STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

GEOLOGY AND MINERAL DEPOSITS OF THE LAKE ELSINORE QUADRANGLE CALIFORNIA

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DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

STATE OF CALIFORNIA
GOODWIN J. KNIGHT, Governor

DEPARTMENT OF NATURAL RESOURCES
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FERRY BUILDING, SAN FRANCISCO 11
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GEOLOGY OF THE LAKE ELSINORE QUADRANGLE CALIFORNIA

By RENÉ ENGEL

and

MINERAL DEPOSITS OF LAKE ELSINORE QUADRANGLE CALIFORNIA

By RENÉ ENGEL, THOMAS E. GAY JR., and B. L. ROGERS

Price $2.50

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LETTER OF TRANSMITTAL

THE HONORABLE EDMUND G. BROWN
Governor of the State of California

DEAR SIR: I am transmitting herewith Bulletin 146, a book containing two papers: *Geology and Mineral Deposits of the Lake Elsinore Quadrangle, California,* prepared by René Engel, and *Mineral Deposits of Lake Elsinore Quadrangle, California,* by René Engel, Thomas E. Gay, Jr., and B. L. Rogers. The principal author, Dr. Engel, first began studying the geology of this area in detail in the 1920's; he has been working with it intermittently since then.

The second paper, which is primarily concerned with the economic mineral deposits of the area, was compiled by two staff members of the Division of Mines, Messrs. Gay and Rogers, working under the supervision of Dr. Engel.

Respectfully submitted,

DEWITT NELSON, *Director*
Department of Natural Resources
October 1, 1959

Frontispiece. View eastward of Lake Elsinore basin, from Ortega Highway (U.S. 74), about half a mile east of main divide summit, Santa Ana Mountains. The town of Willard is in the left foreground, the town of Elsinore on the east margin of the lake. Perris upland surface is in the middle distance on the left; Mount San Gorgonio on the skyline to the left; Mount San Jacinto on the skyline at center.
Photo by Mort D. Turner, January 1954.

GEOLOGY OF THE LAKE ELSINORE QUADRANGLE, CALIFORNIA

By René Engel *

OUTLINE OF REPORT

Illustrations

ABSTRACT

The Lake Elsinore quadrangle covers about 250 square miles and includes parts of the southwest margin of the Perris Block, the Elsinore trough, the southeastern end of the Santa Ana Mountains, and the Elsinore Mountains.

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* Consulting geologist-engineer. Manuscript submitted for publication December 1, 1955.

The oldest rocks consist of an assemblage of metamorphics of igneous effusive and sedimentary origin, probably, for the most part, of Triassic age. They are intruded by diorite and various hypabyssal rocks, then in turn by granitic rocks, which occupy over 40 percent of the area. Following this last igneous activity of probable Lower Cretaceous age, an extended period of sedimentation started with the deposition of the marine Upper Cretaceous Chico formation and continued during the Paloecene under alternating marine and continental conditions on the margins of the blocks. A marine regression towards the north, during the Neocene, accounts for the younger Tertiary strata in the region under consideration.

Outpouring of basalts to the southeast indicates that igneous activity was resumed toward the close of the Tertiary.

The fault zone, which characterizes the Elsinor trough, marks one of the major tectonic lines of southern California. It separates the upthrown and tilted block of the Santa Ana Mountains to the south from the Perris Block to the north.

Most of the faults are normal in type and nearly parallel to the general trend of the trough, or intersect each other at an acute angle. Vertical displacements generally exceed the horizontal ones and several periods of activity are recognized.

Tilting of Tertiary and older Quaternary sediments in the trough have produced broad synclinal structures which have been modified by subsequent faulting.

Five old surfaces of erosion are exposed on the highlands.

The mineral resources of the region are mainly high-grade clay deposits and mineral waters.

INTRODUCTION

The area investigated is situated in southern California between 33° 30′ and 33° 45′ north latitude and 117° 15′ and 117° 30′ west longitude. It comprises the Lake Elsinore topographic quadrangle, published by the U. S. Geological Survey and U. S. Army Corps of Engineers, and covers about 244 square miles.

This region was first mentioned in the geological literature in 1856, when J. B. Trask (1856, p. 19), noted ". . . the high mountain near the Coast, and on the east side of the bay of San Pedro, [is] known as the Santa Ana, deriving its name from the river which flows and discharges its waters into the sea at its base." Dr. Trask also wrote of the streams that yield gold in the vicinity of the Santa Ana Mountains and in the Temescal region.

Although none of the geologists associated with the exploration for a railroad to the Pacific Ocean investigated the region considered, the Santa Ana Mountains were mentioned on the geological map attached to W. P. Blake's report (1853, p. 137-138), and were described as a "range of hills probably of erupted rocks."

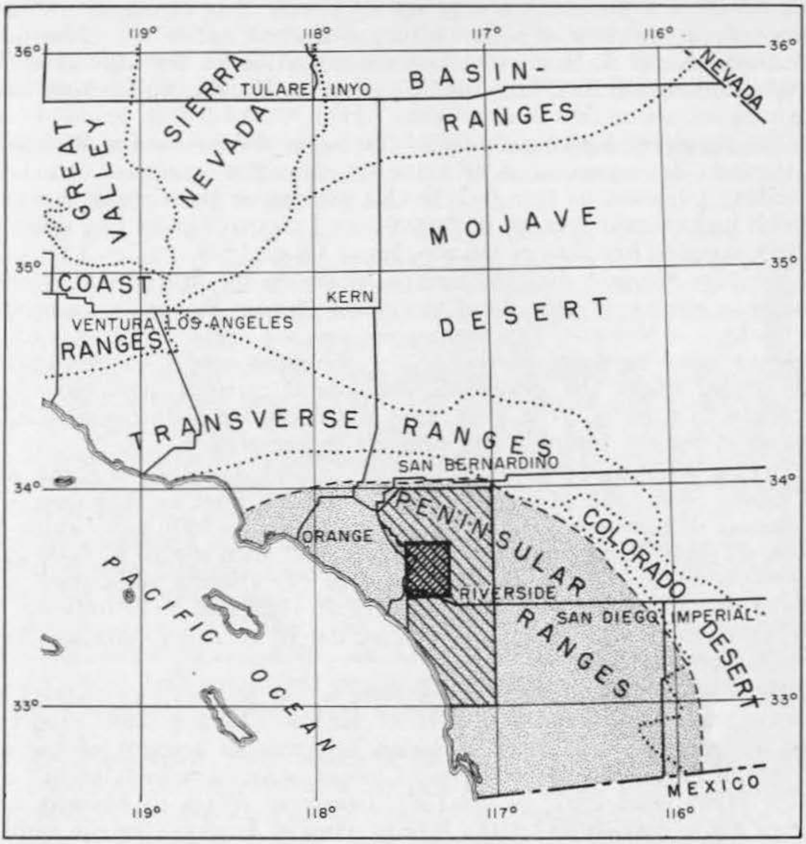

FIGURE 1. Index map of southern California showing location of the Lake Elsinore quadrangle and geomorphic provinces. Also shown are areas covered by recently published geologic maps: California Division of Mines Bulletin 170, Chapt. II, pl. 3, stippled; Bulletin 159, lined.

The first geological exploration in the Elsinore Valley and the Santa Ana Mountains was conducted by J. D. Whitney (1865, p. 175-181), assisted by W. H. Brewer. He described the Santa Ana Range as extending from San Jose Creek at the northwest end, for a distance of about 50 miles to the southwest, and merging with the ranges traversing the country to the north of the Santa Margarita River. In this definition of the Santa Ana Range a separate physiographic unit, the Puente Hills, is included. Today the northern extremity of the Santa Ana Mountains generally is placed at the canyon of the same name. The Whitney report also contains an account of the ascent of Santiago Peak and a description of the rocks encountered in Agua Fria Canyon along the spurs up to the summit. Dr. Whitney noted the presence of metamorphic rocks, tentatively dating them Cretaceous and partly Tertiary in age.

The expression "Temescal Range" was used in the Whitney report to define the hills lying on the northeast side of the Elsinore Valley. The range was described as follows: "The Temescal range of mountains commences on the south side of the Santa Ana River, and runs southeast in a direction nearly parallel with that chain of the same name, from which it is separated by a narrow valley . . . The name Temescal seems to be limited in its application to the hills lying between the Santa Ana and the San Jacinto Creeks, and which cover an area of about 300 square miles."

The porphyry forming a part of this range did not escape Whitney's attention; he compared it to "the fine Swedish varieties" used for building purposes in Europe. He also mentioned the Cajalco tin mine which had created a boom in 1860-61, and stated that he had collected many samples, but that no tin was found by analysis.

Whitney thought that the granite of the Santa Ana Mountains was the same age as the granite of the Santa Monica Mountains, assigning it to the post-Miocene. This assignment was not made, however, without reserve, since he wrote further ". . . We must expect, in this part of the state, where the geological changes of various ages have been brought to a focus, as it were, that the resulting phenomena shall be found extremely complex and difficult to decipher."

Brewer's letters (1861-64, edit. 1930, p. 35) describe his climb with Whitney to the top of Santiago Peak, and his work in that area. The elevation of Santiago Peak is shown by Brewer as 5675 feet, which for such an early survey agrees remarkably well with the U. S. Geological Survey's 5680 feet elevation as given on the Corona quadrangle surveyed in 1894-99. More recent surveys of 1935 and 1939 indicate the elevation to be 5696 feet, as shown on the U. S. Army Santiago Peak quadrangle of 1943.

The Elsinore district is first discussed in the publications of the California State Mining Bureau in H. G. Hanks' (1884, p. 269) report on the minerals of California, in which he gives an account of the discovery of coal at the McIntosh and Cheney mine, now the Alberhill coal mine (Goodyear, 1887, p. 174-176). Goodyear refers to Elsinore as a "new town," writing that the former name of Laguna, for the railway station 2 miles distant, had been changed to conform to that of the town.

H. W. Fairbanks (1893, p. 76-120) made an extensive reconnaissance through San Diego and Orange Counties and explored a large part of the Santa Ana Mountains. His work is referred to frequently in the present report.

The map of California by J. P. Smith (1916) covers the Santa Ana Mountains and Elsinore regions in a general way and was the first map to show the distribution of Triassic, Cretaceous, and Eocene strata, and the areas occupied by plutonic rocks. The present geological work, while modifying these contacts and introducing new ones, does not fundamentally change this early representation of a core of Triassic strata intruded by plutonic rock and surrounded by younger formations.

In a study of the ground waters of the Elsinore and Temescal areas G. A. Waring (1919, p. 69-81) briefly described some of the geological features related to the hydrography of these basins. The geological map, which is attached to Waring's report, covers the San Jacinto and Temecula basins, and distinguishes the water-bearing strata from the non-water-bearing clay beds and rocks of the igneous and metamorphic complex. Waring, however, did not subdivide the complex.

Although it did not cover any part of the Elsinore region, the geological study and mapping of the northern end of the Santa Ana Mountains by Roy E. Dickerson (1914b, p. 257-274) were the first detailed work in that nearby area.

Likewise the work of W. English (1926) covers part of the same area previously mapped by Dickerson in the Corona quadrangle, but does not extend into the Elsinore region.

In the area to the south and southwest of the Elsinore region, A. O. Woodford (1925, p. 154-280) touched upon the broad aspects of the petrology of the Santa Ana Mountains as part of the Eastern Bedrock complex, and distinguished this complex from the Western Bedrock complex or Catalina metamorphic facies.

The writer's study of the Lake Elsinore quadrangle and adjacent areas began in the summer of 1926, and continued intermittently until 1934. Progress reports were presented in 1928 and 1932 before the Cordilleran Section of the Geological Society of America. In 1933 the work formed the basis of a thesis submitted to the California Institute of Technology.

In the meantime other investigators worked in the same region and published their findings. Dudley (1935, p. 487-506) studied the western portion of the Perris Block which includes about 30 square miles in the northeast corner of the Lake Elsinore quadrangle. Larsen (1948) began an investigation of the southern California batholith in 1906, and by 1938 had completed mapping the batholith in the Corona, Elsinore, and San Luis Rey quadrangles.

Acknowledgments. The study of the Lake Elsinore quadrangle was undertaken at the suggestion of the late Dr. John P. Buwalda, former Chairman of the Division of the Geological Sciences of the California Institute of Technology. The writer is indebted to him for many suggestions. Dr. Willis P. Popenoe, then at the Institute, now Professor of Paleontology at the University of California at Los Angeles, kindly cooperated in the study of Triassic and Eocene fossils.

To Dr. George H. Anderson and Dr. Hampton Smith, former graduate students of the California Institute of Technology, the writer is indebted for aid in photographic and laboratory work.

The writer wishes to acknowledge the assistance in field work of Mr. Edward Joujon-Roche, for a few weeks in the summer of 1928 and of Dr. Maurice G. Donnelly, for a month in the summer of 1931; both are former students at California Institute of Technology. Mr. Leo K. Kroonen, Jr., of Corona, aided in the collection of fossils and his help is hereby acknowledged with appreciation.

The courteous cooperation received at all times from the various officials of the United States Forest Service of the Cleveland National Forest, and in particular Chief Ranger Joseph Munhall, was of great assistance.

To Messrs. B. M. Burchfiel of the Elsinore Clay Co., and Charles F. Biddle, M. L. Vincent, and Harvey Gardner of the Alberhill Coal and Clay Company, the writer is indebted for data pertaining to the clay deposits of the Alberhill region. For allowing the writer to work on their properties, acknowledgment is made to Pacific Clay Products, to

Gladding McBean and Company, and to the Los Angeles Brick and Clay Products Company.

For their help and cooperation in completing this report the writer takes particular pleasure in thanking the California Division of Mines and in particular Dr. Lauren A. Wright, Thomas E. Gay Jr., B. L. Rogers, and Mort D. Turner.

To many of the land owners and residents of the Elsinore region the writer is indebted also for their courtesy and cooperation.

Topography and Drainage. The area investigated contains parts of two mountain chains—one to the southwest, the other to the northeast—with a valley between them. These form the northwestern extremity of the Peninsular Ranges.

The Peninsular Ranges province was defined by W. P. Blake (1853, p. 137-138) as the highlands that separate the Colorado Desert and the Gulf of California from the Pacific Ocean and extend in a southeasterly direction from San Gorgonio Pass and the Santa Ana River to Cape San Lucas in Baja California. Subsequently, the term Peninsular Ranges was adopted by Newberry, Orcutt, Fairbanks, and many other authors.

The mountains to the southwest include the Santa Ana Mountains, which culminate in Santiago Peak (elevation 5696 feet), and the Elsinore Mountains (maximum elevation 3456 feet) which merge to the south into the high plateau of the Santa Rosa region.

To the northeast the Temescal Mountains form the southwestern edge of a broad plateau area, modified by medium relief forms, which now is known as the "Perris Block." This name is derived from the town of Perris, near the center of the Elsinore quadrangle. The term "Temescal Range" was first applied by J. D. Whitney (1865, p. 178) to the mountains that extend from the Santa Ana River to San Jacinto Creek. Under this definition are included Arlington Mountain (elevation 1851 feet), Estelle Mountain (elevation 2826 feet), and the hills immediately east of Elsinore (maximum elevation 1945 feet). The writer here proposes to include in the Temescal Mountains the hills that extend to the southeast and form the natural continuation of the mountains.

The Temescal Mountains are thus distinguished from the Santa Ana Mountains. The name Temescal is not used on any maps that were consulted by the writer, in spite of the fact that they were known to have been early defined by Whitney.

Between these two chains lies the Elsinore trough, formed by two major valleys which trend northwestward, joining in the vicinity of Lake Elsinore. Elsinore Valley proper extends in a northwest direction from Lake Elsinore to the Santa Ana River. A low divide southeast of Lake Elsinore, nearly three-quarters of a mile northwest of the town of Wildomar, separates the Elsinore Valley proper from Murrieta Valley which is the southeastern extension of the trough. Murrieta Valley is named after Murrieta Creek, a tributary of the Temecula River which it joins about a mile and a half south of the town of Temecula to form the Santa Margarita River.

The two main trunk streams in the Lake Elsinore quadrangle are Temescal Creek and Murrieta Creek. Temescal Creek collects all the drainage from the northeast slopes of the Santa Ana Mountains and from the southwest slopes of the Temescal Mountains. It receives the overflow waters of Lake Elsinore during periods of high waters, and thus serves as a channel of access for the waters of the San Jacinto basin into the Pacific Ocean by way of the Santa Ana River. The San Jacinto basin forms a large part of the Perris Block and is drained by the San Jacinto River, which flows into Lake Elsinore about a mile and a half south of the town of Elsinore.

The broad valley floor of the Elsinore trough ranges in width from less than half a mile to nearly 4 miles, and is dotted by a series of hills that trend mostly parallel to the general orientation of the trough. The hills are from a few tens of feet to about 500 feet above the mean elevation of the valley floor.

Hills that trend transverse to the trough are prominent in the part of the trough that lies northwest of the lake.

Climate and Vegetation. The climate of the Lake Elsinore quadrangle ranges from temperate sub-tropical to temperate, as defined by R. D. Salisbury (1919, p. 604-606, 611). Temperate sub-tropical climate prevails in the southwestern part of the quadrangle where the Peninsular Ranges are directly exposed to the ocean winds laden with moisture. Temperate climate characterizes the northeastern slope of the Santa Ana-Elsinore Mountains, the Elsinore trough, and the Perris Block.

The temperature variation in the coastal region is less marked than in the inland region. The maximum temperature range is 49° C in the first and 60° C in the second.

*Table 1: Climatological data for Elsinore and several nearby localities **

	Coastal region				Inland region			
	Los Angeles		Tustin		Elsinore		San Jacinto	
Temperature	°F	°C	°F	°C	°F	°C	°F	°C
Average maximum	72.9	22.5	75.0	24.0	80.6	27.0	79.9	26.5
Average minimum	52.6	11.5	48.5	9.0	46.2	8.0	45.8	7.5
Average annual	62.7	17.0	61.7	16.5	63.5	17.5	62.3	17.0
Highest	109.0	43.0	111.0	44.0	116.0	47.0	115.0	46.0
Lowest	28.0	-2.0	23.0	-5.0	17.0	-9.0	7.0	-14.0
Rainfall								
Average annual precipitation, inches:	14.95		12.69		12.80		13.14	
Clear days								
Average number annually	157		----		243		236	

* Data compiled after Weather Bureau 1932; Lynch 1931, pp. 22-25; and Waring 1919, p. 13.

The humidity of the coastal region greatly exceeds that of the inland region, where fogs are rare. In early spring and toward fall one can see the fog driven by wind from the ocean, climbing the western slope of the Santa Ana Mountains to the crest where it resolves into a mist.

The greater humidity in the southwestern part of the area helps to sustain a more luxuriant vegetation than may be seen in the northeastern part where the low precipitation and higher temperature during the summer usually prevail. Conifers grow on the southwestern slopes of the Santa Ana Mountains, and locally on some of the northeastern slopes near the crest of the range, but are absent in the Elsinore trough and on the Perris Block. Otherwise the difference in the vegetation in the two areas is mostly a matter of quantity, as the species are similar.

The slopes of the Santa Ana Mountains support a dense growth of chaparral consisting mostly of scattered manzanita, cacti, and sage which increases the difficulty of geological work. Live oaks and walnuts grow in the mountain and plateau regions to the southwest, and occasionally in sheltered places to the northeast; sycamores and cottonwoods line the streams.

Grasses, suitable for grazing, grow in the high plateaus and also in the most humid parts of the lowlands lying in the northeast portion of the area.

Communications and Industries. The principal town of this area, Elsinore, is about 70 miles by road from Los Angeles and may be reached by an excellent system of highways. A branch of the Atchison, Topeka, and Santa Fe Railroad connects Elsinore with Corona, where it joins the main line from Los Angeles to eastern points. Ample transportation is thus available, contributing to the development of the economic resources.

Agriculture—chiefly farming, fruit-growing and cattle-raising—is the main industry. Two of the largest ranches of southern California, the Rancho Santa Margarita and the Rancho Santa Rosa of the Vail Company, use extensive land holdings for grazing and farming. Clay mining and the manufacture of ceramic products are other major economic activities of the region.

The tourist trade also is important in the commercial life of this district, particularly around Lake Elsinore, a natural water playground except during low-water cycles. Visitors are also attracted by the mineral waters of Elsinore, Glen-Ivy, Murrieta, and San Juan Hot Springs.

STRATIGRAPHY AND PETROLOGY

The Lake Elsinore quadrangle contains a section of varied rock types that includes an assemblage of mildly to moderately metamorphosed rocks of sedimentary and igneous origin, intruded by a series of plutonic and hypabyssal rocks. These collectively constitute a group of rock units that has been called the "basement complex." The younger sediments deposited on this complex and Pleistocene basalt complete the stratigraphic sequence.

The oldest determined rocks in the quadrangle are of Triassic age. No sedimentary rocks of Jurassic age have been found. During this period, sedimentation apparently was superseded by igneous activity which extended into Cretaceous time.

Upper Cretaceous and Eocene strata were deposited on the metamorphic and igneous assemblages. The latter part of the Tertiary record is missing in the Lake Elsinore quadrangle, although to the northwest and southeast Miocene and Pliocene strata are found.

The upper Pliocene, Pleistocene, and Recent records are preserved as various poorly consolidated, unfossiliferous deposits.

Metamorphic Rocks

The metamorphic rocks consist of rocks of undoubted sedimentary origin, correlative with the Santa Ana formation of Upper (?) Triassic

Table 2. Sedimentary, metamorphic, and igneous rocks of the Lake Elsinore quadrangle.

Age	Formation	Approximate maximum thickness (feet)	Percent of total area
Recent	Alluvium silts and sands	200	8.5
	Unconformity		
Pleistocene	Younger fanglomerate and terrace deposits (untilted)	100+	4.6
	Unconformity		
Lower Pleistocene or older	Older fanglomerate (tilted) sandstone, siltstone, tuffs	250+	1.0
	Basalt	520	1.6
	Unconformity		
Paleocene	Martinez formation marine fossiliferous limestone and sandstone; continental clay shales, sandstone and lignitic coal	1,500	0.8
	Unconformity		
Upper Cretaceous	Chico formation conglomerate and sandstone	3,000+	1.0
	Unconformity		
Lower (?) Cretaceous	Aplite, pegmatite and some basic dikes		0.2
	Quartz monzonite		0.2
	Granodiorite		36.0
	Quartz diorite		4.5
Upper (?) Jurassic	Dacite porphyry		1.0
	Andesite and andesite porphyry		6.5
	Quartz latite porphyry		2.0
Lower (?) Jurassic	Diorite and gabbro		6.0
Upper (?) Triassic	Santa Ana formation meta-volcanic rocks (meta-andesite flows and intrusions); meta-sedimentary rocks (shales, slates and phyllites; sandstone; conglomerate and limestone lenses)	25,000 ±	26.0
Pre-Triassic (?)	Metamorphic rocks (rocks of undetermined age and origin, mapped with Santa Ana formation)		

age, including the Bedford Canyon formation (Larsen, 1948, p. 18-22); and of rocks of igneous origin, extrusive and hypabyssal, including the Santiago Peak volcanics (Larsen, 1948, p. 22-36). Some rocks are so altered that their nature cannot be ascertained; some are contact rocks produced by the action of the later intrusives upon the sedimentary and earlier igneous rocks. In order to simplify the geologic map, the contact rocks have been included in the Santa Ana formation.

Upper (?) Triassic Santa Ana Formation

The rocks to which the name "Santa Ana formation" is applied form a broad band, 2 to 3 miles wide, that traverses the northern part of the area from Railroad Canyon westward to the Clevelin Hills,* northwest of Elsinore. Although the band disappears under the alluvium at the end of Lake Elsinore, it is exposed without interruption from a point near Leach Canyon westward toward Los Pinos Peak and Trabuco Canyon. The same band extends westward for about 3 miles into the Corona quadrangle where it joins the main mass of Triassic rocks exposed in the Santa Ana Mountains.

North of this band the Santa Ana formation is exposed in a few scattered areas, the largest of which is about 2 miles square. These occurrences are separated from the main body by various intrusives and by faulting.

To the south a few isolated masses of this formation are enclosed by granodiorite; to the southeast in the Santa Rosa region a few rec-

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* The name Clevelin Hills has been applied to the range of low hills about a mile wide and 4 miles long, extending northwestward from Elsinore on the northeast side of the Glen Ivy fault.

ognizable patches of these older sedimentary rocks are associated with undifferentiated metamorphic rocks, that are mostly of igneous origin.

To the southwest a band of these sedimentary metamorphic rocks extends northwest from Tenaja Canyon to San Juan Canyon, a distance of about 7 miles. In the Lake Elsinore quadrangle these rocks occupy an area of about 64 square miles or about 25 percent of the total area.

The Triassic rocks were intruded by diorite, andesite, dacite porphyry, or quartz latite porphyry in the northern part of the area, and by the quartz diorite and granodiorite. Contacts between Cretaceous sedimentary rocks and the Triassic metasedimentary rocks do not exist in the Lake Elsinore quadrangle, but in the Corona quadrangle to the west are excellent exposures of the unconformity between the Cretaceous and Triassic sediments.

Petrology. The most abundant rock types in this formation are slate and phyllite. As the phyllite is the more abundant, sandy clay and silt apparently predominated over shale in the original sedimentary rock.

Next in abundance is quartzite, few beds of which are pure. Most of them appear to be derived from arkosic sandstone. In the field they commonly resemble metamorphosed felsite or the silicified rocks found in the vicinity of intrusive contacts.

The slate and most of the quartzite, where unaltered, are colored black by organic matter. They ordinarily can be distinguished by differences in their degree of fissility.

Most of the quartzite weathers more reddish than the slate as it contains a high proportion of iron. The arkosic sandstones or quartzites weather buff and reddish and show pitted surfaces due to the alteration of the feldspar and femic minerals. The pure quartzites are white to purplish gray.

A microscopic study of these rocks revealed that even the purest clay shales or slates contain a high proportion of quartz in small grains, in a matrix of clay minerals, sericite, and a few minute grains of feldspar. Feldspar is common in slates spotted with blebs of andalusite or sillimanite.

Many of these rocks are cemented by quartz. Silicification is one of the most common phenomena related to the contact metamorphism of these sediments, particularly by granodiorite.

Crossbedding in the slates and quartzites were observed at several places, particularly in the Potrero de Los Pinos region, but for distances that are too short to permit a determination of the length of the foreset beds. They appear to fan out irregularly, however, and to resemble cross-laminations produced in alluvial fans and deltas of subaqueous origin.

A few patches of conglomerate and sedimentary breccia commonly grade into the arkosic sandstones. The clasts range in size from granule to pebble, rarely exceeding 1-$\frac{1}{4}$ inches (32 mm) in diameter, are well-rounded to subangular. The fragmental constituents in order of decreasing abundance are quartzite, slate, and igneous rocks of which diabase and a red porphyry predominate. The source of the red porphyry is unknown. The grains of the breccia are smaller and subangular to angular in shape, in general of the same composition as those of the conglomerate, but more of them are quartz. Both rocks are a grayish brown color and weather to buff and rusty tints.

Locally interspersed in the slates are patches and lenses of limestone. Where fresh they are blue-black, rather dense, and fine-grained. They weather to a light buff cream. Where silicified, they are also black, but very hard and flinty. Near intrusive contacts they ordinarily have crystallized into grayish white marbles locally banded with biotite.

Some limestone lenses just west of the Lake Elsinore quadrangle show little alteration and contain fossils. In the mapped area, small limestone patches with indistinct boundaries were found in sections 13 and 14, T. 5 S., R. 5 W., near the margins of a body of quartz latite porphyry. Another lens, highly silicified, was found in section 25. In section 28, T. 5 S., R. 4 W., at about the same stratigraphic position as the occurrence in section 25, an elongated lens of limestone, approximately 1500 feet long and 70 feet thick is interbedded with slates. The limestone body in section 28 also is crystalline and silicified, and, in addition has tremolite developed at its contact with an aplite dike. On the north side of McVicker Canyon in section 33, T. 5 S., R. 5 W., S.B., a small lens of marble occurs near the contact of Triassic metasedimentary rocks with the granite. Near the Old Dominion mine in section 7, T. 6 S., R. 5 W., a small body of micaceous marble lies near the contact of the metasedimentary rocks and dacite. No limestone was found in the southern part of the district.

FIGURE 2. Index map showing fossil-collecting localities in the vicinity of Lake Elsinore quadrangle.

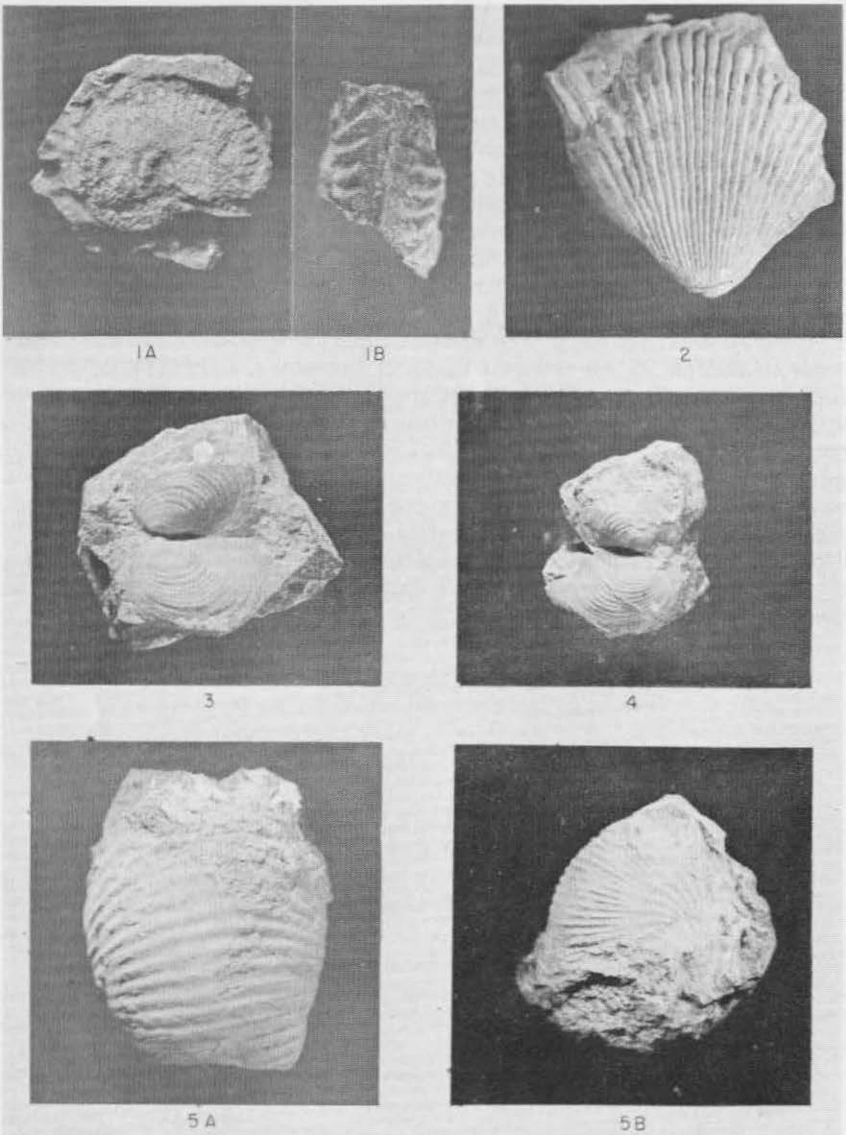

FIGURE 3. Fossils collected from localities C-3 and C-4. 1A, *Discotropite* (?), Upper Triassic, from locality C-4, side view. 1B, same as 1A, front view. 2, *Halorella rosittana* Bittner, Upper Triassic, locality C-3. 3, *Daonella sanctaeanae* Smith, Upper Triassic, locality C-4. 4, Same as 3. 5A, *Juvavite* (?), Upper Triassic, locality C-4, front view. 5B, same as 5A, side view.

Schist and gneiss are developed only locally, and apparently are produced as contact metamorphic and dynamic effects near intrusive rock masses. Gneissic and schistose rocks are particularly well developed along sinuous contacts that show marked embayments of quartz diorite and granodiorite in the Triassic rocks. This is well shown in the northeastern part of the area. Although true schist is rare, the slate and shale generally show development of mica and chlorite and are moderately schistose. They can properly be designated as phyllites. Small patches of graphite and sericite schists included in the slates are in Railroad Canyon, in the extreme northeast end of the area, not far from dioritic intrusions to the east.

Some of the quartzite is spotted. The spots of one typical specimen were found to contain an assemblage of quartz, plagioclase, and partly altered cordierite. Close proximity of these spotted rocks to an igneous rock mass suggests that they were formed by contact metamorphism of impure sandstones.

Dense flint-like black layers that resemble chert are intercalated in the slate. Microscopic examination indicates that they have the mineralogical composition of slate, but have been highly silicified.

Silicification also is exhibited in several specimens of breccias in which the fragments of slate and other rocks are entirely separated by a secondary quartz matrix.

In places, at the contact between granitic rocks and the Triassic sediments, hornfels is produced by the fusion of sandstone or shale into dark-colored glass in which remnants of unfused material are enclosed.

In summary, the Triassic sedimentary rocks have been affected first, by a mild dynamothermal metamorphism associated with deep burial and folding; and second, by contact metamorphism related to igneous intrusion. The first type of metamorphism produced mostly recrystallization and a partial alignment of the minerals, thus developing phyllite and quartzite. These effects correspond to those of the metamorphic epizone described by Grubenmann and Niggli (1924, p. 394-413). The second has produced locally such minerals as cordierite, sillimanite, andalusite, staurolite, tremolite, and biotite and has been accompanied by intense silicification. These effects increase with the proximity to the contact of the metamorphic rocks and the intrusives, especially quartz diorite and granodiorite.

Structural Relations. The major structural feature of the Triassic rocks in the belt that traverses the northern half of the Lake Elsinore

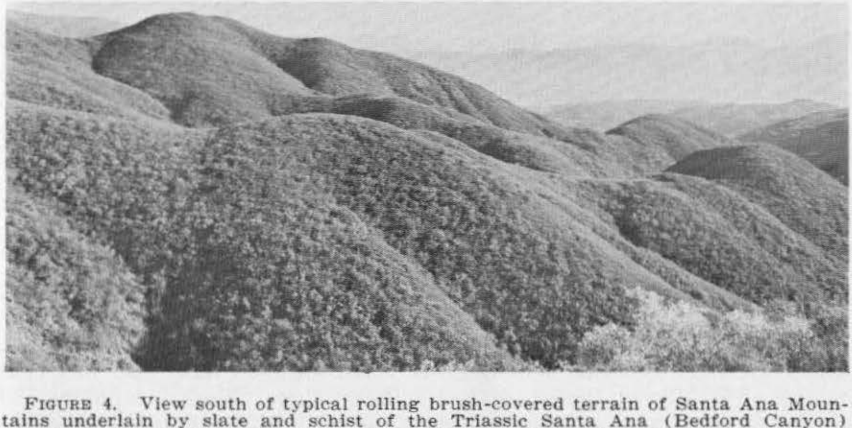

FIGURE 4. View south of typical rolling brush-covered terrain of Santa Ana Mountains underlain by slate and schist of the Triassic Santa Ana (Bedford Canyon) formation. View from Main Divide truck trail, about 1½ miles northwest of Ortega Highway (U.S. 74). *Photo by Mort D. Turner, 1954.*

quadrangle in a monocline that extends from the mouth of Trabuco Canyon on the west margin of the area to the vicinity of the Good Hope mine to the northeast. It strikes N. 45° W., and dips 51° NE., and shows subordinate folding and faulting. In Los Pinos Peak region the beds are folded into a syncline and anticline whose axes are about 2 miles apart.

Flow and fracture cleavages associated with jointing are common in the slate and phyllite. Several joint sets were studied in detail; in each, the strike and dip of slate or flow cleavage proved to be parallel with the bedding plane. On the other hand, fracture cleavage is divergent, as observed in quartzite at a few localities. In the southeastern part of the area near Mesa de Colorado, the quartzite beds exhibit a fracture cleavage that strikes N. 62° E., and dips 70° SE., whereas the bedding strikes N. 40° E., and dips 35° NW.

Thickness. The greatest thickness of undisturbed Triassic sediments in the area was measured northeast of Lake Elsinore, between the North Elsinore fault and the north end of Railroad Canyon, where unfaulted beds that dip 50° NE. exceed 28,000 feet in thickness. Although about 6,000 feet of this extends beyond the area mapped, the entire Triassic section could not be measured as it extends beneath the alluvium of the San Jacinto River flood plain.

On the southwest side of the trough, from the mouth of Trabuco Canyon, in the Corona quadrangle, to Los Pinos synclinal axis, the thickness of the Santa Ana formation on the west limb of the syncline is 19,000 feet or more. In the Lake Elsinore quadrangle the measurable thickness on the east limb of Los Pinos anticline is only 8,600 feet.

Since the northeast section appears structurally to be the downthrown portion of the east limb of Los Pinos anticline, the total thickness of the Santa Ana formation might well reach 36,600 feet. However, the relation between the northeast and southwest sections could not be ascertained on account of the discontinuity of outcrops due to faulting and the lack of a well defined key bed. Similar conglomerate and limestone beds found on both sides of the Elsinore trough suggest a repetition of strata produced by faulting, but without furnishing precise data as to the amount.

Age and Correlation. The first fossils to be found in the Santa Ana Mountains were reported by Fairbanks (1893, p. 109). During an exploration of the eastern flank of these mountains, he followed Coldwater Canyon near Temescal up to the divide at the head of the canyon, and in climbing along a ridge leading up to the summit north of the canyon discovered impressions of a small unidentified bivalve shell.

In a tributary to Silverado Canyon (probably Ladd Canyon), on the southwest slope of the Santa Ana Mountains, he found specimens of a bivalve shell and faint traces of corals and univalve shells.

About 1905-08, W. C. Mendenhall of the U. S. Geological Survey, in the course of his studies of the water resources of southern California, examined the southwest slope of the Santa Ana Mountains, and collected fossils in the slates of Ladd Canyon, and also near the mouth of Bedford Canyon on the northeast slope. These were identified by Dr. Stanton of the U. S. Geological Survey (Willis, 1912, p. 505-506) as *Rhynchonella, Spiriferina, Terebratula,* and fragments of crinoid stems. These were believed by Stanton to clearly indicate the Triassic age of the fauna. He suggested that it was probably Upper Triassic, but stated that the absence of ammonites and other diagnostic forms precluded a more precise determination.

Some of the fossils collected by Fairbanks in Ladd Canyon eventually were studied by J. P. Smith (1914, p. 19, 145) who recognized the genus *Daonella* and described a new species, *Daonella sanctaeanae*. This pelecypod was associated with an undetermined species of *Rhynchonella* and a rough-shelled ammonite which also could not be definitely determined. Smith (1914, p. 19) assigned this assemblage to the lower middle Triassic.

None of the workers noted above clearly described the fossil localities. In 1928, the writer, accompanied by B. N. Moore, then a graduate student in geology at the California Institute of Technology, searched carefully for fossils in the various outcrops exposed in the central and east branches of Ladd Canyon (Corona quadrangle) and on the ridges between Bedford and Ladd Canyons. Only a few undeterminable casts were found.

In the winter of 1930-31, Leo Kroonen Jr. found determinable fossils in limestone on his property in the east branch of Ladd Canyon, in SE¼SE¼ sec. 34, T. 4 S., R. 7 W., S.B. This limestone occurs as resistant lenses in a thick series of sandstone, shale, and conglomerate, and crops out on the west slope of the canyon about 200 feet above the bottom of the stream. The limestone is fine grained, is cut by numerous veinlets of secondary calcite, and is partly silicified.

This locality yielded a fair assemblage, but only the following genera and species were recognized:

Daonella sanctaeanae Smith
Discotropite sp.
Juvavite (?) sp.

The first of these, a pelecypod, was identified by means of the figures and description given by J. P. Smith. The last two are ammonites and belong to the Tropitoidae. The *Discotropite* specimens, in spite of their fragmentary nature, show the flattening of the sides, the high keel and the ornamentation in the sickle-shaped ribs, that characterize this genus as described by Hyatt and Smith (1927, p. 38-42). S. W. Muller (1933) has suggested that the genus *Halorella* might also be present.

The identification of the genus *Juvavite*, still is conjectural and based upon analogies with the plates shown by Smith (1927, p. 54) and Diener (1925, p. 63-65). These specimens have rather compressed, convex sides and rounded venter, and dichotomous ribs that extend continuously around the venter.

The presence of *Discotropite* and another *Tropite* in this fossil assemblage indicates conclusively an Upper Triassic age, as the Tropite group did not appear before Upper Triassic time. These fossils apparently were collected from the locality described by Fairbanks in 1893.

The Upper Triassic designation does not agree with the assignment by J. P. Smith of *Doanella sanctaeanae* to the lower Middle Triassic, but Smith states that this pelecypod was associated with a ". . . . rough-shelled ammonite not definitely determinable." Moreover Smith (1914) indicates *Doanella* as extending to the lower Upper Triassic.

Another fossil locality lies south of Bedford Canyon on the second spur that leads to the summit of the range, in the SW¼ NW¼ sec. 29, T. 4 S., R. 6 W., S.B. The fossils are enclosed in a small lens of black limestone that weathers to a light-gray buff color. They are all brachiopods, and have been tentatively identified as belonging to the genera *Halorella* and *Rhynchonella* (?). These fossils were found at a stratigraphic position about 15,000 feet above the limestone bed on the Kroonen Ranch. *Halorella* is considered by Haug (1922, p. 852) to be a characteristic Triassic genus.

Stanton's Upper Triassic designation coupled with the recognition of an Upper Triassic assemblage in the lower bed, permits a conclusion that the Santa Ana formation is probably Upper Triassic in age.

Correlation. J. P. Smith (1898, p. 779-780) suggested the name "Santa Ana limestone" for the hard black siliceous limestone exposed on the west slope of the Santa Ana Mountains. Later the same term was used by F. J. H. Merrill (1915, p. 639) in a broader sense to designate the metamorphic rocks of the Santa Ana Mountains, including the limestone. The name "Santa Ana limestone" appears on the correlation chart of geologic formation names of California, compiled by M. Grace Wilmarth for the U. S. Geological Survey, 1927 (Sheet IV), as the Triassic in Orange County.

Later the name "Santa Ana" was used by F. E. Vaughan (1922, p. 378) for a sandstone of probable Pliocene age, exposed along the Santa Ana River in San Bernardino County. However, this usage is not valid as the term had been used previously in a different sense.

The name "Silverado formation" was used by B. N. Moore (1930, p. 6) to designate most of the Triassic rocks of the southwest slope of the Santa Ana Mountains. These have been correlated by the writer with the metamorphosed sediments exposed in the Elsinore quadrangle, and the name "Silverado formation" conflicts with the older name "Santa Ana formation" which the writer believes preferable on the basis of priority.

For the same reason the writer does not favor the name "Elsinore formation," proposed by Dudley (1935, p. 493-497) for the metamorphic rocks of the Railroad Canyon area which the writer has correlated with the main body of Triassic rocks.

The writer therefore proposes a continuance of the usage of the earlier name "Santa Ana formation" to designate the metasedimentary rocks of upper (?) Triassic age.

Triassic rocks that are exposed from the mouth of Ladd Canyon to the mouth of Bedford Canyon, and which include the two fossiliferous limestone beds and lenses, were traced southward from Ladd Canyon through Silverado to Trabuco Canyon by B. N. Moore (1930). Moreover, the same slate and quartzite beds are continuously exposed from the mouth of Trabuco Canyon to the mouth of Leach Canyon in the Lake Elsinore quadrangle. Therefore the metamorphosed sedimentary rocks in the Lake Elsinore quadrangle are the same as those exposed in the Ladd-Bedford section and are part of the Santa Ana formation. On the other side of the Elsinore trough the beds extending from the Clevelin Hills to Railroad Canyon probably also belong to this formation as they closely resemble the rocks in the type section.

In the regions adjoining the Santa Ana Mountains, slate, quartzite, and schist have been described by various authors, and tentatively correlated on a lithologic basis with the Triassic metasedimentary rocks of the Santa Ana formation. Included in this group are the schists of Julian, as described by F. S. Hudson (1922, p. 190); the slates of the Santa Monica Mountains, descibed by Hoots (1931, p. 88-89); and those in the northern portion of the Puente Hills described by English (1926, p. 15). In the absence of fossils in these various localities, the correlation is only suggested.

Physiographic Expression. In general the rocks of the Santa Ana formation are hard, and commonly form resistant ridges where they are in contact with softer and more easily eroded rocks, such as the younger sediments or the andesite. Their hardness is comparable with that of the igneous rocks, and they are eroded at about the same rate. However, differences in composition cause the soils formed by weathering of Triassic sediments to be more favorable for plant growth than those produced by most of the igneous rocks. Thus the difference in quantity of vegetation is often an indication of buried metamorphic rocks.

Metamorphic Rocks of Undetermined Age

The metamorphic rocks of undetermined age include some metasedimentary ones that appear to be partly in the Santa Ana formation, but which are too altered to be positively correlated. Some are derived from igneous rocks, intrusive or effusive, and commonly appear to have been dynamothermally metamorphosed to the same degree as the sedimentary rocks with which they are associated.

Distribution. Most of the contact rocks which border the large intrusive masses have been mapped with the Santa Ana formation. The meta-igneous rocks, although covering a larger area than the contact-metamorphosed sedimentary rocks, are irregularly distributed and hardly can be separated from the metasedimentary rocks, with which they are associated and into which they merge. The largest body of meta-igneous rocks is in the southeast where it occupies an area of 4 or 5 square miles, and forms the edges of the Santa Rosa plateau.

Petrology. The contact rocks include impure marble that contains biotite and magnetite. Other contact rocks show feldspathization; these include the quartz breccias which occur in the southwestern part of the Lake Elsinore quadrangle near a contact between arenaceous shales and andesite. Most of these contact rocks are so highly silicified and recrystallized that they have lost their original character. They include biotite dioritic gneisses produced by assimilation.

The igneous rocks included in the metamorphic complex consist mostly of felsites that appear to be metarhyolites, meta-andesites and altered tuffs.

In the northeast part of the area, in sections 15, 16, 19, 21, and 24, T. 5 S., R. 5 W., felsite (mostly meta-andesite), forms small isolated bodies, and locally occurs as flows between layers of Triassic slate. These flows can be traced only for short distances. East of the town of Elsinore, the Triassic metasedimentary rocks apparently are intruded by andesite, which later was metamorphosed with them. That this meta-andesite was originally an augite-andesite, is indicated by phenocrystic remnants of oligoclase-andesine (An_{40}) and abundant augite. The andesite also was thoroughly invaded and partly replaced by quartz. Most of the feldspars are epidotized and the augite has been altered to chlorite.

In the southern part of the region, metafelsite is found on the Santa Rosa Rancho and also east of Verdugo Potrero in section 18, T. 7 S., R. 5 W., where tuffaceous breccias are interbedded with the slate.

The total thickness of these rocks was not determined because they probably include some of the Triassic sedimentary rocks so thoroughly altered by contact metamorphism that their true identity cannot be determined, and because of the discontinuous nature of the metafelsite flows. These flows may be most extensive in the Santa Rosa region where a large mass is bordered on the east by slate and quartzite that dip under it. The estimated maximum thickness is about 4,500 feet.

Age and Correlation. In spite of their discontinuity and variations the metafelsites are clearly distinguishable from the later volcanics and hypabyssal rocks by their degree of metamorphism and type of jointing.

Igneous Rocks

Diorite-Gabbro Group

Diorite and gabbro (largely San Marcos gabbro of Larsen, 1948, pp. 41-53) comprise the oldest plutonic rocks of the region and have been mapped by the writer as a single unit. Although diorite locally resembles gabbro, microscopic examination shows that the rocks mapped as the diorite-gabbro group are mostly hornblende diorite. Some occurrences of diorite are so rich in hornblende as to be hornblendite. Others contain hypersthene and resemble the norite described by Dudley (1935, p. 501), and by Larsen (1948, p. 46).

The acidic facies of the diorite-gabbro group consists of diorite and quartz diorite. The rocks of this group are distinguished from the later plutonics, either by complete absence of biotite, or by its presence in very small proportions as compared to the proportion of hornblende. By this means the dioritic rocks can be distinguished from the granodiorite and quartz diorite which are later, and from dark-colored gneissic assimilation rocks near the contacts between granodiorite and metamorphic rocks.

Distribution. The diorite-gabbro group covers a total surface of about 14 square miles, or nearly 6 percent of the entire area.

In the northwest corner of the quadrangle the diorite-gabbro group is represented by a hornblende quartz norite which occupies about 1 square mile in the vicinity of Glen Ivy Hot Springs.

To the southeast it covers extensive areas in the Elsinore Mountains south of Willard, and in the Temescal Mountains east of Elsinore. The average composition of these masses is hornblende quartz diorite.

In the Elsinore Mountains, basic phases of the diorite-gabbro group, grading from hornblende quartz gabbro to hornblendite, are exposed in small areas and appear to be segregations in the quartz diorite mass. Hornblendite schlieren are abundant. Other small bodies of gabbro occur in the northern part of the quadrangle, either as part of a diorite-gabbro mass or as inclusions in a younger intrusive. A very small body of gabbro near the Good Hope mine is included in a later body of quartz diorite.

Diorite underlies two large areas totalling about 3 square miles in La Cienega and Tenaja regions south of the center of the map. Other large masses of diorite are exposed to the southeast in the Santa Rosa region, and a few scattered patches are close to or intrude the Triassic rocks.

Petrology. The rocks of this group are dark gray and characteristically show a black mottling. They usually are darker than the younger acid plutonics. They weather brown and red and show low etching and pitting.

The most common types are medium-grained, hypidiomorphic, and show an inequigranular fabric that ranges from seriate porphyroid to intersertal (Iddings, 1909). The salic minerals, with rare exceptions in the gabbroic types, exceed femic minerals in volume by the average ratio of about 2 to 1. The average proportion of plagioclase is around 55 percent and that of quartz about 15 percent. In the more basic types quartz is a minor constituent.

The average composition of the plagioclase falls in the range of basic andesine (An_{50}) to labradorite (An_{60}), although some of the zoned feldspars show an outer rim of oligoclase. A few laths of labradorite-bytownite are locally poikilitically included in hornblende.

Some of the feldspar crystals are partly replaced by quartz which transgresses the earlier quartz grains. This replacement, although possibly deuteric in origin, is probably an effect of the later granitic intrusion. Much early quartz shows a slightly wavy extinction which helps in distinguishing it from the later quartz.

The femic minerals are mostly hornblende, minor biotite and hypersthene in very small grains. The most common accessories are magnetite and apatite. Near contacts with the granite masses, hydrothermal alterations are shown by the development of epidote, sericite, and chlorite.

An acidic type of hornblende quartz diorite underlies a small area near Los Pinos mine, and contains albite-oligoclase (An_{12} average) which shows zoning toward albite. Near the mine this rock is propylitized by the mineralizing solutions and exhibits metasomatic replacement of the silicates by pyrite.

Structural Relations. These rocks intrude the metasedimentary rocks of the Santa Ana formation and other metamorphic units. In these they form small stocks and chonoliths. In turn the diorite is intruded by the quartz latite porphyry and the andesite and dacite porphyry which preceded the granitic plutonics (quartz diorite, granodiorite, quartz monzonite).

Where the diorite and the quartz diorite-granodiorite are associated the diorite exists only as roof pendants in the younger rock. The largest roof pendant forms the Elsinore Mountains. Many of these bodies of diorite lie between granitic and metamorphic rocks in positions that suggest that the granitic magma penetrated the diorite more easily than the metamorphic rocks. Such relationships occur in the southeastern part of the Elsinore Mountains, in sections 23, 25, and 26, T.

6 S., R. 5 W., in Los Alamos Canyon, Stewart Canyon, and many other places. The apparent ease with which granitic plutonics penetrated the diorite instead of the metamorphic rocks may be an effect of the greater miscibility of the reaction products and solutions resulting from the action of the granitic magma on the diorite, as compared to those resulting from such action on the slate and quartzite. With diorite the similarity of composition would foster high miscibility, and thus reaction and solution would continue until equilibrium is reached on a large scale. With the metamorphic rocks the dissimilarity of composition would tend to limit the miscibility and solution effects would be confined to a smaller mass. As a result, the granitic magma would advance by headward stoping more rapidly in the diorite than in metamorphic rock.

Another explanation, given by Esper S. Larsen, Jr. (1948, p. 43), is "that the gabbro was still hot and probably not completely crystalline when the quartz diorite was intruded." This implies that the diorite-gabbro is of the same age as the rocks of the granitic group, whereas evidence in the Lake Elsinore quadrangle indicates that after the diorite-gabbro intrusion into the Triassic sediments some time elapsed before the granitic rocks were intruded. This evidence is (1) a similar degree and intensity of metamorphism in the Triassic sediments and in the intruded diorite-gabbro; (2) the development of parallel systems of joints in both types of rocks and discordance with joints in younger intrusive granitic rocks, (3) the existence of an erosion surface which bevels the Triassic-diorite complex and which in places is preserved by andesite flows. This surface is well exposed in the southwestern part of the quadrangle in the Verdugo Potrero region. These jointing phenomena are easily observed in Railroad Canyon and vicinity (road to Elsinore Lodge, foot of hill 2246 feet).

Consequently, the diorite-gabbro probably was completely crystalline when the granitic rocks were intruded.

Age and Correlation. As rocks of the diorite-gabbro group intrude the Santa Ana formation of Upper (?) Triassic age and the associated metamorphic rocks, then in turn are intruded by all post-metamorphic pre-Upper Cretaceous igneous rocks, they are tentatively assigned a Jurassic age.

This group is probably partly correlative with the rocks of the same type described by W. J. Miller (1935, 1946), F. S. Miller (1937) and Larsen (1948, p. 41-53).

Physiographic Expression. As distinguished from the latter granitic rocks, the diorite-gabbro masses weather to a more subdued surface, are rarely serrated on their summit, form slopes with few boulders, and ordinarily are covered with denser vegetation sustained by rusty brown soils.

In areas where the diorite-gabbro group and metamorphic rocks are similarly exposed to weathering, the diorite forms the hollows, whereas the metamorphic rocks form ridges and hills.

Quartz Latite Porphyry

The rocks mapped as quartz latite porphyry (Temescal Wash quartz latite porphyry of Larsen, 1948, pp. 36-39) range in composition from dacitic to rhyolitic.

These rocks intrude the metamorphic rocks and in turn are intruded by andesite porphyry and the later granitic plutonics. They form a large part of the southwest edge of the Perris Block on the northeast side of the Elsinore trough where they cover nearly 5.5 square miles. They appear to be limited to this region. Dacite occurs on the southwest side of the Santa Ana Mountain crest, and is separated from the nearest quartz latite area by more than 2 miles of granodiorite. Thus, the northern and southern quartz porphyries cannot be correlated with certainty. Consequently, these rocks are mapped as two separate units, although they may represent two facies of the same intrusion.

The quartz latite porphyry is a dark greenish-gray rock mottled white by numerous feldspar phenocrysts. Inclusions of slate or other metamorphic rocks are common. Although mostly angular, they locally are moderately well-rounded and show evidence of assimilation. In some places these inclusions are so numerous that the rock appears to be a breccia composed of highly silicified slate fragments, that average ½ to ¾ of an inch in diameter (13 to 20 mm), surrounded by the quartz latite porphyry. This breccia ordinarily is at the margin of metamorphic rock bodies and probably formed under strong pressure and at a relatively shallow depth. Much of this rock is hypocrystalline and contains a brown glass in various proportions.

Most of the phenocrysts are medium-grained and consist of orthoclase in carlsbad twins, andesine (An_{40}), and quartz in euhedral forms that have been partly resorbed by the groundmass. Some of the plagioclase phenocrysts are zoned; oligoclase was the most alkaline type noted. The feldspars commonly are altered to epidote, sericite, calcite, and kaolinite. Although femic minerals are rare as phenocrysts, they probably exist in the groundmass but are too small to be determined. Two of the sections contain small crystals of pyroxene (probably augite) altered to uralite and chlorite.

The groundmass contains mostly feldspar microlites which, in three of the slides examined, consist of orthoclase and andesine, in almost equal proportions—a latite composition. Some contain more plagioclase than orthoclase; more rarely the rocks are richer in orthoclase.

The quartz latite porphyry resists weathering to stand in sharp relief. It forms steep slopes on the northeast side of the Temescal Valley.

Andesite

A later emplaced andesite, unlike the earlier andesite which is associated with the metamorphosed igneous rocks is relatively fresh and does not show metamorphism except when altered near contacts with the later intrusions. Moreover, it is clearly intrusive into the metamorphic and dioritic rocks, and its areal extent is far greater than that of the meta-andesite.

Distribution. The rocks of this group are confined mostly to the southwest corner of the quadrangle where they form a large body. In the southeast corner, a small mass underlies Pleistocene basalt. In secs. 15 and 21, T. 5 S., R. 5 W., S.B., andesite occurs in small disconnected patches which are similar in composition to the andesite in the masses noted above and is correlative with them. The later andesite occupies an area of about 15.5 square miles, or nearly 6.5 percent of the quadrangle.

Petrology. The andesite is mostly porphyritic and has an aphanitic to fine granular groundmass. Most of the phenocrysts are plagioclase in laths or equant crystals whose white color contrasts with the greenish gray groundmass. The rock weathers light greenish but shows some brown limonite stains.

Microscopic study shows this rock to be porphyritic and to range from hyalocrystalline to holocrystalline and to average more than 50 percent groundmass. The feldspar phenocrysts range in composition from andesine to basic labradorite, and average An_{53}.

The microlites in the groundmass range from oligoclase to oligoclase-andesine in composition. The plagioclases are commonly altered to epidote, calcite, and sericite. The femic minerals are hornblende, pyroxene (ordinarily altered to uralite), and very minor altered olivine (?), which suggest a transition into a more basic facies.

This basic type of andesite apparently grades into the more abundant acidic type. In the lower portion of San Mateo Canyon the gradation is well shown by a series of andesitic flows that aggregate several hundred feet in thickness and range from porphyritic andesite, to a magnetite rich diabase which can be traced laterally into the normal andesite. This relation suggests that the basic facies occurs as local segregations in the main andesitic body.

The andesite is locally brecciated and contains inclusions of clastic quartz grains derived from the Triassic sediments.

Structural Relations. The andesite intrudes the Triassic diorite-gabbro rock complex, and shows textural relations that suggest that the bodies are sills or the deeper portions of flows. Some of the bodies probably are feeders for these flows extruded on an erosion surface previously developed on this complex. The existence of the flows is indicated by textures that show that parts of the andesite bodies cooled near the surface, and by andesite-filled depressions on a surface of moderate relief developed in the complex before the extrusion of the andesite.

These relationships are well shown in the southwest portion of the quadrangle. Most of the andesite shows jointing, and can thus be distinguished in the field from the younger basalt which rarely is jointed.

Age and Correlation. The andesite intruded the diorite, and was in turn intruded by the dacite porphyry. This relation suggests that the surface on which the andesite flowed was eroded after dioritic intrusion, and before the extrusion of the andesite. Thus if the diorite is of early Jurassic age, the andesite may well be of Upper Jurassic age.

Lithologic similarities and similar age relationships suggest that the andesite of the southwest corner of the Lake Elsinore quadrangle is correlative with similar rocks mapped by B. N. Moore (1930, p. 32) in the Santa Ana Mountains, and designated by him the "San Juan Hot Springs volcanics." The same rocks are included by Larsen (1948, p. 27) in the "Santiago Peak volcanics."

Physiographic Expression. The relative ease with which it weathers, and its existence as flows, causes the andesite to form flat-lying or gently rolling land surfaces which are deeply cut by canyons. The plateau-like physiography of the regions covered with andesite is well illustrated by Verdugo Potrero east of the center of T. 7 S., R. 6 W. The andesite weathers to mildly fertile, brown argillaceous soils.

Dacite Porphyry

Dacite porphyry, which covers less than 2.5 square miles of the southern flank of the Santa Ana Mountains or about 1 percent of the total area, forms isolated dikes and irregular masses that intrude metamorphic rocks, diorite, and andesite. Its relation with granodiorite is not clearly shown because these two rocks were not seen in contact with each other. However, its association with the Triassic sediments and older igneous rocks, suggests that the dacite porphyry is older than the granodiorite as is the quartz latite porphyry.

Petrology. Where fresh, the dacite is dark to light gray, but weathered surfaces are bleached to colors that range from yellowish white to buff. It is characterized by quartz phenocrysts in bipyramidal forms which stand in relief over the more alterable matrix. The other minerals that were noted megascopically are a few plagioclase phenocrysts and rare hornblende. The groundmass is aphanitic. Locally the rock shows a flow structure.

Viewed under the microscope, the rock is commonly seen to be hypocrystalline. The quartz phenocrysts are euhedral or subhedral and are persistently corroded by the groundmass into characteristic skeletal and dendritic forms. The quartz crystals are commonly shattered in many directions which bear no relation to the surrounding groundmass. This character and the bypyramidal form of the larger quartz crystals suggest that beta-quartz crystallized before the complete solidification of the magma, and that it inverted to low or alpha quartz as the rock cooled. This suggests that the dacite porphyry was intruded at a high temperature but in rather cold rocks under shallow cover. Quartz phenocrysts from a dike in the Verdugo Potrero region were first investigated by F. W. Wright and E. S. Larsen (1909, p. 443) whose discussion of inversion phenomena served as a guide in the above discussion.

The feldspars consist mostly of oligoclase locally associated with a small amount of orthoclase microlites and andesine. The femic minerals are characteristically altered and so sparsely distributed that they are difficult to identify. Amphibole and biotite, both altered to chlorite, are the most common. Much of the amphibole is uralitized by alteration of pyroxene. Secondary epidote has developed at the expense of the plagioclase and some that penetrates the corroded quartz crystals appears to have crystallized along the lines of shattering noted above.

The groundmass of some of the specimens examined consists of spherulites which probably were derived from the devitrification of glass. As these specimens were collected near granodiorite, the devitrification may have been caused by heat from the intrusive.

A comparison of dacite porphyry with the quartz latite porphyry shows that the feldspar phenocrysts in the dacite are smaller than in the quartz latite; very little or no orthoclase is present in the dacite, whereas orthoclase is invariably present in the quartz latite; the dacite contains more quartz, and the corrosion effects are everywhere more pronounced than in the quartz latite.

Age. The dacite porphyry is probably younger than the andesite and older than the granodiorite. Thus it is younger than the quartz latite porphyry. The relatively close association of these effusive and hypabyssal rocks, in composition and distribution, suggests that a limited period of volcanic activity was closely followed by the intrusion of the granitic plutonic rocks. Consequently, an Upper (?) Jurassic age is tentatively assigned to the series quartz latite porphyry—andesite—dacite porphyry.

The dacite porphyry resists weathering and commonly stands in bold relief. Where it is associated with the metamorphic rocks, which also are resistant, this difference is less marked than in the dacite—andesite association. The dacite forms sharp ridges and spurs, and separates canyons deeply cut into the andesite.

Granitic Plutonic Rocks

Emplacement of the quartz latite porphyry, andesite, andesite porphyry, and dacite porphyry successively was followed by an interval of quiescence and invasion on a regional scale by a complex granitic batholith.

The granitic plutonic rocks exposed in the Lake Elsinore quadrangle are quartz diorite, granodiorite, and quartz monzonite. They merge into one another so that they can not everywhere be clearly differentiated in the field. These rocks cover about 100 square miles of the quadrangle, or approximately 40 percent of the total area. They occur on both sides of the Elsinore trough, on the Perris and Santa Ana Mountain blocks. On the Santa Ana Mountain side, near the center of

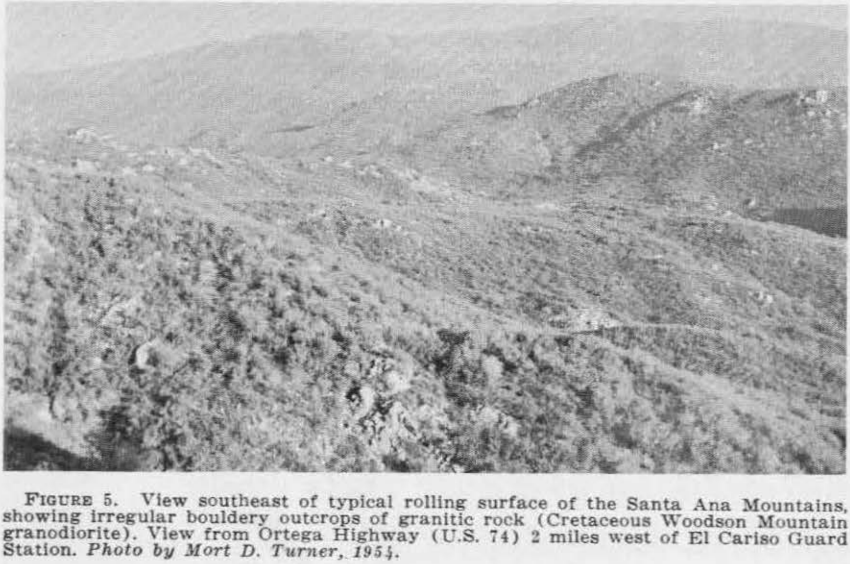

FIGURE 5. View southeast of typical rolling surface of the Santa Ana Mountains, showing irregular bouldery outcrops of granitic rock (Cretaceous Woodson Mountain granodiorite). View from Ortega Highway (U.S. 74) 2 miles west of El Cariso Guard Station. *Photo by Mort D. Turner, 1954.*

the quadrangle, they cover a nearly continuous area of about 80 square miles. These rocks can be traced for many miles to the northwest and southeast of the region covered in this report, and are part of a large complex batholith, which forms most of the Peninsular Ranges.

Quartz Diorite *

Quartz diorite is particularly prominent in the region south of Perris where it covers a large area between the Good Hope mine, Railroad Canyon, and North Elsinore. Here the contrast between the quartz diorite and the granodiorite exposed in Arroyo del Toro is very striking. The quartz diorite is the darker and contains numerous inclusions. A small rock mass that extends southeast from Estelle Mountain, although slightly different in composition, is included in the quartz diorite. It is correlative with the Estelle quartz diorite described by Dudley (1935, p. 502).

A large mass of quartz diorite is exposed on the eastern face of the Elsinore Mountains and south of Willard. A small mass occurs along Highway 74 in San Juan Canyon. A large body of quartz diorite is exposed in the southeast corner of the quadrangle on the edge of the Santa Rosa Plateau. The total area covered by quartz diorite represents about 11½ square miles, or 4½ percent of the total area of the quadrangle.

Petrology. The quartz diorite is a medium-grained rock. The femic minerals which form as much as one-fifth of the rock impart a dark gray color. The rock contains abundant dark elongated inclusions, or schlieren, that ordinarily consist of biotite and hornblende. It weathers to form rusty gray, sandy, and mostly barren soils and large boulders.

Under the microscope the texture is seen to range from equi- to inequigranular seriate homeoid to porphyroid. Quartz, plagioclase (oligoclase to andesine), biotite, hornblende, and small amounts of orthoclase are the major constituents. Some uralite is present locally.

Age and Correlation. Near the Good Hope mine the quartz diorite intrudes Triassic rocks and a small mass of gabbro. Similar relations are observed in the Santa Rosa region. Around Estelle Mountain the quartz diorite intrudes the quartz latite porphyry. Moreover, in San Juan Canyon the quartz diorite is intruded by the granodiorite. Consequently, the quartz diorite is intermediate in age between the quartz latite and the granodiorite. The age relationship of the quartz diorite with the andesite and the dacite porphyry is not fully demonstrated by field evidence, but the quartz diorite is inferred to be later than both. The tentative Jurassic age assignment to the quartz latite porphyry and the dating of the granodiorite as pre-Upper Cretaceous suggest that the quartz diorite is early Cretaceous. Its correlative is the Perris quartz diorite of Dudley (1935, p. 501) or Bonsall tonalite of Larsen (1948, p. 58).

Physiographic Expression. The quartz diorite exposures are characterized by prominent dark boulders, that weather more easily than the granodiorite.

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* Largely Bonsall tonalite (Larsen, 1948, pp. 58-67).

Many of the femic mineral inclusions in the quartz diorite are more resistant to weathering than the rock mass, producing a rough surface texture. In the quartz diorite mass south of Perris these inclusions trend generally east, but near the metamorphic rocks they ordinarily are parallel with the contacts.

Granodiorite *

The granodiorite is exposed on both sides of the Elsinore trough. To the north it occurs in Arroyo del Toro, Cottonwood Canyon, and the southeast extension of the Temescal Mountains. In the trough itself this rock forms only a few isolated masses which intrude all of the rocks from metamorphic rocks to quartz latite porphyry. To the south it underlies a large part of the Santa Ana-Elsinore Mountains. The surface covered by granodiorite totals nearly 88 square miles, or about 36 percent of the area of the quadrangle.

Petrology. The granodiorite is a coarse, light-gray rock which through weathering develops abundant boulders or blocks and disintegrates to whitish gray soils that are mostly barren.

Quartz, feldspar, biotite, and locally hornblende, are visible to the naked eye. At some places, such as the hills south of Cottonwood the texture is extremely coarse and shows grains that are as much as half an inch in diameter. This locality may represent the deepest portion of the batholith in the Lake Elsinore quadrangle .

Under the microscope the texture is shown to be mostly equigranular seriate homeoid. Oligoclase is common and orthoclase is everywhere present, but ordinarly in smaller proportions than the plagioclase. At a few localities for example, in Horsethief Canyon and east of Sitton Peak, the orthoclase exceeds the plagioclase, and the rock is a true granite which grades into the granodiorite. Several of the thin sections contain microperthite and zoned crystals of plagioclase that show a core of labradorite and an outer rim of oligoclase. Quartz forms about a third of the rock.

Inclusions. The granodiorite commonly contains elliptical or spindle-shaped autoliths and schlieren made up mostly of biotite and subordinate hornblende. These generally are oriented in a northwest direction, paralleling the major tectonic lines.

Xenoliths, in contrast with these, do not show a persistent systematic orientation and they are mostly sub-angular. The most abundant ones, probably due to their resistance to assimilation, consist of metamorphic rocks; but inclusions of diorite-gabbro and other rocks intruded by the granodiorite are also found.

Contact Effects. Very remarkable exomorphic effects have been produced by: 1. thermal and chemical action: Solution, recrystallization, induration, addition of quartz, tourmaline, and secondary biotite; 2. dynamic action shown by sheeting, which locally is associated with lit-par-lit injection and nearly complete granitization of the Triassic sedimentary rocks. Such sheeting has been observed in many places

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* Largely Woodson Mountain granodiorite of Larsen (1948, pp. 76-82).

and is particularly well shown at the following localities: near the mouth of Rice Canyon in section 28, T. 5 S., R. 5 W.; (sheeting direction N. 35° E., dip 50° NW); on the east side of La Cienega, in section 3, T. 7 S., R. 5 W.; in Los Alamos Canyon, with sheeting parallel to aplite and pegmatite dikes (N. 70° E., 20° NW); Rinconada Canyon (sheeting direction, north, dip 80° E.).

At some localities endomorphic action has produced a darker and more basic granodiorite border phase and chilled borders. These were noted at El Cariso and Sitton Peak.

A gneissic contact rock commonly marks the borders between metamorphic rocks and granodiorite, and consists of bands of biotite and subordinate hornblende in a highly siliceous groundmass of medium- to fine-grained quartz and feldspar. The local addition of feldspar (albite-oligoclase) has produced separate bands.

Structural Relations. The granodiorite not only intrudes the older rocks, but in general underlies them, and they are interpreted as roof pendants or masses which are limited laterally and also in depth by the granodiorite. This is true even of the large band of Triassic rocks which crosses the northern part of the area from east to west. The relations between roof pendants of Triassic rocks and the granodiorite are well illustrated in Los Alamos-Rinconada region.

Evidence that bears on the manner of intrusion of granite into the metamorphic-diorite complex is well shown in Stewart Canyon at an elevation of about 1900 feet. The diorite-gabbro occupies the creek bottom and the lower slopes on the east side to a height of about 300 feet where it is overlain by 250 feet of granodiorite. The diorite-gabbro is intruded by multiple sheets of fine-grained granite and aplite, where parallelism suggests lit-par-lit injection. Moreover, the diorite-gabbro is permeated by numerous irregular dikelets of granitic rock, that locally form an intrusive breccia. Many of the diorite fragments show contact effects that have resulted from solution and by reaction with the granitic magma. Most of these inclusions are oriented approximately parallel to the sheets. On the west side of the canyon the contact between the granodiorite and diorite-gabbro is exposed on the bottom of the creek for about half a mile.

These features suggest that the granodiorite intrusion expanded over the dioritic-metamorphic mass along a surface of contact that dips west at an angle of 14° to 25° and is flatter towards the east.

Observations in Los Alamos Canyon, between the mouths of Rinconada and Wild Horse Canyons, show similarly that the complex of metamorphic rocks and diorite-gabbro was intruded by granite and associated pegmatite in lit-par-lit fashion. These sheets traverse Los Alamos Canyon at an acute angle and are nearly parallel, with an average strike of N. 70° E. and a dip of 15-25° NW. Besides the contact rocks already described intrusive breccias, made up of large angular or sub-angular fragments of the intruded rocks, were noted in several exposures. These are surrounded and apparently were rolled over by the granodiorite intrusion.

On the northeast side of Wild Horse Canyon a strongly developed sheeting in granite is emphasized by parallel aplite and pegmatite dikes and simulate bedding. Pressure and rapid cooling of the granite against the older rocks probably produced this initial jointing along which the dikes were subsequently injected.

At several places in these canyons the surfaces of contact of the granite with the intruded rocks are exposed. These dip at low angles to the west and southwest, and show that the granodiorite was thrust over the intruded rocks in the easterly and northeasterly direction.

In most other places along this intrusive contact, where the dip of the contact surface may be observed or inferred, it passes under the intruded mass rather than above it. Thus, except locally, general arching or bulging through forced injection dominates.

Age and Correlation. The granitic rocks are younger than the quartz latite and the dacite porphyries, and older than the Upper Cretaceous Chico formation.

In the northern portion of the area (sec. 13, T. 5 S., R. 5 W.) the relations between the quartz latite porphyry and the intruding granodiorite are well expressed by chilled borders, contact patterns, and quartz latite inclusions in the granodiorite. At several places the andesite is intruded by granodiorite, as on the main divide trail (sec. 27, T. 5 S., R. 6 W.) and in the southwest part of the area. The relation with the dacite porphyry is not visible anywhere, but the close association of this rock with the andesite suggests that it is probably earlier than the granodiorite.

In the southwest corner of the quadrangle beds of the Chico formation lie with depositional contact on andesite and Triassic metamorphic rocks, both intruded by granodiorite. Thus the granodiorite probably is early Cretaceous in age and may be correlative with the youngest plutonic acidic intrusives observed in the adjoining regions.

In the San Gabriel Mountains Arnold and Strong (1905, p. 183-204), then later W. J. Miller (1926, 1930, and 1934) recognized a biotite granodiorite and a granite of later age than the diorite. Similarly in the Santa Monica Mountains, Hoots (1931, p. 89) mentions biotite granite, diorite, and granodiorite, although their age relationship was not determined.

Vaughan (1922, p. 363-374), in his study of the San Bernardino Mountains, describes a post-Carboniferous diorite of earlier age than the Cactus granite which he relates to the late Jurassic, Sierran intrusive epoch.

In the San Jacinto Mountains Fraser (1931, p. 494-540) discovered an intrusion of gabbro that preceded that of the granite and granodiorite which probably is correlative with the Cactus granite of the area to the north.

In San Diego County, in La Jolla region, Hanna (1926, p. 220-224) noted that a biotite quartz diorite intrudes metamorphic rocks of probable Triassic age. Hudson (1922, p. 190-208) and Donnelly (1934, p. 331-348) in the Julian district describe the following succession: (1) Julian schists (Triassic ?); (2) hornblende quartz diorite (Stonewall); (3) biotite hornblende granite (Rattlesnake); and (4) gabbro-norite-diorite (Cuyamaca intrusives), which may represent a departure from the usual regional order of succession. Farther south W. J. Miller (1933, and 1935, p. 123-132) found a group of plutonic rocks that intrudes the metamorphic complex. These begin with a gabbro-diorite and end with granodiorite and quartz diorite.

The similarity in rock types and in the order of intrusions strongly suggests that the last plutonic acidic intrusions are correlative with the granitic plutonics of the Lake Elsinore quadrangle. Since this view was first expressed, (Engel, 1932 and 1933) studies by Dudley (1935) and Larsen (1948) have contributed much to the solution of the problem of correlating plutonic rocks in southern California. A comparison of their studies with the present one suggests that the granodiorite of the Lake Elsinore quadrangle is equivalent to the Steele Valley granodiorite (Dudley, 1935, p. 502) and the Woodson Mountain granodiorite (Larsen, 1948, p. 76-82).

Physiographic Expression. The granitic areas are characterized by prominent boulders that produce a jagged and chaotic topography. The granite ridges show serrated edges and stand in bolder relief than the areas underlain by the older diorite-gabbro.

Quartz Monzonite

Quartz monzonite underlies four small areas that total about half a square mile. Two of these are in the north-central part of the quadrangle at Shaw Mountain in sections 24 and 25, T. 5 S., R. 5 W. and east across the road to North Elsinore. The other two are near the western edge near Sugar Loaf and San Juan Canyon. These two are part of a single body of quartz monzonite that lies mostly in the adjacent Santiago Peak quadrangle.

This rock has a pinkish color and weathers more easily than the granodiorite. It is medium equigranular and contains quartz, orthoclase, plagioclase, biotite, and hornblende in various proportions. Under the microscope a specimen from Shaw Mountain was seen to contain orthoclase and oligoclase-andesine in nearly equal proportions. Together they comprise about half of the rock. The remainder is gray purplish quartz, interstitial in part, some biotite, rare hornblende, and the alteration minerals chlorite and sericite. The southern occurrence of this rock has nearly the same composition except that it contains microperthite and uralite with less quartz and is more altered.

On the flanks of Shaw Mountain the quartz monzonite intrudes the quartz latite porphyry, and the small body to the east intrudes the Triassic metamorphic rocks. The relation of the quartz monzonite to the quartz diorite is not clearly shown. In the southern exposures the quartz monzonite intrudes the granodiorite.

This rock may be correlative with the Cajalco quartz monzonite described by Dudley (1935, p. 502) and the granodiorites mentioned by Larsen (1948, p. 95-96).

Quaternary Basalt

Distribution. In the southeastern portion of the quadrangle, basalt-capped mesas dominate the landscape. They occur mainly near the margin of the Lake Elsinore quadrangle and extend into the San Luis Rey quadrangle towards Deluz and Fallbrook. The largest exposure of basalt in Lake Elsinore quadrangle is that of the Mesa de Colorado, southwest of Santa Rosa Ranch. The presence of basalt remnants capping the granite near the southeastern end of the Elsinore Mountains indicates that at one time these basalts covered a more extensive portion of the Santa Ana Mountain block. The presence of a patch of altered basalt on the main divide truck trail just southeast of Trabuco Peak shows that basalts probably once extended nearly as far north as Trabuco Peak, but have now been almost entirely removed by erosion. The area now covered by basalt represents approximately 1 percent of the area of the quadrangle.

The basalt was studied in detail in two localities: Mesa de Burro, about 1 mile east of the Lake Elsinore quadrangle (on Murrieta quadrangle just southwest of Murrieta); and Mesa de la Punta, in the southeastern corner of Lake Elsinore quadrangle.

Basalt flows occur on both sides of the road from Murrieta to the Santa Rosa Ranch, near the southeast corner of the Lake Elsinore quadrangle. They overlie the metamorphic rocks and thus cover the top of the mountain slope facing the Elsinore trough on its southwest side.

To the south and southwest of Santa Rosa Ranch several basalt covered mesas form a semi-circular crest of about the same elevation (2050 feet) as Mesa de Burro. A section through the lava flows exposed to the south of the road was measured. From the road, at an elevation of 1825 feet, to the 1950-foot contour, the ground is covered with soil and weathered basaltic fragments. From 1950 feet to 1980 feet elevation, large lava blocks are visible, few of them in place. The scoriaceous to massive textures of the blocks suggest that there are two flows. From the 1980-foot contour to the top of the mesa, slightly higher than 2000 feet, the outcrops, which are in place, show three flows. The best exposed part of the 15-foot flow shows a fine grained porphyritic texture in its lowest third.

On the north side of the road near the base of the mesa a dike of diorite porphyry cuts an altered andesite, which underlies the basalt. From the andesite (1820-foot elevation) to the top of the mesa (2000 feet) four and possibly five lava flows are indicated by the repetition of the vesicular structure. They are horizontal and appear concordant; no indication of erosion intervals was observed. On the contrary, the underlying andesite shows a strong angular discordance of about 70 degrees. The presence of slates with a similar attitude below the andesite indicates that this andesite is a part of the Triassic basement complex.

A good example of stream capture is visible at the top of the Santa Rosa grade. Rejuvenation by faulting has caused the streams of the valley side to cut faster than the streams of the plateau drainage, and behead their tributaries. Similar cases of piracy are observable along the northeast face of the Santa Ana Mountain block.

A small hill detached from Mesa de la Punta on its northeast side was investigated near the divide at an elevation of 1790 feet in Murrieta quadrangle, about a quarter of a mile east of Lake Elsinore quadrangle.

Four or more horizontal basalt flows cover an erosion surface in mica schist and other metamorphic rocks, in which the schistosity shows an average strike of N. 45° W. and dip of 73° SW. The face of this hill becomes extremely abrupt and for the last 100 feet toward the top (elevation 1990 feet) the basalt stands at an angle of 70 to 80 degrees.

The basalt talus slope is only 30° and tends to become flatter at the level of the metamorphic rocks.

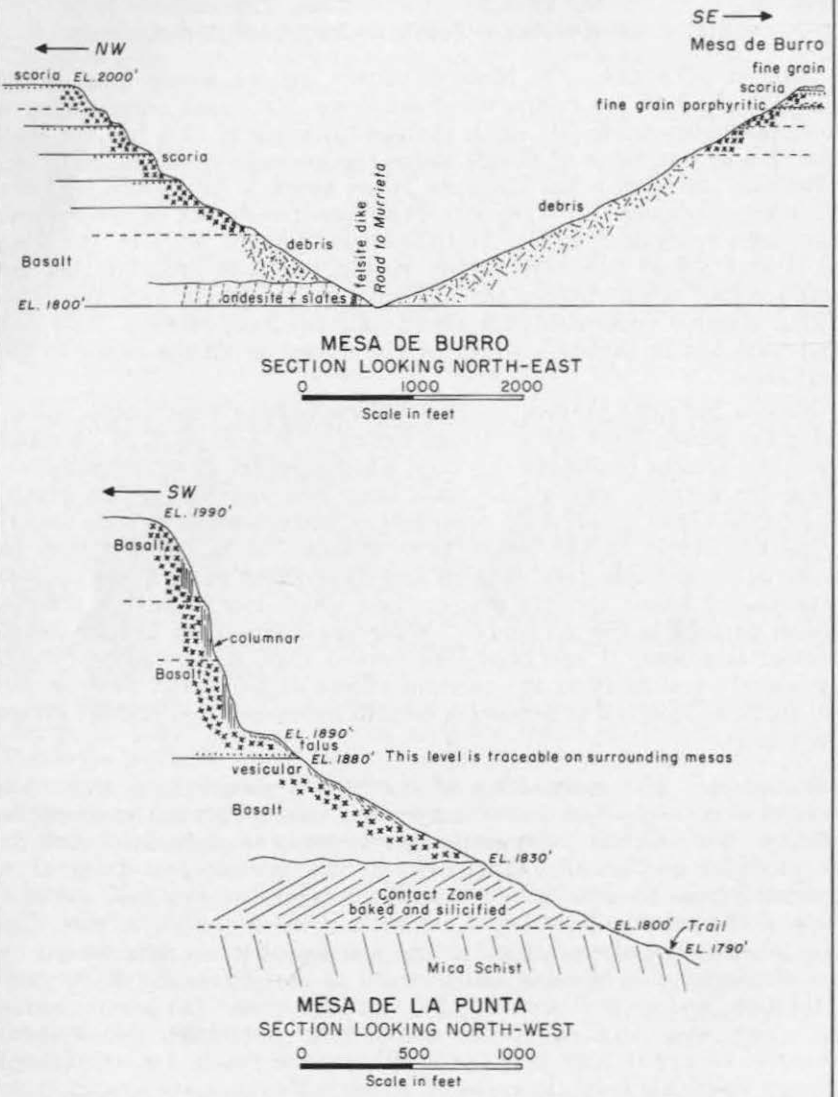
In a northeasterly direction across Murrieta quadrangle, older flows, probably andesites, are exposed. The andesite appears to be jointed at steep angles and is cut by light colored dikes. The andesite is beveled by horizontal flows of younger basalt under which it disappears.

Number of Flows. On Mesa de Burro, on the Santa Rosa grant (T. 7 S., R. 4 W.) a minimum of six flows is exposed representing a total thickness of 135 feet or an average thickness of 22.5 feet for each flow. Under the talus of debris above the andesite-basalt contact, two flows may be buried. On Redonda Mesa, about 1 mile south of Lake Elsinore quadrangle in Margarita Peak quadrangle, six or seven flows have been recognized with a total thickness of about 200 feet. On Mesa de la Punta four flows are clearly visible, but it is probable that six and possibly seven covered the old erosion surface cut into the mica schist. Basaltic rocks occupy a fairly uniform level between 1880 feet and 1900 feet in elevation which can be traced on all the mesas to the southeast.

Except for some gravels, no Tertiary rocks have been found underlying the basalt. Near the southeast corner of T. 6 S., R. 5 W., a small body of Palocene sandstone and clay, which appears as a remnant overlying the granite, may at one time have been covered by the basalt. Fairbanks (1893, p. 102-103) described extensive sandstone beds underlying the basalt on the Santa Rosa Plateau. It is possible that he referred to the baked residual soils and clays which occur at the contact between the basalt and the granite, and which locally have a sheeted aspect parallel to the old surface. Wherever exposed the granite-basalt contact is a zone of red brick-like burned clay, soil or gruss, which apparently results from the thermal effects of the basalt flow on the old surface. This red coloration is helpful in tracing this contact across the region.

Petrology. The composition of the basalts ranges from that of a normal olivine basalt to that of a pyroxene basalt, showing an andesitic affinity. The texture, commonly scoriaceous, is aphanitic, usually porphyritic, and at time fine-grained. The microscopic study of a specimen from Mesa de Burro, considered typical of the most common type of the basalts of the region, shows a decided ophitic texture. Olivine phenocrysts altered to antigorite and hematite are surrounded by a groundmass of plagioclase laths, joined in part by augite of last consolidation, and a small amount of interstitial glass. The plagioclase is andesine: Ab_{54} An_{46}. Magnetite is relatively abundant, and a small quantity of pyrite may be present. Where the basalt has assimilated foreign materials from the rocks on which it flowed, some hybrid types are produced. They are characterized by a large amount of quartz, which, by its undulose extinction and embayed edges, shows clearly a foreign origin and is probably derived ultimately from the metamorphic rocks. These hybrid basalt types commonly contain primary and some secondary biotite which has crystallized along fractures.

Thickness and Structural Relations. The thickness of basalt ranges between a possible maximum of 450 feet on Mesa del Tenaja (south of



MESA DE BURRO
SECTION LOOKING NORTH-EAST

MESA DE LA PUNTA
SECTION LOOKING NORTH-WEST

FIGURE 6. Profiles drawn through Quaternary basalt flows.

Tenaja guard station near the center of the south border of Lake Elsinore quadrangle) to about 100 feet or less in the Elsinore Mountains. From the facts that (1) the thickness increases toward the southeast, and (2) that the granite surface on which the basalt flowed slopes in the same direction, it is concluded that the basalt flowed from vents now obliterated but probably situated to the northwest of the region studied. From the facts that (1) the basalt capping the mesas is still nearly horizontal, (2) the different flows can be lithologically correlated, and (3) the surface of the basalt slopes 3° SE, it is believed that no large movements have taken place since. However, it should be noted that on some of the mesas local movements may have occurred; for instance, on the Mesa del Tenaja, the granite surface slopes southeastward and the basalt flows which surmount it tilt westward about 4 degrees.

Age and Correlation. From lithologic analogies, these flows, however disconnected, by faulting or erosion, are considered to be parts of a formerly continuous rock body.

The assignment of the basalts to the Quaternary, probably lower Pleistocene, is based on (1) the relative freshness of the basalts; (2) the fact that nowhere have they been found covered by sedimentary deposits, but, on the contrary, have by alteration formed the present soil; (3) recognition of Tertiary strata of probably Paleocene (Martinez) age underlying them; and (4) their position on an old erosion surface that truncates the granite and metamorphic rocks alike. This basalt is correlative with the mesa-forming basalt (Larsen, 1948, p. 107) and the Santa Rosa basalt (Mann, 1955, p. 9).

Dike Rocks

Dike rocks may be divided into three groups depending upon their relative age: 1. pre-granitic dikes intruding all rocks preceding the granitic pluton; 2. post-granitic and pre-basaltic dikes intruding the granitic pluton and all preceding rocks; 3. post-basaltic dikes intruding the Quaternary basalt and all preceding rocks.

The dikes of the first group are the correlatives of the hypabyssal rocks already described under andesite, quartz latite, and dacite porphyry.

The rocks of the second group consist of aplite and pegmatite with rare andesite porphyry. Dikes of aplite and pegmatite are numerous in the granitic area to the south of Lake Elsinore, where they form prominent outcrops contrasting by their light color with the darker surrounding rock masses. To the north, pegmatite dikes are fewer but in the eastern part of the area they attain a large development and may form chonolithic bodies. The largest of these bodies is found in NE¼ sec. 14, T. 6 S., R. 4 W., where a roughly elliptical mass of pegmatite and aplite, intersected by quartz veins, intrudes the granodiorite and covers an area of about a quarter of a square mile. Besides the normal constituents quartz and feldspar,* some of the pegmatites contain biotite, tourmaline, topaz, dumortierite, and rare cassiterite. The dikes of the second group mark the end of the igneous activity of probable early or middle Cretaceous age.

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* Mostly microcline replaced in part by albite-oligoclase with development of microperthite.

The third group is represented by a hornblende andesite porphyry dike exposed on the east margin of the quadrangle at the base of Mesa de Burro. It intrudes the basalt and the Jurassic (?) andesite on which the basalt flows are resting.

Sedimentary Rocks

Upper Cretaceous—Chico Formation

The Chico * formation occupies only a small triangular area of about 2 square miles which lies in the southwest corner of the area mapped and which is part of a strip about 3 or 4 miles wide, extending southeast and northwest into the San Luis Rey and Corona quadrangles. The beds of Chico were unconformably deposited on the margin of the Santa Ana Mountain block where the basement consists of Triassic rocks and andesite. The Chico strata consist of grayish-buff conglomerate and coarse, poorly bedded sandstone, mostly debris from granodioritic, metamorphic, and andesitic rocks, apparently derived from a source to the northeast. No fossils were found in the area of the map.

In the area investigated, the Trabuco formation, the poorly consolidated, massive, red sandy conglomerate which forms the base of the Cretaceous section in the Santa Ana Mountains (Packard 1916, p. 140), is apparently lacking, since nowhere were the typical red conglomerate beds found.

Paleocene—Martinez Formation

The Martinez formation is found almost exclusively in the Elsinore trough in isolated areas mostly small in size, resting on the metamorphic-igneous rock complex and underlying the Quaternary fanglomerates.

Distribution. Paleocene rocks are exposed in numerous clay pits which are distributed over an area on the flanks of the hill which extends southeast from the Alberhill Coal mine to Terra Cotta. The area covers about 1½ square miles in secs. 22, 23, and 26, T. 5 S., R. 5 W. On the west side of Alberhill and south of the Los Angeles Brick and Clay Products Company plant, the same formation is well exposed in the clay pits which cover an area of 0.4 of a square mile.

To the northwest, near Lee Lake, several small areas of Paleocene rocks are exposed. Some of these are remnants lodged in depressions on the weathered surface of the quartz latite porphyry. Other larger areas are exposed toward the middle of the trough. South of Lee Lake Paleocene beds extend from beneath a cover of fanglomerate on the edge of a tilted block of granite and metamorphic rock. In the SW¼ sec. 7, T. 5 S., R. 6 W., is one of the three fossil localities of the area where the most diagnostic species were found (fossil locality El. 1). Farther to the northwest another area of Paleocene, covers about a quarter of section 12 and includes another fossil locality.

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* The term Chico was first applied to Upper Cretaceous strata in the Santa Ana Mountains by Packard (1916, p. 141). In 1937 Popenoe (1937, p. 380) divided the Chico into the Ladd and Williams formations. On the basis of fossil evidence, the Cretaceous rocks exposed in the Lake Elsinore quadrangle apparently correspond to the Baker Canyon member of the Upper Cretaceous Ladd formation of Popenoe.

In the neighborhood of North Elsinore, several pits and shafts through the alluvium and fanglomerate penetrated the underlying Tertiary beds. At the Elsinore Clay Company's pits, in the bed of Arroyo del Toro, fossil plants were collected; sections were measured in two of the pits. About half a mile to the west on the dump of the Langstaff prospect shafts, fragments of poorly preserved lamellibranchs were obtained.

East of Lucerne a narrow strip of clay shale nearly 1 mile long is exposed along the southwest base of the Clevelin Hills. At other places in the valley, also underlying the fanglomerate, small exposures of Tertiary beds are visible. The total area covered by the Paleocene in the Elsinore trough amounts to about 4½ square miles or nearly 2 percent of the Lake Elsinore quadrangle.

South of Morrell Ranch, in the Elsinore Mountains, in the SE¼ sec. 36, T. 6 S., R. 5 W., several prospect pits were dug to explore clay deposits lying in depressions in the surface of the deeply altered granitic rocks. Some of these clays, which show no bedding and are more or less mixed with quartz and remnants of granitic rock, were produced by alteration in situ of the granodiorite. Purer clays are interbedded with nearly horizontal sandstone and were exposed after the basalt capping of the surrounding hills was eroded. The section as exposed in a narrow strip about 500 feet long and 50 feet wide on the east side of this valley is as follows:

	Thickness
Gray buff sandstone	3.0 feet
Gray sandy clay	2.5 feet
Coarse sandstone	4.0 feet
Ferruginous clay	3.0 feet
— — erosional unconformity — —	
Altered granodiorite	

The beds have a strike of N. 5 E. and dip 1°15′ SE. Although no fossils were found, these clay and sandstone beds are correlated on the basis of lithologic similarity with the Martinez of the Elsinore trough. They represent the only remnant of Paleocene beds found on the Santa Ana-Elsinore Mountain block in the Lake Elsinore quadrangle. On the basis of the evidence furnished by these Tertiary beds, the vertical displacement of the Elsinore Mountain block relative to the Elsinore trough is estimated to be a minimum of 1900 feet.

Stratigraphy and Lithology. The Tertiary-Paleocene section is made up of an alternation of coarse- to fine-grained sandstone, sandy shale, clay shale and claystone with intercalations of lignite or impure coal beds, and a few lenses of fossiliferous limestone. Conglomerate beds are rare, the most prominent occurrence is at the base of the Tertiary section in the hills about 1 mile east of Alberhill. This conglomerate consists of well-rounded, pebble-sized fragments of the rocks which form the metamorphic igneous complex on the northeast side of the trough. This conglomerate bed is overlain by sandstone beds intercalated with clay shales. Farther up the section near the Alberhill main tunnel clay pit, coal beds are overlain by other clay shales and sandstone.

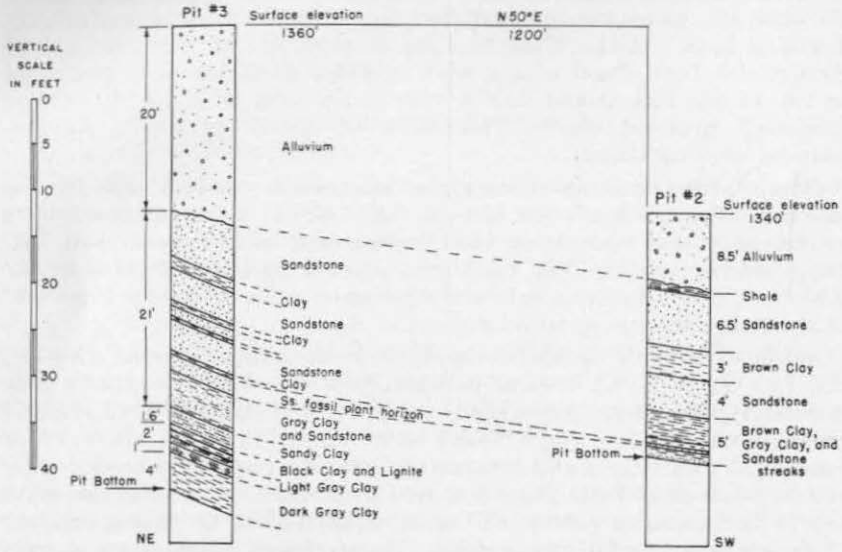

FIGURE 7. Section through Morton Clay Company's No. 2 and No. 3 clay pits.

Table 3. Tertiary—Paleocene Section **
along Highway 71, NW of Lee Lake, in NE¼ sec. 12 T. 5 S., R. 6 W., S.B. just north of Lake Elsinore quadrangle.

		Thickness
	Light buff sandy siltstone, angular-subangular quartz grains, plagioclase, altered biotite, some sericite, kaolinite, chlorite and rare apatite	4.0 feet
(A)	Buff reddish sandstone, medium to fine grained, subangular-angular quartz and altered feldspar, biotite and hornblende, chlorite, kaolinite. Screen analysis given below	1.5 feet
	Buff sandy shale, fine-grained quartz and bleached biotite, clay minerals	1.5 feet
	Arkosic conglomerate and coarse sandstone with small flat pebbles of granodiorite (30 mm. x 15 mm. average), angular quartz and plagioclase grains; interbedded with micaceous shale varves	1.5 feet
(B)	Light buff sandy shale, more or less concretionary, fine-grained quartz, some feldspar, altered biotite, chlorite and clay minerals. Screen analysis given below	5.5 feet
	Sandstone (similar to A)	1.0 feet
	Total	15.0 feet

Screen analyses *

Sizes: (mm.)	*Mesh:*	*(A)*	*(B)*
1.98 -0.991	9- 16	0.3 percent	0.06 percent
0.991-0.495	16- 32	7.5 percent	0.56 percent
0.495-0.246	32- 60	31.7 percent	2.50 percent
0.246-0.123	60-115	14.8 percent	4.98 percent
0.123-0.061	115-240	13.3 percent	8.10 percent
minus—0.061	—240	32.4 percent	83.80 percent
		100.0 percent	100.0 percent

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* In both samples A and B, no grains were larger than 1.98 mm.
** This section is about 1200 feet higher stratigraphically than the limestone bed at fossil locality El 2.

The Tertiary section was measured at several well exposed localities, but correlation was hampered by the lack of markers traceable between exposures of the lenticular beds. Almost invariably, the exposures of Tertiary rocks are separated by areas covered by fanglomerates, or else are disconnected by faulting.

In the Alberhill region, thin, lenticular beds of limonite or red ochre interbedded with the red clays suggest that during the deposition of the Martinez series marked climatic changes took place. The fossil evidence shows that the shoreline of the Martinez sea was probably close to these deposits, and that the environment alternated between a humid shoreline and an estuary. On the other hand, the limonitic bands suggest that the climate may have been semiarid at times.

Although "olive green concretions probably containing glauconite" have been reported in some of the Martinez shale beds of Baker Canyon (English, 1926), no glauconite was found in the Martinez of the Elsinore region.

Most of the sandstone contains a large amount of mica, mainly biotite, commonly altered to chlorite, as well as minerals from the surrounding highland rock masses, indicating that the greater part of the Martinez was derived from the margins of the trough. Mechanical and mineralogical analyses were made of one typical sandstone and typical shale exposed west of Lee Lake in the NE¼ sec. 12, T. 5 S., R. 6 W. These results are given in the accompanying table. The derivation of the Martinez series from a source material in the immediate vicinity shows that diastrophism was already active in the Elsinore trough as early as Paleocene time.

The small clay pockets on the southwestern edge of the Perris Block were produced in situ, as they merge gradually into the unaltered quartz latite porphyry beneath. They are impure, ferruginous, and unstratified.

The maximum thickness of Martinez (about 1500 feet) in the Lake Elsinore quadrangle is exposed west of Lee Lake. On the south side of Santa Ana Canyon, north of Sierra Peak, thickness is less than 400 feet. Toward the southeast, the exposed thickness of the beds decreases to 100 feet in the Alberhill region.

Detailed study of the Alberhill area by B. H. Rogers in 1955 led him to divide the Martinez section into three units. The lowermost unit, here referred to as the Carbonaceous member, is as much as 20 feet thick and consists of white, gray and yellowish claystone containing lenses of coarse, angular, quartz sand, and discontinuous layers of lignite and carbonaceous clay. The member lies unconformably upon residual clay derived from Mesozoic Santa Ana formation metasedimentary rocks, and contains plant remains and brackish water shells (fossil locality EL-3) which are described in a following section.

The middle part of the formation, here referred to as the Claystone member, is as much as 35 feet thick and consists of sandy claystone interbedded with irregular layers and lenses of clayey sandstone. Ordinarily, the sand component is fine to very coarse grained angular quartz. In some places the claystone in this member is white to gray; in other places it has a red and gray mottled color.

Table 4. Fossils recovered from clayey, sandy, limestone beds at localities El 1A, El 1B, and El 2.

Pelecypods	El 1A	El 1B	El 2
Callocardia simiensis Nelson R. N. Nelson (1925) p. 413, pl. 52, figs. 3a, 3b; pl. 53, figs. 5, 6, 7.	x	x	–
Cardium brewerii Gabb C. A. Waring (1917) p. 92, pl. 14, fig. 9.	–	–	x
Cardium linteum (?) Conrad Nelson (1925) p. 411, pl. 52, figs. 1a, 1b, 1c.	–	x	–
Crassatellites claytonensis (?) Dickerson Dickerson (1914a) p. 131, pl. 10, figs. 4a, 4b.	x	–	x
Crassatellites studleyi Dickerson Dickerson (1914a) p. 129, pl. 10, fig. 1.	–	x	–
Glycimeris veatchii Gabb Waring (1917) p. 75, pl. 8, figs. 2, 7, 8.	–	x	–
G. veatchii major Stanton Id. p. 75, pl. 10, figs. 3, 4.	x	–	–
Macrocallista furlongi Nelson Nelson (1925) p. 412, pl. 52, figs. 5, 6a, 6b.	–	x	–
M. stantoni (?) Waring Waring (1917) p. 77, pl. 14, figs. 1, 6.	–	–	x
Mactra (?) sp.	x	–	–
Nemodon morani (?) Waring Nelson (1925) p. 405, pl. 49, figs. 11a, 11b, 12a, 12b.	x	–	–
Ostrea sp.	x	–	x
Pedalion sp. (?)	–	x	x
Solen sp. (?)	–	–	x
Tellina herndonensis (?) Dickerson Dickerson (1914a) p. 136, pl. 2, fig. 9.	–	–	x
Venericardia venturensis Waring Waring (1917) p. 80, pl. 11, figs. 6-9.	x	x	x
Yoldia gesteri (?) Dickerson Dickerson (1914a) p. 124, pl. 7, fig. 5.	–	–	x

Gastropods	El 1A	El 1B	El 2
Amauropsis martinezensis Dickerson Dickerson (1914a) p. 142, pl. 13, figs. 4a, 4b.	x	x	–
Fissurella sp.	–	x	x
Fusus aratus (?) Gabb Id. pl. 16, fig. 4.	x	–	–
Gyrodes robustus Waring Waring (1917) p. 84, pl. 13, figs. 11, 12.	x	x	x
Polinices simiensis Nelson Nelson (1925) p. 420, pl. 54, figs. 1a, 1b, 1c.	x	–	x
Turritella infragranulata (?) Gabb Gabb, W. M. (1864) p. 212, pl. 32, fig. 279.	–	–	x
Turritella pachecoensis Stanton Stanton, T. W. (1895-96) p. 1043, pl. 66, fig. 1 and 2.	x	x	–

The upper unit, here referred to as the Green Shale member, has a maximum exposed thickness of 50 feet, and consists of coarse-grained to conglomeratic, micaceous, feldspathic, sandstone interbedded with sandy claystone and sandy micaceous clay shale. The mica characteristic of this unit is a greenish mineral with a pearly luster, having the appearance of weathered chlorite. Most of the claystone and shale is light to dark greenish gray with a waxy luster. In some areas red and gray mottled claystone similar to that in the Claystone member occurs in the Green Shale member as discontinuous layers less than 5 feet thick. The fossiliferous impure limestone lenses found in the Lee Lake area are included in the Green Shale member (fossil localities El-1,2).

Most of the commercial refractory clays that are mined in the Alberhill area are in the Carbonaceous and Claystone members of the Martinez formation.

In the Lake Elsinore quadrangle the Martinez formation is characterized by marked lateral variations in thickness and lithology. Although the Carbonaceous member and the overlying Claystone member occur in outcrops less than half a mile in diameter, the Green Shale member overlaps these underlying members and appears to be a laterally continuous deposit, which covers the entire area underlain by the Martinez formation.

Structure. The Martinez formation has the form of a very irregular, shallow, faulted syncline that trends northwest along the Temescal Valley.

In the Alberhill-Terra Cotta region the Martinez beds are folded into a broad syncline, the Sloan syncline, whose axis runs nearly parallel with that of the Elsinore trough and plunges northwest under the fanglomerate. This broad fold is well defined in the area of the Sloan clay pits south of the Los Angeles Brick and Clay Product Company's plant at Alberhill. The south dips of the Paleocene beds exposed in the Elsinore Clay Company's pits, together with the north dips of similar beds under the fanglomerate on the northeast flank of the Clevelin Hills, indicate the presence of a buried syncline in the North Elsinore region. The axis of this syncline appears to be in alignment with the axis of the Sloan syncline.

In the northern part of the area near Lee Lake, a limestone outcrop on the east side of the fault in section 7, T. 5 S., R. 5 W., shows a southeast dip, whereas about a mile to the southeast the dips are to the southwest. This relation suggests the presence of a south-trending syncline hidden beneath the fanglomerate.

West of the fault in section 7, the limestone dips 30° to the north. This abrupt change from southeast dips just east of the fault is part of the evidence for this fault.

Age and Correlation. Goodyear (1888, p. 176) stated in a description of the Cheney Coal mine (present Alberhill Coal mine): "The formation is either very recent Tertiary or perhaps post-Tertiary in age . . ." Five years later, Fairbanks (1893, p. 108) wrote: "The strata evidently belong to the Miocene-Tertiary, for a little farther down the valley fossils of that age are found. . . . Two miles south of the Temescal Post Office there is an outcrop of soft sandstone carrying Miocene fossils" (fossil locality El 1).

In 1916 J. P. Smith published his geological map of California (1916), which showed a single area of Eocene, rather than Miocene, northwest of Lake Elsinore. In support of this age assignment, Waring (1919, p. 70) stated "fossil plants collected from the Alberhill beds by Dr. Stephen Bowers have been identified by F. H. Knowlton to be of Eocene age, and they are probably contemporaneous with part of the beds of the Badlands north and east of Moreno. . . ."

Although Martinez fossils were found in the Santa Ana Mountains by Dickerson, (1914b, p. 69) as early as 1913, the formation has not been mapped in the Elsinore Valley.

Three localities (El 1A, El 1B, and El 2) yielded determinable fossils from clayey sandy limestone beds. The fossils were characteristic of the Martinez stage.

In spite of the uncertainties in correlating these beds, disconnected as they are by faults and covered by fanglomerate for more than 4 miles, the lithology and sequence probably justify the dating of the base of the Tertiary section as lower Martinez (Paleocene).

In the Alberhill-Terra Cotta region no fossiliferous limestone is present, but a sandstone near the old Terra Cotta brick plant (fossil locality El3) contains fossil plant impressions and the fine-grained black fissile shale bed beneath it contains poorly preserved shell fragments (Sutherland 1935, pp. 61-63).

The plant remains are leaf imprints identified as *Cupania oregonia* (?) (Chaney and Sanborn) associated with a few *Allophylus wilsoni* (?) and possible *Tetracera* (Chaney and Sanborn, 1933, pp. 63-64, 81, 82, 87). This assemblage probably is related to the subtropical Eocene Goshen flora.

The shell fragments were identified by W. P. Popenoe as consisting of pelecypods mostly of the genus *Cyrena* and some *Corbicula*, which, though they do not define the age, are good evidence of fresh- or brackish-water environment.

Fossil plant impressions were collected in the sandstone overlying the clay in the Elsinore Clay Company's pits (old Morton clay pits) near North Elsinore. They are few in number and so fragmental that their identification is only tentative. They are mostly stem remnants, assigned to the genus *Equisetum* (Lesquereux 1878, p. 69, pl. 6, figs. 5, 9) on account of their deep striae and short sheaths; acutely dentate and rare leaves probably belonging to *Platanus* (Lesquereux 1883, pl. 49, fig. 1) and to *Allophylus wilsoni* (?) Chaney and Sanborn (Chaney and Sanborn, 1933, pp. 81-82, pl. 24, figs. 1-4, 6; pl. 25, fig. 6).

The thickening of the Martinez section and the progressive change of the depositional environment of the rocks from fresh-brackish to marine in a northwesterly direction, and the fact that the fossils collected from the limestone beds were reworked suggest that the Paleocene shoreline was close to the most southeasterly exposures of Paleocene strata in the Elsinore trough.

Paleogeography. The Martinez sea covered the northwestern end of the Santa Ana Mountains at least as far south as the southeast corner of T. 6 S., R. 5 W. From this point, the Martinez sea extended eastward to the mouth of the Arroyo del Toro. To the west, the southern limit is not well defined. The Martinez probably merges into the Domengine in a southerly direction as suggested by the work of Woodford and others. Its southern limit is in the neighborhood of San Juan Hot Springs. The Martinez shoreline overlapped the southwestern edge of the Perris Block, as shown by the Emsco clay deposits in Dawson Canyon. If the McKnight clay deposits in the northwestern portion of the Santa Ana Mountains south of Corona are correlative with the Claymont deposits on the south side of Santa Ana Canyon, they show the probable extent of the Martinez sea in that region.

Physiographic Expression. When exposed to weathering and erosion the Martinez beds tend to form a rather subdued and rounded landscape, merging with the more recent formations. Thus they do not produce distinctive physiographic forms. However, when exposed in ravines or cuts they are easily distinguished by their prominent coloration, which ranges from white to red and brown. In many localities clay-bearing soils derived from the Martinez beds are characterized by a sponginess resulting from alternating hydration and desiccation. A grass cover is more common than brush.

Quaternary—Lower Pleistocene (?) Fanglomerate

Except for the Recent alluvium, poorly sorted pebble and boulder deposits of possible lower Pleistocene age are the only sedimentary units that are younger than the Martinez formation.

Beds consisting mostly of rounded cobbles and boulders of quartz latite porphyry unconformably overlie the Martinez formation and form cappings commonly less than 10 feet thick on the low hills located within and along the borders of the Temescal Valley. Pebble conglomerate consisting mainly of angular to subrounded grains of decomposed granitic rocks occurs as alluvial fans flanking the northeast side of the Santa Ana and Elsinore Mountains and the southwest side of the hills east of Lake Elsinore, and as valley fill in the Temescal Valley.

Poorly consolidated coarse gravel and arkosic sand deposits form cones at the mouths of the canyons issuing on both sides of the Elsinore trough. The cones are particularly well developed on the southwest side, against the Santa Ana Mountains and are evidence of the relatively rapid elevation of that side as compared to the other. The pebbles and boulders forming these conglomerates range from 2 or 3 inches to as much as 3 feet in diameter, the average being rather towards the smaller sizes. The pebbles are mostly granitic, but some were derived from metamorphic and porphyritic rocks.

Two types of fanglomerates have been distinguished in the Lake Elsinore quadrangle on the basis of lithologic composition, degree of consolidation, and structural relationships. Bedding in both fanglomerates is rather poorly defined, but a primary dip is commonly discernible, which increases with nearness to the mountain flank, but rarely reaches more than 4 or 5 degrees in the younger fanglomerate. On the other hand the older fanglomerate beneath it dips as much as 10 or 12 degrees, indicating a post-depositional tilt of at least 5 or 6 degrees. The younger fanglomerate surfaces, moreover, are less dissected by erosion than the older ones, which may be due to the difference in tilt or the longer exposure to weathering agencies. It is clear that the younger fanglomerate has been less affected by repeated faulting than the older fanglomerate.

The older fanglomerate has a coarser average size of particles than the younger, contains a larger proportion of pebbles of metamorphic and porphyritic rocks (mostly quartz latite porphyry), and shows greater development of limonite, which stains the outcrops. Because the older fanglomerate is distributed only along the margins of the Santa Ana Mountains and the Clevelin Hills its development appears to be directly connected with the growth of the Santa Ana Mountain block. South of Lee Lake the older fanglomerate is 210 feet thick, and north of Lucerne it is 165 feet thick.

The younger fanglomerate occurs as benches and fan slope accumulations at the mouths of canyons along both sides of the Elsinore trough. It is overlapped by Recent alluvium. The components of this fanglomerate are less altered and less indurated than those of the older fanglomerate. It contains a larger proportion of granitic material than the older one. From a pebble count made in Railroad Canyon it was found that 60 to 75 percent of the pebbles were granodiorite. The balance consisted mainly of slate and quartzite, with some diorite, rare mica schist, and a few fragments of basic intrusive rocks. The predominance of granodiorite fragments is particularly interesting because the nearest source of this type of rock is more than half a mile away; the surrounding country rocks are all metamorphic. These facts indicate the magnitude of the former extension of these fans, the large amount of erosion that they represent, and the considerable stripping that they have undergone since they were deposited. The younger fanglomerate occupies a larger area than the older one, an estimated 4 percent of the mapped area. The average thickness of the young fanglomerate is around 10 feet and locally may exceed 60 feet.

Because they have not been deformed to such a high degree as certain Pliocene beds in the nearby Bedford Canyon area the deposits are likely post-Pliocene, possibly lower Pleistocene in age.

The Recent alluvium consists mostly of silt and sand, with some gravel of fluviatile origin. The thickness of alluvium at the northwest end of Lake Elsinore has been estimated, on the basis of drill logs, to be about 160 feet. Most of the soil of the region is grayish sandy loam, though there is some red soil. The color change is probably due to an increase in the iron content of the source material; it is possible, however, that the red soil is an older residual soil formed in a warmer climate.

STRUCTURE

The Elsinore trough is essentially a graben between the Santa Ana and the Perris blocks. It is a complex graben, divided lengthwise into several smaller tilted blocks by a system of faults. The Santa Ana Mountain block has been uplifted on its northeastern margin and tilted to the southwest. The Perris Block stands high with respect to the trough, but is at a lower elevation than the eastern margin of the Santa Ana block. Apparently the Perris Block is not tilted except on its margins and probably has moved relatively little.

The Elsinore fault system constitutes one of the major tectonic elements of southern California. Its rift features can be traced from the east side of the Puente Hills in the vicinity of Pomona through the Peninsular Ranges to the Gulf of California. The Elsinore fault system is probably one of the oldest structural features in California.

Compared to faulting, folding is of minor significance in the Lake Elsinore quadrangle, although the Triassic strata and also the Martinez beds are folded. Most of the folding in the Triassic, however, probably occurred before the initiation of the Elsinore fault zone, whereas the Tertiary folding may have been contemporaneous with and related to the faulting. The major structural feature of the Triassic rocks is a monocline that dips to the northeast and may be the limb of a former broad anticline whose crest was west of the present Santa Ana Mountains. The Tertiary folding has been essentially synclinal with axes that parallel the trough.

The prevalence of northwest trends in faulting, folding, major joints and orientation of schlieren shows that, during much of the geologic history of this region, the forces that produced these factors were oriented very nearly in the same direction.

Faulting in this region commonly is shown by such direct evidence as slickensides, gouge and breccia, displacement of strata or dikes, and abrupt changes in the attitude of beds. Physiographic evidence consists of sagponds, displaced stream courses and alluvial cones, kernbuts and kerncols, triangular facets, and broad rectilinear arrangement of topographic features.

The principal structural element of the Elsinore trough consists of a system of faults which may be divided into two major groups: (1) piedmont or longitudinal faults, forming the northeast and southwest boundaries of the trough and separating it from the highlands of the Perris and Santa Ana-Elsinore Mountain blocks respectively; and (2) internal or transverse faults, which are between the faults of the first group or intersect them.

On the northeast side of the trough, from northwest to southeast, the piedmont fault group is represented by Lee Lake and North Elsinore faults, and the southeast extension of the Glen Ivy fault. The southwest side is marked by the Glen Ivy and Willard fault zones. These faults are parallel to the general trend of the trough and are en echelon with respect to one another. The piedmont faults of the southwest side are better defined than those of the northeast side as they show bolder scarps and generally more youthful forms. The major piedmont or longitudinal faults are:

Lee Lake Fault. On the north side of Lee Lake a well-exposed zone of strong parallel jointing with slickensides in the quartz latite porphyry is indicative of a fault. The average strike of this zone is N. 70° W. and the dip 52° SW.

To the northwest across Temescal Canyon, this fault is interrupted by a block that has moved southward on the Twin Springs right lateral fault and has deflected the stream course to the north.

Although a southeastward extension of the Lee Lake fault has not been proved, and is not shown on the map, its existence probably best explains the alignment of a series of rock facets and truncated spurs along Temescal Creek, with the back slopes and cols that interrupt several of the spurs between the canyons north of Alberhill. North of Shaw Mountain, a prominent divide between a northwest-flowing tributary of Temescal Creek and drainage to the southeast marks the southeastern prolongation of this same fault line. Still farther in the same direction it becomes lost in the uneven topography produced by a complex pattern of metamorphic rocks intruded by quartz latite porphyry and granodiorite. The difference in elevation between the trough and the southwest margin of the Perris Block, which near Estelle Mountain is as much as 2700 feet in less than 2 miles, cannot satisfactorily be explained as only an effect of erosion. Moreover, the lower slopes of this margin are very abrupt. The slope near Lee Lake, for example, averages about 45° for the lowest 500 feet. This abrupt form may have been produced by an increase in the cutting by Temescal Creek and the rapid lowering of its bed, but Temescal Creek now appears to be aggrading. The only alternative is to assume the presence of a fault that for a distance of about 5 miles lies along the northeast side of the trough. From the straightness of the alignment of these various features, the dip of this fault is inferred to be nearly vertical. Its average strike is N. 70° W.

North Elsinore Fault. The North Elsinore fault can be traced by means of abrupt dissimilarities encountered along its strike, either in the Tertiary rocks or in the metamorphic rocks. Prospects for coal and clay on the Langstaff Ranch showed beds of clay on the northeast side of the fault and none on the southwest side. In metamorphic rocks, on a ridge northeast of the town of Elsinore, an abrupt change of dip and strike in the slates and quartzites and truncation of dikes closely corresponds to a saddle on this ridge. Moreover, in the eucalyptus grove on the north side of the Atchison, Topeka and Santa Fe railroad tracks, this fault line is still visible in the form of a crevice in the alluvium on the southwest side of a road that traverses the grove. This crevice has been somewhat obliterated by caving and filling, but in 1926 it was traceable for at least an eighth of a mile and formed a trench that in places was more than 10 feet deep and averaged 2 or 3 feet in width. Small and shallow anastomosing cracks oriented subparallel to the major one were then visible, but they have now entirely disappeared. According to residents of the valley, this system of crevices was developed at the time of the San Jacinto earthquake in 1918.

The straightness of the course, N. 53° W., of the North Elsinore fault suggests that it is nearly vertical. No estimate of the movement on this fault is possible.

Glen Ivy Fault Zone. The Glen Ivy fault zone is a prominent feature that enters the Lake Elsinore quadrangle in the northwest corner near Glen Ivy Hot Springs and extends southeast toward Lucerne at the northwest end of the lake. About 1 mile northwest of this point, the fault zone leaves the margin of the Santa Ana-Elsinore Mountain block to pass under the alluvium and crosses the trough along the Clevelin Hills on the northeast side of Lake Elsinore. It disappears again under the alluvium and the fanglomerate at the southeast end of the lake.

The northwestern segment of this fault zone, between Glen Ivy and Lucerne, represents the piedmont fault system on the northeast side of the Santa Ana Mountain block. It consists of several parallel to sub-parallel step faults, that correspond to different lines of breaks, kerncols, and kernbuts. These faults can be traced only for distances of less than a mile, and appear to be en echelon or to intersect each other at acute angles. This fault zone is as much as a quarter of a mile wide and apparently decreases in width toward the southeast. Near Glen Ivy the fault line scarp at the mountain base is featured by remarkably prominent triangular facets. Its trace can be followed southeastward toward Lucerne by means of conspicuous rift features, such as longitudinal and abnormal drainage patterns accompanied by cols and saddles which show a N. 54° W. alignment.

Although the surface of the basal piedmont fault is not exposed anywhere along its course, attitudes of the short parallel subsidiary faults within the fault zone indicate that the dip of the surface is either vertical or steeply dipping to the northeast. In this zone, parallel jointing and brecciation are so highly developed that falls and steps in the bottom of canyons have been developed by differential erosion.

Geological and physiographic evidence shows that the region southwest of the fault has been upthrown relative to the northeast side, and that in Pleistocene time the vertical movement exceeded the horizontal. A throw of 1500 feet to 2000 feet is indicated by the correlation of the Estelle Mountain surface and the Los Pinos-Trabuco Mountain surface. Horizontal movements along this fault are suggested by the deflection of some of the stream courses that cross the fault zone and enter the trough. The deflection of some of the courses may be caused primarily by sags in the alluvium that were produced by downward movements which developed longitudinal drainage lines parallel to the trough. Where the deflected stream courses are still in hard rock, however, the deflection cannot be explained other than by strike slip faulting. This is shown in Horsethief Canyon, and even better in a small canyon immediately east of Kline Ranch where the deflections are to the southeast on the valley side. In Horsethief Canyon the final stream course trends north, whereas in the Kline Ranch area, the trend is eastward. In both localities the horizontal displacement is small and probably not in excess of 100 feet. As a whole, the Glen Ivy fault zone is right lateral and was developed under tensile stresses.

In its central portion, between Lucerne and the delta of the San Jacinto River, the Glen Ivy fault crosses the trough. Northwest of Lucerne the fault is marked by a scarp in the fanglomerate. This scarp has receded by erosion, but the trace of the fault is still indicated by a partially obliterated sag. Farther to the southeast the Glen Ivy fault is indicated by a scarp that forms the face of the Clevelin Hills which border Lake Elsinore on its northeast side.

In the Clevelin Hills area the upthrown side is on the northeast whereas in the area to the northwest the reverse is true. This reversal of movement suggests that the Glen Ivy fault is rotational and that its pivot is about 1 mile northwest of Lucerne. This also is indicated by a low divide from which drainage flows to the northeast and north toward Alberhill, and to the southeast toward Lake Elsinore. This divide is close to the supposed pivot line of the rotational fault.

This reversal also may have been caused by the independent movement of blocks on transverse faults that separated the Glen Ivy fault line into segments. However, movements on transverse faults, and on the Lucerne fault in particular, apparently took place before those on the Glen Ivy fault. This is shown by the relative recency of well-preserved physiographic features along the Glen Ivy fault, whereas along transverse faults they are almost entirely obliterated.

The dip of the Glen Ivy fault surface is nowhere observable in the Lake Elsinore quadrangle, but the straightness of the fault line scarp along the Clevelin Hills suggests a vertical or nearly vertical dip. The absence of correlative outcrops across the fault precludes a reliable estimate of the total displacement. Drilling near Lucerne on the downthrown side of the fault has shown that the contact between the lower Pleistocene fanglomerate and the Tertiary strata is at an elevation of 1000 to 1100 feet, whereas on the upthrown side the same contact is exposed at an elevation of about 1400 feet. This indicates a throw of about 300 to 400 feet since lower Pleistocene time. No indications of horizontal displacement were noted. The average strike of the Glen Ivy fault zone is N. 57° W.

Willard Fault Zone. The Willard fault zone forms the northwest face of the Elsinore Mountains and extends southeastward to the end of the Elsinore trough south of Temecula where it ends against the Agua Tibia Mountains. The fault line is well marked by the bold scarp of Elsinore Mountain. It is traceable as a straight line for about 11 miles and is marked at a few places by triangular facets. The recency of the movements of this fault or its parallel subsidiaries is shown by small hills and knolls detached from some of the mountain spurs. At one place, about half a mile west of Wildomar on the Lord Ranch, a small granite hill about 100 feet high lies between the piedmont fault to the northeast and a parallel branch to the southwest. A sag pond is on the south side of the col that separates this hill from the mountain. It records the most recent movement along this fault zone, which otherwise is marked along its length by slicing and abnormal drainage near the base of the scarp, and kernbuts and kerncols on the higher slopes.

The Willard fault zone consists of several major faults. The first is marked by a slope break at an elevation of 1450 feet, and is entirely in metamorphic rocks. The second lies along the contact between the metamorphic rocks and quartz diorite at an elevation of about 1700 feet. It strikes N. 75° W. and intersects the Willard piedmont fault which trends N. 53° W. The third is shown by a slope break encountered in quartz diorite at an elevation of 1850 feet, where an extensive line of kernbuts and cols lies along the mountain face. Another slope break marking yet another fault, is at an elevation of about 2100 feet; it probably represents the southern limit of the fault zone which, near Willard, has an apparent width of more than half a mile.

The straightness of the fault line suggests that the dip of the fault surface is nearly vertical or steeply dipping to the northeast. On the upthrown side of this fault is the Elsinore Mountain block to the southwest, and on the downthrown side is the Elsinore trough to the northeast. A direct measurement of the throw was not made as correlative strata are not exposed on opposite sides of the fault. However, the correlation of geomorphic surfaces on the Elsinore Mountain side and the southwest margin of the Perris Block suggests a throw of about 1500 feet. No stream displacements that permit an estimate of the horizontal movement have been observed. Many of the streams that reach the fault line tend to parallel it.

Wildomar Fault Zone. The Wildomar longitudinal fault zone limits the Elsinore trough on its northeast side and is marked by a prominent alignment of sags, fault-line scarps, and displaced outcrops. These features are exposed on the northeast side of State Highway 71 as far south as Temecula and northwest to Rome Hill. The width of the fault zone is about a quarter of a mile; the average strike is about N. 56° W., and the apparent dip is vertical. The upthrown side is on the northeast near Wildomar and on the southwest at Rome Hill, indicating a rotational fault that pivoted at some point between Wildomar and Rome Hill.

Among the internal or transverse faults forming the Elsinore fault zone, the most important are:

Temescal Fault. The Temescal fault cuts across the trough and ends to the west at the Glen Ivy fault near Compton Ranch, and to the east at the Alberhill fault. The average strike is N. 75° W., the dip 50° NE. Toward Alberhill, the fault splits into a southern branch oriented N. 70° W., dipping 52° NE. The north, or major branch, is well exposed in a roadcut southwest of the plant of the Los Angeles Brick and Clay Products Company near Alberhill. A brecciated zone more than 100 feet wide intersects the quartz latite porphyry and the slates of the Santa Ana formation. The north block moved northwest and downward relative to the south block; the strike slip is estimated to be about 1800 feet, and the throw about 600 feet. Both the Compton and the Twin Springs faults end against the Temescal fault.

High Power Fault. North of Kline Ranch, nearly parallel to the Temescal fault, the High Power fault forms a dissected scarp separating the diorite-gabbro from the metamorphic rocks and the clays resting upon them on the downthrown side.

Lucerne Fault. The Lucerne fault, at the northwest end of Lake Elsinore, intersects the longitudinal piedmont faults and is displaced to the south by the Glen Ivy fault. It separates the crystalline rocks from the alluvium, produces sags in the metamorphic rocks, and is marked by the spur between McVicker and Leach Canyons.

That the south branch of the Lucerne fault is older than the longitudinal piedmont faults is also indicated by the subdued topography of the mountain front. The spurs along the Lucerne fault are profoundly dissected, show gentle slopes and hardly any truncations. Near their mouths the canyons have a flat profile and join the alluvial surface at grade. The contrast of this region with the one to the north along the Glen Ivy fault or the one to the south along the Willard fault is very striking.

The measurable strike of the south branch of the Lucerne fault averages N. 10° E., but near its intersection with Los Pinos fault, it may branch in a western direction. The apparent dip is east, and nearly vertical, and the upthrown side lies to the west. On the north branch, the upthrown side lies to the east.

Other transverse trends similar to that of the Lucerne fault are observable on the northern and southern extensions of the Elsinore trough beyond the limits of the Lake Elsinore quadrangle.

On the Riverside quadrangle west of Glen Ivy Hot Springs a fault having a strike of about N. 15° W. shows rift features at the heads of the fans where stream courses are displaced. Near Hunter's Ranch, the mouth of a stream on the valley side is displaced about 150 feet to the north.

West of Murrieta on the Murrieta quadrangle, a change in the direction of the mountain face from N. 53° W. to N. 20° W. very likely marks a transverse fault. The fault is along a bold mountain scarp exposed from the Santa Rosa grade to the mouths of Slaughterhouse and Vail Cañons, near elongate hills of young fanglomerate, and deflects the courses of Vail and Murrieta Creeks. Hard rocks, mostly metamorphic, underlie the mountain face and are covered in part by young terrace fanglomerate. The terraces probably formed when the river was some 50 feet higher, before movements on the fault system rejuvenated the stream.

To the southeast, the mountain face again trends about S. 50° E. Recent drilling for water east of Murrieta reached Quaternary basalt under a thick cover of alluvium, Pleistocene fanglomerate and arkose. According to John Mann (1949) this evidence indicates a minimum throw of about 3300 feet.

Major Faults of the Santa Ana-Elsinore Mountain Block

In the southwest corner of the Lake Elsinore quadrangle two northwest trending faults are exposed:

Aliso Fault. The Aliso fault is a reverse fault with an average strike of N. 47° W., and a dip of 50° SW., showing left lateral movement; it is well expressed in rock patterns and by a series of drainage lines transverse to the consequent drainage lines of the streams flowing southwest.

Tenaja Fault. The Tenaja fault is also a reverse fault, more curviline than the Aliso fault, with a strike ranging from N. 82° W. at the southeast end, to N. 45° W. at the northwest end. The estimated dip is about 80° NE. The measured strike slip is around 1,300 feet and shows right lateral movement. Both faults are caused by hinge line adjustments of the Santa Ana-Elsinore Mountain block during its elevation on the northeast side along the Elsinore trough, and general tilt to the southwest.

Several faults transverse to the hinged line trend and apparently younger in age, criss-cross the mountain block. The most important ones are the following, shown on the geological map:

Los Pinos Fault. Los Pinos fault is a straight line feature extending from Hot Springs Canyon to the Elsinore trough, with an average strike of N. 60° E., separating Los Pinos Peak block to the north on the upthrown side from the Potrero de los Pinos on the downthrown side to the south. The fault is evidenced by abrupt termination of rock patches at its trace, prominent physiographic alignments, and some fracture zones. The direction of strike slip could not be determined.

San Juan Fault. San Juan fault is exposed along the south face of a low divide separating Morrell and Bear Canyons. The average strike is N. 55° E. and the dip ranges from 60° to 70° NW. Several brecciated zones are seen along the course of the fault, and movement appears to be normal left lateral.

Stewart Fault. The Stewart fault shows displaced contacts between the diorite and granodiorite indicating normal and right lateral movements with a throw of about 130 feet and a strike slip of 350 feet. The upthrown block is on the northeast side, the average strike is N. 23° W., and the dip is probably vertical.

Harris Fault. The Harris fault is a prominent feature with an average strike of N. 12° W. It can be traced for about 8 miles, either through displacements of outcrops or physiographic features. The movements are normal and right lateral with strike slip of about 1,300 feet and probable throw to the northeast of more than 1,000 feet. The region between the Stewart and the Harris faults forms the upthrown block of the Wildhorse Mesa.

GEOMORPHOLOGY

Detailed investigation of land forms, relief, stream gradients, differential weathering, and soils led to the recognition in the Lake Elsinore quadrangle of four old surfaces of erosion, which from the top down are: (1). Trabuco surface, between elevations of 3,900 to 4.575 feet; (2). Los Pinos surface, from 2,900 to 3,530 feet; (3). La Cienega surface, from 2,100 to 2,550 feet; (4). Santa Rosa surface, from 1,700 to 1,900 feet.

In the Corona quadrangle, northwest of Lake Elsinore, another surface was studied and outlined: the Santiago surface between elevations 4,800 and 5,680 feet. All these surfaces are exposed on the Santa Ana-Elsinore Mountain block. On the Perris Block side across the trough, two surfaces of erosion were correlated with the two upper ones on the southwest side of the trough. On the strength of that correlation the fault throw is estimated to be around 3,000 feet in the northern portion of the area and to decrease toward the southwest. That figure corroborates the estimates based on the displacement of the Martinez clay beds established by the author (1933) and on basalts by Mann (1955).

GEOLOGIC HISTORY

Extensive outcrops of undifferentiated metamorphic rocks of metasedimentary and meta-igneous origin, but more intensely metamorphosed than the Mesozoic metasediments, support the view that deposition took place during the Paleozoic and was followed by igneous activity and folding.

The oldest determinable fossil-bearing rocks are upper (?) Triassic marine limestone lenses (Santa Ana-Bedford formation) interbedded with arenites and pelites, suggesting variable marine conditions. The presence of conglomerates in that series indicates deposition close to an area undergoing erosion. Triassic deposition was terminated by extensive folding, then followed by intrusion of dioritic-gabbroic plutonic rocks.

A period of quiescence followed, during which an erosion surface was developed on the Tria-Jurassic metamorphic-igneous complex. Renewed igneous activity at the close of the Jurassic gave numerous acidic flows and dikes (Santiago Peak volcanics).

At the beginning of the Cretaceous, a prolonged batholithic activity started, which affected all the Peninsular Ranges. Very large areas were invaded by granodiorite and related plutonic rocks. Then extensive erosion took place and was followed during the Upper Cretaceous (Chico) by a marine transgression on the western margin of the original Santa Ana-Perris block.

Slight uplift of this margin caused erosion before another marine transgression during the Paleocene created alternating marine estuarine and littoral deposition on a large part of the original block.

During the Neocene, a marine regression toward the north restricted the deposition of sedimentary strata to thin veneers; these veneers protected the Paleocene from complete destruction. During most of the Pliocene, the Santa Ana-Perris block was essentially a lowland with major drainage to the northeast.

At the close of the Pliocene or beginning of the Pleistocene, there was renewed volcanic activity and outpouring of basalt toward the southeast. It was about that time that the major movements on the Elsinore fault system started. With the growth of the fault scarps, several fanglomerates and associated sediments, separated by unconformities, were deposited in the fault trough and erosion surfaces representing several pauses during uplift were carved on the highlands.

MINERAL DEPOSITS OF LAKE ELSINORE QUADRANGLE, CALIFORNIA †

BY RENÉ ENGEL,** THOMAS E. GAY JR.,* AND B. L. ROGERS *

OUTLINE OF REPORT

Illustrations

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† Manuscript received for publication December 1, 1955.

Illustrations—Continued

INTRODUCTION

This report, *Mineral deposits of Lake Elsinore quadrangle*, was written to accompany the preceding report, *Geology of the Lake Elsinore quadrangle*, to describe the economic geology of the quadrangle. The *Economic map of the Lake Elsinore quadrangle*, plate 2 of this bulletin, shows the locations of nearly all the mineral deposits discussed below, and is frequently referred to.

Dr. Engel made the original field investigation of the mineral deposits from 1926 to 1934, and intermittently thereafter until 1947, when plate 2 was prepared. Mr. Gay revisited nearly all deposits—except those of clay and coal—and prepared all but the clay and coal sections of the report, incorporating all data available in 1955. Mr. Rogers reexamined all deposits of clay and coal in 1955, and prepared those sections of the report, as well as plates 5, 6, and 7. Dr. Engel critically reviewed the report in its final form. The authors acknowledge with thanks the original documents and photographs of the Good Hope mine made available by the owner, Mrs. Velna L. Teater; and the cooperation of Alberhill Coal and Clay Company, Los Angeles Brick and Clay Products Company, and Pacific Clay Products in the preparation and publication of maps and data on their clay operations.

The economic mineral resources of the Lake Elsinore quadrangle include the metals arsenic, copper, gold, lead-silver-zinc, manganese, and tin; and the nonmetallic commodities clay, coal, limestone, silica, stone (including granitic dimension stone, building stone, metavolcanic road metal, and slate), and hot mineral springs. The earliest economic development of the area, dating back at least to 1857, centered around the placer gold deposits north and east of Elsinore. The Good Hope gold mine has a reported yield of about $2,000,000, by far the largest of any gold mine in Riverside County. In the last 50 years, clay from deposits in the Alberhill area has been the quadrangle's most important mineral commodity in terms of tonnage, dollar value, and continuity of production.

The following section is arranged alphabetically with metals first, nonmetallic commodities next, and mineral springs last. A tabulation of all deposits in the quadrangle, with summary descriptions, is at the end of the report.

METALS

Arsenic

Arsenic, in the mineral arsenopyrite, occurs in the veins of several deposits in the quadrangle, including the Lucky Strike, Yaeger, Mammoth, and Shining Star. An assay of 15.07 percent arsenic was reported from the Yaeger gold mine.* The Shining Star deposit was briefly worked but no production is recorded.

Shining Star Deposit (1). Location: Town-lot building site on the north flank of a small flat-topped hill just north of Pottery Street at Lewis Street, in the northwest part of Elsinore, in section 6, T. 6 N., R. 4 W., S.B. Ownership: not determined; in 1929 James Wrench of Elsinore held three claims on the deposit.

The deposit is on a fault contact between slate and quartzite of the Triassic Santa Ana (Bedford Canyon) formation, and Jurassic (?) diorite and gabbro (San Marcos gabbro). Aplitic dikes occur in the gabbro, and both rock types are decomposed near the surface, especially near the fault zone.

The fault zone, about 3 feet wide, trends N. 20° W. and dips about 68° SW as exposed in the shaft collar. Sugary siliceous material occupies the fault zone; parallel siliceous veins are reported in the adjacent rocks.

The deposit contains gold and arsenopyrite, with traces of black manganese oxide. A sample representative of a 2-foot width of vein was reported to assay $4.80 in gold, 12 percent arsenic, 7 percent sulfur, and 18 percent iron (Tucker 1929, p. 469).

In 1929 development consisted of two near-vertical shafts, 22 and 30 feet deep, and a 75-foot crosscut adit driven southward, its portal about 250 feet northwest of and 150 feet below the collar of the 30-foot shaft. The adit crossed five veins from 1 foot to 2 feet wide. In 1955 all workings were boarded but apparently uncaved. No production is reported; the property has been idle for many years.

Copper

No commercial deposits of copper have been found in the quadrangle, although traces of copper occur in gold ores, with base metal sulfide ores, and with iron oxide minerals. Small amounts of copper have been produced as a by-product at the Good Hope gold mine and the Old Dominion lead-silver-zinc mine. Minor showings of copper are exposed in the Silver Shine prospect adjacent to the Mammoth iron prospect.

The Beehive deposit in the southwest corner of the quadrangle is the only known deposit that has been explored primarily on the occurrence of copper minerals. This deposit is on the steep west wall of San Mateo Canyon about three-fourths of a mile S. 70° W. from the Mammoth iron prospect. The Beehive deposit consists of three undeveloped claims located in granodioritic country rock that encloses several small bodies of altered igneous rock reported to assay as high as 7 percent copper.

Gold

Both placer and lode gold deposits have been mined in the quadrangle. Placer deposits were discovered first and have been intermittently mined, but lode deposits account for most of the quadrangle's total recorded yield of gold. Placer deposits in the gently sloping wash between the Good Hope mine and the San Jacinto River (Railroad

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* Unpublished communication from the Commissioner of General Land Office, 1928 (?).

FIGURE 1. Good Hope mine. View southward of headframe, mill, and dump, taken about 1892. *Photo courtesy of Mrs. Velna L. Teater.*

Canyon) were among the first to be worked and were opened in the middle and late 1800s (Crawford 1894, pp. 220-221). This area is described (Crawford 1894, pp. 220-221) as an ancient north-trending river bed whose source lay to the north; the river bed is readily traceable from a point 2 miles north of Good Hope for several miles toward Elsinore. Where it reaches the San Jacinto River it is several hundred feet wide, more than 100 feet deep and apparently consists of two or more channels. Although little deep or systematic mining of the river bed was in evidence in 1894, most of the area had been worked by Mexican miners, and every gulch and ravine cutting the river bed is reported to have contained gold. Lack of water for hydraulic mining presumably hampered mining operations.

Binkley's' and Tyler's diggings (Merrill 1919, p. 527), near the junction of Cottonwood Creek and the San Jacinto River, east of Elsinore, were active as early as 1876, but the deposits and the operations have not been described in detail. The antiquity of mining in the Cottonwood Canyon area is mentioned by Merrill (1919, p. 527), who cites verbal reports of a 12-inch elder tree seen growing in an old arrastre bottom in the early 1880s and a location notice dated 1857 found just east of the Lake Elsinore quadrangle, on Redtop Mountain in T. 6 S., R. 3 W. These areas have been virtually inactive for 50 years or more, and are now largely inaccessible to mining because of private ownership of the land for dwelling, ranching, and water storage purposes.

A third placer mining area is in Lucas Canyon near the west edge of the quadrangle several miles south of Highway 74. About 1900 much excitement was occasioned by the discovery of gold in Lucas Canyon. Although two men are reported to have panned out about $40 an hour in one place, prospectors are said to have seldom made more than one dollar a day (Larsen 1951, p. 48). Barren gravel 10 to 20 feet thick covered the pay dirt. Claims in the area have been active as recently as the early 1950s but the output was not determined by the writers.

Lode deposits of gold are distributed throughout the quadrangle, principally in the form of quartz veins that cut Mesozoic granitic rocks or, rarely Triassic metamorphic rocks. Most of the gold-bearing lodes, including the Good Hope and Lucky Strike veins, are in the northeast quarter of the quadrangle. Scattered properties such as the Yaeger, Blue Goose, and San Mateo group in the western half of the quadrangle contain gold-bearing veins of minor importance.

Good Hope Mine (8). Location: about 5 miles northeast of Elsinore on the northwest side and about 200 feet northwest of Highway 74. The property includes 160 acres (NW¼ sec. 15, T. 5 S., R. 4 W., S.B.) and part of a claim extending northeast into section 10. Ownership: Patented land belonging to Mrs. Velna L. Teater, 500 South Occidental, Los Angeles.

The Good Hope mine yielded as much as $2,000,000 in gold (Merrill 1919, p. 527) during the 1880s and 1890s, but its output in the past 50 years has been discontinuous and relatively minor. As early as 1890 the mine was reported to be flooded. Unless pumped, ground water stands at about 60 feet below the surface; flooding has contributed in large part to the inaccessibility of the mine workings.

The following account of the mine's history is compiled from various published and unpublished descriptions, and personal communications from persons acquainted with the property (see references in tabulated list under Good Hope mine).

The Good Hope mine lies within Cretaceous granitic rocks that are deeply weathered near the surface and lie beneath a thick mantle near the mine. The major rock type encountered in the mine workings is gray homogeneous quartz diorite (Bonsall tonalite) which reportedly ranges in composition from syenitic granite to diorite. In the mined area the country rock is strongly chloritized and kaolinized. Mineralized zones are delimited by seams of gouge, talcose materials, and clay. Felsitic dikes and porphyritic basic dikes, from a few feet to as much as 30 feet wide are traceable as far as a mile on the surface, in the vicinity of the mine. Most of the dikes are parallel to the northward trend and steep west dip of the mineralized zone. One east-trending basic dike appears to mark the northern limit of gold deposition.

The Good Hope system of quartz veins strikes about N. 12° E., dips about 60° NW., and is discontinuously exposed in pits and shaft collars along the strike for more than 3300 feet. At the surface, the Good Hope vein system is about 100 feet wide, and consists of several quartz seams of subparallel strike from 3 to 20 feet apart, that appear to unite about 200 feet below the surface. In depth the quartz seams appear to form an irregular mineralized zone that ranges in width from 3 to 10 feet, and locally splits into two or more zones. The Back vein is a minor subparallel vein that splits from the Good Hope vein zone at a depth

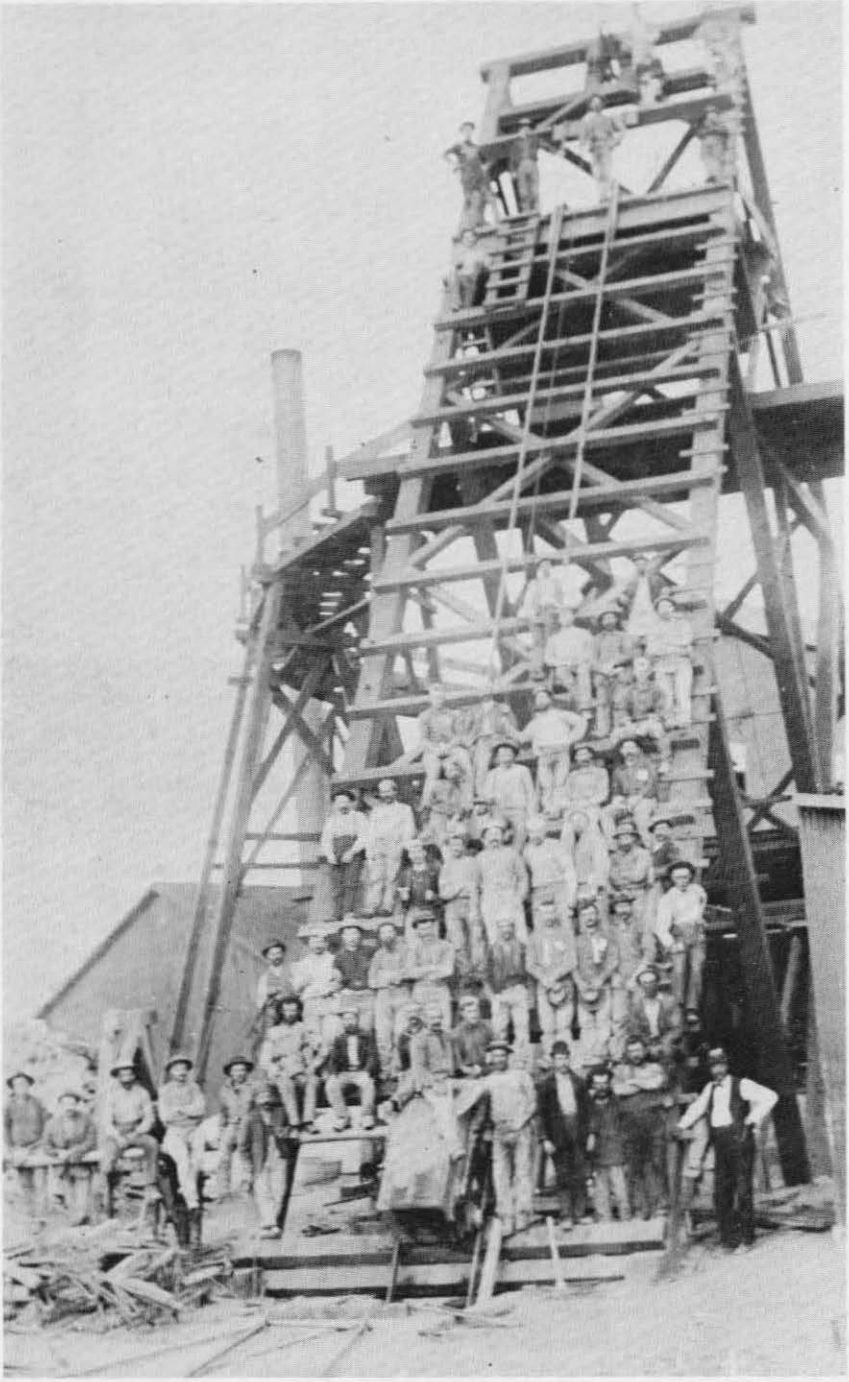

FIGURE 2. Good Hope mine. View southeastward of headframe and employees, with mill in background, taken about 1892. *Photo courtesy of Mrs. Velna L. Teater.*

of 180 feet, and is about 27 feet on the footwall side at the 95-foot level. The main ore shoot, which averages 18 inches in width in a vein 5 feet wide, pitches to the south at 45 degrees to 75 degrees down to the 350-foot level (J. M. Sigafus, owner, personal communication, 1908). Quartz seams commonly follow the hanging wall and footwall of the vein zone, and decomposed talcose granitic material fills the zone between. The vein quartz is strongly fractured and impregnated with secondary calcite and is friable where exposed. Although clay seams border the quartz seams and the vein zone, wall rock generally is hard and firm. The richest mineralization commonly is found in the quartz veins along the footwall of the zone, particularly at irregularities in the wall, or in small off-shoots into the footwall. With depth, the vein zone becomes more regular, and increases in richness. The ore is predominantly native gold in quartz, but the proportion of gold that occurs in sulphide minerals increases with depth. At the 300-foot level as much as one-third is in pyrite. Small amounts of galena are reported, and low values in silver—less than one ounce per 100 ounces of gold—were recovered.

The grade of the ore was consistent over the 3300-foot length of the vein sampled or mined. In the period 1890-92 ore mined along 1,875 linear feet of the vein averaged 24 inches in width and returned $15 to $20 per ton from the mill (gold $20.67 per troy ounce). An early report (Burnham 1893) quotes an average recovered value of $23.78 per ton, from the record of the entire mill run to that date. The same report states that the width of pay ore in all open workings averaged about 18 inches. A comprehensive assay survey throughout the mine, made about 1895, showed an average assay value of $22.51 per ton in gold for 209 samples. Ore shoots sampled were rarely wider than 30 inches, and most commonly they were 18 inches or less in width.

Little evidence remains to support the commonly quoted production figures of $1,500,000 (Cheatham 1909, p. 9) and $2,000,000 (Merrill 1919, p. 527) in bullion.

The total value of mine production to 1908 was placed at $600,000 to $700,000 by J. M. Sigafus, owner of the mine since 1889. If one adds $260,000 reported produced before 1889 (Burnham, 1893) and less than $10,000 produced in the 1930s (Harford, H. M., 1954, personal communication), the total value of output is less than a million dollars. For one of the mine's most steadily active periods, from March 4, 1890, to February 1, 1892, a return of 3,165 ounces of bullion of various finenesses, containing $51,465 in gold and $438 in silver, is listed in unverified returns from the U. S. Assay Office.

Mine workings are by far the most extensive of those of any mine in the quadrangle. Stoping was virtually confined to the Good Hope vein zone and little or no gold was found outside the vein walls.

The history of the mine began about 1874 when Mexican placer miners and a Frenchman named Mache first located the Good Hope vein zone. It apparently had been the original source of much of the placer gold mined for years prior to 1874 in the arroyo east of the mine. The Good Hope vein zone was found as a "blind lead" through systematic prospecting at the upstream limit of gold-bearing gravel. The vein was opened in numerous places along its course and the ore milled in arrastres, remnants of which remain in the arroyo south of the present mill. The north end of the vein was developed first, and was known as the San Jacinto claim. This operation soon consolidated with the Good Hope operation on the same vein about 1,000 feet to the south. Prior to 1889, when J. M. Sigafus and E. A. Bird acquired the property, $260,000 was reported produced (Burnham 1893) from workings nowhere deeper than 110 feet. From 1889 to 1894 the mine was intermittently active for a total period of about 24 months, yielding $5,000 to $10,000 net per month (Bird 1919). This work connected the San Jacinto and Good Hope workings underground and established the continuity of the vein zone. During this, the mine's main period of activity, more than 100 men were employed and almost all the workings shown on plate 4 were driven. The main shaft was deepened to 575 feet, and a pumping station was established at the 450-foot level. Five levels were developed: The A level, 80 feet below surface, was stoped 900 feet north and 500 feet south of the main shaft. Number 1 level, 225 deep, was driven 1,300 feet north, and 600 feet south of the main shaft. Number 2 level, 350 feet deep, extended 800 feeet north, and 425 feet south of the shaft. Number 3 level, 450 feet deep, driven 525 feet north, and 225 feet south of the main shaft, was the lowest level stoped, and yielded the highest grade ore. Number 4 level, at 550-foot depth, extended 225 feet north, and 225 feet south of the main shaft. All ore above the 250-foot level was reported removed (J. M. Sigafus, owner, personal communication, 1908).

In 1893 the mine's status and the preceding year's activity were summarized as follows (Burnham 1893):

Length of ore shoot	3300 feet
Lowest depth attained	416 feet
Length of vein developed	3000 feet
Width of vein fissure	4 to 10 feet
Average width of pay streak	2 feet
Average recovery per ton milled	$23.78
Ore milled	2434 tons
Bullion produced (past 12 months)	$57,879.78
Total expenses (past 12 months)	$15,509.00
Total bullion produced	$317,879.78

About 1893 the property was bought by a Haverhill, Massachusetts, corporation. In 1894, a 20-stamp mill was built. Litigation which began about 1895 tied up the property for the next 10 years. During this period an average of about 2,000 ounces of gold was produced each year by different lessees. Shortly after 1900, a cyaniding operation recovered a reported $11 per ton from an unstated tonnage of mill tailings. Ore bodies already outlined were removed during this period, while little exploration or maintenance work was done, and the mine became flooded and unsafe.

From 1903 to 1932 the mine was in bad condition and virtually inactive. Machinery was removed or destroyed and workings were largely inaccessible due to flooding and caving. In 1919 the mine was purchased by J. F. Hook for $450 at a tax sale and the inoperative machinery sold as junk.

About 1923, the present owner acquired the property but it remained inactive until about 1932 when the mine was leased and reopened by Good Hope Development Company. The main shaft was cleared and

FIGURE 3. View eastward of Good Hope mill building, long inactive, with mine dump in foreground. Perris surface is in near background, Mount San Jacinto on right skyline. *Photo by Mort D. Turner, 1954.*

retimbered to the 350-foot level, and more than 200 feet of level workings driven on the 95-foot and 166-foot levels. A 20-ton capacity mill used amalgamation, leaching, and flotation methods to treat several thousand tons of old dump as well as new development ore. Several hundred ounces of gold were recovered before financial difficulties and mine safety regulations caused the closing of the mine in 1936.

The most recent attempt to open the mine was that of the Panamint Mining Company, which leased the property from 1947 to 1953. The main shaft was reopened to a depth of 115 feet and a new 50-foot shaft was sunk near the south end of the property. One to three miners were active but no production resulted. In 1955 all shafts were inaccessible and had badly caved collars. No operative machinery remains, and all workings below about 50 feet are flooded and presumably largely caved.

Lucky Strike Mine (13). Location: Northeast base of low hill just southeast of Highway 74 about 3 airline miles northeast of Elsinore in sec. 21, T. 5 S., R. 4 W., S.B. Ownership: R. S. Fisher and R. L. Reade, Elsinore (1945) own an undetermined area of patented land (formerly railroad land), including the mine.

The Lucky Strike is a lode mine of undetermined but small production, that was last reported active in 1919 (Merrill 1919, p. 529) and has been idle for many years.

Country rock is quartz diorite (Bonsall tonalite) widely exposed in the area. Within 20 or 30 feet of the surface it is quite weathered and disintegrated. A quartz vein, about 15 inches wide at the surface, strikes N. 80° E., and dips 45° S in the collar of the main shaft, but apparently turns to strike N. 55° E. and dip 55° SE where exposed 100 feet to the east. The vein is discontinuously exposed for several hundred feet across the low hill. Alluvium covers the extensions of the vein on each side of the hill. At the surface, the vein quartz is strongly stained with iron oxides and has a well-defined clay selvage. A second, more northerly vein, not exposed on the surface, is reported also to strike east, but to dip 35° and intersect the main vein at the 50-foot level. The veins contain free gold, silver, marcasite, pyrite, arsenopyrite, and copper oxide stains; the north vein has the higher silver content. On the 50-foot level the vein is reported to range in width from 2 to 24 inches, and to average about 10 inches (Sampson 1935, p. 513). On this level the oreshoot is reported to be about 85 feet long (Sampson 1935, p. 513).

Mine openings include the main shaft, inclined 45° along the main vein and 150 feet deep, and a second inclined shaft of undetermined depth about 100 feet to the east. In 1955 both shafts were caved at a depth of about 30 feet and inaccessible. Past reports indicate the existence of a 100-foot drift to the north (presumably east) off the main shaft on the 50-foot level, and a 150-foot drift in the same direction on the 150-foot level. Although the lower level was under water in 1935, it was reported to have exposed a 30-inch width of sulphide ore bearing 25 ounces of silver and $8 in gold per ton (Sampson 1935, p. 513).

In 1935 the mill equipment included jaw crusher, hammer mill, classifier, and concentrating table. All equipment except the headframe was removed prior to 1955.

Yaeger Mine (20). Location: Precipitous south side of upper Trabuco Canyon, about 2¼ airline miles east of U.S. National Forest Guard Station at mouth of Holy Jim Canyon, and about 6 airline miles west of Willard in sec. 2, T. 5 S., R. 6 W., S.B., projected. Ownership: Nine patented claims owned by Lillian E. Yaeger, 108 West Brookdale Place, Fullerton.

The Yaeger mine is a long-inactive lode mine that was located in 1887, yielded a small amount of gold-silver concentrates prior to 1900, and has been virtually inactive since. Patent to nine of the original 15 claims was obtained in 1926, and although contested by the Forest Service, was confirmed in 1928. All but minor parts of the mine openings were caved or dangerous to enter in 1955. Much of the following description is taken from past reports, published and unpublished (see references in tabulated list under Yaeger mine).

The country rock in the mine area consists of Triassic quartzite and slate of the Santa Ana (Bedford Canyon) formation. Quartz veins associated with vein-like bodies of granitic rock are localized along fault or shear zones that strike N. 30-40° W. and dip 45° to 60° NE. Four parallel veins were explored. These range from 1 foot to 10 feet in width, and contain oreshoots from 6 inches to 5 feet wide. The veins were named the Iron Chief, Cold Spring, Black Bear, and Trabuco. The disposition and spacing of the veins is unknown to the writers. The Iron Chief vein, bearing chiefly magnetite, is well-defined and hard, and occurs between walls of quartzitic rocks. The other veins, apparently mineralized shear zones, are less well defined. In addition to gold and silver, minor percentages of lead, zinc, and copper are present as sulphides; pyrite and arsenopyrite are locally abundant, disseminated in mineralized zones. Portions of the veins are strongly oxidized. Backs were generally strong, and no timber was used underground.

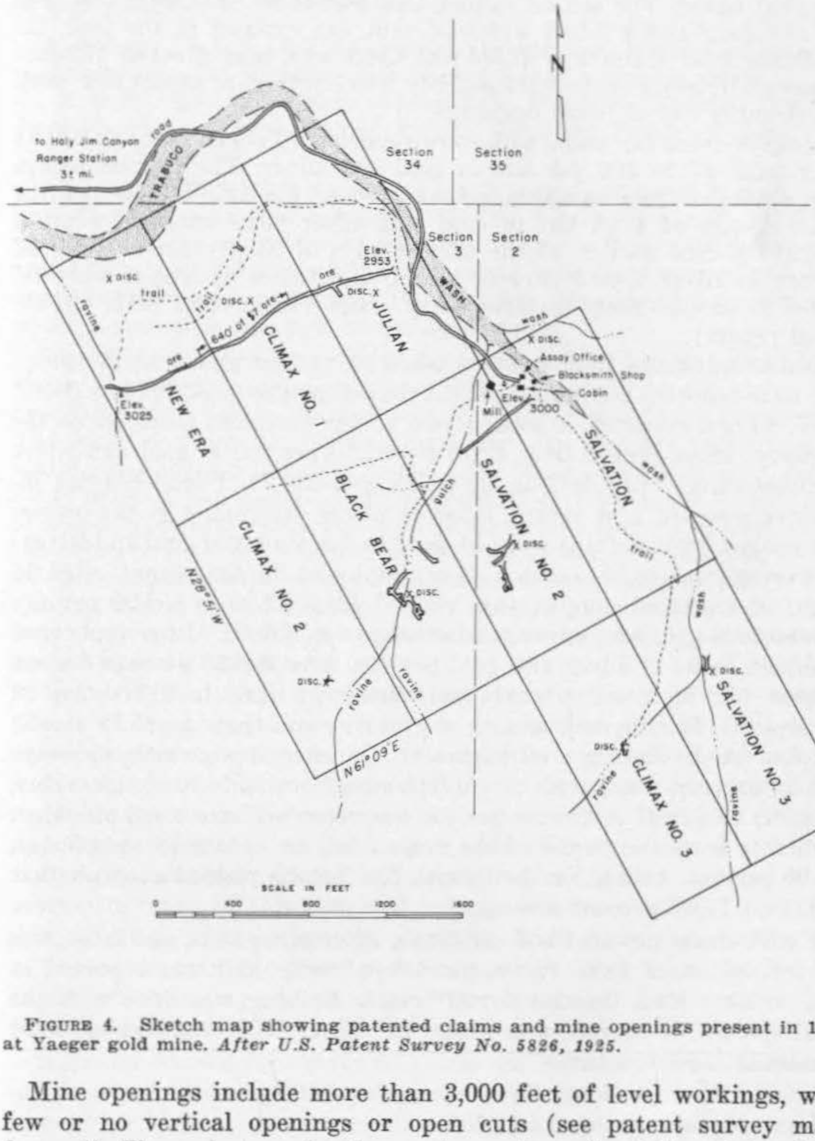

FIGURE 4. Sketch map showing patented claims and mine openings present in 1925 at Yaeger gold mine. *After U.S. Patent Survey No. 5826, 1925.*

Mine openings include more than 3,000 feet of level workings, with few or no vertical openings or open cuts (see patent survey map, figure 4). The main tunnel, whose entrance is on the Julian claim about 1,000 feet west of the camp buildings, extends nearly 2,000 feet about S. 60° W. It crosscuts three veins. Little or no stoping or lateral exploration is indicated.

The following descriptions of the mine openings are taken largely from Huguenin (1917, unpublished report). A 65-foot adit was driven on the Iron Chief vein. Just east of the camp buildings is the portal of a 560-foot southwest-trending crosscut adit in which a 5-foot width of ore was reported at the face. On the Cold Spring claim (unpatented) two drift adits existed as early as 1917; the lower of these was 197 feet long, but caved. The second tunnel, 200 feet above the lower one, was 300 feet long and a 3-foot width of vein was exposed in the face. On the Black Bear claim was a 300-foot drift adit, and a caved 122-foot crosscut adit below it. In 1917 activity was confined to assessment work and cleaning out of caved openings.

Samples from the main adit were reported (Tucker 1925, p. 62) to assay from $7 to $20 per ton in gold and silver. The highest assays were obtained from samples collected where the adit intersected the veins. Assays of $7 a ton in gold and silver were obtained along a central 640-foot portion of the adit. Assays of $5 per ton in gold, $2 per ton in silver, 2 to 3 percent nickel, and traces of copper were reported in samples from the Iron Chief claim (Huguenin, 1917, unpublished report).

Numerous assays from samples taken at various places on the property were reported during the patent contest proceedings, 1926 to 1928.* F. W. Yaeger reported 20 assays from widely scattered localities on the property. These ranged from $2.18 to $97.50 per ton in gold and silver in undetermined proportions, and averaged $30.71. Forest Service inspectors reported nine assays, taken at places designated by the owner, that ranged from nothing to $2.51 per ton for combined gold and silver; the average was $0.89. Jacob Yaeger, applicant for the patent, cited 18 assays of scattered samples that ranged from $2.00 to $55.00 per ton in combined gold and silver; the average was $20.08. Other reports of combined value of silver and gold per ton were $26.68 average for six samples (R. H. Stevens, analytical chemist); $1.81 to $17.04 for 39 samples (G. W. Paymal, mining engineer); and trace to $5.79 for 18 samples (A. L. Koebig, civil engineer). Of interest were several assays high in arsenic, computed by undetermined methods to dollar value. An assay of $28.31 in arsenic per ton was reported from a sample taken 2,315 feet from the portal of the main adit; an unlocated sample ran $16.00 per ton. An adit on the Climax No. 3 claim yielded a sample that contained 15.07 percent arsenic.

A mill, steam powered and consisting of crusher, rolls, and table, was constructed about 1895. It was used but briefly, and was reported in 1926 to have been inactive for 30 years. Nothing was done with the small amount of concentrates produced. About 1950, fire destroyed the remaining mill structure.

Total production from the property was 465 pounds of ore of undetermined value shipped in 1895.

Iron

Unworked deposits of magnetite and hematite are present in the Mammoth claims in the southwest corner of the quadrangle. Magnetite was reported (Huguenin, 1917, unpublished report) in one of the veins

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* Commissioner of General Land Office unpublished communication to Register, Los Angeles, California, reference Los Angeles 041582 "N" AKJ, contest No. 5292, United States vs. Jacob Jaeger, about 1928 (undated) 21 pp.

at the Yaeger gold mine, but was never mined. Iron minerals are abundantly present in the form of pyrite, pyrrhotite, and arsenopyrite at many of the mines in the quadrangle but none of these minerals has been of commercial interest to date.

Mammoth Claims (26). Location: Lower San Mateo Canyon, just upstream from its junction with Nickel (Quail) Canyon in sec. 7, T. 8 S., R. 6 W., S.B. Ownership: Howard V. Harrison, Thomas Dunston, Paul Harris, and Beth Harris French, Box 502, Fallbrook, own eight unpatented claims.

The Mammoth claims cover a discontinuously exposed belt of magnetite-bearing rock that trends N. 45° W. for about a mile northwest and half a mile southeast of San Mateo Creek. The zone follows the trend of a fault parallel with, but nearly a mile southwest of, the Aliso fault. Country rock is Jurassic (?) andesite (Santiago Peak volcanics) widely exposed in this part of the quadrangle.

The most extensive outcrops of magnetite are on the Mammoth No. 3 claim. Outcrops extend nearly the 1500-foot length of the claim, separated by areas, 100 to 300 feet wide that are covered with overburden. The exposed magnetite bodies apparently dip steeply; they range in width from about 5 to about 20 feet. The largest single outcrop, on the south bank of San Mateo Creek, is about 18 feet wide and 30 feet long. M-scope exploration indicates that near-surface magnetite adjacent to the outcrops reaches a width of as much as 50 feet, not counting 15- and 20-foot wide horses of country rock within several outcrops (H. V. Harrison, personal communication, 1955). Assays indicate 62 percent iron, with traces of chromium, vanadium, nickel, cobalt, and titanium, according to the owners.

Magnetite, in very fine grains, apparently has replaced sheared phases of the andesitic country rock. Unreplaced siliceous material is abundant throughout most of the magnetite rock as streaks and disseminated grains. The rock has a dull black, almost powdery appearance on fresh fractures. Except when pulverized, even the most siliceous-appearing fragments of the magnetite-bearing rock are strongly attracted to a magnet. Pyrite is present in small grains in some of the magnetite rock and thin seams of gypsum fill many joints.

In addition to the magnetite deposits of the Mammoth claims, iron is present in hematite-bearing deposits which occur in a parallel belt about 3000 feet long and about 1500 feet southwest of the southeasterly Mammoth claims.

Although known for nearly 60 years, the Mammoth deposits are still practically undeveloped, largely because of the steep and inacessible terrain. A 12-foot adit and bulldozer cuts expose the large magnetite body on the southeast bank of San Mateo Creek, but only exploration with a magnetic detector has been done on the other outcrops. In 1946-47 several miles of jeep road, with grades as steep as 17 percent, was bulldozed down the west wall of San Mateo Canyon from Indian Potrero to the deposits. By 1953, when rains washed out the road, about 15 tons of magnetite rock was hauled up from Mammoth No. 3 claim for tests that were still in progress in 1955.

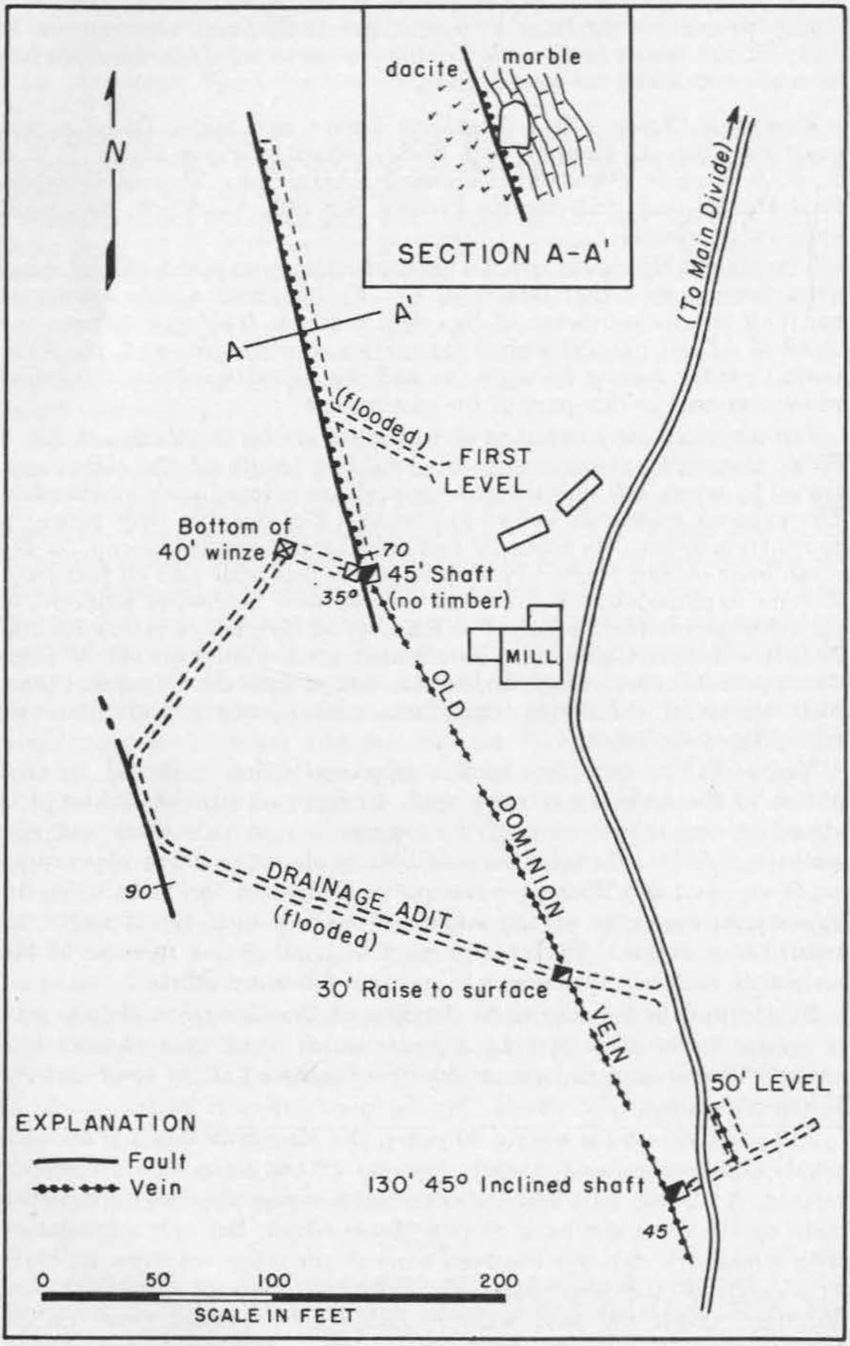

FIGURE 5. Sketch map showing mine openings present, but largely inaccessible, in 1953, at Old Dominion lead-silver-zinc mine. *After description by Earl Frevert, co-owner, 1953.*

Lead-Silver-Zinc *

Lead-silver-zinc ore has been mined at the Old Dominion mine. Several prospects to the north and east of Elsinore show minor amounts of complex sulfide ore but production has never been reported. A small proportion of silver was recovered at the Good Hope mine; assays from most of the quadrangle's copper and gold deposits also showed by-product silver.

Old Dominion Mine (27). Location: Near the head of Long Canyon, just southwest of the main divide crest about 3 airline miles west of Willard. Ownership: V. B. Anderson, 117 Spurgeon Street, Santa Ana, and Earl Frevert, 218·East Second Street, Santa Ana, own about 660 acres (sec. 7, T. 6 S., R. 5 W., S. B., formerly railroad land).

The Old Dominion mine, has been intermittently active on a small scale, yielding a total of several hundred tons of complex sulfide ore between 1894 and 1943. Steady production has been hampered by metallurgical difficulties in treating the ore.

The mine is near the northeast-trending Los Pinos fault zone in Triassic Santa Ana (Bedford Canyon) quartzite, slate and marble. In the vicinity of the mine the rock is more intensely metamorphosed than normal (Larsen 1948, p. 132). A small body of dacite forms the west or footwall of the vein whereas quartzite and marble predominate on the east or hanging wall side. Mineralization appears to be restricted to the Old Dominion vein, which is in a shear zone that trends N. 25° to 30° W. and dips 45° to 70° NE. It is exposed intermittently for a strike distance of about 300 feet north from Long Canyon to an offsetting fault. The vein zone is 6 to 8 feet wide, and nearly parallel to the bedding direction in the adjacent metasedimentary rocks.

In outcrops the vein zone consists of brecciated silicified metasedimentary rock. The metallic minerals have been oxidized to porous iron oxide so that their original nature is obscure. Past reports indicate that the oxidized material passes at shallow depth into "a mass of intimately mixed, fine-grained sulfides of lead, iron, copper, and zinc" (Crawford 94, p. 25). This ore consists of quartz, altered feldspars, and hornblende, with pyrrhotite, pyrite, and galena. These minerals could be seen in specimens which the writer gathered from the dump in 1955. Sphalerite and chalcopyrite are abundant and intimately mixed with the other sulfide minerals in a fine-grained massive complex ore. Gold, silver, nickel, and tin are also reported to be present (Larsen 1948, p. 132; Bedford 1946, p. 11).

Inconsistency between assays of samples from different parts of the vein indicates erratic distribution of values, and makes difficult the development of a consistently effective milling process. Assays range from 2 to 20 percent lead; from a trace to 10 percent zinc; and from a trace to nearly 5 percent silver (Paul Harris, personal communication, 1954). A shipment of 100 tons of ore in 1942 assayed 0.02 ounces of gold and 25.8 ounces of silver per ton, 0.3 percent copper, 3.5 percent lead, 3.1 percent zinc, and 21 percent iron for a total value of $13.63

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* The compound heading lead-silver-zinc is here applied to deposits with complex sulfide mineralization, wherein ore minerals, predominantly galena and sphalerite, are mixed so that all three metals are present in recoverable proportions throughout the ore.

Partial assays of eleven samples from the Old Dominion mine *

No.	Location	Gold (ounces per ton)	Silver (ounces per ton)	Lead (percent)
1.	Old dump	0.02	3.6	tr.
2.	Near vertical shaft, 50-foot depth	0.16	18.6	0.12
3.	First level adit at vertical shaft	0.05	11.2	tr.
4.	First level adit	0.05	17.5	6.64
5.	Vein north of first level adit	0.35	25.0	12.09
6.	Inclined shaft, 60-ft. depth	0.04	20.3	0.76
7.	Near Number 6	0.01	13.8	1.74
8.	Inclined shaft, 20-ft. depth	0.08	41.4	6.63
9.	Inclined shaft, ore dump	tr.	6.8	tr.
10.	Inclined shaft, ore bin	tr.	19.5	0.20
11.	Inclined shaft, selected ore from bin	0.03	45.2	8.51
	Average metal content	0.07	20.3	3.36

* Earl Frevert, 1942, personal communication.

per ton; 15 tons of selected ore was reported to assay 0.03 ounces of gold and 45.2 ounces of silver per ton, 8.7 percent lead, and 9.11 percent zinc (Tucker 1942, unpublished report).

Underground mine openings have been entirely flooded or caved since prior to 1953. Most of the following description is taken from an unpublished report by W. B. Tucker, prepared in 1943.

An inclined shaft at the southern edge of the workings follows the vein beneath Long Canyon on a 45° incline eastward. The shaft was 65 feet long in 1942, and was deepened to 130 feet in the early 1940s, when a 20-foot drift was driven northwest at the 50-foot level. An 18-inch shoot of high-grade lead-zinc ore along the hanging wall of the vein zone yielded the $13.63 ore shipped in 1942.

About 100 feet north of the inclined shaft a crosscut adit, the "drain tunnel" was driven about N. 70° W. from a point just west of the road in the bottom of Long Canyon. About 40 feet from the portal it crosses the Old Dominion vein, which is small at that point. A 30-foot raise was driven to the surface at the vein intersection. The adit extends several hundred feet past the vein, curving more than 90 degrees to the right and finally joining a winze in the north end workings. A fault encountered by the adit at its westernmost point is reportedly the source of water which presently floods the adit. The north end workings are just northwest of the mill, about 300 feet from the inclined shaft. The vein here strikes N. 40° W., and dips 70° NE. A crosscut adit, the "first level," also dammed and flooded, is driven N. 70° W. from a point just north of the mill buildings through quartzite and marble. Fifty feet from the portal is a north trending vertical fault that is explored to northward by a 180-foot drift. The fault is also explored for 75 feet southward by a drift which joins the bottom of a 45-foot shaft sunk on the vein-fault intersection. A 40-foot winze inclined 35° W. from the bottom of the shaft, reaches to a depth of 80 feet where the previously described drainage adit joins from the southwest. At this depth the dip of the fault flattens somewhat to the west, and the ore is cut off.

As early as 1894, unsuccessful attempts were made to smelt the ore (Crawford 96, p. 33). A variety of mill equipment has accumulated at the mine since then in the effort to develop a successful milling process. Equipment present but not operative in 1955 included a diesel-electric power unit, flotation cells, jaw crusher, rod mill, ball mill, and spiral classifier.

The mine is known to have been active for several-year periods about 1894, 1927, and 1942. From 1943 to 1955 a variety of laboratory tests were made to find a practicable method to recover salable products.

Manganese

Manganese minerals occur in several outcrops in the rolling hills northeast of Elsinore on the west side of Railroad Canyon. Manganese showings, commonly black manganese oxides altered from rhodonite, are entirely in siliceous zones that appear to have been chert lenses in Triassic Santa Ana (Bedford Canyon) slates. Only one property, the Beal-McClellan, has yielded ore. This is reported to total less than 100 tons and was shipped about 1941. Confusion exists in past reports: workings on the Beal-McClellan property have been erroneously described as on the Elsinore deposits, which have never been developed. Abundance of silica with the manganese minerals has hindered development of all known deposits in the quadrangle.

Beal-McClellan Property (Black Eagle and Newport, Brum and Newport) (29). Location: Headframe is on the ridge line of the west side of Railroad Canyon, about 100 yards north of the south boundary of sec. 23, T. 5 S., R. 4 W., S.B. Ownership: G. S. Beal and R. W. McClellan, Elsinore, and G. R. Smith, La Habra, hold patent (1950) to what was formerly railroad land.

The deposit lies in the bedding plane of Triassic Santa Ana (Bedford Canyon) slate, that here strikes N. 60° to 65° W. and dips 50° NE. The manganese-bearing zone is 3 to 4 feet wide as exposed in mine workings, and can be traced discontinuously for more than 250 yards down a steep draw eastward. Wall rock of the zone is slate; the manganese however, impregnates a siliceous layer, apparently a banded chert bed somewhat recrystallized (Trask 1950, pp. 180-182, contains complete description). Northwest of the headframe several minor manganiferous zones with parallel trend are exposed.

Just east of the ridge line, manganese minerals occupy nearly the whole width of the chert zone as exposed in mine openings. To the east and west however, manganese content in the zone decreases and is seen as parallel dark bands in the chert and siliceous slates. Similar dark banding occurs in the slates just northwest of the ridge line exposures.

The ore consists of black manganese oxides, both hard and soft, apparently formed by partial to complete oxidation of rhodonite. Prismatic rhodonite crystals as long as 0.2 of an inch have been reported (Trask 1950, p. 181). Dark brown massive opaline material, sparingly present, has been tentatively identified as neotocite or bementite (Trask 1950, p. 181). An analysis of a sample from the property showed 34.42 percent manganese, 9.52 percent silica, and 0.14 percent phosphorus (Bradley 1918, p. 57). A dump sample contained 30.87 percent manganese (Trask 1950, p. 182).

Development and mining have been confined to the richest part of the exposed portion of the zone which is in the 75-foot segment just east of the ridge line. About 50 feet below the ridge line an irregular drift adit extends about 80 feet into the hillside. The first 40 feet of the adit have been extended upward into an irregular open stope about 25 feet high and 3 or 4 feet wide. In the stope the ore was apparently about 2½ feet in maximum width, with much pinching and swelling and several minor offsets by faulting. The most completely oxidized, hence most valuable ore appears to be within 20 feet of the ground surface and to grade downward into unreplaced rhodonite and chert. The interior limit of the stope shows gradational decrease in manganese to thin streaks of manganese oxide and silicate minerals or siliceous rock. Two 10-foot crosscuts into the hanging wall, at about 40 and 60 feet from the portal of the adit, penetrate barren slate. About 150 feet below and east of the headframe, black and white banded siliceous rock, apparently the strike extension of the chert band, has been prospected in a small cut, but no ore has been removed. Similar streaked rock is also exposed on the strike of the same zone about 200 yards east of the headframe, on the north wall of the steep draw. Here an inclined open cut about 30 feet long, 10 to 15 feet wide, and as much as 5 feet deep exposes a 2-foot width of black manganese-bearing rock amid streaked chert. Apparently no ore was mined. West of the headframe, several open cuts and shallow pits expose showings of similar manganiferous siliceous rock for a distance of several hundred feet, but apparently no ore has been mined.

As early as 1900, development was reported in the area of this deposit (Aubury 1906, p. 336), but not until the second world war was ore removed on a commercial basis. According to Trask (1950, p. 181) a production of 50 tons is listed from the claim; the 1941 production was said to be 30 tons. In 1945, the property was idle, but it was reported that several cars of ore previously shipped to Kaiser Steel Company at Fontana contained 30 to 35 percent manganese (Tucker 1945, p. 150). No subsequent work has been done to alter the estimate that no more than 100 tons of additional oxide ore could be expected from the developed ore bed (Trask 1950, p. 182).

Past reports (see references in tabulated list under Elsinore mine) describe under "Elsinore deposits" two showings of manganese in secs. 23 and 24, T. 5 S., R. 4 W., S.B., a "West group" in section 23 on the west side of Railroad Canyon, and an "East group" in section 24 on the east side of the canyon. Country rock in both areas is Triassic Santa Ana (Bedford Canyon) slate.

A comparison of these reports with field observations made in 1955 confirms the speculation by Trask (1950, p. 181) that these descriptions were based on observations at the Beal-McClellan deposit. All workings reported in section 23 (e.g. Aubury 1906, p. 336; Bradley 1918, p. 58; Merrill 1919, p. 546; Tucker 1929, p. 493; Jenkins 1943, p. 83; Trask 1950, pp. 182-183; and Tucker 1945, p. 150) apparently apply to the Beal-McClellan deposit. No other workings for manganese were noted in section 23 in 1955.

The East group of Elsinore claims (Merrill 1919, p. 546) was reported to be half a mile north of the West group and to extend as far as 1½ miles east of the railroad in the bottom of Railroad Canyon (Bradley 1918, p. 58). Merrill (1919, p. 546) indicates that this group includes three parallel veins that crop out discontinuously for a strike distance of several hundred feet, the central vein being poorly exposed but possibly 16 to 20 feet wide. A later report (Bradley 1918, p. 58), quoted with slight modification by Trask (1950, pp. 182-183), apparently applies this description of the central vein of the East group to a vein on the West group, actually the Beal-McClellan property. The East group deposits may lie off the quadrangle and to the east.

Tin

About 7 miles off the Lake Elsinore quadrangle, to the northwest of Elsinore, is the Cajalco or Temescal tin deposit, the principal locality in the state that has yielded tin in commercial quantity. The geologic environment of the Cajalco mine is very similar to portions of Lake Elsinore quadrangle, suggesting the possibility that tin may be present in the quadrangle.

Two minor occurrences of the pegmatite mineral tourmaline are known in the hills north and east of Elsinore and traces of tin ore are reported with one occurrence, the Chief of the Hills tin group. The area was prospected in the late 1920s but no tin-bearing minerals were identified by name and reported, and no tin was produced. Several prospects in the quadrangle (e.g. numbers 33 and 34 on plate 2) are labeled "Sn" although no tin-bearing minerals have been recognized. In the mid-1930s several prospectors sought tin in the hills a few miles east of Elsinore but little or none was found in any of these prospects (Larsen 1948, p. 133; Bedford and Johnson 1946, p. 10).

No trace remains to identify the unproductive American Flag and Monarch tin properties reportedly comprising at least 20 open cuts and shallow pits in the granitic and metamorphic rocks about 2 miles east of Elsinore (Bedford and Johnson 1946, pp. 10-11).

Uranium-Thorium

Uranium- and thorium-bearing minerals have not been reported in the quadrangle, but traces of radioactivity are found along San Juan Canyon for about 5 miles east of the western edge of the quadrangle. Anomalous radioactivity occurs in metamorphic rocks of the Santa Ana (Bedford Canyon) formation in quartz diorite, granodiorite, diorite, and gabbro. A number of claims were staked along Highway 74 late in 1954, apparently on the basis of Geiger and scintillation counter indications of radioactivity. Little or no discovery work or improvement was visible on the claims, which were idle in January 1955.

NONMETALS

Clay *

The Alberhill area, in the northern part of the Lake Elsinore quadrangle and at the southeast end of the Temescal Valley, contains the largest known high-aluminous clay deposits in southern California. These deposits have been developed by 24 clay pits south of the town of Alberhill in secs. 21, 22, 23, and 26, T. 5 S., R. 5 W., S.B. In 1955 twelve pits were active; these were operated by the Alberhill Coal and

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* In the following discussion the rock units referred to as Bedford Canyon formation and the Santiago Peak volcanics correspond in general to the units referred to as the Santa Ana formation and the Jurassic (?) volcanic and hypabyssal rocks respectively in the preceding paper in this bulletin. The term Silverado formation is used in place of Martinez formation to designate the Tertiary clay-bearing sedimentary rocks.

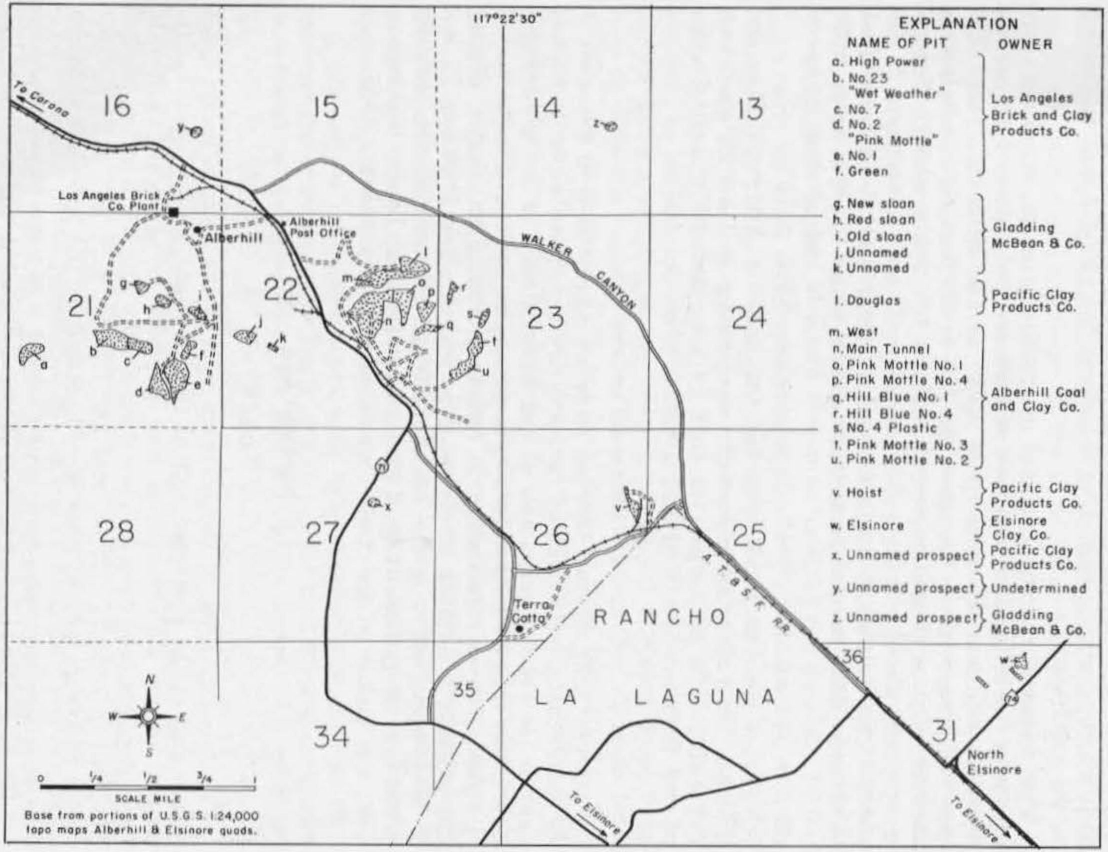

FIGURE 6. Sketch map showing location and general outline of clay pits in the Alberhill area.

Clay Company,* the Los Angeles Brick and Clay Products Company, and Gladding, McBean and Company.

Geology of Southern Temescal Valley

The regional geology of southern Temescal Valley, which includes the Alberhill clay district and several clay deposits northwest of the Lake Elsinore quadrangle, is shown on plate 3. The area covered by this map is underlain by plutonic, metamorphic, sedimentary and volcanic rocks that range in age from Triassic to Quaternary. Crystalline igneous and metamorphic rocks are exposed at many places and appear to underlie the entire region.

The oldest rocks are slates, argillites, and quartzites, with lesser amounts of conglomerate and siliceous dolomitic limestone, of the Triassic Bedford Canyon formation T bc). These metamorphic rocks have been invaded by several series of volcanic rocks all probably of Jurassic age. These include (1) the Santiago Peak volcanics (Js), a series of mildly metamorphosed flows, tuffs and breccias which range from latite to andesite and which in the northwestern Santa Ana Mountains unconformably overlie as well as intrude Bedford Canyon rocks; (2) quartz latite volcanic breccia (Jqlb), a shallow intrusive rock which contains quartz phenocrysts and anhedral feldspar phenocrysts, and which is related to the Santiago Peak volcanics; and (3) quartz latite porphyry (Jql), a dense, blue-black to gray hypabyssal rock with aphanitic groundmass and abundant phenocrysts of quartz and feldspar (includes Temescal Wash quartz latite porphyry of Larsen, 1948). The Bedford Canyon metasedimentary rocks also have been intruded by a series of later Mesozoic plutonic and dike rocks, most of which represent the southern California batholith (Larsen, 1948). The oldest plutonic rock is probably Cretaceous in age and is mapped as diorite-gabbro (Kdg). It ranges widely in composition from a coarse grained hornblende quartz diorite to hypersthene biotite gabbro, and locally norite. These rocks commonly exhibit a diabasic, locally coarsely ophitic, texture. They include the San Marcos gabbro of Larsen (1948) and diorite and gabbro of Engel (this bulletin). A younger, also undifferentiated, group of Cretaceous plutonic rocks is shown as granodiorite (Kgr) on the geologic map. These are medium to coarse grained leucocratic rocks, which range from diorite to granodiorite. They include the Woodson Mountain granodiorite, and the Bonsall and Estelle tonalites of Larsen (1948); and granodiorite, quartz diorite, and quartz monzonite of Engel (this bulletin). The Woodson Mountain granodiorite is typically a coarse grained, white to brownish-gray rock, in which biotite is commonly abundant. Oriented inclusions of the San Marcos gabbro, and streaks of dark mineral segregations characterize the Bonsall tonalite, which is ordinarily medium-grained, and light to dark gray. The Estelle tonalite is similar in mineral composition to the Bonsall tonalite, but finer grained and darker colored and lacks the numerous large dark inclusions found in the Bonsall tonalite.

The structure of southern Temescal Valley is characterized by a complex of fault pattern that, in general, delineates a group of down-dropped blocks to form Temescal Valley. Most of the major faults trend

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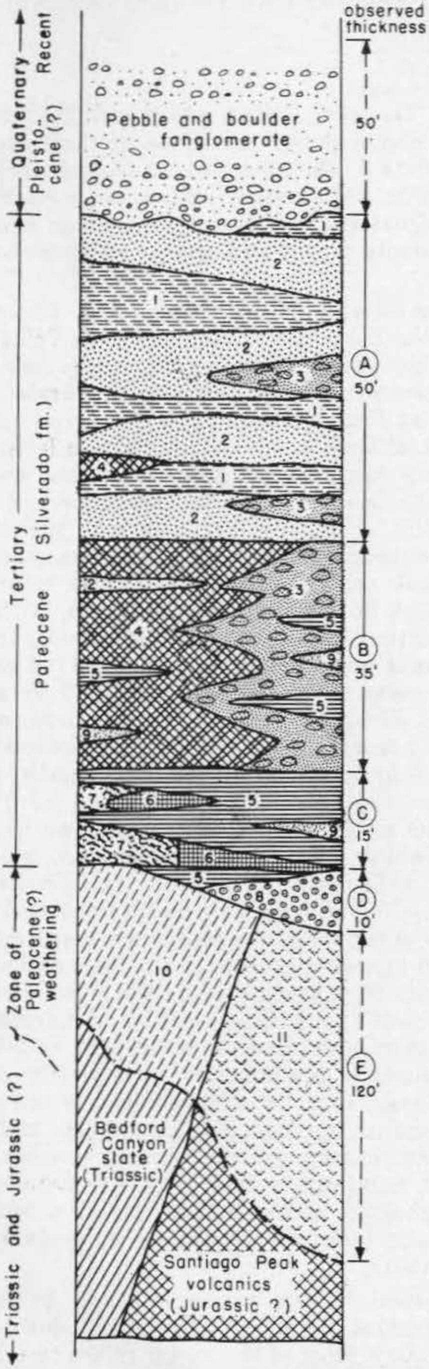
*The clay deposits of Alberhill Coal and Clay Company were leased to Pacific Clay Products in 1956 under a long-term agreement.



EXPLANATION

Ⓐ Green to gray, waxy clay shale (1) interbedded with arkosic, micaceous, coarse-grained sandstone (2); locally contains 1' to 8' thick layers and lenses of sandy, pink and white mottled claystone (3) and sandy white, yellow and gray claystone (4).

Ⓑ Sandy, white, yellow and gray mottled claystone (4) containing lenses of white to gray claystone (fire-clay) (5) and lenses of coarse-grained, angular, clayey quartz sandstone (9). Pink and white sandy, mottled facies of claystone (3) is most abundant in western part of area.

Ⓒ White to gray claystone (fire-clay)(5) interbedded with lignite (7) and dark gray to black, carbonaceous fire-clay (6); contains lenticular layers of clayey pebble conglomerate, and coarse-grained, quartzose clayey sandstone (9).

Ⓓ White, yellow and red pisolitic claystone (8) with white gray claystone (fire-clay) (5); occurs in lenticular bodies in upper part of residual clay.

Ⓔ White, yellow and red plastic claystone of residual origin, derived from slate (10) and volcanic rocks (11).

FIGURE 7. Generalized stratigraphic column showing lithologic features of clay-bearing units in Alberhill area.

northwest and are part of the Elsinore system of high angle reverse faults.

Geology of the Clay Deposits

The clay deposits in the Alberhill area are confined to a single zone which contains clay of both residual and sedimentary origin. The residual clay was formed by the deep weathering of the Mesozoic crystalline bed-rock, apparently in Paleocene time. The sedimentary clay was eroded and transported from the ancient surface and is now part of the Silverado formation, of probable Paleocene age, which unconformably overlies the residual clay. In the Lake Elsinore quadrangle this clay-bearing zone underlies an area of about one and one-half square miles along the borders of and within the Temescal Valley. It is about 80 feet in average thickness and has a maximum thickness of about 150 feet. Most of the higher-grade commercial clay apparently occurs in the areas already developed by clay pits.

The residual clay deposits are as much as 130 feet thick, and grade downward and laterally into (1) metasedimentary rocks of the Triassic Bedford Canyon formation, (2) andesitic rocks of the Jurassic (?) Santiago Peak volcanics, (3) Jurassic (?) quartz latite porphyry, and (4) Cretaceous (?) diorite-gabbro. Slaty cleavage, outlines of feldspar phenocrysts and angular fragments, and hexagonal quartz grains are remnant features that indicate that the residual clay was derived from slate, volcanic breccia, and hypabyssal igneous rocks respectively.

Although sedimentary clay occurs throughout the 100 foot maximum exposed thickness of the overlying Silverado formation, the layers of clay of commercial importance generally occur only in the lower half. Individual layers are commonly less than 20 feet thick and less than 30 acres in areal extent. Layers of sandy, non-commercial material occur interbedded with the clay throughout the section.

The Silverado formation generally is overlain by Quaternary fanglomerate that is about 20 feet in average thickness and locally is as much as 200 feet thick. In open pit operations this waste material must be removed to expose the commercial clay.

The attitudes of the clay-bearing zone suggest a shallow, northwest-trending synclinal structure that is cut by northwest- to northeast-trending high angle faults which in some places mark the boundary between clay and relatively unweathered crystalline rocks. These faults have observed displacements that range from a few inches to at least several tens of feet. Although the clay beds locally dip as much as 30 degrees, the average dip is less than 10 degrees. The lithologic features of the clay-bearing units are shown in the generalized stratigraphic column of the Silverado formation in figure 7. Table 1 summarizes the salient geologic, economic and operational data pertaining to the clays in each of the 24 clay pits in the Alberhill area.

The clay-bearing zone is broadly divisible into five units which show marked ranges in thickness, color, and lithology from one clay pit to the next, but which persist throughout the area. The lowermost unit is a vari-colored, massive, plastic, residual clay which is indicated by unit E in figure 9. In some places unit E is overlain by a massive pisolitic "bone clay" (unit D) which probably also is of residual origin. Unit C, the lowermost clay unit that clearly is of sedimentary origin,

Table 1. Geologic and operational data

Name of pit	Owner	Shape and dimensions[1]	Dates of active operations	Types of clays and maximum observed thickness[2]	Attitude of clay layers
[3] a. High Power	Los Angeles Brick and Clay Products Co.	Irregular, elongate, 400′x150′x25′	1925 to 1930, now idle.	D 5′ E	17° NNW
b. No. 23 (Wet Weather)	Los Angeles Brick and Clay Products Co.	Rectangular, 800′x350′x85′	1929 to 1955 (first opened before 1910).	A 15′ *B 15′ *C 15′	Flat to 15° NE
c. No. 7	Los Angeles Brick and Clay Products Co.	Rectangular, 450′x100′x70′	1925 (?) to 1955.	B 20′ E 10′	20° NNW
d. No. 2 (Pink Mottled)	Los Angeles Brick and Clay Products Co.	Triangular, 800′x300′x100′	1925 (?) to 1955.	*E 25′ A 50′	
e. No. 1	Los Angeles Brick and Clay Products Co.	Circular, 700′x130′	1890 to 1955.	*B 30′ *C 15′	Flat to 17° NE
f. Green	Los Angeles Brick and Clay Products Co.	Irregular, elongate, 350′x140′x25′	?	A 25′	
g. New Sloan	Gladding McBean & Co.	Circular, 350′x50′	1920 to 1929. Now idle.	A 20′ B 10′ D 15′	25° SW
h. Red Sloan	Gladding McBean & Co.	Oval, 500′x250′x50′	1920 to 1929, now idle.	A 20′ *B 12′	20° SW
i. Old Sloan	Gladding McBean & Co.	Oval, 500′x200′x50′	1890 to 1929, now idle	A 20′ B 4′ C 4″ D 5′ E 10′	14° W to 29° SSW
j.	Gladding McBean & Co.	Rectangular, 600′x300′x80′	1953 to 1954. Now idle	A 30′ *B 30′ (ave.) C 5′ *D 4′ *E 2′ 6′ 6′	

pertaining to clay pits of the Alberhill area.

Remarks	Commercial name	Uses	General remarks
Brown.			
Yellow, weathered slate exposed in floor of pit.			Fire clay overlaid brown bone, now mined out; was used in refractory clay products.
North rim of pit only.			Clay faulted against weathered slate at south rim of pit.
Pink and white mottled.		Face brick.	
Pale to dark gray, sandy, lignitic clay.	Fire clay.	Fire brick.	
Red and gray mottled claystone; 5′ layer of of coarse grained micaceous sandstone.	No. 7 Pink	Face brick.	Clays mined mostly by hand methods.
Red and white mottled.		Heavy clay products.	Commercial clays exposed only in south wall of pit. Unit A exposed in north wall. Material in east half of pit is reworked residual clay.
Three 2 to 6 foot layers of red and gray mottled clay interbedded with micaceous, clayey sandstone.		Heavy clay products.	
Pink and gray mottled plastic clay; 2′ to 5′ layer of pisolitic bone clay.	No. 1 Pink (below bone layer)	Face brick.	Pink mottled clay above bone is as much as 20 feet thick, and is used in heavy clay products.
Two to 6 feet of dark gray and lignitic carbonaceous fire clay overlain by yellow to pale gray fire clay; clayey quartz conglomerate layers interbedded.	No. 1 Fire clay	Fire brick and other refractory clay products.	Yellow and pale gray fire clay pinches out at south end of pit.
Greenish gray, sandy claystone interlayered with coarse-grained micaceous sandstone.	Green	Filler clay in heavy clay products; grog.	Grog used in fire brick made by calcining green clay at about 2400° F.
Waste.			
Pink and white mottle, sandy, plastic.	Sloan Mottle	Heavy clay products.	
White with yellow limonite streaks; massive.	Bone	Refractory clay products.	
Waste.			
Pink and white mottle, and white, sandy clay.	Sloan Mottle	Heavy clay products.	
Waste. Pale gray, sandy.			
Dark gray, carbonaceous.		Refractory clay products.	First mined for fire clay in about 1890 by underground methods.
White to yellow massive.			
Pink and white mottle.		Heavy clay products.	
Waste.			
Red and gray mottle, sandy.	Sloan Mottle	Heavy clay products.	
White fire clay (PCE + 33)		Refractory clay products.	Recent slumping on faces, and water in bottom has obscured geology. Data presented taken from unpublished field notes made by Mort Turner.
White, pink, and red.	Bone	White clay used in refractory clay products.	
Red, massive.	Rojo	Refractory clay products.	
Reddish, plastic.	Pink Shale	Heavy clay products.	
Yellowish.	No. 2 Shale	Heavy clay products.	

Table 1. Geologic and operational data

Name of pit	Owner	Shape and dimensions[1]	Dates of active operations	Types of clays and maximum observed thickness[2]	Attitude of clay layers
k.	Gladding McBean & Co.	Rectangular, 300′x150′x50′	1954 to 1955.	A 25′ *B 15′	5° S
l. Douglas	Pacific Clay Products	Northern half of West pit, (see same)	1890 to 1955.	*E 20′	
m. West	Alberhill Coal and Clay Co.	Rectangular, 1700′x270′x80′	1885 to 1955.	A 30′ B 30′ C 12′ D 5′ E Bottom of pit	10° WSW to 6° ENE
n. Main Tunnel	Alberhill Coal and Clay Co.	Oval, 1400′x850′x100′	1885 to about 1935; some mining up to 1955.	A 30′ *B 30′ C 8′ D 5′ E 20′	16° SW in east part; 8° NE in west part.
o. Pink Mottle No. 1	Alberhill Coal and Clay Co.	Circular, 300′x150′	1890 to 1900, and 1925 to 1950.	*E 150′	
p. Pink Mottle No. 4	Alberhill Coal and Clay Co.	Waste removed from surface of triangular area 500′x500′	1954 to 1955.	*E Surface exposure.	
q. Hill Blue No. 1	Alberhill Coal and Clay Co.	Irregular, elongate, 800′x200′x25′	1890 to 1955.	A 15′ *B 12′	6° SW
r. Hill Blue No. 4	Alberhill Coal and Clay Co.	Irregular, elongate, 400′x200′x25′	1914 to 1955.	A 5′ *B 10′ *C 5′	5° WSW
s. No. 4 Plastic	Alberhill Coal and Clay Co.	Rectangular, 150′x75′x30′	1930 to 1955.	*E 30′	
t. Pink Mottle No. 3	Alberhill Coal and Clay Co.	Rectangular pit 200′x130′x60′ at north end of triangular excavation 500′x500′x25′	1930 to 1955.	*E 80′	

pertaining to clay pits of the Alberhill area.—Continued

Remarks	Commercial name	Uses	General remarks
Waste.			
Lower 10 feet pink and white mottle, sandy; upper 5 ft. white to gray, sandy.	Lower 10′ Sloan Mottle	Sloan Mottle used in heavy clay products.	
Red and gray mottle residual and reworked residual clay derived from Mesozoic metasedimentary rocks.	Douglas Red	Sewer pipe.	In early days, mined for sedimentary fire clay that overlaid the residual clay.
Waste	Stripping		
White to gray, sandy.	West blue	Refractory clay products.	Similar to Main Tunnel clay (but inferior in quality).
Lignite and carbonaceous clay.	SH-3 SH-4	Pottery and other refractory products.	SH-4 underlies the lignite and may be of residual origin.
Yellow, red, and white	Bone	White clay used in refractory products.	
Red and white mottle; residual and reworked residual.		Red and yellow clay used in sewer pipe.	
Waste.	Stripping		
White to gray, sandy.	Main Tunnel	Refractory clay products.	Clay graded according to quartz sand content.
Lignite and carbonaceous clay.	SH-3 and SH-4	Refractory clay products.	Similar to unit C in West pit.
Yellow and white.	Bone	Refractory clay products and sewer pipe.	Discontinuous layer.
Red and white mottle; severely weathered Meszoic volcanic and metasedimentary rocks.		Heavy clay products.	
Red and gray mottle; weathered volcanic breccia.	Pink mottle No. 1	Sewer pipe and other heavy clay products.	
Red and gray, and yellow and white mottle; weathered slate and other metasedimentary rocks.	Pink mottle No. 4	Sewer pipe.	Drill data indicates deposit more than 100 feet thick; clay similar to Pink Mottle No. 3.
Green, waxy, clay shale interbedded with sandstone.	Hill blue green	Filler clay in sewer pipe.	First mined by underground methods.
White to gray clay lenses in red and white mottled sandy clay.	Hill Blue No. 1	Refractory clay products.	
Green, waxy clay shale.	Hill Blue Green	Filler clay in sewer pipe.	
White, locally sandy.	Hill Blue No. 4	Refractory clay products	
Yellow fire clay.	No. 4 yellow	Refractory clay products	
White, red, and yellow residual clay; grades downward to weathered slate.	Plastic White and plastic Red	Plastic White used as bonding clay in refractory clay products; red used in heavy clay products.	
Red and white, and yellow and white mottled; weathered slate.	Pink Mottle No. 3	Sewer pipe.	Large proportion of current production from this pit.

Table 1. Geologic and operational data

Name of pit	Owner	Shape and dimensions[1]	Dates of active operations	Types of clays and maximum observed thickness[2]	Attitude of clay layers
u. Pink Mottle No. 2	Alberhill Coal and Clay Co.	Irregular, elongate, 800′x100′ to 400′x80′	1900 to 1955.	A 10′ B & C 5′ *E 70′	10° S.
v. Hoist	Pacific Clay Products	Irregular, elongate, 600′x200′x60′	1887 to 1912.	C 8′ D 6″ *E 30′	6° to 10° SW
w. Elsinore (previously Morton)	Elsinore Clay Co.	1920-1923 to 1955.	Elongate, triangular, 400′x150′x40′	B 22′ C 11′	15° SW

[1] Length × width × depth, or diameter × depth; depth is maximum observed height of pit walls.
[2] Letters refer to units in columnar section. Asterisks indicate most important clays in pit.
[3] Letters refer to clay deposits located on sketch map.

consists of lignite and carbonaceous fire clay and lies unconformably either upon unit E or unit D. Unit B which conformably overlies unit C is a massive, sandy claystone that is white to pale gray in some areas and red and white mottled in other areas. Unit A conformably overlies and overlaps unit B, and consists of green to gray, waxy clay shale interbedded with coarse grained, arkosic, micaceous sandstone. In some areas, especially in the Temescal Valley floor, Unit A is unconformably overlain by Quaternary pebble and boulder fanglomerate.

Utilization of Clays

The clays of the Alberhill area are used to produce two main types of clay products. Red-burning, residual clay (unit E), the red and white mottled facies of the claystone unit (unit B), and some of the green, waxy clay shale (unit A) are used to make heavy clay products such as sewer pipe, face brick, and tile. White "bone clay" (unit D), fire clay (unit C), and the white facies of the claystone unit (unit B) are used in the production of refractory clay products such as fire brick, flue lining, and, in lesser amounts, pottery. The ceramic properties of some of these clays are shown in table 2.

Coal and clay were first discovered in the Alberhill area in the early 1880's. In the early days they were mined by underground methods in which hand tools and man and mule power were employed. Since about 1940, clay has been mined almost entirely by open pit methods. Although modern equipment, such as bulldozers and power shovels, are now used to mine almost all of the clay used in heavy clay products, the fire clay is still selectively mined by hand methods so that the high grade, relatively pure clay can be kept separate from the sandy clay.

pertaining to clay pits of the Alberhill area.—Continued

Remarks	Commercial name	Uses	General remarks
Red and gray mottled; weathered volcanic breccia.	Stripping Pink Mottle No. 2	Face brick and other heavy clay products.	Bricks made from this clay used in original buildings on the campus of the University of California at Los Angeles and in many old buildings in downtown Los Angeles.
Light gray clay and micaceous quartz sandstone.			
White to light gray.			
Upper half yellow, pisolitic; lower half red and gray mottle.	Hoist pit Blue and Red	Sewer pipe and other heavy clay products.	Residual clay grades laterally and downward into slate.
Light gray, sandy clay; 2′ layer of white clay.		Refractory clay products.	Two abandoned clay pits nearby.
Two feet of lignite and black plastic carbonaceous clay at base; upper 4′ light gray, silty, clay shale. Underlain by as much as 19 feet of sandy, dark gray to bluish claystone.		Refractory clay products.	

From 1895 through 1955 a total yield of nearly 6 million tons of clay has been reported as mined in Riverside County, all but a small part of which came from the Alberhill area for use in refractory and heavy clay products.

The known reserves of high quality, white-burning refractory clay have been nearly depleted, but relatively large reserves of lower quality, sandy, buff-burning fire clay still exist. Extensive exploratory drilling and mining operations have exposed large reserves of plastic, red-burning residual clays.

In 1955, as much as 800 tons of clay per day was being mined from the deposits in the Alberhill area. Most of this output consisted of the red burning, plastic residual clays from the Pink Mottle pits owned by the Alberhill Coal and Clay Company, and the residual and sedimentary pink mottle clays from Pit No. 1 owned by the Los Angeles Brick and Clay Products Company.

Alberhill Coal and Clay Co. (35). From about 1890 to mid-1956 the Alberhill Coal and Clay Co. has mined coal and clay from their deposits near Alberhill. Although the company did not manufacture clay products, they supplied large tonnages of high-aluminous clay to ceramic plants in the Los Angeles area.

The clay pits owned by the company are contained in an oval shaped area of about one-third of a square mile and lie in the eastern half of section 22 and the western half of section 23, T. 5 S., R. 5 W., S.B.M. (see figure 8). The pits are on the southwest slope of an elongate, northwest-trending hill that is bounded on the west by the Temescal Valley and on the east by Walker Canyon. Plate 5 shows geology of this area.

Table 2. Chemical composition and ceramic properties of clays from Alberhill Coal and Clay Company deposits. (Compiled by René Engel).

CLAY TYPE	PIT	UNIT[1]	CHEMICAL COMPOSITION—PERCENT							IGNITION LOSS				P.C.E.	Fired Color	Dry Shrinkage	Burned Shrinkage	OTHER DATA
			Al_2O_3	SiO_2	Fe_2O_3	CaO	MgO	Alk.	TiO_2	Volat. $+H_2O$(350°)	H_2O(105°C)	Total	Author[2]					
West Tunnel Blue	West Tunnel	B	15.5	55.1	9.8	1.4	2.4	1.0	1.0	8.1	5.6	99.9	J. H. Hill	19	Buff			Moderate plasticity.
No. 1 Red Mottled	No. 1	E	28.0	50.0	6.0 (FeS_2 3.0)			3.0 (+CaO + MgO)		10.0		100.0	A.C.C.		Dark Red			Medium plasticity.
No. 1 Pink Mottled	No. 1	E	15.0	68.0	7.7	—	tr.	2.7	0.9	4.6	0.6	99.5	J. H. Hill	19+	Dark Red	6.5	15.0 (C.4) 16.5 (C.9)	Water of plasticity =23.0% Absorption—C.4 =14.4 Absorption—C.9 =10.0 Mod. of Rupture—C.4 =2420 Mod. of Rupture—C.9 =3135 Very good plasticity.
No. 1 Bone	No. 1	D	43.4	54.8	0.7	tr.	tr.	0.8		0.2		99.9	A.C.C.	33–34				
S.P.	No. 1													22				
No. 3 Pink Mottled	No. 3													19				
West Yellow (Same as Upper Douglas)	Main Tunnel and No. 1 Pit	A (upper)	19.2	62.1	5.0	2.0	0.7	1.2		10.0		100.2	G. McB.	14	At C.12 Black	7.0	12.4 (C.12)	Water of plasticity=31.5% to 32%.
		A (lower)	27.5	58.0	2.5	.5	.3	1.1		10.0		99.9	A.C.C.	28	Buff	9.0	4.4	
Sandy, Main Tunnel	Main Tunnel	B	13.8	77.4	1.3	.8	tr.	1.3		5.6		100.2	G. McB.	27 to —30	Light Cream	4.0	10.0 (C.12)	Similar to Smooth Bunker (see Page 2), but contains more sand. Water of plasticity=24.3%.
Three Star, Main Tunnel (Select Main)	Main Tunnel	B	18.9	62.6	1.8	—	—	1.6 (incl. Ca+ Mg)		14.9		99.8	G. McB.	28 to —30	Light Cream			Selected from Sandy Main Tunnel, crushed through 8 mesh and washed on 100 mesh screen. Final product contains 20 to 30% of sand and some coal (+100 mesh).
Extra-Select Main Tunnel (SH 3 or No. 10	Main Tunnel	B	26.6	59.2	1.3	—	—	1.1 (incl. Ca+ Mg)		11.3		99.5	G. McB.	31	White			Selected from Sandy. May contain from 2 to 5% mostly coal and some sand (+100 mesh).
			26.2	59.4	2.2	.2	.2	.1		11.6		99.9	A.C.C.					

Smooth Bunker	Main Tunnel	B	22.2	66.6	1.5			1.5		7.9		99.7	G. McB.	27 to −30	Light Cream to Buff	6.0	8.0 (C.4) 7.5 (C.9)	Water of plasticity =17.0% Absorption—C.4 =21.6 Absorption—C.9 =20.7 Mod. of Rupture—C.4 =680 Mod. of Rupture—C.9 =853 Sand and some coal content by by washing: 45% (+100 mesh).
Main Tunnel Bone	Main Tunnel	D	39.5	44.2	2.1	.4	tr.	tr.	1.5	12.1	0.3	100.1	A.C.C.	32 to −33	Gray-white to Buff	3.0	12.0 (C.12)	Non-plastic.
Main Tunnel Lower Bone	Main Tunnel	D																
S.H.-4 High Alumina (Immediately below coal bed)	Main Tunnel	C	42.2	37.7	0.5	0.7	tr.	0.1		18.9		100.1	G. McB.	34 to 35	White	5.0	16.8 (C.12) 22.0 to 25.0 (C.13)	Fired texture: dense and hard. Water of plasticity =31.7% Good plasticity but sticky; hard to dry and poor bond in mixes.
S.H.-4 Low Alumina	Main Tunnel	C	33.3	47.1	0.9	.6	tr.	0.1	1.4	12.9	3.9	100.2	J. H. Hill		White			Good plasticity.
Yellow Owl	Main Tunnel (Upper)	E												17	Red	high	18.6 (C.11)	Good plasticity.
No. 4 Plastic Red (Top Clay)	No. 4	E	20.2	66.4	4.5			3.4 (+CaO+MgO)		6.0		100.5	G. McB.	26		5.5		Fired texture: tight. Water of plasticity =33.3% Excellent for tightening refractory mixes.
No. 4 Plastic White (Lateral variation of Plastic Red)	No. 4	E												22				Similar to No. 4 Plastic Red but with less iron and slightly weaker bond.
Hill Blue Fire Clay	Hill Blue No. 4	B																Sand by washing: 18-25% (+100 mesh).
Hill Blue	Hill Blue No. 4	B	23.4	57.5	2.5	0.9	0.5	1.0		8.6	5.2	99.6		30-32	Buff		15.0 (C.13)	Selected from H.B. fire clay by washing. Contains 8-12% sand (+100 mesh). Plasticity fair.
Hill Blue Green	Hill Blue No. 4	A												11-14	Red			

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[1] Unit letters refer to units described in Fig. 7.
[2] Source of data; A.C.C.: Alberhill Coal and Clay Co.; G.McB.: Gladding McBean and Co.; J. H. Hill: reference—Hill, (1923).

FIGURE 8. View eastward toward south face of Alberhill Coal and Clay Co. West clay pit, showing 4-foot layer of black lignite overlain by white sandy fire clay. Lignite and fire clay pinch out at upper left hand corner of photo. Lignite layer was source of early coal production in Alberhill area. *Photo by Charles W. Jennings, 1955.*

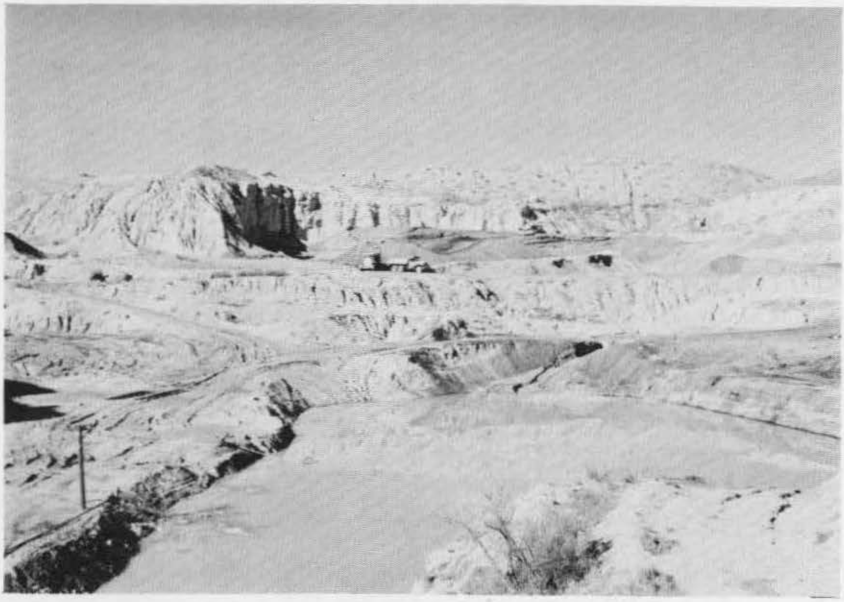

FIGURE 9. View north toward Alberhill Coal and Clay Co. Main Tunnel clay pit. Black lignite and carbonaceous fire clay, and white, sandy fire clay in right half of photo dip gently westward. Pink and white mottled residual clay overlain by white sandy fire clay in left half of photo dip gently eastward. *Photo by Mort D. Turner, 1952.*

The West pit (figure 10) is the northernmost operation, and the north boundary of the pit is the north boundary of the property owned by the Alberhill Coal and Clay Co. South of and adjoining the West pit is the Main Tunnel pit (figure 11) which is continuous with the Pink Mottle No. 1 pit to the east. The Pink Mottle No. 4 pit lies east of the Pink Mottle No. 1 pit and is flanked on the south and east sides by the Hill Blue No. 1 and Hill Blue No. 4 pits respectively. The No. 4 Plastic, Pink Mottle No. 3, and Pink Mottle No. 2 pits are aligned in a north-south trending zone at the southeast end of the Alberhill Coal and Clay Company properties.

In general, the commercial clay zone is confined to the area of these pits, and is about 130 feet in maximum thickness. Residual clay formed by weathering of slate and volcanic rocks comprises most of the clay exposed in the Alberhill Coal and Clay Company pits.

Both residual and sedimentary clays are mined from the Alberhill Coal and Clay Company deposits. Red and buff burning plastic clay of residual origin which is used primarily in heavy clay products such as sewer pipe and face brick is mined by mechanized methods from Pink Mottle pits No. 1, 2, 3, and 4 and the No. 4 Plastic pit (table 1). White to cream burning, high aluminous sedimentary clay which contains various proportions of quartzose sand, and carbonaceous clay and lignite is selectively mined by hand methods from the West pit, Main Tunnel pit, and the Hill Blue pits (table 1). These fire clays are used mainly in refractory clay products such as fire brick, furnace lining, and pottery. Most of the 32 differently-named clays sold by the Alberhill Coal and Clay Company can be classified as varieties of the two main types of clay above mentioned.

In 1955 all of the active clay deposits of the Alberhill Coal and Clay Company were being mined by means of open pits. The pink and red mottled residual clay was mined with mechanized equipment such as bulldozers, scrapers, and carry-alls. The fire clays of sedimentary origin were selectively mined by hand methods.

During the early years of operation, high grade refractory clays similar to the Hill Blue and Main Tunnel clays were the only clays mined by the Alberhill Coal and Clay Co. These clays, which were mined underground by hand methods, were sacked underground and shipped by rail mostly to Los Angeles producers. By 1923, the Company was mining about 12 varieties of clay including some red burning clay with a relatively low alumina content. Although in 1923 the clays were being used to make 21 different products, most of it was being sold to producers of face brick and fire brick. In 1922 the Company shipped 2,500 fifty-ton carloads of clay to local and Los Angeles producers. By 1945, a large proportion of the 7,000 tons per month of clay that was being mined at Alberhill was the red-burning plastic clay used extensively in sewer pipe. By 1945 the total 50-year output of clay from the Alberhill Coal and Clay Company deposits was estimated at 2,000,000 tons (Tucker 1945). In 1945, about 500 tons of clay per day was being shipped from these deposits. Seventy-five percent or more of this clay was red-burning plastic clay mined from the Pink Mottle pits. In 1955 about 450 tons of red-burning plastic clay was being delivered daily by trucks to the Pacific Clay Products plant at Los Nietos where it is used to make sewer pipe. A smaller amount of fire clay was being produced for Kaiser Steel Corp., Santa Fe Railroad, and various pottery manufacturers.

Elsinore Clay Company (36). The Elsinore Clay Company, formerly the Morton Clay Company, mines clay from an open pit in section 31, T. 5 S., R. 4 W., S.B.M., near North Elsinore. Lignite and refractory carbonaceous claystone, and gray to buff clay shale are exposed in the pit that was being mined in 1955.

The deposit was first mined by the Morton Clay Company in the early 1920s. In about 1930 the property was purchased by the Elsinore Clay Company which has intermittently mined the deposit since that time.

Of the three clay pits on the property, one was being mined in 1955.

Gladding McBean and Company (37). Gladding McBean and Company, which manufactures heavy clay products, refractory clay products and pottery at plants in Los Angeles, has mined in the Alberhill area since about 1925. The Company owns a narrow, northwest-trending strip of land about 4500 feet long that lies northeast of and adjacent to the clay properties owned by the Los Angeles Brick and Clay Products Company. This strip, which is in the west half of section 22 and the east half of section 21, T. 5 S., R. 5 W., S.B.M., contains 5 clay pits (see figure 8).

The southernmost pit is the only one of the group that was being mined in 1955. Although the clay deposits developed by the three northernmost pits, referred to as the Sloan pits, were discovered as early as 1885, they were most actively mined by the Los Angeles Pressed Brick Company and Gladding McBean and Company during the period between 1920 and 1929. The Los Angeles Pressed Brick Company merged with Gladding McBean and Company in about 1926. The two most southerly pits have been operated by Gladding McBean and Company since about 1950.

Except for minor variations in lithology and thickness, similar sequences of clay-bearing units are exposed in all the pits. The section contains little or no carbonaceous material, in contrast to Alberhill and Western pits. In the southernmost pit, only sedimentary clay and sandstone are exposed, but the other four contain both sedimentary and residual clays. White, yellow, and red, massive, pisolitic bone clay of probable residual origin is exposed in and was mined from the three Sloan pits. The white bone clay was used to make refractory clay products at the Los Angeles Pressed Brick Company plant at Alberhill. Pink and white mottled plastic residual clay underlies the bone clay in the northernmost of the Sloan pits and was probably used in the production of heavy clay products. A layer of sedimentary fire clay that is used in refractory clay products, and which is less than one foot thick, overlies the bone clay in the southernmost of the Sloan pits and the northernmost of the recent Gladding McBean pits. In all of the pits, a layer of red and gray mottled, plastic, sandy, sedimentary clay as much as 50 feet thick overlies the sedimentary fire clay. This clay which is called the Sloan Mottle has been and was in 1955 being mined for use in the production of heavy clay products.

In the early days, the Sloan pits were mined by hand methods. The recent Gladding McBean pits however, have been and were in 1955 being mined almost entirely by machine methods.

Los Angeles Brick and Clay Products Co. (38). The Los Angeles Brick and Clay Products Company produces clay products at a plant located immediately south of the town of Alberhill. The clay is mined from open pits owned by the company and located about 0.7 mile south of the plant. The plant was built in 1925 and has since been in continuous operation.

All of the clay pits are within the southern half of section 21, T. 5 S., R. 5 W., S.B.M. and lie along the northern edge of a group of small hills northeast of the Santa Ana Mountains (see figure 8).

Five of the six clay pits owned by the Company were operating in 1955. The High Power pit which has been idle since about 1930 is located about 1,500 feet west of the operating pits. No. 23 pit (figure 12) which is adjacent to and west of the No. 7 pit is the westernmost of the active workings. No. 1 pit (figure 13) which is the largest and oldest of the Company's clay pits lies about 1,000 feet southeast of the No. 7 pit and lies east of and adjacent to the No. 2 pit. The Green pit is located about 200 feet north of the No. 1 pit.

The commercial clay zone which in this area is as much as 100 feet thick occurs in an L-shaped belt within the area of the operating pits. The west boundary of the zone is defined by north-northeast and west-trending normal faults. Most of the clay exposed in the Los Angeles Brick and Clay Products Company pits is sedimentary in origin, and more fire clay is mined from here than from any other deposit in the Alberhill area. A one hundred-foot thickness of sedimentary clay and sand of the Silverado formation is exposed in the No. 1 pit. Plate 4 shows the geology of the No. 1 pit.

Four types of clay are mined from the pits (figure 14). Yellow plastic residual clay which is the lowermost unit in Pit No. 1 (table 1) is used to make sewer pipe. No. 1 fire clay is a white to dark gray, carbonaceous, refractory clay that occurs as a sedimentary layer in pits No. 1 and No. 23. It is employed in the manufacture of fire brick and flue linings. No. 1 pink is a pink and white mottled, locally sandy, plastic sedimentary clay that is used to make face brick. It is mined from pit No. 1 and pit No. 7. No. 2 red which is mined from No. 2 pit, is a red to yellow plastic residual and basal sedimentary clay used in the production of face brick, sewer pipe, and tile.

During 1954, about 4,500 tons of clay were used each month in the production of clay products at the Los Angeles Brick and Clay Products Company plant at Alberhill (figure 15). All of this clay was taken from the pits owned by the company. Of the total amount of clay used, about 35-40 percent was used in face brick, 20-25 percent in fire brick, 20-25 percent in sewer pipe, 15 percent in flue linings, and a small amount in floor and roofing tile.

The Los Angeles Brick Co. acquired their clay properties from the former owner, the California Clay Manufacturing Company, and built their plant in 1925. Except for the No. 1 pit which was in operation as early as 1890, all of the deposits have been developed since 1925.

FIGURE 10. View east toward Los Angeles Brick and Clay Products Co. No. 23 clay pit. Black lignite and carbonaceous fire clay, and white sandy fire clay dip 5° to 20° N. *Photo by Mort D. Turner, 1952.*

FIGURE 11. View southeast toward Los Angeles Brick and Clay Products Co. No. 1 clay pit. Slate and residual clay are exposed in lower part of pit; white sedimentary fire clay and red and white mottled sandy claystone are exposed on benches in upper part of pit.

FIGURE 12. Mining sedimentary fire clay in Los Angeles Brick and Clay Products Co. No. 1 clay pit.

Pacific Clay Products. Pacific Clay Products which produces sewer pipe at a plant in Los Nietos, California, owns two properties in the Alberhill area. One is developed by the Douglas pit north of and adjacent to Alberhill Coal and Clay Company West pit; the other is developed by the Hoist pit about one and one-half miles southeast of the Douglas pit (see figure 8). In mid-1956 Pacific Clay Products acquired exclusive rights to the Alberhill Coal and Clay Co. deposits, under a long-term operating agreement.

Clay deposits in the Douglas pit were first mined in the period 1885-1890. In the early operations, sedimentary fire clay comparable to the Sh-3 clay that overlies the lignite in the West pit was mined from the Douglas pit. This layer of fire clay was mined out at some time after 1930. During recent years, red and white mottled plastic clay has been mined from the Douglas pit for use in the production of sewer pipe. This clay probably consists of both residual material and of sedimentary material near the base of the Silverado formation.

The Hoist pit (figure 16) was opened in about 1890 by the Pacific Sewer Pipe Company. Yellow and red and white mottled plastic residual clay was mined here and transported to the Pacific Sewer Pipe Company plant at Terra Cotta where it was used to make sewer pipe, hollow tile building blocks, and other heavy clay products. The pit was abandoned when the company closed down in 1912. The property has been idle since about 1912 when it was acquired by Pacific Clay Products.

FIGURE 13. View southwest toward Los Angeles Brick and Clay Products Co. Alberhill plant. Clay pits and stock piles in background. *Photo by Mort D. Turner, 1952.*

FIGURE 14. View west toward Pacific Clay Products Co. Hoist clay pit. Red and white mottled residual clay is overlain by sedimentary claystone, shale, and sandstone that dip 5° to 15° SE. *Photo by Mort D. Turner, 1952.*

Coal

Coal was discovered in the Alberhill area in 1883. From 1885 to about 1900 a lignitic variety was mined at the present (1955) site of the Alberhill Coal and Clay Company's operations by Cheney and Colliers and later by the Alberhill Coal and Clay Company. Since 1900 very little coal has been marketed from the Alberhill area. Although small tonnages of coal are still removed in the present clay operations, it is not considered to be of commercial interest.

In the West and Main Tunnel clay pits of the Alberhill Coal and Clay Company a layer of coal which is as much as 10 feet thick and which has an average thickness of about 4 feet is interbedded with fire clay at the base of the Silverado formation (figure 10). This layer is the source of the early production of coal in the Alberhill area. The coal is a soft, lignitic variety, and in many places grades laterally and vertically into black carbonaceous clay. An analysis taken from Irelan (1887) shows the following composition:

Water	19.00 percent
Volatile matter	46.50 percent
Fixed carbon	21.90 percent
Ash	12.60 percent

The coal was mined by the room and pillar method and with hand tools. It was sacked underground and shipped by rail to Los Angeles. Some of it was sold to the Good Hope gold mine for use as fuel to drive the steam powered hoist. Clay was mined from the same adits as the coal.

Discontinuous layers of coal less than one foot thick, which are probably part of the same deposit that occurs in the Alberhill Coal and Clay Company properties, occur with fire clay at the base of the Silverado formation in Pit No. 23 of the Los Angeles Brick and Clay Products Company. A two-to four-foot layer of coal was reported by Goodyear (1888, pp. 175-176) to occur near the bottom of an 80-foot shaft located in the southwest quarter of section 26, T. 5 S., R. 5 W., S.B.M., near the town of Terra Cotta. The shaft is a part of the Dolbeer & Hoff mine which has been idle since about 1890.

Limestone

One potentially economic occurrence of limestone is known in the quadrangle. There is a lens of impure limestone in Triassic metamorphic rocks about 2 miles northeast of Elsinore. Two stone kilns were erected at the deposit and a small quantity of lime burned prior to 1890, but apparently none since. Limited reserves of raw material, and development of large-scale lime-producing facilities in nearby localities apparently have hindered lime production in the quadrangle.

Best Ranch Deposit (44). Location: Low rolling country about 2¼ miles northeast of Elsinore, about one mile southeast of Highway 74, in section 28, T. 5 S., R. 4 W., S.B.M. Ownership: John A. Snyder, Route 2, Box 220, Perris, holds patent to 160 acres including the old quarry site and kilns.

The Best Ranch limestone deposit is disposed along the bedding direction of a large exposure of slate of the Triassic Santa Ana (Bedford Canyon) formation, which strikes northwesterly and dips about 50° NE. Limestone is exposed in a discontinuous line of elongated outcrops, trending N 75° W, over a strike distance of half a mile or more. The largest, and only quarried outcrop, is the southeasternmost, occupying a small hilltop just south of the Best Ranch buildings. This outcrop is about 75 feet in maximum width and 100 yards or more in exposed length. The adjacent outcrop, about 200 yards to the northwest, is about 50 feet wide and at least 100 feet long. Strike dimensions of the bodies are not clearly shown because of soil cover between outcrops.

The limestone is massive light- to dark-gray and characteristically mottled, especially on weathered surfaces. Small white markings suggest organic remains but no recognizable fossils have been found. An undetermined but apparently small percentage of dolomitic material is present in some places. Silica occurs in the form of cherty and jaspery streaks and small pods as much as several inches wide and several feet long. Silica increases in abundance towards the east end of the main outcrop.

Minor shearing and contortion of the limestone is indicated by crumpling of cherty streaks, brecciation, recementation, and formation

FIGURE 15. View southeastward of Best Ranch limestone deposit, showing two stone kilns (left) and small open cut quarry (near top of knoll, right) which yielded the few tons of limestone burned, prior to 1890. The limestone lens exposed in the small hill is about 75 feet wide and 100 feet long, a part of the Triassic Bedford Canyon formation.

of caliche. Abundant unoriented silky sheafs of tremolite blades occur in at least one zone that covers an area of about 75 square feet near the southern edge of the main outcrop. Silicification of the limestone occurs adjacent to a steeply dipping aplite dike which strikes N 80° W, cutting the southern contact between the limestone and the slate.

A five-foot pit and a shelf 20 feet long and as deep as 8 feet are cut in the west end of the main outcrop, and apparently were the source of the few tons of limestone burned. A 60-foot crosscut adit driven S 30° W through the next outcrop to the northwest established the width of limestone at 15-foot depth as 50 feet between slate walls.

Two stone lime kilns each about 25 feet tall, are standing about 150 feet northwest of the main limestone outcrop. Made of country rock, the kilns were built sometime prior to 1890, and reportedly produced a good quality of lime (Goodyear 1890, p. 151). The small size of the quarry pit, and the unworn condition of the kilns indicates very few tons of lime were produced. A plan to manufacture hydraulic cement using this lime apparently was unsuccesful and the kilns and deposit have been idle since 1890.

Silica

Silica, in the form of massive quartz, has been produced from one locality on the quadrangle, the Nettleton deposit. This deposit is largely depleted, and has been inactive many years.

Nettleton Deposit (45). Location: North and east side of prominent hill about 4 miles southeast of Elsinore and about 1⅔ miles south of Railroad Canyon dam, in section 14, T. 6 S., R. 4 W., S.B.M. Ownership: M. G. Nettleton, Temecula, holds patent.

A body of Cretaceous aplitic and pegmatitic leucogranitic rock within Cretaceous (Woodson Mountain) granodiorite contains pods of milk-white quartz, and an unoutlined mass of quartz-sericite rock. The quartz, on the north side near the top of the hill, has been extensively exposed and quarried. The quartz-sericite rock, on the east side of the hill, has been explored in minor workings, but little or none removed.

The quartz occurs as an irregular vein-like body, or bodies, in a discontinuously exposed zone that trends about N. 45° E. and dips steeply southeastward to vertical. As exposed in workings near the top of the hill the zone is 20 to 30 feet wide and at least 300 feet long. Adits several hundred feet farther northwest may reach extensions of the zone underground but quartz is not exposed on the surface.

Exposures indicate that individual lenses or pods in the zone are as large as 6 feet wide and 15 feet long, although larger masses may have been removed.

The quartz-bearing zone is much shattered, slickensided, and sheared. Bodies of pure quartz are separated by impure gougy material containing ground quartz, feldspar, mica, chlorite, and iron oxides. Unfilled drusy cavities and outlines of quartz crystals as long as several inches are present in the deposit. Small segregations of muscovite crystals, some nearly a half inch across, and a few thin veins of quartz, orthoclase, and muscovite are present. A fault strikes N 35° E and dips 60° NW to bound cleanly the quartz zone against leucogranite on the south.

The main opening is a large sidehill open cut at the southeastern end of the exposure near the top of the hill. This pit is about 30 feet wide and 50 feet long, with a face as high as 40 feet. It was mined in part as a glory hole. An irregular inclined opening, about 8 by 10 feet in plan, leads from the quarry floor through the quartz-bearing zone 50 feet down to a 100-foot haulage adit. A cable-drawn rail tramway was used to move the quartz about 150 yards straight down the hill for loading on horse-drawn wagons. Caved portals and substantial dumps at the wagon-loading station indicate level workings of undetermined length or purpose.

The deposit has been inactive since about 1930 when an undetermined tonnage of quartz was quarried for unspecified purposes. The haulage track, cable tramway, and wooden structures are dismantled or inoperative, and underground openings dangerous or inaccessible. Exposed reserves of quartz cannot be removed without considerable development work.

About 300 yards eastward on the same hill a body of soft fine-grained quartz-sericite rock occurs, also within deeply weathered leucogranitic rock. As exposed underground, the quartz-sericite rock appears to be mainly confined to a 15-foot wide belt associated with a fault zone that trends N 15° E and dips 75° NW.

The area has been explored by a 100-foot crosscut adit driven N 55° W through the shattered zone with a 40-foot winze 75 feet from the portal. A 15-foot caved pit exposes the quartz-muscovite rock 50 feet uphill from the adit portal. No stoping was done; the deposit has been idle for years.

Stone

Small tonnages of granitic rock, slightly metamorphosed argillaceous sandstone, metavolcanic rock, and slate have been quarried at various points in the northeast part of the quadrangle. Nearly all the stone produced was for building or road-surfacing purposes, and was used locally.

Granitic Rock

Cretaceous (Woodson Mountain) granodiorite, which is widely exposed in the quadrangle has been quarried in minor amounts for dimension stone. Building stone, curbstone, and lintels have been produced; unfinished foot-square lintels as long as 10 feet are found near quarry sites. This rock has been obtained from half a dozen places within an exposure of granodiorite covering about 3 square miles in the Arroyo del Toro area near the center of the north edge of the quadrangle (map numbers 46, 47, 48). The rock is a light gray, medium-grained biotite granodiorite with little or no internal planar structure. Beneath the ground surface it weathers readily, but rounded boulders found on outcrops are characteristically sound and hard.

FIGURE 16. View eastward of small boulder-covered hill in Arroyo del Toro area, consisting of Cretaceous Woodson Mountain granodiorite. Rubble heaps mark sites where boulders have been split into dimension stone.

"Quarrying" consists of splitting suitable boulders into pieces of desired size and shape. The boulders are split wherever they lie on top of the ground, and no preliminary drilling, blasting, or hoisting is required. Selected boulders as large as 5 by 8 by 10 feet are drilled with holes 4 to 12 inches deep and about 8 inches apart long the desired splitting plane. Special wedges (plugs and feathers) are driven to split the rock. An advantage in this technique is that only the finished pieces need be transported; all unusable stone and broken rubble is left at the site of the original boulder. Difficulty apparently arises in judging the rift, grain, and hard way because of the random orientation of the boulders.

In 1954 none of the quarries was active.

Metamorphosed Argillaceous Sandstone

An unusual phase of the Triassic Santa Ana (Bedford Canyon) formation has been quarried at one locality (map number 49) in the center of the east half of section 14, T. 5 S., R. 4 W. The stone is a fine-grained, gray-green micaceous sandstone, nearly a graywacke, mildly metamorphosed. An imperfect plane of fissility is marked by subparallel orientation of sericite and chlorite flakes. This plane strikes N 20° W and dips 60° NE, and is approximately parallel to slaty cleavage in nearby slates of the same formation.

FIGURE 17. Dimension stone blocks split from boulders of Cretaceous Woodson Mountain granodiorite in Arroyo del Toro area, showing small drill holes in which plugs and feathers were used to split the stone.

The stone is not notably strong nor easily broken into large slabs, but several tons have been used nearby for building foundations and walls. Stone has been removed from two pits about five feet deep, 10 and 20 feet long. None has been quarried for many years.

Metavolcanic Rock

Volcanic rocks of the Triassic Santa Ana formation (Santiago Peak volcanics) have been quarried at two sites for use as road surfacing material. Epidotized, andesitic flow rock was obtained from a shelf quarry (map number 51) about 75 feet long and 30 feet wide with a 50-foot back, just north of the mid-point of the east edge of section 24, T. 5 S., R. 5 W. Chloritized basic flow rock, and bleached and banded metamorphosed tuff were obtained from a hilltop quarry (map number 40) about 40 feet in diameter and 5 feet deep, in the east half of the south edge of section 19, T. 5 S., R. 4 W. Both sites have been inactive many years.

Slate

Triassic Santa Ana (Bedford Canyon) slate, widely exposed in the Railroad Canyon area about 4½ miles northeast of Elsinore, has been quarried at several localities. Some has been used for flagstones (Larsen 1948, p. 129), some for building stone (Dudley 1935, p. 494) and some ground for roofing granules (Tucker 1929, p. 524).

Although exposures of the slate cover many square miles in the quadrangle, in only a few localities is it sufficiently hard, fissile, unweathered, and unfractured for such use. Some of the best slate in the quadrangle crops out along the west side of Railroad Canyon, on the south half of section 23 and the north half of section 26, T. 5 S., R. 4 W. (map numbers 53 and 54). Here the slaty cleavage strikes about N. 80° W. and dips 45° N. It is hard, relatively unfractured, dark blue-gray in color, but with abundant light-colored sandy streaks parallel to the slaty cleavage. Although pronounced, the slaty cleavage is not perfect enough for the splitting of roofing slates. Irregularities in the cleavage plane, and the close spacing of cross fractures and cross veins render the slate unfit for blackboard or electrical use. Pieces as large as a foot square and about one inch thick apparently can be produced without undue labor or waste; larger pieces must be correspondingly thicker.

An estimated total of several hundred tons of slate has been removed from about 6 sites in the area described. The largest quarry is a shelf about 100 feet long with as much as 15 feet of back (map no. 54). In 1954 no trace was seen of the Rainbow Mining and Mineral Products Company 20-ton plant reported (Tucker 1929, p. 524) to have ground slate for roofing purposes sometime prior to 1929. No slate is known to have been produced in the area for several years prior to 1954.

Water Resources

A summary of recent investigations into the water resources of the Elsinore basin was published in February 1953 as Bulletin No. 9 of the State of California Water Resources Board, entitled "Elsinore Basin Investigation". The reader is referred to pages 11-22 of that report which summarize the water supply problem, and include descriptions of the Elsinore Basin, sources of supply, consumptive uses, ground water hydrology, and quality of water.

Mineral Springs

The mineralized thermal springs at Elsinore have been well known for many years and are used for recreation and health purposes. Many small hot springs formerly issued along the northeast side of Lake Elsinore. In the early 1890's an irrigation canal was cut through that area, and during the next few years most of the springs ceased to flow and adjacent quagmires dried out (Waring 1915, p. 42). During the early 1900s hot wells were dug at the sites of several defunct springs to continue the supply of hot water. In 1926 the City of Elsinore sank two wells (map No. 55) which have yielded hot mineral waters in undiminished quantity since then.

The hot water originates in fissured Jurassic (?) diorite (San Marcos gabbro) and Cretaceous granodiorite (Woodson Mountain) on the northeast side of the Glen Ivy fault. The mapped trace of the fault lies from a half to two thirds of a mile southwest, but the disturbed zone apparently extends to the hot spring-hot well area. The Glen Ivy fault is an effective barrier separating the zone of thermal water from the principal ground water basin which is overlain by Lake Elsinore (Water Resources Board Bulletin 9, 1953, p. 15).

Ground water from the thermal zone is moderately mineralized, chiefly primary saline in character, and soft. Sodium is the most abundant positive ion; carbonate, bicarbonate, and chlorine predominate among the negative ions. The spring waters contain sulphur which possibly was derived from beds of tule mud through which the water passed before reaching the surface (Waring 1915, p. 43), but hydrogen sulphide gas, probably produced by sulphate-reducing bacteria, is still noticeable in hot water from the deep wells.

City of Elsinore * *(55).* Two 450-foot wells were drilled in section 6, T. 6 S., R. 4 W., S.B.M., near the north edge of Elsinore in 1926 to provide a municipal water supply. Well number one is in the City Maintenance Yard, just west of the north end of Langstaff Street; well number two is about 500 feet southeast of well number one and in the low ground between Langstaff and Riley Streets. Each well spudded in alluvium but below 30-foot depth is entirely in fractured granitic rock. In 1955, the water level stood at 128 feet and was pumped from the 160-foot level, leaving a 290-foot reserve depth to draw from if necessary. The hot water is pumped to a reservoir 80 by 180 by 16 feet deep where it is aerated and cooled for public consumption. Two private establishments, the Lake Elsinore Hotel, and the Pachanga Mineral Springs, obtain water directly from the hot pump line for use in mineral baths. A score or more of health bath establishments receive water from the regular city supply and reheat it for their uses.

Average water consumption in the City of Elsinore from 1945 through 1950 was 480-acre feet per season. Ground water storage in the source area of the City wells is believed, from geologic considerations, to have been little changed during the period 1927 to 1950 (Water Resources Board Bulletin 9, 1955, pp. 21, 22).

An analysis by the California Division of Water Resources of City of Elsinore well Number 1 in August 1953 follows:

Ion	Equivalent Parts Per Million	Parts Per Million
Ca	0.1	2
Mg	0.1	1
K + Na	4.18	96
CO_3	1.1	33
SO_4	1.05	78
Cl	2.2	50
NO_3	0.042	2.6
B	---	0.63
*Radon	---	0.71×10^{-10} curies per liter

* Analysis furnished by Rene Engel.

Water temperature out of ground: 108°F; pH: 9.7; Electric conductivity $\times 10^6$ @ 25°C: 540.

Of importance is the presence of about 5 parts per million of fluoride ion. This exceeds the U. S. Public Health Service and California State

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* Technical details provided by C. O. Soots, City of Elsinore Superintendent of Public Works, personal communication, 1955.

Department of Public Health mandatory limit of 1.5 parts per million fluoride ion concentration desirable in domestic water supplies. The Riverside County Health Department has therefore requested the City of Elsinore to find a substitute supply of water of acceptable quality (State Water Resources Board Bulletin 9, 1953, p. 22).

Creswell Baths (56). Location: Franklin Street between Main and Spring Streets, Elsinore, at the common corner of sections 5, 6, 7, and 8, T. 6 S., R. 4 W., S. B. M. Owners: Noritatsu and Mitsuyo Nakai.

A private well on the property yields hot waters for various hydrotherapeutic purposes. An analysis of the water by Edward S. Babcock and Sons, Riverside, in 1941 follows:

	Equivalent parts per million (milligram equivalents)	Parts per million
Total solids	---	402
SiO_2	---	51
Fe + Al	---	tr.
Ca	.65	13
Mg	.17	2
Na	5.01	115
CO_3	1.60	48
HCO_3	---	---
SO_4	1.88	90
Cl	2.35	83
B*	---	tr.

* Spectrographic analysis.

Lake Elsinore Hotel (Bundy Hot Springs, Wreden) (57). Location: Main and Franklin Streets, Elsinore. Ownership: Dr. William E. Schwartz, 604 N. Sierra Drive, Beverly Hills, owns the land; George Lewis, Murray Feinberg, and M. L. Herbener own the hotel.

First known as Bundys Elsinore Hot Springs and later as Wreden Hot Springs, this establishment is one of the two oldest spas in Elsinore. By 1915 the original spring had failed and been replaced by a well that yielded warm sulphureted waters used both for drinking and for bathing (Waring 1915, p. 43). Water has been obtained direct from the hot pump line of the City of Elsinore wells since 1926. The mineral waters are used at hotel facilities for drinking, either with or without aeration; and mineral, steam and swimming pool bathing.

A partial analysis of the water from the original spring follows: Analyst: E. W. Hilgard (Waring 1915, p. 43). Water temperature 112°F.

Ion	Parts per million
SO_4	55.0
Cl	17.0
$HCO_3 + CO_3$	*81.0
Na+K	*83.3
SiO_2	60.0
Ca + Mg	*14.0
Total solids	*310.3
H_2S	present

* Figures recalculated by Rene Engel.

Lakeview Inn Hot Springs (58). Location: Graham Avenue between Langstaff and Riley Streets, Elsinore. Owner: Kurt Miller, Elsinore.

Also known in the past as Elsinore Hot Springs, the Lakeview Inn property is one of Elsinore's two earliest established hot springs resorts. In 1888 a large bathhouse was built. By 1908 the baths were supplied by water pumped from three wells dug in former spring locations (Waring 1915, p. 42). Temperature of the water was 125°F (Waring 1915, p. 387). In 1945 the spa was reported using hot sulphureted water from 3 shallow wells for use in mud and tub baths (Tucker 1949, p. 179). The wells have since been abandoned and the Inn building converted to an antique shop.

Partial analyses of water from two of the original springs follow: Analyst: E. W. Hilgard (Waring 1915, p. 43). A: "original hot spring", B: "white sulphur spring".

	Parts per million	
Ion	A	B
SO_4	80.0	45.0
Cl	35.0	52.0
$HCO_3 + CO_3$	*49.7	*62.0
Na + K	84.0	80.0
SiO_2	32.0	50.0
Ca + Mg	*13.2	*16.0
Total solids	*293.9	*305.0
H_2S	0.1	present

†Radon—3.16×10^{-10} curies/liter

* Figures recalculated by Rene Engel.

† Analysis by Rene Engel.

LIST OF MINERAL DEPOSITS

The list of mineral deposits on the two following pages has been arranged alphabetically by commodities to accompany Economic Map of the Lake Elsinore Quadrangle, plate 2. (All townships are south, and all ranges west of San Bernardino base and meridian.)

METALS

Map No.	Name of Mine or Claim	S	T	R
	Arsenic			
1	Shining Star	NW ¼ 6	6	4 proj.
	Copper			
2	Beehive	NE ¼ 1	8	6 proj.
(9)	Joker & Catherine (see under gold)			
(28)	Palisades group (see under lead-silver-zinc)			
3	Silver Shine prospect	NW ¼ 6	8	5 proj.

Map No.	Name of Mine or Claim	S	T	R
	Gold			
4	Argonaut group	NE ¼ 9	6	4
	Arroyo del Toro prospects	6, 7 (?)	5	4
	Binkley's diggings	2	6	4
5	Blue Goose	NW ¼ 23	7	6 proj.
6	Brady prospect	NE ¼ 4	6	4
7	Golton group (Mineral Chief)	NW ¼ 20	5	4
8	Good Hope (Gold Prince, San Jacinto)	NW ¼ 15	5	4
9	Joker & Catherine (San Juan Creek prospect)	NE ¼ 2	7	6 proj.
10	Lake View prospect	NW ¼ 4	6	4
11	Lee prospect	SE ¼ 14	6	5
12	Los Pinos (Old Niggerhead)	SW ¼ 12	6	6 proj.
13	Lucky Strike (Ophir)	SE ¼ 21	5	4
14	Musick	NE ¼ 23	5	4
–	O'Brien	16 (?)	5	4
(27)	Old Dominion (see under lead-silver-zinc)			
15	Owens	NE ¼ 15	5	4
16	Purple Hope (Bob Cat No. 1)	SE ¼ 24	5	5
17	Red Bird No. 1	SE ¼ 24	5	5
18	San Jacinto	S ½ 10	5	4
(26)	San Mateo Canyon prospects (see Beehive under Copper; Mammoth under Iron)			
–	Tyler's diggings	10	6	4
19	Wrench prospect	S ½ 34	5	4
20	Yaeger (Hendricks district)	2, 3	6	6 proj.
		34	5	6 proj.
21	Yvonne (Lucas Canyon)	S ½ 10, 11	7	6 proj.
22	Unnamed prospects	W ½ 23	5	4
23	Unnamed prospect	N ½ 14	5	4
24	Unnamed prospect	SE ¼ 15	5	5
25	Unnamed prospect	NE ¼ 22	5	5
	Iron			
26	Mammoth	6, 7	8	5 proj.
		31	7	5 proj.
		36	7	6 proj.
	Lead-Silver-Zinc			
–	Acme	7 (?)	6	5
27	Old Dominion (Ortego)	SE ¼ 7	6	5
28	Palisades group	SE ¼ 4	6	4
	Manganese			
29	Beal-McClellan (Black Eagle, Newport, Brum and Newport, Elsinore in part)	SW ¼ 23	5	4
–	Elsinore (East group, West group)	23, 24 (?)	5	4
30	Robinhood No. 4	NE ¼ 33	5	4
31	Unnamed prospect	NW ¼ 34	5	4
	Tin			
–	American Flag	4, 9	6	4
32	Chief of the Hills tin group	NE ¼ 4	6	4
		NW ¼ 3	6	4
–	Monarch	4, 9	6	4
33	Unnamed prospect	S ½ 22	5	4
		N ½ 27	5	4
34	Unnamed prospect	SW ¼ 4	6	4
	Uranium-Thorium			
–	Unnamed claims along San Juan Canyon	1, 2	7	6 proj.
		36	6	6 proj.
		31	6	5 proj.

NONMETALS

Clay

Note: Letters in parentheses under map number refer to sketch map of deposits, figure 8.

Map No.	Name of Mine or Claims	S	T	R
35	Alberhill Coal & Clay Co. holdings	22, 23	5	5
(g)	Hill Blue No. 1 pit	SE ¼ 22		
(r)	Hill Blue No. 4 pit	NW ¼ 23		
(n)	Main Tunnel pit	NE ¼ 22		
(s)	No. 4 Plastic pit	NW ¼ 23		
(o)	Pink Mottle No. 1	NE ¼ 22		
(u)	Pink Mottle No. 2	SW ¼ 23		
(t)	Pink Mottle No. 3	SW ¼ 23		
(p)	Pink Mottle No. 4	NE ¼ 22		
(m)	West pit	NE ¼ 22		
36 (w)	Elsinore Clay Co. (Morton pit)	NE ¼ 31	5	5
37	Gladding, McBean & Co. holdings	21, 22	5	5
(g)	New Sloan pit	NE ¼ 21		
(i)	Old Sloan pit	NE ¼ 21		
(h)	Red Sloan pit	NE ¼ 21		
(j)	Unnamed pit	SW ¼ 22		
(k)	Unnamed pit	SW ¼ 22		
(z)	Unnamed prospect	SE ¼ 14		
38	Los Angeles Brick & Clay Products Co. holdings	21	5	5
(f)	Green pit	SE ¼ 21		
(a)	High Power pit	SW ¼ 21		
(e)	No. 1 pit	SE ¼ 21		
(d)	No. 2 pit	SE ¼ 21		
(c)	No. 7 pit	SE ¼ 21		
(b)	No. 23 pit (Wet Weather)	S ½ 21		
39	Oak Park prospect	NE ¼ 18	5	
40	Pacific Clay Products holdings	22, 26, 27	5	5
(l)	Douglas pit	NE ¼ 22		
(v)	Hoist pit	NE ¼ 26		
(x)	Unnamed pit	NE ¼ 27		
41	Sievert prospect	SE ¼ 34	6	5
42 (y)	Unnamed prospect	SE ¼ 16	5	5
	Coal			
43	Alberhill Coal and Clay Co. Coal deposit (previously Colliers and Cheney coal mine)	NE ¼ 22	5	5
–	Dolbeer & Hoff	SW ¼ 26	5	5
	Limestone			
44	Best Ranch	S ½ 28	5	4
	Silica			
45	Nettleton	NE ¼ 14	6	4
	Stone			
46	Unnamed granite quarry	SW ¼ 18	5	4
47	Unnamed granite quarry	SE ¼ 18	5	4
48	Unnamed granite quarry	NW ¼ 17	5	4
49	Unnamed metasandstone quarry	E ½ 14	5	4
50	Unnamed road material pit	SE ¼ 19	5	4
51	Unnamed road material pit	NE ¼ 24	5	5
–	Rainbow slate group	?	5	4
52	Wrench slate prospect	S ½ 34	5	4
53	Unnamed slate quarry	S ½ 23	5	4
54	Unnamed slate quarry	N ½ 26	5	4
	Mineral Springs			
(57)	Bundy (Lake Elsinore Hotel)			
55	City of Elsinore wells	SE ¼ 6	6	4 proj.
56	Creswell Baths	Corner 5, 6, 7, 8	6	4 proj.
57	Lake Elsinore Hotel (Bundy Hot Springs, Elsinore Hot Springs, Wreden, Wrenden)	Corner 5, 6, 7, 8	6	4 proj.
58	Lakeview Inn Hot Springs (Elsinore Hot Springs)	NE ¼ 7	6	4 proj.

TABULATED LIST OF MINERAL DEPOSITS IN LAKE ELSINORE QUADRANGLE

In the following list appear summary references to all known mines and mineral deposits in the quadrangle, arranged alphabetically with metals preceding nonmetals. Information was gathered from observation, literature, and communications, from informed persons, and although believed authentic, is largely unverified by the authors.

Numbers in the first column refer to locations on the Economic Map, plate 2. The unnumbered claims and mines are not shown on the map. Numbers in parentheses indicate the claim or mine name is an alternate name; the preferable one is referred to in the "Remarks and references" column.

Under "name of claim or mine" appear all known names applied to the property, past, and present. Alternate names follow the preferred name in parentheses and appear in alphabetical order as cross-references elsewhere on the list.

Owners listed are the most recent ascertainable. Unless otherwise noted, the owner is assumed to be the operator also.

Under the column headed "Location" uncertain section locations are indicated by a question mark. Under "T" is the number of the township (west) and under "R" the number of the range (south) of the San Bernardino base and meridian. "Proj." indicates the township grid was projected from elsewhere on the map.

In the last column all known references to the deposit appear in parentheses at the end of the remarks. Different references are separated by semicolons. Names are those of the authors of the references and are listed alphabetically in the bibliography of the report. The number preceding the colon indicates the year the reference was published; the number or numbers between the colon and the semicolon are the page numbers. (Thus "Tucker 29:480" after the Good Hope gold mine refers to an article by Tucker published in 1929. In the bibliography this is seen to be Tucker, W. B., and Sampson, R. J., 1929, Los Angeles Field Division—Riverside County: California Div. Mines Rept. 25, pp. 468-526. A description of the Good Hope mine appears on page 480 of that report.) The word "herein" at the end of the list of references indicates a description in the body of the text of this report.

ARSENIC

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
1	Shining Star	James Wrench, Elsinore (1945)	NW¼6	6S	4W	SB proj.	North side of flat-topped hill north of Pottery at Lewis Streets, northwest Elsinore. (Tucker 29:468-469; 45: 123-124, plate 35; herein.)

COPPER

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
2	Beehive	Howard V. Harrison, Thomas Dunston, Paul Harris, Beth Harris French, Box 502, Fallbrook (1955)	1	8S	6W	SB proj.	West wall of San Mateo Canyon, 2/3 of a mile S 75° W from junction of Nickel (Quail) and San Mateo Cañyons. Irregular bodies of chloritized, brecciated, sheared granitic and aplitic rocks within Woodson Mountain (?) granodiorite country rock contain bornite, chalcopyrite, malachite, and chalcanthite efflorescence. Mineralized bodies elongated N-S parallel with and in shear zones in country rock. Largest outcrops about 150 ft. by 50 ft. Assays reported by owner as high as 7% copper, $4 per ton in gold, with traces of silver. Explored by 10-ft. adit in 1916; 100-ft. adit driven N in 1932, now caved, followed 2½% copper. Inactive since 1932 except jeep road bulldozed through deposit in 1947, and samples tested.
	Defiance District (American Queen, Coleman, Copper King, Della, Fisher)	C.C. Jones, Los Angeles (1914)		8S	6W	SB proj.	Near San Mateo Canyon; apparently includes Beehive copper and Mammoth iron deposits. (Hubon 02:6; Merrill 16:665-666.)
(9)	Joker and Catherine						See under Gold.
(28)	Palisades group						See under Lead-silver-zinc. (Eric 48:294, map; Tucker 29:491; 45:148.)
3	Silver Shine	Howard V. Harrison, Thomas Dunston, Paul Harris, Beth Harris French, Box 502, Fallbrook (1955)	6	8S	5W	SB proj.	Adjacent to Mammoth iron claims (which see) about 1/4 mile northeast of juncture of Nickel (Quail) and San Mateo Canyons, about 1/8 mile south of San Diego County line. Quartz vein, carrying minor amounts of chalcopyrite and secondary copper carbonate minerals is traceable

COPPER (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Silver Shine (continued)						several hundred feet striking N 60° E, dipping 88° SE, through body of sheared diorite within andesitic country rock (Santiago Peak volcanics). Prospected by means of small open cut and short adit prior to 1932. No production; long idle.

GOLD

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
4	Argonaut group	J.H. Wrench, Elsinore (1937)	NE¼9	6S	4W	SB	Southernmost knob of low hills about 1½ miles east of Elsinore, about 1/4 mile south of Palisades prospect. Country rock is diorite and gabbro (San Marcos gabbro), generally shattered and deeply weathered. Gold was sought in or adjacent to aplitic and basic dikes of various attitudes. North of hill aplitic dike, 18 in. wide, strikes N 30° W and dips vertically in fracture zone about 8 ft. wide, partly filled with smaller dikes, clayey and limey materials. Zone explored by 14-ft. pit, now somewhat caved. About 250 yards away on south slope of hill, large dike-like body of thoroughly shattered and altered fine-grained dark igneous rock is faulted against the decomposed dioritic rock. A 12-ft. adit and, 50 yards to the east, a 75-ft. adit have been driven northerly exploring this contact zone. Shallow pits and trenches, both north and south of hill, explore minor dikes in weathered diorite. Little or no production indicated by the workings; idle for years.
	Arroyo del Toro prospects	Not determined	6,7(?)	5S	4W	SB	Arroyo del Toro, about 5 miles north of Elsinore. Prospecting in Woodson Mountain granodiorite, Triassic Santa Ana (Bedford Canyon) slates, and Temescal Wash quartz latite prophyry, in the drainage of Arroyo del Toro. Date and results of prospecting not determined; no activity for years. (Larsen 48:130; 51:47.)
	Binkley's diggings	Not determined	2	6S	4W	SB	Near junction of Cottonwood Canyon with San Jacinto River, just south of Railroad Canyon Dam, about 3 airline miles east of Elsinore. Active in 1876, extent or success of operation undetermined. Long idle. (Merrill 19:527.)

GOLD (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
5	Blue Goose	George W. Williams, Box 462, San Juan Capistrano, and Charles Christopherson, Box 205, San Juan Capistrano (1954)	23	7S	6W	SB proj.	Near north rim of Verdugo Canyon, 1/2 mile south of Wheeler Ranch, about 10 airline miles southwest of Willard. Brecciated zone near contact of andesite (Santiago Peak volcanics) and dacite porphyry replaced and filled by quartz, sericite, and limonite derived from oxidation of pyrite. Low values in gold and silver reported. Neither definite vein nor ore minerals visible. Undeveloped prospect. Idle.
(16)	Bob Cat No. 1						See Purple Hope.
6	Brady prospect	E.H. Brady, Elsinore (1937)	NE¼	6S	4W	SB	Southwest slope of hills about 1½ miles east of Elsinore. Contact of diorite and gabbro (San Marcos gabbro) with Triassic Santa Ana (Bedford Canyon) schist, where vein quartz accompanies a 4 to 6 ft. wide aplitic dike, now much fractured and decomposed, that strikes N 50° W, dips vertical. Manganese oxide stains. Dike zone explored by 35-ft. vertical shaft, now inaccessible, with lateral workings of undetermined extent at bottom. About 75 yards southeast of this shaft a 15-ft. shaft, largely caved, and a 25-ft. connecting adit, driven N, expose similar rocks. In the gully bottom, about 200 yards south of these workings an inaccessible 35-ft. shaft and 3 caved pits explore the same intrusive contact. Production, if any, undetermined but small. Idle for years.
(9)	Catherine						See Joker.
(8)	Gold Prince						North extension of Good Hope, which see. (Merrill 19: 532.)

GOLD (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
7	Golton group (Mineral Chief)	D.V. French and J.S Hopper (1946)	NW¼20	5S	4W	SB	Northwest side of unnamed small valley in foothills about 2½ airline miles north-northeast of North Elsinore. Two vuggy quartz veins 1½ and 3 ft. wide occur about 250 yards apart in northerly trending, steeply dipping zones 3 to 5 ft. wide of shattered, porous, iron- and manganese-stained siliceous rocks in Temescal Wash quartz latite porphyry. Westerly vein explored by 10-ft. open cut and 15-ft. irregular inclined shaft; easterly vein by 65-ft. adit driven N. 25° W in shear zone. Similar occurrences are exposed in a 12-ft. deep pit about 200 yards north of the easterly vein, and in a few small open cuts. In the next gully, about 1/4 mile southeast of these showings, a zone of similarly stained vuggy quartz in coarser grained country rock has been explored by a small shaft now flooded to within 7 ft. of surface. Production, if any, undetermined but small; idle for years. (Tucker 29:480; 45:plate 35.)
8	Good Hope (Gold Prince Goodhope, San Jacinto)	Mrs. Velna L. Teater, 500 S. Commonwealth, Los Angeles (1955)	NW¼15	5S	4W	SB	Northwest side of Highway 74 about 5 airline miles northeast of Elsinore. (Burnham, F.R., 1893: unpub. report; Crawford 94:221-223; 96:311; Daniell, John, 1948: unpub. report; Dudley 35:488,506; Fairbanks 93:106,107, 384; Goodyear 88:527; 90:151; Larsen 48:129-130; 51: 46; Merrill 19:529,532-533; Sampson 35:509-511, pl. VIII; Tucker 22:222; 29:471,480; 45:132-133,134, plate 35; herein).
(20)	Hendricks District						See Yaeger (Goodyear 90:153).

GOLD (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
9	Joker and Catherine (San Juan Creek prospect)	J.A. Boyle and W. Edkins (1938)	NE¼2	7S	6W	SB proj.	North side San Juan Canyon about 1/4 mile from Highway 74, about 1½ airline miles from west edge of quadrangle. Irregular quartz vein cuts, replaces massive slate of Triassic Santa Ana (Bedford Canyon) formation. Vein several ft. wide in places contains dark sphalerite, pyrrhotite, and some chalcopyrite; reported to be fairly rich in gold. No production; idle for many years. (Larsen 48:131-132; 51:48.)
10	Lake View prospect	Mack and Thurman, Elsinore (1937)	NW¼4	6S	4W	SB	South side of low hills about 1½ miles northeast of Elsinore, about 3/4 mile north-northwest of city dump. Deeply weathered and chloritized diorite (San Marcos gabbro) includes shear zones containing alaskitic, aplitic, and pegmatitic dikes. Gold sought in shear zones which strike N to NE, dip 60° to 35° SE. Workings include pits 15 and 25 ft. deep about 75 ft. apart in a SW-NE line, with a 12-ft. adit driven northward between them, exploring different shear zones. A 15-ft. pit 100 yards north exposes a 6-in. shear zone in pegmatitic diorite. Little or no production; idle for years.
11	Lee prospect	Not determined	SE¼14	6S	5W	SB	East base of Elsinore Mountains, about 2 miles southeast of Willard, about 1/3 mile southwest of Grand Avenue. Fault contact between Triassic Santa Ana (Bedford Canyon) slate and quartzite and diorite and gabbro (San Marcos gabbro) explored by 25-ft. crosscut adit driven S 85° W. Contact is 10 ft. from face of adit. Triassic rocks strike about N-S, dip 50° W to vertical in contorted zone at portal. Alaskite dike 8 in. wide at portal parallels bedding of metamorphic rocks. Neither ore mineralization nor definite vein visible. Adit filled with sand to within 2 ft. of top; no production; idle many years.

GOLD (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
12	Los Pinos (Old Niggerhead)	E.S. Brady, 4314 Gateway Avenue, Los Angeles (1954)	SW¼12	6S	6W	SB proj.	Head of Hot Spring Canyon, on southeast slope of Los Pinos Peak, about 5 airline miles west of Willard. Deposit consists of gold-bearing quartz veins near contact of Triassic Santa Ana (Bedford Canyon) slates and quartzites and diorite and gabbro (San Marcos gabbro). Local residents report several hundred feet of shafts and adits on the property, mostly inaccessible since early 1900's. Sampling prior to reopening mine undertaken in 1954, with unreported results. Production, if any, not determined. Inactive in 1955.
(21)	Lucas Canyon claims						See Yvonne. (Larsen 48:132; 51:48.)
13	Lucky Strike (Ophir)	R.S. Fisher and R.L. Reade, Elsinore (1945)	SE¼21	5S	4W	SB	Southeast side of Highway 74 about 3 airline miles northeast of Elsinore. (Crawford 96:313; Merrill 19: 529,532; Sampson 35:513, pl. VIII; Tucker 29:486; 45: 137-138, plate 35; herein.)
(7)	Mineral Chief	D.V. French and J.S. Hopper (1946)					See Golton group.
14	Musick	Dr. H.L. Musick, (decd.) 2236 Whittier Blvd., Los Angeles (1937)	NE¼23	5S	4W	SB	West side Railroad Canyon, 1/8 mile from stream, about 4½ airline miles northeast of Elsinore. Thin quartz stringers 1-2 in. wide occur in schistosity planes of Triassic Santa Ana (Bedford Canyon) slate, strike N 5°-20° W, dip about 70° NE. Gold sought in a series of workings, now badly caved and overgrown, along a strike distance of about 150 yards. A vertical shaft, now inaccessible, is at least 40 ft. deep despite caving, and may be the main source of the large tonnage of dump material present. Shallow pits and trenches are present but apparently the property has been inactive many years. Production, if any, not determined.

GOLD (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	O'Brien	Mrs. O'Brien, Perris (1894)	16(?)	5S	4W	SB	Low hills about 4½ airline miles northeast of Elsinore, 1 mile west of Good Hope mine. One lode claim reported in 1894. Details and subsequent history not determined; idle many years.
(27)	Old Dominion						See under Lead- silver-zinc.
(12)	Old Niggerhead						See Los Pinos.
(13)	Ophir						See Lucky Strike. (Crawford 96:313; Merrill 19:532; Sampson 35:513; Tucker 29:486; 45:137; herein.)
15	Owens	William A. Owens, Route 2, Box 228E, Perris (1954)	NE¼15	5S	4W	SB	Rolling area about ½ mile southeast of Highway 74 about 5 miles northeast of Elsinore, 3/5 of a mile due east of Good Hope mine. Diorite aplite dike 3-5 ft. wide trends N 10° E, discontinuously exposed for 100 yards or more through deeply weathered quartz diorite (Bonsall tonalite). Gold sought in 4 shallow pits and shafts now largely caved, in line trending for 75 yards N 25° E across aplite dike. Deepest shaft, at southwest end of workings, is 30 ft. deep but caved near collar and inaccessible. A little iron-stained, fractured vein quartz lies on dump. According to owner no production is known, and the workings have been abandoned since prior to 1900. Ruins of a stone arastre remain at the road corner 250 yards southwest of the 30-ft. shaft.
16	Purple Hope (Bob Cat No. 1)	H.L. Long, W.E. Giles, M. Isaac, G.J. Issac, 8232 South Nutwood Street, Anaheim (1954)	SE¼24	5S	5W	SB	North side of prominent hill, about 2-3/4 miles east of Alberhill. Metamorphosed tuffs and related volcanic sediments of Santa Ana formation (Santiago Peak volcanics). Bedding strikes N 35° W, dips 60° SW. Prominent outcrop of bleached, shattered rock stained by iron and manganese oxides and abundant clayey gouge. Explored by incline driven northeast but caved at 6-ft.

GOLD (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Purple Hope (continued)						depth; 15-ft. trench with 8-ft. back; several shallow pits. Production undetermined but small; long idle.
17	Red Bird No. 1	A.W. Meier and J. Taylor, address not determined (1947)	SE¼24	5S	5W	SB	Northeast side of prominent hill about 2-3/4 miles east of Alberhill. Metamorphosed tuffs and related volcanic sediments of the Triassic Santa Ana formation (Santiago Peak volcanics) about 100 yards east of contact with (Temescal Wash) quartz latite porphyry. Dike-like outcrops trend N 30° W, dip 60° W, explored and mined in open pit 20 ft. deep, 25 ft. wide, 35 ft. long, and smaller pits. Concrete mill foundation remains; all machinery gone. 1000 tons or more of mill tailings on dump largely chloritized volcanic rock with iron oxide stain. Production undetermined. Idle many years.
18	San Jacinto	Mrs. Velna L. Teater, 500 South Commonwealth, Los Angeles (1955)	SE½10	5S	4W	SB	Northwest side of Highway 74 about 5 airline miles northeast of Elsinore, about 1/2 mile northeast of Good Hope mine. Claim of Good Hope group, on northeast extension of same vein system. See Good Hope. (Tucker 45:plate 35.)
(9)	San Juan Creek prospect						See Joker (Larsen 48:132-133; 51:48).
(1, 2, 26)	San Mateo Canyon prospects						Lower San Mateo Canyon, for about a mile north of its junction with Nickel (Quail) Canyon, and several miles south of that point, off the quadrangle. Woodson Mountain (?) granodiorite and andesite porphyry of Santiago Peak volcanics contain unproved showings of gold, silver, copper and iron. Prospected intermittently since about 1900; assays and tests made. Area inaccessible until jeep roads built in late 1940's. See Beehive and Silver Shine under Copper; Mammoth under Iron. (Larsen 48:132; 51:48.)

GOLD (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Tyler's diggings	Not determined	10	6S	4W	SB	Railroad Canyon, about 2½ airline miles east of Elsinore. Active in 1876 with undetermined results. Long idle. (Merrill 19:527.)
19	Wrench prospect	J.H. Wrench, Elsinore (1937)	S½34	5S	4W	SB	West side of Railroad Canyon about one mile northwest of dam and 2½ miles northeast of Elsinore. Quartzite and slates of Triassic Santa Ana (Bedford Canyon) formation that strike N 70° W, dip 45° NE contain quartz stringers and irregular silification in a sheared zone 3–4 ft. wide, about parallel to the schistosity. Quartz is drusy, and trends in part athwart shear direction. Workings include open cut 10 ft. wide, 20 ft. long, now caved to average depth of about 5 ft. A moderate-sized dump indicates concealed underground workings. Production, if any, small; idle for years.
20	Yaeger (Hendricks District)	Miss Lillian Yaeger, 108 West Brookdale Place, Fullerton (1954)	2,3 34	6S 5S	6W 6W	SB proj.	South side of upper Trabuco Canyon about 6 airline miles northwest of Willard. (Crawford 96:272; Goodyear 90:153; Tucker 25:62; herein.)
21	Yvonne (Lucas Canyon claims)	George W. Williams, Box 462, San Juan Capistrano and Charles Christopherson, Box 205, San Juan Capistrano (1954)	S½10, 11	7S	6W	SB proj.	Upper Lucas Canyon, about 8½ to 9 airline miles southwest of Willard. Placer sand and gravel in Lucas Canyon creek bottom. About 1900, placer gold was discovered here and in Lucas Canyon west of the quadrangle. Prospectors said to have seldom made more than $1 a day although $40 an hour was reported panned at one place by two men. Pay dirt covered by 10 to 20 ft. of barren gravel that has been worked intermittently since the 1940's. Production undetermined but small. (Larsen 48:132; 51:48.)
22	Unnamed prospects	Not determined	W½23	5S	4W	SB	Northwest side of rolling hills between Railroad Canyon and Highway 74, about 4½ airline miles northeast of Elsinore. Triassic Santa Ana (Bedford Canyon) schists

GOLD (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
							and slates cut by NE-SW trending faults, and by NW-SE trending aplitic and alaskitic bodies. Quartz in sheer zones, and disintegrated siliceous material prospected in linear series of trenches and shallow pits extending nearly 1/4 of a mile in NE-SW direction. Openings thoroughly caved-in and overgrown; the deepest, near the southwest end, is about 10 ft. Little or no production; idle many years.
23	Unnamed prospect	Not determined	N½14	5S	4W	SB	Rolling hills about 7 airline miles northeast of Elsinore, 4/5 of a mile southeast of Highway 74, 150 yards south of center of north side section 14. Glassy quartz vein 3 ft. wide, strikes N- S, dips 70°-80° W, in bedding plane of Triassic Santa Ana (Bedford Canyon) slate. Septum of decomposed granitic dike rock divides vein. Quartz traceable several hundred feet to north in float. Gold sought in vertical shaft on vein 50 ft. or more deep but inaccessible. Production, if any, not determined; long idle.
24	Unnamed prospect	Not determined	SE¼15	5S	5W	SB	Northeast base of hill about 1/3 of a mile northeast of Alberhill. West-trending fault zone in metavolcanic rocks of the Santa Ana formation (Santiago Peak volcanics) prospected by 10-ft. adit driven SW. No production; idle many years.
25	Unnamed prospect	Not determined	NE¼22	5S	5W	SB	Northeast base of hills, about 3/4 of a mile due east of Alberhill. Sheared weathered Triassic Santa Ana (Bedford Canyon) shale and slate strike N 30° W, dip 60° NE, prospected by 185-ft. crosscut adit driven S 40° W. No production; idle many years.

IRON

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
26	Mammoth	Howard V. Harrison, Thomas Dunston, Paul Harris, Beth Harris French, Box 502, Fallbrook (1955)	6,7 31 36	8S 7S 7S	5W 5W 6W	SB proj.	About 1/4 of a mile south of San Diego County line and 1/4 of a mile northeast of juncture of Nickel (Quail) and San Mateo Canyons. Adjacent to Silver Shine copper prospect. (Harrison, H.V., 1955, personal communication; Munhall, J.K., 1954, personal communication; herein.)

LEAD - SILVER - ZINC

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Acme	Bud Waller, Perris (1896)	7(?)	6S	5W	SB	Adjoining Old Dominion mine, about 7 miles west of Elsinore. Vein explored by open cut and adit 100 ft. below outcrop, reported in 1894. Production and subsequent activity undetermined. (Crawford 94:25; 96: 33.)
27	Old Dominion (Ortego)	Earl Frevert and V.B. Anderson, 216 East Second Street, Santa Ana (1954)	SE¼7	6S	5W	SB	Head of Long Canyon, about 3 airline miles west of Willard. (Bedford 46:11; Crawford 94:25; Harris, P.M., 1954, personal communication; Larsen 48:132; 51:48; Sampson 35:514, pl. VIII; Tucker, W.B., 1943, unpub. repts.; Tucker 25:64; herein.)
(27)	Ortego						See Old Dominion. (Tucker, W.B., 1943, unpub. repts.)
28	Palisades group	George Peterson, Elsinore (1929)	SE¼4	6S	4W	SB	Foothills about 2 airline miles east of Elsinore. Sheeted, fractured zone, 2-3 ft. wide, strikes N 60° E, dips 50° SE in deeply weathered diorite and gabbro (San Marcos gabbro). Associated with iron-stained dioritic dike and dark green diabasic and lamprohyric dikes. Limonite and secondary calcite occur in fractures. Ore minerals not visible, although "spotted values" in silver, lead, copper, and gold reported in 1929. Workings, disposed for several hundred yards in NE-SW direction, include inaccessible 30-ft. inclined shaft on sheeted zone and several shallow pits to southwest. Nearly 1/4 mile northeast are several caved pits 4-7 ft. deep, and one 35-ft. adit in similar rocks. Production, if any, undetermined but small; idle for years. (Eric 48:294, map; Tucker 29:491; 45:148, plate 35.)

MANGANESE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
29	Beal-McClellan (Black Eagle, Newport, Brum and Newport; Elsinore in part)	G.S. Beal, R.W. McClellan, Elsinore, and G.R. Smith, La Habra (1950). Leased 1942-47 to A.P. Manion, Perris.	SW½23	5S	4W	SB	Near top of northwest wall of Railroad Canyon, about 5½ airline miles northeast of Elsinore. (Bradley 18:56-57, 94; Merrill 19:546 ("West Group"); Jenkins 43:83, 154, map; Sampson 35:515; Trask 50:180-182; Tucker 29:493; 45:150; herein.)
(29)	Black Eagle and Newport						See Beal-McClellan. (Jenkins 43:83; Trask 50:180-182; Tucker 45:150, plate 35.)
(29)	Brum and Newport						See Beal-McClellan. (Bradley 18:56-57, 94; Trask 50: 180-182; Tucker 29:493.)
	East group						See Elsinore. (Merrill 19:546.)
	Elsinore (East group, West group)	Charles P. Carter, Elsinore (1929)	23,24 (?)	5S	4W	SB	Railroad Canyon, about 5½ airline miles northeast of Elsinore--main deposit reported west of creek (West group); minor showing reported east of creek (East group). Confused in past reports with Beal-McClellan mine, in same section. Prospect only--no development or production. (Aubury 06:336; Bradley 18:58; Harder 10: 165; Jenkins 43:83, 155, map; Merrill 19:546; Sampson 35:515; Trask 50:181, 182-183; Tucker 29:493; 45:150, plate 35; herein.)
30	Robinhood No. 4	Giles D. and Eunice M. Robbins, 2754½ Nebraska Avenue, South Gate (1942)	NE¼33	5S	4W	SB	Low hills about 1½ miles southeast of Highway 74 about 2 miles northeast of Elsinore. Triassic Santa Ana (Bedford Canyon) chloritic shaly slate, strike N 60° W, dip 60° NE, contains 3-ft. wide manganiferous siliceous layer in bedding plane. Black manganese oxide, mostly hard, replaces pink crystalline rhodonite, and black-stained silica. Manganiferous layer massive, except 6 in. of parallel banding on each border suggests layering, possibly of chert beds. Exposures limited to 10-ft.

MANGANESE (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
30	Robinhood No. 4 (continued)						trench with 7-ft. face; 3-ft. pit 50 ft. southeast on same lens, and a 10-ft. long outcrop of similar material 30 ft. to southwest and 100 ft. south of trench. No production; idle.
31	Unnamed prospect	Not determined	NW¼34	5S	4W	SB	Low hills about 2 miles southeast of Highway 74, about 2½ miles northeast of Elsinore. Triassic Santa Ana (Bedford Canyon) slate strikes N 65° W, dips 50° NE. Siliceous bed 4½ ft. thick contains black manganese oxides, hard and soft, with black stained silica and a little pink rhodonite. Black banding and fissility in manganiferous layer parallels bedding suggestive of chert. Manganese-bearing layer exposed along 20-ft. trench with 5-ft. face; offset segment of similar zone exposed in shallow pit just southeast; no outcrops remain. No production; idle for years.
	West group						See Elsinore (Merrill 19:546).

TIN

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	American Flag and Monarch	Not determined	4,9	6S	4W	SB	Location reported "2 miles east of Elsinore", not identified in 1955. Twelve claims, in 3 groups, in Triassic Santa Ana (Bedford Canyon) slates and quartzites and granitic rocks (Bonsall tonalite ?) and basic dikes. No veins; "dikes" are mainly colored streaks in granitic rocks. Explored by at least 20 open cuts, pits, and shallow shafts. Six samples taken from places designated by former owners as carrying 22 to 80 lbs. tin per ton were found to contain less than 0.4 lb. tin per ton; less than 0.2 lb. nickel and 0.4 lb. cobalt. (Beford 46:10.)
32	Chief of the Hills tin group (mislabeled "Mn" on economic map)	J.M. Mack, C.L. Berry, and Mary Briner, Elsinore (1926) (public domain 1945)	NE¼4 NW¼3	6S	4W	SB	East side of high point on ridge one mile west of Railroad Canyon Dam, about 2 airline miles east of Elsinore. County rock is Triassic Santa Ana (Bedford Canyon) slate, quartzite, and metaconglomerate; beds strike N 5° to 20° W, dip 80° E. Comb quartz veins 2 to 3 in. wide on edge of metaconglomerate body; much discoloration by iron, manganese (?) oxides. Tin reported to occur as reddish brown crystals lining cavities in minutely crystalline tourmaline associated with 5 fine-grained granitic dikes (1929); tin minerals not found by writer in 1954. Reported assays of 0.30 to 2.21% tin (1929), and 7% tin (1941). Prospected in late 1920's by shallow trenches and 100-ft. vertical shaft with crosscuts driven 20 ft. east and 10 ft. west at bottom. West crosscut reported driven in material that assayed 0.31 to 1.22% tin. Shaft open but inaccessible in 1954, inhabited by owls. No production; idle many years. (Larsen 48:133; 51:49; Sampson 35:516; Segerstrom 41:551; Tucker 29:496; 45:152, plate 35.)
	Monarch						See American Flag. (Bedford 46:10.)

TIN (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
33	Unnamed prospect	Not determined	S½22 N¼27	5S	4W	SB	About 3/4 of a mile southeast of Highway 74, about 3½ airline miles northeast of Elsinore. Pegmatite dike trends northeasterly through quartz diorite (Bonsall tonalite) near contact with Triassic Santa Ana (Bedford Canyon) slates. Traces of topaz and tourmaline exposed in shallow open cut; tin-bearing minerals not observed in 1954. No production; idle many years. (Larsen 48: 133; 51:49.)
34	Unnamed prospect	Not determined	SW¼4	6S	4W	SB	Southern base of low hills about one mile east of Elsinore, about 1/4 of a mile west of city dump. Deeply weathered diorite and gabbro (San Marcos gabbro) cut by sheared aplitic dike 5 ft. wide, traceable more than 100 yards trending N 65° E. Tin minerals reported sought in several shallow pits along the southeast edge of the dike, and a 30-ft. shaft, caved at the bottom and inaccessible at the westernmost exposure of the dike. Little or no production; idle many years. (Larsen 48: 133; 51:49.)

URANIUM AND THORIUM

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
	Unnamed claims	Not recorded	1,2 36 31	7S 6S 6S	6W 6W 5W	SB proj.	Along San Juan Canyon (Highway 74) in western slope of Santa Ana Mountains. (Herein.)

CLAY

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
35	Alberhill Coal and Clay Company	Alberhill Coal and Clay Company, Alberhill; leased to Pacific Clay Products in 1956.					
(q)	* Hill Blue No. 1 clay pit		SE¼22	5S	5W	SB	(Dietrich 28:163-169; Hill 23:205; Tucker 45:160; herein.)
(r)	Hill Blue No. 4 clay pit		NW¼23	5S	5W	SB	(Dietrich 28:163-169; Hill 23:205; Tucker 45:160; herein.)
(n)	Main Tunnel clay pit		NE¼22	5S	5W	SB	(Aubury 06:221; Dietrich 28:163-169; Hill 23:194,200; Irelan 87:176; Merrill 15:567,568; Sutherland 35:65.)
(s)	No. 4 plastic clay pit		NW¼23	5S	5W	SB	(Herein.)
(o)	Pink Mottle No. 1 clay pit		NE¼22	5S	5W	SB	(Hill 23:208; herein.)
(u)	Pink Mottle No. 2 clay pit		SW¼23	5S	5W	SB	(Hill 23:208; Tucker 45:160; herein.)
(t)	Pink Mottle No. 3 clay pit		SW¼23	5S	5W	SB	(Tucker 45:159; herein.)
(p)	Pink Mottle No. 4 clay pit		NE¼22	5S	5W	SB	(Herein.)
(m)	West clay pit		NE¼22	5S	5W	SB	(Aubury 06:221; Dietrich 28:163-169; Hill 23:196; Merrill 15:569; herein.)

*Letters refer to locations of clay deposits on sketch map.

CLAY (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
36 (w)	Elsinore (Morton)	Elsinore Clay Company	NE¼31	5S	4W	SB	(Tucker 45:161; herein.)
37	Gladding, McBean and Company	Gladding, McBean and Company, Main office: 2901 Los Feliz Blvd., Los Angeles					
(g)	New Sloan clay pit		NE¼21	5S	5W	SB	(Dietrich 28:172; Sutherland 35:70; herein.)
(i)	Old Sloan clay pit		NE¼21	5S	5W	SB	(Aubury 06:223; Dietrich 28:172; Sutherland 35:70; herein.)
(h)	Red Sloan clay pit		NE¼21	5S	5W	SB	(Dietrich 28:172; Sutherland 35:70; herein.)
(j)	Unnamed clay pit		SW¼22	5S	5W	SB	(Herein.)
(k)	Unnamed clay pit		SW¼22	5S	5W	SB	(Herein.)
(z)	Unnamed clay prospect		SE¼14	5S	5W	SB	Located on south face of hill, about 3,000 ft. northeast of Walker Ranch. Caved adit trends northward into hill. Residual red and white mottled, plastic clay derived from weathering of volcanic rocks is exposed over surface area about 200 ft. in diameter.
38	Los Angeles Brick and Clay Products Company	Los Angeles Brick and Clay Products Company, plant: Alberhill; main office: 1078 Mission Road, Los Angeles					
(f)	Green clay pit		SE¼21	5S	5W	SB	(Herein.)
(a)	High Power clay pit		SW¼21	5S	5W	SB	(Tucker 45:160; herein.)

CLAY (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
(e)	No. 1 clay pit		SE¼21	5S	5W	SB	(Dietrich 28:174,175; Sutherland 35:70; Tucker 45:160; herein.)
(d)	No. 2 clay pit		SE¼21	5S	5W	SB	(Dietrich 28:174,175; herein.)
(c)	No. 7 clay pit		SE¼21	5S	5W	SB	(Herein.)
(b)	No. 23 clay pit (Wet Weather)		S½ 21	5S	5W	SB	(Dietrich 28:174,175; Merrill 15:272; (photo), 574; Sutherland 35:70; Tucker 45:160; herein.)
39	Oak Park clay prospect	Not determined	NE¼18	5S	5W	SB	Located about 3/4 of a mile southeast of Lee Lake 1000 ft. south of State Highway 71. Two open trenches 60 x 15 x 15 ft. expose 5 to 7 ft. of micaceous sandstone and 3 ft. of greenish gray, waxy, clayey siltstone.
40	Pacific Clay Products	Pacific Clay Products, Main office: 306 West Avenue 26, Los Angeles					
(l)	Douglas clay pit		NE¼22	5S	5W	SB	(Dietrich 28:176; Sutherland 35:75; herein.)
(v)	Hoist clay pit		NE¼26	5S	5W	SB	(Dietrich 28:178; Merrill 15:570; herein.)
(x)	Unnamed clay prospect		NE¼27	5S	5W	SB	Open trench 60 x 10 x 6 ft. located about 200 ft. southeast of State Highway 71, exposes white clayey sandstone overlain by gray and orange, micaceous shale of the Silverado formation.
41	Sievert clay prospect	Not determined	SE¼34	6S	5W	SB	Sandy residual clay formed by weathering of granodiorite is overlain by about 10 ft. of red to gray buff sandstone and 2½ ft. of gray, sandy claystone.

CLAY (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
42 (y)	Unnamed clay prospect	Not determined	SE¼16	5S	5W	SB	Surface exposes purplish red, plastic residual clay derived from weathering of volcanic rocks of Santiago Peak volcanics.

COAL

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
43	Alberhill Coal and Clay Company coal deposit (Colliers and Cheney coal mine)	Alberhill Coal and Clay Company, Alberhill	NE¼22	5S	5W	SB	Underground workings were in the area now occupied by the West and Main Tunnel clay pits. (Hanks 86:117; Irelan 87:175; Tucker 45:159; herein.)
	Dolbeer and Hoff	Pacific Clay Products Company	SE¼26	5S	5W	SB	(Irelan 87:175; herein.)

LIMESTONE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
44	Best Ranch	John A. Snyder, Route 2, Box 220, Perris (1955)	S½28	5S	4W	SB	Rolling hills about one mile southeast of Highway 74, about 2-1/4 miles northeast of Elsinore. (Goodyear 90: 151; herein.)

SILICA

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
45	Nettleton	M.G. Nettleton, Temecula (1954)	NE¼14	6S	4W	SB	Prominent hills about 4 miles southeast of Elsinore. (Herein.)

STONE, GRANITE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
46	Unnamed granite quarry	Not determined	SW¼18	5S	4W	SB	Arroyo del Toro area, about 3½ miles north of Elsinore (Dudley 35:506; herein.)
47	Unnamed granite quarry	Not determined	SE¼18	5S	4W	SB	Arroyo del Toro area, about 3-3/4 miles north of Elsinore. (Dudley 35:506; herein.)
48	Unnamed granite quarry	Not determined	NW¼17	5S	4W	SB	Arroyo del Toro area about 4 miles north of Elsinore (Dudley 35:506; herein.)

STONE, METASANDSTONE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
49	Unnamed metasandstone quarry	Not determined	E½14	5S	4W	SB	Low rolling hills about 1/4 of a mile northeast of San Jacinto River, about 6 airline miles northeast of Elsinore. (Herein.)

STONE, METAVOLCANIC ROCKS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
50	Unnamed road material pit	Not determined	SE¼19	5S	4W	SB	Southern tip of rolling hills 3 miles due north of Elsinore. (Herein.)
51	Unnamed road material pit	Not determined	NE¼24	5S	5W	SB	Southeastern end of hills about 4 miles northwest of Elsinore. (Herein.)

STONE, SLATE

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION SEC.	T.	R.	B & M	REMARKS
	Rainbow slate group	Rainbow Mining and Mineral Products Company (1929)	?	5S	4W	SB	"Three miles north of Elsinore"; not found by writer. Probably in area of slate outcrops in Railroad Canyon. Triassic Santa Ana (Bedford Canyon) dark, red, yellow, and brown slates in beds 6 to 8 ft. thick quarried prior to 1929 and ground in a 20-ton capacity plant for roofing purposes. Production undetermined; long idle. (Tucker 29:524.)
52	Wrench slate prospect	J.H. Wrench, Elsinore (1937)	S½34	5S	4W	SB	See Wrench prospect under gold. About 200 ft. east of the gold prospect an open pit with face 20 ft. long and 5 ft. high exposes fissile slate of Triassic Santa Ana (Bedford Canyon) formation; strike N 60° W, dip 65° NE. Curvature of slaty cleavage planes, abundant cross fractures, and tendency of slate to fray on weathered edges limit commercial possibilities of this quarry site. No production; idle for years.
53	Unnamed slate quarry	Not determined	S½23	5S	4W	SB	West side of Railroad Canyon, about 1/4 of a mile from stream, about 4 miles northeast of Elsinore. (Dudley 35:494; Larsen 48:129; 51:45; herein.)
54	Unnamed slate quarry	Not determined	N½26	5S	4W	SB	West side of Railroad Canyon, about 1/4 mile from stream, about 4 miles northeast of Elsinore. (Dudley 35:494; Larsen 48:129; 51:45; herein.)

MINERAL SPRINGS

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
(57)	Bundy Hot Springs (Bundy's Elsinore Hot Springs)						See Lake Elsinore Hotel. (Merrill 19:580,581; Tucker 29:523; 45:181; Waring 15:43,387.)
55	City of Elsinore wells	City of Elsinore, (C.O. Soots, Supt. of Public Works, City Hall, Elsinore) (1955)	SE¼6	6S	4W	SB	Two wells in Elsinore: No. 1 in City Maintenance yard, west of north end of Langstaff Street; No. 2 well 500 ft. southwest of No. 1, between Langstaff and Riley Streets, north of Flint Street. (C.O. Soots, 1955, personal communication; herein.)
56	Creswell Baths	Noritatsu and Mitsuyo Nakai, Spring and Franklin Streets, Elsinore (1955)	Cor. 5,6,7, 8	6S	4W	SB	Spring and Franklin Streets, Elsinore. (Herein.)
(57, 58)	Elsinore Springs						Includes both Lake Elsinore Hotel, and Lakeview Inn hot springs. (Larsen 48:128; 51:45; Tucker 45:181; Waring 15:42-43,387.) See also Lake Elsinore Hotel.
(58)	Elsinore Hot Springs						See Lakeview Inn hot springs. (Waring 15:42-43,387.)
57	Lake Elsinore Hotel (Bundy's Elsinore Hot Springs, Bundy Hot Springs, Elsinore Springs, Elsinore Hot Springs, Wreden, Wrenden)	Dr. Wm. E. Schwartz, 604 North Sierra Drive, Beverly Hills. Leased to George Lewis, Murray Feinberg, and M.L. Herbener, Box 236, Elsinore (1955)	Cor. 5,6,7, 8	6S	4W	SB proj.	Main at Franklin Streets, Elsinore. (Larsen 48:128; 51:45; Merrill 19:580,581; Tucker 29:523; 45:181, plate 35; Waring 15:43,387; herein.)

MINERAL SPRINGS (CONT.)

MAP NO.	CLAIM, MINE, OR GROUP	OWNER NAME, ADDRESS	LOCATION				REMARKS
			SEC.	T.	R.	B & M	
58	Lakeview Inn Hot Springs (Elsinore Springs, Elsinore Hot Spring)		NE¼7	6S	4W	SB proj.	Graham at Riley Streets, Elsinore. (Merrill 19:580; Tucker 29:521-523; 45:179, plate 35; Waring 15:42-43, 387; herein.)
(57)	Wreden (Wrenden)						See Lake Elsinore Hotel. (Tucker 45:181, plate 35.)

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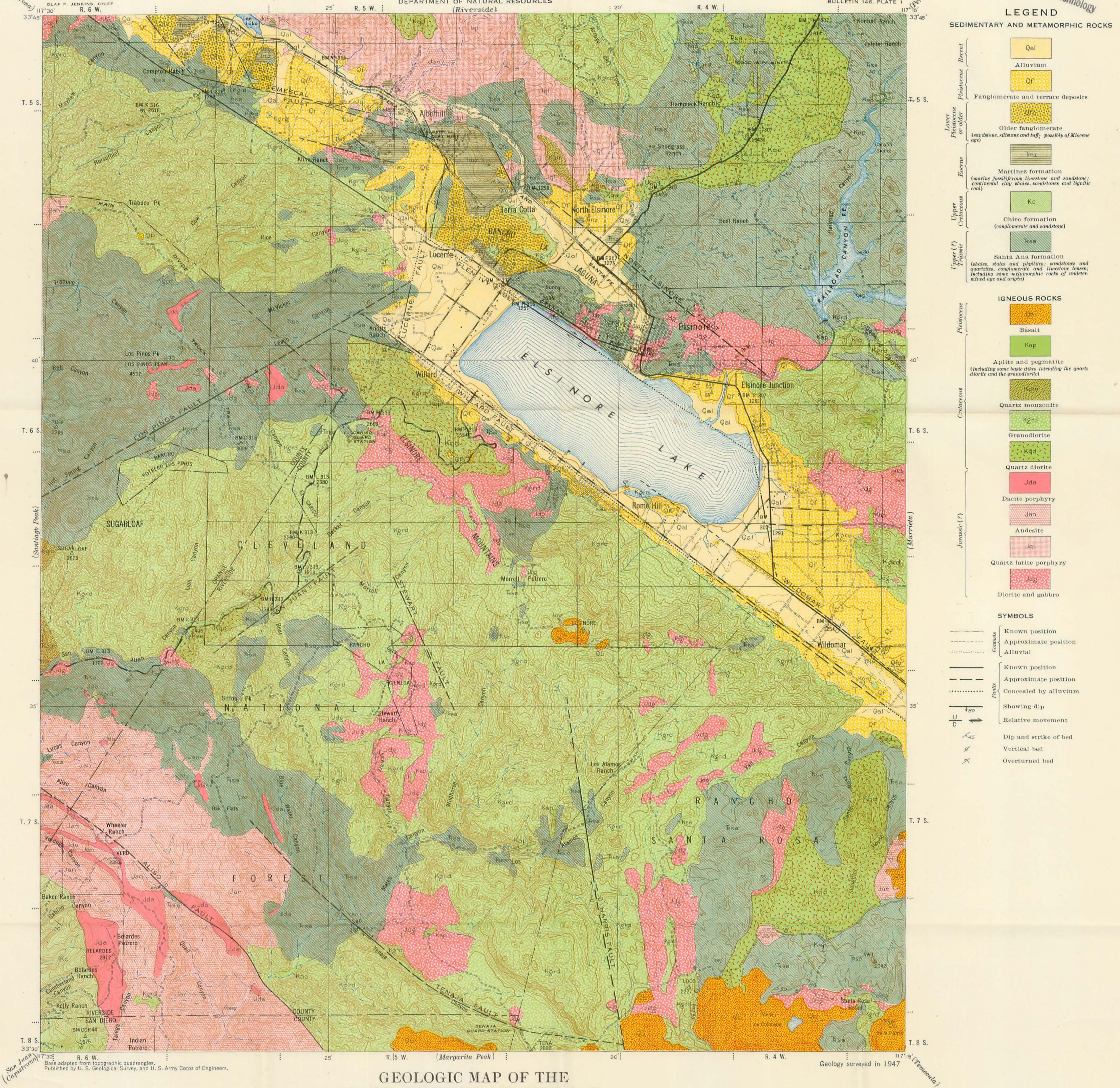
BULLETIN 146, PLATE 1



Base adapted from topographic quadrangles.
Published by U. S. Geological Survey, and U. S. Army Corps of Engineers.

Geology surveyed in 1947

GEOLOGIC MAP OF THE LAKE ELSINORE QUADRANGLE

By René Engel

Scale $\frac{1}{62500}$

Contour interval 50 feet.

Datum is mean sea level.

CDMG
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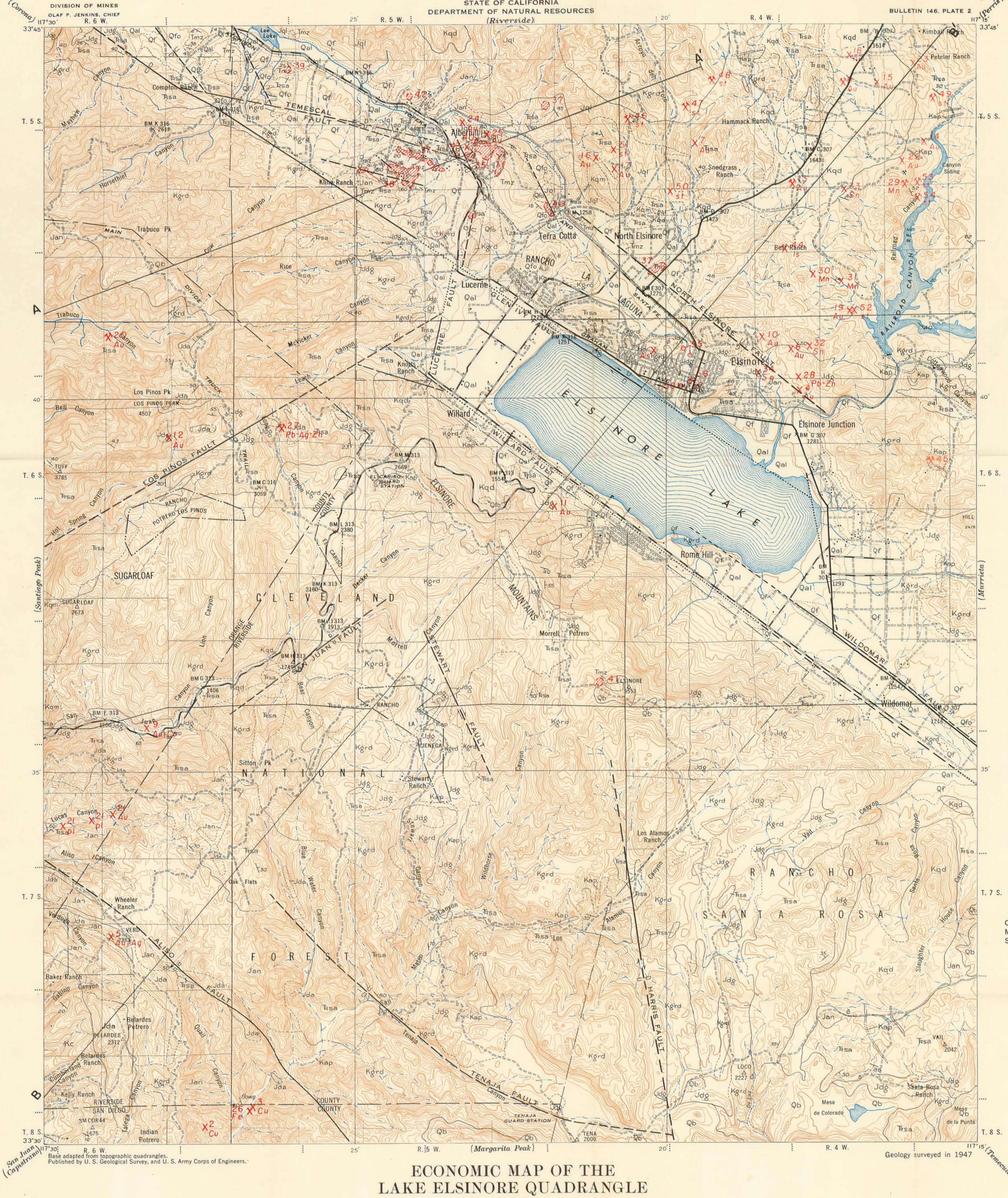
BULLETIN 146, PLATE 2



ECONOMIC MAP OF THE LAKE ELSINORE QUADRANGLE

By René Engel

Scale 1/62500

Contour interval 50 feet.
Datum is mean sea level.

LEGEND

SEDIMENTARY AND METAMORPHIC ROCKS

Recent	Qal	Alluvium
Pleistocene	Qf	Fanglomerate and terrace deposits
Lower Pleistocene or older	Qfo	Older fanglomerate (*sandstone, siltstone and tuff; possibly of Miocene age*)
Eocene	Tmz	Martinez formation (*marine fossiliferous limestone and sandstone; continental clay shales, sandstones and lignitic coal*)
Upper Cretaceous	Kc	Chico formation (*conglomerate and sandstone*)
Upper (?) Triassic	Ʀsa	Santa Ana formation (*shales, slates and phyllites; sandstones and quartzites, conglomerate and limestone lenses; including some metamorphic rocks of undetermined age and origin*)

IGNEOUS ROCKS

Pleistocene	Qb	Basalt
Cretaceous	Kap	Aplite and pegmatite (*including some basic dikes intruding the quartz diorite and the granodiorite*)
	Kqm	Quartz monzonite
	Kgrd	Granodiorite
	Kqd	Quartz diorite
Jurassic (?)	Jda	Dacite porphyry
	Jan	Andesite
	Jql	Quartz latite porphyry
	Jdg	Diorite and gabbro

SYMBOLS

Contacts	———	Known position
	- - - -	Approximate position
	....	Alluvial
Faults	———	Known position
	— — —	Approximate position
	....	Concealed by alluvium
	80	Showing dip
	U/D ⇌	Relative movement
	45	Dip and strike of bed
		Vertical bed
		Overturned bed
	X	Prospect
	⚒	Mine
	▨	Clay deposit
	⊙	Hot spring well

Abbreviations: As-arsenic, Ag-silver, Au-gold, C-coal, Cu-copper, Fe-iron, ls-limestone, Mn-manganese, Pb-lead, pl-gold placer, si-silica, Sn-tin, st-stone, Zn-zinc

Numbers refer to tabulated list in text.

Edition of 1958

COMG Engel

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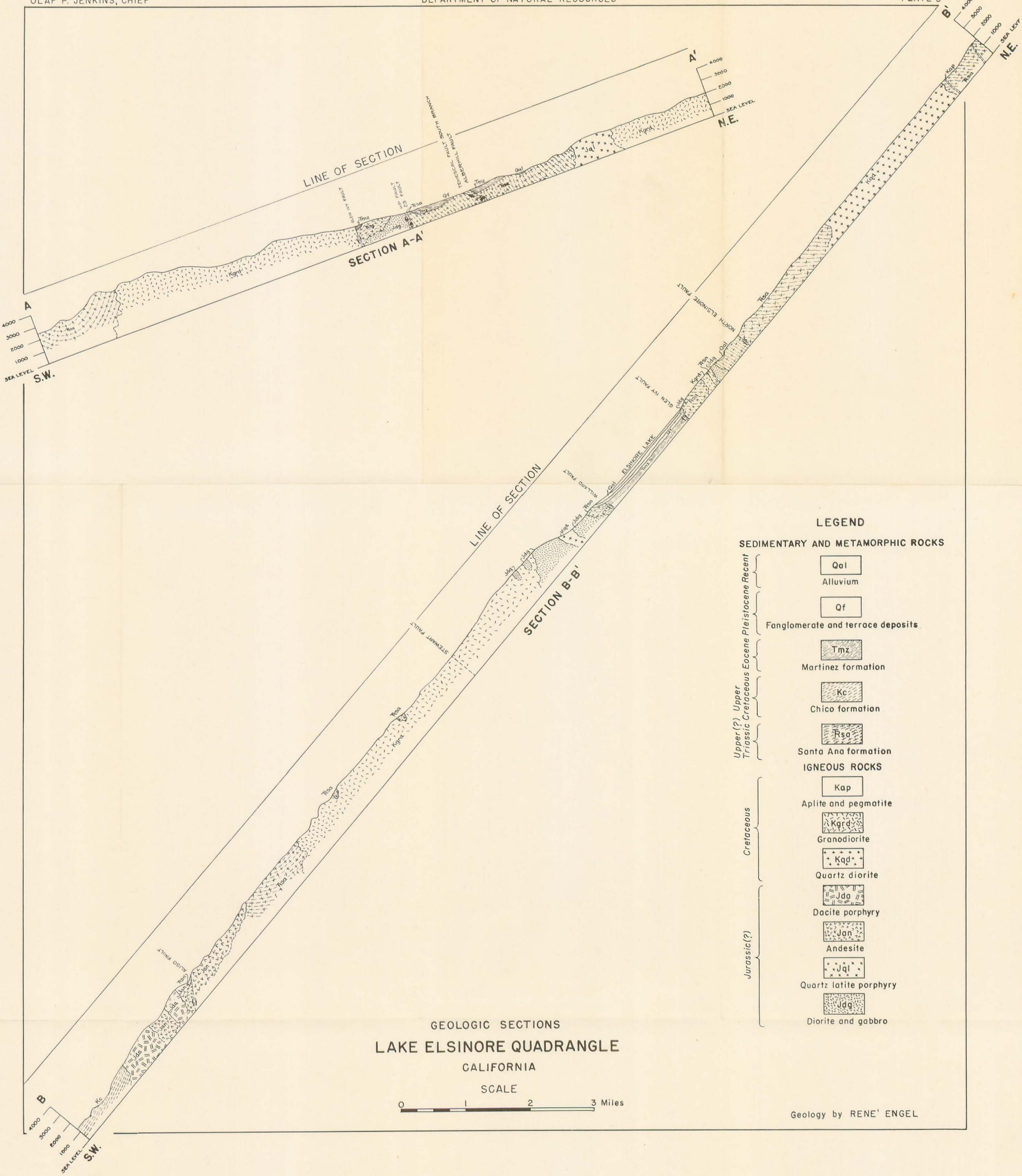
BULLETIN 146
PLATE 3



LEGEND

SEDIMENTARY AND METAMORPHIC ROCKS

Recent
Qal — Alluvium

Pleistocene
Qf — Fanglomerate and terrace deposits

Eocene
Tmz — Martinez formation

Upper Cretaceous
Kc — Chico formation

Upper (?) Triassic
Rsa — Santa Ana formation

IGNEOUS ROCKS

Cretaceous
Kap — Aplite and pegmatite
Kgrd — Granodiorite
Kqd — Quartz diorite

Jurassic(?)
Jda — Dacite porphyry
Jan — Andesite
Jql — Quartz latite porphyry
Jdg — Diorite and gabbro

GEOLOGIC SECTIONS

LAKE ELSINORE QUADRANGLE

CALIFORNIA

SCALE
0 1 2 3 Miles

Geology by RENE' ENGEL

CDM6 Engel

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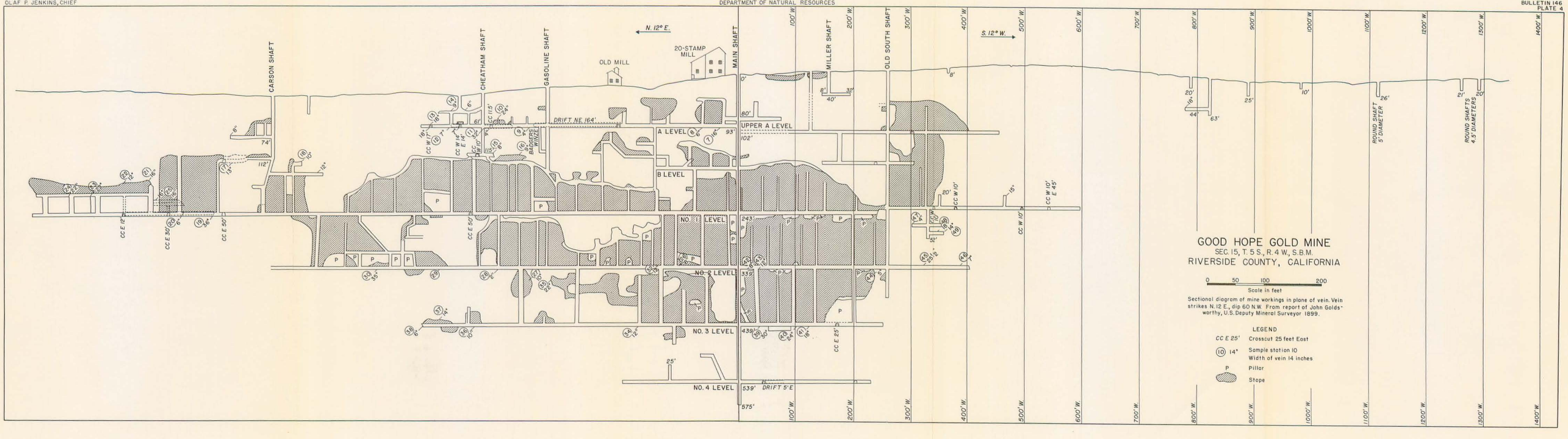
BULLETIN 146
PLATE 4



GOOD HOPE GOLD MINE

SEC. 15, T. 5 S., R. 4 W., S.B.M.
RIVERSIDE COUNTY, CALIFORNIA

0 50 100 200
Scale in feet

Sectional diagram of mine workings in plane of vein. Vein strikes N. 12 E., dip 60 N.W. From report of John Goldsworthy, U.S. Deputy Mineral Surveyor 1899.

LEGEND

CC E 25' Crosscut 25 feet East

⑩ 14" Sample station 10
Width of vein 14 inches

P Pillar

▨ Stope

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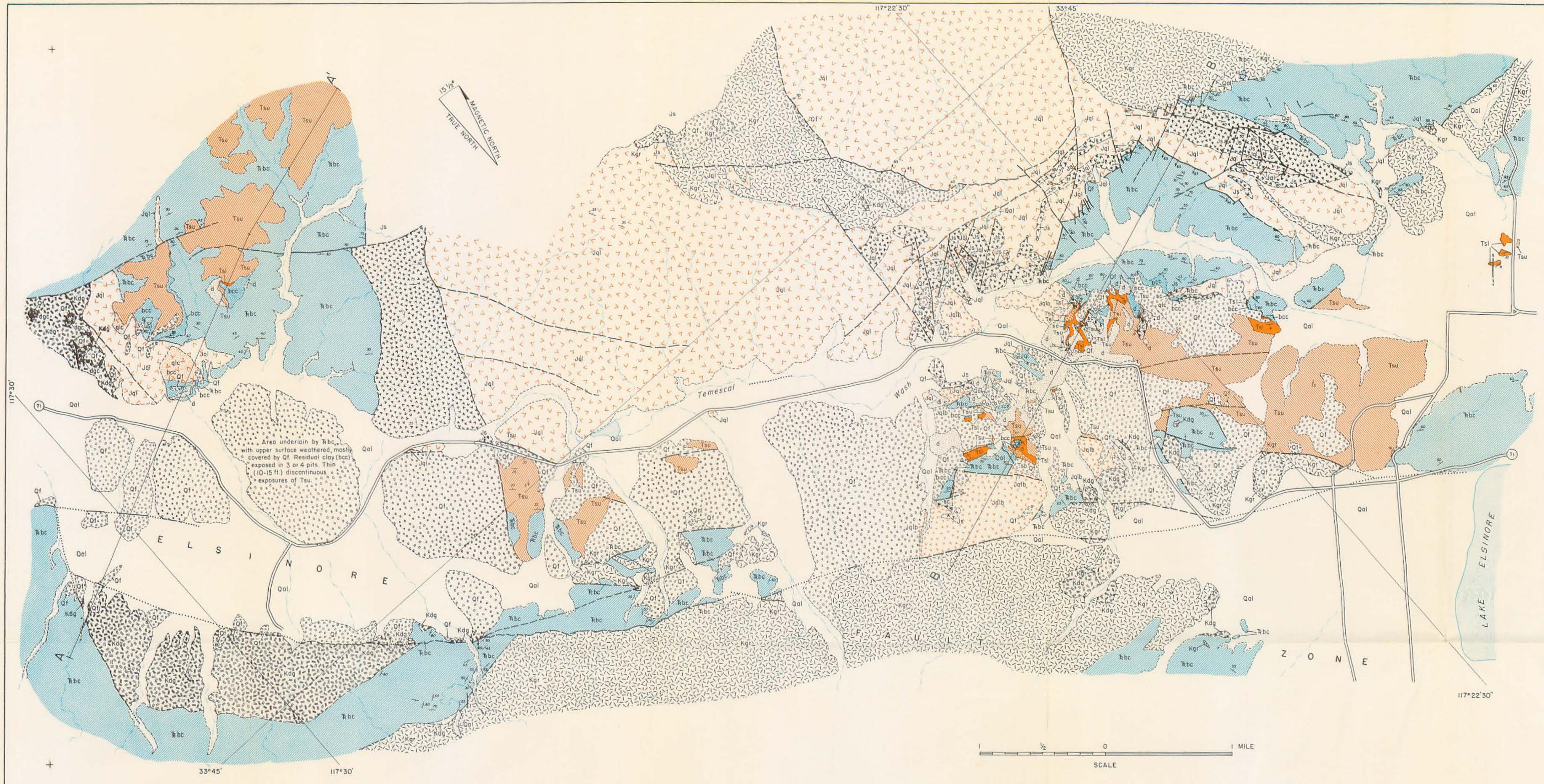


Geology surveyed by Bert H. Rogers, 1954-1955

EXPLANATION

QUATERNARY
- Recent
  - d: Debris. Stockpiles and waste.
  - Qal: Alluvium. Gravel, sand, and silt.
- Pleistocene (?)
  - Qf: Fanglomerate. Includes terrace deposits.

TERTIARY
- Paleocene — Silverado formation[†]
  - Tsu: Green clay shale and micaceous arkose.
  - Tsl: White, and red, white and buff mottled claystone. Carbonaceous claystone and lignite at base.
  - Tsb: Basal clay breccia. Angular fragments of residual clay and weathered parent rocks in clay matrix - fills local depressions in pre-Silverado weathered surface.

[†] (Martinez fm. on Plate I.)

CRETACEOUS
- Kgr: Granodiorite. Medium-to coarse-grained diorite to granodiorite.
- dgc / Kdg: Diorite-gabbro. dgc: Residual clay derived by weathering of diorite-gabbro. *

JURASSIC (?)
- qlc / Jql: Quartz latite porphyry. qlc: Residual clay derived by weathering of quartz latite porphyry. *
- Jqlb: Volcanic breccia. Intrusive rock related to Santiago Peak volcanics.
- sc / Js: Santiago Peak volcanics. Latite to andesite, mostly porphyritic, breccias and tuffs. sc: Residual clay derived by weathering of Santiago Peak volcanics. *

TRIASSIC
- bcc / ₮bc: Bedford Canyon formation. Slate, argillite, quartzite, silicious dolomitic limestone and conglomerate. bcc: Residual claystone derived by weathering of Bedford Canyon formation. *

* before deposition of Silverado formation

Contact (dashed where inferred, indefinite, or concealed).

Trace of fault, with dip of fault plane (dashed where inferred, dotted where concealed).

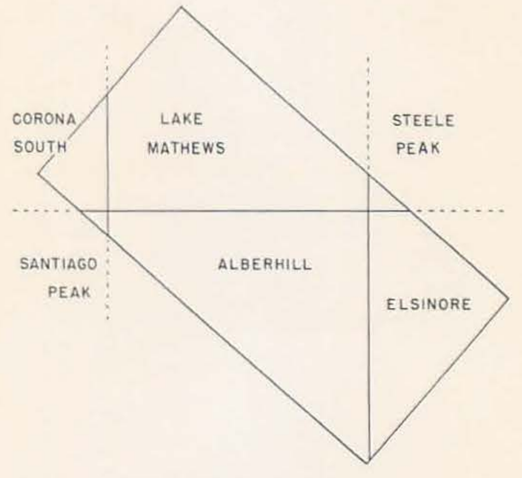
Strike and dip of beds

Strike of vertical beds

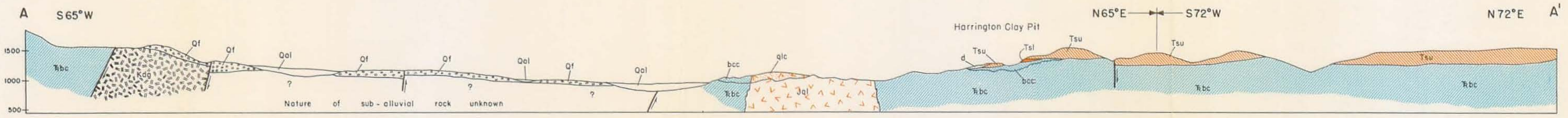
Slide or slump

Presumed dip, suggested by indistinct bedding

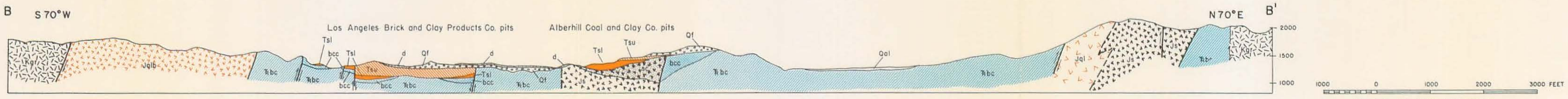
Strike and dip of overturned beds



INDEX MAP SHOWING PORTIONS OF U.S.G.S. 7½-MINUTE QUADRANGLES INCLUDED IN GEOLOGIC MAP



Cross-section A-A' across northern portion of Geologic Map of Southern Temescal Valley, by Bert H. Rogers



Cross-section B-B' across southern portion of Geologic Map of Southern Temescal Valley, topography and geology modified from Bert H. Rogers

GEOLOGIC MAP AND SECTIONS OF THE SOUTHERN TEMESCAL VALLEY REGION

CDMG

Engel

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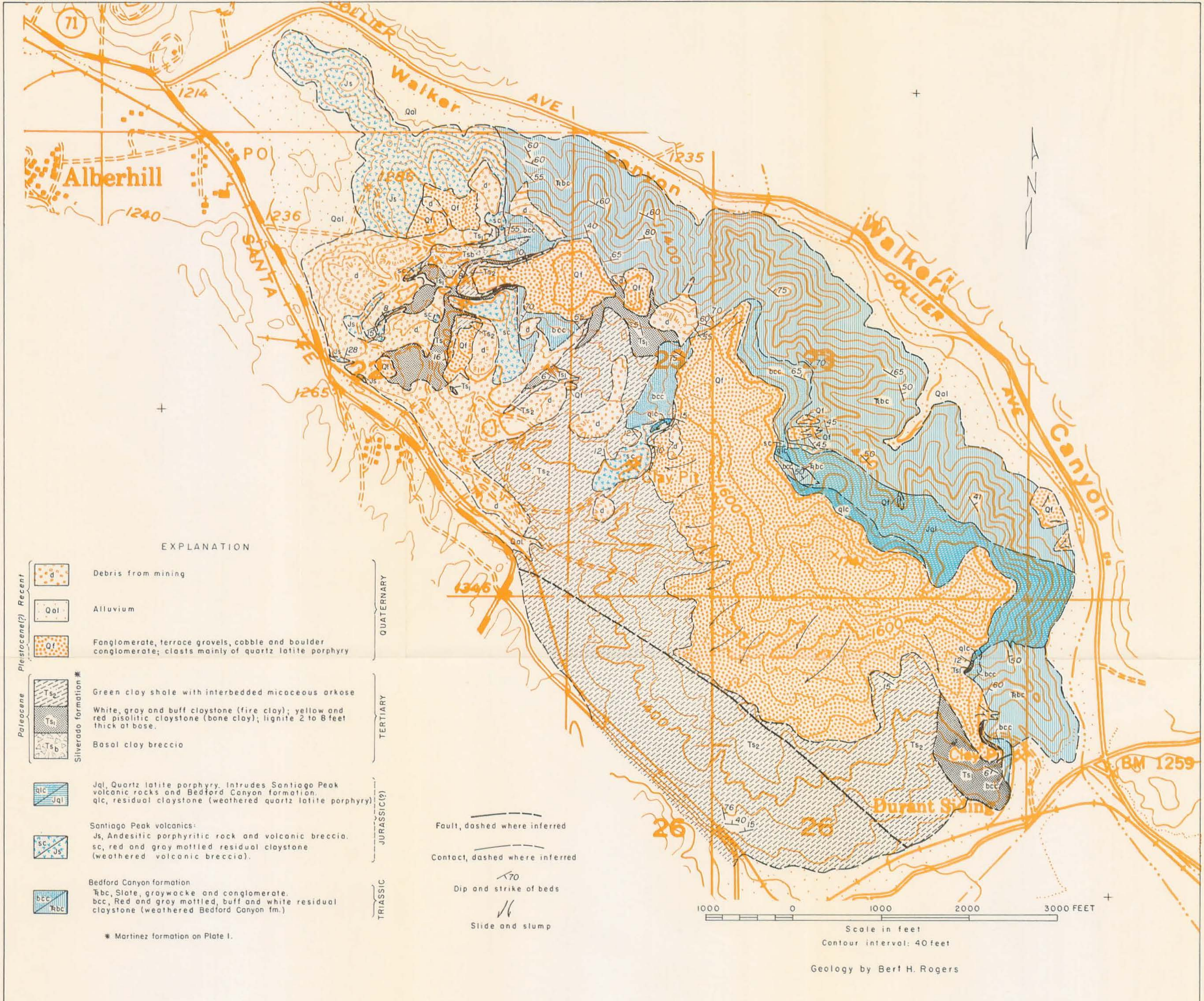
BULLETIN 146
PLATE 6



EXPLANATION

Recent / Pleistocene(?)	d	Debris from mining	QUATERNARY
	Qal	Alluvium	
	Qf	Fanglomerate, terrace gravels, cobble and boulder conglomerate; clasts mainly of quartz latite porphyry	
Paleocene — Silverado formation *	Ts2	Green clay shale with interbedded micaceous arkose	TERTIARY
	Ts1	White, gray and buff claystone (fire clay); yellow and red pisolitic claystone (bone clay); lignite 2 to 8 feet thick at base.	
	Tsb	Basal clay breccia	
	qlc / Jql	Jql, Quartz latite porphyry. Intrudes Santiago Peak volcanic rocks and Bedford Canyon formation. qlc, residual claystone (weathered quartz latite porphyry)	JURASSIC(?)
	sc / Js	Santiago Peak volcanics: Js, Andesitic porphyritic rock and volcanic breccia. sc, red and gray mottled residual claystone (weathered volcanic breccia).	
	bcc / Rbc	Bedford Canyon formation Rbc, Slate, graywacke and conglomerate. bcc, Red and gray mottled, buff and white residual claystone (weathered Bedford Canyon fm.)	TRIASSIC

* Martinez formation on Plate I.

Fault, dashed where inferred

Contact, dashed where inferred

70

Dip and strike of beds

Slide and slump

1000 0 1000 2000 3000 FEET

Scale in feet

Contour interval: 40 feet

Geology by Bert H. Rogers

GEOLOGIC MAP OF ALBERHILL COAL AND CLAY COMPANY
CLAY DEPOSITS
RIVERSIDE COUNTY, CALIFORNIA

CDM6

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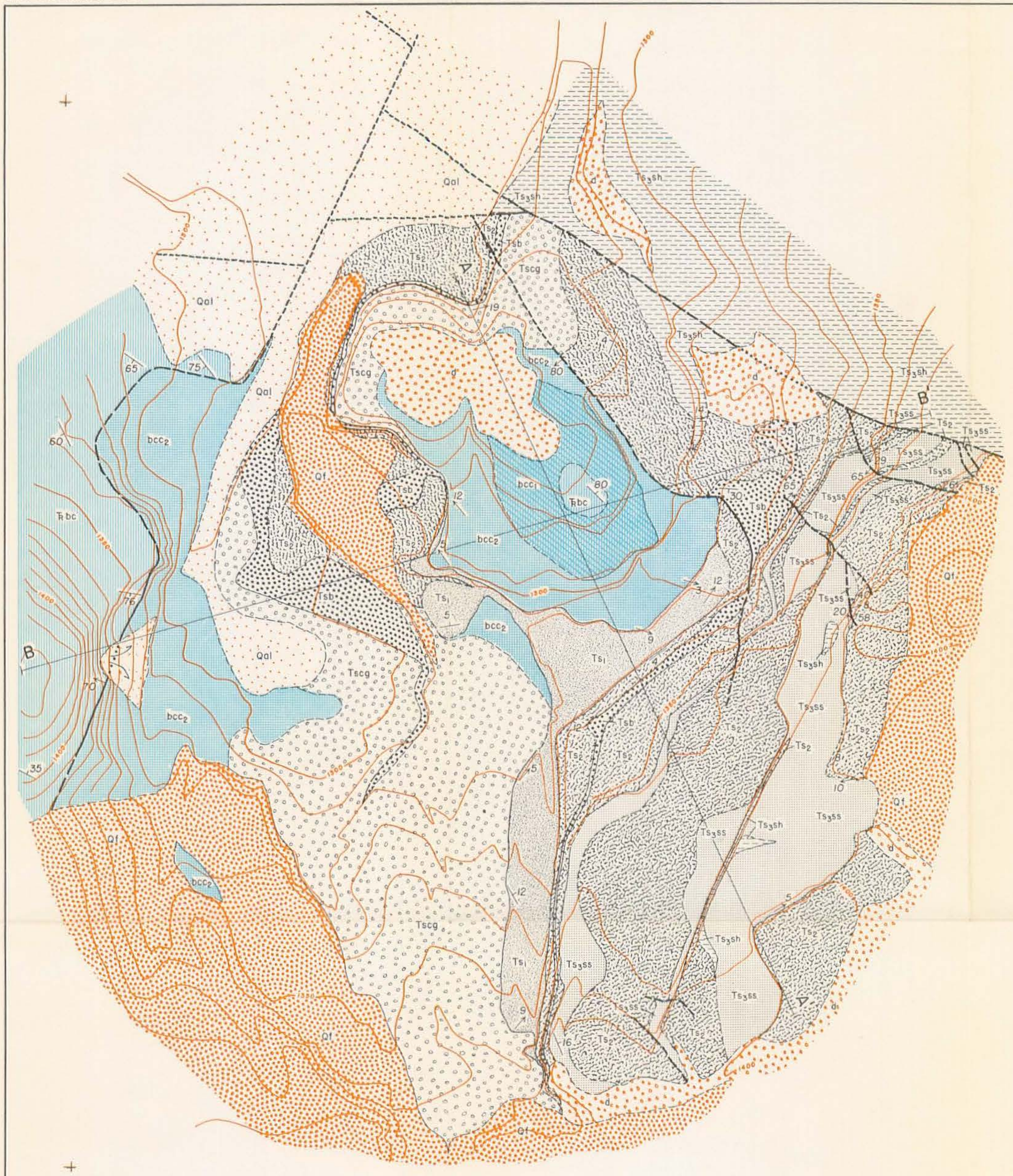
BULLETIN 146
PLATE 7



EXPLANATION

		Symbol		
Recent		d	Debris from mining	QUATERNARY
		Qal	Alluvium	
Pleist.(?)		Qf	Fanglomerate, terrace gravels, coarse sand and pebble conglomerates	
Paleocene	Silverado formation[1]	Ts3ss / Ts3sh	Interlayered green clay shale (Ts_3sh) and micaceous arkose (Ts_3ss)	TERTIARY
		Ts_2	Massive "pink mottle" claystone	
		Tsb	Pisolitic claystone ("bone clay")	
		Ts_1	White, gray and buff claystone (fire clay)	
		Tscg	Clay conglomerate basal unit in places	
	Bedford canyon formation	bcc_2	Red, yellow and gray residual claystone	TRIASSIC
		bcc_1	Yellow and gray weathered slate	
		Tr bc	Greenish gray slate, argillite and conglomerate, moderately weathered	

[1] (Martinez fm. on Plate I.)

70

Fault showing dip, dashed where approximate

Fault, inferred

Fault, concealed

Contact, dashed where approximate

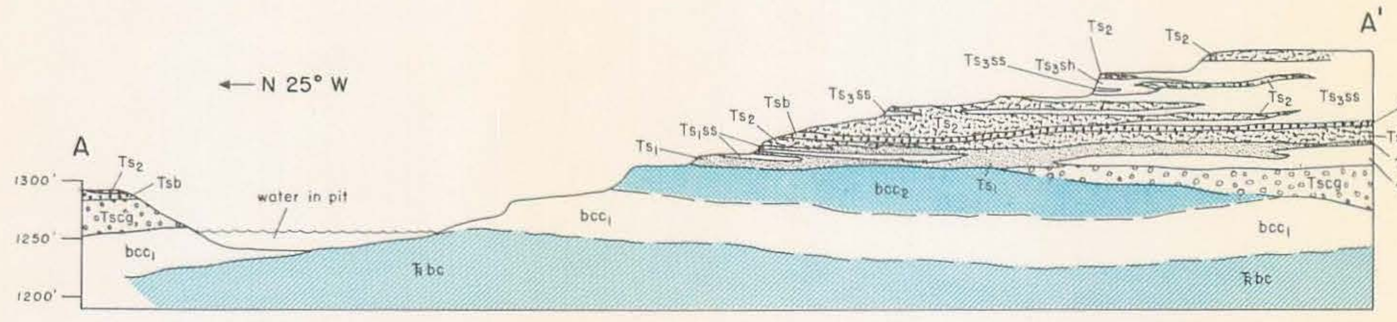
10

Strike and dip of beds

5

Presumed dip from indistinct bedding

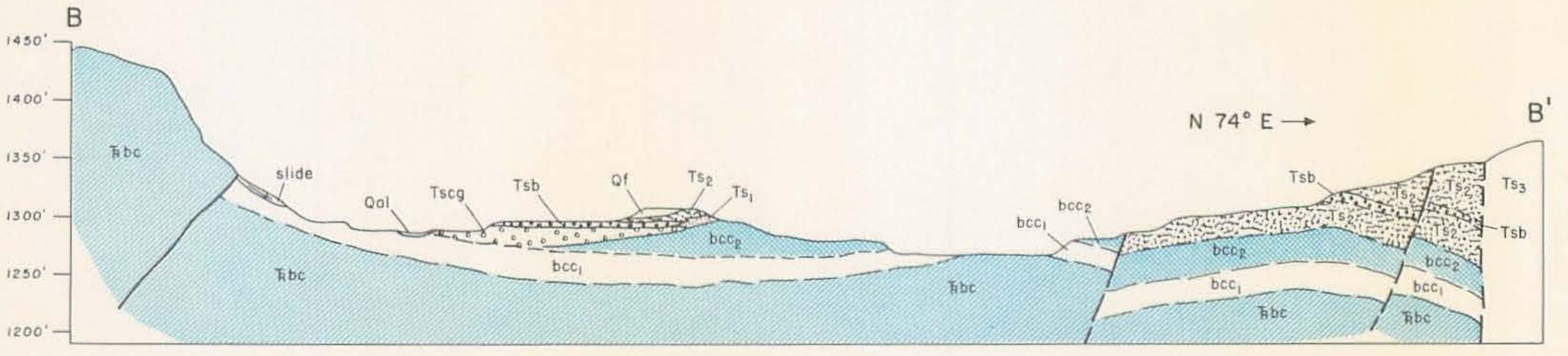
Slide or slump



Cross section A-A' across Los Angeles Brick & Clay Products Co. Clay Pit No. 1, by Bert H. Rogers

Geology by Bert H. Rogers, March 1955

Topography by Bert H. Rogers and C. H. Gray, March 1955



Contour interval = 10 feet

0 100 200 300 400

SCALE IN FEET

Cross section B-B' across Los Angeles Brick & Clay Products Co. Clay Pit No. 1, by Bert H. Rogers

GEOLOGIC MAP AND SECTIONS OF LOS ANGELES BRICK AND CLAY PRODUCTS COMPANY NO. 1 CLAY PIT, ALBERHILL, RIVERSIDE CO., CALIF.