THE GEOLOGY OF THE JURUPA MOUNTAINS, SAN BERNARDINO AND RIVERSIDE COUNTIES, CALIFORNIA

By Edward M. MacKevett

In partial fulfillment of the requirements for the degree of Master of Science, Division of Geological Sciences, California Institute of Technology, Pasadena, California

1950

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

ABSTRACT

The Jurupa Mountains are in the western parts of San Bernardino and Riverside Counties, California. The geographical center of the Jurupa Mountains is about 44 miles east of Los Angeles and 7 miles northwest of Riverside. This report describes an area of approximately 15 square miles.

Crystalline rocks comprise the bulk of the Jurupa Mountains and probably are the northernmost exposures of the rocks typical of the Southern California batholith. The oldest rocks in the Jurupa Mountains are a series of pre-batholithic metasedimentary rocks which are questionably Triassic in age. This series is composed of quartz-biotite gneiss, impure quartzite, biotite-quartz schist, marble, calc-silicate contact rocks, and amphibole schist, listed in order of abundance. Characteristically, these rocks occur as septa between the intrusive plutons. The largest deposits of marble and contact rocks are at Jensen's quarry, a locality renowned for its rare minerals. San Marcos gabbro occurs in a few hornblende-rich, island-like bodies within the later intrusive rocks, and it is the oldest of the batholithic rocks. Bonsall tonalite is the most widespread rock in the Jurupa Mountains. It contains abundant inclusions near its contacts, and commonly has good foliation and lineation. The Woodson Mountain granodiorite is a leucocratic rock that has several textural variations. It generally crops out in large boulder-like masses and is one of the most erosion-resistant rocks in the area. Pegmatite dikes are abundant in the Jurupa Mountains and are characterized by bold, rib-like outcrops. Alluvium, mainly in the form of fan material that is locally overlain by aeolian sand, practically surrounds the Jurupa Mountains.

The Jurupa Mountains are in the northern part of the Perris fault block. No definitely-known faults occur in the Jurupa Mountains. The batholithic rocks of the Jurupa Mountains were probably emplaced as a sequence of plutons by a combination of processes of which stoping was the

most important.

The economic resources of the Jurupa Mountains are marble, for making cement, and granodiorite and tonalite, mainly for rip-rap. In addition, several abandoned gold prospects are present. Most of these are on quartz stringers within the gneiss or schist.

INTRODUCTION

Geography

The Jurupa Mountains are in the western part of San Bernardino and Riverside Counties, California. The center of the mapped area is approximately 44 miles east of Los Angeles and 7 miles northwest of Riverside (fig. 1). Intermittent streams and alluvial fan distributaries trend southward to the Santa Ana River and drain the Jurupa Mountain area. The eastern part of the Jurupa Mountains is characterized by steep ridges that trend about north 15 degrees east. The western part of the Jurupa Mountains has moderate slopes and an east-west topographic trend. The maximum relief in the mapped area is 1490 feet. U. S. Highway 60 traverses the southern part of the mapped region and provides access to the Jurupa Mountains. Vineyards border the Jurupa Mountains on the north, east, and west. Rural residences are scattered throughout the area adjacent to the southern slopes of the Jurupa Mountains.

The climate is semi-arid, and the Jurupa Mountains have a Sonoran type of vegetation characterized by the predominance of chaparral. Nearby Riverside has an average annual rainfall of about 11 inches.

Nature and scope of work

This report is based on the mapping of an area of about 15 square miles. This field work was done intermittently from April 1949 to March 1950, and was supplemented from time to time by laboratory investigations. Aerial photographs of the United States Department of Agriculture were used as a base for the mapping, together with enlargements of the United States Geological Survey topographic maps of the Fontana and Guasti quadrangles. Both map and air photograph bases were at a scale of a quarter

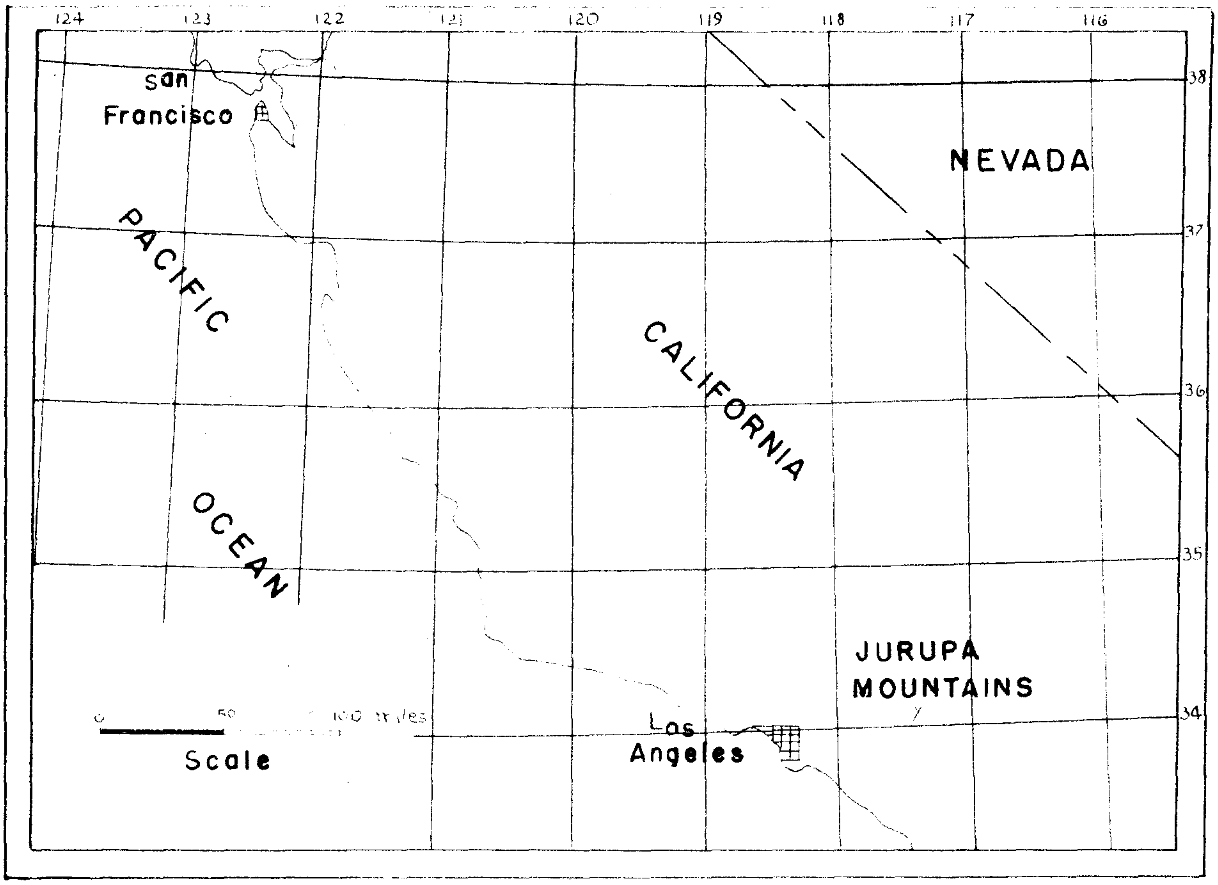
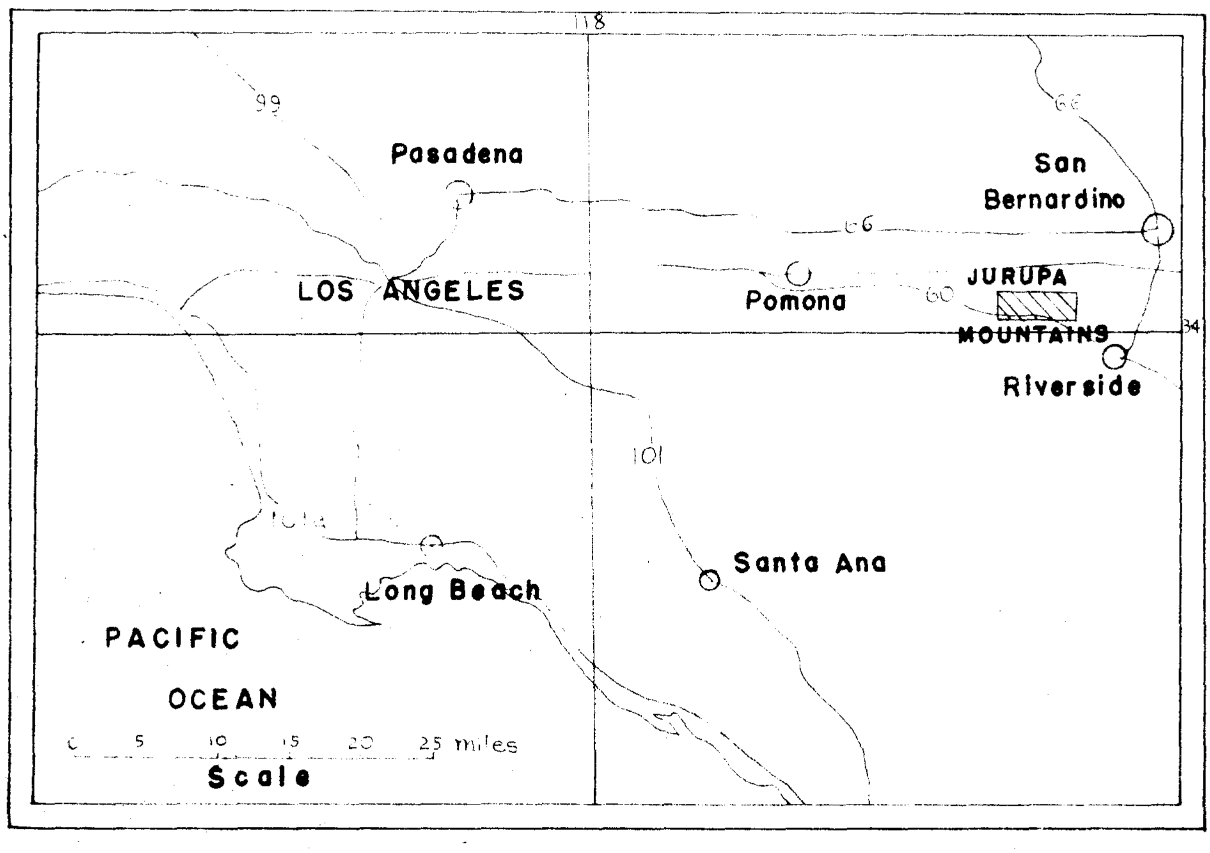


FIG. I. INDEX MAPS SHOWING LOCATION OF THE JURUPA MOUNTAINS



of a mile to the inch. Most of the work was done on the topographic maps, which proved to be very accurate and detailed.

In addition to the geologic map of the Jurupa Mountains (pl.1) a plane-table map of Jensen's quarry was made on a scale of 200 feet equals one inch (pl. 2). Seventy six rock specimens were collected, and petrographic studies were made on thin sections cut from fifteen of these specimens. On the basis of the field and laboratory studies, eight geologic units have been delineated in plate 1. Limitations of time made it impracticable to divide these units further. Moreover, it was not possible to make detailed mineralogical studies of the contact-metamorphic deposits and of the pegmatites in the area.

For purposes of description the Jurupa Mountains are here divided into three parts: (1) a large, nearly isolated hill northeast of Jensen's quarry; (2) the central, more mountainous area from the longitude of Jensen's quarry to the narrows immediately north of Shannahan's quarries; (3) the irregular hills that lie west of Shannahan's quarries.

Purpose

The present investigation was undertaken to obtain a reasonably detailed map of an area never before studied by other than reconnaissance methods. This area constitutes one of the northernmost known occurrences of rocks characteristic of the Southern California batholith, and it is possible to correlate individual rock types with those so well described from large areas to the south by Larsen. 1/ The Jurupa Mountains contain

- -

1/ Larsen, E. S., Batholith and associated rocks of Corona, Elsinore, and San Luis Rey quadrangles, Southern California: Geol. Soc. Amer. Memoir 29, 1948.

- -

deposits of marble from which cement is made and also granitic rocks of economic importance. Several of these deposits have been exploited by quarrying methods. Jensen's quarry, a locality renowned for its rare minerals, lies within the mapped area. Pegmatites are abundant, and information on their habits has been obtained by mapping them.

Acknowledgments

I wish to express my gratitude to Dr. R. H. Jahns of the California Institute of Technology, who suggested and supervised this project and who provided several valuable suggestions regarding the contents of this manuscript. R. E. Cobb gave his time generously in capably aiding the plane tabling of Jensen's quarry. J. A. Roddick aided in taking the photomicrographs. The Riverside Cement Company was cooperative in permitting geologic investigations at Jensen's quarry.

General geology

The Jurupa Mountains are in the northern part of the Perris fault block, as defined by Dudley. 2/ This structural unit is bounded on the

- -

2/ Dudley, P. H., Physiographic history of a portion of the Perris Block, Southern California: Jour. Geol., vol. 44, p. 358, 1936.

- -

east by the San Jacinto fault, on the west by the Elsinore-Chino fault system, and on the north by the base of the San Gabriel Mountains.

The Jurupa Mountains are composed of crystalline rocks and probably contain the northernmost outcrops of igneous rocks that clearly are a part of the Southern California batholith. 3/ These crystalline rocks consist

- -

3/ Larsen, E. S., op. cit. 1948.

- -

of a complex series of pre-batholith metasedimentary rocks, and batholithic rocks that range from gabbro to leucogranodiorite in composition. Alluvium of the Cucamonga fan, derived from the San Gabriel Mountains to the north, practically embraces the Jurupa Mountains and extends northward for about ten miles to the base of the San Gabriel Mountains. The San Gabriel Mountains are made up mainly of crystalline rocks and are bounded on the south by a large frontal fault zone. There is a possibility that some of the rocks of the San Gabriel Mountains are equivalent to some of those in the Jurupa Mountains; however, on the basis of cursory examination of some of the San Gabriel rocks and on descriptions made by Miller 4/, the writer is

- -

4/ Miller, W. J., Geology of the western San Gabriel Mountains: Univ. of Calif. at L. A. Publ. in Math. and Physical Science, 1934.

- -

not impressed with the petrographic similarities of the rocks in the two areas.

The nearest exposed rocks west of the Jurupa Mountains are the Tertiary formations of the Puente and San Jose Hills in the vicinity of Pomona. The Santa Ana Mountains, composed of Tertiary and Mesozoic rocks, lie to the southwest. To the east and south, with the exception of local alluvial deposits, the Jurupa Mountains are coextensive with a crystalline rock terrain that is dominated by gabbros, tonalites, and granodiorites of the Southern California batholith. The region between the Jurupa Mountains and the base of the San Bernardino Mountains, about 14 miles to the northeast, consists largely of alluvial fans. The San Bernardino Mountains are composed mainly of crystalline rocks.

PRE-BATHOLITH METASEDIMENTARY ROCKS

General statement

Scattered bodies of metamorphosed sedimentary rocks that are older than the batholithic intrusions are widespread in the Jurupa Mountains. Gneiss, schist and quartzite are the most abundantly represented rock types. These have been grouped together on the map (pl. 1) as siliceous metamorphic rocks. Marble is much less common in the Jurupa Mountains, but it has been mapped as a separate unit because of its commercial importance. The degree of metamorphism appears to range from moderate to strong. Local contact zones contain such high-temperature minerals as grossularite, diopside, idocrase, and wollastonite; these indicate high-temperature metamorphic facies near some of the contacts with intrusive rocks. In general, contact metamorphic effects are negligible in the gneiss, schist, and quartzite.

This metamorphic complex has been termed the Jurupa series by Daly,5/

5/ Daly, J. W., Paragenesis of the mineral assemblage at Crestmore, Riverside County, California: Amer. Mineral., vol. 20, p.639, 1935.

who believes it to be of questionably Paleozoic age. The Jurupa series probably is correlative with the Triassic(?) Elsinore metamorphic series of Dudley. 6/ The writer prefers to regard metasedimentary rocks of the

6/ Dudley, P. H., Geology of a portion of the Perris Block, Southern California: Jour. Mines and Geol., vol. 31, pp. 487-505, 1935.

Jurupa Mountains as being questionably of Triassic age, mainly on the basis of the geographic proximity of the fossiliferous Triassic Bedford Canyon formation 7/ in the Santa Ana Mountains. The Bedford Canyon formation is

- -

7/ Larsen, E. S., op. cit. p. 18, 1948.

- -

less metamorphosed, so that the two units are not very similar lithologically. However, the fact that those parts of the Bedford Canyon formation that are of high metamorphic rank strongly resemble the Jurupa Mountain metasediments, and the fact that the Bedford Canyon formation includes lenses of limestone that are similar in size and proportion to the marble lenses in the Jurupa Mountains suggests a possible correlation.

Woodford 8/ believes that masses of marble at Crestmore, about two and

- -

8/ Woodford, A. O., Crestmore minerals: 39th Report of the State Mineralogist, Calif. State Mining Bureau, p. 336, 1943.

- -

three quarter miles east of Jensen's quarry, are probably Upper Paleozoic in age. He infers this from the occurrence of the fossiliferous Furnace limestone 9/ in parts of the northeastern San Bernardino Mountains, about

- -

9/ Woodford, A. O. and Harriss, T. F., Geology of Blackhawk Canyon, San Bernardino Mountains, California: California Univ. Dept. Geol. Sci., Bull. 17, pp. 265-304, 1928.

- -

40 miles northeast of the Jurupa Mountains, and from evidence cited by Webb 10/ that the marble at the Winchester quarry (about 38 miles to the

- -

10/ Webb, R. W., Evidence of the age of a crystalline limestone in Southern California: Jour. Geology, vol. 47, pp. 198-201, 1939.

- -

southeast) is Mississippian in age. However, outcrop areas of Furnace limestone are separated from Crestmore (and the Jurupa Mountains) by two major faults of considerable displacement, the San Jacinto and the San Andreas, and Webb's dating is based on only one fossil, a cyathophylloid coral, that was found in a talus pile.

Siliceous metamorphic rocks

Siliceous metamorphic rocks constitute the most widespread lithologic unit mapped in the Jurupa Mountains. In the eastern part of the area these rocks are predominantly biotite-rich gneisses and schists; in the central part biotite-rich gneisses and muscovite and biotite bearing quartzites; and in the western part they are mainly impure quartzites. Foliation is commonly well developed in these rocks. In most cases it is steep dipping and parallels the contact of the nearest intrusive body. In places the foliation is highly contorted and ptygmatically folded. Wherever observed in the same outcrop the foliation and the bedding seem to be parallel in both plan and section. The siliceous metamorphic rocks attain a maximum apparent thickness of about 3500 feet in the eastern part of the mountains, but the characteristic occurrence of these rocks as narrow septa between masses of intrusive rocks precludes any estimate of original thickness.

Gneiss and schist

Gneiss and subordinate schist are the most abundant of the siliceous metamorphic rocks. Both the gneiss and the schist contain numerous lit-par-lit stringers, mainly of quartz. The gneissic banding ranges from quartz-rich bands about a millimeter in thickness to bands that attain thicknesses of two centimeters. In places the gneiss appears to be intimately associated with material of magmatic derivation.

Most of the gneiss consists chiefly of quartz, subordinate biotite, alkali and plagioclase feldspars, and some muscovite. In the typical gneiss gray and dull-white bands alternate on fresh surfaces. The rock as a whole weathers to a light brown.

Less commonly the gneiss is light gray on fresh surfaces and weathers to a mottled gray and white. A little of the gneiss is tan on fresh surfaces and brown on weathered ones. Facies containing granulitic textures occur in some of the gneisses. Some of the less-metamorphosed gneisses have local relic textures in part; the subangular shape of many of the minerals in the original sediments is retained. Quartz with a distinct greasy luster is characteristic of a few of the gneisses. Clay minerals, chlorite, and limonite are the principal weathering products of the gneiss.

The schists are less abundant than the gneisses and less diversified in composition. They commonly are gray-biotite-quartz schists that weather dark brown. A dark-gray schist that consists largely of fine-grained amphiboles occurs sparingly throughout the Jurupa Mountains. It is best exposed in the west face of the Declezville quarry where it occurs as inclusions in Bonsall tonalite that reach lengths of several tens of feet.

A typical quartz-biotite gneiss forms a septum between Woodson Mountain granodiorite and Bonsall tonalite on the slopes of the first hill southeast of the eastern Shannahan quarry. It has distinct gneissic banding; the white layers are about one millimeter thick and the gray layers average near five millimeters in thickness. Under the microscope it has the following characteristics:

Mineral	Estimated Percentage	Remarks
Quartz	60%	mostly in anhedral grains; has strain shadows and sutured texture; ranges in diameter from 0.2 mm. to 1.2 mm.
Plagioclase	16%	An_{33}
Biotite	10%	pleochroic, tan to dark reddish brown.
Augite	7%	
Orthoclase	5%	highly altered
Sphene	1%	

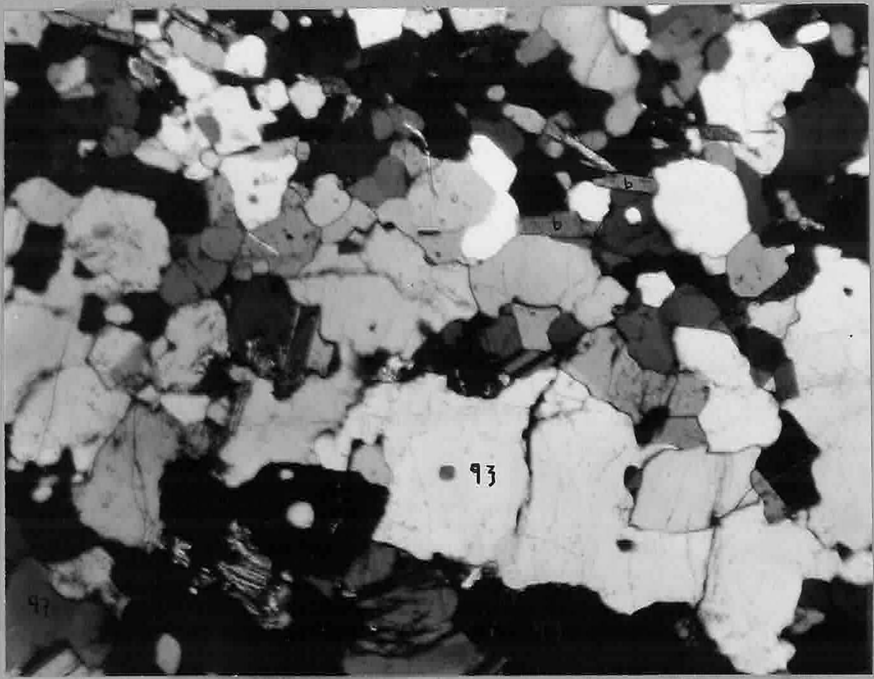


Figure 2. ——— Photomicrograph of part of thin section described on page 8. Note parallelism of quartz (qz) of similar orientation and alignment of biotite (b). X nicols. X39.

Figure 3. ——— Photomicrograph of part of thin section described on lower part of page 9. Field consists mainly of quartz, plagioclase and biotite. X nicols. X39.

Apatite Ore minerals Zircon	1%	as inclusions in biotite

<u>Secondary minerals</u>

Clay minerals	developed from feldspars
Uralite	developed from augite
Chlorite	developed from biotite
Limonite	

A quartz-biotite gneiss collected about a foot from a contact with tonalite near the two adjacent gold prospects in the south-central part of the mapped area consists of felsic bands that reach 15 millimeters in thickness and mafic bands that attain a thickness of 5 millimeters. Under the microscope it has the following characteristics:

<u>Mineral</u>	Estimated <u>Percentage</u>	<u>Remarks</u>
Quartz	65%	ranges from 0.2 mm. to 2.0 mm. in diameter; highly strained; also has a few small fractures
Biotite	15%	average size of crystals about 0.8 mm. by 0.4 mm.; pleochroic from almost colorless to a light reddish brown
Plagioclase	10%	An_{34}
Orthoclase	6%	may completely enclose partly digested plagioclase
Muscovite	3%	
Sphene Ore minerals Zircon Rutile	1%	

<u>Secondary minerals</u>

Sericite	developed from feldspars
Chlorite	developed from biotite
Clay minerals	developed from feldspars

Limonite

Epidote(?)

A thinly-banded specimen of quartz-biotite gneiss collected from near the middle of the thick metamorphic section in the eastern part of the area has the following characteristics when observed beneath a microscope:

Mineral	Estimated Percentage	Remarks
Quartz	60%	has strain shadows and sutured texture; maximum diameter 0.7 mm.
Biotite	15%	pleochroic, tan to dark reddish brown
Plagioclase	10%	An_{34}
Muscovite	7%	
Orthoclase	5%	highly altered
Hornblende	2%	pleochroism similar to that of biotite, but less intense
Sphene Ore minerals Apatite Rutile Zircon(?)	1%	
Secondary minerals		
Clay minerals		developed from feldspars
Epidote		
Limonite		
Sericite		developed from feldspars
Chlorite		developed from biotite

Quartzite

Impure quartzite is the prevailing metasedimentary rock in the western part of the Jurupa Mountains, where it reaches an estimated maximum apparent thickness of 2000 feet. The quartzite is a crudely banded, light-

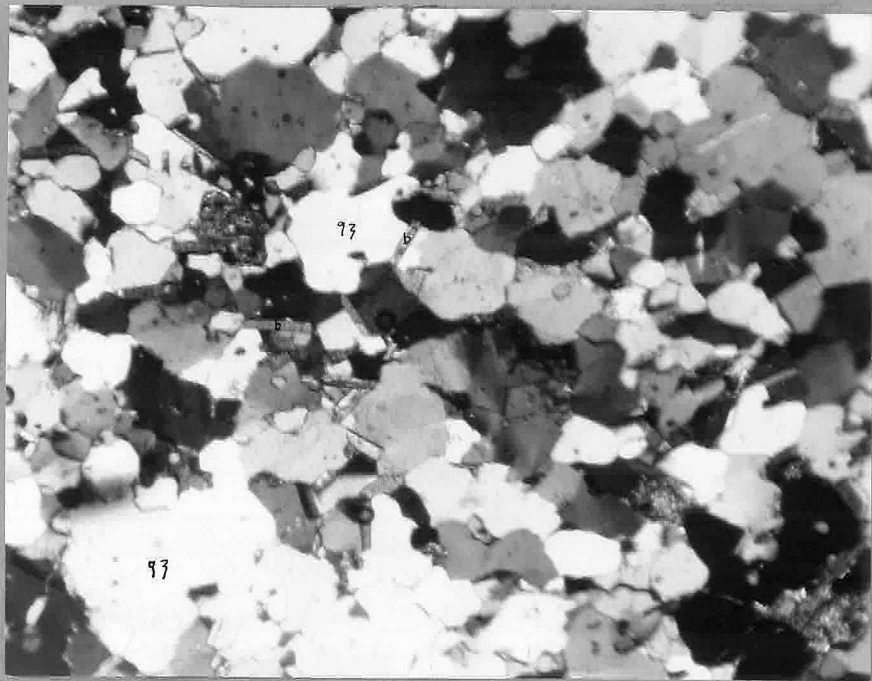


Figure 4. ----- Photomicrograph of quartz biotite gneiss described on page 10. Field consists mainly of quartz (qz) and biotite (b). X nicols. X39.

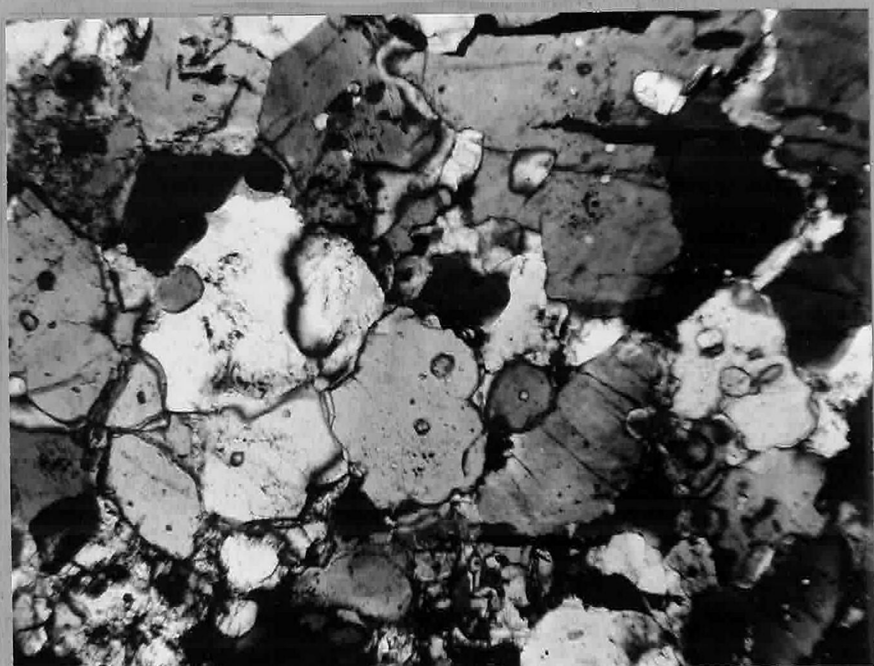


Figure 5. ----- Photomicrograph of quartzite described on page 11. Field largely made up of anhedral quartz crystals. X nicols. X39.

gray rock with a greasy, vitreous luster. Weathered surfaces range from yellow brown to dark reddish brown. Biotite and chlorite are the chief constituents of the dark bands in most of the quartzite. Pyrite crystals that reach 0.2 millimeter in diameter are disseminated throughout the quartz of some of the quartzites. Minute needle-like crystals of sillimanite(?) occur locally along fractures within the quartzite. Clay minerals are present in some of the quartzites and probably were derived from feldspars. Quartzite is resistant to erosion and the trend of many of the ridges in the Jurupa Mountains is controlled by the trend of quartzite beds that underlie them.

A thin section cut from a typical quartzite, collected in the south-central part of the area, has the following characteristics when observed under a microscope:

Mineral	Estimated Percentage	Remarks
Quartz	85%	apparently not as much strained as quartz in the gneiss; size range from 0.2 mm. to 2.0 mm. in diameter
Muscovite	7%	
Biotite	4%	pleochroic, pale yellowish brown to tan
Hornblende	2%	pleochroism similar to that of biotite
Apatite		
Zircon		as inclusions in quartz
Ore minerals	2%	usually in elongated blebs
Sillimanite		in long fibers and needles
Secondary minerals		
Chlorite		common in cracks between quartz grains

Contact-metamorphic rocks

Zones of calc-silicate contact rocks that attain 10 feet in thickness are well developed at Jensen's quarry, near the marble bodies a short distance west of Jensen's quarry, and in the westernmost metamorphic rock that appears to be a roof pendant in the Woodson Mountain granodiorite in the western part of the area. These contact rocks are divisible into three general classes: (1) dark-brown, greasy-appearing skarn, composed largely of grossularite, generally with subordinate calcite, quartz, and epidote; (2) a white rock that weathers light gray and is composed almost entirely of wollastonite; (3) a quartz-rich rock that ranges from white to light gray in color and is characterized by idocrase, diopside, sphene, grossularite, or augite(?); either singly or in combination. 11/ Rough

---

11/ A detailed mineralogical study of the contact-metamorphic deposits is beyond the scope of this report. The mineralogy of the deposits in Jensen's quarry is similar to that at the world-famous localities of nearby Crestmore. Dr. Joseph Murdoch of the University of California at Los Angeles has made some mineralogical investigations at Jensen's quarry and has described some of the rare minerals that occur there. For a detailed description of the mineralogy at Crestmore the reader is referred to Woodford's paper, "Crestmore Minerals" or the paper by J. W. Daly, "Paragenesis of the Mineral Assemblage at Crestmore, Riverside County, California." Both of these papers are cited in this report and are included in the List of References Cited.

---

surfaces of weathering characterize the outcrops of most of the calc-silicate rocks.

Marble

Recrystallized limestone, chiefly fine-to medium-grained marble, is thickest and most broadly distributed in and around Jensen's quarry, and in the hills immediately west of this quarry. It also occurs at the Glen Avon quarry where it forms definite lenses within siliceous metasedimentary rocks. These lenses are 70 feet in maximum thickness. A bed of marble about a foot thick is present in the westernmost metamorphic body that appears to be a roof pendant in the granodiorite, but it is not shown on the map.

The marble is resistant to erosion and crops out boldly. It is white and is composed largely of medium-to coarse-grained calcite. The marble occurs as beds that rarely exceed two feet in thickness. Graphite is abundantly disseminated in a few of these beds, and periclase, brucite, and hydromagnesite also occur in the marble. Rarer constituents, described by Murdoch and Fahey 12/ from Jensen's quarry, comprise spinel,

12/ Murdoch, Joseph, and Fahey, J. J., Geikielite, a new find from California: Amer. Mineral., vol. 34, pp. 835-838, Nov.-Dec. 1949.

pyrite, pyrrhotite, diopside, forsterite, and geikielite. Layers of yellowish predazzite, a few inches to a foot thick, are associated with the marble.

The stratigraphic position of the marble in the metasedimentary series is not determinable from evidence in the Jurupa Mountains. Daly 13/ believes

13/ Daly, J. W., The geology and mineralogy of the limestone deposits at Crestmore, Riverside County, California: Unpublished Master's Thesis, Calif. Inst. of Technology, p. 17, 1931.

lieves that the limestone (marble) deposits at Jensen's quarry are correlative with the Chino limestone (marble) at Crestmore, which he believes to be stratigraphically higher than the greater part of the siliceous metasediments. Commonly the marble is separated from the intrusive rocks by a narrow zone of calc-silicate rock.

BATHOLITHIC ROCKS

San Marcos gabbro

Isolated bodies of gabbro occur in the southern half of the central and western parts of the Jurupa Mountains. This gabbro is rich in hornblende and characterized by zoned feldspars in the bytownite range. The gabbro is probably a hornblende-rich facies of the San Marcos gabbro, a widespread member of the Southern California batholith. Miller [14] proposed the name of San Marcos gabbro for gabbroic rocks that occur in the San Luis Rey quadrangle. This name has been used loosely to include rocks ranging in composition from norite and olivine gabbro to quartz gabbro. The San Marco gabbro probably is the oldest rock of the Cretaceous(?) Southern California batholith. [15]

14/ Miller, F. S., Petrology of the San Marcos gabbro, Southern California: Geol. Soc. Amer. Bull., vol. 48, p. 1397-1426, 1937.

15/ Larsen, E. S. op. cit. p. 43.

Two textural varieties of gabbro occur in the Jurupa Mountains. One of these is a dark-gray, medium-grained rock that weathers to a dark reddish brown, and forms the bulk of the gabbro masses. The other is a mottled dark gray and white, brown-weathering rock that is confined to the peripheral zones of the masses. It may represent a facies of the gabbro that was contaminated by later intrusive rocks, although there is no mineralogical evidence to indicate this. The typical texture of the peripheral gabbro consists of zones of medium-grained crystals, surrounded by zones of fine-grained crystals, which is suggestive of a heterogeneous origin for this rock type. Irregular segregations that are rich in hornblende occur in some of the gabbro bodies. Most of the gabbro occupies high topographic positions in the Jurupa Mountains as it is resistant to erosion; although a few of the gabbro bodies are in areas of subdued topography.

A specimen of gabbro from near the center of the largest gabbro mass in the Jurupa Mountains, a body in the south-central part of the area, is typical of the bulk of the gabbro. It has an average crystal size of around a millimeter in length, and the following properties when examined beneath a microscope:

Mineral	Estimated Percentage	Remarks
Plagioclase	60%	zoned An_{80-90}; numerous inclusions, mostly apatite
Hornblende	26%	pleochroic in shades of light brown
Augite	10%	
Ore minerals	2%	
Quartz	1%	
Apatite	1%	
Secondary minerals		
Chlorite		developed from hornblende
Uralite		developed from augite
Limonite		
Clay minerals		developed from plagioclase

A specimen of gabbro from the same body as the preceding specimen, but collected approximately 15 feet from the southeastern border of the gabbro, has the following properties under the microscope:

Mineral	Estimated Percentage	Remarks
Plagioclase	60%	zoned $An_{72-82(?)}$; average crystal size about 1.7 mm. by 0.8 mm.
Hornblende	30%	pleochroic in shades of light brown; contains abundant inclusions of ore minerals; crystals average 1.0 mm. in length
Augite	9%	some ore mineral inclusions
Ore minerals	1%	
Secondary minerals		
Limonite		
Uralite		developed from augite

Figure 6. ----- Photomicrograph of part of thin section of gabbro described on bottom of page 15. Field dominantly plagioclase (pl) and hornblende (h). X nicols. X39.

Figure 7. ----- Photomicrograph of part of thin section of border facies gabbro described on page 16. Note range in crystal sizes. Plagioclase (pl), hornblende (h) and augite (au) are the dominant minerals. X nicols. X39.

Chlorite	developed from hornblende
Clay minerals	developed from plagioclase

A specimen of border-facies gabbro obtained two feet from a tonalite-gabbro contact in the gabbro body that tops the 1700 foot peak in the first hills west of Jensen's quarry has the following microscopic characteristics:

Mineral	Estimated Percentage	Remarks
Plagioclase	60%	zoned in bytownite range; crystals as large as 3.5 mm. in length and 1.0 mm. in width; generally 1.5 mm. in longest direction.
Hornblende	20%	pleochroic, tan to light greenish brown; most crystals between 0.75 mm. and 1.5 mm. in length.
Augite	12%	
Biotite	4%	
Quartz	2%	
Ore minerals Apatite	2%	

Secondary minerals

Chlorite	developed from hornblende
Uralite	developed from augite
Clay minerals	developed from plagioclase
Limonite	

A thin section of gabbro from the large gabbro body adjacent to the questionable fault in the south-central part of the area shows the following properties beneath the microscope:

Mineral	Estimated Percentage	Remarks
Plagioclase	58%	zoned, An_{75-82}; largest about 3.0 mm. by 1.0 mm.; commonly crystals are near 1.5 mm. in length

Hornblende	30%	pleochroic, tan to brown
Augite	9%	
Quartz	1%	surrounds a few small plagioclase crystals
Biotite	1%	pleochroic, yellow brown to green brown
Ore minerals Apatite	1%	

Secondary minerals

Limonite

Chlorite — developed from hornblende

Clay minerals

Epidote(?)

Gabbro from the gabbro body nearest the highest peak in the area is medium grained and has the following properties when examined beneath the microscope:

Mineral	Estimated Percentage	Remarks
Plagioclase	50%	zoned An_{88-90}; numerous inclusions, mostly apatite; largest observed crystal 3.0 mm. by 1.5 mm.; most abundant crystals about 1.5 mm. by 0.8 mm.
Hornblende	30%	pleochroic, tan to greenish brown; largest observed crystal 2.0 mm. in length
Augite	14%	shows schiller structure
Hypersthene(?)	2%	shows shiller structure
Ore minerals	2%	probably magnetite
Apatite	1%	
Sphene	1%	

Figure 8. ——— Photomicrograph of part of thin section of gabbro described on bottom of page 16 and top of page 17. Note abundant hornblende crystals. X nicols. X39.

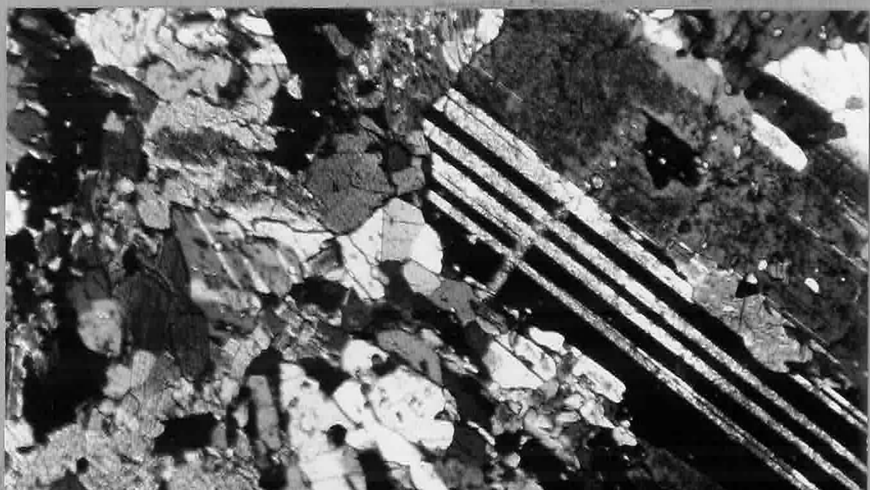


Figure 9. ——— Photomicrograph of part of thin section of gabbro described on bottom of page 17. Large plagioclase crystal has well developed carlsbad and albite twinning. The plagioclase is almost entirely surrounded by a finer-grained area in which hornblende and augite are the principal minerals. X nicols. X39.

Secondary minerals

Sericite	developed from plagioclase
Chlorite	developed from hornblende
Limonite	
Clay minerals	

Leucocratic gabbroic facies occur near the margins of some of the gabbro bodies. A specimen of leuco-gabbro collected a foot from the eastern contact of the largest gabbro mass in the south-central part of the Jurupa Mountains has the following properties beneath the microscope:

Mineral	Estimated Percentage	Remarks
Plagioclase	85%	zoned, An_{68-74}; average crystal size 2.0 mm. by 1.0 mm.
Hornblende	8%	pleochroic, tan to greenish brown
Augite	5%	
Ore minerals	1%	
Sphene Apatite	1%	

Secondary minerals

Chlorite	developed from hornblende and augite
Uralite	developed from augite
Clay minerals	developed from plagioclase

Bonsall tonalite

Bonsall tonalite is the most abundant rock in the Jurupa Mountains. This rock was named by Hurlbut 16/ from exposures near Bonsall, a village

---

16/ Hurlbut, C. S. Jr., Dark inclusions in a tonalite of Southern California: Amer. Mineral., vol. 20, no. 9, p. 609-630, 1935.

Figure 10. —— Photomicrograph of part of thin section of leucogabbro described on page 18 showing abundant large plagioclase crystals. X nicols. X39.

in the San Luis Rey quadrangle in northern San Diego County. This rock is widespread throughout the Peninsular Range areas of Southern California and northern Baja California. The Bonsall tonalite is probably correlative with the San Jose Quartz Diorite of northern Baja California, a rock that has been described by Woodford and Harriss. 17/ On the basis

- -

17/ Woodford, A. O., and Harriss, T. F., Geological reconnaissance across Sierra San Pedro Martir, Baja California, Geol. Soc. Amer. Bull., vol 49, p. 1314, 1331, 1938.

- -

of field evidence in northern Baja California, Woodford and Harriss believe this rock to be Upper Cretaceous in age.

Typically, the Bonsall tonalite contains numerous inclusions of gabbro, or metamorphic rocks, or both rock types. It varies considerably in texture, and probably represents a series of separate, closely-related intrusive masses or plutons. The inclusions generally are elongate, and few exceed two feet in length. Biotite and hornblende, the principal ferromagnesian minerals in the tonalite, commonly are oriented with their long axes parallel. This together with inclusions, gives the rock distinct foliation and lineation. However, some parts of the tonalite lack good foliation and lineation. The Bonsall tonalite is medium to coarse grained, and ranges in color from light to dark gray.

Salients of tonalite penetrate the gabbro in a few places, and pegmatite dikes genetically related to the tonalite locally cut across the metamorphic rocks. A few of the tonalite-gabbro contacts may be gradational. The contacts between tonalite and metamorphic rocks are in most places nearly vertical. The tonalite disintegrates more readily when exposed to weathering agents than any of the other batholithic rocks. Some deeply-weathered areas, largely underlain by tonalite, are well dissected by intermittent streams and gullies and form areas of irregular topography. A good example of this feature occurs on the western slopes of the hills between 1500 and 2500 feet southeast of the Declezville quarry. In the north-central part of the Jurupa Mountains, where granodiorite and tonalite are in contact, the granodiorite side of the contact is characterized by large, bouldery outcrops. A subdued, grus-covered surface is on the side underlain by tonalite. Some large residual, boulder-like tonalite bodies protrude above the weathered surface. Weathering "plums" consisting of round bodies of fresh tonalite that reach four feet in diameter, apparently entirely surrounded by disintegrated, granular tonalite, are conspicuous in some of the road cuts on Highway 60. Sharp contacts occur between the weathering "plums" and the disintegrated material. The inclusions are more resistant to weathering and commonly stand out in bold relief above the tonalite.

A specimen of medium-grained hypautomorphic tonalite collected from the easternmost road cut of Highway 60 in the area that tonalite is exposed in has the following properties beneath the microscope:

Mineral	Estimated Percentage	Remarks
Plagioclase	68%	zoned, An_{27-33}; average crystal 2.0 mm. long, 1.0 mm. wide; largest crystals reach 5.0 mm. in length.
Quartz	10%	mostly in subhedral and anhedral crystals
Hornblende	8%	pleochroic, light greenish brown to dark greenish brown
Biotite	8%	pleochroic, yellow brown to greenish brown
Orthoclase	4%	some involved in myrmekitic intergrowths
Microcline	1%	

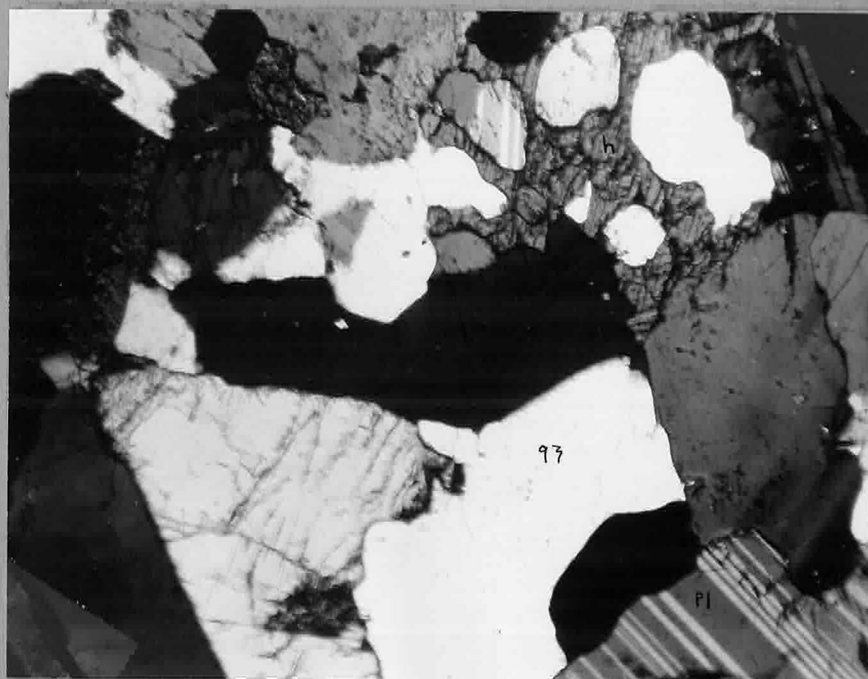


Figure 11. ——— Photomicrograph of part of thin section of tonalite described on page 20 showing relationship between quartz (qz), plagioclase (pl) and hornblende (h). X nicols. X39.

Apatite		as euhedral inclusions in plagioclase
Sphene Ore minerals	1%	

<u>Secondary minerals</u>

Sericite	developed from plagioclase and orthoclase
Chlorite	developed from hornblende
Clay minerals	developed from plagioclase and orthoclase

Tonalite from the mass that underlies the highest peak in the Jurupa Mountains has the following properties when observed beneath the microscope:

Mineral	Estimated Percentage	Remarks
Plagioclase	61%	zoned, An_{33-40}; mostly subhedral crystals; average crystal 1.0 mm. by 2.0 mm.
Quartz	20%	mostly anhedral crystals; slightly fractured and has strain shadows
Biotite	10%	pleochroic, tan to chestnut brown
Hornblende	5%	pleochroic, tan to dark greenish brown
Augite	2%	
Sphene Zircon Ore minerals Apatite	2%	

<u>Secondary minerals</u>

Antigorite	developed from augite
Chlorite	developed from biotite and hornblende
Clay minerals	developed from feldspars
Epidote	
Sericite	developed from plagioclase

Woodson Mountain granodiorite

Granodiorite is best exposed in the vicinity of the second highest peak in the central part of the Jurupa Mountains. This locale consists almost entirely of cliff-like, bold outcrops of Woodson Mountain granodiorite.

The Woodson Mountain granodiorite was named by Miller 18/ on the basis

18/ Miller, F. S., op. cit. p. 1399, 1937.

of his work in the San Luis Rey quadrangle. The Woodson Mountain granodiorite is a leucocratic rock that ranges in color from white to light gray and contains only a small proportion of ferromagnesian minerals. It varies from fine grained to coarse grained; the finer-grained facies generally are confined to marginal zones of the plutons. No evidence for the age relationship between the coarse-grained and fine-grained facies was obtained in the Jurupa Mountains. Dr. Jahns 19/ believes that the fine-grained facies of the Woodson Mountain granodiorite is the younger of the

19/ Jahns, R. H., Oral communication; May, 1950

two in the Pala district of Southern California as there it commonly cuts across the coarse-grained granodiorite. The granodiorite is locally gneissic, and in a few places it contains inclusions that appear to have been digested to varying degrees. This "mixed zone" is much narrower than that of the Bonsall tonalite and gneissic banding is not as widespread as it is in the tonalite. Rarely the granodiorite has a porphyritic texture, with phenocrysts of flesh-colored microcline, that attain six millimeters in maximum dimension, embedded in a fine-grained quartz-feldspar matrix. Contacts between the granodiorite and the metamorphic rocks commonly are nearly vertical.

The Woodson Mountain granodiorite clearly is younger than most of the other crystalline rocks in the area, as it transects them. Many of the pegmatite dikes are derivatives of the Woodson magma, and these cut all the types of crystalline rocks of the Jurupa Mountains. The granodiorite is one of the most resistant of the rocks in the Jurupa Mountains. It commonly crops out in large exfoliation boulders, termed by Larsen [20]

20/ Larsen, E. S., op. cit. p. 114, 1948.

"boulders of disintegration". The outer shells of these boulders are moderately disintegrated and crumbly. Small scale cavernous weathering and incipient pedestal rocks are local features of the granodiorite.

One thin section of Woodson Mountain granodiorite has the composition of quartz monzonite. However, this discrepancy is believed to be due to a local microcline-rich area in the thin section and not to be representative of the rock. This specimen is of a medium-to coarse-grained rock that has a crudely-developed porphyritic texture. It was obtained approximately 1600 feet east of the eastern Shannahan quarry. Under the microscope the thin section of this specimen has the following properties:

Mineral	Estimated Percentage	Remarks
Plagioclase	35%	An_{25-28}; most crystal dimensions between 1.0 and 4.0 mms.; involved in a little myrmekitic intergrowth
Microcline	35%	may surround and embay plagioclase; largest observed crystal 9.0 mm. by 4.0 mm.
Quartz	24%	strain shadows
Biotite	5%	pleochroic, light tan to dark greenish brown

Figure 12. ——— Photomicrograph of a part of the thin section described on the bottom of page 23 and the top of page 24. Large mass of microcline (mi) has numerous poikilitic inclusions. Other minerals in field are quartz (qz), biotite (b), and plagioclase (pl). X nicols. X39.

Figure 13. ——— Photomicrograph of part of thin section of granodiorite described on page 24. Crude banding is suggested. Field consists of quartz (qz), plagioclase (pl), microcline (mi) and biotite (b), X nicols. X39.

Apatite Ore minerals Sphene	1%	

Secondary minerals

Sericite	developed from feldspars
Clay minerals	developed from feldspars
Chlorite	developed from biotite

A specimen collected from the westernmost of the twin peaks in the north-central part of the area is a medium-to fine-grained hypautomorphic rock. Microscopic examination reveals the presence of a small amount of myrmekitic intergrowth; the following other properties:

Mineral	Estimated Percentage	Remarks
Plagioclase	46%	An_{26}: occurs in subhedral crystals that average 1.0 mm. by 0.7 mm.
Quartz	30%	anhedral crystals; largest observed crystal 3.0 mm. by 3.0 mm.
Microcline	17%	subhedral crystals
Biotite	5%	pleochroic, tan to chestnut brown
Muscovite	1%	
Sphene Zircon Ore minerals	1%	pleochroic halos in biotite

Secondary minerals

Sericite	developed from plagioclase
Clay minerals	developed from feldspars

Pegmatites

Pegmatite dikes are abundant in the Jurupa Mountains. They are best developed in the eastern and in the western parts of the mapped area. Although pegmatites have not been differentiated on plate 1, three types of pegmatites are represented in the Jurupa Mountains: (1) pegmatites that appear to be related in composition and genesis to the Bonsall tonalite; (2) pegmatites that appear to be related in composition and genesis to the Woodson Mountain granodiorite; and (3) granite pegmatites that are characterized by a great predominance of alkali feldspars and quartz, very large crystals, and an irregular areal distribution. The granodiorite pegmatites are the commonest type in the Jurupa Mountains. The granite pegmatites probably are the youngest pegmatites in the area and are the least abundant.

Pegmatites cut across all the other crystalline rock types in the mapped area. The dikes range in width from less than an inch to about 24 feet, and in length from a few feet to at least 5,000 feet. Their bold, rib-like outcrops are conspicuous on the slopes and ridges of the area. The pegmatites have a wide range in crystal size and a variety of subordinate textures. Some of the perthite crystals in the granitic pegmatites exceed 20 centimeters in length. The pegmatites are predominantly white in color owing chiefly to the presence of abundant white perthite.

The tonalite pegmatites are characterized by a large amount of plagioclase. A few of the tonalite pegmatites contain hornblende, for example the westernmost pegmatite shown on plate 1.

Mineralogically, the typical granodiorite pegmatite consists of perthite (generally microcline and oligoclase), light-gray quartz, plagioclase (other than that in the perthite), biotite, black tourmaline, and muscovite. Less common are andradite and limonite (pseudomorphous after pyrite).

The granite pegmatites are characterized by very-coarse crystals, a relatively-low plagioclase content, and a more diversified mineralogical assemblage than the other pegmatites.

Murdoch and Webb[21/] reported beryl crystals from a pegmatite a short

21/ Murdoch, Joseph, and Webb, R. W., Minerals of California: Calif. State Div. of Mines Bull. 136, p. 70, 1948.

distance west of Jensen's quarry. The feldspars are the dominant minerals of most of the pegmatites, but quartz predominates in a few, as in the small bleb-like masses of quartz-rich pegmatite in the central part of the Jurupa Mountains. Some of the pegmatites are locally finer grained, and aplitic along their outcrops.

Most of the pegmatites have crude symmetrical zoning. Typically, this zoning is as follows: (1) a narrow quartz-rich core commonly with well-developed perthite euhedra and, less commonly, subhedral tourmaline; (2) an intermediate zone, about twice as wide as the core, that consists largely of perthite. This zone may have a graphic texture. Biotite is generally abundant contiguous to the core, and muscovite is less commonly present: (3) a wall zone approximately six times the width of the core and consisting mainly of a medium-grained mixture of quartz, feldspar and biotite. Commonly the wall zone is thinly banded.

There are exceptions to the described internal arrangement for the Jurupa Mountain pegmatites. In places the core lenses out, and the intermediate zone occupies the central position. A few of the pegmatites are asymmetrically zoned, and many are devoid of any clearly recognizable zoning. The phenomenon of multiple zoning, in which several quartz-rich cores are present, occurs in some of the larger pegmatites. Multiple zoning is apparently brought about by the late injection of pegmatitic material into fractures developed in the already solidified portions of the pegmatite.

In general the zoning in the pegmatites of the Jurupa Mountains conforms with the zoning classification proposed by Cameron, Jahns, McNair, and Page;22/ the commonest discrepancy being in the characteristics of

---

22/ Cameron, E. N., et. al., Internal structure of granitic pegmatites: Mon. 2, Econ. Geol., p. 20, 1949.

---

the wall zone. The wall zones of the Jurupa Mountain pegmatites are generally composed of much smaller crystals than the wall zones typical of the pegmatites of the proposed classification.

Graphic intergrowths are uncommon in the pegmatites of the Jurupa Mountains. They generally are of the well-known graphic granite type, involving perthite and quartz; however, graphic intergrowths between tourmaline and quartz are present in some of the dikes. Some of the pegmatites that traverse the siliceous metasedimentary rocks contain a few small inclusions of country rock.

The pegmatites resist weathering and are commonly the controlling factor in ridge development. They are most abundant in the siliceous metasediments and may either crosscut or trend parallel to the bedding. Almost all of the pegmatites of the Jurupa Mountains dip steeply. Most of the pegmatites in the western part of the area are not traceable into the granodiorite for more than two or three feet beyond the granodiorite-siliceous metasediment contact.

The pegmatites of the Jurupa Mountains contrast with most of the famous gem-bearing pegmatites farther south in Riverside and San Diego Counties both in attitude and mineralogy. The Jurupa Mountains pegmatites are much steeper dipping than the typical gem-bearing pegmatites and also lack the lithia minerals that are characteristic of most gem pegmatites.

QUATERNARY SURFICIAL DEPOSITS

General statement

Two Quaternary surficial deposits have been differentiated and mapped. They are old alluvium and recent surficial deposits. The symbol used on plate 1 for the old alluvium is Qoa; that for the recent surficial deposits Qal. Old alluvial fan deposits constitute the old alluvium. The recent surficial deposits in the area mapped include: (1) coarse gravel and sand of the Cucamonga fan; (2) aeolian sands; (3) recent alluvium from the Jurupa Mountains; and (4) a few talus and slope wash deposits which mask significant amounts of the underlying rock.

Recent surficial deposits

Recent surficial deposits are widespread in the mapped area. Their maximum thicknesses were not determined in the present investigation.

Cucamonga fan deposits

The Cucamonga fan almost surrounds the Jurupa Mountains. It contains a wide assemblage of clastic material mostly derived from the San Gabriel Mountains. Some of its constituent boulders exceed two feet in diameter. Distributaries traversing the Cucamonga fan have locally cut deeply into the fan. Southwest of the Declezville quarry, a long straight, stream-cut bank, about 40 feet in maximum height, is a conspicuous topographical feature in the alluvium.

Aeolian sands

Aeolian sands overlie a large part of the Cucamonga fan in the mapped area. This sand is best exposed along the northern front of the Jurupa Mountains, where the prevailing winds have locally piled it up in "drifts" and climbing dunes. These dunes and "drifts" are active, and sand movement can be observed on them on windy days. The constituent sand of these deposits is white in color and largely quartz and feldspars. The aeolian deposits probably do not exceed 40 feet in thickness.

Recent alluvium from the Jurupa Mountains

Recent alluvium from the Jurupa Mountains forms fan deposits bordering most of the southern slopes of the mountains. This alluvium is characterized by smaller fragments than the typical Cucamonga fan material, and by containing rocks common in the Jurupa Mountains.

Talus and slope wash

Talus and slope wash locally obscure small areas of the underlying rock. Both talus and slope wash are best represented in the vicinity of Jensen's quarry.

Old alluvium

Old alluvium reaches an estimated maximum apparent thickness of 80 feet in the Jurupa Mountains. It is best exposed in the easternmost road cut of Highway 60 within the mapped area. The old alluvium is a crudely-stratified fan deposit that consists of irregularly-shaped rock fragments that reach a foot in length, sand and gravel. The rocks of the old alluvium were apparently derived from the Jurupa Mountains. This fan material is generally rather well consolidated and occurs at high levels and as bench cappings.

STRUCTURE

General Structure

The Jurupa Mountains may represent a region of structural transition between the prevailing structural trends of the Peninsular Ranges to the south and those of the Transverse Ranges to the north. The general structural trend in the Peninsular Ranges is about north 35 degrees west. The Jurupa Mountains internal structural trend averages north 70 degrees west, and they have an east-west topographical trend. The structural and topographical trends of the San Gabriel Mountains are generally east-west.

The Jurupa Mountains are in the northern part of the Perris fault block. The Perris fault block is bounded by the San Jacinto fault on the east, the frontal fault zone of the San Gabriel Mountains to the north, and the Elsinore-Chino fault system to the west.

Faults

The bulk of evidence in the Jurupa Mountains disfavors any large, continuous faults, and, most likely, the lines of rupture that are mapped as questionable faults on plate 1 are essentially joints along which a very small amount of movement took place and which provided channelways for local hydrothermal solutions. These questionable lines of rupture are the only evidence of faulting in the Jurupa Mountains. The presence of faulting is suggested by: (1) a few distinct linear structural features that transect the topography (these are best seen on aerial photographs); (2) a probable local offset and curving of some of the rock units that strike into the faults(?); (3) the apparent truncation of a pegmatite dike by a fault(?); (4) local zones of hydrothermally altered rock and siliceous material along the traces of the faults(?).

Conversely, the only bedrock exposures along the faults(?) reveal no trace of movement, and offset bedding hasn't been definitely established, mainly due to the dearth of critical outcrops.

It is possible that the Jurupa Mountains are an upfaulted block, and that they are bounded by marginal faults; however, no evidence was found to substantiate this hypothesis and the following negative evidence is offered: (1) the rocks of the margins of the Jurupa Mountains are virtually in the same state of weathering as those that underlie the central parts of the mountains. They are rather fresh and lack shattering, shearing, brecciation, hydrothermal alteration, or other features normally associated with large faults; (2) the borders of the Jurupa Mountains are marked by numerous salients and embayments, and hence do not have the linear aspect that frontal faulting commonly produces.

Internal structures

Foliation is abundantly developed in the granitic intrusive rocks, especially the tonalite, and in the siliceous metasediments. Generally the foliation in the intrusive rocks and the foliation in the metamorphic rocks are parallel and dip steeply. The foliations are also parallel to the contacts between the two rock types. In most places the contacts dip steeply outward from the intrusive bodies.

Foliation in the intrusive rocks is primary and apparently is due to late-stage magmatic flowage. Evidence for this is the parallel alignment of ferromagnesian minerals and parallelism and elongation of xenoliths. The directional trends of the primary foliation vary; however, the commonest trend is between north 70 and 85 degrees west.

Foliation in the metamorphic rocks probably is secondary. This foliation generally trends between north 40 and 60 degrees west in the eastern part of the Jurupa Mountains; its trend is variable in the central part, and in the western part the dominant trend is between north 70 and 85 degrees west.

The best-developed set of joints in the Jurupa Mountains are steeply dipping and trend northwesterly. A more poorly-developed group of steeply-dipping joints is approximately at right angles to the first. The Woodson Mountain granodiorite commonly has a set of near-vertical joints approximately normal to its contacts, and a less well-developed set of joints parallel to its contacts. Many other joints in the area, commonly poorly developed, cannot be easily assigned to any of the above joint sets.

Mode of emplacement of the batholithic rocks

The primary magma of the batholith is believed by Larsen 23/ to have

23/ Larsen, E. S., op. cit. p. 171, 1948.

been gabbroic in nature, and the different batholithic rock types are believed by him to have resulted from the differentiation of this magma. He is of the opinion that stoping probably played an important role in the emplacement of the magma. Evidence of this includes the numerous xenoliths in the different plutons, and parallelism of the invaded rock-intrusive contacts. In general, evidence in the Jurupa Mountains substantiates Larsen's belief regarding the importance of stoping. Inclusions are plentiful in the intrusive rocks of the area, particularly in the Bonsall tonalite. These inclusions are commonly less than two feet in length, but a few attain greater sizes. The inclusions probably are due to the incorporation of the wall rock in a viscous, cooling magma. The processes of assimilation and forcible intrusion were likely active to much lesser extents than stoping in the emplacement of the batholithic rocks in the Jurupa Mountains. Assimilation is present on a small scale near many contacts between the intrusive rocks and the siliceous metasediments, and it probably took place on a larger scale at greater depths where it is likely that a hotter magma contacted the invaded rock. Assimilation is suggested by the partially digested condition of some of the inclusions.

Smith 24/ on the basis of petrofabric analyses of some of the marble

- -

24/ Smith, Alexander, Structural petrology at Crestmore, California: Unpublished Doctoral Thesis (minor), Calif. Inst. of Technology, p. 26, 1947.

- -

from Jensen's quarry states:

"The specimens show strong maxima of the optic (C) axes narly normal to the (intrusive) contact....."

On the basis of girdle patterns at Jensen's quarry, Smith believes that the folding of the marble might have been caused by the intrusion of the magma. However, this evidence may only be applicable to the latest folding.

Larsen 25/ believes that the forces that deformed the rocks of the

- -

25/ Larsen, E. S., op. cit. p. 120, 1948.

- -

Peninsular Ranges must have acted from the same directions from pre-batholithic times to the present. Daly 26/ points out the fact that quartz

- -

26/ Daly, J. W., op. cit. The geology and mineralogy of the limestone deposits at Crestmore, Riverside County, California: p. 12, 1931.

- -

grains in the metamorphic rocks show more evidence of stress than quartz in the igneous rocks, and he believes this to indicate that at least part of the metamorphism had been effected before the intrusion.

It is likely that stoping was the dominant process involved in the emplacement of the Jurupa Mountain intrusive rocks. Assimilation probably took place on a small scale, and forcible intrusion may have occurred locally.

ECONOMIC GEOLOGY

General statement

The mineral resources of the Jurupa Mountains that are or have been utilized are: marble, mainly for cement-making purposes, from Jensen's quarry and from the Glen Avon quarry; tonalite from the Declezville quarry; and granodiorite from the Shannahan quarries and from the small unnamed quarry near the 117 degree 30 minute meridian. A few smaller-scale operations were active in the past, but none of these were carried beyond the prospecting stage. Several gold prospects are present in the siliceous metasediments and a few in the gabbro. Some of the pegmatites have been prospected by means of small cuts.

Marble deposits

Jensen's quarry

Jensen's quarry, where marble is quarried by the Riverside Cement Company for the manufacture of cement, contains the largest and best-known marble deposits in the mapped area. Jensen's quarry lies in the southeastern part of the Jurupa Mountains. This property is divisible into three main parts: the south quarry (shown on pl. 1 and pl. 2); the main quarry (shown on pl. 2); and the north quarry (shown on pl. 1).

The geology at Jensen's quarry is dominated by the intimate association of marble with siliceous metamorphic rocks and salients of intrusive rocks. Bedding in the marble bodies strikes northeasterly and dips between 60 and 80 degrees to the southeast. Smith 27/ believes that

- -

27/ Smith, Alexander., op. cit. p. 16, 1947.

- -

the marble at Jensen's quarry may be in a tight, easterly-plunging fold.

However, there doesn't appear to be any field evidence to substantiate this belief. The marble bodies attain apparent maximum thicknesses of at least 200 feet.

The main quarry is approximately 420 feet long (in a northwesterly direction) and 200 feet wide. The north face of this quarry has a maximum relief of 230 feet. The rim of the south face is not more than 75 feet higher than the quarry floor.

The south quarry is roughly 320 feet in an east-west direction and 200 feet in a north-south direction. The maximum vertical distance between the rims and toes of the faces of this quarry is about 100 feet.

The north quarry is nearly 1000 feet in length and has a steep southern face that reaches elevations that exceed the elevation of the quarry floor by 150 feet.

The present production is entirely from the main quarry. The irregular association of the marble with other rocks precludes any accurate estimate of the marble reserves. The hill between the main quarry and the north quarry has been extensively prospected by diamond drilling, and it is likely that the Riverside Company will quarry the marble there at some future time.

The marble at Jensen's quarry, like most Southern California marbles, has a relatively high magnesia content. However, this deleterious factor for cement making is apparently offset by the proximity of the Riverside Company plant at Crestmore, the modern and efficient methods employed there, and the nearness to the large cement-consuming districts of metropolitan Southern California. A paved, company-owned road connects the Crestmore plant and Jensen's quarry.

Information on the history of Jensen's quarry is rather sketchy. The quarry was apparently developed during World War I by the Riverside Cement Company and production maintained until 1927 when the property was shut down. There was little activity at Jensen's quarry from 1927 to 1948. The Riverside Company did not resume large-scale operations at Jensen's quarry until 1948. Although no production records are available for Jensen's quarry it is undoubtedly supplying a substantial portion of the marble used at Crestmore.

Glen Avon quarry

At the Glen Avon quarry (on the southern slope of the western part of the Jurupa Mountains) marble occurs in the two steeply-dipping, lense-like bodies that trend nearly east-west. These bodies are within a bedded sequence of siliceous metasedimentary rocks. The marble lenses attain maximum exposed dimensions of 750 feet in length and 70 feet in thickness. They have been exploited by two open cuts. The longest of these cuts extends about 150 feet parallel to the strike of the marble bodies. These deposits haven't produced in several years. During 1928 two men worked these deposits and shipped marble to Los Angeles where it was ground and employed as chicken grit. The low reserves appear to limit the possibility of future significant production from this deposit.

Other marble deposits

A marble body which appears to have commercial possibilities lies about 1500 feet west of the main Jensen's quarry, and the marble's eastern contact dips 50 degrees east. The only other marble body shown on plate 1 caps a hill about 2500 feet southwest of the main Jensen's quarry. The apparent small volume of this deposit and its inaccessibility are factors that inhibit future development.

Granitic rocks

Shannahan quarries

The Shannahan quarries are in the "narrows" near the boundary between the western and central parts of the Jurupa Mountains. Woodson Mountain granodiorite is obtained at these quarries. The workings consist of two quarries and a few small prospect cuts (not shown on pl. 1). The easternmost quarry, the largest of the two, has a face 700 feet in length and 75 feet high. An almost east-west trending set of joints, commonly about 8 to 10 feet apart, and other joints that trend northerly, enhance quarrying operations at this location. Regolith locally overlies the granodiorite and averages one foot in thickness.

These quarries were formerly known as the Bly brothers quarries. They were first operated around 1900, and granodiorite from them was used for building purposes in Riverside and Los Angeles. In 1928 about 150 tons of granodiorite was produced per month from these workings. The granodiorite was shipped to Los Angeles where it was ground and used for roofing granules and chicken grit. Intermittent operations characterize the recent history of these quarries. The main recent use for the rock from the Shannahan quarries has been for rip-rap. In 1949 large quantities of rock obtained at these quarries was used for breakwater construction in the Long Beach harbor. The reserves are large.

Declezville quarry

The Declezville quarry is in Bonsall tonalite on a northward-projecting salient of the western part of the Jurupa Mountains. The Declezville quarry is the oldest and largest quarry in the area. The north-south trending face of the Declezville quarry is approximately 1400 feet in length and reaches a maximum height of 100 feet above the quarry floor. The east-west trending face is about 700 feet long and rises more than 100 feet above the quarry floor.

The tonalite at this quarry is relatively free from inclusions. Weathering has formed a dark-brown soil to a depth of about three feet below the rim of the quarry. Quarrying is abetted by evenly-spaced, northwest-trending joints.

The Declezville quarry is owned by the Southern Pacific Railroad, and was first operated by the railroad prior to 1900. In 1905 practically the entire output from this quarry was used as rubble in the government breakwater at San Pedro. At the present time this quarry is leased to the Columbia Construction Company, a subsidiary of the Kaiser Steel Corporation. As part of their lease the Columbia Construction Company produces a small amount of rip-rap for the Southern Pacific Railroad. The bulk of the recent production was for rip-rap that was used in the Long Beach breakwater. This quarry has been inactive since the early part of 1950. The Declezville quarry is served by a paved road and by a spur line that connects with the main east-west line of the Southern Pacific Railroad. The reserves of this quarry are vast.

Other workings in granitic rocks

A small working about 50 feet long, 20 feet wide, and 15 feet high is in the Woodson Mountain granodiorite on the northern slope of the Jurupa Mountains near the 117 degree 30 minute meridian at an altitude of 925 feet. The granodiorite at this location is fine-grained and free from inclusions, and it probably is quarried for building purposes, although no data are available on the production from this locality. Some other small cuts are in the granodiorite in the western part of the Jurupa Mountains, but none of these are more than prospects.

Gold and pegmatite prospects

Several abandoned gold prospects are present along quartz stringers and blebs, commonly within the siliceous metasedimentary rocks. A few of the prospects are in gabbro, and some of the workings are in tonalite. Aside from a small amount of limonite staining, none of the deposits show any criteria suggestive of ore mineralization.

Most of these deposits appear to be similar to the gold deposits of the Julian schist in the Peninsular Ranges of San Diego County. Both the Jurupa Mountain deposits and the Julian schist deposits generally consist of narrow, irregular quartz stringers in a matrix of siliceous metasedimentary rocks, and the deposits of both of these regions probably were formed by hydrothermal solutions emanating from a similar source.

Two inclined shafts and three prospect adits in a small area on the southern slopes of the central part of the Jurupa Mountains form the greatest concentration of the gold prospects. The longest adit is about 75 feet and the deepest shaft has a slope dimension of approximately 65 feet. The most recent-appearing working in the Jurupa Mountains is in the gabbro on the southern slopes of the western part, and consists of a vertical shaft about 40 feet deep, and trail and dirt road connections with the highway.

Many of the pegmatites have been prospected by means of small trenches, cuts, and drifts of "coyote hole" proportions. However, there apparently never was any commercial production from these pegmatites.

REFERENCES CITED

Cameron, E. N., Jahns, R. H., McNair, A. H., and Page, L. R., Internal structure of granitic pegmatites: Monograph 2, Econ. Geol. 1949.

Daly, J. W., The geology and mineralogy of the limestone deposits at Crestmore, Riverside County, California: Unpublished Master's Thesis, Calif. Inst. of Technology, 1931.

———— Paragenesis of the mineral assemblage at Crestmore, Riverside County, California: Amer. Mineral., vol. 20, 1935.

Dudley, P. H., Geology of a portion of the Perris Block, Southern California: Jour. Mines and Geol., vol. 31, 1935.

———— Physiographic history of a portion of the Perris Block, Southern California: Jour. Geol., vol. 44, 1936.

Hurlbut, C. S. Jr., Dark inclusions in a tonalite of Southern California: Amer. Mineral., vol. 20, 1935.

Larsen, E. S., Batholith and associated rocks of Corona, Elsinore, and San Luis Rey quadrangles, Southern California: Geol. Soc. Amer. Memoir 29, 1948.

Miller, F. S., Petrology of the San Marcos gabbro, Southern California: Geol. Soc. Amer. Bull., vol. 48, 1937.

Miller, W. J., Geology of the western San Gabriel Mountains: Univ. of Calif. at L.A. Publ. in Math. and Physical Science, 1934.

Murdoch, Joseph, and Fahey, J. J., Geikielite, a new find from California: Amer. Mineral., vol. 34, 1949.

Murdoch, Joseph, and Webb, R. W., Minerals of California: Calif. State Div. of Mines Bull. 136, 1948.

Smith, Alexander, Structural petrology at Crestmore, California: Unpublished Doctoral Thesis (minor), Calif. Inst. of Technology, 1947.

Webb, R. W., Evidence of the age of a crystalline limestone in Southern California: Jour. Geology, vol 47, 1939.

Woodford, A. O., Crestmore minerals: 39th Report of the State Mineralogist, Calif. State Mining Bureau, 1943.

Woodford, A. O., and Harriss, T. F., Geology of Blackhawk Canyon, San Bernardino Mountains, California: California Univ. Dept. Geol. Sci., Bull. 17, 1928.

——————————— Geological reconnaissance across Sierra San Pedro Martir, Baja California, Geol. Soc. Amer. Bull., vol 49, 1938.