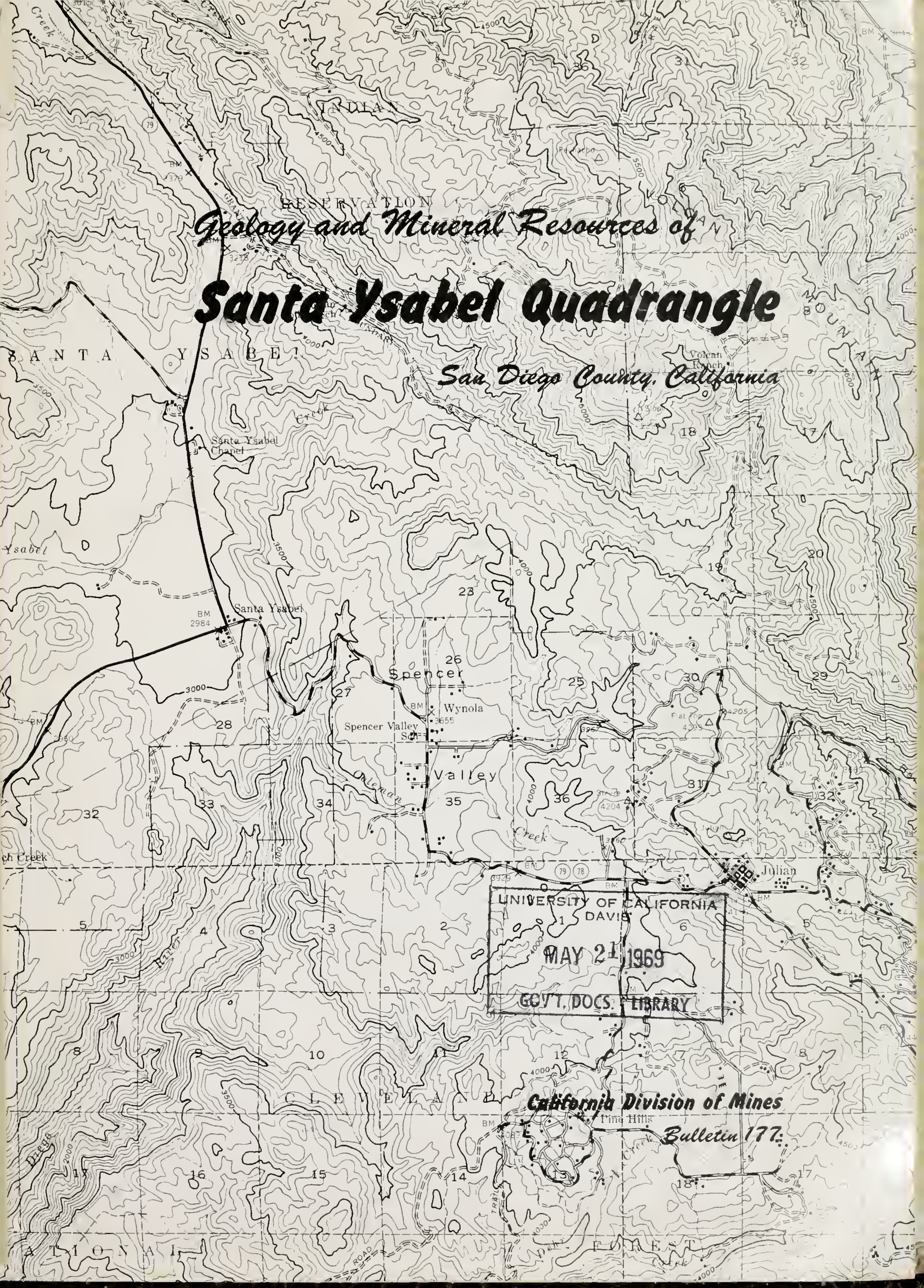
# Geology and Mineral Resources of

# Santa Ysabel Quadrangle

## San Diego County, California



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DEPARTMENT OF NATURAL RESOURCES
DeWITT NELSON, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO 11
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SAN FRANCISCO BULLETIN 177 1958

# GEOLOGY AND MINERAL RESOURCES OF SANTA YSABEL QUADRANGLE SAN DIEGO COUNTY, CALIFORNIA

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To His Excellency
The Honorable Edmund G. Brown
*Governor of the State of California*

Sir:

I have the honor to transmit herewith Bulletin 177, Geology and mineral resources of Santa Ysabel quadrangle, San Diego County, California, prepared for publication 1958 under the direction of Gordon B. Oakeshott, Chief of the Division of Mines, Department of Natural Resources. The descriptive text is accompanied by a colored geologic map and an economic map, both on a topographic base, a structure map and sections, and numerous photographs. The report represents the work of Richard Merriam of the Department of Geology, University of Southern California, Los Angeles, California. Supplementary to the descriptive geology is a section on the mines and mineral deposits prepared by Richard M. Stewart, Mining Geologist with the Division of Mines.

The Santa Ysabel quadrangle lies in the north central part of San Diego County. Hydrothermal gold-bearing quartz veins of the Julian district have been the most important mineral resources in the area, but mining activities are limited. The mines here were most active during the period 1870 to 1880 and the value of the total estimated production from the district is between $2,500,000 and $3,000,000. Small tungsten deposits have yielded some ore. Nickeliferous pyrrhotite bodies near Julian have been prospected but the proved reserves are small. Marble has been quarried from deposits interbedded in the Julian schist.

This report represents the results of basic geologic studies and should be of value in the development of natural resources within the area.

Respectfully submitted,

DeWitt Nelson, Director
Department of Natural Resources

# GEOLOGY OF SANTA YSABEL QUADRANGLE SAN DIEGO COUNTY, CALIFORNIA

By Richard Merriam *

## OUTLINE OF REPORT



### Illustrations



## ABSTRACT

The Santa Ysabel quadrangle lies along the east edge of the composite Peninsular Ranges batholith of Cretaceous age. The oldest rocks are Triassic (?) schists which occur as small roof pendants and as one large body in the vicinity of Julian. Jurassic (?) gneissose quartz diorite is intimately mixed with much of the schist, the two making a complex into which were intruded various members of the Cretaceous batholith. These intrusions are limited to gabbro and several tonalites. Structural features of the igneous rocks suggest that emplacement may have been accomplished by stoping in some places and by forceful injection in others.

Pleistocene (?) continental gravels occur as remnants of a once continuous extensive blanket in the northern portion of the quadrangle.

The two most prominent structural features are the Elsinore fault and the San Felipe fault. These and a few minor faults strike northwest. Northeast-striking joints influence the topography locally. The faulting, and, to some extent, schistosity, lineation, and foliation, are reflected by the topography, which is characterized by northwest-trending valleys and highlands. Some of the latter have summit areas of low relief. Such areas are not at the same altitude and may be explained by faulting, differential resistance of different rock types, or a combination of both.

Mining activities, although once extensive, are quite limited. Nickeliferous pyrrhotite and hypothermal gold-quartz veins are the principal types of deposits. Marble interbeds in the schist have been worked but the quarries are idle.

Groundwater is probably the most important of the natural resources. San Jose Valley and San Felipe Valley are the best situated portions of the area in this respect. In many places faults have had a notable effect on the position of the water table.

## INTRODUCTION

The Santa Ysabel quadrangle lies in the north-central part of San Diego County, California. The western boundary of the quadrangle is about 30 miles east of the Pacific Ocean and the southern boundary approximately the same distance north of the Mexican border. The area is a 15-minute quadrangle covering more than 200 square miles.

Two state highways and a number of fairly good county roads permit access to most of the region. State Highway 78 is the chief east-west road; Highway 79 crosses the area from the southeast to the northwest.

The topography was originally mapped by the U. S. Geological Survey as the Ramona quadrangle, scale 1:125,000. Later the southeastern quarter of this quad-

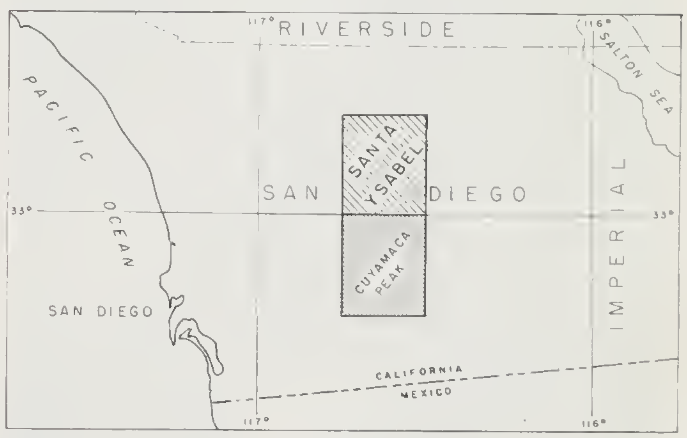


Figure 1. Index map showing location of Santa Ysabel quadrangle. Geology of the Cuyamaca Peak quadrangle was published in Division of Mines Bulletin 159 (1951).

* Department of Geology, University of Southern California, Los Angeles, California. Manuscript submitted for publication 1952.

rangle was mapped by the U. S. Army on the scale of 1:62,500 with a 100-foot contour interval and named the Santa Ysabel quadrangle.

The topography is dominated by the northwest trend of the principal valleys and ranges. The most prominent mountain mass, Volcan Mountain, trends in this direction and is paralleled by the principal valley, San Felipe Valley. Elevations on Volcan Mountain range from 4,000 to 5,000 feet whereas the adjacent lowlands are about 2,500 feet. Thus relief of 2,000 feet is common. Highest points on the quadrangle are Volcan Mountain, 5,700 feet; North Peak (of the Cuyamaca group of peaks) near the south edge of the area, 6,000 feet; and San Ysidro Mountains in the northeast corner of the quadrangle. Lake Henshaw occupies a prominent topographic low in the northwest corner of the quadrangle. The northeast-trending gorge of the San Diego River is the chief feature of the southwest corner of the quadrangle; at elevation 1,000 this is more than 1,000 feet lower than any other major valley.

The divide between western drainage to the Pacific Ocean and eastern drainage to the Salton Sea passes through this quadrangle; approximately two thirds of the quadrangle area drains westward. The headwaters of the San Luis Rey River carry off precipitation in the north. The eastern section is drained by San Felipe Creek and its tributaries in Banner Canyon, Chariot Canyon, and others. The drainage in the southwestern portion is divided between Santa Ysabel Creek and the San Diego River, the latter taking the bulk of the runoff.

The area lies on the boundary between the semi-arid western and arid eastern regions. Annual precipitation gradually increases from 18 inches in the west to more than 30 inches along the high divide of Volcan Mountain and North Peak. Eastward from this line it rapidly decreases to well below 10 inches per year. Temperatures are not extreme over most of the area although snow is common in the highlands in the winter, and summer highs of over 100 degrees are characteristic of the eastern desert region.

Most of the hills of the western half of the Santa Ysabel quadrangle are covered by brush composed of manzanita, chamise, lilac, several varieties of sage, scrub oak, and similar shrubs. The valleys and some of the hills of this section are chiefly open grasslands dotted with live oaks and a few sycamores. The high-divide section north and south of Julian is covered in part by conifers, alders, and deciduous oaks. Where timber is absent brush as described above is the cover. Meadow-like areas in the highlands support various grasses. The desert portions in the east are characterized by a typical desert flora of various cacti, creosote bush, mesquite and a small variety of juniper.

With the exception of the vicinity of Julian (population 500) which is the only town, the area is thinly populated. Numerous very minor settlements of the cross roads type are widespread. Several Indian reservations occupy a total of nearly 10 percent of the area. Much of the remainder is within the limits of Cleveland National Forest.

A large part of the quadrangle is utilized for grazing, cattle raising being the largest single industry. Scattered small deciduous orchards and vineyards are of distinctly secondary importance. Two or three small resorts attract a limited number of vacationists.

Mapping was done on the U. S. Army topographic base, scale 1:62,500, although aerial photographs were used in part. Three groups of photographs are available, two sets made by the Agricultural Adjustment Administration and another by the San Diego County Assessor's office.

A strip along the western part of the quadrangle was first mapped in 1938-39 (Merriam, 1940) on the old Ramona sheet, the only map available at the time. The strip was re-mapped and the remainder of the Santa Ysabel quadrangle completed in 1950-51 on the new topographic base.

*Previous Geological Work.* The earliest geological descriptions of the area are in general reports covering the entire county or a large part of the Peninsular Ranges. One of the first published papers was by W. F. Blake (1856), who made a very brief study on a trip from San Felipe Valley to San Diego.

In 1888 there appeared a short report by W. A. Goodyear which was chiefly concerned with mining but also contained a good description of the physiography. Goodyear was probably the first to compare the Peninsular Ranges to the Sierra Nevada.

H. W. Fairbanks made a reconnaissance survey in 1893. He noted the various rock types encountered on a traverse from Julian to Ramona, recognizing distinct types in what had previously been lumped as "granite". His dating of the intrusives as "Jurassic or Cretaceous" agrees well with present information.

Little further work was published until 1914 when Merrill (1916) wrote a paper on San Diego and Imperial Counties. It is concerned with mining features and little mention is made of the geology of this specific area.

An exhaustive report by A. J. Ellis and C. H. Lee on the groundwater of the western part of the county was published in 1919. They critically discussed the physiography; and though they studied the sediments in some detail, they grouped igneous and metamorphic rocks as "crystalline complex".

The first detailed petrographic work was done by F. S. Hudson (1922), who studied an area in the southern part of the Santa Ysabel quadrangle and the northern part of the Cuyamaca Peak quadrangle.

The physiography of a large part of the Peninsular Ranges was studied and described by Sauer (1929), his being the most extensive work on that phase of the region.

A restudy of the Cuyamaca and Julian districts by Donnelly (1934) added little to the knowledge of the surface geology but contributed information regarding the gold mines of the region.

A paper by the present writer (Merriam 1946) described the geology of the western part of the Santa Ysabel quadrangle in a reconnaissance fashion.

A detailed study of the geology of a small portion of the quadrangle was made by Creasey (1946) during an investigation of nickel mineralization south of Julian. One of the principal features of this work is the critical examination of the gabbro and related rocks.

The most extensive study of any part of the Peninsular Ranges was made by Larsen (1948) in the Elsinore, Corona, and San Luis Rey quadrangles which lie to the northwest and west of the area with which this paper is concerned. In addition to a detailed geologic map of these quadrangles, this report includes petrographic descriptions and chemical analyses of many formations also found in the Santa Ysabel quadrangle.

The most recent contribution to the literature on geology of the general region was made by Everhart (1951) in his report on the Cuyamaca Peak quadrangle which joins the Santa Ysabel sheet along the latter's southern boundary. This paper includes an excellent structure map which materially aids in the understanding of many aspects of the crystalline rocks.

## GENERAL GEOLOGY

The Santa Ysabel quadrangle covers part of the Cretaceous composite batholith of southern and Lower California. Although the limits of this batholith have not been definitely established, it appears that the Santa Ysabel quadrangle is on or near its eastern edge. Metamorphic rocks, principally quartzite and mica schist, occur as small roof pendants and as one extensive body in the vicinity of Julian. A complex of schist and granodiorite of pre-batholith age underlies wide areas. This complex has been invaded by several intrusions of granitic rock ranging from gabbro to tonalite. More silicic types are common in parts of the batholith west and south of this area. Post-batholith continental sediments blanket much of the northwestern section; these are older than the Recent alluvial deposits which lie in most of the valleys.

Several northwest-striking faults are responsible for the most prominent topographic features, chief of which are Volcan Mountain, San Felipe Valley, and San Jose Valley (occupied by Lake Henshaw). Well-developed joints and possibly some faults have produced minor but numerous northeast-trending valleys.

## ROCK UNITS

### Julian Schist

Metamorphic rocks, principally schist, are in a large area in the central and southern part of the quadrangle, and in small isolated patches throughout the area. These remnants are too small and scattered to permit simple interpretation of the regional structure or stratigraphy. Although some bodies of metamorphic rocks are generally distinct, there are areas of mixed rocks and zones of injection gneiss; thus some segments of the contacts shown on the map accompanying this report are arbitrary.

Quartz-mica schists and related rocks are the dominant rock type of this group although quartzite is in appreciable quantities and amphibolite is present. The distribution of these types does not appear to be systematic in any way.

The structure of the Julian schist is described in this report under the section on structure; briefly, however, the strikes are mostly northwest, although local deviations are common and probably are related to the emplacement of intrusions. The schistosity dips steeply and parallels the original bedding.

*Quartzite.* Two types of quartzite occur, massive and laminated. The former is more common west of the Santa Ysabel quadrangle. Occurrences here are limited to a few small, reef-like masses. However, pods or lenses of massive quartzite interbedded with schist are widespread.

Laminated quartzite grades into quartz-mica schist. Individual bands range in thickness from a fraction of an inch to several inches. Micaceous layers are responsible for the laminated nature of the rocks; even though these may be absent locally, alternate gray and white streaks remain distinct. In thin-section the rock is fine to medium granoblastic, sometimes lepidoblastic. Quartz in polygonal or rounded grains amounts to more than 80 percent. Microcline is the most common feldspar, although orthoclase and andesine may be present. Muscovite flakes are commonly found poikilitically enclosed within the feldspar crystals. Magnetite and garnet are typical accessories.

*Schist.* The schist exhibits a much wider variety than do the quartzites. Quartz-biotite-muscovite schists are most common; other types are quartz-mica-sillimanite schist, gray muscovite-andalusite schist, amphibolite and fissile mica schist.

The quartz-mica schist is commonly streaked or banded white and gray, brown where weathered. Parting is well marked but discontinuous, irregular, and foliated, rather than smooth and slaty. In thin-section, polygonal and sutured grains of quartz make up at least half of the rock. Plagioclase, ranging from oligoclase to andesine, never exceeds 10 percent of the rock, but it is generally present. Biotite and muscovite are usually present in about equal amounts, but either may greatly predominate in individual bands. Zircon, spessartite, and tourmaline are unevenly distributed accessories.

PHOTO 1. Julian schist exposed in roadcut on Highway 79 near Julian.

PHOTO 2. Julian schist exposed in Chariot Canyon. This exposure is blockier in appearance than that shown in photo 1. *Photo by R. M. Stewart.*

Sillimanite is a common mineral throughout the metamorphic rocks. In only a few places is it sufficiently abundant to warrant its use in the rock name. Such rocks are moderately coarse-grained well-foliated schists. Sillimanite, in white bundles 1 or 2 cm long, similarly oriented, is best seen on weathered surfaces. Under the microscope the bulk of the rock appears to be quartz and muscovite. Sillimanite needles and tufts lying more or less parallel to the schistosity penetrate the quartz and mica. A minor amount of plagioclase ($An_{40}$) is present. Biotite is abundant in some sections.

Andalusite rocks are at least as common as sillimanite rocks. Andalusite rocks are exposed in a roadcut 2 miles east of Wynola and on the east side of Julian Ridge between Chariot Canyon and Cuyamaca Reservoir. In hand specimens these rocks are gray, somewhat finer-grained than other varieties of schist, nearly phyllitic and porphyroblastic. Andalusite prisms, 2 or 3 mm thick and several times as long, are sparsely distributed throughout. Thin sections show the finer material to be quartz, biotite, and muscovite with or without fine needles of sillimanite. The andalusite porphyroblasts are wreathed by muscovite or may be partially replaced by that mineral.

*Amphibolite.* Amphibolite rock makes up less than 10 percent of the metamorphic rocks. It is generally a distinct unit, although inseparable lenses are found in the schist. Exposures of the rock may be seen about a mile northwest of Witch Creek, on the south border of Santa Ysabel Valley, and a mile southwest of Pine Hills. Excepting the last-named outcrop, which is fairly coarse-textured, the typical rock is relatively dense and fine-grained, and has linear structure but poor schistosity. The color ranges from light gray or green to black. The texture in thin section is medium to fine granoblastic. More than 50 percent of the rock is hornblende with the following optical properties: $\alpha$ 1.665, $\beta$ 1.675, $\gamma$ 1.685; $Z \wedge C = 20°$; pleochroism, X-pale yellow, Y-olive green, Z-deep bluish green. Varying proportions of quartz and plagioclase ($An_{20-30}$) make up the remainder.

*Marble.* Medium to coarse massive marble crops out in two places on San Ysidro Mountain. Here nearly vertical beds, as much as a few tens of feet in thickness, are intercalated with quartz-mica schist.

*Origin of the Metamorphic Rocks.* The conditions of metamorphism seem to have been principally those of a mesozone regional type, although some highly injected rocks may approach katazone gneiss, and some of the well-laminated gray phyllitic rocks may best be classed as epizone. In the terminology of Eskola, the rocks range from the epidote-amphibolite facies to the amphibolite facies. As far as could be determined, neither texture nor mineral assemblage bears any systematic relation to igneous contacts. With the exception of scattered zones of injection gneiss, contact effects are absent. Distinct zones of sillimanite and andalusite could not be found; in fact, the two minerals are found together in many rocks.

Metamorphism has, of course, largely destroyed the details of primary structures and textures, but the general nature of the original rocks is still apparent. The massive quartzites were probably thick-bedded sandstone, some of which may have been arkosic. Laminated quartzite and quartz-mica schist may originally have been well-bedded sandstones with shaly or tuffaceous interbeds. The andalusite and sillimanite rocks probably represent argillaceous sediments of various types, although the possibility of the introduction of alumina is admitted.

Marble, of course, resulted from the metamorphism of minor limestone bodies.

*Age of the Metamorphic Rocks.* Because of the almost total absence of fossils, most estimates of the age of the rocks must be based on lithologic comparison with formations of known age.

The cast of a single fossil found as float suggested a Triassic age for the schists of Chariot Canyon (Hudson,

PHOTO 3. Northeastern slope of Banner Canyon. Volcan Mountain to the right. Northwest strike of Julian schist is indicated by slight color banding on slope. Edge of schist belt passes just to right of small hill in center. *Photo by R. M. Stewart.*

1922, p. 190). This correlates well with age determinations made on metasedimentary rocks in the Santa Ana Mountains (Larsen 1948, p. 18). However, fossiliferous Mississippian rocks near Winchester (Elsinore quadrangle) are interbedded with rocks lithologically similar to some of the schists of the Santa Ysabel quadrangle. Although more than one age may be represented, the writer feels that the bulk of the metamorphic rocks here are approximately equivalent to the Bedford Canyon formation described by Larsen (1948, p. 16), which is Triassic.

### Stonewall Quartz Diorite

Intrusive rocks of intermediate composition which are older than the gabbro and younger than the schist have been noted and classified in various ways by earlier workers in the general region. Hudson (1922, p. 191) first described the Stonewall quartz diorite, classified it as quartz diorite, and named it for the type locality of Stonewall Peak in the Cuyamaca quadrangle.

Donnelly (1934, p. 340) preferred the term "granodiorite" but recognized a considerable range in composition, whereas the present writer used the term "Stonewall formation" to include both granodiorite and quartz diorite (Merriam 1946, p. 230). Everhart (1951, p. 61) states that most of the formation in the Cuyamaca Peak quadrangle is granodiorite, including the type locality. In the Santa Ysabel quadrangle, there is undoubtedly a variety of rock types in the formation as it was mapped. It may be that more than one instrusion is represented, or that assimilation has locally changed the composition. The term "Stonewall quartz diorite"* which seems adequate for the Santa Ysabel quadrangle, will be used in this report for the relatively massive, unadulterated granitoid rocks of this group. Such rocks were mapped separately only in an area of 1 or 2 square miles in the northern end of the quadrangle, although numerous exposures too small to map are widely distributed. The composition of this body may be nearer to that of granodiorite than quartz diorite; however, the widely distributed small unmapped bodies are chiefly quartz diorite, as is the igneous portion of the "mixed rocks," which is considered genetically equivalent to the massive phase.

Most of the Stonewall quartz diorite is medium to coarse grained and light gray where fresh. Dark schlieren are common. Massive and nearly structureless parts show a preferred orientation of mineral grains, especially of the dark components. The texture is phanerocrystalline, hypautomorphic granular. In most samples, highly strained quartz makes up 40 percent by volume. Plagioclase ($An_{25}$ to $An_{40}$) comprises more than 50 percent of most of the rock. Microcline is seen in some sections but is rare. Biotite may show a slight parallel orientation. Hornblende is generally present and locally exceeds the biotite in amount. Primary epidote, sphene, and zircon are accessory minerals.

### Mixed Rocks

Much of the Stonewall quartz diorite is so intimately mixed with schist that it was not feasible to separate the two in the mapping. This "mixed rock" unit, then,

PHOTO 4. Mixed rocks at contact of Julian schist and Stonewall quartz diorite at north end of Santa Ysabel Valley.

is a complex consisting of migmatites, schist bodies ranging from schlieren to streaks a few tens of feet long, and small lenses or irregular bodies of relatively uncontaminated quartz diorite. Mixing appears to have been principally mechanical, the igneous material having been emplaced along planes of schistosity or having completely engulfed small schist bodies which generally retain distinct form and mineral composition.

Contacts of the mixed rocks against members of the Cretaceous batholith are generally sharp, whereas those with schist or Stonewall quartz diorite are gradational so that their positions as shown on the geologic map are somewhat arbitrary. Gneissose phases of the Lakeview and Bonsall tonalites locally resemble the mixed rocks, making contacts difficult to discern.

Outcrops of mixed rocks are prominent and well exposed; areas of several tens—or even of a few hundreds of feet—covered by very sparse vegetation or overburden are common. Such exposures exhibit prominent gneissose foliation produced by alignment of biotite and hornblende and by banded distribution of light and dark minerals. Parallel to subparallel or braided vertical joints more or less concordant with the ever-present gneissose structure are common. The general attitudes of this structure are shown on the structure map where they may be seen to roughly parallel the principal structural features of the region. They are everywhere parallel to the schist structures but in many places are crosscut by batholithic intrusions. Although steep dips are the rule, some are rather low.

The average hand specimen is a coarse- to medium-grained aggregate of quartz, plagioclase, biotite, and hornblende. Fresh specimens are medium to light gray, but weathering causes the rock to become light reddish brown.

In addition to the megascopic gneissoid structure, a textural parallelism is revealed under the microscope. The texture is the result of the bending of biotite flakes, and the crushing and recrystallization of quartz and feldspars. In most sections, plagioclase ($An_{25}$ to $An_{45}$)

* "Quartz diorite" is used here instead of "tonalite" because of previous use in the literature.

is the most abundant mineral, amounting to 60 percent by volume. Potash feldspars are rare. Quartz, one of the chief minerals, appears as highly strained, nearly granulated crystals with sutured boundaries. Biotite is the principal ferro-magnesian mineral. Green hornblende is less common and is not present in some specimens. Apatite, sphene, and zircon are the usual accessories.

### San Marcos Gabbro

A considerable variety of related rocks in this range has been mapped together. This grouping is believed to be justified on the basis of similarities in outcrops and local structural features, similar relations to batholithic and pre-batholithic rocks, and systematic mineralogical and chemical variations.

Gabbro outcrops range from angular blocks to small boulders of disintegration. Deep weathering locally has produced friable gruss, and outcrops are poor. Areas underlain by gabbro are covered by heavy red-clay soil which supports a dense growth of brush.

Rocks in the San Luis Rey, Elsinore, and Corona quadrangles, which are unquestionably correlatives, have been called San Marcos gabbro by Miller (1937) and Larsen (1948, pp. 41-53). However the terms Cuyamaca gabbro and Cuyamaca basic intrusive have been used in the Julian area and the Cuyamaca Peak quadrangle (Creasey 1946; Everhart 1951, pp. 66-74; Hudson 1922, pp. 175-252). In this report all rocks of this type will be referred to as San Marcos gabbro.

Gabbro and related rocks are distributed in small patches throughout the southwestern half of the quadrangle. None is known east of the Elsinore fault. This limitation, however, does not hold for the San Luis Rey, Elsinore, and Corona quadrangles. Exposures of gabbro cover about 5 percent of the Santa Ysabel quadrangle.

The variability of this formation has been noted by geologists, but only Creasey mapped separate units. The chief types distinguished in the present study are olivine gabbro, hornblende gabbro, and norite. Small quantities of pyroxenite, peridotite, and quartz-hornblende gabbro are present.

The olivine gabbro is a dark gray, medium to fine-grained equigranular rock. The texture is generally mosaic, because of the equant development of most of the minerals. Fresh plagioclase ($An_{90}$ to $An_{95}$) makes up 50 to 65 percent of the rock. Its polygonal grains have broad twinning lamellae and are free from zoning. Olivine, which is approximately 25 percent $Fe_2SiO_4$, makes up as much as 15 percent of the average rock. It occurs in irregular rounded grains, many of which are surrounded by reaction rims of pale hypersthene. Hornblende, which is always less than 5 percent of the rock, may form large poikilitic crystals, some containing vermicular spinel. Pale green augite may form up to 15 percent of the rock.

Through an increase in olivine and decrease in other ferro-magnesian minerals troctolite may result. Hypersthene is locally abundant enough to form an olivine norite phase. The substitution of hypersthene for olivine may be so extensive as to produce eucrite.

The hornblende gabbro is generally more coarse-grained than the olivine types, and ranges in color from dark gray to greenish gray. Plagioclase constitutes at least half of the average rock. It ranges from $An_{45}$ to $An_{80}$ and may show normal zoning. Some of the larger crystals have cores of $An_{90}$. Hornblende, ranging widely in amount, may be a pale- to deep-green variety formed as reaction rims around olivine, hypersthene or augite, or green-brown poikilitic crystals up to 5 or 6 cm long which appear to have crystallized directly at a late magmatic stage. Pale green uralitic hornblende is also present.

Limited portions of the hornblende gabbro exhibit distinct bands consisting of dark and light parallel streaks which in most cases bend in broad sweeping curves. Individual dark bands average 1 to 2 cm in width and may divide and rejoin or coalesce with other bands to produce a braided appearance. However, uniform parallel banding is equally common. The dark bands are generally two or three times as wide as the light bands and contain large amounts of hornblende, while the light bands consist almost entirely of plagioclase. Contacts between bands are gradational; mineral grains interlock across the boundary and there is no great difference in texture. The bulk mineral composition is not different from that of the average massive hornblende gabbro. The distribution of the structure bears no relation to contacts.

Auto-injection structure such as that described by Miller (1938) was observed only at the north end of Santa Ysabel Valley. These rocks are composed of two distinct phases, one medium to fine grained not unlike the usual hornblende gabbro, the other coarse grained, nearly pegmatitic. The latter penetrates the former in highly irregular forms, with crystals interlocking across boundaries. The chief difference between the two phases is textural, although more hornblende may occur in the coarse part. The proportions of the phases vary; in places the finer is very subordinate and forms irregular angular patches within the interstitial coarse portion. In other places vein-like structures of the coarse gabbro penetrate the finer gabbro; the coarse injections are 1 to 10 cm wide and carry hornblende crystals as long as 5 cm. Miarolitic cavities contain plagioclase crystals 1 to 2 cm long.

### Green Valley Tonalite

The Green Valley tonalite is limited to two small masses at the west edge of the area, although it is a widespread rock unit farther to the west and south, as mapped by Larsen and Everhart; there it locally grades into the gabbro. In the Santa Ysabel area its contacts are not gradational, although the Lakeview Mountain tonalite carries numerous Green Valley tonalite inclusions near the contact between the two formations. No other contacts are exposed, but relations elsewhere show the Green Valley tonalite to be younger than the San Marcos gabbro and older than the Bonsall tonalite.

The typical specimen is a uniform, medium-grained plutonic rock ranging from light to dark gray. It is notably massive and structureless in the area studied. The only textural and mineralogic peculiarity is the large poikilitic biotite grains with sieve structures and continuous cleavage surfaces 1 to 2 cm long that are prominent on fresh fractures.

In thin section the rock is characterized by abundant partly replaced grains. These include augite replaced by hornblende, and calcic plagioclase replaced by more

PHOTO 5. Green Valley tonalite overlain by mixed rocks near Ballena Valley. *Photo by R. M. Stewart.*

sodic plagioclase. The abundance of poikilitic hornblende and biotite grains is evidence of late readjustments.

About half of the rock is plagioclase ($An_{40}$ to $An_{50}$) which is slightly or not at all zoned. In addition to the unzoned plagioclases there are numerous crystals with one or two calcic ($An_{55}$ to $An_{90}$) zones, or with cores of that composition. Quartz, in anhedral grains with sharp extinction, averages from 10 to 20 percent of the tonalite. Hornblende makes up approximately 10 percent of most sections. It forms separate individuals of uniform composition, or is found as reaction zones around augite. There is rarely more than 1 to 3 percent augite. Hypersthene, which is limited to the darker phases of the rock and never exceeds 5 percent, may be partly replaced by hornblende. Biotite is the most plentiful ferromagnesian mineral, making up as much as 15 percent of most specimens. Large poikilitic flakes are the most common form. Zircon, sphene, apatite, and magnetite are abundant accessory minerals.

### Lakeview Mountain Tonalite

The Lakeview Mountain tonalite is found in an extensive, continuous area in the north-central part of the quadrangle and in one body on the western edge. Although none has been reported to the south or east it is fairly common to the west and northwest. It appears to be younger than the Green Valley tonalite, and Larsen (1948, p. 58) found it to be older than the Bonsall tonalite. In the area here described, its contacts with rocks other than the Green Valley tonalite are poorly exposed, hence no definite age determination could be made.

The texture of the Lakeview Mountain tonalite is phanerocrystalline, hypautomorphic granular with average grain sizes of 2 to 5 mm. The tonalite is distinguished by its very white feldspars and clean-cut ferromagnesian minerals which are commonly euhedral. The amount of hornblende usually equals or exceeds that of biotite; in this respect the Lakeview Mountain tonalite differs from the other tonalites. Plagioclase is the most abundant mineral and makes up at least half of the rock. It ranges from $An_{38}$ to $An_{45}$. Orthoclase appears in nearly all sections but seldom exceeds 5 percent. Quartz, with minute, randomly oriented inclusions makes up about one fourth of the rock. Hornblende is mostly automorphic in the prism zone and averages 10 percent of the rock. Biotite occurs as large, sometimes pseudo-hexagonal plates. Epidote, formed by saussuritization, but also appearing as a primary mineral, is widespread and composes up to 2 or 3 percent of the rock. Sphene, apatite, and zircon are the usual accessories.

Residual boulders of disintegration characterize the Lakeview Mountain tonalite terrain. Such boulders range

PHOTO 6. Residual boulders produced by weathering of Lakeview Mountain tonalite. Exposure along Highway 79 east of Lake Henshaw. *Photo by R. M. Stewart.*

up to a few tens of feet in diameter and are surrounded by large quantities of gruss. Structures are not prominent in the Lakeview Mountain tonalite except along some contacts where a gneissose appearance results from streaking of dark inclusions. Joint systems are locally distinct, as in the area west of Ballena.

#### Bonsall Tonalite

The Bonsall tonalite was named by Hurlbut (1935), who described its occurrence in the San Luis Rey quadrangle. The Perris quartz diorite and Val Verde tonalite are considered equivalent to the Bonsall, which is probably the most extensive rock of the Peninsular Ranges; however, exposures cover less than 5 percent of the Santa Ysabel quadrangle. The dominant rock type is medium-grained and light gray; in places it is massive but commonly it exhibits marked banding as the result of parallel orientation of minerals and the streaking of dark inclusions. This banding is not as apparent within the Santa Ysabel quadrangle as in most other areas. A nearly massive, leucocratic tonalite with somewhat finer grain is grouped with the typical Bonsall tonalite.

Zoned plagioclase constitutes at least 50 percent of the rock. Rarely this plagioclase ranges up to 65 percent of the rock, and the quartz decreases in proportion. The range in composition is from $An_{36}$ in the leucocratic type to $An_{50}$ in the melanocratic types. Oscillatory zoning is nearly universal, and very calcic cores are common. Orthoclase is widespread. Myrmekitic intergrowths replace parts of some grains of this mineral. Hornblende makes up approximately 10 percent of the normal rock but is rare or lacking in the leucocratic variety. Biotite is always present, making up as much as 15 percent of the rock. About 20 to 25 percent of most specimens consists of anhedral grains of quartz with sharp to slightly undulatory extinction. Pyroxene is notably rare except in melanocratic phases where its presence probably indicates assimilation of gabbroic material. Sphene is the most abundant accessory; and some crystals are as large as 3 to 4 mm; the mineral is not, however, universally present. Apatite and zircon are more widespread accessories.

#### Emplacement of Batholithic Rocks

Inasmuch as this study covers but a small part of the batholith, the conclusions stated below should be considered tentative and not necessarily generally applicable to the entire batholith.

Emplacement of the gabbro in the Julian-Cuyamaca region may possibly have been by forceful injection, as indicated by the manner in which the schist wraps around the gabbro. Other features, however, are not compatible with such a process: the gabbro is unusually massive, even at contacts, and schistosity of the metamorphic rocks is no more prominent at contacts. Furthermore, gabbro bodies in other parts of the quadrangle appear to crosscut schistosity. Emplacement by assimilation is improbable in view of the lack of contamination. Although there are variations in composition, they are not systematically related to contacts or to type of country rock. The high density of the gabbro as compared with that of the older rocks, and the absence of stoped blocks are factors against the hypothesis of stoping.

The two small areas of Green Valley tonalite may have been emplaced by forcing aside the pre-batholithic complex, as the western area is part of a nearly circular, boss-like intrusion with concentric schist bodies.

It has been suggested (Merriam 1940, p. 368) that the Lakeview Mountain tonalite, on the boundary between the Santa Ysabel and Ramona quadrangles, was emplaced by ring fracture stoping. However, this process could not have occurred in the case of the large irregular mass southeast of Lake Henshaw. There the crosscutting, somewhat blocky outline of the intrusion suggests piecemeal stoping, although inclusions that might be stoped blocks are rare. The very uniform composition, the absence of non-igneous minerals, and the sharp contacts rule out the possibility of emplacement by any process related to assimilation.

The Bonsall tonalite is characterized by abundant inclusions that are generally streaked parallel to and more numerous near contacts with older rocks. Thus some, and possibly most, of the space for injection of this tonalite was gained by stoping. The manner in which older structures are truncated by the Bonsall tonalite rules out emplacement by distension of wall rock.

To summarize: evidence for emplacement by forceful injection is generally lacking, although locally this process may have furnished some space. Processes such as melting or replacement were probably not active, considering the sharpness of contacts and lack of mineralogical and chemical correspondence between wall rock and intrusive. Stoping was probably effective in emplacing some of the tonalites.

#### Quaternary Sediments

Continental sediments composed of gravel, sand, and silt, older than the alluvium of the present valleys, form irregular remnants surrounding the basin occupied by Lake Henshaw in the northern part of the quadrangle. Such deposits are also widespread to the northwest in the Temecula area; there they have been termed the Pauba formation (Mann, 1955). The name Pauba formation is not used here, for, although the fanglomerates are similar in most respects, there is no way of correlating ages; in fact evidence indicating the age of the Santa Ysabel sediments is exceedingly indirect and indefinite.

Within the Santa Ysabel quadrangle the fanglomerates have been considerably dissected, and presumably have been removed from large areas. Where the base of the formation is exposed the sediments appear to lie directly on a moderately irregular surface of batholithic rocks. No accurate determination of thickness could be made, but continuous exposures ranging in vertical thickness from 50 to 100 feet are common. It is likely that much greater thicknesses are present nearer the center of the Lake Henshaw basin, but this portion is outside the Santa Ysabel quadrangle.

Lithology of the formation is that of typical alluvial fans derived from crystalline rocks of granitic or intermediate composition. The principal rocks present are granodiorite, tonalite, aplite, pegmatite, quartzite, and gneiss. The finer grades consist of fragments of relatively fresh plagioclase, orthoclase, microcline, biotite, hornblende, and quartz. The feldspars may be exception-

PHOTO 7. Low hills in middle distance are composed of Pleistocene (?) arkose fanglomerate. Exposures on Warner Ranch along Buena Vista Creek. *Photo by R. M. Stewart.*

ally abundant locally, especially in sections adjacent to bodies of Lakeview Mountain tonalite, where the sediment has nearly the same composition as the tonalite. The term arkose would be applicable to this part of the formation (Temecula arkose).

Particle sizes range up to 2 feet, although the bulk of the fanglomerate is made up of cobbles and pebbles with sands and silt interstitial or in lenses. The larger clasts are moderately well rounded and become more abundant in an eastward direction.

Stratification is generally indistinct or absent but cross lamination, cut-and-fill structure, and similar features are prominent.

The source of the fanglomerate was no doubt the adjacent highlands of igneous and metamorphic complex lying to the east and northeast. The conditions prevailing at the time of deposition differed from those of today, for removal and deposition apparently were more rapid because of greater relief, greater precipitation, or both.

As to age, the fanglomerate can only be said to be post-Cretaceous and pre-Recent alluvium. However, if it is equivalent to the Pauba formation, it is Pleistocene (Mann, 1955).

## STRUCTURE

The major structural features within Santa Ysabel quadrangle are the northwest-trending faults; minor features are the joint systems, schistosity, and gneissic structure.

PHOTO 8. Pleistocene (?) arkose exposed in road cut northeast of Lake Henshaw.

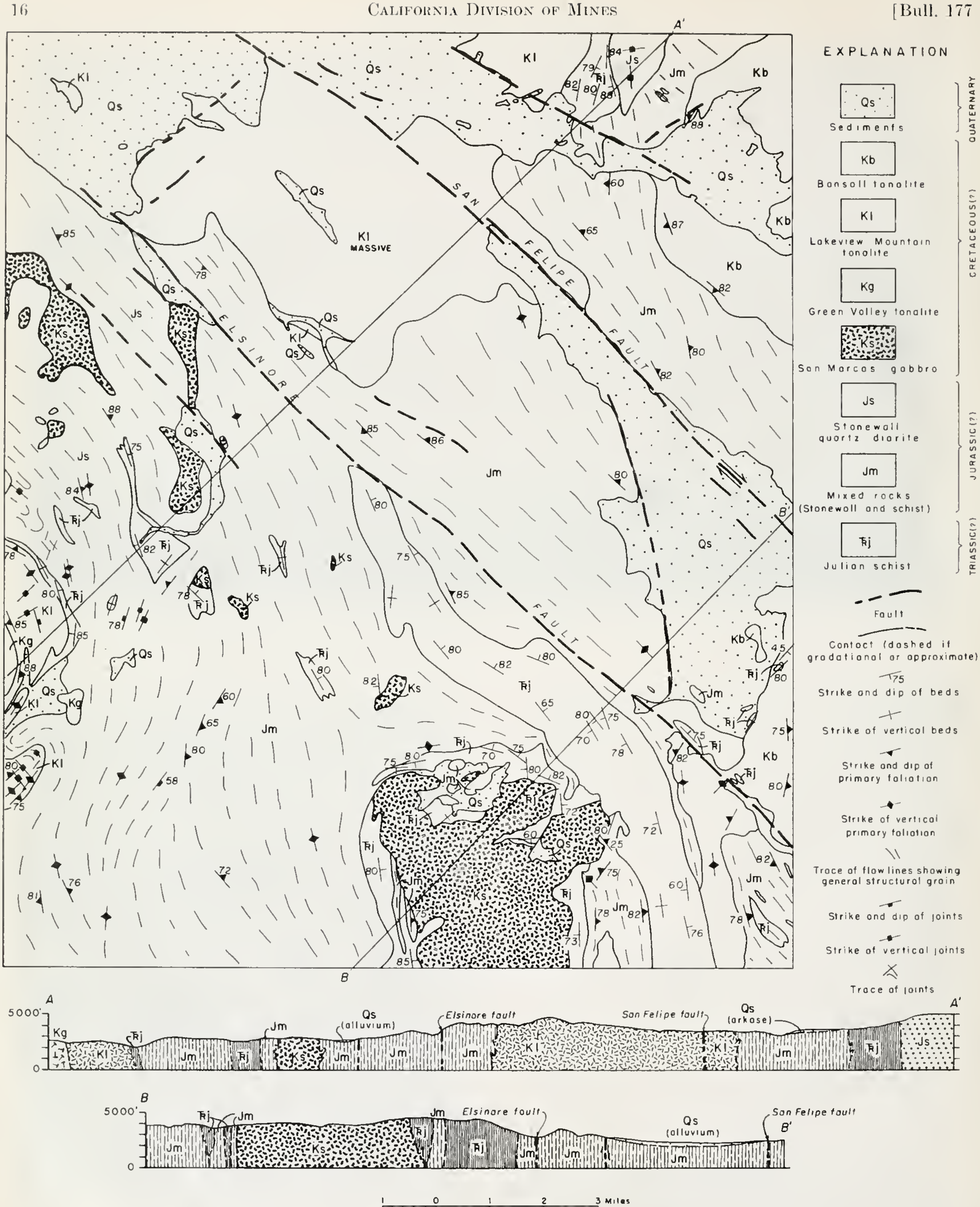


FIGURE 2. Structure map and sections, Santa Ysabel quadrangle.

PHOTO 9. Trace of the Elsinore fault zone follows foot of mountain along south shore of Lake Henshaw. Palomar Mountains in range at far right. Carrizo Creek flows down valley (also along fault zone) in left foreground. San Luis Rey River flows westward from Lake Henshaw through gap in center background. *Photo by R. M. Stewart.*

### Julian Schist

In the Julian schist, attitude of schistosity—also generally that of the bedding—is the most obvious structure in the field. The dips are for the most part essentially vertical and the strikes are commonly parallel to contacts and to long dimensions of the schist bodies. The bulk of the formation follows the regional northwest strike, although exceptions to this are common, particularly in the south part of the area where the schist wraps around a large gabbro body.

### Igneous Rock Structures

No attempt was made to map in detail all of the various primary igneous structures. However, even a sketchy consideration of some of the more obvious elements is enlightening. Several igneous formations exhibit distinct schlieren, streaked inclusions, and segregations. Where these are absent the rocks often show a parallelism of tabular or flaky minerals. Locally, joint systems are prominent enough to be easily mapped and included in the structural picture.

*Stonewall Quartz Diorite.* The Stonewall quartz diorite exhibits quite distinct structures, chiefly the platy arrangement of schlieren or inclusions of schist. The latter are widespread and range from hand-specimen size to streaks large enough to map. Locally the rocks are gneissose to schistose. There is considerably more detail than can be shown on the accompanying map. Attitudes rarely can be determined accurately, but near-vertical dips are the rule. Strikes parallel those of the schist but may be crossed by batholithic rocks.

*Lakeview Mountain Tonalite.* The Lakeview Mountain tonalite is massive over wide areas but shows a distinct systematic structure in the small area west of Ballena. Here streaked dark inclusions parallel nearly all contacts. Platy inclusions are essentially vertical. Vertical joint planes are both parallel to and normal to some contacts.

*Bonsall Tonalite.* Characteristically the Bonsall tonalite contains abundant inclusions most of which are streaked or platy parallel to contacts with older rocks. In the Santa Ysabel quadrangle, inclusions are not so abundant, although some idea of the structure can be gotten from them.

All other igneous rocks in the area are massive or possess only local or unsystematic structures.

### Faults

The evidence for faulting is largely indirect in Santa Ysabel quadrangle, because displacement in the batholithic rocks is difficult or impossible to detect. Furthermore, the strikes of most of the schist bodies more or less parallel the faults. The massive, poorly bedded nature of the younger sediments renders them useless in measuring displacements. Crushed zones are rarely exposed in any of the rocks. However, fairly good evidence for faulting lies in the extensive alignment of springs and straight streaks having a shallow water table. Such streaks, although in arid and semiarid climate, support rows of oaks, willows and swamp grasslands. Physiographic evidence is plentiful, but other structures such as joints and schistosity may account for many of the same features.

*Elsinore Fault Zone.* The Elsinore fault zone can be traced almost continuously to the type locality near Elsinore. In the Santa Ysabel quandrangle, it is marked by springs along the south side of Lake Henshaw and beyond the Volcan Indian School. In Banner Canyon, a row of small offset spurs marks its position. The term zone is believed to be appropriate, for the fault exhibits a braided plan with several mappable subparallel branches. The type of displacement is not readily apparent. There is a high scarp on the southwest side of Lake Henshaw, whereas Volcan Mountain stands high on the northeast side of the zone. This could result from dif-

PHOTO 10. Trace of Elsinore fault zone down Banner Canyon into Rodriguez Canyon. Granite Mountain in far center. Offset spurs in left center. *Photo by R. M. Stewart.*

ferential movement of several blocks separated from one another by faults transverse to the Elsinore fault zone. Another explanation could be movement with a large horizontal component.

*San Felipe Fault Zone.* The San Felipe structure lies along the east side of San Felipe Valley and probably has been an important factor in the formation of the valley. Near San Felipe it resembles the Elsinore fault zone in its braided nature, but elsewhere it appears to be a simple fault. Offset streams indicate right lateral movement for this fault, although the amount of movement is not determinable. Pleistocene sediments in San Jose Valley have been cut and the water table raised on the upper side, as evidenced by springs along the fault outcrop. San Felipe fault can be traced southeastward into the Borrego and Cuyapaipe quadrangles, and northwestward through the San Jose Valley.

*Miscellaneous Faults.* The west side of San Felipe Valley is probably bounded by a fault, although evidence is largely physiographic. Aligned springs mark its southern end near Banner. This may be considered a branch of the San Felipe fault, but its movement appears to be more vertical than horizontal.

Physiographic features suggest that a northeastward-striking fault may bound the northwest end of Volcan Mountain, where it joins San Jose Valley and Lake Henshaw.

Several short faults parallel to the regional structures were mapped. They may be branches of the two major fault zones. One bounds the north end of Santa Ysabel Valley and continues northwestward to Mesa Grande. Others lie in the Volcan Mountain region.

## PHYSIOGRAPHY

That the Peninsular Ranges present several physiographic problems has been recognized by nearly all who have worked there. Completely satisfactory solutions to these problems have not been published. Most of the work has been of reconnaissance type over large areas; or, if detailed, it has covered too small a portion of the whole area. The present study falls in the latter category, and although features representative of most of the problems are found in the Santa Ysabel quadrangle, a wider investigation is needed to obtain satisfactory solutions to several problems. Consequently, the following discussion is intended merely to point out the general elements, together with any details exhibited in Santa Ysabel quadrangle which pertain to the problems.

The major topographic features of Santa Ysabel quadrangle are largely determined by structure. The principal mountain masses and intervening valleys are the products of faulting. San Felipe Valley, San Jose Valley, and probably Montezuma and Santa Ysabel Valleys are structural, graben-like features.

Smaller topographic features are related to jointing, schistosity, contacts, and minor faults.

Structural controls are so strong as to obscure other influences. For example, differential resistance, while important in some parts of the batholith, is of distinctly secondary importance in this region. In general, gabbro is noticeably more resistant and forms peaks, whereas schist (unless it is a thick-bedded, quartzose type), Green Valley tonalite, and Lakeview Mountain tonalite are less resistant. The massive Stonewall quartz diorite is moderately resistant.

Drainage patterns are typically dendritic in massive rocks such as the tonalites, gabbro, and much of the Stonewall quartz diorite. However, the principal lines of drainage—such as Carrista Creek, Carrizo Creek, Banner Canyon, Rodriguez Canyon and probably Matagual Valley and Chariot Canyon—have patterns related to faults, or lines of probable faulting. Although Buena Vista and San Ysidro Creeks lie in a strongly faulted section, they traverse easily eroded fanglomerate, and so have developed simple dendritic patterns.

Numerous other streams have prominent straight stretches in their patterns. This may result from faulting in some instances, to straight joints or schistosity in others. Jointing and schistosity are the dominant controls in the San Diego River, Dye Canyon, and smaller streams in this vicinity.

Santa Ysabel Creek is apparently an exception to the rule of structural control. Although a short section of one branch follows the Elsinore fault, and the west end follows a contact, the creek meanders across the Elsinore fault and other prominent structures. It is one of the largest through-going streams and probably was able to maintain its course regardless of faulting.

Throughout the quadrangle are scattered areas of relatively low relief composed of rolling hills and sluggish drainage. These include the central portion of the Santa Ysabel Indian Reservation on Volcan Mountain, the section traversed by the road to Mesa Grande on the west edge of the quadrangle, Spencer Valley, and several smaller unnamed valleys. These correspond more or less to Everhart's (1951, p. 103) "meadows" and originated in various ways. Some may be situated in easily weathered and eroded rock surrounded by more resistant rock types. Others may represent remnants of an old erosion surface. Although there may be little or no correspondence in elevations, this can be explained by faulting.

All the major drainage lines are characterized by numerous deviations from the ideal concave upward profile. Nick points, although present, are less common in Santa Ysabel quadrangle than elsewhere in the Peninsular Ranges, because of the lack of contrast in resistance of the formations.

Some of the outstanding irregularities in long profiles have resulted from faulting. Thus Santa Ysabel Creek and several unnamed streams begin with relatively low gradients in the Volcan area but soon plunge down the steep Elsinore fault scarps to the west, then resume low gradients as they traverse the lowlands.

## GROUNDWATER

Groundwater is one of the most important natural resources of Santa Ysabel quadrangle, and the present trend is toward even greater importance. Groundwater resources of parts of the quadrangle have already been described by Ellis and Lee (1919).

*San Jose Valley (Lake Henshaw).* San Jose Valley has an area of about 32 square miles, much of which lies within the Santa Ysabel quadrangle. It is roughly rectangular in plan and is bounded on all sides by granitic mountains. Depending upon the precipitation of the current year and other factors, as much as half of the basin is covered with waters of the artificial Lake Henshaw. The exposed portion is underlain by Recent alluvium and Pleistocene gravels to a depth of 200 feet or more. These sediments have slight basinward dips, especially those in the northeastern sector. Because much of the drainage lies in this portion, the conditions are favorable for recharging the underground reservoir of the valley. The water table has always been shallow, generally 10 feet or less. Numerous northwest-striking

PHOTO 11. Elsinore fault zone in Banner and Rodriguez Canyons as seen from Julian Ridge. Ranchito mine is in flat of Rodriguez Canyon below Granite Mountain at right. San Felipe Valley extends northward in left center. *Photo by R. M. Stewart.*

faults have brought the water table to the surface in many places. Warner's Hot Springs was produced in this way.

In 1951 the owners of Lake Henshaw drilled a number of wells in the upper part of the basin; the water was pumped into the lake to augment the accumulation from surface runoff.

San Ysidro and Buena Vista Creeks are tributaries to the main San Jose Valley. Groundwater from San Ysidro Mountain and Montezuma Valley passes down this drainage and is locally brought to the surface by faulting. There is every indication that fairly productive water wells could be drilled in this area.

*Montezuma Valley.* Montezuma Valley is underlain by a thin layer of alluvium covering an irregular bedrock surface. It is bounded on the north by the San Ysidro Mountains which, rising 2,000 feet above the valley, make the only important contribution to the groundwater of the valley. Due to the bedrock configuration, characterized by the trough of San Ysidro Creek along the north side of the valley, the runoff from San Ysidro Mountains does not reach most of the valley in appreciable quantities. Inflow to the water table is very meager except in the northern part of the valley.

Faults, which are probably the continuation of those producing the springs at Warners and vicinity, pass through Montezuma Valley bringing water to the surface at a few places. Several springs along the foot of San Ysidro Mountain probably result from faulting.

Bedrock in Montezuma Valley is probably largely Bonsall tonalite which is a favorable formation for the drilling of laterals. Such wells are most likely to be successful.

*Santa Ysabel.** Appreciable quantities of groundwater are limited in Santa Ysabel valley to the area adjacent to Santa Ysabel Creek. There the alluvium may be as much as 100 feet in thickness. The flow of surface water, which fluctuates widely, is the chief factor governing the yield from this alluvium. Elsewhere in the valley bedrock is shallow, its cover is largely relatively impervious residual material, and conditions are generally unfavorable for productive wells. A minor fault along the north end of the valley produces a row of small springs.

*San Felipe Valley.* San Felipe Valley has an area of approximately 20 square miles. It appears to have been formed structurally as a roughly triangular graben bounded on the east by the San Felipe fault. The high area to the west and southwest, that is, Volcan Mountain, Julian, and Julian Ridge, constitutes the chief source of surface and subsurface water for the valley. Banner Creek, entering from the southwest, varies in volume but is perennial and seldom flows less than one second-foot. San Felipe Creek, flowing southward from the north end of the valley, is intermittent. Extensive alluvial fans, dipping steeply in their upper portions, emerge from canyons on Volcan Mountain. As the annual precipitation in these mountains averages more than 30 inches, this is an ideal situation for recharging the groundwater reservoir.

The water table is shallow throughout most of the valley. This has been noted in the few small wells and is also indicated by vegetation such as willows, cottonwoods, and swampy grasslands.

## GEOLOGIC HISTORY

The earliest event recorded in the geologic history of Santa Ysabel quadrangle is the deposition during the Triassic (?) of a series of sediments, principally terrigenous, but containing some volcanics, which are now represented by the metamorphic rocks. The sediments were metamorphosed and complexly intruded by the Stonewall quartz diorite and related rocks. The date of this intrusion is tentatively placed in the Jurassic. The whole complex was then subjected to a period of regional metamorphism of intensity approximately equivalent to that of the mesozone.

In the Upper Cretaceous, batholithic rocks were emplaced: first gabbro, then Green Valley tonalite, Lakeview Mountain tonalite, and Bonsall tonalite, in that order. In some portions of the Peninsular Ranges outside the Santa Ysabel quadrangle, batholithic invasion continued, emplacing several granodiorites and quartz monzonites.

Although the geologic record from Cretaceous to Pleistocene is missing in Santa Ysabel quadrangle, sediments in the nearby Ramona and El Cajon quadrangles indicate almost complete deroofing of the batholith by upper Eocene time.

Coarse Oligocene (?) breccias in the adjacent Borrego quadrangle suggest that the Santa Ysabel area was elevated at that time.

During the Pleistocene (?), fanglomerates accumulated in parts of the Peninsular Ranges, the particular position and thickness being controlled by faulting which created basins. Faulting has continued to the present and has been the dominant factor in producing the existing topography. This was accomplished directly by the relative elevating of some sections and depressing of others, and indirectly by the dissection made possible by rejuvenation of streams.

* No name indicated on topographic map; this is the valley occupied by Santa Ysabel Creek and the town of Santa Ysabel.

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

BULLETIN 177, PLATE 1-A


## LEGEND

QUATERNARY

*Recent*

Qal — Alluvium

Ql — Lake beds

*Pleistocene*

Qt — Temecula arkose

CRETACEOUS

Kb — Bonsall tonalite

Kl — Lakeview Mt. tonalite

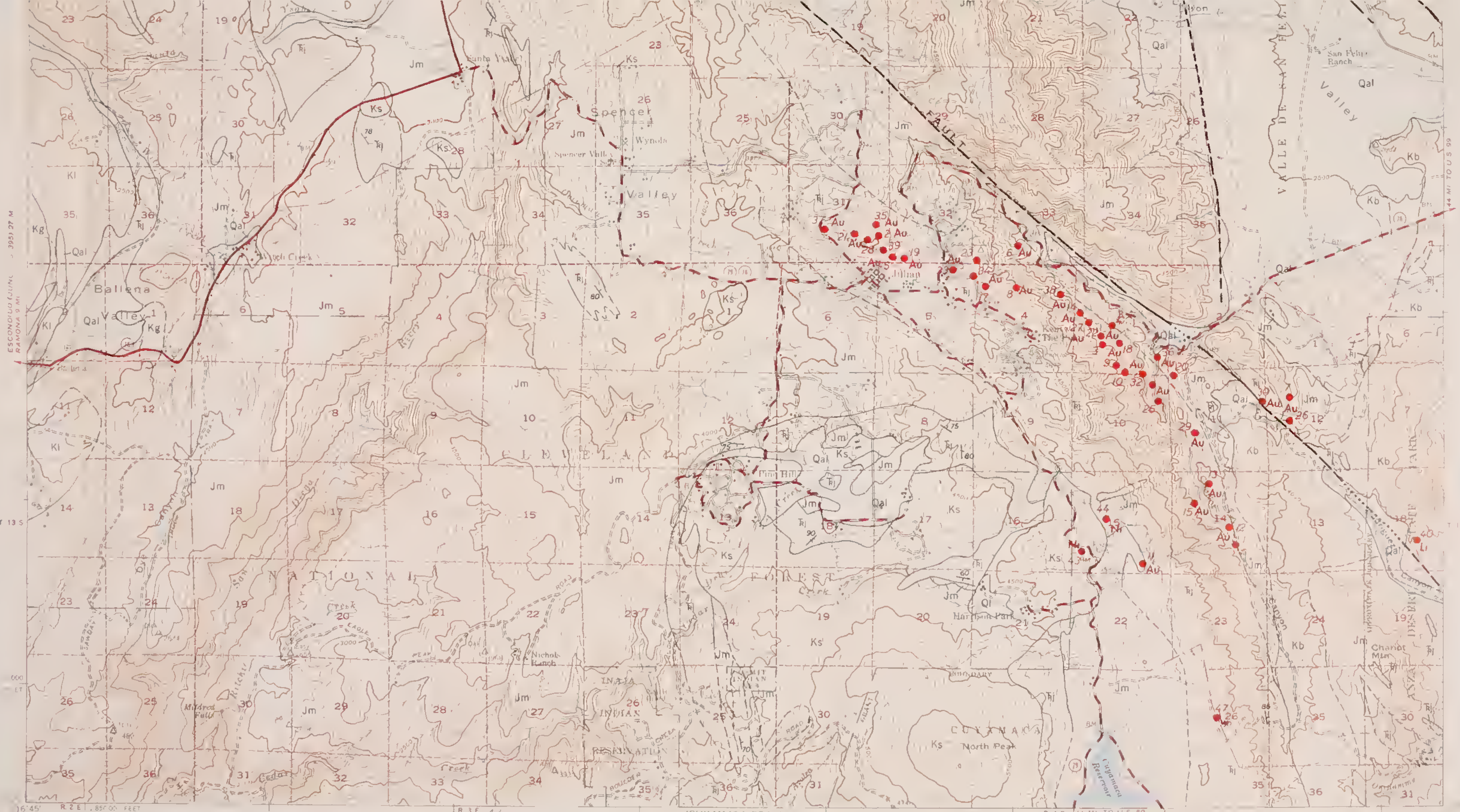
Kg — Green Valley tonalite

Ks — San Marcos gabbro

JURASSIC (?)

Js — Stonewall quartz diorite

Jm — Mixed rocks
*(Quartz diorite and schist)*




Jm

Mixed rocks
*(Quartz diorite and schist)*

JURASSIC

Ŧi

Julian schist

m

Marble

TRIASSIC (?)

Contact
*Dashed where approximate*

Fault
*Dashed where approximate, dotted where concealed*

Probable fault

Strike and dip of foliation and bedding

32 Au

MINE LOCATIONS

Au – Gold  Li – Lithium  m – Marble  Ni – Nickel
W – Tungsten  w – Wollastonite

NUMBERS REFER TO TABULATED LIST. MINE LOCATIONS COMPILED AND FIELD CHECKED BY DIVISION OF MINES 1957

Mapped by the Army Map Service
Published for civil use by the Geological Survey

Control by USGS, USC&GS, Glover, and USCE

Topography from aerial photographs by multiplex methods
Aerial photographs taken 1939

Polyconic projection  1927 North American datum
10,000-foot grid based on California coordinate system, zone 6

Dashed land lines indicate approximate locations

No distinction is made between barns, dwellings, commercial and industrial buildings

# ECONOMIC MAP OF THE SANTA YSABEL QUADRANGLE CALIFORNIA

By Richard Merriam

Geology mapped by Richard Merriam
1938-39, 1950-51

SCALE 1:62500

1 ½ 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 .5 0 1 2 3 4 5 KILOMETERS

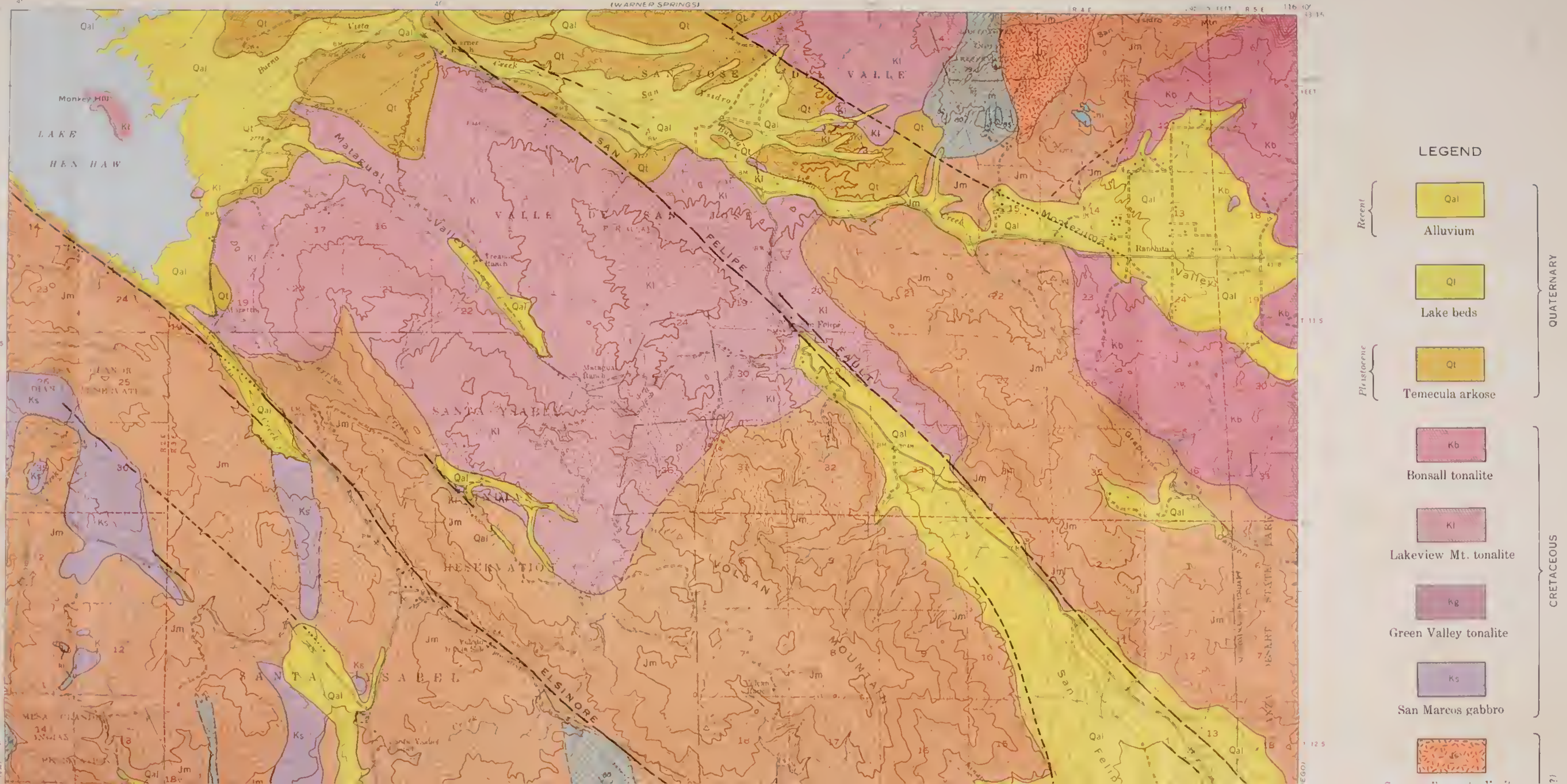
CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL

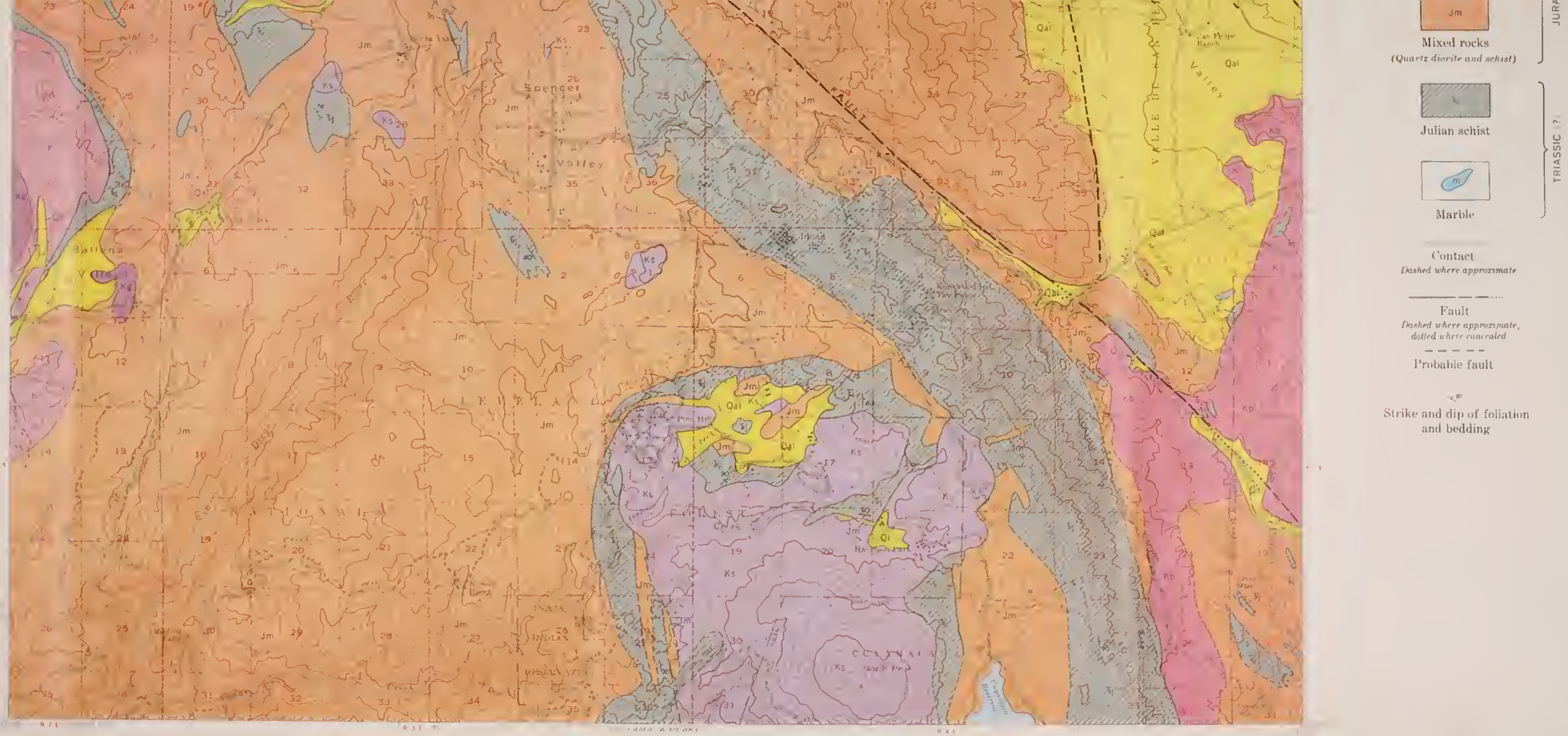
1958

DIVISION OF MINES
OLAF P. JENKINS, CHIEF

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

BULLETIN 177, PLATE 1



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