggest that "the Catalina and Pelona schists may grade into one another, and may be of the same age, possible pre-Cambrian". The present incomplete state of knowledge of the metamorphic terranes of southern California does not permit a more definitive statement.

Hershey (1902a, pp. 274-277) named and briefly described the Pelona schist on the basis of a traverse across the Sierra Pelona. Thirty years later, Webb (1932, pp. 12-28) described the geology of an area along the southeast flank of the Sierra Pelona. Clements (1932, pp. 16-20) studied the western tip of the Sierra Pelona during the course of his investigations in the southeastern Tejon quadrangle. Simpson's study (1934, pp. 378-381) of the Elizabeth Lake quadrangle includes the outcrops of Pelona schist on Portal Ridge and most of the Sierra

Pelona. In 1939, Hill (pp. 1-118) described the petrography of the Pelona schist in detail. Wallace (1949, pp. 786-787) briefly described the Pelona schist in his study of a part of the San Andreas rift.

The following discussion of the Pelona schist is limited to the exposures of the Pelona schist in the Sierra Pelona, except where otherwise stated. Along the southern margin of the range, the schist is intruded by granitic rocks. Much of the contact between the schist and granite is obscured or deeply buried by overlapping sedimentary rocks of Tertiary age. Elsewhere the schist of the range is in fault contact with granitic rocks or with Cenozoic sediments.

Slightly more than 7,400 feet of mica schists and actinolite-chlorite schists, with rare beds of quartzite and layers of interbedded quartzite and limestone, is exposed in Bouquet Canyon. Table 1 summarizes this sequence.

About 5,000 feet of the exposed Pelona schist consists of silvery-gray muscovite schist and chlorite-muscovite schist. The layers in the schists, which may be in part original stratification, range in thickness from a fraction of an inch to several inches, and some probably are nearly a foot thick. Porphyroblasts of quartz and grayish sodic plagioclase are abundant, and are one to two millimeters in maximum dimension. Laminae of biotite schist are commonly interlayered with muscovite schist.

An average mineral composition of the muscovite schists, as computed from Hill's (1939, pp. 50-55) detailed petrographic data, is as follows: oligoclase, 55 percent; muscovite, 17 percent; quartz, 14 percent; chlorite, 2 percent; biotite, 3 percent; clinozoisite, 3 percent; calcite, magnetite, epidote, pyrite, sphene, and other opaque minerals, 6 percent.

The muscovite schists grade mineralogically into the chlorite-muscovite schists. An average mineral composition of the chlorite-muscovite schists, as computed from Hill's (1939, pp. 55-62) data, is as follows: albite-oligoclase, 41 percent; muscovite, 17 percent; quartz, 15 percent; chlorite, 15 percent; clinozoisite, 7 percent; epidote, graphite, sphene, magnetite, and garnet, 1 percent. The most notable changes that accompany the gradation into chlorite-muscovite schist are an increase of chlorite and clinozoisite and corresponding decreases in the percentage and anorthite content of the plagioclase. The only notable chemical change is an increase in magnesia and water associated with minor decrease in amount of the other oxides (table 2). Graphitic mica schists are present locally in San Francisquito Canyon.

Dark green actinolite-chlorite schists form most of the bulk of the remainder of the exposed section in Bouquet Canyon. Variations in composition are not notable. The porphyroblasts of white albite-oligoclase range in size from one to five millimeters, and in places they are sufficiently large and abundant to give the schist a distinctly knotty appearance. As calculated from the petrographic data of Hill (1939, pp. 63-68), an average mineral composition is as follows: albite-oligoclase, 44 percent; chlorite, 18 percent; actinolite, 18 percent;

Table 1

Measured section of Pelona schist[1]

Thickness in feet	Description
325	Mixed rock along contact with granite; transitional types from granite to pennine-oligoclase-quartz schist.
2300	Muscovite schist, with a few thin quartzite beds.
725	Muscovite schist and actinolite-chlorite schist; thin talc dike near base.
925	Muscovite schist and actinolite-chlorite schist interlayered; quartzite and crystalline limestone common; chlorite-muscovite schist in place of muscovite schist in lower one-third of unit.
1975	Muscovite schist and chlorite-muscovite schist.
750	Actinolite-chlorite schist.
225	Chlorite-muscovite schist.
200+	Actinolite-chlorite schist; some chlorite-muscovite schist.
	- - - - Base of exposed section. - - - -
7425+	Total exposed thickness.

[1]Section measured northward from south line of section 16, T. 5N., R. 15W., in Bouquet Canyon, San Francisquito quadrangle, Los Angeles County, California. Thicknesses obtained by graphical methods. Modified from Hill, 1939, p. 48.

clinozoisite, 11 percent; epidote, 4 percent; calcite, 2 percent; pyrite, chalcopyrite, limonite, and quartz, 3 percent. Muscovite and biotite are conspicuously absent from these greenschists.

Quartzite and limestone, although quantitatively minor parts of the section, form the only mappable units within the Pelona schist. The quartzite beds, two to ten feet thick, are composed of individual layers of nearly pure quartzite that are less than one inch thick. The layers are separated by thin, gray-green laminae that are micaceous and calcareous. These quartzites are extremely rare in the lower one-third of the exposed schist section.

The limestone is bluish gray, and forms beds that range in thickness from one-quarter of an inch to several feet. These are separated by quartzite layers less than one inch thick. Layers of actinolite-chlorite schist one to five feet thick also are present. The limestones and interbedded quartzites are so intricately contorted that stratigraphic thicknesses cannot be determined, even where the outcrop thickness is nearly 100 feet. The limestones invariably are interbedded with quartzite, and some with actinolite-chlorite schist. The thickest of the limestone beds are consistently the most highly contorted. One of these contorted areas is illustrated in Figure 2. Scattered grains of quartz occur in the limestone beds, and graphite also is present in small amounts. The quartzite beds are cemented with calcite.

A few dikes of talc schist, talc-actinolite schist, and talc-serpentine schist are present in the section. These are slightly discordant with respect to the foliation of the host schists. Very small quantities of the talc have been mined, but the lenticular nature and limited size of the talc concentrations have prevented commercial exploitation. These bodies are probably altered ultrabasic dikes.

Masses of quartz are common, and range from veins a fraction of an inch thick and a few feet long to massive bodies ten feet thick and several hundred feet long. They commonly lie parallel to the foliation of the host rocks, although some transect the foliation at low angles. Some of the larger masses contain minor amounts of manganese oxides.

The boundary between the Pelona schist and the adjacent gneiss along the southern face of the Sierra Pelona is an intrusive contact, in the opinion of the writer. The evidence for this is the local abundance of small crystals of garnet and a general coarsening of grain size near the contact, as well as the presence of blocks of schist that resemble Pelona schist incorporated within the gneiss. The gradational nature of the contact and poor exposures obscure the relations. Wallace (1944, p. 95) observed similar features farther east along this same contact, and arrived at the same conclusion.

The beds of limestone and quartzite clearly are of sedimentary origin. The purity of the quartzites indicates that originally they must have been orthoquartzites. Table 2 presents the approximate chemical

Table 2

Composition of Pelona schist with average graywacke, shale and spilite (a)

	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	59.9	58.1	64.2	58.4	50.6	51.2
Al_2O_3	21.0	20.0	14.1	15.5	17.3	13.7
$FeO+Fe_2O_3$	0.7	--	5.2	6.5	3.5	12.0
MgO	1.1	5.4	2.9	2.5	9.0	4.6
CaO	2.9	2.1	3.5	3.1	7.9	6.9
Na_2O	5.1	4.6	3.4	1.3	4.7	4.9
K_2O	2.2	2.0	2.0	3.3	--	0.8
H_2O	1.1	2.8	2.2	5.0	3.0	1.9
Others (b)	6.0	5.0	2.5	4.4	4.0	4.0

(1) Muscovite schist, Bouquet Canyon, California. Computed chemical composition derived from average mineral composition (see text).

(2) Chlorite-muscovite schist, Bouquet Canyon, California. Computed chemical composition derived from average mineral composition (see text).

(3) Average graywacke, F. J. Pettijohn, 1949, Sedimentary rocks, p. 250, Harper and Brothers.

(4) Average shale, F. W. Clarke, 1924, Data of geochemistry, U. S. Geol. Surv. Bull. 770, p. 30.

(5) Actinolite-chlorite schist, Bouquet Canyon, California. Computed chemical composition derived from average mineral composition (see text).

(6) Average spilite, N. Sundius, Geol. Mag., vol. 67, p. 9, 1930.

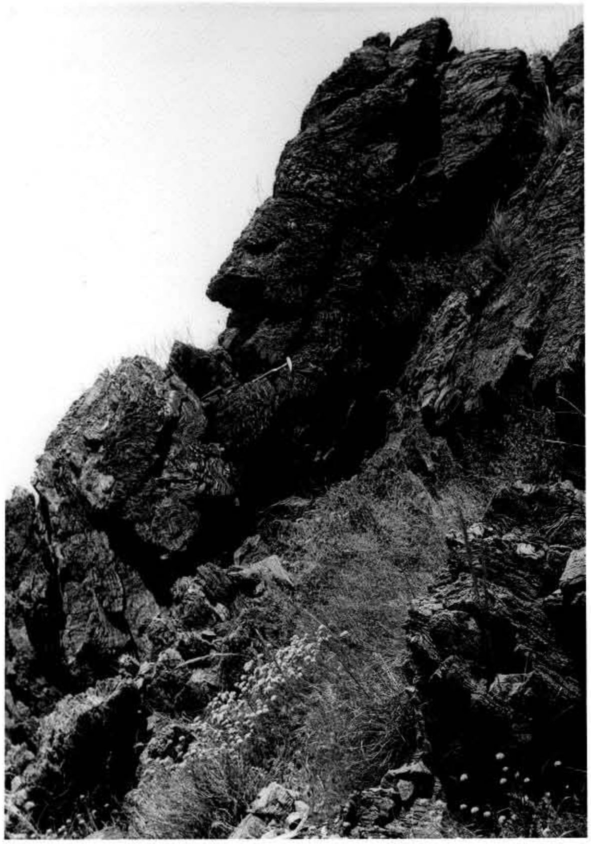
(a) Computations based on chemical compositions as given in Dana's textbook of mineralogy, W. E. Ford, 1932, 4th ed., John Wiley & Sons, Inc. 851 pp.
Albite is assumed to have the composition $Ab_{95}An_5$; albite-oligoclase as $Ab_{90}An_{10}$; and oligoclase as $Ab_{80}An_{20}$. Chlorite has been assumed to be pennine. Actinolite has been assumed to have Mg:Fe::3:2.

(b) Mostly FeO, CaO, CO_2, and TiO_2 for columns 1, 2, and 5; mostly TiO_2, CO_2, P_2O_5, and MnO for columns 3, 4, and 6.

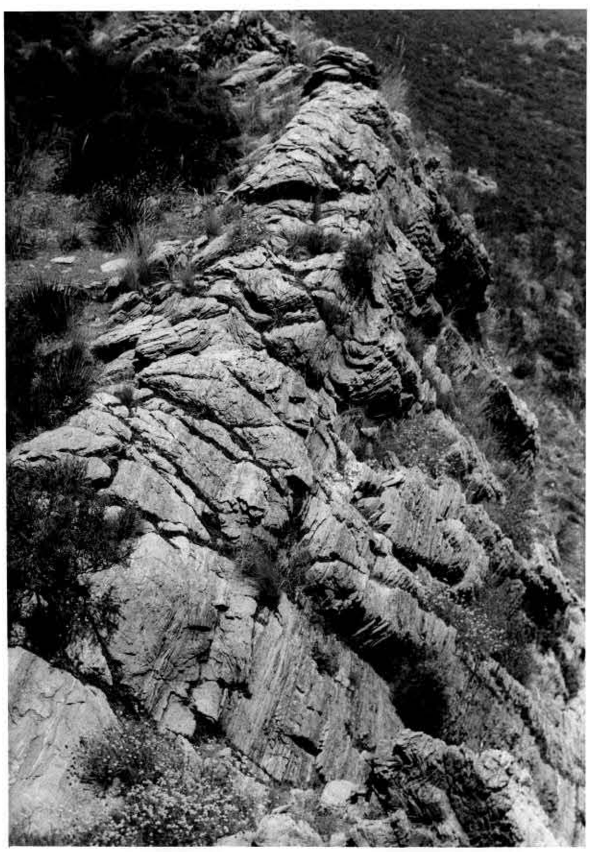
Figure 2. Intricate folding of interlaminated quartzite and limestone of the Pelona schist.

(a) Cross section of contorted layering. Limestone layers are etched out so that the quartzite layers outline the structure. View southwest near head of Fall Canyon, Sierra Pelona.

(b) View northeast at same locality as above, showing the consistent plunge of the minor folds.



(a)



(b)

composition of the major rock types in the Pelona schist, which are compared with the composition of an average graywacke, average shale, and average spilite.

The muscovite schist and chlorite-muscovite schist are similar to graywackes in composition. The significant point is the dominance of soda over potash in all three rock types. Other sedimentary rock types, (e.g., average shale, column 4, table 2) show a dominance of potash over soda. The absence of any relict current bedding and the thick sequence of essentially uniform lithology also suggest that the muscovite schist and chlorite-muscovite schist were derived from original graywackes. The actinolite-chlorite schist, on the other hand, approaches a spilite in composition. The serious discrepancy in iron oxides is probably due to the assumed composition of chlorite, actinolite, clinozosite, and epidote used in the calculations.

A general change in composition can be noted in the section of the Pelona schist that is exposed in Bouquet Canyon. The lower part of the section is actinolite-chlorite schist and chlorite-muscovite schist, while the upper part is muscovite schist with minor quartzite. The lower chlorite-rich schists probably indicate the deposition of volcanic detritus eroded from nearby regions. This detritus may have been derived from the volcanics extruded earlier during the deposition of the original materials which now compose the Pelona schist.

This set of presumed original rocks, including graywacke, basic volcanics, and minor orthoquartzite and limestone, comprises the types commonly ascribed to eugeosynclinal deposits (Kay, 1951, p. 86).

The age of the Pelona schist is based on correlation with the Rand schist. According to Hulin (1925, pp. 29-31), the Rand schist is pre-Cambrian in age because its degree of metamorphism is in marked contrast to that of nearby lower Paleozoic strata. Further, some fragments of what may be Rand schist are present in some rocks of doubtful Paleozoic age.

Miller (1946, pp. 516-517) believes that the Pelona schist is late pre-Cambrian in age, and that it is younger than the plutonic rocks of the San Gabriel complex. These plutonic rocks are presumably of pre-Cambrian age, and are known to inject the metasedimentary Placerita formation, of presumed early pre-Cambrian age. These intrusive rocks, in turn, have been injected by the more widespread plutonic rocks in the San Gabriel Mountains that are probably still younger. Wallace (1949, p. 787) suggests that the Placerita formation may be a correlative of the Pelona schist, a view that this writer considers reasonable. Certainly the question merits further attention and study. Hill (1939, pp. 105-107) concludes that the only definite age assignment that can be made for the Pelona schist is pre-Cretaceous, as the schist has been intruded by granitic rocks similar to those of the Jurassic Sierra Nevada batholith. This writer can add no further data that would lead to a more specific age assignment for the Pelona schist.

Gneissic complex

Gneiss is exposed in large areas on Mint Canyon Ridge and eastward in a belt parallel to the Sierra Pelona. Hornblende-feldspar-mica gneisses, intruded by dikes of gneissic granite, form the bulk of the exposed rocks. The grain size and mineral percentages vary over wide ranges.

Near Mint Canyon Spring are outcrops of an augen gneiss in which tabular porphyroblasts of microcline are slightly more than one inch in average length and as much as two inches in maximum length. These porphyroblasts are sub-parallel to the nearly vertical foliation. Microscopic study (Judson, 1935, p. 35) shows that the rock consists of about 50 percent microcline and 25 percent quartz. The remainder is chiefly biotite, and some muscovite and albite-oligoclase also are present. Accessory minerals include apatite, magnetite, zircon, and sphene.

A second area of augen gneiss was noted by Simpson (1934, p. 384) in Texas Canyon near the Silver King Mine. In addition to this area, Judson has mapped several fault slices of augen gneiss in this vicinity. Detailed study by the writer has shown that these outcrops are monolithologic sedimentary breccias of the Vasquez series that are composed of augen gneiss fragments which had their apparent source from the area of augen gneiss exposed near Mint Canyon Spring. These sedimentary breccias will be discussed in the section on Vasquez series stratigraphy.

A small body of gneiss lies along the Bee Canyon fault just southwest of Bouquet Reservoir. This may be a slice from the extensive gneissic terrane north of the Bouquet Canyon fault.

The presence of a few thin beds of limestone and quartzite suggeststhat the gneissic zone south of the Sierra Pelona may represent a highly injected phase of the Pelona schist. Wallace (1949, p. 787) has made a similar suggestion on the basis of studies farther east. The trend of the foliation of the gneiss generally is parallel to the trend of the foliation of the main schist body. Much of the gneiss, however, may be of earlier origin, and possibly is a correlative of the San Gabriel formation in the San Gabriel Mountains. Miller (1934, p. 65) has concluded that:

> "The available evidence, then, points to the pre-Cambrian, and probably older pre-Cambrian age of the Placerita, Rubio diorite and meta-diorite, and Echo granite formations, as well as the greater part of the San Gabriel formation, but it must be admitted that the age is not absolutely proved."

Granitic intrusive rocks

The term "granite" is used in this report to include all quartz-bearing intrusive rocks, although some gneisses and metamorphic rocks may be present locally. According to Simpson (1934, pp. 384-385), quartz diorite is the dominant compositional type, and shows textural transitions to hornblende diorite and quartz monzonite on the one hand,

and aplite on the other. Quartz syenite is the dominant plutonic rock in the northwestern part of the Ravenna quadrangle. These rocks are poorly exposed because of deep weathering that in large part has been aided by minute fracturing.

Simpson's (1934, pp. 384-385) description of the quartz diorite and quartz monzonite, the undifferentiated granitic rocks of Plate 2, is as follows:

> "Hornblende is the most abundant ferro-magnesian constituent of the dioritic types, and biotite of the monzonitic, but there are abundant intermediate types containing both. The rocks commonly have a medium to coarse granitic texture, but fine-grained types are not rare. Andesine is the predominant type of plagioclase feldspar with microcline about equally abundant in the monzonitic types."

The plagioclase feldspar is partly altered, and individual crystals commonly have an opaque, dead-white appearance. Muscovite is the mica present in much of the rock that underlies the eastern Mint Canyon Ridge. Potash feldspar locally forms phenocrysts as much as one-half inch in length. Fine-grained ferromagnesian minerals constitute less than five percent of the rock, most of which is strikingly leucocratic. Numerous fracture surfaces are stained with limonite.

Miller (1946, p. 517) correlates these granitic rocks with the Lowe granodiorite of the San Gabriel Mountains. In addition, he regards Simpson's "monzonite aplite", the granitic rock that intrudes the schists on the southeast flank of the Sierra Pelona, as a facies of the Lowe granodiorite.

A faint vertical gneissic structure, which trends nearly northwest, can be observed in the granite of the eastern Mint Canyon Ridge. The most prominent joint set is parallel to this gneissic structure, and for that reason is indicated on the map as the rift direction.

The Lowe granodiorite ranges in composition from quartz monzonite to hornblende diorite (Miller, 1934, pp. 41-45). This rock and its variants underlie extensive areas in the San Gabriel Mountains, and have supplied much of the detritus in the sedimentary deposits of the Soledad basin. The average percentage of each mineral, in the Lowe granodiorite, as well as the range noted by Miller, is as follows: quartz, 23.5 (5-40); orthoclase, 20 (5-40); microcline, 8.5 (1-77); oligoclase-andesine, 45.5 (12-65); biotite, 1 (0-3); hornblende, 0.6 (0-10); magnetite, 0.5 (0-2); some apatite, zircon, and titanite; and rare garnet, augite, and epidote.

Miller recognizes three main facies of the Lowe granodiorite:

(1) A white to light gray, medium- to fine-grained rock that consists principally of potash feldspar, plagioclase, and quartz, with scattered grains of biotite and elongate crystals of hornblende; phenocrysts of pink potash feldspar, one inch in average length, are set in the groundmass. This is the most common type.

(2) A medium- to fine-grained, massive variety with a granitoid texture, and is white or light gray to pinkish gray in color.

(3) A foliated, generally non-porphyritic variety, which is relatively richer in hornblende than the two other varieties.

The Parker quartz diorite is light to medium gray, medium to coarse grained, and has a distinctly gneissoid structure. This rock was named by Miller (1934, p. 37), who designated the type locality as Parker Mountain, immediately west of Acton. Analysis of several thin sections by Miller yield the following average percentages of minerals: oligoclase-andesine, 59; microcline, 13; quartz, 18; hornblende, 3; biotite, 1.5; epidote, 3; sphene, 1.25; magnetite, 1; apatite, 0.25; frequently some zircon present. These analyses probably represent atypical varieties because hornblende and biotite, in quantities of 10 to 15 percent each, are observed commonly in many outcrops and are oriented, thus developing a prominent lineation and planar structure. Miller believes that the Parker quartz diorite is probably a slightly more basic facies of the Lowe granodiorite.

Miller (1934, pp. 40-41) describes the quartz syenite of the eastern Soledad basin as a medium-grained rock, light brownish gray to light brown, that ranges in structure from non-foliated and massive to distinctly gneissoid. Webb (1938) also has published a petrographic description of this syenite. Miller's thin section analyses give the following ranges in mineral percentages: microperthite, 58-60; microcline, 5; oligoclase, 4; quartz, 3-8; altered monoclinic pyroxene, 4-16; altered biotite, 5-14; secondary magnetite, 2-4; epidote, 1-3; apatite, 2; rare zircon. The quartz syenite can be distinguished from the Parker quartz diorite by its brownish color and absence of hornblende. Miller believes that the quartz syenite may be a variant of the Parker quartz diorite.

Although the granitic rocks are variable in detail, large areas are underlain by rocks so similar in lithology that they can be grouped into a single intrusive type. Simpson (1934, p. 384) states that the individual plutons of the intrusive rocks have gradational boundaries.

Simpson (1934, p. 384) also believes that because all of the granitic rocks south of the Sierra Pelona are more or less granulated, they are older than the Sierran intrusives. Miller (1934, p. 83), on the other hand, considers these granitic rocks to be members of the Sierran intrusive types of Jurassic-Cretaceous age. In the opinion of the writer, it can only be said that the intrusives are pre-Martinez and post-Pelona schist in age. The granulation may well be the result of stresses that were active during the extensive deformations of the Soledad basin during Cenozoic time.

IV STRATIGRAPHY

General statement

Marine sandstones and siltstones, with minor amounts of conglomerate, are present west of Bouquet Reservoir. These represent the Paleocene Martinez formation and lie in fault contact against Pelona schist, granite, or the Vasquez series. Their total thickness is not known.

The Oligocene (?) Vasquez series consists dominantly of coarse conglomerates that attain a maximum known thickness of about 12,000 feet. In addition, nearly 4,000 feet of interlayered andesite and basalt flows and sills is present within the Vasquez series east of Mint Canyon. These rocks were deposited in at least three separate basins, each with an independent history for much of Vasquez time. The individual basins coalesced late in Vasquez time, thanks to burial of the intervening ridges by encroaching fans that developed northward and westward from the ancestral San Gabriel Mountains.

The Tick Canyon formation, of late Lower Miocene age, rests with a distinct angular unconformity upon the strata of the Vasquez series. The Tick Canyon formation appears to have been laid down in two separate basins, each of which reflects a distinct source area. The material deposited in each basin was derived in large part from the underlying Vasquez section.

Unconformably overlying the Tick Canyon formation are the siltstones, sandstones and interbedded conglomerates of the Upper Miocene Mint Canyon formation. In the vicinity of Mint Canyon, this formation is about 4,000 feet thick. It consists mainly of floodplain deposits, intercalated with some lacustrinal deposits and minor amounts of volcanic tuff.

Thin gravels veneer numerous terraces that lie at the foot of the Sierra Pelona and border the major stream valleys. Large landslides are common in several areas underlain by the Pelona schist. Recent alluvium is present in all the major valleys and extends into tributary valleys for short distances.

Generalized section

		Thickness in feet
Quaternary		
Recent	Alluvium -- unconsolidated sands and gravels.	0-50
	Landslide material -- common in areas underlain by Pelona schist; composed of detritus that ranges widely in grain size.	0-100
Late Pleistocene (?)	Terrace gravels -- sands and gravels, commonly with clasts of Pelona schist, and locally with fragments of granitic rocks.	0-50
	------------- Unconformity-------------	
Tertiary		
Upper Miocene	Mint Canyon formation -- silts and sands, generally buff-colored, and poorly consolidated, with	0-4,000

	local beds of conglomerate and tuff; coarse basal conglomerate of Pelona schist detritus west of Mint Canyon.	
	-----------Minor unconformity-----------	
Late Lower Miocene	Tick Canyon formation -- sandstones, siltstones, and conglomerates, red to buff-colored; coarse basal conglomerate of granitic debris west of Mint Canyon, and of volcanic debris east of Mint Canyon.	0-900
	---------- Unconformity ----------	
Oligocene (?)	Vasquez series -- conglomerates, sandstones, and fanglomerates, well to poorly cemented, light colored; size of fragments generally increases to the south and east within each basin of deposition; lacustrinal facies and borate beds are present locally;	0-12,000
	interlayered sheets of andesite and basalt east of Mint Canyon	0-4,000

----------Unconformity----------

Paleocene	Martinez formation -- sandstones and siltstones, with minor conglomerates, moderately well cemented; marine; total thickness unknown.	200+

----------Unconformity----------

Martinez formation

Marine sediments of the Paleocene Martinez formation crop out as a thin wedge west of Bouquet Reservoir. This wedge of sediments is bounded on the north by the Bouquet Canyon fault and on the south by the Bee Canyon fault (pl. 1).

Clements (1932, p. 34) describes the Martinez section in the southeastern portion of the Tejon quadrangle as consisting of hard, well-bedded, well-sorted gray to buff sandstone with interbedded shale. The strata are steeply tilted, and have dips that range from 65° to 90°. A few beds of well-rounded pebble-cobble conglomerates are composed of volcanic rocks, quartzite, gneiss, and granodiorite, in decreasing order of abundance.

As observed by the writer, the Martinez formation near Bouquet Reservoir is a yellowish-brown, well-cemented, medium-to coarse-grained sandstone interbedded with thin layers of siltstone. A few pebbly beds also are present. Weathering of the silty interbeds leaves the steeply dipping sandstones standing as prominent ribs.

Vasquez series

General discussion:- The Vasquez series consists of nearly 12,000 feet of nonmarine conglomerates and sandstones, interlayered with which is nearly 4,000 feet of flows and sills of andesite and basalt in the area east of Mint Canyon (pl. 1). The sedimentary beds were laid down in local fault-bounded basins of deposition that appear to have been separate from one another during much of Vasquez time.

In order to facilitate further discussion, the basins of Vasquez deposition are herein designated, from east to west, the Vasquez Rocks basin, the Texas Canyon basin, and the Charlie Canyon basin (fig. 3).

The beds of Vasquez age now exposed in the Vasquez Rocks basin all lie east of Mint Canyon and almost all entirely north of the Santa Clara River (pl. 1). The Mint Canyon Ridge (fig. 3) marks the northern limit of this basin, while the eastern limit is not known accurately, but it appears to be in the vicinity of the San Andreas fault.

The Texas Canyon basin is now represented by rocks of the Vasquez series that are exposed in the region southeast of the Pelona fault and northwest of the Vasquez Canyon fault (fig. 3). The Tick Canyon and Mint Canyon formations unconformably overlie the Vasquez series along the southern margin of the exposed basin, and the Vasquez series itself unconformably overlies the Pelona schist along the northern

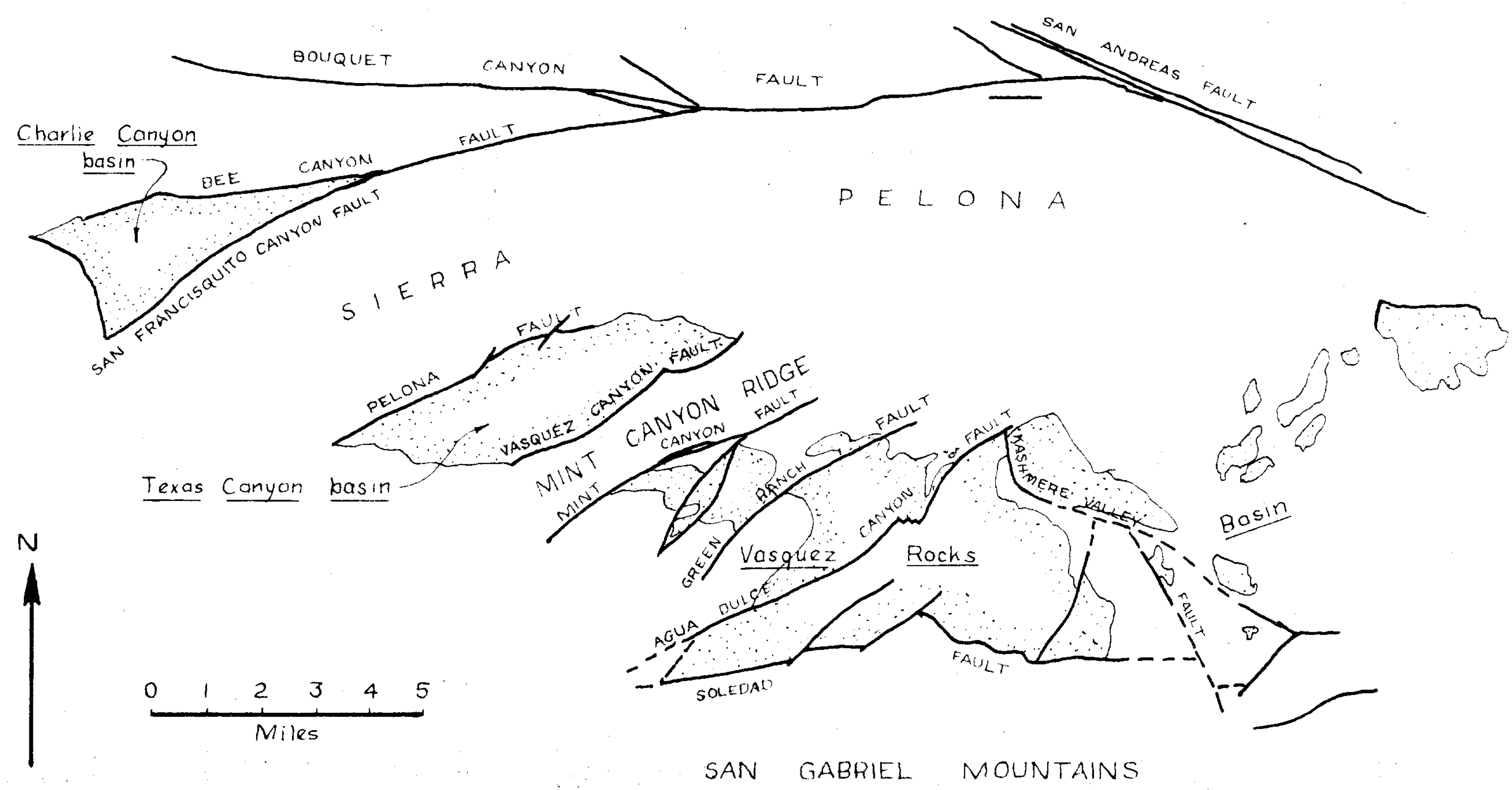


Fig. 3 Distribution of major faults and outcrops of the Vasquez series in a part of Soledad basin

margin. The subsurface continuation of the Texas Canyon basin to the southwest is unknown, but it could well have been connected during a part of Vasquez time with the Charlie Canyon basin.

The Charlie Canyon basin, which lies west of the Sierra Pelona between San Francisquito and Elizabeth Lake Canyons (pl. 1), is now marked by the wedge-shaped exposures of the Vasquez series in and near Charlie Canyon (fig. 3).

The rocks of the Vasquez series were originally described by Hershey (1902b, pp. 350-355), who termed them the Escondido series and designated the exposures in Tick Canyon as the type section. Kew (1924, pp. 38-39) tentatively referred this series to the Oligocene Sespe formation of the Ventura basin and noted that the best exposed sections are in Agua Dulce and Escondido Canyons. Simpson (1934, pp. 391-395) rejected Kew's correlation with the Sespe formation, retained the name Escondido, and suggested that it is the continental equivalent of the marine mid-Miocene Topanga formation exposed in the Santa Monica Mountains 40 miles to the southwest. Sharp (1935b, p. 314) suggested the name Vasquez to replace Escondido, a term that is preoccupied.

According to Jahns (1940, p. 153),

> "The exact age of the series is shrouded in doubt. Because all attempts to find fossils in the more promising strata have proved unsuccessful, the various postulated ages of Eocene, Oligocene, and middle Miocene have been based on non-paleontological evidence."

Jahns (1940, pp. 170-171) states further that:

> "Although the Vasquez beds may never have been directly connected with the whole or any part of the Sespe, they probably were laid down in a somewhat similar topographic environment during a period corresponding to at least a part of the Sespe. An Oligocene age is tentatively assigned to the series, pending the discovery of fossil remains, although the associated flows suggest a time range extending into the lower Miocene."

This writer concurs with the above analyses and conclusions.

Texas Canyon basin:- The Vasquez series is exposed over an area of about 12 square miles in the general vicinity of Texas Canyon. It rests with a steeply dipping depositional contact on the Pelona schist along the north margin of the basin, and is in turn unconformably overlain by the Tick Canyon and Mint Canyon formations along the southern boundary. The Vasquez strata are in fault contact with granitic intrusive rocks along the Pelona fault to the northwest. The southeast boundary is formed by the Vasquez Canyon fault which brings granite and gneiss against the rocks of the Vasquez series.

The exposed section may be as much as 10,000 feet thick, but accurate determinations are impossible because of extensive faulting, absence of marker horizons, and major changes in lithology along the strike.

Poorly sorted pebble and cobble conglomerates form the basal units of the Vasquez series. The clasts are subrounded, range in size from one inch to one foot, and consist of andesite and of coarse-grained pink granite. Fine-grained leucocratic granitic rocks also are represented among the clasts. Beds of well cemented conglomerate, ranging in thickness from six inches to four feet, alternate with thin beds of coarse, dark red sandstones throughout this basal unit. Cobbles of dark green to dark brown andesite and basalt are abundant in the coarser beds, and pebbles and cobbles of Martinez sandstone and quartz-bearing volcanic rocks also are present. This basal unit is about 2,300 feet thick.

Coarse breccias are abundant in the next higher stratigraphic unit and are well exposed in many places. Sandstones and conglomerates, such as are found in the underlying unit, also are common. The fragments as well as the matrix of the breccias are composed either of augen gneiss or of fine-grained, leucocratic granite. Large areas of pre-Cretaceous crystalline complex underlying the adjoining Mint Canyon Ridge consist either of augen gneiss or of fine-grained, leucocratic granite and constitute the probable source area for the Vasquez breccias. The ratio of fragments to matrix in these breccias is high, with the result that the fragments all interlock.

The breccias composed of augen gneiss fragments are the most prominent type in and near section 18, T. 5N., R. 14W. The workings of the Silver King Mine are in one of these breccias. Striking exposures of this breccia type are present in the west fork of Rowher Canyon. The breccia composed of fine-grained, leucocratic granite is well exposed in a small canyon 200 yards west of Bouquet Canyon and 200 yards north of the northernmost exposures of the Mint Canyon formation (fig. 4). Other good exposures are present in both the east and west forks of Rowher Canyon. Breccias of these types are indicated on Plate 2.

These breccias are rarely more than 100 feet thick and may be nearly one-half mile in exposed length. They are conformable with the underlying and overlying sedimentary beds and wherever the contacts are exposed they are depositional in nature. Locally scour channels in the underlying beds are filled by the breccias. The bedding of sandstones underlying some of the breccias may be deformed in a manner similar to that illustrated in Figure 6b. Thus, instead of being long, brecciated slivers of crystalline rocks faulted into the Vasquez series, these breccias are of sedimentary origin. These may be debris flows similar to those found in arid regions (see, for example, Blackwelder, 1928; Sharp and Nobles, 1953). Some may grade into landslide deposits in the source areas.

The thickness of the presumed debris flows or slides in Rowher Canyon is unknown, although they are probably more than 100 feet thick. In the vicinity of the Silver King Mine, the augen gneiss breccias are about 100 feet thick, and thin rapidly along the strike. The leucocratic, fine-grained granite breccia west of Bouquet Canyon is about 100 feet in maximum thickness, and thins abruptly as it is traced along its strike to the west. This decrease in thickness suggests that it consists of a series of individual flows, each 20 to 30 feet thick,

(a)

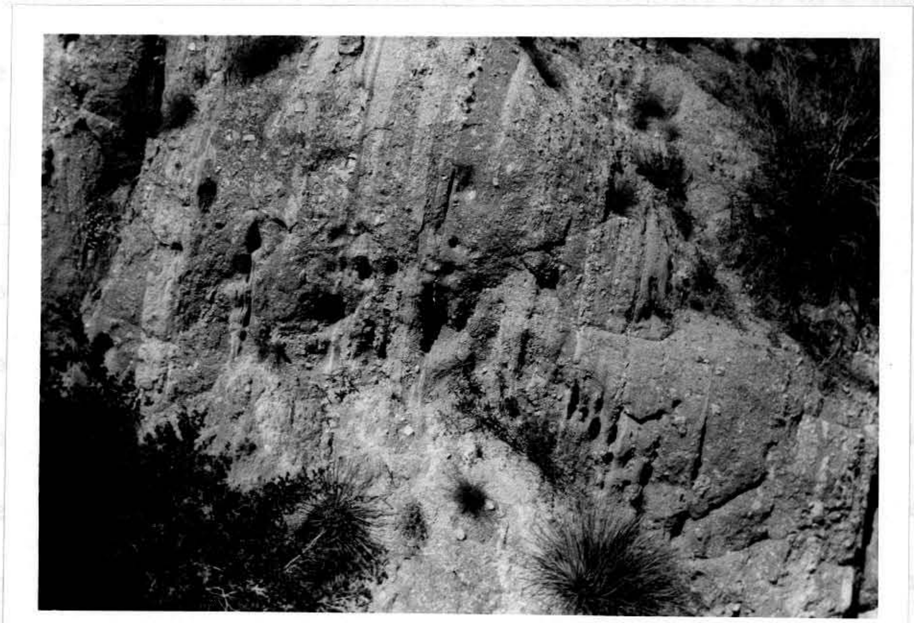
(b)

Figure 4. Sedimentary breccia of the Vasquez series.

(a) Upper surface of a sedimentary breccia composed of fragments of fine-grained granite. Largest boulder in picture is about four feet in longest dimension. Dark streaks are caused by water flowing down the face of the exposure. View north in canyon 200 yards west of Bouquet Canyon and 200 yards north of the northernmost exposures of the Mint Canyon formation.

(b) Section through the sedimentary breccia shown above. View west in stream cut above waterfall shown in Figure 4a.

(a)



(b)

Figure 5. Sedimentary breccias of the Vasquez series.

(a) Section of breccia composed of fragments of coarse-grained, pink-orthoclase granite. Largest fragment shown is about 15 inches in longest dimension. Thin arkose bed near right edge of photo shows dip of strata. Stratigraphic evidence indicates that these beds are overturned. View east. Locality 100 feet south of the Pelona fault and 200 yards east of Bouquet Canyon.

(b) Zone of thin sheets, three inches to one foot thick, of pebble breccias and coarse arkoses composed of detritus of a coarse-grained, pink-orthoclase granite. These beds are stratigraphically 50 feet higher in the section than Figure 5a, and are overturned also. Locality 50 feet east of Figure 5a.

which were deposited in rapid succession. To the east, this unit can be traced into conglomerates whose cobbles and boulders were derived from the same granite.

A third variety of breccia, in which angular blocks of coarse-grained, pink-orthoclase granite are scattered through a sandy matrix, occurs in thick, massive, well-cemented beds, which form prominent hogbacks throughout the area. The largest group of these hogbacks forms the massive cliffs south of Texas Canyon at the junction with Fall Canyon, where more than 400 feet of these breccia beds are exposed. A similar sequence is exposed in the north wall of the small canyon entering Bouquet Canyon from the east at a point 100 yards south of the Pelona fault (fig. 5). In both areas, the breccias are well cemented and have a pale brick-red color caused by iron staining. In Bouquet Canyon, the breccia fragments are commonly 1/2 to 2 inches in diameter, although clasts as large as one foot in diameter are present. In Texas Canyon the largest fragments noted are nearly three feet in diameter. These clasts are nearly all of a coarse-grained, pink-orthoclase granite, and the associated matrix is disintegrated material of the same composition. A few buff or red arkose beds one to six inches thick outline the bedding. Bedrock outcrops of a pink-orthoclase granite that is similar to the breccia fragments are present where Mint Canyon traverses the Mint Canyon Ridge. The total thickness of all the breccias exposed is about 700 feet.

Breccia beds three to six inches thick are common in the part of the section that immediately overlies the unit described above. These beds contain pebbles and cobbles of augen gneiss, leucogranite, and biotite gneisses along with the dominant pink-orthoclase granite. Dull brick-red, thinly-layered, fissile siltstones and sandstones are interbedded with these breccias. A few beds which consist of yellowish-white sands and pebble breccias also are present. Conglomerates are abundant in this portion of the section (fig. 6). The largest boulder noted in these conglomerates, is ellipsoidal in shape with major and minor axes five feet and three feet, respectively. The largest boulders in a single bed, as well as the boulder described above, commonly are composed of augen gneiss.

The uppermost unit composed of dark-colored conglomerates is in striking contrast to the underlying light-colored conglomerates. Both the matrix and the conglomerate clasts change in color and composition across the contact.

The light-matrix sediments are in fairly continuous layers two inches to two feet thick. They commonly are fine- to coarse-grained sandstones with interbedded pebble to cobble conglomerates. All of the clasts of the conglomerates are subrounded to subangular. Most consist of both fine- and coarse-grained, leucocratic granitic rocks and augen gneiss which have been derived from the bedrock outcrops of Mint Canyon Ridge. The sandy matrix also consists of light-colored detritus that probably was derived from the leucocratic granites.

Figure 6. Depositional features of sediments of the Vasquez series.

(a) Typical coarse, well-cemented conglomerate contained within the Vasquez series. Clasts composed of granitic and gneissic rock types, although minor amounts of Martinez sandstone and volcanic rock types also are present. Large boulder under the hammer is composed of augen gneiss. Black area is a small pool of water. At the falls near the mouth of Fall Canyon.

(b) Contemporaneous deformation of arkosic beds in the Vasquez series, apparently by rapid deposition of the overlying conglomerate prior to lithification of the arkose. One-fourth mile west of the Silver King Mine, Texas Canyon.

(a)

(b)

This unit is at least 2,500 feet thick.

The dark-matrix sediments, in contrast, are dominantly crudely bedded cobble to boulder conglomerates. The clasts commonly are of dark biotite gneisses and the matrix is finer material of the same composition. It is at this horizon that clasts of anorthosite first appear in the section as it is traced stratigraphically upward. The only known outcrops of anorthosite in place are those of the San Gabriel Mountains more than six miles to the south. Clasts of basalt also are common in this unit. Boulders of basalt and anorthosite as much as five feet in length are common along the divide between Texas and Vasquez Canyons. These dark-matrix beds are poorly consolidated, in contrast to the underlying units, many of which are well-cemented. Sedimentary breccias derived from the Mint Canyon Ridge also are common in Vasquez Canyon. Thus, the Mint Canyon Ridge evidently was partially buried and the ancestral San Gabriel Mountains became the dominant source of detritus for the Texas Canyon basin. The contacts indicated on the map do not represent a single horizon, but mark the base of successive waves of material as the fans from the San Gabriel Mountains built north and west across the basin. This dark-matrix unit was mapped by Judson (1935, pp. 51-56) as the Mint Canyon formation. This upper unit may be nearly 5,000 feet in maximum thickness although 3,000 feet represents the probable average thickness.

Vasquez Rocks basin:- The Vasquez Rocks basin is the largest known basin of Vasquez time. It also contains the thickest known section of Vasquez beds, which comprises nearly 12,000 feet of coarse conglomerates and sandstones. An additional 4,000 feet of flows and shallow intrusives of andesite and basalt is exposed. The presence of these volcanic rocks is the chief difference between this basin and the other basins of Vasquez deposition.

A section of basal conglomerates is nearly 1,000 feet thick, and consists dominantly of coarse boulder beds that were derived from the local basement rocks. These conglomerates contain clasts of Parker Mountain quartz diorite, Lowe granodiorite, other granitic types, anorthosite, and diabase. Jahns (oral communication, 1953) reports a breccia composed of Pelona schist fragments at the base of this unit in a small area near the head of Kashmere Valley. This is the only occurrence of Pelona schist fragments in the Vasquez series known to the writer, with the possible exception of a similar breccia in the Texas Canyon basin.

Individual beds of the basal conglomerate, some ten feet or more in thickness, commonly contain clasts of a single rock type. The fragments are subangular to subrounded, and range in diameter from a fraction of an inch to several feet. The sparse matrix of sand and granules is cemented by calcite and iron oxides.

Overlying the beds of basal conglomerate is a 4,000-foot section of volcanic rocks that contain interbeds of conglomerate. Several workers (Kew, 1924, p. 91; Miller, 1934, pp. 70-72; Bonillas, 1935, pp. 3-7; Sharp, 1935a, p. 54) have studied these volcanic rocks. Both extrusive flows and shallow sills and dikes have been recognized. They range in composition from andesite to basalt. The bulk of the phenocrysts are plagioclase which ranges from andesine to sodic-bytownite. Pigeonite and hypersthene are the only other common identifiable minerals. Biotite and olivine also have been reported.

Nearly 7,000 feet of conglomerates and sandstones form the next higher unit in the Vasquez Rocks basin. These contain clasts of the same rock types as those in the basal conglomerates, except that anorthosite is absent. The lower part of this unit is generally coarser than the remainder. A transitional unit of nearly 1,000 feet of sandstones with some conglomerates forms the next higher stratigraphic unit. The conglomerates contain clasts of both anorthosite and granitic rocks. Overlying this transitional unit is 3,000 feet of conglomerates and sandstones, in which the clasts are almost exclusively anorthosite, rocks genetically associated with anorthosite, and fine-grained dike rocks. This upper anorthosite-bearing conglomerate becomes coarser as traced upward in the section.

The stratigraphic units described in the previous paragraph were recognized and separated by R. B. Campbell (unpublished map, 1951). Only the contact between the transitional unit and the uppermost anorthosite-bearing conglomerate is shown on Plate 1. This contact is not the trace of any particular horizon, but instead represents a separation of units based on composition.

The conglomerates decrease in coarseness as they are traced along the strike to the northwest. Borates, a continuous gypsum zone beneath the lowest volcanic zone north of the Green Ranch fault, and ripple-marked siltstones testify to the presence of intermittent lakes along the base of the Mint Canyon Ridge during the part of Vasquez time represented by the Vasquez beds now exposed in that region.

Direct correlation with the Texas Canyon basin has not been possible because of the existence of the Mint Canyon Ridge, which evidently separated the two basins during most of Vasquez time. It is suggested, however, that the volcanics of the Vasquez Rocks basin mark a period of unrest that may be reflected in the zone of sedimentary breccias of the Texas Canyon basin. A second possible correlation might involve the transitional unit of the Vasquez Rocks basin and the beginning of deposition of the dark-matrix, anorthosite-bearing conglomerates in the Texas Canyon basin.

Charlie Canyon basin:- About 3,700 feet of massive conglomerates and sandstones of the Vasquez series crops out in the Charlie Canyon basin. These beds lie in fault contact with the Pelona schist to the southeast, the Martinez formation to the north, and the Mint Canyon formation to the southwest (pl. 1).

An unknown thickness of Vasquez beds has been eliminated by faulting. A conglomerate zone, less than 30 feet thick, is the lowest unit exposed. Tightly folded red sandstones, siltstones, and minor conglomerates, nearly 500 feet in aggregate thickness, overlie the basal unit. About 2,700 feet of well-cemented conglomerates and sandstones constitute the bulk of the section. The conglomerates contain clasts of the following rock types, listed in order of decreasing abundance (Ruiz-Elizondo, 1953, p. 26): porphyritic quartz diorite; fine-grained, leucocratic quartz diorite; porphyritic diorite; light gray to pinkish granite that is coarse grained, and even pegmatitic in places. The following rock types are present in small amounts: purplish red, banded, porphyritic andesite; anorthosite; red, aphanitic, fine-grained volcanic rocks that have not been specifically identified; and black, fine-grained norite (?).

The presence of anorthosite and norite (?) suggest that the ancestral San Gabriel Mountains supplied at least a part of the detritus for this area, unless, of course, another source of anorthosite clasts existed during Vasquez time, and was later eroded away or buried by younger deposits.

Breccias of fine-grained granite fragments, overlain by 500 feet of breccias composed of Pelona-schist fragments, comprise the highest known stratigraphic units assigned to the Vasquez series by Ruiz-Elizondo. The massive breccia that forms the basal conglomerate of the Mint Canyon formation west of Bouquet Canyon is lithologically similar to the Pelona-schist breccia in Charlie Canyon. This writer believes that the Vasquez breccia of Pelona-schist fragments is the basal conglomerate of the Mint Canyon formation, which has been preserved in a tight syncline along the southern margin of the Charlie Canyon basin.

Tick Canyon formation

The recognition of both primitive and advanced mammalian forms in the Mint Canyon formation (Maxson, 1930, pp. 81, 85; Stirton, 1933, p. 575; 1936, p. 188) led Jahns (1939, pp. 818-825) to undertake detailed stratigraphic studies which enabled him to separate the Tick Canyon formation from the basal part of Kew's (1924, pp. 52-53) Mint Canyon formation, and thus resolve the anomalous association of mammalian types.

In the type area near Vasquez Canyon, Jahns (1940, p. 154) notes that:

> "the (Tick Canyon) formation consists of 593 feet of reddish-brown clay, siltstone, and sandstone, with a thick, irregular zone of poorly lithified boulder to cobble conglomerate at the base. Nearly everywhere else, it is much thinner, with an average thickness of approximately 350 feet."

The basal conglomerate of the type area is composed of large fragments of rock types derived from the underlying Mint Canyon Ridge, on which the coarse beds rest unconformably. Pebble beds of Pelona-schist detritus are present in the upper part of this formation.

The Mint Canyon Ridge seems to have separated two basins of accumulation during Tick Canyon time. East and south of Mint Canyon, the Tick Canyon formation thickens rapidly to a maximum of 900 feet in Tick Canyon. Farther south it thins again, and near Soledad

Canyon it is partially overlapped by the Mint Canyon formation. It rests with a strong angular unconformity on beds of the Vasquez series, and near Mint Canyon only the basal 2,000 feet of the Vasquez series remains beneath the overlapping Tick Canyon formation. The cobble conglomerates east of Mint Canyon contain clasts of well-rounded, dark-colored volcanic rocks with only rare clasts of granitic rock types. The lower part of the Mellenia series of Hershey (1902b, pp. 356-358) is the equivalent of the Tick Canyon formation as defined by Jahns.

Mint Canyon formation

Kew (1924, pp. 52-53) renamed Hershey's Mellenia series the Mint Canyon formation. He discussed the general stratigraphic relations of this unit, as did Maxson (1930, p. 81) in his later description of the vertebrate fauna from the formation. Jahns (1940, pp. 155-162) presented a detailed stratigraphic section of the 4,044 feet of his restricted Mint Canyon formation as exposed between Mint and Bouquet Canyons.

An excellent brief description of the relationships between the Tick Canyon and Mint Canyon formations is made by Jahns (1939, p. 821) as follows:

> "The Mint Canyon formation, comprising slightly more than 4,000 feet of gray sandstone and conglomerate, variegated siltstone and clay, and minor tuffaceous beds, overlies the older Tick Canyon strata in all places where the latter are exposed. Although there is but one slight indication of angular discordance between the formations,

> the sedimentary break suggested by their faunal differences does appear, probably as a disconformity. The location of this contact at the base of a thick conglomerate zone is fixed with certainty by fossil occurrences, and its unconformable nature is further evidenced by a general change in lithology, certain minor structural discrepancies, and by the irregular distribution of the Tick Canyon beds."

The observations of this writer were restricted to the basal units of the Mint Canyon formation. The basal conglomerate (member 1 of Jahns' section, 1940, p. 162) is a thick-bedded, cobble to boulder conglomerate with fragments of Pelona schist and dark gneiss, alternating in six- to ten-foot layers with conglomeratic sandstones. Its cliff-forming nature, as well as its distinctive lithology and brown color, aid in identifying this basal unit of the Mint Canyon formation.

Where the Tick Canyon formation is missing, the basal conglomerate rests with a strong angular unconformity upon strata of the Vasquez series. The rock types so abundant as clasts in the upper Vasquez series, including the augen gneiss, pink-orthoclase granite, volcanics, and anorthosite, are absent from the basal Mint Canyon formation; in their place are the many varieties of Pelona schist and dark-colored gneisses. About 1,000 feet west of Bouquet Canyon, this basal unit is a coarse breccia of Pelona-schist fragments. Farther west, it is a conglomerate that wedges out against the ancestral Sierra Pelona. Distinctive beds in the overlying sandstones and siltstones can be followed across the buried trace of the Pelona fault, thus proving that there has been no activity on this fault since the beginning of Mint

Canyon deposition.

To the east, the schist-bearing basal conglomerate wedges out 2,000 feet east of Mint Canyon. From this point east, the basal unit of the Mint Canyon formation is a conglomerate composed of well-rounded pebbles and cobbles of volcanic rocks very similar to the conglomerate units found within the underlying Tick Canyon formation.

The Mint Canyon formation contains vertebrate fossils that have been variously identified as Upper Miocene or Lower Pliocene age. It lies beneath the marine "Modelo" formation of uppermost Miocene Neroly age (Jahns, 1939, p. 822), and hence is here regarded as Upper Miocene.

Terrace deposits

Gravel deposits now topographically above the modern stream beds are present over most of this region. Except for those along the southern flank of Mint Canyon Ridge, the terrace gravels shown in Plate 2 are composed almost entirely of flat cobbles of Pelona schist and fragments of milky, white quartz. The gravels along the southern flank of Mint Canyon Ridge are composed of granitic and gneissic detritus derived from the ridge. These deposits range in thickness from a few feet to nearly 50 feet, with an average thickness of 20 to 30 feet.

No attempt was made to distinguish between various erosion surfaces associated with these deposits. In general, however, four major benches at about 400, 200, 100, and 25 feet above present stream levels can be recognized. Other, less well-defined benches occur at intermediate levels.

Wallace (1949, p. 792) believes that the schist-bearing gravels along the San Andreas rift, northeast of the Sierra Pelona, are of late Pleistocene or early Recent age. In that area, they overlie fossiliferous Harold beds of Pleistocene age. The terrace gravels along the south flank of the Sierra Pelona, in the region under discussion, are probably of the same age. West of this map area, terrace deposits lie with an unconformity upon the Saugus formation (Kew, 1924, p. 89) which is in part late Pliocene and in part early Pleistocene in age.

Landslides

Large landslides are common within the Sierra Pelona. The entrenching of the major streams during Recent time has oversteepened the slopes and aided the development of the slides. Lubrication supplied by the abundant mica in the deeply weathered and fractured Pelona schist has assisted in the down-slope movement.

Landslides have been mapped only in those areas where the sliding has completely concealed the geologic relations. Elsewhere in areas underlain by Pelona schist, creep has partially obscured the geological relationships.

Alluvium

Recent alluvial deposits occupy all the major stream valleys, and also is present in many of the larger gullies. The alluvium is composed of sands and gravels interbedded with silts. All areas of alluvium are subject to flooding during major storm periods.

V STRUCTURE

General statement

The most outstanding feature of this region is the abundance of northeast-trending left-hand faults, some of which offset earlier normal faults that trend nearly east. Northwest-trending right-hand faults, such as the nearby San Andreas fault, are common in southern California but are missing from the Soledad basin.

The earlier normal faults probably were active prior to Vasquez time, and may have been intermittently active during Vasquez time as well. Activity of these faults ceased prior to Tick Canyon time. The left-hand faults were active after Mint Canyon time, and ceased motion prior to deposition of the late Pliocene Saugus formation.

The rocks of the area are extensively faulted, but are little folded. The relatively few folds that do occur are open and broad. The competent Vasquez strata have been tilted and faulted without much folding except in the upper Tick Canyon area, where they have been compressed into tight folds. This folding occurred during two periods, the earlier of which was in pre-Tick Canyon time. This deformation was more intense than the later, post-Mint Canyon deformation. During the later deformation the Tick Canyon and Mint Canyon formations were warped into broad folds.

The Pelona schist has been broadly warped, although locally small isoclinal folds also have been observed. This folding is believed to be mainly the result of pre-Tertiary deformation.

The granitic and gneissic rocks are jointed and fractured to an extreme degree. Although the jointing seems to be random in orientation for the most part, a very prominent set in the granitic rocks of the Mint Canyon Ridge trends northwest with a nearly vertical dip.

Structure of the Pelona schist

Within the Pelona schist, the major and minor structural features of megascopic scale are consistent with an axis of maximum compressional stress oriented north-northwest and south-southeast.

Foliation in the schists is parallel to bedding in most places. On minor drag folds, however, the foliation lies parallel to the axial planes of the folds. A lineation, formed by crinkling in the planes of foliation, commonly plunges gently south-southwest (fig. 7a). A second, locally well developed lineation also is represented by crinkling of the foliation, and plunges down the dip of the foliation. In addition, the minor folds in the intricately contorted limestone and interbedded quartzite plunge consistently to the south-southwest at low angles, although commonly they plunge more gently than the lineations observed in the schists.

Two well-developed sets of joints occur in the quartzite that is interbedded with limestone. The angles of intersection between the two sets are 60° and 120°, and the 120° angle is bisected by the axial plane of the minor folds.

Post-metamorphic diastrophism has developed a slight shearing and granulation in the limestone that is interbedded with the jointed quartzite.

The structural features described above probably were developed contemporaneously with the metamorphism of the schists. The age of the metamorphism is not known, however, although it may be the same as that of the Sierran intrusives.

Pelona fault

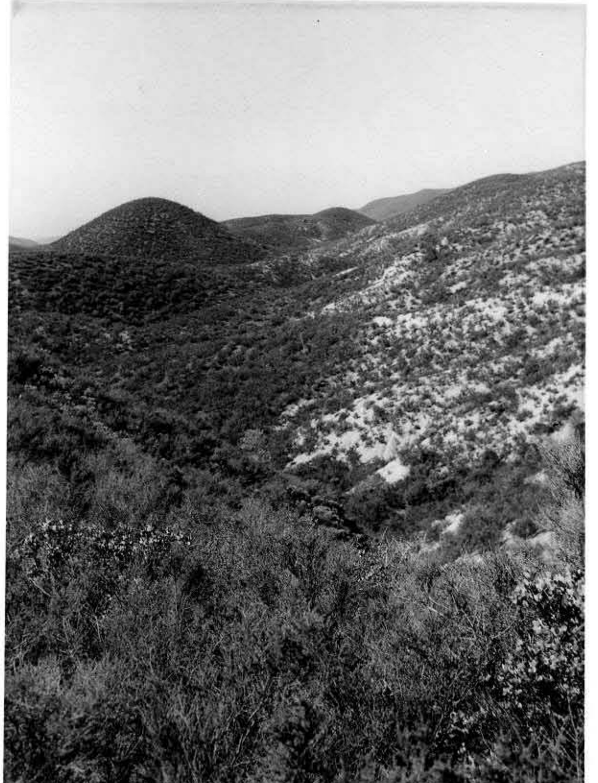
The Pelona fault has been considered the "master fault" of the Soledad basin, and was traced by Simpson along the entire southern margin of the Sierra Pelona, or for a distance of more than 20 miles. The initial purpose of this study was to determine the relationship of the Pelona fault to the other faults of the Soledad basin and to the San Andreas fault. Actually, the Pelona fault is traceable for about six miles from a point one mile west of Bouquet Canyon northeastward to its intersection with Texas Canyon. At this point, the amount of offset has been reduced to virtually zero, and the fault does not appear to exist farther east. How far it extends to the west is unknown, because the trace of the fault is buried by beds of the Mint Canyon formation.

Figure 7. Lineation developed in the Pelona schist and view of the easternmost part of the Fall Canyon segment of the Pelona fault.

(a) Muscovite schist variety of the Pelona schist showing a prominent lineation developed by crinkling of foliation. Sierra Pelona Truck Trail near junction with the Fall Canyon Truck Trail.

(b) View west along the contact between the Vasquez series (dark-colored rocks on left) and granite (light-colored rocks on right). Contact in foreground is believed to be depositional. West from the round knob, Hill 2647, the contact is a fault with displacement increasing to the west along the Fall Canyon segment of the Pelona fault. Locality is about one-half mile north of the Silver King Mine.

(a)



(b)

The Pelona fault trends east-northeast for its entire length, and marks the southern base of the Sierra Pelona. The dip of the fault plane varies about 10^{o} in either direction from the vertical, and steep south dips are most common. However, the fault dips southward at angles between 30^{o} and 45^{o} in the Fall Canyon segment, which is the reach from a point 1,000 feet west of Fall Canyon eastward to the end of the fault. The displacement increases westward along the fault to an unknown maximum at a point that probably lies somewhere along the Bouquet Canyon segment, which is the portion of the fault that straddles Bouquet Canyon and is nearly four miles long. Exposures of the fault plane are rare, but it can be located within a few feet in many places thanks to the striking contrast between the brick-red rocks of the Vasquez series on the south and the white granitic rocks on the north.

The zone of fracturing that surrounds the fault commonly is several tens of feet wide, although the crushed zone rarely is more than a few feet wide. Slickensides on the fault plane in Fall Canyon plunge 25^{o} to the southeast. Slickensides in rocks of the Vasquez series occur on closely spaced fractures that lie parallel to and within a few hundred feet of the Pelona fault near Bouquet Canyon, and these also plunge 25^{o} to the southeast. These slickensides indicate a dominant left-hand motion along the fault with a large vertical component in which the north side has risen with respect to the south.

The diagrammatic sections of Figure 8 illustrate the relations across the various segments of the Pelona fault. In the Bouquet Canyon segment the Pelona fault intersects the strike of the Vasquez beds at an angle of nearly 30°. The Vasquez strata in this reach are vertical or slightly overturned against the fault plane (fig. 9). The rocks that bound the fault plane are jointed and fractured for distances of several hundred feet on both sides of the plane. The Bouquet Canyon segment has the maximum known offset along the fault, as at least 5,000 feet of basal Vasquez beds is cut out along this reach. In the Mystic Canyon segment, the strike of the fault and the strike of the Vasquez strata are nearly parallel. Deformation of the surrounding rocks has not been so intense, as is shown by the 60° southward dips of the Vasquez beds and by the lesser degree of fracturing. In the Fall Canyon segment, the author believes that the actual trace of the Pelona fault lies buried under the Vasquez series (fig. 7b). The observed fault breaks represent adjustments along the contact between the Vasquez series and the underlying crystalline rocks in response to oblique displacements at depth, as illustrated in Figure 8. The propriety of considering the Fall Canyon segment as a portion of the Pelona fault might be questioned, but it is here included as the easternmost extension of the fault because the displacements observed are genetically related to the eastward diminution of slip along the Pelona fault.

The writer can offer no satisfactory explanation for the narrow belt of granite that lies between the Pelona fault and the Pelona schist. The contact between the Pelona schist and granite in general dips steeply south, so that the belt of granite probably tapers out downward

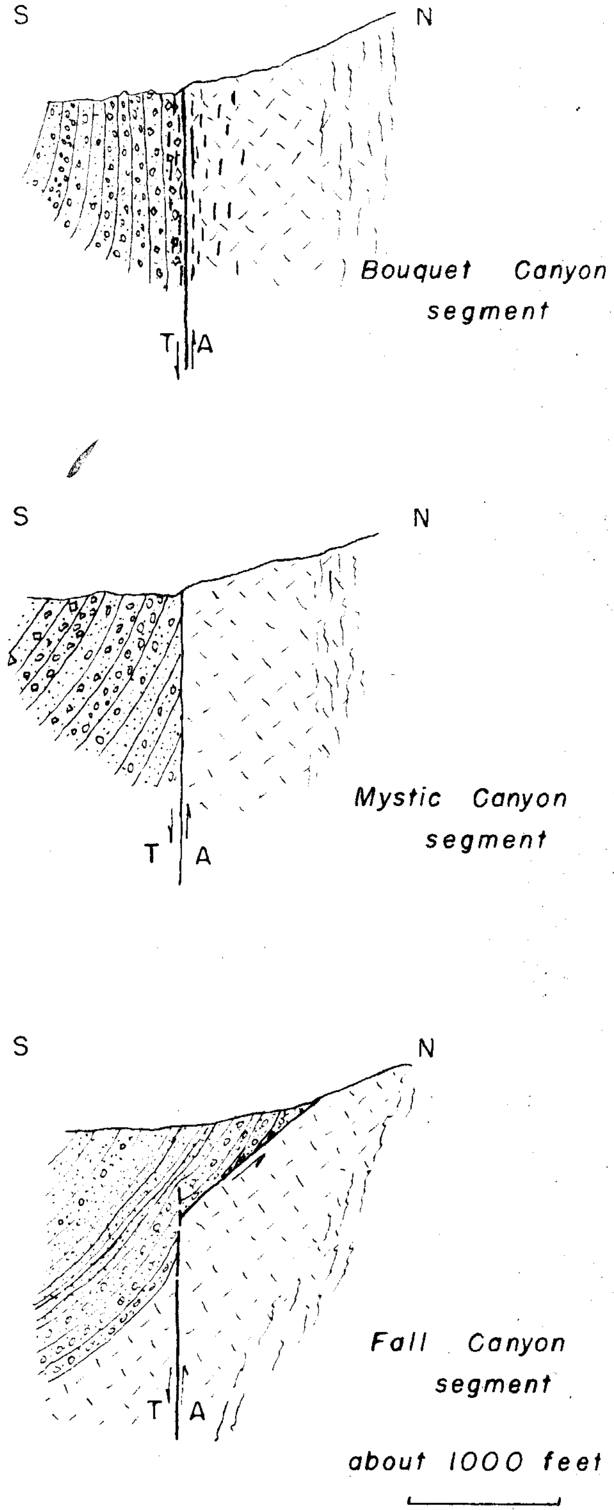
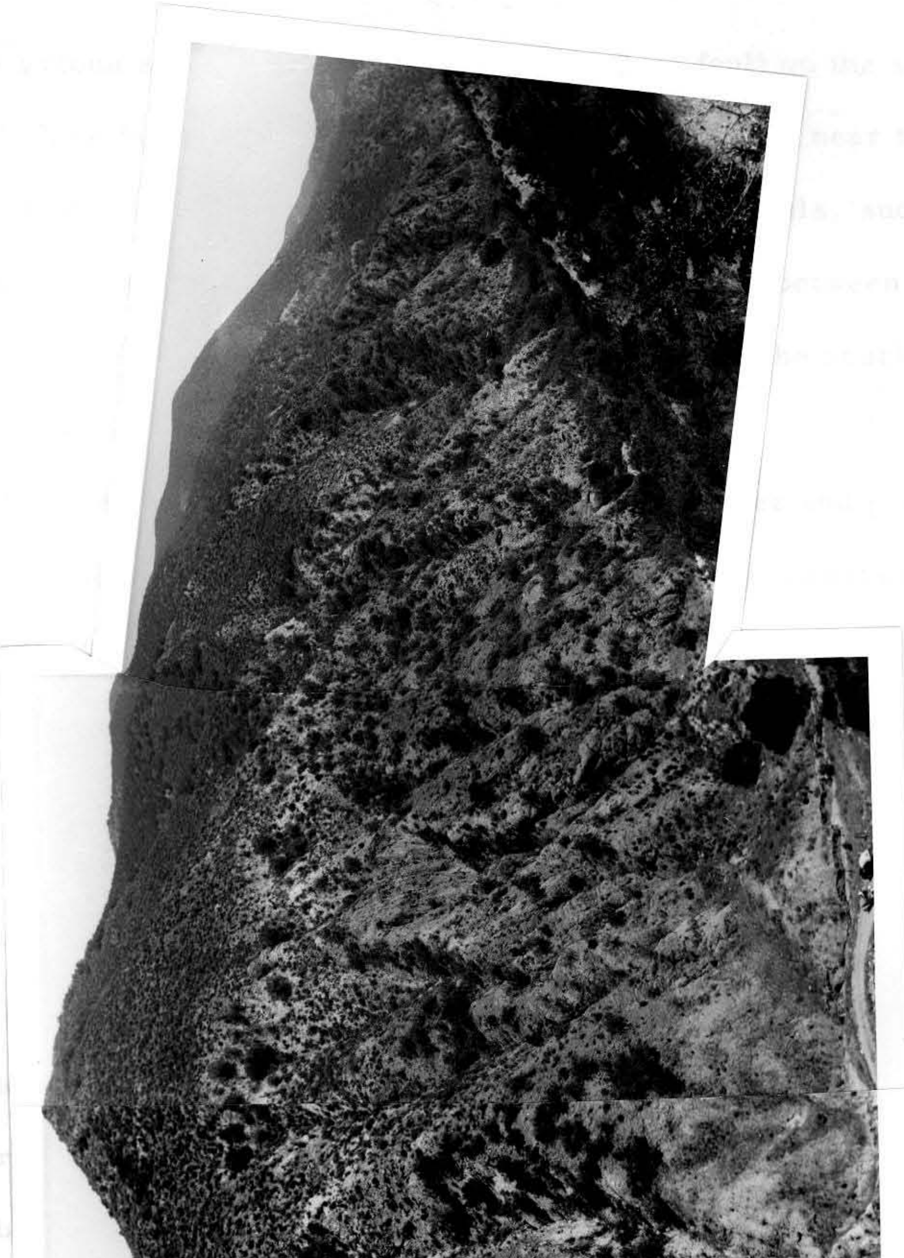


Fig. 8 - Diagrammatic cross sections of the Pelona fault

Figure 9. Panorama of a part of the Bouquet Canyon segment of the Pelona fault. View is from north at left edge of panorama to northeast at the right edge. The Pelona fault separates the dark-colored rocks of the Vasquez series in the foreground from the light-colored granite, which forms the prominent band across the middle of the panorama. Dark-colored rocks in the background are part of the Pelona schist. Details of the sedimentary features of the Vasquez series in the foreground are shown in Figure 5. Bouquet Canyon is 100 yards to the west (to the left of panorama).



against the Pelona schist on the north and the Pelona fault on the south. Thus, the Pelona fault at depth probably originated along or near the contact of the Pelona schist and the granite. At higher levels, such as those presently exposed, the steep, south-dipping contact between schist and granite has been displaced northward with respect to the nearly vertical fault plane.

The Pelona fault was active during post-Vasquez and pre-Mint Canyon time, and probably the major displacements occurred prior to Tick Canyon time. The presence of the basal Vasquez units which cross the projected eastern extension of the fault plane without any apparent offset precludes any offset along this part since the beginning of Vasquez deposition. There is no evidence available to indicate whether this fault moved prior to Vasquez time.

The presence of small fragments of Pelona schist in the upper parts of the Tick Canyon formation indicates that the western part of the Sierra Pelona had been uplifted, and that much of the sedimentary cover had been stripped from the schist prior to late Tick Canyon time. The fine-grained nature of most of the Tick Canyon formation indicates that the bulk of the uplift and erosion might well have occurred prior to the deposition of the Tick Canyon formation.

The flood of coarse fragments of Pelona schist in the basal conglomerate of the Mint Canyon formation is suggestive of a reactivation of the Pelona fault during the time interval represented by the disconformity between the Tick Canyon and Mint Canyon formations.

The basal conglomerate of the Mint Canyon formation apparently pinches out at the trace of the Pelona fault, as though it had been deposited against a fault scarp. Several distinctive beds in the overlying unit of the Mint Canyon formation have been traced without a break across the buried end of the Pelona fault.

Vasquez Canyon fault

The Vasquez Canyon fault trends northeast from Vasquez Canyon for a distance of about five miles to the base of the Sierra Pelona. The maximum known displacement is in Vasquez Canyon, where the entire thickness of the Vasquez series in the Texas Canyon basin, amounting to about 10,000 feet of strata, has been faulted against the granite and gneiss of the Mint Canyon Ridge. The displacement rapidly decreases to the northeast, so that probably less than a few hundred feet of offset remains at the point where the fault enters the Pelona schist, from which point it cannot be traced to its ultimate termination.

The fault plane dips north at angles between 50° and 60°, except in its westernmost exposed part, where it is essentially vertical. The direction of movement is not known, but the writer believes it is a normal fault with little or no strike-slip offset. The fault itself is marked by a zone of brecciation a few feet or less in thickness, and commonly about one foot. In some areas, fracturing of the Vasquez series is noticeable for distances of at least fifty feet from the fault zone.

Displacement ceased on the Vasquez Canyon fault prior to Tick Canyon time, because the basal beds of the Tick Canyon formation lie across the trace of the fault without apparent offset. The Texas Canyon basin must have been downfaulted prior to, and probably intermittently during, Vasquez time along the Vasquez Canyon fault and other faults. Evidently the basin was sufficiently deepened to contain the thick sequence of Vasquez strata now exposed.

The Vasquez Canyon fault has no prominent topographic expression. Along most of its trace, an erosion surface, now partly buried by terrace deposits, has beveled the rocks on both sides of the fault.

Mint Canyon fault

The Mint Canyon fault is exposed along the southern base of the Mint Canyon Ridge for a distance of at least six miles. It commonly consists of two or more subparallel branches that generally trend east-northeast. The dip of the fault plane is nearly vertical, although some of the northern branches may dip about 60° south. Each fault plane, or group of planes, lies in a zone of crushed rocks as much as 100 feet in width.

The southwestern extension of the fault is buried under the alluvium of Mint Canyon. Similarly, the trace of the fault is buried to the northeast under the terrace and alluvial deposits of the Sierra Pelona Valley. The fault must either die out or change direction in the Sierra

Pelona Valley, because no observable offsets of the Pelona schist are present along the south flank of the range from Mint Canyon to Summit.

Several episodes of movement have occurred along the Mint Canyon fault. These are thought to have taken place: probably just prior to, and contemporaneous with, early Vasquez time; during the interval between Vasquez and Tick Canyon deposition; and during post-Mint Canyon time but prior to development of Quaternary terraces, and possibly prior to deposition of the Saugus formation.

The displacements prior to, and possibly contemporaneous with, Vasquez deposition are postulated. The Mint Canyon Ridge appears to have been the predominant source of detritus for the Texas Canyon basin during most of Vasquez time. At the same time, it supplied very little detritus to the northern margin of the Vasquez Rocks basin. Thus, either the ridge was so extremely assymetrical that it yielded very little detritus in a southward direction, or the directions of drainage were such that material from the ridge was moved out beyond the line of present outcrops. Probably both these conditions prevailed during Vasquez time. The assymetry is best explained by displacement along the Mint Canyon fault, which resulted in development of a steep south slope and a gentle north slope.

The lava flows of the Vasquez Rocks basin probably kept the alluvial fans of the Mint Canyon Ridge from encroaching far into the basin. The presence of lacustrine deposits interlayered with the flows of the Vasquez series along the southern flank of Mint Canyon Ridge is evidence of the possible damming effect of these flows. Erosion during pre-Tick Canyon time removed most of the Vasquez beds from this area, and thus we cannot determine whether the termination of volcanic activity allowed fans to build southward from the Mint Canyon Ridge for any great distance before the ridge was partially buried by fans extending northward from the ancestral San Gabriel Mountains.

The uplift of the Mint Canyon Ridge and surrounding terrane was caused by faulting along the Mint Canyon fault during the interval between Vasquez and Tick Canyon times. The direction or amount of offset is not known. The tight folding of the Vasquez beds in upper Tick Canyon indicates that extensive movements probably occurred.

The last offsets along this fault took place after Mint Canyon time. The apparent strike-slip component of offset, as measured on the top of the basal conglomerate of the Mint Canyon formation, is about 6,000 feet. The minimum stratigraphic offset of the top of the basal conglomerate is roughly 4,000 feet. The actual direction of offset along the fault is unknown, because no linear elements have been found. The numerous faults present in upper Tick Canyon are predominantly left-hand in nature, and the southeast side of each has moved northeast with respect to the northwest side. Similarly, the Mint Canyon fault may be left-hand, with a small dip-slip component in which the south side has dropped with respect to the north side. Thus the net-slip probably is 4,000 to 6,000 feet, or, as a rough estimate, about one mile.

Green Ranch fault

The Green Ranch fault is difficult to locate accurately over much of its trace length, and no exposures of the fault zone have been observed. The part of the fault near Green Ranch is the most prominent, because of the occurrence there of a wide crushed zone and of marked differences in lithology on either side of the fault. The fault zone in the vicinity of Green Ranch is nearly 100 feet wide, and it can be traced northeast from Spring Canyon for a distance of at least five miles to where it is buried by broad fans and terrace gravels. Its buried continuation may be cut off by the KashmereValley fault, but it seems more likely that the Green Ranch fault dies out northeastward, and hence does not exist at the possible projected extension of the KashmereValley fault.

Offsets on the Green Ranch fault occurred during post-Mint Canyon time, and prior to the deposition of Quaternary terrace deposits. The magnitude and direction of displacement are unknown. Most investigators in this area have assumed left-hand displacement along the fault by analogy with faults of similar trend and age in this region. The base of the Mint Canyon formation has been offset about 6,000 feet in the event of movement of this type; the base of the volcanics in the Vasquez series less than 4,000 feet; and the base of the Vasquez series has been shifted less than a few hundred feet. Thus the offsets along the fault appear to decrease progressively to the northeast. Some of the displacement of the Green Ranch fault may be absorbed in a postulated fault that trends north into the Sierra Pelona Valley. This latter fault also would explain the radical change in attitude of the Vasquez series on either side of the Sierra Pelona Valley.

Other major faults

The other major faults that have been named in this region are herein discussed only briefly, in part because the writer has had to rely on the published record for most of his information regarding these faults.

The Bouquet Canyon fault and its western continuation, the Clearwater fault, can be traced for distances of more than 20 miles westward from the San Andreas fault. A continuous chain of narrow and deep valleys has been eroded along the fault zone. From the San Andreas fault to Bouquet Reservoir, the Bouquet Canyon fault separates Pelona schist on the south from granite and gneiss on the north. West of Bouquet Reservoir, the Martinez formation forms the south boundary of the fault. The fault is poorly exposed over the eastern segment, but can be followed by means of a series of well-defined cols along the trace. Its dip probably is nearly vertical.

Wallace (1949, p. 798) noted the floods of Pelona schist detritus in the Mint Canyon formation and in the Quaternary terrace gravels, and he related these deposits to movements on the Bouquet Canyon fault immediately prior to the deposition of these units. Wallace (1944, p. 91) apparently favors the view that the San Andreas fault truncates the Bouquet Canyon fault, rather than the view that the Bouquet Canyon fault is a branch or spur from the San Andreas fault.

Northwest of the map area in the Tejon quadrangle, Clements (1932, pp. 128-132) has named the Clearwater fault, which is the continuation of the Bouquet Canyon fault. In this area, he was able to distinguish two directions and periods of offset. The earlier offsets occurred between Martinez and Vasquez times. They were dip-slip in nature, and the north side of the fault moved up with respect to the south side. The preservation of a westward-thickening wedge of Martinez sediments on the north side of the fault led Clements to believe that the amount of offset increases to the east. The later offsets were left-hand in nature, and took place between Vasquez and Modelo times.

Clements also discusses the Bee Canyon and San Francisquito Canyon faults. These faults bound the exposed Vasquez rocks in the Charlie Canyon block. The Bee Canyon fault is a steep reverse fault that is traceable eastward from Elizabeth Lake Canyon to Bouquet Reservoir. The San Francisquito Canyon fault varies from a low-angle thrust to a steep reverse fault along most of its trace in San Francisquito Canyon. Its northwest-trending continuation may be right-hand in nature, although this is only an inference based on the known offsets of other, nearby faults.

The Bee Canyon and San Francisquito Canyon faults are believed to be genetically related. Along the San Francisquito Canyon fault, the Vasquez series is thrust over the Mint Canyon formation. An anticline continues to the southwest from the intersection of the San Francisquito fault and the northwest-trending fault. Both the Mint Canyon and Modelo formations are involved in this folding (pl. 1). The Vasquez series lies against both the Mint Canyon and Modelo formations along a northwest-trending fault that forms the present western boundary of the Charlie Canyon basin of Vasquez deposition. Thus, the age of the displacements along the San Francisquito fault, and presumably also along the Bee Canyon fault, is post-Modelo. Terraces overlie the fault traces, thus providing an upper limit to the date of faulting. Clements prefers to correlate the major faulting with a mid-Pleistocene orogeny in the region.

The Agua Dulce Canyon fault crosses the canyon of the same name slightly more than a mile north of Soledad Canyon. This name is suggested to replace the earlier designation of Bee Canyon fault (Sharp, 1935a, map) to avoid duplication of names in this region. The post-Tick Canyon offsets are left-hand (R. B. Campbell, 1953, personal communication). Before and probably during Tick Canyon time, the south side of the fault moved up with respect to the north side, and evidently furnished a source for anorthosite-bearing conglomerates in the basal Tick Canyon formation. Campbell also believes that the Tick Canyon formation was deposited against the Agua Dulce Canyon fault scarp, and that possibly none of the Tick Canyon formation was deposited in the area south of the Agua Dulce Canyon fault.

The Soledad fault is a normal fault that dips 50° to 70° north. It varies in nature from essentially a simple plane to a zone of brecciation several tens of feet wide. It formed the southern margin of the eastern Soledad basin. Intermittent offsets during Vasquez time deepened the Vasquez Rocks basin sufficiently to allow accumulation of the known 16, 000 feet of Vasquez sediments and volcanic rocks. It continued to move for an unknown length of time after Vasquez deposition. The fault probably is pre-Tick Canyon in age, if only by analogy with the Vasquez Canyon fault. Further, it seems to have been cut off to the east by Middle Miocene movements along the San Andreas fault (L. F. Noble, personal communication, 1953). Minimum offset along the fault is indicated by the known thickness of 16, 000 feet of the Vasquez series lying against it. In addition, the San Gabriel Mountains rise several thousand feet above the outcrop of the Soledad fault, but some of this uplift might be accounted for by movement along other faults within the range.

The Kashmere Valley fault (Sharp, 1935a, p. 68) has a northwest trend, and traverses the length of Kashmere Valley. Little is known about the movements on this fault, except that the northeast side has been dropped nearly 4, 000 feet with respect to the southwest side. Near Parker Mountain, the Kashmere Valley fault splits. One branch passes east of Parker Mountain, and is known as the Acton fault. The other branch lies west of Parker Mountain, and retains the original name.

Other faults

The Soledad fault has been offset along several high-angle, left-hand faults that trend northeast. Horizontal slickensides are common along these faults. These left-hand faults generally are parallel to, and probably are genetically associated with, the Agua Dulce Canyon fault.

Almost without exception, the numerous minor faults that have been mapped are nearly vertical, and show a left-hand motion. Although the evidence of slickensides is lacking, the high-angle faults that offset the Pelona fault are believed to be of this same type. The known exceptions are a few gently-dipping strike-slip faults that cut strata of the Vasquez series in upper Tick Canyon.

Folds

Only the folding of the Cenozoic rocks is discussed in this section of the report. Folds in the Pelona schist have been discussed earlier in connection with the structural features of the Pelona schist.

In general, the folds in the stratified Cenozoic rocks are open and have gently dipping flanks. The only tight folds that have been observed are closely associated with extensive faulting.

Little is known of the structure of the wedge of Martinez sediments between the Clearwater and Bee Canyon faults. Detailed studies have been made in a few small areas, and most of these have resulted in detection of nearly isoclinal folds. It is likely that most of the rocks in this wedge have been greatly deformed, and they would provide an interesting but difficult subject for future research.

Folding is very rare in the thick-bedded, competent rocks of the Vasquez series. Faulting is the usual mode of failure of these beds. The lower thin-bedded sandstones of the Charlie Canyon basin have been deformed into isoclinal folds that trend parallel to the Bee Canyon fault. These folds have amplitudes of a few hundred feet or less.

The other area of folding in the Vasquez series lies between the Mint Canyon and Green Ranch faults. The folds trend slightly south of west, and plunge to the west. Their axial planes dip steeply north, probably at angles of about 70°. The flanks of the folds dip more steeply than 50°, and may be nearly vertical. The folding was a part of the pre-Tick Canyon deformation, and was followed by extensive erosion that removed most of the Vasquez series. The strata of the Tick Canyon formation then were deposited upon the irregular surface of erosion. Later, post-Mint Canyon folding along the same general axes tightened the folds in the Vasquez series and warped the overlying Tick Canyon and Mint Canyon formations into open folds.

The basal strata of the Vasquez series in the Vasquez Rocks basin were tilted as much as 35° during uplift of the eastern Soledad basin. Some of this tilting, possibly the major part, occurred during the earlier deformation between Vasquez and Tick Canyon times.

Joints

Joints are abundant and closely spaced in the granitic and gneissic rocks of this region. In general, the most prominent joint direction in the gneiss is parallel to the foliation, which commonly trends east-west. The principal joint direction in the granitic rocks of the Mint Canyon Ridge is parallel to a faint gneissic structure that strikes northwest and is nearly vertical. This gneissic structure is interpreted as the rift, or plane of easiest parting, of the granite, and is indicated by a subscript "r" on the joint symbol where noted.

Most of the jointing in the granitic and gneissic rocks is seemingly unsystematic, but preferred attitudes might be demonstrated by statistical studies of the joints.

Jointing observed in well-cemented beds in the Vasquez series is commonly nearly parallel to nearby faults, and probably is genetically related to them.

VI. STRUCTURAL EVOLUTION OF THE NORTHERN SOLEDAD BASIN

The deposition of the extensive and thick sequence of graywackes and basic volcanic rocks that was later metamorphosed to become the Pelona schist constitutes the first recorded geological event in the Soledad basin. Miller (1934, p. 63) believes that the Placerita metasediments of the San Gabriel Mountains are older than the Pelona schist because the Pelona schist is a more uniform and less metamorphosed unit. The present author, however, reiterates the suggestion made earlier by Wallace (1949, p. 787) that these two formations may be correlatives of each other. The exact age of these formations is unknown, although they have been tentatively assigned to the pre-Cambrian by several investigators.

In the San Gabriel Mountains, the Placerita formation "has been invaded in turn by bodies of hornblende-rich diorite, granite, anorthosite, diorite, quartz syenite, and granodiorite" (Miller, 1934, p. 3). Miller believes the first three named rock types to be pre-Cambrian in age, and to be separated by an interval of profound erosion from the last three rock units, which are believed to be correlatives of the Sierran intrusives of late Jurassic age.

The granitic rocks along the southern flank of the Sierra Pelona are correlatives of Miller's Lowe granodiorite, the youngest major intrusive unit in the San Gabriel Mountains. The Pelona schist may have been metamorphosed at this time, although some of the earlier intrusives may be more properly correlated with the metamorphism. On the other hand, the metamorphism may bear no direct relation to these intrusives, and instead may be the result of some other episode in the history of the region. It seems certain only that the metamorphism of the Pelona schist was pre-Cretaceous in age. Possibly petrofabric studies of the schist would furnish a clue as to the number of orogenic periods involved in its history.

The Cenozoic era was one of almost continuous structural unrest in the Soledad basin. Normal faulting characterized the early

Tertiary period, and the great thickness and coarseness of the Vasquez series provides much of the evidence for the major phases of faulting during this time. Strike-slip faulting was more characteristic of later Tertiary time, and was followed by normal faulting that trended nearly normal to the early Tertiary pattern. No faulting has occurred in the Soledad basin during late Quaternary time.

The end of Martinez deposition closed a period of relative crustal stability for this region. The Martinez sea represents the only major marine transgression during the Tertiary for which there is any direct evidence. The only other marine incursion took place during the Upper Miocene, when only a part of the western Soledad basin was submerged. Normal movement along the Clearwater fault (Clements, 1937, p. 231) uplifted the rocks to the north, and subsequent erosion stripped all of the Martinez formation from this area. Diminishing displacements farther west along the Clearwater fault have resulted in preservation of a wedge of the Martinez formation that now appears under a cover of continental Vasquez strata.

Normal faulting probably outlined the three Vasquez basins of deposition at this time. Mint Canyon Ridge, the Parker Mountain area, and the ancestral San Gabriel Mountains were uplifted, and served as major sources of detritus during Vasquez time.

The presence of Martinez clasts and quartz-bearing volcanic clasts in the Texas Canyon basin presents the problem of a potential source area. These clasts may have been derived from rocks to the north and northeast, beyond the limits of the present basin. On the other hand, their association with rocks derived from the Mint Canyon Ridge makes it probable that they came from the same general source area, and that subsequent erosion has removed the correlative rock units from the ridge. If this is true, it is possible that an unknown thickness of the Martinez formation could be preserved beneath the Vasquez series in the central part of the Soledad basin.

In each of the basins of deposition during Vasquez time, the main supplies of material lay to the south and east. The southern part of the Charlie Canyon basin contains great thicknesses of conglomerates that presumably were derived from a source to the south, possibly the western extension of the Mint Canyon Ridge. In contrast, the northern part of this basin contains arkoses that may have been derived from beds of the Martinez formation farther north. The basal units of the Vasquez series in the Texas Canyon basin commonly are arkoses, and may represent reworked Martinez sediments that were stripped from nearby areas.

The largest basin, in terms of areal extent and thickness of contained Vasquez sediments, is the Vasquez Rocks basin. The basal conglomerates, locally nearly 1,000 feet thick, are composed of detritus from the crystalline "basement" rocks of the vicinity. The flood of volcanic flows that then poured across this basin, and now crop out from Mint Canyon eastward to the San Andreas fault, probably caused changes in the drainage pattern of the region. These lava flows may have been extruded concurrently with renewed uplift of the ancestral San Gabriel Mountains along the Soledad and other faults. The numerous debris flows of the Texas Canyon basin, which were derived from the Mint Canyon Ridge, indicate that the Mint Canyon Ridge may have been uplifted at this time. The great thickness of the Vasquez series along the Soledad fault probably indicates that the basin of deposition was subsiding more or less continuously while the San Gabriel Mountains were being uplifted.

The broad fans of Vasquez time spread across the Vasquez Rocks basin, eventually buried the Mint Canyon Ridge, and then began to supply detritus to the Texas Canyon basin. The presence of anorthosite clasts in the Charlie Canyon basin suggests that this basin, too, was integrated into the system of northward drainage and deposition late in Vasquez time.

Movement on the Pelona, Vasquez, Mint Canyon, and Soledad faults must have continued after the termination of Vasquez deposition. The entire region was uplifted at this time, and active erosion of the Vasquez series was initiated. The amount of erosion is unknown, as the lateral change in thickness of the Vasquez series across the basin is not known. In the Vasquez Rocks basin, the overlap of the Tick Canyon formation moves progressively down-section until only the basal 2, 000 feet of the Vasquez beds remains at the junction with the Mint Canyon fault, the point of maximum known erosion.

The Vasquez series was folded and uplifted along the northern margin of the Vasquez Rocks basin by renewed uplift of the Mint Canyon Ridge. The ridge was raised high enough to cause deposition of the Tick Canyon sediments in two separate basins.

South of the Mint Canyon fault, the Tick Canyon formation thickens rapidly to the center of the Vasquez Rocks basin and thence thins sharply against the Agua Dulce Canyon fault. Much of the detritus in the Tick Canyon and Mint Canyon formations was derived from rocks of the Vasquez series. The sheets of coarse conglomerate in the dominantly fine-grained Tick Canyon formation may mark local uplifts in adjacent areas.

The time break between the Tick Canyon and Mint Canyon formations may represent a period of non-deposition or one of slight erosion. The sudden flood of coarse fragments of Pelona schist, at the base of the Mint Canyon formation, suggests that this hiatus marks the time of the final uplift of the Sierra Pelona along the Pelona fault. The great abundance of Pelona-schist detritus in the Mint Canyon formation west of Bouquet Canyon indicates that the drainage was generally southwestward from the newly uplifted Sierra Pelona. The thinning and termination of the schist-bearing basal conglomerate just east of Mint Canyon, and the great dominance of volcanic clasts in the basal Mint Canyon formation east of this point, show that the eastern part of the Sierra Pelona was not uplifted at this time. Burial of the Mint Canyon Ridge was completed by the basal schist-bearing conglomerate, thus allowing the remainder of the Mint Canyon formation to be deposited in a single broad alluvial basin.

The next episode of faulting, which can be regarded as post-Mint Canyon, pre-Saugus in age (Jahns, 1940, p. 169), resulted in movements along fractures with northeast trends. These are dominantly left-hand faults, although some may have large dip-slip components. A second northwest-trending set of faults, which is quantitatively minor in amount and displacement, seems to be the complimentary shear set of the northeast-trending faults. The uplift of the Sierra Pelona and San Gabriel Mountains may have caused compression and jostling of the rocks in the Soledad basin with resultant development of the compressional shears. Faults of this trend and nature are overlain in the map area by Pleistocene terrace deposits.

This late Tertiary deformation in general caused tilting, with concomitant uplift of the margins of the Soledad basin. Renewed folding in the vicinity of upper Tick Canyon accentuated the earlier folds in the Vasquez series, and gently flexed the beds of the overlying Tick Canyon formation. The continuation of these folds into the Mint Canyon formation shows that the flexing was post-Mint Canyon in age, as well. Normal faults of northwest trend (e.g., Kashmere Valley fault) offset the strike-slip faults. These faults are not presently active because Quaternary terrace deposits overlie them without any apparent offsets.

Inasmuch as the Lower to Middle Pliocene Anaverde formation east of the Sierra Pelona along the San Andreas fault (pl. 1) is devoid of

Pelona-schist detritus, the Sierra Pelona could only have attained its present elevations since Anaverde time. The uplift of the Sierra Pelona, prior to the deposition of the Upper Miocene Mint Canyon formation, affected only the westernmost part of the range. By Anaverde time either the Western Sierra Pelona must have been reduced to a mass of low relief, or the area supplying detritus to the Anaverde formation must not have contained any Pelona schist. In discussing the Anaverde formation, Wallace (1949, p. 792) states that "the granite cobbles of the arkose are almost identical with the granite north of Elizabeth Lake which is also typical of some of the other granites of the Mohave Desert." Thus it seems reasonable to assume a source for the Anaverde formation that lay to the north in the Mohave Desert, rather than a source in a low-lying or non-existent Sierra Pelona to the west.

The Pleistocene and Recent offsets along the San Andreas fault apparently have not reactivated any of the faults of the Soledad basin, because Pleistocene terrace gravels lie without break across many of the faults in the basin. The only noticeable effect has been to continue the uplift of the Sierra Pelona and the San Gabriel Mountains, and to continue the active downcutting of this region. The extensive Quaternary terrace gravels that surround the Sierra Pelona are composed principally of Pelona-schist detritus, which indicates that a major uplift of the Sierra Pelona was early in the Pleistocene. The absence of Pelona schist from the early Pliocene Anaverde formation, and its abundance in the Pleistocene terrace deposits and in the underlying

Saugus formation farther west, indicate that the strike-slip shears of the Soledad basin were active during the interval between Mint Canyon and Saugus time, or between late Upper Miocene and late Pliocene.

VII REGIONAL RELATIONSHIPS OF THE STRUCTURAL FEATURES

At least three general periods of faulting can be recognized in the eastern Soledad basin during Cenozoic time. The earliest was post-Martinez and pre-Vasquez in age, and involved movement on east-trending normal faults. This implies the minimum compressive stress axis to be in a north-south direction.

The period following Vasquez time and preceding the late Upper Miocene encompasses a number of apparently overlapping types of offsets. The difficulty in dating accurately the periods of diastrophism is caused by the fragmentary stratigraphic record. Normal faulting continued after Vasquez deposition ceased. In upper Tick Canyon, the Vasquez series was folded along axes that trend nearly east. These folds shortened the Vasquez section in a north-south direction by nearly 30 percent. This folding may represent the beginning of the north-south maximum compressive stress that has continued in effect up to the present time. Seismic data show that this stress orientation is being maintained at the present time (Dehlinger, 1952, p. 172).

All of the deformations described above are pre-Tick Canyon in age. The Pelona fault probably is also pre-Tick Canyon in age, although it may have been rejuvenated after Tick Canyon time and before Mint Canyon time. Although Jahns (1940, pp. 163-166) has found local evidence of angular discordances, the hiatus in most places is a disconformity, and may thus reflect uplift and non-deposition resulting from offsets along the Pelona fault.

The northeast-trending left-hand faults of post-Mint Canyon age imply a maximum compressive stress oriented in a north-south direction. The Bee Canyon and San Francisquito Canyon faults also represent this period of faulting. Within the map area these faults are overlain by terrace deposits of late Pleistocene age. Farther west, faults of the same type and trend are overlain by the Saugus formation (Jahns, oral communication, 1953), thus fixing the upper limit of offset as late Pliocene. Crowell (1952, pp. 2026-2035) believes that large right-hand displacements occurred along the northwest-trending San Gabriel fault during the period essentially in accord with that fixed for the left-hand faults just described. Thus the left-hand faults of the Soledad basin may be complementary fractures to the San Gabriel fault.

On the other hand, the same relationship would hold for the San Andreas fault. Hill and Dibblee (1953, p. 453) speculate that the San Gabriel fault might be an ancestral portion of the San Andreas. The San Gabriel fault has a rather impressive bend south of the Soledad basin in the San Gabriel Mountains which might preclude any further strike-slip displacements along it. Further speculation along this line of thinking would involve progressive bending of the San Gabriel fault as a result of the left-hand displacements that accumulated in the Soledad basin. Ultimately, the San Gabriel fault became "locked", the strains continued to accumulate, and the present trace of the San Andreas fault developed to eliminate the kink. This would imply a fairly recent origin for the San Andreas fault, at least that part of it that transects the Transverse Range province.

These conclusions, that the present trace of the San Andreas fault is of recent origin and that the San Gabriel fault marks the trace of an earlier part of the San Andreas fault, are not compatible with those of L. F. Noble who believes that the early Tertiary Soledad fault has been offset along the present trace of the San Andreas fault in Middle Miocene deformations.

Another possible interpretation of the Cenozoic deformations of the Soledad basin is that they are related to intermittent uplifts of the San Gabriel Mountains and the Sierra Pelona. Thus, the changing stress orientations within the Soledad basin may be explained by differential movements of the various blocks of the region.

If the assumption is made that the Cenozoic deformations of the Soledad basin are genetically related to the San Andreas fault, then the San Andreas fault could not have been active during the early Tertiary, or if it was active, then it must have been moving in some direction other than the present right-hand motion.

Thus, summarizing briefly, a complete change of stress orientation appears to have taken place since Martinez time (Paleocene).

The normal faulting of early Tertiary age indicates a north-south minimum compressive stress, and the mid-Tertiary faulting represents a period of change during which a maximum compressive stress in a north-south direction ultimately was developed. The younger orientation has been maintained, and strains have continued to accumulate to the present time. These stress orientations, if of wide regional extent, require the San Andreas fault to have right-hand motions only from mid-Tertiary to Recent times. If they are more local, then it might seem more reasonable to explain the changing stress patterns in the Soledad basin by intermittent jostling of the rocks of the basin by movements of the San Gabriel Mountains block and the Sierra Pelona block.

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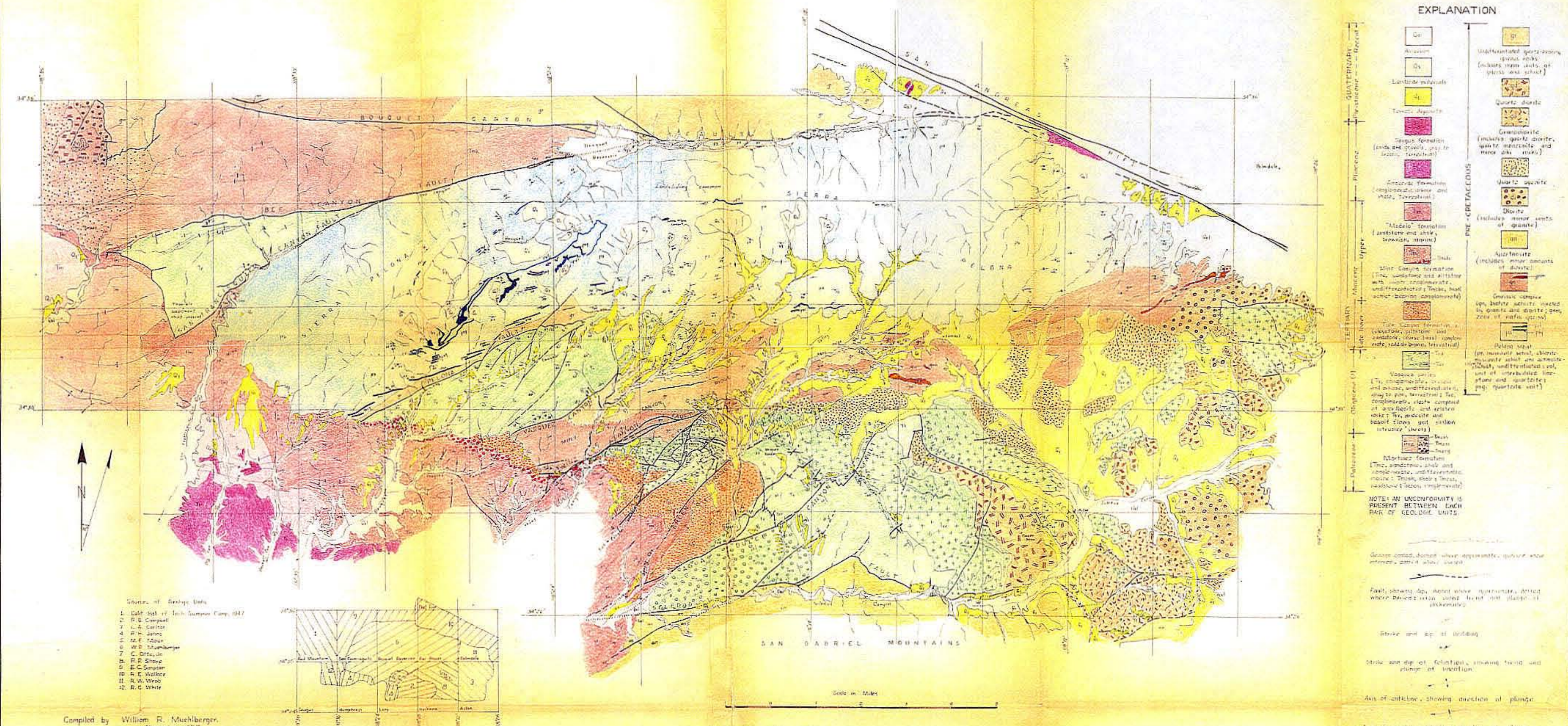


GEOLOGY OF THE NORTH PART OF THE
SOLEDAD BASIN, LOS ANGELES COUNTY, CALIFORNIA

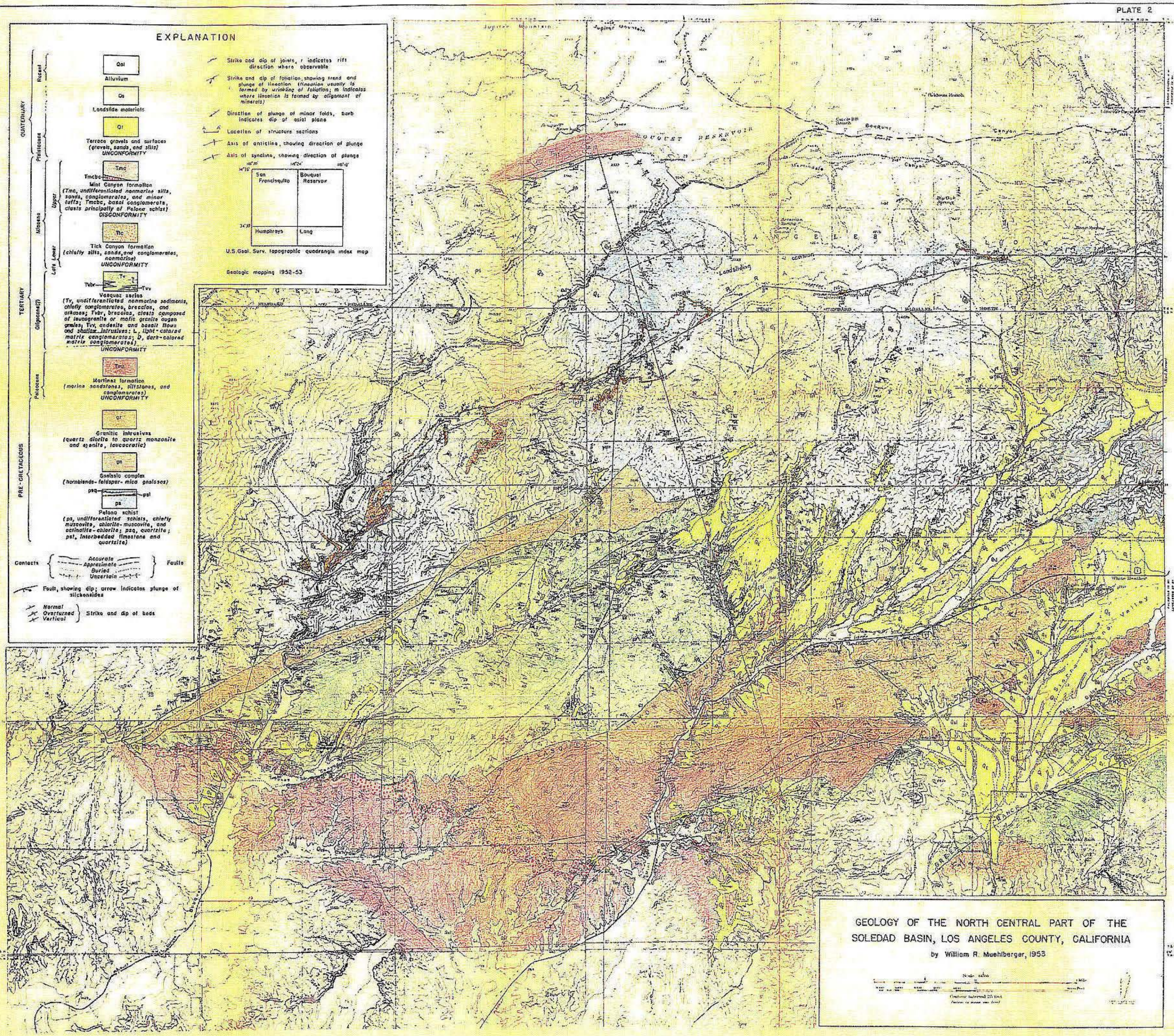
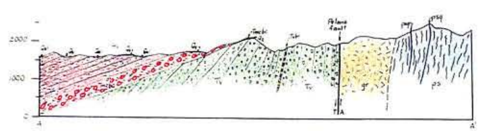
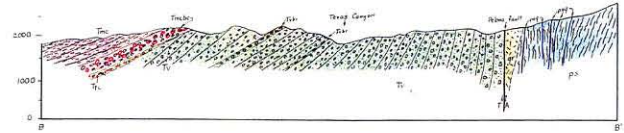
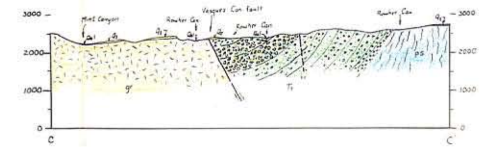


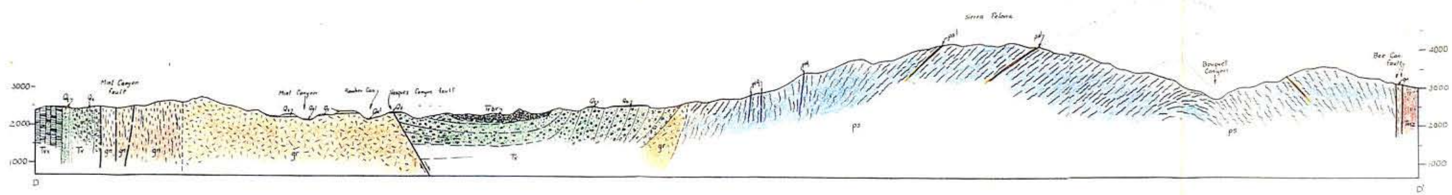
PLATE 2
EXPLANATION
QUATERNARY
Recent
Pleistocene
TERTIARY
Miocene
Upper
Late Lower
Oligocene(?)
Paleocene
PRE-CRETACEOUS
Qal
Alluvium
Qs
Landslide materials
Qt
Terrace gravels and surfaces
(gravels, sands, and silts)
UNCONFORMITY
Tmc
Tmcbc
Mint Canyon formation
(Tmc, undifferentiated nonmarine silts, sands, conglomerates, and minor tuffs; Tmcbc, basal conglomerate, clasts principally of Pelona schist)
DISCONFORMITY
Ttc
Tick Canyon formation
(chiefly silts, sands, and conglomerates, nonmarine)
UNCONFORMITY
Tv
Tvbr
Tvv
Vasquez series
(Tv, undifferentiated nonmarine sediments, chiefly conglomerates, breccias, and arkoses; Tvbr, breccias, clasts composed of leucogranite or mafic granite augen gneiss; Tvv, andesite and basalt flows and shallow intrusives; L, light-colored matrix conglomerates; D, dark-colored matrix conglomerates)
UNCONFORMITY
Tmz
Martinez formation
(marine sandstones, siltstones, and conglomerates)
UNCONFORMITY
gr
Granitic intrusives
(quartz diorite to quartz monzonite and syenite, leucocratic)
gn
Gneissic complex
(hornblende-feldspar-mica gneisses)
psq
psl
ps
Pelona schist
(ps, undifferentiated schists, chiefly muscovite, chlorite-muscovite, and actinolite-chlorite; psq, quartzite; psl, interbedded limestone and quartzite)
Contacts
Accurate
Approximate
Buried
Uncertain
Faults
Fault, showing dip; arrow indicates plunge of slickensides
Normal
Overturned
Vertical
Strike and dip of beds
Strike and dip of joints, r indicates rift direction where observable
Strike and dip of foliation, showing trend and plunge of lineation (lineation usually is formed by wrinkling of foliation; m indicates where lineation is formed by alignment of minerals)
Direction of plunge of minor folds, barb indicates dip of axial plane
Location of structure sections
Axis of anticline, showing direction of plunge
Axis of syncline, showing direction of plunge
San Francisquito
Bouquet Reservoir
Humphreys
Lang
U.S. Geol. Surv. topographic quadrangle index map
Geologic mapping 1952-53
BOUQUET RESERVOIR
GEOLOGY OF THE NORTH CENTRAL PART OF THE SOLEDAD BASIN, LOS ANGELES COUNTY, CALIFORNIA
by William R. Muehlberger, 1953

STRUCTURE SECTIONS TO ACCOMPANY PLATE 2









0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10,000

Feet

Vertical scale equals horizontal scale

Altitudes given in feet above sea level