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QUICKSILVER DEPOSITS OF THE PARKFIELD DISTRICT, CALIFORNIA

BY
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CONTENTS

Page

ILLUSTRATIONS

Page

QUICKSILVER DEPOSITS OF THE PARKFIELD DISTRICT, CALIFORNIA

By Edgar H. Bailey

ABSTRACT

The Parkfield district, one of the minor California quicksilver districts, lies on the southern end of the Diablo Range, in the southeastern part of Monterey County and the westernmost tip of Kings County. Although quicksilver was first discovered in 1873, the mines were comparatively inactive until 1915. Of the total production of the district, which amounts to 3,772 flasks of quicksilver, more than two-thirds was recovered between 1914 and 1920.

Two geologically similar areas, separated by 10 miles of unmineralized rocks, have been mapped. These areas contain (1) sedimentary, volcanic, and metamorphic rocks belonging to the Franciscan formation, of probable Jurassic age, (2) sedimentary rocks of Cretaceous age, (3) a few outcrops of fossiliferous strata assigned to the Temblor formation, of middle Miocene age, (4) large masses of serpentine emplaced along fault zones in post-Miocene time, (5) lenses of silica-carbonate rock formed by the alteration of the serpentine, and (6) large areas of landslide.

The central part of each area is occupied by a large serpentine lens, which is bounded on the north by a nearly vertical fault and on the south by a northward-dipping thrust fault. At Table Mountain the thrust fault can be seen to overlie middle Miocene beds. The productive ore bodies occur in serpentine or in silica-carbonate rock, some being in bedrock near the faults bounding these serpentine masses and some in landslides that extend down the slopes from the serpentine outcrops.

The principal ore minerals are cinnabar and native mercury. The cinnabar, which is by far the more abundant, is partly hypogene and partly supergene. Hypogene cinnabar occurs as encrustations and fracture fillings in silica-carbonate rock and sheared serpentine, and it also forms impregnations and pockety replacements in sandstone of the Franciscan formation. Supergene cinnabar, which locally enriches landslide masses to form minable ore bodies, forms pink films on crushed rock in the landslide as well as darker coatings of microcrystalline cinnabar and bright-red crystalline encrustations. Native mercury is most abundant in the sandstone ore, but some of it is associated with cinnabar in sheared serpentine.

The ore bodies occur (1) in silica-carbonate rock and slightly silicified sheared serpentine underlying subsidiary thrust faults, which are structurally related to the faults that bound the serpentine, (2) in sandstone of the Franciscan

formation beneath the overthrust serpentine, (3) in large blocks or groups of blocks of silica-carbonate rock, that form parts of extensive landslides, and (4) in landslides consisting mostly of crushed serpentine but containing scattered blocks of ore that have subsequently been enriched by the deposition of supergene cinnabar.

Reserves amount to only a few hundred flasks of quicksilver, but there are chances of finding new ore bodies. New development work which was under way in the summer of 1941 yielded a small amount of quicksilver, and further development may possibly find a new ore body. If a price of $200 a flask is maintained the mines of the district can be expected to yield a small production for at least a few years.

INTRODUCTION

The Parkfield district lies in the southeastern part of Monterey County and the westernmost tip of Kings County, Calif., on the crest of the southern end of the Diablo Range (fig. 14). Quicksilver ore is found in two geologically similar areas, which are separated by a barren zone about 10 miles long. The northwestern area, on Mine Mountain in Tps. 22 and 23 S., R. 16 E., will be referred to as the Patriquin area; the southeastern area, in T. 23 S., Rs. 15 and 16 E., will be referred to as the Table Mountain area.

Parkfield is the nearest town to both areas. The Patriquin mine is connected with the main road between Parkfield and Coalinga by 3 miles of dirt road, that are passable only in the dry summer months; and the road from the Table Mountain area to Parkfield, being steep and rough, is also impassable in the winter. San Miguel, the nearest station on the Southern Pacific Railroad, is 26 miles from Parkfield.

Little geologic work has been done in the vicinity of the mines, although the surrounding area has been mapped in considerable detail by English,[1] by Arnold and Anderson,[2] by McLaughlin and Waring,[3] and by others.

1/ English, W. A., Geology and oil prospects of the Salinas Valley-Parkfield area, Calif.: U. S. Geol. Survey Bull. 691-H, pp. 219-250, 1918.

2/ Arnold, Ralph, and Anderson, Robert, Geology and oil resources of the Coalinga district, Calif.: U. S. Geol. Survey Bull. 398, 1910.

3/ McLaughlin, R. P., and Waring, C. A., Petroleum industry of California: California State Min. Bur. Bull. 69, pp. 425-426, 1914.

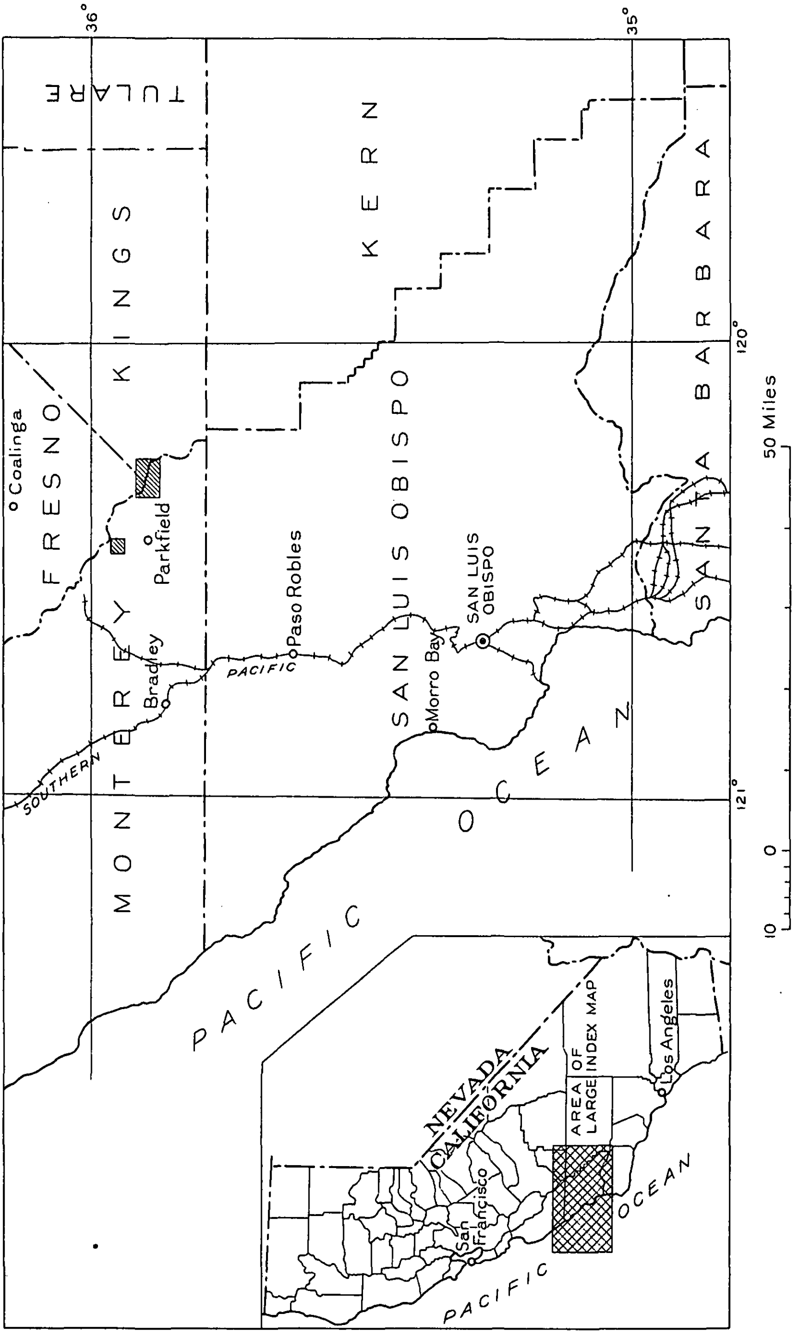


Figure 14.--Map showing location of the Parkfield district, Calif., and the areas comprising plates 17 and 19.

The field work for this report was done during 4 weeks in June and July 1941. W. Bradley Myers assisted in mapping the

Patriquin area and in all of the underground mapping; Fred B. Roberts assisted in mapping the Table Mountain area.

The operators and miners in the district were uniformly courteous and helpful. The writer is also indebted to E. B. Eckel of the Geological Survey for advice during the field work and the preparation of this report. F. C. Calkins, H. G. Ferguson, and T. B. Nolan also contributed many helpful suggestions.

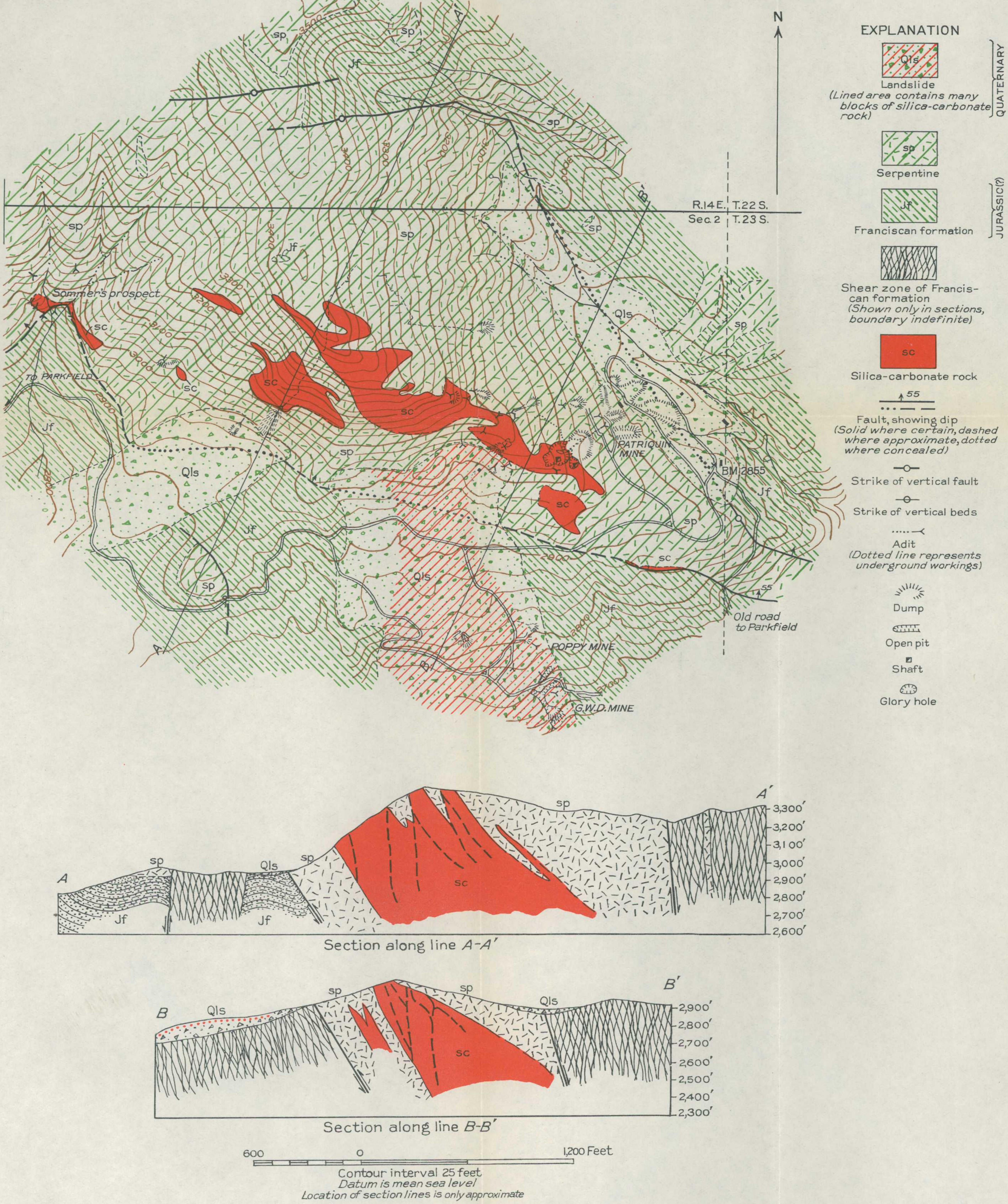
History and production

The first discovery of quicksilver in the Parkfield district was made at the Patriquin mine in 1873 by a man named Pitts, who abandoned the property after producing 60 flasks in that year. In 1902 a few flasks were produced from the Kings mine, but most of the production of the district came between 1915 and 1920, in which period 2,673 flasks were produced. The total recorded production of the district through 1940 is 3,772 flasks. The table on page 147 shows the recorded annual production of the various mines.

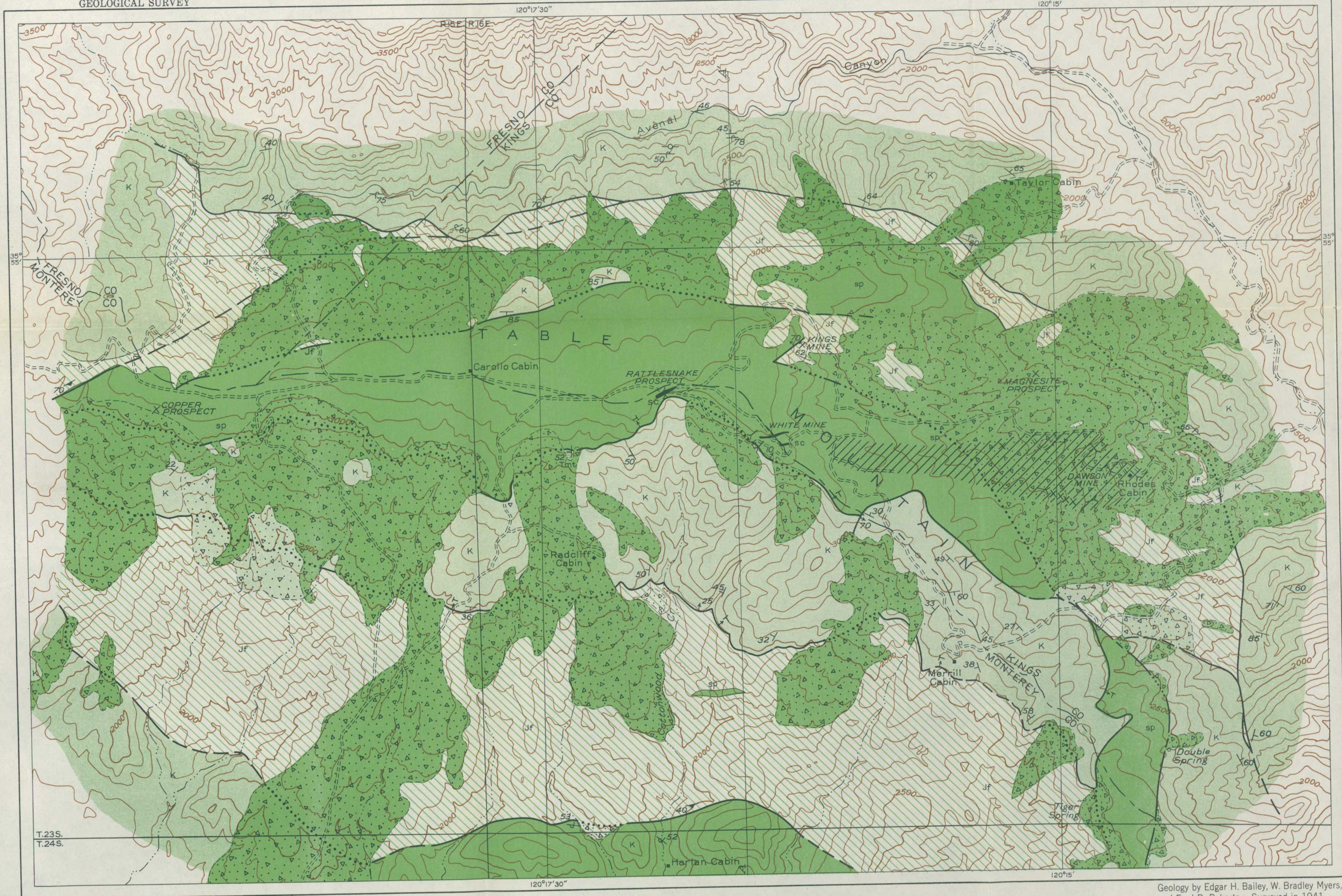
GEOLOGY

In the two areas mapped for this report (see pls. 17 and 19), there are exposed (1) sedimentary, volcanic, and metamorphic rocks assigned to the Franciscan formation, which is probably Jurassic, (2) sedimentary rocks of Cretaceous age, (3) a few outcrops of sandstone and shale assigned to the Temblor formation, of middle Miocene age, (4) large masses of serpentine emplaced along fault zones in post-Temblor time, (5) lenses of silica-carbonate rock formed by the alteration of the serpentine, and (6) large areas of landslide, some of which are Quaternary in age and some are possibly older.

In both areas a large lenticular mass of serpentine forms the core of the mountain; the serpentine is believed to have



GEOLOGIC MAP AND SECTIONS OF THE PATRIQUIN AREA



Topographic base by Geological Survey
U. S. Department of the Interior
Parts of The Dark Hole and Reef Ridge Quadrangles

Geology by Edgar H. Bailey, W. Bradley Myers, and Fred B. Roberts. Surveyed in 1941

EXPLANATION

QUATERNARY

Landslide
(Color shows dominant rock in slide)

Landslide
(Contains many blocks of silica-carbonate rock)

TERTIARY

Tmt — Temblor formation of middle Miocene age. Fossiliferous sandstone, shale, and conglomerate

CRETACEOUS

K — Sedimentary rocks
(Dominantly dark shale; also buff sandstone, limestone, and conglomerate)

sp — Serpentine

JURASSIC (?)

Jf — Franciscan formation
(Mainly gray sandstone and dark shale; many lenses of chert; bodies of basic volcanic rock altered to greenstone. Shear zone shown only in section)

sc — Silica-carbonate rock

Fault showing dip and overthrust side T
(Solid where certain, dashed where approximate, dotted where concealed)

45 Strike and dip of beds

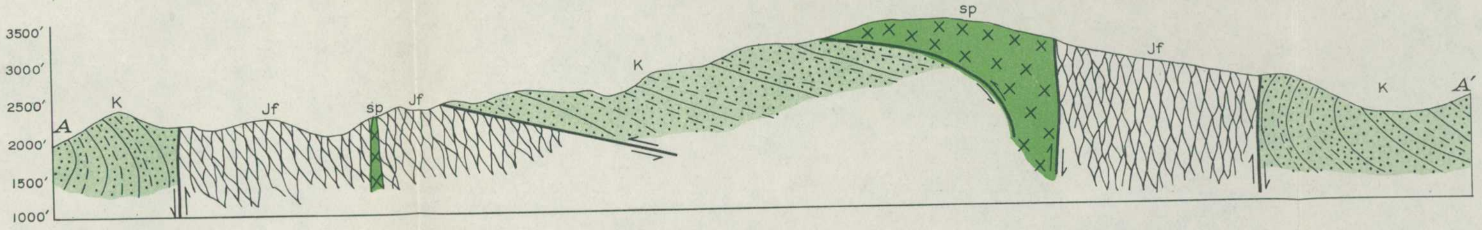
75 Strike and dip of overturned beds

Strike of vertical beds

40 Strike and dip of foliation

Adit

× Prospect



GEOLOGIC MAP AND SECTION OF THE TABLE MOUNTAIN AREA

1 ½ 0 1 Mile

Contour interval 100 feet
Datum is mean sea level

Recorded quicksilver production, in flasks,1/ from the mines of the Parkfield district, California, 1873-1940 2/

Year	Patriquin area			Table Mountain area		
	Patriquin 3/	G.W.D. 4/	Poppy 4/	Kings 5/	Dawson 6/	White 7/
1873.....	60	...	...	...	.....	...
1902.....	.....	...	...	?	.....	...
1905.....	.....	...	...	250	.....	...
1910.....	.....	...	...	100	.....	...
1915.....	183	...	...	200	.....	...
1916.....	355	...	...	280	.....	3
1917.....	368	...	...	...	.....	...
1918.....	152	...	...	...	75	...
1919.....	.....	...	...	...	613	...
1920.....	311	...	...	...	136	...
1921.....	.....	...	...	...	100	...
1922.....	16	...	...	...	106	...
1923.....	45	...	...	...	9	...
1924.....	16	...	...	...	.....	...
1925.....	198	...	...	...	1	...
1927.....	48	...	...	...	.....	...
1931.....	.....	...	...	...	4	...
1932.....	.....	...	3	...	.....	...
1935.....	6	...	...	11	20	...
1936.....	4	...	...	...	5	...
1937.....	36	...	...	2	9	...
1938.....	.....	...	...	11	.....	...
1939.....	.....	3	...	11	8	...
1940.....	.....	4	...	10	.....	...
Total..	1,798	7	3	875	1,086	3

1/ A flask contained 76½ pounds previous to June 1904, 75 pounds thence through 1927, and 76 pounds since January 1928.

2/ From records of the California State Min. Bur. No recorded production for years not listed.

3/ Published with permission of Mr. F. A. Anstey, owner.

4/ Published with permission of Mr. N. Gillette, owner.

5/ Published with permission of Mr. L. K. Anderson, owner.

6/ Published with permission of Mr. J. Ellena, owner.

7/ Published with permission of Mr. L. S. White, owner.

been intruded along a fault zone not as peridotite but as serpentine. The northern boundary of each serpentine mass is a nearly vertical fault, while the southern boundary is a northward-dipping thrust fault. The more important mines of the district lie on the serpentine side of these faults.

Lithologic units

Franciscan formation

The Franciscan formation, probably of Jurassic age, is the oldest formation in the district. It consists of shale, sandstone, conglomerate, chert, basic volcanic rocks now converted to greenstone, and various metamorphic rocks. The exposed thickness is probably more than 3,000 feet, but the complex structure together with the absence of distinctive beds makes the exact determination of thickness impracticable. Nearly all of the contacts with younger formations, other than alluvium and landslides, are faults.

Dark-brown to black siltstone devoid of lamination is probably the dominant rock within the areas studied, although it is rarely exposed. It differs from the Cretaceous shale in having a darker color, in containing no concretions, and in lack of lamination.

The sandstone in the Franciscan formation shows considerable variety. It is generally medium- to fine-grained and light gray in color, but locally it weathers to a light-tan color. Small rock fragments are abundant in some specimens; lenses of carbonized wood and shale flakes locally indicate bedding which elsewhere is indeterminable.

Conglomerate, which can only with difficulty be distinguished from the Cretaceous conglomerate beds, is relatively rare in the Franciscan formation.

Chert lenses up to a few hundred feet long form bold outcrops, and where the soil is deepest they provide the only outcrops. The chert is mostly red, pink, or green in color, but some of it is white. It is thin-bedded, chert layers 1 to 2 inches thick being separated by 1/8-inch layers of shale. Many of the chert bodies are intricately folded; others are strongly brecciated.

Greenstone is less abundant than chert in the Franciscan formation. It is most easily recognized by its dull-green color, fine-grained texture, a hardness greater than that of most serpentine, and intricate brecciation.

Metamorphic rocks of varied composition are associated with the unmetamorphosed Franciscan rocks; the commoner varieties are recrystallized chert, glaucophane schist, hornblende gneiss, and various phyllites.

The soil cover above the Franciscan rocks is generally gray in color and contains scattered angular fragments of chert.

Cretaceous rocks

Cretaceous sedimentary rocks are exposed on the flanks of Table Mountain (pl. 19). Their total thickness in the section north of Table Mountain is probably a few tens of thousands of feet, but only the lower part of this section is included in the mapped area.

The dominant sediments are thinly laminated brown or gray-black shales that contain elliptical limy concretions. The concretions and the distinct lamination distinguish these shales from those of the Franciscan formation, which, too, is more contorted and sheared than the Cretaceous rocks. Thin layers of buff or tan flaggy sandstone interbedded with the shale stand out as prominent ribs. The sandstones are medium- to fine-grained and contain abundant feldspar. Lenses of conglomerate occur at a few places in the Cretaceous strata. The pebbles, which range in size from 1 to 8 inches and are generally well rounded, consist of chert and volcanic rocks derived from the Franciscan formation, together with granite, porphyry, and quartzite. A single 3-foot bed of limestone, which contained poorly preserved fossils, was found three-fourths of a mile northwest of the Kings mine.

The buff-colored soil, nearly devoid of rock fragments, derived from the Cretaceous rocks, is easily distinguished from the stony gray soil derived from rocks of the Franciscan formation.

Temblor formation

Rocks assigned to the Temblor formation of middle Miocene age crop out at only one place, on the south slope of Table Mountain and beneath the serpentine-capped thrust fault. Gray to buff fossiliferous sandstone is the most prominent rock, but buff shale and conglomerate are equally abundant. Miss Myra Keen of Stanford University kindly identified some of the better-preserved fossils and reported them to be of the same age as those found in the Temblor formation at the type locality.

Serpentine

Large bodies of serpentine, derived from ultrabasic rocks, form the cores of Table Mountain and Mine Mountain and contain the more productive mines of the district. The least altered of the ultrabasic rocks are dark bluish-green to black on fresh surfaces, but they weather to reddish-yellow and reddish-brown hues. Crystals of pyroxene, or pseudomorphs of serpentine minerals after pyroxene, ranging in size from a quarter of an inch to as much as 4 inches in length characterize the massive varieties. Minute shiny black crystals of picotite are commonly present, and chromite and magnetite are locally abundant. Veinlets and networks of chrysotile asbestos cut nearly all kinds of the serpentine. The thoroughly serpentinized rocks are bright green and locally slickensided. Along shear zones the rock is softer and lighter-colored than elsewhere; the shearing has almost everywhere caused the development of a schistose texture.

The serpentine is believed to have reached its present position not as peridotite but as serpentine. The lines of evidence which lead to this conclusion are (1) the absence of metamorphic effects in the vicinity of the serpentine, (2) the complex shearing in the serpentine mass itself, and (3) the shape and form of the serpentine lenses. The serpentine was thrust over middle Miocene sedimentary rocks, and, moreover, the shape of the mass indicates this thrusting may have been closely related to the emplacement of the serpentine. The large volume of serpentine landslide material, as well as the absence of other rocks within these slides, suggests upward movement of the serpentine in relatively recent time.

Silica-carbonate rock

Most of the ore bodies lie in masses of more or less thoroughly silicified or carbonatized sheared serpentine known as silica-carbonate rock or "quicksilver rock". The recognition of this type of rock is thus of the utmost importance in the search for ore.

Two rather distinct varieties are abundant. The commoner one consists mainly of hard black chalcedonic quartz that locally has a schistose texture inherited from sheared serpentine. Pyrite is sparsely distributed in this rock, and minute shiny black grains of picotite are widespread; veinlets of carbonates and late clear quartz are locally abundant. The other variety is composed essentially of sugary buff-colored carbonate and closely resembles ordinary limestone. Generally this rock is quite massive and shows no traces of shearing, but careful examination will usually disclose a few grains of picotite or an isolated pyroxene pseudomorph. Some of the silica-carbonate rocks show interfingering of these two varieties.

In the Patriquin area, the masses of silica-carbonate rock are extensive and stand out as knobs and prominent outcrops on the main ridge, but in the Table Mountain area the rock occurs only in small lenses, erratically distributed, and its outcrops are less conspicuous.

Landslides

Landslides are prevalent on the slopes of the Diablo Range in the Parkfield district, and they are of economic importance because they locally contain workable ore bodies.

In the Patriquin area (see pl. 17), three landslides have been mapped. The central one of these, which originated in the vicinity of the glory hole of the Patriquin mine, contains minable ore in the Poppy and G. W. D. mines. The part of this slide that contains many silica-carbonate blocks is indicated on the map by a distinctive pattern. The other two slides consist mainly of serpentine and rocks of the Franciscan formation, and contain only small scattered pieces of silica-carbonate rock.

In the Table Mountain area (see pl. 19), about a fourth of the surface is covered with landslides. The dominant rock of each slide, as is shown on the geologic map, is in most places serpentine. Good exposures of this slide material in steep canyons show that it is composed of rounded boulders of serpentine, some more than 10 feet in diameter, surrounded by intricately sheared, slickensided, and completely crushed serpentine. No characteristic differences between the slide material and the serpentine in place could be found; the areas mapped as landslide with dominant serpentine are known to be such either because the areal mapping indicates that these areas must be underlain by other rocks or because of their characteristic landslide topography.

A landslide area extending from the White mine to the Dawson mine contains an extraordinary number of blocks of silica-carbonate rock, and as it is a favorable place for future prospecting it is shown on the map by a pattern different from that used for ordinary landslides.

Structure

The structure of the two areas shown in plates 17 and 19 is similar in many respects; in each of them the core of the mountain is an elongate body of serpentine separated from sedimentary rocks on its north side by a vertical fault and on the south side by a northward-dipping thrust fault which in the Table Mountain area is of post-Miocene age.

The structure of the Patriquin area may best be understood from the section on plate 17. Wide shear zones, lying within areas of Franciscan rocks and parallel to the elongation of the serpentine, are diagrammatically shown in this section but are not shown on the surface map because of their indefinite and gradational contacts. The central mass of serpentine, which forms most of the higher ridge in the area, is the southeastern end of a lens which crops out over an area about 3 miles long and not more than half a mile wide.

A large lens of silica-carbonate rock, which is discontinuous in surface outcrop but is seen underground to be a single mass, forms a steep backbone along the southern part of the main serpentine ridge and is parallel to the southern contact of the serpentine. This silica-carbonate rock was formed in place just after the intrusion of the serpentine along a major shear zone, and its distribution is at least in part controlled by the predominant shear direction in the serpentine mass. The contacts of the serpentine with the silica-carbonate rock are sharp faults in some places and gradational in others, but these two kinds of contacts could not be differentiated on the map because of the poor surface exposures. The upper limit of the silica-carbonate lens is everywhere seen underground as a low-angle fault that dips to the northeast. The two largest ore bodies in the area were formed immediately below this fault.

Within the large silica-carbonate lens are many faults, which strike nearly parallel to the elongation of the serpentine mass and dip northeastward at angles ranging from vertical to 30°. Some and possibly all of these are thrust faults. Few of these faults can be found on the surface; the major faults shown in sections A-A' and B-B' of plate 17 were seen underground. The faults in the serpentine and silica-carbonate rocks have been the locus of repeated movements, which began with the emplacement of the serpentine and continued until after the formation of the silica-carbonate rock. Within the serpentine the fault zones, which are some tens of feet in width, are composed of rounded, generally slickensided, boulders up to 6 feet in diameter, surrounded by soft, thoroughly sheared serpentine. Most of the fault zones between serpentine and silica-carbonate rock are only a few feet wide and contain a zone of "alta" (black or gray gouge), but a few are several times as wide and contain angular blocks of silica-carbonate in a matrix of sheared serpentine. The fault zones within the silica-carbonate rock are locally composed of small blocks of silica-carbonate rock loosely cemented by carbonates, but in the main they are narrow fractures with smooth slickensided walls.

Table Mountain (see pl. 19) has a core of serpentine, which crops out in a narrow arcuate zone concave toward the south. Several landslides consisting mainly of serpentine like that of the ridge in the Patriquin area, have flowed down the northern and southern slopes of the ridge to Avenal Canyon and Turkey Flat respectively, and because of these slides the contacts of the serpentine can rarely be seen. The northern contact west of the Kings mine was seen to be a nearly vertical fault, but for nearly 2 miles southeast of the mine it is covered by slide. The southern contact of the serpentine as exposed in an adit a few hundred feet southeast of the White mine is a thrust fault that strikes northwest and dips northeast at an angle of less than 10°. West of the adit this thrust fault is traceable intermittently for a distance of 3 miles and has a low dip throughout this distance, but east of the adit it steepens within a mile to nearly vertical. Most of the mines of the Table Mountain area are in the serpentine close to these boundary faults; the others are in landslides.

The serpentine of Table Mountain is flanked on the south by Cretaceous sandstone and shale, which have a northwesterly strike, and dip steeply to the northeast. The serpentine is thrust over the Cretaceous rocks. The Cretaceous rocks, in turn, have been pushed over the Franciscan formation on a thrust fault which dips 25° northward into the mountain where best exposed but which elsewhere is probably flatter. This overthrust is unusual in that it brings younger rocks upon older. The serpentine and the Cretaceous rocks are nearly surrounded by an elliptical belt of intricately sheared rocks of the Franciscan group with an average width of less than a mile, elongated parallel to the strike of the thrust fault and split at its eastern and western ends. The belt of Franciscan rocks is bounded both to the north and to the south by nearly vertical faults of large displacement, which bring these rocks into contact with overturned Cretaceous strata. The Cretaceous beds that dip steeply inward toward Table Mountain on both sides form the overturned links of two eastward-trending synclines, which lie mainly outside the mapped area.

Small isolated patches of Cretaceous rocks occur also on the brush-covered north slope of Table Mountain, near the vertical northern contact of the serpentine mass; these are believed to be parts of a fault sliver that was dragged in along the boundary fault. A small area of fossiliferous sandstone tentatively correlated with the middle Miocene Temblor formation crops out a quarter of a mile east of the road up Table Mountain, below the thrust fault under the serpentine.

ORE DEPOSITS

The ore bodies that have been found in the district have the following different modes of occurrence:

(1) In silica-carbonate rock and slightly silicified sheared serpentine underlying subsidiary thrust faults and shear zones, which are structurally related to underlying major thrust faults at the base of the serpentine. Such an occurrence is exemplified by the Patriquin ore body.

(2) In sandstone of the Franciscan formation beneath thrust faults capped by serpentine, exemplified at the Kings mine.

(3) In large blocks of silica-carbonate rock, or groups of blocks, in extensive landslides, exemplified at the Dawson mine.

(4) In landslides, consisting mostly of crushed serpentine but with scattered blocks of ore, which have been locally enriched by the deposition of secondary cinnabar, exemplified at the G. W. D. mine.

The character of the ore body for each of the mines of the district is shown in the table on the following page.

Bedrock deposits

The primary ore bodies in bedrock contain cinnabar, deposited by ascending hydrothermal solutions, that has filled veins and encrusted numerous fractures in silica-carbonate rock. Most of these ore bodies are in fractured silica-carbonate rock below the flatter segments of subsidiary thrusts, which lie above, and probably branch from, major thrust faults. The local structural control responsible for the localization of each of the bodies is discussed in the description of the individual mines.

The richest ore body in the Kings mine was 70 feet long and 28 feet high. It contained, in addition to cinnabar, considerable native quicksilver, and parts of it assayed more than 100 pounds of quicksilver to the ton. The larger ore body in the

Geologic occurrence and character of mineralization of the mines of the Parkfield district.

	Patriquin area					Table Mountain area			
Mine	Patriquin	G. W. D.	Poppy	Gillette	Sommer	Kings	Dawson	White	Rattlesnake.
Country rock	Silica-carbonate.	Serpentine and silica-carbonate.	Serpentine and silica-carbonate.	Silica-carbonate.	Serpentine.	Serpentine and sand-stone.	Silica-carbonate.	Silica-carbonate.	Silica-carbonate.
Geologic occurrence.	Below sub-sidiary thrust faults.1/	Landslide	Landslide	Landslide	Below sub-sidiary thrust faults.1/	Thrust-fault (?)	Landslide	Below sub-sidiary thrust faults.1/	Below sub-sidiary thrust faults.1/
Ore minerals	Cinnabar, metacinna-bar (?).	Cinnabar	Cinnabar	Cinnabar	Cinnabar	Cinnabar and mercury.	Cinnabar	Cinnabar	Cinnabar.
Character of quicksilver mineralization.	Hypogene	Hypogene and supergene.	Hypogene and supergene.	Hypogene	Hypogene	Hypogene	Hypogene	Hypogene	Hypogene.

1/ A term used in this report for minor thrust faults which branch upward from a major thrust fault.

Patriquin mine had a volume of about 50,000 cubic feet and averaged nearly 20 pounds of quicksilver to the ton.

Landslide deposits

Blocks of silica-carbonate ore, probably of the same origin as the bedrock ore, are scattered through extensive landslides that consist mainly of serpentine. The Dawson mine is believed to be in a large block of this kind or in a group of such blocks.

Secondary cinnabar locally enriches landslide rubble that contains primary ore. Along favorable zones, it forms thin, pink films on the soil-like matrix of the landslide, and coatings of "paint" and thin encrustations of bright-red crystals on blocks of serpentine and silica-carbonate rock. These enriched zones, as may be seen at the G. W. D. mine, are several feet wide and as much as 50 feet in length, but they are probably of relatively shallow depth. They are said to contain 3 to 8 pounds of quicksilver to the ton.

The secondary cinnabar is believed to have been deposited by ground water which percolated downward perhaps the entire length of the slide, about 1,500 feet, slowly dissolving cinnabar from scattered blocks of ore. The precipitation of the cinnabar was probably caused by surface evaporation.

Mineralogy

Cinnabar.--Cinnabar is the most abundant quicksilver ore mineral of the district. Bright-red crystalline cinnabar coats silica-carbonate rock and fresh serpentine in both the Patriquin and Table Mountain areas, and it also impregnates and replaces sandstone in the Table Mountain area. Exceptionally, in both areas, it forms massive veins considerably less than an inch in thickness. The finely crystalline, pulverulent variety known as "paint" is rare in the district. Secondary, or supergene, cinnabar, deposited by ground water, is economically important at the G. W. D. mine, where it forms pale-pink films, "paint" crusts, and small bright-red crystals. There is no direct evidence of cinnabar enrichment in the other mines.

Metacinnabar.--Metacinnabar, the black mercuric sulfide, is reported to occur in the Patriquin mine [4/] and is said by local miners to occur in other mines of the district, but none was found during this investigation.

Native mercury.--Silver-white globules of mercury are an important constituent of the ore of the Kings mine, where they occur with cinnabar in cavities in sandstone and leached silica-carbonate rock.

Mercury oxychlorides.--Yellow eglestonite (H_4Cl_2O) and sulfur-yellow terlinguaite (H_2ClO) are found locally as thin fracture fillings in calcite veinlets that cut sandstone in the Kings mine.

Carbonates.--Mixed carbonates, probably dominantly ankerite and dolomite, are prominent constituents of the ore-bearing silica-carbonate rock. Aragonite ($CaCO_3$) in small clear crystals occurs as discontinuous veinlets in serpentine.

Pyrite.--Minute crystals of pyrite replace the black flinty variety of silica-carbonate rock, and colloform coatings of pyrite encrust late quartz in the Patriquin mine. Oxidation of the pyrite has given rise to sulfate mine waters which have deposited diamond-shaped transparent crystals of gypsum ($CaSO_4.2H_2O$) and long needles of epsomite ($MgSO_4.7H_2O$) in several of the older mine workings.

Sulfur.--Sulfur is reported [5/] to have been found in the adits that explored the silica-carbonate ore body of the Patriquin mine.

Barite.--Thin tabular crystals of barite ($BaSO_4$), deposited late, occur in the Patriquin ore body.

4/ Forstner, William, The quicksilver resources of California: California State Min. Bur. Bull. 27, p. 124, 1903.

5/ Idem.

Wad.--A black, sooty coating on the walls of open fractures gives reactions for manganese and is probably to be classed as wad, the amorphous oxide of manganese. Local miners consider it a guide to ore.

Magnesite.--Several small magnesite ($MgCO_3$) prospects have been opened on Table Mountain. The mineral is dead white and brittle, and occurs in sheared serpentine as "cauliflowers" ranging from an inch to nearly a foot in diameter.

Chromite.--Jet-black, massive chromite ($FeCr_2O_4$) float occurs locally in the large landslide west of the road up Table Mountain, but no deposit in place has been found.

Copper minerals.--A foot-wide vein of chalcopyrite and possibly other sulfides cuts the Franciscan rocks a few hundred feet south of the G. W. D. mine.

A small prospect, locally known as the "Copper mine", a few miles west of the Carollo Cabin on Table Mountain, explores a shear zone in serpentine that contains chalcocite (Cu_2S) and specks of native copper.

MINE DESCRIPTIONS

Patriquin area

Patriquin mine.--The Patriquin mine, formerly known at various times as the Pitts, the Cholame, and the Parkfield, is owned by F. A. Anstey of Oakland, Calif. It is in sec. 2, T. 23 S., R. 14 E., in southeastern Monterey County. The first ore found in the Parkfield district was discovered here in 1873. The mine yielded 60 flasks in its first year, and then was abandoned until 1913. The major production was made between 1915 and 1920, during which period 1,369 flasks were produced. Since 1918 the production has been erratic and the control of the mine has changed hands a number of times. It has been inactive since 1937. Its total production has amounted to 1,798 flasks of quicksilver.

The cinnabar forms brilliant red crystalline veinlets and encrustations, most of them in fractured silica-carbonate rock but some of them in unsilicified but thoroughly sheared serpentine. There were two main ore bodies in the mine (see secs. A-A' and B-B', pl. 18). One, lying in and beneath a large glory hole at the crest of the serpentine ridge, had a volume of about 50,000 cubic feet; the other, lying to the north at a lower elevation and about 250 feet west of the portal of the main haulageway level, was about a third as large.

As is shown in section B-B', plate 18, both ore bodies occurred beneath a fault that trends northwest and dips northeast. The rock above this fault is sheared serpentine; the rock below is either silica-carbonate rock, locally containing ore, or sheared but otherwise unaltered serpentine.

The local structural control for the ore body found below the glory hole could not be determined with certainty because of the great amount of slumping and because all of the old ore chutes which extended down to the mine level were caved at the time of the author's visit. Immediately beneath the southern edge of the glory hole the ore body lay under a thick blanket of fault gouge, which strikes eastward and dips north. The fault is rolling; near the surface it has a dip of 68°, but 30 feet lower its dip is only 35°. This fault was joined in its steeper part by several steeper converging faults. There was good ore, averaging about 20 pounds of quicksilver to a ton below the blanket of gouge in the brecciated zone at the intersection of these many fractures. Whether or not the ore body extended down the dip of the major flat fault is not known, but no ore occurs along the fault at the haulageway level 90 feet lower.

The localization of the lower ore body was determined by several intersecting faults, which underlie the main fault that forms the upper limit of the silica-carbonate rock. These are shown in section A-A' on plate 18. Beneath the rather poorly defined southwestward-dipping fault, and also, to a lesser extent, below the flatter part of the lower fault, good ore was deposited.

Very little ore is believed to remain in the mine. Directly under the glory hole, in very unsafe ground, there is some good ore, which can be expected to yield about a hundred flasks of quicksilver but which probably cannot be gotten out unless the nearly barren overburden is first removed. In the lower ore body there still remains a little ore that would run 5 pounds of quicksilver to a ton.

As the thrust fault above the silica-carbonate rock has been prospected without result by many tunnels in the vicinity of the main Patriquin mine, little chance remains of discovering any large ore body at the surface; and to find any small ore bodies that there may be in the mine would probably require a greater outlay for prospecting than they would repay. Immediately below the thrust fault at depth, lies the best chance of finding additional ore bodies in the mine. There is no indication that the ore extends to any considerable depth below the present working level; the lowest ore body in the mine was bottomed, and the downward steepening of the controlling fault is an unfavorable feature.

The soil in the vicinity of the workings is reported to contain quicksilver and possibly can be worked profitably with high quicksilver prices.

G. W. D. mine.--The G. W. D. mine, owned by N. Gillette, is located in sec. 2, T. 23 S., R. 14 E., approximately 1,500 feet south of the Patriquin mine. It yielded 7 flasks of quicksilver between 1937 and 1940.

The workings consist of two small open cuts and several short adits, which explore narrow near-surface zones of secondary cinnabar enrichment, a few of which are as much as 50 feet long. An attempt to concentrate the ore before retorting is now being made, and if this operation is successful it may be possible to work at a profit low-grade ore stripped from the surface.

The ore lies in a landslide mass of silica-carbonate and serpentine rubble derived from the vicinity of the Patriquin glory hole to the north. The cinnabar contained in it is of both primary and secondary origin. Blocks of silica-carbonate rock contain seams and coatings of small crystals of primary cinnabar, but they are too scarce to constitute an ore body. The principal ore bodies are zones of soil and crushed rock that, besides containing scattered primary cinnabar, have been considerably enriched with secondary cinnabar. They are said to contain from 3 to 8 pounds of quicksilver to the ton.

Poppy mine.--The Poppy mine, owned by N. Gillette and T. E. Washburn, is located in sec. 2, T. 23 S., R. 14 E., in Monterey County, adjoining the G. W. D. claim. It produced 3 flasks of quicksilver in 1932. The main workings consist of a number of short adits and several shallow pits. The geology and ore is identical with that of the G. W. D. mine, both mines being situated on the same landslide. The mine was not operating in 1941, and little future production from it can be expected.

Gillette prospect.--The Gillette prospect, owned by Henry Ludeke and leased by Nate Gillette, lies a short distance south of the area mapped in plate 17. It is in sec. 2, T. 23 S., R. 14 E., in Monterey County, about a mile south of the G. W. D mine and 1,000 feet lower. This is a new prospect and has made no production. The cinnabar forms narrow veinlets in silica-carbonate rock which is similar to that in the G. W. D. and Poppy mines, described above, and is believed to be part of a slide that came from the top of the hill near the Patriquin glory hole.

Sommer's prospect.--The prospect owned by L. J. Sommer in sec. 2, T. 23 S., R. 14 E., in southwestern Monterey County, is shown near the western border of plate 17. The prospect consists of several short adits in the vicinity of the fault that brings serpentine and silica-carbonate rock into contact with sandstone of the Franciscan formation. Some of the adits have gone through a narrow rib of silica-carbonate rock without encountering ore. Other adits, driven at a slightly lower elevation to prospect the underlying sandstone, do not reach the fault zone and contain no ore. In the upper tunnels, thin films of cinnabar on fresh serpentine have been found in small quantity, but the rock in which these films occur probably contains less than 1 pound of mercury to the ton and cannot be regarded as ore.

Table Mountain area

Kings mine.--The Kings mine, successively known as the Table Mountain and Fredanna mines, was owned by L. K. Anderson and leased by Bert Harvey in 1941. It is located in sec. 20, T. 23 S., R. 16 E., in southwestern Kings County. Its first recorded production was made in 1902. It has been operated intermittently since that time, and was most productive in 1915-16, when it yielded 480 flasks. The average yearly production since 1938 has been 11 flasks, and the total production as recorded by the California State Mining Bureau is 876 flasks. The only uncaved workings consist of a 60-foot shaft, from which there are drifts, less than 100 feet in aggregate length, between the 38-foot and 60-foot levels, and an adit lower down which is now being driven.

Finely to coarsely crystalline cinnabar, closely associated with native mercury, here fills fractures in weakly silicified serpentine and impregnates sandstone and shale. Metacinnabar and the mercury oxychlorides, eglestonite and terlinguaite, are said to occur in the mine but were not seen by the author. The country rock is sheared serpentine, slightly silicified in places and cut by veinlets of calcite, and sandstone and shale of the Franciscan formation.

Landslides are prevalent in the vicinity of the mine, so that only scattered outcrops can be found and the local structural control of the ore body can only be inferred. Much, and possibly all, of the ground that has been developed by the shaft and the new adit has slid from a ridge that lies a little more than a hundred yards west of the shaft. Near the top of this ridge, a thrust fault which strikes N. 60° E. and dips 70° N. separates serpentine from the underlying sandstone of the Franciscan formation. It is highly probable that much of the ore in the slide was originally deposited along this fault, although other ill-defined shear zones exposed on the edges of the slide area may have exerted some control on the deposition of the ore.

Because of the caved workings and the scarce outcrops, it is impossible to make any accurate estimate of the reserves of the mine. On the 50-foot level of the old shaft, the base of an ore body, said to have been 70 feet long and 28 feet high, is exposed in a tunnel driven in under the old stope now filled with waste. A foot-wide mineralized zone in sheared serpentine, said to assay more than 100 pounds of quicksilver to the ton, is exposed in this adit, but it cannot be mined because of the unsafe overburden. In the new lower adit, native mercury and cinnabar occur in crushed sandstone of the Franciscan formation, and to a lesser extent in shale. Single specimens averaging better than 20 pounds of quicksilver to the ton can be easily obtained, but no continuous bodies of ore have yet been developed. The western extension of the adit is in essentially barren serpentine. More than 150 samples cut from all accessible workings and from the surface are said by Mr. L. K. Anderson, the owner of the mine, to average 9 pounds of quicksilver to the ton; but no information is available as to how the samples were taken or whether or not they were cut at regular intervals.

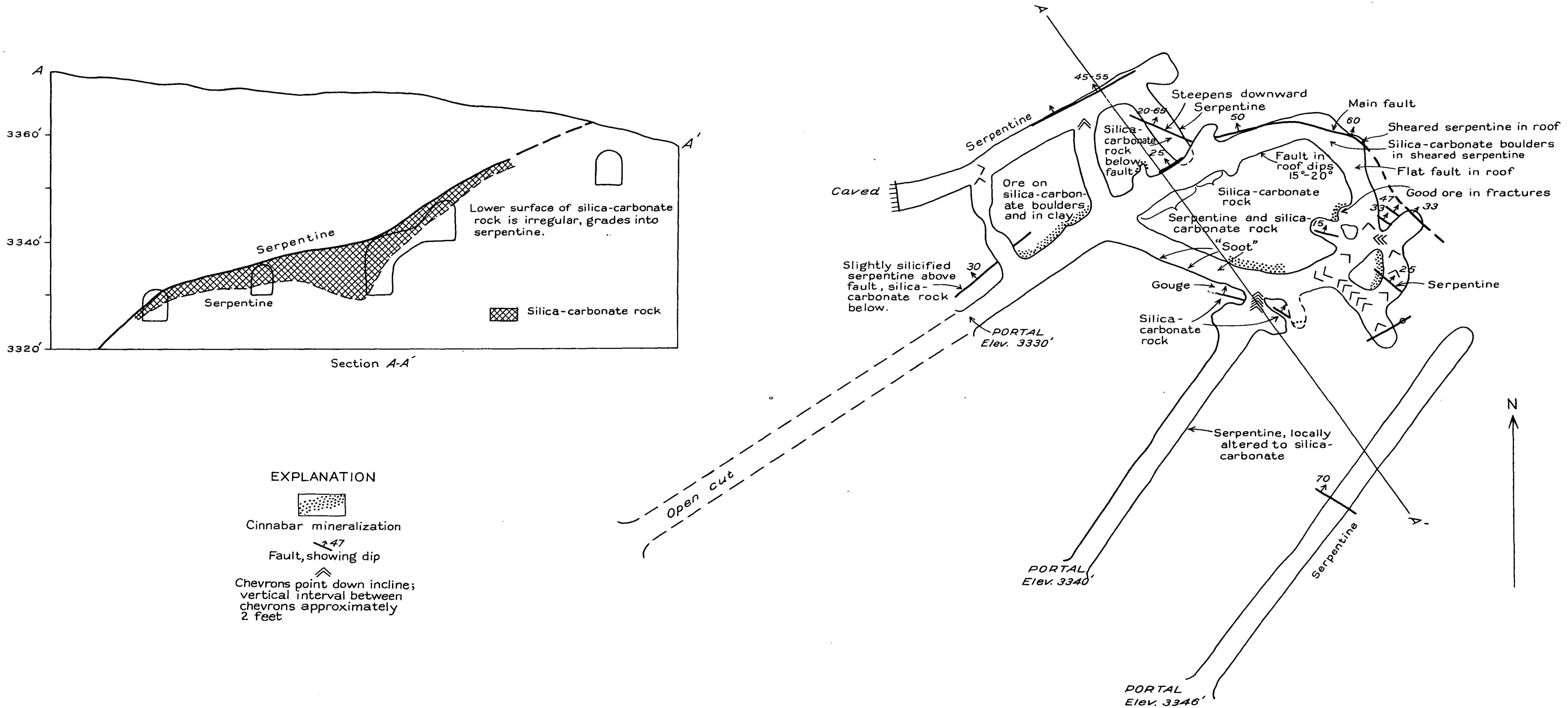
Dawson mine.--The Dawson mine, owned by Jack Ellena and operated by C. C. Jones and W. E. Karns under a 13-year lease, is located in sec. 28, T. 23 S., R. 16 E., in Kings County. The first recorded production was made in 1918, when 75 flasks were recovered. By the end of 1922 the production total had reached 1,030 flasks. Since 1922, 46 flasks have been produced.

The mine is in a rubble of serpentine and black chalcedonic silica-carbonate rock which is part of a landslide that extends from near the top of Table Mountain to Avenal Canyon, a distance of nearly 2 miles. The main ore body was mined from a shallow glory hole and from several hundred feet of now inaccessible workings about 30 feet below the glory hole.

The principal ore mineral is cinnabar, but metacinnabar also is said to be present. The cinnabar forms crusts and fills fractures in the silica-carbonate rock, and it occurs in the earthy gouge between these boulders. Some rich ore, averaging probably more than 40 pounds of quicksilver to the ton, occurs in the landslide debris, but the average grade of the ore that has been retorted is probably less than 10 pounds to the ton.

The ore body in the glory hole is said by the local miners to have been bottomed at shallow depth. The retort ore between the underground workings and the base of the glory hole was stripped from the surface in 1941. This work can be expected to yield at most only a few hundred flasks of quicksilver, and unless other large bodies of ore are discovered nearby in the landslide no further production from the mine can be expected.

White mine.--The White mine, formerly known as the Table Mountain claim, is owned by Lee S. White and is located in sec. 30, T. 23 S., R. 16 E., in southeastern Monterey County. The only recorded production was made in 1916, when 3 flasks of quicksilver were recovered in a 12-pipe retort. The mine has been reopened and was expected to begin production on a small scale by the fall of 1941.



MAP AND SECTION OF THE WHITE MINE

25 0 50 Feet

471466 O - 42 (Faces p. 166)

Cinnabar forms thin coatings in fractures, most of them in black chalcedonic silica-carbonate rock, but some of them in unsilicified sheared serpentine. The ore is immediately below a low-angle fault that strikes eastward and dips at varying angles to the north. Here the sheared serpentine has been converted to silica-carbonate rock for distances ranging from a few inches to more than 10 feet. Repeated movements on the fault have broken the silica-carbonate rock and locally admixed this rock with unaltered serpentine. Nearly vertical late fractures coated with wad--locally called "soot"--are common but bear no direct relation to the better ore zones.

The best ore probably contains less than 10 pounds of quicksilver to the ton, and most of the ore contains no more than 2 pounds to the ton. Little future production can be expected. As the lowest portal of the mine is only a few feet above the nearly flat thrust fault below the serpentine mass, development work downward might possibly uncover an ore body in the underlying sediments.

Rattlesnake prospect.--The Rattlesnake prospect, owned by Harold G. Dennis, is located in sec. 30, T. 23 S., R. 16 E. This is a new adit being driven to the north through sheared serpentine to intersect a lens of silica-carbonate rock which crops out on a hillside about 50 feet above. The portal is about 30 feet above the thrust fault at the base of the serpentine capping Table Mountain.

The soil on the hillside above the mine is said to pan cinnabar, but no ore was seen in the silica-carbonate body above and little production from this property can be expected.

OUTLOOK

Although the Patriquin area has produced 1,800 flasks of quicksilver, little ore is in sight there that could be profitably mined. Of the two major ore bodies in the Patriquin mine, one is exhausted and the other has been mined in such a fashion that it would be hazardous to recover the remaining ore. So many prospects have explored the silica-carbonate lens that it is unreasonable to suppose that any large ore bodies will be found. The soil in the vicinity of the Patriquin mine is said to be of high enough grade to be profitably mined. Altogether, it seems unlikely that the area will produce more than a few flasks a year.

In the Table Mountain area, the known reserves of minable ore can be expected to yield only a few hundred flasks of quicksilver, but the chances of finding new ore are fairly good. New development work that was carried on in the summer of 1941 yielded a small amount of quicksilver, and further development was in progress at the end of the year. Scattered outcrops containing ore but as yet not thoroughly prospected are known by the local miners. Many of these are in landslide, but other mines in landslide blocks in the area have yielded more than 1,000 flasks. If a price of about $200 per flask is maintained, the mines of the Table Mountain area can be expected to yield a small production for a few years.

SUGGESTIONS FOR PROSPECTING

Suggestions for future development work in the Patriquin mine have been offered in the description of the mine. The geology of the surrounding area offers little clue as to where additional ore bodies might be found. The best ore is confined to the lenses of silica-carbonate rock, and these are believed to have been thoroughly prospected, although small ore bodies may have been missed. Blocks of ore probably could be found in the area of landslide to the south, but most of the slide is so broken that such blocks would be small.

The Table Mountain area has not been thoroughly prospected, and there are several places where new ore bodies of small size might be found. Between the White mine and the Dawson mine is a fairly continuous zone of scattered outcrops of silica-carbonate rock, which are doubtless boulders forming part of a landslide that consists mainly of serpentine. The Dawson mine has yielded more than 1,000 flasks of quicksilver from an area containing an extraordinary number of such blocks, which have slid, without becoming widely separated, from a ledge that probably cannot be found and may have been eroded away. However, other areas along the zone between the White and Dawson mines should be carefully prospected. One boulder of good ore in this zone cannot be considered an ore body; but there may be spots where a number of blocks have kept together in sliding and would constitute a workable ore body similar to that of the Dawson mine.

The Kings mine has explored the land in sec. 20, but the geologically similar area in the vicinity of sec. 19 has not been carefully investigated.

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