

EXPLANATION

QUATERNARY

- Qal Alluvium
Arkosic sand and gravel, volcanic debris, and fine-grained clastic and chemical plug sediments.
- Qts Stream terraces
Arkosic stream sands and gravels. Mostly remnants of an older alluvial cover.
- Qtp Pediment terraces
Arkosic sands and gravels; locally cemented with caliche.
- Qp Playa deposits
Duff clay, silt, and arkosic stream sands and gravel. Locally contain saline layers.

UNCONFORMITY

Tqr Ricardo Formation
Reddish to buff, lenticular, calcareous, arkosic conglomerate and sandstone, clay and siltstone. (Members 5, 7, and 8 of Dibblee, 1952)

Tsd Hornblende andesite
Reddish to purple, porphyritic to aphanitic hornblende andesite. Tr = flow, Tst = intrusion

UNCONFORMITY

Tr Rhyolite
Tr - Buff, reddish to pale purple, massive, vesicular, porphyritic rhyolite in flow and welded tuff breccia.
Tr - White to buff, yellow and reddish-purple porphyritic to aphanitic dacite to rhyolite in plug and dike. Locally has glass borders.

Tbd Basalt
Dark gray, porphyritic, xenolithic hornblende augite basalt dikes.

Tsv Sandstone, tuff and basalt flows
Tsv - Red to buff arkosic sandstone and conglomerate; green to white buff, siliceous tuff and tuff breccia; green to pale purple rhyolite tuff breccia.

Tsb Dark gray, hypocrystalline, trachydolitic, porphyritic, xenolithic, hornblende augite basalt flows.

UNCONFORMITY

gr Aplite
Fine to medium-grained, equigranular granite apatite stocks and dikes.

gr Granite
Coarse-grained, rusty equigranular biotite granite.

dd Dacite
Pale gray, porphyritic dacite dikes.

gd Granodiorite
gd - Coarse- to medium-grained, equigranular to porphyritic biotite granodiorite.
gdx - Unfoliated biotite granodiorite and xenoliths of schistose and gneissic rocks.

PRE-MESOZOIC (?)

ms Metasedimentary rocks
Unfoliated metasedimentary rocks. Consists of fine-grained, white to dark gray, thin-bedded limestone, dolomite limestone, and basaltic argillaceous layers; fine-grained, alternately laprot, pale and dark gray quartz-arkosic schist. Green to white, laminated, hornblende-andesite gneiss.

Geology of the Southeast Quarter of the Cross Mountain Quadrangle, Kern County, California

By HOWARD S. SAMSEL**

Introduction: The southeast quarter of the Cross Mountain quadrangle includes an area of about 75 square miles that lies at the southeastern end of the Sierra Nevada, along the northwestern edge of the Mojave Desert. Rocks that crop out in this area range in age from pre-Mesozoic (?) to Recent. They comprise pre-Mesozoic (?) metamorphosed marine sedimentary rocks, Mesozoic plutonic igneous rocks, Tertiary shallow intrusive and volcanic rocks, Tertiary nonmarine sedimentary rocks, and Quaternary nonmarine sediments. Fossils were found by the writer in lower Pliocene sedimentary rocks.

Segments of two major fault systems, the Sierra Nevada frontal fault system and the Garlock fault, cut through the area and both of them form abrupt changes in topography. The southernmost trace of the Sierra Nevada system is truncated by the Garlock fault.

Pre-Mesozoic (?) Rocks. Metasedimentary rocks of marine origin, about 1,400 feet thick, crop out in a narrow belt about a mile long adjacent to the Garlock fault zone one mile west of Cinco. These rocks, the oldest exposed in the area, consist of three apparently conformable units: the lower unit, 600 to 700 feet thick, that consists of fine-grained, gray dolomitic limestone with thin argillaceous layers; a middle unit, about 300 feet thick, that consists of quartz-sericite schist; and an upper unit, 300 feet thick, that consists of hornblende-andesite gneiss. The schist increases in degree of metamorphism progressively to the northwest, and the overlying gneiss grades into granodiorite to the northwest. These rocks occur as peninsulas preserved in granodiorite.

Mesozoic Rocks. Granodiorite, dacite, granite, and granite aplite and vein quartz related to these rocks underlie more than half of the mapped area.

Granodiorite is the oldest of these rocks and has the widest distribution. Locally, it is composed of quartz monzonitic to quartz dioritic facies and in the northwest part of the area contains abundant xenoliths composed of dark schistose and gneissic rocks. Some of the larger xenoliths crop out over areas as large as 100 square feet and all have sharp boundaries.

Coarse-grained biotite granite crops out in the north-central part of the area and in smaller areas farther south. It intrudes granodiorite. Granite aplite (locally in dikes and small stocks and quartz veins intrude granite) and are considered to be genetically related to it.

Abundant northwest-trending dikes of dacite, which are more resistant to weathering than the granodiorite, the only rock in which they occur, crop out mostly in a mile-wide belt about 2 1/2 miles long and centered 2 miles north of Cinco. These dikes, some as much as 60 feet wide and a mile long, have long been noted for their content of large euhedral orthoclase crystals (Murdoch and Webb, 1942, p. 323). The dacite may be Tertiary in age.

Tertiary Rocks. Rocks of Tertiary age include nonmarine sedimentary rocks, shallow intrusive rocks, and several volcanic flows. The age relationships between these units are only partially established but they were most probably deposited or intruded in the order that they are described below.

Nonmarine sedimentary rocks and interlayered volcanic flows crop out in a west-dipping succession that crosses Jawbone Canyon at Blue Point and at Red Hill adjacent to the Cliff Canyon fault in section 28. At Blue Point these strata, 3,200 feet thick, lie unconformably upon a surface of weathered granite. The basal beds are composed of crossbedded, red, arkosic sandstone and conglomerate in some places, and white, siliceous volcanic tuff in others. They are overlain in places by arkosic and white tuff, and in other places by pale-green, welded volcanic tuff-breccia. The tuff-breccia attains a maximum thickness of 1,200 feet and pinches out to the north and south. Hornblende augite basalt flows, a total of 1,300 feet in thickness, overlie the tuff-breccia, arkosic, and tuff, and, in turn, are overlain by green to pale purple, welded volcanic tuff breccia. The tuff-breccia ranges in thickness from 750 feet to 1,500 feet, and locally contains interbeds of arkosic and basaltic graywacke. It crops out only south of Jawbone Canyon. North of Jawbone Canyon, the basalt flows are overlain by nonmarine sedimentary rocks, 300 to 400 feet thick, that consist predominantly of buff-colored, calcareous, arkosic conglomerate and sandstone, and partly siliceous greenish to white tuffs and tuff-breccias.

The Red Hill outcrop consists of variegated acid volcanics including rhyolite dikes and flows associated with tuffs, clays, arkosic sands, and conglomerates. Although this sequence is here correlated with the Blue Point area, there is also a strong lithologic similarity with the lower part of the Ricardo Formation as mapped in the adjacent Saltdale quadrangle (Dibblee, 1952).

Dikes of hornblende augite basalt intrude the Tertiary and pre-Tertiary rocks. They crop out mostly in an area 1 mile southwest of the White Rock mine where they intrude granodiorite.

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trend west-northwest. The basalt is similar in composition to that in the basalt flows and the dikes may have been, in part, sources of material for the flows.

Rhyolitic volcanic rocks crop out over about 2 square miles at Cross Mountain and are composed of about 400 feet of flows and tuffs and associated plugs and dikes. The flows and tuff lie directly upon granodiorite and are intruded by plugs and related dikes which also intrude the sedimentary rocks in Jawbone Canyon and are the probable source of the volcanic rocks. The flows and tuffs are rhyolitic and are in part devitrified and silicified. Plugs and dikes are conspicuous in outcrop. The plugs underlie the principal peaks and the dikes form a west-trending swarm across the south part of the map. Rhyolite dikes also crop out north of Jawbone Canyon along the contact between granite and granodiorite. The rhyolite of Cross Mountain is pre-early Pliocene in age, probably middle Tertiary.

Hornblende andesite crops out on the north slope of Chuckwalla Mountain, one quarter to 2 miles southeast of the White Rock mine. The outcrops consist of five remnants of a previously connected flow and a plug or neck that was the source of the flow. The flow material dips away from the plug. The flow material, a maximum of 200 feet thick, has probably been reduced in thickness by erosion. The andesite of Chuckwalla Mountain is younger than the rhyolite of Cross Mountain as it rests upon eroded rhyolite. It may be correlated with andesite volcanic rocks in the lower part of the Ricardo Formation in El Paso Mountains.

The Ricardo Formation was named by and assigned an age of early Pliocene by Merriam (1914, p. 276). The uppermost beds have been dated as Pleistocene by Dibblee (1952, p. 29). The formation is exposed east of the Cliff Canyon fault and extends beyond the eastern border of the Cross Mountain quadrangle through Red Rock Canyon, the type locality, into the northwest slope of El Paso Mountains, as mapped by Dibblee (1952, pl. 1). The upper 3,500 feet, composed of coarse arkosic sandstone, conglomerate, clay and siltstone is exposed in the Cross Mountain quadrangle; the lower 3,500 feet, composed of sedimentary rocks, volcanic flows and tuff, is exposed farther east.

Quaternary Rocks. Quaternary rocks consist, in probable order of deposition, of playa clays interbedded with silt and arkosic sands and gravels, dissected terrace deposits of arkosic sands and gravels, stream terrace gravels, and Recent alluvium. The dissected terrace deposits overlie a pediment surface that cuts across levels of the Ricardo Formation north of Jawbone Canyon and granite farther west.

Structural Features

The principal structural features in the Cross Mountain area are segments of the Sierra Nevada fault system and the Garlock fault. The Sierra Nevada fault system consists in this area of three branching faults or fault zones that appear to converge northward. All three faults dip moderately to steeply eastward and exhibit normal downward movement of the east block of each fault relative to the west block. The faults are, from west to east, the Jawbone fault zone, the White Rock fault zone, and the Cliff Canyon fault.

The Jawbone fault zone consists of several branches along the west side of the area. A four-mile segment of the zone extends north-northeastward from Cross Mountain to a point about 1 1/2 miles northwest of Blue Point. There is an offset about half a mile eastward from which point a single branch extends 3 miles farther north-northeastward to the edge of the map. It probably extends several miles beyond this point.

The White Rock fault zone extends from a point on the south edge of the Cross Mountain quadrangle boundary north to Jawbone Canyon where it appears to join the Jawbone fault zone beneath alluvium. It may extend farther south to the Garlock fault.

The Cliff Canyon fault extends from the Garlock fault 5 miles north-northwest to the north edge of the map. It is more clearly exposed along most of its trace than the Jawbone and White Rock fault zones. Exposures are particularly good on the south side of Water Canyon and in the north part of Cliff Canyon where west-dipping strata of the Ricardo Formation are truncated and are juxtaposed with Mesozoic plutonic rocks. The southern half-mile segment of the Cliff Canyon fault swings abruptly east-southeastward suggesting drag folding along the Garlock fault.

Displacement along all three faults is undetermined but it is at least equal to the thicknesses of the tilted sedimentary rocks adjacent to them as none of these rocks are exposed in the adjacent blocks. The earliest movement followed deposition of the lower Pliocene or middle Tertiary rocks; it may have continued or recurred in Recent time.

The Garlock fault zone consists mostly of a single fault continuously exposed for about 4 miles along the southeast edge of the area mapped. This fault is probably the northwesternmost of several faults that are parallel to it and lie concealed beneath the alluvium to the southeast. The topographic difference between the two sides of the fault is 3,000 feet, presumably the result of vertical displacement along the fault. Evidence of left-lateral displacement is lacking in this area but is suggested by a fault at the south end of the Cliff Canyon fault. Movement has occurred along the Garlock fault since intrusion of the rhyolite (mid-Tertiary?) and has continued to Recent time as indicated by deformation of playa sediments.

Northwest-trending, west-northwest-trending, and north-trending faults, with small to moderate displacement, are common through much of the mapped area as

shown on the geologic map. The principal folds in the area are an anticline and a syncline in the Ricardo Formation north of the mouth of Jawbone Canyon and a syncline in Tertiary sedimentary rocks north of Blue Point. Metamorphic rocks west of Cinco are strongly deformed. Deformation of the metamorphic rocks probably began before the intrusion of the granodiorite and has continued intermittently to as late as Recent time, when the movement occurred along the Garlock fault.

Geologic History. A tentative summary of the principal geologic events is collated in the table below.

Geologic event	Uplift, folding, faulting	Result
Pre-Jurassic (?)		At least 1,400 ft. of marine limestone, argillaceous and arkosic sediments.
Mid-(?) Jurassic		Batholithic intrusion of granodiorite rocks, metamorphism of pre-Jurassic rocks. Dacite dike intrusion(s), mineralization(?).
Late (?) Jurassic		Erosion, unconformity, no known faulting.
Cretaceous (?)		Batholithic intrusion of granite. Emplacement of pegmatite, apatite and pyroxene.
Early Tertiary		Erosion, unconformity, no known faulting.
Mid-Tertiary (?)		Deposition of 3,200 feet of continental, arkosic sediments, and acid to basic volcanics. Intrusion of basalt dikes.
Post Mid-Tertiary to pre-Pliocene		Unconformity with angular discordance. Minor folding and faulting. Extrusion of rhyolite flows, 400 feet thick. Intrusion of rhyolite plugs, dikes and tuffs. Deposition of arkosic sandstone, conglomerate, clay and siltstone and intrusion of andesite plug and dikes. Continued deposition of the nonmarine sediments.
Lower Pliocene		Deposition of more than 3,000 feet of Ricardo Formation composed of continental, arkosic sediments, tuff, and basalt flows.
Pleistocene		Erosion. Deposition of playa and alluvial deposits. Stream aggradation.
Recent	Late Pleistocene to Recent	Faulting and rejuvenation of topography and drainage. Mojave basin rapidly filling with playa and alluvial deposits. Degradation of 200 feet of alluvial fill in canyons.

Mineral Deposits. Minerals of economic interest in the southeastern quarter of the Cross Mountain quadrangle include gold, tungsten, antimony, lead, copper, silver, quicksilver, uranium, rock for use as roofing granules, and clay. Orthoclase and quartz crystals, opal, chalcedony, and silicified wood fragments are of interest to rock and mineral collectors.

In recent years the emphasis on mining in the Cross Mountain area has switched from metallic to non-metallic minerals. The value of clay and roofing granules mined in recent years is greater than the total value of metallic minerals mined in the area.

Three companies have mined material for roofing granules, one company is mining clay, one gold and one silver prospect have been under recent development, and uranium prospects have been explored since 1952. The area has reserves of limestone, clay, and perhaps uranium that might be utilized in the future.

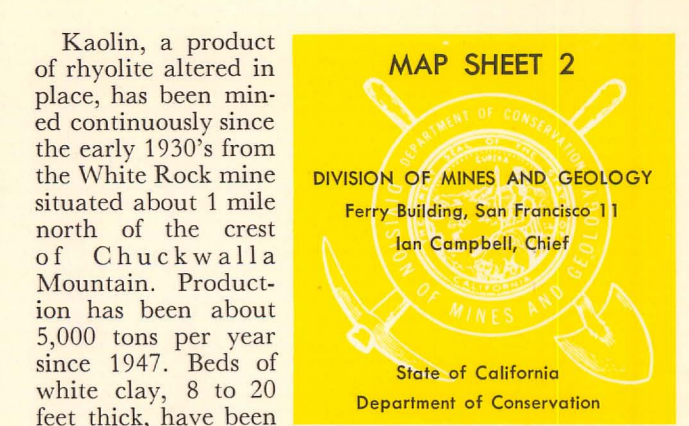
The greatest search for gold has been along quartz and rhyolite veins and dikes in granodiorite and granite in which gold is commonly associated with pockets and stringers of iron, copper and lead sulfides. The Miles mine at the east end of Antimony Flat was being developed intermittently during the 1950's. There north-west-trending quartz veins that dip northeast have been developed by shallow inclined shafts. Silver, in an undetermined form, was discovered in the late 1950's in fractures in granite about two miles south of Blue Point. Nearly continuous exploration has been conducted in this area since that time but to date the occurrences are unproductive.

Antimony in the form of the sulfide, stibnite, is common in west-trending veins and stringers in granodiorite in the southwest part of the mapped area, which is known as Antimony Flat. Activity was first reported in this district in 1904 and a moderate but undetermined amount of antimony ore was mined between then and 1941.

Small quantities of quicksilver have been mined from stringers and veinlets of cinnabar in rhyolite dikes and in metasedimentary rocks. Rhyolite dikes along the north flank of Cross Mountain have yielded several tens of pounds of cinnabar which was collected and sold as mineral specimens, and cinnabar veinlets in metamorphosed carbonate rocks have been prospected at a locality on the south side of Chuckwalla Mountain.

The principal sources of tungsten have been a small scheelite-bearing pendant of metamorphic rocks in granodiorite about 1 mile west of Jawbone well and small lenses of wolframite and scheelite in brecciated and sericitized granite 1 mile north of Blue Point.

Since 1954, uranium-bearing minerals have been found in a west-trending fault zone 1 mile north of Blue Point and in rhyolite about 3 miles northeast of Blue Point. Both deposits are unproductive to date.



Kaolin, a product of rhyolite altered in place, has been mined continuously since the early 1930's from the White Rock mine situated about 1 mile north of the crest of Chuckwalla Mountain. Production has been about 5,000 tons per year since 1947. Beds of white clay, 8 to 20 feet thick, have been exposed by shallow cuts and trenches at irregular intervals along outcrops that extend northward from Blue Point for about half a mile. White to gray and red beds of bentonitic (?) clay are exposed on the east side of the Cliff Canyon fault, just north of the Garlock fault. The beds, several tens of feet thick, are interlayered with volcanic debris. They have been developed by shallow open cuts.

Rhyolitic, welded tuff-breccias in the Tertiary sedimentary rocks near Blue Point are crushed and sized for use as roofing granules. The principal colors mined to date have been various shades of green but small amounts of pink granodiorite and maroon granite are also utilized. Several thousand tons of rock have been produced since 1953. One firm operates a crushing plant installed at Blue Point in 1953. Other firms haul rock from quarries in Jawbone Canyon to crushing plants elsewhere.

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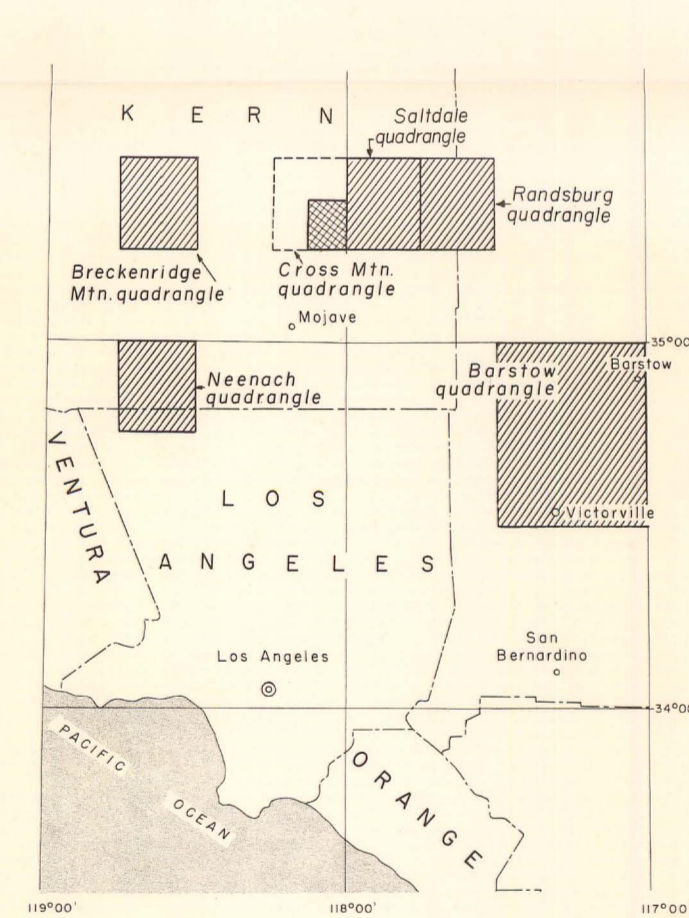
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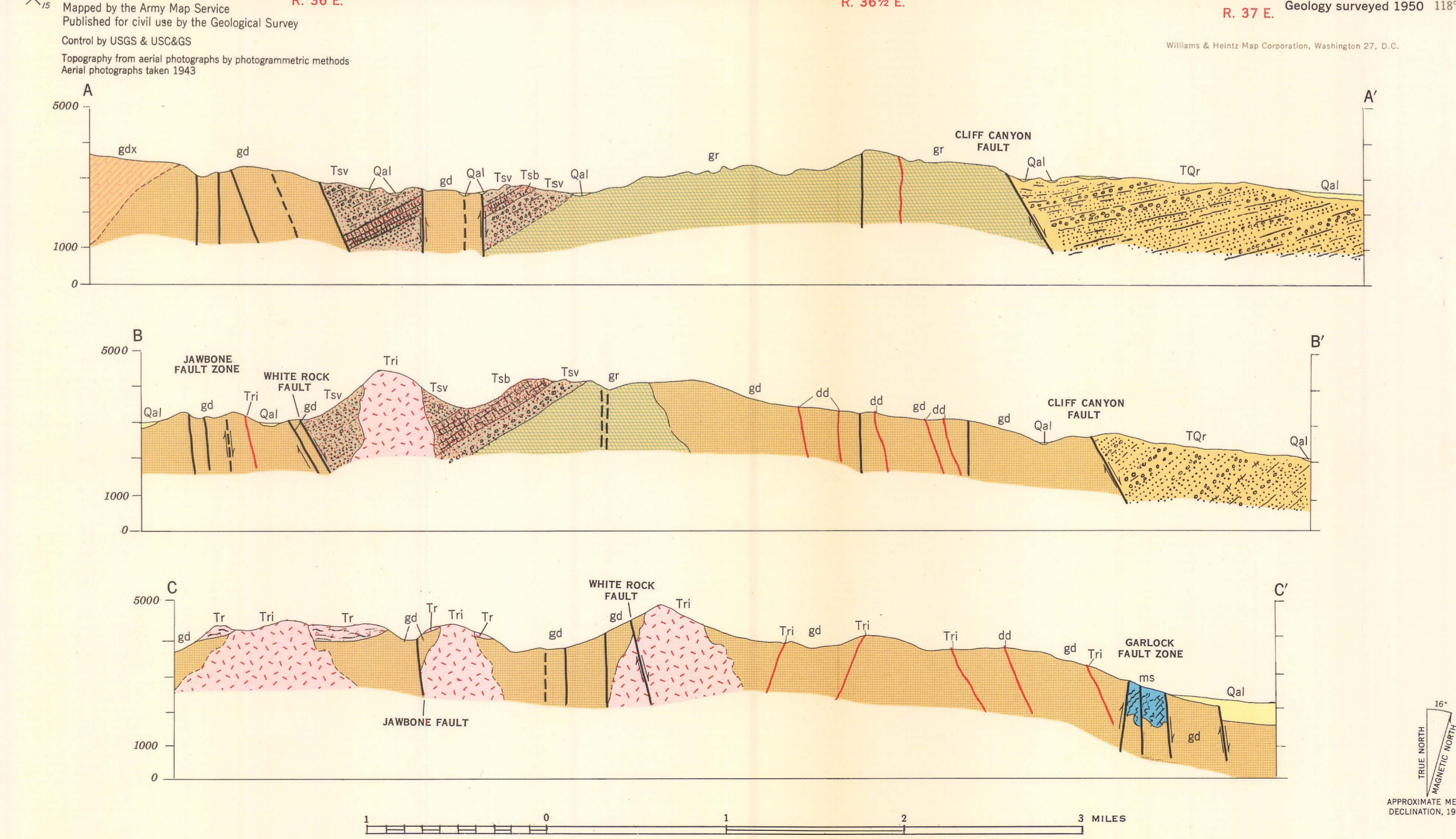
Index map of part of southern California showing location of Cross Mountain quadrangle and part covered by this report (cross hatched). Previously published geologic quadrangle maps in vicinity are shown (line pattern).

Tabulation of Igneous Rocks

Map unit	Rock unit	Composition (mineral and percent)	Texture and structure	Remarks
Ta	Andesite flow	Zoned andesite (Anp to Anso, 40%), hornblende (10%), devitrified groundmass (35%), -biotite, magnetite, and apatite.	Aphanitic. Hypocrystalline and microphyritic, flow banded to massive. Poorly developed columnar jointing.	
Tai	Andesite intrusive	Plagioclase (Anp to Anp, 30%) and hornblende -biotite, apatite, quartz and magnetite.	Aphanitic. Hypocrystalline, porphyritic, glomerophyritic.	Source of flow material. Intrudes rhyolite plug.
Tr	Rhyolite flows	Quartz (25%), orthoclase (20%), oligoclase (10 to 15%), microcline (5%), devitrified and silicified groundmass (50%).	Hypocrystalline, porphyritic, flow banded, vesicular. Aphanitic groundmass.	
Tri	Rhyolite plugs and dikes	Plugs - (dacite to rhyolite) plagioclase (usually oligoclase), microcline, orthoclase, and quartz-biotite, muscovite, apatite, and magnetite. Dikes are less basic than plugs. Sanidine (20%), quartz (10%), groundmass (60%) -magnetite and apatite.	Plugs - finely porphyritic to aphanitic, flow structures and columnar jointing. Dikes are generally more coarsely porphyritic than plugs.	Contains abundant xenoliths of granitic and schistose rocks. Some plugs have perlitic black oxidized borders. Deeply leached and hydrothermally altered. Kaolinized.
Tbd	Hornblende-augite basalt dikes	Similar to Tsb	Porphyritic, xenolithic. Flow banding and parallel alignment of long axes of crystals.	May have been, in part, sources of material in Tsb.
Tsb	Hornblende-augite basalt flows	Labradorite, zoned (Anp to Anso, 45%), hornblende (15%), augite (10%) -devitrified glassy groundmass.	Hypocrystalline, trachydolitic, porphyritic, xenolithic. Flow structures.	Quartz xenoliths constitute as much as 3 percent of the basalt and are surrounded by rims of pyroxene (?).
ga	Granite aplite	Plagioclase, orthoclase, and quartz. Mafic minerals scarce. Up to 35 percent quartz.	Equigranular, fine to medium grained.	Occurs as stocks and dikes. Quartz veins commonly associated with the aplite. Locally pegmatitic.
gr	Biotite granite	Oligoclase (10 to 15%), microcline (30%), quartz (35%), biotite (8 to 15%) -augite, muscovite, magnetite, apatite, zircon, and apatite.	Coarse-grained, holocrystalline, hypidiomorphic granular, jointed. Cataclasis common.	Intrudes granodiorite.
dd	Dacite	Plagioclase (Anp to Anp, 25%), orthoclase (10 to 15%), biotite (10%), quartz (10 to 15%) -hornblende, zircon, apatite, and magnetite.	Hypocrystalline, cryptocrystalline. Phenocrysts of plagioclase, quartz, orthoclase, and hornblende in pale gray groundmass.	Occurs solely as dikes and only in granodiorite.
gd	Biotite granodiorite	Oligoclase (30 to 35%), microcline (15%), quartz (25%), biotite (15%) -orthoclase, muscovite, magnetite, zircon and apatite.	Coarse to medium grained. Holocrystalline, hypocrystalline granular and porphyritic. Sometimes poikilitic.	Intrudes metasedimentary rocks and is, in turn, intruded by dacite. Contains thin apatite and pegmatite dikes older than the granite.
gdx	Biotite granodiorite containing schist and gneiss	As above.	Coarse to medium-grained, holocrystalline, porphyritic, occasionally gneissic and schistose. Directionally textured.	Xenoliths composed mostly of biotite-hornblende gneiss and biotite schist.

Tabulated list of mines and prospects

Map No.	Name of mine or prospect	Mineral commodity	Remarks
1	AAA-60	gold	Prospect
2	Antimony Cons.	antimony	Some production before 1942.
3	Big 4	silver	Recent exploration
4	Blue Point	tungsten	Minor production
5	Carbonate	lead	Prospect
6	Cowboy	antimony	Minor production (?)
7	Daves Mining Co. (mill site)	roofing granules	Active. Moderate production
7a	Daves Mining Co.	granules	"Sea foam green" quarry
7b	Daves Mining Co.	granules	"Emerald green" quarry
7c	Daves Mining Co.	granules	"Rose bronze" quarry
7d	Daves Mining Co.	granules	"Vintage red" quarry
8	Granite King	gold	Some production
9	High-Low	tungsten	Minor production
10	Mammoth	mercury	Prospect
11	Miles	gold	Prospect
12	Miller Ranch	uranium	Prospect
13	Picture Ranch	stone	Some production (?)
14	Silver Lady	uranium	Prospect
15	Skyline	gold	Moderate production
16	White Rock	clay	Active. Production since 1930's
17	White Swan	clay	Prospect



GEOLOGIC MAP AND SECTIONS OF THE SOUTHEASTERN QUARTER OF THE CROSS MOUNTAIN QUADRANGLE, KERN COUNTY, CALIFORNIA