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

GEOLOGICAL SURVEY
W. C. Mendenhall, Director

Bulletin 936-D

CHROMITE AND QUICKSILVER DEPOSITS OF THE DEL PUERTO AREA STANISLAUS COUNTY, CALIFORNIA

BY

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Strategic Minerals Investigations, 1942
(Pages 79–110)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1942

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - Price 30 cents

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ABSTRACT

The Del Puerto chromite and quicksilver area is in western Stanislaus County, in the central part of the Coast Range of California. The major geologic units are Jurassic (?) and Cretaceous sedimentary rocks, which contain the quicksilver deposits, and ultrabasic intrusive rocks, which contain the chromite deposits.

The chromite occurs almost exclusively in dunitic members of the ultrabasic complex. Most of the commercial deposits consist of pods and irregular bodies of massive high-grade granular chromite in zones of shearing, which are believed to have localized the emplacement of the ore. Deposits of lower-grade granular chromite also have been mined and concentrated. The total reported production from all the properties of the area during the period 1916-18 was about 3,600 tons of ore containing 40 percent or more of Cr_2O_3, and 2,000 tons of milling ore averaging 20 percent Cr_2O_3. Most of the readily available chromite was removed during this period, and no new deposits have been disclosed by subsequent work. The only mine at which a fair tonnage of ore is in sight at the present time is the Black Bart, where 1,200 tons have been blocked out above the bottom of the shaft. Further exploration of this deposit may uncover at least another 1,000 tons. Most of the ore bodies in the Del Puerto area that have been mined out were small, containing no more than a few hundred tons each, and there is no reason to believe that any larger deposits will be discovered by further exploration.

The quicksilver deposits of the Del Puerto area occur in or near fissure zones that cut the sedimentary rocks adjoining the ultrabasic mass. Total past production amounts to 200 flasks, shipped in 1915 and 1916 from the Summit mine. No significant tonnage of quicksilver ore is now in sight at any place in the district, though there is promise that development work at the Adobe Valley mine may uncover commercial ore.

INTRODUCTION

The chromite and quicksilver deposits of the Del Puerto area are in T. 6 S., R. 5 E., Mt. Diablo meridian, in the central

part of the California Coast Range. The area is in Stanislaus County, about 25 miles west of Patterson (fig. 4). There are active manganese, magnesite, chromite, and quicksilver mines and prospects within 5 miles of the area, but these were not studied during this examination. The area is accessible by way of a

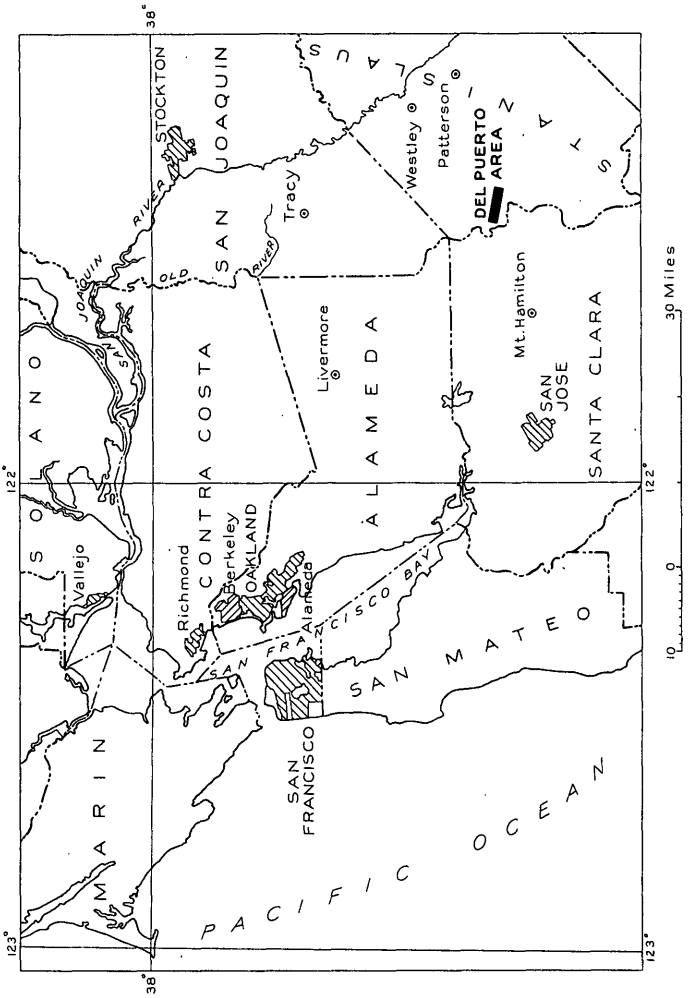

Figure 4.--Index map showing location of Del Puerto area, Stanislaus County, Calif.

graded dirt road from Patterson, which is on the Southern Pacific Railway and is the shipping point for the mines. The maximum relief from the highest hills to the level of Puerto Creek is 2,000 feet, and much of the terrain is exceedingly rough, precipitous, and brushy. Puerto Creek generally flows

the year round, and carries enough water for milling on a small scale, but elsewhere water is scarce during the dry season, which commonly lasts from June to December.

Basis of report

The present report is based on 10 weeks of field work from mid-November 1940 until late January 1941, and 4 days in May 1941. An area of 5½ square miles in and about Del Puerto Canyon was mapped on a scale of 600 feet to 1 inch, and two small areas in the vicinity of the Adobe Canyon and Black Bart chromite mines were mapped on a scale of 200 feet to 1 inch. The work was under the immediate supervision of F. G. Wells. The field work was done by H. E. Hawkes, Jr., D. P. Wheeler, Jr., R. H. Merriam, J. S. Livermore, and A. E. Bradbury. The report was prepared mainly by H. E. Hawkes, Jr., with the assistance of F. G. Wells and D. P. Wheeler, Jr., and friendly and helpful criticism has been given by F. C. Calkins and H. G. Ferguson.

The Survey is indebted to the officers of the West Coast Chrome Co., and especially to E. D. Brown, the superintendent on the job, for many courtesies. The California State Division of Mines kindly made available much of the detailed information regarding the size, grade, and general character of the chromite deposits that was gathered by E. L. Young of the Bureau of Mines, United States Department of the Interior, and others in 1917 and 1918.

The only published report on the Del Puerto chromite deposits is in Bulletin No. 76 of the California State Mining Bureau, which describes the properties as they were early in 1918.

History of mining

Chromite.--Chromite mining in the Del Puerto area began in 1916, though before that magnesite, manganese, and quicksilver had been mined or prospected for. In the two years following

1916, there was extensive prospecting for chromite; several small high-grade deposits were developed, and they yielded, in all, 3,600 tons of shipping ore. A mill for treating disseminated ore was constructed by the Chrome Concentrating Co. at the confluence of Adobe and Puerto Creeks, and 2,000 tons of such ore was concentrated there. Various official records of production statistics for this period give conflicting figures for tonnage and grade; what are believed to be the most reliable have been compiled in the accompanying table. Mining was stimulated during the period from 1916 to 1918 by high wartime prices and by the construction of a narrow-gauge railway to the area from Patterson, which provided relatively cheap transportation. After the war, however, the market for chromite collapsed; railway service was discontinued, and the properties were shut down.

Chromite in the Del Puerto area

Mine	Ore previously mined			Reserves 1/	
	Tons	Grade (percent Cr_2O_3)	Period	Tons	Grade (percent Cr_2O_3)
Adobe Canyon 2/.....	500	40	1917	350	10
No. 5 3/ (5 deposits).....	1,272	40-44	To November 1918.	100	5
	5/ 270	51			
Black Bart 2/.....	414	35	To Aug. 31, 1918.	1,200	15
Black Bear 4/.....	342	50	1918	None	..
Lucky Girl 3/.....	150	42	1917	300	10
Chrome Camp 2/ (2 deposits).....	930	40	1917	None	..

1/ Computed from results of recent examination.
2/ Report of U. S. Geol. Survey in files of California Div. Mines, San Francisco.
3/ Report of U. S. Bur. Mines in files of California Div. Mines, San Francisco.
4/ Files of U. S. Bur. Mines, Washington.
5/ Concentrates.

Except for a little prospecting the chromite deposits received no further attention until 1940, when the West Coast Chrome Co. acquired the mineral rights to 3,000 acres, comprising most of the original workings, and installed a small mill; but, apart from 152 tons of chromite ore shipped in 1940, the

activities of this company have been confined to developing and mining their manganese holdings, which lie immediately southwest of the Del Puerto area.

Quicksilver.--Interest in the quicksilver of the Del Puerto area dates from the 1870's, when the Summit vein was discovered.[1/] A 50-ton furnace was erected at the Summit property in 1901, but no production was reported until the period 1915-16, when 200 flasks of quicksilver were shipped. Since 1916 the mine has been idle. The Orestimba, or Winegar, and the Adobe Valley deposits were discovered and developed in the early 1880's, but the mines in them were closed in 1888 and have remained idle until recently. Within the last year, the Adobe Valley mine has been cleaned up and provided with a hoist, installed preparatory to its reopening; a 50-ton furnace also is being set up at the property.

GEOLOGY

The chromite deposits occur within a large elongate body of ultrabasic rocks, locally called serpentine, which trends in a general easterly direction as shown in figure 5 and plate 10. On the southern and part of the northern contacts, the ultrabasic rocks are faulted against metamorphosed Franciscan sandstones and shales probably of Jurassic age. Less metamorphosed sandstones and shales of Upper Cretaceous age lie to the northeast of the ultrabasic rocks, from which they are separated in most places by gabbroic intrusions. The quicksilver deposits are found in both Franciscan and Cretaceous rocks.

1/ The geology, production, and history of the quicksilver mines and prospects of the Del Puerto area have been treated in California State Min. Bur. Bull. 27, p. 188 ff., 1903, and Bull. 78, p. 197 ff., 1918, and in the California Journal of Mines and Geology, vol. 35, pp. 472-473, 1939.

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Sedimentary rocks

Franciscan formation.--The distribution of rocks assigned to the Franciscan formation is shown in figure 5 and plate 10. The

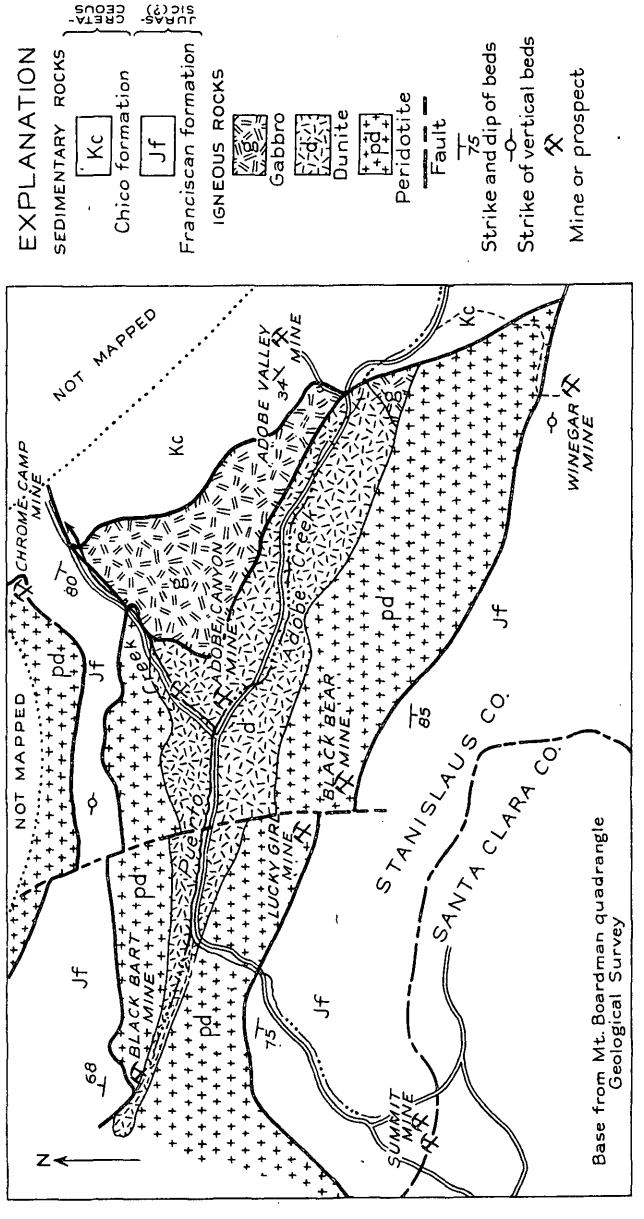

Figure 5.--Geologic sketch map of Del Puerto area.

correlation of these beds with the Franciscan formation, which is probably of Jurassic age, is based on their lithology, the character of their metamorphism, and their relations to younger

rocks. These rocks consist mainly of green sandstone, gray shale, and white or red chert, which forms thick and extensive lenses and crops out prominently. In places the cherts are accompanied by deposits of manganese carbonates, which near the surface have been largely weathered to oxides. The manganese deposits west of the Del Puerto chromite area are not considered in the present report.

The Franciscan sedimentary rocks are characterized by intense crushing, local folding, and the development of an intricate network of fine quartz veinlets. At many places they have been completely recrystallized to garnet rock or to staurolite schist, or, at some places on the contacts with the ultrabasic intrusives, to glaucophane schist.

Chico formation (Upper Cretaceous).--Sedimentary rocks assigned to the Chico formation lie northeast of the mass of ultrabasic rocks. They are part of a belt of Cretaceous formations which flank the Coast Range on the east throughout the length of the San Joaquin Valley. The formation is composed of green quartzose sandstones and gray shales, with thin fossil-bearing calcareous layers. The interbedded layers of sandstone and shale are mostly thin, though some of them are as much as 30 feet thick. The strike of the bedding averages about northwest but departs widely from that direction in many places. In the vicinity of the Adobe Valley quicksilver deposit the sandstone and shale have been thoroughly altered.

The assignment of these rocks to the Chico formation, of Upper Cretaceous age, is based on fossils collected by D. P. Wheeler, Jr. and examined by Ralph Stewart of the Geological Survey.

The formation is distinguished from the Franciscan by its less intense metamorphism and by the absence of manganiferous chert members.

Ultrabasic igneous rocks

The ultrabasic rocks in which most of the chromite deposits of the Del Puerto area occur form the eastern part of a large mass in the center of the Coast Range. The chromiferous area within this body is 3,000 to 8,000 feet wide and elongate in a general easterly direction (pl. 10). It continues west of the mapped area to form the country rock for the Red Mountain magnesite deposits; its exact width and lateral extent in this direction have not been determined. To the east, it tapers to a point half a mile north of the Winegar quicksilver prospect, as shown in figure 5. The original shape of the intrusive body may have been modified by faulting along its contacts with the sedimentary rocks. Another elongate mass of ultrabasic rocks, parallel to the main body, lies immediately north of the area of plate 10 and forms the country rock for the Chrome Camp mine. There is no direct evidence to indicate the relative ages of the ultrabasic rocks and the adjoining sedimentary rocks in the Del Puerto area, though similar igneous rocks elsewhere are thought to be post-Franciscan and pre-Chico.

The ultrabasic rocks include peridotite, dunite, and pyroxenite.

Peridotite.--The ultrabasic rocks mapped as peridotite in plate 10 consist essentially of olivine and pyroxene. Strictly speaking, these rocks are mainly lherzolite, for they contain both orthorhombic and monoclinic pyroxenes in addition to the olivine; but they include some saxonite, which is similar to lherzolite except that it contains no monoclinic pyroxene. Peridotite makes up two linear bands in the area covered by plate 10, one on either side of a central dunite mass. The pyroxene content of the peridotites ranges from almost zero to 50 percent, and averages about 20 percent. The pyroxene and olivine grains are commonly from 2 to 4 millimeters in diameter.

The only accessory minerals are magnetite and a little chromite, which occur as rounded grains rarely more than 1 millimeter in diameter.

Cleavage faces of the pyroxene crystals are prominent on weathered surfaces, and serve to distinguish the peridotites from dunite in the field. The color of the rock at the surface is commonly a reddish buff, with local variations to brick red or brownish gray; the unweathered rock is deep green to gray. Numerous serpentinized joints and fractures cause the peridotite to break into subangular blocks, the largest about a foot in diameter. A sticky, claylike soil which supports a hardy growth of chamisal and deer brush overlies the deeply weathered rock.

Dunite.--Dunite differs from peridotite in not containing pyroxene as an essential mineral. The largest body of dunite in the mapped area forms a core in the ultrabasic mass, elongated parallel to the main contacts with the sediments. A smaller mass occurs in Peachtree Canyon, near the southern contact of the complex with the Franciscan sedimentary rocks.

Intense serpentinization of the olivine causes the dunite to fracture without regard to any primary textures. Thus the outlines of the original crystals cannot be distinguished in the field, and the rock appears as a homogeneous fine-grained mass. Accessory grains of chromite are common throughout the rock, and are helpful in differentiating dunite from peridotite where serpentinization has completely destroyed the primary silicate minerals. Weathered dunite is stained an even buff color by iron oxides; the unweathered rock is dark green to gray. One of the characteristic features of dunite in this area is its tendency to break down at the surface into small angular chips an inch or less in length.

The contacts between the dunite and peridotite are regular and well-defined. Locally, this condition is the result of shearing, but in most places the contact is believed to be

intrusive. Almost all of the chromite deposits of the Del Puerto area lie within dunite.

Pyroxenite.--Pyroxenite, composed largely or entirely of monoclinic pyroxenes, forms relatively small masses both in peridotite and dunite and in gabbro. These masses are of three kinds. Those believed to be the earliest are irregular even-grained bodies ranging in length from a few inches to several hundred feet. Except for one occurrence in peridotite at the Black Bart mine, pyroxenite intrusions of this type are confined to dunite, and mainly to the Adobe Canyon and Black Bart chromiferous areas. They have not produced any visible metamorphism. Another, probably later, group of pyroxenite bodies, clearly intrusive, is similar mineralogically to the supposedly earlier type but is restricted to parts of the ultrabasic mass where gabbroic intrusives are most common. Some of these bodies are large enough to be shown on plate 10, but most are no more than a few inches in thickness and appear to be controlled by early jointing. Their grain size ranges from 2 millimeters or less to several inches in large pegmatitic crystals. A third type of pyroxenite, composed of large crystals of clinopyroxene, was observed at several localities within gabbro. It occurs in bodies of oval plan as much as 50 feet long, separated from the gabbroic country rock by a transitional contact zone only an inch or two wide.

Alteration of the ultrabasic rocks.--Much of the olivine in the ultrabasic rocks has been altered to serpentine, some of it so thoroughly that only scattered relics of the original olivine crystals remain. The dunite in general appears to have been more intensely serpentinized than the peridotite, which at several localities is free from serpentine. Schistose serpentine occurs in zones of shearing and along the contacts of gabbroic intrusions. Such completely serpentinized rock is characterized by lustrous dark-green slickensided fracture surfaces.

Secondary magnesite ($MgCO_3$) is common throughout the area in zones of shearing and brecciation, particularly along the shear zone separating the ultrabasic rocks from the Franciscan sediments on the south. On the west side of Red Mountain, a few miles west of the mapped area, it is abundant enough to be mined on a large scale. There are several magnesite prospects within the mapped area. At least a part of the magnesite in this zone is later than the faulting.

Gabbroic complex

A complex of gabbro and allied rocks is exposed northeast of the Adobe Canyon chromiferous area, where it appears to have been faulted against the ultrabasic rocks. The complex is made up of a multitude of dikes and irregular bodies that range in composition from pyroxenite to granodiorite. Associated quartz veins are believed to represent the extreme silicic end of this range, but its most abundant rock is a gneissic gabbro that consists essentially of white feldspar and black pyroxene in the proportion of about two to one. Small bodies of gabbro, intrusive into the dunite, occur along the north side of Adobe Canyon (see pl. 10), where the dunite along the contacts is serpentinized and contains metacrysts of feldspar. The gabbroic complex as a whole is believed to be, like these smaller bodies, younger than the ultrabasic rocks.

Structure

Primary igneous structures.--The planar and linear arrangement of chromite in some of the disseminated ore deposits, as at locality 5 east of Puerto Creek (see pl. 11), strongly suggests an igneous flow structure. At this locality the chromite occurs in dikelike bodies in which narrow bands and elongate lenses composed largely of rounded grains of chromite alternate with similar bands of lean or barren dunite.

Near the confluence of Adobe and Puerto Creeks, a system of regular, widely spaced, parallel joints in the dunite has given the rock, as viewed from a distance, a stratified appearance. The joints are commonly serpentinized, and in some places they have provided openings for the injection of later pyroxenite dikelets.

Faulting.--Most of the contacts between the major geologic units of the area are characterized by abruptness, truncation of primary igneous and sedimentary structures, lack of metamorphism at igneous contacts, and zones of intense shearing and serpentinization--all evidence for a certain amount of faulting. The contacts that have been interpreted as faults are shown in figure 5. Apparently both the ultrabasic and gabbroic rocks have behaved, in the main, as structural units during postintrusive deformation, but one minor cross fault, striking slightly west of north, transects the ultrabasic mass. The apparent horizontal displacement is about 400 feet at the north side of the area and 800 feet at the south side. The dip could not be determined. Minor fault fissures of random orientation have served as loci of quicksilver mineralization in the areas underlain by sediments.

Shear zones.--Serpentinized shear zones and fissures not only are characteristic of the contacts of the ultrabasic complex with other rocks but also occur within the complex. For those within the ultrabasic rocks the direction and magnitude of displacement cannot be determined. Certain of them appear to be closely related to ore localization. The shear zones in general can be grouped into three classes: (1) Relatively tight slickensided and serpentinized fractures; (2) homogeneous wide zones composed of schistose antigorite (a variety of serpentine), and (3) breccia zones in which foliated antigorite envelops blocks of unaltered country rock.

CHROMITE

Four types of chromite occurrence were noted in the Del Puerto area: (1) Disseminated grains of chromite averaging 1 millimeter in diameter scattered throughout the dunite and certain masses of peridotite; (2) grains of similar size in sheets, pods, or irregular masses, which contain from 5 to 50 percent chromite; (3) massive chromite in tabular bodies; (4) sharply angular fragments of chromite embedded in a matrix of olivine or antigorite.

The deposits of chromite that were discovered and mined out in the period from 1916 to 1918 were of types 2 and 3 and were all small; the largest single deposit was that of the main No. 5 mine (see pl. 11), from which 800 tons of shipping ore is said to have been taken. The table on page 82 shows the past production and shipping grade of the deposits in the Del Puerto area. Grab samples collected by the writers were analyzed with the results shown in the following table.

Analyses of chromite ore and concentrates from the Del Puerto area (in percent)
[R. E. Stevens, analyst]

	Crude ore		Concentrate			
	Chromite	Cr_2O_3	Cr_2O_3	Cr	Fe	Cr:Fe
Adobe Canyon (1) 1/.....	68	40.85	60.00	41.08	13.00	3.16
Black Bart (7).....	71	30.50	42.70	29.21	11.62	2.52
E. Black Bart (8).....	35	14.50	41.03	28.10	13.51	2.08
No. 5 (6).....	53	30.70	57.62	39.43	16.36	2.41

1/ Numbers in parentheses refer to locality numbers on plate 11 and figure 7.

The only other chromium mineral observed in the Del Puerto area is uvarovite, or green chrome garnet, tiny crystals of which form grass-green coatings on slickensided fractures in massive ore. The mineral is of no commercial importance. The most common gangue mineral associated with chromite is antigorite, or platy serpentine; olivine also is present in some of the low-grade deposits of granular chromite.

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Localization

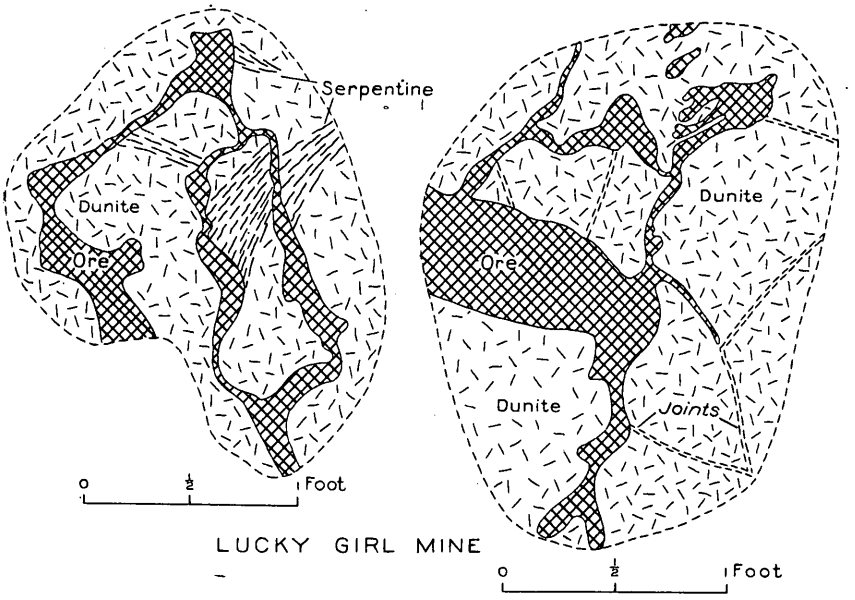
Country rock.--Of the 45 occurrences of granular or massive ore observed in the area, all but three are wholly in dunite. The most important of the three exceptions, the Black Bart deposit, lies in a zone of shearing that transgresses the peridotite-dunite contact. The other two are in peridotite; they are made up of very small pods of massive chromite, only a few inches long, in wide zones of intense shearing and serpentinization. No deposits of granular chromite were found in the peridotite.

Plate 10 shows the distribution of chromite mines and prospects, with the exception of the Chrome Camp mine. Most of the deposits are clustered in the Adobe Canyon area (pl. 11). Other chromiferous areas occur in the vicinity of the Black Bart mine (see fig. 7) and in the narrow strip of dunite in Peachtree Canyon. The ore is not distributed systematically with respect to the contacts of the dunite, or of the ultrabasic mass as a whole.

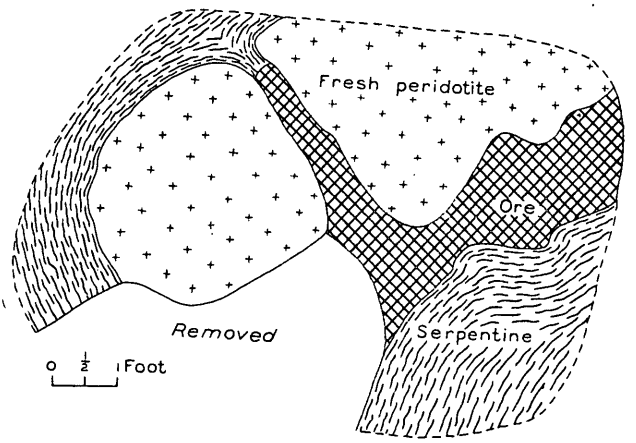
Ore structure.--An outstanding feature of the massive ore, and of much of the granular ore also, is its localization in shear zones; in all but one of the 11 deposits that contain massive chromite, the ore lies in well-defined fissures. Throughout the area the strike of the ore associated with fissure zones is remarkably consistent, never deviating more than a few degrees from east, and is almost parallel to the direction of elongation of the Del Puerto ultrabasic body.

Fissure ore most commonly forms lenticular or tabular bodies a few inches to a foot or more in width, parallel to the trend of the shearing and in sharp contact with barren silicates. In some cases several unconnected disc-shaped bodies of chromite were observed within the same fissure, whereas the tabular bodies of massive chromite, which are not associated with fissures, are unsystematic in both strike and dip. In most of

these deposits post-ore shearing has fractured and brecciated the chromite. At the Black Bart mine, however, there is a steeply dipping tabular body of granular chromite, with inter-



LUCKY GIRL MINE



BLACK BART MINE

Figure 6.--Typical chromite structures.

stitial antigorite, in intensely slickensided barren serpentine. The ore shows none of the strong foliation or other evidences of shearing which prevail in the barren country rock, and it

thus appears to have been emplaced after the zone of shearing had already been largely or entirely developed. In some other occurrences, also, of fissure ore, irregular veinlets and stringers of massive chromite follow joints and fill spaces between breccia fragments in the shear zone (see fig. 6), so that the jointing and brecciation must have occurred before the emplacement of the ore.

A large part of the chromite ore, therefore, came to its present position when the ultrabasic rocks were rigid enough to be broken, and to afford openings in which chromite could be deposited. The ore-bearing fluids did not migrate far, for very little ore has transgressed the limits of the parent dunite.

Several deposits of chromite appear to have been fed through fault fissures. The ore at the easternmost workings on the north side of Adobe Canyon (locality 2 on pl. 11) is thought to be related to a fault that strikes N. 85° W. and dips 75° N. The chromite occurs in horizontal sheets of massive and granular ore; the sheets are thickest, most numerous, and of highest grade next to the fault, and they decrease in size and grade away from it on both sides. Small pods of massive chromite also occur in the fault fissure itself. The present fissure, which is later than most of the ore structures, is probably the result of reopening along the original fissure which formed the ore channel. Prospecting in this type of deposit should be guided by traces of such original ore channels as well as by the horizontal layering of the ore.

A related but slightly different type of deposit occurs at the No. 5 property (pl. 11). It is a single discontinuous sheet of granular chromite a few inches wide on the average and having a total length of 600 feet. The tabular shape of this body points to localization along a plane of weakness, which presumably was developed in late magmatic time, for, apart from the presence of the ore, all traces of the presumed fissure have

been destroyed by recrystallization of the olivine. A similar "sheeting" structure is common in many of the small deposits of disseminated chromite throughout the area. The attitude of the chromite sheeting, wherever it could be observed, is indicated on plate 11. It has no consistent orientation comparable with that of the ore fissures.

Recommendations

Exploration for new deposits in the vicinity of mines that have been exhausted should be concentrated along the fissure zones, which appear to have controlled the original ore. There is no apparent reason why more ore bodies of the types already found should not be uncovered by further development of the known ore zones. It should not be expected, however, that new deposits will be any larger than those that have been already found and mined out.

Specifically, further development is recommended for both deposits in the Black Bart group. It is believed that there may be roughly 1,000 tons of undeveloped low-grade ore below the present workings of the main Black Bart mine, in addition to the 1,200 tons which apparently remains in the ground above the bottom of the winze. Exploration of the ore fissures in the Adobe Canyon, Peachtree Canyon, and Chrome Camp deposits in depth might also be worth while, though the lateral limits of the known ore have already been reached in previous mining operations.

Reserves

Except for the fact that most of the higher-grade ore is bounded by the limits of a zone of shearing, no means was found of predicting the thickness or grade of ore beyond what can be seen. The figures given in the table on page 82 were derived by computing the product of the average width of the ore body, the

exposed length, and an assumed average depth taken as one-quarter of the exposed length--an assumption that is thought to be conservative. It is likely that further exploration may uncover tonnages in excess of these estimates. In the Del Puerto area as a whole, the ore in sight as calculated from the results of the present survey amounts to 1,850 tons containing 10 to 15 percent Cr_2O_3. Much of this could be hand-picked to shipping grade.

Mine descriptions

Almost all of the important chromite deposits in the Del Puerto area are held at the present time by the West Coast Chrome Co. of San Francisco. This company owns seven claims, covering the Black Bart, Adobe Canyon, Black Bear, and Lucky Girl properties, and has a lease on the mineral rights of 3,000 acres, comprising most of the land formerly held by the Mineral Products Co. The Chrome Camp mine, north of the area mapped, is situated on the county prison reservation.

Mr. E. L. Young of the Bureau of Mines, United States Department of the Interior, visited and reported on many of the chrome mines of this area in 1918. As a large part of the mines described herein were inaccessible at the time of the present survey, Young's unpublished reports, in the files of the California State Division of Mines, have been freely drawn upon.

In the following descriptions, numbers in parentheses refer to key numbers locating the deposits on the maps, plates 10 and 11 and figure 7.

Adobe Canyon group.--The Adobe Canyon mine was formerly operated by McGuire, Holbrook, and Springer, and was known at that time as the Mountain View and Gray Fox claims. It is located in the $SW\frac{1}{4}$ sec. 14, the $SE\frac{1}{4}$ sec. 15, and the $NE\frac{1}{4}$ sec. 22 (pl. 11).

The main workings (1) are situated on the northeast slopes of Adobe Canyon a few hundred feet from its confluence with Puerto Creek. E. L. Young [2/] described this mine as follows:

> Ore was found outcropping around the west, southwest, and south sides of a hill and dipping into the hill. The occurrence was very irregular and the ore varied in grade from a good shipping grade to ore too poor to mill. The ore was mined from open cuts, the largest of which was over 100 feet in length and 30 feet in depth. In this ore body there was a center core of high-grade blocks of chromite surrounded by a much larger tonnage of disseminated ore mixed with serpentine. Smaller cuts showed smaller quantities of shipping ore and very little milling ore. The ore bunches are not shown to be on the same fracture, but their positions indicate that such is the case.

Past shipments of high-grade ore and concentrates from this mine are said to have totaled 500 tons. The workings have caved to a large extent since operations were discontinued, and it is at present impossible to examine the site of the original ore body in detail. A body of milling ore, estimated roughly at about 350 tons of 10-percent grade, remains in the upper glory hole. The present operators have done a small amount of exploratory work at a showing on the slope below the main deposit, but without making any significant discoveries.

About 700 feet a little south of east from the main glory hole, another small deposit of chromite has been opened (2). Here the ore lies in flat sheets and appears to be related to a fault trending N. 85° W.

Seven small chromite bodies on the southwest side of Adobe Canyon have been prospected by trenching and tunneling, but these appear to be small and of low grade.

No. 5 group.--The No. 5 group (see pl. 11) was formerly operated by the Mineral Products Co.; at present it is held by the West Coast Chrome Co. This group contains five deposits on the slopes of Del Puerto Canyon, immediately north of the Adobe Canyon group.

2/ Young, E. L., Unpublished report for U. S. Bureau of Mines, in files of California State Division of Mines.

The largest deposit (3) was opened up on the west side of the canyon. It was inaccessible at the time of the present examination, but it is described by E. L. Young [3] as follows:

> A large open cut which was made in mining high-grade chromite found on the railroad grade on the north bank of Puerto Creek. Ore was found to crop out almost continuously for 200 feet along the road cut and to extend flat into the hill for from 30 to 70 feet. The deposit was mined partly by open cut and partly by tunnels and flat stopes and has produced to date over 800 tons of shipping ore. The high-grade ore forms a ledge and has a flat dip to the east. This ore is from a few inches to several feet in thickness and is almost continuous. Most of it has been mined out, but directly under it and separated from it by from 1 foot to 8 feet of serpentine is a ledge of disseminated ore of about 15 percent grade. This has been opened up by a number of drifts since May 1918 and is now furnishing about 20 tons of concentrating ore, which is the mill run of the Chrome Concentrating Co. Two thousand tons of ore have been milled from this ledge, which is from 2 to 5 feet in thickness, over 300 feet long, and 90 feet in maximum breadth. There remains blocked out between 1,500 and 2,000 tons of milling ore, with fair chances of new ore being found, for the ledge has not been found to give out but to pinch to a size where it will not pay to mine.

This whole block of ground has caved and slid into the canyon. Recently the West Coast Chrome Co. excavated a large part of the caved material with a bulldozer in an unsuccessful attempt to locate an extension of the ore.

Another small body of ore (4) was developed 600 feet southwest of the workings (3), by open-cut methods. It was a disseminated tabular deposit striking N. 35° W. and dipping 65° NE. About 250 tons of milling ore is said to have been taken from two pits at this locality. At present there is very little ore in sight and no immediate prospect of developing any more.

Across the canyon from this deposit and probably forming part of the same ore zone, granular ore occurs in a discontinuous sheet or series of linear pods that strikes east and dips north (5). This ore has been opened by pits and tunnels, from which 500 tons of 40-percent ore is said to have been mined. Present reserves are limited to a few tons of low-grade material.

Black Bart group.--The Black Bart group (see fig. 7) is now held by the West Coast Chrome Co. The main workings (7) are in

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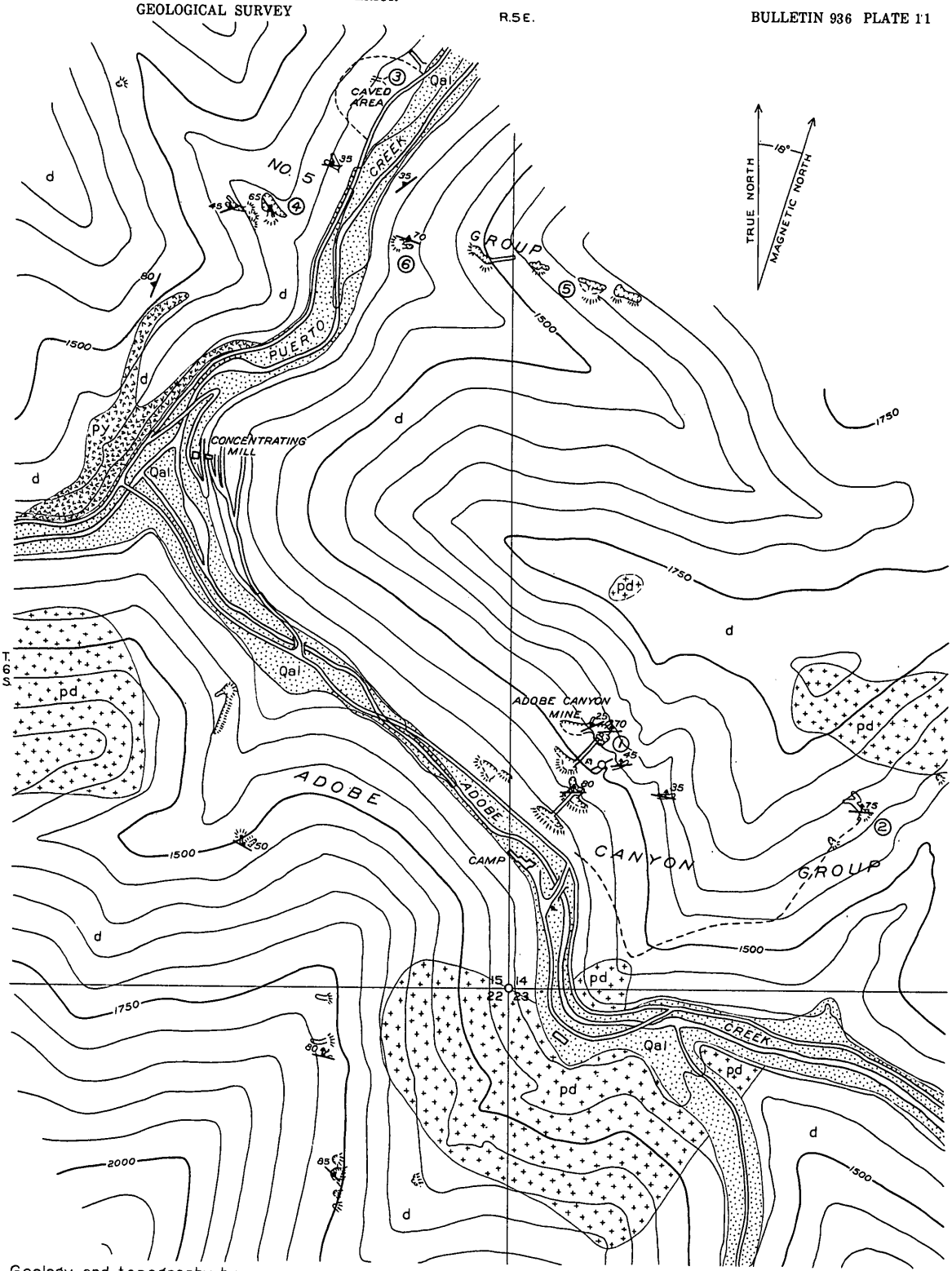
3/ Young, E. L., op. cit.



EXPLANATION

- Qal — Recent river deposits
- Py — Pyroxenite
- d — Dunite
- pd — Peridotite
- 80 — Strike and dip of chromite fissure
- Strike of vertical chromite fissure
- 30 — Strike and dip of chromite sheeting
- Open cut
- Tunnel
- Dump
- ② — Locality referred to in text

Geology and topography by
H. E. Hawkes, Jr., and R. W. Merriam
November-December 1940

200 0 800 Feet

Contour interval 50 feet
Datum is mean sea level

GEOLOGIC MAP OF ADOBE CANYON CHROMITE AREA

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sec. 16, on the north side of Hideout Canyon, 2 miles west-northwest from the Adobe Canyon area. Water for milling is available in Hideout Creek during most of the year.

The chromite deposits on the group were not discovered until the latter part of 1917, so that a considerable quantity of ore still remained untouched when operations were discontinued in 1918. E. L. Young [4] reports as follows:

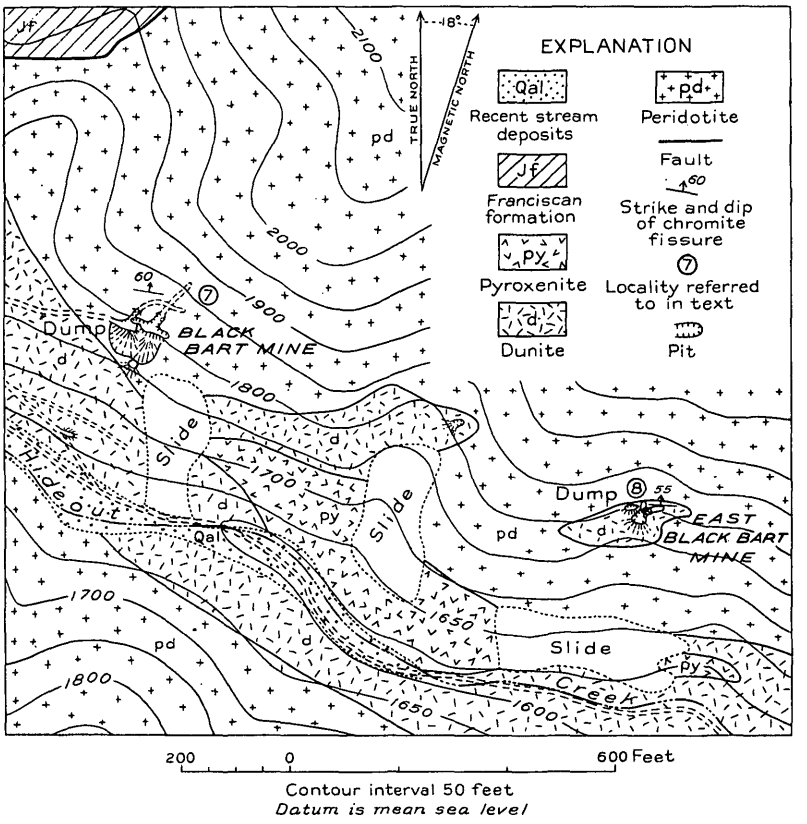

Figure 7.--Geologic map of Black Bart chromite area.

In 1917 about 50 tons of 38-percent ore was mined on this property, which was all the ore that was exposed on the surface. There remained only a fracture in the serpentine, which showed a plain trace of chrome in very small bunches. A tunnel passing some 20 feet under this open cut and following the fissure showed 90 feet of almost continuous ore, varying in width from 1 to 6 feet. From this tunnel a winze is now being sunk. The incline is about 5 feet high, measured normal to the dip, and followed the ore all the way down. The ore varies in width from 2 feet to the full height of the winze, with ore of unknown

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4/ Young, E. L., op. cit.

depth still in the hanging wall. The winze is still being sunk, and is in ore at the bottom. The ore is massive and fairly hard, being different from any other ore found in the district; all the other properties have a soft granular ore, enclosing soft serpentine and magnesite.

At the time of the present examination the workings (see fig. 8) were still accessible. It is estimated that 1,200 tons of ore lie between the bottom of the inclined shaft and the surface, and that another 1,000 tons or more may lie below the

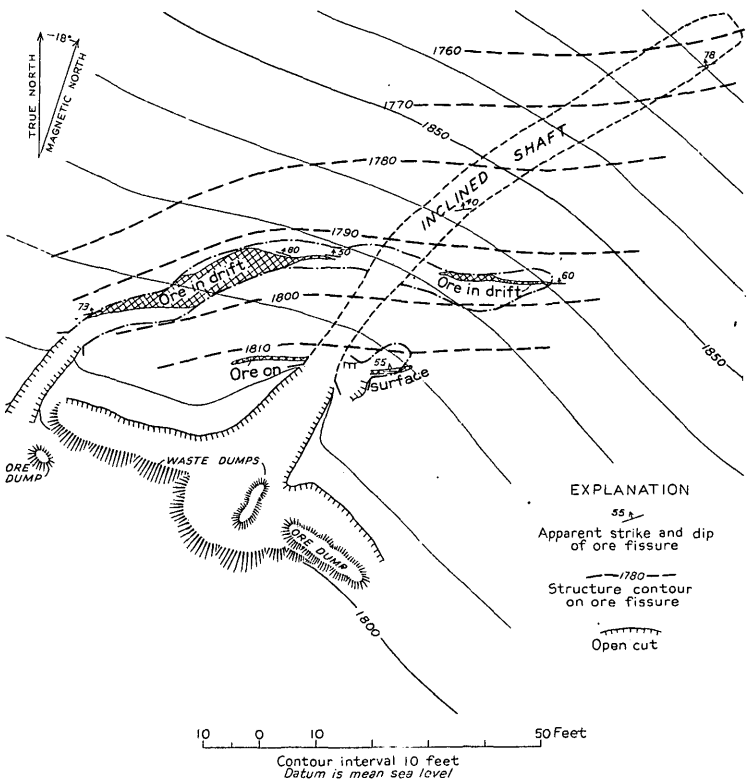

Figure 8.--Plan of Black Bart chrome mine.

present workings. The average width of chromite-bearing material is 18 inches to 2 feet. The massive ore is mixed with blocks of barren serpentine, which would have to be picked out by hand. A grab sample of hand-picked ore from the dump ran 33.8 percent Cr_2O_3; the pure chromite in this sample assayed

41.25 percent Cr_2O_3 and had a chromium-iron ratio of 2.28. The ore lens and the enclosing shear zone dip to the north at angles ranging from 40° to 80°, and as there is little indication in the present workings that the ore is giving out with depth, further development work should be carried downward as well as laterally.

East of the main workings another smaller deposit (8) has been opened up by a shallow winze. The surface exposure and the

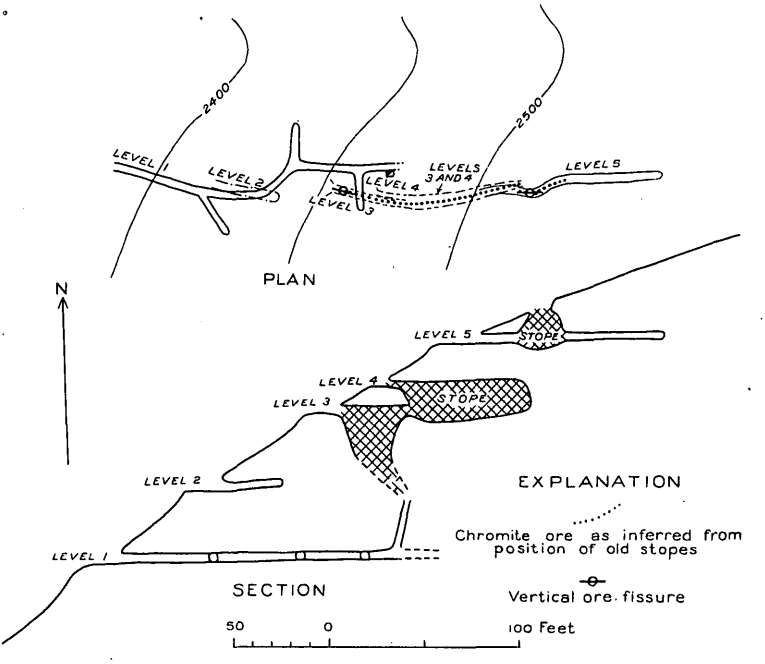

Figure 9.--Plan and section of Black Bear chrome mine.

structural relations of the chromite at this locality are similar to those at the main mine.

Black Bear mine.--The Black Bear mine (9) (see pl. 10) is owned by the West Coast Chrome Co. It is located in the central part of sec. 22, halfway up the north slope of Peachtree Canyon and about a mile east of the junction of Peachtree and Puerto Creeks. A well-graded trail leads from the road to the mine.

The Black Bear ore body (see fig. 9), like most other chrome deposits in the Del Puerto area, lies in a shear zone in dunite. The strike of the shearing is east, approximately parallel to the contact with the Franciscan, which lies only a few hundred feet to the south. The average width of the ore body in the

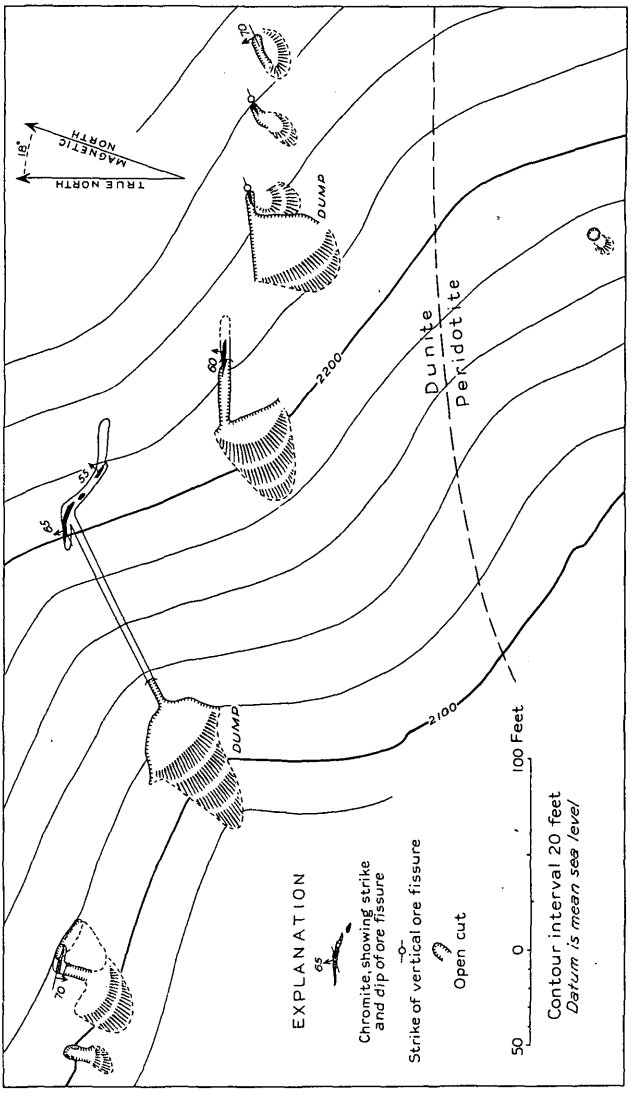

Figure 10. Plan of Lucky Girl chrome mine.

stoped areas is about 18 inches. Ore was taken from several narrow stopes, but none was found in a lower tunnel which was driven along the shear zone, beneath the stopes.

Lucky Girl mine.--The Lucky Girl mine (see fig. 10) formerly operated by G. L. Finster of Patterson, is now held by

the West Coast Chrome Co. It is located in the northwest corner of sec. 22, on the north side of Peachtree Canyon, 3,400 feet east of its junction with Puerto Creek. The workings are close to the graded trail which leads from the county road to the Black Bear mine.

Lenses and pods of granular and massive chromite occur in a shear zone that trends N. 80° E. and extends for a distance of 500 feet. The eastern part of the fissure was first developed by open cuts and short tunnels, and E. L. Young [5] reports that 150 tons of 42-percent ore was mined in these workings from 70 feet along the fissure. A lower tunnel and 75 feet of drift were driven later, but they appear to have revealed only one small pod of massive chromite. It is possible that a small tonnage of ore could be developed by systematic drilling in search of other such pods.

Chrome Camp mine.--The Chrome Camp mine (see fig. 5), formerly held by the Mineral Products Co., is now included in the Stanislaus County prison reservation. It is in the southern part of sec. 14, on the crest of a ridge half a mile north of Del Puerto Canyon, about 2 miles northeast of its junction with Adobe Creek.

The peridotite which forms the country rock at the mine is separated from the main ultrabasic mass by a band of Franciscan sedimentary rocks 700 to 3,000 feet wide. At present almost no ore is visible in the workings. E. L. Young reported in 1918 as follows:[6]

> Chromite found outcropping on the east and west side of a hill about 400 feet above Puerto Creek. Mined by an open cut on the west side, showed a length of about 50 feet and extended down to along its dip for about 35 feet to a pinch. More than half of the ore in this mine was mined and no work was done to try and see if it did not repeat in depth on the fissure. Ledge seems to have had a strike of S. 80° W. and dip flat to the north. The deepest part of the cut was not over 15 feet and from this cut over 500 tons of 43 percent chrome ore was shipped

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5/ Young, E. L., op. cit.
6/ Idem.

and the waste dump is full of small pieces, which would probably make up at least 50 tons more if they could be recovered.

On the east side of the hill and about 500 feet distant an outcrop was found and mined by an open cut and a short tunnel from this cut following the ore, and a stope almost to the surface from the tunnel. This showing also produced several hundred tons of 43 percent ore, but when the ore gave out the work stopped and no prospecting was ever undertaken. The showings are probably on the same fracture, although there is a slight difference in strike and dip.

The ore in the western deposit appears to have been localized in the wide shear zone separating the ultrabasic rocks from the Franciscan sedimentary rocks; the relations in the eastern deposit are obscure. Since, according to Young, no systematic attempt was made to explore the ore zones after the ore bodies were mined out, further exploration might be worth while.

QUICKSILVER

Quicksilver has been recognized in the sedimentary formations immediately adjoining the ultrabasic mass of the Del Puerto area at three localities, and has been mined in the Adobe Valley and Summit mines and the Winegar prospect, all shown in figure 5.

Cinnabar (HgS) is the only quicksilver mineral observed in the area. It occurs most commonly in thin minute crystals coating fracture surfaces, though at some places it is coarsely crystalline. The deposits have been so thoroughly weathered and leached that the primary gangue minerals could not be readily determined. At the Adobe Valley mine, soluble sulfates are abundant in the workings and marcasite was found on the dump. Specimens from the dumps of the Summit mine contain brecciated chert and "silica-carbonate" rock--a mixture of carbonate, limonite, and amorphous silica that is characteristic of many California quicksilver deposits.

The cinnabar in all three of the Del Puerto occurrences was deposited in fractures and minor openings related to strong faults. Such favorable fractures appear to form most readily

in sandstone. The ore at the Adobe Valley mine, for example, occurs in fractures in the sandstone footwall of a fault whose hanging wall is composed of dense, massive shale; the ore at the Winegar prospect lies in sandstone that adjoins a vertical fissure; and at the Summit mine the ore appears to lie in the sandstone footwall of a fault where serpentine forms the hanging wall.

Past production and reserves

A fair showing of ore is exposed on the 40-foot level of the Adobe Valley mine, but it apparently does not extend to the lower levels. At the present stage of development here, no estimate of reserves is possible, though additional underground work might block out a significant tonnage. The mine has produced a little ore.

The fissure at the Winegar prospect contains cinnabar in small pockets, but the grade across a mining width is believed to be too low to mine profitably. About 200 tons of ore was mined in the 1880's but none was shipped.

The Summit mine produced 200 flasks of quicksilver from low-grade ore. At present the workings are inaccessible and no estimate of reserves is possible.

The past production record and the apparently low grade of the ore at the three properties indicate that the reserves are very small and that no production is likely to be made except when prices are very high; and even then it is doubtful whether the annual production would be more than a few flasks.

Mine descriptions

Adobe Valley mine.--The Adobe Valley mine, formerly held by E. P. Newhall of Livermore, Calif., is now owned by Paul Gerber of Patterson and operated by Peter Saracco of San Francisco. The property, which is not all in one tract, consists of

2,400 acres, partly in secs. 13 and 24, T. 6 S., R. 5 E., and partly in secs. 18, 19, 20, 29, and 30, T. 6 S., R. 6 E. The mine is in sec. 24 of T. 6 S., R. 5 E. (pl. 10). Three miles

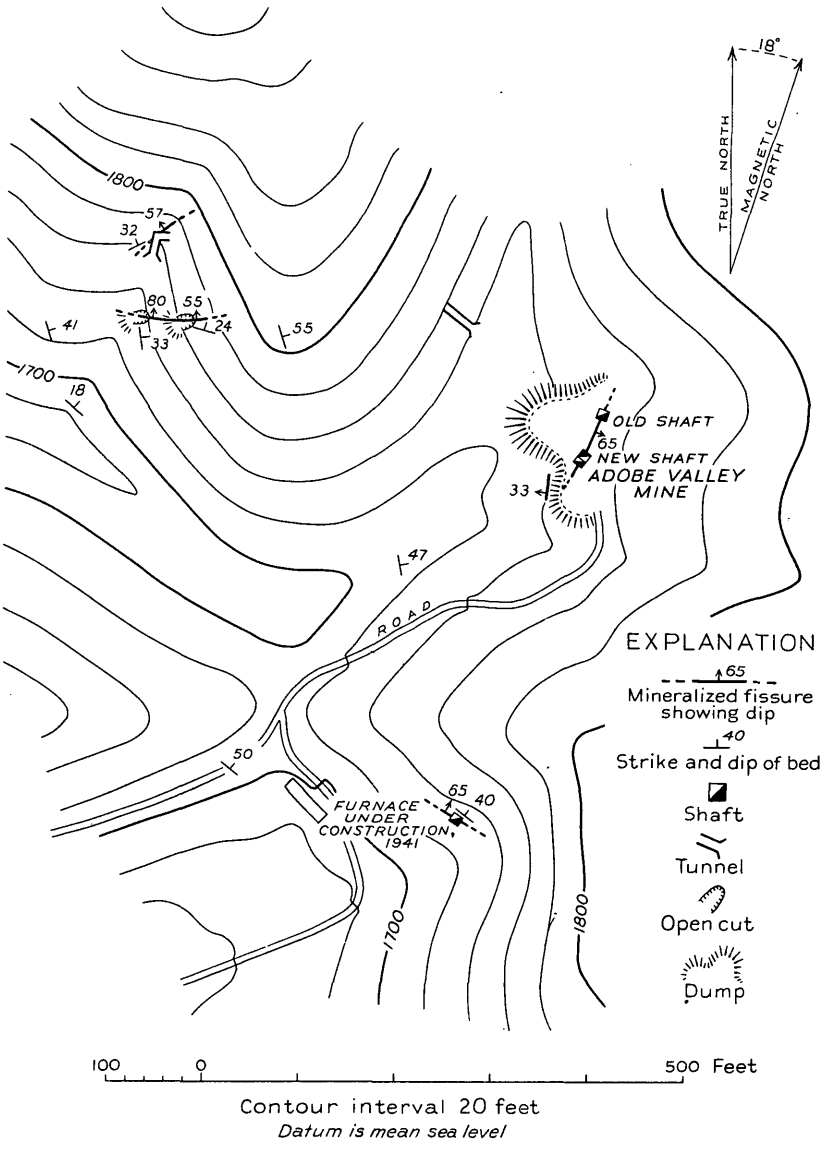

Figure 11.--Map of Adobe Valley quicksilver area.

of rough dirt road leads from the mine to the Del Puerto county road at the junction of Puerto and Adobe Creeks.

Cinnabar, as shown by traces of the mineral in the soil, is widely distributed in the Adobe Valley quicksilver area. In the

three explored localities, the ore is apparently related to conspicuous fault fissures (fig. 11). The deposits all lie on different fissures, however, and form no consistent pattern.

The largest of these deposits was explored during the period 1884-88, when a 180-foot shaft was sunk and several hundred feet

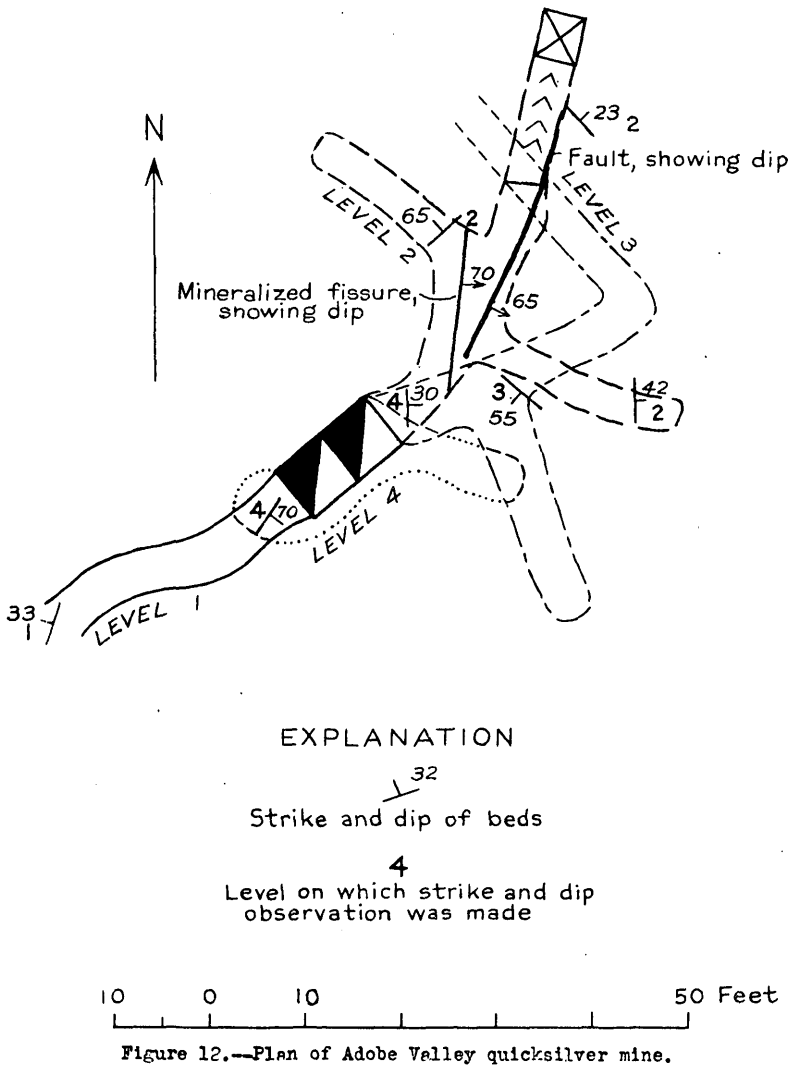

Figure 12.—Plan of Adobe Valley quicksilver mine.

of tunnel driven. No underground exploration has been dore since. Within the last year, the old shaft has been unwatered and a new shaft timbered to a depth of 115 feet and the old

levels at 25 (level 1), 40 (level 2), 70 (level 3), and 90 (level 4) feet below the collar have been cleaned out (fig. 12).

The country rock consists of thick-bedded sandstone, interlayered sandstone and shale, and thin-bedded shale of the Chico formation, all thoroughly fractured and altered. The cinnabar occurs in fine fractures in sandstone. The distribution of the ore is erratic, and it is difficult to estimate its grade, or to recognize the limits of commercial ore, from mere inspection of the drift walls.

On the second level, the ore is confined to the footwall of a fissure striking N. 5° E. and dipping 70° E.; it is localized in fine fractures striking N. 50° E. and dipping 65° NW. A plane of major displacement, which separates shale on the east from sandstone on the west, lies a few feet east of the ore fissure (fig. 12). Minor structures indicate that the relative movement on both faults was down on the east side.

The structure on the lower levels is not so clear; no well-defined fault can be identified below the second level. Here the mineralized fractures are apparently more erratic than above in both attitude and distribution. On the third level a drift extends in a northwesterly direction along a zone of fracturing, which could not be examined because of bad ground but which cannot be related to the faults exposed on the second level. The fourth level shows cinnabar in fractures with an average strike of N. 35° E., and dip of 70° SE.

In July 1941 a 50-ton furnace was being installed on the property.

Winegar prospect.--The Winegar prospect is owned by Emma Rose of New York and E. S. McCurdy of San Francisco; at the time of visit it had been optioned to P. S. Winegar of Vernalis, Calif., and Paul Kraft and C. E. Fish of Patterson. The property was formerly part of the Phoenix Mines. It has been called

the "Orestimba" goup, but as there is a better-known Orestimba mine west of Newman, Calif., this name had better be avoided.

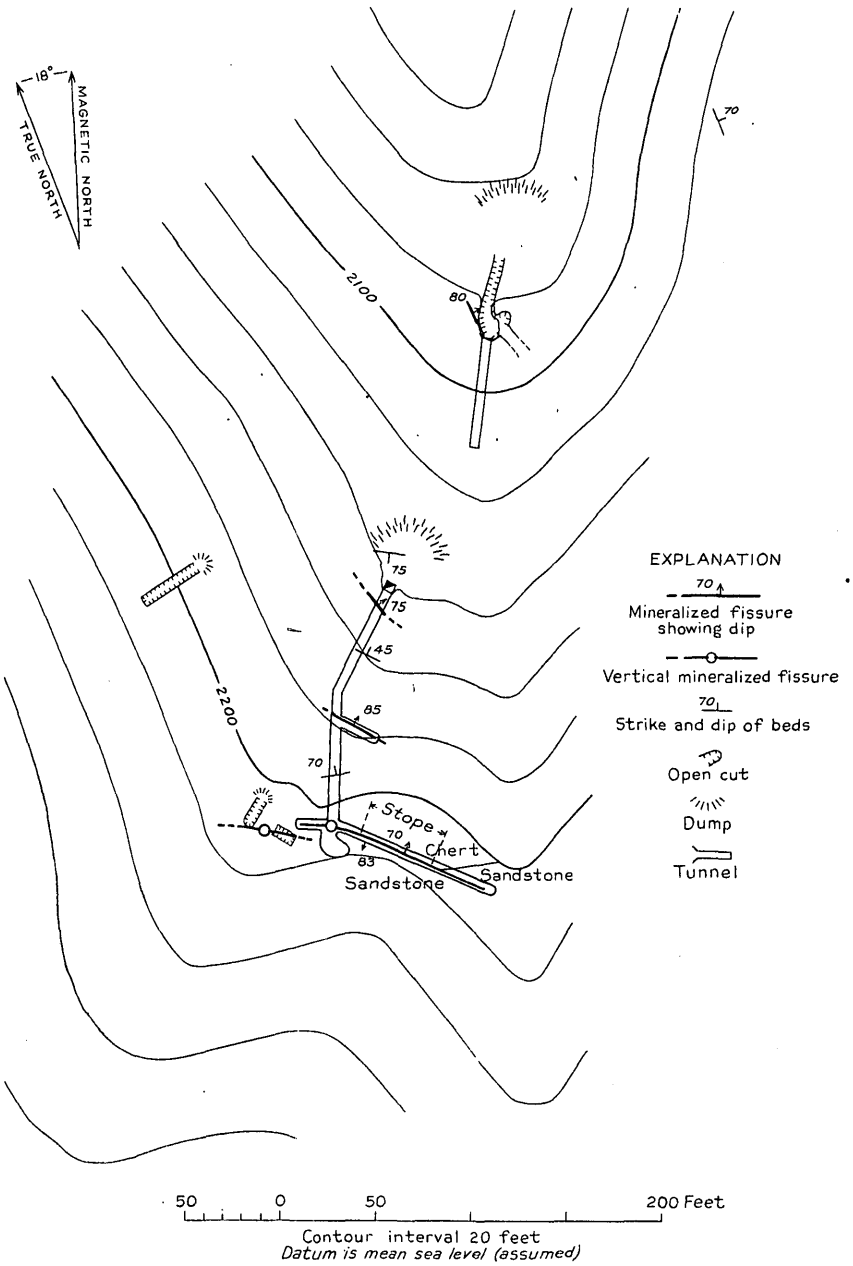

Figure 13.—Plan of Winegar quicksilver prospect.

The property consists of 1,920 acres of patented land in secs. 25, 35, and 36, T. 6 S., R. 5 E. The workings are located in

the central part of sec. 25, about a mile and a half south of the Adobe Valley mine (fig. 5).

Franciscan sandstone and chert form the country rock. The main body of ore is exposed on the surface at the collar of a caved shaft, and it is encountered in a drift 70 feet below the surface exposure (fig. 13). In the drift, the ore is localized on the southwest side of a fault striking N. 40° W. and dipping 70° NE. to 83° SW., which separates chert on the east from sandstone on the west. A stope roughly 40 feet long by 15 feet high and 5 feet wide has been mined out, and the ore has been piled on the dump. The cinnabar is irregularly distributed as fracture fillings in a 5-foot fracture zone in the sandstone. Near the southeast end of the drift, sandstone lies on both sides of the fault, the fissure zone narrows to less than 2 feet, and the ore dies out. A lower tunnel was driven, presumably to intersect the ore at greater depth, but was abandoned before the fissure was reached; a trace of cinnabar is exposed at its portal.

Summit mine.--The Summit mine, formerly part of the Phoenix Mines, is owned by Emma Rose of New York and E. S. McCurdy of San Francisco. It is in sec. 20, T. 6 S., R. 5 E., near the Stanislaus-Santa Clara County line and the watershed between the Puerto and the Arroyo del Valle drainage (fig. 5). By road it is 39 miles southeast of Livermore and 26 miles west of Patterson.

With few exceptions the workings have caved and are inaccessible. As well as could be determined, the ore is localized in fissures in the footwall of a fault that separates serpentine from sandstone and chert of the Franciscan formation. Three separate veins were mined from a shaft and three adit levels.[7/]

In 1915-16 this mine produced 200 flasks of quicksilver from ore averaging 5 to 6 pounds of mercury to the ton. The ore was burned nearby in a 50-ton Scott furnace.

7/ Bradley, W. W., Quicksilver resources of California: California State Min. Bur. Bull. 78, p. 199, 1918.