UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

Bulletin 931-Q

QUICKSILVER AND ANTIMONY DEPOSITS OF THE STAYTON DISTRICT, CALIFORNIA

BY

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Strategic Minerals Investigations, 1941
(Pages 405-434)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1942

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - Price 40 cents

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QUICKSILVER AND ANTIMONY DEPOSITS OF THE STAYTON DISTRICT, CALIFORNIA

By Edgar H. Bailey and W. Bradley Myers

ABSTRACT

The Stayton district, which lies 13 miles northeast of Hollister, Calif., includes parts of San Benito, Santa Clara, and Merced Counties. The district has yielded about 1,700 flasks 1/ of quicksilver, mostly between 1870 and 1880, and a few tons of antimony ore.

The rocks of the district include Jurassic (?) (Franciscan formation) and Cretaceous (?) sedimentary rocks, serpentinized ultrabasic rocks intruded into the Franciscan rocks, Miocene (?) basaltic and andesitic extrusive rocks, and several intrusive bodies of Miocene (?) andesite and rhyolite. The basaltic extrusive rocks were arched into a northward-trending asymmetrical anticline, then planed by erosion and capped by the andesitic rock. All the rocks are cut by northward-trending faults along which there have been several periods of movement.

Veins containing stibnite occur mainly in the basaltic rocks along faults in the central part of the district. They are estimated to contain several tens of thousands of tons of potential ore averaging about 1½ percent of antimony.

Cinnabar, the only commercially important quicksilver mineral, has three different modes of occurrence: (1) Veins and coatings in fractures in broken antimony veins, (2) coatings on otherwise unmineralized fractures in basalt, and (3) veins and replacement deposits in silica-carbonate rock derived from serpentine.

The possible reserves of the five largest mines amount to slightly more than 1,000 flasks of quicksilver. The largest mine, the Stayton, is probably capable of producing nearly 100 flasks per year for a few years. Additional prospecting along broken antimony veins immediately below the contact between the two volcanic units might uncover additional deposits of medium-grade quicksilver ore.

INTRODUCTION

The Stayton quicksilver and antimony district is on the crest of the Diablo Range 90 miles southeast of San Francisco and 13 miles northeast of Hollister, California (fig. 46).

1/ A flask contains 76 pounds.

It is in Tps. 11 and 12 S., R. 7 E., in the northwestern corner of the Quien Sabe quadrangle. The district lies mostly in northeastern San Benito County, but it also includes parts of southeastern Santa Clara County and western Merced County. The only good road into the district extends from Hollister, on the Southern Pacific Railroad, to the Stayton mine, which is the

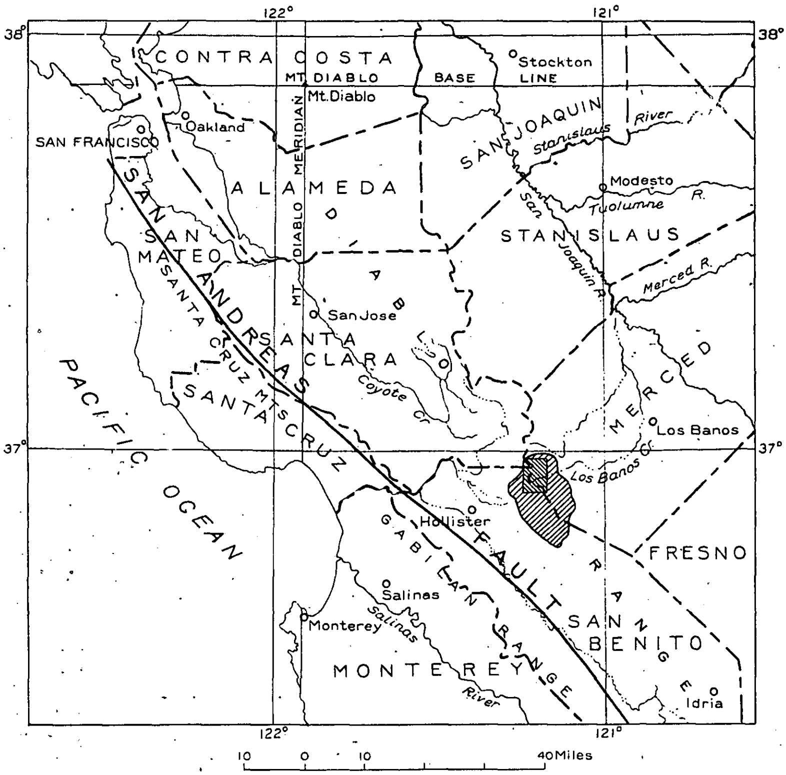

Figure 46.--Index map of southern California showing the location of the Stayton district and the approximate extent of the Miocene (?) volcanic field. Solid black shows area mapped; ruled area shows volcanic field.

largest in the district; other roads are passable only during the dry summer months.

Little geologic work has been done hitherto in the region. Becker [2] briefly mentioned the mines, and Forstner [3] made a reconnaissance map of the area in 1903.

2/ Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, p. 380, 1888.

3/ Forstner, William, The quicksilver resources of California: California Min. Bur. Bull. 27, pp. 128, 147-149, 1903.

The field work furnishing the basis for this report was done during approximately 2 months in the spring of 1941. The areal geology was plotted on airplane photographs and later fitted to photographic enlargements of the Quien Sabe topographic sheet.

The operators and miners in the district, especially Mr. R. B. Knox, owner and operator of the Stayton mine, were uniformly courteous and helpful. The writers are indebted to E. B. Eckel of the Geological Survey for advice during the field work and the preparation of this report.

HISTORY AND PRODUCTION

The veins of the Stayton district were mined for antimony when first worked, between 1870 and 1875, but the more valuable cinnabar was soon discovered. By 1876 the Stayton Mining Co. had gained control of the Gypsy, Stayton, and several smaller mines, and the company is reported 4/ to have produced about 1,000 flasks of quicksilver before 1880. The Comstock mine in the northern part of the district was also discovered in the seventies and produced about 300 flasks prior to 1880. The production of the district from 1880 to 1920 is not known but is believed to have been very small. An accurate record is available only for the Stayton mine, which has produced 390½ flasks since the revival of mining in 1920.

Production of quicksilver, in flasks, from the Stayton mine, 1920-40 1/

1920	17	1932	9
1921	10	1933	12
1922	½	1934	1
1924	5	1935	18
1927	20	1936	9
1928	85	1937	11
1929	78	1938	18
1930	60	1939	10
1931	14	1940	13
		Total	390½

1/ From records of the California State Mining Bureau. Published with the permission of Mr. R. B. Knox.

4/ Forstner, William, op. cit., p. 147.

The total quicksilver production of the district prior to 1940 is summarized in the table below.

Mine	Years	Quicksilver (flasks)
Comstock mine......................	1870-1880	300
Stayton and Gypsy mines.............	1870-1919	(?) 1,000
Stayton mine........................	1920-1940	390
Approximate total...............	....	(?) 1,690

The amount of antimony produced is unrecorded, but the total probably is only a few hundred tons.

GEOLOGY

The Stayton district is underlain chiefly by Tertiary igneous rocks, for it lies in the north-central part of a dissected Tertiary (Miocene?) volcanic field, which extends over an area of about a hundred square miles (fig. 46). Exposures of pre-Tertiary rocks are relatively small, and lie mainly in the lowest canyon bottoms and around some volcanic plugs that have upturned the invaded rocks, as is shown on the geologic map of the district (pl. 64). Parts of the district are covered by Quaternary landslides and alluvial deposits; these require no further mention.

The pre-Tertiary rocks were divided for mapping into two units. One unit includes some typical rocks of the Franciscan (Jurassic?) formation and some younger sedimentary rocks that are probably of Cretaceous age. These rocks are much folded, faulted, and crushed, but no dominant structural trend was recognized in them. The second unit includes serpentine and masses of silica-carbonate rock derived from serpentine. The serpentine is intrusive into the Franciscan rocks but nowhere cuts the Cretaceous (?) rocks. There are pebbles of serpentine in the Cretaceous (?) conglomerate.

The Tertiary igneous rocks were divided for mapping into four units. The oldest includes basaltic extrusive rocks, flows, and interbedded layers of agglomerate and tuff, which are separated from the older pre-Tertiary rocks by a major unconformity. These basaltic rocks are arched in a north-trending asymmetrical anticline which was formed and partly eroded before the extrusion of the andesitic extrusive rocks that make up the second unit. The third unit comprises andesitic rocks of intrusive bodies, some older than the andesitic extrusive rocks, some younger, and some of undetermined relative age. The youngest Tertiary igneous rocks are intrusive bodies of rhyolitic rock. Although some of the intrusive bodies turned up the adjacent layers of older rocks, others cut sharply across the bedding.

The structural features of principal interest are north-trending faults, along some of which the ore bodies occur. All the known ore bodies are along faults in the basaltic rocks, except one that is in an andesitic intrusive body and one that is in a body of silica-carbonate rock.

Pre-Tertiary rocks

Franciscan (Jurassic?) and Cretaceous (?) rocks

The Franciscan rocks are dark-brown to black silty shale, gray or greenish arkosic sandstone, conglomerate, light-green to cream-colored chert, and basic intrusive and extrusive rocks that are now altered to greenstone. The total thickness is unknown.

The Cretaceous (?) rocks include black shale, gray sandstone which weathers either buff or brown, and chert conglomerate. The exposed thickness within the district is more than 500 feet. These rocks are lithologically similar to those in Cretaceous formations in the Coast Range, but no attempt was made to establish the correlation fully. The absence of massive chert,

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greenstone, and serpentine in the Cretaceous (?) rocks, as well as their uncrushed condition, serves to distinguish them from the Franciscan rocks.

Serpentine

Serpentine crops out only in three small areas in the northwestern part of the district. The rock is various shades of green, but in some places it is nearly white. Small crystals of picotite, a black, nearly opaque mineral with brilliant luster, generally stud the serpentine, and in fresh rock magnetite is also abundant. The texture resembles that of a coarse sandstone in which the grains are elongated as a result of slight shearing; the texture is probably a relict of the intrusive peridotite from which the serpentine is believed to have been formed.

Some of the serpentine has been further altered to the peculiar rock termed "silica-carbonate rock" or "quicksilver rock." In the Stayton district the silica in this rock is largely chalcedonic quartz. Most of this rock has a sheared or irregularly schistose structure which it probably inherited from the serpentine. Nearly all of the silica-carbonate rock found on the surface is weathered, and is characteristically stained pale tan by iron oxides. As the carbonates are readily dissolved, outcrops are also distinguished by a deeply pitted surface on which an irregular and intricate network of narrow walls separates lens-shaped cavities. In the vicinity of the Comstock mine the rock is largely chalcedonic quartz and pyrite with very little carbonate and is like the twice-silicified rock described by Ross.[5] This rock stands out as an elongate reef because of its resistance to erosion.

5/ Ross, C. P., Quicksilver deposits of Mayadmas and Sulphur Bank districts, California: U. S. Geol. Survey Bull. 922-L, p. 333, 1940.

Tertiary igneous rocks

Basaltic extrusive rocks

The basaltic rocks cover more than half of the area mapped. Their aggregate thickness differs greatly from place to place and locally amounts to more than a thousand feet.

The dominant rock, represented by nearly three-quarters of the surface exposures, is massive but intricately fractured basalt. The basalt is poorly exposed, but soil derived from it contains small angular fragments that are easily recognized. Although the basalt is nearly black when fresh, almost all specimens found on the surface are brown or tan because of weathering. Commonly only a few very small crystals can be seen in the dense rock, but some varieties contain phenocrysts of plagioclase an eighth of an inch long. Vesicles, which are rare, are filled with limonite at some exposures and with calcite or chabazite at others. In the vicinity of the large irregular intrusive body of andesite in the eastern part of the district, the basalt is hydrothermally altered almost beyond recognition.

Soft, white- to buff-colored tuff interbedded with the basalt is particularly abundant in the western and southern parts of the district. The tuff resembles sandstone for it is generally composed of small, light-colored grains with little finer-grained matrix, and it is generally well-bedded and in a few places cross-bedded. The characteristic fragments, which are generally about the size of a pea or smaller, consist of tuff of a somewhat lighter color than the matrix. Scattered at fairly wide intervals through the tuff in some exposures are angular blocks of black basalt a foot long. In the southwestern corner of the district these angular blocks are so numerous and prominent that here the rock is aptly termed a basaltic agglomerate. In outcrops of this rock the matrix is hardly noticeable because of the abundance and resistant nature of the blocks.

A mottled-green or brownish-green tuffaceous agglomerate is the most common rock in the area south and east of Antimony Peak. The agglomerate can be distinguished from the overlying andesitic agglomerate only with difficulty. However, it is so well indurated that the boulders are the least resistant part of the rock and weather out leaving a pitted or cavernous surface, whereas in the overlying andesitic unit the boulders protrude as knobs on weathered outcrops.

Andesitic extrusive rocks

The andesitic extrusive rocks are more than 1,500 feet thick. The dominant variety is an agglomerate with an igneous matrix, but tuffaceous agglomerate and tuff are locally abundant in the lower part.

The agglomeratic character of the rock is most noticeable in weathered outcrop where the slightly more resistant boulders stand out. The boulders range from 6 inches to 3 feet in size. Most of the agglomerate is light gray or pink, but some denser varieties are red or nearly black. Phenocrysts of pale-yellow plagioclase, a quarter of an inch long and amounting to a tenth of the rock, are embedded in a fine-grained, nearly glassy matrix. Crystals commonly form complexly twinned or intergrown clots, and some are rounded and altered on the surface to soft white kaolin. Hornblende, occurring in only minor quantity, is generally altered to a soft, brownish-gray aggregate; biotite is commonly fresh. A platy fracture is locally developed, and incipient short parallel cracks and open spaces are usually present.

A few flows are probably present in the upper part of the unit. On Henrietta Peak and in the two areas east of Mariposa Peak and east of the Stayton mine bodies of intrusive andesite are included in the areas mapped as extrusive andesite.

Andesitic intrusive rocks

At least three kinds of andesitic intrusive bodies can be distinguished within the area. One kind, characterized by sharp contacts, nearly circular outline, arching of the surrounding formations, and lack of any contact-metamorphic effects, is best represented by the plug at the head of Quien Sabe Valley. Such bodies were intruded after the arching of the basaltic rocks, but before the deposition of the andesitic extrusive rocks.

The second kind is exemplified by the large irregular intrusive body that is exposed in the area surrounding the fork of North Los Banos Creek. Numerous tongues and dikes that border the mass could not be mapped in detail in the time available. Hydrothermal metamorphism has altered the surrounding basalt but appears to have had little effect on the invaded shale. Several large slivers of basalt caught in the intrusive mass are shown on the map, but others are not delineated. The relative ages of this irregular intrusive body and the andesitic extrusive rocks were not determined.

The third kind, characterized by sharply angular contacts and absence of metamorphic effects, is exemplified by the large intrusive mass at the northern boundary of the area. Masses of this kind, as well as certain other masses which have not been mapped, are intrusive into the andesitic agglomerates.

Rhyolitic intrusive rocks

Two small plugs of rhyolite crop out in the northeastern corner of the district. The rock is light-colored, in places white, and contains small phenocrysts of quartz as well as orthoclase. The shape of the eastern mass evidently was controlled by pre-existing fractures. The only obsidian found in the district occurs along its sheared southern edge.

The rhyolite is probably the youngest igneous rock in the area, as it is intrusive into the effusive as well as one of the younger intrusive andesites.

Faults

More than a score of northward- and northwestward-trending faults have been mapped within the district. Movement along them occurred or recurred during at least three, and possibly four different stages: (1) Between the deposition of the basaltic and andesitic units, (2) after the deposition of the andesitic unit and prior to the antimony mineralization, (3) following the antimony mineralization but before the quicksilver mineralization, and possibly (4) after mineralization. The faults formed after mineralization are confined to the southwest quarter of the area mapped. All the others are mineralized, and it is probable that many of them were active during all but the last period of movement.

The mineralized faults, which contain the ore bodies, strike west of north through the middle of the area. None of them is known to be more than 2 miles long, and many are much shorter. Those on the west are reverse faults which dip steeply to the west. The dip of the mineralized fault on the east slope of Antimony Peak ridge changes sharply along the strike. In the south, near the Stayton mine road, the fault dips steeply to the west and is reverse. At the first canyon crossing, some 600 feet north, the dip decreases to 35° W. A little farther north, where it crosses the southern elbow of Antimony Peak ridge, it is vertical, and in the good exposures along the slope of the ridge it dips 65°-75° E. and is normal with a displacement of more than 500 feet. Still farther north, west of Antimony Peak, exposures are poor, but the fault is believed to be again nearly vertical. Other faults of the district show less extreme changes in dip.

The fault of the Gypsy vein is normal and dips west at a moderate angle. It allows a keystone block in the anticline to be depressed west of the Gypsy vein, and in this respect it is similar to all of the mineralized faults along which the crest of the anticline has been lowered (pl. 64, section A-A').

The faults of the district are readily traceable only where mineralized and, therefore, may be more continuous or more widely distributed than is suggested on plate 64.

A group of more than a dozen faults in the southwestern quarter of the district are not silicified or otherwise mineralized. The positions of some of these faults are shown by topographic features such as ponds and short troughlike valleys. These faults seem to be geologically very young, and were probably formed after the ore deposition.

ORE DEPOSITS

Antimony veins

Most of the antimony deposits of the Stayton district consist of stibnite-bearing quartz veins along northward-trending faults within the basalt. These veins crop out on both sides of Antimony Peak ridge and extend southward a short distance beyond the Stayton mine where they pass under the younger andesitic rocks. Although the exposures are good, neither the veins nor the faults were found on the southern side of the narrow ridge covered with andesitic agglomerate.

The antimony veins and the adjacent parts of the wall rock are commonly resistant to erosion and consequently stand up above the surface of the ground as low irregular walls. The weathered outcrops of the more silicified and mineralized parts of the veins generally are relatively smooth and stained yellowish green. Most of these veins are a few feet wide but a few exceptional ones exceed 30 feet. They are bordered by kaolinized and somewhat silicified breccia made up of angular fragments about 1 inch in size. The breccia is irregularly cut, replaced, and cemented by veins of black chalcedonic quartz containing pyrite and some needles of stibnite. Small pods and irregular veins of stibnite with little or no quartz replace and fill fractures in the black quartz vein filling.

The breccia can be found throughout most of the length of the veins, but it is invariably of low grade, averaging less than 1 percent of antimony. Veins of nearly pure stibnite, which form small lenses and pockets less than a foot wide and containing only a few cubic feet of ore, locally increase the tenor of the ore considerably above 1 percent. The abundance of these lenses, which can only be established by careful prospecting, ordinarily determines whether the mining of a block of ground is profitable.

Three small mines, the Ambrose, Shriver, and Blue Wing, have produced some antimony from widely separated parts of three different veins. Numerous small pits, drifts, and small prospects on other veins may have yielded a few sacks of hand-picked ore although there is no record of the amounts produced.

Quicksilver deposits

The quicksilver deposits, which are more valuable than the antimony deposits, are cinnabar-filled fractures in and near portions of the southeastern antimony veins. Isolated quicksilver deposits not related to antimony veins occur west of Mariposa Peak and also in the northwestern corner of the district. Three distinct types of quicksilver deposits have been mined in the district: (1) Fractured antimony veins with later cinnabar encrustations and impregnations, (2) cinnabar fillings in otherwise unmineralized fractures in basalt, and (3) cinnabar veins and replacements in silica-carbonate rock derived from serpentine.

Faults localize the ore bodies of all the principal mines. Within the fault zones the cinnabar commonly coats rather closely spaced, nearly vertical, late fractures.

The ore shoots exist where these cinnabar-filled fractures are abundant or, exceptionally, where single veinlets of cinnabar about an inch thick are closely paralleled by a few thinner veinlets which increase the tenor of the ore. No large ore bodies have been found.

Most of the ore mined in 1941 at the Stayton mine contained less than one-half of 1 percent of quicksilver (10 pounds to the ton), but the tenor was raised by hand-sorting to about 2 percent.

Mineralogy

Cinnabar (HgS) is the only commercially important quicksilver mineral of the district. No native mercury is known in any of the mines, and metacinnabar occurs only in the Comstock mine. Bright-red cinnabar replaces quartz, chalcedony, and opal in the silica-carbonate rock of the Comstock mine, but elsewhere it is found as coatings or crusts in open spaces. Some of the crusts are purple-red and crystalline; the majority are microcrystalline or, in the lower-grade ores, the earthy bright-red variety known as "paint." Although some evidence for re-solution of cinnabar was found there is no direct evidence that the "paint" has formed through the action of surface waters.

A few veinlets of massive metacinnabar (HgS), partly replaced by cinnabar, were found in the Comstock mine.

Stibnite (Sb_2S_3) is the only antimony ore mineral recognized in the district. It is steel gray to lead gray in color, and in large crystals it shows brilliant metallic luster on fresh surfaces. It occurs as small needles in clear, gray to black, sugary quartz veins and as more coarsely crystalline masses in veins up to 10 inches in width. A few crystals are found in open cavities. Fractured stibnite crystals are coated with cinnabar in mines of the central and eastern part of the district. Jet-black velvety coatings of minute needles of stibnite deposited on cinnabar encrustations in the Stayton mine may be of supergene origin.

All of the more common oxides of antimony are probably present as surface coatings and replacements of stibnite in the shallow, oxidized parts of the stibnite veins. Brownish valentinite (Sb_2O_3), white waxy senarmontite (Sb_2O_3), white or light-yellow cervantite ($Sb_2O_3 \cdot Sb_2O_5$) are the common oxides, and the bright-yellow hydrous oxide stibiconite ($Sb_2O_4 \cdot H_2O$) is less common.

Minute crystals of sulfur occur with antimony oxides on stibnite in a few places.

Pyrite is present in all of the mines of the district but is particularly abundant in the Stayton mine. Much of it occurs as small cubes or pyritohedrons in vein quartz that is older than the antimony mineralization, but some is definitely younger. The oxidation of the pyrite in the Yellow Jacket and Stayton mines has introduced considerable amounts of sulfuric acid into the mine waters. Some of the sulfates occurring as secondary encrustations on the mine walls are epsomite ($MgSO_4 \cdot 7H_2O$) in long tapering hairlike needles, melanterite ($FeSO_4 \cdot 7H_2O$) in bright-green stalactites, and rarer white fibrous gypsum ($CaSO_4 \cdot H_2O$).

Barite ($BaSO_4$) occurs as thin tabular crystals with quartz in the Yellow Jacket mine and in the gossan of one of the prospects on Mariposa Peak, but it is nowhere abundant.

Jarosite, a hydrous sulfate of potassium and iron, forms rare yellow-brown colloform crusts in a few antimony veins in the district.

Although gold was not seen in any of the antimony veins

Mr. R. B. Knox [6] reported that they contain between \$0.50 and \$6 worth of gold to the ton.

Carbonates are locally developed in the silica-carbonate rock in the vicinity of the Comstock mine. Their buff coloration on weathering suggests they are dominantly ankerite. A few hollow, scalenohedral, quartz-coated molds found in the Stayton mine dump indicate the former presence of calcite crystals in the quartz-stibnite veins.

Paragenesis

All gradations exist between veins with only antimony, in the Ambrose mine, through deposits with both antimony and quicksilver, as in the Gypsy and Stayton mines, to quicksilver deposits with no antimony, in the Mariposa deposit. The antimony and quicksilver deposition took place during several successive stages some of which were separated by periods of fracturing whereas others were gradational. The mineral composition of each vein is probably dependent on whether the vein was open during early, middle, or late stages of ore deposition. The stages that have been recognized in each of the mines are shown in the table on page 420.

Origin and localization

The antimony veins were probably deposited at relatively low temperature and pressure by aqueous solutions ascending from deep-seated igneous sources. Although the mineralized area is surrounded by numerous igneous intrusive bodies, no direct genetic relation between them and the veins can be demonstrated. That the antimony veins are later than at least some of the intrusive andesite bodies is indicated by the presence of a vein along a fault in one of the larger plugs. In the vicinity

6/ **Oral communication.**

Mineralization of veins in the mines
of the Stayton district 1/

Stage	Ambrose	Blue Wing	Gypsy	Stayton	Mariposa	Comstock
Chalcedony or quartz and pyrite.....	?	A	A	M	...	?
Black flinty quartz and stibnite...	?	A	R	R	...	...
Stibnite.....	A	A	...	...	...	...
Fracturing...	...	M	M	A	...	...
Cinnabar and quartz, chalcedony, or opal....	...	...	A	M	...	A
"Paint" cinnabar......	...	R	A	A	M	R
Stibnite (supergene?).....	...	...	...	R	...	...

1/ A, abundant; M, moderate; R, rare.

of Antimony Peak two faults in andesitic extrusive rocks contain antimony veins, which suggests that part of this mineralization followed the faulting. These facts indicate that the earliest mineralization in the area is later than all igneous activity except possibly the emplacement of the intrusive rhyolite. The quicksilver deposition took place at a later date for it is separated from the antimony mineralization by a period of fracturing.

Many of the antimony veins end upward a few feet below the unconformity between the basaltic and andesitic rocks, and neither antimony nor quicksilver deposits are known to occur in the andesitic rocks except along faults bordered on one side by basalt. Some, and possibly all, of the mineralized faults were developed before the deposition of the andesitic rocks. Where there has been no later movement such fractures offered conduits along which mineralizing solutions could flow easily. The solutions probably penetrated the agglomerate in a few spots, but the relatively open spaces of the underlying fracture zone offered the most favorable locations for deposition of stibnite and accompanying quartz. Even after renewed movement on the faults much the same conditions prevailed. The andesitic agglomerate, which readily yielded to crushing and kaolinization, was perhaps even more impervious than before; on the other hand, the massive basalt and well-indurated tuffaceous agglomerate of the basaltic unit, together with quartz-stibnite veins, were shattered but not ground or crushed. Conditions were again favorable for ore deposition in the lower rocks, but the tightly sealed fractures above offered little chance for mineralization.

RESERVES

Antimony

The antimony reserves of the district cannot be closely estimated because high-grade pockets are distributed sporadically. The breccia veins, exclusive of rich pockets, average less than 1 percent of antimony, and although the total amount of antimony in them is a few tens of thousands of tons, the average grade is much too low for mining to be profitable, even with the high average price of 22 cents per pound that prevailed during the war years of 1915-18. Small high-grade pockets might be mined selectively but cannot be expected to yield large tonnages. These pockets do not appear to be sufficiently numerous to increase the average tenor of any considerable length of breccia vein to more than 1½ percent. In the Ambrose mine, on one of the best veins in the district, the tenor of the ore in the stopes must have been approximately 6 percent. Probably no ore body containing more than a few tons will average above 5 percent antimony, and mining on larger scale must be done on ore averaging less than 1½ percent.

Quicksilver

The quicksilver reserves of the Stayton district are comparatively small. Assuming that new ore bodies similar to those that have been stoped will be found along unprospected segments of vein zones adjacent to the mines, a future production of more than 1,000 flasks may be expected. The Stayton mine is probably capable of yielding nearly 100 flasks per year for a few years if operated on a larger scale. The other mines of the district can be expected to add very little.

Although the mines of the district are estimated to contain only slightly more than 1,000 flasks, the chances of finding new ore bodies are rather good. Between the Stayton and Gypsy mines a part of the vein zone has been prospected, but further prospecting might uncover additional shoots of medium-grade ore. There is also a good possibility that additional ore will be found in the area lying west and south of the present workings of the Stayton mine. The edge of what may be a large ore body, said to average 2 pounds to the ton, is exposed in the western workings of the Stayton mine. Such ore might be worked profitably by large-scale stripping operations with prices only slightly higher than $185 per flask. The chances of finding quicksilver deposits elsewhere in the area seem more remote.

SUGGESTIONS FOR PROSPECTING

Additional quicksilver deposits in silica-carbonate rock should be sought in the northwestern corner of the district and farther north and west outside of the area mapped. The best place to prospect the eastern antimony veins for cinnabar is at higher altitudes immediately below the contact between the two volcanic units or below the projection of this contact where it is now removed by erosion.

The most favorable place to prospect for cinnabar ore along the exposed fault zones in basalt is between the Gypsy and Stayton mines. The Stayton vein is not exposed above the mine road, but the faulting of the contact between the two volcanic units indicates that the fault zone at least crosses the ridge to the south. The projection of this vein immediately below the andesitic agglomerate is also worth investigating. An ore body might be found in the pre-Tertiary sedimentary rocks below the Stayton vein, but the estimated depth to these rocks below the surface, about 1,300 feet, makes the chance for finding ore rather remote. Small amounts of good ore were found southeast of the Mariposa mine, and perhaps other small pockets might be found along this same zone.

No quicksilver ore is known to occur in the andesitic agglomerate or in andesite and rhyolite intrusives in the district; these rocks may be regarded as the least favorable in which to prospect.

DESCRIPTION OF MINES

Antimony mines

Of the several small antimony mines in the district, only one, the Ambrose, was open in the spring of 1941 when the field work was done.

Ambrose mine.--The Ambrose mine, also known as the Rip Van Winkle mine, (see fig. 47) is in sec. 30, T. 11 S., R. 7 E. in the northeastern corner of San Benito County. The mine has not been operated for more than 20 years, and production probably has not exceeded 100 tons of antimony. The lowest level could not be examined because it was flooded; if any large stopes exist along this flooded level they would increase the estimate of past production. Hand-sorted ore shipped from the mine averaged 38-50 percent antimony.

The only ore mineral is stibnite which, together with a little milky quartz, forms a nearly continuous vein that strikes N. 20° W. and dips 65° SW. in and close to the southern border of an andesitic intrusive body. The vein, which is split at several places, swells from almost nothing to a width of

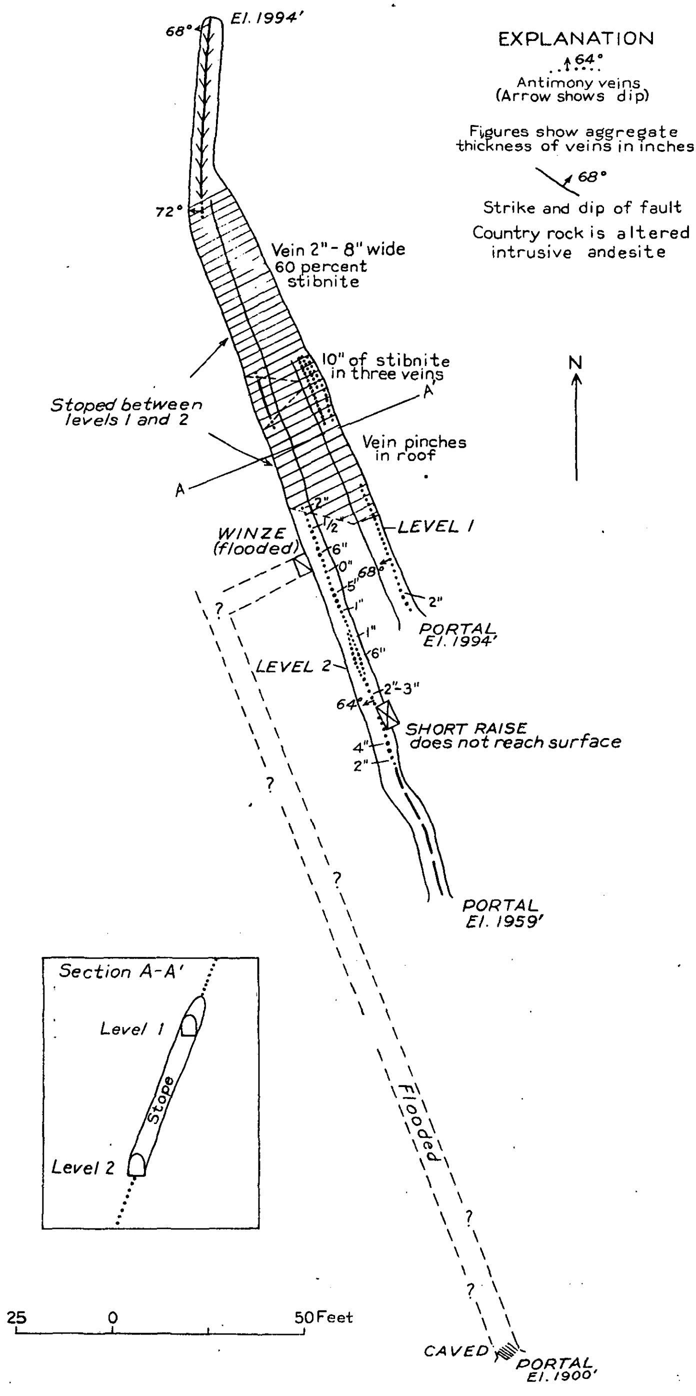

Figure 47.—Geologic map of the Ambrose mine.

10 inches within short distances, but in the main stope the average width perhaps exceeded 5 inches. The wall rock is kaolinized adjacent to the vein for only a few feet and contains minor amounts of disseminated pyrite.

The vein pinches in the roof of the upper level and may die out upward, for it could not be found on the hillside immediately above; however, at the top of the ridge along the continuation of the altered zone, a 4-inch vein of nearly pure stibnite is exposed in a small trench. On the second level the stibnite vein ends 200 feet from the portal, but the fracture continues as far as it has been prospected, a distance of about 50 feet. Whether the vein continues southward into the surrounding Franciscan rocks is not known as exposures are poor, but the decreasing width of the vein southward in the mine suggests that the mineralization is confined to the intrusive rock.

Only small reserves are in sight in the mine. The presence of undiscovered ore bodies along the vein in any direction, except possibly downward, seems improbable. The ore near the portal between the two upper levels cannot be expected to yield more than a few tons of antimony.

Blue Wing mine.--The Blue Wing mine, owned by Mr. R. B. Knox, is in sec. 5, T. 12 S., R. 7 E., a few hundred yards southwest of the Stayton mine. It is believed to have produced a few tons of hand-sorted ore. As the mine is now flooded the following information is that offered by Mr. Knox, supplemented by the authors' examination of the rock on the small dump.

The workings consist of a vertical shaft approximately 75 feet deep with a drift to the north and a short, shallow drift to the south. The ore is in northward-trending quartz-stibnite veins in basalt. The vein is apparently discontinuous, but locally it contains lenses of nearly pure stibnite slightly less than a foot thick. Cinnabar was found in vugs and along fractures in the upper 20 feet of the stibnite vein, but it did not occur below this level.

The vein was carefully prospected a few years ago, and at that time was considered of too low grade to be worked for either antimony or quicksilver. A few tons of ore containing nearly 50 percent of stibnite remains on the dump.

Shriver mine.--The Shriver mine, located in sec. 31, T. 11 S., R. 7 E., had been caved for a number of years prior to 1941. The vein has been opened along two tunnels with an aggregate length of 1,200 feet. Small amounts of quicksilver ore have been found near the surface, and assayed specimens of the antimony vein have yielded $25 in gold and $17 in silver per ton.[7] One and one-half tons of high-grade antimony ore was shipped from the mine in 1893.[8]

Quicksilver mines

Stayton mine.--The Stayton mine, owned by Mr. R. B. Knox, is in sec. 5, T. 12 S., R. 7 E. in western Merced County. Located in 1870, it has been the principal producer in the Stayton district. The first mining is said to have been for stibnite, but between 1876, when the Stayton Mining Co. gained control of the property, and 1880, quicksilver was mined, and it is reported that about 1,000 flasks were produced from the Stayton and Gypsy mines. After the early eighties the mine was inactive, except for a short period in 1917-18, until 1920 when Mr. Knox began small-scale operations. Since 1920 the mine has yielded approximately 400 flasks of quicksilver. It is equipped with a 12-ton furnace and a retort.

The ore is cinnabar in veinlets that fill fractures in both fresh and kaolinized basalt along a north-trending normal fault

7/ Irelan, William, Jr., California State Min. Bur., 10th Ann. Rept. of State Mineralogist, p. 517, 1890.
8/ Crawford, J. J., California State Min. Bur., 12th Rept. of State Mineralogist, p. 23, 1893-94.

zone which has a dip of 58° W. As is shown on the mine map, plate 65, cinnabar extends from the footwall across the fault zone and into the hanging wall for a distance of at least 75 feet. Although "paint" can be found throughout most of this distance, the minable ore is confined to several narrow veins. Minable ore was found against the footwall, 7-12 feet west of the footwall below a zone of clay gouge, and in small amounts along a series of parallel fractures 60 feet west of the footwall on the 30-foot level. The location of the stopes suggests that the ore was localized by slight bulges in the footwall where there are changes of a few degrees in strike.

On the 150-foot level there are 775 feet of drift. The footwall is said to steepen to nearly vertical on this level, and ore is said to occur above, but not in, the steep portion of the fault. An inclined shaft that follows the dip of the footwall is said to reach the 250-foot level,[9] but all of the workings more than 25 feet below the 70-foot level were either flooded or filled with waste or gas during the authors' investigation in 1941. On the 250-foot level, where the dip of the fault is less steep, additional ore is reported.

In the northern part of the mine a vuggy quartz-stibnite vein immediately above the footwall is crushed on the 70-foot level, but 250 feet from the portal it is less thoroughly fractured and wider. Apparently this vein exerted no control on the cinnabar mineralization. Open cracks, as much as a foot wide and containing good quicksilver ore, are said to occur in the southern part of the 150-foot level along this vein.

An adit, driven to intersect the vein 70 feet north of the main portal passed through a small high-grade pocket of cinnabar along what is probably the northerly extension of the footwall

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9/ Bradley, W. W., Quicksilver resources of California: California State Mining Bur. Bull. 78, p. 121, 1918.

of the main Stayton vein. A westward continuation of the crosscut exposed only thin streaks of cinnabar.

As in most cinnabar mines, nearly all ore of furnace grade was stoped as it was found. This fact, coupled with the inaccessibility of the lower levels, makes any estimate of reserves difficult. The mine was being operated in 1941 by three men who had no difficulty in taking out and retorting enough hand-sorted ore to yield a couple of flasks of quicksilver each month. Development work has shown that ore suitable for hand-sorting to an average of 40 pounds to the ton occurs above and west of the 30-foot level. The intervening 60-foot zone, between this level and the footwall, contains many stringers and coatings of "paint" but is said to average less than 2 pounds of quicksilver to the ton. The grade is consequently too low for furnace ore at present prices ($185 per flask), although the ore could be very cheaply mined by stripping from the surface. According to Mr. R. B. Knox the ore is not bottomed at the 250-foot level, nor do the workings run out of ore to the south. The absence of cinnabar from the crosscut to the north of the mine indicates that the ore does not continue in this direction. The eastern side of the footwall has never been prospected for more than a few feet, and as the fault zone is known to be multiple, some additional ore might be encountered east of what is considered to be the footwall.

The best area for future development lies to the west, as the zone of alteration and shearing is known to be at least 400 feet wide in the nearby Yellow Jacket mine. A large amount of additional prospecting and development work may be necessary before workable ore bodies are found, but it seems highly probable that the future production of the mine should at least equal its past record of about 1,000 flasks. As the mine was being operated in 1941, development work was very slow but more than paid for itself by the recovery of ore found in small rich stringers.

Yellow Jacket mine.--The Yellow Jacket mine, owned by Mr. R. B. Knox, is in sec. 5, T. 12 S., R. 7 E., in western Merced County. The portal is slightly more than 500 feet northwest of

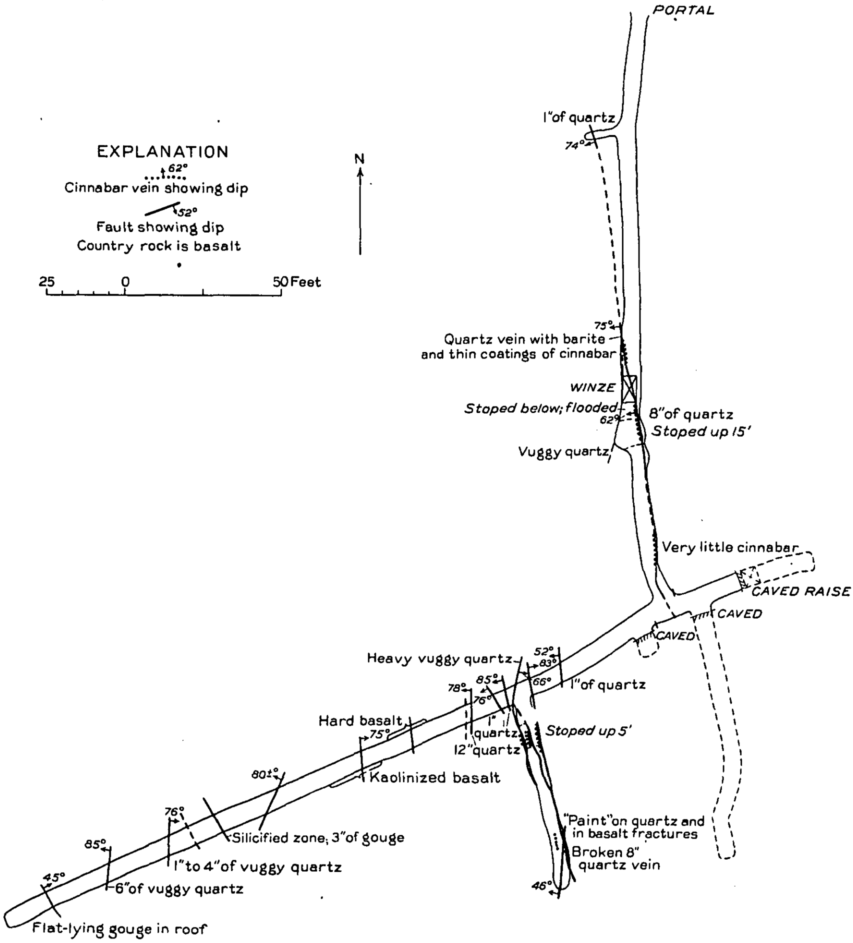

Figure 48.--Geologic map of the Yellow Jacket mine.

the portal of the Stayton mine. Only a few tons of ore have been taken from the mine.

The main workings, as shown in figure 48, are entirely in fresh and kaolinized basalt. They consist of a 175-foot adit extending to the south and a 275-foot crosscut, most of which lies west of the adit. Cinnabar coatings on a quartz vein and rare barite in the adit 100 feet from the portal did not continue beyond short stopes in the roof and floor. In the crosscut another vein zone 55 feet west of the adit also contained a few rather thin seams of cinnabar. Several other steeply dipping quartz veins which strike a few degrees west of north were intersected in the crosscut. The veins are broken locally but nowhere highly brecciated; only in a few places do they contain any stibnite. Several zones of silicified rock parallel the veins but do not contain quartz veins.

Although some ore has been found in the mine no ore was in sight in 1941. The mine is apparently in a nearly barren zone and future development cannot reasonably be expected to reveal more than small, scattered ore bodies.

Gypsy mine.--The Gypsy mine, owned by Mr. R. B. Knox, is in sec. 5, T. 12 S., R. 7 E., in western Merced County. It is about 2,400 feet north of the Stayton mine on the same wide fracture zone, but probably not on the continuation of the same vein. Its production record can only be inferred; perhaps less than half of the 1,000 flasks taken from the district prior to 1880 came from this mine. The mine was recently leased, and operations on a small scale were expected to begin in the summer of 1941.

The mine workings open in July 1941 are shown in plate 66. They consist of a stope open to the surface and extending down an incline for about 100 feet, several short drifts, and two adits. An inclined shaft, reported to have reached a depth of 40 feet below the present accessible workings, is now caved.

The mine explored a silicified zone 10-17 feet thick along a normal fault which strikes N. 20° W. and dips 37°-51° SW. The country rock is a well-indurated tuff-breccia of the basaltic unit.

The silicified zone is defined by slickensided fault planes at its hanging wall and a sinuous gradational contact at its footwall. The rock of the zone apparently has been subjected to several stages of mineralization separated by intervals of movement along the fault. The earliest silicification of the tuff-breccia was accompanied by deposition of light-gray sugary quartz and small amounts of pyrite. This vein material was later fractured and cemented by drusy quartz containing a few minute needles of stibnite. Still later movements brecciated this silicified rock and formed the fractures which now contain cinnabar.

Cinnabar, the only ore mineral, occurs as light-red to deep-purple massive vein fillings in steep fractures, and as colloform coatings encrusting quartz crystals in small vugs. Light yellow-brown opal locally accompanies the cinnabar.

The ore body, composed of numerous steep fractures filled with cinnabar, was about 50 feet long and 5-10 feet thick, and extended down the dip of the fault for 75 feet. The average tenor is believed to have been about 10 pounds of quicksilver to the ton. A slight upward roll of the fault plane, involving only small changes of strike and dip, possibly localized the ore body. The fault zone in the southern workings is only slightly silicified and contains no ore, but part of the barren zone in the northern workings is thoroughly silicified.

The reserves in sight are small, but exploration of the vein zone at depth might reasonably be expected to find additional ore bodies. A clean-up of the ore in the walls would not yield more than 100 flasks of quicksilver. The segment of vein between the Gypsy mine and a resistant outcrop of the vein 500 feet to the south has not been adequately prospected and is one of the most favorable places in the district for future exploration.

Comstock mine.--The Comstock mine is in sec. 19, T. 11 S., R. 7 E., in the extreme southeastern corner of Santa Clara

County. Forstner [10/] reported that the mine was not operated for a number of years prior to 1903. A single sentence by Raymond [11/] indicates the existence of a retort in 1875. No production figures are obtainable. The grade of the ore left in the stopes together with the size of the stopes suggests that about 300 flasks may have been recovered. The lower levels of the mine were flooded in 1941 so the full extent of the workings could not be determined.

The mine is in serpentine and in silica-carbonate rock which extends along the western edge of the serpentine from the mine to one fork of Pacheco Creek 300 yards to the south. The serpentine east of the silica-carbonate rock forms a northward-trending belt about 600 feet wide.

The major structural control for the ore body (see pl. 67) is exerted by a fault that strikes N. 55°-65° E. and has an average dip of 30° S. The serpentine on the hanging wall is highly silicified and almost everywhere converted to dense black flinty chalcedonic quartz containing disseminated pyrite. All of the cinnabar found in the mine occurs above the fault in this silica-carbonate rock. The cinnabar is closely associated with the silica; it replaces the black chalcedonic quartz, and occurs in very siliceous irregular veinlets, and to a lesser extent in small veinlets of nearly pure cinnabar cutting the quartz. Some ore is found in a series of fractures nearly parallel to the main fault. No ore is known to occur in or below the zone of gouge that lies along the main fault and is as much as 2 feet thick in places.

A secondary control for the deposition of the cinnabar is a series of irregular, nearly vertical fractures trending approxi-

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10/ Forstner, William, op. cit., p. 172.
11/ Raymond, R. W., Mineral resources west of the Rocky Mountains: U. S. Treas. Dept., 7th Annual Report, p. 14, 1875.

mately N. 40° W. All of the best ore was found in the upper workings around the old stopes which follow these fractures.

The mine appears to be nearly worked out. Crosscuts immediately above the fault zone, the most favorable place for ore, extend 25 feet east and 85 feet west of the main incline but do not expose any ore. Some ore with metacinnabar, largely replaced by cinnabar, occurs in a vein along the eastern incline which connects with the open surface stope. A clean-up of the retort ore in sight, supplemented by any possible ore in the block between the two main inclines, probably would not yield more than 100 flasks of quicksilver.

Other small lenses of silica-carbonate rock in the first canyon west of Wildcat Canyon might be profitably prospected.

Mariposa mine.--The Mariposa mine is in sec. 28, T. 11 S., R. 7 E., in the northeastern corner of San Benito County. There is no record of production from the mine, though Forstner's report on the Stayton district indicates that the claims were staked prior to 1903.

The workings shown in figure 49 consist of a 350-foot drift and several shorter drifts. The main drift is in basalt, but material on the dump indicates that altered intrusive rock was reached in the easternmost workings. The principal shear zone, 60 feet wide, consists of a series of faults most of which strike N. 45°-70° W. and dip moderately to steeply northeast. Cinnabar is present in only very minor amounts although, according to Mr. R. B. Knox, a small ore body was taken out of a raise from the southern branch of the drift. Silicified rock is rare, and no stibnite was seen. The mine has probably produced little ore, and reserves are negligible.

Approximately 1,400 feet southeast of the Mariposa mine on the same altered zone are three shafts. The timbered one is flooded to within 30 feet of the surface. About 600 feet farther to the southeast is a caved drift which may extend several hundred feet to the northwest. A shallow prospect pit, 115 feet southeast of the timbered shaft exposes a fractured zone in basalt which is faulted against intrusive andesite on the east.

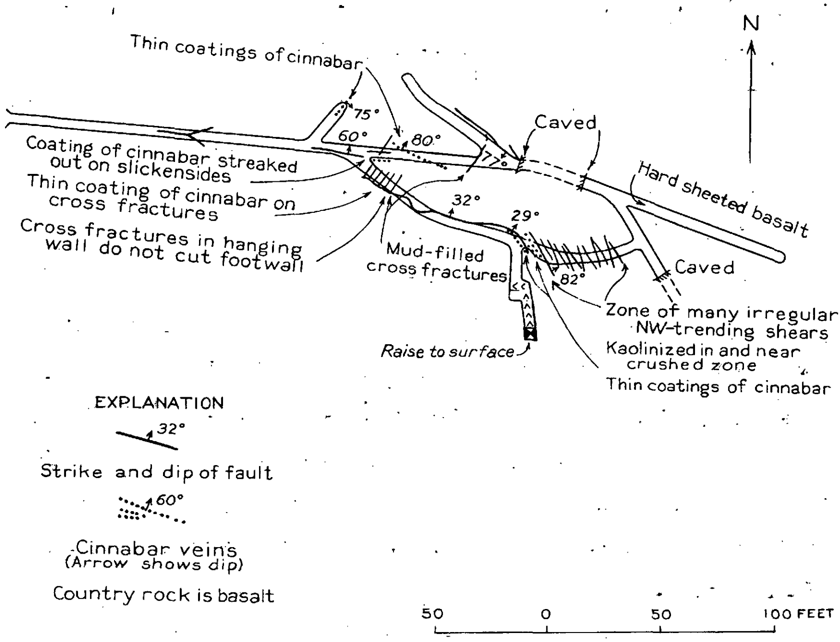

Figure 49.—Geologic map of the Mariposa mine.

On the basalt side of the fault, "paint" is distributed through a 6-foot zone, the central part of which contains ore of good retort grade.

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