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THE QUICKSILVER RESOURCES OF CALIFORNIA.

(SECOND EDITION.)

ISSUED BY

THE CALIFORNIA STATE MINING BUREAU,

FERRY BUILDING, SAN FRANCISCO.

UNDER THE DIRECTION OF

LEWIS E. AUBURY, - - State Mineralogist.

SACRAMENTO.
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LETTER OF TRANSMITTAL.

To Hon. George C. Pardee, *Governor of the State of California, and the Honorable the Board of Trustees of the State Mining Bureau:*

Gentlemen: I have the honor to transmit the results of the recent work of the State Mining Bureau in investigating the Quicksilver Resources of California, and which are embodied in Bulletin No. 27.

This is the third of a series of bulletins, issued under my direction, on special features of the mining industry in California, and in which will be found a description of the geology of all the deposits of economic importance in the State, together with maps and such data as it was possible to obtain. The geological field work for this bulletin was performed by Mr. William Forstner, Assistant in the Field, of the State Mining Bureau. No description of any mine or prospect, nor of the geology of any part of the territory, has been given except after personal investigation by Mr. Forstner.

In treating of the geology and the genesis of ore deposition, subjects of which differences of opinion exist, endeavors have been made to present as briefly and clearly as possible the different opinions, and some suggestions have been added which have resulted from Mr. Forstner's personal observation.

In the chapter on the metallurgy of quicksilver, it has been the aim more to give the general principles upon which the different methods of treatment are based than to make a mere detailed description of the different installations.

The courtesy generally shown by the owners and superintendents of the different mines deserves special mention. With only one exception, at every mine all information which would be of value from a technical and often from a commercial standpoint was given with the greatest courtesy. This is the more appreciated, as quicksilver is a product for which the demand is to a certain extent limited, and it is only natural that operators do not feel inclined to disclose all the facts pertaining to their business.

I wish to extend my thanks to Mr. J. W. C. Maxwell, who assisted in the revision of the technical and descriptive portions of the bulletin; to Mr. Charles G. Yale, for assistance in the editorial part of the work; and to Mr. E. B. Preston, for the classification of specimens of ores and formations submitted.

To the many owners and superintendents of quicksilver mines and prospects who lent their assistance, I wish also to extend my thanks, for without their valuable aid it would have been impossible to present the full results of the work as herein set forth.

Very respectfully,

LEWIS E. AUBURY,

State Mineralogist.

San Francisco, June 30, 1903.

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THE QUICKSILVER RESOURCES OF CALIFORNIA.

By WM. FORSTNER, E.M.,
Assistant in the Field.

CONDITION OF THE INDUSTRY.

Quicksilver has been produced in California since 1850. The table published in the report of the Eleventh Census (1890), page 188, compiled by Mr. J. B. Randol, giving the annual production of the various mines from 1850 to 1889, indicates that in the decade 1850 to 1860 the New Almaden mine was about the only producer. In the latter part of the 60's, the New Idria, Redington, and Ætna mines began to produce. The greatest number of mines were in operation between the years 1874 and 1880. This activity was due to the high price of quicksilver obtained in 1874, when the prices per flask in San Francisco were: highest, $126.22; lowest, $84.15. In 1875 the price dropped to $49.75, and until 1883 the average price was about $30. The lowest price was in this period for awhile, $25. For years the price remained rather low, but in the last few years it has maintained a figure which gives the operators a fair remuneration. These low prices in 1879 and 1880 caused the closing of a number of quicksilver mines, and for some years quicksilver mining was carried on only at a few of the large mines. In later years the price of quicksilver has risen, although by no means to that of the prosperous times, and gradually the old mines, closed for years, are being reopened. In the meanwhile the older mines, which have been steady producers for many years, appear to have worked out their bodies of high-grade ores, and are all now working what in years past would have been classed as poor ores. In the well-managed properties, however, where they have availed themselves of the more economical methods of mining and especially of reducing the ores, a fair interest on the investment is earned from these low-grade ores. The yearly production of quicksilver in California has been as follows:

TABLE GIVING YEARLY PRODUCTION OF CALIFORNIA MINES AND AVERAGE PRICE PER FLASK IN SAN FRANCISCO.

Year.	Flasks Produced.	Average Price per Flask.	Year.	Flasks Produced.	Average Price per Flask.
1850 (*a*)	7,723	$99 45	1879	73,684	$29 85
1851	27,779	66 93	1880	59,926	31 00
1852	20,000	58 33	1881	60,851	29 83
1853	22.284	55 45	1882	52,732	28 23
1854	30,004	55 45	1883	46,725	28 75
1855	33,000	53 55	1884	31,913	30 50
1856	30,000	51 65	1885	32,073	30 75
1857 (*b*)	28,204	48 73	1886	29,981	35 50
1858	31,000	47 83	1887 (*c*)	33,760	42 37½
1859	13,000	63 13	1888	33,250	42 50
1860	10,000	53 55	1889	26,464	45 00
1861	35,000	42 05	1890	22 926	52 50
1862	42,000	36 35	1891	22,904	45 25
1863	40,531	42 08	1892	27,993	40 71
1864	47,489	45 90	1893 (*d*)	30,164	36 75
1865	53,000	45 90	1894	30,416	30 70
1866	46,550	53 13	1895	36,104	37 04
1867	47,000	45 90	1896	30,765	34 96
1868	47,728	45 90	1897	26,648	37 28
1869	33,811	45 90	1898	31,092	38 23
1870	30,077	57 38	1899	29,454	47 70
1871	31,686	63 10	1900	26,317	44 94
1872	31,621	65 93	1901	26,720	48 46
1873	27,642	80 33	1902	29,552	43 20
1874	27,756	105 18	1903	32,094	42 25
1875	50,250	84 15	1904	28,876	37 62
1876	75,074	44 00	1905	24,655	35 94
1877	79,396	37 30	1906	19,516	36 50
1878	63,880	32 90			

(*a*) Report 11th Census. 1850 to 1865, great bulk of quicksilver produced by the New Almaden mine.
(*b*) The New Idria mine begins to produce 1857.
(*c*) From 1887 to 1893, Dr. Day's Report, U. S Geol. Survey.
(*d*) 1893 to date. Annual Statistical Bulletins, California State Mining Bureau.

Quicksilver furnaces are great consumers of wood, and even those mines which are located in well-timbered regions find the cost of their fuel steadily increasing. Only in exceptional cases can mines get their cordwood delivered for $3.50 per cord; generally the price is higher, in some cases double that figure. Hence most of the quicksilver mine managers are eagerly looking for a substitute for cordwood as fuel in their furnaces. Up to the present time, however, this has not been found.

As mentioned above, many of the quicksilver mines have been idle for some years, and of these it is very difficult to obtain either reliable historical data, or details of the old workings or of the output of mercury. Even in the mines which have been in continuous operation, large portions have been worked out and abandoned, and it is nearly impossible to get the desired information regarding these portions of the mines. In regard to several of the principal mines of the State, belonging to the Napa Consolidated and affiliated companies, these data were to a great extent destroyed in 1898, in which year the main office in Oathill was burned and most of the mine maps, etc., were destroyed.

Whatever information of this character it was possible to collect, is inserted in the descriptions of the respective mines. It may here be stated that in accordance with the general scheme of this Bulletin, its contents are confined strictly to the occurrence of quicksilver in the State of California, for which reason all reference to mines and works in other localities is omitted.

GEOLOGY OF THE QUICKSILVER BELT IN CALIFORNIA.

The quicksilver deposits in California are, with a few scattered exceptions, located in the Coast Ranges. There is a very marked difference of opinion among the geologists who have made a special study of this territory, regarding two points: First, as to the age of the metamorphic series which form such a prominent part of the rocks in this territory; and secondly, as to the origin of the serpentine. They all agree that violent geological disturbances took place in this region at some period within the Mesozoic age. These disturbances were sudden and sharp, resulting in the crushing and fracturing of the strata rather than their uplifting and folding [Whitney, Auriferous Gravels, page 15], and gave this series a characteristic structure, which serves to its identification. The epoch of this revolution is placed by Becker at the end of the Neocomian or Lower Cretaceous, while Fairbanks and others place it at the close of the Jurassic epoch, hence as pre-Cretaceous.

The rock series metamorphosed by the revolution is called by Becker the Neocomian, and also occasionally the Metamorphic series; by Fairbanks, the Pre-Cretaceous or the Metamorphic series; by Lawson, the Franciscan series. These rocks rest upon a basement complex consisting of crystalline limestones and schists and granites. The granite does not appear at the surface north of the bay of San Francisco, except on the coast twenty miles north of San Francisco at Point Tomales; but south of San Francisco there are two ages of granitic uplifts. The granite is intrusive in the older strata. The crystalline rocks of the basement complex are only found at a few points; the granitic uplifts brought them within a zone of such effective erosion that the granite was almost entirely denuded before the next period of subsidence and deposition of the Franciscan series set in. The age of the crystalline rocks of the basement complex is either Carboniferous or older. [See Bulletin Geological Society of America, vol. VI, pages 79–81.]

Intimately mingled with the rocks of the Franciscan series are large masses of serpentine. Becker holds that these are prominently altered sedimentaries [see Mineral Resources, 1892, U. S. G. S., page 144]; while Fairbanks holds these serpentines to be exclusively derived from eruptives. A. C. Lawson is of the same opinion, so far as the serpentines in the peninsula of San Francisco are concerned. Apparently the latter views as to the origin of the serpentine in the Coast Ranges are entertained by all the geologists on the Pacific Coast. The serpentine bodies occur in different forms and the rocks themselves vary very sensibly in structure in different regions and in the various bodies of serpentine. In places the serpentine occurs in bodies indicating an original dike formation and showing intrusive phenomena; while in other places large areas of serpentine occur which can hardly be conceived to be derived from eruptive masses, and wherein are found small areas of sandstone and occasionally shales, indurated but slightly altered, in places even unaltered. In other places the serpentine overlies or underlies the sandstone and shales without any intrusive phenomena. During the investigation in the preparation of this Bulletin, in the neighborhood of New Idria [see general description of the New Idria district, page 125] and near Cambria, San Luis Obispo County, sandstone and serpentine were found intimately associated. Samples of these occurrences are in the museum of the State Mining Bureau, and a slide of the first mentioned has been prepared and photographed.

Both views of the origin of the serpentine can be sustained by microscopical examination. [See, for instance, Becker, Mon. XIII, U. S. G. S., page 275, and following; A. C. Lawson, 15th Ann. Report, U. S. G. S., pages 417, 433, and 447; etc.] It may be argued that both views are correct and that probably the serpentine is an alteration product of both sedimentaries and eruptives in this region, as is the case elsewhere. This view is that of the majority of geologists. In 1888 this question was submitted to the American Committee of the International Congress of Geologists [see American Geologist, vol. II, page 180], in the following form:

Question N—Is serpentine (1) sometimes, (2) always an alteration product, (3) of eruptives, (4) of sedimentaries, (5) of either?

Thirteen answers were received, which can be summarized as follows: Twelve declared serpentine to be an alteration product, and one characterized it as an original aqueous rock. Three of the first twelve took the view that it is exclusively an alteration product of igneous rocks; one exclusively of sedimentary rocks; two, generally of igneous rocks, but could also be such of sedimentary rocks; and five that it is an alteration product of both eruptive and sedimentary rocks, while one leaves this part of the question unanswered.

Professor van Hise remarks, in his Principles of North American Pre-Cambrian Geology [16th Ann. Report, U. S. G. S., Part I, page 689]: "Actinolite, serpentine, and magnetite "have been observed to replace quartz. In the case of the two "former minerals their relation to the quartz suggests that the "other constituents, with the exception of silica, were at hand "or were furnished by the percolating water out of which the "serpentine and actinolite formed; and that the quartz itself "may have furnished the necessary silica to produce these "minerals." [On page 691:] "Among basic sedimentary rock "serpentine very often develops."

E. S. Dana [Mineralogy, 1898, page 477] states: "Microscopic "examination has established the fact that serpentine is largely "produced by the alteration of chrysolite; in other cases it has "resulted from the alteration of pyroxene or amphibolite." [See also Williams, Lithology, page 254.]

A. C. Lawson, in describing the deformations of the earth-crust which have influenced the geology of the San Francisco peninsula [15th Ann. Report, U. S. G. S., page 466], mentions "an invasion of the upper portion of the Franciscan series by "peridotite magma, which solidified in the form of dikes or "laccolitic lenses."

The granites of that part of the Coast Range which contains the quicksilver belt appear only at the surface south of San Francisco. Lawson has carefully studied granite in two places: the Montara granite in the San Francisco peninsula [above cited, page 411], which he describes as a coarse gray hornblende, biotite granite, which originally was a hornblende granite; and at Carmel Bay [Bulletin Geological Department, University of California, vol. I], which he describes as a coarse porphyritic granite. Similar granite rocks are found in the Santa Lucia Peak, and in the San José range.

Fairbanks has studied extensively the granites in the Coast Range south of San Francisco, and considers them as true mica feldspar quartz granites, differing from the granites in the Sierra Nevada, which are usually hornblendic. [Bulletin Geological Society of America, vol. VI, page 79.]

H. W. Turner [Am. Geol., vol. XI, page 324] supposes these granites to be of Carboniferous age. Fairbanks thinks this may be true or they may be older.

Accepting the suggestion of Becker that the entire Coast Range is underlaid by granite [Mon. XIII, page 140], a source of ferro-magnesian silicates other than the suggested post-Franciscan peridotite intrusions is present in this region. Lawson [above cited, page 434] calls attention to the fact that the entire period of accumulation of the Franciscan series was a period of volcanic activity, and that the lower portions of this series were traversed by igneous rocks, which arriving at the surface, became constituents of the upper portion of the series.

It appears most probable that all of these materials have contributed to the formation of the bodies of serpentine found in this region. As van Hise remarks [above cited, page 691], "Material for the serpentines may be furnished in part or in "whole by minerals present, *or the material of the serpentine* "*may come from an extraneous source.* Also, widespread for-"mations may be extensively serpentinized, so as to give for "considerable areas almost solid masses of serpentine."

The pressures which caused these deformations produced great heat from dynamic action, which was increased by that obtained from the intruding magmas; consequently both pressure and temperature were raised during the deformations, causing an increased chemical activity of the circulating waters, and it appears only reasonable to assume that all available sources for the formation of serpentine masses were called upon.

The later intrusions, forming the dike and laccolitic lenses, can be generally defined by the phenomena of contact metamorphism accompanying them; while the large, widely-distributed masses of serpentine were probably formed by magnesian solutions acting upon the rock material. [Mon. XIII, pages 121–127, and 273–278.] The ferro-magnesian silicates are probably derived from the basal granite, and perhaps from intrusives, which would explain the entire lack of contact metamorphism phenomena at the contact of many serpentine bodies with the other rocks. This lack of contact metamorphism and intricate mixture of serpentine with the sandstones and shales of the Franciscan series, and even probably with the schists of the basal complex, can be extensively studied in the New Idria district.

As already stated above, there is a great diversity of opinion as to the historical geology of the Coast Ranges. The accompanying table of comparison will set this forth. [See American Geologist, vol. XI.]

Age.	Period.	Gabb—California.	White and Becker—California.	Diller and Stanton—North California and Oregon.	Lawson.
Cenozoic.	Miocene.				Monterey Series. Light color'd Sandstone?
	Eocene.			Tejon.	
Mesozoic.	Upper Cretaceous.	Tejon. Martinez. Chico.	Chico Tejon. Probable place of the Wallalla.	Hiatus and Unconformity.	Franciscan Series.
			Hiatus of White. Unconformity of Becker.	Shasta-Chico Series: Chico.	
	Lower Cretaceous.	Shasta.	Shasta: Horsetown. Knoxville, including Mariposa.	Horsetown. Knoxville.	
	Jurassic.	Mariposa.		Mariposa.	

This difference of classification is closely related to the above-mentioned difference of opinion as to the period wherein took place the disturbances which caused the metamorphism of the rocks deposited after the first-recorded intrusions. J. S. Diller says [Bulletin Geological Society of America, vol. IV, page 206]: "The Cretaceous of north California, embracing the "Chico, Horsetown, and Knoxville beds, are essentially con-"formable, hence the upheaval must have been pre-Neocomian." Becker places the upheaval after the Horsetown series, referring to it as post-Neocomian. Fairbanks indorses Diller's opinion, and names the Metamorphic series the Pre-Cretaceous series.

Whatever may be its age, this Franciscan series presents some distinguishing characteristics which facilitate its identification from the underlying crystalline limestones and schists of the basement complex, and from the overlying younger rocks. This series consists mainly of sandstones, associated with some shales, cherts, and occasionally limestone. The sandstones are rather massive; the bedding planes have often intercalated beds of shale. They are very generally altered through a process of recrystallization and cementation by silicification. All grades of alteration can be observed, from nearly unaltered arkose sandstone to compact jasper, or jaspilite (a term suggested by Wadsworth). [See 16th Ann. Rep. U. S. G. S., Pt. I, page 702.] Interbedded with the sandstones are limestones, cherts, and volcanic rocks.

The chert beds form a very characteristic member of this series, but are much more prominent in the districts north of San Francisco than in those south. They have been extensively discussed by Becker, Fairbanks, and Lawson. The first named refers to them as schistose rocks which have been subjected to a process of silicification, and classes them as phthanites. Blake supposed that they had resulted from the metamorphism of shales and sandstones by igneous action. J. J. Newberry [General Geology of California, page 66] says: "Whether the material of which they are composed is thrown "up from below, or, as is more probable, it is a metamorphosed "form of the associated rocks, it is evident that the material "has been subject to great heat." Fairbanks [Bulletin Geological Society of America, vol. VI, page 71] classifies this formation as jasper. Lawson [above cited, page 420] as Radiolarian cherts, which designation appears the most correct.

The following is a concise statement of Mr. Lawson's study of this formation:

"These beds consist of alternate thin sheets of chert, ranging generally from one to four inches in thickness, only "exceptionally having a much greater thickness, with partings of shale from one eighth to one half inch thick. Sometimes the regularity is much less marked, and in the less "ferruginous varieties of the chert beds the sheets of chert "assume occasionally a lenticular form. The difference of "opinion as to the proper classification of this formation is "due to the fact that petrographically these cherts are not "uniform. In many cases they are true jaspers; in others "the silica is chiefly amorphous, and the rocks have a flinty "character; in still other cases the proportion of iron oxide "is so great that the cherty character disappears and the "beds become locally very soft. All gradations between "cherts composed almost wholly of amorphous silica, to those "which are a holocrystalline aggregate of quartz granules, "are found. The amorphous silica differs, however, from opal, "in that it has a much higher specific gravity and contains "much less combined water. The cherts are, then, minutely "granular aggregates of crystalline silica, tending more toward "the chalcedonic than to the quartz variety, with varying pro-"portions of amorphous silica, mixed with ferric oxide and "ferric hydrate, sometimes uniformly distributed, or again in "patches or streaks. The mass is intersected by numerous "small, often microscopical veins, the smaller filled with chal-"cedonic, the larger with quartzose silica, and occurring in two "sets of fissures crossing at high angle. Zoisite is often found "in the vein filling. These chert beds contain round or oval "spaces, occupied by chalcedony, which are the residual casts "of Radiolaria. The intervening shale consists of silica, iron, "considerable magnesia, and a small amount of alumina with-"out any clastic material. The association of chert beds with "the sandstone precludes the possibility of their formation "under deep-sea conditions, which would be indicated by the "absence of fragmental material."

The most probable hypothesis of their formation is, as suggested by Lawson, that the silica was derived from siliceous springs and precipitated in the bed of the ocean in local accumulations, in which Radiolarian remains were imbedded. The alteration of the beds of chert with partings of shale may perhaps be ascribed to an intermittent action of the springs. These chert beds occur throughout the Coast Range in a sporadic manner, and are especially of interest, as in some mines they form the ore-bearing zones. Associated with these rocks of the Franciscan series are metamorphic schists which appear to represent stages of alteration of rocks of very diverse origin, and may be principally the result of contact metamorphism, which, as H. W. Turner remarks, "is, however, yet to be fully demonstrated." As already stated above, the rocks of this series are further associated with many and various igneous intrusives, entirely separate from the later Tertiary and post-Tertiary igneous ejections.

There must have been a considerable difference in the geological history of the northern and southern part of the quicksilver belt. South of San Francisco the Franciscan series were elevated and eroded to such an extent that the Tejon is found resting directly on the granite and a second elevation, and post-Miocene erosion must have followed, as the Pliocene is also found resting direct on the granite. North of the bay of San Francisco, the erosion of the Franciscan series has been much less, so that between the bay and Clear Lake the granite does not appear at the surface and the younger formations all rest on this series.

The metamorphism of the Franciscan series was eminently a process of recrystallization of the clastic sediments into holocrystalline feldspathic rocks, carrying ferro-magnesian silicates, and in the formation of vast quantities of serpentine. [See Becker, above cited, page 57.] The serpentinization was posterior to the former process, which included a silicification which altered part of the shales to jaspery masses and formed in these and in other rocks innumerable minute veins of quartz. [*Ibid.*, page 393.]

There are reasons to believe that the metamorphism of this series took place at no great depth. The rocks were often crushed into a confused mass of rubble by dynamic action [see above, page 12], which is often recemented by metamorphic process. The readjustment of the strata under pressure hence took place largely through fracturing, rather than through flowage and flexure of the rocks, consequently they can not have been buried at great depths.

A much later silicification process took place attendant upon or just prior to the ore deposition and of a distinct character from that above mentioned, in many cases resulting in the formation of a black opal rock. This opal replaces constituents of the rock masses, particularly but not exclusively serpentine. The opal is often deep black, resembling some varieties of obsidian, and is accompanied by small amounts of crystalline silica, quartz, and chalcedonite—the name suggested by Dr. Becker [above cited, page 390] for a mixture of opal and crystalline silica; sometimes it contains a small amount of calcite. A perfect network of minute bands of quartz often traverses the opal, resulting from infiltration into fissured opal. This material is seldom, if ever, free from sulphides of iron, occasionally of nickel, and at least traces of cinnabar are invariably found close to it (hence its local name of "quicksilver rock"), showing its close relation to metalliferous solutions. While some of this opaline rock has certainly been deposited in pre-existing openings, a large part is a substitution product. The silica solutions seem to have permeated more or less fractured rocks, principally serpentine, dissolving the bases and depositing the opal.

This silicification process is closely related to the deposition of cinnabar ores and to the later igneous phenomena. As above stated, cinnabar is often found in the filling of minute cracks in the opaline rock, accompanied by quartz and chalcedonite, but seldom if ever imbedded in the opal. Hence this silicification process must have preceded the ore deposition; but the effects of the two processes are so closely related that the former must have been an earlier stage of the latter. The fact that mercuric ores are hardly ever found in direct contact with the opal is hard to explain, as it would suggest that the siliceous solutions during that period of the process were entirely barren of mercuric sulphide. The solutions during the ore deposition were, however, also certainly siliceous, and hence it is hard to understand why the former should have been entirely barren. Dr. Becker offers as explanation the hypothesis that the cinnabar was separated from the solutions in the fissures when the siliceous fluids permeated the rocks, through a mechanical process more or less analogous to dialysis. The difficulty is, however, that metallic salts are crystalloid bodies and pass readily through membranes, while silica is colloid. In the Manhattan mine, Napa County, sulphide of mercury is, besides, found intimately mixed with the chalcedonite. This silicification process was directly connected with the later igneous eruptions and intrusions. Perhaps the greater heat during the first part of the period covered by this process may offer an explanation for the absence of mercuric sulphide in the opal then formed. [See, on this point, Genesis of the Quicksilver Deposits, page 26.]

Calcite and dolomite form besides the silica the gangue minerals accompanying the cinnabar. Sometimes these carbonates are in direct contact with the cinnabar. The associated metallic minerals are in nearly all cases pyrite and marcasite; very often arsenious and antimonious minerals, and sometimes copper minerals. Cinnabar ores are nearly exclusively deposited in pre-existing openings. Ore bodies precipitated by substitution are very rare. Where cinnabar deposition can now be observed the same rule holds good. The later igneous eruptions, to which the ore deposition is related, are of Tertiary or later date. Becker [above cited, page 152 and following] cites three different periods: The first, pre-Pliocene, during which large masses of andesite were ejected—a bluish-gray rock, containing pyroxene and feldspar crystals imbedded in a ground mass of feldspar and magnetite. A later andesitic eruption, very late Pliocene or at the close thereof; the andesites belonging to a special group having a trachytic character, for which Becker proposes the name Asperites. Rhyolite, probably younger than the andesites, is found near New Almaden and in the northwestern part of San Luis Obispo County. Basalt eruptions, belonging to the Quaternary and more recent periods. These eruptions are closely related to the fissure system of the former upheavals, which had established lines of weakness, along which the strata adjusted themselves to the posterior deformations. The ore depositions were most probably formed by mineral springs connected with the volcanic activity of the post-Andesitic period; hence they belong to the post-Pliocene period. According to Becker, this is indicated by the usual association of cinnabar with basalt, or as in New Almaden with rhyolite, and also by the unimportance of cinnabar deposits in andesite. It is a striking fact that most of the prominent mines north of San Francisco are in close proximity to basaltic or relatively recent eruptions, as for instance: The Ætna mines, a basalt dike on the Silver Bow claim, and basalt in the Star claim; the Oathill mine, a large basalt body in close vicinity to the mine; the Corona and Twin Peaks mines, between the basalt of Oathill and that of the Howell Mountains; the Great Western, a body of basalt south and in close proximity to the mine; the Sulphur Bank, basalt all around the mine; the Manhattan, surrounded by basalt to the east and north; the Boston, within half a mile of the basalt in the Manhattan ground.

In the southern field the geological conditions vary very much. In the New Idria district no definitively post-Tertiary igneous rocks can be found, and those rocks which show indications of igneous origin are so altered that it requires microscopic study of the rocks to determine whether they are altered eruptives or sedimentaries. In the Stayton district, the country rock near the ore deposition is prominently basaltic, sometimes closely related to Becker's asperites. In San Luis Obispo County, in the Pine Mountain, Adelaide, and Oceanic districts, the scattered exposures of igneous rock are of rhyolite. In Santa Clara County the only eruptive rock in the neighborhood of the ore deposits is rhyolite.

ORE DEPOSITS.

The peculiar characteristics of quicksilver, so different from those of all other metals, render the study of the conditions governing the genesis of quicksilver deposits an intricate problem; in fact, some of the phenomena occurring in those deposits have as yet not been fully explained.

Quicksilver occurs in nature principally as a sulphide, occasionally to a small extent associated with the native metal. The compounds of mercury with chlorine, selenium, tellurium antimony, etc., are all rare minerals, and probably the result of secondary concentration.

Quicksilver differs in many characteristics from gold, which occurs in nature principally as native metal, though occasionally as a telluride. Gold is soluble in solutions of alkaline sulphides and iodides, ferric sulphate, and carbonate of sodium above 200° C. Chlorine is a prominent solvent of gold, especially in desert regions. In whatever form gold may be transported, it is precipitated either as a telluride, or as metallic gold associated with tellurides and sulphides; whether gold is precipitated in nature as a sulphide is, as yet, uncertain, because the existence of a sulphide of gold in nature has not been definitely established. At all events, this sulphide of gold would be an unstable compound, while sulphide of mercury is a very stable compound. These differences are here presented, because the fact that gold is present in cinnabar deposits has been used as a strong argument in the discussion of the genesis of those deposits.

Quicksilver also differs greatly from silver in its chemical behavior toward other elements. The original forms of silver deposits are, besides sulphides, sulphantimonious and sulpharsenious salts. In the zone of oxidation, silver occurs to some extent in the native state, but much more commonly as a chloride, cerargyrite.

Mercuric sulphide is not found intimately associated with the sulphides of lead, zinc, and iron, as is the sulphide of silver. Sulphide of iron is often found in contact with mercuric sulphide, but no mixtures of the sulphides, like argentiferous galena, etc., have been found. Oxidation products of mercuric sulphide, similar to those of the sulphides of lead, zinc, copper, and iron, are also unknown.

Quicksilver differs further materially from all other metals in its behavior toward heat. Nearly all metals have high melting and boiling points, but mercury becomes a solid at —39.5° C., and boils at 357° C., even vaporizing to a certain extent at ordinary temperatures.

Following is a list of the known quicksilver ores:

AMALGAM.—A compound of silver and mercury, AgHg or Ag_2Hg_3.

Arguerite, from Coquimbo, Chili. $Ag_{12}Hg$.

Kongsbergite, from Norway. $Ag_{18}Hg$.

Color silver white, in isometric crystals and massive.

AMMIOLITE.—A compound of mercury containing antimony and copper, also a little sulphur and iron. An earthy powder; color deep red or scarlet. Possibly antimonate of copper mixed with mercuric sulphide. Rare.

ARGUERITE.—See Amalgam.

BARCENITE.—Related to Ammiolite, but contains no copper. Possibly antimonate of mercury. Rare.

CALOMEL, OR HORN QUICKSILVER.—Mercurous chloride, Hg_2Cl_2. Color light yellowish or gray; luster adamantine, translucent or subtranslucent. Tough and sectile. Not abundant.

CINNABAR.—Mercuric sulphide, HgS or Hg_2S_2. Color bright red to brownish-red and brownish-black. Streak, scarlet-red. Subtransparent to nearly opaque. Crystals often tabular, sometimes acicular; also massive and in earthy coatings. Cinnabar is the principal mercurial ore.

Hepatic Cinnabar, or *Liver Ore*, contains some carbon and clay; color and streak brownish.

Metacinnabarite, or black sulphide of mercury, HgS or Hg_3S_3. Amorphous, color black, resembling graphite, streak same color. Fracture like tetrahedrite. Recrystallizes on slow cooling into cinnabar.

COCCINITE.—Iodide of mercury. Color red to yellow, sometimes green and greenish-gray. In acicular crystals or massive. Rare.

COLORADOITE.—Telluride of mercury, HgTe. Color grayish-black. Rare.

GUADALCAZARITE.—Sulphide of mercury; closely allied to metacinnabarite. Part of the sulphur is replaced by selenium, some zinc is also present, although these latter two metals are probably no essential portions of the mineral. Rare.

KONGSBERGITE.—See Amalgam.

LEHRBACHITE.—A combination of selenide of mercury and of lead. Rare.

LEVIGLIANITE.—A ferriferous guadalcazarite. Rare.

LIVINGSTONITE.—A combination of sulphides of mercury and antimonium, HgS, $2\,Sb_2S_3$. Color grayish-black, generally fibrous, also massive, resembling stibnite. Rare.

MAGNOLITE.—Mercurous tellurate, $HgTe_2O_4$. Rare.

MERCURY, NATIVE.—Occurs to some extent in many quicksilver mines, exceptionally in large quantities, generally in disseminated fine globules.

METACINNABARITE.—See Cinnabar.

ONOFRITE.—A sulphide of mercury, wherein the sulphur is partly replaced by selenium, Hg (S, Se), often associated with tiemanite. Rare.

TIEMANITE.—Selenide of mercury, HgSe. Color dark steel gray, resembling galena. Rare.

TERLINGUAITE.—Oxychloride of mercury. Rare.

TOCORNALITE.—Iodide of silver and mercury. Color pale yellow; granular and massive. Rare.

The hydrocarbons *Idrialite* and *Aragotite* in places carry cinnabar. Rare.

In Hungary a copper ore, consisting of sulphides of copper, iron, zinc, mercury, antimony, and arsenic, is found, often rich enough in mercury to warrant the special extraction of that metal as a by-product.

This list shows that mercury combines in nature almost exclusively with sulphur, which in rare instances is partially or totally replaced by its closely related elements, selenium and tellurium; and that mercury also, but rarely, combines with the halogens chlorine and iodine.

From a practical point of view, sulphide of mercury and native mercury are the only products requiring consideration, the others being of no commercial importance.

GENESIS OF QUICKSILVER ORE DEPOSITS.

The majority of the geologists who have treated the subject of ore deposits consider them, as they exist to-day *in situ*, as principally the result of precipitation from aqueous solution. [See Genesis of Ore Deposits, pages 57 and 73, F. Posepny; *ibid.*, page 284, C. R. van Hise; *ibid.*, page 658, Prof. J. H. L. Vogt, etc.] More especially in reference to quicksilver deposits. [Monograph XIII, U. S. Geological Survey, page 416, G. F. Becker; American Journal of Science, vol. XVII, 3d series, S. B. Christy; Genesis of Ore Deposits, page 596, W. Lindgren.]

A concise exposition of the modern views of the genesis of ore deposits is required to explain the special phenomena observed in quicksilver ore deposits, and the deductions to be derived therefrom.

There is no reason for supposing that the heavy metals of ore deposits come from the enormously compressed centrosphere; hence the conclusion that the ore deposits are derived from the crust of the earth. Indeed, a notable number of ore deposits may be referred to eruptive processes connected, not with the heavy interior, but with the crust of the earth, which must be regarded as being at least 50 kilometers in thickness.

This crust can be divided into zones from two different standpoints:

(*a*) The zone of *fracture*.

The intermediate zone of *combined fracture and flowage*.

The zone of *flowage*.

These zones are delimited by the manner in which the rocks yield to deformation. In the upper zone of fracture, the strata yield to deformation by fracturing; in the deepest zone, only spaces of microscopic size can exist, and the deformation process is similar to that of mashing or kneading.

The maximum depth (assuming no lateral pressures occur) beyond which the strongest rock material will yield to deformation by flowage can be placed at 12,000 meters. In regions of orogenic and eruptive actions, the lateral stresses may materially reduce this depth, which probably may have to be further reduced, because of the greatly increased plasticity of the rocks saturated with superheated water. It therefore follows that all fissures must disappear at a certain depth.

As rocks are of varying strength, and as lateral pressures materially influence the conditions under which the rocks exist, there must be a zone of combined fracture and flowage below the zone of fracture. This belt has a considerable thickness, possibly over 5000 meters.

The earth crust may also be subdivided from a physico-chemical standpoint, controlled by the relations between chemical action and heat and pressure, into:

(*b*) The *Upper Physico-chemical* zone, resubdivided into:

Upper Belt—Belt of weathering.

Lower Belt—Belt of cementation.

The *Lower Physico-chemical* zone.

Near the surface, where temperature and pressure are low, the preponderating reactions are heat-developing. In the lower zone the heat-absorbing reactions preponderate, according to van Hoff's law. [W. Nernst, Theoretical Chemistry, page 583.]

Two important reactions separate these zones: *First*, tne reactions between oxygen and sulphur. In the upper zone oxygen replaces sulphur, resulting in great liberation of heat and expansion of the volume of the solid compound. In the lower zone sulphur replaces oxygen with condensation and great absorption of heat. This reaction is the more important when considering that oxide of iron, in the form of magnetite, is one of the constituents of eruptive rocks (rocks of deep-seated origin). *Secondly*, the reaction between carbon dioxide and silica. In the upper zone, especially in the belt of weathering, carbon dioxide replaces silica, acting specially upon silicates; the liberated silica passing into solution in a colloidal form and not ionized [Kahlenberg and Lincoln, Journal of Physical Chemistry, 1898, page 88], and carried downward into the belt of cementation. In the lower zone silica replaces carbon dioxide, with great absorption of heat and with condensation; the carbon dioxide entering into the solution.

The depths at which these reactions reverse for different compounds, and for the same compound under different conditions, are very variable, and are greatly affected by the fact whether the latter are mass-static or mass-dynamic.

The water circulation through the earth crust represents a cycle, caused chiefly by gravitation stress, and is due to the fact that the water entering the ground at a certain level, after a short or long underground journey, issues at a lower level.

From the point of view of the genesis of ore deposits, only the water that enters that part of the earth crust situate below ground-water level is of importance. Its temperature increases with depth, and below 3000 meters, in the zone of fracture, it is in the form of superheated water, having consequently great chemical activity.

There is a strong tendency for water entering through an indefinite number of small openings to converge into larger openings which are located on the lines of weakness in the formations. These waters reach, in the lowest part of their course, where they possess their highest chemical activity, the zone wherein sulphur is the more active agent, so that they dissolve prominently sulpho-compounds out of the rocks, through which they percolate in capillary and supercapillary openings, until saturated, and hold them in solutions in ionized form. The precipitation out of these solutions is the result of supersaturation due to several causes, among which the most prominent are dilution and loss in temperature and pressure.

It is more than probable, from the intimate association of igneous rocks with a large majority of ore deposits, that they are the main source of the metallic ores; and that there is a direct genetic relation between ore deposits and eruptive processes. A number are, in fact, intimately connected with eruptive magmas, especially through eruptive after-action, as sublimation, gaseous action, igneous-aqueous action, etc., by which the heavy metals were in great part extracted from such magmas. As the eruptive magmas, at least those of deep origin, are admitted to contain a more or less notable admixture of water, with other constituents of hydrous or gaseous character, the formation of minerals on cooling and the subsequent cycle of solution and reprecipitation, as above described, will take place.

In this connection the following quotation is important: "It is thought highly probable that under sufficient pressure "and at a high temperature there are all gradations between "heated water containing mineral material in solution and a "magma containing water in solution. If this be so, there "also will be all stages of gradation between true igneous "injection and aqueous cementation, and all the various phases "of pegmatization may thus be fully explained." [C. R. van Hise, 16th Ann. Rep., vol. XI, page 647.]

The foregoing explains the reason that the metals are originally deposited principally in the form of sulpho-compounds; which, in the upper portion of the earth crust, in the belt of weathering, under the action of the various gases, especially carbon dioxide and oxygen, and of organic bodies, are transformed into various oxidation products thereof, including the native metal. [See on this subject more particularly: F. Posepny, Genesis of Ore Deposits; C. R. van Hise, Principles of North American Pre-Cambrian Geology, 16th Ann. Rep. U. S. Geological Survey, Pt. I; *ibid.*, Physico-Chemistry of Metamorphism, Bulletin Geol. Soc. of Am., vol. IX; J. L. H. Vogt, Problems in the Geology of Ore Deposits, Genesis of Ore Deposits, page 636 and following; etc.]

The opinion that quicksilver deposits are formed in accordance with the general principles above described is based upon observations at Steamboat Springs and Sulphur Bank, and finds confirmation in the associated minerals within those deposits which bear evidence of precipitation out of aqueous solutions. The following observations on this subject are of sufficient importance to be shortly discussed:

Most of these deposits show that at some time during their history they have been the scene of intense solfataric action, and a great many are in contact or in close proximity to eruptive phenomena.

Mercury boils at 357° C., but volatilizes to some extent at ordinary temperatures.

Liquid mercury combines with sulphur in the manufacture of vermilion in the dry way, below the melting point of sulphur, 120° C.; in the wet way, sulphide of mercury forms between 45° and 50° C. Hence the combination of mercury and sulphur takes place between liquid mercury and sulphur. That in the wet process a heat below 50° C. is insisted upon would indicate that the combination of liquid mercury and sulphur can only take place within the immediate vicinity of the surface, as the proximity of igneous-aqueous action to the quicksilver deposits during some time of their history will cause the increase of heat in depth to be much more rapid than the ordinary static rate of 1° C. per 100 feet. (At Sulphur Bank, Dr. Becker gives the heat of the water of the Herman shaft at the surface 128° F., and at a depth of 300 feet 176° F.)

In vapor form mercury combines with sulphur at high temperatures, proof of which can be found in the bricks of old furnaces wherein cinnabar and native mercury are often found in large quantities; the mercurial vapors must have recombined with free sulphur in vapor form and recrystallized as cinnabar. The agency which causes the recombination of these dissociated vapors, at practically the same temperature, is as yet undetermined.

All these considerations have caused a great number of operators of quicksilver mines to retain the old theory of ore formation by sublimation, and to hold the opinion that mercury is brought into the lithosphere, and possibly even into the belt of weathering, in the form of mercurial vapors. These, under favorable conditions, form mercuric sulphide, which then follows the cycle of solution and precipitation indicated by Messrs. Becker and Christy, namely, a solution of a double sulphide of mercury and sodium (HgS, nNa_2S) in waters holding in solution: alkaline-sulphides, -sulphydrates, and -hydrates, or neutral or acid sodium carbonates partially saturated by hydrogen sulphide; and a precipitation mainly due to decrease in temperature and pressure or to dilution.

Dr. Becker [Mon. XIII, U. S. G. S., above cited, page 419 and following] thoroughly discusses this subject and gives extensively his reasons for considering the cinnabar deposits as exclusively formed by precipitation from solutions. Prof. S. B. Christy [Am. Journal of Science, vol. XVII, 3d series, 1879, page 453 and following] had previously given his reasons why he arrived at the same conclusion. He made several tests as to the solubility of mercuric sulphide in different solutions under varying conditions of temperature and pressure, and regarding its precipitation out of those solutions. A short extract from his article will be of great interest:

"The tests were made at temperatures varying from 200° to "250° C., and pressures varying from 260 to 500 pounds per "square inch. The duration of the tests varied from three to ten "hours, and in each case the cooling was allowed to take place "gradually and undisturbed. Their result proved that waters "containing solutions of alkali sulphides and some natural min- "eral waters to which sulphydric acid had been added, will, "under certain conditions of temperature and pressure, dissolve "mercuric sulphide; that increase in pressure aids rather than "retards this solution, and that cinnabar is deposited from such "solutions in the crystallized form when temperature and pres- "sure are slowly lowered, while the occasional occurrence of "metacinnabarite, or black amorphous sulphide of mercury, was "explained by the sudden dilution or cooling of the depositing "waters, or the local mixing, during crystallization, of agents "causing rapid precipitation."

Professor Christy in the course of these tests obtained out of a solution of potassic sulphydrate wherein amorphous mercuric sulphide was placed, a coherent mass of crystals of cinnabar, perfectly simulating the crystals which occur in nature. He further argues that while the deposition of cinnabar from mercury in vapor form occurs in the masonry of furnaces, condenser walls, etc., the same can not account for the same action in ore deposits, because the high temperature required to volatilize mercury and cinnabar would destroy the gangue minerals almost invariably associated with the ore in nature, such as dolomite, calcite, bitumen, and pyrites, which besides are never found in the occurrences of cinnabar and mercury in the masonry of furnaces and condenser walls, directly traceable to volatilization and sublimation.

There are some fundamental differences between quicksilver ore and gold ore deposits, which must be noted. All the quicksilver deposits worked up to the present time show a lack of persistence in depth, and at a rather shallow depth in the different deposits their cinnabar content becomes too low for commercial purposes. The approach of this impoverishment is in nearly every case accompanied with the occurrence of native mercury, while in gold deposits generally, once the sulphide zone is reached, the character of the ore remains nearly permanent.

Dr. Becker attributes this phenomenon to the precipitation of native mercury by dilution of the solution, or by the action of decomposition products of organic matter; the latter causing the presence of hydrocarbons so often found accompanying quicksilver ores. [Mon. XIII, U. S. G. S., page 437.] That the native mercury is mainly found in the lower parts of the mines is ascribed by him to the fluidity and high density of the metal. [*Ibid.*, page 388.]

As to the precipitation of native mercury by dilution, when the precipitation is caused suddenly, the product is a black mass of metacinnabarite with a very small quantity of native mercury [*ibid.*, pages 429, 430, and 436]; hence the copresence of cinnabar and native mercury would involve a re-solution and precipitation and slow cooling of the metacinnabarite without affecting the native mercury present.

The reduction of mercuric sulphide through decomposition products of organic matter would relegate the locus of this reaction to the upper portion of the deposit, and as those agents are active at the present time, native mercury ought to be found, at least to some extent, in the upper horizon of all quicksilver deposits.

Prof. S. B. Christy remarks on the occurrence of native mercury: "Unless we regard it as an effect of local oxidation "of a very stable compound, its appearance is well nigh inex-"plicable upon either hypothesis" of production by sublimation or deposition from solution. [Am. Journal of Science, vol. XVII, 3d series, page 463.]

The oxidation of mercuric sulphide takes place at high temperature; mercuric sulphate being formed in the condensers nearest the furnaces, but not having been found in nature.

Whatever may be the cause of the formation of native mercury, its fluidity and density can hardly account for all phenomena of its occurrence. In the Socrates mine, Sonoma County, native mercury is found in fine globules within compact rock, while in the fracture planes of the same rock cinnabar is found associated with the native metal; if the cinnabar was the original form wherein the metal was deposited, some traces of it ought to be found in the compact rock, where the decomposing agents can not have been as active as in the fracture planes. Original deposition as native metal and subsequent transformation into sulphide appear here more probable.

The quicksilver deposits are closely connected with eruptive phenomena—either the presence of eruptives, or intense solfataric action. As Professor Vogt states: "In the exceedingly "numerous deposits in some way connected with eruptive "processes, the nearness of igneous rocks must have caused "increase of temperature (and also of pressure?). This is "often so great as to exceed for heavy compounds the critical "temperature." [Genesis of Ore Deposits, page 659.]

The source of the great heat in most of the quicksilver mines can, in many cases, be traced directly to the chemical reactions taking place at the present time. Chemical activity being increased by temperature and pressure, it is only reasonable to suppose that, at no great depth, conditions exist which would keep the mercury in a gaseous state.

The suggestion of Professor Vogt: "With regard to younger "veins especially, we must keep in mind a possible extraction "from laccolitic magma in depth" [*ibid.*, page 656], may in many cases offer an explanation for the genesis of quicksilver deposits, where no extrusive igneous rocks are found in their vicinity. Erosion is the cause of the absence of quicksilver deposits in older formations. This erosion is much more considerable than generally taken into account. [See *ibid.*, page 670.] Professor de Launay, comparing ore deposits occurring relatively near the surface in less denuded regions with those deep below the surface in strongly denuded regions, takes as instance of the former quicksilver deposits, "which occur "chiefly in recent rocks near volcanic eruptives, while from "older ranges, partly destroyed by erosion, they have disap-"peared with other débris."

The cinnabar deposits are in many cases connected with alteration zones in the country rock, caused by *silicification*, forming by preference in those zones. The latter, however, do not uniformly contain cinnabar, and the same form of alteration of the rocks is found throughout the Neocomian outside of the quicksilver belts. This process of silicification is more especially characteristic of the belt of cementation. [See above, page 27.] The term cementation designates the binding together of the rock particles by infiltration of mineral materials in solution, and their deposition as minerals in the interstices of the rocks.

The process of serpentinization resembles that of silicification. The material for the serpentine may be furnished partly, or in whole, by the minerals present in basic sedimentary rocks, which are altered through this process, or the material may come from extraneous sources. [Van Hise, 16th Ann. Rep., Part I, page 691.]

As serpentine may replace quartz, the presence of cemented and indurated sandstones, chalcedonite, phthanite, and serpentine may represent various phases of the physico-chemical process of cementation in the belt of fracture.

This silicification process forms different materials in different localities. It forms a great quantity of black opal, containing some quartz and chalcedonite (a mixture of opal and crystalline silica). A considerable portion of the sandstones of the Coast Ranges show the effects of this silicification process, in varying degrees.

The cinnabar forms in the cracks, seams, and fissures of the silicified material. The richness of the cinnabar ore is to a great extent dependent upon the size of the cavities favorable for deposition and consequently upon the compactness of the fissure-filling; hence rich ore bodies are principally found in those parts where the fissure-filling has been crushed and distorted.

COST OF MINING AND REDUCTION.

The cost of mining and reduction of quicksilver ores differs very sensibly in the various mines. The nature of the ground is one great cause of this difference. In some mines the ground is such that little or no timbering is required. In others, the ground is so bad that the stopes have to be timbered and filled. In some mines the air is generally good, while in others the heat is so great that the men work under disadvantage.

The cost of timber and cordwood also varies very much, some districts being well provided with timber, while others are at considerable distance from the source of supply.


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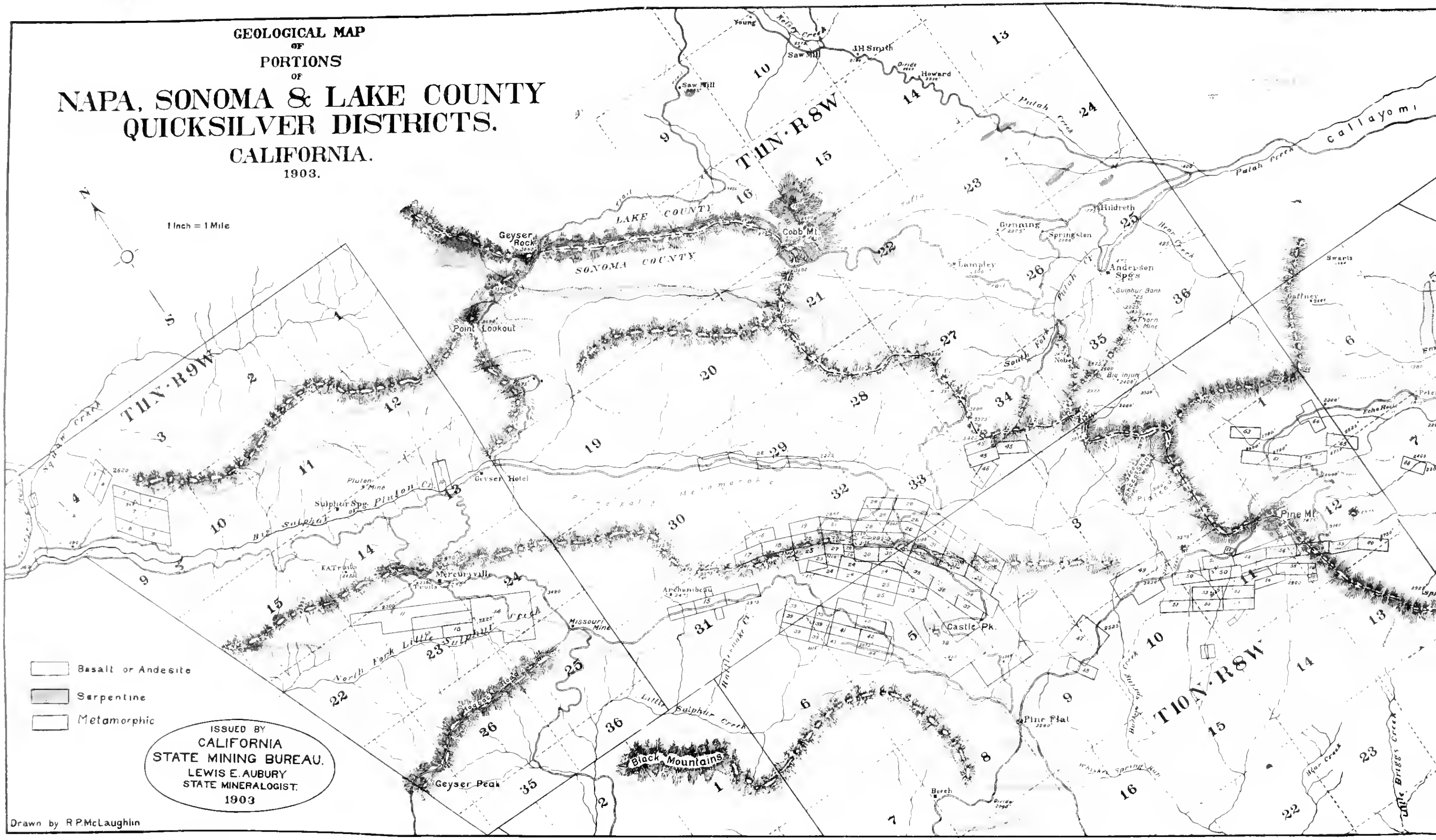


Geology by Wm. Forstner, E.M.

MAYACMAS D.

No. — Name of Mine.

1—Sunrise.
2—Cloverdale.
3—Mercury.
4—Manzanita.
5—Albian.
6—Mattole.
7—Mount Vernon.
8—Philadelphia.
9—Waterloo.
(1–9: Cloverdale Mine.)

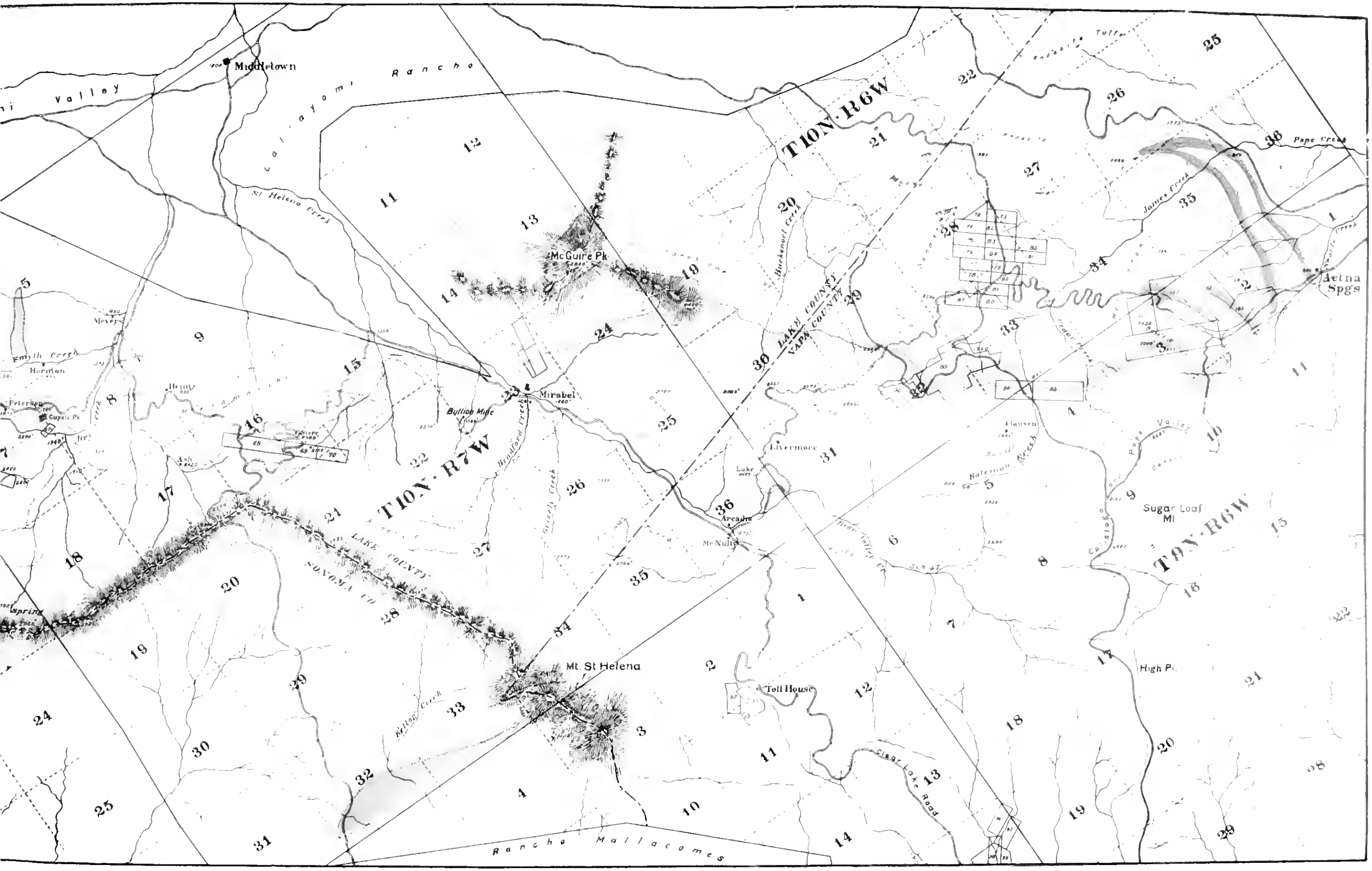
10—Geyser, Sulphur.
11—Black Bear Group.
12—Pluton Den.
13—Clyde.
14—Culver—Baer Group.
15—Rattlesnake.
16—Tunnel Site.
17—Incandescent.
18—Almaden.

19—Mate.
20—Eureka Nos. 1 and 2.
21—Captain.
22—
(19–22: Eureka Con.)
23—Cedar.
24—Quicksilver.
25—Queen Group.
(24–25: Crown Point Q. Mining Co.)
26—Lookout.
27—Diamond.
28—Mercury.

29—Socrates.
30—Mercury.
31—Great Northern.
32—Hope.
33— "
(32–33: Crown Point Q. Mining Co.)
34—Denver.
35—
36—
37—
(35–37: Lucky Stone Group.)
38—Hurley.

39—Pacific.
40—Hercules.
41—Sonoma.
42—
43—
44—
(39–44: Crown Point Quicksilver Mining Co.)
45—Pontiac.
46— "
47—Boston.
48—Empire

49—Double Star.
50—Occidental.
51—Healdsburg.
52—Edith.
53—Cinnabar King Group.
54—Eugenie.
55—Maud.
56—Dragon.
(54–56: Bacon Con.)
57—Napa.



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No.	Name of Mine.	
58	St. George.	Bacon Con.
59	Golden Gate.	Bacon Con.
60	Eagle.	Bacon Con.
61	Helen.	
62	Young America.	
63	Chicago.	
64	Wall Street.	
65	Jewess.	
66	Middletown.	
67	"	

No.	Name of Mine.	
68	Gem.	Great Western.
69	Great Eastern.	Great Western.
70	Hope.	Great Western.
71	Liverpool Con.	Standard Q. Co.
72	Eureka Con.	Napa Consolidated.
73	" "	Napa Consolidated.
74	" "	Napa Consolidated.
75	" "	Napa Consolidated.
76	" "	Napa Consolidated.
77	" "	Napa Consolidated.

No.	Name of Mine.	
78	Eureka Con.	Napa Consolidated.
79	" "	Napa Consolidated.
80	" "	Napa Consolidated.
81	Contention.	Napa Consolidated.
82	Minnesota.	Napa Consolidated.
83	Manzanita.	Napa Consolidated.
84	Mercury.	Napa Consolidated.
85	Bone.	Napa Consolidated.
86	Fanny.	Napa Consolidated.

No.	Name of Mine.	
87	Osceola.	Napa Consolidated.
88	South Side.	Napa Consolidated.
89	Corona.	
90	Napa Con.	
91		
92	Beecher.	
93	New Granada.	
94	Twin Peak.	
95	" "	

No.	Name of Mine.	
96	Ida Easly.	
97	Old Discovery.	
98	Twin Quartz.	
99	Good Enough.	
100	Silver Bow.	Etna Con.
101	Phœnix.	Etna Con.
102	Red Hill.	Etna Con.
103	Starr.	Etna Con.
104	Pope.	Etna Con.
105	Washington.	Etna Con.

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DISTRICTS NORTH OF SAN FRANCISCO.

MAYACMAS DISTRICT.

The Mayacmas District, as defined by Dr. G. Becker [see Mon. XIII, U. S. G. S., page 368], embraces parts of Napa, Lake, and Sonoma counties, along the Mayacmas range, of which Mount St. Helena and Mount Cobb are the most prominent mountains. [See geological map of portions of Napa, Sonoma, and Lake counties quicksilver districts, in this Bulletin.]

Quicksilver deposits are found on both sides of the range; the main belt, however, lies in its eastern part north of the range, crosses it near Pine Mountain (between Mount St. Helena and Mount Cobb), and lies principally south of it, west of Pine Mountain in Sonoma County.

The general trend of the belt is northwest. In its southeastern part, in Napa County, it is in very close proximity to a region of very intense and probably prolonged eruptive action, covering Tertiary and post-Tertiary periods. The center of eruptions in this region was probably in the territory bounded by Mount St. Helena, the Twin Peaks (or Sugar Loafs), and High Peak; the flows have, however, spread over a large adjoining territory. Outside of this are found a great many other eruptive bodies in this district, of which the more prominent are: The basalt body on Oathill, some smaller ones in the territory of the Ætna Consolidated Company, an andesitic eruptive body northeast of Oathill, Pine Mountain, Cobb Mountain, and others. This district is hence a region of intense eruptive action. Large masses of lava have covered parts of it, and while partly eroded, extensive sheets of tufa cover at present parts of it to a greater or less depth, and make it very difficult to determine the limits of the cores of igneous rocks. The present deeply carved topography of the region is largely governed by the erosion of this capping.

The older rocks are mainly represented by sandstones, sometimes nearly unaltered, sometimes thoroughly altered into schists, with all intermediary gradations. Serpentine is very prominent, mostly a hard, dry variety, in places disintegrated and pulverized by weathering, showing as large bare spots along the ranges. Even where not bare, the serpentine can be detected at a distance by a sparse vegetation, while on the balance of the surface a very close growth of brush or grass is found. The relation of the serpentine to the quicksilver deposits is not clear. Most of these are associated with, or in close proximity to, serpentine; but others, like those at Oathill and Cloverdale, are entirely away from the serpentine; and where the serpentine is very prominent and continuous over a certain width, no deposits of any value have been found; as, for instance: between Oathill and the Mirabel around the head of Bucksnorter Creek; on the ridge between Bear Creek and Dry Creek; on the main ridge between the headwaters of Dry Creek and Briggs Creek. Neither are workable quicksilver deposits found in the serpentine. Where serpentine is associated with any deposits, these are always contact deposits, while both the Oathill and Cloverdale mines are in the sandstone.

The quicksilver deposits appear from their association with the opaline rock, which is presumably an alteration product of serpentine by silicification, to be related to the serpentine to a certain extent. The fact that, where it is very wide, no paying deposits have been found, would indicate, however, that either the sandstones contain the primary disseminated metal, which is concentrated through some process of secondary concentration, or else in the large bodies of serpentine the concentration took place only in those parts affected by contact metamorphism. While this holds true only for the southeastern part of the district, it must be remarked that in the northwestern part, in Dry Creek and Pine Flat districts, there is in many cases an undoubted relation between the quicksilver occurrence and igneous actions. In the Dry Creek district the only deposit of any ascertained consequence is the Helen, which lies very close to the tufas of Pine Mountain. There are undoubted signs of igneous rocks in the Pine Flat district on both sides of Big Sulphur Creek; some of these igneous dikes run, as far as determined, in a direction which would bring them near the ore deposits of the Eureka mine; others were found near the Cloverdale mine. For a great number of deposits, these relations are not yet determined. Considering the intimate relation of quicksilver deposits and aqueo-igneous actions and the general geological conditions in this region, it may, however, be expected that, at least, laccolitic relations exist there.

Between the Corona and St. Helena Creek, a distance of four miles in an air line, along the headwaters of Bucksnorter Creek, the belt of serpentine is very wide. Between St. Helena Creek and Bucksnorter Creek the Standard Quicksilver Mining Company has in the last few years spent a considerable sum of money prospecting, but so far without any favorable result.

To the west of the Great Western mine are the headwaters of Dry Creek, a bowl-form basin nearly encircled by the main ridge and by a ridge dividing Dry Creek from the drainage of Putah Creek. Serpentine is very prominent in a great portion of the Dry Creek basin, and again barren of any workable deposits of cinnabar, notwithstanding some very prominent, peculiar croppings, standing out boldly in the serpentine. These croppings, especially prominent in the Wall Street and Jewess grounds, consist of a network of white quartz seams, mostly thin amorph quartz, with occasional concretions of botryoidal form; the ground mass is a light yellow-brown, ochreous mass; this material is locally called "dry bone," and so far as yet observed, never indicates a workable ore deposit. The same is found on the Bacon Consolidated and Cinnabar King ground (Pine Mountain), and also in the Double Star mine (Pine Flat). (Lawson's silica-carbonate sinter.)

Pine Mountain is a mass of andesitic tufa, most probably with an eruptive core, of small dimensions and very steep sides, and entirely disconnected from the Mount St. Helena and the Mount Cobb groups of eruptives. Its main ridge is not over 25 feet wide, and about 300 feet long; elevation, 3475 feet. The tufa is of a light grayish color, and has spread over a part of the adjacent ravines. No signs of basaltic rock could be found on the ridge. The Helen mine is situated on the eastern slope, near the edge of the tufa, and on the southwestern, western, and northwestern slopes are located a series of mines, comprising the Cinnabar King and Bacon group of mines. The northwestern slope is very steep and partly covered by tufa, which covers alternate beds of serpentine and metamorphosed sandstones. At the contacts wide belts of croppings show, partly in place, partly covering the side hill with large bowlders. These croppings resemble very much those of the Wall Street and Jewess. In the cañon continuing below the old road from Middletown to Pine Flat a very well-defined cropping on the contact of serpentine and sandstone is seen. [See Fig. 1.] A great amount of work has been done here; remnants of old shafts and tunnels are found everywhere on the hillsides, but all work is now abandoned. Several pockets of very rich cinnabar ore were found at different points at the surface, but none appear to have been found persistent in depth.

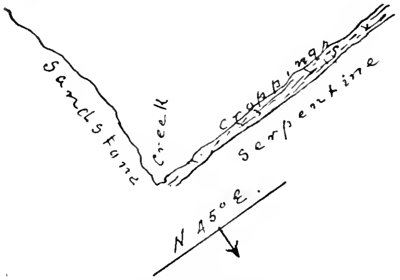
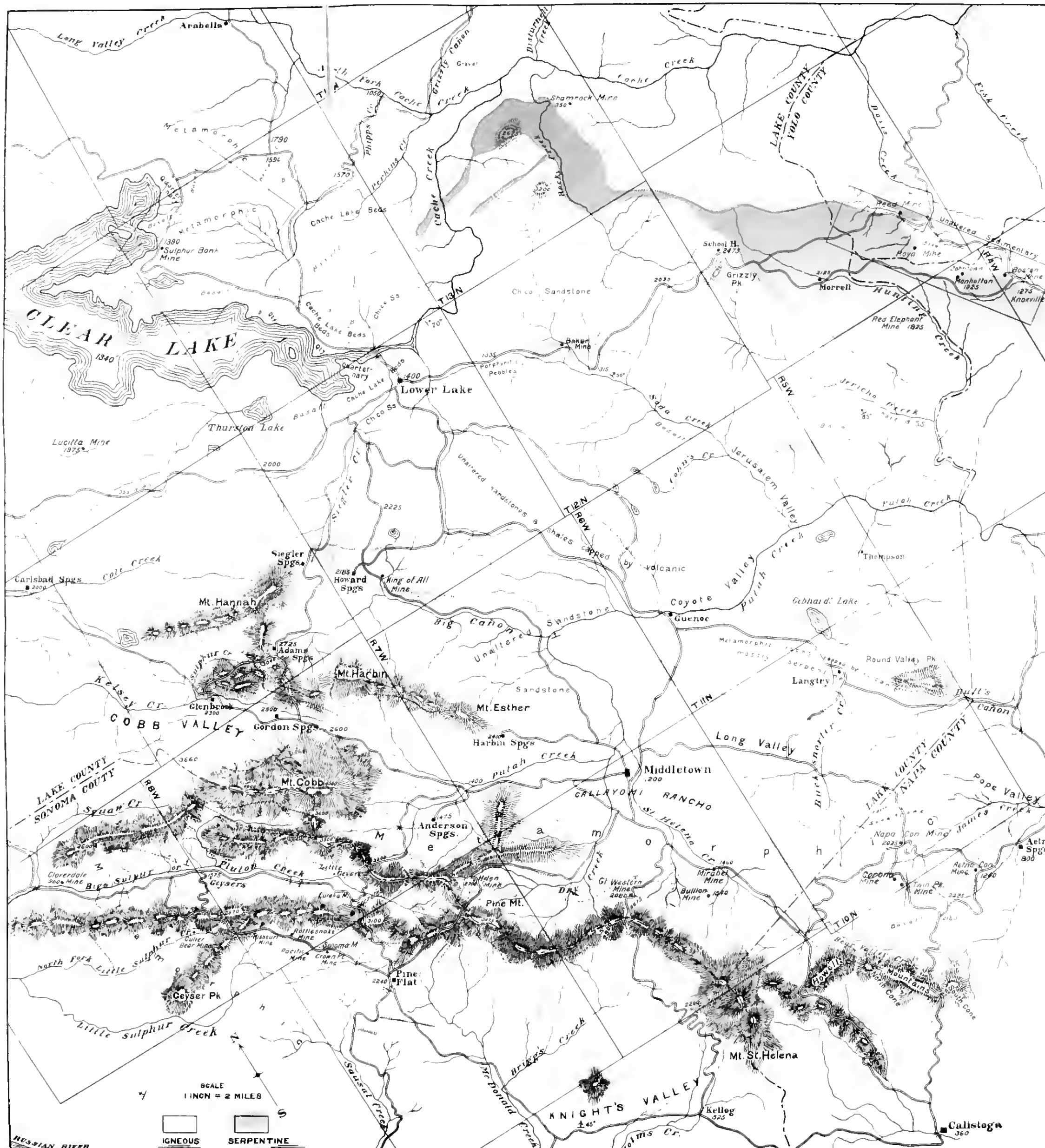


FIG. 1. Section of northwest slope of Pine Mountain, Sonoma County.

The headwaters of Putah Creek are situated in a basin on the south slope of Mount Cobb. In this basin are a great number of hot springs, of which Anderson Springs are by far the most prominent. These springs generally contain a great amount of sulphur, and in several places sulphur deposition and rock decomposition by sulphurous fumes are taking place. Here, as in other parts of the district, cinnabar deposition does not occur in or close to those places where hot waters and vapors reach the surface. There are no cinnabar mines in this basin—only a few prospects, which can scarcely be said to give, up to the present, much promise of turning into mines; a condition partly due to insufficient development.

The mines around Mount St. Helena have a considerable supply of timber in their vicinity, although the Ætna, Oathill, Corona, Mirabel, and Great Western mines have made serious inroads on the supply. The Oathill mine is the only one having a sawmill. The other mines must use round timbers, or get their timbers from the sawmills in Lake County at the foot of Mount Cobb. In the Pine Flat district, the timber supply is rather scant. There is one sawmill in the district. Round timbers cost per set, including lagging, from \$2.50 to \$2.75; timbers, 7 cents per linear foot; lagging, 3½ cents apiece;



GEOLOGICAL MAP OF NAPA, SONOMA, LAKE, AND YOLO COUNTY QUICKSILVER DISTRICTS.

ISSUED BY CALIFORNIA STATE MINING BUREAU—LEWIS E. AUBURY, STATE MINERALOGIST, 1903

UNNAMED IGNEOUS AREAS ARE EITHER ANDESITE OR ASPERITE sawed square sets at mill, $2.15; lagging, 15 at 7 cents, $1.05; cordwood averages from $2.50 to $3 per cord.

This district connects by several good roads with railroads. The southeastern and central parts, by three roads to Calistoga—one from Oathill, the toll road from Middletown, and the toll road from the Great Western mine; distances, from 12 to 20 miles. The northwestern part connects with Calistoga and Healdsburg, and for the most extreme northwestern portion also with Cloverdale; distances, from 16 to 20 miles.

CLEAR LAKE DISTRICT.

The southern borders of Clear Lake and the adjoining territory have been a region of great volcanic activity; a great part of the territory south, southeast, and east of Clear Lake bears evidence of having at one time been covered by lava flows, most of the ridges being covered with eruptive flows. [See Report State Mining Bureau of Cal., X, page 232.] Whether these were ejected from a few large vents, or from a great number of disseminated minor vents, has not yet been determined. In close proximity to Clear Lake, at Mount Konockti or Uncle Sam, and in the territory northwest of Sulphur Bank, such vents are undoubtedly located. These eruptions took place at different periods, and ejected lavas of different compositions. Mount Konockti is formed by later andesites, which are also found to the northeast of the lower part of Clear Lake; but in the close neighborhood of Sulphur Bank the eruptives are principally, but not exclusively, basalts. These latter eruptions must have been recent, the basalt overlying the Quaternary Cache Lake beds. To the northeast of the lava flows in this district is a very extensive belt of serpentine; but the rocks underlying the lava flows are, north of Putah Creek, prominently sandstones and shales. [See geological map of Napa, Sonoma, Lake, and Yolo counties quicksilver deposits.]

Around Lower Lake lumber is worth $17 per 1000 feet (B. M.); round timber, 6 cents per linear foot; lagging, 6 cents apiece.

This district finds its railroad outlet through Calistoga. Lower Lake is 33 miles distant from that town.

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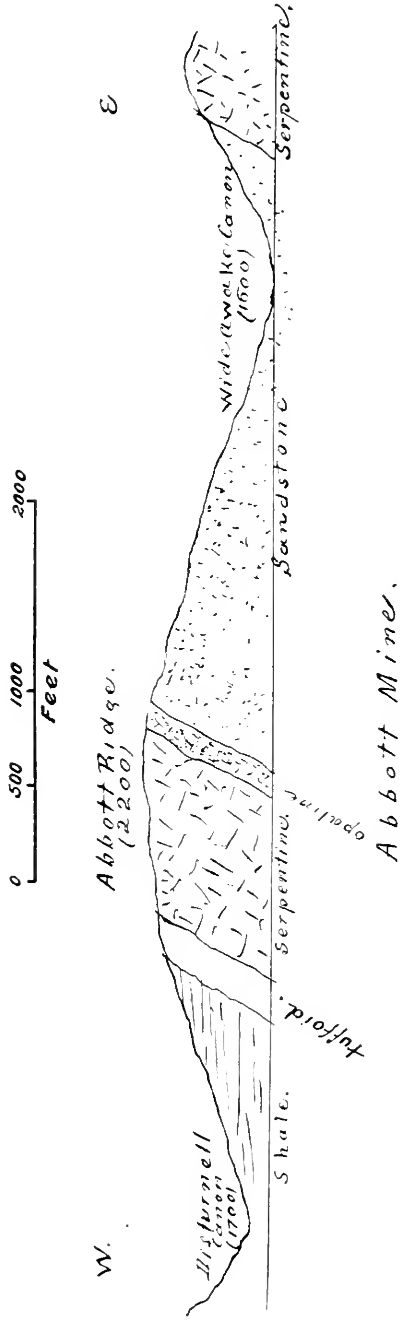


FIG. 2. Sulphur Creek District—Section over Abbott Ridge.

SULPHUR CREEK DISTRICT.

The Sulphur Creek district comprises the headwaters of Sulphur Creek, on the line between Lake and Colusa counties, east of Clear Lake. This region has been considerably eroded, a great amount of its débris covering to a considerable depth the country lying to the west toward Cache Creek, a distance of three miles in an air line. The ridge near the Abbott mine, forming the watershed between Cache Creek and Bear Creek, is in places covered with wash gravel, some of the pebbles being derived from igneous rocks.

Two nearly parallel belts of serpentine run through the district [see special map of the district and Fig. 2] with a northwest trend. The western runs partly on above-mentioned divide; the serpentine is very siliceous in character and rather opaline. On its eastern contact with a belt of rather soft sandstone lies a zone of crushed opaline. To the west of this serpentine, between it and the adjoining shales, is a zone of a light gray or yellow material, containing inclusions (varying in size from small pebbles to bowlders of considerable size) of obsidian, chalcedonite, and opalinized serpentine. The matrix of this breccia is a tuff, or better, a tuffoid (a tuff altered by regional metamorphism, according to Mügge). [See Williams, Lithology, page 290.] The same material is found in the Elgin mine.

The surface of this serpentine has been leached by acidic waters, leaving a peculiar hard, siliceous material of a light bluish-gray color, full of cavities, and occurring in thin slabs. Near the surface the serpentine is generally not silicified, but the ledge matter is largely a much crushed opaline rock, more friable and less hard than the opaline in the tuffoid. This serpentine belt is not very long and is surrounded by shales and argillaceous sandstones. [See map of district.] To the east is a wider and more continuous serpentine belt, at the western contact of which are located the Wide Awake, Empire, and Manzanita mines.

The shales contain bitumen, sometimes forming heavy oil, and sometimes lighter gaseous hydrocarbons. The waters percolating through these formations are often charged with hydrogen sulphide. Occasionally they form hot springs. A hot sulphur spring at Blanck's Hotel [see map] was cut off by the Wide Awake shaft when the latter was sunk from the 200 to the 300 foot level, at a distance of 1300 feet from the spring, and a depth of about 300 feet below the spring, and never reappeared, cold water now issuing from the same spring. This proves that this spring was caused by hot ascending waters, following a gentle slope of about 1300 feet horizontal to 300 feet vertical. The great amount of mineralized waters, the siliceous sinters and sulphur deposits formed by extinct solfataric springs, and the still existing hot sulphur springs, indicate strong irruptive action. As no igneous rocks appear at the surface in the immediate neighborhood, this may have been laccolitic. In the bed of Sulphur Creek a conglomerate is constantly forming, the pebbles in the creek being cemented by deposits from the water, which is charged with sulphur and sulpho-salts.

The shales and sandstones occur unaltered and in various stages of alteration. A belt of limestone passes through the Manzanita property, course southeast, adjoining to the west a belt of conglomerate, a water formation, similar to that now forming in the bed of Sulphur Creek. About three fourths of a mile farther on, in the same direction, but without any surface connection with this limestone, is found a small body of fossiliferous limestone, with fossils of the Cretaceous age (*Rhynchonella whitneyi*).

In the Sulphur Creek district the cost of sawed timber is very high, the nearest sawmill being 28 miles distant and the roads very heavy; the mines use exclusively round timber at 8 cents per linear foot for 6 inches (smallest) diameter. Cordwood (oak) costs $5 per cord.

KNOXVILLE DISTRICT.

The Knoxville district, situated at the junction of Lake, Napa, and Yolo counties, was in former times the scene of much activity. A number of the mines then in operation—Reed, Andalusia, Royal, and Grizzly—are closed down and abandoned, and the newer prospects—Harrison, New England, Red Elephant, etc.—have as yet disclosed nothing important.

The two mines at present in operation (the Boston and the Manhattan) offer, however, many points of interest. These mines are in proximity to a basaltic body; the Manhattan is in contact therewith, and the Boston is in very close proximity and practically in line with the direction of the main fissure through which the basalt was ejected. This basalt is the only eruptive body coming to the surface in the district, and lies on the contact between the large belt of serpentine which runs in a southeasterly direction from Cache Creek and the unaltered Neocomian to the northeast thereof. This serpentine belt, which reaches into Napa County and is several miles wide, contains, as far as yet ascertained, only sporadic signs of cinnabar ore, and it is very doubtful if any workable deposits will ever be found therein.

There is no timber in the vicinity of Knoxville. It has to be hauled from Lower Lake, 18 miles. Round timber, 8 inches (smallest) diameter, costs 10 cents per linear foot. Cordwood, oak, $5; pine, etc., $3.50 per cord. Oak is so much superior to pine in the furnace that at $5 per cord it is not more expensive than the latter at $3.50 per cord.

This district connects with the railroad at Rumsey, a distance of 15 miles; generally supplies are hauled from Napa, 40 miles distant.

QUICKSILVER MINES IN THE COUNTIES OF CALIFORNIA.

COLUSA COUNTY.

Central Mine.—Sulphur Creek District. Empire Consolidated Quicksilver Company, owner; R. A. Boggess, general manager, Sulphur Creek, Colusa County. Consists of the Central, Dewey, and Little Giant claims, in Sec. 29, T. 14 N., R. 5 W. [See Report State Mining Bureau of Cal., XI, page 185; XII, page 359.] This mine covers a small triangular territory on the left bank of Sulphur Creek, and is traversed by a ledge with a northwestern strike, on the contact of a decomposed rock, probably serpentine, and shales in which some ore was found near the surface.

Elgin Mine.—Sulphur Creek District. Elgin Quicksilver Mines, owner; C. F. Humphrey, president, No. 137 Montgomery street, room 15, San Francisco. In Sec. 13, T. 14 N., R. 6 W. [See Report State Mining Bureau of Cal., XI, page 182; XII, page 359.] The mine is situated near the head of Sulphur Creek, and is at present idle. The main tunnel is caved in 120 feet from the entrance. The ledge matter is a tuffoid very highly impregnated by sulphur, and decomposed. The entire territory covered by this mine is so highly impregnated by sulphur that attempts have been made to distill sulphur from the rock. Another tunnel, 60 feet below the main tunnel, is also caved in; hot water, very high in sulphur, is flowing out of it. A number of shallow openings on the line of the croppings show on the dump some cinnabar-bearing material. The excessive heat in the mine interfered to a certain extent with its operation. Some quicksilver was, however, made in a 10-pipe retort furnace belonging to the property.

Empire Mine.—Sulphur Creek District. Empire Consolidated Quicksilver Company, owner; R. A. Boggess, general manager, Sulphur Creek, Colusa County. This consists of four claims—Empire, Hidden Treasure, Mercury King, and Mercury Queen.

In Sec. 28, T. 14 N., R. 5 W. [See Report State Mining Bureau of Cal., XI, page 186.] There are several drifts and open cuts on the property, but none showing any ore body of consequence. The company is now sinking a vertical shaft in the northwestern part of the property.

Manzanita Mine.—Sulphur Creek District. Manzanita Gold Mining Company, owner; G. V. Northey, lessee, Sulphur Creek, Colusa County. In Sec. 29, T. 14 N., R. 5 W. [See Mon. XIII, U. S. G. S., page 367; Report State Mining Bureau of Cal., X, page 160; XI, page 184; XIII, page 126.] This mine was opened about 1865, but was worked only for gold until 1892, when it was also worked for quicksilver, and up to lately mostly by surface work and short drifts. The rocks of a large part of the territory covered by this mine consist of sandstones and shales, intersected by narrow quartz seams, containing gold, sometimes associated with cinnabar; these seams had occasionally very rich spots, but as they are very thin, and separated by wide blocks of barren country rock, their working was not very profitable and could only be carried on at all by surface cuts, etc. The deposits occur on both sides of Sulphur Creek; on the west side of the creek the formation is sandstone; on the opposite side of the creek it is more shaly. In both places, extensive old works can be seen at and near the surface. Beyond this surface zone the shaly country rock east of the creek is barren. Farther down along the creek, on the same side close above the mill, the sidehill consists of a white rock, evidently the country rock leached by waters coming from sulphur springs formerly situated higher up the hillside. This leached material carries both gold and quicksilver. The leaching process is, however, only superficial, and the mineralization must be due to the action of the same waters, for the country rock past this zone of leaching has proven to be barren. At present the gold deposits are not worked. The work is confined to the quicksilver deposit on the northeastern part of the Manzanita claim, where the ore carries only quicksilver and no gold. The shaft is on the top of a knoll, at an elevation of 475 feet above Sulphur Creek. A ledge of conglomerate, from 20 to 30 feet wide, of the same nature as the conglomerate now forming in the bed of Sulphur Creek, crosses the hill in a northwesterly direction, and on the southeastern sidehill siliceous sinters are found.

In the mine near the shaft a whitish friable material (leached sandstone) carries sensible amounts of cinnabar. The ledge is very winding in both strike and dip; the accompanying gouge is also very irregular. The hanging-wall shale is in places altered to a whitish material very similar to that above mentioned. The ledge material, especially in the lower 150-foot level, is principally chalcedonite. In places conglomerate is found on the foot wall of the ledge, but it is doubtful if the real foot wall has been reached. This deposit shows plainly that it is the result of deposition out of solfataric waters, as well in the ore body as by their action on the adjacent rocks. To the west of the deposit lies a belt of limestone, adjoining at the west to a belt of conglomerate.

In the old workings are found some phenomena, which have a bearing on the genesis of cinnabar ores. In an abandoned tunnel, on walls which originally showed no signs of cinnabar, a great amount of sulpho-salts is forming, accompanied in places with cinnabar, generally as a coating of the wall, but occasionally successive layers of silica have been found inclosing a thin seam of cinnabar. As proof that this cinnabar formation is going on at present, pieces of barren country rock lying on the floor have been coated with cinnabar on the face touching the wall similarly coated, while no signs of cinnabar can be found on any other face, nor on any similar rock not in contact with the wall. The cinnabar must hence have been derived by exudation out of the wall rock. The tunnel is perfectly dry, and the only water found therein on the floor is some seepage from the surface after heavy rains, this cinnabar formation taking place at a very shallow depth.

The reduction works of the Manzanita mine are specially interesting, as the quicksilver ores are successfully concentrated, and the concentrates treated in retorts at a sensibly reduced cost per ton of ore treated. [See chapter on Metallurgy.]

Wide Awake Mine (Buckeye).—Sulphur Creek District. W. H. Martin, Crocker Building, San Francisco, and A. A. Gibson, Sulphur Creek, Colusa County, owners. In Secs. 28 and 29, T. 14 N., R. 5 W. [See Report State Mining Bureau of Cal., XI, page 187; XIII, page 594.] The main workings consist of a vertical shaft 500 feet deep, with some short drifts. This shaft is now filled with water above the first level. Near the northwest end of the claim is an open cut with some short tunnels and winzes. Rich ore pockets have been worked out, but do not seem to continue in any direction. The mine is equipped with a very fine reduction plant consisting of a 24-ton fine-ore furnace, which has, however, been scarcely used.

LAKE COUNTY.

Abbott Mine.—Sulphur Creek District. Empire Consolidated Quicksilver Mining Company, owner; R. A. Boggess, general manager, Sulphur Creek, Colusa County. Includes the Abbott and Disturnell mines. In Secs. 30, 31, and 32, T. 14 N., R. 5 W. [See Mon. XIII, U. S. G. S., page 368; Report State Mining Bureau of Cal., XI, page 239; XII, page 360; XIII, page 595.] This mine was discovered in 1862. In 1870 a furnace of a daily capacity of 10 tons was erected and operated until 1879. The mine was idle from 1879 to 1889. In 1899 the property was equipped with a 40-ton Hüttner & Scott

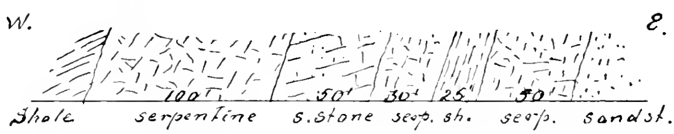


FIG. 3. Abbott Mine, Lake County—Section over the serpentine.

furnace. The total production has been about 30,000 flasks. Including the old works there are 15,000 linear feet of shafts and drifts. The deepest working is 350 feet below collar of the Boggess shaft. This mine lies on the southwestern contact of a serpentine belt, strike northwest, with a shale country rock, occasionally sandstone. The serpentine varies in width from a few hundred feet to a quarter of a mile, and is about 2½ miles long. To the northeast is a belt of sandstone, rather narrow in the southern portion, but widening rapidly going northward. [See map of Sulphur Creek District.] The serpentine is interstratified with beds of shales and sandstone [see Fig. 3—a crosscut on the road from the Abbott mine to Sulphur Creek]; the same alternations are found underground. For instance, near the intersection of the Reardon tunnel and the first level [see Fig. 4]; near the Boggess shaft in the first level, where two serpentine ledges have been exposed [see Fig. 5]; in drift II of the old works [see Fig. 5], etc. To the west of the serpentine lies the body of brecciated tuffoid—more especially described in the general description of the Sulphur Creek district. The map of the mine workings indicates that they follow generally the line of contact of the tuffoid, with the shales lying west thereof. At some places, as at the intersection of the Reardon tunnel and the first level [see above], serpentine is found west of this contact. There is no doubt that the same alternations of serpentine and shales take place east of the territory at present opened. The extensive slides found at the surface in Disturnell Cañon, and the reverse dip found, the rocks having been tilted over by the pressure of the sliding material, lead to the expectation of irregularities in the underground formations. Near the Boggess shaft this is very clearly illustrated. The shales west of the serpentine contain some hydrocarbons. In places petroleum is found; in others, gases of light inflammable hydrocarbons emanate from the rock, or bubble up through the water. A few feet southeast of the end of the Reardon tunnel in the first level is a mineral spring containing carbonate of magnesium, calcium, sodium, and lithium, and also some sulphur compounds. The cinnabar ore forms in these bands of serpentine, more especially in close proximity to the tuffoid; exceptionally the ore is found in the shale. The gangue is generally strongly crushed opaline. Metacinnabarite occurs occasionally, but no native mercury has as yet been found. The cinnabar is disseminated through the crushed opaline, partly as face metal, but also in seams and pockets. The ore zones contain a great amount of iron sulphides, in varying quantities, rendering it very difficult to regulate the temperature in the furnace. Very little gouge is found between the ore bodies and the walls. The ground in the ore zones and in the shales is often swelling, but the tuffoid stands very well.

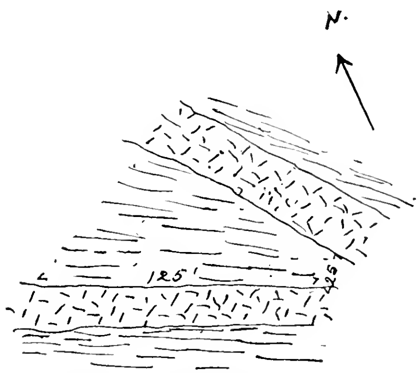


FIG. 4. Abbott Mine—Plan near intersection of Reardon tunnel and first level.

In the lower 250-foot level at the Boggess shaft, an ore body was found, averaging 30 feet in width and 150 feet long, which pinched out in the intermediary level 50 feet above, reappearing, however, in the upper 150-foot level. In the intermediary level, 140 feet from the shaft, 50 feet of fair ore was found. In the first (upper) level, two ore bodies were followed, and a crosscut is started at the southeast end of the lower level to cut the more easterly ore body. [See Fig. 5.]

The first level has been driven over 1500 feet, largely in the hanging-wall shales, to find the ore bodies existing in the northwestern part of the Lightner level, about 65 feet above the first level. Two ore bodies, marked A and B, were found and stoped. Near A, a shaft is sunk from the first level to tap this ore body below, to a depth of 130 feet. The ore bodies opened farther east by the Lightner level have not as yet been reached by the first level. The territory between a point 250 feet west of the Boggess shaft and A, a distance of about 1000 feet in an air line, below the level of the collar of the shaft, is practically unexplored ground; old surface workings indicate that such exploration might lead to a discovery of workable ore bodies.

The mine is equipped with a 48-ton Scott furnace. The ore is dried on a special drier located between the crusher and the furnace, having its own heating furnace.

The Anderson Prospects.—Mayacmas District. In Secs. 25 and 35, T. 11 N., R. 8 W. Owners, the Anderson family, Anderson Springs, Lake County. On the ridge between Bear Creek and the south fork of the Putah, in section 35, about half a mile south of Anderson Springs, a seam of good cinnabar ore has been to some extent opened up in a very much decomposed sandstone. About one quarter of a mile southeast of Anderson Springs, in Sec. 25, T. 11 N., R. 8 W., at an elevation of 300 feet above the springs, the formation is strongly saturated with sulphur, which has thoroughly decomposed the country rock, wherefrom its local name of Sulphur Bank. The upper part consists of thin, flat beds of quartzose rocks interbedded with clay seams (possibly a series of chert beds, like the ledge matter of the Great Western, but too decomposed to be absolutely classified). The quartzose rock carries on its fracture faces cinnabar; when broken it proves to contain a great amount of

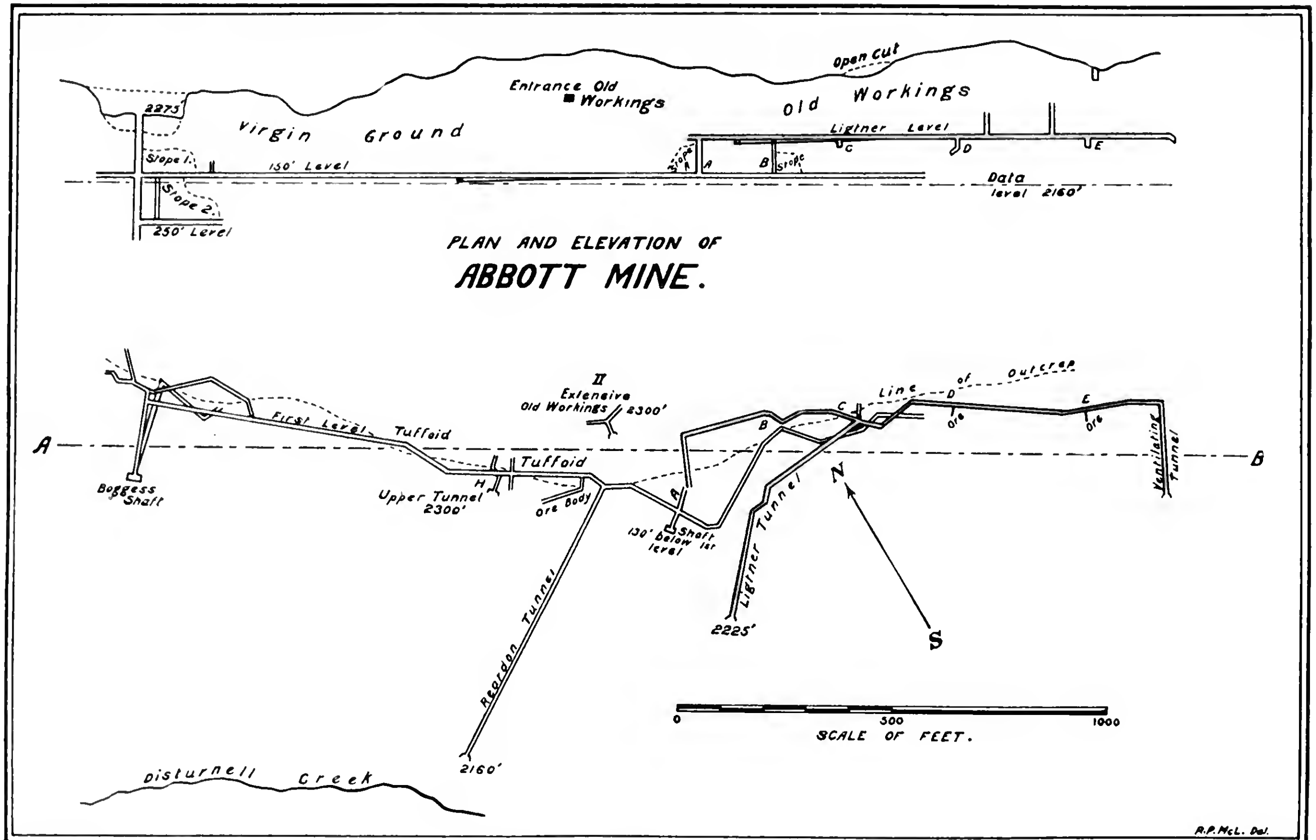

Open Cut
Entrance Old
Workings
Old Workings
Virgin Ground
2275'
Slope 1.
150' Level
Slope 2.
250' Level
Ligtner Level
Stope
A
B
Stope
C
D
E
Data
level 2160'
PLAN AND ELEVATION OF
ABBOTT MINE.
First Level
Tuffoid
Tuffoid
Extensive
Old Workings
2300'
Boggess
Shaft
H
Upper Tunnel
2300'
Ore Body
Reardon Tunnel
2160'
130' below 1st
level
Shaft
Ligtner Tunnel
2225'
Line of Outcrop
Ore
Ore
Ventilating
Tunnel
N
S
0
500
1000
SCALE OF FEET.
Disturnell Creek
R.P.McL. Del.

Fig. 5.

iron sulphides. Its structure would indicate that the two metallic sulphides were not deposited simultaneously. [See 16th Ann. Rep. U. S. G. S., Part II, page 448, 3d line from top.] The softer decomposed clayey material does not contain any cinnabar; this material was probably decomposed by the action of the waters highly charged with sulphur on the less compact seams. This sulphur deposition must be of a different period from that of the sulphides. Below these beds lies thoroughly decomposed sandstone, having a nearly vertical bedding, wherein lies a 2-foot seam of quartzose material, similar to the more compact part of above described beds, standing parallel to the dip of the inclosing sandstone and carrying some cinnabar. All the water at this Sulphur Bank is cold, while a quarter of a mile distant are the hot sulphur springs and blowholes, from which hot sulphur vapors emanate, without any formation of cinnabar ore.

Baker Mine.—Clear Lake District. S. T. Palstine, Lower Lake, Lake County, owner. In Sec. 16, T. 12 N., R. 6 W. [See Mon. XIII, U. S. G. S., page 368; Report State Mining Bureau of Cal., X, page 67; XII, page 360; XIII, page 595.] Consists of the Baker and Trade claims. This mine lies on a belt of serpentine cutting through the sandstones and probably abutting against the basalt bounding Soda Creek Valley to the west. The lower tunnel crosscuts the formation, and as the slope of the hill is very flat, it gains very little depth. The first 140 feet are in very tough black clay, then 20 feet of serpentine, when the ledge is reached, along which they have drifted for 250 feet. In a stope 20 feet high, the seams have been partially filled with quartz, upon which have been deposited a coating of iron pyrites, which are coated with metacinnabarite. Cinnabar also forms in the serpentine associated with iron pyrites. Farther on in the drift it forms in the fissures and seams of serpentine, and is to a less degree associated with iron; yet throughout the entire mine iron occurs very prominently in association with cinnabar and metacinnabar. About 800 feet north of this tunnel is a tunnel, course about north, 75 feet long. The ledge matter is an opaline silica, carrying cinnabar and iron pyrites, entirely different from that in the first named tunnel where the gangue is quartz. A little southeast of this tunnel and about 25 feet lower, another tunnel runs about east at right angles to the preceding, crosscutting the formation. This tunnel is caved in, but judging from the material on the dump it has reached the ledge. About 300 feet northwest of this tunnel and 30 feet lower, a third tunnel has been run S. 54° E., for 235 feet; then S. 24° E., 26½ feet to the opaline ledge, where it is connected by a winze with the end of the former tunnel; the ledge is about 25 feet wide. To the northwest of these works a strong mineral spring is forming quite a large mound on the hillside. The mine is equipped with a 10-pipe retort furnace.

The Big Injun Group.—Mayacmas District. In Sec. 2, T. 10 N., R. 8 W., and Sec. 35, T. 11 N., R. 8 W.—on both sides of

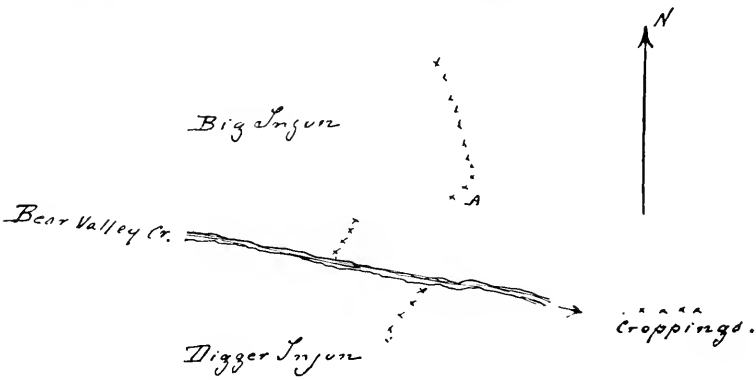


FIG. 6. Big Injun Group, Lake County.

Bear Creek. Consists of two claims, the Big Injun and the Digger Injun. The property is located on a very irregular and disconnected line of croppings, showing only over a short distance south of Bear Creek, and apparently faulted or displaced in the gulch through which that creek flows. [See Fig. 6.] The country rock is serpentine and sandstone, very much mixed. On the south side of the creek only surface indications of cinnabar are found. On the north side, cinnabar ore has been found in many shallow openings; in one, 3 inches of good cinnabar ore is disclosed in a quartz seam in the opaline rock over a length of 15 feet, but nothing assuring permanency in depth has yet been developed.

[Since writing the above, these claims have been segregated. The Big Injun belongs to the New Phœnix Mining Company, and the Digger Injun to the Congress Mining Company. Theo. A. Bell, president, Behlow Building, Napa.]

Chicago Mine (Ural).—Mayacmas District. In Sec. 1, T. 10 N., R. 8 W. About half a mile west of the Wall Street mine, and nearly at the head of Dry Creek. [See Report State Mining Bureau of Cal., XIII, page 595.] Owners, U. G. Schreves, of Mirabel, Lake County, and others. In a large open cut, from which former owners have taken 125 flasks of quicksilver,

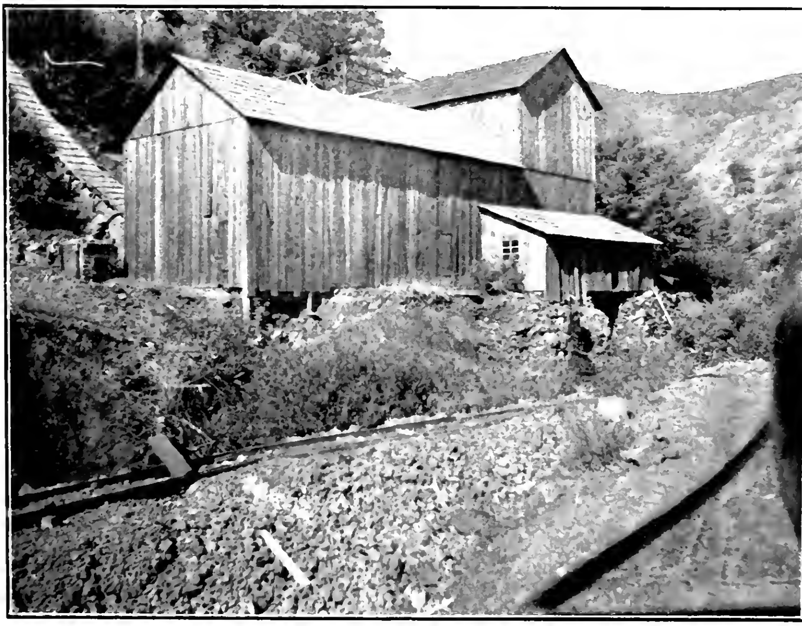


PHOTO No. 1. CHICAGO PLANT.

with a short drift and a shaft 12 feet deep, is a ledge of hard opaline rock, with only a little cinnabar in the cross fissures, having a strike N. 23° W., and a dip to the southwest about 60°. This is overlaid by a seam carrying cinnabar and also some native mercury, in turn overlaid by one foot of softer ledge matter carrying fair values in cinnabar and native mercury; then comes about 4 feet of more or less decomposed serpentine, and then the serpentine hanging wall. The foot wall is probably serpentine, but has not been uncovered. [See Fig. 7.] A lower tunnel, 65 feet below the open cut, 80 feet long, has a long stope 40 feet high to the surface and at the breast a winze 16 feet deep; both on the same seam, which here has a metal-carrying zone 3 feet wide, showing no native mercury. [See Fig. 8.] A very crooked crosscut tunnel, 60 feet lower down the hillside, has not reached the ledge.

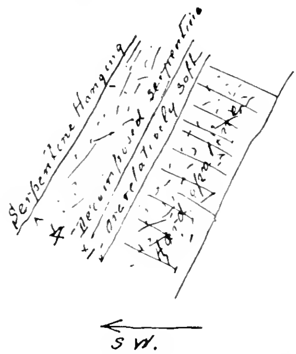


FIG. 7. Section of Chicago Mine.

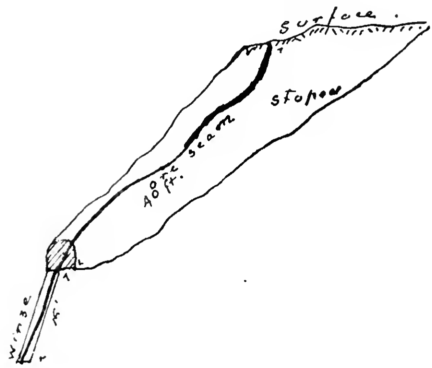


FIG. 8. Section of Chicago Mine.

Great Western Mine.—In Secs. 16, 21, and 22, T. 10 N., R. 7 W. Owner, The Great Western Quicksilver Mining Company, E. W. Newhall, president, Nos. 309–311 Sansome street, San Francisco; John Andrews, superintendent, Quicksilver, Lake County. [See Mon. XIII, U. S. G. S., page 358; Report State Mining Bureau of Cal., XI, page 64; XII, page 361; XIII, page 595.] The Great Western mine was opened in 1873, and has been a constant producer since 1874. The total production is about 90,000 flasks. There are about 18,000 feet of drifts and 1150 feet of shafts in the mine; the greatest depth of the workings is 750 feet. This mine is situated about two miles northwest of the Mirabel and Bullion mines. The serpentine belt in the intervening space is very wide and prominent, but as yet no workable cinnabar deposits have been discovered therein, nor on its contact with the eruptives forming the main ridge northwest of Mount St. Helena. Whether the latter are only lava flows from the igneous masses forming Mount St. Helena, or form part of these masses, has not yet been determined. At and near the Great Western mine the serpentine belt is much narrower, being confined between a wide sandstone formation to the east and the above-mentioned body of eruptive rocks.

The present workings are southeast of those in operation

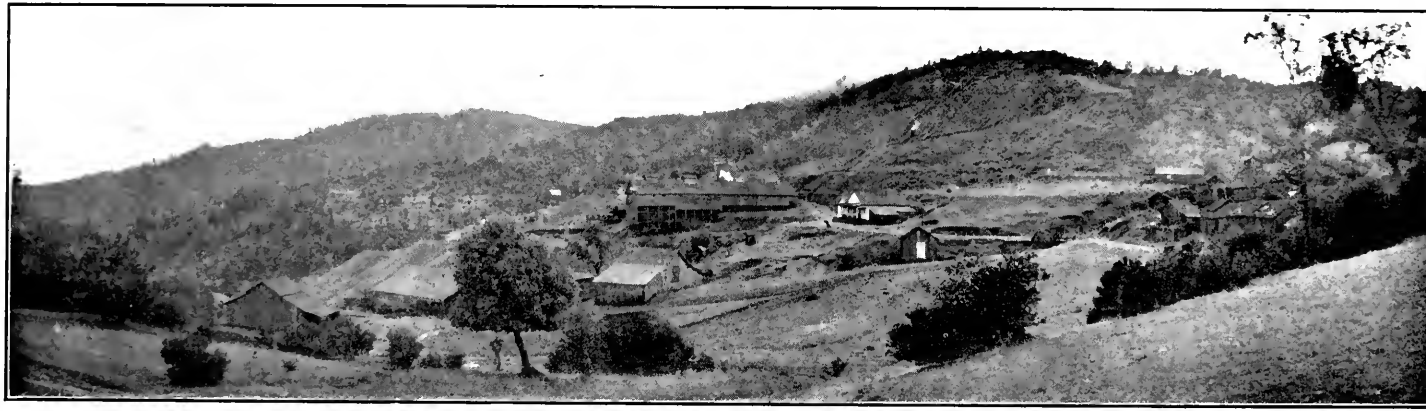


PHOTO No. 2. GREAT WESTERN QUICKSILVER MINE.

when Dr. Becker examined the mine [see Mon. XIII, U.S.G.S.], which explains some differences between the two descriptions. The general strike of the ore body is northwest, with a southwestern dip of about 70°. The foot wall is a very hard sedimentary rock altered by silicification, locally called greenstone. The hanging wall, at least at the surface, is serpentine. The ledge matter is formed by a series of thin beds of chert, having their bedding planes parallel to the strike of the ledge and interstratified with clay seams. This chert is locally called quartzite. The dip of the serpentine is flatter than that of the ledge matter, and the intervening, widening space is filled with black "alta." [See Fig. 9.] The main working shaft is sunk vertically in the foot-wall greenstone, and is on the 600-foot level, 340 feet northeast of the ledge.

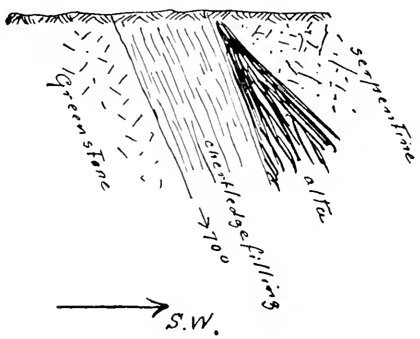


FIG. 9. Cross-section of Great Western Mine.

The ore forms in the chert ledge, in a very irregular manner; generally in the seams, and as face metal in the fractures of the chert, but in the richer parts of the ledge disseminated through the chert itself, associated with iron pyrites. The ore bodies occur very irregularly in this chert zone, and the only available indication for the occurrence of pay ore is the fact that the mineralization is in general the strongest in those parts where the chert beds have been more or less crushed. The ore forms very seldom in the serpentine, but some bunches of very hard and rich ore have been found in the serpentine, without, however, any continuity. The black gouge is less clayey and less foliated than generally in these ore deposits. The increase in width of the hanging-wall gouge in depth is the reason that no serpentine is uncovered in the lower workings; and as no crosscuts have been run through the gouge to the hanging-wall country in the lower levels, the persistency of the serpentine in depth is not established. On the 600-foot level a body of good grade ore, over 200 feet long and 50 feet wide, has been opened up, which continues upward to about 70 feet above the 500-foot level. A "horse" has come in, and throws the ore body somewhat out of its course, so that it has not yet been reached in the 700-foot level. A drainage tunnel, 2200 feet long, runs through the foot-wall material, connecting with the 500-foot level. This tunnel crosses some very narrow belts of serpentine, but passes mainly through sandstone, until at about 1200 feet from the entrance it reaches a belt, 500 feet wide, of decomposed, impervious shales, next to which lies the foot-wall greenstone, about 450 feet wide, which is more or less decomposed near the ledge, but at a distance of a few feet therefrom becomes very hard and compact, and carries considerable iron pyrites. [See Fig. 10.] This greenstone has certainly not the appearance of being the source of the cinnabar, as the sandstone at Oathill, Ætna, etc. The formation

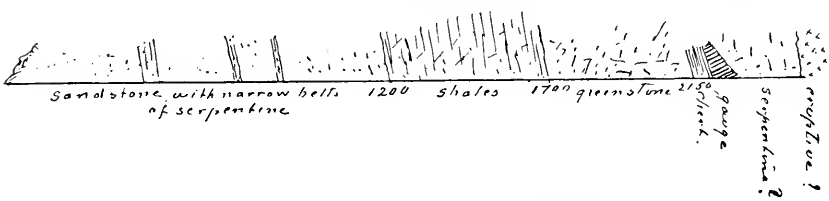


FIG. 10. Section over the Great Western Mine.

shows great displacement and distortion and great bowlders of the neighboring series are found imbedded in the rock, indicating strong dynamic action. On the strike of the ledge ore is at present only extracted from one ore shoot, but the company is doing considerable underground prospecting work to find reserves for future development. The ore is treated in a Litchfield furnace of 50 tons capacity.

Helen Mine (American).—Mayacmas District. In Sec. 1, T. 10 N., R. 8 W. About half a mile south of the Wall Street mine, in the upper part of Dry Creek basin. Owner, Andrew Rocca, Middletown, Lake County. [See Mon. XIII, U. S. G. S., page 375; Report State Mining Bureau of Cal., XII, page 362.] This mine is at present the only one in the Dry Creek basin which produces quicksilver. It lies very close to the tufas of Pine Mountain. The vein matter is a mixture of opaline rock and serpentine, containing numerous inclusions of a black flinty rock. The strike of the ledge is about due east and west: its dip underground southerly, rather flat, 30° to 40°.

The ledge lies at the contact of the sandstone and serpentine [see Fig. 11], and can be readily traced on the surface for quite a distance. In places the ledge crops out boldly above the sandstone, showing occasionally the clay gouge, weathered to a white color, indicating that the black color is principally due to iron, probably in the form of mono-sulphide. At the north end of the claim, eruptive rock (probably basaltic) shows on the surface near the hanging wall, but as no eruptive rock has as yet been found in the underground workings, this may be a flow from Pine Mountain. The cinnabar is accompanied by a great amount of iron sulphide; it forms mostly in the fissures and cracks of the vein filling, sometimes forming seams of solid cinnabar an inch or more wide. The strike of these cin-

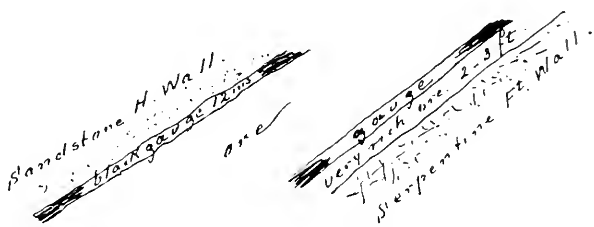


FIG. 11. Cross-section of Helen Mine, Lake County.

nabar seams is parallel to the general strike of the ledge. In the ore shoot the vein filling is less compact on the foot wall, and the cinnabar seams are in places several inches wide, the cinnabar besides permeating the entire rock. A gouge seam separates this richer ore from the overlying relatively poorer ore, which seems to indicate a movement during the period of metal deposition, the gouge seam localizing the latter deposition. [See Fig. 11.] The ore shoot, in fact, as far as at present opened, shows cinnabar in nearly every fracture plane. The ledge is reached by a crosscut tunnel, running nearly south, through the foot-wall serpentine and driven to the hanging-wall sandstone, which it reaches at a distance of 347 feet, with 140 feet of backs. The ledge as cut by the tunnel is 120 feet wide, of which 100 feet is ore-bearing. The ore shoot has been developed along the strike over a length of 80 feet. At the breast of the tunnel a vertical shaft is in process of sinking, which has cut through the vein and is in the foot-wall serpentine. A lower tunnel, running about parallel to the one above described, 1300 feet long, has not yet reached the vein, due to its flat southerly dip.

A 10-retort plant, with a daily capacity of 1500 pounds of ore, is in operation to test the value of the ore mined. The great amount of iron sulphides carried by the ore necessitates a very slow treatment, only one charge being treated per twenty-four hours.

Jewess Mine.—Mayacmas District. In Secs. 1 and 12, T. 10 N., R. 8 W.; Secs. 6 and 7, T. 10 N., R. 7 W. Some work has been done on croppings of the same character and probably belonging to the same body as those on the Wall Street mine, on the opposite or southwest side of Dry Creek. These croppings appear to be barren. A tunnel, run about 75 feet lower down the sidehill, has caved in, but the dump shows no sign of ore. Judging from common report no ore has ever been taken out of this property.

King of All Consolidated Group.—Clear Lake District. Owners, D. Jones, No. 137 Montgomery street, San Francisco; W. G. Temper, Lower Lake, Lake County. In Secs. 29 and 32, T. 12 N., R. 7 W. The group consists of the King of All, Trejon, Cinnabar Queen, and Eagle Bird claims. This mine is situated on a belt of serpentine, having a general northwest trend. Bad Cañon Creek runs through this property and cuts through the serpentine to the underlying schist. The lower tunnel, a little above the bed of the creek, is in serpentine. Its direction is nearly west. At about 100 feet from the mouth a side drift is run in a northwesterly direction on a spur, with a small stope showing the serpentine walls. The tunnel passes two other spurs, and at 150 feet reaches what is considered the main ledge, which has a northwesterly course, with dip nearly vertical. The tunnel is run 12 feet farther, the breast being still in ledge matter. There is so much fire damp in this mine that, as the air blower could not be used, it was too dangerous to break any ore; hence the character of the ledge matter could not be determined. The wall rock is in places strongly decomposed, showing the action of solfataric waters. To the northeast of the serpentine lies a large body of tufas and volcanic bowlders, and about a mile north of the King of All mine is Howard Springs, a region of very strong solfataric action, containing within a very small area forty-two mineral springs, some hot, others cold, and of the most varying chemical composition. It is claimed that in the waters of one of the springs, mercurial salts have been detected. The ore composition in the King of All mine has most probably some connection with the solfataric action at these springs. The igneous rocks above alluded to belong probably to the system of the Mount Konockti eruptives. That they are in some way connected with the genesis both of the mineral springs at Howard Springs and of the cinnabar ore deposits at the King of All mine, appears very probable.

Lucitta Mine.—Clear Lake District. G. W. Pardee, B. G. Pardee, B. R. Parrott, Lower Lake, Lake County, owners. In Secs. 20 and 21, T. 13 N., R. 8 W. This property, on the southern slope of Mount Konockti, or Uncle Sam, consists of four claims: the Lucitta, Lucitta Extension N., Lucitta Extension S., and Lucitta Extension W. [See Fig. 12.] The work, however, has been concentrated in the southern half of the Lucitta claim. The entire formation is igneous, bowlders of andesites being prominent, the intervening material being a decomposed tufa bleached by solfataric action. White beds of leached metamorphic shales are found in these igneous masses, and occasionally bodies of clay. In the lower tunnel (No. 1) cinnabar has been deposited on the face of the bowlders and in the decomposed tufa, occasionally forming bunches of ore, apparently of good grade. Such an ore body is found in the first crosscut [see Fig. 12]. In the middle tunnel (No. 2) the country rock is the same as in the lower tunnel. The best ore is found in the side drift, 60 feet long, running southeast and branching from the southwest crosscut near breast. Past the crosscut the drift enters into very hard, barren material. The ledge matter appears to be a metamorphic bleached shale, occasionally gritty; while very much broken up, it shows a tendency to a stratification dipping southwest. The material in the upper tunnel (No. 3) is principally decomposed tufa, carrying some ore. The main drift has caved at 100 feet from the mouth, and two curved drifts have been run to reach the territory past the cave; the left-hand drift shows good ore in the breast. The plan shows that this ore lies above that opened in tunnel No. 3; hence this ore body is probably continuous for a depth of 80 feet. A little higher up the mountain is an open pit, 25 feet deep. The walls are formed entirely by decomposed and leached tufa, with bunches of cinnabar ore all through the material. Similar bunches of cinnabar ore are found in the decomposed tufa on the hillside all over the claim, but only in the middle tunnel a regular ledge is exposed, which, from the appearance of the breast of the left-hand drift in the upper tunnel, is probably covered up by the cave. A small prospect

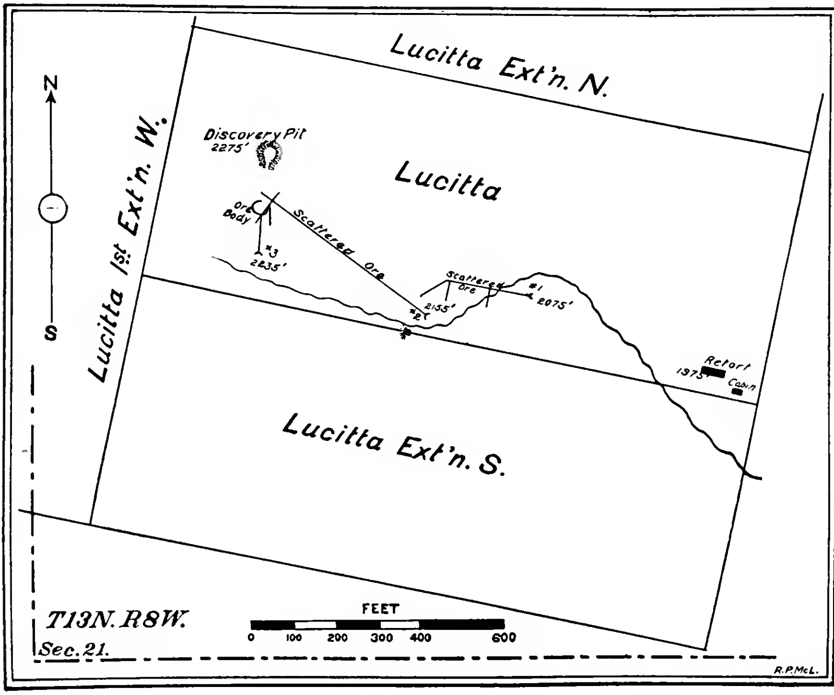


FIG. 12. Lucitta Mine.

opening near the dump of tunnel No. 2 shows solfataric action, and formations very similar to those at the surface at Sulphur Bank. The mine is equipped with a 10-pipe retort furnace.

Middletown Mine.—Mayacmas District. In Sec. 7, T. 10 N., R. 7 W.; about half a mile southwest of the Jewess. Owner, W. H. Parsons, Middletown, Lake County. An outcrop similar to that on the Jewess and Wall Street, on which some work has been done on the top of the ridge, showing a small amount of cinnabar through the ledge matter. The country rock is nearly all serpentine. About 90 feet lower a tunnel

35 feet long shows very hard, cherty material, carrying some specks of cinnabar. A crosscut tunnel 50 feet long is started about 200 feet below the upper croppings in very decomposed country rock, probably schist.

Shamrock Mine.—Clear Lake District. Owners, J. C. Ansel, Sulphur Creek, Colusa County; J. B. Mason and ——— Swift, Knoxville, Napa County. In Secs. 14 and 23, T. 13 N., R. 6 W. It consists of the Shamrock and Shamrock Extension claims. The mine is on Rocky Creek, a tributary of Cache Creek, in a very extensive belt of serpentine, which to the southeast extends to the Knoxville district. Rocky Creek makes a sharp curve on the ground of this mine, forming a narrow peninsula, about 100 feet above the bed of the creek, which has been crosscut by two tunnels; the one starting from the up-stream side has caved in and is inaccessible; the other, on the down-stream side, runs in a course S. 60° W., first through 125 feet of shales, then 75 feet through decomposed serpentine and sandstone bowlders. At this point drifts have been run N. 68° W., and S. 68° E., mainly in gouge; but little ore can be seen in these drifts.

Standard Quicksilver Company.—Mayacmas District. Z. W. Christopher, superintendent, Mirabel, Lake County. This company owns a large tract of land in the neighborhood of Mirabel, on both sides of St. Helena Creek. [See Mon. XIII, U. S. G. S., page 375; Report State Mining Bureau of Cal., VIII, page 325; XI, page 64; XII, page 360; XIII, page 595.] The *Mirabel*, formerly the Bradford, which was opened in 1887 and at the time was a great producer, on the western bank of St. Helena Creek, is considered worked out by the present owners. It was abandoned in 1897, and has filled with water. The total production of this mine was 30,590 flasks; the greatest depth of the workings is 500 feet; 22,500 linear feet of drifts were driven and 750 feet of shaft sunk. The company has as yet not succeeded in developing any workable deposits east of St. Helena Creek. On the west side, a little to the north of Mirabel, in Sec. 23, T. 10 N., R. 7 W., the company opened up the *Bullion* mine, nearly on a line running from the Mirabel to the Great Western mine. This mine is located on a ledge having a general strike about north (N. 8° W.) and dipping to the east. The dip of the ledge, rather steep near the surface, flattens out with depth, and consequently the vertical shaft started in the hanging-wall sandstone cuts the vein and enters the foot-wall serpentine. [See Fig. 13.] The nature of the hanging-wall material, metamorphic sandstone, was ascertained while sinking the shaft; against the vein lies a very wide belt of gouge, through which no crosscut has been driven below the 450-foot level. The ledge varies sensibly in width, but its average may be placed at 35 feet. The ore forms in fissures running *across* the vein, starting from the hanging wall and feathering out toward the foot wall; sometimes these cross fissures occur close together and then form workable ore bodies. This ore formation would indicate a secondary concentration of the mercury from the sandstone; but then the displacement which caused the very heavy gouge on the hanging wall must have been posterior to the ore concentration in the ledge. Where the ledge is barren, the opaline rock forming its filling is very compact. The property is equipped with a 40-ton Hüttner & Scott furnace, provided with a mechanical drawing apparatus, and brick condensers provided with waterbacks.

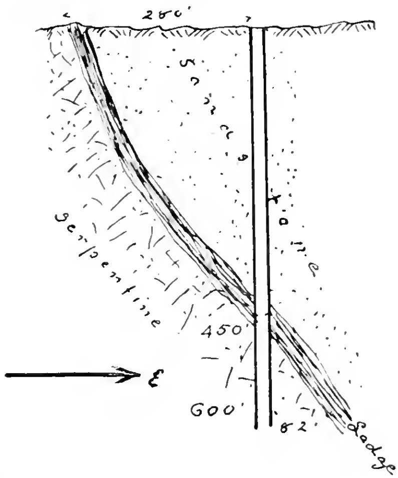


FIG. 13. Section of Bullion Mine (Standard Quicksilver Company).

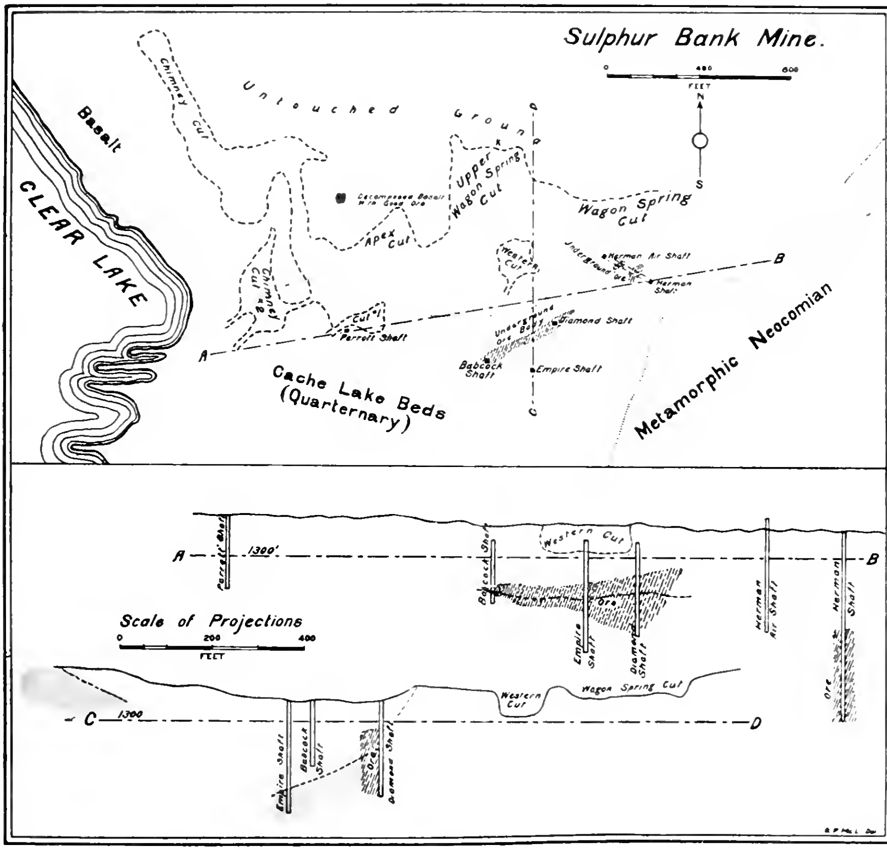
Sulphur Bank.—Clear Lake District. Empire Consolidated Quicksilver Mining Company, owner; R. A. Boggess, general manager, Sulphur Creek, Colusa County. In Secs. 1, 2, 3, 6, 8, 11, 12, 13, 17, 18, and 20, T. 13 N., R. 8 W., and Sec. 14, T. 13 N., R. 7 W. [See Mon. XIII, U. S. G. S., page 254, etc.; American Journal of Science, vol. XXIV, 3d series, page 23, *et seq.*; Report State Mining Bureau of Cal., X, page 238; XI, page 63; XII, page 361; XIII, page 597.] The Sulphur Bank mine was opened in 1875 and worked until 1883, during which period the Herman shaft was sunk. Work was resumed in 1887 and continued until

1897, during which period the Diamond and Babcock shafts were sunk. In 1899, work was again resumed and has been prosecuted until the present time. The total production of the property has been 92,000 flasks, the greater part being obtained from the surface workings. This property has been extensively described and discussed by several geologists, principally because it afforded special occasion to study the relations between solfataric waters and the genesis of ore deposits. In Mon. XIII, U. S. G. S., a very detailed geological map of the property is given.

PHOTO No. 3. WESTERN CUT—SULPHUR BANK MINE.

The deposit may be considered from two points of view: the surface developments and the underground developments.

The surface developments in their present state give the impression of an abandoned hydraulic mine, there being extensive shallow cuts, more or less filled with bowlders of barren igneous rocks. [See photograph of Western cut, Sulphur Bank mine.] The igneous rock was determined by W. Jackson in 1880 as augite-andesite, mainly because of the absence of olivine; but in Mon. XIII, above cited, it is classified as basalt.



Sulphur Bank Mine.
FEET
Basalt
CLEAR LAKE
Untouched Ground
Chimney Cut
Upper Wagon Spring Cut
Wagon Spring Cut
Apex Cut
Western Cut
Herman Air Shaft
Herman Shaft
Underground Ore
Diamond Shaft
Perrott Shaft
Babcock Shaft
Empire Shaft
Cache Lake Beds (Quarternary)
Metamorphic Neocomian
A
B
C
D
1300'
Scale of Projections
0
200
400
Ore
Wagon Spring Cut

FIG. 11.

and the latter determination is generally accepted. These basalt bowlders may be a flow from the craters, yet discernible to the northeast of the bank, or may have been ejected from a vent close to the bank, which has as yet not been uncovered. Up to the present time this basaltic flow has been found everywhere overlying the altered sedimentaries. As the cinnabar deposits are not restricted to the territory covered by the lava flow at the Bank [see Fig. 14], and as most careful investigation has failed to disclose any cinnabar or mercury in the undecomposed basalt, this basalt can not be the source of the metal.

The upper crust of the lava deposit, to a thickness of a few feet, consists of a white silica, the residue of the complete decomposition of the basalt, by the combined action of the highly

FIG. 15. Sulphur Bank Mine—Elevation of Upper Wagon Spring Cut at (X).

sulphurous solfataric waters and the atmosphere, forming sulphuric acid ($H_2S + 4 O = H_2SO_4$), which decomposed all the silicates in the rock and left the pure silica. Immediately below the surface zone, where oxygen was not so abundantly present, free sulphur was formed ($H_2S + O = H_2O + S$). This took place to such an extent that originally the property was worked for sulphur. About 2000 tons of sulphur have been extracted.

The basalt occurs in places as masses of bowlders, which near the surface are surrounded by shells of decomposed material of grayish color and very much disintegrated. Below these bowlders and in places reaching very near the surface, as in the bank of the Upper Wagon Spring cut [see Fig. 14 at *x* and Fig. 15] and in the Apex cut, the basalt has a more or less bedded form. When first uncovered, the basalt bowlders have a rough surface; but when in contact with the atmosphere for a short time, their outer shell readily decomposes and disintegrates, giving them a waterworn appearance. The neighborhood of Sulphur Bank is at present a region of great solfataric action, not so intense, however, as in the past. A number of cuts have been run, covering a territory 2000 feet long and 800 feet wide, and having a general northwestern direction. These surface works are mostly in the territory covered by the lava flow, but to the south, and especially to the southeast in the Wagon Spring cut, near the Herman shaft, the sedimentaries come to the surface. Iron, mostly as oxide, is extensively found in this surface zone; in places the black coloring of the material is due to iron oxides. Sulphur, as already mentioned, is also very prominent, in the forms of free sulphur, metallic sulphides and sulphates, and free sulphuric acid. Hydrocarbons, mostly in minute globules, are also present. Mercuric sulphide (cinnabar) is one of these metallic sulphides, and occurs in many places sufficiently concentrated in seams and pockets to form workable ore bodies. In the bowlder zone it forms in the disintegrated material filling the interstices of the bowlders; in the bedded zone it occurs in seams, which allowed the passage of the ascending solfataric waters, and wherein the latter deposited the cinnabar with a more or less gelatinous opaline silica.

Underlying the basalt are sedimentaries. It is greatly to be regretted that the management of this property has not taken pains to preserve geological descriptions of the underground works, which are all caved in, except the Empire shaft, now in progress of sinking. The latter is so tightly timbered, owing to bad ground, that it offers no opportunity to study the formations through which it has passed. The following remarks regarding the sedimentary formations are only fragmental and are collected from different sources:

The sedimentaries consist of: the Cache Lake beds (Quaternary), conglomerates, sand beds, and argillaceous and calcareous deposits, which are generally very friable and at Sulphur Bank thoroughly decomposed by solfataric action. According to Professors Le Conte and Rising these beds appear to be more tilted to the east, near the Herman shaft, and nearer to the volcanic vent or vents than westward near the Babcock and Diamond shafts. Underlying the Cache Lake beds are the Lower Cretaceous, Neocomian rocks, prominently sandstones, most highly metamorphosed. Professors Le Conte and Rising seem to assume that the Cache Lake beds belong to the same period as these underlying sandstones, determined by Becker to be Neocomian. On the contact of the Cache Lake beds and the metamorphosed sandstone is found a brecciated zone, which in the neighborhood of the Herman shaft appears to be tilted at a steep angle, dipping southward. On the line of cross-section A B [see Fig. 14], the contact is also dipping south between the Babcock-Diamond line and the Empire shaft, but only at an angle of about 30°. [See cross-section C D.]

Taking low water in Clear Lake as datum, the depth of the contact in the shafts is: Empire shaft, 185 feet; Babcock shaft, 100 feet; Diamond shaft, 90 feet.

The Quaternary beds are highly siliceous and interbedded with strata of very loose material, acting as quicksand, disintegrated by the percolating solfataric waters. In the Wagon Spring cut where they appear at the surface, the brecciated zone, consisting of fragments of shale and sandstone inclosed in a clayey material, formed a channel for the ascending solfataric waters, which deposited therein cinnabar and pyrites. This deposit will be discussed hereafter in this chapter.

A great number of short tunnels, drifts, and winzes have been run in the banks of the cuts, and shallow shafts have been sunk in their bottoms, to excavate pockets of cinnabar ore. In nearly every bank of the cuts formation of cinnabar is taking place at the present time. Often, when breaking down the cinnabar-carrying surface, no signs of cinnabar are found in the uncovered surface. This formation of cinnabar, which can not be an exudation product, may be explained by the fact mentioned by Becker (Mon. XIII, page 260) that the waters at the surface contain small quantities of mercuric sulphide in suspension, but none in solution, caused by the presence of ammonia. These suspended particles will be deposited on arriving at the surface. In the Western cut a deposition of cinnabar occurs, which, in the writer's opinion, can not be explained except as a deposition from mercurial vapors. In this cut a small shaft 12 feet deep was sunk, but had to be abandoned on account of the peculiar gas occasionally occurring in quicksilver mines, especially attacking the eyes of the men, blinding them temporarily with intense suffering. (Some claim this gas to be methane.) [See also Great Eastern Mine.]

Near this shaft very hot gases emanate from the floor of the cut and form incrustations on a bowlder of basalt lying in the proximity. These incrustations on the top of the bowlder show signs of cinnabar, which can not come from any other source than from these gases.

In the same cut not 20 feet interdistant, are two springs, one cold, the other hot, from both of which gases are constantly emanating, which would tend to indicate that the gases and waters are not derived from the same source. The depth of the surface workings has been limited by the water level. Shallow shafts prove that cinnabar occurs below the floor of the cuts as well as in their banks; but the relation between the cinnabar occurrence at the surface and that underground has as yet not been clearly established.

The territory developed by the underground workings does not underlie that developed by the surface workings, except for a slight portion near the Herman air shaft, and is much more restricted than the surface workings. [See Fig. 14.] Unfortunately all the old shafts have caved and are inaccessible. The Empire shaft, in process of sinking, has been started with the purpose of reaching, by drifting, ore bodies presumed to exist under the Western cut; these drifts will have to run through the ground underlying the caved-in stopes of the Diamond shaft. [See below.]

The Herman shaft is geologically the most interesting, as in these works connection might be traced between surface and underground phenomena. The details available at the mine are very deficient, but a description of the works in this shaft in 1880 and 1881 is found in the above-cited article by Professors Le Conte and Rising, from which the following is quoted: "The upper level, 210 feet, runs (in a course about N. 60° W.) "from 70 to 80 feet in barren sandstone and shale, dipping "about south, the rock being comparatively dry and cool; then "cuts through a breccia, carrying a great amount of hot waters, "containing considerable alkaline sulphides, carbon dioxide, "and hydrogen sulphide; temperature, 160° F., with very strong "emanations of carbon dioxide. This breccia contained the "ore. The level, of a total length of 232 feet, cut through this "ore body and reached barren ground."

The plans of the works [see Fig. 16] show a second smaller ore body, not mentioned in above description. Becker, who visited the shaft in 1887, states (Mon. XIII, page 263): "An "important ore body was followed down; * * * the shaft "is 417 feet deep, with seven levels. * * * This body has "been worked out, and only the lowest portion was accessible. "The small amount of ore remaining consisted of partially "metamorphosed sandstones and shales carrying small stringers "of cinnabar, quartz, and pyrite. I was not able to get satis-

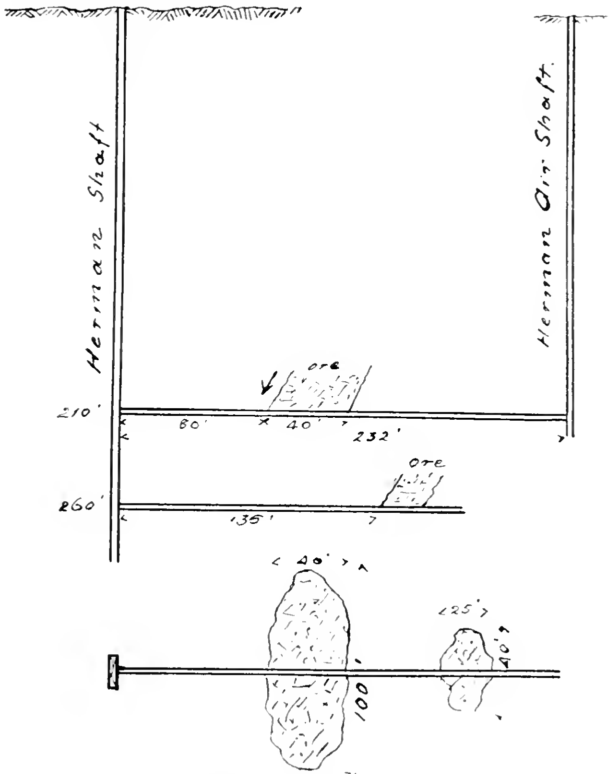


FIG. 16. Sulphur Bank Mine—Section and plan of Herman shaft.

"factory information as to the depth from the surface of the "contact between the Lake deposits and the brecciated meta- "morphic sandstones and shales."

The above quoted article of Le Conte and Rising continues: "The lower level, 260 feet, reached the ore body at 136 feet "from the shaft. The varying dips on the different levels show "that the strata are very much broken up. The brecciated "layer, which as in the Wagon Spring cut is composed of frag-

"ments of shale and sandstone, forms also here the water "channel. Where the ascending water is abundant, the matrix "is hot mud; where the rock is drier, this has changed into a "paste containing disseminated metallic sulphides, or into a "regular indurated deposit from solfataric waters. The spaces "between the fragments are sometimes only partially filled; "the lining of the cavities is generally cinnabar, sometimes "pyrites, or silica, or all of them; the silica grading from chal-"cedonic into gelatinous. [See Fig. 17.] The ore deposit is "not entirely confined to the breccia. Its form is very irregular; "sometimes ore bodies "are separated by bar-"ren rock, sometimes "they enter the shat-"tered sandstone, leav-"ing the breccia. No "free sulphur is found "in the ore bodies. The "irregularity of the ore-"bearing fissures shows "that the shattering ef-"fects were not confined to the brecciated strata."

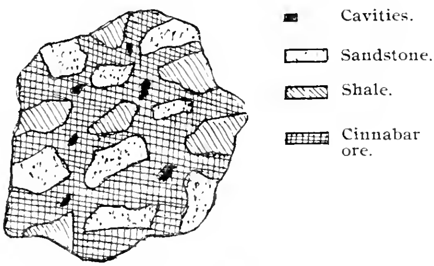


FIG. 17. Sulphur Bank Mine—Ore formation in Herman shaft.

Comparing this ore occurrence with that at the surface in Wagon Spring cut, near the Herman air shaft, which is found in a soft brecciated stratum several feet wide, consisting of fragments of shale and sandstone with a matrix of blue clay mud, through which hot alkaline waters at 125° F., highly charged with hydrogen sulphide and carbonic and boracic acids, are ascending, and in which considerable cinnabar and pyrites have been deposited, the conclusion is that both deposits have probably the same genesis, though their relation is not clearly established.

The following part of the quotation cited above from Mr. Becker's work: "I was not able to get satisfactory information * * * of the contact between the Lake deposits and the metamorphic sandstone and shale," indicates that in his opinion the formation at the surface in Wagon Spring cut belongs to the lake beds. No underground ore bodies have been found in these beds, possibly due to the fact that these beds offered a greater number, but more minute channels to the waters, and the ore deposition was subsequently less concentrated; for it may be accepted as a fact that the cinnabar deposits at the surface and underground belong to the same system of water circulation.

From the accompanying section of the Diamond shaft [see Fig. 18] it may be concluded that here the lake beds overlie the metamorphic shales and sandstones [see also sections on Fig. 14], rendering the assumption that such is the case in the Herman shaft all the more probable. The material at the surface in the Wagon Spring cut is so thoroughly decomposed that it is impossible to decide this question by its study.

The accompanying sketch of the old works of the Diamond shaft [see Fig. 18] shows the ore body in the metamorphic sandstones underlying the surface formations. Judging from the plans, the ore body was in places 40 feet wide. It is reported that at the time the shaft collapsed the lower level had not reached the limits of the ore body. Including the results of the workings of the Babcock shaft (also collapsed), the length of this ore body may be placed at 500 feet; but it is doubtful if any of this ground will be available in the future because of the collapse of both shafts, as this treacherous ground is saturated clear to the surface with hot acidic waters. No data are available to judge whether the ore formed in a brecciated contact zone, or in fractures cutting through strata; in other words, whether the ore bodies resembled the upper part of the deposit in the Herman shaft, as described by Le Conte and Rising, or the lower part, as described by Becker.

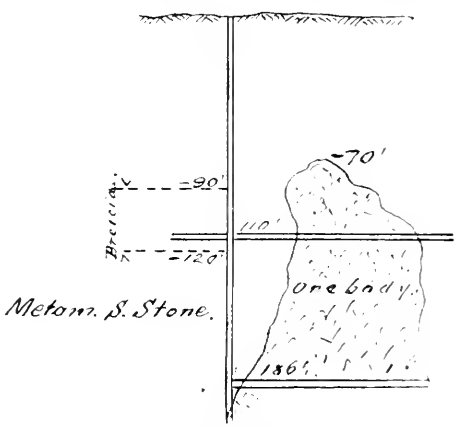


FIG. 18. Sulphur Bank Mine—Section of Diamond shaft

The breccia in the Diamond and Empire shafts, judging from dump samples, appears to be a fragmental sandstone recemented by silica, which, being softer, offered more favorable conditions for ore deposition than the more compact metamorphic sandstone. If, as it appears to do in the Empire shaft, the formation becomes more compact in depth, the ore deposits will probably accordingly decrease in value.

Summarizing, it may be stated that deposition from solfataric waters is the prominent mode of ore formation, but that mercurial vapors are present and probably play their part in this process. The solfataric waters are highly charged with active chemical agents, but the source from whence they derive their mercuric contents is at present unknown; the igneous bodies, however, to which the basalt surface flow belongs, are certainly not the source thereof.

The increase in heat with depth in the Herman shaft is worthy of note. At the surface, 128° F.; at 200 feet depth, 160° F.; at about 300 feet, 176° F. Assuming the surface heat of 128° F., those at 200 and 300 feet depth, according to the general rule of increase by static influence, would be respectively 132° and 134° F. This shows that in regions of solfataric action the increase in heat with depth is extremely rapid, and that conclusions regarding physico-chemical phenomena must take this rapid rate of increase into account, even for zones of shallow depths.

The great heat, the chemical composition of the underground waters and gases, and the character of the rock, render the underground exploration of this property a very serious undertaking.

This property is equipped with four furnaces, of which one is a Knox & Osborne 25-ton furnace, the others are Hüttner & Scott furnaces, respectively of 40, 17, and 30 tons, and with a furnace having nine ⌓ retorts.

Thorn Mine.—Mayacmas District. In Sec. 36, T. 11 N., R. 8 W. On the north side of Bear Creek, south of Anderson Springs. Owner, D. H. Thorn, Anderson Springs, Lake County. This prospect lies very close to the top of the ridge. Near the surface some pockets of good ore were found, but did not continue in depth. The underground works, 60 feet below the upper works, show as yet no ore at all, and in the upper works the ore bodies pinched out at a very slight depth.

Utopia Mine.—Clear Lake District. In Sec. 25, T. 13 N., R. 6 W., about opposite Lakeport, near the east shore of Clear

Lake. The Utopia Quicksilver Mining Company, owner; M. S. Sayre, of Lakeport, president. [See Report State Mining Bureau of Cal., XIII, page 597.] The company is contemplating opening this mine.

Wall Street Mine.—Mayacmas District. In Sec. 1, T. 10 N., R. 8 W. Owner, W. H. Parsons; postoffice, Middletown, Lake County. [See Mon. XIII, U. S. G. S., page 375; Report State Mining Bureau of Cal., XII, page 362.] The former owners spent considerable money in exploration works, without satisfactory results. Their old workings are largely caved in, the furnace is destroyed and its site practically obliterated. In an old tunnel (2440 feet elevation) [see Fig. 19] there is a ledge of hard siliceous rock, carrying some metal along a seam, and penetrating from that seam into the small fractures of the rock, forming a poorly mineralized zone about 18 inches wide, with a strike northwest, and a southwesterly dip, which shows, however, only over a length of 40 feet, and about 50 feet along the

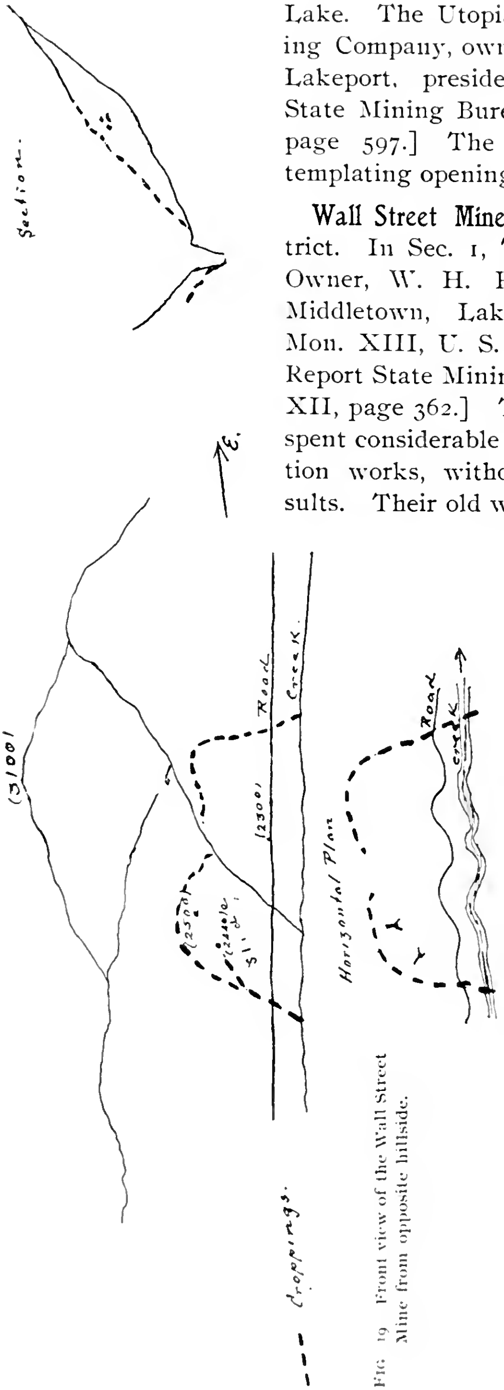


FIG. 19. Front view of the Wall Street Mine from opposite hillside.

dip. This mineralized zone is apparently cut off to the east by a body of hard, compact serpentine, and has not been found past this point. Both walls are serpentine, and there is no gouge on either wall. It appears as if a vein has cut through the point of the hill, and only carried metal in the eroded dome. The eastern branch directs toward the workings of the Jewess, which have proven barren.

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Aetna Consolidated Quicksilver Mines.—Mayacmas District. In Secs. 2, 3, and 4, T. 9 N., R. 6 W. Owner, The Ætna

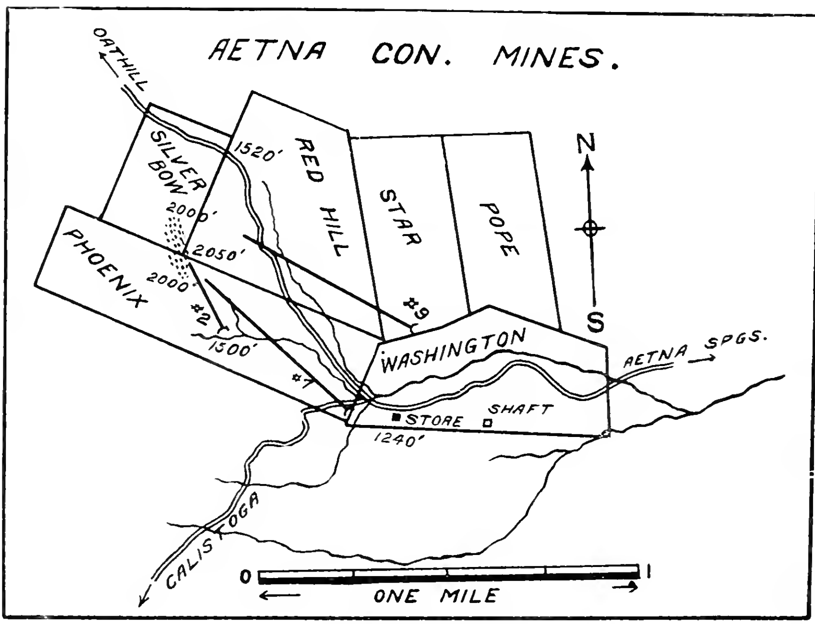


FIG. 20. Ætna Consolidated Mines.

Consolidated Quicksilver Mining Company, 70 Kilby street, Boston, Mass.; B. M. Newcomb, Oathill, Napa County, Superintendent. [See Mon. XIII, U. S. G. S., pages 354, 371; Report State Mining Bureau of Cal., XI, page 72; XII, page 362; XIII, page 597.] This group of mines is situated at the southeast end of the belt as at present developed. [See Fig. 20.] It comprises the Phœnix, Silver Bow, Red Hill, Star, Pope, and Washington mines. These mines were formerly

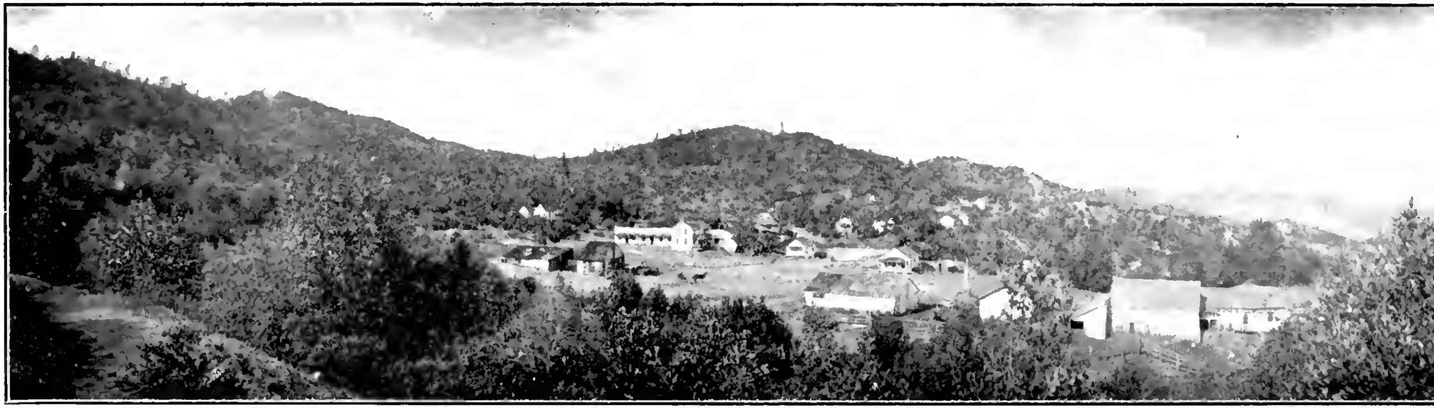


PHOTO No. 4. ÆTNA QUICKSILVER MINE.

large producers, but in the last few years have produced no quicksilver. The property can hardly be described as lying in

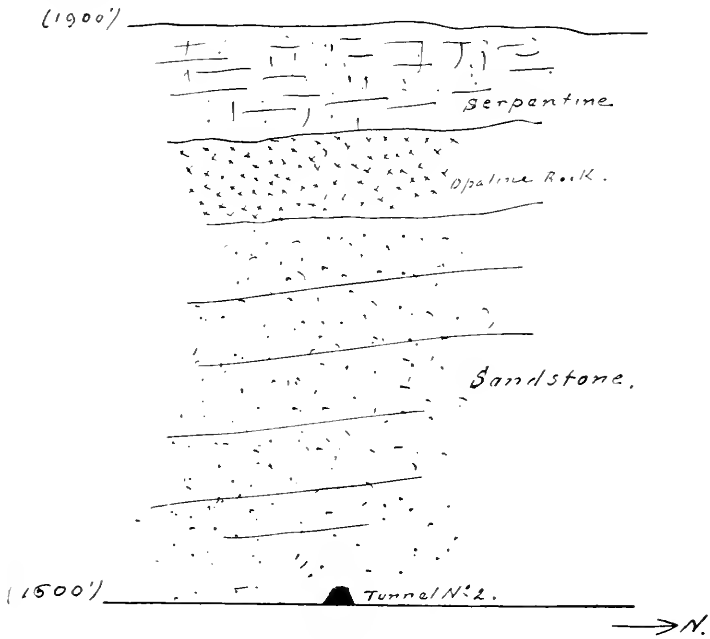


FIG. 21. Ætna Consolidated Mines—Elevation at mouth of Tunnel No. 2.

James Creek cañon [Mon. XIII, U. S. G. S., page 374], but would be more properly described as located on the northern slope of a ridge running in a northeasterly direction from the Twin Peaks and capped by lava.

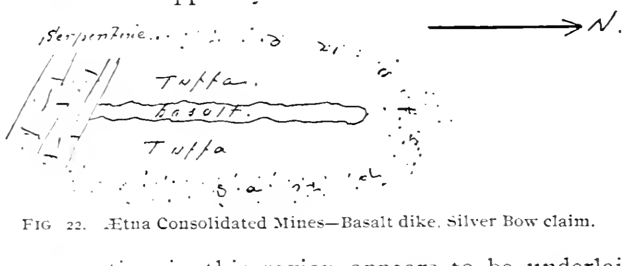


FIG 22. Ætna Consolidated Mines—Basalt dike, Silver Bow claim.

The serpentine in this region appears to be underlaid by sandstone [see Fig. 21], being a break above tunnel No. 2 in the Phœnix claim. Tunnel No. 7 runs toward a basalt dike, which breaks through to the surface, and reaches the contact at a depth of from 800 to 1000 feet. This dike shows at the surface for a length of about 1000 feet; the underground works which run around the dike show it to be surrounded by sandstone. [See Fig. 22.] The basalt is cut off at the surface by the same serpentine showing in Fig. 21; but from the fact that the latter does not go through the sandstone, the surface indications are not convincing that this basalt dike does not connect with the main seat of eruption, having uplifted the serpentine and broken through the sandstone. The tufa surrounding the basalt is more siliceous and probably older than the basalt. It overlies the sandstone but not the serpentine, confirming the above supposition. The tufa overlying the serpentine has probably been eroded. For some reason, in this region the tufa is invariably found overlying the sandstone but not the serpentine. In the Star claim another short dike of basalt, about 100 feet long, has been followed at its contact with the sandstone to a depth of 600 feet.

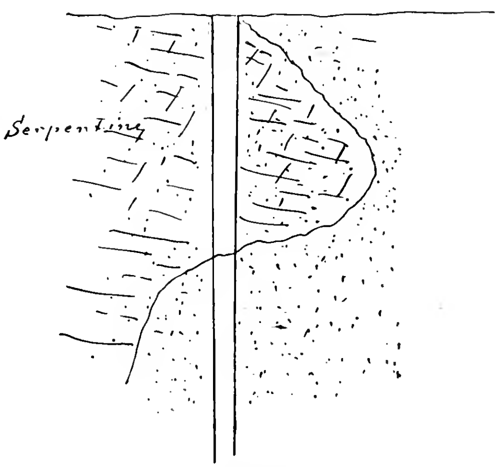


FIG. 23. Ætna Consolidated Mines—Section of Washington shaft.

The Washington shaft disclosed a boss of serpentine, which carried a good body of ore, while in the sandstone but little ore was found. [See Fig. 23.] In the Phœnix workings, at tunnel No. 9, only sandstone was found underground in the Red Hill claim, while the surface of that claim is almost entirely covered by serpentine and its allied opaline rock; a winze sunk from this tunnel follows a contact between igneous rock and sandstone to a depth of 1000 feet.

All the sandstone in this neighborhood contains some cinnabar disseminated through it; but so far workable ore deposits have only been found near the igneous rocks and the serpentine, indicating a secondary concentration in connection with the igneous rocks and the serpentine.

The company is at present doing prospecting work, in order to determine whether workable ore bodies can be found on the contact with the large dike on the Silver Bow claim above described. [See Fig. 22.]

Bella Union Mining Company.—This property is in Secs. 20 and 28, T. 7 N., R. 5 W., one and a half miles south of Oakville. [See Mon. XIII, U. S. G. S., page 377: Report State Mining Bureau of Cal., XII, pages 364 and 365; XIII, page 599.]

Boston Mine (formerly the Redington).—Knoxville District. Boston Quicksilver Mining Company, owner. B. M. Newcomb, general superintendent, Oathill, Napa County; J. B. Mason, superintendent, Knoxville, Napa County. In Secs. 6 and 7, T. 11 N., R. 4 W. [See Mon. XIII, U. S. G. S., page 284; Report State Mining Bureau of Cal., XI, pages 69–72; XII, page 363; XIII, page 599.] The Redington Quicksilver Mining Company supposedly worked out the ground in the original shaft and abandoned the works in 1882. In 1890 Mr. McMillan started on a narrow seam of cinnabar several hundred feet northwest of this shaft in the serpentine formation, which upon development showed so profitable that the northwest shaft was sunk and this territory worked until 1898. The present owners have reopened and retimbered the old shaft, and by a systematic exploration not only found some good ore bodies in the foot- and hanging-wall veins, but also opened up large ore bodies in the serpentine lying in the intervening territory. This vein has supplied the majority of the ore which the present company has passed through its furnace, and shows at present large ore reserves. The result proves again the great importance of systematic exploration work in a quicksilver mine.

The ore bodies in this mine form in the same serpentine which runs along the southwestern border of the mineralized zone of the Manhattan mine. This belt extends for several miles to the southwest, but, except at its contact with the Neocomian at Knoxville, does not contain a single ore body of any consequence. The mineralized zone of the Boston mine has a northwest strike, and dips at about 45° to the northeast. Its cross-section is given in Fig. 24.

In the Neocomian sandstone, about 1200 feet northeast of the ore zone, some work has been done, confirming the fact that cinnabar forms in the sandstones; tests of the latter taken from various places indicate that cinnabar is disseminated all through this formation. Combining this fact with the absence of cinnabar in the serpentine, even when in close proximity to the igneous rocks in the Manhattan ground, and with the fact that in the Boston mine the workable ore bodies are in the serpentine, the suggestion offers itself that the genesis of ore

PHOTO No. 5. BOSTON QUICKSILVER MINE.

formation in this mine is similar to that in the Ætna mine—secondary concentration of the ore disseminated in the sandstones connected in some way with the serpentine and igneous rocks. While, as far as known, no igneous rocks are present in this mine, basalt is known to extrude within half a mile from it, and it is very probable that intrusions of igneous rocks or laccolitic bodies may have influenced the concentration in conjunction with the serpentinization process. This supposition finds confirmation in the fact that deposits from solfataric springs can be traced from the Manhattan to the Boston mine.

The intense chemical actions which have undoubtedly taken place in this zone, and the great amount and variety of sulphur compounds found therein, indicate undoubtedly close connection with igneous actions, and can hardly be attributed exclusively to the reducing agency of organic matter or ferrous salts on waters carrying sulphites or sulphates in solution. [See Genesis of Ore Deposits, pages 348–350.]

The mine is opened by two shafts. The original shaft, in which the works are at present prosecuted, is on the southeastern part of the mineral zone near the furnace. This shaft is 600 feet deep, but the lowest level at present in operation is at 390 feet. Below that level the works are under water. The second shaft is 640 feet northwest of the furnace, and has been sunk to a depth of 400 feet.

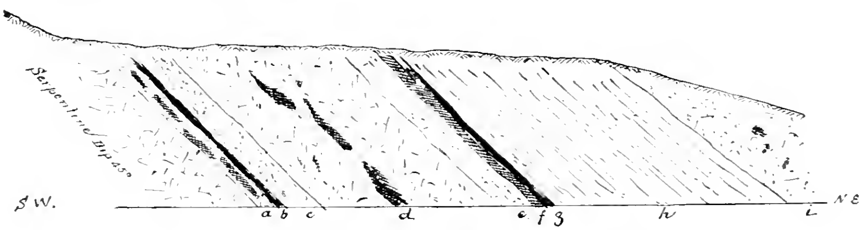


FIG. 24. Boston Mine—Section over the mineralized zone.

a. Footwall vein in opaline.
b. Narrow stratum of clay.
c. Serpentinized breccia (20–40 ft.).
d. Silicified serpentine 100–200 ft. wide, inclosing ore bodies forming the "serpentine vein."
e. Decomposed serpentine.
f. Hanging-wall vein.
g. Clay.
h. Shales 100–200 ft. wide.
i. Sandstones carrying some cinnabar.

The three parallel veins can be said to be inclosed in serpentine, for the clay on the hanging-wall vein shows by its structure to be decomposed serpentine. The gangue in the hanging-wall vein is more or less decomposed opaline. That of the footwall vein is also opaline, but much less decomposed. The serpentine of the central vein is silicified. The ore forms in the multitudinous seams traversing the serpentine, mainly in a direction parallel to the general northwest strike of the zone. The ore shoots in the vein are very persistent in depth as far as opened up, and up to 200 feet long. The vein fillings being all siliceous, the cinnabar deposition is probably related to this silicification. The entire mineral zone is, however, also highly permeated with sulphur. In various places in the mine considerable exudations of sulpho-salts are found. Iron pyrites are also very prominent in the fissures, especially in or close to

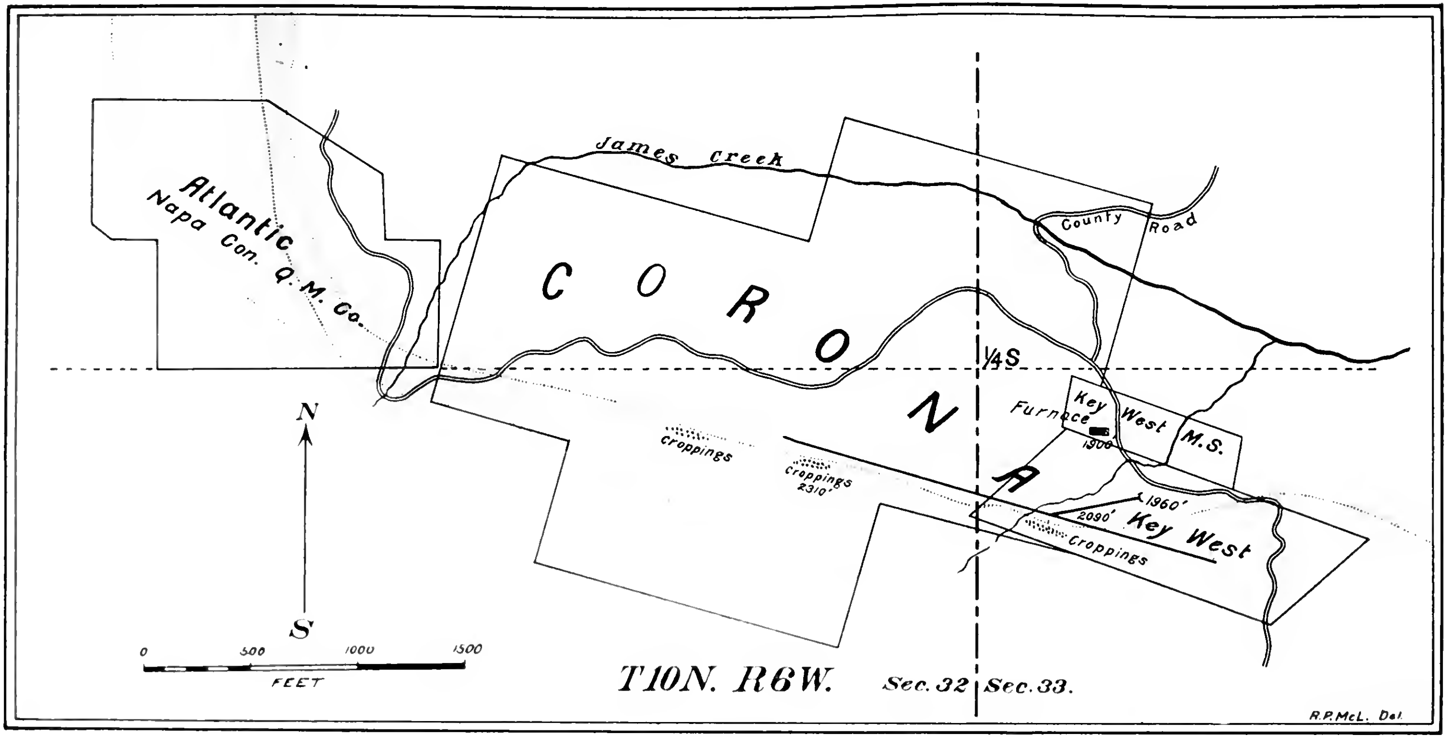


FIG. 25.

Green – Serpentine, Red – Tufa, Yellow – Metamorphic Rock.

the cinnabar deposits. Experience therefore shows that considerable contents of iron pyrites indicate the proximity of bodies of cinnabar ores. The cinnabar occurs generally in crystal form, often columnar. Occasionally acicular crystals are found in the vugs. Some metacinnabarite is found, generally as coating of iron pyrite aggregates. The mine is equipped with a 60-ton Hüttner & Scott furnace.

Corona Mine.—Mayacmas District. In Secs. 32 and 33, T. 10 N., R. 6 W. [See Report State Mining Bureau of Cal., XIII, page 597.] The Vallejo Quicksilver Mining Company, owner; J. B. McCauley, president and superintendent, Oathill, Napa County. The mine is at the head of James Creek, on the contact of a serpentine belt and the Oathill sandstone formation. [See Fig. 25.] The ore occurs in a zone of black chert rock, lying between a sandstone foot wall and probably

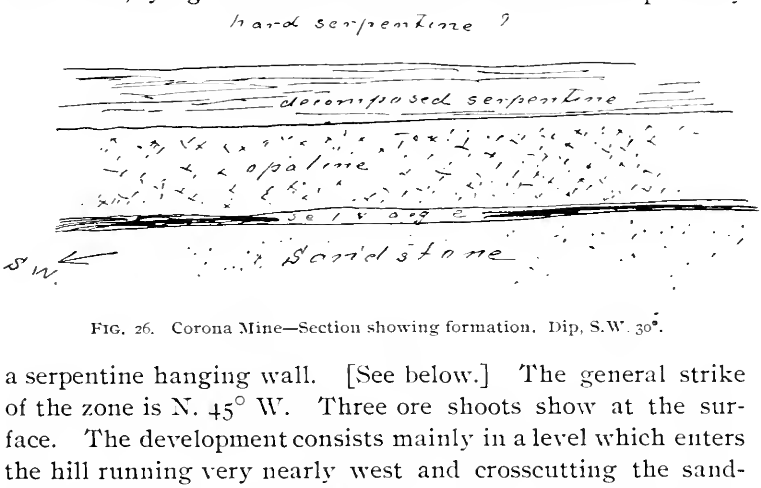


FIG. 26. Corona Mine—Section showing formation. Dip, S.W. 30°.

a serpentine hanging wall. [See below.] The general strike of the zone is N. 45° W. Three ore shoots show at the surface. The development consists mainly in a level which enters the hill running very nearly west and crosscutting the sandstone foot wall for about 400 feet. The sandstone is here mixed with some shales. At 400 feet, the tunnel cuts the vein and follows it about 800 feet to the southeast, and 1300 feet to the northwest. The tunnel cuts the vein at the southeasterly ore shoot, with about 130 feet of backs. The workable ore body is here from 10 to 15 feet wide, the cinnabar forming in fissures running through the opaline rock. Underlying the latter is a white talc, wherein pieces of white and gray rock are found, determined as phthanite, indicating that originally a body of shales overlaid the sandstone and were silicified, probably by the same solution which formed the overlying chert beds. [See Fig. 26.] This ore shoot has in the past produced some rich ore, but at present no work is being done upon it: the development work being centralized on the middle ore shoot, which the tunnel cuts at a depth of 350 feet below the surface. A vertical shaft, 100 feet deep, has been sunk from the tunnel level on this shoot. The tunnel is driven northwest to cut the third ore shoot. Part of the tunnel is run in the sandstone foot wall, determining its persistency, but no crosscut has been run into the hanging wall. A very soft decomposed material overlying the ore body was crosscut to a width of 35 feet, without finding unaltered material; hence the assumption of a serpentine hanging wall rests on surface indications. The black chert wherein the ore makes is from 40 to 45 feet wide; it has a very irregular bedding system, which, if any, may be said to be a little more prominent across the vein, but the higher mineralized portions seem to follow the trend of the ledge. The central ore shoot has been opened for a length of 160 feet, and has been persistent in depth from the surface to the present depth of 450 feet. The cinnabar forms occasionally in such hard and compact material that it can scarcely be understood how it found access to its place of deposition. There is no apparent difference between the barren and the cinnabar-bearing chert; the former may be in its general texture a little more compact. A special feature of this mine is the very great amount of sulphide of iron accompanying the cinnabar. The furnace, of 50 tons capacity, is very much like an ordinary Scott furnace; the ore is so highly pyritous that very little fuel is required. This feature has the objection that the heat in the furnace is very irregular, and generally far too high, entailing a great loss of mercury.

La Joya Mines.—The Standard Consolidated Quicksilver Mining Company, owner. The property is in Sec. 24, T. 7 N., R. 6 W., three miles southwest of Rutherford. These mines have been idle for several years and the works are caved in. Regarding La Joya mine, Mr. von Leicht reported in March, 1898, three known ore bodies, separated by barren stretches, in an altered serpentine, cropping at the surface as yellow ochery matter, on the contact of sandstone and serpentine to the southwest of the former; strike northwest. The gangue

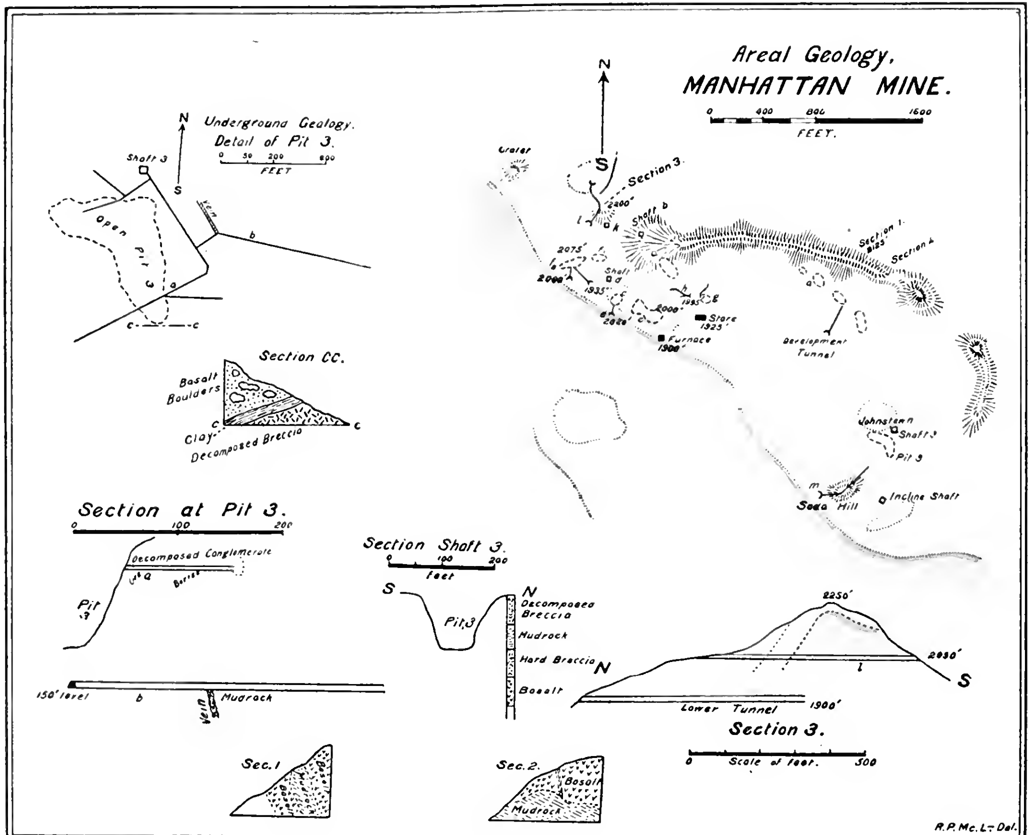


FIG. 27.

Red — Igneous. Green — Serpentine. Yellow — Metamorphic Rock.

minerals as reported are: silicates and calcites, no iron pyrites or sulphur. Since this report was made some further exploration work had been done. A 20-ton Fitzgerald furnace has been erected, but not used as yet.

Manhattan Mine.—Knoxville District. Lake Mining Company, owner; R. B. Knox, Knoxville, Napa County. In Sec. 6, T. 11 N., R. 4 W., and Sec. 1, T. 11 N., R. 5 W. [See Mon. XIII, U. S. G. S., page 282; Report State Mining Bureau of Cal., XI, pages 70–72; XII, page 363; XIII, page 598.] The

PHOTO No. 6. MANHATTAN QUICKSILVER MINE.

first work on this mine was performed at Johntown in 1863. [See Fig. 27.] As the ore was reduced at the Redington mine its product was credited to that property. Work was resumed in 1868 until 1877, then the mine was idle until 1884, but has been in constant operation since that year. Total production, about 15,000 flasks.

The study of this mine is especially interesting in regard to the relation of igneous rock and the ore deposition. The ore deposits are found in a belt having a general northwestern direction, lying between basalt to the northeast and serpentine to the southwest. The basalt does not show at the surface in a continuous line; the full red line on the plan of the mine represents as nearly as possible the line of its vent. The territory between the basalt and the serpentine is almost entirely covered by tufa, except in the following places:

At Johntown is a small exposure of the "mudrock" in which the original discovery of cinnabar in this mine was made.

North of the furnace and close to the serpentine lies a large body of chalcedony, formed most probably by mineral springs.

On the northwestern end of the property is found the hill represented by section 3, showing a body of serpentine almost entirely covered by tufa.

The underlying country rock is an altered Neocomian [see Becker, Mon. XIII, page 464], crushed and altered into a material which is found through the entire mine in various conditions of hardness. Near water channels it is a dark-colored clayey material, which grades into a light-gray rock without any discernible cleavage or fissility, generally rather soft, occasionally darker colored, very hard and fine-grained. Its position near the eruptive rocks, and comparisons with the silicified shales of the neighborhood of Mount Konockti, suggest that the shaly country rock was crushed and ground by the eruptive actions, and its original stratification destroyed. The harder portions are probably the result of contact metamorphism, as they are generally found in contact with, or close to, the igneous rock. This material is locally called "mudrock," and is found also in other mines. It was found in the lower level of the Wide Awake shaft (Sulphur Creek), and in some of the mines in San Luis Obispo County. On the contact of the "mudrock" and the basalt occurs a breccia, generally very hard, locally called "niggerhead," probably fragments of country rock recemented, due to the action of the adjoining basaltic extrusions.

Underground explorations have proven that the surface indications in many instances do not represent underground conditions. Sections 1, 2, and 3 show that the presence of basalt at the surface does not indicate an igneous dike persistent in depth. The section of shaft No. 3 shows basalt underlying 150 feet of breccia and "mudrock," while levels *a* and *b* show basalt near the surface and none in the underlying territory. The section over pit No. 3 (CC) shows how basalt bowlders and tufa have spread over the country rock. It would require systematic underground exploration to determine the exact location of the fissures through which the basalt extruded. One fact is, however, beyond doubt: The eruptive actions are intimately connected with the ore deposition. Through the serpentine runs a very prominent cropping of opaline material, near its northeastern boundary, which cropping is almost continuous to the Boston mine, where large ore bodies have been found therein. A great amount of exploration work has been done on these croppings without disclosing any ore, until recently a seam of fair ore, from 6 to 12 inches wide, has been discovered therein, about 400 feet southeast of the furnace.

All the territory between the basalt and the serpentine shows the action of mineral springs, which have formed large beds of sinter and other siliceous material.

Commencing at the southeastern part of the property are the works on Soda Hill. The underground works are at present inaccessible. At water level they encountered gas and water highly charged with sodium, arsenic, etc.—salts. The opaline ledge crops here very plainly in the serpentine, and considerable work was done to explore it, but the ledge was found to be absolutely barren. This hill is surrounded by knolls formed by mineral springs now dried up. The surface of the hill is covered by tufa, in which several shallow pockets of cinnabar were found, but in the long tunnel (*m*) [see plan] driven under the hill no ore was found. The formation proved to be principally breccia. On the east slope of the hill an incline shaft, 25 feet deep, was sunk on two parallel seams of black ore.

Northeast of Soda Hill (N. 50° E.) lies pit and shaft No. 3, the most extensive works on the property. The pit is in the form of an L. The north and south leg is 250 feet, the east and west leg 200 feet long. The average depth is about 100 feet, and 120 feet at its deepest point. The walls of the pit are partly basalt, more or less leached, partly tuff and decomposed breccia; in the northwest corner the "mudrock," exposed at Johntown, appears. The bottom of the pit shows the richest in the northern part, but cinnabar ore seams are found all through the formation, generally vertical, but following the prominent seams in the rocks in every direction. A number of tunnels have been run from the pit into the adjacent territory, especially toward the basalt to the east, but as the pit walls are nearly vertical, their entrances are nearly all inaccessible. A tunnel (*a*) [see section over pit], in the southeastern part of the pit, about 25 feet below the surface, which is accessible, shows first decomposed breccia, partly carrying some ore, partly barren. At 100 feet from the mouth solid basalt comes in. On the contact of the breccia and the basalt lies a belt of opaline rock, largely decomposed, but traversed by hard ribs of undecomposed opaline, accompanied by seams of ore. This material carries some lime. The same section shows that at a lower level basalt is absent, vertically under its occurrence in tunnel *a*, and that even were basalt found by driving tunnel *b* further, this could hardly belong to the same body as that found in *a*. Shaft No. 3 runs into basalt at a depth of 150 feet [see section] and remains in that formation underlying "mudrock" to its bottom at 230 feet. The 150-foot level, from which tunnel *b* is run, is mainly in very hard, dark-colored breccia. At this level metamorphic sandstone replaces the breccia and persists to the 200-foot level. [See sketch of pit No. 3.] Below the 150-foot level the ore, which in the breccia is scattered in seams and pockets throughout the formation, is concentrated in a contact between the sandstone and the "mudrock," persisting below the 200-foot level, as far as yet ascertained. The "mudrock" appears to surround the sandstone. With the appearance of the sandstone is introduced a change of the gangue from siliceous to calcareous, calcite beginning to appear in the veins, while the waters contain carbon dioxide. Here then the replacement of silica by carbon dioxide takes place below a zone where silica predominates. This may be attributed to the influence of basalt on the higher horizon, locally heating the rocks and hence favoring the formation of silicates.

Adjacent and to the northwest of pit No. 3 lies the surface exposure of "mudrock" at Johntown. This exposure does not cover over two acres. The original discovery of cinnabar was made here, but all the works are almost entirely obliterated. Nearly north of Johntown, at a distance of about 600 feet, is the southeastern end of a row of pits lying in a northwesterly direction, pretty close to the ridge which marks probably the vent of the basalt extrusion. These pits are on a fissure called the Bunkhouse vein. The ore occurs in lenses on which the pits are sunk, the intervening spaces being nearly barren. Occasionally large ore chambers are found in the ore lenses. The ore forms in seams in the "mudrock," but prominently in the tuff and in the breccia, and occasionally in limestone which is, nearly always, only found in connection with the ore, near the surface in nodules. In this connection it must be noted that the Knoxville basalt carries a high percentage (7.72%) of lime (CaO) [see Mon. XIII, page 159], and thus the lime in the ore bodies may readily be accounted for. Sections 1 and 2 give details of the formation as exposed in the pits and levels run from them. The development tunnel now being run in a northeasterly direction cuts first through a whitish decomposed tuff, then successively through basalt, breccia, ledge matter, and "mudrock." The ledge matter, which dips away from the basalt, is a fine-grained, hard, slightly silicified "mudrock," the cinnabar forming principally on its contact with the breccia.

West of this deposit, near the serpentine, is a large deposit of siliceous material (*c*), prominently chalcedony, partly of a sintry nature formed by solfataric springs, the remnants of previous igneous action, which has now ceased entirely. The siliceous material is mostly in somewhat contorted beds, slightly resembling the chert beds of the Cretaceous, dipping southeasterly and having a varying thickness, rather inconsiderable. This deposit, locally known as St. Quentin, is about 400 feet long, in a northwesterly direction. Some isolated small knolls of the same formation are, however, found farther to the northwest. There are three pits on this deposit. The two southerly pits are only separated by a wall of a few feet wide at the surface. The third, most northerly, is smaller and shallower. A tunnel (*e*) has been run under this pit about 30 feet below the surface in a breccia formed of fragments of various rocks cemented by silica. At the breast some chalcedony is found. The cinnabar occurs generally in the seams of the siliceous beds, often mixed with sand, so that it can be removed with scrapers out of the seams. In the eastern part of the deposit the siliceous material is impregnated throughout with the cinnabar in a microcrystalline condition, indicating a contemporaneous deposition of the cinnabar and the silica. No macroscopical crystals of cinnabar are found anywhere in this deposit. The ore has not been found to persist in depth in any of the three pits.

To the north of the St. Quentin lies the basalt shaft and pit. The vertical shaft lies north of the pit. At a depth of 130 feet, the lower level was run from the shaft under the pit, which is about 400 feet long in a north and south direction. Both shaft and pit start in basalt. At 130 feet "mudrock" came in the shaft from the west. The territory under the pit is also reached by a long tunnel (*h*), with a shaft at the end, 20 feet in depth, which communicates with a large chamber 40 feet wide, 45 feet high, and 80 feet long in the bottom, situated under the pit, entirely excavated, having contained a large body of good ore. The ledge on which the pit is located has a north and south strike, varying from that of the other deposits. It is entirely inclosed in basalt, and in depth abuts abruptly against a stratum of hard sandstone, dipping slightly east, from 2 to 6 feet thick; the ore only occasionally penetrating slightly into seams of this stratum, which is underlaid by "mudrock." This body of basalt, 110 feet high, is hence only a surface flow, which is confirmed by (*d*) and (*f*). [See below.] The ore bodies in the basalt were so profitable that extensive explorations were made in the "mudrock" to find their continuation in depth, but without result; hence the conclusion that the ore deposition is intimately connected with the basalt, and that the hard stratum overlying the "mudrock" prevented the solutions from entering therein, acting as an impervious stratum. The ledge matter is throughout associated with calcite. [See above, Bunkhouse vein.] The ledge pinched materially about 50 feet from the surface; at this horizon the vein filling is limestone, containing narrow seams of cinnabar. In the lower part it consists of very profitable ore seams interstratified with seams of limestone about a foot wide. In the northern end of the deposit "mudrock" is more prominent.

A couple of hundred feet northwest of the basalt shaft another north and south vein (*b*) has been worked in a weathered basalt from 1 to 4 feet wide, and from 150 to 200 feet long. To a depth of 50 feet this vein was in places very rich. At that depth, however, the rock suddenly hardened and simultaneously the vein became poorer, and had to be abandoned at a depth of 60 feet.

To the southwest of the basalt pit, between this pit and pit No. 3 of St. Quentin, a shaft (*d*) has been sunk to the underlying "mudrock" which was also found in a pit (f_1) west of the basalt pit.

Extensive works (f_2) west of the basalt pit and northwest of St. Quentin, near the serpentine, consist of a large open cut, tunnels, and stopes, showing that large bodies of ore have been taken out of this ground. The formation is leached igneous rocks, chalcedony seams, and brecciated sandstones. Two drifts have been run toward these works. The upper tunnel, 75 feet below the surface at the open cut, cuts through silica concretions, then leached basalt, basalt, and on the contact of the basalt with an altered sandstone a vein dipping southwest, which, judging from the old stopes, contained a number of ore bodies of lenticular form. The lower tunnel, 140 feet below the same surface, runs mainly in serpentine material; at 300 feet it cuts across a vein having a nearly east and west strike; an understope, 20 feet deep and 70 feet long, shows that the ore body lies in hardened contact "mudrock." A shaft 80 feet deep shows that the basalt lies here north of the "mudrock," while in the upper tunnel it lies south thereof. The stope [see cross-section, Fig. 28] showed good ore, metacinnabarite, and some native mercury in pockets next to the basalt. When the stope reached the understoping in the lower tunnel, it was shown that the lower vein had a cross strike to that on which the vein understoping was done, and the latter was never found below.

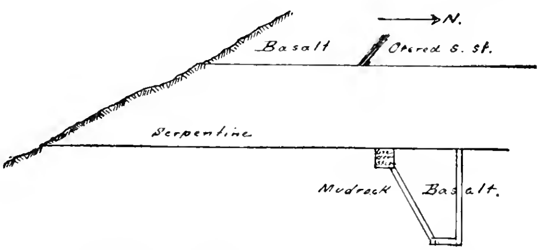


FIG. 28. Manhattan Mine—Section over the works at (f_2).

At the northwest end of the property is the knoll of which section 3 gives a cross-section. Several small pockets of ore were found in the tufa overlying the top. The tunnel (*l*) cuts through the entire knoll, running for the greatest part in serpentine. Ore was only found in the basalt near the northern end. It forms in seams in the basalt. In some of these seams the main filling is formed by bands of iron pyrite, with thin, intercalated seams of cinnabar; in others the filling is opaline silica. The ore in the surface pockets carried also considerable iron pyrite. The hill is mainly serpentine and shale; the absence of basalt in the lower tunnel may be caused by a fault, the upper part of the basalt having slid northeast with the slope of the hill.

While the mine is not a great producer, it is of great geological interest, because the relations between the igneous rocks, the country rock, and the ore deposits can be so well traced. The absence of ore deposits in the serpentine, even where it is contiguous to the igneous rocks, must be noted. In opposition to the ore occurrence in the Oathill mine, the ore deposits are all contiguous to the basalt and do not extend to any distance from it, except in the St. Quentin deposit, where the cinnabar has been deposited from solfataric waters, which must have been related to the basalt. Again, in the Ætna mine the prevailing conditions indicate that the cinnabar was disseminated through the sandstone, and formed into workable ore bodies by secondary concentration in some way connected with the serpentine and basalt, while in this mine all indications tend to the conclusion that the igneous rocks are the direct source of the cinnabar. In the neighboring Boston mine there are reasons to suppose a course of ore formation similar to that in the Ætna mine. Considering that the Boston and Manhattan deposits are only one mile interdistant, and that from the topography it might be inferred that while not appearing at the surface, the vent through which the basalt extruded in the Manhattan persists toward the Boston, the entirely different nature of ore formation in these two mines is very noteworthy.

It is to be regretted that in no place in the Manhattan mine has the commercial development of the ore deposits caused the underground works to be run in a manner to determine the vent of the basalt extrusion, or whether on or near this vent deposits of greater persistence in depth would be found. The fact that every deposit as yet opened in this mine terminates in depth with the basalt, justifies the expectation that such persistence might be the case.

The irregular basalt occurrences found in the mine are probably intrusions, which follow pre-existing fissures, joints, bedding planes, or contacts, which would account for the lack of heat effect on the adjoining rocks by these igneous intrusives. [See N. S. Shafer, Bulletin Geological Society of America, vol. X, page 253.]

South of the furnace in the serpentine is an exposure of breccia covering a couple of acres, which is used as building-stone.

The mine is equipped with one coarse-ore and one fine-ore Knox & Osborne furnace, both of 24 tons capacity. The coarse-ore furnace is only used for about two months in the year, the great majority of the ore as it comes from the mine being proper material for the fine-ore furnace.

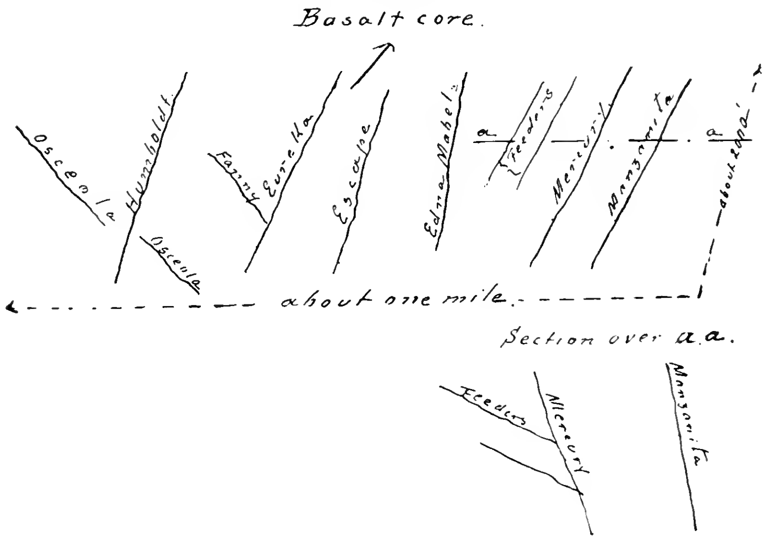


FIG. 29. Napa Consolidated Mines. [See page 91.]

Oathill Mine (or Napa Consolidated Quicksilver Mines).—Mayacmas District. In Secs. 27, 28, 33, and 34, T. 10 N., R. 6 W. The Napa Consolidated Mining Company, of Boston, Mass., owner; B. M. Newcomb, Oathill, Napa County, superintendent. [See Mon. XIII, U. S. G. S., page 355; Report State Mining Bureau of Cal., XI, pages 65–72; XII, page 364; XIII, page 598.] This property covers a large area of ground between James Creek and Bucksnorter Creek. It has been for years since its opening in 1876, and is still, one of the largest producers in the State.

The cinnabar deposits in these mines lie entirely in a belt of

PHOTO No. 7. OATHILL QUICKSILVER MINE.

sandstones, which abut and surround a core of basalt. The sandstones occur in thin beds, with partings filled with attrition products and clay. The stratification and also the mineralized zone have a general tendency toward parallelism to this core. [See van Hise, 16th Ann. Report, U. S. G. S., Part I, page 637.] Nearing this core the stratification becomes more irregular and contorted. The veins, practically fissure fillings in the sandstone country rock, are from a few inches to a few feet wide. Their general plan is given in Fig. 29. They are in their strike independent of the bedding planes, and carry generally a clay gouge on the foot wall. In places chambers have been formed in the walls of the fissures, on that side of the vein where the sandstone was not protected by a clay gouge from the action of the percolating solutions.

A peculiar phenomenon occurs at the crossing of the Humboldt and Osceola veins. In both veins near the crossing shoots of good ore, about 500 feet long, were found. The Humboldt vein, which is more of a conglomerate nature than any of the other veins, persists on both sides of the crossing; but the Osceola is hardly discernible at the crossing point and makes only at a certain distance on both sides of the crossing point. [See Fig. 30.]

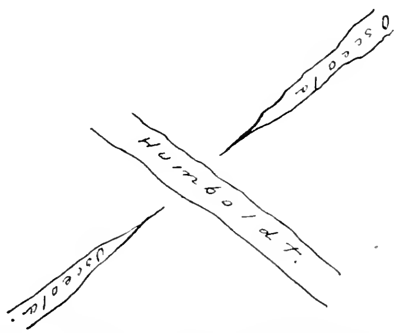


FIG. 30. Napa Consolidated Mines—Crossing of two veins.

The secondary concentration of the workable ore bodies in this group of mines must probably be attributed to the contact-metamorphic action of the basalt core. It is, however, a noteworthy fact that here the ore bodies do not persist to the basalt core. The explanation may be that the heat and pressure due to the intrusion of this large body of basalt raised the temperature so high in the close neighborhood of its intrusion that the mercury was carried off in vapor form and deposited in a region where the temperature and pressure were lower. The mine is equipped with two 50-ton Scott furnaces, one of which was rebuilt in 1902 after sixteen years of service.

Philadelphia Mine.—Mayacmas District. In Sec. 26, T. 10 N., R. 6 W. Owner, M. Pluth, of Oathill, Napa County. The mine is located in the southeastern end of the divide between James Creek and Pope Valley, running down from the Oathill divide. The belt of serpentine running northwest from Ætna Springs along the southwest ridge of Pope Valley, crossing James Creek, near its mouth, follows the divide for some distance, and some promising float is found on top of the ridge. A crosscut tunnel 270 feet below the ridge has not yet reached the ledge; its breast is in basalt, indicating an igneous core in this divide.

Red Elephant and Northern Light Mines.—Knoxville District. In Sec. 3, T. 11 N., R. 5 W. The former mine is owned by W. G. Tremper, of Lower Lake, Lake County. The latter mine, south of the Red Elephant, is owned by Fr. Josh, of Lower Lake, Lake County. In the Red Elephant, a little surface cinnabar has been found, but none of a number of shallow cuts and pits show any cinnabar ore in place.

Summit Mine.—In Sec. 19, T. 7 N., R. 5 W. S. W. Keeney, No. 563 Parrott Building, San Francisco, owner.

Twin Peaks Mine.—Mayacmas District. In Sec. 4, T. 9 N., R. 6 W., and Sec. 33, T. 10 N., R. 6 W. Owners, B. A. Wilson, F. Smyth, and H. Herrick, of Middletown, and J. Hayes, of Harbin Springs, Lake County; B. A. Wilson, superintendent, Oathill, Napa County. This mine can only as yet be considered as a prospect; it has, however, some good ore, which is reduced in a small retort furnace. The cinnabar ore is formed in the cracks and fissures of the opaline rock, and is accompanied by a sensible amount of iron sulphides. The ore body lies rather flat, and has a strike nearly north and south, dipping about 30° to the west. Above the ore lies a layer of grayish-green talc (probably decomposed serpentine), which shows cinnabar all through it; above which lies a black gouge, which in places shows clearly the structural forms of the original opaline rock. The formation in this mine, which lies close to the igneous bodies, is very much distorted; but when found in place, the ore bodies will probably be found on the same contact of serpentine and sandstone as the neighboring Corona mine. The property is equipped with a 10-pipe retort, and the ore must have been of a good grade, as the monthly product is reported to be 40 flasks.

SOLANO COUNTY.

St. John Mine.—In Sec. 33, T. 4 N., R. 3 W. The St. John's Consolidated Quicksilver Mining Company, owner; Ch. Bone, president; J. H. Sayre, secretary, room 5, No. 405 Montgomery street, San Francisco; A. A. Tregidgo, superintendent, Vallejo, Solano County. This mine was opened in 1873 and was operated until 1880, during which time it produced 11,530 flasks. Work was then abandoned until 1899, when the present company resumed by reopening some of the old works.

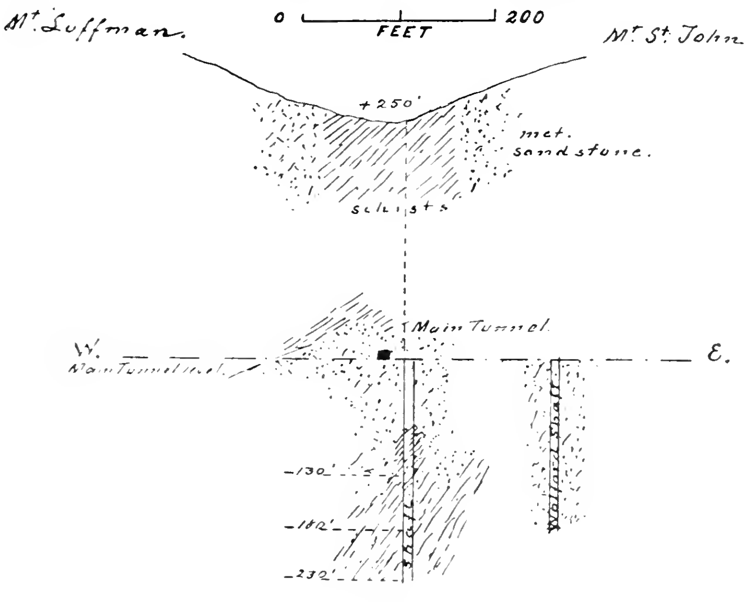


FIG. 31. St. John Mine—Section east and west over main tunnel shaft.

The mine is located in a basin between Mount Luffman to the west and Mount St. John to the east. These mountains are characterized by the bold outcrops of two bodies of metamorphic sandstones. Nearly the entire intervening surface is covered by sandstone débris, but all the dumps of the old tunnels show schist, and in some of the larger cuts the contact of the schists and sandstones can be found. The sandstones especially those of the Mount St. John ridge, show a prominent north and south fracture system. The schists probably lie in a trough, having a general northern trend in the sandstone

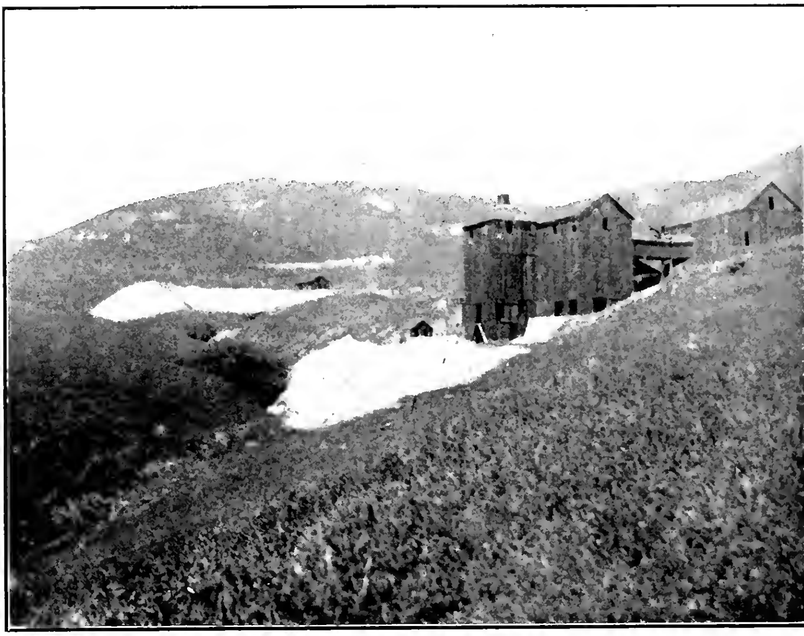


PHOTO No. 8. ST. JOHN MINE AND FURNACE.

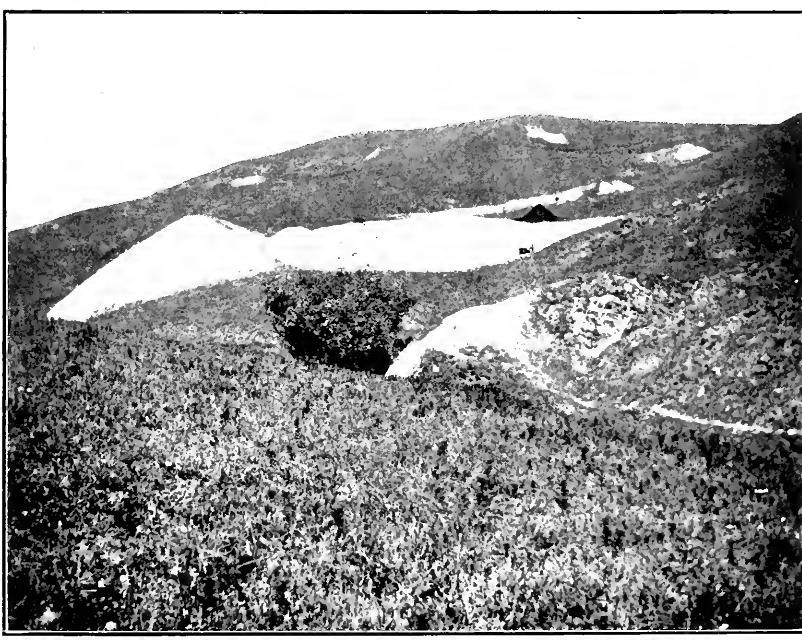


PHOTO No. 9. ST. JOHN QUICKSILVER MINE.

formation; but whether the latter formation underlies the entire territory has not as yet been determined. Fig. 31 shows that below the level of the main tunnel another body of schists lies in the sandstone. The contact of the sandstones and the schists is very irregular and intricate. The schists appear to carry some magnesia, at least sulphate of magnesia forms in the main tunnel in a couple of places. The ore croppings are found at, or in close proximity to, the ridges of sandstone. There are a great amount of open cuts, drifts, and shallow shafts on these croppings. The principal work, however, was done in the main tunnel, through which two distinct ore bodies—the main tunnel ore shoot and the San Miguel ore shoot—have been worked. The former was cut by the main tunnel at a depth of 250 feet below the surface, and a shaft sunk on it from that level to a depth of 180 feet. The San Miguel ore shoot was reached by a crosscut about 100 feet long, at the end of which a shaft 180 feet deep was sunk, all in sandstones. The latter works are at present inaccessible. The main tunnel, course nearly north, which has been retimbered, reaches the old stopes at 1120 feet from the entrance. It runs through schists, near the entrance thinly bedded, contorted, in places showing slickensides, and becoming more massive in depth. This material resembles very closely the "mudrock" in the Manhattan mine. At 700 feet from the mouth the tunnel intersects a sandstone dike, about 6 feet wide, course N. 60° E.

The metamorphic sandstone is in places altered to quartzite, and in other places is somewhat porphyritic. It shows zones of fractures, nearly parallel with the contact, not over one to one and a half inches interdistant. These are sometimes cut off by a set of more irregular cross fractures, causing the rock to break very irregularly, sometimes conchoidal. The ore forms principally in the zones of parallel fracturing and adjoining thereto. Where the fissuring allowed it, the cinnabar was deposited with a quartzose gangue. Often it forms face metal on the fissure walls, which show signs of movements after the deposition. Where the rock is more compact, small aggregates of minute cinnabar crystals are disseminated through the rock, generally associated with iron pyrite. The mineralization was contemporaneous with, or anterior to, this metamorphism.

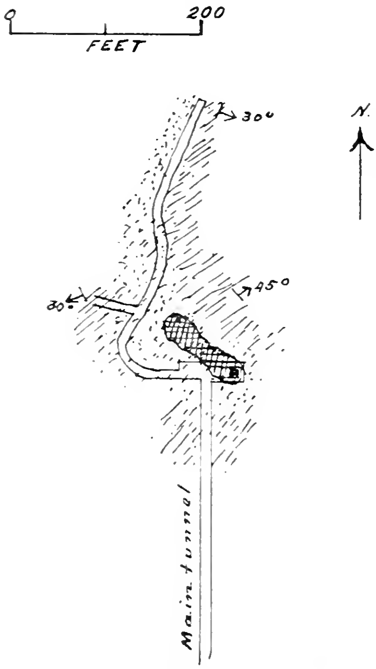


FIG. 32. St John Mine—Plan showing main tunnel west of shaft.

Possibly the cinnabar was originally diffused through the sandstone and leached out and concentrated during the metamorphism of the sandstone. At and below the level of the main tunnel the ore forms exclusively in the sandstone, but nearer the surface it is found in the schists.

At the point of intersection with the main tunnel ore shoot, the main tunnel makes an offshoot to the west to avoid the old works [see Fig. 32], and continues then in a northeasterly direction (N. 20° E.). It passes first through sandstone, and then follows the northeastern contact between the sandstone and the schists. No ore has as yet been found in this drift. Judging from the old stopes the ore body at the level of the main tunnel was about 70 feet long and from 15 to 25 feet wide. Below this level two ore bodies were worked from the shaft—one west, the other east and southeast of the shaft—separated by about 60 feet of barren ground. The stope on the ore body west goes down to the 130-foot level, where it forms a

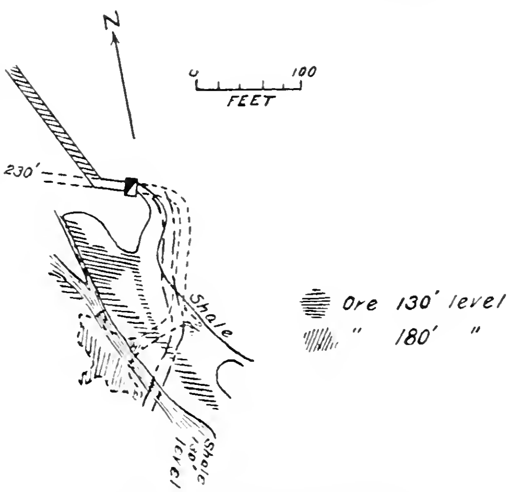


FIG. 33. St. John Mine—Plan of works in main tunnel shaft.

body about 60 feet long and from 6 to 8 feet wide, having a course of about N. 10° W., starting about 30 feet from the shaft. [See Fig. 33.] The ore body east of the shaft on this level is larger and more irregular. In the 180-foot level the contact of the sandstone and schists east of the shaft runs about N. 50° W. In the sandstone are found three zones of cinnabar deposition running about parallel to the contact, going from the latter southeast, respectively, one inch or less, 2½ and 4 feet wide. The sandstone has not been cut through by the crosscut, 54 feet long, from the northeast contact. The stope is about 40 feet long on the strike. The shaft has lately been sunk 50 feet deeper. In the 230-foot level the course of the same contact is about north, but the works have not as yet exposed any ore. The mine is equipped with two coarse-ore shaft furnaces of the John Neat patent. For a detailed description of the plant, see the chapter on Metallurgy.

SONOMA COUNTY.

Almaden, Incandescent, and Tunnel Site Group.—Mayacmas District. C. C. Thomas and E. Grimmer, owners, Pine Flat, Sonoma County. In Secs. 31 and 32, T. 11 N., R. 8 W. Includes the Almaden, Incandescent, and Tunnel Site claims. To the northeast of the Eureka mine. No development.

Bacon Consolidated Group.—Mayacmas District. Includes the Edith, Maud, St. George, Golden Gate, and Eagle mines, in Secs. 11 and 12, T. 10 N., R. 8 W. B. Getleson, owner, Middletown, Lake County. Idle.

Boston Group.—Mayacmas District. Wm. F. O'Leary, A. C. Huebner, and J. Conran, owners, Healdsburg, Sonoma County. This group consists of three claims—the Boston, Earlene, and Hope—in Secs. 3, 9, and 10, T. 10 N., R. 8 W. Two short tunnels are run on this property. The upper tunnel, very close to the crest of the ridge, course N. 63° W., is 100 feet long; at the breast a drift of about 25 feet long, on a course about north, is run on the vein; a thin seam dipping about 30° to the north runs parallel with this drift and carried some cinnabar. The lower tunnel, 75 feet below the upper, runs on the same course 320 feet; it cuts, at 230 feet from the entrance, a vein having a nearly north and south course. The hanging wall is too decomposed to state the character of the rock; the foot wall is sandstone. The vein filling is opaline rock, with a bedding across the vein. In the north crosscut, 25 feet long, the vein narrows at the breast; in the south crosscut, 10 feet long, some ore was found near the main tunnel, but at the breast no cinnabar was found.

Cinnabar King Group.—Mayacmas District. Cinnabar Mining Company, owner; E. S. Rowland, secretary, Healdsburg, Sonoma County. The group includes the Cinnabar King, Champion, Paymaster, Goodenough, and Helen claims, and two millsites on the southwestern slope of Pine Mountain, in Sec. 11, T. 10 N., R. 8 W. [See reports State Mining Bureau of Cal., XI, page 461; XII, page 371; XIII, page 602.] This property is the only one on the west slope of Pine Mountain on which some work has been done lately. The general course of the croppings is northwest. Several open cuts show some ore on the dumps. This ore forms in silicified serpentine, in seams parallel to the strike. The dip of the ledge is southwesterly. There is on the property a shaft 55 feet deep, on a very flat incline; a lower tunnel, 660 feet long, at a level 200 feet below the collar of the shaft; and an upper tunnel 87 feet below same collar. These works are inaccessible.

Cloverdale Mine.—Mayacmas District. In Secs. 3, 4, 9, and 10, T. 11 N., R. 9 W. This includes the Cloverdale, Sunrise, and Mount Vernon groups, the Mercury and Manzanita claims, and some inclosing lands, on both sides of Big Sulphur Creek, near the mouth of Squaw Creek. Owners, H. B. and C. A. Lawley, The Geysers, Sonoma County. [See Mon. XIII, U. S. G. S., page 376; Report State Mining Bureau of Cal., XIII, page 603.] This mine was opened in 1872, the furnace being constructed in 1875, and run for twenty-six months, producing about 3200 flasks of mercury. The works were closed down in 1878. Work was resumed in 1898 by the present owners, who started the furnace in November, 1899. The latter has run steadily for the last eighteen months, producing about 720 flasks. At the end of 1902 it was producing about 50 flasks per month. The mine workings consist, besides several large open cuts, of about 1500 feet of drifts and 150 feet of shafts. On the Mount Vernon group very little development has been done. A body of thinly-bedded cherty rock between sandstone walls has been opened up in the Mount Vernon claim by a shaft and two tunnels. The latter, which are almost vertically above each other [see Fig. 34], show some face cinnabar on the fissure planes of the chert. The strike of this body of stratified chert is about northeast, the dip very irregular about southeast. In the upper tunnel the seams between the chert beds carry sulphur, the only similar occurrence seen on the property.

The property is traversed by several nearly parallel ledges of thinly-stratified chert, inclosed by sandstone. These ledges have generally a northwest strike and northeast dip. The thickness of the chert beds varies from a half to three inches; that of the clay seams from a knife blade to quarter of an inch, except in one place, in the Murphy tunnel or No. 4 ledge, where chert and clay seams are for some distance much thicker. In places, both the chert and clay are colored light green by silicate of iron. In the same tunnel the thick gouge above the chert consists for some distance of decomposed sandstone and clay interbedded like the chert formation. No serpentine is found on the property—the country rock being all sandstone; but on the ridge of the divide between Squaw Creek and Big Sulphur Creek, above the mine, some porphyritic and dioritic rocks are found, cutting through the sandstone which forms the backbone of the ridge. The chert shows very plainly on the lower part of above-mentioned dividing ridge, which has there a general direction nearly east and west, and is cut at an obtuse angle by those ledges.

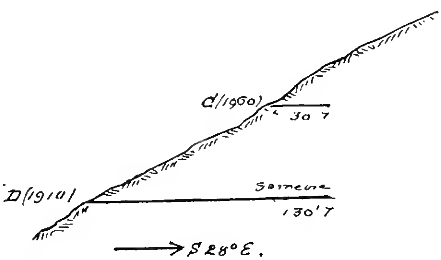


FIG. 34. Cloverdale Mine—Section over works, Mount Vernon claim.

Starting up the ridge from the furnace, the first ledge, No. 1, about 25 feet wide, is barren at the ridge, but to the southeast, in the Glory Hole tunnel, shows very good ore.

On the next ledge, No. 2, the former company twenty years ago mainly concentrated its work, producing 3100 flasks from it. The ledge was worked both by open cut and in the Catsin's tunnel. At present this ledge is worked on the south

FIG. 35. CLOVERDALE MINE.

slope of the ridge by three open cuts, forming a nearly continuous line of workings [see photograph Fig. 35, K_1, K_2, and K_3]; the open cut at the top of the ridge (K_1) is 60 feet high and 48 feet wide, and furnishes at present, practically without sorting, all the ore run during the summer season through the furnace, which has a capacity of 7 tons of ore per day and produces from 45 to 50 flasks per month. The more compact and regularly bedded part of the ledge carries the metal mostly as face metal and incrustations in the fissures; the crushed portions are much richer and carry the metal more in seams and bunches.

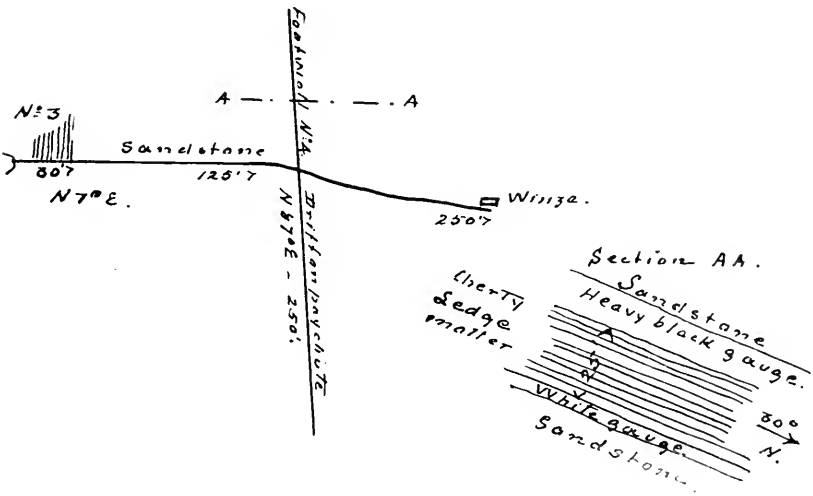


FIG. 36. Cloverdale Mine—Plan and section of Murphy tunnel.

The next ledge, No. 3, is only separated from No. 2 by a narrow belt of sandstone, and has been extensively worked by open cut in the Old Ray workings on the north slope. It shows only slightly on the south slope of the ridge, principally in the mouth of the Murphy tunnel. [6, Fig. 35.]

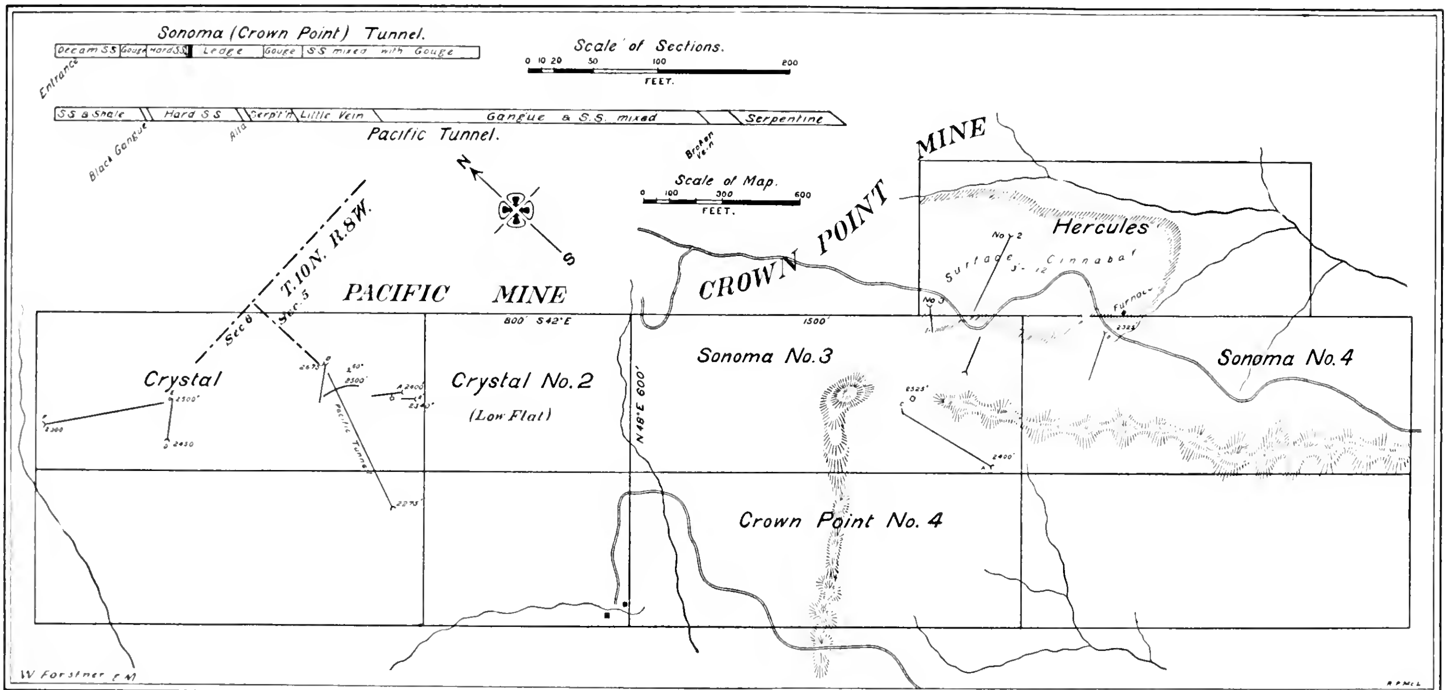
Ledge No. 4, or Murphy ledge, shows principally in the Murphy tunnel. It is about 25 feet wide. [See Fig. 36.] The chert beds are mostly from one to three inches wide, the gray clay seams one quarter to one inch; cinnabar ore making principally on the faces, richer nearer the hanging wall, which is peculiarly interstratified, as above mentioned, with clay seams like the chert beds. These chert beds, wherein the cinnabar ore makes, are very similar to the ledge matter of the Great Western.

The company has a small incline furnace of 7 tons capacity per day, and a 10-pipe retort furnace.

Clyde Mine.—Mayacmas District. G. Hemmingway and F. Baumeister, owners, The Geysers, Sonoma County. In Sec. 24, T. 10 N., R. 8 W., on the north fork of Little Sulphur Creek (Devil's Den Cañon). This mine is close to and partially surrounded by the Culver-Baer property, and is located on the same ledge of croppings as the Old Oakland (Lost Ledge and Geyser) group of that property. The croppings show very boldly on the northeast bank of the creek, and the latter is full of large ore bowlders. The old works are inaccessible, but on the dumps several tons of ore of a good quality are found.

Crown Point (Sonoma) Mine.—Mayacmas District. The Crown Point Quicksilver Mining Company, owner; S. S. Bogle, secretary, Santa Rosa, Sonoma County. It includes the Sonoma Nos. 3 and 4, Hercules, and Crown Point Nos. 4, 5, and 6, in Sec. 5, T. 10 N., R. 8 W. [See Mon. XIII, U. S. G. S., page 376; Report State Mining Bureau of Cal., XIII, page 603.] In former years rich surface pockets were worked to advantage; they were situated adjacent to a serpentine belt, having general strike N. 48° W. [See map of Mayacmas District, and Fig. 37.] Two tunnels (A and B), respectively 325 and 200 feet long, and a shaft (C) 50 feet deep with a drift 40 feet long in the bottom, represent the later development work, which has, however, as yet not disclosed any valuable ore bodies. This work has been done in a very unsystematic manner and proves little or nothing as to the future of the property. The company started in the fall of 1902 some systematic prospecting work.

Culver-Baer Mine.—Mayacmas District. This is in Secs. 24, 23, and 14, T. 11 N., R. 9 W., along the headwaters of the north fork of Little Sulphur Creek (Devil's Den Cañon). It includes the Fairfax, Sunny Side, Republic, Bush, Colfax, and Culver-Baer No. 1 and No. 2 claims, representing the former Oakland and Geyser group; and the Union, Hardscrabble, Ridge, Black Bear, and West End claims, representing



Sonoma (Crown Point) Tunnel.
Decam S.S.
Gouge
Hard S.S.
Ledge
Gouge
S.S. mixed with Gouge
Entrance
Scale of Sections.
0 10 20 50 100 200
FEET.
S.S. & Shale
Hard S.S.
Serp't'n
Little Vein
Gangue & S.S. mixed
Serpentine
Black Gangue
Alta
Pacific Tunnel.
Broken Vein
Scale of Map.
0 100 300 600
FEET.
N
S
T.10N. R.8W.
Sec. 8
Sec. 5
PACIFIC MINE
CROWN POINT MINE
Hercules
No. 2
No. 3
Surface
Cinnabar
Furnace
800' S42°E
1500'
N48°E 600'
Crystal
Crystal No. 2
(Low Flat)
Sonoma No. 3
Sonoma No. 4
Crown Point No. 4
Pacific Tunnel
2300
2450
2500'
2400'
2525'
2275'
2325'
W. Forstner E.M.

FIG. 37.

the Black Bear and Kentuck group. Owner, the Culver-Baer Mining Company; president, A. V. McNabb, Santa Rosa, Sonoma County; general manager, G. B. Baer, Cloverdale, Sonoma County; superintendent, F. Baumeister, The Geysers, Sonoma County.

This property covers the old mines of the Oakland and Black Bear group. This mine was a producer from 1875 to 1879, producing about 6900 flasks, but was then shut down,

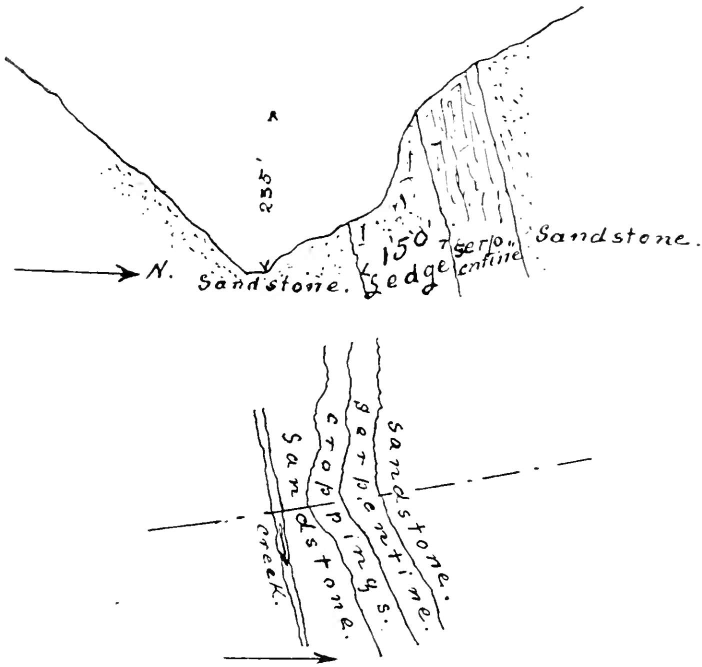


FIG. 38. Section Culver-Baer Mine.

work being resumed only in 1901. [See Mon. XIII, U. S. G. S., page 376; Report State Mining Bureau of Cal., XII, page 371; XIII, page 602.] The ledge is indicated by a persistent and very strong cropping of ledge matter, with a general east and west course, on the north bank of the cañon, about 150 feet wide, dipping north into the mountain, winding a little but following rather closely a line parallel to the creek. [See Fig. 38.] These croppings consist mostly of silicified foot-wall sandstone, changed into a blocky material with a great number of quartz seams; sometimes serpentine (hanging wall), also traversed by quartz seams, occurs. This ledge material is rather hard and compact. The ore is not making on the faces, but mostly inside the rock; often while not appearing on the surface, the pieces of rock prove rich in cinnabar when broken up. Very little sulphide of iron accompanies the cinnabar. Especially in the old Geyser claim, about opposite the new furnace site, the cinnabar occurs in its rarer form of crystallization in acicular (needle-shaped) prisms. Higher up the cañon, in the old Lost Ledge ground, the cinnabar occurs in the ordinary tabular crystal form.

The old underground works in the Old Oakland and Geyser group are caved in, and a crosscut tunnel driven by the present company is also inaccessible. This tunnel, 890 feet long, is on the level of the new furnace, reaching the ledge at a depth of 375 feet below the old croppings, where it found ore. The old works on the Lost Ledge ground (upper part of the property) reached the same depth in the ore body.

The sandstone foot wall along the ledge is greatly eroded, forming the creek. On the hanging wall is a narrow belt of serpentine overlaid by a wide belt of sandstone. This belt of serpentine seems to persistently accompany the outcrop. The amount of ore in sight in the croppings, that can be quarried, is so large that the company is erecting a 20-ton Fitzgerald incline furnace, without undertaking for the present any further underground development work.

The western part of the property, the Black Bear group, covering the Old Kentuck ground, has been leased to W. T. Brush and others, of Cloverdale, Sonoma County.

The croppings so prominent in the eastern part follow Devil's Den Cañon into the Clyde mine, then turn a little northward and re-enter the Black Bear group. In its western part they are abruptly cut off by a body of serpentine, having a nearly east and west course. The present lessees are cleaning out some of the old works.

Double Star Mine.—Mayacmas District. In Secs. 2, 3, 10, and 11, T. 10 N., R. 8 W. The property is on the old road from Middletown to Pine Flat, at the headwaters of Little Sulphur Creek, and consists of the Double Star Nos. 1, 2, and 3, Hercules, and Giant. Owners, Wm. Peters, of Healdsburg, Sonoma County, and others. A vertical shaft was sunk on croppings identical with those on Pine Mountain, the Wall Street, etc.; it has been abandoned and a crosscut tunnel run 170 feet below its collar, in the serpentine, which at 400 feet from its entrance cut the fissure on which the shaft was sunk. Short drifts were run both ways on the fissure, showing the same material as on the surface, but no cinnabar ore. At 650 feet the tunnel reached sandstone, mixed with "alta"; drifts were run both ways on the supposed contact, without disclosing any ore. The breast of the tunnel at 670 feet is in mixed sandstone, gouge, and decomposed serpentine. It is, in fact, doubtful if the real sandstone has as yet been reached.

Eureka Mine.—Mayacmas District. In Sec. 32, T. 11 N., R. 8 W., on the divide between Big Sulphur and Little Sulphur creeks, to the northwest of the Socrates mine. Includes the Eureka No. 1 and No. 2 (Old Flagstaff), Mate, and Captain claims, and Eureka millsites; and the Electric, Creekside, Trout, and King Arthur claims in Big Sulphur Creek, in Sec. 29, T. 11 N., R. 8 W. Owner, Eureka Quicksilver Mining Company; C. R. Cormack, secretary, No. 215 Sansome street, San Francisco. [See Mon. XIII, U. S. G. S., page 375.] A belt of serpentine passes through the southern part of the Eureka claims near the ridge of the hill, with a general strike about northwest, and a southwesterly dip. [See Fig. 39.] This serpentine forms the hanging wall of a contact, the foot wall being sandstone. In the main tunnel, this arkose sandstone is very much decomposed, the silicates having been largely altered to clay by weathering. On the foot wall lies a heavy gouge, and the ledge matter, which is cut at a depth of 170 feet, is very hard. In a higher tunnel very fair ore was found, the material being much softer. Two drifts have been run from the main tunnel along the ledge, but have not as yet reached any pay shoot. The hillside is very steep, and heavy slides have occurred. The two bodies of thinly-bedded material (probably chert)—one in the Captain, with a strike of N. 77° E., the other higher up the hillside on the Eureka No. 1, strike N. 23° W.—belonged probably to the ore body.

Lower down in the Mate is a body of very light-colored, loose-grained sandstone, carrying quicksilver in the form of cinnabar and of incrustations of black sulphide of mercury. Sufficient work has not yet been done on this material to decide

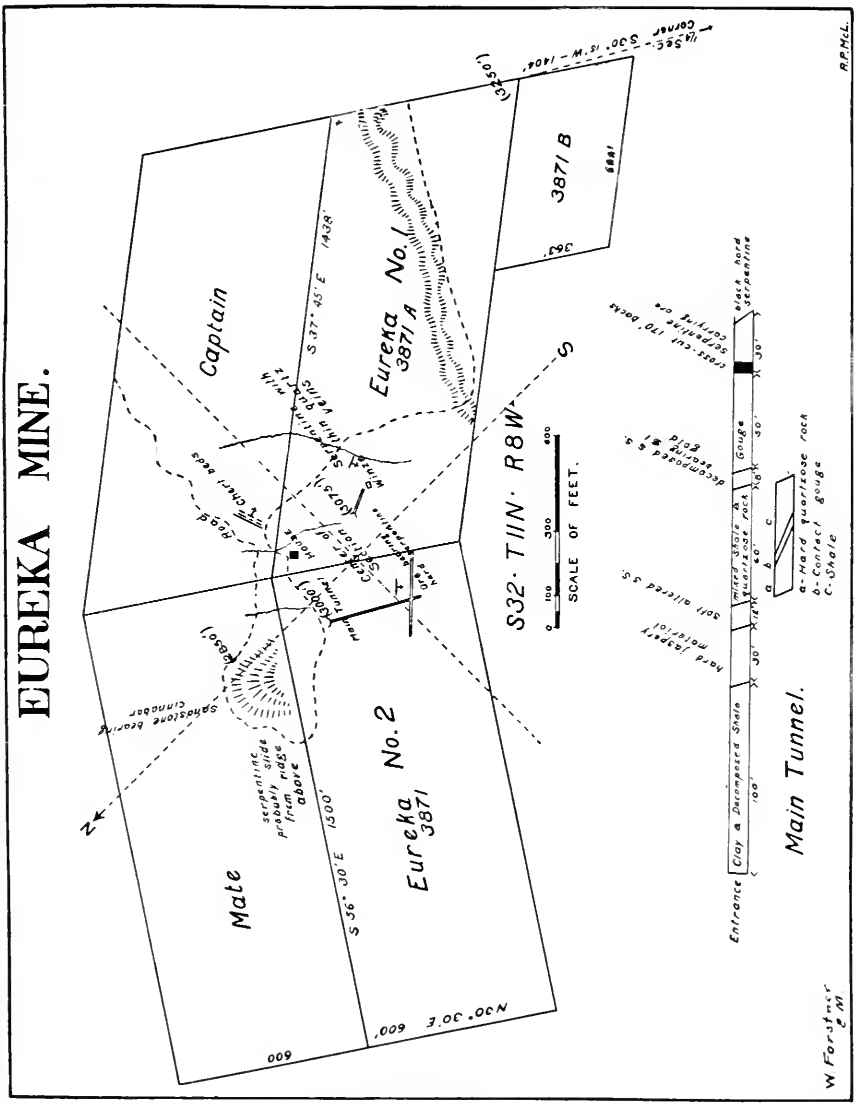

EUREKA MINE.
Captain
Mate
Eureka No. 1
3871 A
Eureka No. 2
3871
3871 B
S 37° 45' E 1438'
S 56° 30' E 1500'
N 30° 30' E 600'
600
S32· T11N· R8W
SCALE OF FEET.
0 100 300 600
Main Tunnel.
Entrance
Clay & Decomposed Shale
mixed Shale & quartzose rock
Gouge
black hard serpentine
hard jaspery material
Soft altered S.S.
decomposed S.S. bearing gold
cross-cut 170' backs serpentine carrying ore
a-Hard quartzose rock
b-Contact gouge
c-Shale
sandstone bearing cinnabar
serpentine slide probably from ridge above
Road
chert beds
thin veins of quartz with serpentine
Winze
House
Main Tunnel
hard ore
Center of Section
1/4 Sec. Corner
S 30° 15' W 1404'
W. Forstner E.M.
R.P.McL.

FIG. 39.

about the extent and importance of this deposit of quicksilver ore. A thin seam of cinnabar ore, three inches wide at the surface, has been cut by a tunnel at a depth of about 30 feet, showing a width of one foot. The mine is equipped with a 20-ton Fitzgerald furnace, built in the latter part of 1902.

Great Eastern and Mount Jackson Mines.—Near Guerneville. The Great Eastern Quicksilver Mining Company, owner; A. Abbey, superintendent, Mercury, Sonoma County: or No. 44 Nevada Block, San Francisco. In Secs. 16 and 17, T. 8 N.,

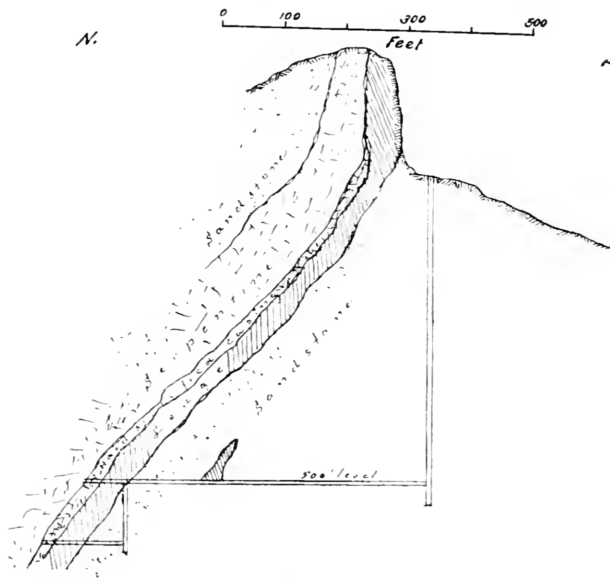


FIG. 41. Section over the Great Eastern Mine.

R. 10 W. [See Mon. XIII, U. S. G. S., page 362; Report State Mining Bureau of Cal., VIII, page 633; XI, page 460; XIII, page 602.] These mines are peculiar in so far that they are at a considerable distance from all other workable deposits and also from any known eruptives. The outcrop is prominent, but only for a relatively short distance (about 1900 feet), and follows pretty closely a belt of serpentine [see Fig. 40], cutting through the irregularly metamorphosed rocks of the Coast Range, probably of Neocomian age. The strike is very nearly east and west—in the Great Eastern, N. 75° W.; in the Mount Jackson, N. 63° W. The croppings stand almost vertical near the surface, but in depth dip northeasterly. The sandstone

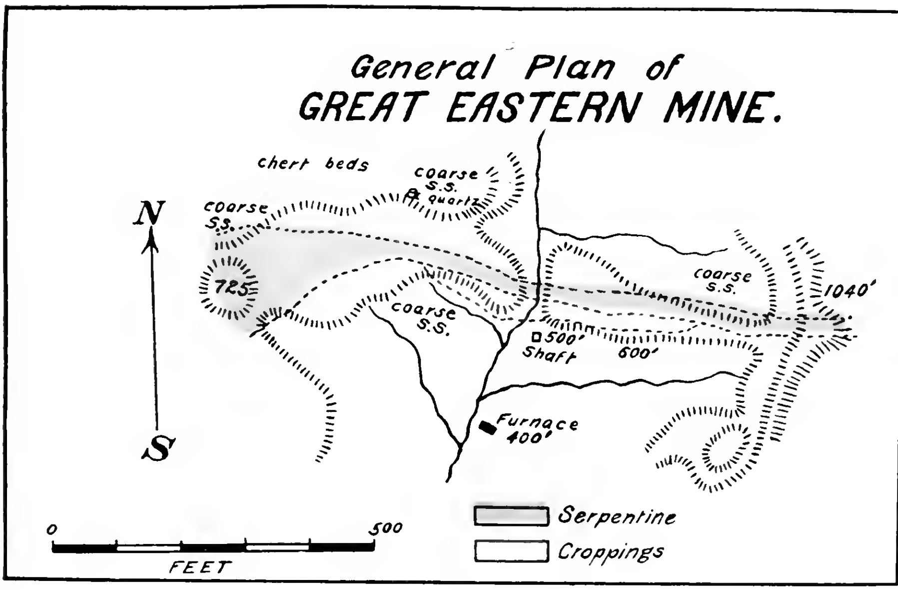

General Plan of
GREAT EASTERN MINE.
chert beds
coarse S.S. & quartz
coarse S.S.
725
coarse S.S.
coarse S.S.
1040'
500'
Shaft
600'
Furnace
400'
N
S
0
500
FEET
Serpentine
Croppings

FIG. 40.

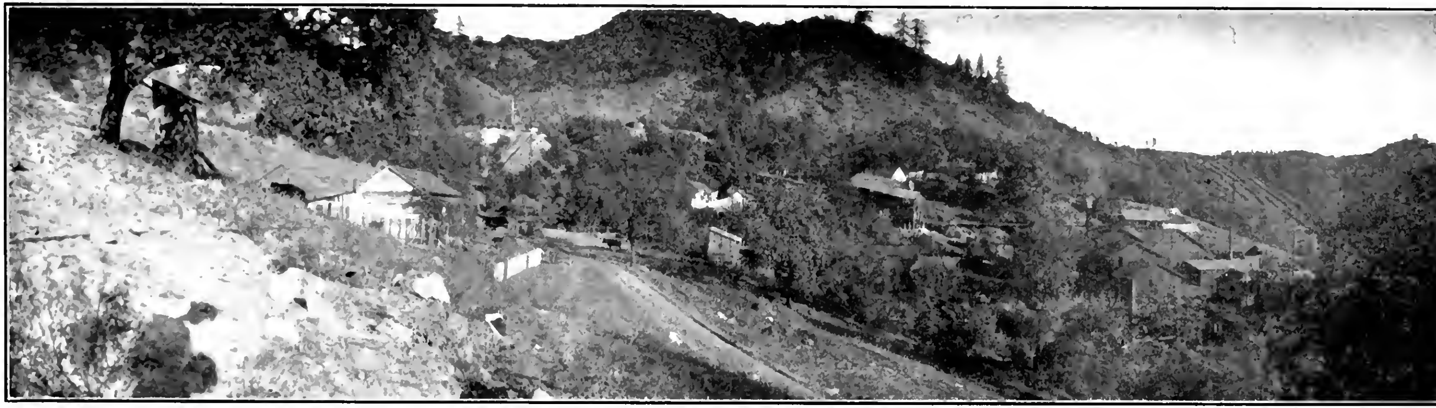


PHOTO No. 10. GREAT EASTERN QUICKSILVER MINE.

foot wall has been considerably eroded, leaving the croppings of the ledge in bold relief. [See Fig. 41.]

The main shaft is sunk vertically in the sandstone foot wall to a depth of 500 feet, and the cross drifts from the shaft to the vein on the various levels show that no serpentine occurs in the foot wall. The hanging wall is serpentine. The croppings [see Fig. 41] are about 200 feet above the level of the shaft, and were worked through several drifts and cuts. At present all the ore comes from the lower levels.

On the 500-foot level, a detached ore body has been found, 120 feet southwest of the main ore vein, in the foot-wall sandstone, and has been opened up for about 60 feet, showing good ore. A raise 20 feet high shows that the top of this ore body pitches southeasterly on a strike nearly parallel to that of the main vein. The vein filling is very similar to that of the main vein. The country adjacent to the deposit carries a considerable amount of iron pyrites; strong emanations of fire gas render work in this vein very difficult, as this gas attacks the eyes of the miners. Efforts have been made to collect this gas for analysis, but as yet have not succeeded. On the same level, intervening between the main ledge and the serpentine hanging wall, is a very hard crystalline rock of a grayish color, showing some slight signs of serpentinization, but having no resemblance to the chalcedonite found in other quicksilver deposits. This hard rock has the advantage of allowing the large stopes to be left without timbering or filling, notwithstanding the mine makes considerable water. On one ore body the stope, from 10 to 35 feet wide, is carried to the surface, being sustained by rock pillars left in the poorer parts of the ledge, without any stulling or filling. The same stope is continued downward about 90 feet below the 500-foot level.

A vertical shaft is sunk, starting from the 500-foot level, on the ledge, about 100 feet deep. At the bottom of the shaft in the 580-foot level the foot wall shows very plainly; the ore makes in places clear to that wall with very little or no gangue. Between the ore-carrying zone and the serpentine hanging wall comes first the hard siliceous rock casing above described, then a much softer zone of somewhat decomposed serpentine, and then the hanging-wall serpentine. [See Fig. 41.]

The ore forms in irregular lenticular bodies, more persistent vertically than horizontally. [See Fig. 42.]

The ledge filling is generally a very hard crystalline rock, fissured and cross-fissured in all directions, and recemented by subsequent depositions. The ore forms principally in relatively softer zones in this material. It carries less iron pyrites in the lower levels than at the surface, and the exudations of sulpho-salts are also much less in the lower levels, rendering the ventilation of the mine a relatively easy matter. In the ledge filling are found bunches of soft, whitish, somewhat unctuous material—a decomposition product. It is impossible, due to the complete decomposition, to determine the character of the original material. The material, locally called "caliche," is sometimes barren, and sometimes carries sensible amounts of

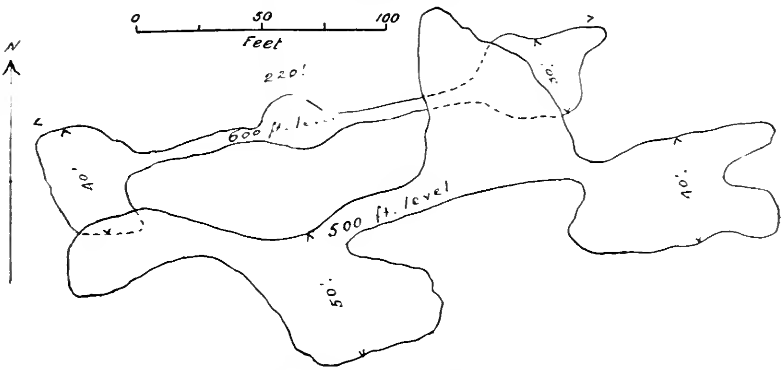


FIG. 42. Great Eastern Mine—Plan showing the form of the ore bodies.

cinnabar, but its presence generally indicates the proximity of cinnabar deposits. On the 580-foot level an exposure of the crystalline fissured rock carrying cinnabar shows that some of these fissures are rather wide, over an eighth of an inch, and that the rock is recemented by quartz containing no signs of cinnabar. Clearly, then, this recementation took place subsequent to the cinnabar deposition.

The absence of gangue, the hard siliceous material on the hanging wall, and the character of the vein filling, all indicate a very strong silicification (cementation) process, but of an entirely different nature from that forming the chalcedonite "quicksilver rock" so often associated with cinnabar deposits. In the levels above the collar of the shaft in the surface croppings some opaline rock is found, and the silicification (cementation) of the ledge matter is less distinct than in the lower levels.

The mine is equipped with one 12-ton coarse-ore Maxwell furnace, and one 16-ton fine-ore Hüttner & Scott furnace, using brick and wooden condensers.

Great Northern Company.—Mayacmas District. W. H. Jordan, president, No. 1311 Claus Spreckels Building, San Francisco. Owns nine claims—Alta, Leota, Minaoka, Little Giant, Columbia, Bluejay, Happy Hooligan, Wizard, and ———, in Sec. 2, T. 10 N., R. 8 W., and Sec. 33, T. 11 N., R. 8 W., situated northeast and parallel to the Old Denver. No important development work has as yet been done on this property.

Hope Mine.—Mayacmas District. Crown Point Quicksilver Mining Company, owner; S. S. Bogle, secretary, Santa Rosa, Sonoma County. Includes the Hope Nos. 1, 2, and 3 mines, in Sec. 4, T. 10 N., R. 8 W. This group is on the southeastern extension of the Eureka and Socrates belt of croppings. The Hope shaft, very near the northwestern end line, is 80 feet deep, sunk on these croppings, but at present is inaccessible. A tunnel has been run partly on the contact and partly in the serpentine hanging wall. The ledge filling is a siliceous material, with a main fissuring parallel to the strike. At the breast a crosscut shows that this fissure filling is 30 feet wide. At the southeast end of this crosscut a winze 15 feet deep has been sunk, but is at present caved in. There are very few signs of cinnabar in the tunnel or in the material on the dump.

Hurley Property.—Mayacmas District. Mrs. M. Hurley, 1820 Pacific avenue, San Francisco, owner. The property consists of 160 acres in Secs. 4 and 5, T. 10 N., R. 8 W., to the southeast of the old Sonoma mine. In this property is found the continuation of the serpentine belt running through the Sonoma, associated on both sides with sandstones. A short surface tunnel near the falls of the creek, close to the west line of the property, shows a ledge having a course nearly N. 45° W., about 30 feet wide, dipping westward. The serpentine belt on the property is generally pretty narrow. Near the house in the east and west center of the property some croppings show on the surface; on these are a shaft 50 feet deep and a caved-in tunnel 150 feet long. It is claimed that some cinnabar ore was found in the bottom of the shaft.

Lookout Group.—Mayacmas District. Judson Brown, Pine Flat, Sonoma County, owner. Includes the Lookout and Diamond claims, in Sec. 32, T. 11 N., R. 8 W.; parallel and adjoining the Eureka Nos. 1 and 2 to the south. No development of any importance.

Lucky Stone Group.—Mayacmas District. C. A. Grimmer, Pine Flat, Sonoma County, owner. Includes the Last Chance, Pay Reef, and Mother Lode claims, in Sec. 4, T. 10 N., R. 8 W., lying parallel and adjoining the Old Denver to the southwest. On the Last Chance, the most northwesterly claim, old workings show some cinnabar ore on the contact of serpentine and sandstone.

Maricoma Mine (Santa Rita).—E. White and others, of Pine Flat, Sonoma County, owners. In Sec. 36, T. 10 N., R. 8 W. Three tunnels have been run on this property; the upper one is 160 feet above the level of the lower tunnel. In the lower tunnel a stope has been raised on an ore body about 6 feet wide, having a serpentine foot wall and a sandstone hanging wall, with a wide gouge on the foot wall, and containing some good cinnabar ore. In the breast of the tunnel the contact carries no cinnabar ore.

Mercury Mining Company.—Macaymas District. F. A. Huntington, president, No. 330 Montgomery street, San Francisco. Owns the Boulevard, Boulevard Extension, Elizabeth, Esperanza, and two other claims northeast of the Socrates mine, and the Prince and Princess southwest thereof. In Secs. 32 and 33, T. 11 N., R. 8 W., and Sec. 2, T. 10 N., R. 8 W. No important development work has as yet been done on this property.

Missouri Mine.—Mayacmas District. L. W. Pittman, The Geysers, Sonoma County, owner. In Sec. 25, T. 11 N., R. 9 W. [See Mon. XIII, U. S. G. S., page 376; Report State Mining Bureau of Cal., XIII, page 603.] It lies to the northeast of the Culver-Baer property. This mine has been idle for years and all workings are inaccessible. The Culver-Baer Company is cleaning out some of these works to test the value of the property.

Napa Mine.—Mayacmas District. In Sec. 11, T. 10 N., R. 8 W. Donzel Stoney, 40 Montgomery street, San Francisco, owner. Idle.

Occidental and Healdsburg Group.—Mayacmas District. In Sec. 10, T. 10 N., R. 8 W. J. Stern, No. 10 Battery street, San Francisco, owner. Idle.

Old Chapman Mine.—W. A. Coalson, of Alexander, Sonoma County, owner. It lies in Secs. 25 and 30, T. 10 N., R. 8 W., at the mouth of Sausal Creek cañon, on Deer Creek. On the south side of Deer Creek a line of croppings, course about N. 15° W., runs down the slope toward the creek, but the underground works have not disclosed any continuation of ore in depth.

Pacific Mines (Crystal or Red Cloud).—Mayacmas District. In Secs. 5 and 6, T. 10 N., R. 8 W. This, the northwestern extension of the Sonoma mine, comprises the Crystal, Crystal No. 2, Crystal Extension Nos. 1, 2, 3, and 4. Owner, Pacific Mining Company; A. Abbey, 611 Market street, Oakland; A. Anderson, superintendent, Pine Flat, Sonoma County. [See Mon. XIII, U. S. G. S., page 376; Report State Mining Bureau of Cal., XIII, page 603.] The country rock is mostly altered sandstone, through which the same belt of serpentine which is found in the northwestern part of the Sonoma mine runs in about the same strike, N. 48° W. [See Fig. 37.] On the surface some croppings show at the southwestern contact of this serpentine belt with the sandstone. A crosscut tunnel (Pacific tunnel), direction nearly north, runs 265 feet below these croppings. Starting in the country rock southwest of the serpentine, it cuts through another belt of serpentine 40 feet wide, 150 feet from the mouth, to the north of which is 60 feet of broken ledge matter (called the Little Vein), upon which, however, no work has been done. At 525 feet the tunnel reaches the foot-wall gouge, then goes through 25 feet of very much broken ledge matter, and at 550 feet reaches the serpentine hanging wall, here about 75 feet wide. Short drifts have been run both ways along the hanging wall, but no workable ore bodies have as yet been found. The same contact has been found in other workings; the croppings show plainly along the crest of the ridge. A tunnel (A) running along the vein, and starting at the southeast end of the hill, about 66 feet above the level of the Pacific tunnel, has disclosed some promising ore. In this tunnel a shaft 40 feet deep has been sunk, which shows some very good ore. Another tunnel (A^1), about 40 feet lower, and nearly parallel to tunnel A, has not yet connected with this shaft.

Pontiac Group.—Mayacmas District. H. S. Beach and E. Warner, of Pine Flat, Sonoma County, and C. Mobley, of Healdsburg, Sonoma County, owners. Consisting of four claims: Pontiac Nos. 1, 2, 3, and 4, in Secs. 33 and 34, T. 11 N., R. 8 W. No important development work has as yet been done on this property.

Rattlesnake.—Mayacmas District. H. C. Lightner, Parrott Estate, San Francisco, and others, owners. In Sec. 31, T. 11 N., R. 8 W. [See Mon. XIII, U. S. G. S., page 376; Report State Mining Bureau of Cal., XIII, page 603.] This mine was worked in 1874, but is at present abandoned and the workings are inaccessible. In this mine the mercury was nearly exclusively found in the native state, as in the Socrates. The country rock, judging from the surface, is altered sedimentaries, with occasional small occurrences of serpentine.

Socrates Mine.—Mayacmas District. In Secs. 32 and 33, T. 11 N., R. 8 W., and Secs. 4 and 5, T. 10 N., R. 8 W. It is on the divide between Big Sulphur and Little Sulphur creeks, where the road from Calistoga to The Geysers crosses. Owners, W. H. Jordan, No. 1311 Claus Spreckels Building, San Francisco, F. A. Huntington, and T. W. Nowlin; H. Davey, superintendent, Guadalupe mine, Santa Clara County. This ledge is on the same contact as the Eureka mine; the croppings show very prominently and can be traced for a considerable distance between the sandstone foot wall and the serpentine hanging wall. The main tunnel [see Fig. 43] is run at a depth of about 200 feet below the top of the ridge, starting in the foot wall material, which is decomposed sandstone mixed with shale and clay. The average strike of the ledge is northwest, but the gouge on the foot wall, which in the Eureka mine is very wide, is much thinner; the ledge matter is soft opaline rock, very much fractured and favorable to ore deposition. The quicksilver occurs mainly as native mercury, the fractures of the opaline rock being filled with native mercury and some cinnabar, the more compact portion of the rock containing minute globules of native mercury. A "horse" of serpentine about 2 feet wide runs through the vein. The ore on the foot-wall gouge is softer and generally richer. In some places bunches of native mercury are found in the sandstone, especially in the southeast drift. The foot-wall black gouge carries oxides of iron, calcium and magnesium, silica, silicate of magnesium, and some free gases (probably free sulphide of hydrogen and carbon monoxide), which are very noxious to the miners. The occurrence of the quicksilver almost exclusively in the native state causes unhealthy conditions underground and great loss of mercury in blasting and handling the rock; the recovery of the mercury from the ore is also a problem, which has as yet been only partially solved.

At present the company is passing the ore through a rotary roaster, 27 feet long, 5 feet 8 inches in diameter, lined with 10-inch firebrick, having a pitch of 6 inches, using wood as a

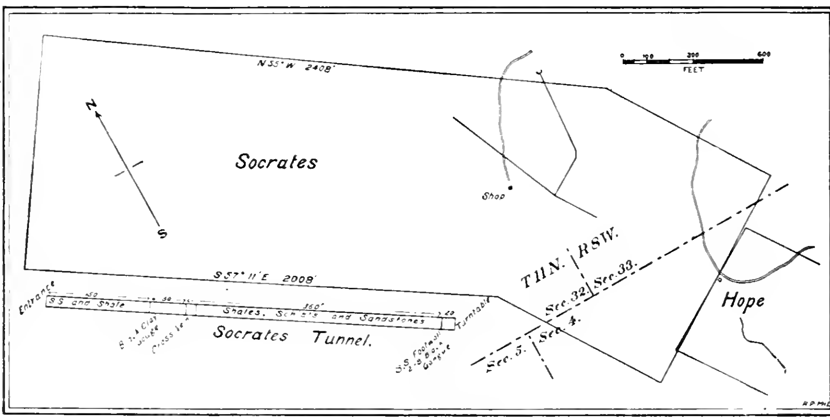


FIG 43. Socrates Mine.

fuel. The rotation is very slow, and the draft is so regulated as to control the amount of oxygen permitted to enter the furnace. From this roaster the vapors pass through a series of condensers to the stack, where it is claimed that the products of combustion exhaust at 100° F. The results appear to be very satisfactory to the owners.

Walker Mine.—Near Guerneville, in Sec. 7, T. 8 N., R. 10 W. L. F. Walker, of Guerneville, Sonoma County, and M. C. Meeker, of Camp Meeker, Sonoma County, owners. Some surface deposits caused a tunnel 560 feet to be driven into the mountain, which at 415 feet from its mouth crosscuts for 60 feet a material showing signs of strong silicification, and then runs along the supposed center of this material for about 90 feet.

Wall Springs Mine.—Near Guerneville, in Sec. 30, T. 8 N., R. 9 W. H. C. Wall, Hilton, Sonoma County, owner; Healdsburg Quicksilver Mining Company, J. C. Hobson, of Hilton, Sonoma County, lessee. A shaft, 70 feet deep, is in process of sinking. It is claimed that the surface material (serpentine) carries cinnabar, but in the material excavated from the shaft no signs of cinnabar could be detected.

YOLO COUNTY.

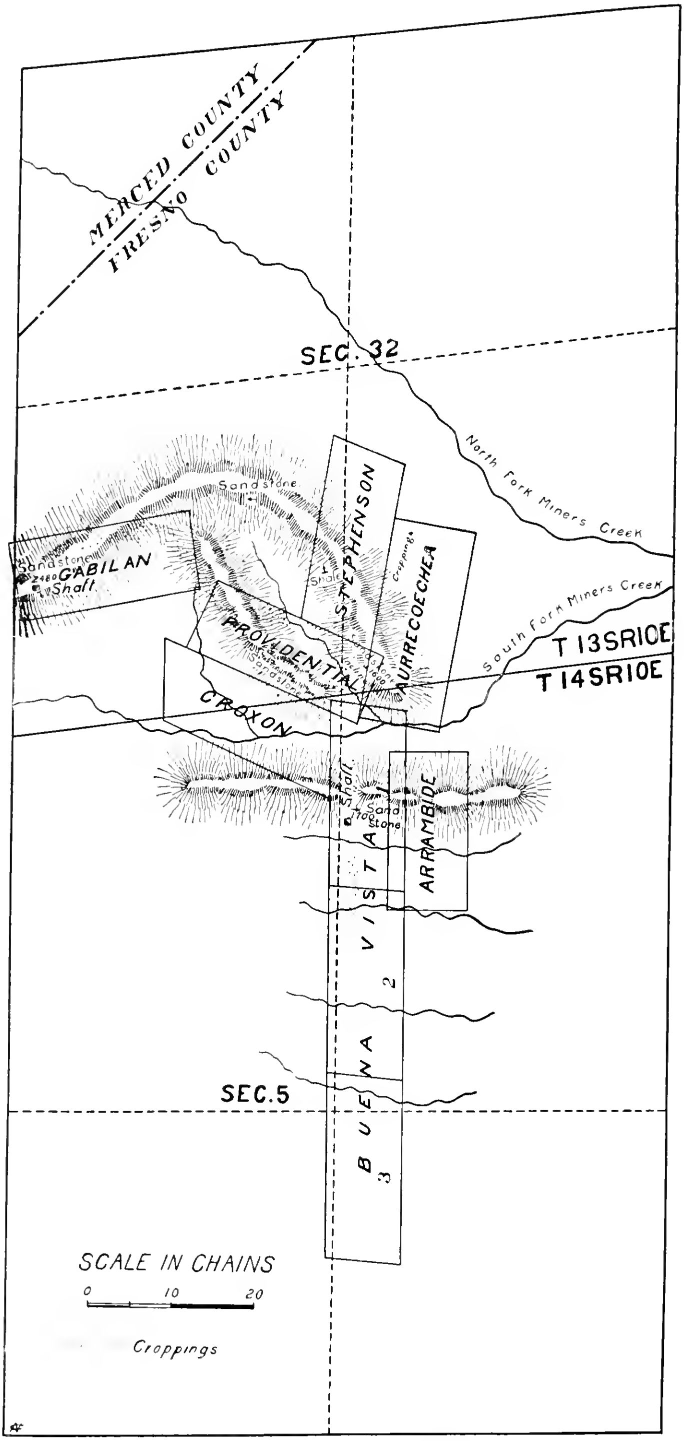
New England and Harrison Mines.—Knoxville District. The New England is in Sec. 26, T. 12 N., R. 5 W., and the Harrison is in Sec. 35, T. 12 N., R. 5 W.; the latter most probably covering the ground of the Grizzly, mentioned by Becker. M. W. Harrison, Knoxville, Napa County, owner. [See Report State Mining Bureau of Cal., XII, page 363; XIII, page 598.] Both mines lie in serpentine. The mineralization is accompanied with silicification, forming a very hard opaline material.

In the New England are abundant signs of decomposition by sulphuric waters. Small blisters with an eggshell envelope, containing oil and sulphur, are found in the rock. Up to the present time, nothing of value has been exposed in this mine.

The Harrison tunnel was inaccessible. The dump shows the ledge matter to be a very hard opaline, carrying some crystals of cinnabar in the seams.

In the wide serpentine belt to the southwest of the Manhattan-Boston line occur croppings of opaline rock which have been prospected for years without any result.

Reed Mine.—Knoxville District. Including the Royal or Soda Springs mine. Merchants Exchange Bank, San Francisco, owner. In Secs. 23, 25, 26, and 36, T. 12 N., R. 5 W. [See Mon. XIII, U. S. G. S., page 283; Report State Mining Bureau of Cal., XI, page 68.] This property was extensively worked, producing 5650 flasks between 1875 and 1879, but has been idle for a number of years. The works are caved in and inaccessible. The surface geology shows that the deposits in the Reed mine are located close to the line of contact of an area of serpentine with unaltered fossiliferous rocks, the ore bodies being contained in an opaline rock formation. The old works of the Royal mine are located on a dike of the same material, 20 feet wide, cutting through the serpentine.



MAP OF THE LITTLE PANOCHE MINING DISTRICT.

DISTRICTS SOUTH OF SAN FRANCISCO.

FRESNO COUNTY.

Arambide and Aurecoechea Claims.—These are in Sec. 32, T. 13 S., R. 10 E., and Sec. 5, T. 14 S., R. 10 E. Owner, George Alferitz, care of Dellepiane & Co., 425 Battery street, San Francisco. These claims are situated near the Providential group of mines [see map of Little Panoche Mining District], in the same formation of metamorphic sandstone, mixed with some shale. In former years considerable mercury was taken out of this property, but the works are now caved in and inaccessible, and the furnace is entirely obliterated.

Mexican Mine.—This comprises three claims (Mexican Mine Nos. 1, 2, and 3), in N.E. ¼ of Sec. 22, T. 18 S., R. 13 E. Owner, Manuel Santos, New Idria, San Benito County. The developed part of the property lies in the northwest branch of Cantua Creek, very close to the contact of the metamorphic series and the Chico sandstones to the northeast thereof. While the surface shows almost exclusively serpentine, the underground workings have proven that this rock is in places only a surface covering, the tunnels all passing the serpentine in from 10 to 15 feet and entering into sandstone.

Tunnel No. 1 [see Fig. 44] is a short tunnel in sandstone, heavily bedded, with a strike N. 13° W., dip S.W. 80°, through which a seam 6 inches wide cuts on a strike N. 25° W., dip N.E. 40°, carrying cinnabar associated with silica and oxides of iron, oxidation product of iron sulphides.

Tunnel No. 2, on opposite side of the gulch, after passing through 10 feet of surface serpentine enters into sandstone. This tunnel has a course south, 60 feet long; 20 feet in a side drift runs S. 45° E. about 30 feet, which cuts a narrow seam of ledge matter, course S. 20° W. The breast of the tunnel follows for some feet a fissure from 18 to 24 inches wide, carrying cinnabar, the gangue being a dark yellow ochery material, indicating that the unaltered ore will be found to carry a great amount of iron sulphide. About 2 feet from the breast is a shaft 30 feet deep on a narrow seam of ore.

A little above a line from No. 1 to No. 2 in the gulch is an open cut 8 feet deep, showing fissures in the sandstone, dipping northeast, filled with silica and seams of cinnabar associated with iron sulphide.

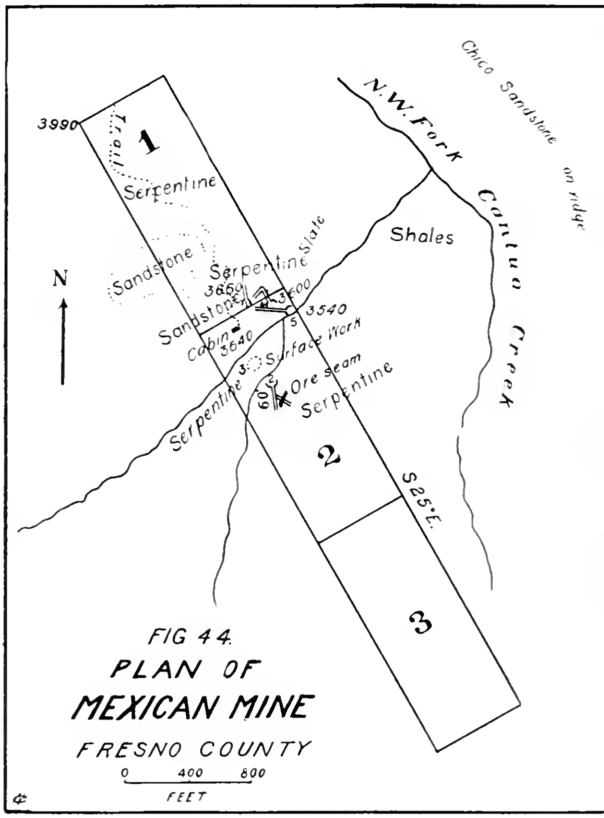


FIG 44.
PLAN OF
MEXICAN MINE
FRESNO COUNTY

Below and to the northeast of these works in the gulch are two tunnels: No. 4, running N. 10° W., 75 feet; then S. 80° W., 50 feet; projected to reach under No. 1. This tunnel is entirely in slate, but at the breast sandstone is coming in the roof. The lower tunnel, No. 5, 300 feet long, course nearly east and west, is entirely in slate. Neither of these tunnels has reached the ore deposits as yet.

Providential Group.—Owners, Thomas Flint, J. J. Croxon, B. P. Stephenson, N. C. Briggs, A. Johnson, B. Vargas, of Hollister, San Benito County. This group consists of seven claims. [See map of Little Panoche Mining District.] The country rock is metamorphic sandstone intermixed with some shale. The strike of the sandstone is prominently north and south; that of the shales east and west. The sandstones and shales have a bluish-gray color. In the sandstone occur narrow, irregular seams of white quartz. A more or less intricate system of leached zones runs through the sandstone, which is apparently leached to a dull white color by the action of some percolating solution. The cinnabar is found in these zones, which is accompanied by nearly continuous seams, from 1 to 2 feet wide, of quartz colored brown by iron and in places forming very large, perfect quartz crystals, indicating a deposition in open places. The zones contain a great amount of oxide of iron, forming yellow ocher and principally red oxide. The cinnabar is found intimately associated with the red oxide. The croppings are prominently indicated by the quartz seams. The country rock is soft and has been very deeply eroded into very steep and deep gulches, and the course of the ledges is in places obscured by probable slides. Their course is indicated on the accompanying map. The material is very deceptive. Relatively very little cinnabar can be seen in the ledge filling, even with a glass; but on washing the material, rich in disintegrated iron oxide, proves it to contain considerable amounts of cinnabar.

The principal work has been done on the Providential and Gabilan claims. In the former an incline shaft has been sunk near the bottom of the gulch at a place where the ledge splits in two. This shaft, course N. 74° E., on an incline of about 50°, is run along a slip, which stands nearly vertical and shows considerable cinnabar. The bottom of the shaft is almost entirely in a black gouge. A drift has been started S. 74° W., to undercut the ground vertically under the collar of the shaft. The sandstone is an arkose, nearly unaltered sandstone. The work on the Gabilan, 880 feet higher, is on the top of the main ridge; there is a shaft about 25 feet deep and some shallow cuts, showing the same leached sandstone, with the quartz seam running through the center of the mineralized zone; the course of the ledge is here N. 54° E., the dip 60° southeasterly. Some work has been done on the Buena Vista, southwest of the Providential, showing the ledge to run north, dipping east 60°, about 3 feet wide. The connection of this ledge with that of the Providential can not, however, be traced on the surface.

KINGS COUNTY.

The mine (no name) in the N.W. ¼ of the S.W. ¼ of Sec. 22, T. 22 S., R. 16 E., belonging to F. W. Hunter, C. F. Francis, and G. H. French, of Parkfield, Monterey County, is situated on Avenal Creek, east of Table Mountain, 14 miles from Parkfield. The mine is at the contact of the serpentine and the Chico sandstone. This contact forms a mass of rubble, gravel, and partly cemented material, intermixed with bowlders of sandstone and serpentine, and clay, which it is claimed on washing proves to contain cinnabar. There is a gray sandstone resembling the sandstone carrying cinnabar in the Oceanic mine, which also here shows cinnabar. This material is found underlaid by cemented gravel pebbles.

The serpentine on the south bank of the creek has all the appearances of being a slide from the side of Table Mountain, and has apparently pushed up the adjoining sandstone beds and been partly projected within those beds. The country has no mining timber, but a fair supply of fuel timber.

The mine (no name) in the S.E. ¼ of the N.W. ¼ of Sec. 28, T. 22 S., R. 16 E., belonging to H. Dawson, of Lemoore, Kings County, is on Table Mountain, 13 miles from Parkfield, Monterey County. There is a shaft about 10 feet deep on some fair croppings, but showing as yet no permanent formation.

The mine (no name) in the N.W. ¼ and N. ½ of the S.W ¼ of Sec. 28, T. 22 S., R. 16 E., belonging to F. W. Hunter, C. F. Francis, and G. H. French, of Parkfield, Monterey County, and Mrs. A. Smith, of Lemoore, Kings County, is on Table Mountain, 13 miles from Parkfield, Monterey County. There are a number of shallow surface openings on croppings which show some cinnabar, but in no place has any permanent formation been disclosed.

MONTEREY COUNTY.

Cholame Parkfield Mine.—In Sec. 35, T. 22 S., R. 14 E., and Sec. 2, T. 23 S., R. 14 E.; 6 miles from Parkfield, and 32 miles from the railroad at San Miguel. Owners, L. S. Patriquin, G. W. Ford, and G. W. B. Anderson, of Parkfield, Monterey County. This property consists of three claims, covering 4500 feet by 600 feet in width, in a course N. 60° W., following as closely as possible a contact of serpentine and highly metamorphosed rocks of the Franciscan series. The outcrop of these metamorphics is not very large. At both ends of the property the surface is entirely in serpentine, which formation forms the prominent surface rock of the vicinity abutting against the Chico sandstone. It is highly silicified, and in many cases only a surface flow; frequently small areas of Franciscan sandstone crop through the serpentine, while in the gulches evidence can be found that shales underlie the serpentine. The contact crosses a side ridge of the main mountain range and the outcrop of the metamorphic rocks covers the apex of this ridge. The contact has been reached by two tunnels starting respectively from the southwest and the northeast side of the ridge, both at about the same level, 350 feet below the highest point. The tunnel from the southwest has just reached the contact at a distance of 964 feet from its mouth, showing some cinnabar at the contact. The tunnel from the northeast reaches the same contact 330 feet from the mouth, and has been driven about 500 feet northwesterly along the contact, showing some ore in several places. The line of contact is very irregular, generally without any gouge, but where there is any gouge, the slickensides show movements in various directions, vertical and horizontal. The sandstone is very much fractured and has been recemented by quartz, calcite, and gypsum. Part of the serpentine has been highly silicified, altered into a chalcedonic material. The cinnabar forms principally in the fractured sandstone, but also occasionally in the serpentine close to the contact. The tunnel from the southwest side demonstrates that the cinnabar deposition in the altered Franciscan sandstones is by no means restricted to the contact. Several large ore pockets have been found in this tunnel over 400 feet from the contact, and about 100 feet therefrom a peculiar deposit carrying a very high percentage of free sulphur, through which cinnabar is disseminated, was cut and followed for a few feet. The metamorphic rocks are very much shattered; large crevices, probably resulting from earthquakes, are frequently found. The entire formation has an ochery character from oxidized iron sulphides, and in several places can be seen the effects of the high heat resulting from the oxidation of these sulphides. There are several surface cuts wherein good ore has been found on the contact. The richest surface deposit, carrying exceedingly rich ore in altered sandstone, is cut off by a body of serpentine. A tunnel run 50 feet below this deposit shows a most irregular formation—flint, serpentine, then a broken mass of bowlders of flint and metamorphosed sandstone mixed with clay, then again serpentine, but no signs of ore. This rich surface deposit, showing seams of nearly pure cinnabar and metacinnabarite in fracture planes of flinty rock, is clearly not in place, but from where it has moved to its present position is as yet an open question. The neighborhood is very sparsely timbered, both in regard to mining timber and for fuel purposes.

Dutro Mine.—This is in the San Carpojo district, in the southwest corner of Monterey County, two miles in an air line from the ocean, at the head of the west fork of San Carpojo Creek, in the S.W. ¼ of the S.E. ¼ of Sec. 28, T. 24 S., R. 6 E. Owner, Frank Dutro Martinez, Santa Maria, Santa Barbara County; G. E. Van Gordon, of Cambria, San Luis Obispo County, lessee. This property is situated on a line of croppings running nearly east and west, in silicified Franciscan sandstone. As far as can be judged the ledge has a southern dip. On the property is a shaft which is claimed to be 100 feet deep and a drift about 40 feet on the ledge. These works are caved in. Judging from the material on the dump the ledge matter is of a flinty character, carrying sensible amounts of cinnabar. The vicinity is well watered and timbered.

Table Mountain Quicksilver Mine.—This property is 12 miles from Parkfield, and 38 miles from the railroad at San Miguel; in Sec. 30, T. 23 S., R. 15 E. Owner, G. W. White, of Parkfield, Monterey County. This mine is located on top of Table Mountain. The surface is nearly exclusively serpentine. The works are located nearly in the center of the claim; the lowest tunnel at about 100 feet below the top of the mountain. At present only one tunnel, 50 feet long, in decomposed serpentine, course N. 60° E., is accessible. On the left side it shows, over a distance of 30 feet, a seam carrying cinnabar, slightly dipping to the northwest. In the decomposed serpentine are found bowlders of flinty quartz carrying some cinnabar, but no permanent formation has as yet been reached. At the southeast end of the claim a shaft 10 feet deep has been sunk on a chalcedonic material showing some cinnabar. Between these two workings a tunnel has been started, course N. 40° E., in shale, 130 feet long, the breast being in decomposed serpentine. Below the entrance of this tunnel the Chico sandstone is found abutting against the serpentine. No ore has as yet been found in this tunnel.

SAN BENITO COUNTY.

San Benito County is traversed by two parallel mountain ranges, the Gabilan and the Mount Diablo, which unite south of the county in Monterey County. Only in the latter—the eastern range—have quicksilver deposits of any consequence as yet been developed. They may be segregated into three districts: The New Idria district, in the southeastern part of the county; the Stayton district, in the extreme northeastern corner, taking in small portions of Merced and Santa Clara counties; and a third district, situated nearly in the center of the county in the mountain cluster between San Benito creek on the west and Tres Pinos and Panoche creeks on the east, which might properly be called the Central San Benito district. The geology of the districts will be treated separately. [See, also, Report State Mining Bureau of Cal., XI, page 370.] They are not referred to in geographical sequence, owing to the alphabetical arrangement of the respective mines in this bulletin.

Central San Benito District.—This district contains only a few scattered mines on which development work has been performed. It is located in the Mount Diablo range, which consists mainly of rocks of the Franciscan series, in places covered by or adjacent to younger formations. Its geological features are mentioned in the descriptions of the Bradford and Cerro Bonito mines, the two principal mines of the district. The country is well timbered, both for mining and fuel purposes. The railroad outlet is at Tres Pinos.

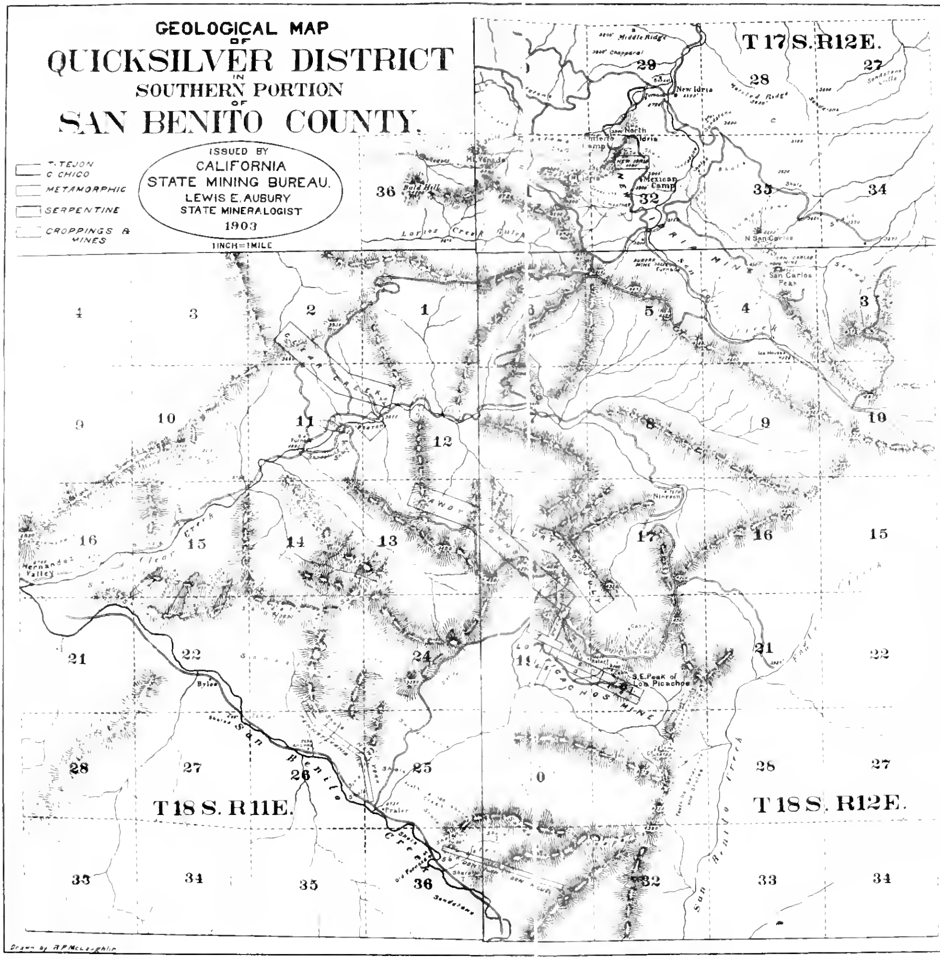
New Idria District.—The New Idria, San Carlos, Sulphur Spring, and Molina mines in this district were discovered in the early 50's by miners who had worked near the present site of the Aurora mine on what was at first supposed to be a silver mine, but which proved to be a deposit of chrome iron.

The geological map of the quicksilver district in the southern portion of San Benito County shows that this district contains a belt of metamorphic rocks having a general northwest strike, bounded on both sides by Chico formations, and consisting of a belt of serpentine in the center, having to the northeast a rather narrow belt of metamorphic rocks, mainly sandstone, and to the southeast a much wider belt of metamorphic rocks, containing, however, much more slate. The main deposits of quicksilver ores are located very close to the contact of the serpentine with these sandstones and shales. They form two parallel lines, one comprising the San Carlos, Aurora, and New Idria mines, and the other the Picachos, Andy Johnson, and Clear Creek mines. The Don Juan and Don Miguel mines are outside of this contact belt, entirely in the metamorphic shales and sandstones.

The mineralized deposits at New Idria are situated on a line having a general northwestern trend. Between the New Idria and San Carlos deposits, which are extensively developed, are the Sulphur Spring and Molina mines, the former being the only one found immediately in contact with the serpentine on this line. The country rock of the New Idria and the San Carlos is very similar; the rocks found in the lower tunnel of the San Carlos are strikingly similar to those found in the New Idria mine. The geological map of this section indicates that the high peaks of the New Idria and San Carlos are formed of sandstones and shales, while surrounded by serpentine. This serpentine is generally a hard, light-colored variety, only occasionally changed by silicification into black opaline rock. West of San Carlos Peak is the Aurora mine, entirely surrounded by serpentine.

Close to the metamorphic series the Chico is sensibly disturbed, but only for a belt not over 1000 feet wide, past which the Chico beds of drab-colored sandstone can be seen outcropping very regularly at the surface.

The serpentine is by far the prevailing rock of the metamorphic series. There are indications that in places the serpentine appearing at the surface is only a surface occurrence and does not persist in depth, as will be seen later herein, and also in the description of the Mexican mine, Fresno County,



Geology W. Forstner E.M.

situated on the northeastern contact of the same belt of the metamorphic series. The serpentinization of the rock is very irregular, and sometimes very light, while in other places the rock is a talcose, bluish-green serpentine, with a more or less conchoidal fracture. Inclusions of bodies of sandstone and shale are found in the serpentine. On a ridge over a mile long, having a course about S. 30° W., running from the divide south of the San Carlos, along the headwaters of Clear Creek toward the Picachos, and at the surface entirely formed of serpentine, all gradations from sandstone to serpentine are found. In one inclusion of a yellow sandstone, at least 100 feet by 50 feet at the surface, seams of serpentine over a fourth of an inch wide cutting through the sandstone can be seen. The accompanying photograph (No. 11) of a thin section (enlarged) conclusively proves the serpentinization of the sandstone. In the belt between the serpentine and the Chico, a great part of the sandstone is so thoroughly recrystallized by metamorphic action that it is very difficult to decide in the field whether the material is metamorphic sedimentary or eruptive.

PHOTO No. 11. Thin Section of Sandstone and Serpentine from New Idria District. 41 Diameters.

In the lower part of Clear Creek near its entrance into the San Benito, a conglomerate is found on the hills, containing pebbles of all kinds of rocks, including serpentine. This region must have been a lake of large dimensions, as conglomerate is found 1100 feet above the level of Hernandez. Another appearance of conglomerate is found overlying metamorphic sandstones and shales, at an elevation of 4700 feet (2150 feet above Hernandez), forming the highest point of the mountain cluster, which forms the big bend of San Benito Creek, south of the Picachos (Dominic Peak).

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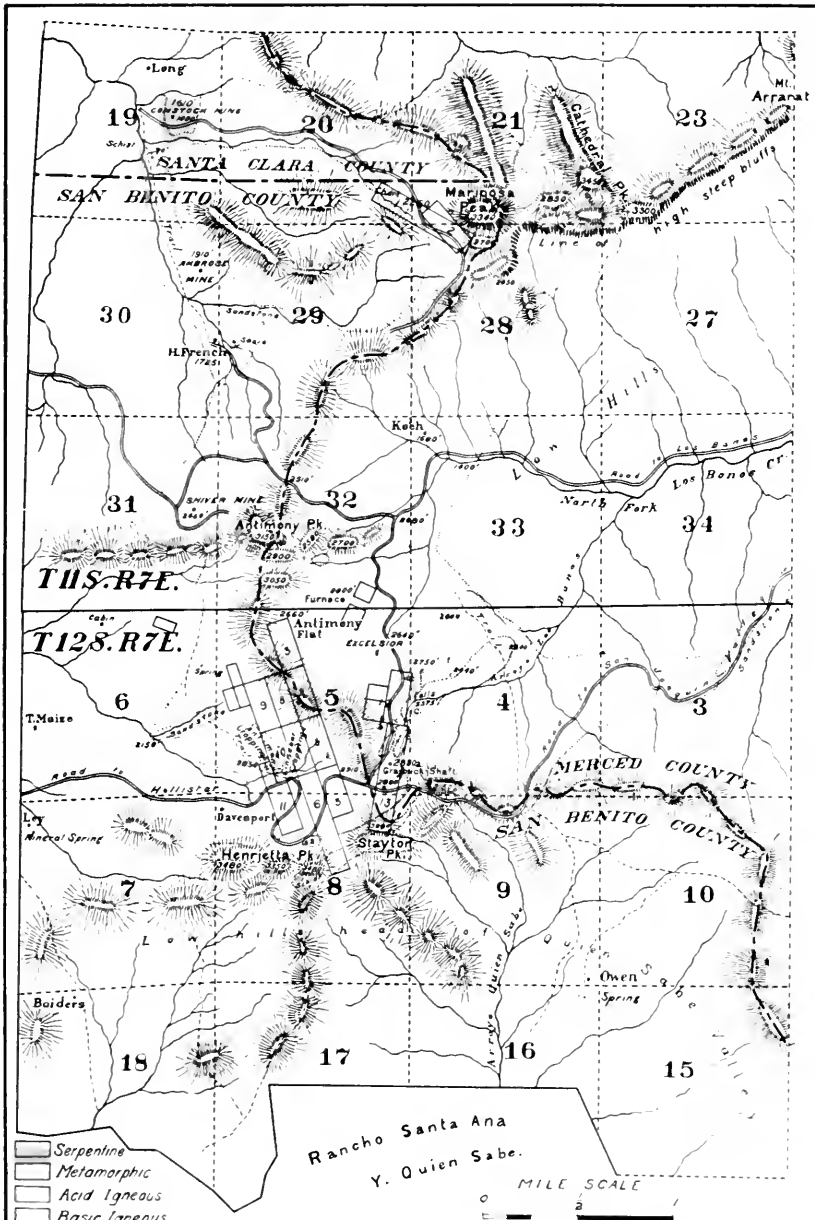
PHOTO No. 11. THIN SECTION OF SANDSTONE AND SERPENTINE FROM NEW IDRIA DISTRICT. 41 DIAMETERS.

In the lower part of Clear Creek near its entrance into the San Benito, a conglomerate is found on the hills, containing pebbles of all kinds of rocks, including serpentine. This region must have been a lake of large dimensions, as conglomerate is found 1100 feet above the level of Hernandez. Another appearance of conglomerate is found overlying metamorphic sandstones and shales, at an elevation of 4700 feet (2150 feet above Hernandez), forming the highest point of the mountain cluster, which forms the big bend of San Benito Creek, south of the Picachos (Dominic Peak).

Along the lower course of Clear Creek and its drainage serpentine and metamorphic sandstones are very intricately mixed. For a considerable distance the creek and its tributaries have cut their beds in the serpentine, while above on the ridges sandstone is extensively represented, indicating that the serpentine underlies the sandstone, which latter is generally strongly silicified. The serpentine itself is generally silicified to a certain extent, and the entire formation, at the surface where the serpentine shows, looks as though the sandstone has been eroded. Part of the serpentine is denuded of vegetation, and the material has deteriorated into a granular mass; but a great portion of the serpentine territory is covered with brush. In some places in the region between Clear Creek and San Benito Creek, the barren serpentine is capped by a few feet of ferruginous chert, containing so much iron that the entire rock has a brownish-red color. These patches are covered with brush, and as the soil in the part of the serpentine belt covered with brush has a much darker appearance than that of the barren ground, which is light yellow to white, it must be supposed that the iron contents of the serpentine have a certain influence on the growth of brush. Whether the iron content is due to the character of the rock which has been serpentinized is as yet an open question.

The schists of the older series are found in a few places—in the bottom of Clear Creek Cañon just above and below the Clear Creek mine, and in San Benito Creek, near the southeast corner of Sec. 22, T. 18 S., R. 11 E. In Clear Creek Cañon the schists underlie the serpentine, and are partly very much distorted, but their strike is about N. 45° E., dip nearly vertical southeast. In San Benito Cañon they are exposed on the east side of the creek, the opposite side being formed of thinly bedded shales, probably belonging to the Chico, having a southeast strike and a southwest dip. The schists are not very wide, and are inclosed in sandstones. Another small cropping of schist is found a little higher up the creek at the New York mine.

In San Benito Cañon, near the Don Juan mine, the nonconformity of the metamorphic series, with a strike nearly east and west and a dip south, and the Chico on the other side of the creek, with a strike S. 45°–60° E., dip southwest, is strikingly illustrated. Going up the cañon above the old retort of the Don Juan mine the metamorphic shales can be seen under-



Geology by Wm. Forstner, E.M.

GEOLOGICAL MAP OF STAYTON MINING DISTRICT.

Issued by the California State Mining Bureau—Lewis E. Aubury, State Mineralogist, 1903.

lying the sandstones, which form nearly the entire surface of Dominic Peak, the mountain between the elbow of San Benito and Picachos creeks, except at its highest point (4720 feet), 1900 feet above the creek, which is covered by a conglomerate, traces of which can be found nowhere on the mountain side. Part of the sandstone is only slightly silicified, principally by quartz seams in the fractures; but on the southern part of the top of this hill, jasper is found in sensible quantity, while this formation is rare on the hillsides. The sandstones are non-conformable with the underlying shales. The chert beds are almost entirely absent in this region. Only one very small exposure in the lower part of Clear Creek has been observed, which contains a great amount of iron oxide. Jasper is also but slightly represented. In fact the silicification process has not been so intense in this region as in other parts of the quicksilver belt. The question might arise whether this phenomenon has any connection with the small representation of igneous rocks and the absence of mineral springs in this region. The small extent of the later opalizing silicification is also to be noted, no belts of opaline rock being found in close proximity to the ore deposits, while such rocks are found to some extent in the mass of serpentine.

The district is from 60 to 70 miles distant from the railroad at Tres Pinos, San Benito County, with which it is connected by two good roads from New Idria via Vallecitos Cañon, and from Hernandez down San Benito Creek.

The supply of timber is rather scarce. The price of cord-wood is from $5 to $6.50 per cord; round mining timber, 11 inches at the small end, costs 12 cents and over per linear foot; square timber, including freight from railroad ($12 to $18 per ton), costs $40 and over per 1000 feet (B. M.).

Stayton District.—This district is situated in the corner of San Benito, Merced, and Santa Clara counties, and comprises parts of these three counties, but being principally in San Benito County is included within the latter. [See geological map of the Stayton District.]

The surface rock of this district is prominently of igneous origin and except in the northwestern part the underlying sedimentaries are almost exclusively found in the bottoms of the deeply-eroded gulches. The post-Tertiary igneous rocks vary greatly in character; from very fine-grained, dark-colored basic, basaltic rocks, to very fine-grained, hard, nearly white acidic rocks. The great majority is, however, a light grayish-colored porphyritic rock, which Whitney [see Geology of California, page 46] classified as trachyte, but which closely answers the asperites described by Becker. [See Mon. XIII, page 151.] There is no doubt that this district has been the locus of repeated igneous eruptions, and that these different igneous rocks represent various stages of magmatic differentiation. [See Prof. W. Brögger, Q. J. of the Geol. Society, vol. L, page 29, and vol. LII, page 607 and following; J. P. Iddings, *ibid.*, page 609, and Bull. Phil. Soc. of Wash., vol. XII, page 151.]

The sedimentary rocks belong to the metamorphic series, prominently sandstones. At one place at the northwest foot of Mariposa Peak, a small exposure of chert was found. Some shales are also exposed, and at one place in Los Banos Creek, at the foot of the grade of the road from Stayton to Los Banos, a fine compact conglomerate is found which may probably represent the conglomerate forming the basal member of the metamorphic series, as described by Fairbanks. [See Bull. Geol. Soc. of America, vol. VI.] This conglomerate must not be confounded with the coarse conglomerate forming at present in the beds of some creeks. Only at one place in the northwest corner of the district, in the old Comstock property, is an exposure of serpentine noted, and this not over 1000 feet wide, abutting to the west against schist and to the east against a flow of basalt.

There are no hot springs in the district, but in the western belt, sulphur emanations, principally carrying antimonious ores, are very prominent, and the ledge matter and part of the wall rocks in all the metalliferous deposits have been so thoroughly leached by sulphurous waters that the determination of their original composition is extremely difficult, if not impossible.

The ore deposition is undoubtedly posterior to the eruption and consolidation of the volcanic rocks. At one place in the Stayton mine, cinnabar can be found replacing some leached minerals in the igneous rocks.

The district is about 16 miles from the railroad at Hollister, San Benito County. The vicinity is practically void of mining timber, but there is ample fuel timber at $3 per cord.

The following claims as numbered on the map are in this district: 1. Santa Cruz; 2. Mariposa; 3. Green Valley; 4. F. Smith; 5. Cold Spring; 6. McLeod; 7. Badger; 8. Fairplay;

9. Santa Clara; 10. Pacific; 11. Last Chance; 12. North Star; 13. Stayton.

Andy Johnson Mine.—New Idria District, in Sec. 13, T. 18 S., R. 11 E., and Sec. 18, T. 18 S., R. 12 E. Thomas Flint, owner, Hollister. This mine is located on the line of croppings mentioned in the general description of the district, running from the Picachos to the Clear Creek mine. All the old works are inaccessible.

Aurora Mine (formerly Morning Star).—New Idria District. In Sec. 5, T. 18 S., R. 12 E. Owners, A. Leonard, San Benito; Thomas Flint, Hollister; Estate of Ig. Ceseño; S. L. Sadler, No. 34 Steuart street, San Francisco; bonded to the Aurora Quicksilver Mining Company, B. J. Potter, president, No. 165 East Twelfth street, Oakland. Contains eight claims, the Aurora, Leonard, Molly O, Morgan, Aurora Extension, Morning Star, Sadler, and Traction. This property was discovered in 1853 and efforts have been made at different times to prospect it. The property is located on a line of croppings having a course S. 15° E., situated south of San Carlos Creek at the foot of San Carlos Peak, and running up about half way to the top of the divide between San Carlos and Clear creeks. These croppings are about 600 feet long and from 50 to 100 feet wide. Their course prolonged to the northwest would come very close to the New Idria mine. They are entirely surrounded by serpentine, and no other rock is found at the surface; neither do the short tunnels and shallow open cuts on the mine show any other material. The upper tunnel, 10 feet long, is 275 feet above the furnace. Another tunnel, 25 feet long, near the bed of the creek, is 25 feet above the same level. Both show only serpentine. There is a large open cut on the hillside in the croppings, from which some ore has been taken. Above the latter is an open cut, 200 feet above the furnace level, which is about 100 feet long and 30 feet high. The course of its face is about northeast. In the northeastern half, a horizontal stratum of opalized serpentine 3 feet wide and carrying seams of cinnabar is found. This property is equipped with a two-chamber Fitzgerald furnace.

Bradford Mine (formerly Cerro Gordo).—Central San Benito District. In Secs. 3, 4, and 9, T. 15 S., R. 8 E. Owner, H. R. Bradford, No. 7 North Market street, San José. This mine lies on Tres Pinos Creek. The drainage of this creek is, up to about one mile below the mine, in gravel beds lying nearly horizontal. At Johnson's place, sandstone appears on the south side of the creek, in narrow beds standing nearly vertical. The sandstone belt runs along the west side of the property; to the east lies a wide belt of serpentine. Both the sandstone and the serpentine have a northwesterly strike. The serpentine as found in the mine workings dips northeast. [See Fig. 45.]

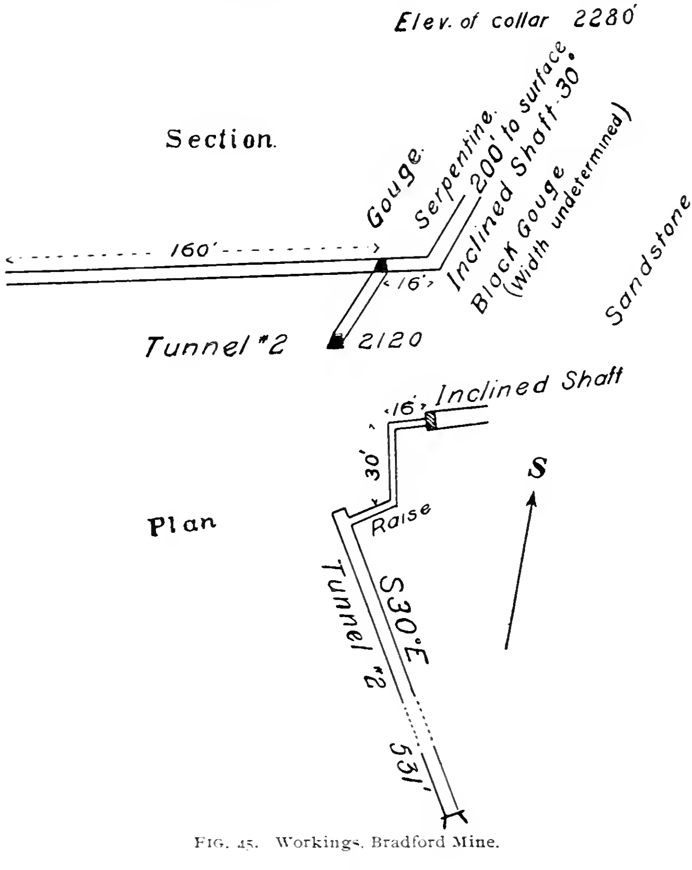


FIG. 45. Workings, Bradford Mine.

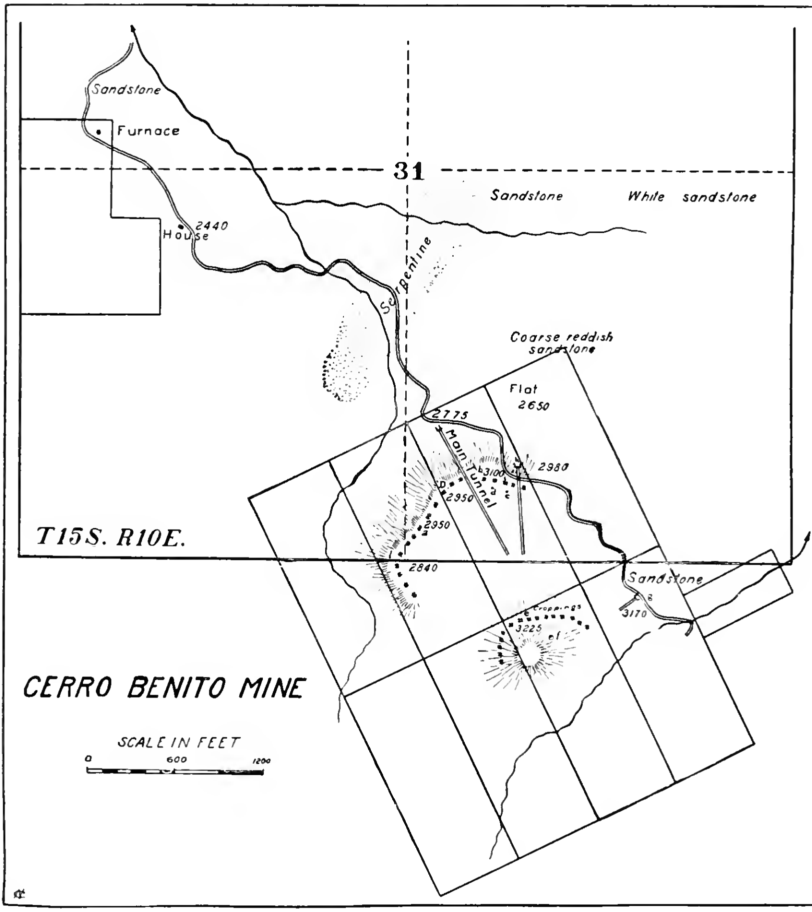
The western part of the serpentine consists of a highly silicified belt of varying width, in part opaline rock, carrying some cinnabar. Between this belt and the sandstone is a wide belt of black gouge, and at least one other belt of black gouge has been found in tunnel No. 2 in the silicified serpentine. The width of the contact gouge between the sandstone and the overlying serpentine is not known, but from surface indications it must be rather wide. Where crosscut at the bottom of the shaft [see Fig. 45], the opalized serpentine between the gouges is only 16 feet wide. The next gouge is at that place 160 feet wide. This opalized serpentine crops out in a northwestern direction past the boundary of the property, and north of the creek. It carries some cinnabar, but as yet no body of workable ore has been found.

The incline shaft, following the contact of the opalized serpentine with the underlying gouge, has been sunk 200 feet on the incline. A tunnel has been run 160 feet vertically below the collar of this shaft; it is 535 feet long, and reaches under the shaft, but follows the contact of the opalized serpentine and the overlying gouge. No ore bodies have been disclosed by this work; however, the serpentine carries some cinnabar throughout.

The surrounding country is well timbered. The mine is 18 miles from Tres Pinos railroad station, connected by a good wagon road. The existence of cinnabar in the locality was discovered in 1859 as an incident of the work of constructing a wagon road by the New Idria Mining Company, and much effort by various parties has since been expended in the prospecting and development of the early find.

Butts Mine.—Central San Benito District. In Sec. 4, T. 16 S., R. 8 E. Wm. Butts, of Pine Rock, San Benito County, owner. The country rock is a coarse sandstone, through which cuts a ledge having a course nearly southwest, dipping north about 50°, wherein some sandstone occurs; seams of silica fill the fractures of the sandstone, and carry a great amount of iron oxides. The formation in the neighborhood of this ledge is very irregular; shales, chert, and some serpentine are found all intricately mixed up. Except near the croppings of the ledge no workable ores have as yet been found. A tunnel 300 feet long has been run, and a shallow shaft about 20 feet deep has been sunk. The property is equipped with a 2 ⌓ retort furnace. The neighborhood of the property contains some fuel timber, but little mining timber. The distance from Tres Pinos railroad station is 21 miles by a good wagon road.

Cannon Mine.—Central San Benito District. In Sec. 4, T. 15 S., R. 8 W. A. C. Cannon, of Emmett, San Benito County, owner. This property lies adjacent to and north of the Bradford, on the same croppings. A drift 130 feet long has been run, with a winze 30 feet deep in the silicified serpentine. At the bottom of the winze is a drift 90 feet long, showing that the serpentine carries some cinnabar, but without disclosing a pay shoot.



Cerro Bonito Mine.—Central San Benito District. In Sec. 31, T. 15 S., R. 10 E., and Sec. 6, T. 16 S., R. 10 E. Cerro Bonito Quicksilver Company, owner; H. R. Bradford, No. 7 North Market street, San José, general manager; James Treadwell, San Francisco, president; S. T. Kennedy, Llanada, San Benito County, superintendent. This mine was opened about

1874 and worked by the old Cerro Bonito Company until 1876. It is stated that the mine has produced about 800 flasks.

The present company, organized September, 1902, has been working this property since then, and is at present reopening the main tunnel. This work has proceeded to a length of 650 feet, the entire length of the tunnel being 930 feet. This tunnel, as far as opened, is in the black gouge mixed with some sandstone; from a shoot connecting with the old upper works, some jaspery material has come down, showing some cinnabar. The company is also refitting the old 25-ton coarse-ore furnace. The old workings consist of a great amount of surface work and numerous underground works, which are largely inaccessible; but those which can be entered show development to have been very extensive. Up to the present time the company has not reopened any large ore bodies.

The entire geology of the neighborhood is very complicated, and from what is disclosed in the works that can be entered, no sufficient data can be collected to give a satisfactory and clear description of the geology. Between the property and Panoche Valley is a flow of basalt—probably a surface flow. This appears, judged from surface indications, to be the only igneous rock in the vicinity. The top of Cerro Bonito Hill, which rises steeply, is surrounded by two lines of bluffs [see map of the Cerro Bonito mine], one forming the top itself, the other from 200 to 300 feet lower and much more prominent, especially on the north and northwest sides, where in places the bluffs are 100 feet high. These bluffs are formed of a hard siliceous material, most probably a metamorphic breccia recemented by silicification. Some black opaline rock is found through this rock, and occasionally some sandstone. The true relation between this breccia and the bedded sandstone can not be traced from the present accessible development works. In three places the breccia overlies the regularly bedded sandstone. Going northwest from the southern part of the property these places are:

First—Sandstone tunnel (*g*) [see map], an extensive and intricate network of underground drifts, winzes, and shafts, in sandstone. At their western end a gouge is found dipping from 10° to 15° in a westerly direction and carrying some serpentine coming in from the roof and overlying the sandstone which lies in nearly horizontal regular beds, especially in the western part of the works; near the mouth of the works some nearly vertical narrow seams of quartz cut through the sandstone.

Second—Farther northwest is an open cut (*i*), from which extensive works run into the hill. In one of these the breccia is found overlying the sandstone, dipping about 30° N., 40° E. This breccia is found continuous to the old open cut works and carries cinnabar all through, overlying a stratum of serpentine.

Third—Northeast of this work is a long tunnel (*h*) running in a southwesterly direction. In this tunnel sandstone is found underlying the breccia, which is for long distances replaced by black gouge. Near the end of the opened part of the tunnel, which is 815 feet long, the cross-section is in horizontally bedded sandstone, with narrow seams of black clay and quartz, which underlies the black gouge. On the hillside above this tunnel are prominent croppings of the breccia.

The ore bodies in these works have never been connected with those in the underground works in the main tunnel, and appear to be a separate deposit. From the fact that in the sandstone tunnel cinnabar is found in the sandstone, it must be concluded that the ore deposition took place through water channels cutting through this sandstone; but the occurrence

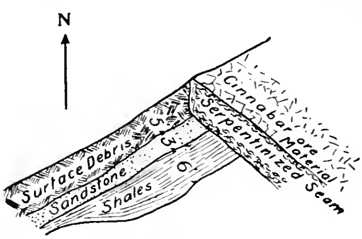


FIG. 46. Elevation open cut (*b*), Cerro Bonito Mine.

of the recemented breccia so extensively overlying unaltered and undisturbed sandstone is as yet unexplained. The large bodies of black gouge (attrition products), showing very important movements in the strata resting upon these same sandstone beds, render the explanation all the more difficult. It is hardly conceivable that all this metamorphic material has been moved into its present position by dynamic action finding its center in Cerro Bonito Hill. The surface workings show a stratum of serpentine, or may be serpentinized material, underlying the breccia forming the croppings and lying unconformably on the sandstones and shales. [See Fig. 46.] The croppings southwest of the discovery point, wherein a short tunnel and a shallow shaft are located, are much more serpentinized and show some cinnabar all through in a softer, more weathered material than in the other croppings.

The cinnabar forms generally in the hard, siliceous brecciated material, which may be considered the gangue rock. It is claimed that very rich ore was found in the surface openings, though none is at present visible; it was probably in the softer and more open parts of the rock.

The vicinity of this mine is supplied with timber for both mining and fuel purposes. The mine is 3 miles from Llanada, a stage station 31 miles from Tres Pinos.

Clear Creek Mine and adjacent **Boston Mine,** also called the Monterey Mine. New Idria District. In Secs. 2, 11, and 12, T. 18 S., R. 11 E. Thomas Flint, of Hollister, owner. These mines lie on a line of croppings which run from the northern end of the Clear Creek mine in a direction about S. 30° E. to the Los Picachos mine, in Secs. 19 and 20, T. 18 S., R. 12 E.; passing through the Andy Johnson mine. They are not continuous, but show sufficiently to trace their line. These croppings are of a light yellow ochery material, traversed by a network of quartz veins and some serpentine seams. In places the rock contains a great amount of iron oxide, becoming brownish-red in color. The cinnabar appears to be scattered all through the rock in those places where it is mineralized.

The upper croppings of the Clear Creek mine, 590 feet above the level of the creek, have been extensively worked and a road has been built from there to the furnace in the creek. The lower croppings, 305 feet above the same level, also show extensive operations, and some good ore can yet be found on the dump. The cinnabar is scattered through the rock in crystalline aggregates and along the fracture seams. While no pyritic ore is found on the dump, it is more than probable that it will prove to be the same mass of silica, highly permeated with iron sulphide, found in the Los Picachos mine. Between the croppings and the creek level some remnants of an almost entirely covered-up tunnel can be seen, and a long tunnel has been run on the line of the croppings about N. 30° W. at the level of the creek, but is at present inaccessible. About one mile below this mine is a dismantled furnace.

Don Juan and Don Miguel Mines.—This group, also called the San Benito, and sometimes the Cody mine, New Idria District, is in Sec. 36, T. 18 S., R. 11 E., and Sec. 31, T. 18 S., R. 12 E. Estate of E. J. Breen, San Francisco, owner. The works are inaccessible, but judging from the dumps the ore forms in a shale interstratified with thin layers of sandstone, which in the rock exposed to the air is colored brown by oxide of iron. The cinnabar forms in the cross joints of the undisturbed rocks, and in crushed pieces along the fracture planes. The main tunnel is 45 feet above the level of the creek. The ore was followed down with a shaft until the water came in too freely to be handled. The strike of the croppings is northwesterly. To the southeast they abut against a body of sandstone, which can be seen, in the cañon running into the San Benito above the mine, to be overlying the metamorphic shales. The latter have an east and west strike, dipping southerly 70°.

Fourth of July Mine.—New Idria District. In Sec. 18, T. 18 S., R. 12 E. Thomas Flint, of Hollister, owner. This property is located on a line of croppings running about parallel to the northeast and lower down the ridge than those of the Andy Johnson. None of the old workings are accessible.

Mariposa Mine.—Stayton District. [See Santa Cruz Mine.]

New Idria Mine.—This property is situated in Secs. 29 and 32, and parts of 28, 33, 34, and 35, T. 17 S., R. 12 E., and Secs. 3 and 4, T. 18 S., R. 12 E. The New Idria Quicksilver Mining Company, owner; B. M. Newcomb, general superintendent, Oathill, Napa County; J. G. Finch, superintendent, New Idria, San Benito County. [See Mon. XIII, U. S. G. S., page 291; Report State Mining Bureau of Cal., VIII, page 483; XI, page 373; XIII, page 599.]

Several mines are embraced under this heading: as the Washington, New Idria, Sulphur Spring, Molina, and San Carlos mines. The mines were discovered and located in 1853, and several of them have been operated to a greater or less extent since that time almost continuously. The company operating the property at present acquired it by purchase in 1895, and has since made many and extensive changes in the earlier mining and reduction methods, so that the works of to-day present a different aspect from those described by Dr. Becker.

The New Idria mine is the principal and the largest profit-producer of all the mines of the group. Several miles of

PHOTO No. 12. VIEW OF NEW IDRIA.

underground work have been developed in this mine, of which over two miles are at present open.

The New Hope vein has not been worked for years, and what Dr. Becker called the stockwercks forms at present the

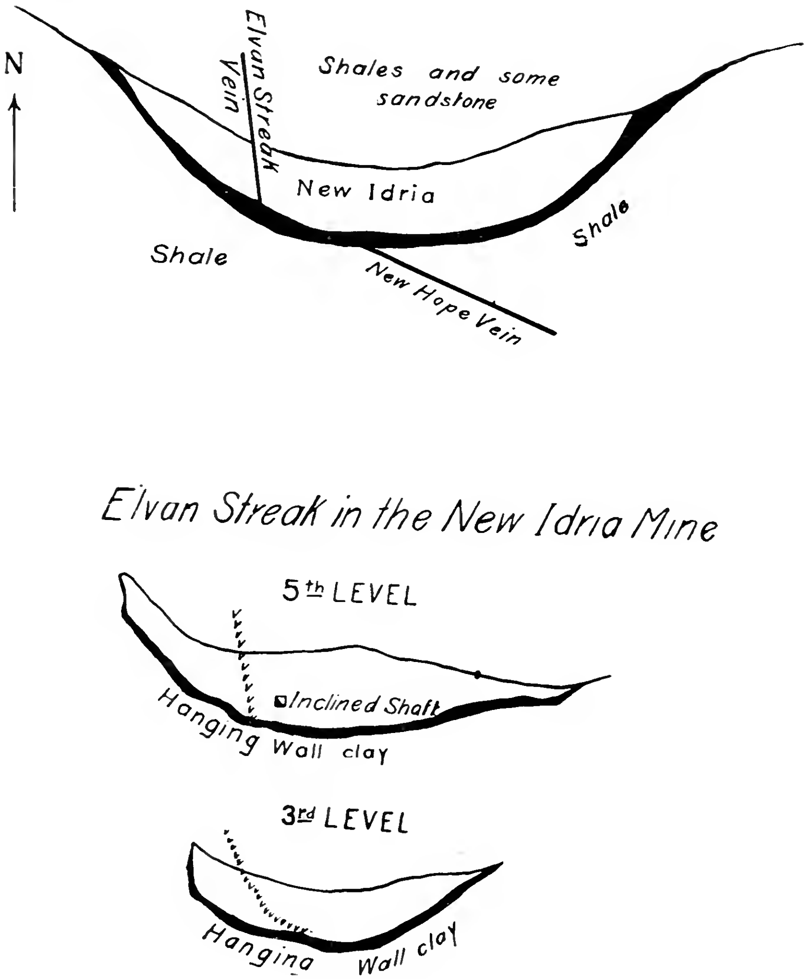


FIG. 47. New Idria Mine.

main worked ore deposit, called the New Idria. [See Figs. 47 and 48.] This deposit has been followed downward to the 700-foot level. Its hanging wall is the clay wall of Dr. Becker; the foot wall is a shale. The Elvan vein has been extensively worked, and is at present worked between the 500 and 700-foot levels. The Bell tunnel is at present inaccessible.

The accompanying sketch [Fig. 48] shows that the deposit has a southerly dip. The stratification of the rock in the ore body is, however, to the north.

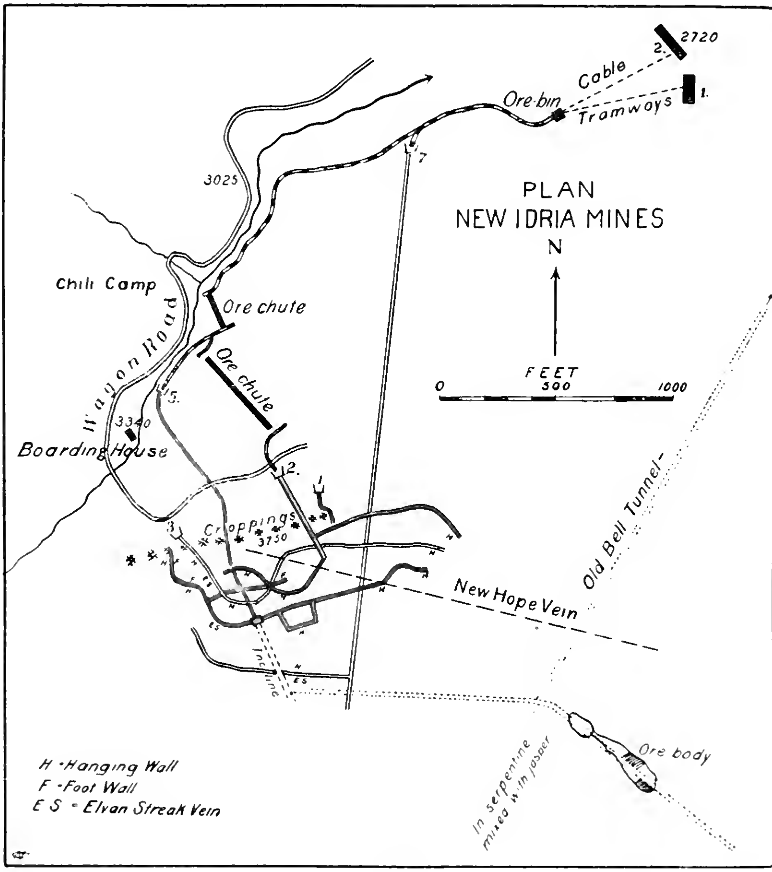


FIG. 48.

The ore makes as a rule in a more or less metamorphic sandstone, but occasionally in metamorphic shale. This deposit is strongly marked at the surface by a line of very bold croppings, in places standing out over 100 feet above the hillside. The general course of these croppings is about S. 80° W. The material of these croppings is a highly metamorphosed sandstone, wherein some less altered sandstone occurs and mixed with some indurated shale, in places containing a great amount of pyrites and their oxidation products. The rock, especially the softer parts, is impregnated with cinnabar, and small aggregates of cinnabar crystals are found disseminated through very hard rock. The fissures and cracks are often found filled with cinnabar, accompanied with calcite and some quartz. The ledge matter contains sensible amounts of sulphur.

Near the western edge of the croppings a very good exposure of the formation is found, showing the clay wall about 10 feet thick, course N. 50° E., dipping S.W. 65°, overlaid by shales, and in its turn overlying sandstone.

The serpentine is a few hundred feet from the New Idria vein at the surface, but does not form either wall permanently as far as at present developed. In the 500-foot level it occurs at the western end overlying the clay wall. [See Fig. 49.] In the 700-foot level a gouge seam containing serpentine is found in the ore body, which would lead one to expect that at greater depth the serpentine may become the hanging wall.

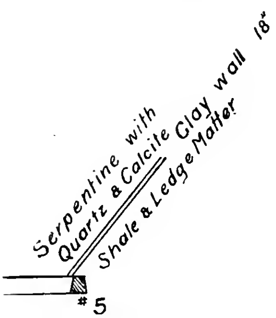


FIG 49. Section west end fifth level, New Idria Mine.

Referring to Figure 47, it can be seen that the ore body lies on an arc of a circle, the walls closing in at both ends. The Elvan vein is closely connected with the New Idria ore body, but the New Hope seems to be independent and, as Dr. Becker observed, does not appear to pass the clay wall to the northwest.

The New Idria vein is very persistent in depth; in fact, shows on the lowest level as good, if not better ore than in the upper part of the mine. The width of the workable ore bodies is very irregular. In places they are 100 feet wide; in other parts of the mine the entire body between walls is either barren or so low grade as to be unworkable. The average dip may be placed at 50°–55°. The cinnabar content of the different portions of the mine depends partly on the physical character of the rock. Where the latter is strongly crushed it contains more cinnabar, yet in places very hard rock is so thoroughly impregnated with cinnabar that it becomes good workable ore. The presence of the cinnabar in this hard rock can only be explained by deposition from solutions by circulating in sub-capillary channels, hence in the deep zone of rock flowage.

The ore is accompanied by sensible amounts of gypsum, due probably to the great amount of sulphur already mentioned. The clay wall is probably a gouge resulting from a movement between the strata, which faulted the formation, and at the place of faulting crushed the rock, thereby causing a zone eminently predisposed for ore deposition. The clay wall has as yet not been prospected any distance on either side of the New Idria ore body. It is probable that other ore bodies will be found on this line of fracturing. The ground in the mine is rather heavy, requiring square-set timbering and filling in the stopes.

Through a very well-conceived plan of chutes throughout the mine and by the use of an old incline shaft connecting the 500 and the 700-foot levels, all ore broken in the mine can be sent down to the latter level, from which point it is carried by tramway to ore bins located on the hillside above the reduction works, where, after passing over grizzlies, it is distributed by two gravity tramways to the fine and coarse ore furnaces respectively. A considerable portion of the ore treated is obtained from the surface, part of it being from the croppings before described, and part from the old dumps, the resultants of early years' working. Much of this material finds its way to the reduction works through the same channel as above described. [See Fig. 47.] Thus the cost of its transportation from the mine to the reduction works is minimized.

The timbers in the 700-foot level are coated with whitewash. By this very simple method these mining timbers, which were formerly covered by fungi and destroyed by the acids in the mine water within a few months, now remain entirely sound after having been in the mine over eighteen months.

The mine is equipped with a Scott fine-ore furnace handling 60 tons per twenty-four hours, and a coarse-ore furnace handling nearly 100 tons per twenty-four hours. [See chapter on Metallurgy, page 197.]

San Carlos Mine.—New Idria District. This is in Sec. 4, T. 18 S., R. 12 E., and forms one of the group of mines of the

New Idria Company. This mine was discovered in 1858 and was worked to a very limited extent—more in the nature of surface prospecting than as legitimate mining work; but in later years discoveries of very rich superficial ore bodies were made, and were worked over quite an extent of surface, with great profit to the owners. Late workings have so far failed to discover any deep deposits of value. As will be seen from the map of the district no serpentine appears at the surface in the ground covered by this mine. The country rock is principally metamorphic shales and sandstone. Some of the rock has the appearance of a probable igneous origin.

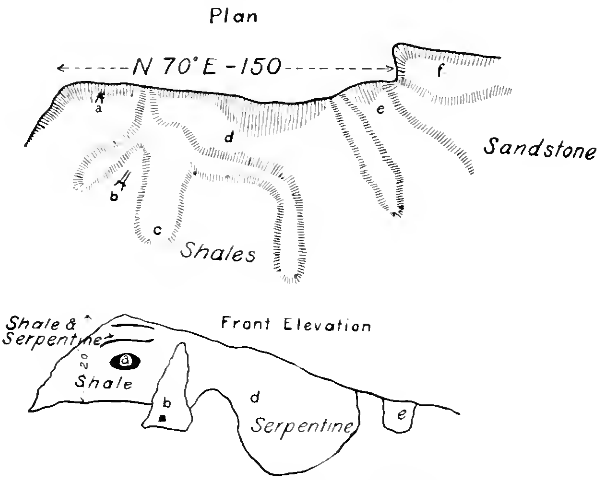


FIG. 50. Open cut, San Carlos Mine.

(*a*) Drift in altered shale.
(*b*) Sandstone carrying some cinnabar.
(*d*) Decomposed serpentine dipping a little north of east.
(*f*) Very hard silicified serpentine carrying cinnabar.

In the face of one of the open cuts [see Fig. 50] serpentine is found containing sensible amounts of cinnabar. This serpentine overlies the shales, and from the appearance of the cuts both the shales and the sandstone carried cinnabar; but this ore did not persist to any considerable depth. The ore formed in all formations, but the channels through which it reached the surface are as yet unproven.

Two tunnels have been run in a northeasterly direction from the northwest side of the peak under the open cuts, about 100 feet below their bottom. These tunnels run principally through metamorphic shale. Some ore was found in them, but not in such quantity or position as to justify the assumption that the channel through which these extensive deposits at the surface were fed has been intersected.

A crosscut tunnel, 260 feet below the latter tunnels and started from the south side of the peak, is now 1100 feet in, running on a course nearly N. 60° W., but has not reached the territory under the open cuts. This tunnel runs through metamorphic shales and sandstones. For the first 500 feet the strata are much distorted and crushed, but after passing through about 50 feet of indurated black clay, stratified in nearly vertical beds and having a strike of about N. 70° W., the formation becomes more regular, both the shales and sandstones having conformable strata. Nearer the breast sandstones prevail, while in the first part of the tunnel shales are the prevailing material. In a gouge seam, standing nearly vertical and cutting through sandstone, are found several quartz seams, some having large quartz crystals. Gypsum and calcite are found in the seams of the shales. Near the breast the sandstone has inclusions of fine-textured rock, and in some of the seams carries chalcopyrite.

Philadelphia and New York Mines.—New Idria District. In Secs. 23, 25, and 26, T. 18 S., R. 11 E. Estate of E. J. Breen, San Francisco, owner. They are located on a stratified shale, colored deeply red with oxide of iron. These shales have a strike about southeast, dip southwesterly, which strike brings them about in the direction of the Don Juan mine, higher up San Benito Creek. In the northwestern part of the property, in the Philadelphia claim, considerable work has been done, consisting of a tunnel 100 feet long, course northeast, a large open cut in the steep hillside, and a smaller cut with a short tunnel, 125 feet above the tunnel. There are no signs of cinnabar ore in the works or on the dump. In the New York mine little or no work has been done.

Ramirez Consolidated Mine (formerly Los Picachos Mine).—New Idria District. In Secs. 19 and 20, T. 18 S., R. 12 E. W. A. Stuart, and others, owners, No. 606 Montgomery street, San Francisco. This mine derived its name of Los Picachos from a series of bluffs cropping boldly above the hillside to an elevation of from 100 to 250 feet. These bluffs belong to the system of croppings showing at the surface in a line, having a course N. 30° W., from this mine across the Andy Johnson to the north end of the Clear Creek mine, a distance of over four miles. The croppings on this mine are not only bolder, but also delineate both sides of a body of siliceous rock cutting through the serpentine country, having a width of from 300 to 600 feet. To the southeast they can not be found further

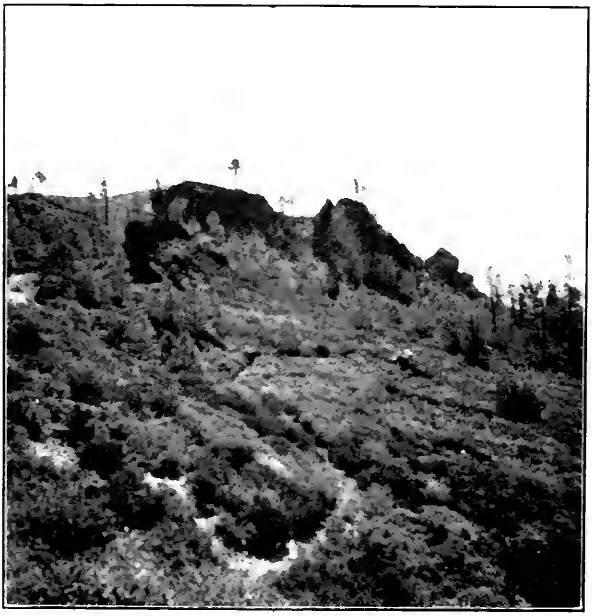


PHOTO No. 13. LOS PICACHOS MINE (RAMIREZ CONSOLIDATED)

than the southeastern Picachos Peak. Beyond the creek coursing around that knoll is only the barren serpentine, without any trace of mineralization. At the surface the croppings are highly colored by the oxidation of the iron pyrites, in places mixed with chalcopyrite, which is found in great amount in the unaltered rock. In the weathered rock cinnabar is found in the fracture planes in seams of more or less thickness; also in bedding planes and in places in crushed zones of the rock. In the unaltered rock, cinnabar occurs mainly as a coating of vugs. After this cinnabar was deposited a posterior deposition of silica took place, covering the cinnabar. The rock itself is not impregnated with cinnabar, probably due to its compactness. The face of the bluffs shows a stratification in the rock forming the croppings; in the southeastern part of the property the strata have a strike S. 40° E., dipping N.E. 60°. The cinnabar is found in the bedding planes; in other places cinnabar is found in the joint planes. In the northwestern part of the mine these strata have a strike N. 30° E., and dip southeast. The line of the croppings is not quite straight, while in the southeast portion the strike is parallel with that of the croppings; it is across that of the croppings in the northwestern portion.

There are a great number of old workings, which at present are inaccessible, and the remnants of an old furnace. The present owners are doing some surface development, having some good ore at the surface. The mine is equipped with a 12-pipe retort furnace.

Santa Cruz and Mariposa Mines.—Stayton Mining District. In Secs. 20, 21, 28, and 29, T. 11 S., R. 7 E., at the western foot of Mariposa Peak. H. French, of Lone Tree, San Benito County, owner. [See Report State Mining Bureau of Cal., XII, pages 365 and 366.] These mines are in a very thoroughly decomposed igneous rock. The old works give out very strong sulphur emanations. In former years they yielded some quicksilver by retorting, but are at present virtually abandoned.

Stayton Mines, including the **Gypsy,** are located in Secs. 5 and 8, T. 12 S., R. 7 E., partly in San Benito and partly in Merced counties. The Stayton Mining Company, owner; S. H. Smith, secretary and general manager, Gilroy, Santa Clara County. [See Report State Mining Bureau of Cal., VIII, page 350; X, page 515; XI, page 371; XII, page 365; XIII, page 599.] These mines were discovered early in the 70's and worked for some years up to 1877. Considerable ore was taken out and worked in one ⌓ retort. The Gypsy mine, which now forms part of this property, was worked in former years by several parties. The last separate owner, the San Benito Mining Company, erected a 10-ton fine-ore Scott furnace, which, however, was never put in practical operation. It is stated that this property has produced between 800 and 1000 flasks by the retorting process.

The mines are located on both slopes of the main ridge of the Mount Diablo range. The principal cinnabar deposits are to the east of the range, mostly accompanied by some stibnite; but some cinnabar-carrying veins are found west thereof, in which territory, however, the principal ore deposits are exclusively stibnite.

The workings on the cinnabar deposits are very shallow; the deepest workings in the Excelsior mine are not over 140 feet on the dip of the vein. [See *g*, map of Stayton Mining District.] A tunnel (*f*) over 1200 feet long, in a direction nearly perpendicular to the general strike of the mineralized zone, cuts the formation at the deepest point at a vertical depth of about 300 feet. It is inaccessible, but judging from the dump the material is principally, if not exclusively, igneous. The strike of the mineralized zones east of the main ridge is nearly north and south, and from south of the cabin to *g*, a distance of over three fourths of a mile, the cinnabar-carrying ledge matter is exposed in several places, dipping west at an angle of about 45°. To the east of this zone lies in its southern part a belt of basalt. The ledge matter is an altered rhyolite, containing besides cinnabar, iron sulphides, gypsum, and occasionally some stibnite. In the southern part, North Star (*b*) and Graybuck (*a*) workings [see Fig. 51], this ledge matter is associated with a belt of chalcedonic quartz, and in places the cinnabar has formed as cavity filling associated with quartz crystallization. This ledge matter contains bunches of iron pyrites, in places rich in copper. In the northern part at *g* the cinnabar forms in a material which to the naked eye has the appearance of a breccia, but under the glass is shown to consist of a dark-colored, close-grained quartz, the darker coloring being due to iron and antimony minerals, with inclusions of much lighter-colored quartz. The ledge filling then shows strong sulphurization and silicification actions, both contemporaneous with the ore deposition. The main ledge is accompanied by a number of small fissures striking a little

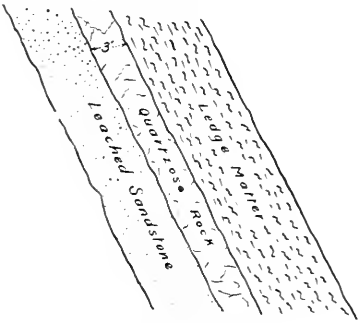
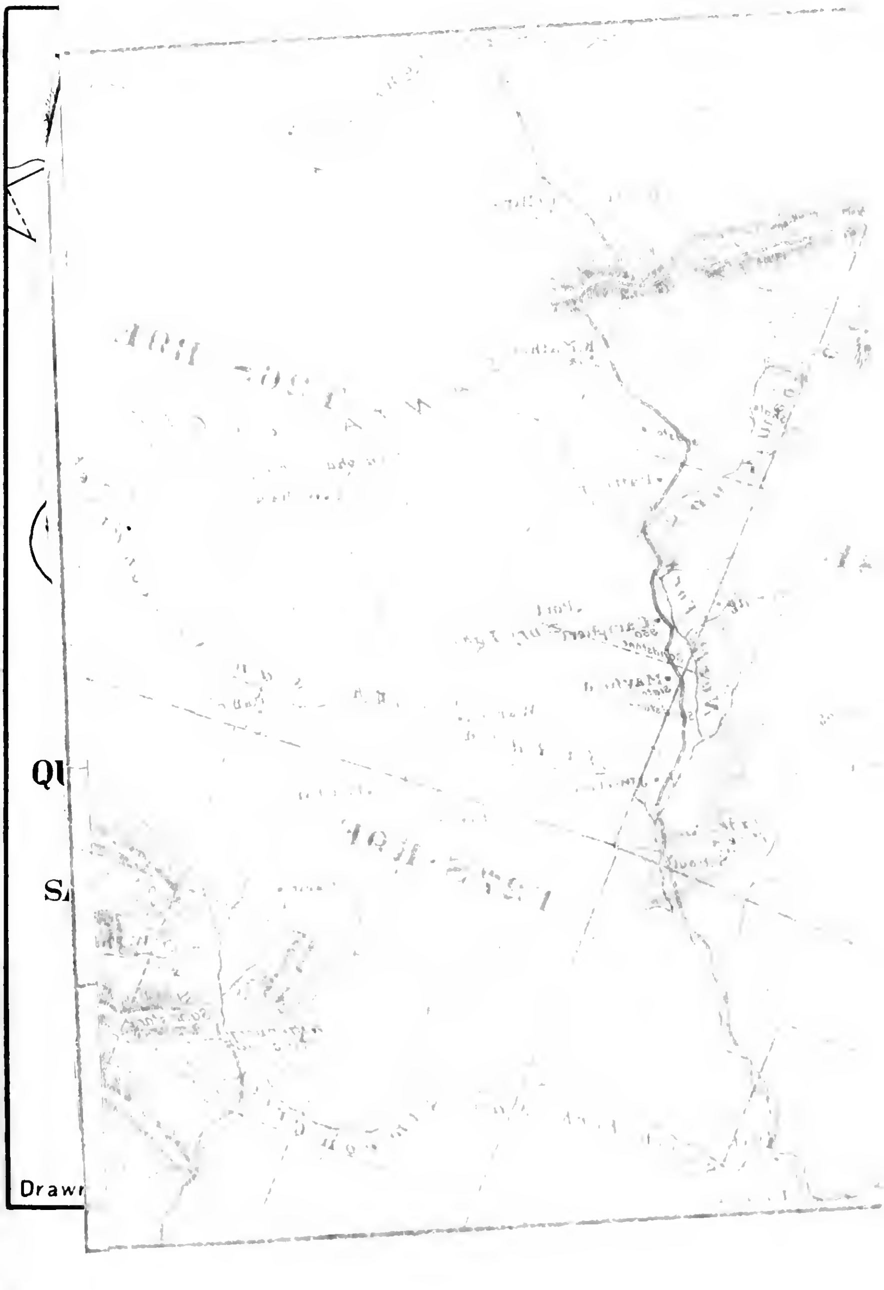
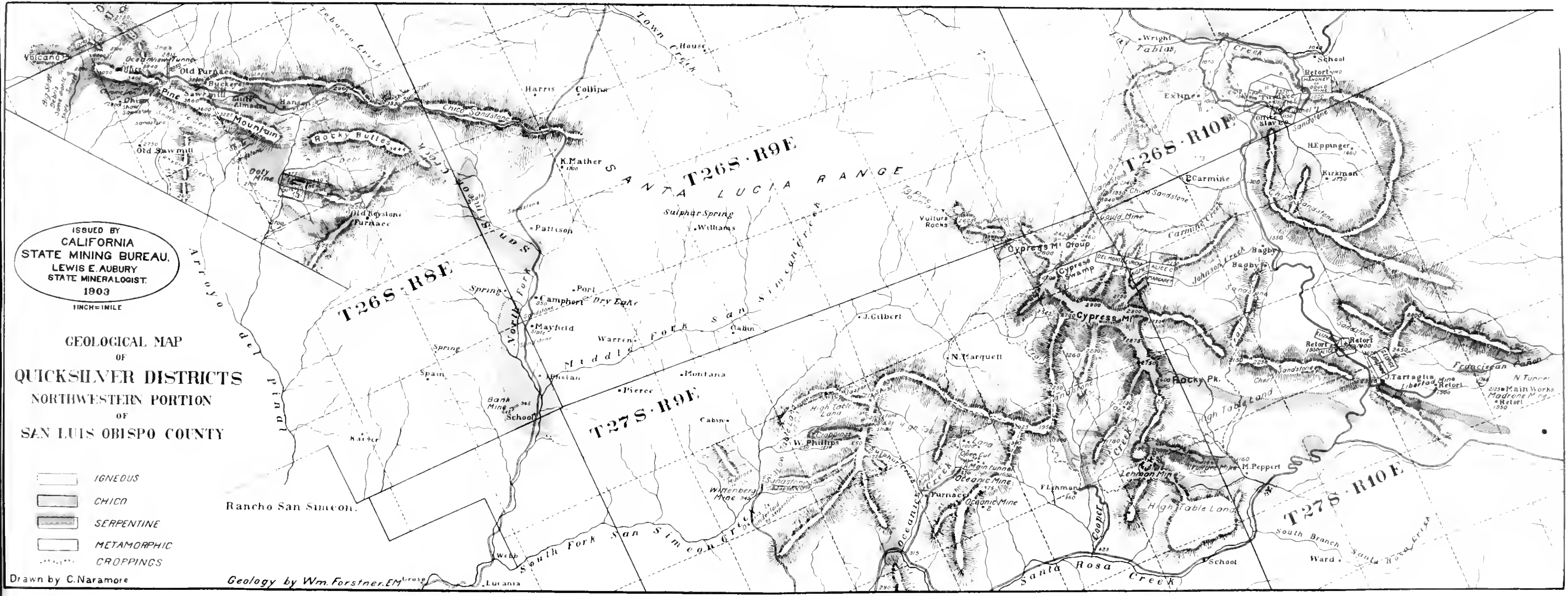


FIG. 51. Section at Graybuck shaft, Stayton Mine.





ISSUED BY
CALIFORNIA
STATE MINING BUREAU.
LEWIS E. AUBURY
STATE MINERALOGIST.
1903
1 INCH = 1 MILE
GEOLOGICAL MAP
OF
QUICKSILVER DISTRICTS
NORTHWESTERN PORTION
OF
SAN LUIS OBISPO COUNTY
IGNEOUS
CHICO
SERPENTINE
METAMORPHIC
CROPPINGS
Drawn by C. Naramore
Geology by Wm. Forstner. EM
T26S·R8E
T26S·R9E
T26S·R10E
T27S·R9E
T27S·R10E
SANTA LUCIA RANGE
Arroyo del Pinal
Rancho San Simeon
South Fork San Simeon Creek
Middle Fork San Simeon Creek
North Fork
Santa Rosa Creek
Oceanic Mine
Cypress Mt
Rocky Pk.
High Table Land
Franciscan Cañon
Chico Sandstone
Rocky Butte
Pine Mountain
Old Furnace
Old Sawmill
Old Keystone Furnace
Sulphur Spring
Cypress Mt Group
Cypress Swamp
Gould Mine
Lehman Mine
Main Works
Madrone Mine
Williams
Pattison
Mayfield
Phelan
Pierce
Montana
Gilbert
N. Marquett
M. Peppert
F. Lehman
Cooper
Webb
Lurania
School
Bank Mine
Wittenberg Mine
W. Phillips
Vulture Rocks
Carmine Creek
Johnson Creek
Bagby
H. Eppinger
Kirkman
P. Carmine
Exline
Wright
Las Tablas Creek
Town Creek
Tobacco Creek
Harris
Collins
K. Mather
Ward
South Branch Santa Rosa Creek

east of south and dipping nearly vertical, running from the west to the main ledge both in strike and dip, a number of which contained some very rich ore, especially near the surface, but none has as yet been followed to its contact with the main ledge; hence the question whether or not they belong to the same fracture system is as yet unanswered.

As above stated, antimony forms the principal metallic ore west of the ridge, yet two cinnabar deposits are found there, close to the top of the main ridge. One, the Pacific (*h*), is situated on a belt of sandstone running north and south, dipping east 75°, having a seam of cinnabar ore 18 inches wide. In close vicinity are found stibnite croppings, striking northwest and dipping northeast. The other cinnabar deposit (*l*), near the road on the divide, is associated with a prominent belt of leached siliceous rocks, showing very peculiar cavities.

SAN LUIS OBISPO COUNTY.

General Geology.—The Santa Lucia range and its spurs cover the northwestern part of San Luis Obispo County, in which section are located nearly all the quicksilver deposits of the county. They are located in zones separated by large sections of country, which sections, as far as yet ascertained, are barren. In the northwestern part of this territory near Pine Mountain there is a line of cones formed of rhyolite, having a general northwestern direction. The cones, while close together, are not connected at the surface. Near Pine Mountain, among the débris of the rhyolite covering the slopes of the cones, are found bowlders of diorite, indicating prior igneous eruptions.

In the Adelaide and Oceanic districts some scattered exposures of rhyolite are found, which have no apparent relation to each other; hence nothing can be inferred relative to the dislocations which caused these eruptions. The serpentine lies principally on the west slope of the main ridge, where it has caused enormous slides, due to its deterioration by atmospheric influences. Its principal exposure is at Cypress Mountain, where, at several places, its contact can be seen with the underlying partly altered sandstones. The entire appearance of the serpentine mass tends to the supposition that it is an altered peridotite. In one place on the northwest slope of the mountain some signs of induration by contact met-

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Adelaide District.—This district comprises the main range from Cypress Mountain, in Sec. 1, T. 27 S., R. 9 E., to the Madrone, in Sec. 22, T. 27 S., R. 10 E., with the territory on the northeast slope, covering the headwaters of Las Tablas and El Paso Robles creeks. The rocks of this district belong prominently to the Franciscan or metamorphic series, principally sandstones, with occasionally some shales, and in a few places exposures of chert beds. One wide body of serpentine is found at Cypress Mountain, extending southward past the headwaters of Santa Rosa Creek. The whole belt has a northwest trend, and a narrower and shorter belt of serpentine lies west thereof. In the northern part of the district, on the main ridge, north of Cypress Mountain, is an exposure of rhyolite, belonging to the scattered exposures above mentioned; it has a northern trend, but is of relatively small dimensions.

The territory comprising this district must at one time have been covered by the Chico series. It is bounded on the east and northeast by the Chico sandstone, and in places larger and smaller patches of the same are found on the top of the ridges, the Franciscan rocks being exposed lower down the hillside or in the cañons. At the contact, the Chico sandstones are so much broken up and contorted that it is impossible to give any data as to the strike and dip of the beds.

A line of croppings which can readily be followed runs in a northwesterly direction through this district; though more or less parallel to the direction of the main ridge of the Santa Lucia range, this line is clearly independent thereof. These croppings, starting from the southern part of the district in the Madrone property, run continuously through the La Libertad, Josephine, Alice, Modoc, and Elizabeth mines. Then they become much less prominent and only show occasionally in the ridge between Johnson and Carmine creeks and farther north toward the Cypress Mountain group. The Karl and Mahoney mines are situated on a belt entirely disconnected from these croppings.

The ore in this district is generally a whitish quartzose material, containing small inclusions of serpentine, the cinnabar forming principally in the seams, which show signs of later silicification. The cinnabar is often accompanied by sensible amounts of iron sulphides, which by their oxidation near the surface give an ochery yellow color to the ore. As a rule, the ore carries more iron sulphides as the cinnabar contents increase. The ore bodies are contiguous to more or less extensive strata of dark-gray to black-colored clays, mixed with bowlders of lighter gray-colored sandstones. They are of the same nature as that of the black clays, generally associated with quicksilver deposits—"alta," only here they are almost invariably indurated. Their outcrops frequently accompany those of the ore bodies; they are of a light gray color, having the appearance of a disintegrated sandstone, traversed by a network of narrow seams of an ochreous yellow color; in places small inclusions of serpentine are found. This material, while contiguous to the ore deposits, is always barren of cinnabar.

A great amount of work has been done in this district, especially between 1867 and 1872; but in no mine, except the Karl, has sufficient development work been done to enable one to judge as to the behavior of the ore bodies in depth. In several properties the surface disclosures would fully justify systematic development work. The policy, however, seems generally to be to hunt for pockets of rich ore, which is treated in retort furnaces, instead of opening large bodies of furnace material.

Oceanic District.—This district is situated on the west slope of the main Santa Lucia ridge, and covers the headwaters of the north fork of Santa Rosa Creek, Cooper Creek, and Oceanic Creek (the three northern forks of Santa Rosa Creek) and the divide between Santa Rosa and San Simeon creeks to the south fork of San Simeon Creek, including Secs. 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 24, T. 27 S., R. 9 E., and Secs. 18 and 19, T. 27 S., R. 10 E. The geology of this district is very complicated. The rocks belong almost exclusively to the Franciscan series, except in the southeastern corner, where the younger formations overlie this series.

There are several scattered exposures of rhyolite in this district, which apparently, however, have no relation to the location of the ore deposits. There are very clearly defined lines of croppings, having a northwestern direction; one, starting in the Vulture mine, crosses the divide and runs through a part of Cooper Creek basin; another, starting southwest thereof, crosses the divide between Cooper and Oceanic creeks, on the ground of the Oceanic No. 2 mine, and runs through the Oceanic mine. A third line of croppings lies northeast of the latter, and may be those of a second or back ledge found formerly in the old works of tunnel No. 4 and below in the upper shaft levels of the Oceanic mine. These croppings go some distance farther northwest, but do not reach the divide between Santa Rosa and San Simeon creeks. On this divide a very bold line of croppings starts northward, forming a contiguous line of bluffs about a quarter of a mile long, flanked on both sides by serpentine, which, however, appear not to carry any cinnabar. The principal material of the croppings is a rather light gray, flinty quartz.

The principal rocks exposed at the surface are, besides the rhyolite above mentioned, sandstone, shales, some chert, and occasionally some serpentine. The sandstone is generally much decomposed, with a brownish or greenish gray color, but not nearly as much silicified as in the Adelaide district. The deep erosions and the fact that the country is continually sliding, lead to the supposition that a large part of the underlying rock is more or less serpentinized, which is confirmed by the fact that in most of the gulches the hard sandstone is found underlaid by shales or serpentine.

In the Lehman property the younger sandstones are found impregnated with cinnabar in close vicinity to the rocks of the Franciscan series, which would tend to show that the period of ore format on was posterior to that of the deposition of those Upper Cretaceous or Eocene rocks. As this deposition was contemporaneous with, or closely following, a strong process of silicification, the highly siliceous character of the ledge matter of most of the mines is readily explained, the Franciscan series having already undergone a prior process of silicification.

Pine Mountain District.—This district is characterized by the great amount of exposures of rhyolite. These rocks are lying in a series of prominent knolls, the débris covering such wide territory that it is impossible to give any estimate of the width of the belt, which, however, is certainly from 100 to 400 yards wide. The outcrops are not continuous, but are separated by short exposures of the Franciscan series. To the west lies a wide belt of serpentine, which rock only shows to the east in the territory of the Pine Mountain group. The entire western slope of the main ridge and that part of the eastern where the serpentine occurs, show extensive slides. Near Rocky Butte, the Chico sandstone lies quite close to the igneous rocks. The enormous amount of débris prevents the observation of any contact metamorphic phenomena. Some bowlders of diorite are found, but none in place. The location of these bowlders would suggest that the vents through which the rhyolite was ejected were old lines of fracturing. The ore deposits are all very close and more or less parallel, but not, as far as yet developed, in direct contact with the igneous rocks.

San Carpojo District.—This district, in the extreme northwestern corner of the county, includes part of Monterey County. This country is very deeply eroded and the sidehills are very steep. The country between San Carpojo Creek and the ocean is prominently a highly silicified Franciscan sandstone. To the east of the creek and forming the backbone of the main ridge is a wide belt of serpentine, along which, on its western line, runs a belt of croppings, which, it is claimed, can be traced from Pine Mountain to the northern watershed of Salmon Creek, where cinnabar has been found in these croppings. In the basin forming the headwaters of the west fork of San Carpojo Creek runs a minor, more local, parallel belt of serpentine, west of which are the croppings on which the Dutro mine is found, and on the ocean slope detached patches of serpentine can be found. There are through this country, besides the cinnabar outcrops, several outcrops of gold ore, on some of which prospecting is being done.

The Adelaide and Oceanic districts are not very well timbered. On Cypress Mountain some durable cypress mine-timber can be found, and to the north thereof there is some good pine timber. The amount of available fuel is also restricted. The Pine Mountain district is better provided with timber. The Pine Mountain mine is equipped with a small sawmill, and there is considerable fuel timber in this district. The cost of timber in the Adelaide district is: round timber, 7 cents per linear foot; lagging, 6 cents apiece; cordwood, \$3.25 per cord. In the Oceanic district, round timber, 3½ cents per linear foot, to which must be added $8 per load for hauling; lagging, 5½ cents apiece; sawed timber, $15 per 1000 feet (B. M.); cordwood (pine), $4 per cord.

The Adelaide district connects with the railroad at Paso Robles, distant from 16 to 20 miles. For the southern part of the district steamship connection is made at Cayucos, distant about 12 miles. The Oceanic district is from 16 to 19 miles from San Simeon, another steamship shipping point. The Pine Mountain district is about 10 miles distant from San Simeon.

Alice and Modoc Group.—This lies in Adelaide District, in Sec. 17, T. 27 S., R. 10 E. California Consolidated Mining Company, owner; Wm. A. Stuart, No. 606 Montgomery street, San Francisco. There are most probably two separate ore deposits in this property. [See Fig. 52.] One, having a course N. 50° E., and a southeasterly dip, is worked from the surface down to a drift (*a*) 75 feet deeper (vertical), and showing there over a length of 40 feet on the strike, the ore body going farther at both ends. The width of the ore body is certainly 8 feet, but the roof is still in ore. From this level an understope 35 feet deep on an incline of about 45° is in progress. Another ore body, having a course N. 70° E., and a southeasterly dip, lies about 200 feet south of the former. It is opened from the surface to a level (*b*) 30 feet (vertical) lower, where it is worked out to a length of at least 60 feet on the strike, and a width of from 6 to 7 feet. Below this level it has been partially worked, and a chute connects this work with the lowest tunnel (*c*), which is on a level with the retort, and 215 feet vertical below the upper works. At the point where the chute connects with this tunnel, 583 feet from mouth, the course of the ore body is nearly east and west, dip south. The same ore body is cut by the tunnel 460 feet from mouth, showing a width of 10 feet, and standing nearly vertical. The property is equipped with two 12-pipe retort furnaces.

Bank Mine.—Pine Mountain District. In Sec. 36, T. 26 S., R. 8 E. E. S. Rigdon, of Cambria, owner. The country rock of this property is entirely serpentine; the ledge matter is a highly silicified serpentine, carrying cinnabar, which latter is also sparingly disseminated through the adjacent serpentine wall material. The tunnel was caved and inaccessible. The

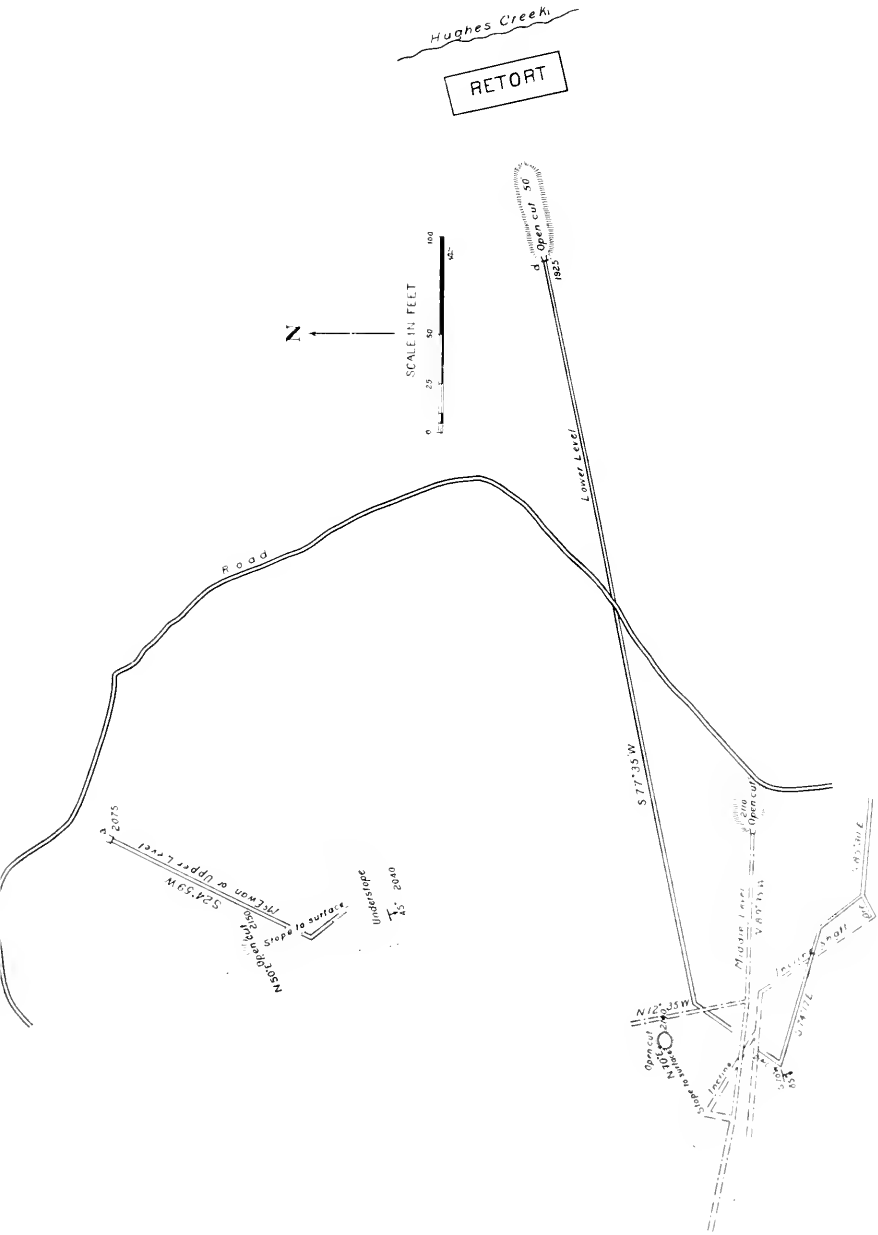


FIG. 52. Plan of Alice and Modoc Mine.

croppings indicate a very flat ledge, strike nearly east, dip north, which is well charged with cinnabar.

Cypress Mountain Group.—Adelaide District. In Secs. 1 and 2, T. 27 S., R. 9 E. J. H. Follis, of San Francisco, and E. Smith and W. S. Forrington, of Paso Robles, owners. This group of mines is located near the only exposure of igneous rocks appearing in this district, and near the prominent serpentine exposure of Cypress Mountain. The dike of rhyolite, about three quarters of a mile long and 800 feet wide, runs about N. 30° W. On the west side lies a readily traceable line of croppings, which has, however, only been superficially opened at one point, in the northwest corner of section 1, by the Columbia tunnel; the material taken out of this tunnel prospects very fairly in cinnabar. Most of the work has been done on the northeast side of the rhyolite dike; on this side the croppings are not very plain, and scattered. In one tunnel an ore body has been cut about 10 feet wide, in a black clay gouge with sandstone bowlders; whether a ledge or a lens of ore can not be stated. On the hanging wall, but apparently belonging to the ledge filling, is a stratum of cherty quartz about 12 inches thick.

Doty Mines.—Pine Mountain District. This property comprises five claims lying adjacent to the northwest of the Quien Sabe mines, in Sec. 14, T. 26 S., R. 8 E. Doty Brothers, of Cambria, owners. The lower tunnel, about 75 feet above the creek level, is inaccessible. Judging from the dump the ore deposit is formed in highly silicified serpentine. Some of the quartz seams have in their center a very narrow seam of cinnabar; in other samples the cinnabar forms in the center of quartz bunches, indicating that the cinnabar deposition is connected with the silica formation, but posterior to the latter. A short tunnel, 25 feet above the lower tunnel cuts very near the entrance, a ledge having a course nearly east and west, about 20 feet between walls. The hanging wall is a very coarse sandstone. The gouge is very solid, the dip nearly vertical. The foot wall, while too near the surface to be absolutely determined, is probably shale, the foot-wall gouge being much softer; its dip is very flat, nearing the hanging wall on the dip.

Elizabeth Mine.—Adelaide District. In Sec. 17, T. 27 S., R. 10 E. H. Eppinger, of San Francisco, owner. This property lies adjacent to the Alice and Modoc, on a line of croppings running N. 30° W. Some surface openings show that bunches of ore have been taken out. The rocks show some signs of cinnabar. A crosscut tunnel, running east toward these croppings, was inaccessible. The dump showed nothing except clayey material. Another tunnel, running from the road in a southeasterly direction, about east of the retort, was also inaccessible. The property is equipped with a 10-pipe retort furnace.

Eureka Group.—Adelaide District. In Secs. 6 and 7, T. 27 S., R. 10 E., and Secs. 1 and 12, T. 27 S., R. 9 E. Mr. R. Wear, of Paso Robles, owner.

George and Josephine Group.—Adelaide District. In Secs. 18 and 20, T. 27 S., R. 10 E. L. G. Sinnard, of Paso Robles, and J. Tartaglia, of Klau, owners. [See Report State Mining Bureau of Cal., X, page 580.] This group lies between the Alice and Modoc and the La Libertad mines, and shows some surface croppings and some shallow tunnels. When formerly worked a small furnace was erected on the property. The old works are inaccessible.

Karl Mine.—Adelaide District. In Sec. 33, T. 26 S., R. 10 E. The Karl Quicksilver Mining Company, owner; J. Bagby, of Klau, San Luis Obispo County, superintendent. A line of croppings runs through this property, entering it in the southwestern part on an east and west course, but turning very shortly after entering the property to a southeastern direction. The character of the croppings also changes a little, in so far as they get a little less ochery than at their point of entrance. The workable ore bodies have been exclusively developed in the southeastern part of the property. A great amount of open cuts and extensive underground works have been made. The company has developed two principal ledges, running nearly parallel N. 50° W., dipping northeast, but approaching each other on the dip. The most southwestern ledge is locally called the serpentine ledge. Its foot wall is a belt of serpentine from 20 to 40 feet wide, rather siliceous in places, as in the tunnel wherein the shaft is located, taking a chalcedonic character; this serpentine, however, does not appear at the surface, but is capped to a depth of from 20 to 30 feet by the croppings of the gouge accompanying the ore deposit. The ledge matter of the serpentine ledge is a loose, coarsely-granulated quartz, carrying iron and mercury sulphides. The entire mass has a grayish-green color. Under the glass scarcely a trace of serpentine can be found among the granules. The color is given by the accompanying clay, which must be derived from the serpentine. In this loosely-granulated quartz are found bowlders of a very hard chalcedonic quartz and of a laminated, somewhat calcareous material. Some of the bowlders carry sensible amounts of cinnabar and pyrite; others are entirely barren, and their relation to the surrounding country rock is not clear. The hanging-wall material of this ledge, which forms also the foot wall of the second ledge above mentioned, is a slightly metamorphosed sandstone. Immediately on the ledge lies a heavy clay, colored green probably by sulphate of iron. The parallel ledge forms in a zone of what appears to be a crushed country rock, probably of a quartzose character, but having some clay in it, probably as a result of the attrition. The ore contains considerable iron pyrite and some free sulphur.

Both these ledges are well developed in the incline shaft sunk from tunnel No. 1, at an angle of 60°, to a depth of 155 feet from the level of the tunnel. The collar of the shaft is 125 feet below the surface. There are wide stopes in the serpentine ledge above the lower level, and the parallel ledge is also opened, showing clearly the difference in character of the two ore bodies, which, however, in this level are much closer together than at the surface. The strike of the ledges in the lower, or No. 3, level is N. 45° W.; the average dip is N.E. 45°. Crosscutting in the same level in a direction N. 35° E. from shaft about 100 feet, the parallel ledge above mentioned is cut, showing also important ore bodies. The foot wall of the ore zone is a chalcedonic material, probably serpentine altered by silicification, and colored green by sulphate of iron. This is underlaid by a dark-gray indurated clay mixed with a lighter, grayish-colored sandstone.

A great part of the product of this mine has been derived from large open cuts. At present, however, the main ore supply comes from the works in tunnel No. 1. The furnace is an 8-tile Scott fine-ore furnace, with fourteen brick condensers and ten stave barrel condensers.

Kismet Group.—Adelaide District. In Sec. 7, T. 27 S., R. 10 E. F. D. Frost and E. Smith, of Paso Robles, owners. The group comprises the Kismet, Margaret, and Alice C. claims. A short tunnel on the Alice C. claim shows some cinnabar-carrying rock near the mouth.

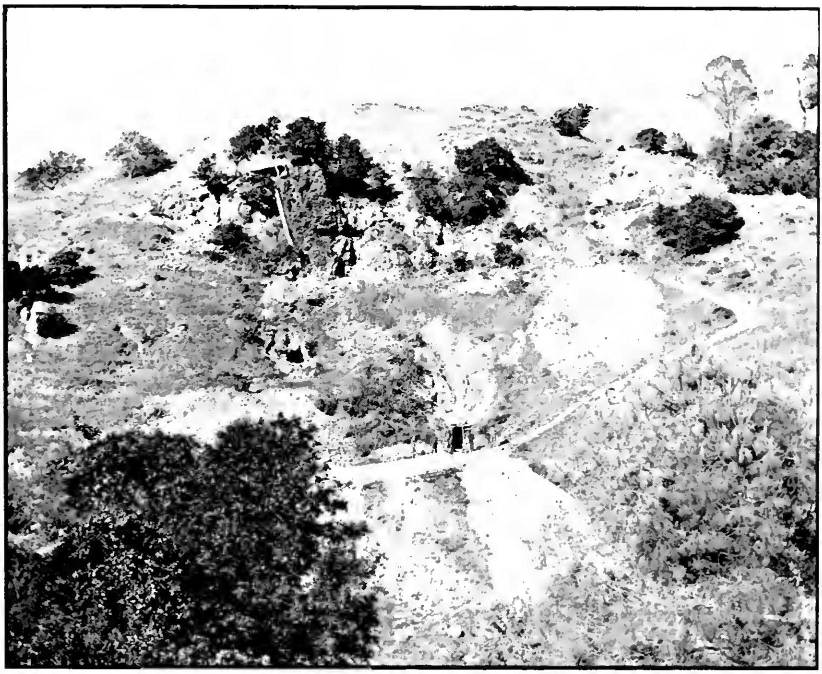


PHOTO NO. 14. LA LIBERTAD MINE.

La Libertad Mine.—Adelaide District. In Sec. 21, T. 27 S., R. 10 E. Libertad Quicksilver Mining Company (G. A. Trafton, of Watsonville, Santa Cruz County, president), lessee; owner, D. McEwen, Cambria, San Luis Obispo County. This mine is located on the contact of a prominent belt of serpentine and a sandstone belonging to the metamorphic series. The general trend of the croppings is northwest. While the croppings would indicate a regular strike of the ledge, the underground works have as yet only developed ore bodies having different strikes and dips, which latter are, however, all eastward or in the hill, as the accompanying sketch of tunnel No. 2 will indicate. [See Fig. 53.] These ore bodies lie in a dark-gray indurated clay, intermingled with a great number of sandstone bowlders carrying some serpentine. This material appears to be the contact zone of the sandstone and serpentine. The ore bodies are formed by rather hard quartzose bodies of a whitish color, having small serpentine inclusions, the cinna-

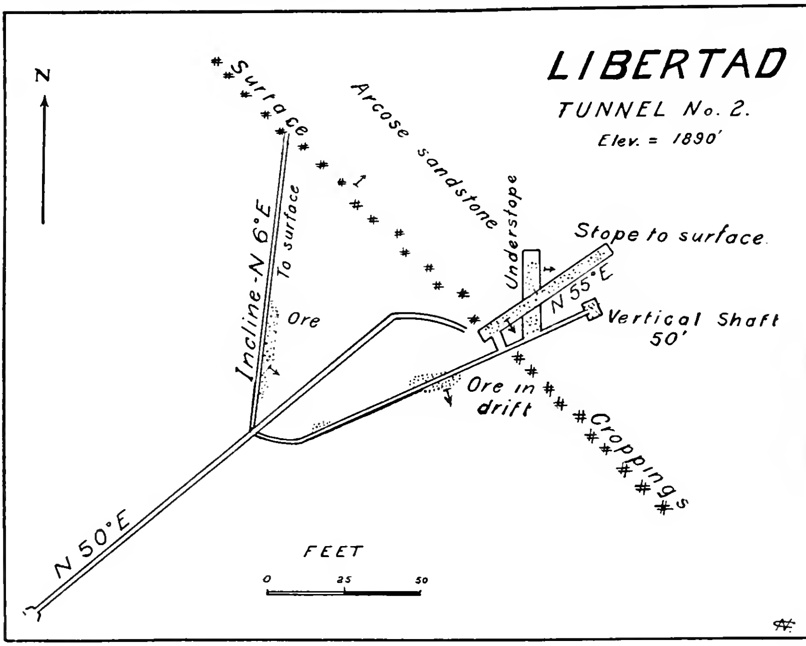


FIG. 53.

bar forming principally in the seams, sometimes one fourth of an inch wide, in a crystalline form.

Following about the same southeasterly strike, the croppings can be traced, until about a quarter of a mile below the retort the ledge crosses the creek, where the exposure shows the ledge with a width of from 8 to 10 feet, having a very rich streak from 6 to 8 inches wide, carrying metacinnabarite associated with the cinnabar; course N. 50° W., dip northeast; the ledge matter being prominently of a flinty character, and with a sandstone foot wall. The ledge in its southeasterly strike diverges from the serpentine and is entirely in the sandstone.

This exposure is 100 feet below the bottom of the shaft in tunnel No. 2, the lowest ore exposure in the northwestern part of the property, and distant therefrom about 1500 feet in an air line.

Southwest of the creek, the ledge crops out again. Panning from the dirt showed here free mercury, which does not show on the northeast side of the creek. The mine is equipped with a 10-pipe retort furnace.

Lehman Mine.—Oceanic District. In Sec. 13, T. 27 S., R. 9 E. F. Lehman, of Cambria, owner. This is in the Upper Cretaceous or Eocene sandstône; this sandstone is a white, fine-grained material, with conchoidal fracture; when broken the fracture planes have a black color and emit a bituminous odor. Strike nearly east and west, dip S. 30°. In the seams of this rock is a dolomitic gangue, carrying some cinnabar. The developments consist of a tunnel 40 feet long, about 200 feet below top of ridge, and a couple of shallow open cuts.

Madrone Mine.—Adelaide District. In Sec. 22, T. 27 S., R. 10 E. Madrone Quicksilver Mining Company, owner, 233 S. Broadway, Los Angeles. The development on this property consists entirely of surface work; the deepest accessible point is not over 25 feet below the surface. These surface works show very good ore, and in one place a well-defined vein, running nearly east and west and dipping very steep northward. The hanging-wall material could not be determined. It carries in places sensible amounts of bitumen. Next to the hanging wall occurs a hard flinty material carrying some cinnabar; then comes softer ochreous rock, in places very rich in cinnabar; and then a breccia on the foot wall, carrying some cinnabar. The foot wall is the indurated grayish clay and sandstone bowlders found in all the mines in the vicinity. The property is equipped with a 10-pipe retort furnace.

Mahoney (Buena Vista or Gould) Mine.—Adelaide District. In Sec. 33, T. 26 S., R. 10 E. J. J. O'Toole, Parrott Building, San Francisco, owner; A. Gould and G. Bell, of Klau, San Luis Obispo County, lessees. This mine lies east of and adjacent to the Karl, and very close to the Chico sandstone, which east and southeast of it apparently overlies the Franciscan series. Considerable work has been done in former times, and also by the present lessees, but no regular formation, either of ore deposition or of country rock, has as yet been developed. The ore is scattered in bunches through a partially indurated clay material mixed with sandstone bowlders, very similar in character to the foot wall of the ore zone in the Karl. Some of these ore bodies are of considerable size (one 400 feet in from tunnel No. 1 was from 10 to 15 feet wide and about 30 feet high), but they are without any regularity of arrangement. This property is equipped with a 10-pipe retort furnace.

North Star Mine (formerly Santa Maria).—San Carpojo District. In Sec. 13, T. 25 S., R. 6 E. William Gillespie and J. H. Alling, of San Simeon, owners. It lies to the southeast of the Polar Star.

Oceanic Mine.—Oceanic District. In Secs. 15 and 21, T. 27 S., R. 9 E. Oceanic Quicksilver Company, owner, No. 2 Baker Block, Los Angeles; A. B. Thomas, president; E. W. Carson, of Cambria, superintendent. [See Report State Mining Bureau of Cal., VIII, page 531; X, page 580; XII, page 366.]

This mine was actively operated from 1876 to 1879, and produced 7400 flasks of quicksilver in that period. The mine was only sporadically worked from that time until the present company came into possession. The latter has reopened the mine and just completed a Scott fine-ore furnace with a minimum daily capacity of 60 tons.

The development of this mine has been done partly by open cuts and partly by underground work. From the surface workings large bodies of ore have been worked out, their general strike being N. 55° W., dipping southwest. The ore bodies show considerable width, and their faces show that considerable ore is yet available for surface work, carrying sufficient cinnabar to be considered satisfactory furnace material. The underground works consist of several tunnels; the lowest tunnel, No. 4, cuts the vein at a depth of 250 feet below the surface. From this level a shaft has been sunk on the vein. The lowest level at present in operation in this shaft is 185 feet below the level of tunnel No. 4. The vein changes its dip to the northeast about 100 feet below the level of the tunnel. The dip, however, is nearly vertical. The strike of the vein is N. 60° W. The southern, or foot wall is a shale "mudrock," which material is rather prominent in the neighborhood of this mine and is very similar to the "mudrock" in the Manhattan and other mines. The real hanging, or northern, wall has not been reached in the underground works. On the ledge matter lies a belt of black clay, with inclusions of harder material very similar to that composing the foot wall. A crosscut 100 feet in length in the 185-foot drift has not cut through this clay selvage. The ledge matter proper (or the matrix wherein the ore makes) is a coarse grayish sandstone, rather compact, through which aggregates of cinnabar crystals and iron sulphide crystals are disseminated, the cinnabar not being confined to seams in the sandstone. The sandstone slakes very sensibly when exposed to the air, and carries some lime. These bodies of sandstone are rather close to the hanging wall. They are inclosed in the black clay, are not continuous, and lie without any regularity in the fissure, nor is the sandstone persistently ore-bearing. As far as observed, they are not connected, although it is not improbable that such is the case, as the clay can hardly have been the channel for the mineral-carrying solutions; they must have found their channel in the less impervious sandstone.

Oceanic No. 2.—Oceanic District. In Sec. 11, T. 27 S., R. 9 E. F. Lehman, of Cambria, owner. This property is located on the ridge between Cooper and Oceanic creeks, on a line of croppings running toward the Oceanic ground. There are some old tunnels, which are caved in.

Pine Mountain Group.—Pine Mountain District. Consists of a group of twenty-two mining claims and several tracts of timber land situated on and around Pine Mountain, mostly on the east slope of the mountain, in Secs. 3, 10, and 11, T. 26 S., R. 8 E. The American Exploration and Development Company, owner; M. Hoytema, care Jabish Clement, No. 212 Sansome street, San Francisco, and San Simeon, San Luis Obispo County, general manager. [See Report State Mining Bureau of Cal., VIII, page 531; X, page 580; X, page 581—Ocean View.]

The principal workings are situated on the east side of the body of rhyolite forming Pine Mountain, which is the most southern of three eruptive cones, very close together, but not connected and of slightly varying material, lying along the backbone of the main ridge. The igneous rock has covered a large territory on both sides with débris. The country rock belongs to the Franciscan series—shale, sandstone, and serpentine, the latter principally on the coast slope and in the southern part of the property from the Pine Mountain tunnel to the Little Almaden. East of the rhyolite of Pine Mountain, a line of croppings can be traced along the foot of the main eruptive body, but has, in many places, slid down the hillside. Most of the workings in the Buckeye, Little Almaden, and possibly the Pine Mountain, are located on such slides, but the Ocean View tunnel probably cuts the ledge in place.

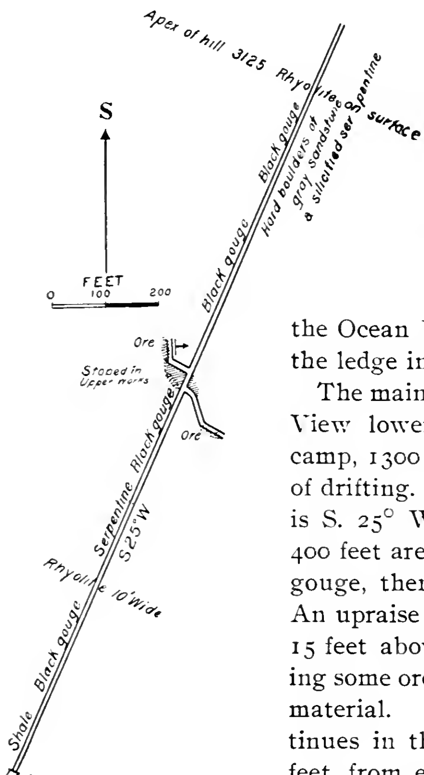


FIG. 54. Lower Ocean View tunnel, Pine Mountain Mine.

The main workings are: The Ocean View lower tunnel, just below the camp, 1300 feet long, still in progress of drifting. The course of the tunnel is S. 25° W. [see Fig. 54]; the first 400 feet are in shale and a black clay gouge, then come 10 feet of rhyolite. An upraise leads here to a short drift 15 feet above the tunnel level, showing some ore in a serpentine quartzose material. The main tunnel continues in this latter material to 610 feet from entrance, then to 786 feet in black clay gouge, where it crosscuts the main ledge on a very obtuse angle. The course of the ledge is nearly south, dipping east. The material is a flinty quartz, stained in places grayish-green by silicate of iron. The cinnabar occurs principally as paint, especially in bunches. Past this ledge to the breast the tunnel is in black gouge. Above the level of this tunnel considerable work has been done. A winze runs up 65 feet and two levels have been run above the tunnel level. There are also two old upper tunnels. Out of these works ore has been taken and treated in the pipe retort furnace.

On the Buckeye a shaft has been sunk on very good croppings, and a drift 350 feet long, S. 76° W., has been run, which connects with the bottom of the shaft at a depth of 78 feet, 300 feet from the entrance. The ore at the lower level is a flinty quartz. The surface is covered with rhyolite bowlders. The tunnel shows that the country is shale, and for the last 200 feet serpentine. This work is, however, most probably in a slide from the main body.

On the Pine Mountain a tunnel running nearly west is 300 feet long. The country rock is serpentine. The tunnel is inaccessible. Judging from the dump, the tunnel has cut serpentine and in the face shale.

The Little Almaden is an open cut. Work has been done on a large body of croppings in a body of serpentine, which shows clearly evidence of sliding.

Polar Star Mine (also called Santa Clara, or Black Hawk).—San Carpojo District. In Sec. 13, T. 25 S., R. 6 E. Owners, Public Administrator, G. E. Van Gordon, E. S. Rigdon, M. W. Minor, and R. A. Minor, of Cambria; S. N. Hitchcock, C. D. Hitchcock, F. H. Little, and W. Little, of San Simeon; H. H. Carpenter, of San Luis Obispo; P. A. H. Arate, of San Luis Obispo. [See Report State Mining Bureau of Cal., X, page 581; XII, page 366—Black Hawk.] This is an old mine; it has been worked sporadically since 1870 by different owners. There is a great amount of surface ore on the south side-hill of San Carpojo Creek, covering near the creek a distance of 250 feet, running 750 feet up the hillside and narrowing to about 40 feet at an altitude of 310 feet vertically above the creek; this surface zone is from 6 to 20 feet deep. Very rich ore has been found in this territory, but as yet the vein has not been exposed. Some exposures of what is probably the southern wall would indicate that the vein had an east and west trend. The country rock is almost exclusively highly silicified Franciscan sandstone. The property is equipped with a two ⌓ retort furnace in good order.

Quien Sabe Mine.—Pine Mountain District. Contains three claims: Quien Sabe Nos. 1, 2, and 3, in Sec. 14, T. 26 S., R. 8 E. G. E. Van Gordon and M. W. Minor, of Cambria, owners. The line of these claims is in a northwestern direction. All the work has been done on the northeastern claim, which abuts with its north end line against one of the branches of the Arroyo del Pinal. The igneous rocks of Rocky Butte lie very close and parallel to the east side line. The intervening space is in Franciscan sandstone. The two eastern claims are located so as to cover a ridge of serpentine, having sandstone on both sides. On both contacts are lines of croppings, charged with cinnabar. Those on the west contact of the serpentine are, however, the more prominent. An open cut on the western croppings shows good ore. The ledge matter is flinty material. Some garnets can be found in this rock. Both cinnabar and metacinnabarite occur in the vein matter. On the eastern croppings a shaft 100 feet deep has been sunk. The character of the ore is very similar to that of the western croppings. From the creek level a tunnel has been started nearly on the center line of the northeastern claim. This tunnel, 240 feet long, has not yet reached the ore deposit. Its face is in black gouge, with inclusions of grayish sandstone and igneous rock. At a distance of 750 feet it will be under the works above described, at a depth of 230 feet.

Rinconada Mine.—In Secs. 21 and 28, T. 30 S., R. 14 E. Mrs. Theresa Bell, of San Luis Obispo, owner. [See Report State Mining Bureau of Cal., X, page 581; XII, page 366.] This property consists of two claims and two millsites, located about 12 miles southeast from Santa Margarita, a station on the Southern Pacific Railroad, and 20 miles from San Luis Obispo. The property was worked from 1875 to 1883, and equipped with two furnaces—one of 20 tons, the other of 60 tons capacity. It was shut down in the latter year and practically abandoned. It was relocated in 1897. In 1898 a 10-pipe retort furnace was erected, but in 1901 the then owner, Mr. Petreida, died, and since that time no work of any consequence has been done on the property.

The country rock is almost exclusively serpentine. Some shale exposures are found in the bed of a creek about a quarter of a mile west of the main workings. The mine is located in a basin formed by a bend of the mountain ridge, and apparently filled by material broken off the ridge. Through this basin runs a line of croppings showing very boldly in the northwestern part of the Tenderfoot claim and in a cliff about a quarter of a mile northwest thereof, the entire intervening surface being covered by large bowlders of croppings. Due west of the first named place, topographically above this line of croppings in a gulch, croppings are also found. The main works consist of extensive open cuts, principally worked in the 70's, with short drifts and inclines—all in the croppings; a yellow ochery material held together by a network of chalcedonic quartz seams. A gulch, course N. 45° E., runs at the northeastern foot of the ridge on which the croppings are located, and three tunnels have been run under these croppings. The upper tunnel near the head of the gulch, 115 feet below the top of the ridge, is caved in. Judging from the dump this tunnel was run in serpentine and shale. Lower down the gulch is another short tunnel, about 50 feet long, entirely in serpentine. About 500 feet lower down in the gulch and about under the northeast edge of the croppings, 50 feet lower vertically than the first tunnel, is the third tunnel, running south about 200 feet, then S. 35° E., 200 feet. This tunnel is in serpentine. The breast is at the contact of the serpentine and the sandstone. About 30 feet from the breast, short crosscuts have been run on a fissure, having on the southeast wall a black clay gouge; a shaft or winze has been sunk in the northeast crosscut, but is covered up and is inaccessible. The country in the neighborhood is well supplied with oak timber for fuel purposes, but mining timber is rather scarce.

Sunset View Quicksilver Company.—San Carpojo District. Consists of a cluster of mines in Secs. 13 and 18, T. 25 S., R. 6 E. José Mariano, of San Simeon, owner. This is southeast of the North Star.

Vulture Mine.—Oceanic District. In Sec. 24, T. 27 S., R. 9 E. F. Lehman, G. E. Van Gordon, and E. S. Rigdon, of Cambria, San Luis Obispo County; A. F. Benton, of San Miguel, San Luis Obispo County; and G. W. Harris, of Pleyto, Monterey County, owners. This property is located on croppings of black, flinty, siliceous rock, more or less charged with cinnabar, in a belt of serpentine. Only very shallow surface work has been done, so that nothing which determines the persistence in depth or the form of the deposit has been disclosed. In one open cut a stratum of clay from 2 to 3 feet wide is exposed, which on panning shows to carry sensible amounts of cinnabar.

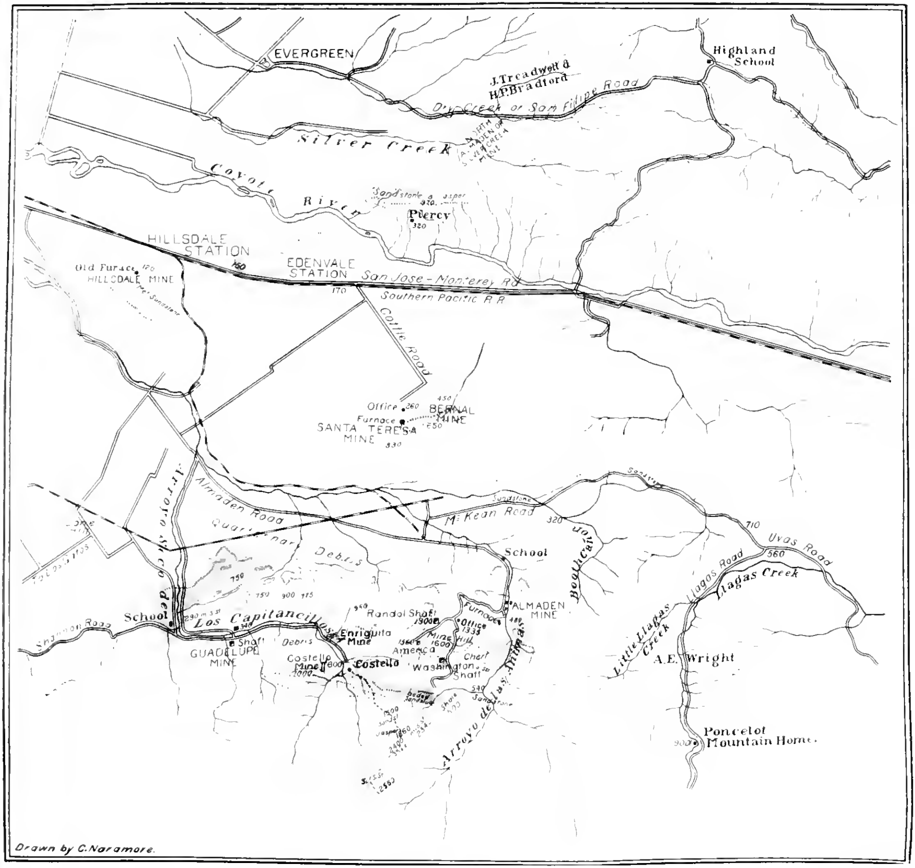
William Tell Mine.—Adelaide District. In Sec. 32, T. 26 S., R. 10 E. A. J. Brunoni, of Cambria, owner. This lies to the west of the Karl mine, on the same ledge of croppings. A tunnel 60 feet long has been run, but no pay ore has been found as yet.

Wittenberg Mine.—Oceanic District. In Sec. 8, T. 27 S., R. 9 E. D. F. Wittenberg, of Cambria, owner. This mine lies against a wide belt of "mudrock," but judging from the surface indications, is underlaid by serpentine. All works are inaccessible at present. The owner is at work reopening them.

SANTA CLARA COUNTY.

The New Almaden district lies southeast of San José, and covers part of the northeasterly foothills of the Gabilan range, and a portion of the Santa Clara Valley. [See map of the New Almaden Mining District.] Through the latter run two spurs of low hills having a general northwestern direction, both diminishing in elevation in this direction and disappearing a couple of miles southeast of San José, where the valley covers the entire territory between the Gabilan and Mount Diablo ranges. One of these spurs, the Santa Teresa hills, runs between the Arroyo Seco and Coyote Creek, and the other between Coyote and Silver creeks. The New Almaden and Guadalupe mines are situated on a ridge which forms the southeastern boundary of that part of the Santa Clara Valley having a general direction N. 45° W., and connected at one point with the main body of foothills of the Gabilan range. This ridge is cut through at the southeast by the Las Animas cañon, a very deep incision, in which are located the hacienda and furnaces of the New Almaden mine. It decreases gradually in elevation going to the northwest, and is cut off northwest of the Guadalupe mine by the cañon of Capitancillos Creek.

These three ridges are to a great extent formed by serpentine, especially the two first named. The serpentine is associated with metamorphic sandstone and jaspilites. Large bodies of croppings can be found in each of these ridges, having also a general northwestern trend, but not coinciding with the backbone of the ridges.



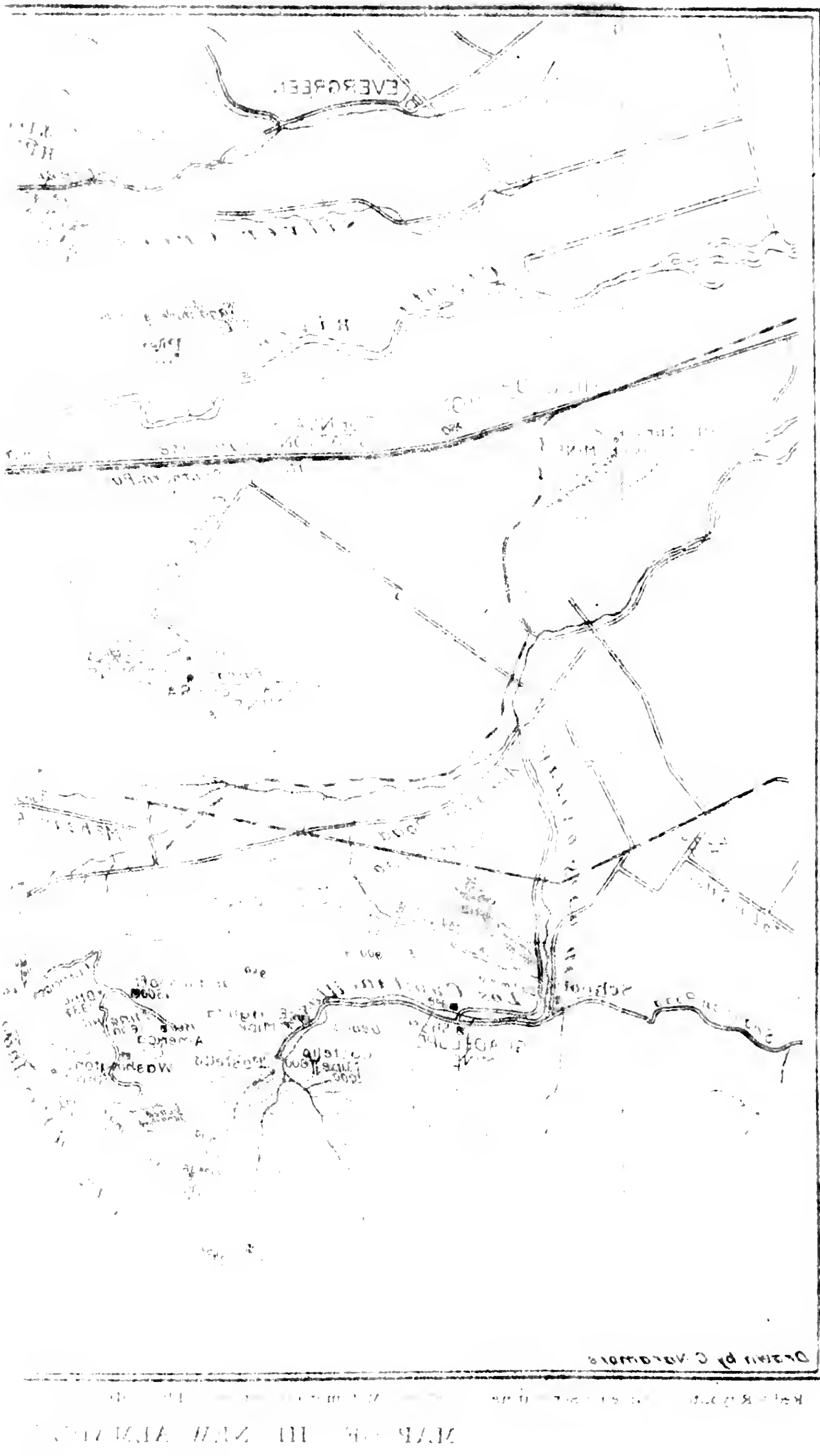
Red = Rhyolite Green = Serpentine Yellow = Metamorphic Series Blue = Miocene 1 inch = 2 miles

MAP OF THE NEW ALMADEN MINING DISTRICT.

Issued by the California State Mining Bureau Lewis E. Aubury, State Mineralogist, 1903.

In the New Almaden ridge the most extensive ore bodies have been found in and close to Mine Hill, the highest peak of the ridge, lying in its southeastern part. From this point going northwestward the croppings, while not continuous, can be traced along the ridge into the territory of the Guadalupe mine, a distance of about 3½ miles. At the surface the serpentine shows in large detached bodies surrounded by the sandstones and shales of the Franciscan series and having a general northwestern trend. This general direction of the serpentine exposures is important in connection with its occurrence underground, proven in the New Almaden mine. The line of ore croppings runs from Mine Hill to the America shaft, passing about 600 feet southwest of the Randol shaft. The underground workings in this territory have shown that the fissures wherein the ore bodies have formed have invariably a serpentine foot wall; hence the serpentine must be considered to occur underground in a continuous body through this entire territory and to be in places covered by overlying sandstones and shales. Southwest of Capitancillos Creek lies another parallel exposure of serpentine, contiguous to which the outcrops of the Costello mines are found. The Santa Teresa and Bernal mines are located in the serpentine of the Santa Teresa hills, and the North Almaden or Silver Creek mine close to those of the most northern ridge. In the latter a great part of the serpentine is very highly altered by silicification, as also the sandstones, a great portion of the rocks being jaspilites. The western slope of the adjoining Mount Diablo range is nearly exclusively formed of shales.

In this district the occurrence of cinnabar-carrying ore bodies is clearly closely allied to that of serpentine, and as the New Almaden was the first extensively worked quicksilver mine in California, this association explains the reason why, for a considerable lapse of time, cinnabar ores were, in the opinion of most quicksilver miners, considered related to this rock formation. The croppings consist of a more or less weathered material having usually an ochreous color from the oxidation products of the iron sulphides, and traversed by a network of quartz seams, from a knife blade to quarter of an inch wide. Overlying the ore bodies is almost invariably found a body of clay, generally black, and containing more or less inclusions of a dark-gray sandstone. As this clay overlies the



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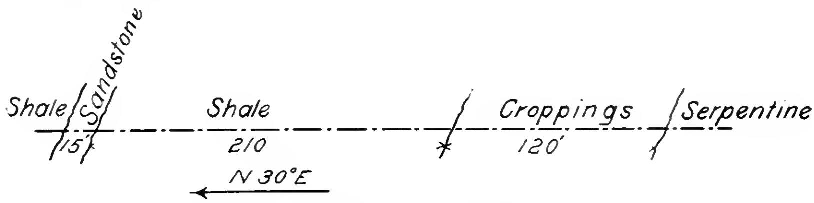


FIG. 55. Section near R. R. B. shaft, New Almaden property.

cropping of "alta" can be seen in San Luis Obispo County. [See general description of Adelaide district.]

In a few places a good section of the formation has been exposed at the surface, as for instance, the R. R. B. shaft of the Enriquita mine, northwestern part of the New Almaden mine, and near the Randol shaft of same mine. [See Figs. 55 and 56.] Both these sections indicate that the hanging wall

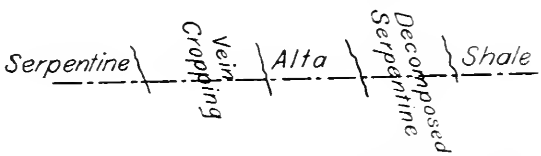


FIG. 56. Section on road above Randol shaft, New Almaden Mine.

proper may be a shale, which, however, is so decomposed at the surface that nothing can be said as to its actual character. About 300 feet below the collar of the R. R. B. shaft, in the Eldridge tunnel, the same formation can be seen underground, that is, the serpentine foot wall, the vein and the overlying "alta"; but as no crosscut has been driven through the latter, no further information as to the character of the hanging wall proper is available. The clay "alta" is but an attrition product of the movement of the walls of the fissure, and hence to call the "alta" a wall of the vein, as is frequently done, is a misuse of geological terms. The rocks of the Franciscan series in this region show a great amount of silicification. The chert beds are, however, almost entirely unrepresented.

To the west of the New Almaden ridge a belt of bedded sandstone is exposed. The beds are from 3 to 5 feet thick and interbedded with thinner beds of shale. The sandstone is rather coarse, and has been classified by Dr. Becker as Miocene. [See Mon. XIII, U. S. G. S., page 312.] The strike is about east and west, dip northerly, not over 20°. The country west of the New Almaden ridge and south of Capitancillos Creek, belonging to the Gabilan mountain system, consists almost exclusively of the sandstones and shales of the Franciscan series, with occasionally some jaspilites. A small exposure of serpentine was found about two miles west of the New Almaden ridge, close to the main ridge. West of the serpentine belt which lies west of the New Almaden ridge, south of Costello's house, a small exposure of glaucophane schist was found. A body of rhyolite lies in the northern part of the New Almaden ridge, having a nearly east and west strike and being about two miles long. To the east smaller bodies of rhyolite are found, probably the continuation of the same body, which must be covered up in the intervening space. This eruptive body apparently has no relation with the ore deposition in this district.

The general character of the ore tends more to the conclusion that the ore deposition was a feature of an intense silicification of the fractured parts of the serpentine; that the fractured zone was a favorable channel for the percolating solutions, which dissolved the ferro-magnesian silicates and other salts of the rock, and replaced them by silica, calcite, dolomite and allied minerals, sulphides of iron and occasionally of mercury; these channels being limited on one side by the impermeable stratum of clay, the "alta"; on the other side, by the limit of fracturing of the serpentine.

There are some small areas of limestone in this district. The most prominent are along the south bank of Capitancillos Creek, where near the Guadalupe mine a limekiln was in operation at one time. It appears, however, that the product was not quite satisfactory, which was due to the presence of bitumen in the rock.

Bernal Mine.—This is situated on the east slope of the Santa Teresa hills, about 8 miles southeast of San José and near Edenvale station, on the Southern Pacific main line. Ygnacio

Bernal, No. 207 Balbach street, San José, owner. This property is traversed by a ravine having a northeasterly course, draining into Coyote Creek; on both sides of this ravine, but especially on the northwest side, where the workings are located, are found some very prominent croppings. The latter are entirely surrounded by serpentine, but as far as ascertained do not connect with those on the southeast slope of the ravine. The direction of these croppings is about northwest. A tunnel, course nearly west, about 215 feet long, is run on the contact of the "alta" and the serpentine; about 30 feet from the breast a good exposure of the formation shows the vein to dip slightly northeast, with a clay gouge on both sides. A short crosscut to the left shows that the overlying gouge is at least 15 feet wide. The gangue is of a very calcareous nature. Nearly 200 feet above this tunnel, on the top of the ridge, a shaft 65 feet deep has been sunk on the croppings, showing some good ore on the dump. About 20 feet southeast of this shaft a shallower shaft, not over 20 feet deep, on the same croppings, shows a more ochreous vein material.

Comstock Mine.—This lies in the extreme southeastern corner of Santa Clara County, in Sec. 19, T. 11 S., R. 7 E., really belonging to the Stayton Mining District. H. French, of Lone Tree, San Benito County, owner. [Report State Mining Bureau of Cal., XII, page 367.] The property is at present abandoned. Some old surface workings and remnants of an old furnace can yet be seen. The mine is located on the only surface exposure of serpentine found in the Stayton Mining District. The ore found is a black chalcedonic quartz.

Costello Mine.—This lies on the southwest side of Capitancillos Creek, about 1½ miles southeast of the Guadalupe mine, and opposite the Enriquita mine of the New Almaden property. M. Costello, of New Almaden, Santa Clara County, owner. The principal workings in this property are located on the sidehill, about 400 feet above the level of Capitancillos Creek; below these, considerable limestone is found in the débris covering the sidehill, and also some croppings of the same rock, but at the level of the works this rock does not occur. The works consist of several shallow cuts and drifts in the débris covering the hillside. One tunnel reaches through the latter into the serpentine. In a crosscut from this tunnel a sandstone was found having on the fracture planes a thin black coating of iron and carrying some cinnabar. All through the débris pieces of ore are disseminated, composed of fragments of a flinty material, generally in a matrix of quartz; occasionally the matrix resembles the tuffoid of the Abbott mine, Lake County. The character of the ore is entirely different from that in the New Almaden ore bodies. No ore deposits in place have yet been found.

Guadalupe Mine.—This mine is on Capitancillos Creek, 10 miles south of San José. The Century Mining Company, owner; H. C. Davey, president, F. A. Lueddeman, secretary, San José, Santa Clara County; San Francisco office, room 1312, Claus Spreckels Building. [See Report State Mining Bureau of Cal., VIII, page 542; XIII, page 600; Mon. XIII, U. S. G. S., page 326.] This mine was discovered in the early 50's, being acquired soon after its discovery by the Santa Clara Mining Association of Baltimore, Md., and was operated by that company until the mine was bought by the Guadalupe Mining Company of California in 1875, when large surface improvements in the way of reduction works and mining machinery were installed and extensive mine development work was prosecuted. Up to 1886 the mine produced 55,910 flasks of quicksilver [see Mon. XIII, U. S. G. S., page 11], and then remained idle until 1900, when H. C. Davey organized the Century Mining Company, which has remodeled the reduction plant, started to unwater the mine, and is at present passing through the furnace a great part of the old dumps and some fillings of the upper parts of the old works. The unwatering of the mine has proven a very difficult undertaking, as the works are at a shallow depth under Capitancillos Creek, which drains a large section of the country.

From the plan of the old works it can be seen that the ore body developed by the main vertical shaft, located on the south side of the creek, had a northwest strike and southwest dip. The second level, 300 feet below the collar of the shaft, connects with an incline shaft started on the opposite bank of the creek and following the vein on its dip. The main shaft was only sunk to the sixth level (625 feet). From this level an incline shaft was sunk, from which the seventh, eighth, and ninth levels were driven. Ore was only developed in the seventh and eighth levels. Besides these works several other shallower shafts and drifts were run, all practically inaccessible.

The property is equipped with two 20-ton coarse-ore furnaces and two 40-ton fine-ore furnaces, modeled according to the Davey patent.

Hillsdale Mine, or old Chapman mine, formerly known as the Chaboya mine, about two miles from San José, near Hillsdale station, lies on the east slope of the northwestern end of the Santa Teresa hills. Oscar Promis, No. 246 South Third street, San José, owner. There are a great number of excavations in the hillside, which, however, reach scarcely any depth, as the crest of the hill is not over 100 feet above the level of the valley. At present these workings show very little ore. They must at one time have produced quicksilver ore, as the remnants of an old furnace are still on the premises.

New Almaden Mine.—This property lies 13 miles south of San José, and covers a territory of 8580 acres. The Quicksilver Mining Company, owner; A. L. Bailey, 20 Nassau street, New York, president; Thomas Derby, New Almaden, Santa Clara County, superintendent. [See Mon. XIII, U. S. G. S., page 310 and following; Report State Mining Bureau of Cal., VIII, page 541; X, page 604; XII, page 370; XIII, page 600.]

This property is the oldest known quicksilver mine in the United States. It was first worked in 1824 by Antonio Sunol, Luis Chaboya, and Robles, and was known as the Chaboya mine. In 1845, Andreas Castillero, a Mexican army officer, "denounced" the mine under the name of Santa Clara mine. After the admission of California into the United States, Castillero and his associates leased the mine for sixteen years to the banking firm of Barron, Forbes & Co. The name of the mine was at the same time changed to that of New Almaden. Ir 1864 the property came into the hands of the present owner.

This mine produced in the earlier years comparatively rich ore, but in later years the richness of the ore has very much decreased and that now worked is of about the general average grade of that in the other large quicksilver mines of the State. The table on pages 176 and 177 gives its production up to the year 1896.

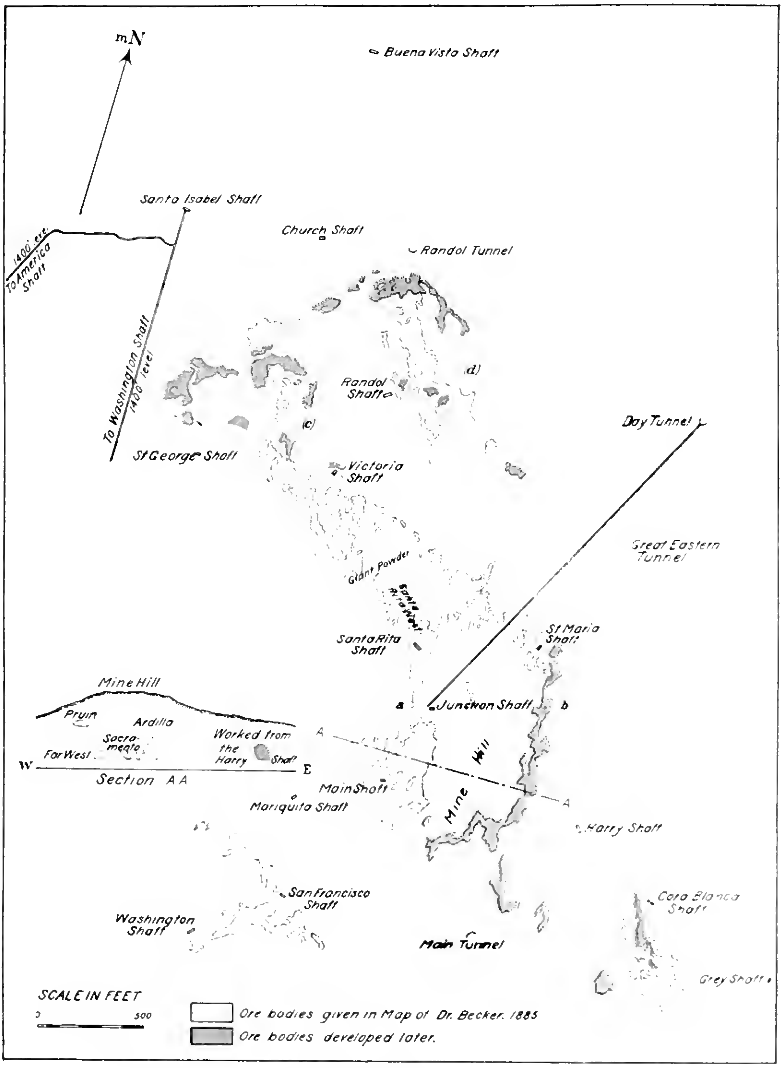


FIG. 57. Ore Bodies in the New Almaden Mine.

The mine workings cover a territory of about 2½ square miles, exclusive of those in the northwestern part of the property. The greatest depth of these workings is 2450 feet below the top of Mine Hill, which is used as the datum point for all underground workings. In this territory eighteen shafts have been sunk, and the underground excavations would be about 84 miles long. The greater part of these extensive workings are at present inaccessible; the Victoria shaft, a short distance to the southwest of the Randol shaft, and the Harry shaft, on the southeast slope of Mine Hill [see map, Fig. 57], are the only two shafts at present in operation. The deepest workings at present followed are 1000 feet below the datum point; and below 1300 feet the mine is filled with water.

The ground in that part of the mine now in operation is remarkably good. A majority of the large stopes are held up with scarcely any timbering, and only in some parts of the mine is square-set timbering required. Most of the gangways require only occasional timbering for short distances. The ground in the Randol shaft formerly worked was, however, much heavier.

The gangways are driven on the contact of the clay gouge, locally called "alta," which overlies the ore bodies, and where the ore bodies are absent, on the contact of the "alta" with the serpentine foot wall, locally called "greenstone."

The ore forms principally in "stockwercks" (that is, in large zones of

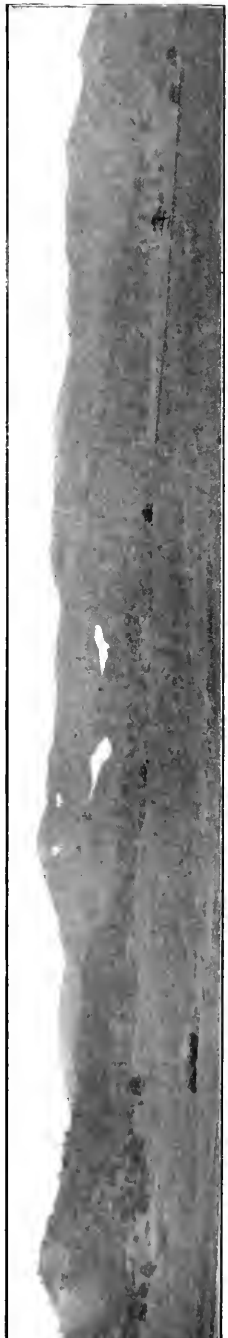


PHOTO No. 15. GENERAL VIEW OF THE NEW ALMADEN MINE.

PRODUCTION OF QUICKSILVER AT NEW ALMADEN, SANTA CLARA COUNTY, CALIFORNIA.

From July, 1850, to 30th April, 1896.

Dates.	Class and Quantity of Ore.			Total Pounds.	Flasks from Furnaces.	Flasks from Washings.	Flasks, Total.	Av'ge Amount per Month. Flasks.	Percentage Yield of Quicksilver.	Number of Months.
	† Grueso, Pounds.	† Granza, Pounds.	† Tierras, Pounds.							
July 1850 to June 1851	....	....	....	4,970,717	23,875	......	23,875	1,989½	36.74	12
July 1851 to June 1852	....	....	....	4,643,290	19,921	......	19,921	1,660	32.82	12
July 1852 to June 1853	....	....	....	4,839,520	18,035	......	18,035	1,503	28.50	12
July 1853 to June 1854	....	....	....	7,448,000	26,325	......	26,325	2,193¾	27.03	12
July 1854 to June 1855	....	....	....	9,109,300	31,860	......	31,860	2,655	26.75	12
July 1855 to June 1856	....	....	....	10,355,200	28,083	......	28,083	2,340¼	20.74	12
July 1856 to June 1857	....	....	....	10,299,900	26,002	......	26,002	2,167	19.31	12
July 1857 to June 1858	....	....	....	10,997,170	29,347	......	29,347	2,445½	20.41	12
July 1858 to Oct. 1858	....	....	....	3,873,085	10,588	......	10,588	2,647	20.91	4
Nov. 1858 to Jan. 1861	Closed	by Injunc	tion.							
Feb. 1861 to Jan. 1862	....	....	....	13,323,200	32,402	2,363	34,765	2,897	19.96	12
Feb. 1862 to Jan. 1863	....	....	....	15,281,400	39,262	1,129	40,391	3,366	20.22	12
Feb. 1863 to Aug. 1863	....	....	....	7,172,660	17,316	2,248	19,564	2,795	20.86	7
Sept. 1863 to Oct. 1863	....	....	....	2,346,000	4,820	700	5,520	2,760	18.00	2
Nov. 1863 to Dec. 1863	54,800	1,586,500	718,000	2,359,300	4,040	407	4,447	2,223½	18.65	2
Jan. 1864 to Dec. 1864	1,259,400	18,730,300	3,287,900	23,277,600	42,176	313	42,489	3,540¾	13.96	12
Jan. 1865 to Dec. 1865	2,288,900	25,749,000	3,910,500	31,948,400	47,078	116	47,194	3,933	11.30	12
Jan. 1866 to Dec. 1866	1,506,000	19,939,100	5,440,200	26,885,300	34,726	424	35,150	2,929	10.00	12
Jan. 1867 to Dec. 1867	731,500	15,689,288	9,603,145	26,023,933	23,990	471	24,461	2,038½	7.19	12
Jan. 1868 to Dec. 1868	2,274,208	14,566,600	12,564,722	29,405,530	25,577	51	25,628	2,135⅔	6.66	12
Jan. 1869 to Dec. 1869	150,000	11,942,175	13,366,000	25,458,175	16,898	......	16,898	1,408	5.07	12
Jan. 1870 to Dec. 1870	30,000	12,531,900	8,535,800	21,097,700	14,423	......	14,423	1,202	5.23	12
Jan. 1871 to Dec. 1871	....	13,661,700	8,373,000	22,034,700	18,563	5	18,568	1,547⅓	6.44	12
Jan. 1872 to Dec. 1872	142,000	12,777,000	8,497,600	21,416,600	18,391	183	18,574	1,548	6.63	12
Jan. 1873 to Dec. 1873	....	8,492,375	8,838,000	17,330,375	11,042	......	11,042	920	4.87	12

Jan. 1874 to Dec. 1874	....	11,294,000	12,160,000	23,454,000	8,867	217	9,084	757	2.96	12
Jan. 1875 to Dec. 1875	....	12,236,000	18,870,200	31,106,200	13,541	107	13,648	1,137⅓	3.35	12
Jan. 1876 to Dec. 1876	....	14,784,550	18,532,400	33,316,950	20,549	....	20,549	1,712½	4.71	12
Jan. 1877 to Dec. 1877	....	13,987,700	23,243,600	37,231,300	23,996	....	23,996	1,999¾	4.93	12
Jan. 1878 to Dec. 1878	....	14,612,154	22,330,071	36,942,225	15,852	....	15,852	1,321	3.28	12
Jan. 1879 to Dec. 1879	....	16,032,085	39,033,050	55,065,135	20,514	....	20,514	1,709½	2.85	12
Jan. 1880 to Dec. 1880	....	15,267,650	46,087,200	61,354,850	23,465	....	23,465	1,955½	2.92	12
Jan. 1881 to Dec. 1881	....	14,430,510	49,710,625	64,141,135	26,060	....	26,060	2,171¾	3.10	12
Jan. 1882 to Dec. 1882	....	19,734,900	52,412,300	72,147,200	28,070	....	28,070	2,339	2.97	12
Jan. 1883 to Dec. 1883	....	21,227,500	55,935,000	77,162,500	29,000	....	29,000	2,416½	2.87	12
Jan. 1884 to Dec. 1884	....	16,410,000	62,841,000	79,251,000	20,000	....	20,000	1,666½	1.93	12
Jan. 1885 to Dec. 1885	....	17,644,300	61,425,000	79,069,300	21,400	....	21,400	1,783	2.07	12
Jan. 1886 to Dec. 1886	....	14,140,690	67,258,000	81,398,690	18,000	....	18,000	1,500	1.69	12
Jan. 1887 to Dec. 1887	....	12,648,300	51,503,000	64,151,300	20,000	....	20,000	1,666½	2.38	12
Jan. 1888 to Dec. 1888	....	11,140,600	46,185,000	57,325,600	18,000	....	18,000	1,500	2.40	12
Jan. 1889 to Dec. 1889	....	9,398,200	48,377,000	57,775,200	13,100	....	13,100	1,091⅔	1.73	12
Jan. 1890 to Dec. 1890	....	8,079,800	37,220,000	45,299,800	12,000	....	12,000	1,000	2.02	12
Jan. 1891 to Dec. 1891	....	5,404,700	45,764,000	51,168,700	8,200	....	8,200	683⅓	1.22	12
Jan. 1892 to Dec. 1892	....	13,694,000	45,498,700	59,192,700	5,610	....	5,610	467½	0.72	12
Jan. 1893 to Ap'l 1894	....	6,797,260	51,411,940	58,209,200	9,449	....	9,449	590½	1.24	16
May 1894 to Ap'l 1895	....	10,136,900	41,979,000	52,115,900	7,000	....	7,000	583⅓	1.03	12
May 1895 to Ap'l 1896	....	8,461,300	56,812,000	65,273,300	6,300	....	6,300	525	0.74	12
Grand totals	8,436,808	443,229,037	1,037,723,953	1,594,049,240	933,713	8,734	942,447	1,802	4.57	523

Product of Enriquita* from 1860 to 1863 .... 10,571 flasks

* A body of ore separate from the main workings. † Grueso and Granza—Spanish words, meaning coarse ore. ‡ Tierras—Spanish word, meaning fine ore

Total product of all the mines on the Company's property to above date, 953,018 flasks of 76½ pounds each, or 72,905,877 pounds, or 36,452.94 tons of quicksilver. Since 1896 the figures of annual product have been kept private by the company.

fracturing), and in reading the following description it must be borne in mind that when speaking of veins in the New Almaden mine, this term does not indicate a well-defined fissure, but that the ore deposition has taken place along zones of fracturing. Judging from the great width of the "alta," the result of attrition caused by the movements of the rock

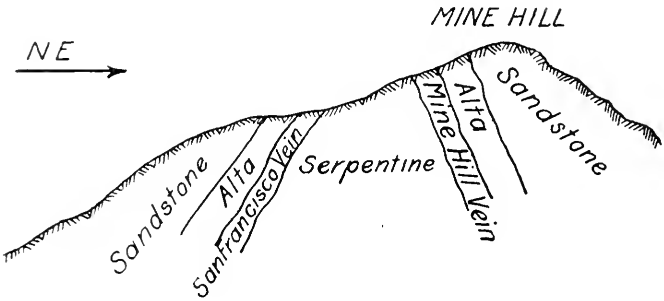


FIG. 58. Section of Mine Hill, New Almaden.

strata, from the wave-like form of ore deposits, from the fact that parallel zones of ore deposition are found, and finally from the character of the vein filling, which shows repeated fissuring and refilling, resulting in a ribbon formation in the seams, the conclusion must be drawn that this fracturing was persistent during a long period of time.

The ore deposits are limited on their hanging-wall side by the "alta," an impermeable stratum through which no water circulation could pass. The foot-wall side is persistently serpentine, hence it must be concluded that in this mine

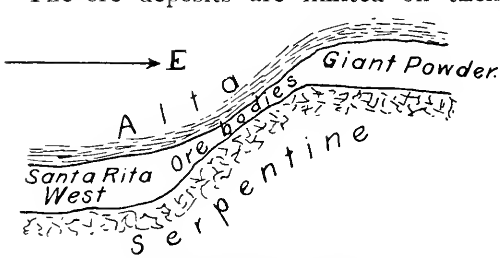


FIG. 59. Section over Santa Rita West, Giant Powder stopes, New Almaden.

the serpentine is associated with the cause of fracturing of the other rock strata, and this would lead to the conclusion that here the serpentine must be considered as an alteration product of intrusive peridotites, not as an alteration of strata of the Franciscan series. This conclusion finds confirmation by a section of the country from Mine Hill toward the Washington shaft. [See Fig. 58.] The fracturing has taken place on both sides of the serpentine, which apparently can not be considered otherwise than as an intrusive body having uplifted the rocks of the Franciscan series.

The ore bodies form principally in those parts of the zones where the dip of the "alta" is very flat, as indicated in Fig. 59—an ideal section over two connected stopes, which have both produced considerable amounts of ore. The contact of the

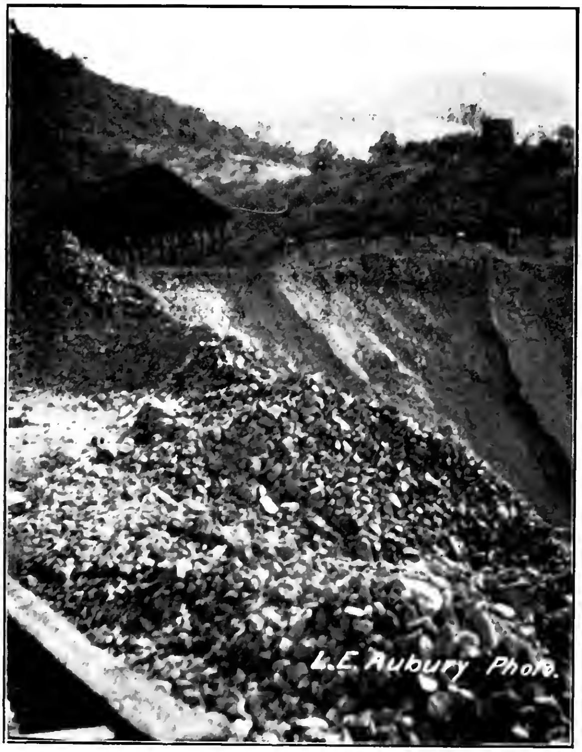


PHOTO No. 16. DUMP OF NEW ALMADEN MINE WORKS.

"alta" with the underlying vein filling, and where this is missing with the serpentine, is very tortuous in both directions, vertically and horizontally, so that in the gangways, which, as above mentioned, follow this contact, it is an exception to find a straight line of any length. The stopes are locally called "labores." The material which fills the zones of fracturing and wherein in places cinnabar forms, is generally rather hard and siliceous, traversed by a network of seams of quartz and dolomite, showing repeated fissuring and filling containing some inclusions of serpentine, the cinnabar forming principally in connection with the seams. In places the vein filling has more of an ochreous character, the matrix being more or less leached out, leaving only the network of seams intact.

The San Francisco vein is mainly composed of this ochreous

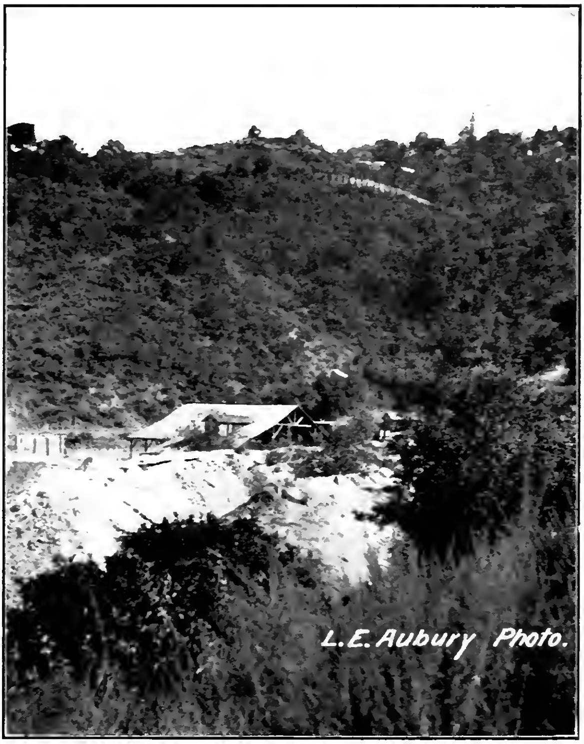


PHOTO No. 17. DUMP OF GREY SHAFT AND MINE HILL, NEW ALMADEN.

ore, wherein are found bodies of very hard rock, resembling diorite, very irregularly fractured. In this vein, the ochreous material lies on the serpentine, no gradual change taking place from the former into the latter, which for from 8 to 10 feet from the vein is changed into a clayey material, gradually changing into hard serpentine.

The general character of the vein filling indicates that, as in most of the other quicksilver deposits in the State, the deposition of cinnabar has been associated with the process of silicification, which characterizes the alteration of the rocks of the Franciscan series.

The general direction of the seams in the vein filling is not parallel to the line of contact with the "alta." The "alta" is often indurated near the vein, and is then locally called "cab." This is especially the case in the upper workings. In

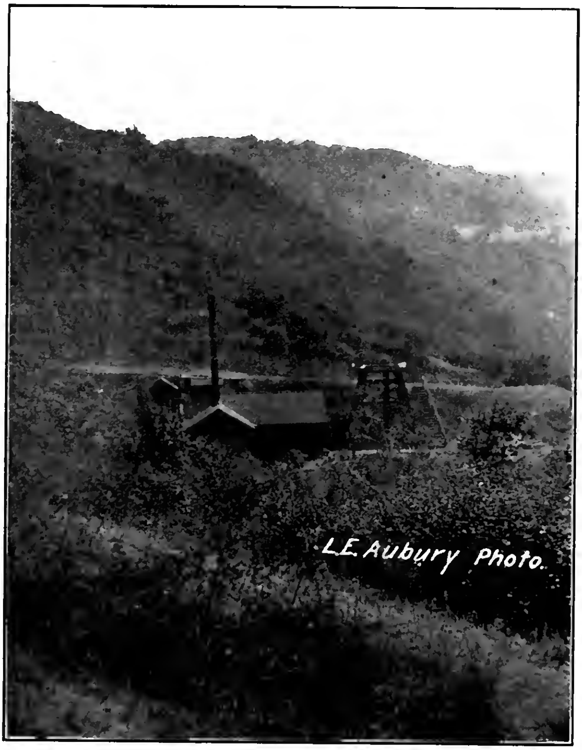


PHOTO No. 18. VICTORIA SHAFT, NEW ALMADEN.

the lower levels, it has more the character of a moist clay; the inclusions of gray sandstone, so frequent in the mines of San Luis Obispo and San Benito counties, while not absent, are much less prominent. Possibly associated with this change in the character of the "alta" is a difference in the distribution of the cinnabar in the pay shoots. In the upper workings the part nearest to the "alta" is seldom the richest, the cinnabar forming more plentiful at from 5 to 8 feet below the "alta," while in the lower workings the richest ore is invariably close to the "alta."

The contact between the "alta" and the vein filling is very sharply marked, but there is a gradual change of the above described vein filling into the material of the serpentine foot wall, the vein material gradually carrying more serpentine, until its has entirely changed into the latter. The hanging

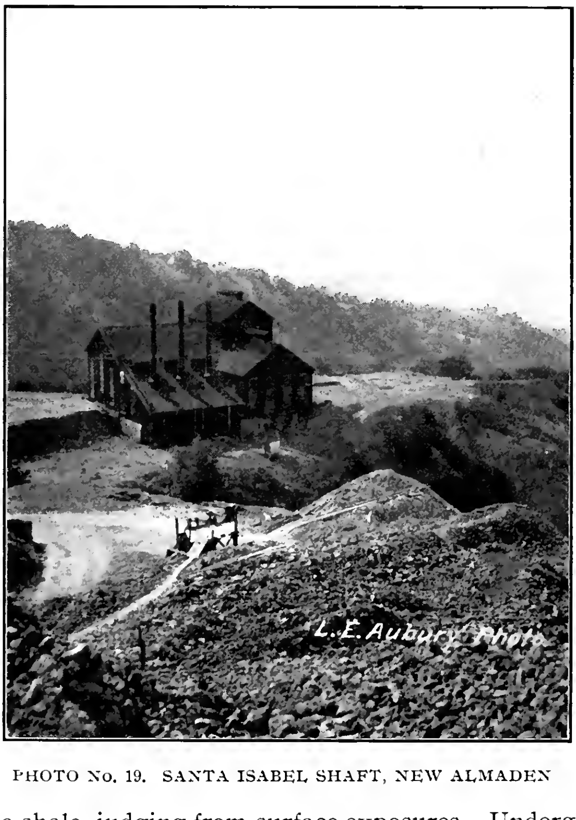


PHOTO No. 19. SANTA ISABEL SHAFT, NEW ALMADEN

wall is a shale, judging from surface exposures. Underground, no crosscut through the "alta" to the hanging wall was seen. [See Figs. 55 and 56.]

In some parts of the mine, especially in the lower workings (as *f*, *i*), in the drift from the Santa Isabel shaft, southwest to the American shaft [see plan, Fig. 57], heavy flows of gas were encountered, principally, if not exclusively, consisting of carbon dioxide, which in that drift were so strong as to force the company to abandon the work. It is generally supposed that this gas is generated by the decomposition of the calcite and dolomite, which are abundant in those parts of the mine, both in the vein filling and in the "alta."

In order to give an intelligible description of the formation of the ore bodies in the New Almaden mine, the old works, at present inaccessible, must be taken into account. The magnifi-

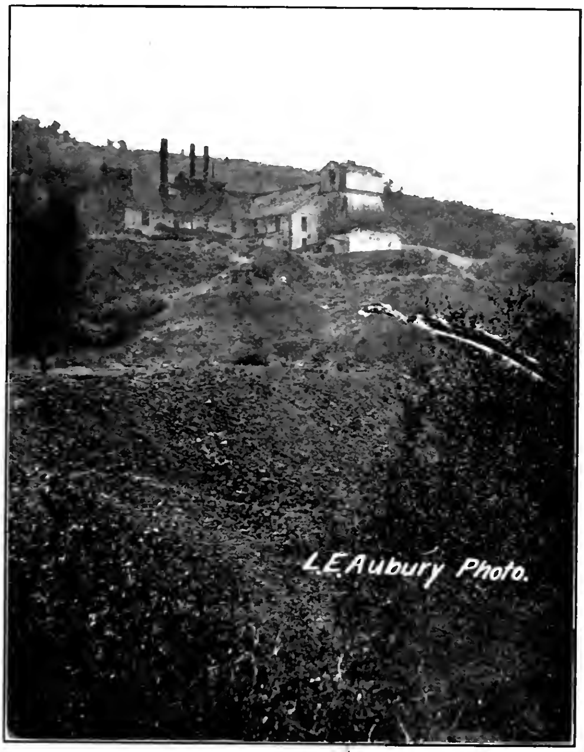


PHOTO No. 20. RANDOL SHAFT, NEW ALMADEN.

cent map of the underground works in the office of the company gives ample opportunity to do this. A reduced copy of this map, up to the date of its publication, 1887, is found in sheet IX of the atlas of Mon. XIII, U. S. G. S. The accompanying plan [Fig. 57] gives an outline of the ore bodies opened up in the mine. The later works are located principally in the upper levels.

One nearly continuous series of ore bodies (*a*) lies on a line starting near the main shaft and going in a northwesterly direction to about 400 feet northwest of the Santa Rita shaft, a distance of about one fourth of a mile. These ore bodies are worked to a depth of not over 700 feet below datum level (top of Mine Hill). In the southern part, near the main shaft, the ore bodies are intricately overlying each other. [See Fig. 57, crosscut AA, a west-east section over this part of the mine.] This may be due to the intrusive serpentine body in Mine Hill before mentioned.

A second series of ore bodies (*b*) lies to the east, and runs nearly parallel to the former. It begins a little southwest of the Harry shaft, and runs to about the Day tunnel, where it connects, by a series of stopes about 400 feet long, with the first mentioned series. These workings go from 400 feet below datum in their southeastern part to 650 feet at the northwestern end.

Running a line from the Giant Powder stope to the Santa Maria shaft, the general direction of the veins south of this line, judging from that of the gangways, which as stated above are run along their hanging contact, is about north with an east dip. North of this line the ore bodies appear to change their course and to lie on a nearly southwest strike with a northwest dip. In this latter part of the mine there are two distinct zones of mineralization—the western zone (*c*), which connects directly with the first above-mentioned series, and the eastern zone (*d*), which appears to be separated from the second series (*b*) by a nearly barren zone, in which, however, not only does the vein persist, but the two zones mentioned by Dr. Becker (Mon. XIII, U. S. G. S., page 320 *et seq.*) make their appearance, there being two levels run on the 900-foot and 1000-foot levels on their hanging-wall contact. From the 700 to the 1700-foot level, there is a barren zone between these two mineralized zones (*c* and *d*). On the latter level a body of ore was worked between them, but judging from the map of the underground workings of the company, below this level, no ore bodies were found in the intervening space. [See plan, Figs. 57 and 60, which give a general idea of this system of ore deposit.]

In the 1400-foot level, Santa Isabel South, running toward the Washington shaft, about 700 feet south of the Santa

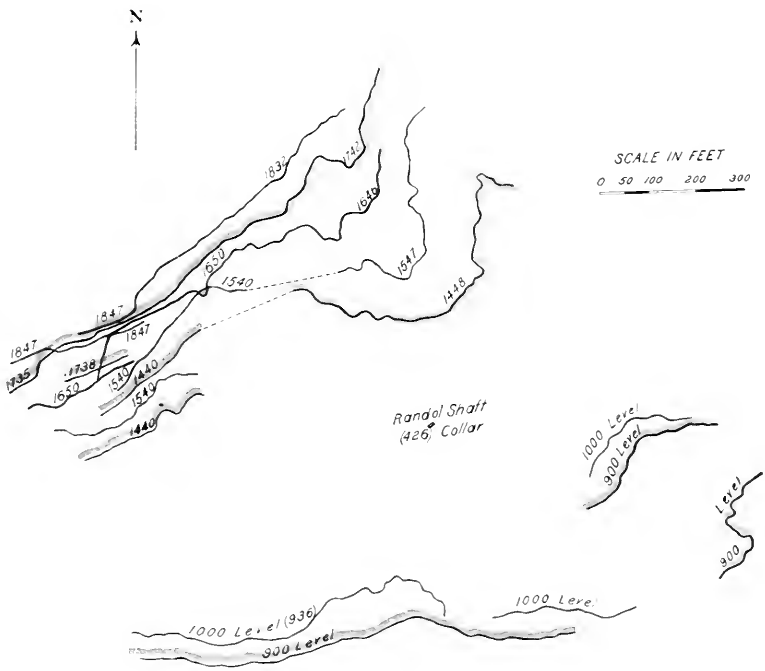


FIG. 60.

Plan of the Clay Walls, New Almaden Mine.

From Atlas, Monograph XIII, U. S. G. S.

Isabel shaft, and near the breast of the 1400-foot level southwest running from the same shaft toward the America shaft, some ore was found. If these ore bodies could be proven to be connected, they would be found to lie in the prolongation of the strike of *c* and *d*, and there would appear to be a line of cross-fissuring, a very possible occurrence in a country as disturbed as the vicinity of the New Almaden mine.

In the knoll southeast of Mine Hill are the Cora Blanca workings, which in former times yielded quite good ore. At present a tunnel is run between the Cora Blanca and Grey shafts in this hill, which has cut a small ore body; the latter has, however, an entirely different appearance from that in the other workings, the gangue consisting of fragments of jaspery material recemented by silica, calcite, and dolomite. The cinnabar is here associated with some iron pyrite.

The most northwestern works on the property, known as the Enriquita mine, are located about 1½ miles northwest of Mine

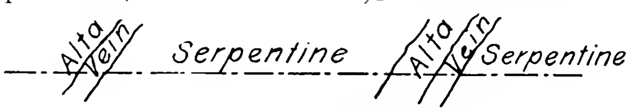


FIG. 61. Section in Enriquita Mine, New Almaden.

Hill. The lowest working is a tunnel starting on a very prominent body of croppings, which in the tunnel forms a sandstone traversed by a very close network of seams refilled by quartz and calcite. At 840 feet from the entrance the tunnel enters the serpentine and splits. The left-hand drift runs to the bottom of the R. R. B. shaft, and then follows the contact of "alta" and vein material, which at the breast disappears, leaving the "alta" directly overlying the serpentine. The right-hand drift also reaches a similar contact and stops at the contact of the "alta" and the serpentine, showing that there is here also a repetition of strata. [See Fig. 61.] Above this level, about 150 feet below the surface, a body of very good ore was worked in former years, from which about 10,000 flasks were obtained.

The mine is equipped with two coarse-ore furnaces of 12 tons capacity each; two medium-sized ore (granitza) furnaces, one of 36 tons, the other of 18 tons capacity; and two fine-ore (tierra) furnaces, one of 36 tons, the other of 24 tons capacity.

There is very little or no mining timber available in the vicinity. The company uses exclusively Oregon pine, costing $18 per 1000 feet (B. M.). Cordwood is not very abundant, and costs $5.85 per cord. The company uses oil as fuel under the steam boilers in both hoists.

Santa Teresa Mine.—This is situated on the east slope of the Santa Teresa hills, about 8 miles southeast of San José, near Edenvale station, on the Southern Pacific main line. The Santa Teresa Quicksilver Mining Company, owner; R. B. Harper, of San José, superintendent. Three tunnels have been run in the mountain. [See Fig. 62.] The lowest tunnel, 700 feet

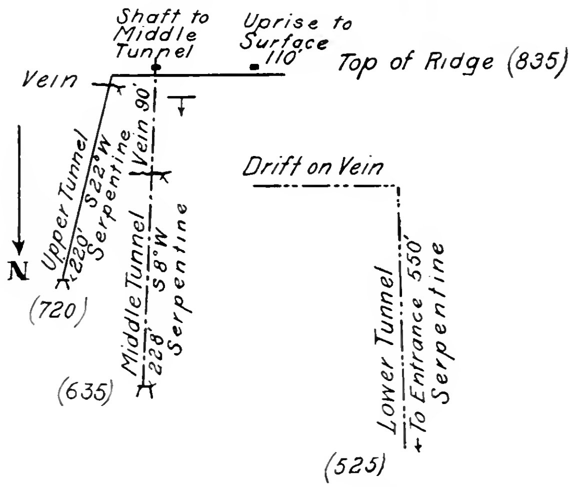


FIG. 62. Sketch of works in the Santa Teresa Mine. Scale, 1″ = 200′.

long, reached the vein at 550 feet from the mouth; its course is nearly south. It turns to the left on the vein and is driven in toward the territory under the two upper tunnels in order to reach the pay shoot in the vein, which apparently dips eastward. The middle tunnel, 110 feet above the former, course S. 8° W., 325 feet long, is in serpentine. It cuts the ledge 228 feet from the mouth. There is no selvage or gouge between the ledge and the serpentine. The ledge stands nearly vertical; the tunnel has not yet passed through the ledge into the opposite wall. The upper tunnel is 85 feet above the middle tunnel, course S. 22° W. It cuts the contact of the serpentine and the ledge at 220 feet from the mouth, and a few feet farther turns to the right in the ledge and runs 187 feet in this direction.

About 50 feet from its turning point is a vertical shaft, which connects with the middle tunnel about 90 feet from the point where the latter cuts into the ledge, showing that the ledge dips north. Between these two tunnels, farther on, a raise goes from the upper level to the surface 110 feet, all in ledge matter. On the level of the upper tunnel several drifts and crosscuts have been run in the ledge matter, showing the latter to be very extensive.

The country rock is all serpentine. The ledge matter varies greatly in character. It is apparently an alteration product of serpentine through silicification, subsequent to a fracturing of the material. The fissures have been filled by quartz and calcite, the silicification varying in different zones of the ledge, probably due to a varying degree of fracturing. In places inclusions of nearly unaltered serpentine are found. In others, as for instance, in an intermediate short level run from the shaft 37 feet above the middle tunnel, the rocks contain a great amount of cavities. Considerable ochreous material is found, probably due to the oxidation of iron pyrite. A 50-ton Scott furnace is in course of construction.

Silver Creek Mines.—This was formerly the North Almaden mine, on the east side of Silver Creek, near Evergreen, about 8 miles from San José. Silver Creek Quicksilver Mining Company, owner; H. R. Bradford, president, No. 7 North Market street, San José. [See Report State Mining Bureau of Cal., XII, page 367; XIII, page 600.]

Access to mine refused to Field Assistant.

Wright Mines.—These lie on Llagas Creek, about 3 miles south of the hacienda of New Almaden, 25 miles from San José. Mrs. A. Rodgers, owner, No. 1801 Leavenworth street, San Francisco. [See Report State Mining Bureau of Cal., XII, page 370; XIII, page 601.] This property was worked to some extent in former years, producing some good ore; but sufficient work has not been done in later times to judge of the possibilities of the property.

STANISLAUS COUNTY.

Summit Group of Mines.—These consist of the South Summit, North Summit, Grayson, Martin, Hayward, White Oak, and Hopkins claims, and four millsites, in Secs. 20 and 29, T. 6 S., R. 5 E., principally in Stanislaus County, but partly in Santa Clara County, on Red Mountain, about 50 miles from San José and 40 miles from Livermore. The Phœnix Quicksilver Mining Company, owner; H. G. Stevenson, Hobart Building, San Francisco, president; E. P. Newhall, Deforest, Santa Clara County, superintendent. [See Report State Mining Bureau of Cal., XIII, page 603.] This property was discovered in the 70's by Mr. Waterford, who turned it over to the Martin Brothers, of Pleasanton. The Messrs. Martin worked it on a small scale and erected a 5-ton furnace and afterward sold it to Mr. A. Hayward and associates, who recently formed the company which is the present owner. It is opened by several tunnels and shafts, which show that there are three distinct zones of mineralization: The Summit vein, having a strike N. 15° E., and a southeasterly dip; a belt of sandstone, having a northwesterly strike, crossing the Summit vein (if it continues past the latter is, however, not yet determined); and the Grayson vein, having also a northwesterly strike, with a northeasterly dip.

The Summit vein is developed by four tunnels and a shaft 40 feet deep on the top of the ridge. The vein is well exposed in tunnels Nos. 1 and 2, which are connected by an incline shaft. Considerable understoping has been done in No. 1, and from No. 2 a shaft has been sunk first vertically until it reaches the foot wall and then along the foot wall at an angle of 54°. The vein is overlaid by "alta." The foot wall is in sandstone altered by silicification. The understopes of No. 1 on the foot wall show a large ore body; one crosscut, 40 feet long, has not reached the overlying "alta." The ledge matter is a serpentine, altered into an opaline rock. The cinnabar is remarkably disseminated through the silica in fine aggregates of crystals. Especially in the upper tunnel a great portion of the ore is weathered into a soft ochreous material, due to the oxidation of the iron sulphides. There is considerable lime in the gangue. The Grayson ledge is more of a sandstone character, with cinnabar coating the fracture planes; the ledge carries also considerable ochreous material. The erection of a 50-ton furnace is contemplated. The manufacture of the brick for this has been started.

Adobe Valley Mine.—In Sec. 24, T. 6 S., R. 5 E. The Stanislaus Quicksilver Mining Company, owner; H. G. Stevenson, Hobart Building, San Francisco, president; E. P. Newhall, Deforest, Santa Clara County, superintendent. This property is at present idle. A vertical shaft, about 180 feet deep, has been sunk, but is filled with water to just below the 100-foot drift. The country rock is apparently a bedded sandstone. The presence of considerable black clay gouge indicates that strong movements have taken place. The rock and the ledge matter carry a great amount of sulphur, occurring as iron and magnesia sulphides, and where these have been decomposed, as sulphates and free sulphur. The sandstone in places is impregnated with cinnabar, associated with iron sulphide, but the works are not enough advanced to admit of judging about the value of the deposit.

Orestimba Mine.—This is on Orestimba Creek, in Secs. 25 and 36, T. 6 S., R. 5 E. The Hazard Quicksilver Mining Company, owner; H. G. Stevenson, Hobart Building, San Francisco, president; E. P. Newhall, Deforest, Santa Clara County, superintendent. The property is at present idle. A short tunnel with several crosscuts, about 200 feet above the creek level, shows that the country rock is a silicified shale.

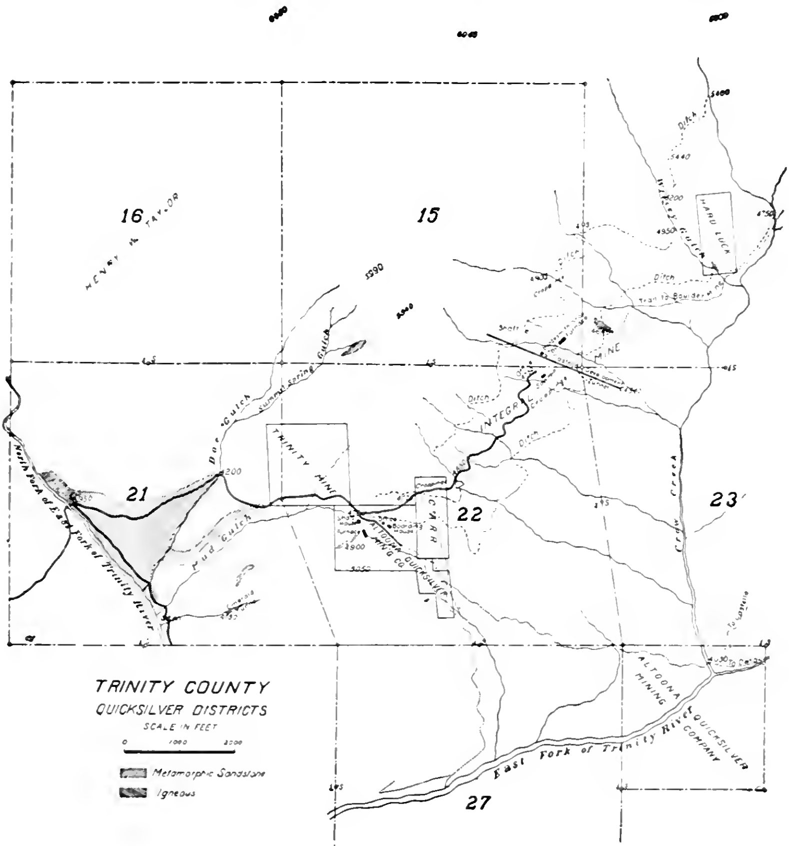
OUTLYING COUNTIES.

EL DORADO COUNTY.

Bernard Mine.—This is in Sec. 4, T. 8 N., R. 10 E. The Bernard Quicksilver Company, owner. L. C. Osteyee, 212 Sansome street, room 11, San Francisco. [See Mon. XIII, U. S. G. S., page 384; Report State Mining Bureau of Cal., XII, page 359.] This property was first developed in the 60's, by G. Folger, of Jackson, Amador County, under the name of the Amador Quicksilver mine. The present owners have reopened the old works, which consist of a vertical shaft about 75 feet deep, connecting with a tunnel about 65 feet lower than the collar of the shaft, starting on a southerly course, about in the same direction as the strike of the slate, and turning nearly at right angles to the right about 180 feet from its mouth. Both the shaft and the tunnel are entirely in the gray slates of the Mother Lode region, which show some cinnabar on panning. After passing the bend, the tunnel crosscuts the the slates, and for about 25 or 30 feet the walls are coated with vermilion. This coating appears, however, to be only superficial, as when breaking down the rock no signs of it are found on the new fractures. This tunnel being very old, this vermilion may be a recent deposition. About a quarter of a mile west of these works a belt of serpentine runs through the country.

TRINITY COUNTY.

Surface indications of quicksilver ores are found in several places throughout Trinity County, but active mining for this metal has only been done in the northeastern part of the county, between Crow Creek, a tributary of the east fork of Trinity River, and the north fork of the east fork of Trinity River. The surface country rock of this section is principally serpentine, which is generally very hard; on the east and west ridge forming the northern boundary of the basin wherein the quicksilver ore bodies occur, a great amount of the chrysotile variety of serpentine is found, which, however, is entirely absent nearer the mineralized section. The Emerald tunnel cuts through the formation in a part of the territory, showing little or no signs of mineralization, hence affording opportunity



to judge about the rock formation of the country in general. It starts in serpentine, but at the breast, about 250 feet in, the material is a diabase altered into greenstone. The material wherein the ore bodies form, being also altered igneous rock, it is very probable that the serpentine is in this territory an alteration product of igneous rocks. The exposures of metamorphics, prominently sandstones, are principally located west of the mineralized zone, on the slope toward the North Fork. One small exposure of igneous rock (quartz porphyry) was found near Crow Creek.

The material wherein the ore bodies form has been very much altered; it is probably a feldspar porphyry. Occasionally small detached exposures of croppings are found in the serpentine. They have an ochreous appearance, and their relation to the ore bodies developed underground is as yet undefined. The works of the Altoona mine being at present inaccessible, the observation of the underground ore appearance was limited to a depth of 120 feet, the greatest depth at which ore bodies are developed in the Integral mine.

Altoona Mine.—This lies in Sec. 22, T. 38 N., R. 6 W., and comprises the Trinity, Altoona, and part of the Blockade mining claims. The Altoona Quicksilver Mining Company, owner, 206 Sansome street, San Francisco. [See Mon. XIII, U. S. G. S., page 366; Report State Mining Bureau of Cal., VIII, page 643; X, page 716; XII, page 371; XIII, page 603.] The Altoona Quicksilver Mining Company acquired this property in 1875, but prior to that time some surface work had been done and relatively considerable quicksilver extracted. In 1879 the mine was closed down by litigation, and so remained until 1894, when work was resumed, a Knox & Osborne fine-ore furnace erected, and the underground development work energetically pushed. A vertical shaft was sunk to a depth of 450 feet, from which five levels were driven; in the lowest level another vertical shaft was sunk 152 feet deep, from which two levels were driven. In all there are seven levels, covering a territory of 1600 feet in a northwesterly and 1120 feet in a northeasterly direction; within which four different veins were worked to a depth of about 600 feet. Three of these veins come together at the lowest level, forming a mineralized zone about 400 feet long and from 4 to 50 feet wide. The fourth vein has no connection with the other, and lies about 400 feet southwest; it has been worked from the third (350 feet) to the first (140 feet) level. The mine makes a very large amount of water, requiring several large pumps and a boiler capacity of 140 H. P. to keep it unwatered, causing a high cost of operation per ton of ore worked; and when, in 1902, part of the reduction plant was destroyed by fire, the mine was shut down, and the water stands now about 18 inches above the floor of the upper level. The furnace has lately been repaired, and the material of the dumps is run through with satisfactory result.

The production of the mine has been: prior to 1875, 1500 flasks; from 1875 to 1879 (retorts), 8010 flasks; from 1894 to 1902 (furnace, 70 months), 19,671 flasks; total 29,181 flasks.

Carr Mine.—This is in Sec. 22, T. 38 N., R. 6 W., and consists of one mining claim. G. Carr, of Carrville, Trinity County, owner. Some surface work of no consequence has been done.

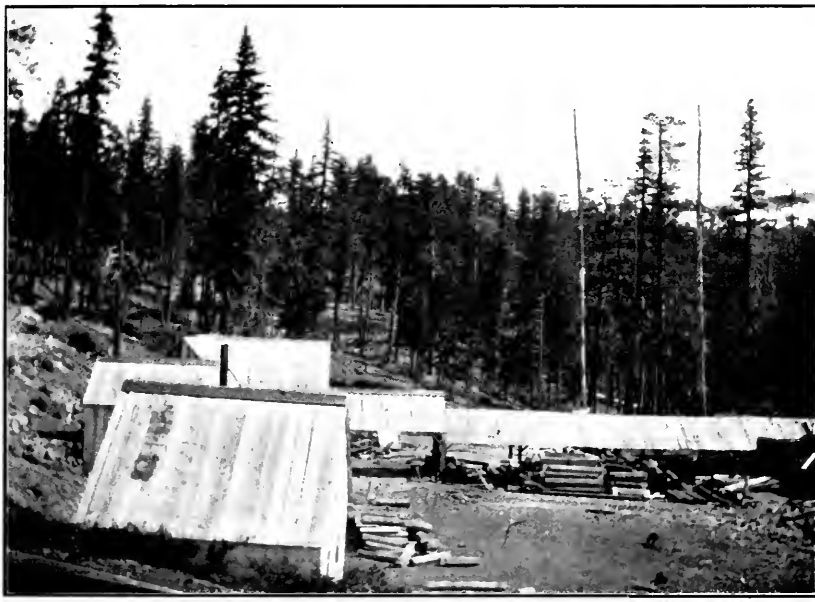


PHOTO No. 21. ENTRANCE—CASTELLA DEVELOPMENT TUNNEL, INTEGRAL MINE.

An exposure of croppings is found on this mining claim in the road between the Altoona and Integral mines.

Integral Mine.—This is in Secs. 14, 15, 21, 22, 23, 27, and 28, T. 38 N., R. 6 W., and consists of forty-six mining claims and several timber sections. The Integral Mining Company, owner; E. W. McGraw, 324 Pine street, San Francisco; Frank A. Mahon, superintendent, Integral, Trinity County. The geology of this property is treated previously in the general description of this district. Some croppings are found between the mouth of the Castella tunnel and the sawmill, but no ore bodies have been cut by this tunnel. Serpentine is also underground the principal country rock. In this serpentine lies a body of highly altered rock, probably an altered feldspar-

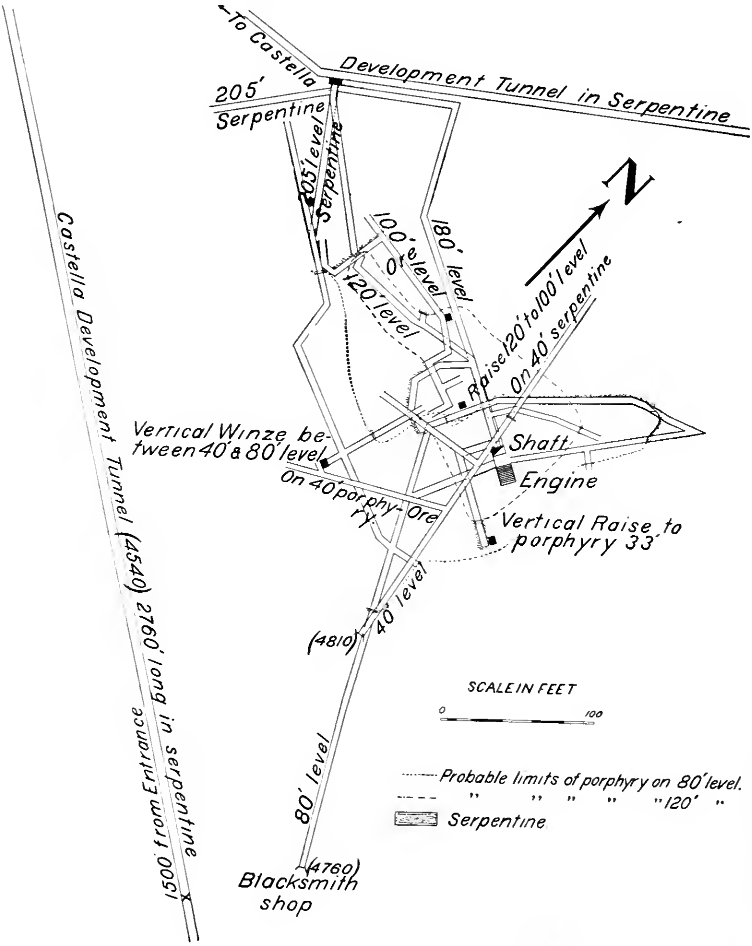


FIG. 62*a*. Underground workings of Integral Mine.

porphyry, as far as ascertained in the form of an irregular lens, with a northwesterly dip. In the parts of the lens which carry ores the material is thoroughly decomposed by the action of the mineral-bearing waters, which deposited there in iron and mercury sulphides, the former being largely, if not entirely weathered into iron oxides, decomposing the gangue rock and giving it a yellow and black color.

The principal system of underground works consist of a shaft, from which four levels, respectively 40, 80, 120, and 180 feet below its collar have been driven, and an intermediate level at 100 feet. [See Fig. 62*a*.] The 180-foot level connects through a vertical winze with the Castella development tunnel, which is 120 feet vertical lower; and from this winze a drift and side drift have been run 25 feet below the 180-foot level. By connecting the points where the serpentine has been cut in the different drifts an approximate representation of the form of the above-mentioned lens of porphyry containing the ore bodies has been given. A great amount of surface work (assessment work) on a number of the claims has been done, without, however, disclosing anything of importance. The property is equipped with a 24-ton fine-ore Knox & Osborne furnace.

Trinity Mine.—This consists of three claims, Trinity Nos. 1, 2, and 3, in Secs. 21 and 22, T. 38 N., R. 6 W. Messrs. Riesch-ling, owners.

OTHER COUNTIES.

Besides the above described mines, there are a number of scattered cinnabar deposits, none of which have been developed to any great extent, in various sections of the State.

In **Contra Costa County,** near Mount Diablo, some cinnabar has been found. [See Mon. XIII, U. S. G. S., page 378.]

In **Del Norte County** [see above cited, page 366, and Report State Mining Bureau of Cal., XII, page 198] some prospecting for cinnabar has been done near the northern border of the county on Diamond Creek, an eastern tributary of the north fork of Smith River. The Mercury group, near the mouth of Diamond Creek, is owned by Israel Dietrick and others. The Diamond Creek group lies near the head of the same creek, close to the State line.

In **Mariposa County** a cinnabar occurrence is mentioned by Professor Whitney. [See Geological Survey of California, vol. I, page 230.]

In **Santa Barbara County** [see Mon. XIII, U. S. G. S., page 382; Report State Mining Bureau of Cal., VIII, page 537; X, page 596; XII, page 366] are the Los Prietos mines in the Santa Ynez range. These produced in former years some quicksilver, but have been idle for a number of years. Another occurrence of cinnabar has been mentioned near the Cuchamma River (the Eagle Quicksilver mine).

In **Shasta County** a cinnabar deposit has been to some extent developed; it is 30 miles northeast of Redding, in Secs. 4 and 5, T. 32 N., R. 1 W. The Clover Creek Cinnabar Company, owner. F. P. Primm, president, Redding.

In **Siskiyou County** [see Report State Mining Bureau of Cal., XII, page 370; XIII, page 602], near Oak Bar, on the headwaters of the west fork of Beaver Creek, in the northern part of the county, some cinnabar deposits have been worked to a slight extent by the Siskiyou Quicksilver Mining Company (G. V. Snow, president), of Oak Bar; the company has also erected a small furnace.

The Barton-Lange is another property; H. J. Barton, owner, Oak Bar. Both properties are non-producers.

Some cinnabar was found in the sluice-boxes of the hydraulic mines in Horse Creek, in this county.

METALLURGY.

The subject has been extensively treated by Crookes and Röhrig in "Practical Treatise on Metallurgy," vol. I (1868); by Egleston in "The Metallurgy of Silver, Gold, and Mercury in the United States," vol. II (1890); also by Prof. S. B. Christy, in vols. XIII and XIV (1884–1886), "Transactions of the American Institute of Mining Engineers," and in "The Imperial Quicksilver Works at Idria" (1884), by the same writer; also in many technical papers, among which the "Mining and Scientific Press" of 1878 and 1879, giving a translation of Mr. Kuss's description of the Almaden mine in Spain; and further, in many European technical publications.

The scope of this paper is a statement of the present condition of the quicksilver industry of California, and hence the older methods, no longer in use in this State, and those used in Europe and elsewhere, will only be alluded to where necessary for a thorough understanding of the subject.

The extraction of mercury from ores containing sulphide of mercury and occasionally native mercury (the only forms wherein mercurial ores of commercial importance are found) can be classified as the metallurgical process of distillation. It is accomplished by subjecting the ores to a certain degree of heat, applied by one or the other of two methods: in tightly-sealed retorts, wherein the ores are heated without coming in direct contact with the products of combustion of the fuel; or in large furnaces, where the heat and products of combustion of the fuel pass direct into the ore mass and are carried off with the heated mercuric vapors, to be subsequently condensed in large cooling chambers. The retorts are generally of cast-iron. The Fitzgerald furnace may, however, be classified as a continuous brick retort furnace.

The essential difference in the two methods lies in the fact that the vapors given off by the ores in the retort furnaces are separated from those resulting from the combustion of the fuel.

Professor Christy, in his exhaustive study on Quicksilver Condensation [Transactions American Institute of Mining Engineers, vol. XIV, page 237], found that in the products of combustion of an average furnace-day at New Almaden, running on 3 per cent ore, those of the fuel amount to nearly 80 per cent of the total; hence the fumes from a retort furnace out of which the mercury must be separated, are much smaller in quantity and moreover less complicated in composition, so that the liquefaction of the mercury is rendered much easier and less costly. The theoretical advantage is, however, entirely obliterated by practical disadvantages which restrict the use of retort furnaces to a few exceptional cases. Their capacity is small, and the relative labor and fuel expense consequently very high, so that even for rich ores they offer a very unprofitable method of treatment. Unless the ores are very free from iron sulphide, quicklime must be added, to prevent the recombination of the mercury and sulphur in vapor form at the mouth of the exit pipe, where sudden cooling takes place. The use of retort furnaces, except for the treatment of soot and of concentrates, may as a rule be considered bad practice. It must be acknowledged that their erection in the case of prospects and new mines has often been favored, because the cost of construction is low, and they offer the mine owner, who has only a limited capital at his disposal, the chance of getting some immediate returns out of his mine. This, however, is done at the cost of the future of his property, for in order to get any results he is forced to extract only the very rich ore, thereby very materially reducing the average of the bulk of his ore bodies. Besides, it may be stated that, with a few exceptions, the products of those retort furnaces have scarcely ever paid for the work of extraction, let alone that of the development of the property.

It was stated previously that these furnaces might be properly employed for the treatment of concentrates. In the text-books treating on this subject, it is generally claimed that: "The attempts of mechanical concentration of quicksilver ores "have usually not been successful, because the cinnabar is so "friable that a greater portion floats off with the water." [Egleston, above cited, page 804.] Mr. G. V. Northey, at the Manzanita mine, in Colusa County, has, however, been very successful in concentrating the ore of that mine. The ore is first crushed rather fine, and then passed through a 5-foot Huntington mill. [See Fig. 63.] The pulp passes through a concentrating plant, having a capacity of from 1 to 2 tons per hour, depending upon the gangue. The plant consists of five bumping-tables, the pulp going first to one table and from this is divided over the four other bumping-tables. The tailings are elevated and sized. The heavier pass over a Bartlett con-

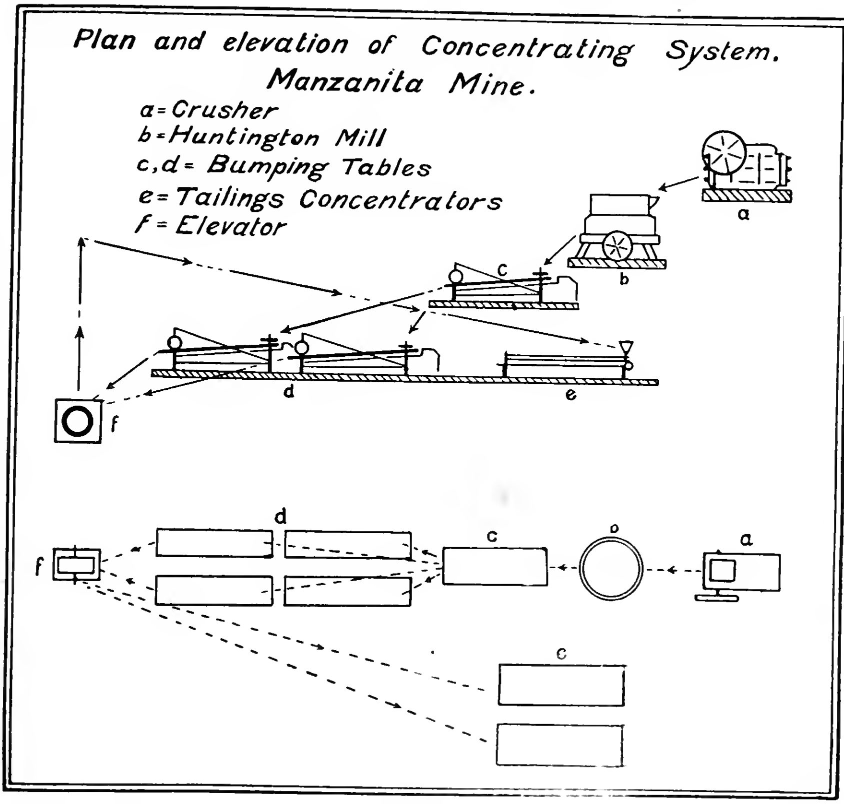


FIG. 63.

centrator, and the lighter over a belt vanner without side shake. This plant is driven by a 25-horsepower Harding distillate engine, using 15 gallons of distillate per twelve hours, laid down (including 28 miles teaming from Williams) at 20 cents per gallon, or $3 per twelve hours. The plant requires one concentrator and two helpers.

The concentration varies according to the amount of iron pyrites in the ore. When the latter are scarce it may reach a high figure, but generally the concentration will be about 20 to 1. When high in iron pyrites the concentration ratio will be too low to produce a material which can be profitably handled in a retort furnace.

The concentrates are dried and retorted in a 10-pipe retort

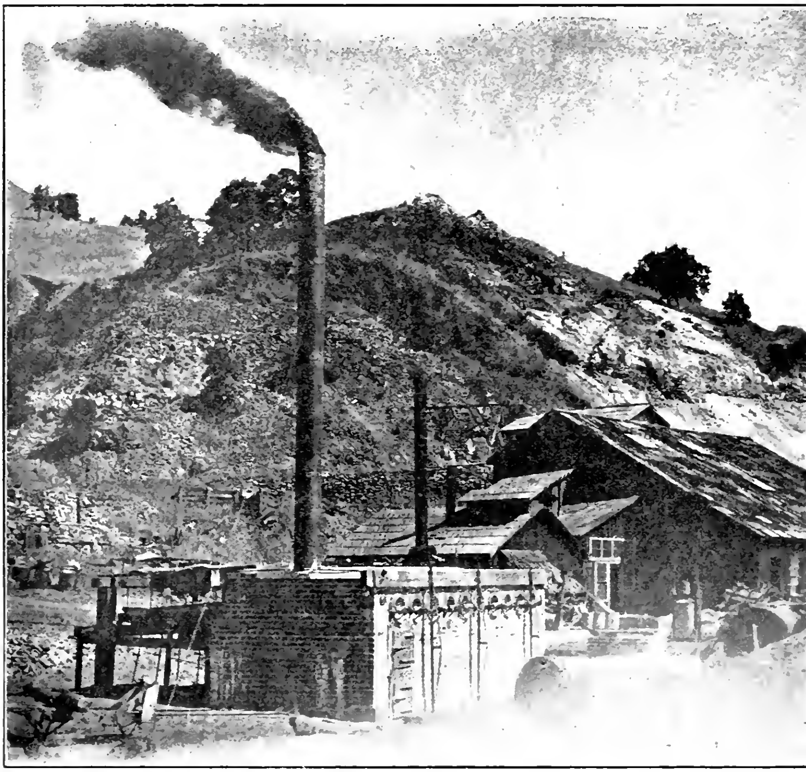


PHOTO No. 22. PIPE RETORT FURNACE, MANZANITA MINE, COLUSA COUNTY

furnace, which has some features worth noting. [See Fig. 64.] By using arches around the pipe spaces, each retort can be taken out separately without interfering with the working of the others. Each retort has a separate mercury outlet, allowing opportunity to judge about its workings, and the water circulation through each water jacket can be regulated separately. The firebox is placed to the side of the first retort, instead of under it, enabling the easy discharging and charging of this retort. By placing the door of the retort inside the wall, cooling of the space against the door and consequent accumulation of mercury at that point are prevented. The

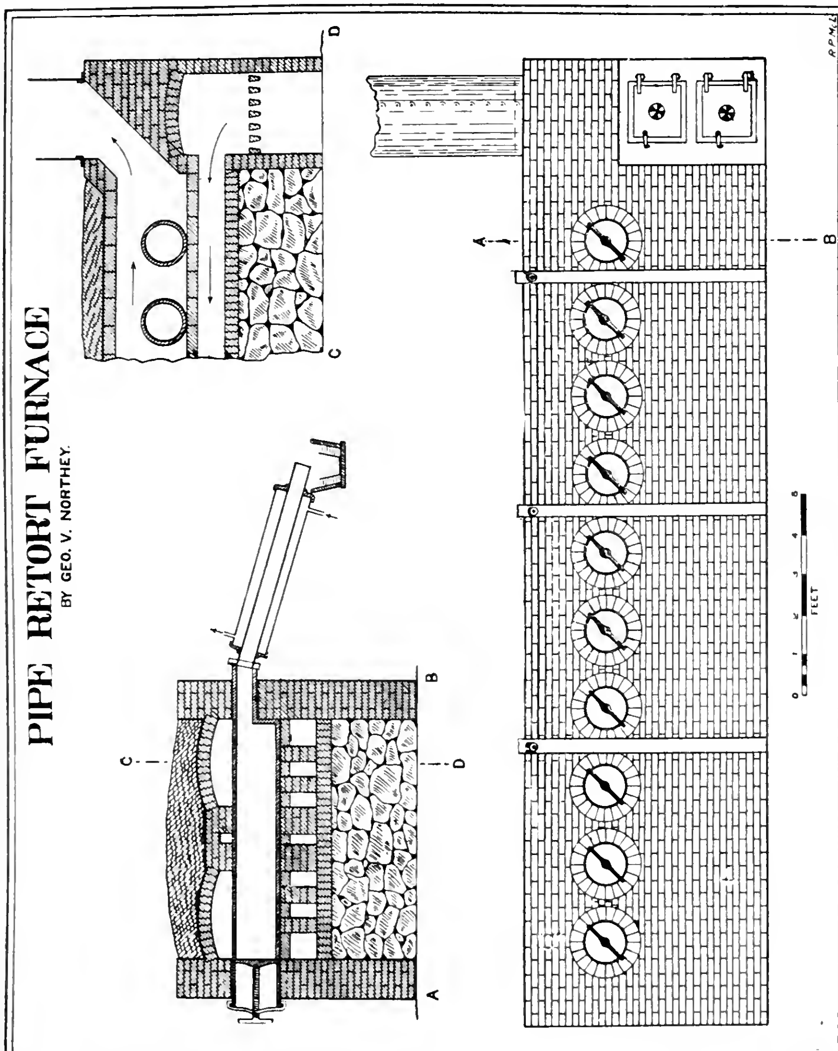


FIG. 64.

charge is from 75 to 80 pounds of concentrates per shift, with the necessary lime, against 150 pounds of raw ore. Two furnace men are required—one per shift.

The expenses of this plant are about $25 per day for labor, fuel, repairs, etc. The 10-pipe retort, with suitable ore, can handle the total product of the concentrating mill, running day and night, concentrating from 20 to 24 tons. The total cost of the plant, not including the mill building, is approximately:

25 H. P. engine	$1,000.00
Rock-crusher	250.00
5-foot Huntington mill	1,500.00
5 bumping-tables	1,000.00
Concentrating table	500.00
1 elevator	100.00
Fittings, pipes, etc.	150.00
Contingent expenses	500.00
	$5,000.00
1 pipe retort, with building and drier	2,000.00
	$7,000.00

This plant in three months turned out 330 flasks of mercury;

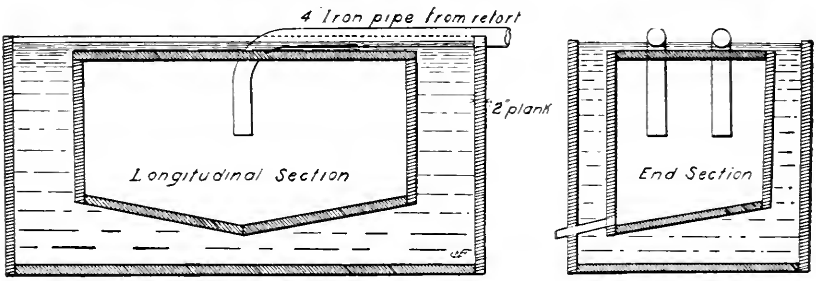


FIG. 65. Condensing plant soot retort, Boston Mine.

and since the visit of the writer, has continued to be operated with about the same results.

This pipe retort furnace may be considered as an example of the best practice for such an installation· the condensing practice is especially very well conceived.

At the Boston mine (Knoxville), the soot is treated in a retort furnace using a condenser formed by a wooden box, surrounded by water, which is constantly renewed, the exit pipe from the condenser being partly immersed in the water covering the top of the condensing box. [See Fig. 65.]

Another arrangement of flues under the pipe retorts, by which the parts of the pipes nearest the front and back walls receive the greatest heat, has been patented by Messrs. Johnson and McKay. [See Fig. 66.] The exit pipes of these furnaces are only 6 feet long, without any attempt at cooling; under their lower end runs a wooden trough wherein the mercury is collected, and a loose burlap sheet is thrown over the end of the pipes and the trough. Whether this installation suffices to condense all the mercury vapors is very doubtful.

Two different forms of cast-iron retorts are used. The pipe retorts vary from 10 to 12 inches in diameter, and from 7 to 9 feet in length, those of 12 inches diameter being generally the shortest. Their capacity is then from 5.22 to 5.9 cubic feet. There must be left sufficient space in the retort so that during the roasting process a sufficient amount of free oxygen will be present to carry off the other vaporized products outside of the mercury. Professor Christy [above cited, vol. XIV, page 236] calculates that 1 kilogram of ore, containing 0.75 kilogram of fixed material and carrying 3 per cent of quicksilver, requires 0.067 cubic meter of air at 0° C. and 760 mm. pressure in

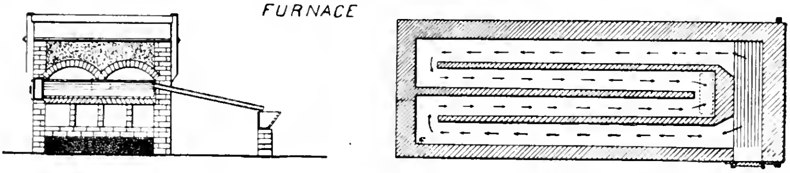
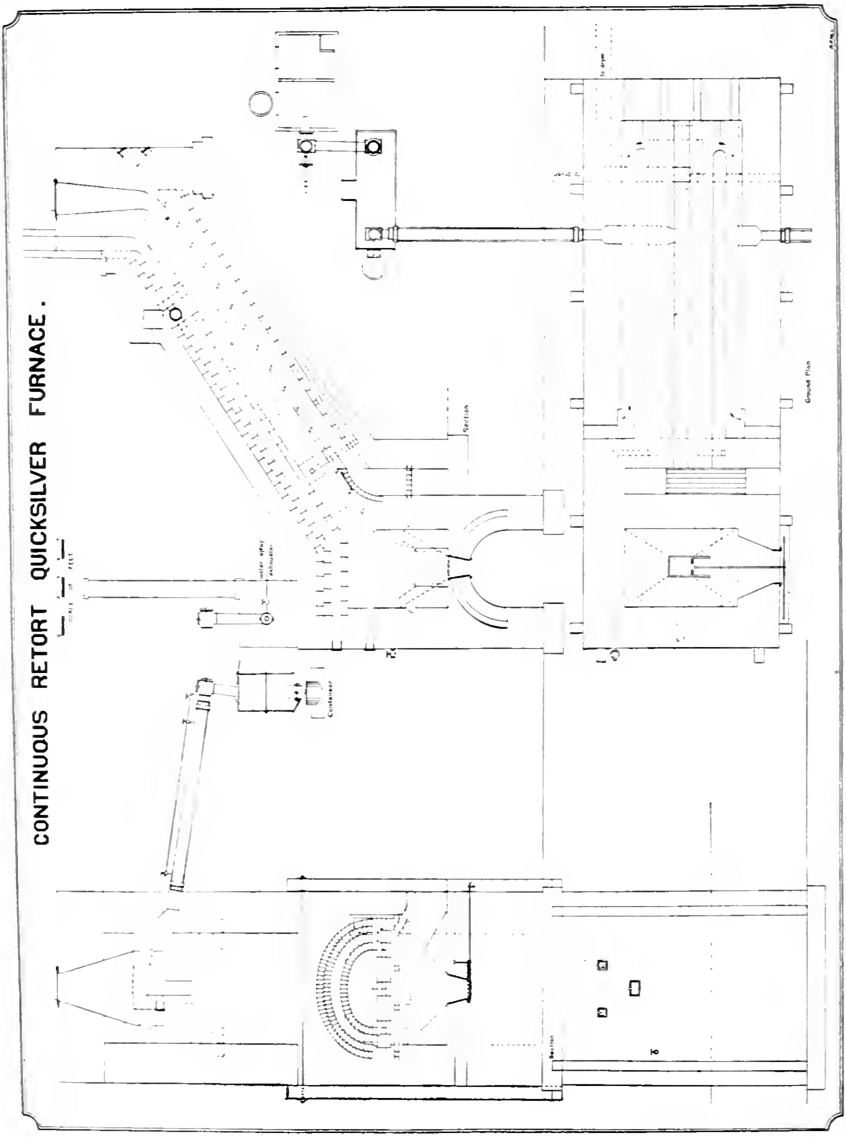


FIG. 66.

order to carry the sulphur off as sulphur dioxide, or at the heat in the retorts, which can be placed at 100° C. when charging, $v=v_{o}(1+a\,t)$; $v=0.067\,(1+\frac{100}{273})=0.091$ cubic meter, which reduced to pounds and feet gives for 1 pound of ore, 1.46 cubic feet of air. In most cases the ores carry sufficient iron sulphides to make the addition of some quicklime very advisable, which will absorb the freed sulphur, according to the equation, $4\,HgS+4\,CaO=4\,Hg+3\,CaS+CaO, SO_3$. The sulphur freed from the reduction of the iron sulphides to ferrous sulphide ($FeS_2=FeS+S$) will also be absorbed by the quicklime. The preceding indicates that the practice of filling the retorts almost completely with ore is wrong; a charge of about 150 pounds of ore, filling about one third of the retort, is the most preferable. The retorts must be kept at a relatively low heat, not exceeding that required for the volatilization of the mercury, from 375° to 400° C. (=750° Fahr.). The distillation of cinnabar ($HgS+2O=Hg+SO_2$) takes place at about 360° C. [Crookes and Röhrig, above cited, page 505.]

The charge generally remains twelve hours in the retort, but at the Helen mine, Mr. Rocca has found that with his



CONTINUOUS RETORT QUICKSILVER FURNACE.

FIG. 67.

highly pyritiferous and rich ore he obtained better results by leaving the charge twenty-four hours in the retort and keeping the heat at its lowest limit.

The ⌓ retorts are generally 18 inches wide and 12 inches high in the center, giving them an area of 1 square foot, and from 7 to 9 feet long. Their charge capacity is consequently larger. Their cost is also much higher—$200 apiece, against $25 for a pipe retort.

The opinions of quicksilver operators differ very much on the relative merits of pipe retorts and ⌓ retorts, both having their adherents; but for soot furnaces those of the ⌓ retorts are probably in the majority.

Mr. C. Fitzgerald has applied the principle of heating the ore without bringing it into direct contact with the products of combustion of the fuel to a continuous retort furnace. [See Fig. 67.] This furnace consists of an inclined, arched channel of firebrick (angle 35°) with a tile floor. It has a charging hopper at the upper end and a discharge chamber with door at the lower end. The flames from the fire chamber pass under this ore chamber along two center flues, return along two outside flues, pass to the top of the arch at the lower end, and go from the upper end to the smokestack. The vapors from the ore chamber are conducted through an iron exit pipe, which is placed near the upper end of the ore chamber and is water-jacketed outside of the furnace, to two condensers. In the second condenser an air current for exhaust is created by a water spray under 100 feet pressure, working on limestone to catch the flour mercury. The capacity of each chamber is rated at 10 tons per twenty-four hours, using one cord of pine wood. In practice the capacity is less. Three of these furnaces have been lately erected—one at the Culver-Baer mine, one at the Uncle Sam mine, both in Sonoma County, and one at the Aurora mine, San Benito County.

The reduction of quicksilver ores on a large scale is conducted in California in shaft furnaces. The evolution of these furnaces from the primitive forms can be found in detail in the above-mentioned metallurgical works. Suffice to say that at present continuous furnaces are exclusively used. They may be subdivided into coarse-ore and tile furnaces, the former only treating lump ore; the latter medium-sized and fine ores.

A reduction plant may be divided into two parts: the furnace and the condensing plant. The latter is just as important as the former. The requirements of a good furnace are: that it burns the rock, that is, that all the quicksilver is eliminated from the ore when said ore is discharged and thrown over the dump; that the charging be done in such a manner as not to allow the escape of any considerable portion of the fumes, thus preventing loss in mercury, and especially danger to the health of the employés; and finally, that the furnace does its work with a reasonable consumption of fuel.

The main portion of the masonry of a quicksilver furnace is built of ordinary brick. The furnace of the Corona mine in Napa County is an exception, being built of tufa instead of common brick. Only those parts which are exposed to the action of the fire and the products of combustion are lined with firebrick. The common bricks are generally burned on the spot, and very often the operators accept and build their furnaces with very inferior material, the result being that even when dried and heated with the greatest care, large cracks appear in the furnace, which are not only detrimental to the regular march of the furnace, but cause a great decrease in its quicksilver production, which, it is true, is not a complete loss, as the metal forms in the furnace bricks as native metal and cinnabar and can be recovered after tearing down the furnace, but which still is a very unprofitable metallurgical treatment. Another cause of rapid deterioration of furnaces is found in too rapid driving, which can only be obtained by raising the temperature in the furnace, generally to a degree which will destroy in a relatively short time the refractory material used in the furnace construction in those parts most exposed to the high heat of the flame. From the data given subsequently on furnace practice, it will be seen what a great difference there is between the time the ore remains in the furnace in different reduction works.

As in all other metallurgical processes, the end to be obtained is not perfection from a metallurgical standpoint, but from a commercial standpoint. As in a gold mill it is often good practice to neglect the extraction of a small percentage of gold out of the ore, so in furnace practice the amount of ore passing through the furnace and the amount of fuel used must be governed by the condition of obtaining the largest results at the lowest cost per unit of produced metal. This depends to a great measure on the special conditions existing in different plants.

It may be here stated that the superintendence of a quick-

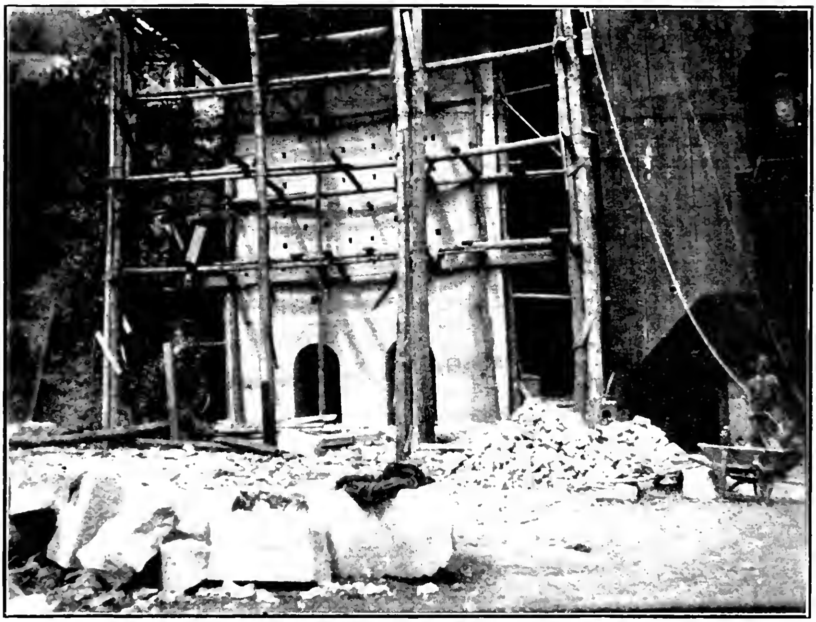


PHOTO No. 23. CORONA FURNACE.

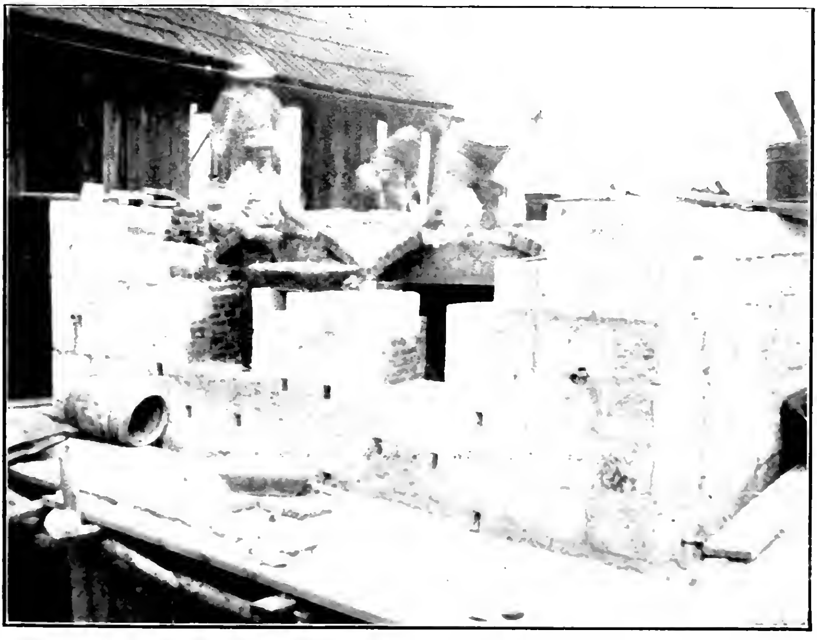


PHOTO No. 24. TUFA FURNACE IN COURSE OF CONSTRUCTION, CORONA QUICKSILVER MINE.

silver reduction plant requires a great amount of technical knowledge, both practical and theoretical, and a constant personal supervision; to put such a plant in the hands of anybody who is not thoroughly competent will invariably lead to disappointment and financial loss.

The coarse-ore furnace is simply a shaft in which the ore is dumped from the top, extracted at the bottom and heated directly by the flame from the fireplace, the products of combustion passing through the ore column. The lumps vary in diameter from 3½ to 9 inches. Various types of these furnaces are at present in operation.

Exeli Continuous Furnace.—This furnace was first introduced in 1871 at Idria, Austria, by Bergrath A. Exeli. Two of these furnaces are in use at New Almaden—furnaces Nos. 7 and 9. Fig. 68 represents this type of furnace, of which a very complete description is given by Egleston [above cited, page 857] and S. B. Christy [above cited, vol. XIII, page 561]. These iron-clad furnaces, built in 1874 and 1875, are still in operation, treating 12 tons of ore every twenty-four hours; the ore remains forty-eight hours in the furnace. While it is generally taken for granted that ores carrying a great amount of metallic mercury can not well be handled in shaft furnaces, these two furnaces in former years gave very satisfactory results when burning the ore from the 1500-foot level, Randol shaft, which contained large quantities of native mercury. The charge consists of about 1600 pounds of ore. These two furnaces require two men per shift, and burn each 0.605 cord of wood per twenty-four hours. The cost of treatment per ton is:

Labor	\$0.4166 (1)
Fuel	0.3025 (2)
Total	\$0.7191

(1) $\frac{4 \times \$2.50}{24} = \$0.4166$ (2) $\frac{0.605 \times \$6.00}{12} = \$0.3025$

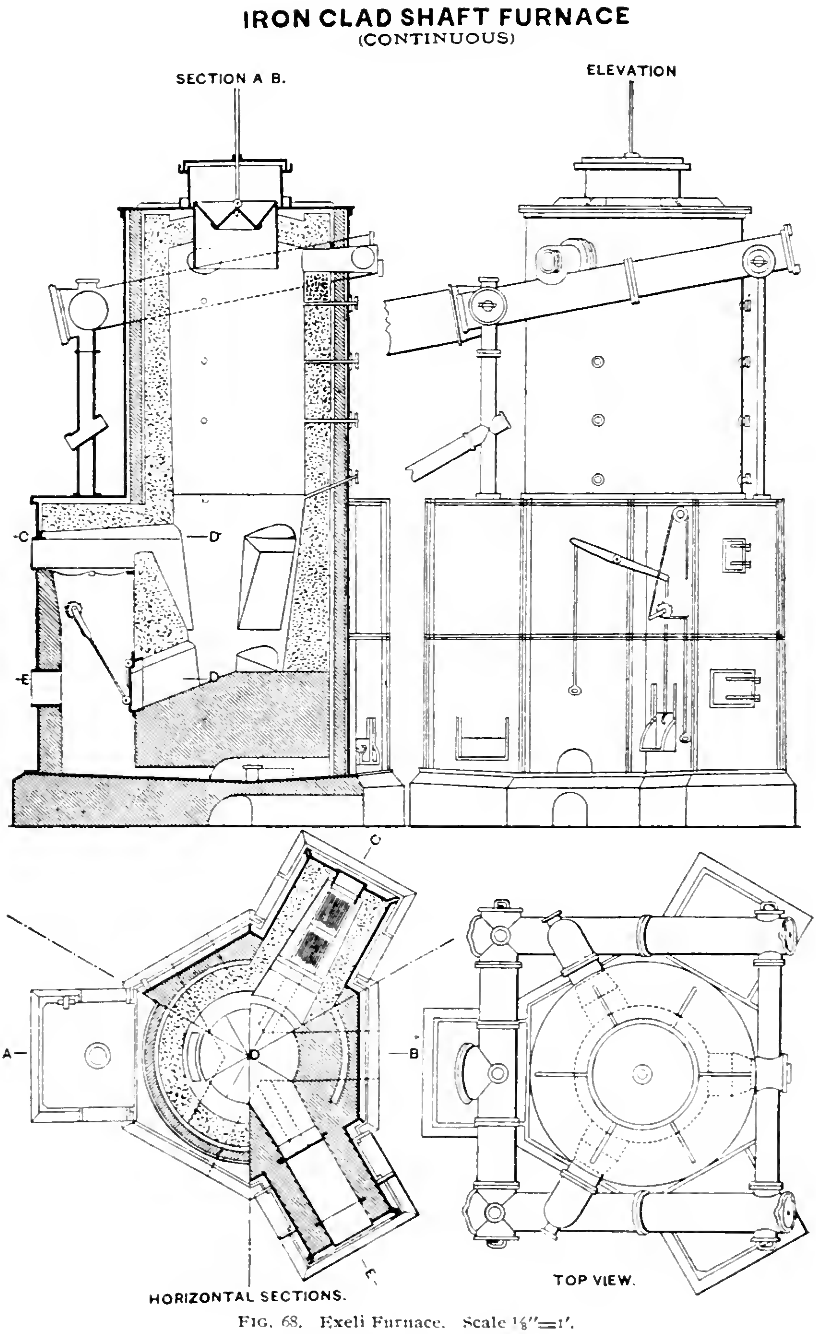


FIG. 68. Exeli Furnace. Scale 1/8″=1′.

Knox-Osborne Coarse-Ore Furnace.—This furnace was patented in 1872. [See Fig. 69.] Formerly a number of these furnaces were in use, but in later years their number has been greatly reduced. One furnace is in use at the Manhattan mine (Knoxville), and the old furnace at the Cerro Bonito mine, San Benito County, has been renovated. [For description, see Egleston, above cited, page 841.]

Some fine ore can be charged with the lump ore, but only sparingly, otherwise it will choke up the passages between the lumps, through which the products of combustion of the fuel must freely circulate. The inventor obviated this by adding some pieces of wood to the fine ore when much of this material was contained in the charge, but this did not fully obviate the trouble; and besides, the addition of fine ores materially reduces the daily capacity of the furnaces. Consequently, since the general introduction of the tiled furnaces, only coarse ore is charged into the various coarse-ore types of shaft furnaces. The cubic content of the furnaces is about 75 tons, and as it handles about 24 tons per day, the ore remains about three days in the furnace. The wood consumption on coarse ore is from one to one and a half cords of oak per twenty-four hours. Three men per shift are required.

Luckhardt Continuous Coarse-Ore Furnace.—This furnace was used in former years at several mines, but at present none are working in California. [See Egleston, above cited, page 838.]

Neat's Coarse-Ore Furnace.—Patented by John Neat. [See Fig. 70.] Two of these furnaces are at the St. John mine, Solano County. This furnace has no fireplace. The ore is charged with coke in alternate layers, using from 3½ to 4 per cent of coke, depending on the draft in the furnace. The drawing space in the bottom of the furnace is open, leaving access to the air and furnishing the draft. The top of the furnace consists of a hopper, with doors at the bottom, moved by levers from the charging floor. At this floor there is besides a cover with a water seal, and provided with a glass panel to judge of the condition of the charge. When the latter is at red heat a charge is withdrawn from the bottom. This is done by withdrawing the fork (*c*), resting on the bar (*d*). The drawing is done at intervals varying from 1¾ to 2¼ hours, according to the draft,

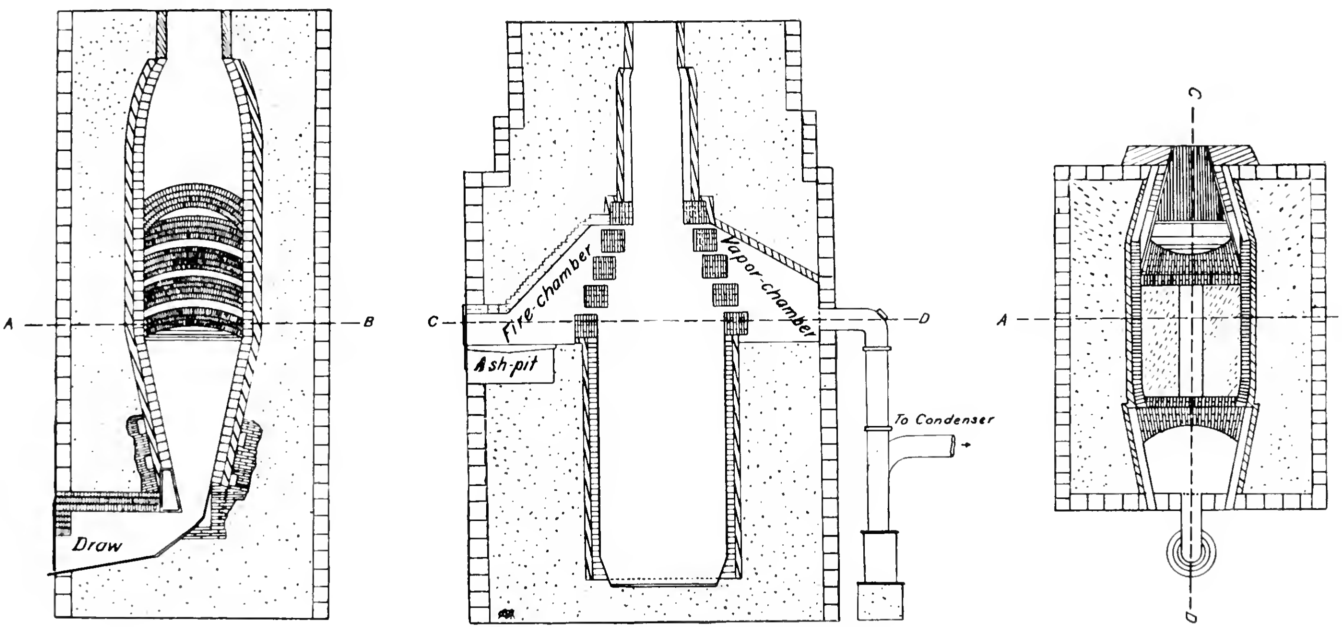


FIG. 69. Knox & Osborne coarse-ore furnace.

which is dependent upon atmospheric conditions. The ore must be in pieces of 1½ inches or over. Judging from the

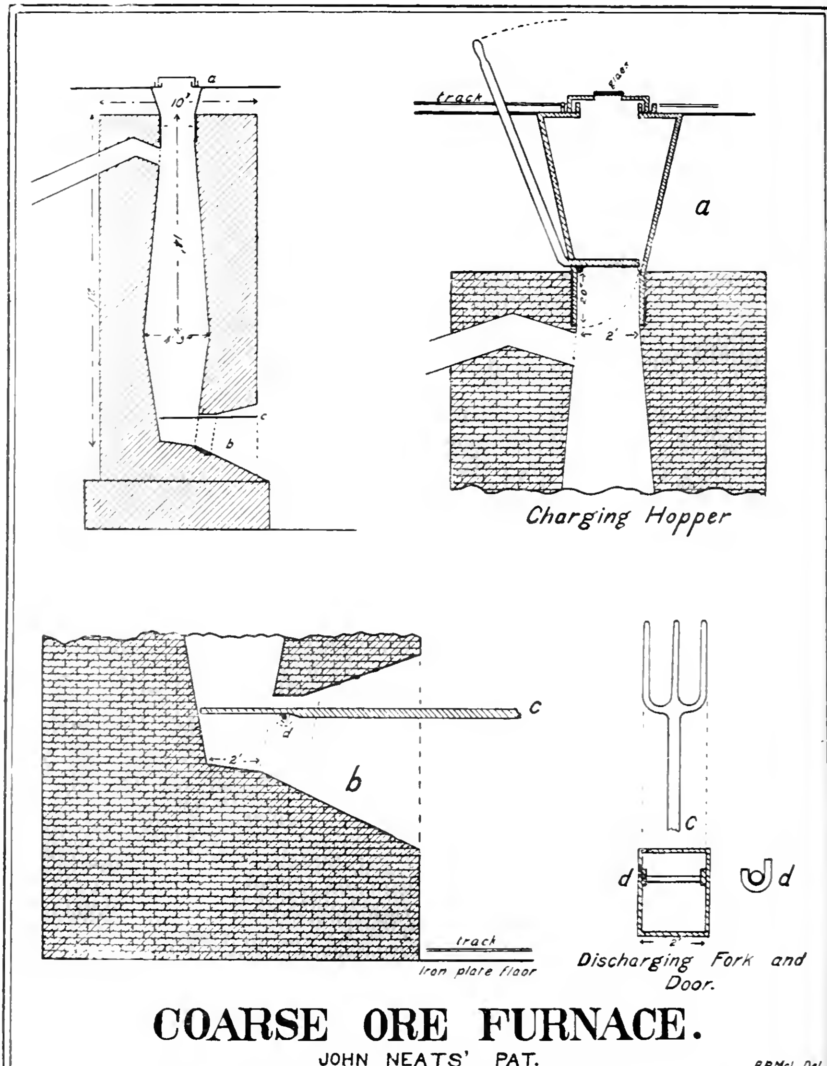


FIG. 70.

furnace dump, a certain amount of clinkering takes place in the furnace.

New Idria Coarse-Ore Furnace.—[See Fig. 71.] This furnace has been designed by Mr. B. M. Newcomb, the general superintendent of several of the principal quicksilver mines in the State.

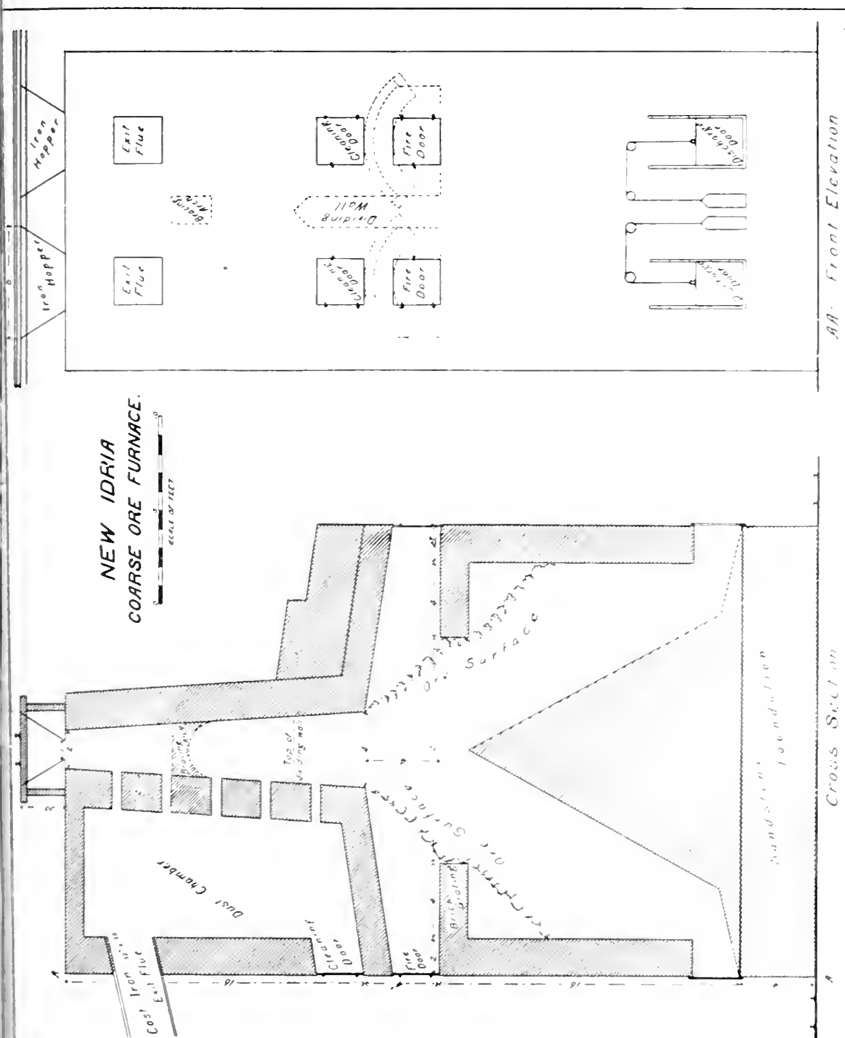


FIG. 71.

As will be seen from the sketch, the fire is applied on both sides of the charge, which is only 4 feet through, and 6 feet long in each compartment at the level of the top of the fire chambers, and is heated at three sides, while besides, as it

PHOTO No. 25. NEW IDRIA QUICKSILVER MINE, SHOWING NEW 80-TON COARSE-ORE FURNACE.

comes into the fire chambers, the charge spreads, thus causing its speedy heating to the highest temperature in the furnace. The depth of the discharge doors below the level of the fire chamber gives the ore a chance to cool off, and to give off the mercury vapors not volatilized during its passage in front of the fire chamber. This furnace is 17 feet wide, 24 feet through at the level of the fire chamber, and has a total height of 42½ feet from drawing floor to charging track. It handles from 90 to 100 tons per twenty-four hours; its cubic capacity is 2400 feet, hence the ore remains a little above twenty-four hours in the furnace. It is run by two shifts of five men each—one furnace man, two chargers, and two drawers—and requires not quite 2½ cords of wood per day. The excessively low fuel consumption is partly due to the high percentage of iron sulphide in the ore.

The fine-ore furnaces belong nearly all to the tile furnace type, with the exception of:

Livermore Furnace.—[See Fig. 72.] Only two of these furnaces are at present in operation—one at the Cloverdale mine, the other at the Culver-Baer mine, both in Sonoma County. The latter is a reconstructed Fitzgerald furnace. For more detailed description of this furnace, see Egleston, above cited, page 887.

The tile furnaces generally adopted in California are the

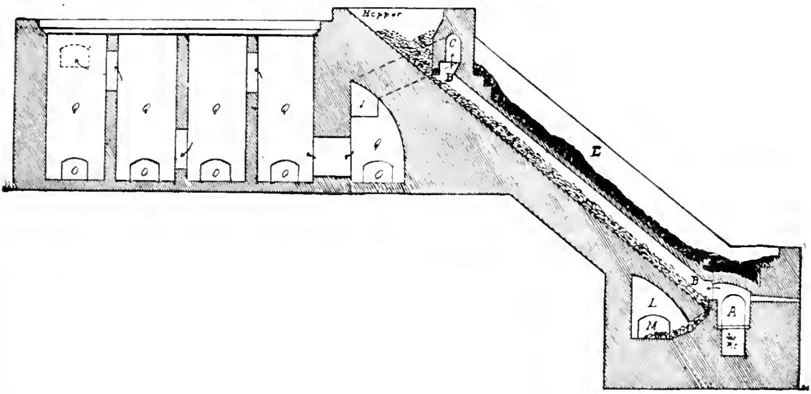


FIG. 72. Longitudinal section. Modified Livermore quicksilver furnace.

Litchfield, the Knox & Osborne fine-ore; and the Hüttner Scott.

Litchfield Furnace has been in operation at the Great Western mine, Lake County, for a number of years, and has given good satisfaction, although admittedly consuming more fuel than the Hüttner-Scott furnace. It resembles closely the latter, except that the heat ascends in the ore chambers between the walls and the tiles, instead of being forced to pass over the tiles.

Knox-Osborne Furnace, for fine ore, is used in the Manhattan, Altoona, and Integral mines. This furnace has a capacity of 24 tons per day. It consists [see Fig. 73] of two ore chambers, across which the inclined tiles are placed in a checkerboard manner; the two upper rows of tiles are of cast-iron, the others of fire clay. The ore glides down along the channels formed by the inclined places. The double fire chamber is at one side

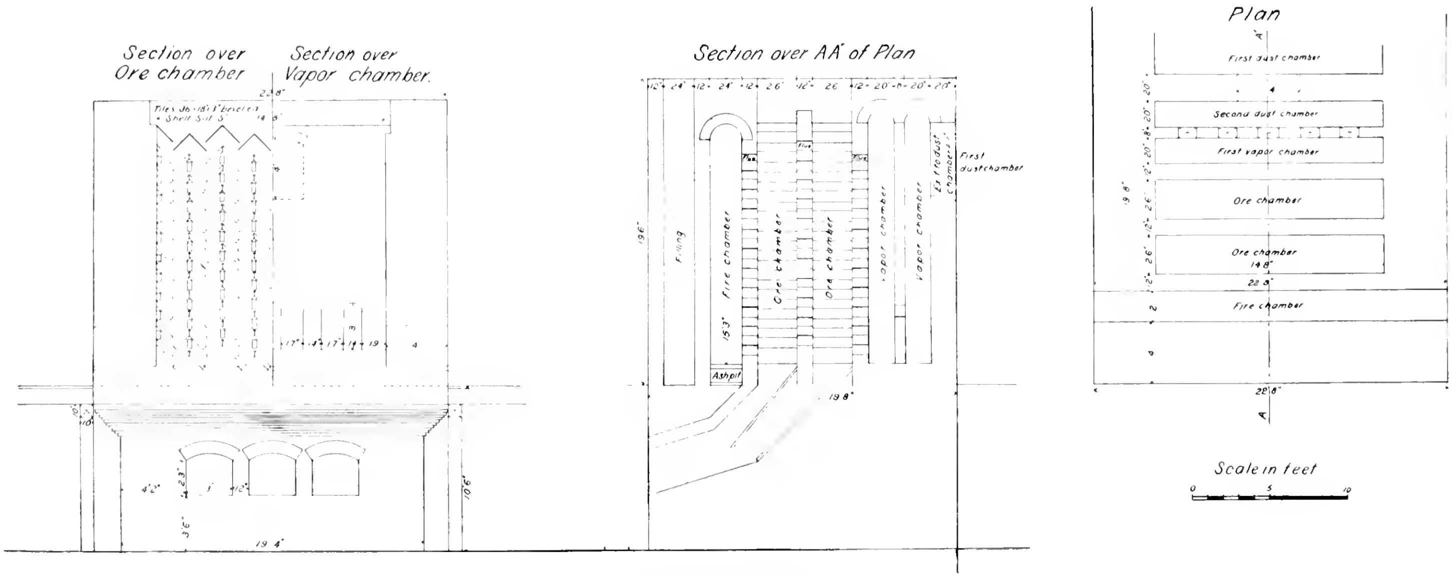


Fig. 73. Knox & Osborne fine-ore furnace.

PHOTO No. 26. CLOVERDALE REDUCTION PLANT.

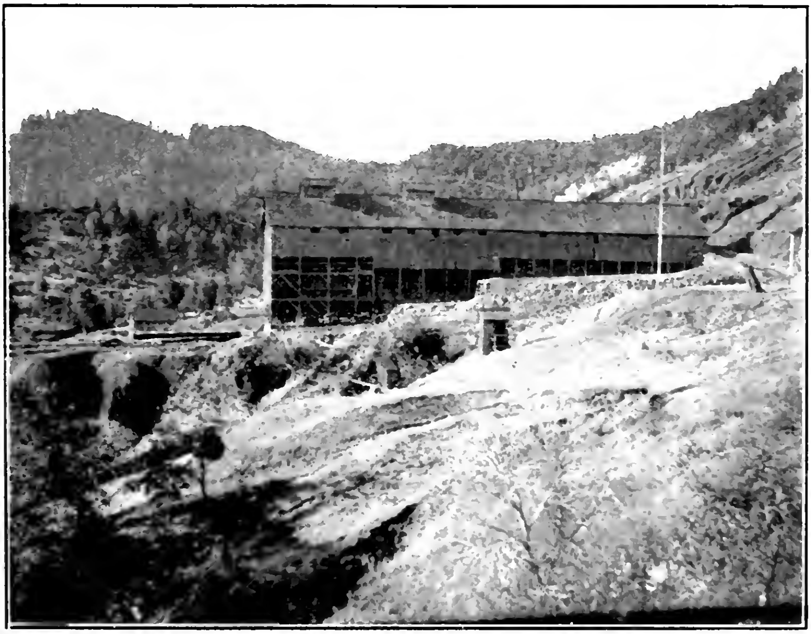


PHOTO No. 27. GREAT WESTERN QUICKSILVER MINING CO. REDUCTION PLANT.

of the ore chamber. The partition walls between the fire chamber and the first ore chamber, between the ore chambers, and between the second ore chamber and the first dust chamber, are pierced with pigeon holes, through which the flames pass, heating the tiles and the ore. The partition wall between the first and second dust chamber, both of which form an integral part of the furnace, has five openings 3 feet high on the level of the floor of the fireplace, creating a down draft

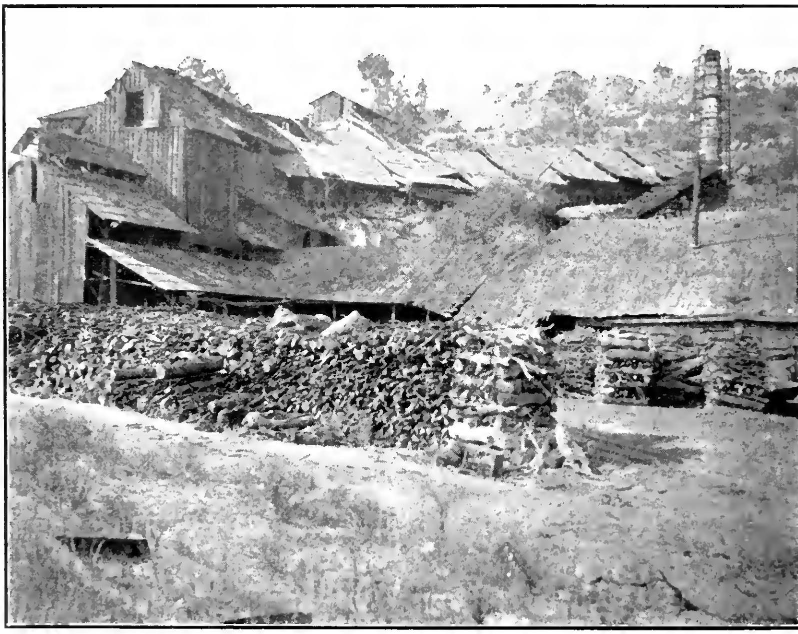


PHOTO No. 28. MANHATTAN FURNACE.

in the furnace. The second dust chamber is provided in its outer wall with a large opening near the top, through which the fumes pass into the first condenser, which is built at the Integral mine contiguous to the furnace. The top of the furnace is open; the charge is placed directly on the upper rows of tiles; the down draft above mentioned being deemed sufficient to prevent the escape of gases from the furnace.

Huttner-Scott Furnace.—[See Fig. 74.] This furnace represents the latest evolution of quicksilver furnaces in California. Originally only used for fine ores, it has been modified to burn

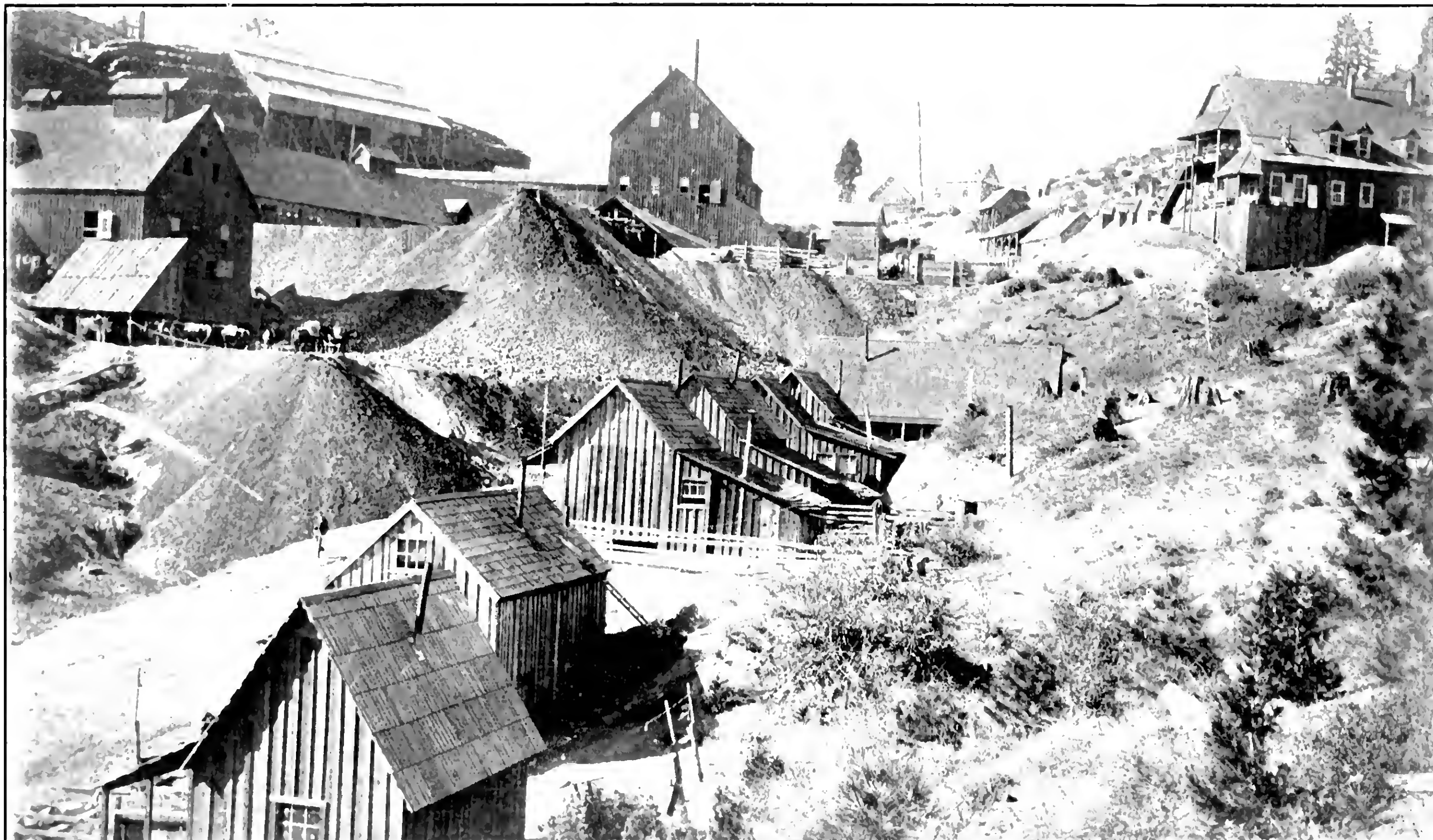


PHOTO No. 29. ALTOONA QUICKSILVER MINE.

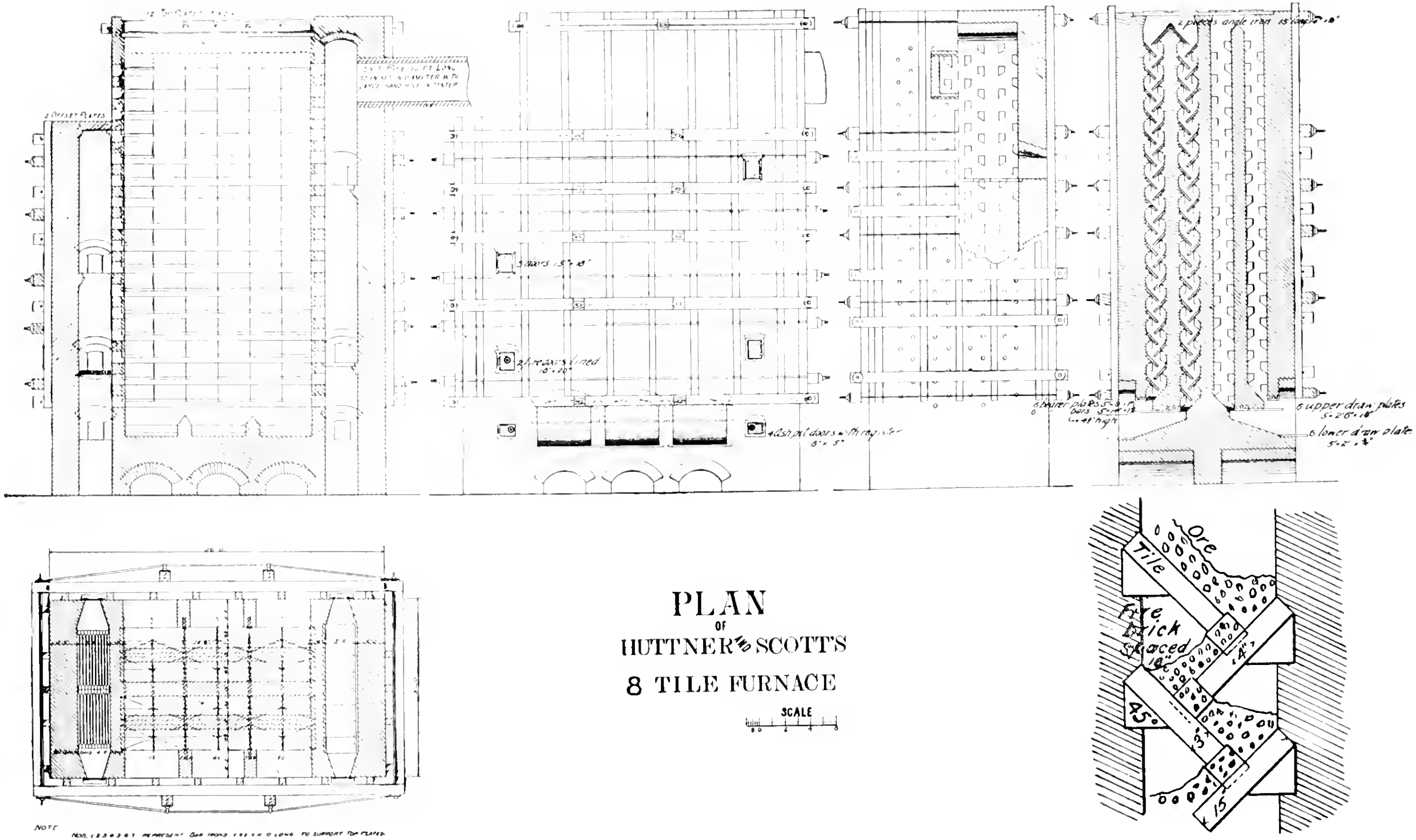

PLAN
OF
HUTTNER AND SCOTT'S
8 TILE FURNACE
SCALE
2 pieces angle iron
6 upper draw plates
6 lower draw plate
4 ash pit doors with register
2 fire doors lined
Ore
Tile
Fire Brick Spaced
45°
15
NOTE

FIG. 74.

also medium-sized ore, up to $3\frac{1}{2}$ inches. It is extensively described and discussed by Egleston [above cited, page 864] and Christy [above cited, vol. XIII, pages 553 and 566]. The tiles form a zig-zag plane, along which the ore fed from the top slides down through the furnace until finally discharged at its bottom through the drawing pit, being gradually heated on its descending course. The size of the ore lumps which can be treated in this furnace is governed by the distance between the edge of one shelf to the face of the next below it, called the shelf-slit. This distance was 3 inches in the first furnaces. Since then it has been increased; the general dimensions now used is 5 or 6 inches, allowing medium-sized ore to be charged. In furnace No. 1, New Almaden, built in 1880, the shelf-slit is 8 inches, the largest used in any furnace of this type.

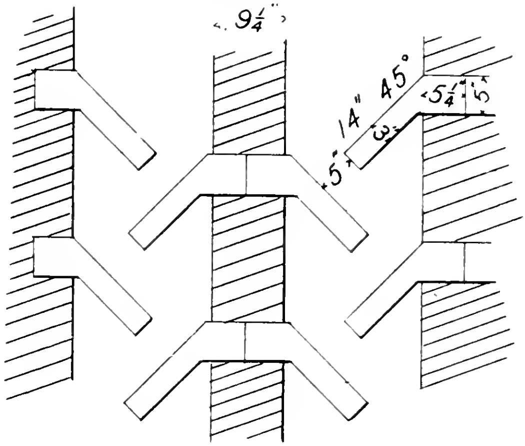


FIG. 75. Tiling of Furnace No. 3, New Almaden.

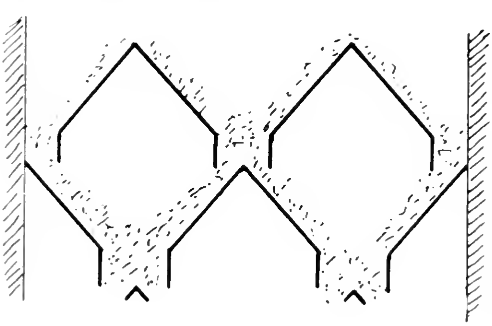


FIG. 76. Tiling of Cermak-Spirek furnace.

Generally the tiles are flat; their largest commercial dimensions are 3 inches by 15 inches by 36 inches. They are imported, and cost, laid down in San Francisco, \$3.50 apiece. Larger tiles, or those of special form, cost more. The detail sketch shows the manner in which the tiles are secured in the ore chamber.

Furnace No. 3, New Almaden, has a different form of tiles. [See Fig. 75, and vol. XIII, above cited, page 575.] These tiles have not proven as satisfactory as the flat ones. In Europe, however, a similar form of tile is commonly used in the Cermak-Spirek furnace. [See Fig. 76.]

All the Hüttner-Scott furnaces have the fire chambers on one side of the ore chambers, and a vapor chamber on the other side, except the Wide Awake furnace at Sulphur Creek, Colusa County, where a fire chamber is placed on both sides of the ore

PHOTO No. 30. FURNACE PLANT, INTEGRAL MINE, TRINITY COUNTY.

chamber. Mr. Gibson claims that thereby the capacity of the furnace is materially increased without increasing the fuel consumption. Mr. Robert Scott is of the opinion that one set of fire chambers is sufficient to heat the ore which can be put through the furnace to the required temperature.

The Hüttner-Scott furnaces are made of various capacities, which are governed by the number of ore chambers in the furnace, and by the height of each ore chamber. Following is a table giving the dimensions of some furnaces:

DATA REGARDING SOME TILE FURNACES.

Name	Daily Output.	Cubic Capacity.	Time Charge Remains in Furnace.	Outside Dimensions. Horizontal		Outside Dimensions. Total Height Above.	Ore Chamber. Length.	Ore Chamber. Width	Ore Chamber. Shelf Slit.	Ore Chamber. Height from Roof to Point of Discharge.	Number.	Fuel per 24 Hours.	Men Employed per Shift.	Remarks
	Tons.	*Tons.*	*Hours*	*Feet*	*Feet.*	*Feet.*	*Feet*	*Inches.*	*Inches.*	*Feet.*		*Cords.*		
New Almaden, No. 1	36	..	30	17½	25½	30	11½	25½	8	27¼	4	1½ to 1¾	3	When worked together only 5 men per shift.
New Almaden, No. 2	18	..	30	12½	24	30	11½	25½	8	27¼	2	....	3	
New Almaden, No. 3	36	..	52	20¾	24¼	41½	11½	22⅜	5	36	6	2½	....	
New Almaden, No. 8	24	32	32	$9\frac{5}{12}$	37	41	8⅔	18	3	30¼	4	2	2	
Boston	60			$13\frac{10}{12}$	26	37	14½	18¾	3	29¾	4	2	.	70 per cent of the mercury in the soot.
Oathill	50	40	20	16	22	37	8½	....	6	31¼	4	2¾	4	
Mirabel	30		..			..	....	....	..	....		2¼		
Karl	60			..	..	....	..	......	..	....			....	
New Idria	60		24			....	..	......	..	......	..			
Sulphur Bank	40					....	....	....		......		1¼		
Sulphur Bank	30			..		......	......	....	..		..	1		
Sulphur Bank	15			..			....	....					..	
Great Western (Litchfield furnace)	40					....	....	..				2¼	..	

At the New Almaden, some furnaces, viz., Nos. 3 and 8, are entirely surrounded by iron plates, and are called "ironclad furnaces." This method of inclosing a furnace gives very good satisfaction, but is very expensive. Generally furnaces are inclosed in a wooden framework strengthened by iron tie rods. In order to prevent this wooden framework from catching fire, especially near the cracks in the furnace, which are almost inevitable, it is advisable to surround them with asbestos, 2

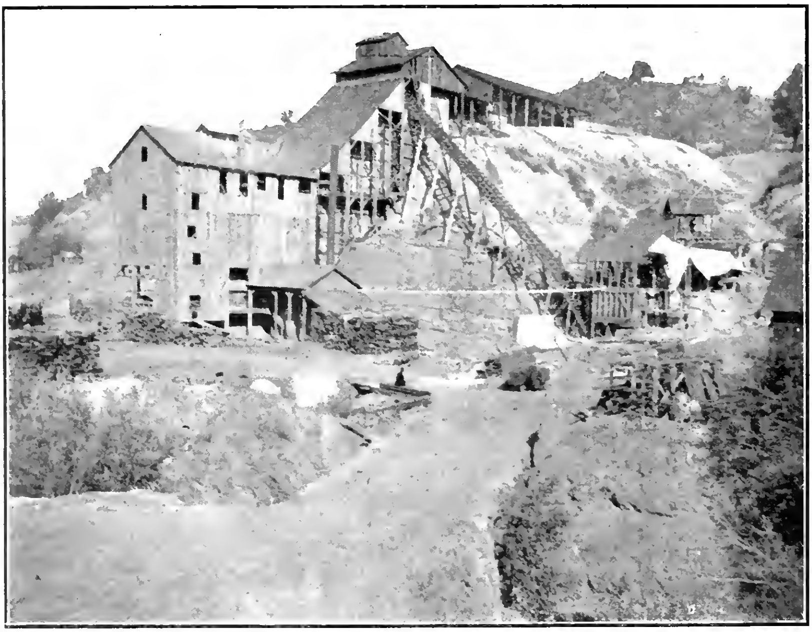


PHOTO No. 31. KARL FURNACE, SAN LUIS OBISPO COUNTY

inches thick. [See Fig. 84.] The later furnaces are commonly of a daily capacity of 10, 20, 30, and 50 tons. The principal materials entering in these furnaces are:

		10-Ton.	40-Ton.	50-Ton.
Common brick	No.	150,000	300,000	400,000
Firebrick	"	12,000	20,000	30,000
Tiles	"	188	360	428
Cement	bbls.	25	40	50

Fire clay.
Timber for frame.
Iron for frame, grates, hopper, etc.

The price of the firebrick is $32.50 per 1000 at San Francisco. The price of tiles 3 inches by 15 inches by 36 inches is $3.50 apiece.

When the ore is charged moist in the furnace a great amount of water vapor will be formed, which not only increases the already excessive amount of fumes out of which the mercury must be condensed, but also the formation of a great amount of sulphuric acid and of sulphates, both of which are very injurious to the condensers. The opinion of operators as to

FIG. 77. Ore Drier, utilizing exhaust steam

the desirable degree of dryness of the ore before charging differs. Some claim that for good practice absolutely dry ore would be preferable, while others consider a relatively superficial drying sufficient. In dry climates sun drying may in cases then suffice. In many furnace plants the ore is dried by spreading over iron plates on the top of the first condensers.

In other plants, for instance at the Oathill, Great Eastern, etc., a special drier is used. [See Fig. 77.] The exhaust steam

PHOTO No. 32. GREAT EASTERN MINE DRYING ORE IN SUN.

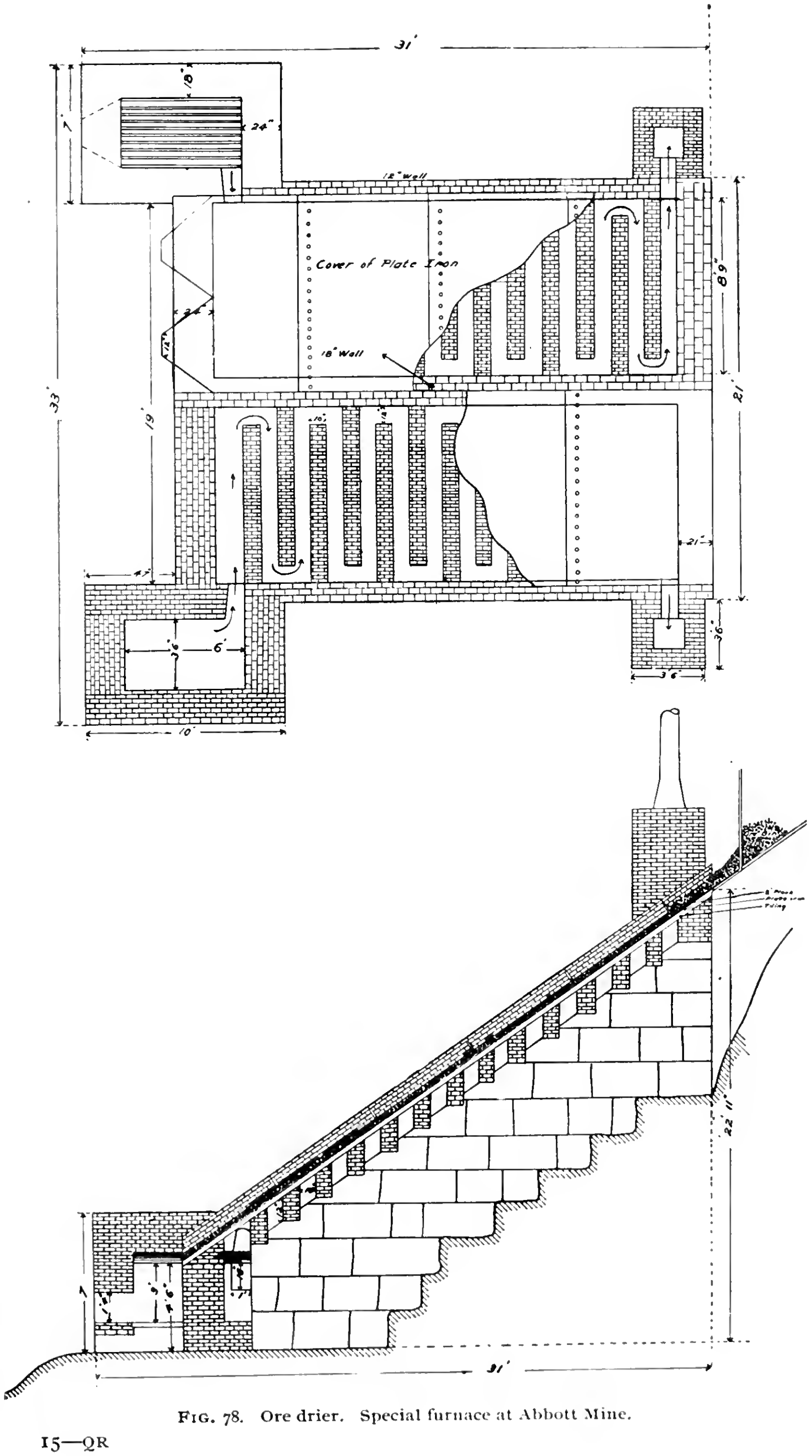


FIG. 78. Ore drier. Special furnace at Abbott Mine.

from the engine driving the fan is passed through coils under the platform on which the ore is spread. At the same time, at Oathill, exhaust steam is brought into the first condenser. At the Abbott mine, a special furnace is used to heat the platform of the ore-drier. [See Fig. 78.] Sixty tons of ore can be dried in twenty-four hours, using two cords of oak wood. The ore charged in furnace No. 3, at New Almaden, passes through a brick shell surrounding a condenser, and provided with a series of tiles placed at an angle of 45°, thereby obtaining the double result of drying the damp ore and materially increasing the condensation in the condenser.

Again in other furnaces the ore is only dried while in the charging hopper and partly in the upper part of the furnace. At the Manhattan furnace a special flue conducts the fumes from the upper three rows of tiles to the first brick condenser. These fumes are principally water vapor, but yet contain some mercury vapors. At the New Idria furnace, where the fumes emanating from the upper part of the charge are highly sulphuric, due to a great amount of iron pyrites in the ore, the device indicated in Fig. 79 has been adopted, which has proven very effective. The pipe (*e*) goes to a special blower, from which the fumes are conveyed to the smokestack. Mr. Robert Scott proposed to dry the ore in the top of the furnace and to carry off the fumes there formed by making the tiles of the upper three rows of cast-iron and hollow, and passing the fumes through these hollow tiles, instead of over the charge. [See Fig. 80.] In order to prevent the clogging at the top of the furnace, rakes worked by levers from the charging floor are used. [See Fig. 81.]

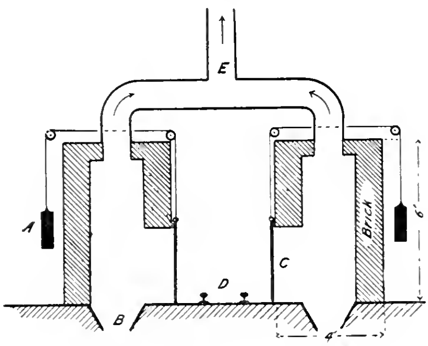


FIG. 79. New Idria fine-ore furnace. Method of conveying fumes from top.

A—Counterweight, chained. *B*—Furnace hopper. *C*—Iron door *D*—Track for side dumping car. *E*—Cast iron pipe (12") to blower and smokestack.

Mr. H. C. Davey divides the furnace into two vertically superimposed compartments. In the lower part the roasting takes place as in the Hüttner-Scott furnace. The upper part is

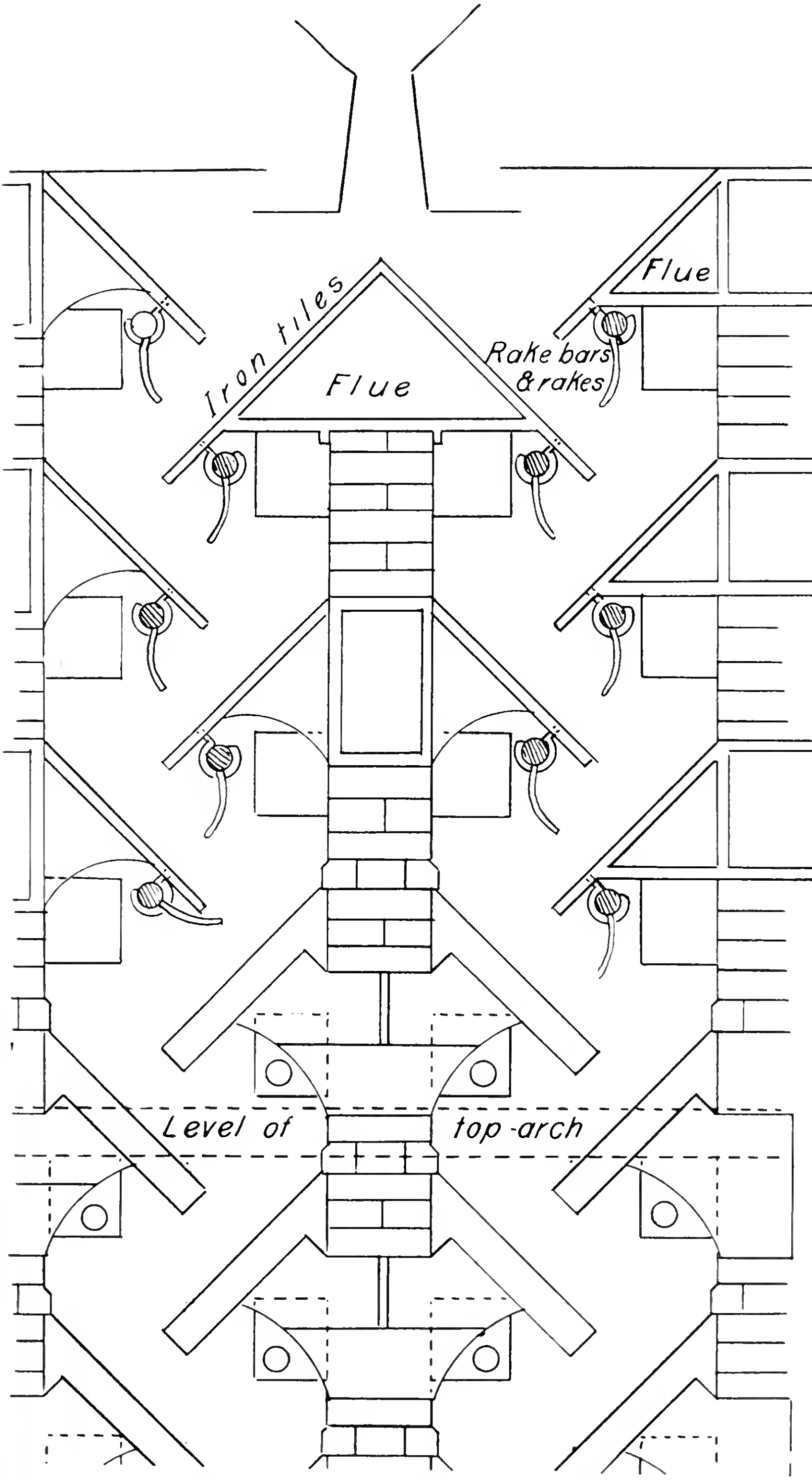


FIG. 80. Top of the modified Scott furnace. Scale ¼″ = 1′.

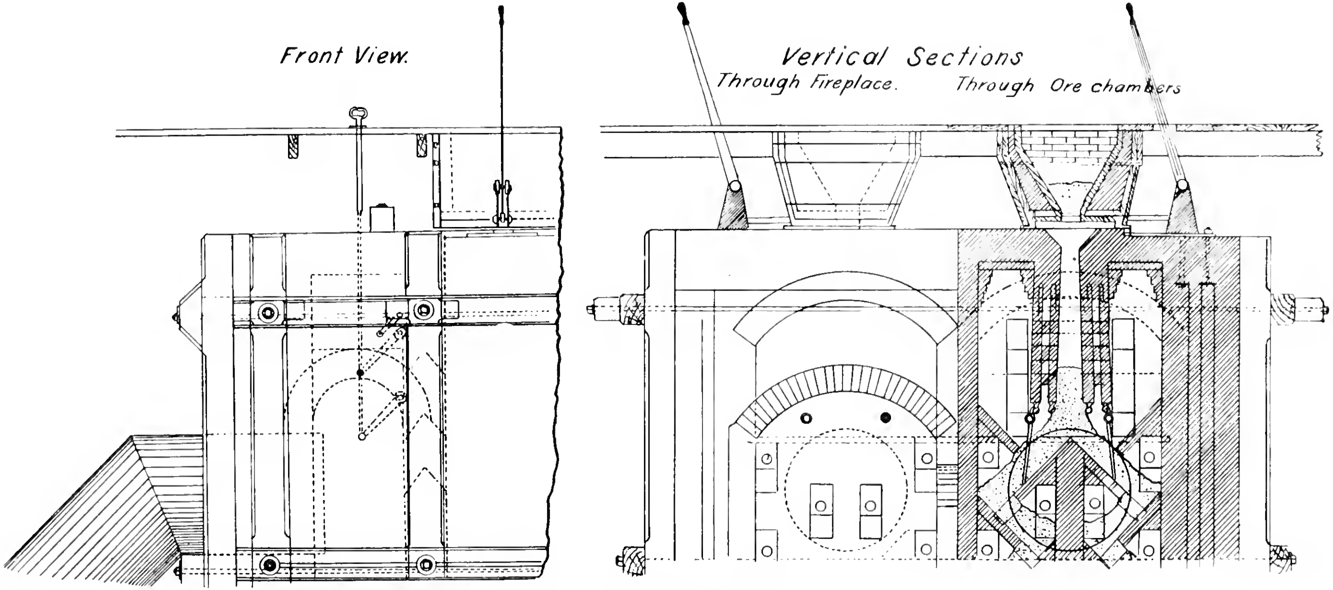


FIG. 81. Top of Hüttner-Scott furnace.

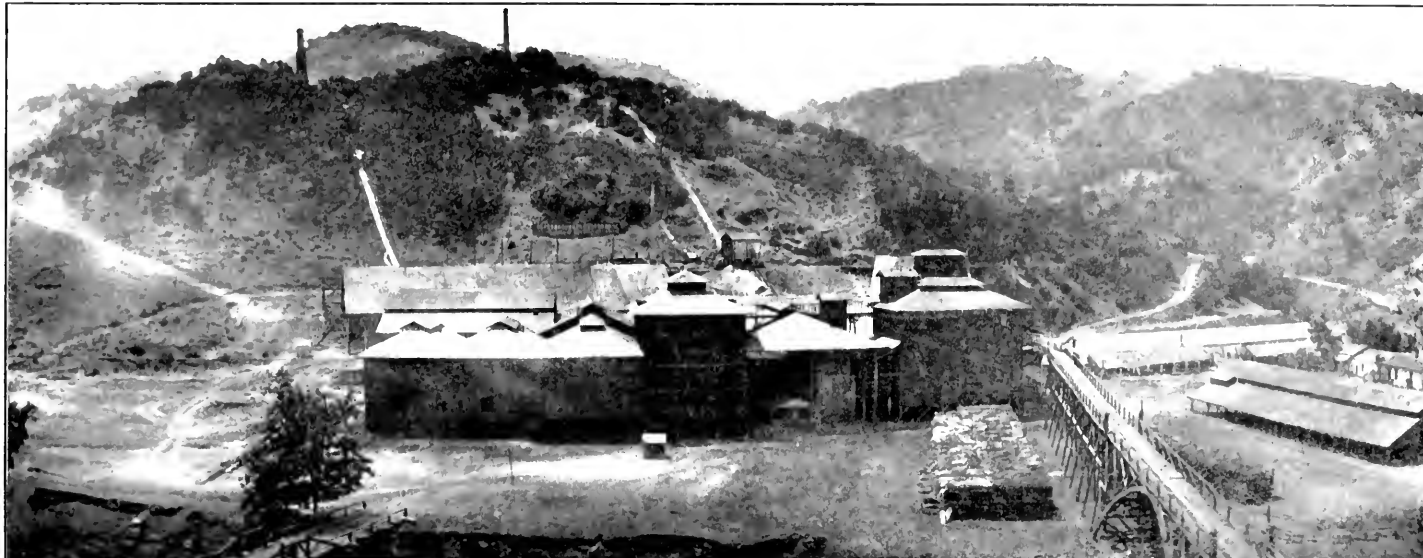


PHOTO No. 33. THE REDUCTION WORKS AT NEW ALMADEN—HACIENDA.

heated, by a separate furnace, only to the temperature required to dry the ore. The ore falls through a narrow vertical throat from the upper into the lower compartment of the furnace. In

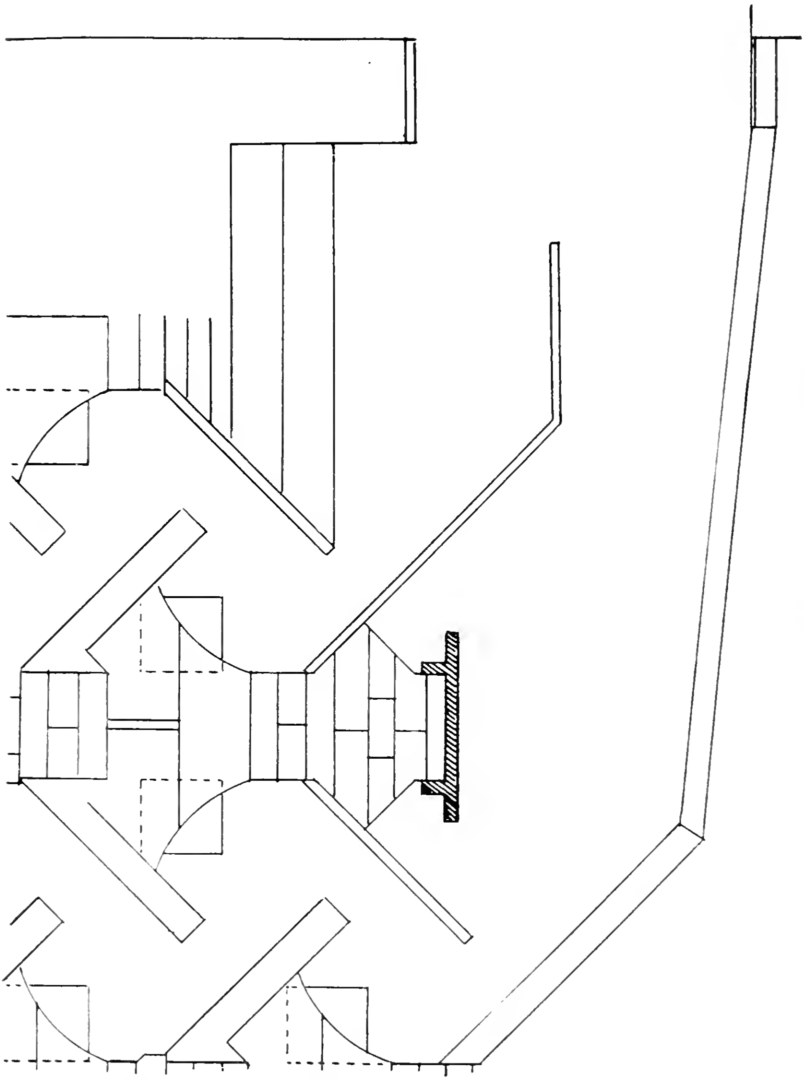


Fig. 82. Discharge Scott furnace. Scale ¼″=1′.

the modified plan of Mr. Scott, above mentioned, this end is attained by bars and rakes. [See Fig. 80.] To cause the ore to move down gradually while charging, the throat below the hopper must have the same width as the shelf-slit.

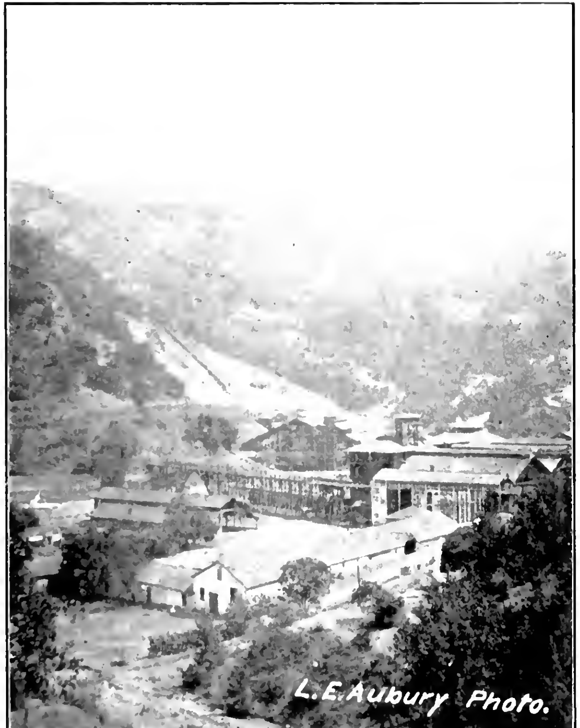


PHOTO No. 34. GENERAL VIEW OF THE REDUCTION WORKS AT NEW ALMADEN—HACIENDA.

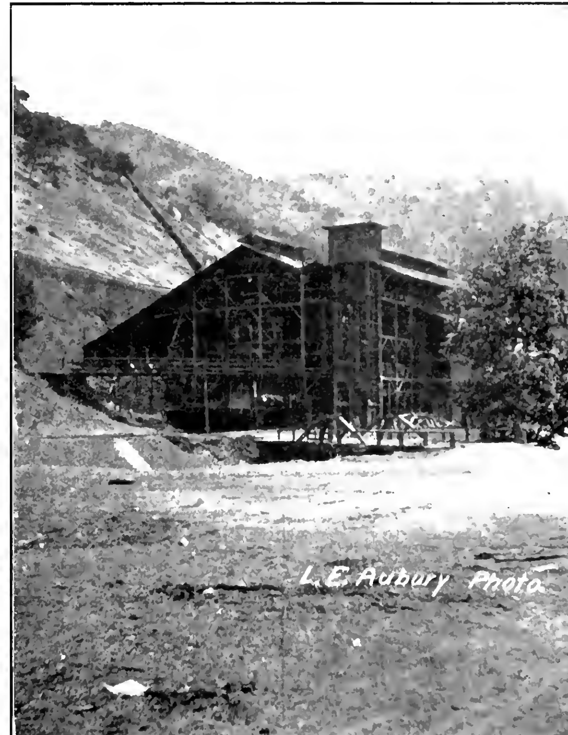


PHOTO No. 35. FURNACES Nos. 1 AND 2, NEW ALMADEN—HACIENDA.

The discharging of the furnace is also done in various ways. [See the detailed plans in Egleston and Christy, and plans in Figs. 73, 74, and 82.] Generally the hood of the flue carrying off the fumes emanating while discharging is close to the timber (*b*), causing danger of hot dust accumulating against the frame timbers, and rendering it difficult to remove the dust. This is obviated by the construction shown in Fig. 83.

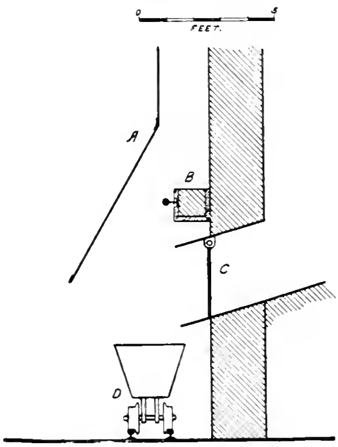


FIG. 83. New Idria fine-ore furnace. Details of drawing door.

A—Sheet iron hood carrying away fumes. *B*—Bracing rod and hood (asbestos covering). *C*—Iron door in iron-lined chute. *D*—Ore car.

The general arrangements of furnace plants are shown in Fig. 84 (Oathill furnace), Fig. 85 (Abbott furnace), and Fig. 86 (St. John furnace), and several photographs. The plan of the New Almaden is given on a large scale in the works of Egleston and Christy, above cited. Most of the furnace plants have been gradually enlarged, and as their site is nearly always in a mountainous region, this gradual enlargement has often forced, by lack of proper room, the condensing plant to be built in a very irregular manner.

The condensing of the fumes emanating from the furnace and the recovery of the mercury offer a very complicated problem. The distillation heat of cinnabar is 360° C., or 680° F., hence the fumes must leave the furnace at a temperature higher, but as near as possible to it; the theoretical product being mercury in vapor form and sulphur dioxide ($HgS+2O=Hg+SO_2$).

In good practice the temperatures of the fumes as they leave the furnace appear to come very near to this limit. [See Christy, vol. XIV, above cited, page 226.]

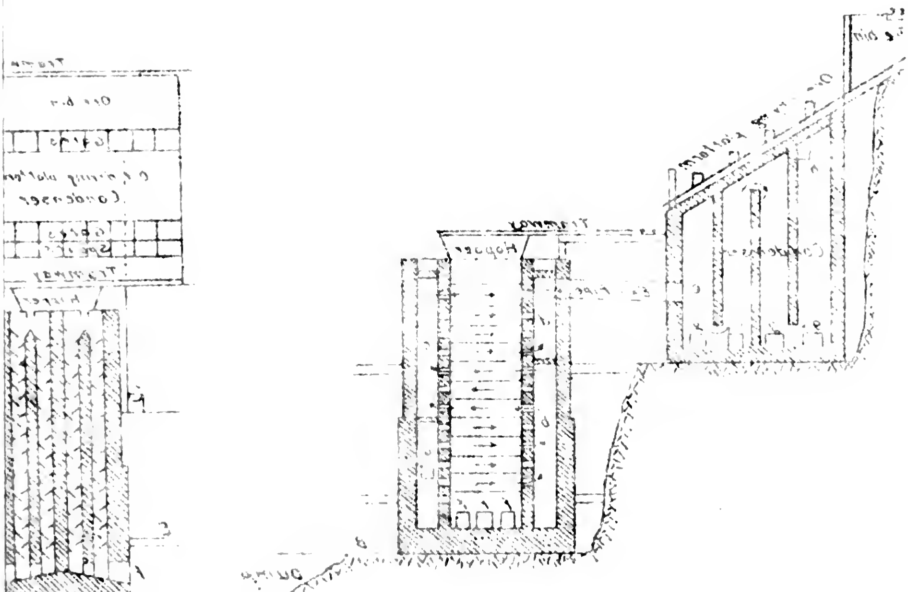
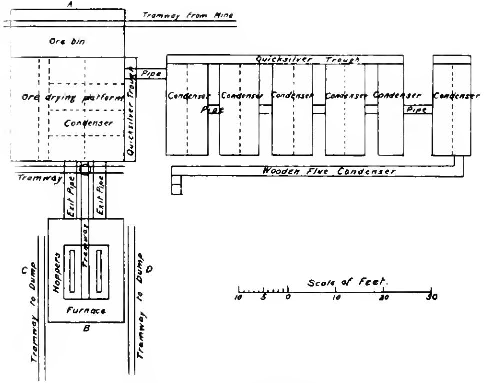
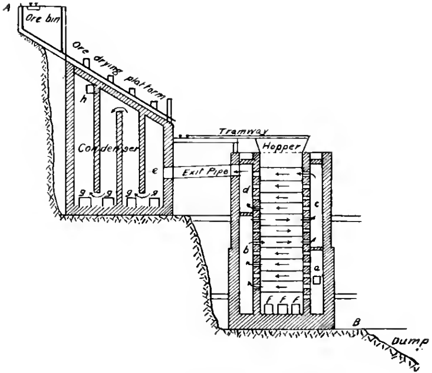


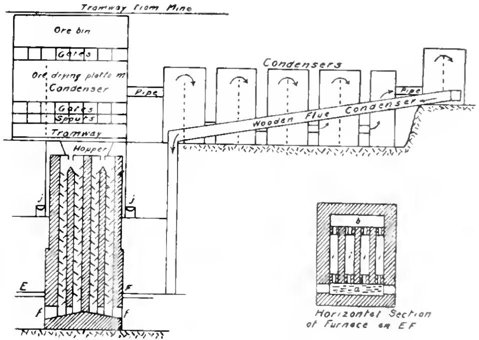
FIG. 84.



General plan of reduction works. (Mineral Industry.)

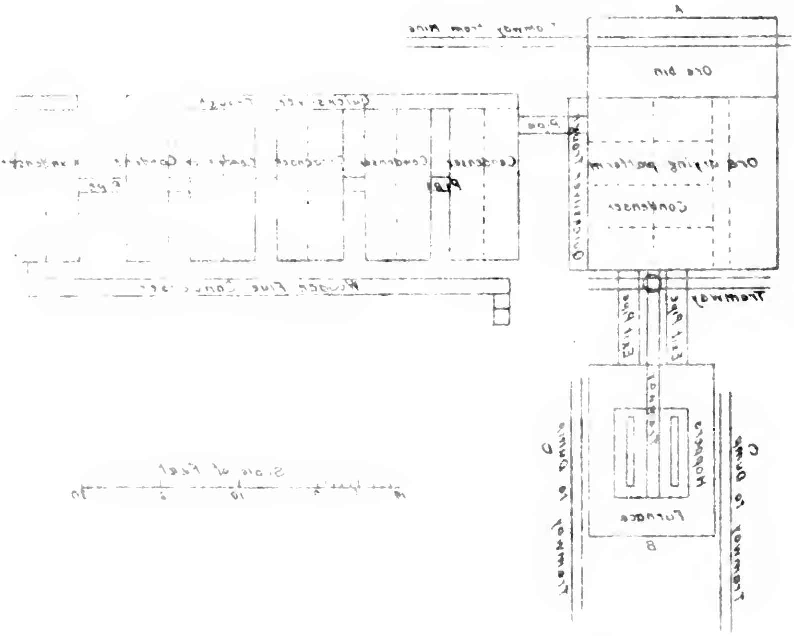


Vertical section of condensers and furnace on *A B*. (Mineral Industry.)



Vertical section of furnace and elevation showing condensers (Mineral Industry.)

PHOTO No. 36. REDUCTION PLANT IN COURSE OF CONSTRUCTION. SILVER CREEK QUICKSILVER MINING CO., SANTA CLARA COUNTY.



General plan of reduction [illegible] (Mineral Industry.)

PHOTO No. 36. REDUCTION PLANT IN COURSE OF CONSTRUCTION. SILVER CREEK QUICKSILVER MINING CO., SANTA CLARA COUNTY.

TEMPERATURE DETERMINATIONS AS TAKEN BY MR. J. R. SMEDBERG, FEBRUARY, 1880, WITH FURNACE NO. 9, NEW ALMADEN.

	Degrees Celsius.	Degrees Fahrenheit.	Fall in Degrees Celsius.
1. Lowest peep-hole (above fireplace)	823°	1513°	....
2. Next higher	946	1735	......
3. Next higher	878	1612	......
4. Topmost peep-hole (near furnace throat)	372	701	......
5. Entrance to first brick condenser*	190.6	375	181.1°
6. End of second brick condenser	37.8	100	152.8
7. End of first glass and wood condenser	25.6	78	12.2
8. End of second glass and wood condenser	17.8	64	7.8
9. End of third glass and wood condenser	15.6	60	2.2
10. End of fourth glass and wood condenser	14.4	58	1.2
11. End of fifth glass and wood condenser	14.4	58	0.0
12. End of sixth glass and wood condenser	13.9	57	0.5
13. End of wooden flue, entrance to sidehill flue	13.3	56	0.6

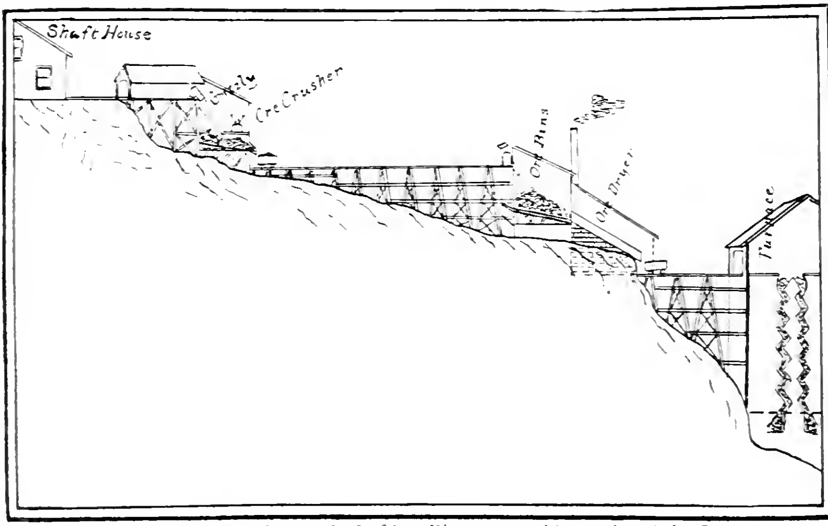


FIG. 85. Sketch showing method of handling ore at Abbott Mine, Lake County.

According to this table, the cooling takes place principally in the down-take and in the two brick condensers, the fumes being cooled to à temperature of 37.8° C., and moisture begins already to appear. It is to be regretted that the results of similar temperature determinations on a modern Hüttner-Scott plant are not available.

*After passing through the iron down-take, see description of furnace

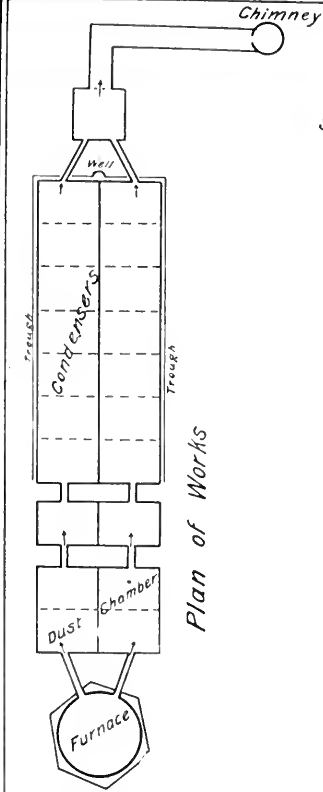
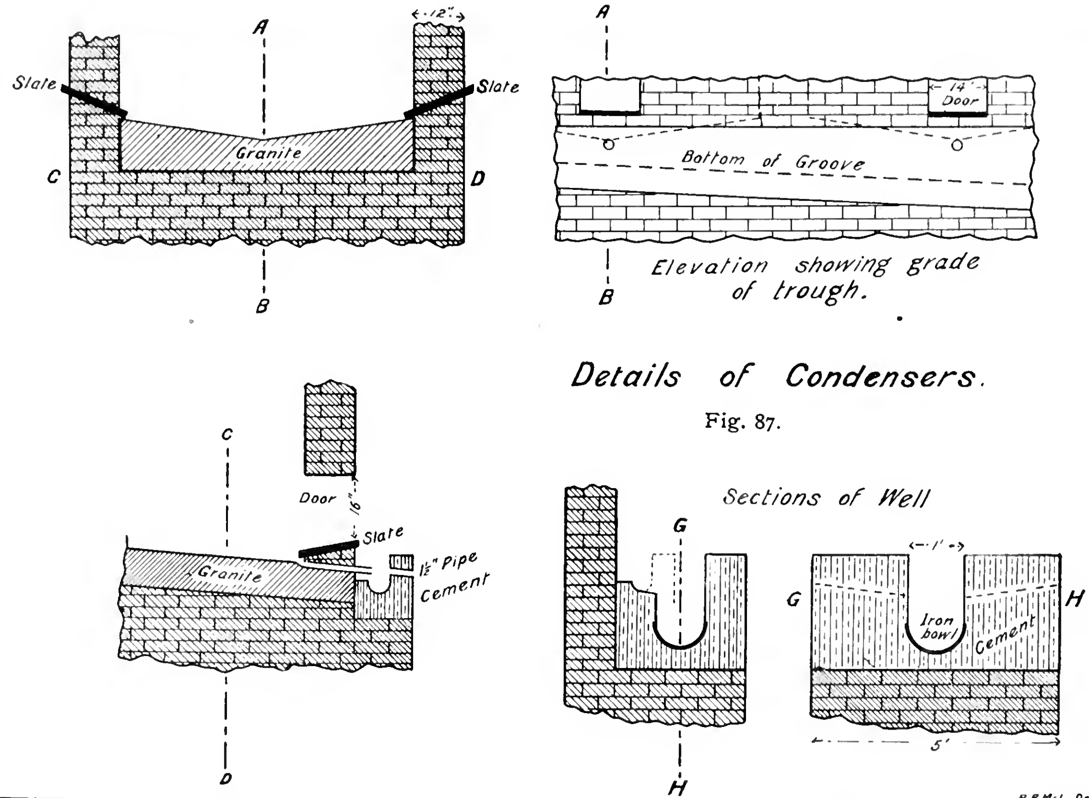


Fig. 86.



Details of Condensers.

Fig. 87.

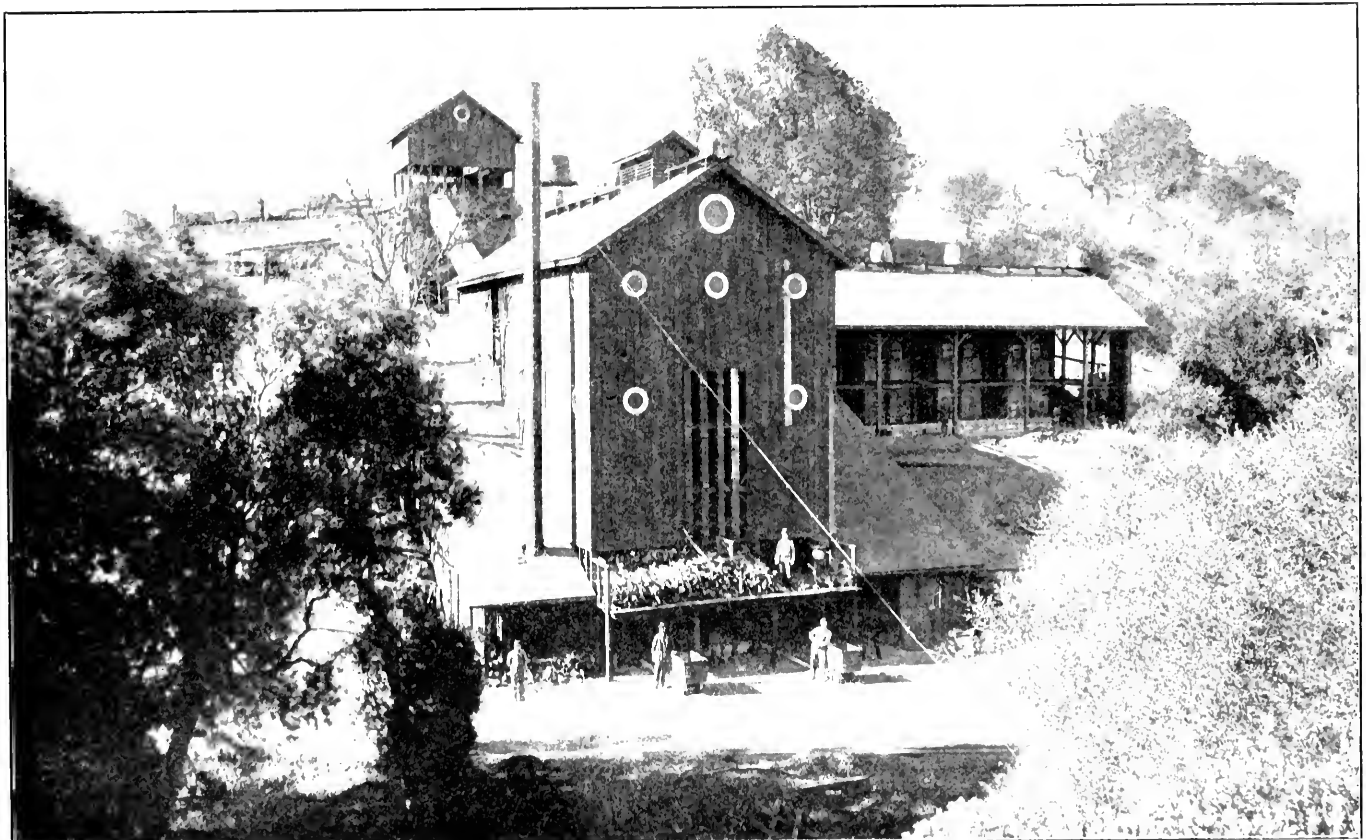


PHOTO No. 37. REDUCTION PLANT, SILVER CREEK QUICKSILVER MINING COMPANY, SANTA CLARA COUNTY.

The fumes as they leave the furnace are far from resembling the theoretical product of distillation of mercuric sulphide. These are mixed with the roasting products of the ore, to wit: water vapor, carbon dioxide, and mechanically entrained ore dust; and the products of combustion of the fuel, to wit: water vapor, carbon dioxide, and mechanically entrained ash. In Volume XIV (above cited), page 234 and following, Professor Christy gives a detailed study of these fumes and their

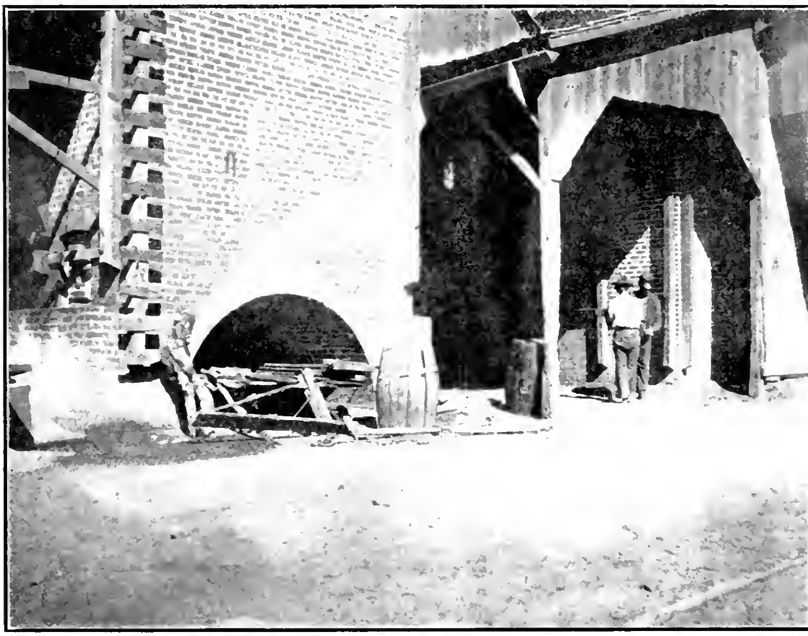


PHOTO No. 38. GREAT EASTERN FURNACES.

behavior, and the conditions for a well-constructed condensation plant. When coming in contact with cool surfaces, the fumes deposit a solid material known as "soot," consisting of the ore dust, ash, some tarry hydrocarbons, and the products of the decomposition of the CO_2 into CO and O. The most important condensed constituents are water, sulphates of iron, alkali mercury, and sulphuric acid. The water absorbs from the condensed vapors, sulphurous acid, chloride of ammonia, hydrocarbons, etc. The sulphuric acid, especially when present in large quantities, as in the case when roasting highly pyritiferous ores, is a most troublesome product, as it attacks every material out of which condensers are constructed. The soot is an intermediate product, which is only detrimental when it forms in excessive quantities. It has the advantage of retaining the minute globules of mercury which form at the moment of sublimation and would otherwise be carried off by the gases. [Mist loss, see vol. XIV, above cited, page 233.] Spirek [L'Industria del Mercuria in Italia, page 14] mentions the fact that the soot causes the mercury contents of the fumes to be below the saturation point.

The products of the condensers are: for the hot condensers near the furnace, mainly dry quicksilver and soot mixed with ore dust; farther on, quicksilver, acid water (containing mainly sulphuric acid), and damp soot; for the last condensers, acid waters, holding various sulphates in solution, colored black by the soot, and carrying some very finely divided quicksilver;

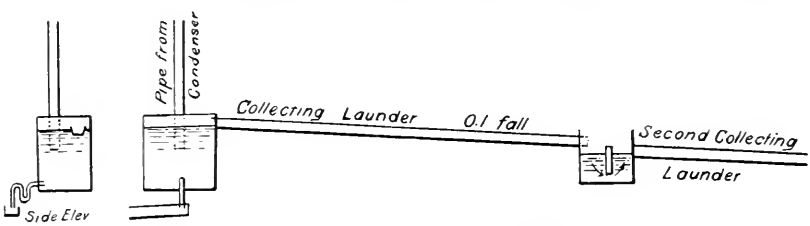


FIG. 88. Installation to save flour mercury, New Almaden.

finally, for the flues to the smokestack, nearly dry soot with very little quicksilver, rarely visible to the naked eye.

The quicksilver is collected in inclined troughs running along the outside of the condensers. [See Fig. 87.] The water vapors contain some very finely divided mercury, which floats on the water brought down by their condensation. At New Almaden, a special installation has been constructed to save this quicksilver [see Fig. 88, which explains itself], and considerable quicksilver is thus secured. Even repeated passage through such settling boxes will not save all the minute quicksilver globules.

The draft in the fire chamber of the furnace and the passage of the fumes through the furnace and the condensing plant to the smokestack are caused and regulated by the introduction of a blower in the course of this travel. Sometimes a fire draft at or near the stack is added, and at the New Idria furnace an

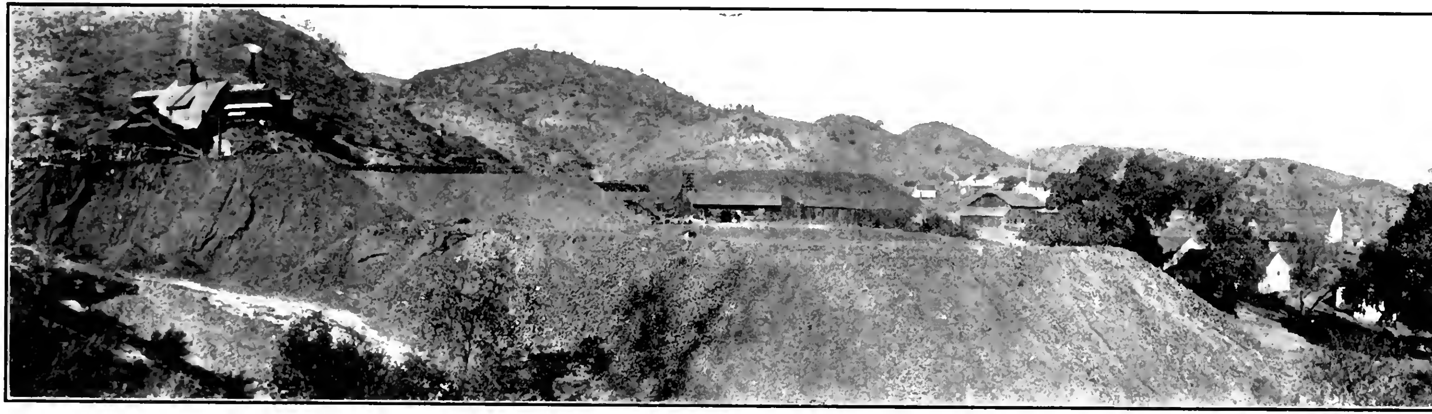


PHOTO No. 39. NEW IDRIA MINE, SHOWING SCOTT FURNACE.

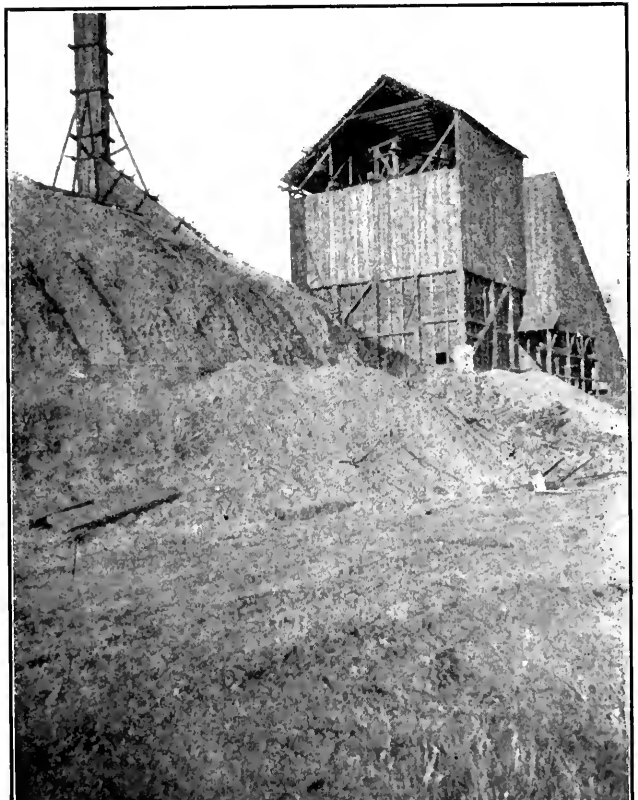


PHOTO No. 40. BOSTON QUICKSILVER MINE, QUICKSILVER FURNACE.

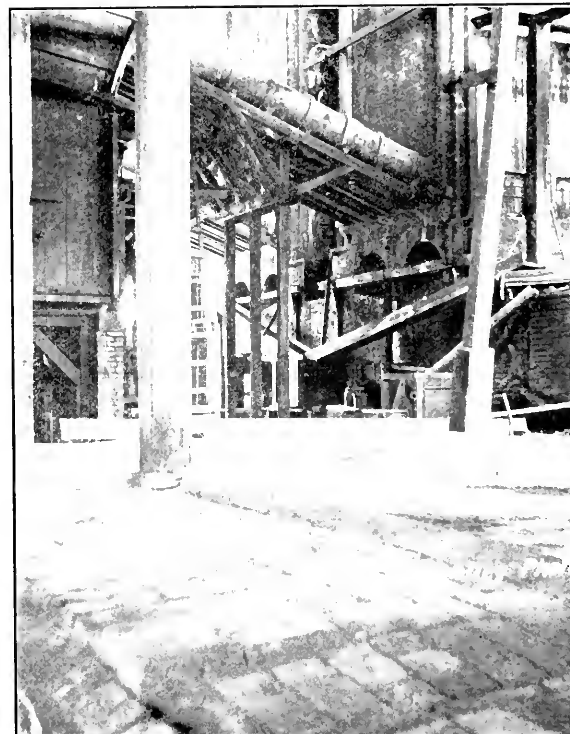


PHOTO No. 41. FLUES CONNECTING FURNACE WITH CONDENSER PLANT, NEW ALMADEN—HACIENDA.

auxiliary blower is used. At the Abbott furnace the blower is placed between the first and second condensers—a very unusual location.

The condensing plant, as above stated, must answer the double purpose of cooling the fumes and causing the deposition of the liquefied quicksilver. Professor Christy [above cited, vol. XIV, page 207] concisely states the various difficulties

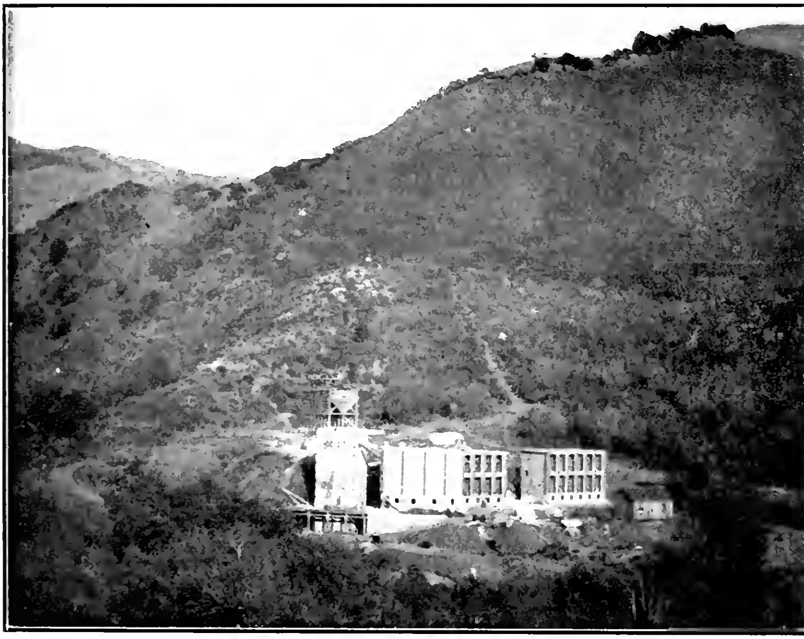


PHOTO No. 42. OCEANIC QUICKSILVER REDUCTION PLANT, SAN LUIS OBISPO COUNTY.

encountered in this operation, as follows: "The quicksilver "fumes furnish often less than one per cent by volume of the "products of combustion with which they are mixed."

When Professor Christy wrote this (1885), the mines were running on much higher grade ore than at present; 0.5 per cent is a fair average (even probably a little too high) of the ore now passing through the various furnaces in the State. The volume of the fumes produced is [see above cited, page 236], per kilogram of ore, 0.185 cubic meter, at 0° C. and 760 mm. Hg: that of the vaporized quicksilver

$$\frac{1 \text{ cu. m.} \times 0.005}{8.96} = 0.00058 \text{ cu. m.},$$

or 0.31 per cent of the total fumes.

"Even the weight of the quicksilver is inconsiderable com-"pared with that of the gases which pass through the con-"denser."

Under the present conditions as above mentioned their percentage would be:

Hg	=0.005	kilogram.
CO_2	=0.100	"
SO_2	=0.040	
N	=0.132	"
Water vapor	=0.100	"
Total weight of dry gases at 0° C. and 760 mm. Hg	=0.377	"
Weight of quicksilver vapor at 0° C. and 760 mm. Hg	=0.005	" or 1.3 per cent of total weight.

Professor Christy continues: "These facts add greatly to the "difficulties of condensation. For in the first place, the heat "must be extracted from the fumes in order that the quick-"silver may be liquefied. Next, the whole volume of the gases "must pass through the condensers at a certain velocity, in "order to maintain the draft of the furnace. The minute "condensed globules of liquefied quicksilver are likely to be "carried off in the form of 'mist.' The gases which escape from "the condensing system are necessarily saturated with quick-"silver vapor at the temperature of escape." (This loss is, however, very small. Assuming, as Professor Christy does [page 245], an average escape temperature of 20° C., the calculated loss would be 0.83 per cent of the total yield [see Table XIII, page 243]; while according to Mr. Spirek [see above, page 18] the soot prevents the fumes from being saturated with mercury vapors.) "Then there is the ever-present "mercurial soot, which requires separate treatment. The "quicksilver itself is ready to escape from any crack or crevice "of the condensers, either as a liquid or a vapor. Finally, as "soon as the condensers become cool enough to act effectively, "they are attacked by the dilute sulphuric acid formed from "the oxidation of the sulphurous acid in the fumes. This "agent slowly attacks and destroys almost every material out "of which the condensers can be made."

To combine the effects of cooling and deposition of the quicksilver in the most preferable manner, three factors must be

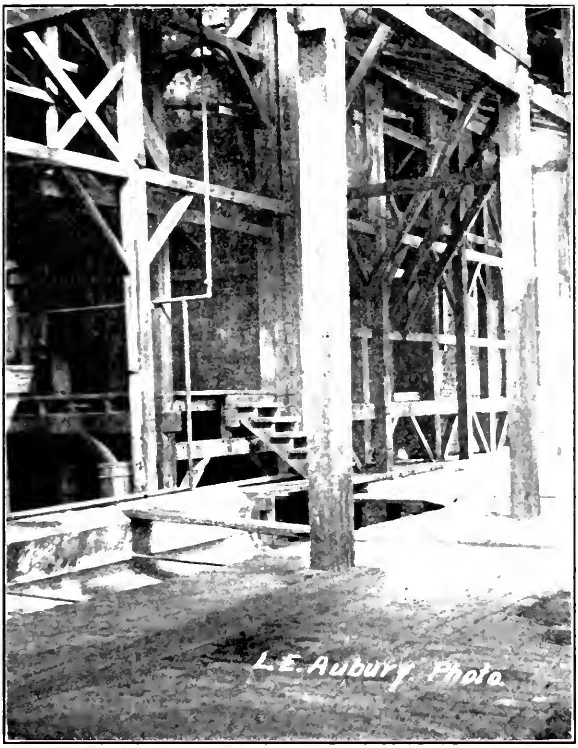


PHOTO No. 43. INTERIOR VIEW OF REDUCTION WORKS, NEW ALMADEN—HACIENDA.

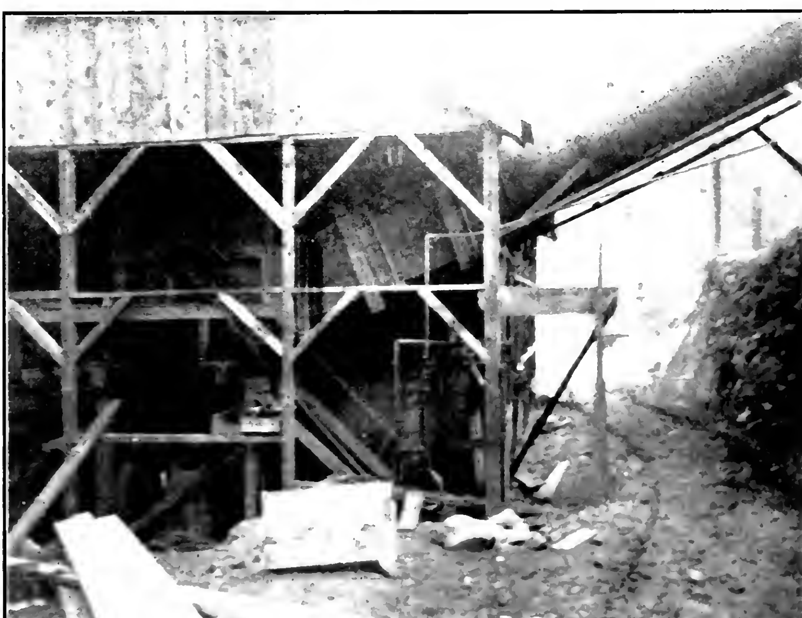


PHOTO No. 44. NEW IDRIA, SHOWING ROUND WOODEN FLUE AND WOODEN TANKS USED FOR CONDENSERS.

considered: the length of the path of the vapors in the condensing system, the interior volume of the system, and the area of the cooling surface. It is to be regretted that very little data regarding these conditions in the different furnace plants are available.

Mr. Robert Scott considers the condensing room required for a 40-ton furnace 17,000 cubic feet, and for a 50-ton furnace, 20,000 cubic feet, which must be increased as the ore diminished

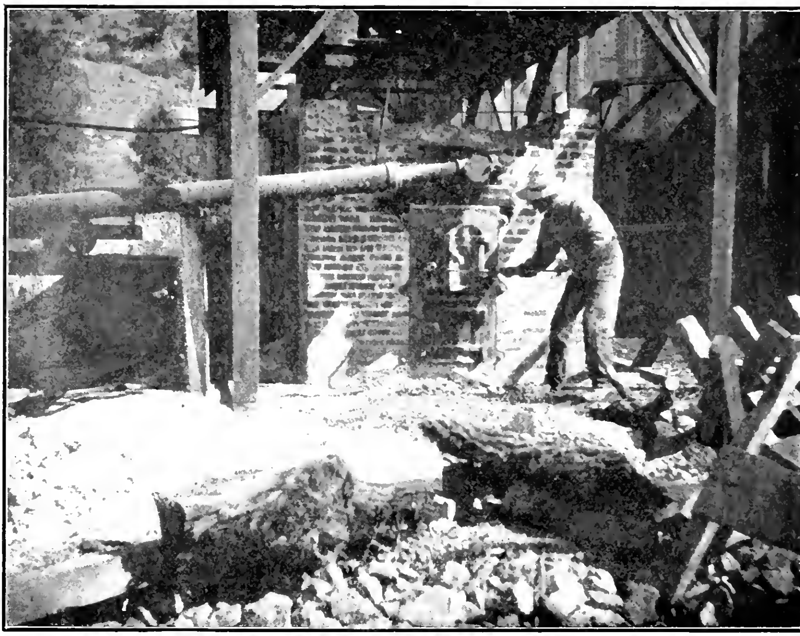


PHOTO No. 45. RETORTING SOOT, GREAT EASTERN MINE.

in grade. Professor Christy [above cited, page 224] gives this data for furnace No. 1 at New Almaden. The totals are: Path of vapors from furnace to top of chimney, about 1000 feet; interior volume, 26,667 cubic feet; cooling area, 18,653 square feet; ratio of cooling area to interior volume is 0.69. It must be remarked that the brick condensers give only a ratio of 0.5. In the brick condensers at present built by Robert Scott, the interior volume is about 1927 cubic feet; the cooling area, 922.5 square feet; giving about the same ratio.

Following is a table furnished by Mr. E. W. Carson, superintendent of the Oceanic Quicksilver Company:

TABLE SHOWING CONDENSING SYSTEM OF OCEANIC QUICKSILVER COMPANY, MAY 1, 1903.

Material of Condenser	Number	Thickness of Walls.	Path of Vapors.	Interior Volume.	Cooling Area.	Condensing or Friction Surface.	Remarks.
		Inches.	*Feet.*	*Cu. Feet.*	*Sq. Feet.*	*Sq. Feet.*	
Brick condensers, first series	7	8	300	18,126	5,077	9,932	Tops covered by cast-iron plates 5/8 of an inch thick; first and second chambers cooled by water.
Brick condensers, second series	6	8	210	9,922	2,732	5,928	
Iron exit pipes	2	1/4	12	118	160	192	
Earthenware pipes	2	1 1/2	8	30	80	92	Cooled by water.
Iron condensers and connecting pipes	4	1	70	221	614	520	Cooled by dripping water; two connecting pipes 18 inches square.
Barrel condensers, wood	8	2	72	2,016	1,850	1,744	T. & G. Redwood.
Wooden flue to barrel condensers	1	1 1/4	108	253	648	648	Redwood.
Wooden flue to stack	1	2	95	316	760	760	Pine.
Wooden stack	1	2	16	53	128	128	Pine, 16 feet high.
Totals			891	31,055	12,049	19,944	Surface exposed to outside air taken as cooling area.

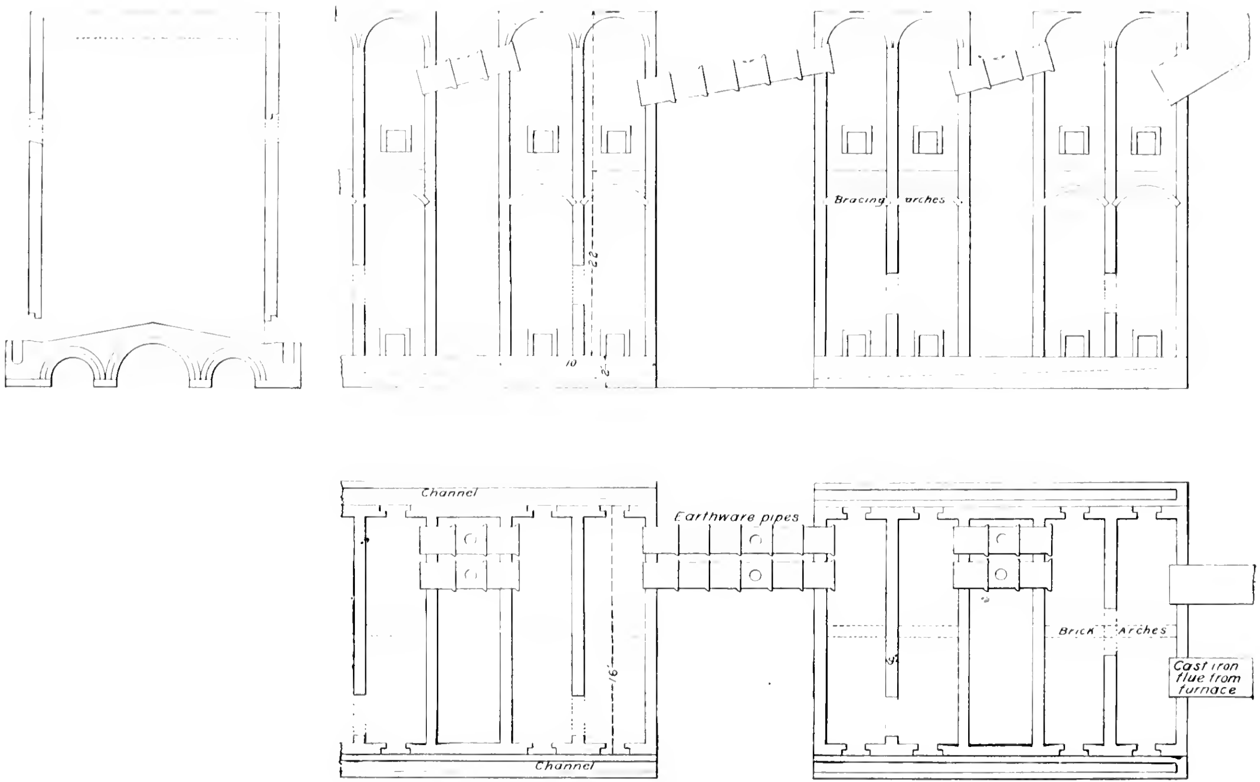


FIG. 89. Scott's Brick Condenser Plant.

The ratio of the cooling area and interior volume is here for the total plant $\frac{12049}{31055} = 0.39$, mainly due to the unscientific construction of the brick condensers (built before Mr. Carson arrived on the property), which show a ratio of $\frac{5077}{18126}$ and $\frac{2732}{9922}$, respectively about 0.28 and 0.27. Mr. Carson has tried to remedy this to some extent by cooling the top of the first two chambers by water. In fact, this plant as constructed a few years ago was a striking example of the result when metallurgical work is placed in ignorant hands.

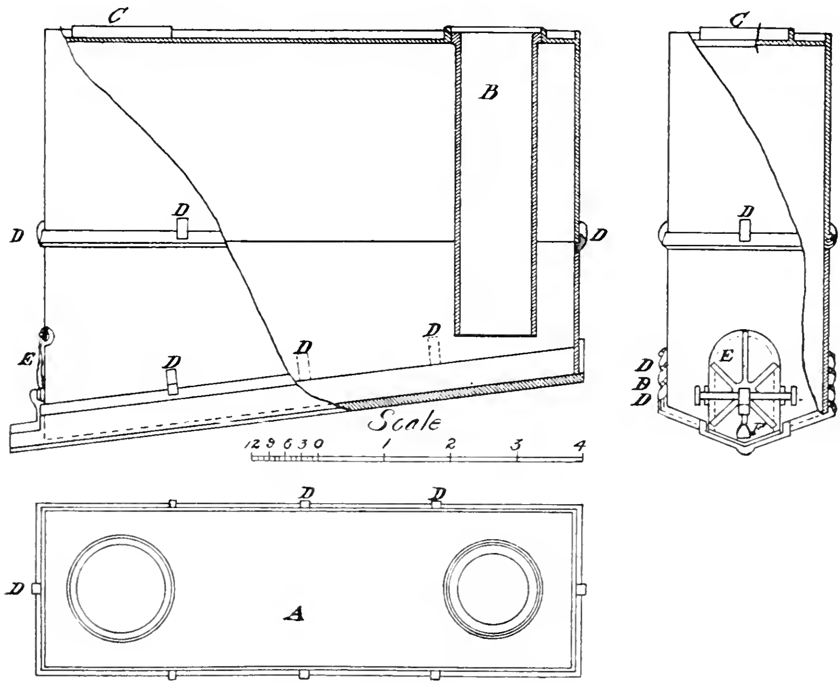


FIG. 90. Knox Ironclad Condenser.

A great number of different condensers, built on varying plans and with varying material, have been devised. Their details can be found in the works above cited. At present the following are in use in California:

Brick condensers are constructed in different dimensions, from 9 by 5 feet, 5 feet high (the small brick condensers at the Great Western mine in Lake County), to 8 by 16 feet, 29 feet high, at the Oceanic. The condensers at present built by Mr. Robert Scott are 14½ by 8½ feet inside, 22 feet high from

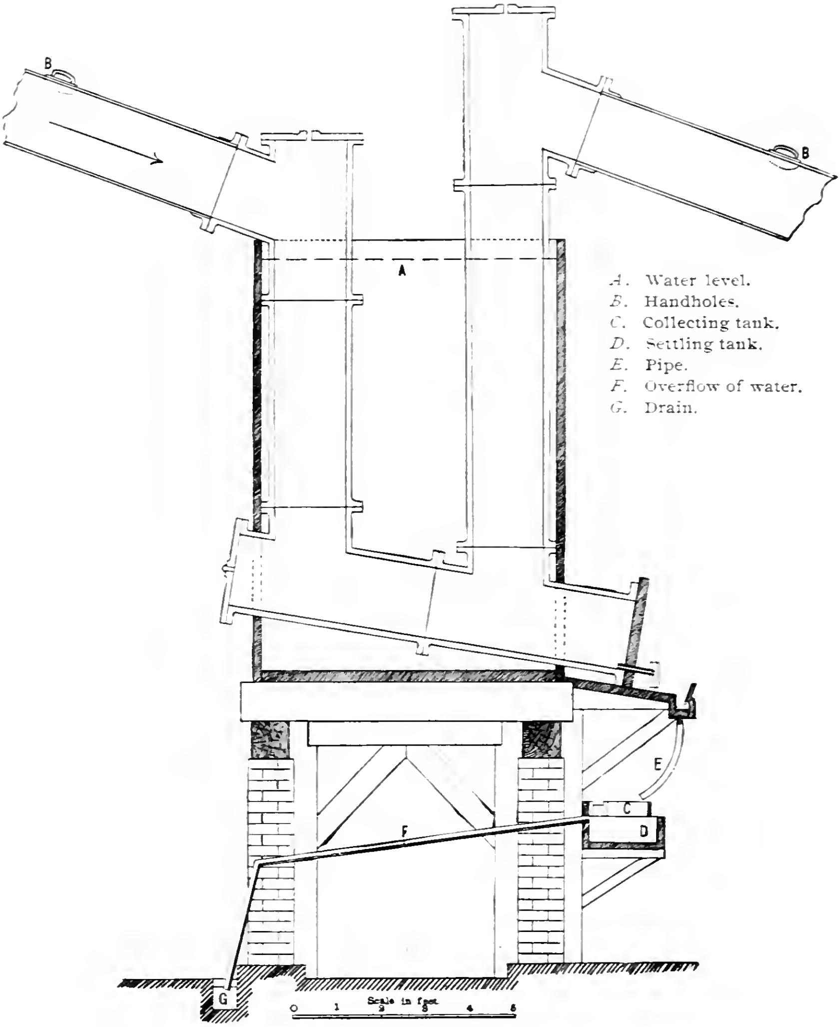


FIG. 91. Water Tank Condenser.

lower part of floor to top of building, with a central partition wall to deflect the fumes on their passage, an inclined bottom with a spring of 15 inches, and earthenware exit pipes. The side walls are 9 inches thick. They are generally arch-topped, sometimes covered by iron plates. [See Fig. 89.] Each condenser is separated from the one adjoining and connected by earthenware pipes; the first and second by iron flues.

To hasten the cooling of the fumes, narrow iron tanks connected by cast-iron pipes have been placed in some plants, mainly in the first condenser at the end walls, water circulating through the installation, called "waterbacks." [See vol. XIV, page 216.] At the Karl mine, San Luis Obispo County, 8-inch tile pipes, through which water circulates, have been placed in the first four condensers.

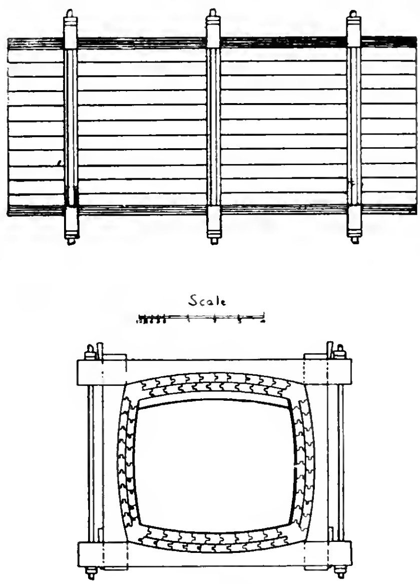


FIG. 92. The Baker Flue.

At the New Idria mine, stone is used for the construction of some condensers.

The iron condensers at present used are generally of the Knox type. [See Fig. 90, and Egleston, above cited, page 846.] Where the ore does not carry too much iron sulphide, they stand very well. At the Manhattan mine, on the coarse-ore furnace, seven iron condensers were installed behind two brick-dust chambers. These have been used from 1874 to 1877 and from 1885 to 1887 continuously, and from 1889 to the present date about two months every year. All joints are luted with Portland cement.

Another iron condenser, the "water tank condenser" [see Fig. 91], is used at New Almaden for furnaces Nos. 7, 8, and 9. [See Egleston, page 860.] These condensers give very good satisfaction.

The farther the parts of the condensing plant are from the furnace, the more they are exposed to the deteriorating effects of waters carrying sulphuric acid, and experience has taught that wood is the only material which will resist the effects to a great extent, especially pitch pine, hence the use of wooden constructions in those parts of the plants which are not exposed to too high temperature. At New Almaden the wooden Baker

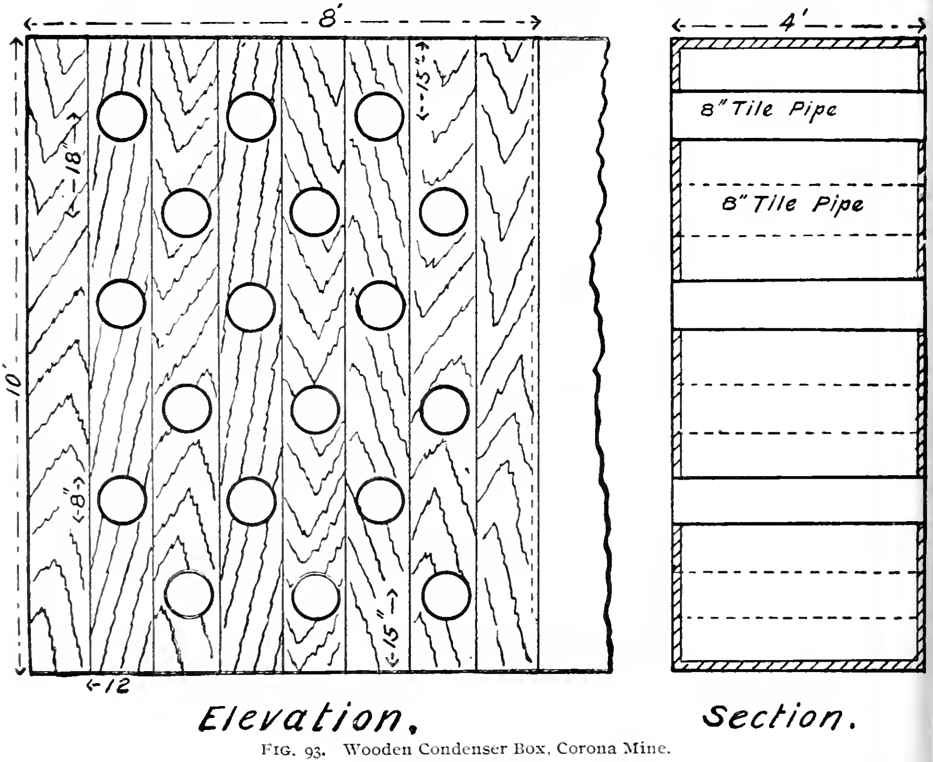


FIG. 93. Wooden Condenser Box, Corona Mine.

flue [see Fig. 92] has been used for years. Stave pipe flues are now frequently used also for connections between brick condensers and for smokestacks. Wooden condensers are frequently constructed, especially in the form of barrels. Those at the New Idria coarse-ore furnace have a diameter of 8 feet and are 14 feet long. Similar wooden barrel condensers are also used at the Karl mine, Oceanic mine, etc. The great difficulty with these stave constructions lies in the iron bands, which are corroded, especially in the lower half of the circle, which at the New Idria have been replaced, as an experiment by wooden bands made of wheel felloes.

At the Corona mine a wooden box has been erected between the fifth brick condenser and the flue to smokestack. This box is 100 feet long and traversed by 8-inch tile pipes for air

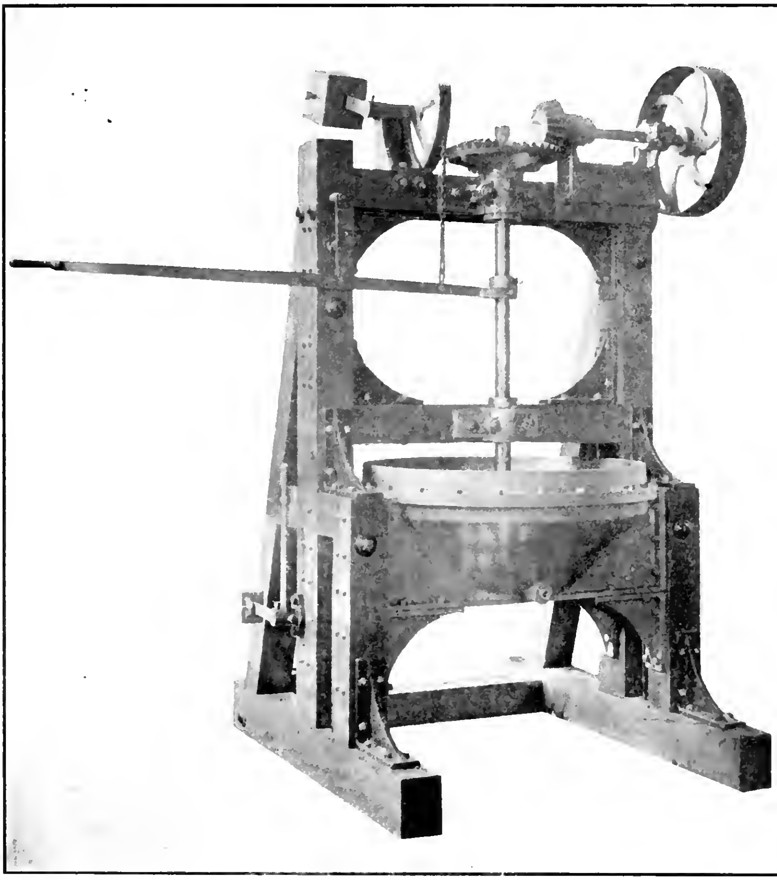


FIG. 94. Soot-Cleaning Machine.

circulation, in order to cool the fumes. [See Fig. 93.] The blower is between the fifth condenser and this box.

In the smaller mines the soot is still worked by hand as described by Egleston [above cited, page 810, and vol. XIV, page 230], but in the larger mines, soot machines are used. [See Fig. 94.] Generally the residue is treated in retort furnaces, but at New Almaden the residue is re-charged in the fine-ore furnace.

ELEVATIONS.

Elevations for which no authorities are given are from barometrical observations during field work for the Quicksilver Bulletin, by Wm. Forstner, Field Assistant.

COLUSA COUNTY.

	Feet.
Central mine—Main tunnel	1675
Divide between Colusa and Lake counties, at crossing of road from Sulphur Creek to Abbott mine	2125
Elgin mine—Main tunnel	2275
Empire mine—Tunnel at southeast end	1715
Tunnel in Sulphur Creek	1475
Manzanita mine—Shaft	1950
Sulphur Creek—Blank Springs Hotel	1575
Schoolhouse	1525
Wide Awake mine—Office	1600

EL DORADO COUNTY.

Bernard Quicksilver mine—Tunnel	925
Cañon—Store	900
Placerville	*1830

FRESNO COUNTY.

Arambide mine—Tunnel	1440
Corner of Fresno, Kings, and Monterey counties	3145
Little Panoche Pass	1800
Mexican mine—Cabin	3640
Providential mine—Tunnel	1600
Ridge on Gabilan claim	2480

KINGS COUNTY.

Avenal Creek at mouth of Bull Pen Gulch	1530

LAKE COUNTY.

Abbott mine—Office	2000
Shafthouse	2050
Adams Springs	2725
Anderson Springs	1475
Baker mine—Retort furnace	1375
Brown's mill on Kelsey Creek	1650

*S. P. R. R. Co.

	Feet.
Bullion mine—Collar of shaft	1540
Chicago mine—Cabin	2700
Clear Lake	1340, † 1400, ‡ 1310
Divide between Adobe and Kelsey creeks near Kelseyville	1725
Divide between Lake and Sonoma counties—	
Crossing Great Western tollroad	2675
Crossing road from Helen to Bacon mine	3210
Pine Mountain	3475
Crossing old road from Middletown to Pine Flat	3300
Crossing road from Middletown to Dewey's mill	3200
Mount Cobb, eastern rim	4500
Mount Cobb, northwest point	4050
Geyser Rock, northwest of Mount Cobb	3660
Glenbrook	2300
Gordon Springs	2500
Great Western mine—Store	2080
Helen mine—Furnace	2760
Howard Springs	2180
Jewess mine—Cabin	2525
Kelseyville	1435
King of All mine—Lower tunnel	1875
Lakeport	1400
Lower Lake	1400
Lucitta mine—Retort furnace	1975
Middletown	1200
Middletown mine—Upper works	2400
Mirabel—Office Standard Quicksilver Co.	1460
Mount McGuire	2750
Red Elephant mine—Cabin	1825
Road from Lower Lake to Abbott mine—	
Forks of Bartlett Springs and Abbott roads	1415
Divide at head of Phipps Creek	1570
Crossing Cache Creek	1050
Road from Lower Lake to Knoxville—	
Crossing branch of Soda Creek at Baker mine	1315
Morgan Valley schoolhouse	2475
Road from Middletown to Glenbrook—	
Divide between Putah and Kelsey creeks	2650
Road from Middletown to Oathill—	
Bridge over Bucksnorter Creek	1190
Sulphur Bank mine—Office	1450
Collar of Diamond shaft	1345
Collar of Empire shaft	1345
Collar of Herman shaft	1365
Wagon Spring cut, bottom	1390
Western cut, bottom	1325
Thorn mine—Tunnel	2040

† Treadwell. ‡ Clear Lake Water Co.

MERCED COUNTY.

	Feet.
Cathedral Peak	3450
Saddle between Cathedral Peak and Mariposa Peak	2850
Stayton mine—Cabin	2880
Old furnace (Gypsy)	2400

MONTEREY COUNTY.

Cholame and Parkfield mine—Top of ridge	3460
Dutro mine, at head of west fork of San Carpojo Creek	1630
Parkfield	1540
Table Mountain—Top of ridge	3300
Table Mountain Quicksilver mine—Cabin	3190

NAPA COUNTY.

Ætna mine—Basalt ridge, Silver Bow claim	2050
Office and Tunnel No. 7	1240
Tunnel No. 5	1400
Tunnel No. 2	1600
Ætna Springs	800
Boston mine (Knoxville)—Office	1275
Calistoga	*363
Corona mine—Boiler house and tunnel	1960
Manhattan mine (Knoxville)—Office	1925
Oathill mine—Office	2025
Philadelphia mine—Works on ridge	2040
Road from Calistoga to Ætna Springs—	
Summit of Howell Mountain	2250
Flat between Twin Peaks	2440
Forks of road to Oathill	2160
Road from Middletown to Calistoga—	
Toll house at Mount St. Helena	2300

SAN BENITO COUNTY.

Antimony Peak, Stayton District	3150
Aurora mine—Furnace	3825
Bradford mine (Cerro Gordo)—Office	1820
Cannon mine—Tunnel	1560
Cerro Bonito mine—Main tunnel	2775
Office	2440
Top of Cerro Bonito hill	3250
Clear Creek mine—Old Monterey furnace	2800
Lower workings	3110
Upper workings	3660
Divide between San Carlos and Clear Creek, crossing of road from New Idria to Hernandez	4410

*S. P. R. R. Co.

	Feet.
Dominic Peak	4720
Don Juan mine—Old furnace	2785
Elkhorn	1100
Emmett schoolhouse	1140
Henrietta Peak, Stayton District	3480
Hernandez P. O.	2540
Hollister	*286
Llanada P. O., Panoche Valley	1540
Los Picachos mine (Ramirez Cons.)—Retort furnace	4600
Mariposa mine, Stayton District—Old works	2700
Mariposa Peak	3340
Mount Venado	4660
New Idria mine—Croppings on top of hill	3750
Furnaces	2720
Mine boarding-house	3340
North Idria Peak, knoll above furnaces	3640
North San Carlos Peak	4660
Office	2590
San Carlos mine tunnel	4500
San Carlos Peak	4980
Upper fall, San Carlos creek	3720
Panoche divide	2240
Panoche P. O.	1250
Park Mills	1440
San Benito	1540
Shiver mine, Stayton District	2460
Tres Pinos	*512

SAN LUIS OBISPO COUNTY.

Alice and Modoc mine—Retort furnace	1900
Bank mine—Main tunnel	345
Cambria	60
Cholame P. O.	670
Cypress Mountain mine—Cabin	2425
Cypress Mountain—Plateau	2900
Divide between Hughes and Santa Rosa Creek on road to Cambria	2350
Divide between San Luis Obispo and Santa Margarita, on wagon road	1550
Doty mine—Lower tunnel	2000
Elizabeth mine—Retort furnace	1950
El Paso de Robles	*722
Exline mine—Tunnel	1010
Karl mine—Furnace	1080
La Libertad mine—Retort furnace	1800
Lehman mine	1975
Madrone mine—Retort furnace	1950

*S. P. R. R. Co.

	Feet.
Mahoney mine—Retort furnace	1140
Oceanic mine—Furnace	400
Main tunnel	770
Oceanic mine No. 2	1575
Pine Mountain—North end of ridge	3125
Top of ridge	† 3560
Pine Mountain mine—Ocean View tunnel	2815
Office	2940
Sawmill	3010
Polar Star mine—Cabin	200
Rinconada mine—Croppings	2040
Furnace	1750
Rocky Buttes	† 3444
Quien Sabe mine—Lower tunnel	1945
San Luis Obispo	* 238
Santa Margarita	* 996
Vulture mine	1460

SANTA CLARA COUNTY.

Bernal mine—Works on ridge	650
Comstock mine, Stayton District—Furnace	1400
Costello mine—Main tunnel	1000
Guadalupe mine—Furnace	340
Guadalupe schoolhouse	290
Hillsdale mine—Old furnace	120
New Almaden mine—America shaft	1560
Mine Hill top	1600
Randol shaft	1220
Office	1335
R. R. B. shaft, Enriquita	950
San José	60
Santa Teresa mine—Office	260

STANISLAUS COUNTY.

Adobe mine—Collar of shaft	1900
Orestimba mine	2250
Summit mine—Office	2250

SONOMA COUNTY.

Bacon Consolidated mine (Pine Mountain)—Old furnace site	2900
Boston mine (Pine Flat)—Cabin	2525
Cinnabar King mine—Cabin	2900

* S. P. R. R. Co.
† U. S. Coast and Geodetic Survey.

APPENDIX

FERRY BUILDING, SAN FRANCISCO, ONE HALF THE UPPER FLOOR OF WHICH IS OCCUPIED BY THE STATE MINING BUREAU.

CALIFORNIA STATE MINING BUREAU.

This institution aims to be the chief source of reliable information about the mineral resources and mining industries of California.

It is encouraged in its work by the fact that its publications have been in such demand that large editions are soon exhausted. In fact, copies of them now command high prices in the market.

The publications, as soon as issued, find their way to the scientific, public, and private libraries of all countries.

STATE MINERALOGIST.

The California State Mining Bureau is under the supervision of Hon. Lewis E. Aubury, State Mineralogist.

It is supported by legislative appropriations, and in some degree performs work similar to that of the geological surveys of other states; but its purposes and functions are mainly practical, the scientific work being clearly subordinate to the economic phases of the mineral field, as shown by the organic law governing the Bureau, which is as follows:

SEC. 4. It shall be the duty of said State Mineralogist to make, facilitate, and encourage special studies of the mineral resources and mineral industries of the State. It shall be his duty: To collect statistics concerning the occurrence of the economically important minerals and the methods pursued in making their valuable constituents available for commercial use; to make a collection of typical geological and mineralogical specimens, especially those of economic or commercial importance, such collection constituting the Museum of the State Mining Bureau; to provide a library of books, reports, drawings, bearing upon the mineral industries, the sciences of mineralogy and geology and the arts of mining and metallurgy, such library constituting the Library of the State Mining Bureau; to make a collection of models, drawings, and descriptions of the mechanical appliances used in mining and metallurgical processes; to preserve and so maintain such collections and library as to make them available for reference and examination, and open to public inspection at reasonable hours; to maintain, in effect, a bureau of information concerning the mineral industries of this State, to consist of such collections and library, and to arrange, classify, catalogue, and index the data therein contained, in a manner to make the information available to those desiring it, and to provide a custodian specially

MINERAL MUSEUM, CALIFORNIA STATE MINING BUREAU.

qualified to promote this purpose; to make a biennial report to the Board of Trustees of the Mining Bureau, setting forth the important results of his work, and to issue from time to time such bulletins as he may deem advisable concerning the statistics and technology of the mineral industries of this State.

THE BULLETINS.

The field covered by the books issued under this title is shown in the list of publications. Each bulletin deals with only one phase of mining. Many of them are elaborately illustrated with engravings and maps. Only a nominal price is asked, in order that those who need them most may obtain a copy.

THE REGISTERS OF MINES.

The Registers of Mines form practically both a State and County directory of the mines of California, each county being represented in a separate pamphlet. Those who wish to learn the essential facts about any particular mine are referred to them. The facts and figures are given in tabular form, and are accompanied by a topographical map of the county on a large scale, showing location of each mineral deposit, towns, railroads, roads, power lines, ditches, etc.

HOME OF THE BUREAU.

The Mining Bureau occupies the north half of the third floor of the Ferry Building, in San Francisco. All visitors and residents are invited to inspect the Museum Library, and other rooms of the Bureau and gain a personal knowledge of its operations.

THE MUSEUM.

The Museum now contains over 16,000 specimens, carefully labeled and attractively arranged in showcases in a great, well-lighted hall, where they can be easily studied. The collection of ores from California mines is of course very extensive, and is supplemented by many cases of characteristic ores from the principal mining districts of the world. The educational value of the exhibit is constantly increased by substituting the best specimens obtainable for those of less value.

These mineral collections are not only interesting, beautiful, and in every way attractive to the sightseers of all classes, but are also educational. They show to manufacturers, miners, capitalists, and others the character and quality of the economic minerals of the State, and where they are found. Plans have been formulated to extend the usefulness of the exhibit by special collections, such as one showing the chemical composition of minerals; another showing the mineralogical composition of the sedimentary, metamorphic, and igneous rocks of the State; the petroleum-bearing formations, ore bodies, and their country rocks, etc.

Besides the mineral specimens, there are many models, maps, photographs, and diagrams illustrating the modern practice of mining, milling, and concentrating, and the technology of the mineral industries. An educational series of specimens for high schools has been inaugurated, and new plans are being formulated that will make the Museum even more useful in the future than in the past. Its popularity is shown by the fact that over 100,000 visitors registered last year, while many failed to leave any record of their visit.

THE LIBRARY.

This is the mining reference library of the State, constantly consulted by mining men, and contains between 4,000 and 5,000 volumes of selected works, in addition to the numerous publications of the Bureau itself. On its shelves will be found reports on geology, mineralogy, mining, etc., published by states, governments, and individuals; the reports of scientific societies at home and abroad; encyclopædias, scientific papers, and magazines; mining publications; and the current literature of mining ever needed in a reference library.

Manufacturers' catalogues of mining and milling machinery by California firms are kept on file. The Registers of Mines form an up-to-date directory for investor and manufacturer.

The librarian's desk is the general bureau of information, where visitors from all parts of the world are ever seeking information about all parts of California.

READING-ROOM.

This is a part of the Library Department and is supplied with over one hundred current publications. Visitors will find here various California papers and leading mining journals from all over the world.

The Library and Reading-Room are open to the public from 9 A. M. to 5 P. M. daily, except Sundays and holidays, and from 9 A. M. to 12 M. on Saturdays.

THE LABORATORY.

This department identifies for the prospector the minerals he finds, and tells him the nature of the wall rocks or dykes he may encounter in his workings; but this department *does not* do assaying nor compete with private assayers. The presence of minerals is determined, but not the percentage present. No charges for this service are made to any resident of the State. Many of the inquiries made of this department have brought capital to the development of new districts. Many technical questions have been asked and answered as to the best chemical and mechanical processes of handling ores and raw material. The laboratory is well equipped.

THE DRAUGHTING-ROOM.

In this room are prepared scores of maps, from the small ones filling only a part of a page, to the largest County and State maps; and the numerous illustrations, other than photographs, that are constantly being required for the Bulletins and Registers of Mines. In this room, also, will be found a very complete collection of maps of all kinds relating to the industries of the State, and one of the important duties of the department is to make such additions and corrections as will keep the maps up to date. The seeker after information inquires here if he wishes to know about the geology or topography of any district; about the locations of the new camps, or positions of old or abandoned ones; about railroads, stage roads, and trails; or about the working drawings of anything connected with mining.

MINERAL STATISTICS.

One of the features of this institution is its mineral statistics. Their annual compilation by the State Mining Bureau began in 1893. No other State in the Union attempts so elaborate a record, expends so much labor and money on its compilation, or secures so accurate a one.

The State Mining Bureau keeps a careful, up-to-date, and reliable but confidential register of every producing mine, mine-owner, and mineral industry in the State. From them are secured, under pledge of secrecy, reports of output, etc., and all other available sources of information are used in checking, verifying, and supplementing the information so gained. This information is published in an annual tabulated, statistical, single-sheet bulletin, showing the mineral production by both substances and counties.

TOTAL GOLD PRODUCT OF CALIFORNIA—1848-1906.

1848	$245,301	1864	$24,071,423	1880	$20,030,761	1896	$17,181,562
1849	10,151,360	1865	17,930,858	1881	19,223,155	1897	15,871,401
1850	41,273,106	1866	17,123,867	1882	17,146,416	1898	15,906,478
1851	75,938,232	1867	18,265,452	1883	24,316,873	1899	15,336,031
1852	**81,294,700**	1868	17,555,867	1884	13,600,000	1900	15,863,355
1853	67,613,487	1869	18,229,044	1885	12,661,044	1901	16,989,044
1854	69,433,931	1870	17,458,133	1886	14,716,506	1902	16,910,320
1855	55,485,395	1871	17,477,885	1887	13,588,614	1903	16,471,264
1856	57,509,411	1872	15,482,194	1888	12,750,000	1904	19,109,600
1857	43,628,172	1873	15,019,210	1889	11,212,913	1905	19,197,043
1858	46,591,140	1874	17,264,836	1890	12,309,793	1906	18,732,452
1859	45,846,599	1875	16,876,009	1891	12,728,869		
1860	44,095,163	1876	15,610,723	1892	12,571,900	Total	1,452,785,763
1861	41,884,995	1877	16,501,268	1893	12,422,811		
1862	38,854,668	1878	18,839,141	1894	13,923,281		
1863	23,501,736	1879	19,626,654	1895	15,334,317		

TOTAL QUICKSILVER PRODUCT OF CALIFORNIA—1887-1906.

	Flasks.	Value.		Flasks.	Value.
1887	33,760	$1,425,000	1899	29,454	$1,405,045
1888	33,250	1,413,125	1900	26,317	1,182,786
1889	26,464	1,190,500	1901	26,720	1,285,014
1890	22,926	1,203,615	1902	29,552	1,276,524
1891	22,904	1,036,386	1903	32,094	1,335,954
1892	27,993	1,139,600	1904	28,876	1,086,323
1893	30,164	1,108,527	1905	24,655	886,081
1894	30,416	934,000	1906	19,516	712,334
1895	36,104	1,337,131			
1896	30,765	1,075,449	Total for 20 years	569,670	$23,215,465
1897	26,648	993,445			
1898	31,092	1,188,626			

MINERAL PRODUCTS OF CALIFORNIA FOR 1906.

The yield and value of the mineral substances of California for 1906 was as follows, as per returns received at the State Mining Bureau, San Francisco, in answer to inquiries sent to producers:

Asbestos	Tons	70	$3,500
Asphalt	Tons	77,756	777,560
Bituminous Rock	Tons	16,077	45,204
Borax (Crude)	Tons	58,173	1,182,410
Cement	Bbls	1,286,000	1,941,250
Chrome	Tons	317	2,859
Clays (Brick)	M	277,762	2,538,848
Clays (Pottery)	Tons	167,267	162,283
Coal	Tons	24,850	61,600
Copper	Lbs.	28,726,448	5,522,712
Fullers' Earth	Tons	440	10,500
Gems			497,090
Glass Sand	Tons	9,750	13,375
Gold			18,732,452
Granite	Cu. ft.	329,810	344,083
Infusorial Earth	Tons	2,430	14,400
Gypsum	Tons	21,000	69,000
Lead	Lbs.	338,718	19,307
Lime	Bbls.	689,268	763,060
Limestone	Tons	80,262	162,827
Macadam	Tons	1,066,164	870,887
Manganese	Tons	1	30
Magnesite (Crude)	Tons	4,032	40,320
Marble	Cu. ft.	31,400	75,800
Mineral Paint	Tons	250	1,720
Mineral Water	Gals.	1,585,690	478,186
Natural Gas	M. Cu. ft.	168,175	109,489
Paving Blocks	M	4,203	173,432
Petroleum	Bbls.	32,624,000	9,238,020
Platinum	Ounces	91.46	1,647
Pyrites	Tons	46,689	145,895
Quicksilver	Flasks	19,516	712,334
Rubble	Tons	489,208	547,519
Salt	Tons	101,650	213,228
Sandstone	Cu. ft.	182,076	164,068
Serpentine	Cu. ft.	847	1,694
Soda	Tons	12,000	18,000
Silver	(Commercial Value)		817,830
Slate	Squares	10,000	100,000
Tungsten			189,100
Zinc	Lbs.	206,000	12,566
Totals			$46,776,085

Quicksilver was produced in Lake, Napa, San Benito, San Luis Obispo, Santa Clara, Solano, Sonoma and Trinity counties.

MINING BUREAU PUBLICATIONS.

Publications of this Bureau will be sent on receipt of the requisite amount and postage. *Only stamps, coin or money orders will be accepted in payment. Do not send personal checks.*

Address all communications regarding publications to *Librarian.*

(All publications not mentioned are exhausted.)

SALE OF MINING BUREAU PUBLICATIONS.

Under Section 8, amendment to the Mining Bureau Act, approved March 10, 1903, your attention is respectfully called to that portion of the amendment which states:

"The Board (Board of Trustees) is hereby empowered to fix a price upon, and to dispose of to the public, at such prices, any and all publications of the Bureau, including reports, bulletins, maps, registers, etc. The sum derived from such disposition must be accounted for and used as a revolving printing and publishing fund for other reports, bulletins, maps, registers, etc. The prices fixed must approximate the actual cost of printing and issuing the respective reports, bulletins, maps, registers, etc., without reference to the cost of obtaining and preparing the information embraced therein."

	Price.	Postage.
Report XI—1892, First Biennial	$1.00	$0.15
Report XIII—1896, Third Biennial	1.00	.20
Bulletin No. 6—"Gold Mill Practices in California" (3d edition)	.50	.04
Bulletin No. 9—"Mine Drainage, Pumps, Etc." Bound	.60	.08
Bulletin No. 15—"Map of Oil City Oil Fields, Fresno County, California"	.05	.02
Bulletin No. 23—"Copper Resources of California"	.50	.12
Bulletin No. 24—"Saline Deposits of California"	.50	.10
Bulletin No. 27—"Quicksilver Resources of California"	.75	.08
Bulletin No. 30—"Bibliography Relating to the Geology, Palæontology and Mineral Resources of California," including list of maps	.50	.10
Bulletin No. 31—"Chemical Analysis of California Petroleum"	---	.02
Bulletin No. 32—"Production and Use of California Petroleum"	.75	.08
Bulletin No. 36—"Gold Dredging in California" (2d edition)	.50	.08
Bulletin No. 37—"Gems and Jewelers' Materials of California." (2d ed.)	.50	.08
Bulletin No. 38—"Structural and Industrial Materials of California"	.75	.20
Bulletin No. 42—"Mineral Production of California"—1905	---	.02
Bulletin No. 43—"Mineral Production of California for Nineteen Years"	---	.02
Bulletin No. 45—"Auriferous Black Sands of California"	.10	.02
Bulletin No. 46—"Index of Mining Bureau Publications"	.30	.06
Bulletin No. 47—"Mineral Production of California"—1906	--	02
Bulletin No. 48—"Mineral Production of California for Twenty Years"	---	.02
Bulletin No. 49—"Mines and Minerals of California"	--	---
California Mine Bell Signals (Cardboard)	.05	.02
California Mine Bell Signals (Paper)	.03	.02
Gold Production in California from 1848 to 1906	---	.02
Register of Mines, with Map, Amador County	.25	.08
Register of Mines, with Map, Butte County	.25	.08
Register of Mines, with Map, El Dorado County	.25	.08
Register of Mines, with Map, Inyo County	.25	.08
Register of Mines, with Map, Kern County	.25	.08
Register of Mines, with Map, Lake County	.25	.08

	Price.	Postage.
Register of Mines, with Map, Mariposa County	$0.25	$0.08
Register of Mines, with Map, Nevada County	.25	.08
Register of Mines, with Map, Placer County	.25	.08
Register of Mines, with Map, San Bernardino County	.25	.08
Register of Mines, with Map, San Diego County	.25	.08
Register of Mines, with Map, Santa Barbara County	.25	.08
Register of Mines, with Map, Shasta County	.25	.08
Register of Mines, with Map, Sierra County	.25	.08
Register of Mines, with Map, Siskiyou County	.25	.08
Register of Mines, with Map, Trinity County	.25	.08
Register of Mines, with Map, Tuolumne County	.25	.08
Register of Mines, with Map, Yuba County	.25	.08
Register of Oil Wells, with Map, Los Angeles City	.35	.02
Map of Mother Lode	.05	.02
Map of Desert Region of California	.10	.02
Map Showing Copper Deposits in California	.05	.02
Map of Calaveras County	.25	.03
Map of Plumas County	.25	.03
Mineral and Relief Map of California	.25	.05
Map of Forest Reserves in California (Mounted)	.50	.08
Map of Forest Reserves in California (Unmounted)	.30	.06

IN PREPARATION—
Map and Register of Madera County.
Report on Minaret District.
Bulletin—"Revised Edition Copper Resources of California."

Samples (limited to three at one time) of any mineral found in the State may be sent to the Bureau for identification, and the same will be classified free of charge. *No samples will be determined if received from points outside the State.* It must be understood that *no Assays or Quantitative Determinations will be made.* Samples should be in a lump form if possible, and *marked plainly with name of sender outside of package, postoffice address, etc. No samples will be received unless charges are prepaid. A letter* should accompany sample and a stamp should be enclosed for reply.

Address all samples and communications regarding samples to *Laboratory*.

LAW RELATING TO MISREPRESENTATION OF MINES BY ANY OFFICER OF A CORPORATION TRANSACTING BUSINESS IN CALIFORNIA.

SECTION 1. Any superintendent, director, secretary, manager, agent, or other officer, of any corporation formed or existing under the laws of this State, or transacting business in the same, and any person pretending or holding himself out as such superintendent, director, secretary, manager, agent or other officer, who shall willfully subscribe, sign, endorse, verify, or otherwise assent to the publication, either generally or privately, to the stockholders or other persons dealing with such corporation or its stock, any untrue or willfully and fraudulently exaggerated report, prospectus, account, statement of operations, values, business, profits, expenditures or prospects, or other paper or document intended to produce or give, or having a tendency to produce or give, to the shares of stock in such corporation a greater value or less apparent or market value than they really possess, or with the intention of defrauding any particular person or persons, or the public, or persons generally, shall be deemed guilty of a felony, and on conviction thereof shall be punished by imprisonment in State prison, or a county jail, not exceeding two years, or by fine not exceeding five thousand dollars, or by both.

SEC. 2. All Acts and parts of Acts in conflict with this Act are hereby repealed.

Approved March 22, 1905.

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