GEOLOGY

of the

LE BRUN AND MINT CANYON QUADRANGLES

LOS ANGELES COUNTY

CALIFORNIA

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Abstract.

The area discussed is ~~discussed~~ in the Le Brun and Mint Canyon Quadrangle which in turn form the southwest corner of the Elizabeth Lake Quadrangle. This area lies about 45 miles north west of Los Angeles and comprises a part of SierraPelona Ridge, Sawmill and Jupiter Mountains. These mountains form a portion of the Transverse Ranges

The Pelona schists make up about two-thirds of the area, and are probably of Archeozoic age. A series of migmatites forming inclusions in the granitic country rock are probably of Pre-Cambrian age also.

These old metamorphics were intruded during Jura-Cretaceous time by a batholith whose average composition is that of a monzonite although different facies of it vary from dioritic to granitic.

The Martinez formation was deposited in lowermost Eocene time and is made up of 9000± feet of sandstones, shales and a few intercalated conglomerate beds. These are marine sediments.

Between Martinez and Mint Canyon times a thick series of fanglomerates, sands, silts, and muds were laid down in local basins. These continental beds are red in color, and make up the Le Brun formation and Vasquez series. Although this series contains no lava in this area, it contains large thicknesses of basic lava south and east of this locality.

The Mint Canyon formation is also continental in origin and lies on the truncated edges of the Vasquez series. It is composed of a basal conglomerate overlain by well bedded sandstones and shales.

Terrace materials of two different ages can be recognized. In addition there is reason to believe that this region was peneplained toward the end of Pliocene time.

The strata of the above formations strike east-west or slightly

southwest-northeast, and with the exception of the Mint Canyon formation they dip very steeply, in places standing vertical. The foliation of the metamorphic rock also has the same general strike and steep dip of the sediments. The Mint Canyon beds dip off relatively gently to the south.

Faulting has been very active in this region and has taken place from middle Miocene time, or perhaps earlier, to the recent. The San Andreas Rift, which passes along just to the north of this area, provides the key to the structural history of the region. Adjacent to the San Andreas Rift large wedges of basement complex shoved up and over the Martinez formation and the Pelona schist, while the faults south of Sierra Pelona Ridge are of the normal type they are not tensional, but compressional faults due to the large horizontal displacement which has taken place along them. Compressional effects such as these are typical along the San Andreas Rift. Folding has played but a minor role in this area.

South of the Sierra Pelona Ridge, long slim wedges of igneous and metamorphic rock have been faulted into the Vasquez series; These horses are found sometimes half a mile from the nearest outcrop of igneous or metamorphic rock.

Introduction.

Location of Area:

The area mapped in this report lies about ten miles north of Newhall, and forty miles northwest of Los Angeles. It comprises the whole of the Le Brun and most of the Mint Canton Quadrangles, about eighty square miles; and lies between parallels of latitude $34^\circ 30'$ and $34^\circ 24'$ and parallels of longitude $118^\circ 30'$ and $118^\circ 18'$. These two quadrangles form the southwest corner of the Elizabeth Lake Quadrangle (scale 1:125,000), which also embraces a part of Antelope Valley and the Tehachapi Mountains. The two quadrangles mentioned include portions of Sierra Pelona Ridge, Jupiter Mountain and Sawmill Mountain which are properly a part of the Transverse Ranges. Some writers[1] include these mountains as a part of the San Gabriel Range, but that is incorrect; as the latter name should be confined to those mountains southeast of the Santa Clara River.

This locality is served by a number of very good roads, and so is readily accessible by automobile. It lies but a few miles east of U.S. Highway99; and, in addition, the main highway to Tehachapi Pass and Owen's Valley passes through Mint Canyon. A paved road through Bouquet Canyon and a well graded dirt road through San Francisquito Canyon also makes it possible for one to go from Saugus to Mojave by way of Leonis Valley. In addition to these thoroughfares, there are numerous dirt roads, constructed by the forest service and power and light companies, interlacing

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1, Johnson, H.R., "Water Resources of Antelope Valley" Water Supply Paper 278, pp.1, (1911).

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② Alameda
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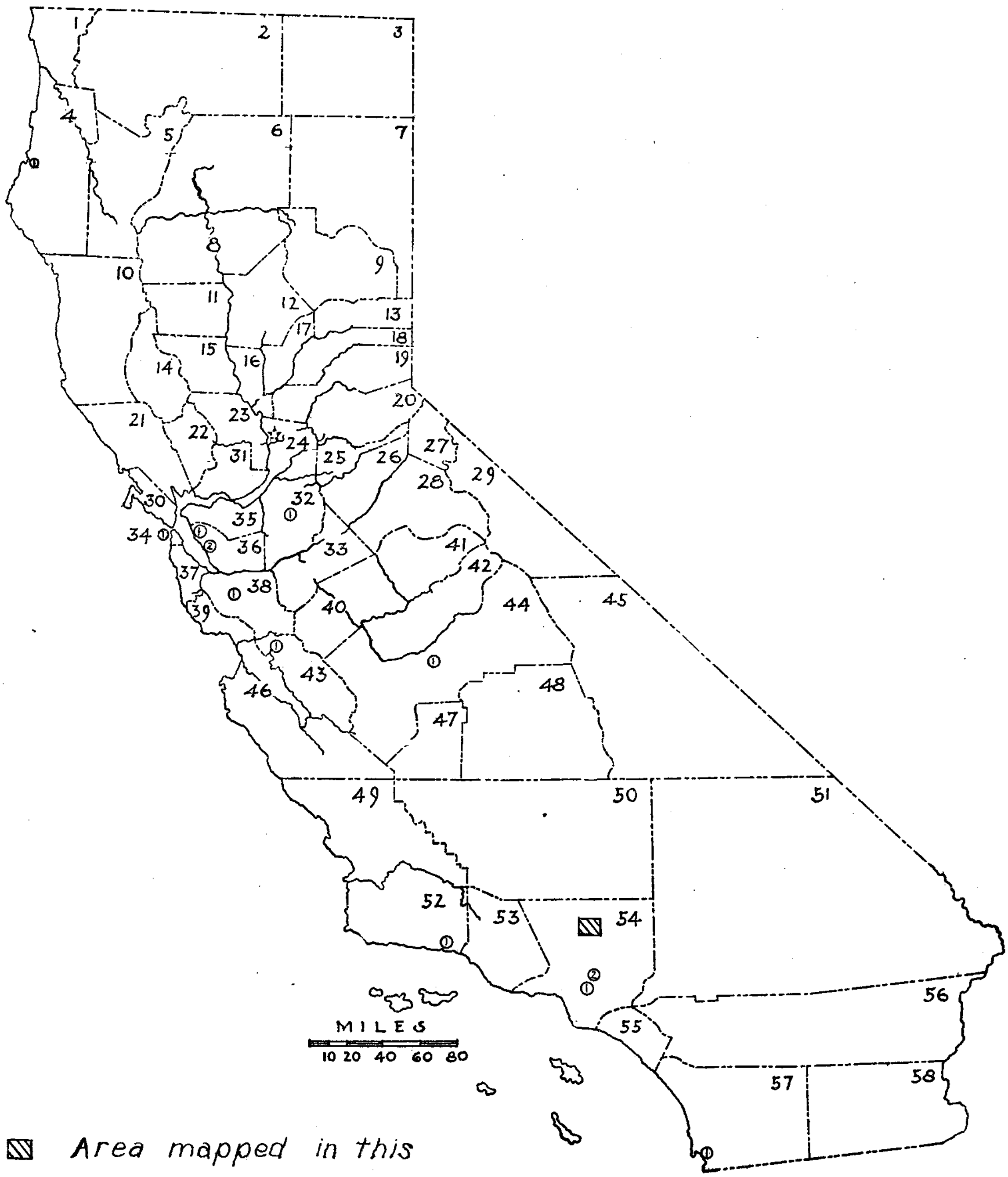

Area mapped in this report.

throughout the area; so that no part of the area is more than an hours walk from the nearest road.

The largest industry of the area is the generation of electricity by water power for the City of Los Angeles, taking advantage of the large drop in the aqueduct line as it crosses the mountains. Two power plants are located in San Francisquito Canyon, each being surrounded by a small settlement. In Bouquet and Mint Canyons there are some residences, mostly week end cottages, and a few ranching and mining properties. With these few exceptions the area is devoid of population and inhabited only by wild life, of which there are many deer, coyotes, and numerous small forms of life.

Previous Work:

Apparently the first geological examination of this area was made by William Blake,[1] a geologist accompanying one of the Pacific Railroad Exploration Parties in 1853. The main objective of these parties was to find a pass through the mountains to the coast for the transcontinental railroad; and, inasmuch, as San Francisquito Pass is one of the few passes through the mountains, quite a detailed examination was made of the canyon. The following is an excerpt from the written report.

"The view to the southward, presented from the summit of the Pass, is peculiarly beautiful. The gorge or valley of the pass is almost transverse to the trend of the main chain; the observer can thus overlook its subordinate ridges, and from the great elevation see beyond them to other ranges nearer the Pacific. Perhaps at

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1, Blake, W.P., U.S. Pac.R.R. Expl., Vol. 5, pp. 55-60, (1853-1854).

favorable seasons the ocean itself may be seen in the distant horizon. The width of the mountain at the Pass being over twenty miles, the ridges are seen in succession coming down to the ravine of the pass, becoming more dim and faint in the distance, until their outlines are blended with distant haze, resting over the heated valleys and plains of the coast slope, ***

Starting from the summit, the first four miles of descent is between the hard granites that rise in rounded edges on either side, and the valley between them is fertile and well wooded. For the next three miles the granites are more laminated and slaty in their structure; they offer less resistance to the wearing action of the stream which has cut a more deep and narrow channel, and commences to descend abruptly, winding about in a series of rapids between rocky and angular points of the granite and metamorphic rocks that rise on each side like walls. Beyond the granite is the belt of sedimentary strata, consisting of sandstone and conglomerate. Here the hills are lower, the valleys more numerous and open, and a view of bold escarpments, formed by the ridges of highly inclined strata, is preserved on both sides. Still lower down the pass the sandstones are not so much disturbed, and the outlines of the hills become more curved; and near the lower outcrop of the auriferous slates, the surface is gently undulatory. The adjoining slates, however, present sharp angular outlines, cut by abrupt and rugged valleys. They are also covered with trees while on the sandstone the vegetation is thin and diminutive".***

In 1855 Trask[1] published a report on the Coast Mountains in which he defined the San Bernadino Mountains as extending from Santa Barbara almost to the Salton Sea, including the Santa Inez, San Rafael, Liebre, Sawmill, Sierra Pelona, San Gabriel, San Bernadino and San Jacinto Mountains. He recognized the fact that the Transverse Ranges, the Tehachapi Mountains and the Sierra Nevada Mountains apparently met at a point near Frazier Mountain, the so-called "structural knot of California".

Working under Whitney,[2] Brewer made a geological survey of many parts of California from 1860-64. At one time he visited San Francisquito Pass, probably in 1863; at this time San Francisquito

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1, Trask, J.B., "Report on the Geology of the Coast Mountains" (1853-54)
2, Whitney, J.D., "Geological Survey of California", Vol.1, (1865).

Pass was part of an important highway, being on the route of the Overland Mail running between San Francisco and Los Angeles. Noticing the Pelona schists, he put them down as Cretaceous in age from a general analogy with other rocks he had seen. It is interesting to note that the San Gabriel Mountains owe their name to Whitney; the former name being Sierra Madre, he thought it would lead to confusion with the name Sierra Nevada.

Jules Marcou[1], engaged in geological exploration for the U.S. Geological Surveys West of the 100th Meridian, had occasion to visit San Francisquito Canyon in 1876, and while there made the following observations.

"It can not be doubted that the Sierra Madre, from Mount San Bernadino to Tejon Pass and Tehachapi Pass, was covered with glaciers during the Quaternary period. The long canyons of San Gabriel, of the Little and Big Tujunga, of Soladad, and San Francisquito, served as receptacles of beds for the glaciers which descended from the many high peaks of this chain of mountains.*** The traces of glaciers are more visible and striking in the San Francisquito Pass, especially near Jesus Gallejos Ranch, where diorites appear as great masses, and not long after reaching a large lateral valley on the right, as one ascends the pass we see a very heavy Quaternary drift with erratic blocks and indications of glacial striae. (Slickensides from the Clearwater fault?)[2]*** Suddenly, immediately after leaving the sandstone, schist and dolerite, we find ourselves before a granite wall which rises abruptly from 100 to 250 feet above the Tertiary rocks". (Clearwater Fault).

In 1902 Hershey[3] published an article on the Pelona Schists and igneous rocks of the region, in which he brings out for the first time the fault relations of Sierra Pelona Ridge. A quite

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1, Marcou, Jules, "Report on the Geology of Southern California", U.S.Geol.Sur.W.100th Mer. Annual Report for 1876, pp.164-169.
2, Bracketts added by present writer.
3, Hershey, O.H., "Some Crystalline Rocks of Southern California", Am.Geol. vol.29, No.5, pp.273-290, (1902).

detailed description of the Pelona Schists follows during which he compares them with the Abram's Schists in Siskiyou County. The same year he published an article on the structure and petrology of the Escondido (Kew's Sespe?) and the Melleina(Kew's Mint Canyon) formation.

In 1924 Kew[1] mapped the area immediately south of this area, the results of which were published in his famous oil bulletin.

In 1928 the St. Francis Dam disaster was the occasion of the publishing of numerous geological reports on the area which will not be mentioned here; as they will be found in the bibliography accompanying this report. In the same year Hill[2] published a report and geological map on the northern part of the Le Brun and Mint Canyon Quadrangles, using a small scale map to map on.

In 1929 Nickell[3] brought out a paper on the geology of part of the Le Brun Quadrangle while Clements[5] wrote a thesis on the area immediately to the west.

A paper covering the whole of the Elizabeth Lake Quadrangle was published in 1934 by Simpson.[4]

1,Kew,W.S.W.,"Geology and Oil Resources of a part of Los Angeles and Ventura County,California," U.S.G.S.Bull.No.753,(1924).
2,Hill,R.T.,"Geology of Reservoir Sites",Part 11 of a report of the Board of Consulting Engineers to the Board of Water and Power Commissioners of the City of Los Angeles, (1928).
3,Nickell,R.T.,"The Geology of the Southwestern part of the Elizabeth Lake Quadrangle between San Francisquito and Bouquet Canyons," on file at California Institute of Technology Library,(1929).
4,Simpson,E.C., "Geology and Mineral Deposits of the Elizabeth Lake Quadrangle, California", Calif. Jour. of Mines and Geol. Vol.30.No.4 Oct. (1934).
5,Clements,T.,"Geology of the southeast portion of the Tejon Quadrangle California", on file at California Institute of Technology Library.

Purpose and method of Investigation:

This work was undertaken primarily as a structural study with a view to working out the underlying structural characteristics of the area and their relation to the San Andreas Rift, which lies but a few miles to the north. The sedimentary units involved were mapped in considerable detail on two maps whose scale is 1:24,000; these maps being only recently available in the form of advance copies. Little could be done from a stratigraphic point of view; in as much as no depositional contacts could be found due to the complexity of the fault pattern. The various units in the basement-complex were worked only in a reconnaisance manner.

The field work for this investigation was accomplished by week-end trips made during the months of September (1934)-March (1935).

Acknowledgements:

The writer wishes to acknowledge the assistance rendered him by residents of the area in facilitating his work, and would especially like to mention Mr. Kapser of Texas Canyon. The work was carried on under the supervision of Dr.J.H.Maxson instructor in geology at the California Institute of Technology, to whom the writer is grateful for many helpful criticisms and suggestions.

Physical Conditions.

Climate:

This locality, situated as it is in Southern California, may be classed as semi-arid; in that the rainfall seldom exceeds 20 inches per year, and is even sometimes less than ten inches per annum. The nearest government weather recording station is at Newhall, about ten miles south of the southern boundary of the area. However, the weather is very nearly the same for this general region, and the figures given out at the Newhall Station may be regarded as typical. The mean annual rainfall measurment over a period of 38 years was 17.54 inches, the minimum recorded in any one year being 4.85 inches in 1877, and the maximum 44.20 inches in 1884. Most of the rain occurs between late fall and early spring of the year, although an occasional shower may fall in summer.

The mean annual temperature at Newhall during a period of 30 years was 61.5°F, with a low of 10°F and a high of 113°F. The region under consideration, bordering as it does the south end of the Mojave Desert, is extremely hot in summer, although the humidity is low. The nights are generally quite cool, however, and one finds it comfortable to sleep under a blanket. One disadvantage is the lack of water, except during the rainy season, making it necessary to carry a sufficient amount to last throughout the day. During the winter season conditions are just reversed, one finds it difficult to work because of the cold. Snow is not uncommon on the higher elevations, and ice is often found on the ground even throughout the day. Added to this is the wind which blows almost constantly, and makes working conditions very uncomfortable. The ideal time of the year to work is Spring, for then the climate is most temperate and the days long.

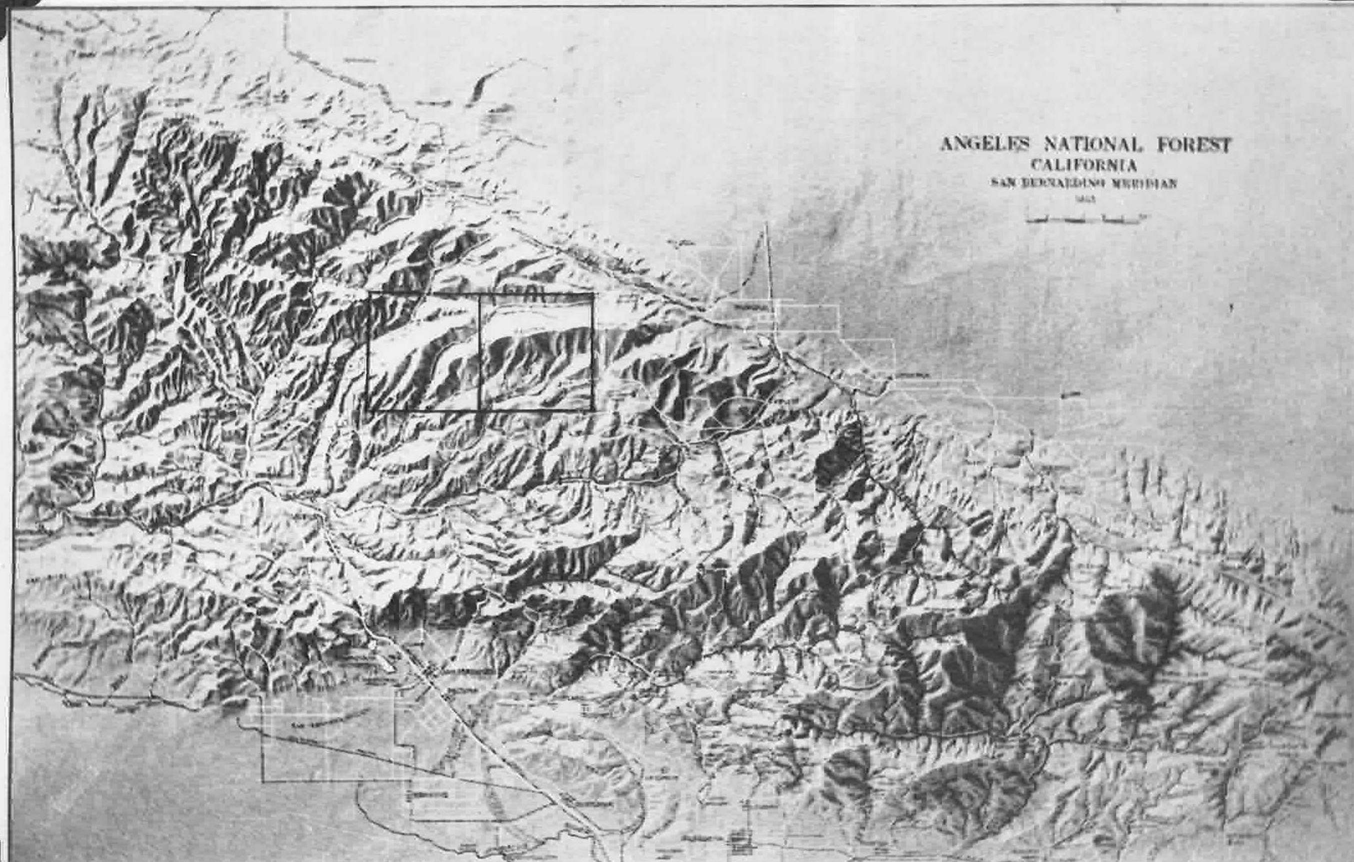
Vegetation:

The vegetation of this region comprises the typical assemblage of semi-arid plants commonly described as chaparral. In many places it forms an almost impenetrable mass and makes mapping exceedingly difficult. This chaparral is made up largely of greasewood (Adenostone fasciulatum), buckthorn (Ceonothus thyrisiflorus), summac (Rhus laurina), California holly (Heteromeles arbutifolia), manzanita (Arctoslaphylos manzanita), yucca (Yucca whipplei), and in places scrub oak (Querus dumosa), In addition to these there are many smaller shrubs such as morman tea (Ephedra california), desert sage (Artemesia tridentata), black sage (Ramona stachyoides), white sage (Ramona polystacha), rabbit brush (Chysothamnus nauseosus), and many flowering plants which brighten up the hillsides in spring. Larger trees such as sycamores, oaks, cottonwoods and junipers, frequent the canyons.

Topography and Drainage:

The mountains comprising this section are quite rugged and attain a maximum height of 5180 feet, the lowest elevation in the area being 1800 feet. The maximum drainage relief[1] however is only 2300 feet, while 1000 to 1500 feet is a good average. The relief is highest to the north and grows less towards the south. The topography represents a stage in late youth of the physiographic cycle; since a part of the late mature surface from the previous cycle is still preserved. The canyons are very steep, V shaped, and are characterized by numerous falls and rapids.

1, Defined by D. Johnson as the relief from the highest elevation to the adjacent lo est elevation


ANGELES NATIONAL FOREST
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SAN BERNARDINO MERIDIAN

The drainage pattern is as yet incomplete, the tributaries to the main truqk streams having eaten only a short way back into the adjacent mauntains; however one might still say that the drainage pattern is fine textured. The drainage is for most part insequent, although lines of weakness developed by faulting have in some places been responsible for the development of subsequent streams; i.e., the upper part of Bouquet Canyon, Bee Canyon and a part of San Francisquito Canyon. Parts of San Francisquito, Bouquet and Mint Canyon Rivers are also antecedent due to recent uplift.

The drainage of the main trumk streams is northeast-southwest, all the drainage eventually running into the Santa Clara River to the south. The tributary drainage is largely north-south due to the fact that the ridges trend east-west. The east-west streams are subordinate except where determined by lines of faulting.

Geomorphology.

Relation of faulting to topography:

The mountaineus terrain making up this area is cut into numerous blocks by a complicated system of faulting. The general trend of these faults is east-west, although there is a tendency for branch faults to split off and take a more southwest-northeast direction. These various fault blocks usually have a topographic expression in the form of long overlapping sub-parallel ridges, the most important being Sierra Pelona Ridge.

One of the most interesting problems in this area is whether the present topography is genetically related to recent movement on any of the numerous faults traversing it; or whether it is due wholly to differential erosion. In this regard it is significant that along the Bouquet Canyon Fault the downthrown side is topographically 500 feet higher than the upthrown side which would be a decidedly anomalous situation if there had been any recent movement along it. The same thing holds true for the San Francisquito Fault. Along the Clearwater and Bee Canyon faults, however, the situation is different. The upthrown side along the Clearwater fault is in some places 1000 feet higher topographically than the downthrown side. However, in other places the downthrown side is the higher. Furthermore, the downthrown side is composed of sandstone and shales which one would expect to erode faster than the hard igneous and metamorphic rocks making up the basement complex. This is more strikingly illustrated in the case of the Bee Canyon Fault. This fault crosses through a wide, open valley (Bouquet

Canyon) with no sign of a displacement, from whence it crosses over into Bee Canyon. Here the downthrown side is 500 feet above the upthrown side; due to the fact that the more easily eroded Martinez sandstones are found adjacent to the Pelona schist. In San Francisquito Canyon, though, the upthrown side is about 1500 feet higher than the downthrown side; yet, here again, the very easily eroded Le Brun formation is found contacting the relatively more resistant Martinez sandstones. Thus it is seen that along the same fault the topographically higher side is not always the upthrown block; but invariably the block composed of the more resistant rock. The most convincing argument of all is that if one stands on a high elevation, it is easily seen that the faults are truncated by a moderately rolling surface formed in a cycle of erosion prior to the present one.

The subsequent drainage developed along the lines of shearing is also a strong argument against recent faulting. According to Cotton[1] the development of subsequent drainage usually takes place after faulting has ceased. Further, the streams no longer are confined to the shear zones, but must have worked down along lines of weakness until the faults, for the most part, are found part way up the sides of the canyons. This has also been noticed by Willis[2] who states, "Erosion valleys may often be used in tracing the continuation of a known fault where it shows no truly active features.*** These valleys develope normal profiles and should not be confused with the types described above (true fault valleys).[3]

1, Cotton, C.A., "Geomorphology of New Zealand", (1926).
2, Willis, R., "Physiography of the California Covert Ranges", G.S.A. Bull. Vo. 36, pp. 660, (1925).
3, Brackets added by present writer.

Looking southward down Dry Canyon, this valley represents a portion of the late mature erosion surface developed during the second cycle of erosion.

Looking up Mint Canyon towards Sierra Pelona Ridge. Terraces cut during the present cycle of erosion can be seen in the foregroud.

They are also much less dependable, as the fault lines show a decided tendency to be found up the slope from the stream, to cut across spurs and generally to diverge from the line of the valley itself".

In the southern part of the area the matter is not so obvious; for while most of the faults cross through the middle of a broad open valley and climb indiscriminately over the highest parts of ridges with no sign of a recent displacement, the fault scarp forming the south flank of Sierra Pelona Ridge cannot thus arbitrarily be classified as a faultline scarp. The faults in this zone are very high angle, often vertical, normal faults with the upthrown block on the north side. The north side is also topographically high, having a drainage relief of 2300 feet; and although for a distance of seven miles the Pelona schist is in contact with sediments, they are very firmly cemented conglomerates for the most part. Also from Mint Canyon to Amaverde Valley, on the edge of Antelope Valley, the schist contacts igneous rocks of the basement-complex. This need not be construed as indubitable evidence for faulting,however, for the schist is very resistant to weathering due to the fact that it weathers out into thin plates which shed the rain and are hard to wash away, while on the other hand the conglomerates and igneous rocks weather out into granular grains and pebbles which are easily transported by water. Although the relief on the south side of Sierra Pelona Ridge may be due to an epoch of normal faulting later in time than the reverse faulting north of the ridge, there are certain other considerations which make this seem improbable. First, notwithstanding the fault crosses many streams, in no place is the drainage deranged, and stream terraces in some places 100 feet above the present stream level truncate the fault. Second, the main fault zone is offset by a small transverse fault which shows no topographic expression and which itself is truncated by the stream terraces high up on the tops of ridges. Third, none of the numerous branch faults of the Pelona Fault show the slightest evidence of any recent displacement, although they are probably of the same relative age as the main fault.

Cycles of erosion:

There is distinct evidence for three cycles of erosion in the area and rather doubtful evidence for a fourth.

In late Pliocene time it is generally conceded by most geologists that Southern California was a region of very low relief. Indeed, the Perris Peneplain is a remnant of that old physiographic surface, preserved by reason of its being down faulted, and so effectually preserved from erosion, English[1] says, "The physiographic history of Southern California, of which there is good record, dates from a time near the end of the Fernando epoch. During Fernando time an extensive surface of low relief was developed over nearly all of the southern part of the state ." This is corroborated by Miller[2] who states, "Remnants of this old age surface are still more or less preserved in the San Gabriel Mountains which have been uplifted as a great fault block largely, if not wholly, during the Quaternary Period".

1, English, W.A., "Geology and Oil Resources of the Puente Hills Region, Southern California", U.S.G.S. Bull. No. 768, pp.64, (1926.)
2, Miller, W.J., "Geomorphology of the San Gabriel Mountains", U. of C. Publ. in Geol. Sci. Vol. 17, pp, 200, (1928.)

View showing the splendid terraces developed on the interfluves of the streams south of Sierra Pelona Ridge.

View looking towards Sierra Pelona Ridge showing the mature surface formed during the second cycle of erosion. St. Francis reservoir site in the foreground.

With only this meager evidence available, the peneplanation of these mountains in late Pliocene time must still remain an open question; however, it can be safely asserted that the relief at that time was very much less than the present relief.

The second cycle of erosion is clearly evident, marking a pause in the uplift of the mountains. It is represented by a rolling surface of late maturity which is a conspicuous feature to any one standing on a high point, and is in marked topographic unconformity with the surface produced by the present cycle. The broad open valley at the head of Dry Canyon is probably the best manifestation of it. This valley is a former course of the San Francisquito River; inasmuch as the valley, instead of heading back into Sierra Pelona Ridge, is obliquely truncated by the canyon wall of the present stream. Where this valley passes from the schist on to the Mint Canyon formation south of the area, there is a rapid drop off to the present stream level, the stream having already eaten headward for a short distance into the schist. Similarly the head of the valley is being attacked by a stream which is eating headward down the valley and which plunges rapidly down to drain into the San Francisquito Canyon drainage. This stream has already eaten down the valley between a quarter to a half mile, leaving an empty void where the head of the valley should normally be. The topographic unconformity is seen in numerous other streams which after flowing along canyons more or less parallel to the mature surface, suddenly descend abruptly by means of a series of waterfalls and rapids to the present stream level.

According to Willis[1] there are three types of surfaces produced by differential uplift along a fault. "They are those uplifted without being deformed, characterized by a sharp and regular topographic uncomformity between the old surface and the new cycle; Tilted surfaces characterized by a consequent drainage system or the tendency to develop such a system; and arched surfaces, characterized by a smooth convex profile not duplicated by other surfaces". It is clearly evident that the surface mentioned above was tilted to the southwest along on axis parallel to the trend of the range, which in turn is parallel to the San Andreas Rift.

The most convincing proof of this is the fact that the surface slopes southwestward to merge gradually into the surface produced by the third cycle. Since the mountains were uplifted along the San Andreas Rift, the uplifted block would be tilted to the southwest, much as the Sierra Nevada block is tilted to the west; confirmation of this lying in the fact that the major lines of drainage, which might be expected to inherit their original trends by entrenchment, is all southwestward also.

In nearly all the canyons, but especially in Texas and Mint Canyons, are a number of flat topped ridges and tables which are capped by terrace material up to 50 feet thick. These terraces represent the third cycle of erosion and in some instances are 150 feet above the present stream channels. These are all that are left of what were once broad open valleys. In Texas Canyon this old val-

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1, Willis, Robbin, "Physiography of California Coast Ranges", Univ. of Calif. Publ. in Geol. Sci. Vol. 36, pp. 676, (1925).

View looking down Mint Canyon showing a number of terraces. A wedge of igneous rock which has been dropped down into the Vasquez formation, is shown in the foreground.

A view looking east showing Mint Canyon in the middle distance. Notice the well developed terraces. The Pelona fault can be seen on the left.

ley was three-quarters of a mile wide compared to its present width of twenty yards, The upper part of Mint Canyon attained a maximum width of one and one-half miles and San Francisquito Canyon likewise attained a maximum width of almost a mile. In San Francisquito Canyon however, the old river valley was confined to the soft easily eroded sediments of the Le Brun formation. All that remains of this former surface is a series of low accordant knolls with a few remnants of terrace capping yet remaining on them. The tops of these knolls lead up to a broadly U-shaped gap through which the San Francisquito river may once have flowed. It is very hazardous to correlate physiographic surfaces over a wide area, but, it is possible that the broad valleys at the head of San Francisquito and Bouquet Canyons may have been a part of the surface cut by the third cycle of erosion.

It is a question whether this surface was tilted or not. In Mint Canyon the terraces are certainly sloping towards the south, but this may represent the normal profile of equilibrium of the old valley. The interfluve terraces south of the area are nearly horizontal and show no effects of tilting while in San Francisquito and Texas Canyons the evidence is inconclusive. It is noticable that in all the east-west canyons the terraces are on the north side in the form of long north-south ridges, the present streams flowing along the south side of the valleys truncating the ridges. This is indicative of tilting towards the south, but it may be that the streams were pushed that way by the flood of material poured into the valleys from the ridges on the north side which invariably are higher than the ridges on the south side. As has already been intimated the tilting of the whole mountain block has been strongly to the southwest, producing a very marked asymmetry in that nine-tenths of the width of the mountain block south of the San Andreas Rift is characterized by southward drainage, while only a narrow strip along the north part of the block drains down into Antelope Valley. In view of this it is hard to escape from the fact that a great deal of tilting has taken place, probably about a fulcrum which runs along just off the south edge of the maps. It might be approximately marked by the line of intersection of the surfaces formed during the second and third cycles of erosion.

As has already been mentioned, the broad valley stage of the third cycle has been dissedted to a depth in some places of 150 feet because of recent uplift. The effect of this has been to develop antecedent streams denoting the beginning of the fourth erosion cycle. The best example of this is the San Francisquito River which after traversing a belt of soft easily eroded sandstones and shales, suddenly crosses the San Francisquito Fault to flow through the relatively hard Pelona schist in entrenched meanders. On the previous page it has been suggested that the San Francisquito River may have flowed through a broad U-shaped gap a few miles west of the dam site. For some reason, perhaps due to a tilting effect, the river swung into its present course and subsequently entrenched itself.

The upper part of this river where it flows through a gorge cut in the basement-complex, also shows rejuvenation by a narrow V-shaped gorge in contrast to the former canyon whose walls were not quite as steep.

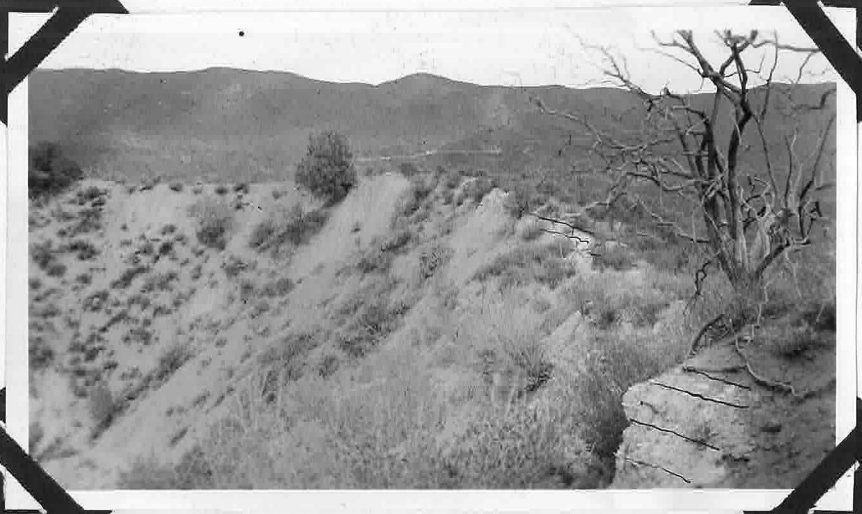
At the head of San Francisquito Canyon is a wind gap which is only a hundred feet or so above Leonis Valley. It is very probable that the drainage from the above valley may once have flowed down San Francisquito Canyon, but due to rapid uplift the stream was beheaded by the fault. This view is strengthened by the fact that the next canyon to the west, Elizabeth Lake Canyon, is still draining part of Leonis Valley at the present time.

As far as one can tell the present tendency of the streams seems to be one of aggradation, for the valleys are silting up. At the junction of Texas and Bouquet Canyons the alluvium in the stream bed is over twenty feet thick, while at the mouth of Bouquet Canyon the stream gravels are a hundred feet thick. In some canyons the streams have excavated a shallow channel about four to six feet deep. However, this usually occurs only in those canyons which shed quantities of soft easily erodable material. Apparently more material is supplied than the stream can ordinarily carry away; and then during a heavy storm or a series of heavy storms, the stream sluices out these easily transported sediments, thereby entrenching itself.

Landsliding and Hillside Creep:

Landsliding is very common in the Pelona schists, and on the sides of San Francisquito and Bouquet Canyons are numerous landslide scars, now overgrown with underbrush. Above the old St. Francis Reservoir site landslides are particularly well shown. They give an effect of irregularly spaced, flat topped shelves resembling terraces. Very few of these bench-like forms can be lined up; and since landsliding is so common, it is most reasonable to assume that they are due to this. Landsliding also occurs to some extent in the Vasquez and Mint Canyon Formations, in the latter formation slipping occurs sometimes on a very low angle due to the plasticity of the clay matrix.

This view was taken looking along the strike of the Martinez sandstone and shale beds. Notice the almost horizontal position of the strata due to hillside slump. The true dip of the beds here is approximately vertical.



The very steeply dipping beds of the Vasquez series are shown overlain by the Mint Canyon formation. The Vasquez strata are exposed in the center of the picture while the Mint Canyon beds can be seen on the extreme right underneath the dead trees.

Related to landsliding is hillside creep which has caused the beds in many places to assume an overturned position. This is particularly well marked in the Martinez formation due to the numerous beds of incompetent shales contained in this sedimentary series. Where hard sandstone stratum stick up in the air on steep hillsides they are commonly seen to bend over, giving a dip which is the reverse of the true dip. Similarly on spurs the strata can be seen to bend gradually over towards the valley. In bottoms of steep canyons running approximately parallel to the strike of the sediments, vertically dipping sandstone and shale beds have been seen to bend over until they assume a horizontal position. Since this happens on both sides of the canyon, the effect is one of an anticline whose axis runs down the stream bed. Where the stream has laid bare the strata, one can, however, see the strata standing on end. The radius of curvature is not small as is usually pictured in textbooks, but may be as large as 50 feet. For this reason unless one is very careful, a false idea of the structure may easily be obtained.

Cavernous Weathering:

The massive sandstones and conglomerate beds of the area are very susceptible to cavernous weathering. The size of the cavities varies from a diameter of a few inches up to five and six feet, and in some cases the depth, the distance from the opening to the back wall, is as much as seven or eight feet. The bottoms of these hollows are filled with disintegrated material which has dropped off the roof and sides, which ordinarily have quite a fresh aspect. Yet if one looks close, he can discern a sort of scale, made up of fragments of the rock cemented together with calcareous cement, covering the sides and top of the cavity. The least touch of the finger nail is sufficient to dislodge these flakes. The location of these cavities seems to be controlled by bedding; for this type of weathering appears to attack certain strata more readily than others. It is also well marked along certain of the joint planes. Evidently the porosity of certain strata and the seepage along joints is responsible for the formation of these cavities; in that the solutions gain access to the surface, and then gradually leach out certain areas of rock not as firmly cemented as others. Temperature changes, hydration, and carbonatization probably also play a part in their formation although the leaching out of the cementing material by solutions is probably the most important formational agency. Where a master joint runs through the beds, these concavities are well developed and tend to join together, ultimately to separate the rock into long tabular leaves. The most common shape of the opening is elongate downward. although round and horizontally elongate openings are not uncommon. The diameter of the mouth is invariably less than the inside diameter, the rim projecting in like a lip on all sides except the bottom, which, slopes downward to the outside.

There is a possibility that the rain and wind might have dislodged fragments of rock which were not firmly cemented together and so have formed these holes. This explanation could not be valid, though, for more than a small number of the openings; because of the fact that many of the openings are well sheltered from the weather. Further, the depth of the opening is so great that no rain or wind could possibly effect the back wall. The outer lip projecting downward would not form if the cavity were due to rain or wind; and the control of jointing and porous strata is too evident to allow of the latter explanation.

Jointing and its relation to stream development:

Jointing has been one of the important controls influencing stream flow in this area. Its effects can be studied particularly well in the smaller canyons in which the strata are usually laid bare due to the rapid cutting of the streams; for, a stream in its attempts to get down to grade will take advantage of every possible weakness in the rock. In streams flowing more closely at grade the effect is not nearly as pronounced. In crossing through the strata the streams usually take a ziz-zag course; first following the strike of the strata for a ways, and then cutting across it perpendicularly to follow one of the major joints, the joint system being at right angles to the stratification; and then swinging back to follow the bedding again.

Water falls are very common in the smaller canyons, the bedding planes usually marking the base of the falls. The strata determining the water falls are often indistinguishable in appearance from strata immediately adjacent to them which have been quarried out; the word quarry is appropriate because of the fact that erosion of the sandstone beds appears to have taken place by removal of blocks. This is in complete disagreement with Cotton[1] who states that vertical strata will form not waterfalls, but rapids; horizontal or nearly horizontal strata alone forming falls.

1, Cotton, C.A., Physiography of New Zealand. (1926).

Stratigraphy.

General Statement:

Metamorphic, igneous and sedimentary rocks ranging in age from Archeozoic (?) to recent are found exposed in this area. The Pelona schists and migmatites, forming inclusions in the country rock, are referred by most geologists to Pre-Cambrian time. Plutonic rocks varying in composition from granodiorite to granite have intruded these old metamorphics, probably during the Sierra Nevadan Revolution of Jura-Cretaceous time.

The oldest sediments in the area are of Martinez age and are made up of a thick series of alternating sandstone and shale beds with a few intercalated conglomerate strata. The Le Brun and Vasquez formations are of indeterminate age, both in relation to themselves and to other formations; although they possess the distinctive lithologic features of sediments many geologists have been calling Sespe. All one can say with certainty is that these rocks are post-Martinez and pre-Mint Canyon in age. Lithologically these sediments are composed of large thicknesses of fanglomerate material together with sandstone, silt and shale beds. The Mint Canyon formation lies unconformably on these latter strata in the only depositional contact between sediments of different ages to be found in the area. This formation is also of continental origin and is composed of poorly stratified fanglomerate material grading up into well bedded sandstone strata. Terrace material is found capping many ridges and is composed largely of greatly weathered Pelona schist fragments.

These rocks have suffered very strong faulting movements, but have been little folded. The bedding of the sediments and the schistosity of the metamorphics is sub-parallel to the major faults; and, with the exception of the Mint Canyon formation, dips steeply both to the north and south. The Mint Canyon strata dip off relatively gently to the south.

Summary of Stratigraphy.

Age	Formation	Thickness	Character
Recent- - -	Alluvial- -	20'	Stream gravels.
	Earlier gravels- -	0- 40'	Stream gravels stranded on sides of canyons.
Pleistocene-	Younger terrace gravels	0-100'	Composed largely of Pelona schist fragments which upon weathering give the gravels a deep maroon color.
	Older terrace gravels	?	Similar to above.
Unconformity			
Upper Miocene	Mint Canyon Formation	3000' (?)	A basal conglomerate of ill-sorted fanglomerates overlain by well bedded sandstones and a few shales, light colored.
Unconformity			
Oligocene(?)	Vasquez- - Series	5000' (?)	A thick series of coarse well cemented fanglomerate material for the most part although loosely consolidated material is also present. This grades up into siltstones and sandstones. These rocks vary from a light grey to deep maroon in color; the latter color being dominant.
	Le Brun Formation- - -	2000'+	A series of blue green shales, maroon sandstones, and a few conglomerate beds which thicken to the south.
Unconformity			
	Martinez Formation	9000'±	Made up largely of well cemented buff colored sandstones, dark colored shales, and a few intercalated conglomerate beds.
Unconformity			
	Pelona Schist	8000'+	A group of metamorphosed sedimentary rocks consisting of green-stone schists, amphibole schist, mica schist, quartzite, and some limestone,

Geological Formations.

Archeozoic (?)

Pelona Schist Series.

Distributation and general features:

The Pelona schist, besides occupying the whole of Sierra Pelona ridge, also makes up a part of Portal Ridge along the north side of the San Andreas Rift, together with a small outlier in Antelope Valley. It occupies an area of 130 square miles altogether, covering about 55 square miles in this area.

This ridge is a fault block, being bounded on both sides by faults, on the north is the Clearwater fault zone, and on the south the Pelona fault zone. It plunges down underneath the Mint Canyon sediments to the southwest. This block is broken by a number of interior faults which parallel the marginal fault zones. The schistosity also strikes parallel to the trend of the ridge, and dips steeply, dipping sometimes to the north and sometimes to the south. This series has a minimum thickness of 8000 feet; for as it is cut off on both sides, its true thickness must remain unknown. An anticline is suggested by the arrangement of the dips and strikes, and as Simpson and Clements also postulated an anticline to the east and west respectively, it is probable that an anticlinal axis does run transversely across the ridge from slightly southeast to northwest.

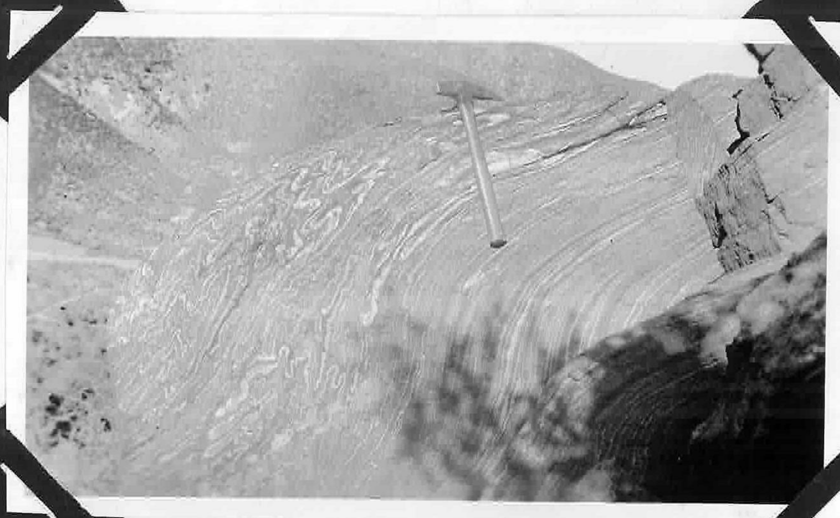
Lithologic characteristics:

The rocks making up this formation are metamorphosed sediments and basic volcanics. While this series is usually called the Pelona schist, certain parts of the formation could better be described under the term banded gneiss. The sedimentary origin of the greater portion of this series is quite evident. Parallel layers differing greatly in chemical composition are distinctive, several limestone beds are present, and the existance of a large amount of graphite schist, and quartzite beds is also indicative. However, certain portions of this series appear to be metamorphosed igneous rocks of plutonic character. They possess more of a gneissic texture and are different from the rest of the schist. Their lithology is quite uniform, and they appear to have a more or less irregular contact with the true schist. A good example of one of these bodies lies between Haskell and Dry canyon not far from the Mint Canyon contact. The existance of volcanics in this formation is shown by the fact that metamorphosed dikes of basic lava cut traversely across the bedding. Sills are also present. These volcanics are now metamorphosed into masses of talc and actinolite, Between Texas and Mint Canyons the writer was able to follow the trace of one of these metamorphosed dikes a few hundred yards up a ridge transverse to the general schistosity.

The schistosity of this series is better developed in some places than it is in others where the rock is more massive, dependent of course on the abundance of mica formed in the rock. Those parts of the section which were composed of shales or impure sandstones have developed a high degree of schistosity, but the more quartzitic rocks possess a gneissic texture. The bedding is every where parallel to the foliation.In general, the schistosity is quite regular, but in places a great deal of contortion has taken place in both the gneissic and schistose rocks.

These rocks are usually fine grained, although in places knotenshiefer have developed forming knots a quarter of an inch in diameter. Greys, blues, and greens are the predominating colors on fresh fracture surfaces. The schists weather to various shades of browns and

A splendid exposure of Pelona schist which was laid bare during the flood caused by the collapse of the St. Francis Dam.



Close folding shown in gneissic member of the Pelona schist.

reds due to their high iron content. One of the most distinctive features of this series is the large number of quartz veins which cut through it. These veins often attain a width of 15 to 20 feet, and the surface of the ground is always covered with glistening white fragments of quartz.

The schist usually weathers down to low rounded topographic forms. However, in some places great masses of rock stand out above the general level, these masses sometimes attaining heights of 50 to 75 feet.

The schistosity is everywhere parallel to the bedding throughout this series, suggesting that static metamorphism rather than dynamic metamorphism was predominant. That these rocks were metamorphosed in the mesozone, the zone in the earth's crust of moderately high temperature, is indicated by the presence of the following minerals characteristic of this zone; i.e. epidote, chlorite, cordierite, muscovite, albite, zoisite, and clinozoisite. The metamorphism is uniform throughout this whole series, the rocks being everywhere recrystallized.

A few thin sections of the most representative rock types were made, although no effort was made by the writer to make a detailed petrographic study of the Pelona schists. A very good petrographic study of the schists was made by Webb.[1]

Mica Schist:

This schist containing 55% quartz, 24% albite, 10% muscovite, 5% chlorite, 2% magnetite, 2% titanite, 1% zircon, and 1% apatite.

1, Webb, R.W., "The geology of East Sierra Pelona Ridge and Vicinity in the Southeast Part of the Elizabeth Lake Quadrangle, California. On file at Calif. Inst. of Tech. Lib. (1932).

The magnetite is altering to hemetite. The quartz and albite, elongated in the direction of the schistosity, are enveloped by long sheafs of mica which weave between the grains.

Quartz-Albite-Muscovite Gneiss:

This rock was interpreted in the field as being a metamorphosed granite which had intruded the original sediments. It is composed of 63% quartz, 23% albite, 7% muscovite, 2% chlorite, 2% titanite, 1% apatite, 1% ziroon, and 1% pyrite. The pyrite and titanite grains are greatly crushed and strung out along the plane of schistosity. As in all these schists the quartz and albite are greatly strained.

Cordierite Schist:

This rock is a knotenshiefer, and has knots about one-eight of an inch in diameter. It contains 51% cordierite, 10% chlorite, 10% orthoclase, 10% quartz, 10% actinolite, 5% epidote, 2% titanite and 2% magnetite. The cordierite is full of inclusions of actinolite and other minerals.

Muscovite Schist:

This specimen contained 66% quartz, 15% muscovite , 15% oligoclase, 2% titanite. 1% zircon, and 1% magnetite and hematite. The magnetite and hematite are crushed and strung out along the plane of schistosity. The muscovite is wrapped around and enclose the other minerals.

Graphite Schist:

This schist is quite common in San Francisquito Canyon. It contains 15% graphite, 32% quartz, 36% muscovite, 10% orthoclase, 5% calcite, 2% chlorite, and magnetite. The graphite, like the muscovite, is in sheafs and is wrapped around the other minerals.

Zoisite Schist:

This rock is a knotenshiefer and is a granular aggregate of minerals so intimately intermixed that a quantitative estimate would be impossible unless special means were resorted to. The minerals making up the aggregate are chlorite, albite, epidote, zoisite, clinozoisite and hematite.

Actinolite Schist:

This schist is a fibrous mass of actinolite and represents the metamorphosed equivalent of a basic lava. It is composed of 97% actinolite prisms, 1% muscovite, 1% hematite, and 1% quartz.

Age:

The age of this series is unknown other than it is older than the Jura-Cretaceous Nevadan Revolution; for it is intruded by monzonitic rocks which are generally considered to be of that age. Hershey[1] compared them with the Abram's schists of Siskiyou County, but J.H. Maxson[2] believes that this correlation is ill-founded. Those who have studied both the Rand and Pelona schists find a remarkable resemblance between the two. Hulin[3] who made a detailed study of the Rand Schist thought that they were probably the same. The writer after discussing the problem with Harrison Evans, who is at present working on the Rand schists, and examining field collections brought in by him, believes that the correlation is quite probable.

An Archeozic age is assigned them because of their degree of metamorphism. Cambrian and even Pre-Cambrian rocks in the Inyo Mountains exhibit a much lower degree of metamorphism, disregarding contact-metamorphism, and so it is at least likely that these schists are very much older and date back to Archeozoic time.

1,Hershey,O.H., "Some Crystalline Rocks of Southern California", Am. Geol. Vol 29. No. 5, pp. 223-240, (1902).
2,Personal communication.
3,Hulin,C.D., Geology and Ore Deposits of the Randsburg Quadrangle, Calif. State Mining Bureau, Bull. 93,(1925.)

A section of Pelona schist exposed below Power House No.2 showing the extreme contortion suffered by some of the more incompetent schist members.

A large boulder of typical granite augen gneiss.

Mesozoic.

Basement-Complex North of the Clearwater Fault Zone:

North of the area is a large terrane underlain by igneous rock which the writer made no effort to differentiate into separate units. A few thin sections were made of representative rocks in different localities to gain a general idea as to its composition. In many places it contains inclusions of old metamorphosed sediments which are best compared with W. J. Miller's[1] San Gabriel formation. It is an injection gneiss or migmatite and is made up of alternating layers of hornblende gneiss and biotite schist. Aplite and pegmatite dikes are numerous and are generally parallel with the textural grain of the rock. The country rock has intruded this series in many places and contains numerous inclusions of it. The larger bodies of these metamorphics are very likely roof pendants because of the fact that their foliation and structure is parallel where-ever they are exposed[2]. The strike of these rocks is east-west while the dip is nearly vertical.

The plutonic igneous rock in this part of the area is very much weathered and decomposed. The hill sides are usually covered with a yellowish granular layer of disintegrated rock, very little soil is present except in protected places. Disintegration has evidently

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1, Miller, W.J. Geology of the Western San Gabriel Mountains. Publ. Univ. Calif. at L. A. in Math. and Phys. Sci. Vol.1, 1934.
2, Lahee, F.H., "Field Geology", pp.142 (1923)

played the dominant role in the breaking down of this rock. The only fresh rock is that exposed in the bottom of canyons where the streams have scoured it clean.

Megascopically this rock is a medium grained phanerite composed of an aggregate of orthoclase and plagioclase feldspar, biotite, some hornblende, and quartz.

This rock varies in composition from a granodiorite to a granite. Biotite is the most common varietal mineral, although hornblende is sometimes present. Andesine in the abundant feldspar, and ranges from a basic andesine to oligoclase andesine. Orthoclase is the next most abundant feldspar together with varying amounts of microcline. The usual accessory minerals are apatite, magnetite, titanite, and zircon in the order of their abundance. The minerals composing these rocks have been more or less altered by hydrothermal solutions. The biotite is quite often bleached and has been altered to chlorite and epidote. When hornblende is present it has also suffered chloritization and epidotization. The feldspars have been sericitized, and the magnetite has been partly converted to hematite.

Pegmatite and aplite dikes cut through this rock; and, being more resistant to weathering, stand out above the weathered surface of the terrane.

Basement-Complex South of the Pelona Fault.

The country rock in the area south of the Pelona fault is finer grained than the igneous rock north of the Clearwater fault, however, it would still beclassed as a medium grained phanerite. It also has a lighter appearance due to a smaller content of ferromagnesium minerals. This rock is cut by a number of pegmatite and aplite dikes,

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1, Simpson, E.C., "Geology and Mineral Deposits of the Elizabeth Lake Quadrangle, California", Calif. Jour. Mines and Geol. Vol. XO. No. 4. (1934).

in the former sheaves of muscovite an inch in diameter are sometimes developed. This plutonic body also contains large inclusions of injection gneisses similar to those found in San Francisquito Canyon.

The composition of this rock was found to be that of a monzonite or granite; however, Simpson[1] reports that in many places it grades into a hornblende diorite facies. In thin sections examined by the writer plagioclase was the dominant feldspar, the composition varying from oligoclase to andesine. Microcline and orthoclase made up most of the remainder of the bulk composition of the rock A small amount of biotite was also present. Zircon, magnetite and titanite were present as accessory minerals. The biotite is partially altered to chlorite while the feldspars are sericitized. Some of the lammellae of the plagioclase are bent.

In view of its lithologic similarity, its adjacency, and its migmatite inclusions, this plutonic body is probably to be correlated with that in the northern part of the area.

Granite Augen Gneiss:

This rock is found only in the Mint Canyon Block and occurs in blocks which have been faulted up into the Vasquez sediments. It weathers to a dark red or brown. Its most distinctive feature is large phenocrysts of microcline, averaging an inch and a half in length and three quarters of an inch in width, whose long axes are aligned in a direction parallel to the flow structure of the rock.

The most abundant mineral of this rock is microcline which makes up almost half of the rock. Albite-oligclase plagioclase is also present, while quartz makes up about a quarter of the rock. Both bio-

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1, Simpson, E.C., Ibid.

tite and muscovite are present, although the biotite greatly predominates. The accessory minerals are apatite, magnetite, zircon, and titanite. The plagioclase feldspar has suffered a certain amount of sericitization, while the magnetite is partly altered to hematite. micrographic intergrowth is present between microcline and quartz, and the twinning lamellae of some of the plagioclase is bent.

Lava dikes can sometimes be seen cutting through the porphyry, and in some cases pass upward into the Vasquez sediments where the two are in depositional contact. This lava is aphanitic with very small phenocrysts of quartz and orthoclase.

Tertiary Formations.

Eocene

Martinez Formations

Areal Distributation and General Features:

Lying between the Clearwater and Bee Canyon Faults is a long narrow wedge of Martinez sediments whose apex points towards the east. These sediments are cut off by the confluence of the above two faults, and cover an area of about eight square miles. They are bounded on the north by plutonic rocks of intermediate composition and on the south by Pelona schist, except for a distance of three miles on the west side of the Le Brun Quadrangle where they are in fault contact with the Le Brun formation. In Bee Canyon a small wedge of Martinez is faulted down inside the latter formation. Nowhere are these strata in normal depositional contact with other rocks; however, in the Tejon Quadrangle to the ~~east,~~ west Clements[1] finds them in depositional contact with the basement.

These sediments strike east-west or slightly northeast-southwest, and have a dip ranging from 50° to 90°. They have a thickness of 9000± feet, the true thickness not being revealed due to faulting. No unconformity of any magnitude is present within this series, the strata all being conformable.

Lithologic features:

This formation is made up dominantly of sandstone and shale with a few interstratified conglomerate beds. The sandstone beds form about sixty per-cent of the series the shales forty per-cent, while

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1, Clements, T., "Geology of the southeast portion of the Tejon Quadrangle California", on file at California Institute of Technology Library.

Martinez sandstones weathering out on a ridge top.

Martinez sandstone beds outcropping on a ridge top.

the conglomerate beds make up only a few per-cent of the bulk composition of the formation. The sandstone and shale beds form alternating series of strata of variable thickness. In places the shale beds attain thicknesses of a 1000 feet, but this is unusual; for in most localities the thickness varies from a few inches up to fifty or sixty feet.

The sandstone is very resistant to erosion and tends to weather out in prominent projections. In places these strata form quite pronounced bluffs, and in the bottoms of canyons water falls are frequent where the streams flow over steeply inclined strata. Cavernous weathering is very common, the hollows varying from several inches to three or four feet in diameter. These features are discusses in another part of the paper in relation to the Vasquez formation; but the conclusions reached are valid for these rocks as well.

A fresh unweathered fracture surface of the sandstones is grey; but wherever they are exposed to the weather, they have assumed a buff coloration, and in places have even become coated with desert varnish. The sandstone is a medium grained arkose and is well sorted although in places very angular pebbles one-half to an inch in diameter are scattered through it. Calcite seams are visible running through these sandstones, and are probably due to leaching of the $Ca\ CO_3$ content of the sediments with a secondary deposition of it in the form of calci along fissures and joint planes. Limonite skeletons can often be picke up along the hill sides. These have very complex shapes, but are usually in the form of boxes with numerous partitions. They have evidently been formed by the filling of fissures and cracks in the sandstone by iron oxide, and upon the disintegration of the rock are left lying on the surface as skeletal frameworks. The sandstone is very well consolidated, and rings when struck with a hammer.

A thin section of a typical sandstone shows it to be made up of

50% quartz, 32% oligoclase and andesine, 2% microcline, 3% magnatite, 2% biotite and muscovite, 10% calcite, 1% zircon, apatite (?), and epidote. The cementing material is mainly iron oxide with some calcite and silica. The individual grains are very angular, even jagged, and show no rounding whatsoever.

The conglomerate beds form a belt several hundred feet wide. The individual beds are about ten feet wide and are separated by sandstone and shale strata. This belt is very persistent, as all the strata in the formation are, and extends from the west edge of the area to Cherry Canyon where it is cut off by the Clearwater Fault. The gravel is fairly well sorted and ranges in size from one-half an inch to one foot in diameter. The average diameter is four inches, and this size makes up the bulk of the beds. It is sub-rounded to rounded. The rocks making up these gravels are 60% granitic, 30% lava, and 10% quartzite and gneiss. This proportion holds fairly well throughout the formation. The conglomerate is well cemented, and has about the same resistance to weathering as the sandstone strata.

The shales are well consolidated, indeed, they have almost a slaty texture. The fissility is developed to a high degree, with the result that the shales weat or out into thim quadrangular chips. This type is commonly spoken of as poker chip shale. Their color varies from grey to blue-green, although they commonly weather to a rusty red or brown. In Cherry Canyon there are numerous interbedded lignite seams in the shales. In various other places in the section one can also find fossil leaf imprints (reed variety) and fragments of carbonized wood. In the upper end of Cherry Canyon, near the Bouquet Canyon reservoir these shales attain a thickness of several hundred to a thousand feet. Concretions are not rare in these shales and seem to be more or less ferruginous. Where found close to a fault zone they are commonly seen with one or more shear planes running through them. In a few

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Under the microscope a thin section of shale revealed a few jagged pieces of quartz, apatite, zircon, pyrite and disseminated carbonaceous material. A long thin fissure filled with pyrite was seen to cut across the thin section.

Stratigraphy and age:

Little can be done from a stratigraphic point of view with these sediments due to the fact that every where in this area they are in fault contact with other rocks. They have been thrust over beds of continental origin regarded by Kew[1] as Sespe(?) in age, but referred to as the Le Brun formation in this report. In the Tejon Quadrangle Clements reports that they are unconformably overlapped by the Mint Canyon and Modelo Formations. He also found them lying unconformably on igneous rocks of probable Jura-Cretaceous age. Ripple marks, cross-bedding, and gradation of material show that the base of the section lies to the north.

These sediments were deposited in shallow water (neritic zone) and under conditions of a rapidly fluctuating sea level. Cross bedding, conglomerate beds, the presence of small angular pebbles in the sandstone, lignite beds, leaf imprints and bits of carbonized wood, all point to accumulation in shallow water. The fact that the strata are continuous over distance of many miles with little thickening or thinning precludes the possibility of deposition under deltaic, esturarine or littoral conditions. The presence of lignite seams points to the fact that lagunal depositional may have prevailed at times. Crustal unrest

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1, Kew, W.S.W., "Geology and Oil Resources of a part of Los Angeles and Ventura County, California," U.S.G.S. Bull. No. 753, (1924).

must have been very marked at this period as shown by the rapidly alternating series of sandstones and shales in beds of varying thickness. Further emphasis is given this view by the conglomerate beds contained in this section. No fossils other than numerous worm tracks were seen in these sediments. This probably is due to three factors.[1] First, that sea bottoms composed of shifting sands are unfavorable to life and are only scantily populated. Second, that black mud bottoms are very unfavorable to organisms due to a lack of oxygen and abundance of hydrogen sulfide, the pyrite found in the shale is proof that the latter gas must have been present. Third, rapidly changing life conditions are unfavorable to all but the most adaptable animals; and, as mentioned above, the extreme crustal unrest in this vicinity at that time must have inhibited life growth to no small degree.

The source of these sediments was probably adjacent to this locality; as the rocks represented in the conglomerates are the type which would be furnished by the basement-complex at the north end of the area, and are of such a size that they could not be transported very far under normal conditions. The lava boulders in these beds could have come from no source which is known to the writer, and it is possible that these volcanics have long since been eroded away, or perhaps buried out of sight. No Pelona schist fragments or rocks representative of the San Gabriel Mountains are contained in these conglomerates. The arkosic nature of the sandstones also indicates a granitic terrane which was undergoing rapid erosion; as can be seen from the fact that the feldspars are relatively fresh and make up a large bulk of the rock. This may be the result of an arid climate favorable to the disintegration of rocks with little decomposition, or may be due to very rapid transportation of material which would allow little time for de-

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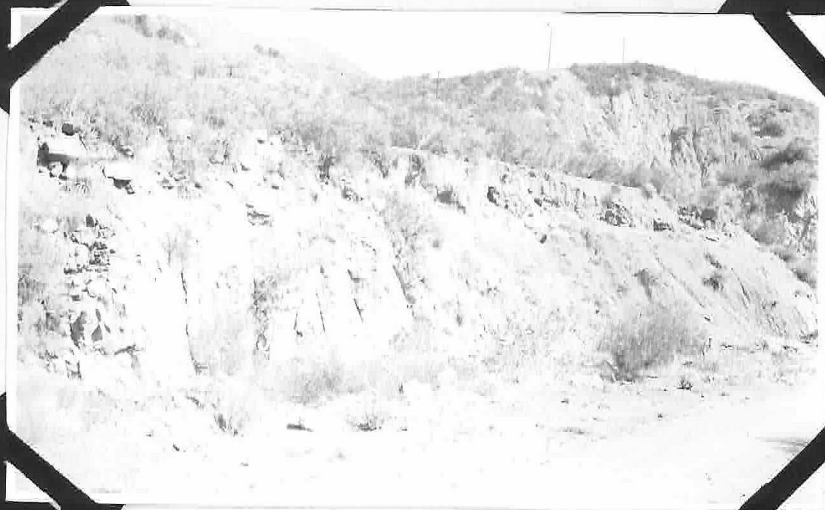
1, Twenhofel, W.H., "Treatise on Sedimentation", (1924).



A typical exposure of Martinez shales and sand-
stones.

A calcareous spring deposit in the Bee Canyon Fault
zone.

composition. The presence of the numerous coal seams at the base of the series would probably favor the theory of a warm moist climate during this epoch.[1]

Clements[2] collected a small faunal assemblage of invertebrates from this formation in Elizabeth Lake Canyon, the fauna being well enough preserved to show that it was Martinez in age. Some Paleontologists regard Martinez timeas equivalent to Paleocene, while others place it as lowermost Eocene; however, it is generally agreed that Martinez sediments are at the base of Tertiary marine sections in this country.

Oligocene (?)

Le Brun Formation.

Areal Distribution and General Features:

The Le Brun formation is exposed in San Francisquito and Bee Canyon. It has the form of a long wedge, and is cut off on both sides by the Bee Canyon and San Francisquito Faults. It is in contact with the Martinez formation along the Bee Canyon Fault and the Pelona schist along the San Francisquito Fault. These sediments are easily eroded and form a low lying block far below the general level of the surrounding country. Their maximum thickness in this area is probably about 2000 feet, although they thicken to the south.

Compressed between two large reverse faults, these strata have been considerably deformed both by folding and faulting. Numerous small thrust faults and folds run through this formation which are too small to map, however, an anticline is present which is shown on

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1, Ibid.
2, Clements, Thomas, "Geology of a portion of the Southeast Quarter of the Tejon Quadrangle, Los Angeles County, California", On file at California Institute of Technology Library, (1929).

the map. Clements has postulated a very complex structure made up of tight overturned folds in the area to the southwest. The dips of the strata are all steep, averaging 50° for the most part. The strike is about N 70°-80° which is parallel to the strike of the Martinez strata.

Lithologic features:

Sandstones, shales and conglomerates, listed in their respective importance, make up the Le Brun formation. In this area the conglomerates are relatively unimportant, although to the southwest they become increasingly more abundant until they make up the bulk of the section.

The sandstones are colored a deep maroon, and are a very striking feature in the landscape. They are only weakly consolidated, and when struck with a hammer are easily pulverized, in some places they can even be crumbled between the fingers. A thin section shows this rock to be composed of about 30% quartz, 5% microcline, 30% orthoclase and oligoclase, 5% biotite, 5% magnetite, and 25% argillaceous and ferruginous material. The feldspars were so altered to kaolin and sericite that it was diffiault to distinguish between the monoclinic and triclinic varities. The biotite was largely altered to chlorite, and the magnetite to hematite.

The shales are grey to grey green in color and contain mica and arenaceous material as impurities. They weather to a maroon color. Their consolidation is variable, in some places they are quite soft whereas in other locations they are reasonably firm. Mud cracks, ripple marks, worm tracks, and questionable rain drop imprints are preserved in some of the strata, while gypsum is very abundant in the shale beds.

Conglomerate beds make up only a very small part of this formation in the area mapped; however, Clements states that to the southeast they form 5000 feet of a 7000 foot section. The gravel has an average size of two to six inches in diameter and is composed of granitic, felsitic, quartzitic, and sandstone material. Hill[1] mentions in a geologic investigation of the St. Francis Dam Site that of fifty pebbles broken, 52% consisted of granite, slate, quartzite, vein quartz and rhyolite, 40% were of a dense sandstone cemented with calcite, and 8% were too much altered to permit identification. These pebbles are all covered with a shiny coat of iron oxide which probably is of epigenetic origin; as they are most common adjacent to sheer zones, where percolating water carrying iron oxide would come in contact with them. A further substantiation of this is that pebbles in the Martinez formation are also coated with iron oxide adjacent to the Bee Canyon Fault, but nowhere else.

Stratigraphy and Age:

These strata are nowhere in depositional contact with other rocks, being in fault contact with Martinez strata to the north and Mint Canyon strata to the south. The strata referred to the Le Brun formation in this report have been correlated by Kew with the Vasquez series to the east. That this is unlikely is shown by a number of facts. Whereas the Vasquez series contains syenite, anorthosite, and lava boulders which came from the general direction of the San Gabriel Mountains, the Le Brun formation contains no rocks of this composition. Furthermore, the source of the Le Brun sediments was to the south and not to the east, shown by the fact that the conglomerates thicken enormously to the south. Again, the Vasquez series is known to be resting on the basement wherever the base of the series is exposed; but between

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1, Hill, R.T., "Geology of Reservoir Sites", Part 11 of a report of the Board of Consulting Engineers to the Board of Water and Power Commissioners of the City of Los Angeles, (1928).

An overturned fold in the Le Brun sandstones and shales.

A typical conglomerate in the Vasquez Formation

Haskell and San Francisquito Canyon, Mint Canyon strata lie on the basement directly with no intervening beds. While the possibility must be recognized that the former formation may have been eroded off this sector, the likelihood is that it never was deposited over this far. It is Clements[1] opinion that the Le Brun sediments were deposited in a local basin of deposition, in which case they should be regarded as a geological unit.

These sediments were most likely deposited in a playa lake, for the absence of fossils, the presence of mud cracks, and rain drop impressions all point to an arid climate. However, this question will be discussed more in detail under the origin of the Vasquez sediments.

1, Paper delivered before yearly meeting of Branner Club, 1935.

Vasquez Series.

Distribution and General Features:

The Vasquez series outcrops in the southern third of the area, forming a strip about six miles long and nearly two miles wide. This section of the area is subdivided by an amazingly complex fault pattern; so that the Vasquez and Mint Canyon formations, and at least two varieties of igneous rock fit together in an irregular mosaic like pieces in a jig-saw puzzle. However, the Vasquez series greatly predominates over the other rocks in areal distribution, and covers in all about six square miles. This strip lies between Haskell and Mint Canyons and parallels the base of Sierra Pelona Ridge. The Pelona fault forms the northern boundary of the Vasquez formation, while the southern margin is in general bounded by a branch fault of the Pelona Fault which runs northeast-southwest. These faults are both of the normal type, and in each case the sediments have been dropped down with respect to the igneous rocks on either side of the fault. In effect these Tertiary formations occupy a graben which is truncated by the Pelona fault to the northeast, and which is obscured by a large thickness of sediments to the southwest.

The strata of the Vasquez series strikes northeast-southwest and dip southward at an angle varying from $50^\circ - 90^\circ$. Their probable thickness is about 5000 feet although nowhere is a true thickness of the formation revealed due to faulting. In a few places these strata were found resting in depositional contact on the basement-complex, although in each instance this has been bought up into the center of the series by faulting.

Lithologic features:

This series is composed of typical continental sediments, and is made up chiefly of fanglomerate, sandstone, and a minor amount of shale.

An exposure of the more loosely consolidated conglomerates of the Vasquez series.

In the foreground is shown a cross section of part of the Le Brun Formation marked by closed folds and overthrusting.

These clastics are dominantly maroon or brick red in color, although some sandstone strata have colorations ranging from light grey to white, and even buff.

The fanglomerates are very well consolidated for the most part and form prominent topographic projections, in some cases hog-backs formed by differential erosion attain a height of 100 feet. In parts of the section however, the boulder beds are extremely poor in consolidation and can be easily dug into with a pick. These softer beds are usually light grey in color. The pebbles making up the fanglomerates range in size from a fraction of an inch to several feet in diameter, the average diameter being six or eight inches, This material is subangular to subrounded. The composition is markedly irregular, for certain rock types appear in some localities and are absent in others. Plutonic igneous rocks of acidic composition, gneisses, basalts, rhyolites, syenites, anorthosites, and granite augen gneiss form the bulk of the boulders. Pelona schist is still not represented in the sediments.

A thin section of one of the basaltic boulders shows it to contain labradorite, olivine, augite, calcite, epidote, magnetite and bowlingite arranged in a hyalopilitic texture. Olivine basalt is found in the Vasquez series south of this area,[1] but the lava contained in the Vasquez rocks to the east is lacking in olivine.[2] A thin section of a rhyolite boulder contained only quartz phenocrysts set in an aphanitic ground mass.

The sandstones are variable in color, consolidation and com-

1, Personal communication from G. A. Dawson.
2, Personal communication from R. P. Sharp.

position. Their color varies from buff, various shades of red and brown to light greys; however, maroon greatly predominates, while the light grey hues are not uncommon. In some places the consolidation compares with that of the Martinez sandstones, while in other places it is very poor. A thin section of one sample showed it to contain 45% quartz, 15% andesine-oligoclase, 10% orthoclase, 5% microcline, 2% biotite (largely altered to chlorite) 1% apatite, 1% magnetite, 1% zircon, and 20% ferruginous cementing material. The grains are very angular. Another thin section of a sample from a different locality contained 30% quartz, 32% plagioclase (the lowest calcic variety being andesine), 2% microcline, 3% muscovite, 3% biotite (largely altered to chlorite), 15% orthoclase, 1% calcite, 1% apatite, 2% zircon, 3% magnetite, 3% hematite, 3% epidote, and 2% lava fragments. It is medium grained, the grains being very angular, and is cemented chiefly by ferruginous material.

Cross bedding and scour channels are numerous in these sandstones and indicate that the base of the section lies to the north. The bedding of the strata is uniform over rather long distances, although in a few cases a very rapid lensing out of thick fanglomerate beds into fine grained sandstones was observed.

The shales in this formation are unimportant and are found generally in association with the more silty sandstone beds. They are impure arenaceous shales, and are most commonly light grey in color. These softer members tend to weather into bad-land forms, and are susceptible to landsliding where they outcrop along the sides of steep canyons.

The Vasquez series rests on the basement-complex wherever the basal contact could be observed; and is overlain in angular unconformity by the Mint Canyon formation of Miocene age, the very steeply dipping beds of the former formation being truncated by the relatively gentle dipping beds of the latter. Although this series does not contain any volcanic members either in the form of extrusives or intrusives with the exception of a few small felsitic dikes too small to map, it is probably the correlative of the Vasquez series to the southeast. These two units are lithologically similar in every way except for their lava content, and are separated by only a few miles. Further, when Hershey[1] first described the rocks in Soledad Canyon under the name Escondido Series, he specifically included the Texas Canyon sediments under this head. R. P. Sharp,[2] finding that Hershey's name was preoccupied, recently renamed these strata the "Vasquez Series", which name is adopted in this report.

The clastic material making up this series was derived from the east, and deposited at the base of a high steeply sloping scarp, probably a fault scarp. The fanglomerates aggregate many thousands of feet in thickness, and although, the material is quite coarse and fairly angular, it is distinctly smaller in size and better rounded than that contained in this same series in the Ravenna Quadrangle.[3] These materials represent very rapid deposition in piedmont aprons under semi-arid conditions. The upper portion of the series is made up of large thicknesses of silts and sandstones which are of lacustrine origin.

Although no fossil material has ever been found in this series, Dr. Stock has described a fauna from the Sespe formation which is lithologically similar to this one. This fauna is of a browsing

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1, Hershey, O.H., "Some Tertiary Formations of Southern California", Am. Geol. Vol. 29, No. 6, pp. 349-392, (1902).
2, Sharp, R.P., "Geology of the Revanna Quadrangle", 34th Annual Meeting of the G.S.A., Cordilleran Section, 1935, (Abstract).
3, Sharp, R.P., Ibid.

such as would inhabit a wooded area in a moist climate. Many geologists are now inclined to the belief that red beds need not indicate aridity. P.E. Raymond[1] points out that the presence of abundant feldspar is not evidense of aridity for it may have only been transported a short distance and quickly buried. The rarity of animal and vegetable remains in red beds he ascribes to the coarse texture of the sediments and their accumulation in fans subaerially which permitted decay to go on rapidly even after buried, aided by warmth and moisture which facilitated bacterial action. He also rejects the idea that arid basins are favorable collecting places for red sediments; for he points out that aeolian action would abrade the material thus removing the red stain. He admits however that red sediments can accumulate in a semi-arid climate.

As the problem of the origin of red beds is still not fully solved, one can not dogmatically say that such and such a climate prevailed during the deposition of these beds. However, the presence of huge thicknesses of fanglomerates would probably indicate deposition under semi-arid conditions. Also the presence of lacustrine deposits made up of fine silts and clays would point to the presence of playa lakes. C.W. Tomlinson[2] states that "the combination of well-watered highlands with less humid or semi-arid lowlands furnishes the conditions for the development of red soils, and at the same time provides for the transportation and deposition of the sediments derived from them without extensive hydration or reduction of the ferric oxide constituent during the transfer". This would appear to fit the above facts quite well.

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1, Raymond, P.E., "Red Color in Sediments", Am. Jour. Sci. 5th Ser. Vol. 13, pp. 234-251, (1927).
2, Tomlinson, C.W., "The Origin of Red Beds", Jour. Geol. Vol. 24, pp. 252,

Hog backs formed by the more resistent conglomerate beds of the Vasquez series.

Outcropping conglomerate beds in the Vasquez Formation

The age of the Vasquez series is indefinite, all one can say is that it is older than the Mint Canyon formation. How much older is difficult to say in view of the lack of paleontologic evidence. The presence of such a profound unconformity as exists between the two formations would argue for a long lapse of time between deposition of the two series of sediments; but as has been frequently pointed out, large unconformities in the Coast or Transverse Ranges do not necessairly represent a large hiatus.

Miocene

Mint Canyon Formation.

Distribbtion and general features:

The Mint Canyon Formation outcrops in the same general area as the Vasquez series, for as stated above the former formation has been faulted down into the latter sediments. This formation extends also far to the south, east, and west of this area. In the southwest corner of the Le Brun Quadrangle, these beds are lying in depositional contact on the Pelona schist.

So far as the writer knows, no one has ever accurately calculated the thickness of this formation, although various estimates varying from 2000-3500 feet have been made. The strata have a relatively gentle dip to the south, rarely does it exceed 20° or 25°.

Lithologic features:

That part of the Mint Canyon formation outcropping in this area ia a coarse, poorly stratified fanglomerate. At the entrance to Texas Canyon the basal portion of this series contains large blocks of Pelona schist embedded in an argillaceous matrix. This was referred to as the Bouquet Canyon Breccia by Woodford[1] who regarded it as the

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1, Woodford, A.O., "The San Onofre Breccia", Univ. Calif. Pub. Geol. Vol. 15, pp. 159-280, (1925).

possible correlative of the San Onofre Breccia. Although the writer found no Pelona schist gragments in any of the rest of the section, except in the basal member in Haskell Canyon, he has been informed that fragments of this rock are quite common throughout the series.[1] This is the first sedimentary record of Pelona schist in the Tertiary formations of this area. The most common type of rock found in these beds are plutonic igneous rocks of acidic composition, i.e.,basalt, granite augen gneiss, biotite gneiss, anorthosite, and red sandstone (Vasquez).

These sediments are extremely difficult to distinguish from the Vasquez series. The only basis the writer could find for making the separation was that the Vasquez series is well stratified and has a very steep dip while the basal Mint Canyon was devoid of stratification for the most part; the Vasquez sediments near the contact take on lighter hues such as light grey and pale pink, while the Mint Canyoh rocks are colored a pale dirty olive green, and the matrix of the Mint Canyon fanglomerates is much more argillaceous than the matrix of the Vasquez fanglomerates.

In Haskell Canyon the Mint Canyon beds are of a totally different type. Massive sandstone beds predominate over interbedded conglomerate and shale beds. A freshly fractured surface of the sandstone has an olive green tinge, while the weathered surface is buff or sometimes light pink. The conglomerates contain Pelona schist, granitic material lava, quartsite, and gneiss fragments. These are poorly sorted and vary from subangular to well rounded. The consolidation is not very good, as a result bad lands forms are well exemplified. Near the contact these beds dip rather steeply, 45°, but as a general rule the dip

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1, Personal communication from J.H. Maxson.

is quite flat, as they have suffered only gentle folding. In the stream beds of tributaries to Haskell Canyon the writer saw one or two outcrops of what appeared to be Vasquez sediments standing almost vertical, however, they were very dubious occurrences to base judgment on and may only have been cemented stream gravels.

Stratigraphy and age:

In this area the Mint Canyon overlaps both the Pelona schist and the Vasquez formation. Further to the south and west the Modelo Formation overlaps it. Its age has been fairly accurately determined by means of vertebrate fossils; a few fresh water invertebrate forms have also been found in it. A faunal study of this formation was carried out by J.H. Maxson.[1] According to C. Stock[2] these sediments are upper Miocene in age and may even extend a short ways into lower Pliocene time. As such they would be equivalent, in part, to the Ricardo Formation.

These sediments are continental in origin and represent fanglomerate and playa lake deposits. The fanglomerates have such a clayey matrix that land-sliding is prevalent wherever they are exposed in a steep slope. It is very likely that these beds were built up by successive mud-flows much in the way postulated by Blackwelder.[3] The Matrix is all slickensided, showing a large amount of differential

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1, Maxson, J.H., "A Tertiary Fauna from the Mint Canyon Formation, Southern California", On file at Calif. Inst. of Tech. Lib.
2, Personal Communication.
3, Blackwelder, E., "Mudflows as a Geologic Agent in Semi-arid Mountains", Bull. G.S.A. Vol. 39, pp. 403-20, (1928).

movement. Further, their material is very angular. As stated above, Woodford considered these sediments to have an origin analogous to the San Onofre Breccia.

Quaternary Alluvial.

Pleistocene.

Older Terrace Gravels:

Although the mature surface carved during the second cycle of erosion still covers large areas, in only one place is any alluvium preserved which was laid down upon it. At the head of Dry Canyon a broad valley is present, down which the San Francisquito River once flowed. Since the valley is beheaded, no drainage flows down it except the rain water which actually falls on its walls and floor over the valley's length, which is only about two miles. This valley is very broad and has a low gradient so that the small amount of water which falls upon it has no transporting power. In no place is it trenched except at its head and foot where deep canyons are rapidly cutting back into it. As the late W.M. Davis would say, it has not yet received news of the uplift. The floor of the valley is covered with a layer of decomposed and disintegrated fragments of Pelona schist.

Younger Terrace Gravels:

Alluvium laid down by streams during the third cycle of erosion is preserved on many ridge tops in the area, as can be seen by referring to the map. It is especially well preserved in Mint Canyon where it covers broad tables. This material attains thicknesses of 50 or 75 feet and is composed largely of Pelona schist, although igneous rock pebbles are not uncommon in it. It has assumed a dark maroon color due to theweathering of the schist which has a high iron content. Fragments of quartz are especially common and cover the ground in great profusion. The gravel composing this material is made up of pebbles and boulders which are from two to three feet in diameter, although those under a foot are most common. In general the material is very angular, although some of the igneous rock is fairly well rounded.

Recent

Earlier Gravels:

Along the sides of some of the canyons, but notably in Texas Canyon stream gravels have been preserved 20 and 30 feet above the stream bed on the sides of the Canyon. These gravels have been extensively prospected and worked for gold. In appearance and composition they are similar to the "younger terrace gravels".

Alluvium:

These gravels are being deposited along the beds of the present stream courses and are composed of various materials. At the mouth of Texas Canyon they are 20 feet thick, while near the mouth of Bouquet Canyon they are about 100 feet thick.

Stream cemented conglomerates are very common along the stream beds in the area. Pebbles and rock fragments varying in size from a few inches up to a foot in diameter are cemented in a calcareous matrix which is extremely hard. It rings when struck with the hammer and is very difficult to break. It usually has a light grey color, and were it not for the fact that it contains large angular fragments of the Pelona schist, would easily be mistaken for some of the Tertiary sediments, particularly the Vasquez series.

Spring Deposits:

Along the Bee Canyon and San Francisquito Faults calcareous spring deposits are very common. They outcrop along the sides of the canyon and their height above the stream bed may vary from a few feet to as much as fifty feet. In some instances they attain a length of 150 feet. The material of which these deposits are composed may be calcareous tufa or banded travertine. This material weathers to a

Looking along the trace of the Bee Canyon Fault showing its juction with the Bouquet Canyon Fault. The trace of the Clearwater Fault can be seen on the extreme left.

View showing a series of ridges capped by terrace gravels on the north side of Texas Canyon. Vasquez beds shown standing almost on end.

dull grey color. Petrified plant material can be seen in these deposits in some places.

Structure.

Regional:

The most distinctive feature of Southern California geology is the large number of active faults which are to be found here. Indeed, the seismic activity of this part of the state was early noticed by the Spanish settlers; for in 1596 one Sebastian Viscaino made the amusing remark "It is not the sea that is dangerous, it is the trembling coast". It might be said that most, if not all, of the mountain ranges in this half of the state are due to recent uplift along an active fault. This is especially true of the area concerned in this report, where the geological record indicates that strong faulting has taken place during the latter part of the Tertiary and the whole of Quaternary time.

The most important structural feature of this region is the San Andreas Rift which runs from Cape Mendocino to the Gulf of Mexico, a distance of over 700 miles. This fault runs along in a northwest-southwast direction, but a few miles north of the area shown on the map; and marks the boundary between the mountains and the desert.

The structural relationship of the mountains bordering the south side of Antelope Valley, of which the mountains in this area are a part, with the adjacent mountain ranges has long been a subject of controversy. Jules Marcou[1] early included them as a part of the Sierra Nevada Mountains, while Whitney[2] thought that they were merely the southward extension of the Coast Ranges, as did Trask.[3]

1, Marcou, Jules, "Report on the Geology of a portion of Southern California", annual Report, Surveys west of the 100th Meridian, (1876).
2, Whitney, J.D., "Geology of California", Vol.1.
3, Trask, J.B., "Report on the Geology of the Coast Mountains", (1853-54).

Looking down San Francisquito Canyon. The Bee Canyon Fault can clearly be seen crossing the picture from right to left. The system of terraces developed on the soft Le Brun sandstones and shales can be seen leading up to a gap in the mature surface developed in a previous cycle of erosion, and which may mark the former course of the San Francisquito River.

Looking east along the Pelona Fault. The steeply dipping beds in the foreground belong to the Vasquez series.

The reason for this confusion is that a number of mountain ranges apparently run together in the vicinity of Tejon Pass, the so-called "structural knot of California". At the present time the east-west trending mountains in this region are referred to a mountain chain known as the Transverse Ranges. This chain, although included in the Coast Ranges by some geologists, is nevertheless a distinct structural unit; inasmuch as the east-west trending faults responsible for the uplift of these mountains are due to an entirely different set of forces than those which produced the north-south alignment of the Coast Ranges.

If one looks at the fault pattern as shown on the map, one of the most noticeable features about it is the fact that the faults radiate out to the south in a manner reminiscent of the vein pattern of one-half of a leaf; the master fault being represented by the center rib. There are two master faults of this type traversing the area. i.e., the Clearwater and Pelona Faults. Both of these faults fray out into a dentritic pattern, the branch faults trending southwest. This is also true of the San Andreas Fault for Noble[1] in speaking of its trace in the vicinity of Cajon Pass says, "This is a focal area, into which many great branch faults converge upon the San Andreas like ribs of a fan".

This radiating pattern is probably due to a relief in pressure, which is directly proportional to the distance from the master fault. That the pressure on the blocks adjacent to the San Andreas Fault must have been terrific is shown by the fact that large mountain blocks have been shoved over each other along high angle re-

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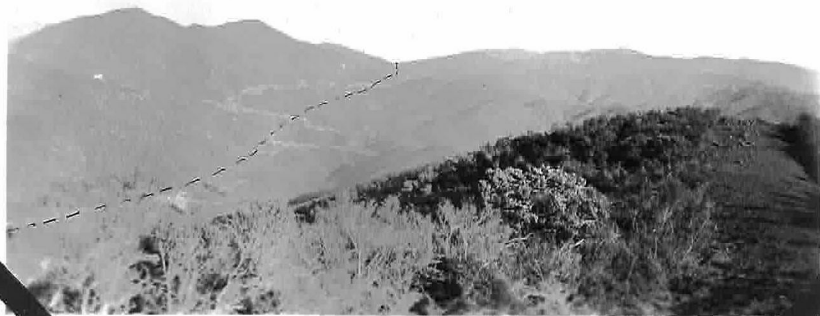
1, Noble, L.F., "The San Andreas Rift in the Desert Region of Southwestern California", Carnegie Institution of Washington Year Book No.31, (1932).



A view looking up Cherry Canyon showing the Clear-water Fault.

Looking toward Leonis Valley from the head of Bouquet Canyon, showing the juncture of the Clear-water Fault with the San Andreas Rift.

verse faults. Slickensides on the fault surfaces of the faults in this area seem to show that the horizontal slip exceeded the vertical slip; indicating that the blocks were acted on by rotational forces tending to slide them along in a horizontal as well as in a vertical direction. It is hard to see how else uplift could take place along such high angle reverse faults; for surely pure compressional forces alone are not competent to effect such a result, but would rather express themselves in the form of low angle over-thrusting. The branch faults in this area have the same relationship to the major faults as shear fractures have to a fault surface, that is they are obtuse to the direction of differential movement; and they doubtless have a comparable origin.

One of the most striking things about these faults is the fact that they invariably die out under a thick series of Tertiary sediments. According to Clements[1] the Clearwater fault is truncated by the Modelo formation which overlies it without being appreciably distorted. In the same way the Pelona fault and its branches apparently die out under the Mint Canyon beds to the south-east of the area. Evidently, as suggested above, a large amount of strain was relieved along these branch faults of the San Andreas, and as the distance from the latter fault increased, the movement was taken up by more branch faults until the fault zone just frayed out. The same phenomenon was noticed in the Coast Ranges by Willis[2] who states, "Some of the larger areas of deposition can not be explained

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1, Clements, T, "Geology of the southeast portion of the Tejon Quadrangle California", on file at Calif. Insti. of Tech. Library.
2, Willis, Robin, "Physiography of California Coast Ranges", Univ. of Calif. Publ. in Geol. Sci. Vol. 36, pp. 676, (1925).

A view up Bee Canyon showing a fault gap of the Bee Canyon fault in the distance.

Road cut showing Bee Canyon fault dipping north, notice wide zone of brecciation.

simply as depressed blocks, even though they are subsiding. These are irregular areas crossing structural lines, bounding the ends of ranges, into which many of the larger faults extend and where they apparently terminate beneath the blanket of sediments. The San Benito Valley is a good example, San Pablo Bay represents such an area which has subsided below sea level. The Los Angeles Basin is still another example. These may be areas of adjustment in which the horizontal components of movement on the great faults are taken up, as so many of these faults end in such areas".

The main deforming stress came somewhere from the south-west to produce a rotational strain in these rocks. Invariably the south side of the fault moved west which corresponds with the direction of movement of the San Andreas fault, although Noble[1] thinks that perhaps a reversal of movement has sometime occurred on this fault. He agrees however "that the San Gabriel mass south of the rift is compressed toward the rift from the south". Another generalization which can be made on the fault movement is that the north side is nearly always the upthrown block, the fault wedge being crowded up and away from the San Andreas fault by the shearing action developed along it.

Local:

In order to facilitate discussion the area will be arbitrarily divided up intoa number of structural blocks which will then be discussed separately. The block made up of basement-complex north of the Clearwater and Bouquet Canyon faults will be referred to as the Jupiter Mountain Block. Lying between the Clearwater and Bee

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1, Noble, L. F., "The San Andreas Rift in the Desert Region of Southwestern California". Carnegie Institution of Washington Year Book No.31, (1932).

Canyon Fault Zone is a wedge shaped mass of Tertiary sediments which will be termed the San Francisquito block, being cut in two by the river of that name. The large area of Pelona schist, making up a distinct topographic and structural unit, will be named the Sierra Pelona Block. It is bounded on the north by the Clearwater Fault and on the south by the Pelona fault. South of the Sierra Pelona Block is a low lying area of intermingled igneous and sedimentary rocks which can convelienthly be discussed as one unit. This will be designated the Mint Canyon Block, after the Canyon of that hame which runs through it.

Before entering on a discussion of the structure, it would probably be advisable to define a few commonly used terms which as yet have no definite connotation. The terms shear zone will be used where it is meant to refer to the gouged or brecciated zone lying between the foot and hanging walls of a fault. The expression fault zone will, however, be used to designate a series of adjacent parallel faults which are obviously related in time and origin.

Jupiter Mountain Block:

Only a very small portion of the Jupiter Mountain Block is on the area mapped, and so t e discussion of its structure will necessairly be rather brief. It is bounded on the north by the San Andreas Rift along which the block was vertically upheaved, with probably a good deal of horizontal displacement also. Several minor faults divide it up into smaller subdivisions. One of these, the San Francisquito Fault, runs along the west side of the upper part of San Francisquito Canyon, the stream in this part[1] of its course probably being subsequent. According to Simpson there is also a branch

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1, Simpson, E.C., "Geology and Mineral Deposits of the Elizabeth Lake Quadrangle, California", Calif. Jour. Mines and Geol. Vol. 30. No. 4. (1934).

of the Clearwater Fault which goes down Spunky Canyon to be terminated by the San Francisquito Fault. This block has the form of a long narrow triangular wedge whose apex is formed by the joining together of the Bouquet Canyon and San Andreas faults. It is a wedge shaped mass that has been shoved over the Pelona schist and Eocene sediments to the south along a high angle reverse fault.

San Francisquito Block :

The San Francisquito Block is also wedge shaped with its apex pointing towards the east, being bounded by three intersecting faults; i.e.,the Clearwater, Bee Canyon and San Francisquito Faults. The San Francisquito Fault is merely an off-shoot of the Bee Canyon Fault. This wedge is made up of two smaller wedges, the largest of which is composed of Paleocene sediments bounded by the Clearwater and Bee Canyon Faults. The smaller wedge consists of Tertiary sediments (Le Brun Formation) of indeterminate age and is bordered by the San Francisquito and Bee Canyon Faults.

The Clearwater Fault zone runs east-west in a nearly straight line and joins the San Andreas to the east. The more southerly fault of this zone is the master fault andn will be the one meant when the Clearwater Fault is mentioned. This fault has been the subject of much controversy. Nickell[1] thought the fault dipped 60° south and that the sediments were thrust over the igneous mass to the north. Clements[2] agreed with Nickell that the fault dipped south, although he admitted it dipped north in places; but, in the only structure section he drew

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1,Nickell,F.A., "The Geology of the Southwest Part of Elizabeth Lake Quadrangle between San Francisquito and Bouquet Canyon", On file at the Calif. Inst. of Tech. Library.

2,Clements, T., "Geology of the Southeast Portion of the Tejon Quadrangle, California", On file at the Calif. Inst. of Tech. Library

View of the Bouquet Canyon Reservoir. Notice the Clearwater Fault exposed is a wave cut cliff.

Looking north along the upper part of San Francisquito Canyon. San Francisquito fault is exposed on the left.

crossing this fault, he showed it dipping north at about 50°. However, he believed it to be a normal fault with the sediments on the down thrown block. Hill[1] represents it as a vertical fault in a cross section of the Bouquet Canyon Reservoir.

While mapping this fault, the writer collected conclusive evidence that the above fault is a reverse fault, dipping north at angles varying from 50° - 75°. At the head of Clearwater Canyon the fault surface is exposed in a road cut dipping 70° to the north. In San Francisquito Canyon the fault is again exposed in a road cut, in addition, the trace of the fault swinging up the canyon shows the angle to be 50° N. a shear zone in Cherry Canyon again shows the dip to be about 50° N; while near Cherry Creek dam in Bouquet Reservoir the sediments are found lying underneath the basement complex, the fault contact dipping approximately 50° north. The same situation is found on the east end of the lake where the waves have cut into an alluvial fan and exposed the fault plane underneath the alluvium.

In the Tejon Quadrangle Clements[2] found some Martinez sediments lying on the basement-complex north of the fault. By this means he was enabled to calculate the vertical displacement which he found to be 4000 feet. He also found that the Sespe formation was shifted two and one-half miles in a horizontal direction, the south side movingwest.Clements, however, thought the vertical and horizontal displacements took place in two different epochs of faulting, the former being Post-Martinez and the latter Post-Sespe and Pre-Modelo in age. The Modelo beds overlie the fault to the west and have apparently suffered no displacement. The fault evidently increases in dis-

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1, Hill, R.T., "Geology of Reservoir Sites", Part 11 of a Report of the Board of Consulting Engineers to the Board of Water and Power Commissioners of the City of Los Angeles, (1928)
2, Clements, T., Ibid.

placement towards the east, as the Martinez has been all stripped off the basement in this direction.

The zone of brecciation along this fault varies from 50-150 feet in thickness. On the north side of the fault a 100 foot band of white igneous rock is found bordering the fault for most of its extent. This rock has been brecciated by numerous shear zones running through it, which are parallel to the main fault. The rock has assumed a green color due to extensive epidotization. Under the microscope it can be seen that the hornblende has been converted largely to epidote and chlorite, while the feldspars have suffered from very strong sericitization. The sediments on the south side of the fault have been considerably mashed up, and where shale beds contact the fault, concretions are found which are highly polished by the movement of the matrix surrounding them. These concretions have also been faulted and recemented. In the Tejon Quadrangle hot springs are found along this fault.

The Bee Canyon Fault branches off the Clearwater Fault in the upper part pf Bouquet Canyon, crosses over into Bee Canyon, and finally runs out of the area along the north side of San Francisquito Canyon. Below the point where the San Francisquito fault branches off it, the Bee Canyon fault has brought the Le Brun Formation into contact with the Martinez. Nickell[1] believed that this was a depositional contact, and stated that a thin pencil of gouge which he found at the contact was due to readjustments between the two sedimentary series. Clements mapped this contact as a vertical fault in the Tejon Quadrangle. However, the writer was able to get a clear cut exposure of this fault in a roadcut, and found that it dipped 55° N.

1, Nickell, F.A., "The Geology of the Southwest Part of Elizabeth Lake Quadrangle between San Francisquito and Bouquet Canyon", On file at the Calif Inst. of Tech. Library.

The zone of brecciation was ten feet wide and there was not the slightest doubt as to its being a fault contact. Further to the west the dip is 75° N. Incidentally in this part of its extent, where it parallels San Francisquito Canyon it can be traced by a series of very excellent fault gaps. North of its juncture with the San Francisquito Fault, the dip of the Bee Canyon Fault also becomes steeper; so that at the head of Bee Canyon it dips 80° W. In the upper part of Bouquet Canyon the Fault is vertical as near as one can tell, and has a zone of gouge and brecciation 75 feet wide.

This fault like the Clearwater fault is a reverse fault, the Martinez having been thrust over the Le Brun formation and Pelona schist. In Bee Canyon Martinez sandstone beds were observed to dip over into the fault indicative of a reverse movement. Conglomerates beds paralleling the fault contain numerous sheared boulders. In most cases the shear plane in these boulders is perpendicular to the strike of the fault, and often it possesses a very low dip. According to Nevins[1] this would indicate a horizontal shearing stress along the strike of the fault which could easily be realized if strike-slip movement had taken place.

Along that part of the Bee Canyon Fault where Martinez sandstones and shales abutagainst the Pelona schist are often found thin slivers of an acidic plutonic rock which have been dragged up along the fault plane. These horses attain a thickness of 50 feet and where ever the fault surface is exposed can usually be seen. Spring deposits

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1, Nevins, C.M., "Principle of Structural Geology", pp. 90. (1931).

are found along this fault, usually in the form of mounds six or seven feet high and up to fifty long. These deposits are made up of calcareous tufa and banded travertine weathering to a grey color.

The San Francisquito Fault is exposed only in a few places in Bee Canyon, in San Francisquito Canyon it is covered with alluvium as far as the St. Francis Dam Site. In Bee Canyon a small parallel fault has dropped a thin slice of Martinez down inside the Le Brun formation. A thin sliver of Le Brun sandstone has also been dragged up along the shear zone of the San Francisquito Fault. At the dam site Ransome[1] found this fault dipping 30°-40° N. Farther south the Le Brun sediments are found thrust over Mint Canyon (upper Miocene) beds; thus, conclusively demonstrating the overthrust character of the movement along this fault.

No folding could be demonstrated in the Martinez formation, these sediments standing on end to form a homoclinal structure. A reversal of dip is quite common, but inasmuch as the dip is rarely less than 70°, this need not necessairly indicate a fold. The writer made a careful traverse across the strike of the formation and in no place were horizontal beds or any indication of a folded structure seen. It might be argued that the beds are folded isoclinally, but this would necessitate a repetition of key strata, particularly conglomerate beds, for which there is no evidence. Nickell[2] postulated an

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1, Ransome, F.L., "Geology of the St. Francis Dam Site", Econ. Geol. Vol. 23, pp. 553-363. (1928)
2, Nickell, F.A. "The Geology of the Southwest Part of Elizabeth Lake Quadrangle between San Francisquito and Bouquet Canyon", On file at the Calif. Inst. of Tech. Library.

Clearwater Fault exposed in a road cut.

Clearwater Fault exposed along the north side of Cherry Canyon. Notice the wide zone of brecciation.

anticlinal structure, as did Blake[1] in 1853; but as has already been mentioned under physiography, unless one is extremely careful an erroneous idea of the structure may easily be obtained due to the prevalent slumping and hill-side creep of the less competent strata.

The sandstone and shale members of this formation are bevelled off by both the Bee Canyon and Clearwater Faults. In particular a very persistant conglomerate bed is cut off by the Clearwater Fault. Hill[2] shows the Martinez cut off to the east by a cross fault running north-south, this is in the area now covered by the waters of the Bouquet Canyon Reservoir. That is utterly erroneous, however, since the Martinez is exposed far east of this supposed cross fault in a wave cut cliff.

The Le Brun Formation lies in a narrow wedge between two large compressional faults. As it is made up of soft incompetent shales and sandstones, a number of tight folds, most of them too small to map, and small thrust faults have originated in them Figure 1 illustrate antypical section of these sediments. The San Francisquito fault is just to the left of the section, accounting for the extreme defor-

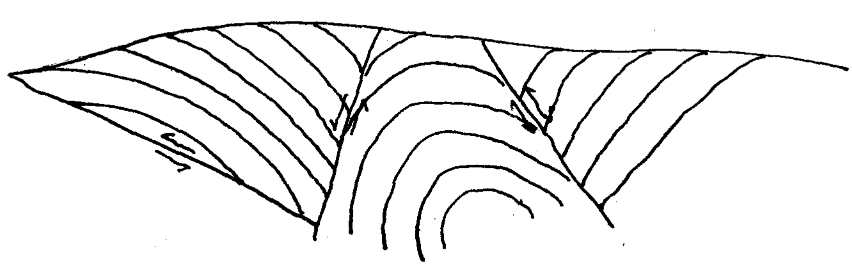

Figure #1

1, Blake, W.P., U.S. Pac. R.R. Expl., Vol. 5, pp. 55-60. (1853-1854).
2, Hill, R.T., "Geology of Reservoir Sites", Part 11 of a report of the Board of Consulting Engineers to the Board of Water and Power Commissioners of the City of Los Angeles, (1928).

Looking north at a section of the San Francisquito Fault, showing the Le Brun formation thrust over the the Pelona schist. View taken adjacent to Power House No. 2, below the St. Francis Dam Site.

View showing the trace of the San Francisquito Fault crossing the St. Francis Dam Site.

mation shown. An anticline is suggested by the arrangement of the dips and strikes, the axis of which seems to be roughly parallel with the faults on either side. This would suggest that it is genetically related to the faulting, and was caused by the compression generated between the two thrust faults. It is very hard to get at the true structure of this series of sediments, because of the severe contortion they have suffered, making attitude readings quite unreliable; and the fact that the strata are usually masked by loose debris and vegetation. In the Tejon quadrangle Clements[1] postulated a hypothetical structure made up of a series of very tight overturned folds. However, the section is much thicker in that area.

Sierra Pelona Block:

The Sierra Pelona Block is bounded on the north and west by the Clearwater, Bee Canyon, and San Francisquito Faults, and on the south by the Pelona Fault. The Pelona Fault is a vertical fault, although its dip may vary 10° either way. From Anaverde Valley to a point just west of where it crosses Mint Canyon, Pelona schist contacts plutonic rocks of intermediate composition along it. From here to a point just west of Bouquet Canyon igneous rock intrusive into the Pelona schist is faulted against the Vasquez Formation, and a short distance farther west the fault passes out into the Mint Canyon formation where it apparently dies out or is lapped over by the sediments. One of the faults in the Pelona Fault zone, which runs through the schist about one-half mile inside the Sierra Pelona block, crosses a depositional contact between the Mint Canyon sediments and the Pelona schist apparently without displacing the contact. This would make it Pre-Mint Canyon in age, but it is probably older than the main Pelona fault; for it shows signs of mineralization.

1, Clements, T., Ibid.

It has already been mentioned that the Pelona Fault Zone is cut by a transverse fault, itself truncated by terrace material which has been dissected 100 feet or more by streams. In view of this fact one can say with assurance that no recent faulting has taken place along these faults for quite some time.

The igneous intrusive has not been mapped before to the writers' knowledge. Hershey[1] said of the Pelona schist, "there are no granite intrusives and few igneous rocks of any kind." Simpson[2] mapped an igneous wedge in Texas Canyon, but he bounded it by faults; however, he did mention that there were evidences of contact metamorphic effect in the schist along the Pelona Fault. The intrusive nature of the contact between the schist and igneous rock can clearly be seen in road cuts and canyons.

There is a suggestion of an anticline in the Pelona schist, but this must be regarded as questionable because on a steep slope the true dip of the schist is often masked by slumping. Again, when a series of schists are standing almost on end a variation in dip of 10° or 15° either way is not always indicative of folding. Simpson maps an anticline in the schist further east, however, and Clements[3] also puts an anticline in the Pelona schist just west of San Francisquito Canyon. So it is proable that there is a sharp anticline running diagonally across the ridge from east to west.

Mint Canyon Block :

South of the Pelona Fault is a complex belt of faulting characterized by a large number of dovetailing slices and wedges of igneous

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1, Hershey, O.H., "Some Crystalline Rocks of Southern California," Amer. Geol. Vol. 29. No. 5, pp. 273-290. (1902).
2, Simpson, E.C., "Geology and Mineral Deposits of the Elizabeth Lake Quadrangle, California," Calif. Jour. Mines and Geol. Vol. 30. No. 4. (1934).
3, Clements, T., Ibid.

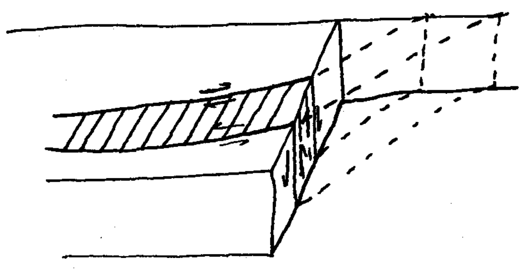
A slickensided surface of a fault in the Pelona Fault zone.

Looking west along the Pelona Fault.

and sedimentary rock. These are by all odds the most interesting and spectacular structures in the whole area. A generalized picture of this block would show a master fault trending east-west with a number of faults branching out feather-wise from it to run in a more southwesterly direction although still retaining a certain parallelism with the main fault. These branch faults are not simple fractures, but bifurcate to loop around long slim slices of both sediments and igneous rock intercalated between the fault surface. These are for the most part, however, made up of igneous rock which is greatly brecciated. The slices sometimes have a width of only 50 to 100 yards and attain a length of one to two miles. The most striking feature of these fault slices is that they are found one-half to three-quarters of a mile from the nearest igneous mass. Often there will be a whole series of parallel slices made up alternately of sediments and plutonics.

These horses were moved into place by both horizontal and vertical components of movement; the blocks being brought up from the basement by the bounding faults so that in effect they are small horsts, and at the same time they were pushed laterally along the fault away from the igneous rock mass of which they were once a part.

The faults in this block vary in dip from vertical to as low as 40° N, and some faults were observed which dipped 70° S.



sketch showing relative movement on faults bounding igneous horse.

Figure #2.

Slickensides and striations on the Pelona fault show that approximately 70% of the movement was horizontal the south block moving westward and downward. Horizontal movement is also indicated on many other faults in the block. The lowermost fault in Spring Canyon between the Vasquez formation and the basement complex shows almost horizontal mullion structure where it is exposed in a small tunnel. Incidentally spring waters have deposited Mg SO4 and NaHCo, in the shear zones of this fault. A great deal of iron oxide and some lead, copper and gold[1] is also found in the rock making up the shear zone.

The movement on the faults in this block has not been in the same relative direction, so that in effect the block is divided into a number of smaller horsts and grabens. These faults, are highangle and vary in dip from 40° to 90°. The faults where dips could be ascertained, all appear to be normal faults. Since the faults on the north side of the ridge are reverse faults it might seem anomalous to have compressional and tensional faults so close together which are apparently of the same age. However, this need occasion no difficulty; for Willis[2] states, "Normal or reverse faults or vertical faults of indeterminate character may result from horizontal displacement on major shear planes. If so, they are produced from compression". This fits into the picture very nicely; for as we have already mentioned, compression and horizontal shears have played a large role in the structural history of this region.

1, Personal communication from resident who had analysis made of material from shear zone.
2, Willis, Bailey, "Geologic Structures", (1934).

No folds could be mapped in the sediments, the chief reason being that faulting has so sliced the sediments up, no one block is large enough to contain a fold. There is a suggestion of a syncline in the southwest corner of the Mint Canyon sheet, but the faults are so numerous in this section that it is hard to be sure. The Vasquez beds dip off very steeply to the south for the most part, the Mint Canyon beds less so.

Economic Geology.

Gold.

Although the mineral resources of this area are relatively unimportant today, they are interesting from a historical point of view. De Mofras[1] records in his book of travels that a Frenchman, Charles Baric by name, first discovered gold in California in the vicinity of Newhall, in 1834. These placers were worked by the padres of the San Fernando Mission who discovered gold bearing gravels in almost all of the Canyons draining the San Gabriel Mountains. In 1850 placer mines wese being worked in San Francisquito, Texas and Mint Canyons, and, in 1880, 500 men were panning gold in these localities.

When the mature surface was developed during the second erosion cycle, the relief was rather low, anf the streams sliggish. As a result the rocks underlying the terrane suffered deep secular decay. Subsequent uplifts rejuvenated the streams enough so that this regolith was stripped off, and its gold content was then concentrated by stream action. Further small intermittant uplifts resorted the gravels and concentrated the gold still more; and today the richest deposits are found in the present stream beds.[2]

Placer Deposits:

The gold is found both in terrace gravels capping the interfluves between streams and in the present stream beds. It is mostly fine flaked gold, although nuggets as big as quarters are found occasionaly by prospectors. These deposits for the most part are only sporadically worked by itinerant prospectors, although in Texas Canyon there are two placer claims which have been worked for the last

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1, Mofras, Dufflet De, "Exploration of the Territories of Oregon and California, 1840,1841,1842", 2 vol.

2, Personal communication from J. Kapser.

20 years.

Cruzon Placer Mine. This mine is in Texas Canyon and is worked by W.H.Cruzon of Newhall. The gravels are on the north side of the canyon and belong to the earlier recent gravels, being found about 30 feet up the side of the canyon. The owner is also working a silver lode which he claims will run $15.00 per ton.

Bibl; Calif. State Mineralogists Report XX111,pp.292,(1927).

Texas Canyon Placer Mine. This mine is owned by John Kapser of Los Angeles and is located about two miles from the mouth of Texas Canyon. The early recent gravels are the ones worked and are found part way up the sides of the Canyon. A well put down by the owner is said to deliver over 200 gallons per minute.

Bibl: Calif. State Mineralogist's Report XX111, pp. 295, (1927).

Vein Deposits:

The Double Eagle Mine is just north of the east end of the Bouquet Reservoir. The gold occurs in a series of parallel quartz veins in quartz monzonite. These veins strike N 15° and have dips varying from 40°-65° NE. The ore runs from $8 to $10 a ton from surface workings with lower values deeper down. The mine is now idle.

Bibl: Calif. State Mineralogist's Reports xx111,pp.293, (1927). X111,pp.204; X11,pp.152; 1X,pp.195.

Graphite:

The Pelona schist series contains a large amount of graphite schist,some of it with a high graphite contact. Several claims have been staked out in San Francisquito Canyon on the more graphitic members of the schist, but no development work has yet been done on them. Graphite deposits also occur in the granitic rocks north of the area, and were formerly mined.

Bibl: U.S.G.S.Mineral Resources, pt.2,pp. 164-165, (1914). Calif. State Mineralogists Reports XV, pp. 502-504,(1915);XV11,pp. 138-139, (1920); XX111,pp. 325-326, (1927).

Building Stone:

Flagstones are mined at several localities in San Francisquito and Bouquet Canyons in the Pelona schist series. These schists are easily split up into slabs and are quite hard when fresh. These stones are mined in three quarries.

Bouquet Canyon Quarry. This quarry is located in Bouquet Canyon 11 miles northeast of Saugus. It is under lease from the U. S. Forest Service to Fry and Jacobs of Sherman, California.

Jones Quarry. This quarry is just north of the Bouquet Canyon Quarry and is leased to the Natural Rock Products Company, owned by H.H.Jones of Pasadena.

San Francisquito Canyon Quarry. These quarries are located near power plant #2 in San Francisquito Canyon are leased to C.J. Ely of Saugus, E.J. Griffith pf Pasadena, and N.H. McCready of Los Angeles.

Bibl: Calif. State Mineralogist's Report XX111,pp.331-332,(1927).

Talc:

Talc deposits are found in the Pelona schist occuring as metamorphosed dikes and sills. The talc is apple green in color, massive, and contains a great deal of actinolite in the form of long green prisms. This material probably represents the metamorphosed equivalent of basic lava sills, and dikes, and perhaps flows. The deposits are not at present being worked.

Historical Geology.

1, Deposition of clay, sand, and of minor amounts of limestone in a marine environment far from shore. Intrusion of basic lava into these sediments in the form of dikes, sills, and possibly flows.

2, Transformation of these clastics into schists and gneisses by load metamorphism in the mesozone of the earth's crust.

3, Close folding of the metamorphosed sediments.

4, Batholitic intrusion of monzonitic magma contemporaneous with the Sierra Nevadan Revolution. The lithologic facies of this batholith vary from dioritic to granitic. The old metamorphics were injected to form migmatites.

5, Profound erosion beveling off the roof of the batholith.

6, Deposition of 9000 feet of sand, clay, and some gravel in the Martinez sea which invaded this region.

7, Erosion and folding of the Eocene sediments.

8, Mountain building on a large scale, probably fault block mountains, and deposition of thousands of feet of coarse fanglomerates, sands, silts and muds in closed basins. Intrusion and extrusion of large amounts of basic lava.

9, Folding and faulting on a large scale followed by profound erosion.

10, Orogenic forces raise new mountains which again pour floods of continental detritus down into low lying basins of deposition. Volcanism is active and supplies volcanic ash which is intercalated in the sediments.

11, Intermittent faulting on a large scale which raised up the present mountains. The uplift took place in four distinct periods.

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