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MERCURY POTENTIAL OF THE UNITED STATES

By Bureau of Mines Staff

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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MERCURY POTENTIAL OF THE UNITED STATES

by

Bureau of Mines Staff

ABSTRACT

Mercury has been used by mankind since prehistoric times. It has been, and is now, widely used in industry and medicine and has unique properties which make direct substitution difficult or impossible. At present its principal uses are for electrical apparatus, control instruments, electrolytic soda preparation, mildew-proofing paints, pesticides, and medical and dental preparations.

Deposits of mercury are less common than those of other base and precious metals, but some of the deposits are very large and have been ample to meet the world's past demands. The price of mercury has had many sharp fluctuations, but in general, the limited number of producers has resulted in a more stable price structure than that of many other commodities.

The United States has been one of the main producers of mercury, and from 1850 to 1961 produced 3,247,704 flasks. Yearly production since World War II has varied from 4,535 to 38,067 flasks.

An estimate of domestic resources of mercury producible at various price ranges was prepared for each mercury mine by combining specific knowledge of mercury mineralization with estimates of potential, based on geologic information and past production history. The sum of the individual estimates for each price range is shown in a table.

A parallel estimate of nationwide production potential was made from a study of past price and production relationships. These were analyzed by plotting yearly production figures against the previous year's price, expressed in dollars of constant purchasing power. An equation was fitted to the data by mathematical means and was used to extend the curve into areas of higher than historic prices. Potential production rates at various price levels were taken from this graph. The estimated yearly production rates were used to make an estimate of total potential based on the premise that production rates and reserves have a proportionate relationship.

Work on manuscript completed July 1964.

The rate of developing mercury reserves during the period from January 1944 to January 1962 is considered, and it is shown that if this rate can be continued, the mercury resources of the United States, at a constant dollar price of $500 per flask, are adequate to support a production of 60,000 flasks per year for 30 or more years.

This publication contains a history and description of the mercury industry in every State which has had production and individual descriptions of all mercury properties which have reported significant production. Accompanying tables give the important facts about all known mercury occurrences.

INTRODUCTION

This publication was prepared to provide in one report reasonably complete information on the domestic mercury production potential. It represents the results of a detailed study of mercury resources on an individual mine basis and an engineering evaluation of the production potential at various price levels, ranging from $100 to $1,500 per flask.

It is not expected that, under normal conditions of world trade, the price of mercury will reach the elevated figures covered in this circular, but the determination of resources available at high incentive prices gives a better overall picture of the domestic mercury industry's basic position and future than does a consideration of only those reserves competitive in present world markets.

The U.S. primary mercury industry has become marginal, and during low price periods, demand is met mainly by foreign mercury. This results in the loss of domestic income from primary mining and processing operations, the necessity of earning foreign exchange to pay for raw material imports, and the weakening of U.S. strategic self-sufficiency in times of emergency. If it should become necessary in the future to obtain a larger proportion of the mercury supply from U.S. mines, a combination of higher domestic prices and improved technology will allow production from much of the material now classified as only potential ore. One purpose of this publication is to make a preliminary estimate of the results possible from a program designed to expand domestic production of mercury.

This study does not include estimates of future mercury consumption at various price levels, although a knowledge of these trends is indispensable for an analysis of future mercury markets. A meaningful examination of future demand at various price levels requires cost studies to show the effect of price rises on substitution, as well as consideration of present trends in mercury use, industrial production, population, and possible new uses. Industry and Government stocks of primary mercury were not considered despite the rather large quantities involved, as their effects would be temporary. This report is concerned mainly with the long-term production potential of the domestic mercury industry. The totals are expressed as flasks producible at graduated price levels in constant dollars (1957-59=100). The money figure is used as a common denominator for grouping mineral resources and takes into account all factors such as extent and grade of resources; accessibility; and cost of exploration, development, and production.

All of the known mercury deposits of the United States have been described or listed in this publication. All mines or prospects which have had any significant production have been described in reasonable detail, and all known mercury mines, prospects, and occurrences and the salient facts concerning each are listed in tables accompanying each State chapter. These data formed the basis of one overall estimate of mercury production potential. In addition, this portion of the report provides a complete reference of mercury properties.

Along with the detailed study of mercury resources, an analysis was made of price-production relationships from 1910 through 1961. A curve was fitted to what was thought to be the significant part of the price-production data, and projections were made beyond the historic price range to give another overall estimate of mercury production potential.

Other Government publications, notably "Mercury, a Materials Survey," by James W. Pennington, published as Bureau of Mines Information Circular 7941 in 1959, provide excellent sources of information on the mercury industry. They cover subjects such as domestic and world reserves; geology; mining and processing technology; world supply; chemical and physical properties and uses; structure of the industry; and legislation and Government programs. These topics were not duplicated in this publication.

ACKNOWLEDGMENTS

Acknowledgment is given to the many public-spirited citizens who furnished information which has been included in this report. This is particularly true of the geologic and mining department staffs of the various States. The acknowledgments sections in the State chapters mention many of these individuals. Mr. Ralph Higgins of the San Francisco Petroleum Research Laboratory of the Bureau of Mines did the computer programing necessary for this report.

CHAPTER 1. - HISTORY

by

Bureau of Mines Staff

GENERAL HISTORY

Mercury is a noble metal which occurs uncombined in nature and which has been known to mankind since prehistoric time. A small vessel containing quicksilver, found in a grave at Kurna in Mesopotamia, was determined to have been made in the 15th or 16th century B.C. Aristotle described mercury in his writings of around 320 B.C. and referred to its use by priests. Chinese records of 200 B.C. mention the use of both cinnabar and liquid metal.

Pliny the Elder, in A.D. 77, tells of the use of mercury to amalgamate and refine gold and its use in gilding and silvering. Cinnabar was also used as a pigment and as a medicine. The source of cinnabar during this period was the Almaden mine in Spain, where the ore was mined under an exclusive license from the Roman Government and transported to Rome for refining. Retorting was used to separate the mercury from the ore.

The alchemists of the Middle Ages considered mercury as a basic constituent of all fusible metals, and their experimentation with it resulted in knowledge of many mercurial compounds which were found to have valuable medicinal properties. By the 16th century, the elemental nature of mercury had become evident and treatises on quicksilver written at this time, describing the metal's properties, the geology of its occurrences, and the refining of its ores are very similar to modern accounts (3).[1]

The Spanish explorations in Mexico, Peru, and Bolivia during the 16th century opened up large gold and silver deposits and created the first large-scale mercury demand for use in amalgamation.

The invention of the mercury thermometer and the use of mercury in scientific instruments required additional mercury during the 17th and 18th centuries. Use of the metal for pigments and medicines also increased. The explosive properties of mercuric fulminate were discovered in 1799, and this compound has been extensively used as an explosive detonator ever since. Electrolytic mercury cells were first employed in the 1890's to produce chlorine and caustic soda and this process has become a major consumer of mercury. In the 20th century, many new and important uses for mercury were found, including medicines, dental amalgams, fungicides, germicides, control instruments and switches, diffusion pumps, tetraethyllead manufacture, incandescent lamps, batteries, mercury-vapor powerplants, antifouling and mildew-proofing paints, and catalysts.

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[1] Underlined numbers in parentheses refer to the bibliography at the end of the chapter.

Principal Producers

Mercury production has been dominated by a relatively few mines, and output has been more subject to cartels and other artificial production limitations than has that of more widespread commodities.

By far the largest producer in the world (and until 1470 virtually the only producer) is the Almaden mine in Ciudad Real Province, Spain, about 150 miles southeast of Madrid. Total output has been over 7 million flasks.

Mercury production began at the Almaden mine about 400 B.C. The mine was operated under Iberian, Roman, and Moorish control until 1151 when Alfonso VII transferred it to the Knights Templars and later to the military-religious Order of Calatrava. When mercury became of prime importance for amalgamating gold and silver from the large deposits of these metals discovered in the colonies in the 16th century, the Spanish Government repossessed the property. A 120-year lease was awarded to the Fugger brothers of Germany in 1525 who replaced the old pot stills with reverberatory furnaces and greatly increased production. Since the expiration of the lease, the mine has been operated directly by an agency of the Spanish Government. In 1651 new furnaces were constructed that remained in operation until 1923 when the plant was rebuilt. Production reached a record of 72,000 flasks in 1927 and subsequently fell, due to voluntary production limitations, the Spanish civil war, and World War II. In 1961 production was estimated at 50,000 flasks.

The Idria mine in the foothills of the Julian Alps, 25 miles northeast of Trieste, in what is now Yugoslavia, was discovered in 1470, and mining was initiated soon thereafter. It has produced over 2.5 million flasks. Political control of the mine area has changed several times, the ownership having been Venetian, Austrian, and Italian; it is currently Yugoslavian. Production in 1961 was about 15,000 flasks.

The Santa Barbara mine and surrounding properties, Department of Huancavelica, Peru, produced 1,470,000 flasks, mainly in the period 1571 to 1790. Repeated attempts to discover new ore bodies in the Santa Barbara area have been unsuccessful.

The New Almaden mine in Santa Clara County, Calif., has produced over 1,050,000 flasks. The relatively small 1961 production came from dumps and near surface workings.

PRICE HISTORY

Since 1910 domestic price movements have been influenced, aside from normal economic variations, by unusual demand during World War I, World War II, and the Korean war; by the Spanish civil war which affected production at the Almaden mine; and by the effects of producers' cartels and Government tariffs and purchase programs.

The period from 1910 to 1914 was characterized by stable prices and production, which varied from $40 to $48 and from 16,000 to 25,000 flasks,

respectively. During World War I the large military demand for mercury resulted in an embargo of shipments by Great Britain and an acute shortage in the United States. The embargo was relaxed in 1916. After U.S. entry into World War I, contracts were made between the War Industries Board and the mercury producers which reserved 40 percent of the domestic output at a price of $105 a flask f.o.b. San Francisco, Calif., or of $105.75, New York, for allocation to war industries and limited the price of the remaining mercury to $125 per flask. At these prices production rose to more than 35,000 flasks in 1917.

With the end of the hostilities and reduction of inventories, prices fell in 1921 to $46 and domestic production dropped to 6,000 flasks. During 1922 an import duty of $19 per flask was imposed upon foreign mercury. This duty represented a sizable increase over the 10 percent ad valorem rate previously in force. As a result of the tariff increase and a general increase in economic activity, the price of mercury rose gradually to $118 per flask, and production increased to 11,000 flasks in 1927.

In 1928 the Spanish and Italian producers formed a cartel to limit sales when world stocks became burdensome. Under the protection of the favorable price relationship established by the cartel, U.S. production reached almost 25,000 flasks in 1931. Because of the large production increase by independents, the cartel sharply reduced its floor price at the end of 1931. As a result, the domestic price fell to $58 and the domestic production to less than 10,000 flasks. The cartel brought the price up slowly to nearly $80 in 1936, and domestic production increased to 17,000 flasks during this year. In 1936, with the outbreak of the Spanish civil war, the cartel became inoperative due to political enmity brought on by Italian aid to the Spanish insurgents. However, production problems brought on by the war and increased demand allowed previously held stocks to be absorbed without disruption of the market. The cartel was reestablished in 1939, but after the outbreak of World War II political considerations made its operation impossible. In 1939 mercury had an average price of $104 per flask and U.S. production was slightly over 18,000 flasks.

The outbreak of full-scale war in 1939, coupled with shipping and producing difficulties, caused a sharp increase in price to $185 per flask in 1941 and an increase in domestic production to 44,921 flasks. With the entry of the United States into World War II, the Government instituted price and import controls, and under an average price of $196 per flask, a modern production record of 51,929 flasks was set in 1943. In January 1944 the Government ceased its purchase of mercury, and the price fell sharply. The price recovered partially in 1945, due to stockpiling in anticipation of increased demand brought on by the development of the mercury battery, but heavy shipments from Spain forced the price down, and it continued down to a low of $76 in 1948. Production reached an alltime low of less than 5,000 flasks in 1950.

The start of the Korean war in June 1950 caused a sharp increase in price, and on January 25, 1951, a general ceiling price regulation was issued which fixed maximum prices of mercury at the highest level at which sales had been made by the individual producer in the preceding 37 days. As most

mercury mines had no production or sales in the base period, the regulation proved difficult to apply, and on August 10, 1951, mercury was exempted from it. Prices continued in the $200 range throughout 1953, and production increased to over 14,000 flasks.

On July 6, 1954, the General Services Administration announced a 3-year guaranteed price program for mercury. The program provided for the purchase of a maximum of 125,000 flasks of domestic mercury and 75,000 flasks of Mexican metal at $225 per flask and also provided for possible purchase contracts with other foreign producers. The program was to end December 31, 1957, irrespective of the amount of mercury purchased. Since the price during most of the 3-year period remained well above the support price, only 9,428 flasks of domestic mercury and 766 flasks of Mexican mercury were purchased. The program was extended for 1 year to December 31, 1958, and the purchase of up to 30,000 flasks of domestic mercury and 20,000 flasks of Mexican mercury was authorized at a price of $225 per flask. Under the extension, 17,463 flasks of domestic mercury and 2,508 flasks of Mexican metal were purchased. Domestic mercury production reached 38,067 flasks in 1958. After the end of the Government purchase program, the price of mercury dropped slowly from the $225 per flask support level to $198 in 1961, and production declined to less than 32,000 flasks.

Table 1 lists the U.S. production and prices from 1910 to 1961 and also the constant dollar price based on 1957-59=100. This shows the past relation between production and the constant-dollar value of the market price at the time of production.

TABLE 1. - U.S. mercury production and prices, 1910-61

Year	Production, flasks	Price		Year	Production, flasks	Price	
		New York price per flask (average)	Constant dollar price per flask (1957-59 = 100)[1]			New York price per flask (average)	Constant dollar price per flask (1957-59 = 100)[1]
1910....	20,330	[2]$47.69	$124	1936....	16,569	$79.92	$181
1911....	20,976	[2]47.16	133	1937....	16,508	90.18	191
1912....	24,734	[2]43.03	114	1938....	17,991	75.47	176
1913....	19,947	[2]40.07	105	1939....	18,633	103.94	246
1914....	16,330	[2]48.95	131	1940....	37,777	176.87	411
1915....	20,756	[2]88.17	232	1941....	44,921	185.02	387
1916....	29,538	[2]127.16	272	1942....	50,846	196.35	364
1917....	35,683	[2]107.72	168	1943....	51,929	195.21	346
1918....	32,450	[2]125.12	175	1944....	37,688	118.36	208
1919....	21,133	[2]93.38	123	1945....	30,763	134.89	233
1920....	13,216	[2]82.20	97	1946....	25,348	98.24	149
1921....	6,256	[2]46.07	86	1947....	23,244	83.74	103
1922....	6,291	[2]59.74	113	1948....	14,388	76.49	87
1923....	7,833	[2]67.39	122	1949....	9,930	79.46	95
1924....	9,952	[2]70.69	132	1950....	4,535	81.26	94
1925....	9,053	[2]84.24	149	1951....	7,293	210.13	217
1926....	7,541	[2]93.13	170	1952....	12,547	199.10	212
1927....	11,128	118.16	226	1953....	14,337	193.03	208
1928....	17,870	123.51	233	1954....	18,543	264.39	285
1929....	23,682	122.15	234	1955....	18,955	290.35	312
1930....	21,553	115.01	243	1956....	24,177	259.92	270
1931....	24,947	87.35	219	1957....	34,625	246.98	249
1932....	12,622	57.93	163	1958....	38,067	229.06	228
1933....	9,669	59.23	164	1959....	31,256	227.48	226
1934....	15,445	73.87	180	1960....	33,223	210.76	209
1935....	17,518	71.99	164	1961....	31,662	197.61	197

[1]Quoted price divided by Bureau of Labor Statistics wholesale price index (1957-59 = 100).

[2]Quoted price for 75-pound flask calculated to equivalents for 76-pound flasks. Figures from Bureau of Mines, Minerals Yearbook, 1960-61.

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CHAPTER 2. - ENGINEERING EVALUATION OF THE POTENTIAL MERCURY PRODUCTION OF THE UNITED STATES

by

Bureau of Mines Staff

DEFINITIONS

The word "potential" is defined by Webster as "existing in possibility as opposed to existing in actuality." Blondel and Lasky (1)[1] define ore potential in relation to ore reserves as all material within the environment with any metal content whatsoever.

Definite criteria for ore reserves were established by the Geological Survey (3) and the Bureau of Mines, and the distinction between "mineral reserves" and "potential resources," which together make up "total resources," was set up by these agencies for the President's Materials Policy Commission (6). In the present report also, the term "mineral reserves" refers only to the material that in some degree has been inventoried in terms of commercial enterprise and does not include material of submarginal grade. "Potential resources" includes marginal and submarginal resources that must wait primarily for more favorable prices to be processed and potential future sources that must wait for new--and in some instances revolutionary--technologies, as well as higher prices.

EVALUATION METHODS

Two approaches are possible in making an estimate of mineral potential. The first requires a geologic and economic study of each mine and occurrence and from this an estimate of the amount of mineralized material available and the amount recoverable at each property with present technological methods at various price levels. The summation of these estimates is the potential of the area. The second approach is essentially one of extrapolation of the price-production relationships that have prevailed in the past to establish possible rates of future production at all price levels and the rates of development of ore reserves in the past to estimate how long these production rates could be maintained. Both methods are used in this analysis.

Using the first approach, a comprehensive study was made of the principal producing areas, and by making certain assumptions (that are explained later), the potential of each property was estimated and a figure obtained for total potential.

Using the second approach, an estimate was made using the domestic price-production history, from which a graph was plotted. A curve was fitted to the plotted points using mathematical methods, and the curve was used for extrapolation to determine probable rates at higher prices. There have not been

[1] Underlined numbers in parentheses refer to the bibliography at the end of the chapter.

enough countrywide ore-reserve studies made in the past to justify plotting a graph showing movement of reserves and these data, therefore, are presented in a table. From these data, a total potential estimate was made.

PRODUCTION POTENTIAL ON AN INDIVIDUAL MINE BASIS

Commercial enterprises are primarily interested in ore that can be produced profitably at current market prices and ordinarily do not develop submarginal material for its own potential value. However, incidental to normal exploration and development at operating mines, information gradually is accumulated about the general mineralization of the mine and its environs.

It is uncommon for mercury mineralization in an area to be confined to only a few large oreshoots in a single fissure, although at past prices only such large high-grade ore bodies have been minable. Generally, extensions of the main structure contain smaller or lower grade oreshoots, as do smaller parallel structures. Fracture zones may contain mercury in tiny veins and stockworks.

Information on the extent of low-grade mineralization even in districts with notable production is necessarily incomplete, and placing numerical values upon its volume and grade is a matter of judgment after consideration of all pertinent factors.

Most mineralized localities contain no oreshoots which were large enough and rich enough for exploitation during any of mercury's high price cycles. Knowledge concerning these areas is fragmentary or unavailable, and estimates of the extent and grade of mineralization are even more a matter of personal discernment than those made for areas with large past production.

Studies of ore potential require, first, a marshaling of available information and opinions about the area concerned and, second, the placing of numerical values upon the indicated potential. Very little new testing can be done, and judgment must be relied upon in all cases.

To approach the estimating problem in a systematic and logical manner requires consideration of all of the many factors involved, in order of their importance and the extent of knowledge available about each. Also required is a study of general price-production relationships, to provide a basis for projecting known production rates into higher price brackets, and a determination of the general relation between rate of production and total reserves, to aid in making total potential estimates when specific information is scanty or nonexistent.

Criteria Used in Estimating Potential

The criteria used in this estimate were weighed as follows:

1. Specific knowledge of existing ore reserves and low-grade mineralization gained by mining or prospecting activities.

2. The geologic environment, such as distance from commercial mineralization, extent of favorable host rocks, and presence of favorable structure.

3. Magnitude of past production.

4. Costs of production, grade of ore, and current status of the property.

5. Individual price-production history.

6. General price-production relationships.

Existing Reserves

In the case of properties where ore reserves have been established by the Geological Survey, private industry, or Bureau of Mines engineers, a study of production costs was made and the price range established for the production potential of the reserve. If further resources of submarginal material were known to exist, they were evaluated similarly. The value of any additional mineralized areas on the property was determined by the field engineer, using the criteria listed above.

Geologic Environment (4, 5)

The most important factor influencing the production potential to be assigned untested ground is the geologic environment of the area. Most large mercury deposits have certain features, and the presence of absence of these features are strong indicators of the chances of discovering mercury at undeveloped localities.

All significant mercury deposits are of primary magmatic origin. Most of them occur in belts of late Tertiary and Quaternary volcanic and tectonic activity.

Small amounts of cinnabar and other mercury minerals have been noted in a variety of hydrothermal occurrences, but almost all commercial production has come from deposits which, judging from appearance and mineral association, were formed at relatively low temperatures and under near-surface conditions. Most of the large mines are known to be Pliocene or later in age.

The most abundant type of mercury deposits have a simple mineralogy. In these, cinnabar and varying amounts of metacinnabarite and native mercury are the only economic minerals; associated sulfides of other metals are very subordinate. Gangue minerals are opal, chalcedony, quartz, calcite, dolomite, pyrite, marcasite, and often stibnite and sulfur. Much less common are deposits of cinnabar in association with pyrite, tetrahedrite, galena, sphalerite, chalcopyrite, gold, arsenopyrite, fluorite, quartz, and calcite. Even less common are deposits of mercuric tetrahedrite, chalcopyrite, sphalerite, galena, quartz, and tourmaline. In exceptional cases, significant amounts of mercury have been recovered as a byproduct of zinc, copper, and gold production.

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Cinnabar deposition is much less dependent upon chemical interactions between wall rock and mineralizing solutions than is the case with most sulfides. Mercuric sulfide is soluble in alkaline solutions which also attack silica as well as in acid solutions which attack limestones. Silica is such a common constituent in rocks and in premineral alterations that cinnabar replacements can form in most rocks. Actually, fracture filling is more common than replacement, but some of the largest mines contain much replacement ore.

Structure is the most important factor in localizing quicksilver deposits. Mineralization is found in veins, breccia zones, and other permeable horizons generally near to major faults. Oreshoots are most frequently found beneath trap structures where an impervious capping of gouge or other material interrupts the ore channel.

The persistence of mercury deposits at depth is a factor of paramount economic interest. The deepest mine developed to date was the New Almaden, in which the deepest workings are 2,400 feet below the outcrop, which was large and extremely high in grade. The New Almaden and the New Idria mines have been productive to depths of 1,500 feet, and the Idria and Santa Barbara mines were bottomed at depths of 1,000 feet. Smaller mines have only reached shallower depths. The thicknesses eroded from above the present outcrops are unknown, but since all of the mines are in areas of active erosion, the amounts were substantial.

The past record of impoverishment at relatively shallow depth requires that all individual deposits be evaluated as having a similar limited downward extent. Considering mercury occurrences as a whole, however, it seems possible that some ore showings might be the tops of large oreshoots which have escaped erosion and the existence of as yet undiscovered major ore bodies is a possibility.

When mercury properties are grouped by production into the categories of large, medium, and small mines, prospects, and occurrences, certain geological characteristics of the most productive group are found to a progressively lesser degree in properties in the other categories. The largest mines are characterized by (1) major faulting and folding; (2) numerous shear and fracture zones; (3) rock alteration frequently of a silica-carbonate nature; and (4) massive mineralization. The greater the concentration of fractures and shear zones resulting from faulting and folding, the greater the production potential in a given mine. The presence of areas of silica-carbonate rock alteration is a very favorable indicator in many mercury districts in California.

Widespread areas of mineralization, in zones, veins, or massive fracture fillings, constitute, at the least, a production potential of lower grade material and indicate the possible presence of high-grade deposits. Mineralization that consists only of cinnabar stains and thin fracture coatings and that lacks areas of local concentration is not likely to contain high-grade ore bodies, but it may have production potential at elevated prices.

Magnitude of Past Production

The magnitude of past production of the mine is important, both for the mine itself and for nearby properties. Large production proves that the district has been subjected to strong mercury mineralization and every nearby area of rock alteration and notable fracturing is a potential source of mercury. Conversely, in areas that have had little production, the failure of the most prominent occurrences of mercury to develop into mines is discouraging. Although these areas have little chance of developing greater production at historic prices, they may have considerable production potential at elevated prices.

For the purpose of this study, the domestic mercury properties are classified as occurrences, prospects, and mines. The mines are further grouped into four categories according to the magnitude of past production. The number of properties and the production in each category by States, are shown in table 2.

Mines. - Mines are properties that have produced more than 100 flasks of mercury. Eight mines, all in California, have produced more than 100,000 flasks, accounting for 72 percent of the total U.S. production from 1850 to 1961 (table 2). An additional 25 mines in 6 States have produced from 10,001 to 100,000 flasks, about 23 percent of the total recorded domestic production.

The 33 mines in the two highest production ranges represent the most favorable areas from which future production may be anticipated. Excellent geologic, economic, and technologic data are available on most of these properties, and the 1957 and 1962 estimates by the Geological Survey are based primarily on the figures for these mines and their immediate environs.

In spite of the preponderance of past production and current reserves among the top 33 producers, the probability that some of the smaller mines and prospects may in the future become important producers must not be overlooked. For example, the Cordero mine in Nevada was a small prospect from its discovery in 1924 until 1941. Since then this mine has been by far the largest producer of mercury in Nevada and is the only Nevada mine that has produced more than 10,000 flasks.

Prospects. - Prospects are properties that have a recorded production not exceeding 100 flasks. A substantial number of these properties may become mines with further exploration or with sustained higher mercury prices. A production potential at suitable price levels has been assigned to those prospects that have favorable geologic indicators or known low-grade ore bodies that cannot be worked at current prices.

Occurrences. - Occurrences are those properties that have had no recorded production. In most instances the geologic environment is unfavorable; there are no reserves and little potential. However, a few recent discoveries, especially in Alaska, had no production to the end of 1961, but sufficient exploration had been done to justify an estimate of potential. These properties, as well as others, on which much exploration was done have as much merit as many of those from which a few flasks were produced, but in the interest of consistency they have been listed in table 2 as occurrences.

TABLE 2. - Mercury production and number of deposits in the United States, 1850-1961, by production range and States
(Production in 76-pound flasks)

State	Total number of deposits	Total production	Large mines, over 100,000 flasks		Medium mines, 10,001 to 100,000 flasks		Small mines: 1,001 to 10,000 flasks		Small mines: 101 to 1,000 flasks		Prospects, 1 to 100 flasks		Mines and prospects, number	Occurrences, number
			Number	Production	Number	Production	Number	Production	Number	Production	Number	Production		
Alaska.....	64	30,115	-	-	1	28,061	1	1,366	2	622	6	66	10	54
Arizona.....	29	7,082	-	-	-	-	3	6,478	2	375	9	229	14	15
Arkansas.....	49	11,404	-	-	-	-	4	6,763	10	4,240	25	401	39	10
California.....	276	2,772,120	8	2,322,668	13	379,482	24	55,438	43	13,185	80	1,347	168	108
Colorado.....	6	-	-	-	-	-	-	-	-	-	-	-	-	6
Idaho.....	23	31,601	-	-	2	31,472	-	-	-	-	5	129	7	16
Montana.....	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Nevada.....	187	[1]134,547	-	-	1	78,677	16	44,549	25	9,541	79	1,780	121	66
New Mexico.....	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Oregon.....	257	[1]103,121	-	-	5	98,582	-	-	11	3,795	42	744	58	199
South Dakota....	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Texas.....	32	147,211	-	-	3	131,350	3	12,585	7	3,121	10	155	23	9
Utah.....	8	3,497	-	-	-	-	1	3,181	2	316	-	-	3	5
Washington.....	69	6,624	-	-	-	-	2	6,547	-	-	7	77	9	60
Wyoming.....	3	-	-	-	-	-	-	-	-	-	-	-	-	3
Totals.....	1,008	[2]3,247,703	8	2,322,668	25	747,624	54	136,907	102	35,195	263	4,928	452	556
Percent of total production.....	-	-	-	71.5	-	23.0	-	4.2	-	1.1	-	0.2	-	-
Cumulative percent of total production.....	-	-	-	71.5	-	94.5	-	98.7	-	99.8	-	100	-	-

[1]Unidentified production distributed among mine groups.
[2]Includes 381 flasks designated as undistributed.

Operating Costs, Grade of Ore, and Current Status

The all inclusive term "cost of production" is closely related to potential. A mineralized body from which mercury can be produced at a certain price has a potential at that price equal to the total mercury in the ore body. In turn, the unit cost of production is the per-ton operating cost plus an amortized share of the startup costs divided by the grade of ore.

Aside from these elementary relationships, the study of individual operating costs and ore-grade trends can tell much about the type of ore occurrence and extraction problems of the mine, while the current status of the property reflects the appeal it has had in the past to mercury investors.

Technologic progress in mining and processing has been uneven. Some extractive operations, such as open-pit mining, underground mining of some types of large ore bodies, and transportation of material, have been greatly mechanized, while others such as stoping in narrow irregular ore bodies with weak walls still require about as high a unit labor output as a generation ago.

In processing operations progress has also been variable. Furnacing output per man was increased by the introduction of improved equipment, and some lower grade ores have been beneficiated before furnacing. However, there has been no production of mercury from low-grade ores by the use of low-unit-cost, large-scale processes. Marginal copper, lead, zinc, and gold mines are operating on ore with a gross value of only $3 to $4 per ton, but it is unusual for mercury ore with a gross value of less than $12 per ton to be mined. Present reduction of mercury ores by furnacing methods can seldom be done for less than $4 per ton, and as yet no cheap treatment method has been applied which gives both low operating costs and high recovery, as does, for example, flotation for copper, lead, and zinc ores or cyanidation for gold ore. Some medium-sized bodies of low-grade mercury ore are known that would be adaptable to low-cost mining if cheap treatment processes were invented, but in general mercury deposits lack the size and regularity that is necessary before low-cost mining methods can be adapted to them. Mercury producers depend upon highly selective mining, which is reflected in high stripping ratios in open cuts and in low output per man underground.

A study of individual cost trends indicates past operating conditions, and by inference, the price necessary to allow a property to resume production.

Data on the grade of ore mined in the past are incomplete and not always accurate. Selective mining and underground hand sorting were not always reflected in the reported tons of ore in place broken. Furthermore, the general practice of operating without close assay control complicates the problem of determining the average grade of ore mined from different parts of the mine and of estimating how much low-grade material was left behind.

Variations in management policies have had a profound influence on the average grade of ore mined and the cutoff point at various price levels. At some properties a reasonably constant net income was maintained over a period of years by mining higher grade ore when the mercury price was low. At other

mines, the reported grade of ore remained nearly constant, but the mine was shut down when the mercury price dropped below the break-even point. In many instances, exploration and development were curtailed during low-price cycles, ultimately resulting in a shutdown when reserves were exhausted or at best causing costly delays in stepping up production to take advantage of improved prices.

The average grade of ore mined and treated in the United States from 1956 through 1961 is given in table 3. The figures represent only newly mined ore; dump material and material obtained from other reworking or cleanup operations are excluded.

TABLE 3. - Average grade of ore mined at mercury mines in the United States, 1956-61

Year	Pounds per ton	Year	Pounds per ton
1956.....	7.5	1959.....	8.6
1957.....	8.4	1960.....	9.7
1958.....	8.6	1961.....	9.2

In conclusion, past grade of ore can be used only as a qualitative modifier of the future production estimates. A mine with a consistent record of production from ore containing more than 12 pounds of mercury per ton obviously has a better potential than a low-grade mine. However, there are a few instances where a large tonnage of ore containing 3 to 10 pounds per ton is inferred. Such resources could be mined at one of the higher price levels considered in this report.

Resources in areas of highly scattered mineralization are assigned to potential at high price groups, and they will require a technologic breakthrough to make them usable at lower prices.

The current status of mines and plants, particularly underground operations, has a vital effect on the cost of resuming operations and consequently on the production potential of the property. The longer the period of inactivity of a property, the more costly the problems of rehabilitation and development of new ore reserves are likely to become.

Individual Price-Production History

The individual price-production relationship during the last years of active exploration or production is a key indicator in determining the price above which a property has potential.

A long production history through both high and low price cycles, but becoming increasingly sensitive to declining prices, may reflect rising constant-dollar costs and exhaustion of reserves. On the other hand, mines that have continued production, even at a reduced level, during periods of low prices have an excellent chance to continue producing for a number of years.

Hence, such mines have been assigned a high production potential, unless other modifying influences are unfavorable.

At shutdown mines, the last year, or sequence of years, during which the property was in production, reflects the constant-dollar mercury price level at which the mine could be operated. If the mine was closed following a price decline, the presumption is strong that it could be reopened when the price rises enough above the level of the latest operations to justify the cost and risk of rehabilitation and probably extensive exploration. Conversely, properties that closed a number of years ago during a stable or rising mercury market may be assumed to have a negligible potential at the former price levels but might become active again at substantially higher prices.

The following paragraphs illustrate more specifically the effect of the time of last production on the estimation of production potential.

Those mines operating in 1961, when the constant dollar average price was $198 per flask at New York, probably can continue production at that price level for about 1 to 3 years, although little development work and almost no exploration work would be justified at more than a few properties. At a price of $250 per flask, most of the 1961 operations could be sustained for 5 years or more, and some properties that became inactive in 1959 and 1960 could be reopened. Furthermore, exploration and development would be substantially encouraged.

It is unlikely that many mines that were closed during the period 1951 through 1958 could be reopened until the constant-dollar price reached about $300 per flask, which was near the peak price for the period.

Mines that became active during the high price cycle of World War II, that were closed within a few years after the abrupt price decline beginning in January 1944, and that have since largely remained idle are unlikely to be able to resume production at a price much below $400 per flask. Mines in this category that have been dismantled and whose workings may have caved would obviously require still higher prices, say $500 per flask or more, to justify reopening. Likewise, prices of $500 or more would be needed to encourage exploration, development, and reequipment of formerly inactive mines that were not reopened during the period 1925-39 when prices were relatively stable at better than the 51-year average (1911-61).

Individual price-production studies were made for all mines credited with a production of over 10,000 flasks. Although there are only 33 properties in this class, together they have contributed 94.5 percent of the U.S. mercury production.

If information concerning the reserves and geologic environment of a specific property was too limited to form the basis of a production-potential estimate, the potential was tentatively established as three times the yearly average of the latest significant continuous production, eliminating abnormally low years. Of course the price range for this potential was determined by using the above criteria.

The justification for using the empirical factor of three times the yearly average of the last significant continuous production is that it is the nearest whole number factor that fits the majority of situations where the past production records demonstrate the ability of the property to continue production at a given constant-dollar price level or to resume production when the mercury price returned to that level after a shutdown in a declining market.

Many of the individual properties having a total production of 10,000 to 1,000 flasks and most of the properties with a production of less than 1,000 flasks were evaluated on this basis. Since the production of these groups has only accounted for about 5 percent of the total production, relatively little potential is indicated for properties in these ranges aside from estimates made on the basis of more precise information. Occurrences were evaluated in the same manner, and since they have reported no production they were credited with no potential except as known from other sources of information. This policy resulted in probable low estimates for the occurrences, prospects, and small-mine types of properties, but time and facilities are not available to make meaningful studies of the more than 1,000 deposits in this class.

General Price-Production Relationships

In most of the mines studied, individual price-production data were available to make an estimate of potential at the price in effect during the last productive period, but estimating potential at higher price ranges required the use of projections.

As far as possible, potential resource estimates are based on knowledge of geology and extent of mineralization at each property, but where this information is lacking, estimates have been made using the following procedure: A graph was plotted showing the price-production relationship of the domestic mercury industry during the period from 1910 to 1961, and the graph was extrapolated into the elevated price ranges considered in this report. The method used in constructing this graph is described in detail in the section on "Production Potential as Extrapolated from Past Price-Production Relationships." Ratios taken from the price-production graph were used to project the potential of known mines to the corresponding elevated price ranges.

This projection requires the assumption that the economic potential (resources) of the United States would follow the same trend in relation to price as the historic and extrapolated price-production relations. This assumption is based largely on engineering experience and spot analogies with other metals, such as copper, lead, and zinc, where far better basic data are available. In the case of all these commodities, eventual production from the low-grade ores promises to be much greater than the production from the high-grade ore bodies which originally formed the only economic source of these metals, and production potential including low-grade ores exceeds the potential based only on high-grade ores by a much larger ratio than the respective production rates would indicate.

In practice the procedure used in estimating potential entailed the following steps:

1. A listing was made of all known U.S. mercury mines, prospects, and occurrences.

2. An exhaustive search for information was made for each property in published literature, unpublished Bureau of Mines reports, and interviews with property owners. In addition, field examinations were made of all large mercury mines and other properties believed to contain potential significant reserves.

3. The data collected were analyzed and translated into resource figures. In many instances estimates were made by the examining engineers; in other instances estimates were made on the basis of the geology and mineralization.

4. Properties for which information was inadequate were arbitrarily assigned a potential equal to three times the yearly average of the latest continuous significant production. For these properties the price range of the resources was determined after consideration of market conditions when the mine ceased production and the estimated cost of rehabilitation and production.

5. Resource estimates in higher price classifications were made if possible on the basis of specific information, but where this was unavailable projections were made by using ratios taken from the overall price-production history of the mercury industry.

Summary of Production Potential

The potential of all the mines and prospects, and such of the occurrences as were thought capable of contributing to future production, were combined in the tabulation shown in table 4, which gives the U.S. mercury potential by States, at selected price levels. The data indicate that an increase in price of $200.00 to $500.00 per flask results in a nearly sixfold increase in resources.

An inventory of mercury resources reported by the President's Materials Policy Commission (6) in June 1952, is presented for comparison in table 5. The Commission's estimates give the reserves available in various grades of ore. The higher grade ores are mainly in remote Alaskan areas where production costs are high.

The two estimates of mercury resources in tables 4 and 5 are made in different units, which at present operating costs have about the following relationship: The 10-pound-per-ton ore at most mines and the 20-pound-per-ton ore from very narrow fissures in Alaskan mines are equivalent to ore minable at $200 per flask; the 5-pound-per-ton ore (countrywide average) is equivalent to $400 per flask ore; and the 2-pound-per-ton ore is a grade which could be extracted at $1,000 a flask and the 1-pound-per-ton ore at $2,000 per flask.

TABLE 4. - Mercury resources of the United States at selected price levels[1] (76-pound flasks)

State	Mercury price per flask					
	$100	$200	$300	$500	$1,000	$1,500
Alaska	-	14,500	33,500	69,500	124,500	142,500
Arizona	-	-	2,500	8,000	12,000	13,500
Arkansas	-	-	-	4,500	6,500	7,500
California	39,000	112,500	258,000	566,500	853,000	941,000
Idaho	-	-	20,500	37,500	65,000	72,000
Nevada	7,500	13,000	34,500	71,500	115,500	157,500
Oregon	-	-	12,500	34,500	55,000	71,000
Texas	-	-	17,500	35,000	54,000	59,000
Utah	-	-	-	-	500	500
Washington	-	-	-	500	1,000	1,000
Total[2]	46,000	140,000	379,000	827,000	1,287,000	1,465,500

[1]Based on 1961 costs and technology.
[2]Totals are cumulative.

TABLE 5. - Mercury resources of the United States as determined in 1952 by the President's Materials Policy Commission

	Measured and indicated	Inferred	Total flasks
In ore averaging 20 pounds per ton	10,000	175,000	175,000
Additional resources:			
In ore averaging 10 pounds per ton	60,000	150,000	200,000
In ore averaging 5 pounds per ton	80,000	120,000	200,000
In ore averaging 2 pounds per ton	125,000	425,000	550,000
In ore averaging 1 pound per ton	75,000	275,000	350,000
Total flasks	350,000	1,150,000	1,500,000

Source: Report of President's Materials Policy Commission, v. 2, June 1952, table 14, p. 155.

The two totals--1,500,000 flasks for the President's Materials Policy Commission report and 1,465,500 flasks for this study--seem conservative when contrasted to the past domestic production of over 3,200,000 flasks taken from high-grade oreshoots. If an analogy is valid between mercury and other metals, more production should eventually come from relatively low-grade material than from the high-grade outcropping ore bodies which in the past have been the only economic source of metal.

PRODUCTION POTENTIAL AS EXTRAPOLATED FROM PAST PRICE-PRODUCTION RELATIONSHIPS

A much simpler method, which may have wide applications, for closely forecasting the effect of advancing prices on the future production of a commodity is based on a study of past production records, especially during sustained periods of increasing price. This method is based on history rather than present position.

Published price and production data are readily available at all times to make this type of study, whereas the effort needed to make a resource inventory on an individual property basis and the confidential classification in which many producers place reserve information puts a resource inventory survey beyond the means of most market analysts.

A study based on history rather than present position must make the assumption that past price-production patterns will be repeated. This implies that future operating conditions will be similar to those experienced in the past, and in general this is true. However, in mineral deposits, rehabilitation, exploration, and production costs increase rapidly as mining depths increase, and the problem of finding new orebodies becomes increasingly difficult as successive generations of prospectors search for new deposits. This has been partially offset by notable advances in plant automation and the development of effective geochemical and other aids to prospecting.

Although it is recognized that the price-production projection is experimental in nature, it is felt that making a parallel history-based forecast to accompany the present position-based forecast is most valuable and interesting. The relatively rapid and inexpensive history study serves as a check upon the presumably more precise and reliable inventory method estimate.

Estimate of Potential Production Rates

The past history of production and price provides a record of how the domestic mercury industry has responded productionwise to highly variable prices. Table 1 lists the production by years, the average yearly price, and the yearly price in constant dollars (1957-59=100) for the period 1910-61.

Figure 1 shows the price movements of mercury from 1910 to 1961. Yearly production in flasks is plotted against the previous years' constant-dollar price, and the points are connected chronologically to show cycles. The upward portions of the cycles, when production is increasing, are shown in heavy, solid lines, and the downward portions are shown in light, dashed lines. The lag of 1 year is used to allow for the lead-time required to achieve new production.

For forecasting future price-production relationships, only those portions of the price cycle which show an increasing price are thought to be significant. When price is increasing, most decisions to undertake production are made free from pressure and on a basis of the economics of the individual project, but when prices are falling, production policies of marginal producers (such as most domestic mercury mines now are) must consider the salvage value of the developed ore at their operations, as shutdowns may be of such long duration as to make it impractical to maintain the mine and plant in the hope of improved prices. Consequently, the production achieved during a falling market may not have been entirely economic, if true charges for depletion and depreciation were considered.

Since 1910 there have been four period of notable mercury demand which resulted in excellent prices for sustained intervals. These periods were

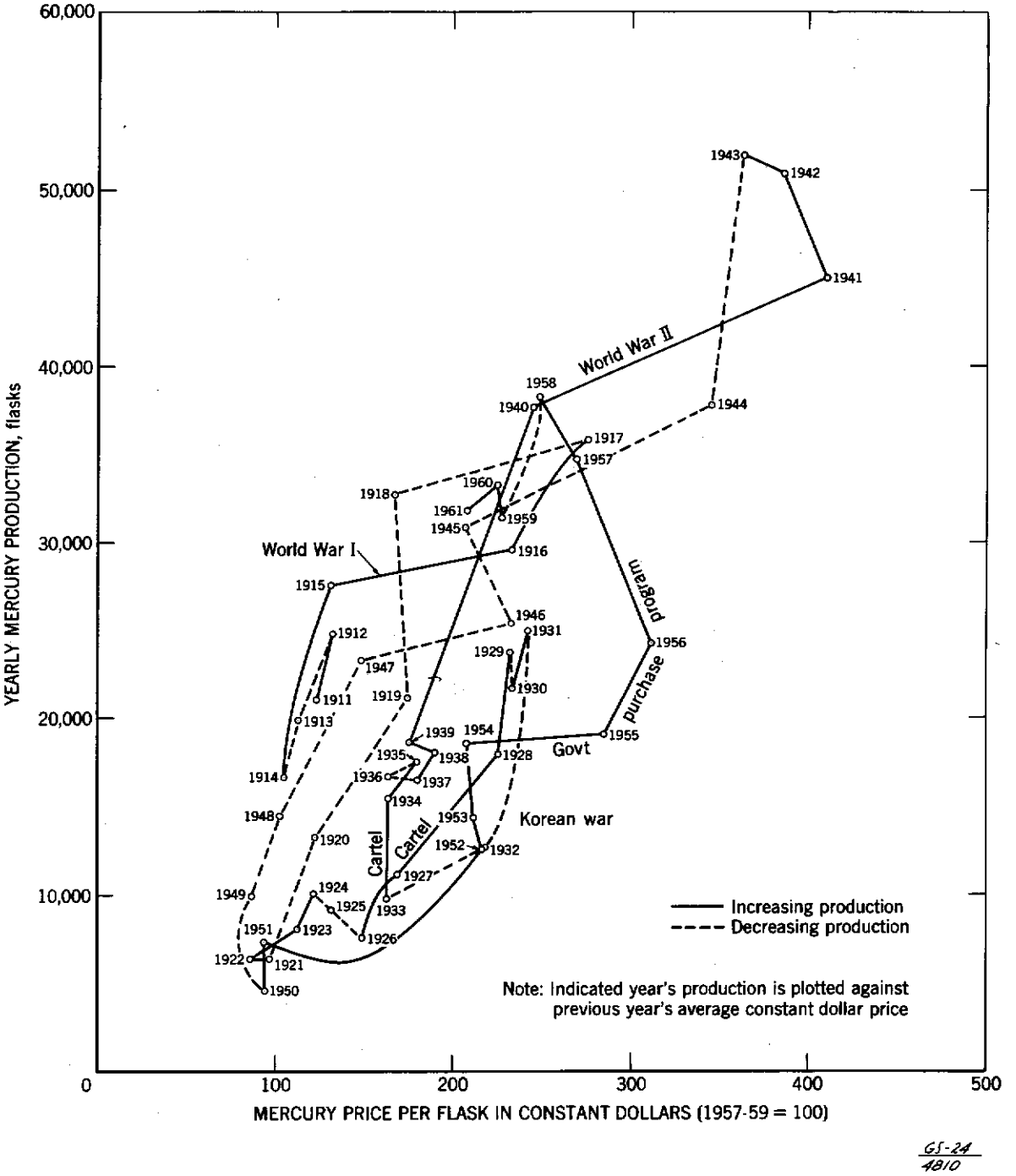

FIGURE 1. - Mercury Price-Production Relationships.

(1) World War I, (2) the cartel period of the 1920's and 1930's, (3) World War II, and (4) the Korean war Government price-support period from 1951 to 1958. In all of these periods, production responded to sharp price increases by equally great increases in total output, and the total domestic output had a remarkably uniform relation to price.

To extrapolate the price-production relations which prevailed from 1910 to 1961 into areas of elevated high prices of $500, $1,000, and $1,500 per flask, the significant production periods during rising price cycles were combined into one average graph. This was done mathematically with the aid of a computer, using the least squares method, and the following equation was developed for the relationship between price and production for the entire 1910 to 1961 period:

$$\text{Production (in flasks)} = \frac{\text{Price (in constant dollars per flask)}}{0.011216 - 0.00000430 \times (\text{price})}$$

Using this equation, the mercury price-production relationship trend was calculated into the high-price area and this trend line is shown in figure 2.

Near the peak of price cycles, mercury production has in the past increased proportionately faster than price. This has slightly distorted the normal price-production relationship, making the graph unsuitable for projections into very high price ranges, although it remains indicative of trends at lower prices.

It seems self-evident that the production rate of a relatively scarce mineral commodity such as mercury cannot be increased indefinitely, despite the size of price incentives offered. However, the limits of production were not reached in the past; there have been no instances before 1961 where the rate of production has decreased after the previous year's price had increased.

To estimate mercury production rates at very high prices, past production history was examined and production levels and rates of production increase were selected that could reasonably be used as limits.

The maximum production in modern times was 51,929 flasks in 1943 achieved at a constant-dollar price of $346. From a study of the calculated price-production trend (fig. 2) it was estimated that a constant-dollar price of $470 per flask would now bring out a production of only 50,000 flasks. This output level is considered the highest that can be substantiated by recent production experience. Price-production estimates below the 50,000 flask production at a $470 constant-dollar price follow the calculated price-production trend and are simply the average of previous price cycles, while estimates above this point were made by extrapolation. Recent past performance has established a minimum 50,000-flask-per-year production when market prices exceed $470. The calculated price-production trend is considered to be a maximum since it is probable that the rate of increase of mercury production will fall at elevated price ranges even though the actual production increases. It is also apparent that the calculated price-production trend is too optimistic. This results from the previously mentioned experience at the peak of each price cycle when production continued to increase despite falling prices. Consequently, for projecting high-cost production, the calculated price-production trend line was adjusted above the $470 constant-dollar price to obtain the final estimated price-production trend line.

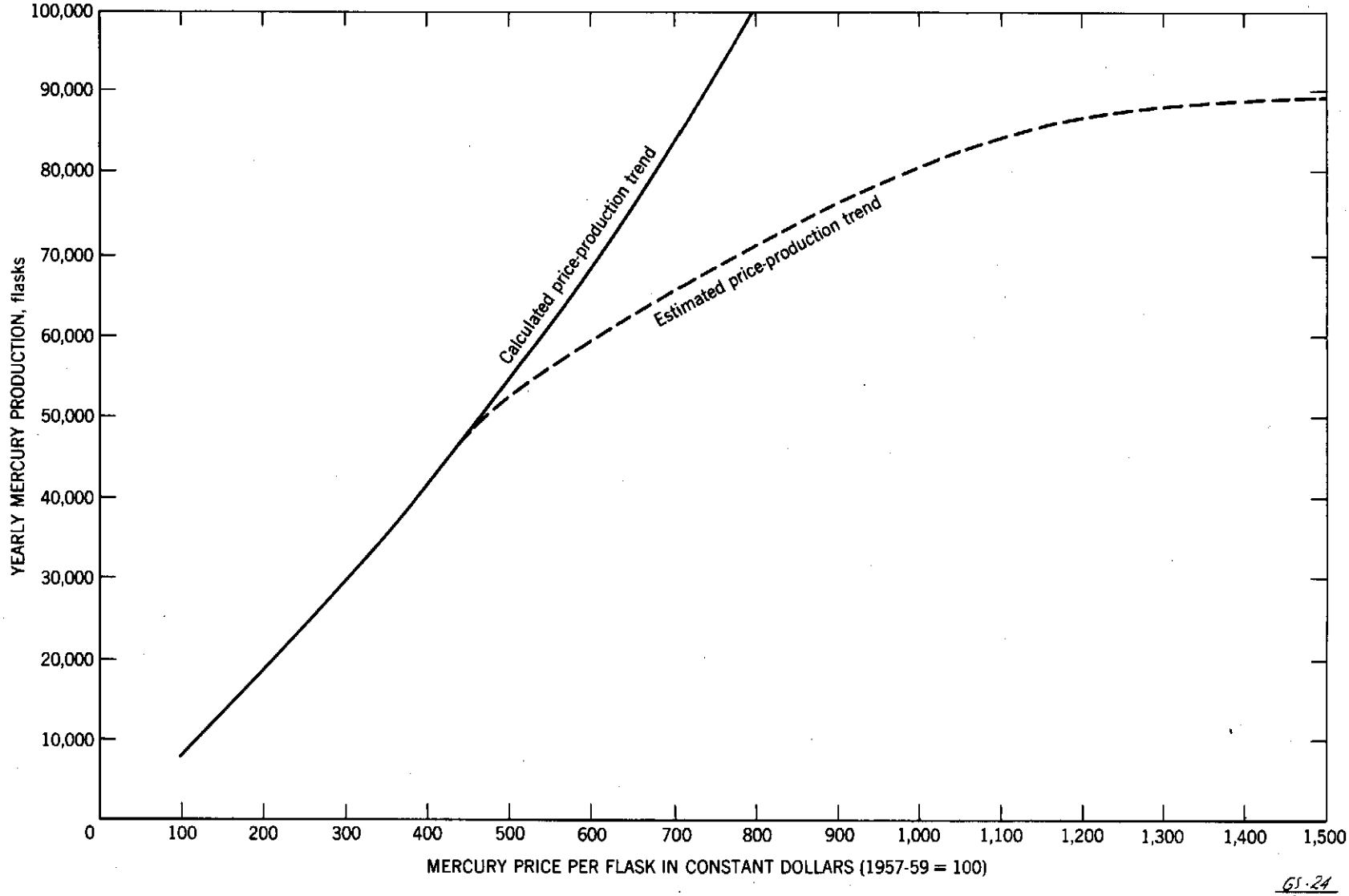

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FIGURE 2. - Mercury Price-Production Trends.

The numerical values for the revised estimates are shown on figure 2 and tabulated in table 6.

TABLE 6. - Potential mercury-production rates

Price per flask:	Potential annual production rate, flasks
$200	19,000
300	30,000
500	53,000
1,000	81,000
1,500	90,000

Other aspects of mercury price-production history were analyzed in this study of potential production rates. Some of the relationships investigated were as follows:

An average constant-dollar profit margin was estimated for mercury for each year from 1910 to 1961, and this was plotted against the succeeding year's production, in a manner similar to the price-production curve shown in figure 1. The resulting graph had approximately the same form and slope as the one secured from the price and production data.

Another forecasting method used was to express each year's production as a function of the production of the 2 previous years, and of the price for the current and 2 preceding years. Although this approach showed some promise, a usable equation could not be fitted to the data.

Estimate of Total Mercury Potential

Normally there is a proportionate relation between metal production and reserves. When reserves fall, the number of producers and the total rate of production falls; therefore, conversely, when production rates rise and new producers start operating, reserves must be increasing. As the price-production graph indicates, considerably higher production will be achieved if mercury prices are substantially increased. This presumes a corresponding increase in reserves. It is obvious that an increase in the price or lowering of production costs will increase ore reserves.

Total mercury-ore reserves for the United States at a price of $250 per flask, as of January 1, 1962, were estimated by the Geological Survey as 228,500 flasks. If these are affected by changes in price to the same degree that rates of production are, potential reserves at various prices would be as shown in table 7.

These estimates makes no allowances for as yet undiscovered ore horizons; they are minimum, rather than probable, total potential figures.

TABLE 7. - Mercury resources of the United States as estimated by extrapolation method

Price per flask:	Resources,[1] (flasks)
$200	100,000
300	280,000
500	500,000
1,000	760,000
1,500	840,000

[1]Totals are cumulative.

They also reflect the low commercial-ore reserves of the mercury industry in 1961, due to 5 years of declining prices which discouraged exploration.

CHANGES IN ORE RESERVES

A substantial quantity of mercury was indicated in the various resource estimates described in the preceding section, but in setting ultimate production figures, the rate of finding ore bodies and adding to reserves must also be considered.

Mercury-ore estimates for the United States were made in January 1944 (2) by the Federal Bureau of Mines and Geological Survey, and in mid-December 1957 (table 8) and early in 1962 (table 9) by the Geological Survey.

TABLE 8. - Mercury reserves by States, in mid-1957[1]
(Flasks of recoverable metal at a price of $250 per flask)

State	Measured and indicated	Inferred	Total
Alaska	30,000	10,000	40,000
Arizona	2,000	3,000	5,000
Arkansas	-	1,000	1,000
California	64,000	90,000	154,000
Idaho	20,000	6,000	26,000
Nevada	31,000	33,000	64,000
Oregon	8,000	7,300	15,300
Texas	2,000	7,000	9,000
Utah and Washington	-	1,000	1,000
Total	157,000	158,300	315,300

[1]Geological Survey, Press Release 21902, Aug. 12, 1957; Bureau of Mines Minerals Yearbook, 1957, v. 1, 1958, p. 836.

The 1944 data are for mercury producible at $195 per flask in 1944; the 1957 and 1962 figures are for mercury producible at $250 per flask. The purchasing power of $195 in 1944 was considerably greater than that of $250 in 1957 and 1962, but improvements in technology reduced costs substantially during the intervening 18 years, and it is thought that the ores included in

the three estimates are reasonably comparable. Table 10 gives the reserve estimates along with production figures for the intervening years.

TABLE 9. - Mercury reserves by States in early 1962[1]
(Flasks of recoverable metal)

State	$190 per flask			$250 per flask		
	Measured and indicated	Inferred	Total	Measured and indicated	Inferred	Total
Alaska	7,000	5,000	12,000	15,000	10,000	25,000
Arizona	-	-	-	1,000	2,000	3,000
Arkansas	-	-	-	-	1,000	1,000
California	31,000	21,000	52,000	79,000	70,000	149,000
Idaho	-	-	-	15,000	5,000	20,000
Nevada	8,000	2,000	10,000	13,000	4,000	17,000
Oregon	-	2,000	2,000	2,500	5,000	7,500
Texas	-	-	-	1,000	4,000	5,000
Utah and Washington	-	-	-	-	1,000	1,000
Total	46,000	30,000	76,000	126,500	102,000	228,500

[1]Tariff Commision. Report to Congress on Investigation No. 332-32 (Supplemental), Tariff Comm. Pub. 57, 1962, p. 35.

TABLE 10. - Changes in U.S. mercury reserves, 1944-62

	Flasks
Reserve estimate, January 1944	330,000
Reserve estimate, December 1957	315,000
Decrease in reserves	15,000
Production, January 1944 to December 1957	276,000
Mercury developed, January 1944 to December 1957	261,000
Reserve estimate, December 1957	315,000
Reserve estimate, January 1962	228,500
Decrease in reserves	86,500
Production, December 1957 to January 1962	134,000
Mercury developed, December 1957 to January 1962	47,500

Under the economic conditions prevailing from January 1944 to December 1957, the mercury-mining industry was successful in maintaining reserves. From December 1957 to January 1962, reserves were drawn on heavily, but these years were characterized by steadily decreasing prices and by uncertainty regarding future conditions, a factor which discouraged capital expenditures for exploration, and some reserves were lost by mine closures during this period.

CONCLUSIONS

In the years 1944 to 1957, the domestic mercury industry was able to maintain its ore reserves, and it is probable that resources of low-grade material would similarly be maintained under conditions of steady demand and high prices.

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The estimated existing resources of 1,465,000 flasks, although mainly in low-grade material, provide a firm foundation for the future mercury industry if increased prices and improved technology should make possible the production of mercury from ores which average 2 to 5 pounds per ton. For comparison, the average grade of ore treated in 1961 was 9.2 pounds per ton.

Judging from the rate of ore discovery during the past 20 years, existing resources plus probable discoveries should last virtually indefinitely at present production rates.

A total yearly production of 60,000 flasks would be required to make the United States self-sufficient in mercury at present rates of consumption. This production, which is approximately twice the 1961 rate, could be maintained for 10 or more years from existing resources producible at a price of $500 (constant dollars, 1957-59=100) per flask. Assuming that new ore bodies will be discovered in the future at the same rate as during the past 20 years, the resources should last 30 years or more.

Enough mercury resources producible at $1,000 per flask exist, along with expected new discoveries, to allow production at a 60,000-flask-per-year rate for many more decades.

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CHAPTER 3. - MERCURY IN ALASKA[1]

by

Kevin Malone[2]

INTRODUCTION AND SUMMARY

Although mercury occurrences in Alaska were noted in the literature as early as 1884, no appreciable output was recorded until World War II when deposits were developed in the Kuskokwim and Yukon River regions. The Red Devil and DeCoursey Mountain mines produced notable quantities of metal during and immediately following the war. After the war demand had been met, the price of mercury declined and mining activity was nearly dormant until 1954. Since then higher prices have led to increased production. Alaska ranked third among the mercury-producing States in 1961; the output was 13 percent of the domestic total.

Cinnabar occurs in the gravels of many widely scattered placer-mining camps in the State; in some cases the mineral has been traced to its source. Production of mercury from placers in Alaska, however, has been negligible; the State's mercury output has come almost entirely from lode deposits. The only area in which substantial lode developments have been made and which has had an appreciable output of metal is the above mentioned Kuskokwim River region and the adjacent DeCourcy Mountain.[3] Operating conditions and other factors affecting mining at the DeCoursey Mountain mine, a few miles over the line in the Yukon River region (23)[4] are similar to those in the Kuskokwim River region. The principal producers have been the Red Devil mine, northwest of Sleetmute; the DeCoursey Mountain mine, at DeCourcy Mountain; and the Cinnabar Creek deposits, southwest of Sleetmute. Recorded mercury production from Alaska through 1961 was 30,115 flasks.

Mine operations in the Kuskokwim area are seriously handicapped by severe winters with temperatures of 40° below zero, lack of transportation and communication services, scarcity and high cost of labor, and an almost complete lack of nearby service and supply facilities. The small, erratic, and discontinuous nature of oreshoots found up to now results in increased exploration, development, and mining costs. Alaska's Kuskokwim River region shows geological evidence of containing important mercury resources. When some of the handicaps now facing the Alaskan operator are reduced and a period of high demand is sustained, Alaska could contribute materially to the nation's mercury supply. Given a more favorable cost-price relationship, the Kuskokwim and perhaps other regions of the State probably could support a major mercury-mining industry.

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[1] For a more detailed account see the author's Mercury Occurrences in Alaska, BuMines Inf. Circ. 8131, 1962, 57 pp.

[2] Physical scientist, Area VIII Mineral Resource Office, Bureau of Mines, Juneau, Alaska.

[3] Accepted spelling. The mine is called DeCoursey Mountain mine.

[4] Underlined numbers in parentheses refer to items in the list of references at the end of the chapter.

ACKNOWLEDGMENTS

Acknowledgment is made to Robert F. Lyman, manager, Roger A. Markle, resident engineer, and Gordon Herreid, geologist, all of Alaska Mines and Minerals, Inc., for data on the Red Devil and DeCoursey Mountain mines. They also contributed a great deal of information on other mercury deposits in the State. The sections on metallurgy and geology were written by Lyman and Herreid, respectively; the section on mining methods and costs was compiled from information contained in an engineering report by Markle and from personal contacts.

For the geology of the Kuskokwim River area, the paper by Cady (2) was freely used.

HISTORY AND PRODUCTION

Mercury occurrences were known in Alaska before 1867, when the territory was sold by Russia. It is now generally believed that cinnabar specimens shown to U.S. officials at the time of transfer were from the Kuskokwim River region--an area that the Russians had explored as early as 1829.

Prior to 1918 several investigators reported occurrences, exploration, and small-scale mining and retorting of cinnabar from placers and lode deposits in the Kuskokwim area and on the Seward Peninsula (4, 6, 15, 22, 28, 30). Minor quantities of cinnabar were recovered from sluicebox concentrates on Candle Creek (near lat 66° N, long 162° W) and were retorted for local gold-placer use (15). The Parks deposit (Alice and Bessie), discovered in 1906, had produced less than 10 flasks by the time of Smith's examination in 1914 (28).

By the beginning of World War II, all of the presently known significant mercury deposits in Alaska had been discovered. None had had any noteworthy production except the Red Devil lode mine, which had produced about 300 flasks.

World War II stimulated the search for mercury. Known deposits were intensively prospected, and the search was pressed in new areas. Some attention was given to deposits outside of the Kuskokwim River region, principally at the Bluff and Olive Creek prospects, but no production from these areas resulted. The Red Devil mine in the Kuskokwim region and the DeCoursey Mountain mine in the Yukon River region were opened, and substantial quantities of metal were produced. The Bureau of Mines and the Geological Survey began examining mines and prospects in 1942. Exploration was done by the Bureau of Mines on the Red Devil, Parks, Barometer, Fairview, Willis and Fuller, DeCoursey Mountain, Lucky Day, Kolmakof, Rainy Creek, and Marsh Mountain deposits between 1942 and 1946. Webber (31) reported on the Bureau's work.

When World War II ended and mercury prices decreased, only the DeCoursey Mountain mine continued to produce. When this mine closed in 1949, virtually no more mercury was produced in Alaska until 1954. Since 1954 under stimulus from the Government's guaranteed price and exploration assistance rendered by

the Defense Minerals Exploration Administration (DMEA) and its successor agency, the Office of Mineral Exploration (OME), Alaska has contributed substantially to U.S. production. With DMEA assistance, work was done on the Red Devil, DeCoursey Mountain, and Marsh Mountain (Red Top) deposits. Recorded production of mercury in Alaska through 1961 was 30,115 flasks (table 11). Of the total, the mines of the Kuskokwim River region and the adjacent DeCoursey Mountain mine produced almost 99 percent.

TABLE 11. - Production of mercury in Alaska 1923-61

Year	Flasks	Year	Flasks
1923.....	(1)	1943.....	786
1924.....	-	1944.....	(1)
1925.....	-	1945.....	(1)
1926.....	(1)	1946.....	699
1927.....	(1)	1947.....	127
1928.....	-	1948.....	100
1929.....	(1)	1949.....	100
1930.....	(1)	1950.....	-
1931.....	(1)	1951.....	-
1932.....	(1)	1952.....	28
1933.....	-	1953.....	40
1934.....	-	1954.....	1,046
1935.....	-	1955.....	(1)
1936.....	-	1956.....	3,280
1937.....	-	1957.....	5,461
1938.....	(1)	1958.....	3,380
1939.....	-	1959.....	3,743
1940.....	162	1960.....	4,459
1941.....	(1)	1961.....	4,129
1942.....	(1)	Total.....	30,115

[1]Figure withheld to avoid disclosing individual company confidential data.

PHYSICAL FEATURES AND CLIMATE

Major mercury occurrences in Alaska lie in or adjacent to the Kuskokwim River region (fig. 3). The region is defined (23) as the area drained by all streams flowing into Baird Inlet, Etolin Strait, and Kuskokwim Bay; Nunivak Island also is included. The Kuskokwim River, with headwaters in the Alaska Range and the Kuskokwim Mountains, flows southwesterly through the region to Kuskokwim Bay on the Bering Sea and is the dominant geographic feature. It flows in a gorge cut through the Kuskokwim Mountains from Sleetmute to Crooked Creek.

Many of the known deposits occur in the rolling foothills of these mountains close to the river. The DeCoursey Mountain mine, just over the boundary line between the Kuskokwim and Yukon River regions, is in the Yukon drainage, about 22 miles by trail from the settlement of Crooked Creek on the Kuskokwim.

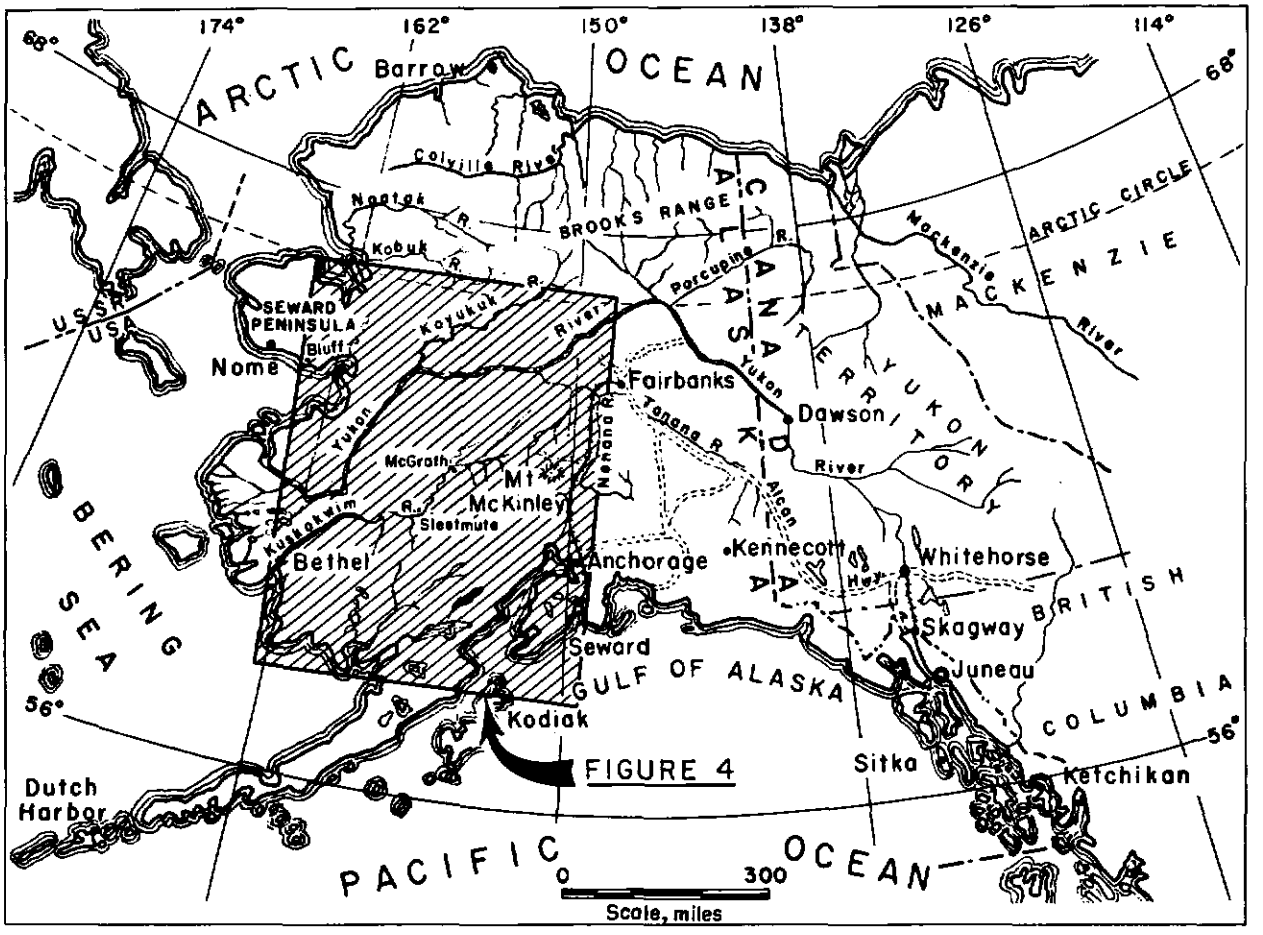

FIGURE 3. - Index Map of Alaska.

The climate is subarctic; winters are long, cold, and dry; summers are short and wet. Winter temperatures are less extreme near the coast than in the interior, but sustained periods with temperatures to 40° below zero are common throughout the region. In summer, daylight extends for 20 hours or more; December and early January have only 4 hours of sunlight. Stretches of rainy weather, sometimes lasting several days, occur in summer when the wind is from the south or southwest. Records for 1958 at McGrath show a total annual precipitation of 14.26 inches and an annual snowfall of 62.7 inches.

Spruce and tamarack suitable for mine and camp timber grow on the river flood plains and on the hill slopes to an altitude of 1,000 feet. Other trees in the same area are suitable for fuel.

There is no transmitted power in the region; electrical energy is generated in small plants at settlements and mining operations. Oil, delivered by barge on the Kuskokwim River or by ship or barge to coastal points, is the main source of power. The placer-gold operation of New York-Alaska Gold Dredging Corp., at Nyac in the western part of the region, uses hydropower. Domestic and milling water is available throughout the area. There is no

connected road system; areas in which mining or other activities are conducted have local roads. Winter sled roads link Bethel with Rex on the Alaska Railroad, but they have not been used in recent years. Foot trails connect the settlements, but travel is chiefly by air or boat.

Mining in Alaska confronts the operator with problems not found in regions of greater development and population. The supply of skilled labor, except in the more populated areas, is meager; in large areas of the State, no skilled labor is available locally. Anchorage and Fairbanks supply skilled labor for the Kuskokwim River region. Transportation of labor to the jobsite is commonly at the mine operator's expense. Living facilities must be provided. They are high in cost and are only partly recovered through employee charges.

Severe winter weather restricts surface work. Exploration and work on surface installations usually is limited to summer; that is, from mid-May or June to September or mid-October. When access to a project is over swampy ground (frequently the case in interior Alaska), equipment and supplies must be moved while the ground is frozen enough to support tractors or vehicles. The cost is high, and it requires a long time to develop a mine and bring it to production.

However, the difficult operating conditions in the Kuskokwim River area do not present an insurmountable obstacle to establishing a mercury-mining industry in the area. Known occurrences of mercury are of higher grade than deposits worked elsewhere in the United States; hence, mining costs can be higher. The expected growth of the State will relieve or eliminate some of the adverse conditions that hamper mining.

Transportation in the mercury-mining area, except locally, is by air, water, or tractor trail; railroad and road systems do not exist. Waterborne freight moves over the Kuskokwim River and its navigable tributaries; Bethel, about 60 miles above the river's mouth, accomodates shallow-draft oceangoing vessels and serves as a port for the region.

Bethel has a population of 223 persons (1), several stores and roadhouses, a post office, and a large Federal Aviation Agency station.

Multiengine aircraft deliver freight and passengers to isolated small settlements. Charter service, by land or float planes, is widely used to reach remote areas. McGrath, served by scheduled airlines, is a staging point for chartered flights in the central Kuskokwim region.

Shortwave radio or mail provides communication within the Kuskokwim River region. Alaska Communications System, a unit of the U.S. Army, provides combination shortwave radio, telephone, and telegraph service between the larger settlements in the region and other settlements in the State and to points outside the State.

GEOLOGY

Many of the Alaska mercury deposits have markedly similar geologic features. Most deposits are associated with sedimentary rocks into which dikes, or less often sills, have been intruded. The sediments are shales, graywackes, and sandstones. The intrusives are andesite, rhyolite, and biotite basalt. The basalt has been altered to silica-carbonate rock, which is pearly gray on fresh surfaces and weathers to a yellow brown. The weathered version, called yellow rock by prospectors, serves as a guide in prospecting. Disseminated ore and massive kidneys of cinnabar occur in oreshoots, often very short in length of strike, bounded by sills or dikes. The shoots are notably persistent along the dip in some deposits; in others they tend to fade at depths of 200 feet or less. Stibnite is a common accessory mineral with the cinnabar.

Deposition of mercury is believed to have been controlled by breaks and fractures associated with the intrusives and to a lesser extent by bedding planes in the host sedimentary rocks. Brecciated zones, both in the altered intrusives and adjacent sediments, are mineralized to widths of several inches, parallel to the contacts. Ore occurs both as veinlets of cinnabar and as disseminations in the altered intrusives and the wall rocks. (The veinlets favor the basalt intrusives.)

Associated minerals are stibnite (Sb_2S_3), realgar (As_2S_3), pyrite, (FeS_2), quartz (SiO_2), calcite ($CaCO_3$), and dickite ($H_4Al_2Si_2O_9$). Native mercury has been observed. Stibnite is commonly abundant but is not commercially significant; at the Red Devil mine, it has caused considerable difficulty in retorting the ores. More complete and detailed geologic information on the Kuskokwim River region has been given by Cady and coworkers (2).

MERCURY MINING DISTRICTS

The Kuskokwim River and Yukon River regions, where the major mercury deposits in Alaska occur, are subdivided into districts and subdistricts which in Alaska have a broader meaning than do mining districts in the conterminous United States. There are no county subdivisions in Alaska, and districts are used to locate all geographic points, not merely areas of mineralization. Therefore, figure 4 shows the ore deposits rather than districts. The mines and prospects shown on figure 4 are as follows:

Location No.:	Property	Location No.:	Property
1.....	Bluff	10.....	Barometer
2.....	Hudson	11.....	Fairview
3.....	Mount Joaquin	12.....	Kolmakof
4.....	White Mountain	13.....	Lucky Day
5.....	DeCoursey Mountain	14.....	Broken Shovel
6.....	Rhyolite	15.....	Rainy Creek
7.....	Willis and Fuller	16.....	Kagati Lake
8.....	Parks (Alice and Bessie)	17.....	Marsh Mountain (Red Top)
9.....	Red Devil		

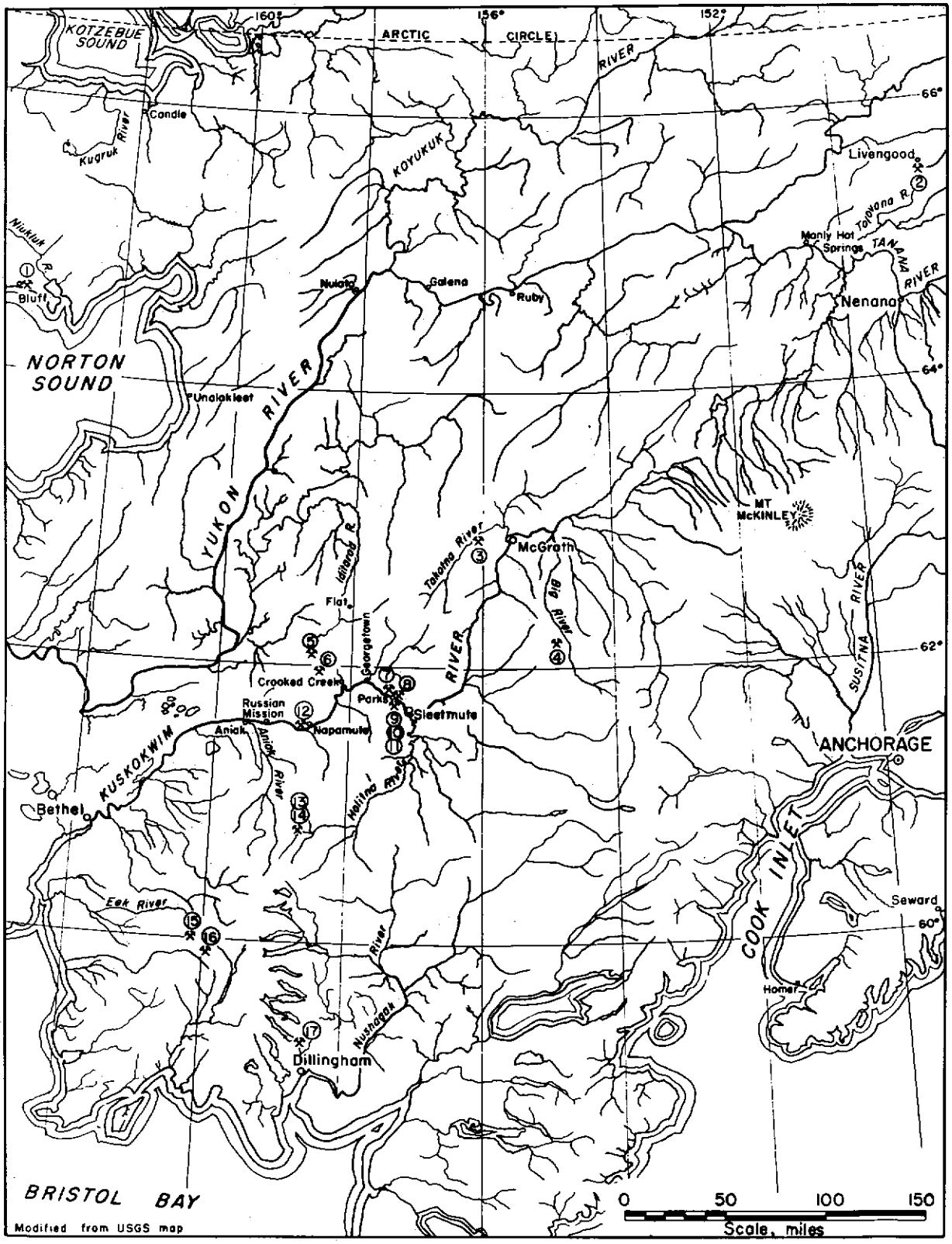

FIGURE 4. - Location Map of Mercury Deposits and Occurrences in Alaska.

DISTRICTS AND PROPERTIES

In the following descriptions of individual properties, complete information on the location, ownership, and bibliography of the property is not included. This information is listed for every known mercury property in table 14 at the end of the chapter and in the interest of brevity is not repeated here.

Kuskokwim River Region Mines and Properties

The Kuskokwim River region has been the main mercury-producing area of the State. Cinnabar was noted in stream gravels early in Alaskan history; later, lode deposits were discovered and they have provided substantial production.

Barometer Prospect

The Barometer prospect lies on the south side of the Kuskokwim River, about seven miles northwest of Sleetmute, at an altitude of 400 feet. It is approximately three claim lengths northwest of the Red Devil deposit. Hans Halverson made the discovery in 1921, locating the Barometers Nos. 1 to 6; the deposit was sold to E. W. Parks in 1923. Various lessees worked the property during the ensuing years. A. G. Skidmore did some work in 1938, producing 8 flasks from 25 tons of ore. Small quantities of mercury were later produced in connection with annual assessment work. Alaska Mines and Minerals, Inc., successor to the DeCoursey Mountain Mining Co., leases the deposit. The property now consists of 10 unpatented claims.

Two deposits, known as the upper and lower, have been prospected. Most of the work has been done at the upper deposit. The country rock is largely shale. To the west, graywacke and sandstone begin to appear. Hydrothermally altered igneous intrusives are associated with the mineralization. Cinnabar occurs irregularly along bedding joints and in openings along fault and fracture zones, particularly near the altered intrusives. Realgar and stibnite accompany the cinnabar.

Prior to 1932 about 200 feet of underground workings were driven. During World War II the Bureau of Mines trenched and sampled the deposit (31). Five trenches across the mineralized zone and an underground crosscut were sampled on the upper deposit. Visible cinnabar was observed over a strike length of 165 feet, but assays proved the zone to be low grade. Underground samples represented the most consistent mineralization found on the deposit. The Bureau's work on the lower deposit did not disclose the structural relationship of the andesite and the ore. However, a few samples showed interesting quantities of mercury.

In 1957 under the DMEA program at the Red Devil mine, 5,400 cubic yards of overburden was stripped from bedrock and 1,000 feet of trenching on the north side of the Red Devil fault was done on Barometer Nos. 3 and 5 claims. The work showed no andesite dikes and no cinnabar mineralization. Excavation of 2,200 cubic yards of trenching on the south side of the Red Devil fault in 1958 also failed to show cinnabar mineralization.

Broken Shovel Group

The Broken Shovel claims are on the north bank of Cinnabar Creek, 4 miles north of the Lucky Day group at an altitude of 1,400 feet. Sleetmute is 85 miles to the northeast. Herschel Landau made the first locations in 1941, and the latest available records indicate that Russell Schaefer now holds the claims.

Mineralization occurs in sedimentary formations intruded by sills. The intrusives have been altered to silica-carbonate rock. The lode, striking slightly west of north, is a narrow irregular quartz vein containing small lenses of cinnabar and stibnite. Some native mercury is reported.

Landau prospected the placer deposits in Broken Shovel Gulch and traced float to the outcrop of the lode. There is some doubt, however, whether the vein uncovered is the source of all the float found in the gulch. The mineralization is similar to that of the Lucky Day group.

Fairview Group

The Fairview deposit is 1 mile southwest of the Red Devil mine near the mouth of McCally Creek, at an altitude of 900 feet. There is no trail to the property. The first locations were made in the mid-1930's; the deposit is now held by Alaska Mines and Minerals, Inc. Graywackes and shales of the Kuskokwim Group have been intruded by a massive rhyolite dike at least 1,000 feet long and 120 feet wide that strikes N 60° W and dips northeast. Cinnabar occurs in a fractured zone cutting across the dike at an acute angle. Stibnite accompanies the cinnabar.

The Bureau of Mines examined the deposit by trenching in 1942 (31). A 25-foot zone at the north end of one of three trenches assayed 2.6 pounds of mercury per ton, and a second 25-foot zone, 10 feet south, assayed 3.5 pounds. Mineralization in the other trenches was too weak to be of interest.

There is no recorded production from the property.

Kolmakof Deposit

The Kolmakof deposit is on the north bank of the Kuskokwim River, 18 miles upstream from Aniak. It is probably the first mercury discovery in Alaska. Spurr reported unsuccessful attempts to exploit the deposit in the early 1890's. The high cost of shipping ore to San Francisco for reduction is given as the reason for the failure.

Willie Rabidoux of Aniak holds the Jaufok Nos. 1 and 2 lode claims. Western Alaska Mining Co. holds the Wamco Nos. 1 through 6. Both groups of claims are unpatented and held by location.

Folded sandstones and shales are exposed in a 200-foot bluff at the Kolmakof prospect. Two andesite sills, 200 feet apart, appear to control mineralization, with the one at the eastern end the more important. Reportedly,

no cinnabar occurs in the eastern sill itself, but appreciable quantities are said to occur in lenses and stringers of quartz near the sill and to extend along joint and bedding planes into the sediments. Maximum width of mineralization is about 4 feet. The quartz lenses carrying the cinnabar are short, narrow, and discontinuous.

The Bureau of Mines explored the deposit during and after World War II. Twenty-nine trenches, aggregating 600 feet in length, were spaced irregularly along a strike length of 350 feet. These trenches exposed mineralization associated with a prominent rhyolite sill. Cinnabar was found in a narrow stringer, as small pods in or adjacent to a narrow shear zone, and as thin films in cross fractures from the shear zone to the hanging wall of the sill which the shear zone roughly parallels.

In 1958 a Bureau of Mines engineer sampled the trenches, using a 3-inch posthole auger, and 145 samples were taken on bedrock at 5-foot intervals. The Bureau's work was not conclusive but did indicate the possibility of mineralization away from the crest of the river bluff.

The deposit has no recorded production. An engineer of one of the major domestic mercury producers examined the property in 1959. No reports on the examination are available.

Lucky Day Group

The Lucky Day deposits are on the Holitna side of the divide between the Holitna and Aniak Rivers. They are on Beaver and Cinnabar Creeks, 85 miles southwest of Sleetmute, at an altitude of 1,400 feet.

Russell Schaefer and Harvey Winchell located the Lucky Day lode deposit in Canary Gulch in the summer of 1941 and placer ground in Cinnabar Gulch and Cinnabar Run in the same year. The original holdings comprised three lode claims and six placer claims. Schaefer later acquired sole ownership of the deposit.

In 1942 and 1943 Schaefer retorted 26 flasks from 3,600 pounds of high-grade float gathered on the property. He maintained a small but consistent output of mercury for several years.

Typical graywacke and shales of the Kuskokwim Group are intruded by large sills of coarse-grained basalt and quartz diabase and by small sills of biotite basalt; some of the biotite basalt is altered to silica-carbonate rock. Alteration extends into the sediments in places (2).

The lode as exposed over a vertical extent of 130 feet consists of a low-grade mineralized zone at least 900 feet long and 50 feet or more wide. Within the zone, several narrow high-grade stringers, averaging 1 inch in width, lie in the bedding-plane fractures in the upper section. Fine-grained dense cinnabar occurs with stibnite and native quicksilver.

There are more cross joints and breccia openings in the lower section of the lode, and the mixed cinnabar and quartz gangue is coarsely crystalline. The high-grade veins in the lode are wider but leaner where exposed in the lower section than they are in the upper section.

Hand-selected high-grade ore from the upper section yielded 55 percent mercury, but similarly selected ore from 100 feet lower on the deposit was only about 5 percent.

The Bureau of Mines examined the deposit during World War II and later. Mercury values ranging from less than 1 pound per ton to 16.8 pounds per ton were found over widths of 1 to 7 feet. Nine samples averaged 10.5 pounds per ton over a 3.2-foot average width. All of the early production from the deposit came from float derived from the high-grade pods. Evidence points to shallow, superficial deposition.

New York-Alaska Gold Dreding Corp. sampled the Lucky Day placer in the spring of 1943. The deposits, in Cinnabar Gulch and Cinnabar Run, are 5 to 10 feet in depth, range in width from 74 feet at the lower end to 10 feet at the upper end, and are 2,100 feet long (31).

Mount Joaquin Prospect

The Mount Joaquin prospect is on the east flank of Mount Joaquin at the head of O.K. Creek (tributary to the Tatalina River) at an altitude of 2,500 feet. Knute P. Lind located the O.K. and Joaquin lode claims in 1957 and did some prospecting. Cinnabar occurs in a limestone inclusion within a large monzonite mass. There is no record of production.

Parks Deposit (Alice and Bessie)

The Parks deposit, on the north bank of the Kuskokwim River, 8 miles downstream from Sleetmute, was discovered by E. W. Parks in 1906. Believed to be the first mercury discovery in the Sleetmute area and second only to the Kolmakof deposit in Alaska, it is credited with most of the small Alaskan mercury production up to the early 1920's. Parks, a trader on the Kuskokwim, prospected the deposit and produced mercury for sale to placer miners in the Iditarod and Flat areas. Total production to the end of 1961 is estimated at 175 flasks.

Parks obtained the early production largely from surface pits and shallow workings. An early crosscut adit, driven 200 feet by Parks, was extended in 1936 by W. E. Dunkle (lessee) to cut the ore zone at 450 feet from the collar and some 160 feet below the outcrops. However, only a small output resulted from this work.

Graywackes and shales make up the country rock on the property. Cinnabar mineralization is found associated with altered andesite sills and dikes. The altered andesite is a light-colored rock, readily distinguishable from the unaltered dark biotite rock from which it is derived; it is a valuable guide in prospecting. Three ore zones occur: The upper zone, on which Parks did

much of his work; an intermediate zone, cropping out some 50 feet lower; and a zone cropping out in the riverbed. The Bureau of Mines trenched and sampled the upper zone during World War II. Over a total length of about 700 feet in the central segment along the strike of the sampled zone, 12 of 14 trenches assayed from 2.2 to 39.0 pounds of mercury per ton of ore. The ore zone was from a few feet to 20 feet wide. Mineralization was found chiefly in the andesite, but extended in places into the unaltered biotite rock.

Rainy Creek Deposit

The Rainy Creek deposit is at the western base of the Kilbuck Mountains on the headwaters of the Eek River, a tributary of the Kuskokwim; Kagati Lake is 7 miles south; Mount Oratia, 7 miles southeast; and Bethel, 80 miles northwest. There is a winter tractor trail 120 miles long between Bethel and Rainy Creek.

The original discovery was made sometime between 1910 and 1920. The ground was staked in the 1920's and some exploratory work was done. Before World War II, Al Jones was reported to have produced 2,000 pounds of high-grade cinnabar from gold placers on Rainy Creek. Recorded production is six flasks, obtained in the 1941 season.

Country rock in the area is sandstone and shale. Mineralization occurs along the bedding planes and is associated with fault planes paralleling the bedding planes. The igneous intrusives usually found associated with mercury deposits in the Kuskokwim region are not exposed. Realgar accompanies cinnabar in a quartz gangue.

The Bureau of Mines explored the property by trenching in 1947. In the most prominent showing, cinnabar occurs within and between two shear zones separated by 16 feet of fractured sandstone. To the southwest, the showing is masked by the overlying sediments; to the northeast, trenching failed to reveal the shear zones or mineralization. The best section sampled assayed 8.1 pounds per ton of ore over a width of 6.33 feet.

Red Devil Mine[5]

The Red Devil mine is on the south side of the Kuskokwim River at the mouth of Red Devil Creek, at an altitude (shaft collar) of 300 feet. Anchorage is 250 airline miles east; McGrath is 100 miles northeast. Twice weekly, scheduled airline service is available from Anchorage to the mine; scheduled and charter service is available from McGrath. Freight and fuel oil are hauled from Bethel by company-owned riverboat.

Hans Halverson made the original Red Devil locations in 1933. A few years later, Nick Mellick joined Halverson as a partner, and additional claims were staked. In early work, Halverson and Mellick produced small quantities of mercury from float and residual placer and, after installing two D retorts, produced 162 flasks in 1940.

[5]A complete description of this mine, with maps and mining and metallurgical methods and costs is given in reference 7, pp. 12-33.

The Bureau of Mines examined the deposit in 1942 and did considerable surface and underground work. The work exposed a spectacular showing of cinnabar and stibnite on one of five vein systems (the "A" series). After the Bureau's work, the mine produced more than 2,000 flasks of metal until 1946, when low mercury prices forced the operation to shut down at the end of the season.

The mine was inactive until 1952. The present operating unit is Alaska Mines and Minerals, Inc. Under this company and its predecessors, the Red Devil developed into the leading mercury mine in Alaska, and an important producer nationally.

The Red Devil is the only mercury-producing property of consequence in Alaska. Production from 1940 through 1961 was 28,061 flasks. Of the total, more than 24,000 flasks was produced after March 1956.

The plant consists of an airfield and a well-equipped camp with bunkhouses, a commissary, a mess hall, offices, shops and warehouses, a modern furnacing plant, and a diesel-electric power unit. Surface and underground mining equipment and installations are efficient and adequate for the operation. Shortwave radio is used to communicate with Anchorage, Sleetmute, and McGrath.

The mine consists of nine unpatented mining claims held by location. Five of these are owned by Alaska Mines and Minerals, Inc., and four by Halverson and Mellick. The mining company leases this group.

Geology. - The Sleetmute mercury district is in a Tertiary volcanic province consisting of graywacke and mudstone associated with basalt, rhyolite, quartz monzonite, and other igneous rocks. The igneous rocks were introduced at various times before, during, and after the uplift of the Kuskokwim Mountains.

The Kuskokwim River apparently occupies the northwest-trending axis of the Sleetmute anticline. The Red Devil deposit lies on the southwest flank, and the Parks deposit on the northwest flank. The richest deposits known in the district--the Red Devil and the Barometer--occur along the Red Devil strike-slip fault zone. The Red Devil fault parallels the strike of the sediments and in detail is a complicated fault zone in which movement was both along bedding planes and along steep fault planes which lace between the bedding planes.

Dikes were intruded parallel to joints formed during the folding of the Sleetmute anticline. Ore solutions were introduced near the end of a subsequent period of strike-slip faulting along the Red Devil fault.

The Red Devil deposits occur in well-bedded, graded graywacke, which in places in interbedded with siltstone or mudstone. In the mine openings the beds have a uniform northwest strike and a 63° SW dip. Mineralization consists of cinnabar and stibnite, with small amounts of orpiment and realgar locally.

The most salient feature of the Red Devil mine is the series of steplike offsets of the crosscutting dikes along the many movement planes in and along the Red Devil fault. Major and subsidiary faulting and complex relations to the lithology, bedding, and jointing of the graywacke-mudstone country rock have resulted in a very irregular ore zone.

Mining Methods. - Oreshoots at the Red Devil mine range from 6 to 30 feet long and from 3 to 10 inches wide. They plunge at an average of 39° and may persist along the plunge for several hundred feet.

The short strike length, narrow width, and flat plunge of the oreshoots result in exceptionally high mining costs, even after allowance for normally high costs in the Alaska interior.

The mine was opened on a number of levels by adits and shafts. In 1961, the principal workings were connected with the Red Devil incline shaft. The known oreshoots extend discontinuously over an area of about 500 by 800 feet, with a vertical range of more than 600 feet.

After a level has been opened for mining, raises are driven on the oreshoots. Underhand stoping is used, starting from the top of the raise with stull and headboard support. Mucking to the level is by hand with an assist from water run in from above. Slusher crosscuts are used in some instances to transfer ore to shafts, winzes, or ore passes.

When the mine was reopened in 1952, the operators applied for a DMEA loan for exploration. After various modifications and amendments, a program calling for expenditures of $288,000 for surface and underground exploration was authorized. Actual expense of the program was $213,000; the Government's contribution was $160,000. When the exploration was discontinued in 1959, the entire Government outlay had been returned by the operator from royalty payments on ore found.

Metallurgy. - The Red Devil mill is essentially a standardized multiple-hearth furnace plant adapted to the local topography and housed for Alaska's year-round weather conditions. Mine-run ore is screened on a 1½-inch-mesh vibrating screen. The oversize passes over a handsorting table for removal of waste rock and then is crushed in circuit with the 1½-inch screen, so that the furnace feed is all minus 1½ inches in size.

The 10-foot-diameter 6-hearth furnace treats 30 to 40 tons per day, depending on the moisture content of the ore, which is usually high. The wet ore often is very sticky, which slows the feed rate by bridging the feed hole. Although the furnace design has been modified somewhat to cope with the wet ore, adding a dryer to the circuit would increase capacity an estimated 50 percent.

Production Costs. - In the period June 1958 to May 1959, about 8,200 tons of ore averaging 37 pounds of mercury per ton was mined and milled. A summary of costs for this period is given in table 12. Wage rates are given in table 13.

TABLE 12. - Summary of costs, Alaska Mines and Minerals, Inc., Red Devil mine, fiscal year 1959

Item	Cost per ton of ore	Cost per flask of mercury
Direct labor, material, and expense:		
Mining	$34.35	$70.95
Milling	13.74	28.25
Payroll taxes, workmen's compensation, and insurance	5.98	12.36
Other direct charges	15.83	32.69
Campsite expense	13.72	28.34
Sales and administrative expense	11.36	23.48
Interest on loans	3.30	6.82
Total direct production costs	98.28	202.89
Depreciation	11.56	23.89
Amortization, exploration and development	21.26	42.91
Other indirect costs	7.14	14.75
Total costs	138.24	284.44

TABLE 13. - Wage rates, Alaska Mines and Minerals, Inc., Red Devil mine, fiscal year 1959

	Rate per hour
Employees:	
Miners and timbermen	$3.00
Trammers and skiptenders	2.50
Hoistmen	2.50
Mill operators	2.60
Mechanics	3.00
Electricians	3.00
Surface labor	2.00-3.00

Rhyolite Deposit

The Rhyolite deposit is near the base of the southwest end of Juninggulra Mountain, 12 miles northwest of Crooked Creek and 300 miles northwest of Anchorage. Crooked Creek, an Eskimo village on the north bank of the Kuskokwim River, has a population of 50, a small trading post, and a post office. The deposit, discovered by Joe Stuver in 1957, is at an altitude of 500 feet.

Sedimentary rocks, chiefly shales and graywackes of late Cretaceous age, form the country rock of the area. Rhyolite extrusives, of which Juninggulra Mountain is principally composed, crop out in the area. Mineralization occurs near the rhyolite-shale contacts as stringers and lenses of cinnabar associated with stibnite. Moss and brush obscure bedrock except high on the rhyolite ridges. The maximum width of the mineralized zones observed was 2 feet. In some instances cinnabar stringers and lenses have a maximum width of 6 inches; these assayed as much as 42 percent mercury, but they appear to be short, erratic, and discontinuous. At one place a silica-carbonate sill 8 to

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10 feet thick has irregularly disseminated mercury mineralization over a section 70 feet long by 20 to 30 feet wide. The section averages 0.1 percent mercury.

In 1959, bulldozer trenching by the Bureau of Mines exposed bedrock at intervals in a 2,000 by 3,000-foot area where previous prospecting by the owners had disclosed abundant float and several in-place stringers with widely varying cinnabar mineralization. The additional trenching disclosed erratically distributed short stringers and small lenses. The depth of overburden and the presence of permafrost were serious obstacles to bulldozer trenching.

No mineralization was found in the rhyolite mass comprising Juninggulra Mountain, but several small cinnabar stringers were found in this formation about 3 miles to the southwest. The DeCoursey Mountain mine, a well-mineralized deposit with a notable mercury production record, is 8 miles to the north. Several intervening creeks have strong placer cinnabar showings. The area, like many in Alaska, warrants additional prospecting.

The deposit has no record of production.

White Mountain Deposit

The White Mountain deposit is between the headwaters of Tatlawiksuk River and Chunitna Creek, some 60 miles southeast of McGrath. The area is uninhabited and is without roads or trails; altitude is approximately 2,500 feet.

Jack Egnaty of Sleetmute discovered the deposit in 1958. Seven claims were located and subsequently leased to Cordero Mining Co. of Palo Alto, Calif.

The area is composed of massive dolomitic limestones, dolomites, shales, and conglomerates. A highly faulted section of dolomitic limestone and shale about 2,000 feet wide is exposed for 4 miles. The known mineralization occurs in the northern part of this faulted zone. Cinnabar has been found in place at both ends and in the center of a strike length of 10,000 feet. Massive cinnabar up to 6 inches thick occurs in well-fractured dolomite in almost horizontal zones at the northern end of the area. Near the center of the mineralized zone, cinnabar occurs as disseminations and irregular masses in fractured yellow dolomite. At the south end, cinnabar occurs in dolomite as several narrow stringers, striking north-south and dipping 90°. No cinnabar was found in the shale. The property has no production record.

Willis and Fuller Group

The Willis and Fuller group of six claims is 1 mile north of the Kuskokwim River, 12 miles downstream from Sleetmute; it is above timberline at an elevation of 700 feet. Alaska Mines and Minerals, Inc., leases the property under option to purchase. Access from the mouth of Willis Creek on the Kuskokwim River is by foot trail; a tractor road connects the property with the Parks deposit about 2 miles east. Willis and Fuller made the original locations in 1909. Development work consists of shallow pits and adits, largely caved, and six trenches cut by the Bureau of Mines in 1942.

Andesite dikes, subsequently altered by hydrothermal action, intrude graywackes, sandstones, and shales. Four roughly parallel dikes containing mineralized zones are known. Bureau of Mines personnel explored a 30-foot dike striking N 30° W and dipping steeply southwest. Mineral deposition is concentrated in a brecciated zone on the hanging wall side of the dike and extends into the dike along fractures. Stibnite occurs with the cinnabar. Webber reports that the entire dike in one trench averaged 1.6 pounds of mercury per ton of ore and that a second trench averaged 3.7 pounds per ton over a 30-foot width. Recorded output is 2 flasks, produced during World War I.

Yukon River Region Mines and Properties

The Yukon River region borders the Kuskokwim River region on the north. The principal deposits are adjacent to the Kuskokwim district but the Hudson prospect is 400 miles northeast.

Canyon Creek Placer

One of the earliest attempts to find the lode source of placer cinnabar was on Canyon Creek, some 20 airline miles northeast of Eagle. James Hudson, working on the gold placer of the area, noted cinnabar in sluicebox concentrates and made a competent but unsuccessful search for the mineral in place as early as 1907. The cinnabar noted by Hudson was washed from the gravels near the mouth of the creek.

The country rock from the mouth of the creek to 1,500 feet upstream is schist. Tertiary conglomerates and sandstones form the bedrock for the next 6,000 feet, and they are succeeded by metamorphosed sedimentaries and greenstone to the head of the valley.

The Geological Survey examined the area in 1942. A rather extensive program of trenching and test pitting failed to show cinnabar in place. In most of the prospect cuts, the gravel contained little or no cinnabar.

DeCoursey Mountain Mine (Corona)

The DeCoursey Mountain mine is north of the Kuskokwim River on Return Creek, a tributary of the Iditarod River. The settlement of Crooked Creek, on the Kuskokwim River, is 18 miles south; Flat, on Otter Creek, is 35 miles northeast. The property can be reached by trail from either Flat or Crooked Creek. The trails are barely passable in summer, but they are suitable for tractor hauling after the freezeup. A small landing strip at the mine allows access by aircraft. The property comprises 14 unpatented claims. Altitude is about 900 feet.

The first locations in the area were made in 1919 by a prospector named DeCoursey. From 1921 to 1924 the property was operated by the Thrift Mining Co., and a small production was obtained. Incomplete records show 45 flasks produced from 14 tons of hand-sorted ore. C. F. Lindfors and associates held the property from 1924 to 1926. Records show 38 flasks produced from 45 tons in 1925. The mine was called the Corona during this period. When Lindfors

died in 1926 or 1927, the deposit reverted to open ground; John and Harry Brink relocated the claims in 1927. From 1927 to 1940 some prospecting was done. There is no record of production during this time.[6]

In 1942, R. F. Lyman, K. M. Johnston, and F. C. Rocheleau formed DeCoursey Mountain Mining Co., a partnership, and took a lease with a 4-year option to purchase (later exercised). Lyman bought out the interests of his two partners and in 1951 sold the holdings to DeCoursey Mountain Mining Co., a corporation. Alaska Mines and Minerals, Inc., a successor to DeCoursey Mountain Mining Co. (through DeCoursey-Brewis Minerals, Ltd.), now holds the property. From 1942 to 1949, Lyman produced approximately 1,200 flasks. No production has been obtained from the property since 1949. After taking over in 1951, DeCoursey Mountain Mining Co. explored the deposit under a DMEA loan. The work indicated that the oreshoots probably continue in depth. However, the company has made no attempt to put the mine into production.

Northwest-dipping graywacke and shale of the Kuskokwim Group, intruded by sill-like bodies of basalt and diabase, form the bedrock at the mine. Both the sedimentary and intrusive formations have been extensively altered to silica-carbonate rock. Alluvium covers the bedrock and masks the geologic features.

Cinnabar occurs in the silica-carbonate rocks and in unaltered formations immediately adjacent. The silica-carbonate rock is more highly silicified at the DeCoursey deposit than at other deposits of the Kuskokwim River region. The resulting brittleness of relatively large masses of wall rock accounts for the wide breccia zones that may dip across the strata but are generally parallel to the strike. Mineralization along bedding-plane joints, which occurs where alteration is confined largely to the intrusives, is less common. Apparent offsets of the large veins are thought to be a result of an irregular fracture pattern rather than of post-ore faulting. Associated minerals are cervantite, arsenopyrite, stibnite, chalcedony, and kaolin. The DeCoursey deposits contain very little stibnite.

Cinnabar occurs over an area 2,600 by 2,000 feet and over a vertical extent of 420 feet. Two vein systems exist. The upper system, exposed from altitudes of 760 to 1,020 feet, includes the Top, Retort, Tunnel, and DeCoursey veins. The lower system, 1,000 feet southwest of the upper system and exposed from altitudes of 640 to 740 feet, has the "A" vein and some unnamed veinlets.

The Tunnel vein has been the most productive. It is opened by adits at the 820-, 871-, and 910-foot elevations. About 750 feet of drifting and crosscutting in the ore zone have been done. The Tunnel vein has been worked or prospected over a strike length of 200 feet and through a vertical range of 130 feet. The mineralized section averages 3.2 feet in width. Production from the vein has been about 800 flasks.

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[6] R. F. Lyman estimates the DeCoursey Mountain mine output at 100 to 300 flasks to 1941.

The Retort and Top veins are in the hanging wall of the Tunnel vein; most of the early production from the deposit came from these two veins. The 820 adit on the Tunnel vein was extended about 500 feet to the northwest, and a prominent fracture was followed for 150 feet; no production resulted from this work. On the surface, the Top and Retort veins have been exposed over a strike length of 300 feet. Cinnabar occurs in discontinuous bedding-plane joints and fractures (Top vein). Production from the two veins has been about 300 flasks, largely from float and residual placer.

The DeCoursey Mountain Mining Co. drilled 2,614 feet of diamond-drill holes in 1953 and 1954 under a DMEA contract. Twenty-five horizontal holes, to explore for downward extensions of the Top and Retort mineralization and parallel leads, were drilled from the northeast section of the 820 adit (Lyman adit). The drilling indicated that mineralization extends at least to the elevation of the Lyman adit. No attempt was made to follow up the diamond-drill findings with exploratory workings.

The DeCoursey and associated veins have been exposed for 300 feet on the surface. The DeCoursey, enclosed in a large body of silica-carbonate rock, has abrupt changes in width and shape. The blocky fracturing of the brecciated silica-carbonate rock gives the vein segments the appearance of postmineral offsets, but no evidence of faulting was found. One cross fracture contained an unbroken continuation of the ore. The DeCoursey vein has produced a few flasks from the vein and from float. Surface exposures have been found over altitudes of 770 to 840 feet.

The "A" vein is opened by an adit and is a mineralized zone 500 feet long at altitudes from 660 to 740 feet. The vein occupies a continuous fissure along the contact of the sediments and a diabase porphyry, locally altered to silica-carbonate rock. Some evidence of faulting and postmineral movement is here, including slickensides on the walls and a polished, greasy-appearing gouge. Production from the "A" vein has been small.

Hudson Mine (Livengood Cinnabar Corp.)

The Hudson mine is in the Tolovana district at the head of the west fork of Olive Creek, a Tolovana River tributary, at an altitude of 1,500 feet. Livengood, a gold-placer camp, is 2 miles north. Mertie states that cinnabar in place was first noted in 1916. Some exploratory work was done on the showing, but nothing considered as potential ore was found. James Hudson prospected the area in the late 1920's and discovered cinnabar in place on the west fork of Olive Creek about one-half mile from the earlier discovery.

According to reports, sedimentary slates and sandstones make up the country rock. At the mine, a highly altered granitic rock is associated with cinnabar. The ferromagnesian minerals of the original rock show as small black specks in the white groundmass. Cinnabar is evenly disseminated through the altered rock as small specks and grains; as the degree of alteration lessens, the rock becomes leaner in cinnabar.

Hudson drove a 134-foot adit and about 135 feet of auxiliary headings into the hill on the deposit. From the reports available it is difficult to determine whether the Hudson adit crosscuts the mineralized zone, drifts along it, or cuts it obliquely. Several areas containing 20 to 30 pounds of mercury per ton were reported between the adit portal and a winze 10 feet back from the adit face.

Other Occurrences

Mertie reports a 30-inch vein of stibnite, cinnabar, and quartz at the head of Wyoming Creek in the Cripple Creek Mountains. The vein occurs at the contact of a monzonite intrusive with sedimentaries; a specimen showed quartz and cinnabar along the walls, with stibnite at the center of the vein. Mertie also reports stibnite and cinnabar lodes on the border of the quartz monzonite area at the heads of Flat, Chicken, and Happy Creeks, in the Iditarod district. Again, the stibnite is at the center of the vein, with quartz and cinnabar along the walls.

Smith reports several small veins containing cinnabar, stibnite, and quartz at the head of Glen Gulch, in the Iditarod district. Mercury mineralization occurs in quartz stringers, both in granite and in sedimentaries. One zone, several feet wide but not persistent along the strike, occurs in slates along the granite contact. Some work was done on the showing, but it was abandoned as unpromising. Small veins of cinnabar associated with gold-bearing quartz stringers are reported in the face of a 70-foot caved adit about 400 feet west of the mouth of Malemute Gulch in the Flat-Iditarod area. The adit is thought to have been driven for the gold prospect. Moffit reports cinnabar occurring with stibnite on the Merinser claim at the head of Slippery Creek, Kantishna district.

The Bureau of Mines, in 1956, prospected for the lode sources of cinnabar found in Flat and Otter Creeks. Over 10,000 lineal feet of bedrock were exposed in bulldozer trenches in the Glen and Black Gulch areas; 83 channel samples were taken from the trenches. In addition, 279 soil samples were taken from the upper Chicken Creek area. The primary source of the cinnabar placer material appears to be a large monzonitic intrusive in contact with argillite and quartzite. The last two are metamorphic products from the local shales and sandstones. Numerous veins and veinlets, some showing fair gold values, were uncovered. No significant cinnabar mineralization was found in place.

Placer mercury occurs in appreciable quantities in the gravels of the Iditarod, Innoke, and Tolovana districts and to a lesser extent in the Marshall, Kantishna, Bonnifield, Rampart, Hot Springs, Circle, Eagle, and Fortymile districts. Joesting lists many occurrences.

Bristol Bay Region Mines and Properties

The Bristol Bay Region is 150 to 200 miles south of the main Kuskokwim mercury area and about 80 miles from Bristol Bay. The deposits are in the headwaters of the Eek, Kanektok, and Nushdgak Rivers. Only minor production has been made from this area.

Kagati Lake Deposit

Some work has been done on a lode prospect near Mount Oratia, 8 miles northeast of Kagati Lake. The prospect, known as the Kagati Lake mercury deposit, is 80 miles southeast of Bethel, at an altitude of 2,600 feet. Atayak Mountain is 3 miles south; Mount Oratia is 4 miles west.

There are no roads or trails in the area; access is by foot, float plane, or by tractor train in winter. The first location was made in 1927 by a man named Gieger, who drove an adit on a shear zone at the south end of the deposit. The adit has since caved, leaving only a dump as evidence of the early work. Gieger allowed his locations to lapse. In 1956, a group called Bethel Exploration Co. staked the property. Sunshine Mining Co. optioned the property the same year and prospected from 1956 to 1958.

Mineralization occurs in two shear zones, 200 feet apart, in granite. The larger zone is well defined, 50 to 100 feet wide, and 1,400 feet long. The smaller zone, 6 feet wide and 200 feet long, is poorly defined and obscured by moss and debris. The main shear zone strikes N 15° W and dips 90°. It is cut off at the south end by a vertical fault, resulting in a cliff 100 feet or more in height; overburden conceals the extension to the north. Little mineralization occurs in either shear zone. A few small pieces of cinnabar with quartz and realgar were found in both zones; several pieces of stibnite float, up to 8 inches, were found at the north end of the larger shear zone. The deposit has no recorded production.

Marsh Mountain Deposit (Red Top Mine)

The Marsh Mountain deposit is on Marsh Mountain, 3 miles east of the settlement of Aleknagik and 17 miles north of Dillingham, at an altitude of 1,000 feet. Red Top Mercury Mine, Inc., holds six claims by location. DeCoursey Mountain Mining Co. and Moneta Porcupine Mines, Ltd., are reported to hold the property under lease. There is a 2-mile tractor road from Wood River to the mine.

Frank H. Waskey discovered placer cinnabar on Arcana Creek in 1941 while prospecting for gold. Charles Wolfe and Clarence Wren prospected the area and traced float up Feeder Creek to mineral in place. Ore occurs in a brecciated zone 100 feet or more wide, in graywacke. Within the zone, one series of high-grade stringers lies parallel to the walls on the footwall side; a second series, also parallel, lies 50 feet from the first. A transverse series cuts across the zone between the first two series. Cinnabar occurs as nearly pure mineral in the stringers; there is little or no dissemination into surrounding rock. The Bureau of Mines examined the property in 1943, and again in 1953, in connection with a DMEA loan. Surface prospecting under the DMEA program was sufficiently promising to warrant underground exploration. The underground work, comprising 550 feet of drifts and crosscuts, showed that the surface mineralization extends downward, but without improvement in grade to the depth explored. The property has produced a few flasks of mercury.

Seward Peninsula Region Mines and Properties

The Seward Peninsula region is on the west coast of Alaska at Bering Strait. The mercury area is 100 miles east of Nome, near the shore of Norton Sound.

Bluff Deposit

At Bluff, on the Seward Peninsula about 50 miles east of Nome, a lode prospect in a 100-foot, nearly vertical bluff on the shore of Norton Sound has been prospected by two adits and a 55-foot test shaft. The deposit is at the mouth of Swede Creek, 2 miles east of Bluff. A landing strip suitable for light aircraft lies about a mile northeast of the settlement. Weather at Bluff is much the same as at Nome. Average yearly temperature at Nome for 1958 was 26.3° F, with a daily maximum high of 55.4° in June and a low of 2.2° F below zero in February. The lowest temperature recorded in the past 10 years was 42° below in 1949. Normal annual precipitation is about 18 inches.

The deposit was located by Sam Tucker in 1922, and explored by J. J. Keenan under lease. Jerry Galvin of Nome obtained a lease in 1942 and moved furnacing equipment to Bluff for use at the deposit. However, the equipment was never set up.

W. S. Wright examined the property in 1946. Limestone, shale, and schist are the principal rock types in the Bluff area, but the mercury deposits occur in quartzite striking N 60° E and dipping 15° NW. Two parallel seams, 35 feet apart vertically, show mineralization. The lower seam is weakly mineralized and has not been prospected. The upper seam, 70 feet above the beach, has been explored by 2 adits, one 70 feet long and one 20 feet long. The shaft east of the face of adit No. 1 is vertical and 55 feet deep. It was not safe to enter at the time of Wright's examination. The deposit has no recorded production.

Miscellaneous Placer Occurrences

Cinnabar occurs in the gravels of Koyana, Swede, and Daniels Creeks and in the beach placers, all near Bluff. Brooks (3), in describing the beach placers at the mouth of Daniels Creek, states, "The heavy minerals associated with the gold are magnetite, nodules of limonite, small pieces of ilmenite, and bits of cinnabar. Cinnabar is fairly abundant in the tailings, ranging from specks to rounded pebbles the size of marbles, but it has not been found in place." Cinnabar has also been recognized in the gravels of Budd Creek, 30 miles northeast of Teller, and by a Bureau of Mines engineer in the Timber Creek area. Two selected specimens from the Timber Creek area contained 0.19 and 0.17 percent mercury.

TABLE 14. - Alaskan mercury properties

Reported property name	District and subdistrict	Reported location	Production, flasks	Development	Mode of occurrence (mineralization, cinnabar unless otherwise noted)	Last reported owner	References in bibliography
			KUSKOKWIM REGION				
Barometer prospect.	Aniak, Georgetown.	South bank of Kuskokwim River, 7 miles northwest of Sleetmute.	16	Several hundred feet of underground workings and surface cuts	In fracture zones..	E. W. Park.....	7, 31
Broken Shovel group.	do.....	North bank of Cinnabar Creek, 85 miles southwest of Sleetmute.	(1)	Underground.....	With native mercury and stibnite.	Russell Schaefer	2, 7
Candle Creek...	McGrath, McGrath.	-	Occurrence.	Unknown.....	Placer.....	Unknown.....	7, 17
Fairview group.	Aniak, Georgetown.	Near mouth of McCally Creek.	do....	Surface trenching	With stibnite along fracture zone in rhyolite dike.	Alaska Mines and Minerals, Inc.	7, 31
Kolmakof deposit.	do.....	North bank of Kuskokwim River, 18 miles upstream from Aniak.	do....	do.....	In lenses near andesite sills in folded sandstone and shale.	Western Alaska Mining Co.; Willie Rabidoux	7, 15, 22, 30, 31
Lucky Day group (Redskin, Cinnabar Creek).	do.....	On Beaver and Cinnabar Creeks, 85 miles southwest of Sleetmute.	1447	Unknown.....	With stibnite and native mercury in silica-carbonate rock and in placers.	Russell Schaefer	2, 7, 25, 31
Mount Joaquin prospect.	McGrath, Tonzona.	Head of O.K. Creek (tributary of Tatalina River).	Occurrence.	do.....	In limestone inclusion within monzonite mass.	Knute P. Lind...	7
Parks deposit (Alice and Bessie).	Aniak, Georgetown.	North bank of Kuskokwim River, 8 miles downstream from Sleetmute.	175	An adit and surface pits.	In altered andesite sills and dikes.	George Willis, and others.	7
Rainy Creek deposit.	Bethel, Bethel.	7 miles north of Kagati Lake, 7 miles northwest of Mount Oratia, 80 miles southeast of Bethel.	6	Unknown.....	With realgar in fault and in placers.	Unknown.....	7, 24, 25, 31
Red Devil mine.	Aniak, Georgetown.	South bank of Kuskokwim River at mouth of Red Devil Creek.	28,061	Extensive underground workings, reduction plant.	With stibnite along fault.	Alaska Mines and Minerals, Inc., and Hans Halverson.	7

See footnotes at end of table.

TABLE 14. - Alaskan mercury properties--Continued

Reported property name	District and subdistrict	Reported location	Production, flasks	Development	Mode of occurrence (mineralization, cinnabar unless otherwise noted)	Last reported owner	References in bibliography
			KUSKOKWIM REGION--Continued				
Rhyolite deposit.	Aniak, Georgetown.	Southwest end of Juninggulra Mountain, 12 miles northwest of Crooked Creek.	Occurrence.	Surface trenching	With stibnite in stringers and lenses.	Unknown.....	7, 8
White Mountain deposit.	McGrath, McGrath.	Between head of Tatlawikuk River and Chunitna Creek, 60 miles southeast of McGrath.	do....	Unknown.....	In highly faulted zone of dolomitic limestone.	Jack Egnaty.....	7
Willis and Fuller group.	Aniak, Georgetown.	1 mile north of Kuskokwim River 12 miles downstream from Sleetmute.	2	do.....	With stibnite along fractures andesite dikes.	Willis.....	7, 31
			YUKON RIVER REGION				
Anvil Creek....	Iditarod....	Unknown.....	Occurrence.	Unknown.....	Placer.....	Unknown.....	11
Auburn Creek...	Casadepega..	do.....	do....	do.....	do.....	do.....	27
Black Creek....	Iditarod....	On Otter Creek, upstream from Flat, near Discovery.	do....	Bulldozer trenches.	With stibnite in quartz vein at contact of monzonitic intrusive with argillite and quartzite.	do.....	15
Bobtail Creek..	Marshall....	On Kako Creek.....	do....	Unknown.....	Placer.....	do.....	(2)
Bonanza Creek..	Chisana.....	Unknown.....	do....	do.....	do.....	do.....	20
Boob Creek.....	Innoko.....	do.....	do....	do.....	do.....	do.....	16
California Creek.	Bonnifield..	do.....	do....	do.....	do.....	do.....	(2)
Canyon Creek placer.	Eagle.....	20 miles northeast of Eagle on Canyon Creek.	do....	Surface workings.	do.....	James Hudson....	14
Deadwood Creek.	Circle.....	Deadwood Creek.....	do....	Unknown.....	do.....	Unknown.....	(2)
DeCoursey Mountain Mine (Corona).	Iditarod....	North of Kuskokwim River on Return Creek, 18 miles north of Crooked Creek, 35 miles southwest of Flat.	1,366	Extensive underground.	In silica-carbonate rock.	Alaska Mines and Minerals, Inc.	7, 31
Dome Creek.....	Fortymile...	Unknown.....	Occurrence.	Unknown.....	Placer.....	Unknown.....	12
Do.....	Kougarok....	do.....	do....	do.....	do.....	do.....	28

Ester Creek....	Tolovana....	do.....	do....	do.....	do.....	do.....	10
Eureka Creek...	Hot Springs.	do.....	do....	do.....	do.....	do.....	17
Flat-Iditarod area.	Iditarod....	Heads of Flat, Happy, Chicken, and Otter Creeks.	do....	Bulldozer trenches and soil samples.	Apparently associated with monzonitic intrusive.	do.....	31
Flat Creek.....	Marshall....	On Stuyahok River..	do....	Unknown.....	Placer.....	do.....	(2)
Franklin Creek.	Fortymile...	Unknown.....	do....	do.....	do.....	do.....	12
Glen Gulch.....	Iditarod....	On Otter Creek, upstream from Flat, near Discovery.	do....	Bulldozer trenches.	With stibnite in quartz vein at contact of monzonitic intrusive with argillite and quartzite.	do.....	28
Grubstake Creek	Bonnifield..	Unknown.....	do....	Unknown.....	Placer.....	do.....	(2)
Hoosier Creek..	Rampart.....	do.....	do....	do.....	do.....	do.....	17
Hudson mine....	Tolovana, Tolovana(?)	Head of west fork Olive Creek, 2 miles south of Livengood.	Unknown....	Adit and auxiliary working.	In highly altered granitic rock.	James Hudson....	15
Hunter Creek...	Rampart.....	Unknown.....	Occurrence.	Unknown.....	Placer.....	Unknown.....	17
Lillian Creek..	Tolovana....	do.....	do....	do.....	do.....	do.....	10
Little Minock Creek.	Rampart.....	do.....	do....	do.....	do.....	do.....	17
Malemute Gulch.	Iditarod....	Flat-Iditarod area, in mouth of Malemute Gulch.	do....	70-foot caved adit.	Associated with gold-bearing quartz stringers.	do.....	-
McKaskey Creek.	Hot Springs.	Unknown.....	do....	Unknown.....	Placer.....	do.....	17
Merinser claim.	Kantishna...	Head of Slippery Creek.	do....	do.....	With stibnite.....	do.....	18
Mogul Creek....	Eagle.....	Unknown.....	do....	do.....	Placer.....	do.....	(2)
Moore Creek....	Iditarod....	do.....	do....	do.....	do.....	do.....	15
Moose Creek....	Bonnifield..	do.....	do....	do.....	do.....	do.....	(2)
Olive Creek....	Tolovana....	do.....	do....	do.....	do.....	do.....	10
Omega Creek....	Hot Springs.	do.....	do....	do.....	do.....	do.....	17
Pioneer Creek..	do.....	do.....	do....	do.....	do.....	do.....	17
Quail Creek....	Rampart.....	do.....	do....	do.....	do.....	do.....	17
Rhode Island Creek.	Hot Springs.	do.....	do....	do.....	do.....	do.....	17
Seventymile River.	Eagle.....	Below the falls....	do....	do.....	do.....	do.....	14
Shirley Bar....	Hot Springs.	Unknown.....	do....	do.....	do.....	do.....	17
Stonehouse Creek.	Fortymile...	do.....	do....	do.....	do.....	do.....	12
Troublesome Creek.	Rampart.....	do.....	do....	do.....	do.....	do.....	17

See footnotes at end of table.

TABLE 14. - Alaskan mercury properties--Continued

Reported property name	District and subdistrict	Reported location	Production, flasks	Development	Mode of occurrence (mineralization, cinnabar unless otherwise noted)	Last reported owner	References in bibliography
			YUKON RIVER REGION--Continued				
Victor Gulch...	Iditarod....	Unknown.....	Occurrence.	Unknown.....	Placer.....	Unknown.....	11
Wade Creek.....	Fortymile...	do.....	do....	do.....	do.....	do.....	9
Wyoming Creek..	Innako.....	Cripple Creek Mountains, head of Wyoming Creek.	do....	do.....	With stibnite in quartz vein at contact of monzonite intrusive.	do.....	31
			BRISTOL BAY REGION				
Kagati Lake deposit.	Bristol Bay, Togiak.	8 miles northeast of Kagati Lake, 3 miles north of Atayak Mountain, 4 miles east of Mount Oratia.	Occurrence.	Caved adit and surface exploration.	With stibnite, quartz, and realgar in shear zone in granite.	Bethel Exploration Co.	7
Marsh Mountain deposit (Red Top mine).	Bristol Bay, Tikchik	On Marsh Mountain, 3 miles east of Aleknagik, 17 miles north of Dillingham.	27	550 feet of drifts and crosscuts.	In stringers in breccia zone.	Red Top Mercury Mine, Inc.	7
Wood River.....	do.....	Above Dillingham...	Occurrence.	Unknown.....	Placer.....	Unknown.....	7
			SEWARD PENINSULA REGION				
Bluff deposit..	Koyuk, Shaktolik.	Mouth of Swede Creek, 2 miles east of Bluff on Norton Sound.	Occurrence.	2 adits and a shaft.	In quartzite.....	Jerry Galvin....	7
Bluff placers..	do.....	Koyana, Swede, and Daniels Creeks and beach gravels.	do....	Unknown.....	Placer.....	Unknown.....	7
Budd Creek.....	Port Clarence.	30 miles northeast of Teller.	do....	do.....	do.....	do.....	7
Timber Creek...	Unknown.....	Unknown.....	do....	do.....	do.....	do.....	7
			COPPER RIVER REGION				
Wood River.....	Nizina.....	Unknown.....	Occurrence.	Unknown.....	Unknown.....	Unknown.....	7
			NORTHERN ALASKA REGION				
Canning River..	Canning.....	North of Brooks Range.	Occurrence.	Unknown.....	Placer.....	Unknown.....	7

[1] Broken Shovel group production included with Lucky Day group.
[2] Data from Alaska Department of Mines.

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CHAPTER 4. - MERCURY IN ARIZONA

by

Robert T. Beckman[1] and William H. Kerns[2]

INTRODUCTION AND SUMMARY

Since 1908 mercury has been produced intermittently in Arizona from small mines operating only when the mercury price was high. This mercury production was small, comprising 0.2 percent of the U.S. total since 1850. Output has been reported from four areas in Arizona, but one area in the Mazatzal Mountains in Gila and Maricopa Counties accounted for over 96 percent of the Arizona total.

Records are incomplete and very little information is available concerning mining and milling costs and ore reserves. Mercury probably will continue to be produced on the same scale; the sporadic occurrence of the ore does not lend itself to large-scale operations.

Total reserves of the area are insignificant, and the possibility of anything but minor production at high prices is remote.

ACKNOWLEDGMENTS

Lewis Smith, geologist, Arizona Division of Mineral Resources, was extremely helpful in the investigation of the Arizona deposits. Acknowledgment is also made to the mine owners and operators for their cooperation.

HISTORY (4)[3] AND PRODUCTION

Mercury was discovered in Arizona in the Dome Rock Mountains about 1878, probably during the search for the lodes from which the famous La Paz gold placers were derived. Mercury was produced from this locality from 1898 to 1914, but no activity has been reported since that time.

The deposits in Copper Basin also have been known for many years. The mercury reportedly was used for amalgamation in the nearby gold mines during the late 1880's and early 1890's. Production evidently was small and no records were kept.

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[3]Underlined numbers in parentheses refer to items in the bibliography at the end of the chapter.

In 1911 E. H. Bowman discovered cinnabar on Alder Creek in the Mazatzal Mountains, and deposits later were found on Sycamore and Slate Creeks. Operations in this area have been the main source of mercury in Arizona and have been producing intermittently since 1913. J. A. and Henry Porterie discovered mercury deposits in the Phoenix Mountains in 1916. Some mercury was produced from these deposits, but the mines in this area are now idle.

A total of 7,125 flasks (76-lb) of mercury, 0.2 percent of the United States total output, has been produced in Arizona since 1850 (table 15). Nearly all production was stimulated by a high mercury price.

Ninety percent of Arizona mercury production has come from three mines, the Ord, Pine Mountain, and National, in the Mazatzal Mountains, 50 miles north of Phoenix (table 15).

In 1960 four small-scale mines in the Mazatzal Mountains were operating.

PHYSICAL FEATURES

The mercury producing areas are in mountainous regions of the State where recent uplift and erosion have resulted in a rugged topography.

The climate is dry with mild winters and hot summers. Vegetation is generally sparse, consisting of cactus and greasewood at lower altitudes; dense brush, scrub oak, and juniper at intermediate levels; and grasses and some yellow pine on the higher mountain slopes.

Most canyons contain intermittent streams which are subject to flash floods during occasional torrential summer downpours. In the main mercury area, water is available either from semipermanent streams or shallow wells.

Transportation in the mercury districts is by truck, mainly over good highways, but the private roads to some of the prospects are in poor condition.

GEOLOGY (4)

Mercury occurs chiefly as cinnabar but to a lesser extent as native mercury and mercurial tennantite in fractures and shear zones. The host rocks are mainly schists, phyllites, and granites of Precambrian and Paleozoic age which in some of the deposits have been intruded by dikes of andesite, diabase, and rhyolite.

The deposits are localized by faults and often are found in areas of rock alteration. The oreshoots are generally narrow lenticular bodies with gradational boundaries. Associated with the mercury in the Mazatzal Mountain deposits are tourmaline and copper minerals; in the Dome Rock Mountains deposits, cinnabar is associated with gold, wulfenite, and copper minerals.

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TABLE 15. - Production of mercury in Arizona, 1908-61

Year[1]	Mazatzal Mountain area mines, flasks				Other Arizona mines,[3] flasks	Total, flasks
	Ord	Pine Mountain	National	Other[2]		
1908.....	-	-	-	-	(4)	(4)
1913.....	-	-	15	-	209	224
1914.....	-	-	6	-	5	11
1915.....	-	-	-	(4)	-	(4)
1916.....	-	-	-	5	-	5
1917.....	-	-	37	-	2	39
1924.....	-	-	(4)	-	-	(4)
1925.....	-	-	(4)	(4)	-	30
1926.....	-	-	(4)	-	-	(4)
1927.....	-	-	(4)	-	-	(4)
1928.....	(4)	-	(4)	-	-	(4)
1929.....	(4)	-	(4)	-	-	(4)
1930.....	-	-	-	-	(4)	(4)
1931.....	-	-	(4)	-	-	(4)
1932.....	-	-	(4)	-	-	(4)
1934.....	(4)	-	-	-	-	(4)
1935.....	(4)	-	-	-	-	(4)
1936.....	(4)	-	-	(4)	-	(4)
1937.....	10	-	15	12	-	37
1939.....	-	-	(4)	-	-	(4)
1940.....	358	313	62	6	1	740
1941.....	384	399	82	8	-	873
1942.....	187	416	5	93	-	701
1943.....	316	213	-	12	-	541
1944.....	177	344	27	-	-	548
1945.....	(4)	-	(4)	-	-	(4)
1946.....	95	-	-	-	-	95
1951.....	-	-	-	(4)	-	(4)
1954.....	102	59	-	2	-	163
1955.....	54	326	66	31	-	477
1956.....	-	5	-	(4)	-	(4)
1957.....	-	-	5	23	-	28
1958.....	-	1	-	52	-	53
1959.....	-	5	-	(4)	1	(4)
1960.....	-	118	-	(4)	-	(4)
1961.....	3	142	2	1	-	148
Total.....	2,901	2,341	1,278	345	260	7,125
Percent of total....	40.72	32.86	17.94	4.84	3.64	100.00

[1]Only those years shown that had a recorded production.
[2]Includes Oneida, Blue Bird, Irl, Rattlesnake, Mercuria, Gold Creek, and other mines.
[3]Includes Dome Rock Mountain and Phoenix Mountain areas.
[4]Figure withheld to avoid disclosing individual company data.

MERCURY MINING DISTRICTS

Mercury occurs principally in four areas, Mazatzal Mountains, Phoenix Mountains, Dome Rock Mountains, and Copper Basin (fig. 5). Occurrences have been reported in nine other areas, but no production has been recorded from them.

DISTRICTS AND PROPERTIES

Table 16 at the conclusion of this chapter lists every known mercury property in the State and gives the salient facts concerning each. Therefore, the following individual property descriptions do not repeat location and ownership data or general references.

Mazatzal Mountains District Mines and Properties

The Mazatzal Mountains in the central part of the State extend in a northerly direction for approximately 50 miles. Bounded on the south by the Salt River, on the north by the East Verde River, on the west by the Verde River, and on the east by the Tonto River, their crest is the boundary line between Gila and Maricopa Counties. The deposits, which have been the major producers in Arizona, are in the central part of the Mazatzal Mountains, along Sycamore and Slate Creeks, deeply incised with narrow canyons separated by high ridges. The area is on the Bush Highway, 63 miles north of Phoenix and 30 miles south of Payson. The properties are in the Sunflower and Brown mining districts.

Most of the area is covered by dense brush. Some yellow pine grows on Mount Ord and Pine Mountain, and cypress grows in some of the sheltered ravines. Scrub oak and juniper grow at an altitude of 4,000 feet.

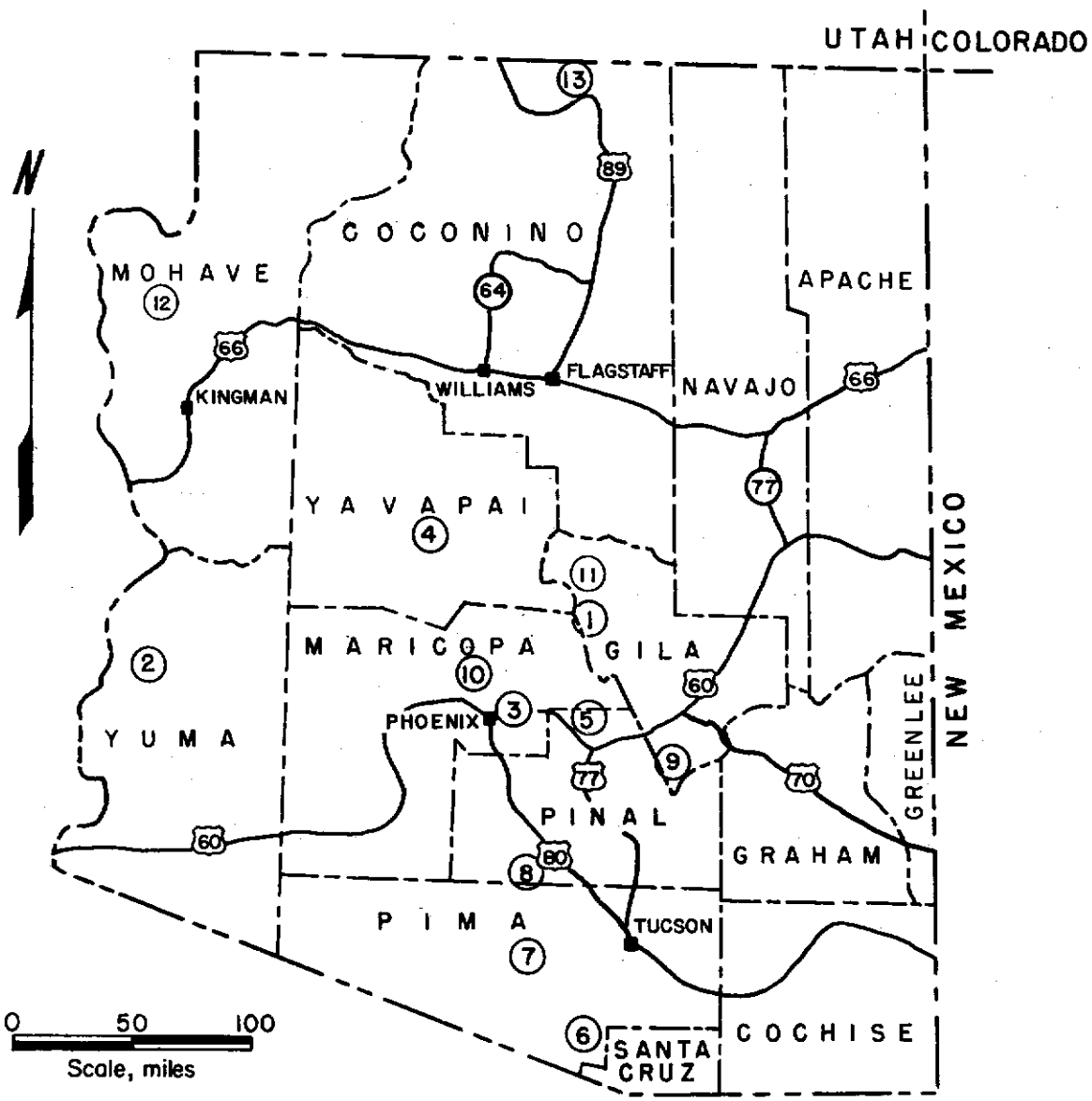
Water is available in both Slate and Alder Creeks during most of the year. In an exceptionally dry period, water may be obtained from shallow wells along the streams.

The Mazatzal Mountains consist of Precambrian rocks overlain by Paleozoic strata and, in some places, Tertiary volcanic or gravel beds.

That part of the range containing mercury deposits is composed of Precambrian rhyolite, shale, slate, quartzite, and conglomerate, locally metamorphosed to phyllite and schist (8).

The rocks have undergone extensive deformation and are cut by inconspicuous faults and shear zones which are generally parallel to the foliation of the slate and phyllite. These faults and shear zones are important structurally because of the influence they have had on the localization of mineral deposition. The ore, which is found in altered zones along faults and shear zones, occurs as narrow, lenticular bodies with gradational boundaries (2).

Cinnabar is the most important mercury mineral, but native mercury and mercurial tennantite are present in small amounts. The cinnabar, usually disseminated in the altered zones, gives a pink color to the rock.



LEGEND

DEPOSITS		OCCURRENCES	
1 Mazatzal Mountains	6 Cerro Colorado	11 Deadman Wash	
2 Dome Rock Mountains	7 Roadside Mine	12 Fey Mine	
3 Phoenix Mountains	8 Mickey Welch	13 Lee Ferry	
4 Copper Basin	9 Cowboy Mine		
5 Nations Mercury	10 Westerdahl		

FIGURE 5. - Location Map of Mercury Deposits and Occurrences in Arizona.

Blue Bird Group (Red Bird, Tonto) ✓ 35 Claim –

The Blue Bird group, immediately east of the Ord Mine on Slate Creek, has been called the Red Bird and Tonto groups. It is owned and operated by C. O. Carlson of Sunflower, who also holds claims along the southeastern side of the National group.

He has an inoperative 8-ton rotary furnace pilot plant on the Blue Bird group.

Gold Creek Group (Northern Light, Bernice No. 1, Big Tunnel)

The Gold Creek group, on Gold Creek, can be reached by following a narrow road westerly along Gold Creek. The group, operated by Grimes and Brunson of Tonto Basin, Ariz., has been known by various other names including the Northern Light group, the Bernice No. 1, and Big Tunnel. In 1960 operators were developing the property, which has not been worked extensively.

Irl Group (Bowman, Robbins, Cornucopia)

The Irl group, on Alder Creek adjacent to the National group on the northeast, consists of 17 claims, which includes Bowman, Robbins, and the Cornucopia groups. This group has had little development and was not being operated in 1960.

Mercuria Group

The Mercuria group, at the head of Gardner Creek, a branch of Slate Creek, can be reached by following the Pine Mountain road for 3 miles, then turning right for about 1 mile.

The Mercuria was operated in 1960 by Oliver Brunson and Gus Packard. The workings are not extensive.

National Group (Arizona Sunflower, Arizona Quicksilver, Sunnyside)

The National group, on Alder Creek, may be reached from Bush Highway by an unimproved road which follows Alder Creek. The group, formerly known as Arizona Sunflower, Arizona Quicksilver, and Sunnyside, consists of 25 claims.

The country rock is largely dark green chloritic and sericitic schists, in which cinnabar occurs along the planes of schistosity as veinlets which widen occasionally to as much as 10 to 12 inches. In some areas the breccia and gouge along the fault zones have been mineralized. The gangue minerals are quartz, tourmaline, carbonates, and occasionally pyrite.

The National plant, which is equipped with a 60-ton-per-day rotary kiln, was not operating in 1960. It has been described by Schuette.

Oneida Group (Ward, L & N) C. O. Carlson

The Oneida group, previously called the Ward and L & N, on the east fork of Sycamore Creek, adjoins the Irl group on the east. In 1960 the owners were building a new type of test mill to replace a flotation plant.

Ord Group

The Ord group, which includes 20 patented claims, lies along Slate Creek adjacent to the Bush Highway. The property has been worked extensively in the past, but when visited in 1960 had not been operated since 1955.

The country rocks are gray and maroon slates and phyllites interbedded with conglomerate and quartzite.

Cinnabar occurs as disseminations in altered phyllites localized along the shear zones and bedding plane faults, which follow the foliation. The small, narrow, and lenticular orebodies strike east-northeast, dip steeply, and rake to the west. Some native mercury is found in the upper workings, and termatite is abundant in the ore zones of the lower workings.

A Defense Minerals Exploration Administration (DMEA) loan was executed for the Ord property, and under its provisions the mine was unwatered and rehabilitated to the 200-foot level, a 93-foot winze sunk to the 300-foot level, 265 feet of drifting and crosscutting done on the 300-foot level and 208 feet of drifting done on the 240-foot level.

The Ord plant has not been operated since 1956. The plant used a 30-ton paddle-conveyor-type furnace designed by Foster and described by Schuette.

Pine Mountain Group (Turnbull)

The Pine Mountain group, on the east fork of Sycamore Creek, can be reached from the pass on Bush Highway by following a narrow winding road for 6 miles in a northerly direction. Leo Cline Jones Bacon

The property, known as the Turnbull, is operated by Brunson, Grimes, and Bacon. Development consists of a small open pit and a 28-foot shaft. The ore sorted from the rock broken in development was trucked to the Rattlesnake plant and stockpiled.

The host rock for the mineralization is a belt of brown schist lying between red slates. Cinnabar occurs as finely disseminated crystals and as "paint." Flat kidneys of quartz are found in the schist. Two rhyolite dikes cut through the formation.

The Pine Mountain plant is equipped with a Gould furnace which cannot be operated without extensive repair.

Rattlesnake Group

The Rattlesnake group, inactive when visited in 1960, lies along Bush Highway at the head of Slate Creek and adjoins the Ord group on the west. It consists of eight claims.

The Rattlesnake plant is a 35-ton Gould rotary furnace, leased from Robert McGhee by William Brunson and Gordon Grimes.

The plant, presently inactive, occasionally is run for short periods and treats most of the ore mined in the area.

Dome Rock Mountains District Mines and Properties

The Dome Rock Mountains, in northern Yuma County, 10 miles east of the Colorado River, are bounded on the west by the Colorado River valley and on the east by the Tyson Wash valley. The range trends north-south and attains an altitude of 3,000 feet.

The deposits lie in the central part of the range about 10 air miles south of Quartzite. They may be reached by traveling south on State Route 95 for 12 miles, then west on an unimproved road for 4 miles, and 8 miles northwest to the claims. The last 8 miles, virtually a "Jeep trail," may be impassable.

The deposits are in a rugged area flanked by highly serrated spurs separated by deep canyons which extend in an east-west direction. The canyons have intermittent streams subject to flash floods during the torrential downpours common to this area.

The area has very hot summers and mild winters. The summer thunder showers account for most of the meager precipitation, but a little snow falls on the higher mountains during the winter. The sparse vegetation consist mostly of cactus and a few thorny bushes.

The part of the Dome Rock Mountains containing the mercury deposits is composed predominantly of sericitic, quartzitic, conglomeratic, and chloritic schists. The cinnabar vein, in a fault in the schist, consists mostly of brecciated quartz with cinnabar disseminated throughout. The oxidized state of the deposit suggests that some of the cinnabar may have been derived from mercurial tetrahedrite.

Cinnabar Group

The Cinnabar group consists of five claims, patented in 1904, and in 1960 was operated by Dean Aglietti of Reno, Nev. The operator was building a road to provide easier access to the property. No other work was being done.

The last reported mercury production was in 1914; there have been several unsuccessful attempts to operate since then.

The deposit has been worked extensively. The seven-level main shaft is reported to be 640 feet deep. The ground was extremely hard to hold and pumping was necessary. Reportedly the workings are caved, flooded and inaccessible.

Carlson Claims

Cinnabar reportedly occurs on the C. O. Carlson group of claims adjoining the Cinnabar group.

French-American Group

The French-American group of prospects is 1½ miles west of the Cinnabar group, up a steep and narrow gulch. Reportedly, these prospects contain cinnabar with tourmaline and quartz.

Phoenix Mountains District Mines and Properties

The Phoenix Mountains, immediately north of Phoenix, trend northeasterly for 8 miles. The entire range is in Maricopa County.

The mercury deposits are in a low pass on Shea Boulevard, 1½ miles from the bridge on Northern Avenue over the Arizona canal. The deposits are west and northwest of Squaw Peak.

The arid climate of this region is typical of the southwestern portion of Arizona. The summers are very hot and the winters are exceptionally mild.

The average annual 8-inch precipitation usually falls as torrential downpours during the summer. The vegetation is mostly cactus and greasewood and is sparse where the land is not irrigated.

The Phoenix Mountains are composed of metamorphosed sedimentary rocks which have been invaded by dikes of olivine diabase which contain quartz veins. The northwestern part of the range is composed of Tertiary and Quaternary volcanics. The mountains are surrounded by and partly buried in detritus derived from the higher slopes of the range.

The mercury deposits occur in schist along fault fractures which generally parallel the schistosity. The ore mineral generally is cinnabar and occurs in well-defined shoots (4).

Brown Mercury Prospect

The Brown Mercury prospect is 12 miles north of Phoenix. The rocks of the area are schists whose foliations strike north-northeast and dip steeply to the east. Within the property were a dozen short adits and test pits in which mercury had been reported to occur. No evidence of the presence of mercury was observed.

Sam Hughes or Rico Mine

The San Hughes mine (also known as the Rico) is about 10 miles north of Phoenix. The property consists of 14 patented claims and fractions. Mercury was discovered in the Phoenix Mountains about 1900 and the Sam Hughes mine was located in 1916. Production has been small.

The principal rock formation in the vicinity is quartz-sericite schist. The ore bodies are found in a fault or shear zone which roughly follows the schist foliations, and which strikes N 25° E and dips 45° to 70° E. Mercury occurs in a quartz gangue as cinnabar, metacinnabarite, and native mercury.

The property has been opened by two shafts, known as the Rico and the Larsen, to a depth of 245 feet and developed by more than 500 feet of drifting. At the Rico shaft, a persistent streak of high-grade cinnabar has been followed from the surface for 100 feet on the dip and 60 feet south on the 100 level. The streak varied in width from 1/8 to 2 inches. Low-grade ore varying in width from a few inches to 5 feet accompanied the high-grade streak. The oreshoot appeared to rake to the southwest. A sample from a 100-ton pile of ore from the Rico shaft assayed 3.9 pounds of mercury per ton; one from a 50-ton pile of material on the dump assayed 0.9 pounds of mercury per ton.

Copper Basin District Mines and Properties

Copper Basin is in the foothills of the Sierra Prieta, 11 miles southwest of Prescott. The deposits are in Yavapai County, 1 mile south of the road that connects Prescott and Skull Valley, in a semicircular basin formed by the junction of several streams.

The topography is mature and well drained. The streams in the area are largely intermittent, and water must be obtained from springs in the district.

The rather sparse vegetation in the immediate area consists mostly of grasses and a few bushes. A few miles to the north, however, yellow pine, juniper, and oak suitable for mine use may be obtained.

Rock in the area between Prescott and Skull Valley is almost entirely medium-grained light-gray granite, intruded by an irregular mass of hornblende gabbro and numerous dikes of andesite and rhyolite. The mercury ores occur generally as siliceous veins along the andesite and rhyolite dikes. Veins may occur in the granite or gabbro.

Cinnabar occurs in portions of these quartz veins with pyrite or as small veinlets in the quartz. The cinnabar-bearing portions of the veins are usually porous and stained by limonite (4). Several groups of claims have been located on these deposits, but little work has been done.

Mercury Group

The Mercury group of five claims is located on the principal zone of mineralization in the area. The property can be reached from Prescott by

proceeding southwest towards Skull Valley for 10 miles, then turning southwest on a branch road that follows a dry wash. This road goes to within one-half mile of the deposit.

The property was not being operated in 1960, and has not been extensively worked.

Other Claims

Some cinnabar reportedly has been found on the Zero Hour claim, which is in the same district as the Mercury group. The Cinnabar King and Cinnabar Queen claims also were located for mercury. No production was reported from these three claims.

Minor Districts and Occurrences, Mines and Properties

Many other occurrences have been reported in Arizona, but little production of mercury has been reported from them and insufficient work has been done on them to determine their economic importance. The locations of these deposits are shown in figure 4.

Cerro Colorado Mine (Heitzelman)

The Cerro Colorado or Heitzelman mine is on the south slope of Cerro Colorado Mountain, 45 miles southwest of Tucson. The mine has been closed for years, but traces of mercury were reported in the silver-lead ore from the mine. The mercury probably occurred in the tetrahedrite contained in the ore.

Chinle Formation

Small percentages of mercury has been reported in the Chinle Formation in northeastern Arizona, particularly near Lee's Ferry. This formation is quite extensive; outcrops of the formation extend north from Lee's Ferry more than 50 miles into Utah, south into Cameron, Ariz., and east about 100 miles into New Mexico, underlying an area of more than 100,000 square miles.

The known deposits, believed to be alluvial, were concentrated from the disintegration of the Chinle formation.

Cowboy Mine

The Cowboy mine, south of Globe, has yielded some specimens containing cinnabar.

Deadman Wash

Cinnabar reportedly occurs in Deadman Wash, 12 miles from its junction with the Verde River. This locality is 9 miles north of the National group on Alder Creek, Mazatzal Mountains. The ore supposedly is a cinnabar-bearing schist.

Fey Mine

Cinnabar has been reported at the Fey mine in the Gold Basin district, Mohave County.

J. Guy Claims

The J. Guy claims are a few miles west of the Cerro Colorado mine, and contain occurrences of cinnabar in quartz stringers. The cinnabar, sometimes present as small grains in the quartz, more often occurs as earthy masses in cavities.

Mickey Welch Claims

The Mickey Welch claims are south of Casa Grande; some specimens containing cinnabar have been found.

Nations Mercury Property (Mountain View Cinnabar)

The Nations Mercury property, also known as Mountain View Cinnabar, is 9 miles east of Apache Junction in Pinal County.

The ore is generally low grade; mercury occurs as very fine globules in a schist formation. This property has not been worked extensively. A small production has been reported.

Roadside Mine

The Roadside mine, 35 miles west of Tucson, was located for copper. Cinnabar occurs in the ore in association with pyrite, chalcopyrite, bornite, and chalcocite.

Westerdahl Claims

Samples containing cinnabar have been taken from the G. A. Westerdahl claims near Morristown.

TABLE 16. - Arizona mercury properties

Reported property name	County	Reported location	Production, flasks	Development	Mode of occurrence (mineralization, cinnabar unless otherwise noted)	Reported owners	References in bibliography
MAZATZAL MOUNTAINS DISTRICT							
Blue Bird (Red Bird, Tonto).	Gila....	Sec 12, T 7 N, R 9 E.	Occurrence.	200-foot adit and surface pits.	Quartz veinlets in schist.	C. O. Carlson..	4
Gold Creek group (Northern Light, Bernice No. 1, Big Tunnel).	do....	Sec 3, T 7 N, R 9 E.	do....	Short adits and shallow open cuts.	Quartz stringers in schist.	Robert McGhee..	4
Irl group (Bowman, Robbins, Cornucopia).	Maricopa	Sec 7, T 7 N, R 9 E.	Small.....	1,500 feet of underground workings.	Quartz veins in schist.	Irl Conway.....	4
Mercuria group.....	Gila....	Sec 3, T 7 N, R 9 E.	Occurrence.	Short adit.....	do.....	Dick Robbins...	4
National (Arizona Sunflower, Arizona Quicksilver, Sunnyside).	Maricopa	Sec 12, 13, T 7 N, R 8 E.	1,278	Extensive workings.	Veinlets in altered schist.	Allen, Allen, and Ross.	4, 5, 7
Oneida group (Ward, L & N).	Gila....	Sec 18, T 7 N, R 9 E.	Small.....	1,700 feet of underground workings.	In quartz veins in quartzite.	Tom Bolick.....	4
Ord group.....	do....	Sec 3, T 7 N, R 9 E.	2,901	Extensive underground workings.	Cinnabar, native mercury, and termatite along shear zones in altered phyllites.	Vance Thornburg	2, 4, 7
Pine Mountain group (Turnbull).	Maricopa	Sec 4, T 7 N, R 9 E.	2,341	Small open pit and 28-foot shaft.	As disseminations in brown schist.	George Cline...	4
Rattlesnake group..	Gila....	Sec 10, T 7 N, R 9 E.	Occurrence.	Test pits and trenches.	Veinlets in silicified zones in schist.	Ed and Irl Conway.	4
DOME ROCK MOUNTAINS DISTRICT							
Cinnabar group.....	Yuma....	Sec 4, T 2 N, R 20 W.	Over 150...	640-foot shaft, seven levels, inaccessible.	Filling in fault breccia in schist.	Jack Fisher....	4
Carlson claims.....	do....	Sec 31, T 3 N, R 20 W.	Occurrence.	Unknown.....	Unknown.....	C. O. Carlson..	-
French-American group.	do....	Sec 6, T 3 N, R 20 W.	do....	do.....	In association with tourmaline and quartz.	Unknown.....	4

PHOENIX MOUNTAINS DISTRICT							
Brown Mercury prospect.	Maricopa	Sec 36, T 3 N, R 3 E.	Occurrence.	Test pits.....	In foliations of schist.	Unknown.....	-
Eureka.....	do....	Sec -, T 3 N, R 3 E.	do....	50-foot shaft, 150 feet of drifts.	In vein in schist.	Louis Larsen...	4
Mercury.....	do....	Sec 27, T 3 N, R 3 E.	do....	Shallow shafts and adits.	In breccia zone in schist.	Unknown.....	4, 6
Sam Hughes or Rico mine.	do....	Sec 34, T 3 N, R 3 E.	Small.....	100-foot shaft, 500 feet of drifts.	With metacinnabarite and native mercury in vein in schist.	Sam Hughes.....	4, 6
Seal Rock.....	do....	Sec -, T 2 N, R 3 E.	Occurrence.	Test pits.....	In altered schist, with kyanite and tourmaline.	Unknown.....	6
COPPER BASIN DISTRICT							
Mercury (Cinnabar King, Cinnabar Queen).	Yavapai.	10 miles southwest of Prescott.	Small.....	Shallow shafts...	Siliceous veins in granite and gabbro.	Unknown.....	4
Zero Hour.....	do....	do.....	Occurrence.	Unknown.....	Unknown.....	do.....	4
MINOR DISTRICTS AND OCCURRENCES							
Cerro Colorado mine (Heitzelman).	Pima....	45 miles southwest of Tucson.	Occurrence.	Silver-lead mine.	In tetrahedrite along with galena and native mercury.	Unknown.....	4
Chinle Formation...	Coconino	Lee's Ferry....	do....	None.....	Ancient placer....	do.....	3
Cowboy mine.....	Gila....	South of Globe.	do....	Unknown.....	Unknown.....	do.....	-
Deadman Wash.....	do....	9 miles north of National group.	do....	do.....	In schist.....	do.....	4
Fey mine.....	Mohave..	In Gold Basin district.	do....	do.....	Unknown.....	do.....	-
J. Guy claims.....	Pima....	45 miles southwest of Tucson.	do....	35-foot shaft....	Quartz veinlets in fault zone in rhyolite.	do.....	4
Mickey Welch claims.	Pinal...	South of Casa Grande.	do....	Unknown.....	Unknown.....	do.....	-
Nations Mercury property (Mountain View Cinnabar).	do....	Sec 31, T 1 N, R 10 E.	do....	do.....	Native mercury in schist.	do.....	-
Roadside mine.....	Pima....	35 miles west of Tucson.	do....	Road cut.....	With pyrite, chalcopyrite, and other sulfides.	do.....	4
Westerdahl claims..	Maricopa	Near Morristown	do....	Unknown.....	Unknown.....	do.....	-

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CHAPTER 5. - MERCURY IN ARKANSAS

by

J. W. Chester[1]

INTRODUCTION AND SUMMARY

Arkansas mercury production was relatively short lived. Total output of about 11,400 flasks was reported from the time of the first significant mercury discovery in 1931 until production ended in 1946. About 35 mines or prospects contributed to the total and the largest mine produced only about 2,400 flasks.

There has been virtually no mercury mining activity since World War II. Development of cinnabar showings on one of the mining properties was resumed in 1958 and a 6-tube retort was constructed, but despite work on the property through 1961, no production was reported.

Practically no developed ore reserves remain and the chances for finding any worthwhile commercial ore deposits in Arkansas appear remote.

ACKNOWLEDGMENTS

The information on most of the properties listed in this chapter was obtained from numerous Federal and State publications, and from county records. A numbered list of the publications is contained in the bibliography at the end of the chapter. The cooperation and assistance of the many mine operations and individuals associated with the mercury mining industry is gratefully acknowledged.

HISTORY AND PRODUCTION

The first significant cinnabar discovery in southwest Arkansas was in 1931, and production of mercury was begun late in the same year (1).[2]

Prospecting and mining spread rapidly over the district in the next few years. Cinnabar was found at more than 100 places, but most of the district's output came from only a few mines (6).

Records of production were not complete but Reed and Wells (7) estimated that the district had produced at least 3,960 flasks of mercury by the end of 1936 although only 3,208 flasks were reported. Activities slackened in 1937 and 1938, gained in 1939 when metal prices began to rise because of World War II, and reached their peak in 1942 when 2,392 flasks of mercury was produced. The boom was over by 1944, when output dropped to 191 flasks, and since then

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[2]Underlined numbers in parentheses refer to items in the bibliography at the end of the chapter.

production of only 11 flasks in 1946 has been reported. Total reported output from the district is shown in table 17.

TABLE 17. - Production of mercury in Arkansas, 1931-46

Period:	Production, flasks
1931-36.....	3,208
1937-40.....	2,021
1941-43.....	5,936
1944-46.....	239
Total.....	11,404

The Arkansas mercury district has been idle since 1946, and many of the productive properties in the vicinity of the Little Missouri River were inundated or isolated, as shown in figure 6, by the reservoir above Narrows dam (4), completed in 1950. Cinnabar occurrences were discovered by prospecting in 1958 near the Bemis Hill mine in the eastern part of the mercury belt, and Big Red Mining Co. built a 6-tube retort there in the summer of that year to recover the mercury, but despite sporadic work through 1961, no production was reported.

PHYSICAL FEATURES

The Arkansas mercury district is in the southwestern part of the State in a narrow belt about 30 miles long, extending across Pike County into Howard County on the west and Clark County on the east (fig. 5). The district is sparsely populated. Nearby towns are Kirby, Amity, and Glenwood to the north, and Antoine, Delight, and Murfreesboro to the south. Murfreesboro is the county seat of Pike County; its population in 1960 was 1,094.

State Route 27 crosses the center of the district between Kirby and Murfreesboro. East-West U.S. Highway No. 70 intersects State Route 27 at Kirby. A branch line of the Missouri Pacific Railroad crosses the eastern part of the district through Antoine, Amity, and Glenwood.

The mercury district is within the Athens Plateau, a subdivision of the Ouachita Mountain region. The topography of the plateau is characterized by a series of long east-to-west ridges and shallow valleys. The outstanding topographic features of the district are two of these long, narrow ridges separated over most of the area by a valley about a mile wide. The maximum relief in the district is about 500 feet. The ridges and valleys are cut by two major gaps, the Little Missouri River and Antoine Creek, southeasterly flowing streams in the western and eastern parts, respectively, of the district. Much of the western part of the mercury district is now inundated by Greeson Lake, which was created in 1950 by construction of the Narrows dam on the Little Missouri River above Murfreesboro.

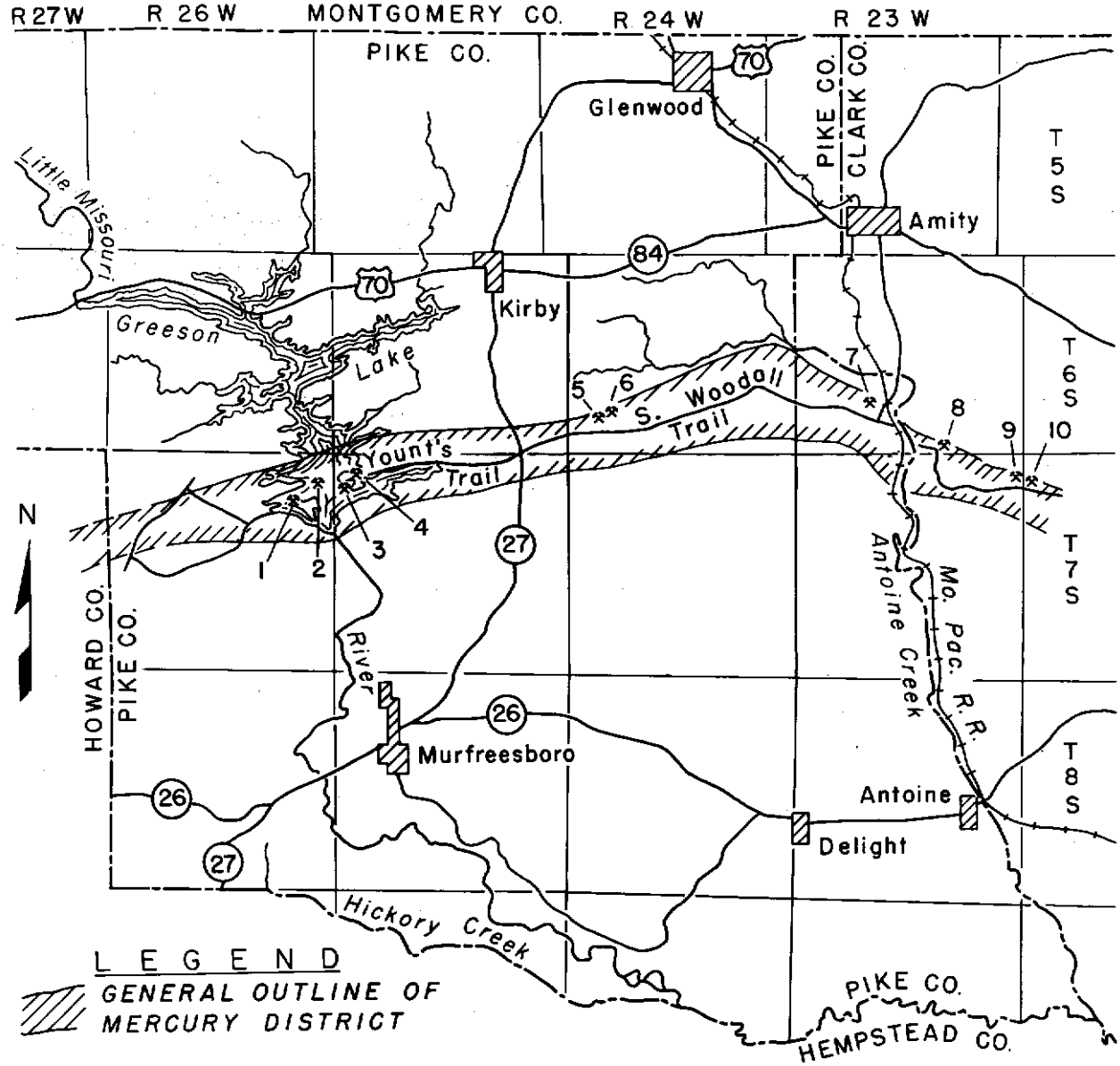

FIGURE 6. - Location Map of Mercury Deposits in Arkansas.

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The mean average precipitation is about 50 inches and mean temperature about 60° F. Vegetation is dense and includes much marketable timber. Farming and lumbering are the principal industries of the district.

GEOLOGY (1, 3, 4, 7)

Outcrops in the Arkansas mercury district are steeply south-dipping Pennsylvanian sedimentaries, including, in ascending order of age, the Stanley Shale, Jackfork Sandstone, and Atoka Formation. The surface expressions of these formations are a series of parallel ridges of sandstone and intervening valleys formed by erosion of the softer shale. The regional strike of the tilted beds is slightly north of east.

The Stanley Shale is generally less than 3,000 feet thick in the district; it contains many beds of sandstone including three members containing mercury deposits. The uppermost of these members is about 1,000 feet below the top of the Stanley. It is 100 feet thick and is separated from a lower 300-foot member, the Gap Ridge sandstone, by 150 feet of shale. The third member, 160 feet thick, lies more than 1,000 feet stratigraphically below the Gap Ridge.

The total thickness of the Jackfork Sandstone is unknown because of inadequate exposures and complicated structural features, but is believed to be about 6,000 feet. Within the district, the Jackfork is composed of about 80 percent sandstone strata and 20 percent shale. Individual sandstone beds are thin, but locally a few may be as much as 100 feet thick.

The Atoka Formation consists of about equal thicknesses of sandstone and shale. The exposures of this formation, however, are mostly outside the mercury belt.

Locally, strikes of strata exposed in the more resistant sandstone ridges in the district vary greatly but in general they correspond to the prevalent easterly trend of the mercury belt. The average dip of the beds is 80° to the south.

The rocks of the district have been deformed by four sets of fault movements with attendant crumpling. Duplication of the Jackfork Sandstone in the ridges both north and south of the older Stanley Shale reflects a major thrust fault movement from the south, which pushed the rocks northward and upward. This was named the Cowhide fault by Reed and Wells (7). The other three sets of faults are subsidiary faults within the overthrust block and are attributed to east-west compression coupled with thrusting from the south (5). The east-west compression also produced small Z- and S-shaped folds and drag folds, adjacent to faults. Structural traps formed in these folds were important loci for ore deposition.

Sandstone is the host rock of the ore deposits and cinnabar is the only ore mineral of importance in the Arkansas mercury district. The cinnabar occurs as large crystals in open fractures, as fine-grained crystals disseminated in sandstone, and as thin seams in the sandstone. Small quantities of native mercury, calomel, eglestonite, metacinnabarite, and livingstonite were

found in some of the deposits. Associated minerals are pyrite and, occasionally, stibnite. The principal gangue minerals are quartz, dickite, and limonite.

About half of the Arkansas output of mercury was produced from ore deposits in the Gap Ridge Sandstone, and the rest mainly from deposits in the Jackfork Sandstone with some from the Atoka. With few exceptions, the productive deposits were in the overriding fault blocks close, or not exceeding a mile from the major thrust fault.

The ore deposits were usually either pipelike or tabular in form. The pipelike deposits occurred at structural intersections, whereas the tabular bodies were more or less parallel to the bedding of the strata. Some ore occurred in and along the walls of quartz veins near the Little Missouri River. Mercury deposition has been ascribed to mineralized solutions that ascended major fault planes and spread out along the subordinate faults and into the folds. Localization of ore bodies apparently was controlled by increased permeability of the sandstone as a result of folding and faulting, and a relatively impermeable shale capping, which acted as a trap.

Virtually all the ore bodies mined in the district were small, with heights greatly exceeding the lateral dimensions. The largest ore body was 100 feet long, 30 feet wide, and 120 feet high; the deepest was 50 feet long and 520 feet high.

Insufficient systematic sampling and assaying were done in the district to give any reliable data on the tenors of the various ores mined. Gallagher (5) estimated, on the basis of incomplete production data, that the mercury content of all material mined before 1937 averaged 3 pounds per ton and that mined for several years after 1937 averaged about 1.3 pounds per ton. During the entire productive life of the district, the grade of sorted ore treated at the various furnaces apparently ranged from 3 to 18 pounds of mercury per ton. Soot, flue dust, and mud generated in the furnace condenser systems were usually treated in retorts, as was some of the ore produced by small operators.

In 1942, test runs were conducted by the Bureau of Mines (8) in four of the district's furnacing plants. The tests indicated that the average grade of ore fed to the plants at that time was 0.553 percent or 11.06 pounds of mercury per ton. Recovery ranged from 91.03 percent to 97.02 percent.

MERCURY MINING DISTRICTS

All of the mercury deposits in Arkansas are related to a single zone of thrust faulting and geologically may be considered a single district.

DISTRICTS AND PROPERTIES

Table 18 at the end of this chapter gives all the information which is available concerning the location, ownership, and bibliography of Arkansas mercury properties. These data are not repeated in the individual property descriptions which follow.

Arkansas Mercury District Mines and Properties

The locations of the principal mercury mines in Arkansas are shown in figure 5, and descriptions of them follow.

Bemis Hill Mine (Ozark, Big Red)

The Bemis Hill mine was one of the larger mercury producers in the district. Total output by the Arkansas Quicksilver Co. and Mid-Continent Quicksilver Corp. from 1931 to 1934 and 1935 to 1941, respectively, was over 1,600 flasks.

The ore occurred in the Jackfork Sandstone between the Amity and Cowhide faults where folding and faulting formed an exceptionally complex structure. Most of the mercury produced at Bemis Hill was derived from ore mined before 1937 from a glory hole and from adits driven into the hill to intersect the downward extensions of surface showings. Ore was produced through a vertical range of 250 feet, but no single oreshoot extended more than 50 feet vertically.

Company and custom ores were treated in a 50-ton Nichols-Herreshoff furnace. This was the only multiple-hearth furnace operated in the district; it contained six hearths with burners on the third, fifth, and sixth hearths. Fuel consumption was about 11 gallons of fuel oil per ton of ore treated.

Gap Ridge Mine

The Gap Ridge mine of Arkansas Quicksilver Mines, Inc., contains one of the largest and richest ore bodies of the district. The main opening, from which most of the ore was produced, was a stope 55 feet long, 6 to 8 feet wide, and 230 feet deep. Other workings in the eastern part of the property include a 70-foot shaft and a 130-foot shaft connected by a drift on the 50-foot level. No major structural control of the ore was evident in the Gap Ridge Sandstone.

The total reported output of mercury from this property, including the East Gap Ridge openings in the adjoining section, was nearly 900 flasks. The Gap Ridge mine was one of the largest producers prior to 1937, and was reactivated for a period in 1941. The Bureau of Mines in cooperation with the Geological Survey explored for mercury on this property in 1941.

The Gap Ridge workings are included within the Greeson Lake withdrawal area, now designated as a public use area.

Humphreys 6, Humphreys 34, and Caddo Mines

The other large mercury producers in Arkansas were in Clark County in the east end of the district. They were the Humphreys 6 and Caddo mines. In addition to the Humphreys 6, the Humphreys 34 mine was worked by Humphreys Gold Corp. from 1942 to 1944. The Caddo mine was operated by Caddo Quicksilver Corp. from 1939 to 1943.

The largest ore body found in the district--100 feet long, 30 feet wide, and 120 feet high--was at the Humphreys 6 mine. The ores in all three of the Clark County mines occurred in Jackfork Sandstone, mainly as disseminations of cinnabar rather than as small, rich pockets which were common in the western part of the district.

These mines were opened by adits, from which drifts were advanced along the zones. The ore below the adit levels was worked from interior winzes and sublevels.

Total output from the three mines in Clark County was probably about 4,000 flasks of mercury.

The ore mined by Humphreys Gold Corp. was treated in a 75-ton Gould-type rotary kiln and that of Caddo Quicksilver Corp. in a 35-ton rotary kiln.

Parker Hill Mine

The Parker Hill mine of the Arkansas Quicksilver Mines, Inc., has had a reported total output of about 2,400 flasks, and this mine was the largest producer of mercury in Pike County and the second largest producer in the district. The first discovery of cinnabar in the district was made here. The ore occurred in a sandstone member of the Stanley Shale Formation below the Gap Ridge member, and appeared to have been trapped in a pronounced fold beneath a shale that was interbedded with the sandstone.

The Parker Hill ore body had a strike length of about 50 feet and was mined from the surface to a depth of 520 feet. It was by far the deepest mine in the district. A 3-compartment shaft was sunk to a depth of 307 feet and an inclined winze from the 307-foot level to the bottom of the ore body. The ore was mined from irregularly spaced levels, 20 to 50 feet apart.

The mined ore was treated in a 15-ton-per-day rotary furnace. The tenor of the ore was reported to have been remarkably uniform throughout the depth mined. The mine is totally inundated by the Greeson Lake reservoir.

Parnell Hill Mine

The Parnell Hill mine of Arkansas Quicksilver Mines, Inc., was opened in the "Bloody Cut," a mineralized zone in Gap Ridge Sandstone, so-called because the mine water was stained red by cinnabar. This deposit, found in 1931, was one of the first cinnabar discoveries in the district and one of the richest. The open cut, from which most of the ore was produced, was 150 feet long, 8 feet wide, and 30 feet deep. Mercury output from 1932 to 1944 totaled about 500 flasks. The mine is included in the Greeson Lake withdrawal area and lies just above the flood level.

During 1941, the Bureau of Mines in cooperation with the Geological Survey explored for mercury on the Parnell Hill property.

Section 32 Mine

The Section 32 mine was worked by Mercury Mining Company in 1935-36, and Superior Mining Co. in 1941-42. The ore was in a bed of the Gap Ridge Sandstone. The mine workings consisted of a shaft 330 feet deep and numerous levels, drifts, and crosscuts. The total reported output of mercury from ores mined at this property was about 600 flasks. The mine was abandoned in August 1942.

U.S. Mine (Hintze)

The U.S. mine of U.S. Mercury Co., was the fifth largest producer of mercury in Arkansas. The ore body, discovered about 1940, was unique in that it consisted mainly of mineralized sandstone fragments and boulders surrounded by shale gouge in a wide fault zone.

The mine lies in a narrow peninsula of the Lake Greeson withdrawal area. The workings include a vertical 160-foot shaft with numerous drifts, crosscuts, and inclined raises on the 112 and 160 levels; a steeply inclined winze was sunk in a southwesterly direction from the 160-foot level with levels at 200, 230, and 270 feet below the surface. The ore between levels was mined by shrinkage stoping. The total reported output of mercury from the U.S. mine was about 900 flasks. Peak production was in 1943, its final year of operation.

The Bureau of Mines in cooperation with the Geological Survey explored for mercury on the U.S. mine property in 1941.

Valley Mine (Mac-Holmes, Caponetto)

The Valley mine worked at various times before 1944 by six or more different companies and individuals, furnished some of the richest ore in the district. The ore occurred in the Gap Ridge Sandstone and was localized by small crossfolds. The average mercury content of the ore treated was about 16 pounds per ton. Mining reached from the surface to a depth of 250 feet. The succession of operators reportedly produced about 500 flasks of mercury.

Miscellaneous Dumps

In 1944 the Bureau investigated 57 mine dumps and the calcine dumps of 13 furnaces and 4 retorts to determine the possibility of recovering mercury from them. Recoverable material, totaling 22,250 tons in only 13 of the mine dumps, or parts thereof, was considered in the estimate to have a content of about 36,000 pounds of mercury. The largest single dump included in the estimate contained 6,000 tons of rock averaging 2.5 pounds of mercury per ton. The mercury content of a 13,000-ton dump of calcines sampled by the Bureau averaged 0.4 pound per ton.

TABLE 18. - Arkansas mercury properties

Reported property name	County	Reported location	Production, flasks	Development	Mode of occurrence (mineralization, cinnabar unless otherwise noted)	Reported owners	References in bibliography
ARKANSAS MERCURY DISTRICT							
Amity.....	Clark.	Sec 19, T 6 S, R 23 W.	Occurrence.	14-foot inclined shaft, trenches.	Coating in fractures.	W. L. Deering..	7, 9
Atoka (Atlas)..	Pike..	Sec 25, T 6 S, R 23 W.	do....	Prospect pits....	In sandstone.....	W. H. Oliver...	9
Bell.....	do..	Sec 6, T 7 S, R 25 W.	Over 100...	Unknown.....	Unknown.....	Reservoir area.	2, 4, 7, 9
Bemis Hill mine (Ozark, Big Red).	do..	Sec 33, T 6 S, R 23 W.	Over 1,600.	Adits, glory hole.	In folded and faulted sandstone	Unknown.....	8
Blount occurrence.	do..	Sec 9, T 7 S, R 26 W.	Occurrence.	None.....	Unknown.....	Southern Kraft Paper Co.	9
Caddo mine.....	Clark.	Sec 1, T 7 S, R 23 W.	Not available.	Adits, drift, winzes, and sublevels.	Disseminations in sandstone.	Caddo Quicksilver Corp.	6
Cox.....	Pike..	Sec 3, T 7 S, R 25 W.	Occurrence.	Two 30-foot shafts, 20-foot trench.	In sandstone.....	A. T. Cox.....	1, 2, 4, 9
Eastburn.....	do..	Sec 5, T 7 S, R 25 W.	do....	Unknown.....	Unknown.....	Reservoir area.	2
Featherstone...	do..	Sec 2, T 7 S, R 24 W.	do....	Small trenches...	Native mercury....	A. Featherstone	9
Floyd.....	Howard	Sec 12, T 7 S, R 27 W.	Small.....	Several pits.....	In sandstone.....	O. Brown.....	7, 9
Funderburk.....	Pike..	Sec 3, T 7 S, R 25 W.	Occurrence.	Unknown.....	Unknown.....	Reservoir area.	1, 2, 9
Gap Ridge mine.	do..	Sec 11, T 7 S, R 26 W.	Nearly 900.	Two shafts.....	Rich ore body in sandstone.	do.....	3
Guess.....	do..	Sec 35, T 6 S, R 24 W.	Occurrence.	Unknown.....	Unknown.....	Ozan Graysonia Lumber Co.	1, 7
Hales (Ajax)...	do..	Sec 6, T 7 S, R 25 W.	About 100..	100-foot shaft...	do.....	Reservoir area.	2, 4, 7, 9
Henry placer...	Howard	Sec 13, T 7 S, R 27 W.	Occurrence.	Unknown.....	do.....	C. J. Henry....	9
Hintze.....	Pike..	Sec 10, T 7 S, R 26 W.	70	do.....	do.....	Ozan Graysonia Lumber Co.	2

TABLE 18. - Arkansas mercury properties--Continued

Reported property name	County	Reported location	Production, flasks	Development	Mode of occurrence (mineralization, cinnabar unless otherwise noted)	Reported owners	References in bibliography
ARKANSAS MERCURY DISTRICT--Continued							
Holmes.....	Pike..	Sec 26, T 6 S, R 24 W.	10	Unknown.....	Fracture filling..	Ozan Graysonia Lumber Co.	1, 7
Hopkins Hill...	do..	Sec 6, T 7 S, R 25 W.	1	Shallow workings.	Unknown.....	Reservoir area.	2, 4, 7, 9
Hudgins (Russell, Section 9).	do..	Sec 9, T 7 S, R 26 W.	17	30-foot shaft, several pits.	In joints.....	S. W. Russell..	1, 7, 9
Humphrey 6 mine.	Clark.	Sec 6, T 7 S, R 22 W.	Not available	Adits, drifts, and winzes.	Disseminations in sandstone.	Humphrey Gold Corp.	6
Humphrey 34 mine.	do..	Sec 34, T 6 S, R 23 W.	do....	Adits, drifts....	do.....	do.....	6
Lowery and James.	Pike..	Sec 5, T 7 S, R 25 W.	12	Shallow workings.	Unknown.....	Reservoir area.	2, 4, 7
Lula-Bell (Isbell, Craige, and Jackfort).	do..	Sec 6, T 7 S, R 24 W.	About 100..	do.....	do.....	do.....	1, 2, 4, 7, 9
Marino.....	do..	Sec 27, T 6 S, R 24 W.	Occurrence.	Two trenches.....	do.....	L. Marino.....	1, 9
Mill Mountain..	do..	Sec 12, T 7 S, R 26 W.	do....	Unknown.....	do.....	Reservoir area.	1, 2, 4, 9
Muddy Fork.....	do..	Sec 16, T 7 S, R 26 W.	About 100..	do.....	do.....	Southern Kraft Paper Co.	7, 9
Occurrence.....	Clark.	Sec 35, T 6 S, R 23 W.	Occurrence.	do.....	Disseminated.....	do.....	1, 9
Do.....	Pike..	Sec 19, T 7 S, R 24 W.	do....	None.....	Unknown.....	Unknown.....	9
Do.....	do..	Sec 21, T 6 S, R 24 W.	do....	do.....	do.....	Southern Kraft Paper Co.	9
Do.....	do..	Sec 31, T 6 S, R 24 W.	do....	do.....	do.....	do.....	9
Do.....	do..	Sec 32, T 6 S, R 23 W.	do....	Unknown.....	In sandstone.....	Ozan Graysonia Lumber Co.	1, 9
Do.....	do..	Sec 36, T 7 S, R 26 W.	do....	do.....	Unknown.....	Unknown.....	9

Palmer.....	do..	Sec 26, T 6 S, R 24 W.	do....	Several trenches and pits.	In sandstone.....	T. P. Palmer...	1, 9
Parker prospect (Big Six).	do..	Sec 12, T 7 S, R 26 W.	100	Two shafts, two winzes.	Unknown.....	G. J. Parker...	2, 4, 7, 9
Parker Hill mine.	do..	Sec 1, T 7 S, R 26 W.	2,400	Shaft, winze, several levels.	In sandstone along fold.	Reservoir area.	2, 3, 7
Parnell Hill mine.	do..	Sec 6, T 7 S, R 25 W.	About 500..	Open cut.....	In sandstone.....	do.....	2, 7
Pyle.....	Howard	Sec 13, T 7 S, R 27 W.	A few.....	Three shallow pits.	do.....	Wm. Pyle.....	1, 7, 9
Rock Fence.....	do..	Sec 13, T 7 S, R 27 W.	13	Shallow workings.	do.....	Z. A. Copeland.	1, 7, 9
Section 17 mine.	Pike..	Sec 17, T 7 S, R 26 W.	Unknown....	Several trenches.	Unknown.....	Southern Kraft Paper Co.	9
Section 32 mine.	do..	Sec 32, T 6 S, R 24 W.	600	330-foot shaft; drifts and crosscuts on several levels.	In sandstone.....	Abandoned.....	6
Section 33 mine.	do..	Sec 33, T 6 S, R 24 W.	Unknown....	None.....	Unknown.....	Southern Kraft Paper Co.	1, 9
U.S. mine (Hintze).	do..	Sec 6, T 7 S, R 25 W.	About 900..	160-foot shaft, two levels, drifts, crosscuts, and raises, a winze with several levels.	Fault zone in sandstone.	Reservoir area.	3, 4
Union (Busby) mine.	do..	Sec 31, T 6 S, R 24 W.	13	Unknown.....	Unknown.....	C. R. Irvin....	7, 9
Valley mine (Mac-Holmes, Caponetto).	do..	Sec 32, T 6 S, R 24 W.	About 500..	250-foot shaft...	Along folds in sandstone.	Unknown.....	7
Wall Mountain..	do..	Sec 35, T 6 S, R 24 W.	43	116-foot shaft, several pits.	Fracture filling in sandstone.	Ozan Graysonia Lumber Co.	7, 9
Wall Rock.....	do..	Sec 3, T 7 S, R 24 W.	1	70-foot shaft....	do.....	do.....	1, 7, 9
Wann (Old Argentine).	do..	Sec 4, T 7 S, R 25 W.	29	30-foot shaft, prospect pits.	Native mercury....	C. O. Meeks....	1, 2, 7, 9
Yantis.....	do..	Sec 6, T 7 S, R 25 W.	6	Unknown.....	Lying on edge of withdrawn area.	Ozan Graysonia Lumber Co. (Reservoir area).	7
Yenzlin.....	do..	Sec 6, T 7 S, R 25 W.	A few.....	Shallow workings.	Unknown.....	Reservoir area.	1, 2, 4, 7, 9

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CHAPTER 6. - MERCURY IN CALIFORNIA

by

George H. Holmes, Jr.[1]

INTRODUCTION AND SUMMARY

The major mining districts of California contain significant potential resources of mercury. Measured and indicated reserves of individual properties are invariably small. In the opinion of the principal mine operators the collective inferred reserves are adequate to maintain production under certain conditions for a 15-year period. Stability of market and incentive measures are the principal elements controlling future mining activities in this commodity. A vigorous program to delineate new sources or extend known reserves would provide a firm foundation for the mercury industry and serve as a safeguard against the possibility of being cut off from foreign sources of supply. Evaluation of resources for this study has been based on field reconnaissance, interviews with mine operators and industrial executives, and a literature review of reports by Federal and State agencies.

Production is handicapped by the characteristically small and low-grade deposits (as compared to foreign mercury sources), high operating cost, and the great amount of exploration and development needed to maintain ore reserves. The few large established mines supplying the major part of the State's output can produce 10,000 to 15,000 flasks of mercury per year under a price of $225 per flask, provided equipment, supply, and operating costs do not increase substantially from 1960 levels.

ACKNOWLEDGMENTS

The author thanks the many mine owners and operators for the cooperation and assistance given in assembling data concerning their properties. Special acknowledgment is made to the management and technical staff of New Idria Mining and Chemical Co., California Quicksilver Mines, Inc., and Bradley Mining Co. for detailed information on their operations; Gordon I. Gould Co., and Pacific Foundry Co., Ltd. (succeeded by Baryhell-Snow-Pacific Co. in 1962), San Francisco, Calif., for data on the manufacture and operation of furnaces and retorts; and technical personnel of the California Division of Mines, the Federal Geological Survey, and the Bureau of Mines for their many helpful contributions and suggestions.

HISTORY AND PRODUCTION

Occurrences of cinnabar in the New Almaden area were known to the Spanish explorers and settlers as early as 1834, but not until 1845 were the fabulously rich ore bodies discovered. Large-scale mining began during 1850 and continued until 1890 when the principal ore bodies were depleted. Smaller scale operations utilizing the lower grade ores have continued intermittently.

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The New Idria mine, the State's second largest producer, is reported to have been discovered in 1853 by Mexican prospectors. Operations started the following year and have been more or less continuous.

An unprecedented demand for mercury was brought about by the gold discoveries of the late 1840's and 1850's, and again during the 1860's; by large-scale hydraulic gold mining in California; and by the discovery of the Comstock lode at Virginia City, Nev. An intensive search for new mercury deposits was initiated during this period. The principal properties discovered were Guadalupe, Santa Clara County; St. Johns, Solano County; Knoxville and Manhattan, Napa County; Abbott, Lake County; Manzanita, Colusa County; Falcon or Gibraltar, Santa Barbara County; Oceanic and Klau, San Luis Obispo County.

The 1870's witnessed the greatest mercury-mining activity in the history of the State. High production continued from the already famous New Almaden and New Indria mines, and the Knoxville and Vallejo districts. In addition, the Great Western, Helen, and Sulphur Bank mines, Lake County, and many smaller properties were discovered and brought into production. The recorded production was 73,194 flasks in 1876 and 79,917 flasks in 1877, the greatest production year for the mercury mining industry in California.

Production continued high through 1883, when the richer ore bodies were depleted. Production varied between 20,000 and 36,000 flasks annually from 1884 until 1906, when it dropped below 20,000 flasks. By 1914 output had fallen to 11,000 flasks, but under the stimulus of World War I it increased to almost 24,000 flasks in 1917. The end of the war and an increase in foreign shipments caused a sharp production drop to only 3,000 flasks in 1921. From this low point, production gradually increased to 13,000 flasks in 1931, from which it fell to a depression low of 4,000 flasks in 1933. The Spanish civil war in 1936 and the World War II in 1939 caused a worldwide shortage and high prices which lifted production to 34,000 flasks in 1943. With the end of World War II, production fell to a low of 4,000 flasks in 1950, but the advent of the Korean war and the General Services Administration purchase program brought out increased production which reached 22,000 flasks in 1958. The 1960 production was 18,764 flasks. Total production from 1850 through 1961 was over 2,772,000 flasks.

By 1895 the principal mineral-bearing areas had been discovered. Except for the Challenge mine in the Emerald Lake district, in San Mateo County, developed in 1955, no significant discoveries of new districts have been made since. Well planned exploration, however, has resulted in the discovery of many new ore bodies at the older mines. Principal mining activities during 1956-61 were in Lake, Sonoma, San Mateo, Santa Clara, San Benito, San Luis Obispo, and Santa Barbara Counties.

A tabulation of mercury production in California for 1850-1961 is shown in table 19.

TABLE 19. - Production of mercury in California, 1850-1961

Year	Flasks	Year	Flasks	Year	Flasks
1850	7,773	1888	33,469	1926	5,651
1851	27,962	1889	26,637	1927	5,672
1852	20,132	1890	23,077	1928	6,977
1853	22,431	1891	23,055	1929	10,139
1854	30,201	1892	28,177	1930	11,451
1855	33,217	1893	30,362	1931	13,448
1856	30,197	1894	30,616	1932	5,172
1857	28,390	1895	36,304	1933	3,930
1858	31,204	1896	30,967	1934	7,808
1859	13,086	1897	26,867	1935	9,271
1860	10,066	1898	31,297	1936	8,693
1861	35,230	1899	29,647	1937	9,743
1862	42,276	1900	26,490	1938	12,277
1863	40,798	1901	26,896	1939	11,127
1864	47,801	1902	29,163	1940	18,629
1865	53,349	1903	30,727	1941	25,714
1866	46,856	1904	29,073	1942	29,906
1867	47,309	1905	24,311	1943	33,812
1868	48,042	1906	20,043	1944	28,052
1869	34,033	1907	17,202	1945	21,199
1870	30,275	1908	16,760	1946	17,782
1871	31,894	1909	15,866	1947	17,165
1872	31,829	1910	16,985	1948	11,188
1873	27,824	1911	18,612	1949	4,493
1874	27,939	1912	20,254	1950	3,850
1875	50,581	1913	15,386	1951	4,282
1876	73,194	1914	11,154	1952	7,241
1877	79,917	1915	14,095	1953	9,290
1878	64,300	1916	20,768	1954	11,262
1879	74,169	1917	23,623	1955	9,875
1880	60,320	1918	22,366	1956	9,017
1881	61,251	1919	15,005	1957	16,511
1882	53,029	1920	9,719	1958	22,365
1883	47,032	1921	3,015	1959	17,100
1884	32,123	1922	3,360	1960	18,764
1885	32,284	1923	5,375	1961	18,688
1886	30,178	1924	7,861		
1867	33,983	1925	7,514	Total	2,772,117

PHYSICAL FEATURES

The general topography of the mineral-bearing areas varies from gentle sea-level slopes to rugged terrain exceeding 4,000 feet in elevation. The larger mines are accessible by good State and county roads. Many of the smaller prospects and abandoned properties can be reached only by poor roads and trails. Electric transmission lines extend to most of the principal producing properties; however, some of the large mines and smaller operators depend on locally generated power. Water supplies are adequate from local sources. Timber is trucked from nearby towns or local sawmills.

Local towns which are supply centers for machinery, equipment, and provisions are not too distant from any of the properties. Transport truck and railroad facilities are within reasonable distances.

The climate is generally temperate in the north and central areas, although winter operations in the extreme northern counties are often impeded by heavy snowfalls. Seasonal rains in some areas also may cause temporary shutdowns, but operations usually continue throughout the year.

GEOLOGY

The mercury deposits in California are classified as hypogene or primary in origin. The majority occur in rocks of the Franciscan Formation comprising sandstone, graywacke, shale, chert, and conglomerate, which have been extensively folded, faulted, fractured, and intruded by large masses of peridotite, hydrothermally altered to serpentine. Ascending mineral-bearing solutions, progressing along major faults and shear zones, easily penetrated the fractured sedimentary rocks and crushed serpentine. Ore bodies were deposited where the solutions were trapped or dammed by an impervious capping of fault gouge, fine-grained overlying rocks, by rolls, or bends in faults which formed inverted troughs, or by abrupt changes in strike of the fault planes. These barriers limited the upward flow of the solutions and confined their precipitation to the fractured and porous rock masses, and assisted in the replacement of the host rock by mercury minerals.

The ore bodies were formed by the filling of fractures and the interstitial spaces of porous rock masses underlying relatively impervious material and by replacement processes. The deposits are relatively shallow, extremely irregular, of limited vertical and horizontal extent and occur as veins, pipes, stringers, or tabular bodies along faults, fault intersections, and shear zones; as fillings in breccia zones; as bunches, lenses, pods, disseminations, or stockworks in the adjacent wall rock; and as lenses or pods in silica-carbonate rock. Silica-carbonate rock is formed by hydrothermal alteration of serpentine along faults or fault contacts with sedimentary rocks. Its composition is mainly chalcedony and carbonates. It is often called "quicksilver rock" because of its frequent association with mercury ore bodies.

Deposits also occur along fault zones in schist, contacts with basic dikes, faults in altered andesite and diorite, breccia zones in conglomerate, and opalized sinter vents of hot springs. Minable concentrations have been found in topsoil overlying serpentine and silica-carbonate rock.

Mineralization is mainly cinnabar, associated with marcasite and pyrite. Metacinnabar and native mercury often are found associated with the cinnabar. Calomel, tiemmanite, and other rare mercury minerals occur in a few deposits. Gangue minerals include calcite, dolomite, quartz, opal, and chalcedony. The mercury minerals occur as veinlets, paint, crystalline fillings, and incrustations in the fissures, fracture zones, and other openings and as irregular replacement patterns of rock minerals.

The tenor of the ore varies greatly, ranging from 5 to 200 pounds of mercury per ton. The grade of ore currently furnaced averages 8 to 12 pounds of mercury per ton; retort ore grades upward from 12 pounds per ton.

A brief description of the geology, type of deposit, and mode of occurrence is given for each mine under the individual sections on the mercury mining districts (49, pp. 364-370; 54, 55, pp. 7-12).[2]

MERCURY MINING DISTRICTS

The mercury mining districts in California are shown in figure 7. The principal deposits with significant production occur within the Coast Range along a southeast-trending belt extending from Clear Lake on the north to Santa Barbara on the south. This belt is about 400 miles long and up to 75 miles wide.

Mining districts in the Coast Range contributing a major production are as follows:

District:	County
Clear Lake	Lake
Wilbur Springs	Lake, Colusa
Knoxville	Lake, Napa, Yolo
East Mayacmas	Lake, Napa
West Mayacmas	Sonoma
Guerneville	Do.
Oakville	Napa, Sonoma
Sulphur Springs Mountain (Vallejo)	Solano
Mount Diablo	Contra Costa
Emerald Lake (Redwood City)	San Mateo
New Almaden	Santa Clara
Stayton	Merced, San Benito, Santa Clara
Central San Benito (Panoche)	San Benito, Fresno
New Idria	San Benito, Fresno
Parkfield	Kings, Monterey
Cambria-Oceanic	San Luis Obispo
Adelaide	Do.
Rinconada	Do.
Cachuma	Santa Barbara
Los Prietos (Gibraltar)	Do.

[2]Underlined numbers in parentheses refer to items in the bibliography at the end of the chapter.

FIGURE 7. - Location Map of Mercury Districts in California.

Mining districts contributing a minor production are as follows:

District:	County
Skaggs Springs	Sonoma
Petaluma	Marin
Del Puerto	Stanislaus
Orestimba	Do.
Bryson and San Carpoforo	San Luis Obispo
Pine Mountain	Do.

Mining districts outside the Coast Range are as follows:

District:	County
Diamond Creek	Del Norte
Patrick Creek	Do.
Klamath River	Siskiyou
Alturas	Modoc
Altoona	Trinity
New River	Do.
Mill Creek	Humboldt
Clover Creek	Shasta
Occident	Mendocino
Nashville	El Dorado
Mogul	Alpine
Bridgeport	Mono
Coso	Inyo
Tehachapi	Kern
Tustin	Orange
San Bernardino County	San Bernardino

DISTRICTS AND PROPERTIES

Table 20 at the conclusion of this chapter lists every known mercury property in the State and gives the salient facts concerning each. In the interest of brevity the following individual property descriptions do not repeat location and ownership data or general references.

Clear Lake District Mines and Properties

The Clear Lake mining district, in south central and southeast Lake County, has been one of the State's major mercury-producing districts, with an output from 1870 to 1961 of about 129,000 flasks. Nearly all of the production came from the Sulphur Bank mine. Several minor properties contributed a small output. Production was intermittent, with periods of activity coinciding with corresponding periods of high mercury prices.

The district has a moderate production potential with output dependent on the price of mercury. The largest reserve remains at the Sulphur Bank mine, although the spotty character of the deposits makes any estimate difficult.

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Open-pit mining of the pipelike ore bodies is necessarily a high-cost operation due to the excessive amount of stripping required. Further work in the Baker mine area could possibly develop a sufficient tonnage of low-grade ore to maintain a small operation. Other prospects in the district have been explored with negative results; the possibility of developing commercial-grade ore at 1961 prices is remote.

Baker Mine

The Baker mine, about 6 miles southeast of Lower Lake at an altitude of 1,700 feet, was discovered in 1870 and worked intermittently until 1933. It was reactivated in 1955-56. Production was small.

Two parallel cinnabar-bearing mineralized zones of varying widths, which extend northwesterly along Franciscan shale-serpentine contacts, have been explored by shallow shafts, adits, and open cuts. The main inclined shaft is accessible to the 98-foot level from which the north drift has been partially rehabilitated. An open cut was excavated on an ore zone about 900 feet northwest of the shaft. Ore produced averaged 3 to 5 pounds mercury per ton.

A 10-ton reduction plant includes a jaw crusher, 18- by 1½-foot horizontal oil-fired rotary furnace, banks of 16 and 5 vertical pipe condensers, and a single D retort. Power is furnished by a diesel electric generator.

Baxter Prospect

The Baxter prospect, 6 miles southeast of Kelseyville, has been inactive since 1929.

Cinnabar occurs in narrow fractures in rhyolite and obsidian. Only a few flasks of mercury have been produced.

Lucitta or Konokoti Property

The Lucitta, or Konokoti, property comprises 4 claims, about 7 miles southeast of Kelseyville. After discovery during the 1880's, the property was prospected sporadically until 1945.

Shamrock Prospect

The Shamrock prospect, about 10 miles northeast of Lower Lake, has been inactive since 1918. History of the property is sketchy and no trace of past activity remains. No production was reported.

Sulphur Bank Mine

The Sulphur Bank mine, one of the State's largest producers, is owned by Bradley Mining Co., San Francisco, Calif. The property, comprising 800 acres, is located along the southeast arm of Clear Lake, about 13 miles by road northwest of Lower Lake and 2 miles south of State Route 20, at an altitude of 1,350 feet.

The property was located in 1865 and worked for free sulfur. The presence of cinnabar below the sulfur-bearing horizon was known, as it caused difficulty in refining the sulfur. The high price of mercury during the 1870's, and a drop in the price of sulfur, were decisive factors in starting mercury-mining operations. Production from underground openings continued for 10 years. Several companies operated the mine intermittently until 1906 when the sulfur dioxide gases and excessive heat made underground mining difficult and forced abandonment of the operations. In 1915 the Sulphur Bank Association acquired the mine and commenced open-pit mining. Operations continued through 1919. Open-pit mining was resumed in 1927 and continued until 1950. The mine was reactivated in 1955.

Rocks in the mine area include Franciscan sandstone and shale overlain by breccia interbedded with lenses of conglomerate and sandstone, which are capped by an andesite flow. All of the rocks have been altered by hydrothermal action. The formations are cut by two major sets of faults; the main zone, which trends easterly and dips to the south, is intersected by a series of steeply dipping, northwest-trending faults.

The ore bodies, structurally controlled by the fault zones and their intersections, occur as high-grade stringers along jointing and sheeting planes in the altered andesite, along the contact of the andesite and the underlying breccia and conglomerate, and as pipelike bodies which follow the pitch of fault intersections in the lower Franciscan sandstone and shale. Commercial deposits have been found from 30 to 40 feet below the surface to a depth of 150 feet.

Surface mining was from a series of connected open pits extending over a wide area. Underground operations were conducted through four major and three minor shafts. Operations in 1957 were from an open cut along the main fault zone at a depth of 150 feet, about 100 feet below the water level of Clear Lake.

Benches in the open pit are about 20 feet wide with 15-foot vertical faces. The ratio of waste to ore mined is high, ranging from 50:1 to 80:1. Broken material is loaded by 3/4- and 1½-yard power shovels into 15-ton-capacity diesel-driven end-dump trucks, which haul ore to the furnacing plant and waste to the mine dumps.

The 60-ton reduction plant includes a jaw crusher, belt conveyors, a 5- by 60-foot oil-burning rotary furnace, fired concurrently to insure complete combustion of the sulfur in the ore, a cyclone dust collector, a series of black iron, tile, and stainless steel vertical pipe condensers, and concrete settling tanks and wooden stack. Soot is treated in a mechanical hoeing machine, and the remaining residue is burned in a 2-D oil-fired retort. Calcines drop to a rotary steel cooler, pass to a steel storage bin, and then are trucked to the waste dump.

Production rate is 60 tons daily; grade of the ore averages 5 pounds of mercury per ton. Fifteen men are employed.

Utopia Property

The Utopia property near Bartlett Landing has been inactive since 1918. No data are available on geology or mine workings. Production was small. The mineralized zone reportedly extended beneath Clear Lake and subsequent flooding of the mine workings caused cessation of operations.

White Elephant or King of All Group

The White Elephant or King of All group, about 10 miles north of Middletown, was prospected prior to 1918; the property has been inactive since. Two short adits were driven along a mineralized zone in serpentine. No production was made.

Wilbur Springs District Mines and Properties

The Wilbur Springs mining district in western Colusa and eastern Lake Counties has been a moderate and consistent producer of mercury since 1862. About 56,000 flasks was produced through 1961. The largest output came from the Abbott mine, with significant production from the Manzanita and Wide Awake properties and a small combined output from other mines in the district. Production, as in other districts in the State, has been intermittent, with maximum activity during periods of high mercury prices. The district is a potential source of mercury with output dependent on relatively high metal prices. Underground operations make for high mining costs and extensive exploration and development is necessary to assure a steady rate of production. The Central and Empire, Manzanita, and Wide Awake mines in the Wilbur Springs area of the district have been idle since 1943. Known ore bodies have been depleted, but geologic conditions appear favorable for the discovery of new mineralized areas. Extensive exploration and development are justified, however, only by high mercury prices and assurance of a stable market. Past work on several of the smaller properties indicated that further investigation might encounter significant tonnages of commercial-grade ore.

Abbott Mine

The Abbott mine is owned by the Abbott Mines, Inc., Williams, Calif. The property includes 400 acres in Lake County, at an altitude of 2,100 feet along California State Route 20 about 24 miles west of Williams.

The mine was located in 1862 and has been an intermittent producer since 1870. Principal production was during 1889-1906 when output exceeded 30,000 flasks. The next operating period was in 1916-17, followed by very limited operations during 1917-40. The International Metals Development Corp. operated the property from 1940 until 1946, when it was acquired by the Abbott Mines, Inc. The Bureau of Mines explored the property in 1948 by diamond drilling, with favorable results. Production has been continuous since then.

Defense Minerals Exploration Administration (DMEA) exploration contracts were in force during 1951-57 to explore the southeastward extension of two hydrothermally altered brecciated serpentine dike systems. Work consisted of

7,847 feet of surface and underground diamond drilling, 815 feet of rehabilitation, and 3,474 feet of drifts, crosscuts, and raises. Cost of the work was about $156,000. In 1960 an Office of Minerals Exploration (OME) loan was initiated to test the Back Dike ore zone to the northwest of the Back Dike ore body. Work done included 450 feet of drifting and 295 feet of diamond drilling, plus rehabilitation work. The cost was about $24,000.

The Abbott ore bodies are contained in complex zones of dikes and sills of serpentine breccia which are interbedded with shale and sandstone beds of the Paskenta Formation of Lower Cretaceous age. Cinnabar occurs with abundant marcasite and some sulfur as fracture fillings in the opalized and altered breccia and in tabular, pipelike, or podlike ore bodies along low-dipping parts of contacts, faults, and fault intersections. The ore bodies vary greatly in size and extent.

Production is entirely from underground operations, as the character of the ore bodies precludes open-pit mining. Operations are from the 200 and 300 levels of the vertical main shaft, and from the Glory Hole, Ventilation, and Turkey Run adits. Mine workings extend for about 3,000 feet laterally and to a maximum depth of about 500 feet. Mineralized areas have been explored extensively by diamond drilling and underground openings.

Stope sizes vary considerably and the comparatively flat dip (35°-45°) of the ore bodies requires a modified method of square-set stoping to suit the particular ore body. Little backfilling is used. Broken material is removed from the stopes by slusher scrapers.

The reduction plant includes a jaw crusher, two 4- by 50-foot, 45-ton-capacity oil-fired rotary furnaces, cyclone dust collector, fan, two banks of vertical pipe condensers, and wooden flue and exhaust stacks. Soot is treated in a mechanical hoeing machine; the residue is burned in two oil-fired D retorts. Calcines drop to a concrete bin and are hauled by mine car to the waste dump.

Power is furnished by diesel electric generators. Production rate is 50 to 60 tons daily; grade of the ore averages 10 to 15 pounds of mercury per ton.

Central and Empire Group

The Central and Empire Group consists of 6 claims comprising 70 acres, in Colusa County, at an altitude of 1,400 feet near the Wilbur Springs resort, about 24 miles southwest of Williams. The Central claims are on the north side and the Empire claims on the south side of Sulphur Creek.

The property was located during the 1870's, but no significant production was made until 1926 when lessees produced a reported $10,000 worth of mercury from the Central group. The mine has been idle since 1927, except for a small production reported in 1942.

Cinnabar occurs erratically in narrow seams and stringers in silicified and brecciated serpentine near a serpentine-shale contact. The mineralized zone was reported to be 25 to 30 feet wide and to extend to a depth of 50 feet.

Mine workings, now caved, include several hundred feet of drifts and crosscuts. No machinery or equipment is on the property.

Elgin Mine

The Elgin mine is near Wilbur Springs in Colusa County, at an altitude of 2,500 feet.

After discovery in 1875, several unsuccessful attempts were made to produce sulfur. Some development work was done during 1892-93 and again in 1905-06 with a small production of mercury. Further activity during 1917 and 1929 was unproductive. No attempt to produce mercury has since been made.

The property is in an area of hot springs activity. The country rocks, serpentine and shale, have been hydrothermally altered by the hot water and gases. Cinnabar, associated with sulfur and calcium and magnesium carbonates, occurs in a silicified zone in the serpentine.

Mine workings include numerous surface cuts and about 500 feet of underground openings, now inaccessible. High rock temperatures, with hot water and gases, made underground mining difficult.

Manzanita Mine

The Manzanita mine comprises 54 acres in Colusa County, about 1 mile west of Wilbur Springs at an altitude of 1,500 feet.

The property was discovered in 1863 and operated as a gold mine for many years. Cinnabar was recovered as a byproduct. From 1902 to 1942 intermittent operations by various companies and lessees yielded over 2,500 flasks of mercury.

Rocks in the area include thinly bedded altered shale, sandstone, and conglomerate, which have been highly faulted and fractured. An irregular-trending silicified zone carrying gold and cinnabar crosses the sedimentary rocks.

The deposit was mined through haulage drifts, adits, and a series of glory holes, all largely inaccessible.

Rathburn Group

The Rathburn group of 5 claims in Colusa County, about 4 miles north of Wilbur Springs at an altitude of 2,000 feet, was worked intermittently prior to 1892. Greatest activity was during 1892-93 when over 100 flasks of mercury was produced. The mine was abandoned in 1915 and relocated in 1956. Activities include road building, bulldozer trenching, and shaft rehabilitation.

Cinnabar occurs in silicified fractures in serpentine. The old mine workings, which explored these mineralized fractures, have caved.

Wide Awake or Buckeye Mine

The Wide Awake or Buckeye mine is in Colusa County, about 1 mile southwest of Wilbur Springs at an altitude of 1,500 feet.

The mine was discovered during the 1870's and worked extensively for several years with a reported output of 1,800 flasks of mercury produced from ore mined from comparatively shallow workings along a serpentine-shale contact. A 470-foot vertical shaft with levels at 190, 290, and 390 feet was sunk during 1896. A small production was made but operations terminated in 1900. Some work was done in 1932 and 1943, and a moderate production was reported. The shaft has since caved and filled with water.

Cinnabar occurs in opalized and altered serpentine breccia along a serpentine-shale contact. The mineralized zone strikes northwest, dips to the southwest, and is traceable on the surface for about a mile. The minable vein on the 190-foot level was reported to be 5 feet wide, with a zone of lower grade material extending to a width of 16 feet.

Mine workings are extensive and include the vertical shaft with three levels and numerous shallow drifts, crosscuts, and stopes, all largely inaccessible.

Wilbur Hill Prospect

The Wilbur Hill prospect in Colusa County, is about one-half mile west of the Wilbur Springs resort. A few flasks of mercury were produced in 1916 from ore occurring in a narrow, mineralized fracture in sandstone and shale. The property has been idle since 1918.

Knoxville District Mines and Properties

The Knoxville mining district comprises an area in northern Napa, northwest Yolo, and southwest Lake Counties and has been a major mercury-producing district, with an output of over 160,000 flasks since 1862. Principal production came from the Knoxville mine, the State's fifth largest producer, with an output during its life in excess of 121,000 flasks. The Reed and Manhattan mines contributed the greater part of the remaining output. Activities were based on high mercury prices; operations declined rapidly when lower prices prevailed.

Under substantially higher mercury prices, a small production from the Knoxville mine could be obtained from marginal-grade ore remaining in place and from stope fill.

The Reed mine offers the best possibility of the district for new production. Continued exploration could encounter new mineralized zones with sufficient ore to support a moderate operation. Again, high mercury prices would be necessary to offset high exploration and mining costs.

Other mines in the district are capable of yielding a small annual production, although much exploration and development is needed. Areas on these properties appear geologically favorable for the occurrence of cinnabar-bearing mineralized zones.

Harrison Mine

The Harrison mine consists of 4 patented claims and 560 acres in Yolo County, about 19 miles southeast of Lower Lake. Altitudes at the mine range from 1,650 to 1,800 feet.

The property was located before 1900 and a few flasks of mercury were produced. Intermittent operations during 1917-18 and 1937-45 resulted in additional small production.

Ore bodies occur in small masses of silica-carbonate rock sporadically distributed along a broad northwest-trending fault zone between serpentine and Knoxville sandstone and shale. Cinnabar occurs in veins and disseminations in the silica-carbonate rock and fault gouge.

Work under a DMEA contract was started in 1957 and completed in 1958. The $28,540 contract comprised drilling a series of diamond-drill holes designed to explore for cinnabar-bearing silica-carbonate bodies within a northwest-trending fault zone. A total of 3,024 feet of drilling was done.

Inaccessible mine workings consist of four adits and several hundred feet of drifts and crosscuts formerly connected to a 125-foot vertical shaft.

Knoxville Mine

The Knoxville mine is in Napa County, 21 miles southeast of Lower Lake, at an altitude of 1,300 feet.

The property was discovered in 1862 and reached peak production during the 1870's. For many years it remained an important producer of the district, ranking fifth in production among the mercury mines of the State. The mine was abandoned and reopened several times between 1903 and 1927. The Gamble brothers acquired the property in 1927. During 1928-31 production averaged over 700 flasks of mercury yearly but decreased rapidly in 1932 and ceased entirely in 1937. From 1941 to 1945, production averaged almost 500 flasks annually from old mine and calcine dumps and from placer material; thereafter production dropped sharply and none has been reported since. Total production from the mine exceeded 121,000 flasks.

The mine is on a northerly trending, easterly dipping thrust fault between serpentine and sandstone and shale. Two east-trending fault zones north and south of the mine limit the extent of mineralization. Cinnabar and metacinnabarite occur in black silica-carbonate rock and gouge along the thrust fault and to a lesser extent along a south cross fault. The mineralized zone narrows perceptibly at depth.

Most of the mine workings have caved and are inaccessible, but they comprise about 15,000 feet of underground openings on several levels over a strike length of about 1,100 feet and an inclined depth of 600 feet. The 40-ton rotary furnace plant has been dismantled.

Manhattan Mine

The Manhattan mine is in Napa County, about 20 miles southeast of Lower Lake, at an altitude of 2,000 feet.

Cinnabar was discovered in the area during the 1860's and the mine operated during 1862-93 and 1895-1905. Since then operations have been intermittent, and only a few hundred flasks of mercury have been produced. Much of the mine's production was included with the output of other properties in the district, but production estimates are a little over 16,000 flasks.

Rocks in the area consist of interbedded basalt and tuff overlain by hot springs deposits and underlain by a northwest-trending fault. Cinnabar occurs in small irregular veins filling joint cracks in the volcanic rocks, as local disseminations in the wall rock adjacent to the veins, and along a fault zone between altered basalt and serpentine.

Mine workings are extensive and include several small and large open pits, a glory hole, shallow shaft, and numerous drifts and crosscuts.

Northern Light Prospect

The Northern Light prospect has been inactive for many years. A weakly mineralized, silica-carbonate zone was prospected, but no production was made.

Red Elephant Mine

The Red Elephant mine is in Lake County, about 20 miles southeast of Lower Lake, at an altitude of 2,200 feet.

The property was located in 1898. Considerable development was done in 1918 but no mercury produced. Intermittent operations from 1929 to 1942 yielded a few hundred flasks. A 20-ton-capacity rotary furnace plant was installed in 1942, but operations were suspended during that year and the mine has been idle since.

The mineralized area is a narrow belt of silica-carbonate rock along a northwest-trending shear zone in serpentine. Cinnabar and native mercury occur in narrow veins crossing the shear zone. The gouge along the shear zone is reportedly cinnabar bearing, but its soft character made mining uneconomic.

Mine workings include the main adit, numerous drifts and crosscuts, and several shafts which explored the shear zone for a length of about 400 feet over an inclined depth of 108 feet. Caving and flooding have made the underground openings inaccessible.

All equipment and machinery have been removed from the property.

Reed Mine

The Reed mine includes 370 acres, about 17 miles southeast of Lower Lake, at an altitude of 1,600 feet.

The property was discovered in 1870, and production during the following decade was about 10,000 flasks of mercury. A long period of inactivity followed which ended in 1940 when the mine was acquired by its present owner. During 1940-47 it was the largest producer of the district, with output of over 16,000 flasks. Operations were suspended late in 1947 because of increased mining costs and a decrease in the price of mercury. Cleanup operations yielded 309 flasks of mercury through 1954. The mine was reactivated by lessees in 1955, and in 1957 the property was leased to Trans-Pacific Metals Inc., Houston, Tex. During 1958-61 a DMEA contract was in effect to explore a silica-carbonate body northwest of the main mine workings. Work done included rehabilitation, 925 feet of drifting, and 3,776 feet of diamond drilling, at a total cost of $102,000.

The property lies on a steep northwest-trending fault between serpentine and sandstone. Cinnabar deposits are in bodies of silica-carbonate rock which occur along the edges of the serpentine and in separate blocks in the gouge zone. The silica-carbonate zone extends for about a mile along the fault and ranges in width up to 100 feet. Most of the oreshoots are in silica-carbonate rock adjoining the footwall gouge. Cinnabar and metacinnabarite occur as small veins and local disseminations in the silica-carbonate bodies and to a limited extent in the gouge.

The mine workings are extensive and are accessible through the main haulage level and a vertical underground shaft from which several levels were driven. They explore the fault zone for a strike length of about 1,400 feet over a vertical range of 400 feet. Workings along the northwest end of the mineralized zone include numerous bulldozer trenches, a crosscut adit, and several drifts.

The original 13-ton rotary furnace and a 40-ton rotary oil-fired furnace remain. The reduction plant also includes a jaw crusher, dust collector, vertical pipe condensers, settling tanks, and stack. Soot is treated in a mechanical hoeing machine; residue is burned in a retort.

Soda Springs Prospect

The Soda Springs prospect comprises one patented claim in Yolo County, a short distance northeast of the Harrison mine at an altitude of 1,800 feet.

A few flasks of mercury were produced from ore mined from three small cinnabar-bearing veins in silica-carbonate rock.

East Mayacmas District Mines and Properties

The East Mayacmas mining district in northwest Napa and southern Lake Counties has been one of the principal mercury-producing districts of the State with an output of over 390,000 flasks, obtained chiefly from the Oat Hill, Great Western, Aetna, and Mirabel mines. The Helen, Corona, and Twin Peaks mines contributed a moderate production, and a minor output came from many smaller properties. Nearly all of this production was made between the early 1870's and 1944; only a small production has been made since.

The known ore reserves of the district have been depleted. Underground openings in the principal mines are caved and little exploration has been done in recent years. Existing mercury prices have not encouraged further activity, due principally to costly mine rehabilitation, the great amount of exploration and development necessary, the high cost of underground mining, and the large capital investment required to support a major operation.

The district has, in the past, been extensively prospected, but it is possible that new mineralized sections in geologically favorable areas and extensions of known ore bodies could be located. Although it is unlikely the district can again reach its past production peak, it still has a moderate production potential. Substantially higher mercury prices and a stable market must prevail before any large-scale activity can be assured.

Work in several areas will yield a small annual production. Exploration in the Anderson Springs area could encounter small commercial ore bodies, as could work in the Helen, Chicago, and Wall Street mines. The former productive Mirabel-Great Western area is inactive, but based on its past record and favorable geologic aspects, extensive exploration for new mineralized sections and lateral and downward continuations of known deposits appear justified.

It is probable that the Oat Hill area could again yield a substantial output, both from remnants of marginal-grade ore bodies and stope fills and from new deposits along the mineralized faults, although a great amount of rehabilitation and exploration would be required. Exploration in the Corona-Twin Peaks area could develop sufficient ore to support a moderate operation. Mines in the Aetna Springs area have been inactive since 1944, but its past production record and the possibility of developing significant tonnages justify exploration for lateral extensions of known mineralized areas.

Aetna Mine

The Aetna mine comprises 5 patented claims in Napa County, about 18 miles north of St. Helena at altitudes ranging from 1,000 to 1,800 feet.

Cinnabar was discovered in 1854, and the property was intermittently worked until 1943. Principal periods of production were from 1868 to 1880 and from 1894 to 1900. A moderate output of mercury also was made from 1912 to 1918, 1926 to 1935, and 1941 to 1943. The mine has been inactive since 1944. Production is estimated at 66,000 flasks of mercury.

The mine was developed chiefly by adits, inclined raises, and a large open pit. Four geologically distinctive deposits were developed by the Phoenix, Star, Pope, and Silver Bow workings. The underground workings have caved.

The Phoenix workings consist of an open cut, glory holes, and 3 levels aggregating several thousand feet over a vertical range of about 200 feet, exploring 3 steeply dipping, nearly parallel, northwest-trending mineralized zones of silica-carbonate rock in serpentine. Cinnabar occurs along fractures and disseminated in the silica-carbonate rock.

The Star workings comprise several thousand feet of drifts and crosscuts over a vertical range of about 250 feet, from which several widely spaced ore-shoots were developed along northwest-trending faults and splits of these faults, in Franciscan sandstone and shale.

The Pope workings consist of two short isolated adits along a poorly defined breccia zone in Franciscan sandstone, shale, and chert. Cinnabar occurs as fracture filling in lenses of chert.

The Silver Bow workings include main adits and numerous levels, sub-levels, and stopes over a 900-foot vertical range, along a zone of brecciated Franciscan sandstone and shale on the hanging wall of a northerly striking, easterly dipping basalt dike. Cinnabar occurs in the dike and along the breccia zone.

Aetna Extension Mine

The Aetna Extension mine adjoins the Aetna mine. The property was discovered during the 1890's, and intermittent periods of work up to 1943 consisted of surface and underground exploration of the extension of the mineralized breccia zone along the hanging wall of the Silver Bow basalt dike, which was developed extensively at the adjoining Aetna mine. Workings include numerous bulldozer cuts and two long crosscut adits (partially caved), 235 feet apart vertically. The lower adit had reportedly reached the breccia zone when operations were suspended. No mercury was produced.

In 1956, development work comprised bulldozer stripping over a wide mineralized zone in an area east of the old workings. Cinnabar occurs disseminated along fractures and shears in Franciscan sandstone and shale. Bulldozed material was tested in a sampling plant.

Anderson Springs Mine

The Anderson Springs mine in Lake County, is about 5 miles west of Middletown at an altitude of 1,750 feet.

Cinnabar was discovered before 1917, but it was not until 1929 that the property was explored and a few flasks of mercury recovered. The mine was active during 1931-32 and 1937-38, and a small production of mercury was made.

Mine workings, which have caved, include several short adits and open cuts and a shallow shaft that explored two cinnabar-bearing faults in highly altered and fractured Franciscan sandstone. High temperatures made underground exploration difficult.

Bacon Consolidated Mine

The Bacon Consolidated property in Lake County, about 6 miles west of Middletown, was located in 1859. A reported 300 flasks of mercury was produced during 1876-77. Apparently a ledge of cinnabar-bearing silica-carbonate rock was explored. Mine workings are caved and the property abandoned.

Big Chief Mine

The Big Chief mine in Lake County adjoins the Anderson mine. The mine was worked intermittently from 1916 to 1945 by various operators. A reported 325 flasks of mercury was produced from ore, which averaged 10 to 20 pounds of mercury per ton.

Numerous trenches and open cuts have been excavated along surface exposures. Underground workings, which have caved, included several thousand feet of adits which explored fault and breccia zones in highly altered sandstone and chert. Cinnabar occurs disseminated in the sandstone and along fractures in the chert.

A two-pipe gas-fired retort has been constructed in recent years.

Big Injun Mine

The Big Injun mine consists of nine claims in Lake County, about 7 miles west of Middletown at an altitude of 2,500 feet.

The deposit was reportedly discovered in 1873, but no work was done until 1916-17 when a small amount of mercury was produced. The mine was idle until 1955 when it was reactivated by the present lessees. A few flasks of mercury were produced during 1955-56.

Old mine workings include three westward-trending adits covering a vertical range of about 100 feet which explore two northwest-trending, northeast-dipping mineralized zones. Cinnabar occurs in brecciated Franciscan sandstone and shale along the contact with a body of silica-carbonate rock. New workings consist of a 30-foot adit. Sorted ore is treated in a 2-D retort.

Bullion Mine

The Bullion mine in Lake County, about 3½ miles south of Middletown, was discovered in 1893 and was worked in conjunction with the Mirabel mine until 1903 when it was abandoned. Production has been estimated at several thousand flasks of mercury. The property was developed over a vertical depth of 400 feet by one main and several smaller shafts, and several thousand feet of drifts, crosscuts, and winzes, which explored an ore body in silica-carbonate

rock along a serpentine-sandstone contact. Workings have caved and are inaccessible.

Chicago Mine

The Chicago mine is in Lake County, about 6 miles southwest of Middletown, at 2,700 feet altitude.

The deposit was located about 1865 and was worked intermittently until 1911. Additional work was done at various times between 1927 and 1943. The mine was reactivated in 1956. Production has been small.

The property is situated on a ledge of silica-carbonate rock which strikes northwest, dips to the southwest, ranges in width from 18 to 25 feet, and extends laterally about 700 feet. Cinnabar and native mercury occur along a shear zone near the center of the silica-carbonate ledge.

Mine workings include about 1,500 feet of adits and crosscuts, and a 150-foot vertical shaft, which explored the mineralized zone over an inclined distance of 240 feet. The shaft and principal workings are caved. Present work is confined to a narrow cinnabar-bearing vein in the silica-carbonate rock. Sorted ore is treated in a D retort.

Corona Mine

The Corona mine is in Napa County, 10 miles southeast of Middletown at an altitude of 2,000 feet.

The property was discovered in 1895 and remained active until 1906. It was worked intermittently during 1941-43. Production was about 5,000 flasks of mercury. Exploration was done during 1956.

Rocks in the area are serpentine, sandstone, and shale. A northwest-trending, southwest-dipping ledge of silica-carbonate rock occurs along a thrust fault between the overlying serpentine and underlying sandstone. The average width of the ledge is about 75 feet, and it contains several oreshoots of varying size. Abundant pyrite occurs with cinnabar, and has caused difficulty during furnacing.

Principal mine workings comprise about 2 miles of openings over a strike length of about 1,500 feet and a vertical range of 400 feet. A drainage tunnel was driven about 300 feet below the old workings.

Granada Mine

The Granada mine includes 200 acres in Napa County, about 20 miles north of St. Helena, at an altitude of 1,200 feet.

The property was discovered in 1929 and was explored intermittently by various lessees until 1956. No mercury was produced. A DMEA contract was in force during 1955-56. Its purpose was to explore for cinnabar in hydrothermally altered graywacke in a geologic setting similar to that of other

mines in the area. Work consisted of 200 feet of mine rehabilitation and 278 feet of drifting and crosscutting at a cost of about $11,000.

Mine workings include several hundred feet of crosscuts, drifts, and shallow winzes on 2 levels, 105 feet apart vertically, which explore mineralized faults in altered Franciscan graywacke.

Great Western Mine

The Great Western mine in Lake County, is 4 miles southwest of Middletown, at an altitude of 2,175 feet.

The mine, one of the principal producers of the district, started producing in 1873 and was worked almost continuously until 1911. Mine dumps were worked during 1912-15, followed by a period of inactivity. The property was reactivated in 1931, and operations continued until 1946. During 1960 Universal Silvers explored the property. Production has exceeded 100,000 flasks; grade of ore ranged from 5 to 15 pounds mercury per ton.

The property comprises two interconnected mines, the Old Great Western and the New Great Western; the latter adjoins the older mine on the northwest.

County rocks in the mine area are serpentine, Franciscan sandstone, shale, and chert. In the Old Great Western area, a northwest-trending ledge of silica-carbonate rock occurs along the contact between serpentine and beds of sandstone, chert and shale. The ore bodies occur in brecciated zones in the chert, as small veinlets of cinnabar and as cinnabar coatings on the fracture faces of the chert. The extensive mine workings have caved, but they were accessible by a 700-foot shaft, several adits, and a 2,200-foot drainage tunnel 500 feet below the collar of the shaft. Six main levels, numerous sublevels, and a winze explored the mineralized area over a 750-foot vertical range. Later work along two mineralized zones was by open-pit mining.

The pipelike ore bodies in the New Great Western area occur in bodies of silica-carbonate rock in a northwest-striking fault contact zone between serpentine and sandstone and shale. Cinnabar occurs in the ore bodies as veinlets and as crystals disseminated in the silica-carbonate rock. The size of the deposits varied greatly; some of the old stopes were as much as 160 feet long, 500 feet deep (down the dip), and 50 feet wide. Underground workings, largely inaccessible, include the haulage adit, three main lower levels, and several minor sublevels extending over a vertical distance of 375 feet. Total workings of the two mines exceed 8 miles.

Hardister Property (Rich Hill, McGuire Peak)

The Hardister property, also known as Rich Hill and McGuire Peak, is located in Lake County, about 11 miles southeast of Middletown.

The mine was discovered before 1917 and was worked intermittently through 1947. Production was small. Mine workings consist of several open cuts and a shallow shaft on a mineralized zone in altered sandstone.

Hays Prospect

The Hays prospect in Lake County, northwest of the Great Western mine was worked prior to 1918 and a small quantity of mercury was produced. Cinnabar was found in silica-carbonate rock along a serpentine-sandstone contact. The property has been abandoned.

Helen Mine

The Helen mine includes a patented claim and 570 acres in Lake County, and lies about 7 miles west of Middletown at an altitude of 2,700 feet.

The mine was discovered about 1871, and several hundred flasks of mercury were produced during 1873-76. A period of idleness followed until the mine was acquired by Andrew Rocca in 1900, who operated it for about 20 years. H. W. Gould Co. purchased the property in 1927, and it was operated under lease by L. S. Peterson and Associates until 1947. Eaton and Smith Contractors, San Francisco, Calif., leased the mine during 1955-56 and did considerable underground development. Over 7,000 flasks of mercury have been produced since 1900.

The mine is in a wide fault zone between serpentine and Franciscan sandstone which strikes northwest and dips southwest. An irregular, discontinuous ledge of silica-carbonate rock occurs along the footwall of the fault zone, which ranges in width from a few feet to over 150 feet. Highly altered basalt dikes occur in the serpentine and the main fault. Principal ore bodies are in silica-carbonate rock, although some ore occurs in dikes and in the sandstone hanging wall. Ore in the silica-carbonate rock consists of veinlets and disseminations of cinnabar. Native mercury occurs to a lesser extent and metacinnabarite and tiemannite have been reported. Disseminations of cinnabar also occur in the basalt dikes. Grade of the ore ranges from 5 to 15 pounds mercury per ton.

Mine workings include over 5,000 feet of adits, drifts, and crosscuts on three main levels, several intermediate adits, and numerous raises, winzes, and stopes covering a strike length of about 1,600 feet over a vertical range of 300 feet. Older workings are caved; recent openings on the 70- and 300-levels are accessible.

The reduction plant is powered by a diesel electric generator. Equipment includes a jaw crusher, a 25-ton-capacity oil-fired rotary furnace, cyclone dust collector, vertical pipe condensers, settling tank, and stack. Soot is hand hoed; the residue is treated in a D-type retort. Calcines are trammed to the waste dump.

Ivanhoe Mine

The Ivanhoe mine in Napa County, adjoins the Aetna Extension property.

The mine yielded over 100 flasks of mercury between 1931 and 1939. Workings comprise 2 adits, about 900 feet apart horizontally, which explored

northerly trending breccia zones in Franciscan sandstone and shale. Principal production was from small ore bodies in the east, or Ivanhoe, workings.

James Creek Placers

The James Creek placers are in Napa County, about 18 miles north of St. Helena.

Operations have been in progress along a 2-mile stretch on the creek below the Oat Hill mine dumps since 1915. Over the years, heavy rains have partially eroded the extensive dumps, spreading the material along the creek and reconcentrating the cinnabar in the creek gravels. Over 400 flasks of mercury have been produced. The placer material is concentrated by sluicing and the concentrate is retorted.

Jewess Property

The Jewess property in Lake County, 4 miles southwest of Middletown has been abandoned. Operations many years ago produced an estimated 60 flasks of mercury from ore which occurred in a northwest-trending ledge of silica-carbonate rock.

Joyce Prospect

The Joyce prospect in Lake County, 7 miles southwest of Middletown, has been explored intermittently. Mine workings comprise 2 shallow shafts which explore a cinnabar-bearing fault in Franciscan sandstone. Stevens Mining Co., Middletown, Calif., worked the dumps and tailings during 1955-56, producing several flasks of mercury. Tailings were treated by washing and concentrating on a slime table; concentrates were retorted.

Kellett Prospect

The Kellett prospect in Napa County, about 1½ miles south of Calistoga, was discovered in the 1870's and prospected intermittently until 1942. A few flasks of mercury were produced.

Mine workings comprise a 350-foot adit, an inclined winze, two raises, and an open cut which explored cinnabar-bearing opalized tuff. Cinnabar occurs as painty coating along joints and seams in opalite veinlets.

Midway Property

The Midway property in Lake County, about 4 miles southwest of Middletown, at an altitude of 1,600 feet, was first worked in 1930. A small production was made from intermittent operations that continued through 1943.

Mirabel Mine (Bradford, Great Eastern)

The Mirabel mine, discovered in the 1870's, is along California State Route 29, 4 miles south of Middletown, at an altitude of 1,250 feet.

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The mine consists of two separate properties divided by St. Helena Creek. The Bradford mine is on the west side and the Great Eastern mine is about one-quarter mile to the southeast, on the east side of the creek. Operations began in 1887 and continued until 1898, when depletion of developed ore reserves forced abandonment of the mine. Mirabel Quicksilver Co. explored the property extensively during 1928-29 and operated successfully from 1930 through 1946. Total mine production exceeded 41,000 flasks of mercury. During 1951-55 Allen Burdick beneficiated the low-grade mine dump and furnace calcine material by grinding in two Ellis mills, concentrating on two Wilfley tables, and retorting the concentrate.

Country rocks comprise a large mass of serpentine, Franciscan sandstone, shale, chert, and greenstone that has been extensively fractured, sheared, and locally altered. Cinnabar, with some metacinnabarite and native mercury, occurs in silica-carbonate rock in tabular and pipelike ore bodies along a northerly trending, serpentine-sandstone contact. The largest ore body was reported to be 240 feet long, 20 feet wide, and 200 feet high.

The Bradford workings include about 2 miles of drifts, crosscuts, and raises, covering a strike length of 1,100 feet over a vertical range of 400 feet, reached through a 350-foot vertical shaft. The Great Eastern mine was developed to a depth of 500 feet by a vertical and inclined shaft and several thousand feet of drifts, crosscuts, and raises. The extensive mine workings are largely inaccessible.

Oat Hill Mine

The Oat Hill mine is in Napa County, 9 miles southeast of Middletown, at an altitude of 2,200 feet.

The mine was discovered in 1872. Production started in 1876 and continued uninterruptedly until 1910 when the high-grade ore bodies were exhausted. Some work was done during 1918-23. H. W. Gould Co., San Francisco, Calif., leased the mine in 1927, operated it until 1930, subleased it to various operators through 1938, and resumed company operations during 1939-44. Since 1951, lessees have been reworking the mine dumps. Total production was about 165,000 flasks of mercury.

Ore bodies occur along mineralized faults in kaolinized Franciscan Formation, an unusual occurrence, as they are far removed from the serpentine commonly associated with such mineralization in California. There are two major fracture systems; one strikes northwest parallel to the long axis of the sandstone, the other has an apparent northeast strike. Principal production has come from the northwest faults, which are normal faults of small displacement and steep dip.

Ore occurs just below and adjacent to the impervious fault gouge. In the footwall areas, alternating strata of pervious and impervious sandstone contain, respectively, zones of ore mineralization alternating with barren zones. Cinnabar occurs in the fault zones, as rich seams of variable thickness parallel to the fault or evenly disseminated in the fault material. Grade of ore mined ranged from 3 to 20 pounds mercury per ton.

Inaccessible mine workings comprised about 20 miles of openings over an area 1 mile long by ½ mile wide, extending through a vertical range of about 1,000 feet.

The Bureau of Mines and Geological Survey explored the property during 1943-44. Results of this work indicated a significant tonnage of low-grade ore. A description of the deposit and mining methods and costs are contained in Bureau of Mines Report of Investigations 4542.

Oat Hill Extension Mine

The Oat Hill Extension mine in Napa County adjoins the Oat Hill mine on the east.

The mine has been operated only intermittently since 1932, with a small production. Previous operations were along extensions of some of the mineralized Oat Hill faults; later work was on the extensive mine dumps. Total production is about 1,000 flasks.

Dump material is moved over a grizzly by a diesel-driven slusher scraper; the undersize drops to an ore bin and the oversize goes to the waste dump. Material from the ore bin is fed by belt conveyor to a trommel; oversize passes to waste and undersize flows to two concentrating tables. Concentrate is treated in a 1-pipe retort. Power is supplied by a diesel electric generator.

Otto-Bullion Mine

The Otto-Bullion mine in Lake County, about 5 miles south of Middletown, was operated during 1944 by Bradley Mining Co. Production was small.

Cinnabar-bearing silica-carbonate rock near a sandstone contact was developed by a 165-foot shaft and 2 short levels. Workings are inaccessible.

Plymouth Mine

The Plymouth mine in Lake County, about one-quarter mile southeast of the Great Eastern shaft, was operated until 1945, with a small output of mercury. No work has been done since.

Development consists of about 2,500 feet of shallow shafts, adits, drifts, and crosscuts, now inaccessible, which explored a cinnabar-bearing tabular body of silica-carbonate rock.

Pope Creek Placers

The Pope Creek placers are in Napa County, about 17 miles north of St. Helena.

Cinnabar-bearing gravels along the creek are concentrated by sluicing and the concentrate is treated in a 3-pipe retort. Production has been small.

Research Mine

The Research mine in Lake County, 6 miles southwest of Middletown, has been idle since 1943.

Past history of the property is obscure, but principal work was done in 1941 when a small quantity of mercury was produced. Upper mine workings include about 400 feet of drifts and crosscuts, and a 55-foot raise. The lower level consists of a 500-foot crosscut adit. Cinnabar is sparsely disseminated in a northwest-trending body of silica-carbonate rock in serpentine.

Scott Ranch Property

The Scott Ranch property is in Napa County, about 1 mile northwest of the Aetna mine.

No production has been reported, but the property was explored with geophysical prospecting and underground workings.

Thorne Mine

The Thorne mine is in Lake County, about one-half mile south of the Big Chief mine and 6 miles west of Middletown.

The deposit was discovered about 1909 and worked intermittently until 1929 with a production of about 500 flasks of mercury. Some work was done during 1943-45 but production was small.

Mine workings include several short adits and numerous open cuts along a northerly trending zone of altered Franciscan sandstone. Cinnabar occurs disseminated in the sandstone.

Toyon Mine

The Toyon mine is in Napa County, about 21 miles north of St. Helena, at an altitude of 1,350 feet.

The property was discovered in 1929. Intermittent operations since 1933 have produced about 100 flasks of mercury.

Cinnabar occurs disseminated in gouge along fractures in a northwest-trending zone of sheared, faulted, and hydrothermally altered Franciscan mudstone and graywacke. Mine workings include an inclined shaft, two main adits, and several sublevels and winzes covering a vertical range of about 150 feet. In 1956 work was from a 30-foot vertical winze sunk from the main crosscut adit.

Ore was treated in a locally designed 3-ton-capacity oil-fired horizontal batch-type rotary furnace.

Twin Peaks Mine

The Twin Peaks mine is in Napa County, about three-quarters of a mile southeast of the Corona mine.

The mine was first operated from 1902 through 1907. It was worked subsequently during 1915-18 and 1941-43. No work has been done since. Over 200 flasks of mercury were produced.

Mine workings, largely inaccessible, comprise about 4,200 feet of adits and crosscuts which explore a cinnabar-bearing ledge of silica-carbonate rock along a serpentine contact with sandstone and shale. Only one oreshoot was exploited.

Valley Mine (Lidell)

The Valley or Lidell mine, at Aetna Springs, Napa County, is the site of the original discovery of cinnabar in the district.

A small quantity of mercury was produced about 1890, but hot water and gases in the mine workings forced abandonment of operations. The property was reactivated during 1957. A DMEA contract was undertaken in 1958 to explore a silica-carbonate body within a serpentine mass in a favorable area, and some trenching was completed.

The old mine workings are inaccessible, but reportedly include a 100-foot shaft from which 600 to 800 feet of underground openings were extended.

Wall Street Mine

The Wall Street mine consists of three patented claims in Lake County, 5 miles west of Middletown, at an altitude of 2,275 feet.

The property was discovered about 1865 and worked intermittently until the 1940's with a production of over 350 flasks of mercury. The mine was reactivated in 1954 and acquired by its present owner in 1956. Mine development and construction of a reduction plant were done during 1956-57 and a few flasks of mercury were produced.

Cinnabar and native mercury occur in small ore bodies along a mineralized zone within a northerly-striking, westerly-dipping ledge of silica-carbonate rock in serpentine. Mine workings include several thousand feet of adits and crosscuts and several stopes extending through a vertical range of about 90 feet. Part of the upper workings and the lower adits are accessible.

The reduction plant, powered by a 100-kw diesel electric generator, includes a jaw crusher, 30-ton oil-fired rotary furnace, dust collector, vertical pipe condensers, settling tank, and stack. Soot is hand hoed. Residue is treated in a 3-pipe oil-fired retort. Calcines are transported by belt conveyor to the waste dump.

Whitney Prospect

The Whitney prospect in Napa County, about 10 miles southeast of Middletown, has been idle for many years.

Mine workings have flooded, but were reported to consist of two shallow shafts, several drifts, and crosscuts which explored a mineralized serpentine-shale contact. Production was very small.

Williamson Lease

The Williamson lease is in Napa County, about 17 miles north of St. Helena.

Alluvial and dump material was concentrated by sluicing. Concentrates were either retorted or treated chemically by the sodium sulfide method of leaching. A few flasks of mercury were produced.

West Mayacmas District Mines and Properties

The West Mayacmas mining district is in northeast Sonoma County. Production since the 1860's has been moderate, approximating 38,000 flasks of mercury. Principal producers of the district, which have been active recently, are the Cloverdale, Culver-Baer, and Socrates mines, whose combined output has exceeded 90 percent of the total production. Output from the many smaller mines has been a few thousand flasks.

The district has experienced several periods of activity which coincided with relatively high mercury prices. Little ore is developed ahead of mining and consequently, reserves cannot be reliably estimated. The grade of ore mined has declined steadily, and the district has a moderate production potential only if mercury prices are high. Extensive successful surface prospecting was done in the past, and further work of similar nature appears justified in geologically favorable areas. Many oreshoots encountered underground did not extend to the surface, and additional underground exploration could encounter extensions of known ore bodies and new mineralized areas.

In recent years considerable exploration and development has been done at the principal mines and at several smaller properties in the district. The Culver-Baer, Dewey, Black-Bear group, operated by Buckman Mines, has been extensively developed and work was also done at the Cloverdale and Socrates properties. Based on past production records, it is doubtful if work at many of the old prospects would be productive, although it is possible that under the stimulus of high mercury prices, sufficient ore could be developed to support small retort operations.

Ann Belcher Prospect (Lucky Stone)

The Anne Belcher prospect is 15 miles northeast of Healdsburg. Originally part of the Lucky Stone group located in 1870, the property has been inactive for many years. Caved mine workings include a 400-foot adit which explored a

weakly mineralized, narrow mass of silicified serpentine. No production was reported.

Black Oak Mine

The Black Oak mine is about 15 miles east of Cloverdale, at an altitude of 2,500 feet. A few flasks of mercury were produced in 1943. During 1957 bulldozer stripping was done.

Underground mine workings include three adits, now caved, aggregating several hundred feet. These developed mineralized fault zones in Franciscan chert. Cinnabar occurs in fractured chert and fault gouge.

Buckeye Mine (Mount Vernon)

The Buckeye mine is 14 miles east of Cloverdale at 2,000 feet altitude.

The property was located in 1864 as the Mount Vernon claim of the Cloverdale group and relocated in 1910 under its present name. Intermittent operations to 1943 produced a small quantity of mercury.

Mine workings comprise several adits, drifts, and stopes which developed a northwest-striking, northeast-dipping lens of fractured chert. Cinnabar occurs erratically as paint and encrustations along fractures in the chert.

Buckman Mines Group (Black Bear, Culver-Baer, and Dewey)

The Buckman mines include the old Black Bear, Culver-Baer, and Dewey properties, about 22 miles northeast of Healdsburg, at altitudes ranging from 1,500 to 2,200 feet. The several mines have been extensively developed.

Black Bear Mine.--The Black Bear mine was discovered during the 1870's. Intermittent operations between 1888 and 1900 produced a few flasks of mercury. Further work was done in 1943, followed by a period of inactivity until acquired by the present owner. Old mine workings include about 1,200 feet of adits, drifts, and a shallow shaft which explored mineralized silica-carbonate rock along a north-northwest-trending, northeast-dipping serpentine-sandstone contact. Cinnabar was found along the sandstone hanging wall.

Culver-Baer Mine.--The Culver-Baer mine was located in 1872, operated during 1874-80, 1900-12, 1915-19, and intermittently from 1930 to 1961. Production exceeded 12,000 flasks of mercury. Old mine workings, largely inaccessible, consist of about 8,000 feet of adits, shafts, and crosscuts that explore an elongated body of serpentine, locally altered to silica-carbonate rock, surrounded by Franciscan sandstone and shale. Cinnabar, with minor metacinnabarite and native mercury, occurs in ore bodies in the silica-carbonate rock beneath minor northwest-trending faults. In 1955-57, extensive open pitting was conducted on an ore zone above old workings, and a long crosscut adit was driven 150 feet below these workings, to explore for downward extensions of known deposits and new mineralized areas. During 1957-61, the major production came from these underground extensions.

Dewey Mine.--The Dewey mine was located in 1940 and intermittent production through 1950 yielded a small quantity of mercury. Old workings consist of about 600 feet of adits and several open cuts which explore a lens of serpentine locally altered to silica-carbonate rock containing small rich ore bodies. In 1955-57, work included extensive underground exploration on 2 levels (120 feet apart vertically) along a mineralized fault zone in Franciscan sandstone and graywacke. Cinnabar occurs in small high-grade lenses within the fault zone and at some intersections of the fault, with minor cross faults.

The reduction plant includes a jaw crusher, a 4- by 60-foot, 100-ton-capacity, oil-fired rotary furnace, cyclone dust collector, fan, a series of forty 18-inch vertical pipe condensers, scrubber, and stack. Soot is hand hoed; residue is treated in an oil-fired D retort. Calcines drop to a 20-ton-capacity slag pit, and are discharged by gravity to the waste dump.

Cinnabar King Group

The Cinnabar King group, of five claims and two millsites, is about 17 miles northeast of Healdsburg at an altitude of 3,000 feet. No work has been done since 1910. Development includes a 55-foot shaft and about 600 feet of adits, all inaccessible, which explored lenses of silica-carbonate rock in which cinnabar is disseminated. Production was very small.

Cloverdale Mine

The Cloverdale mine, comprising six patented claims and one millsite, is 12 miles east of Cloverdale at altitudes from 1,300 to 1,600 feet.

The claims were located in 1863, and the first period of operation was during 1875-81. Operations were resumed in 1901 and continued intermittently until 1943. In 1951, the mine was reactivated and has since been explored extensively by the Mining Division of Buckman Laboratories. Total production has exceeded 17,500 flasks of mercury. Grade of ore ranged from 2 to 20 pounds mercury per ton.

The ore bodies are in two strata of Franciscan chert, separated by a steep fault zone. The upper stratum strikes northwest and dips northeast; the lower stratum strikes west and is nearly vertical. Franciscan sandstone and shale overlie the upper layer; both chert strata are underlain by greenstone. Cinnabar and some native mercury occur along fractures in the more broken chert.

Mine workings, largely inaccessible, comprise several glory holes and numerous small stopes reached through a system of about 10,000 feet of adits and drifts. Recent work comprised bulldozer stripping and open cutting. Ore is treated in a 30-ton-capacity rotary furnace plant.

Contact Mine

The Contact mine is about 18 miles northeast of Healdsburg at 2,850 feet altitude.

The property was located along with other mines of the area during the 1870's when the search for mercury deposits was at its height. However, no production was recorded until 1932. Nearly 1,000 flasks of mercury were produced from 1932 to 1942. The mine was idle until 1956 when work was resumed by Calida Mining Co.

Mine workings, largely inaccessible due to caving and flooding, include the main inclined shaft from which several levels were driven, two adits, an inclined winze, and a drainage tunnel that explore an easterly-striking, northerly dipping, serpentine-sandstone contact containing bodies of silica-carbonate rock. Cinnabar and native mercury occur in the silica-carbonate rock and sandstone, and locally in the serpentine.

Crystal Mine

The Crystal mine is about 18 miles northeast of Healdsburg at an altitude of 2,350 feet.

The property was located in 1877 and explored intermittently between 1877 and 1943, but no production was made. Some work was done during 1956-57.

Mine workings, largely inaccessible, include about 2,000 feet of adits, crosscuts, and shallow shafts extending over a vertical range of about 200 feet. These workings explore several lenses of silica-carbonate rock along a serpentine-sandstone contact. Cinnabar occurs in the silica-carbonate rock, in fault gouge, and to a lesser extent in the sandstone.

During 1956-57 work included trenching, open pitting, and reopening of the lower adit. A small crushing and concentrating plant was assembled. Sorted high-grade ore and concentrate were treated in a gas-fired 2-pipe retort. The property is now idle.

Denver and Hope Prospects

The Denver and Hope prospects, about 18 miles northeast of Healdsburg, have been idle since the 1860's.

Mine workings have caved. The Denver property was developed by a 1,000-foot adit and the Hope property by an 80-foot shaft which explored small lenses of silica-carbonate rock near a sandstone-serpentine contact. Cinnabar occurs sparsely disseminated in the silica-carbonate rock. A few flasks of mercury were produced.

Esperanza Mine

The Esperanza mine is 15 miles east of Cloverdale. The property was located before 1917, and intermittent operation to 1947 produced a few hundred flasks of mercury.

Mine workings, mostly caved, include about 10 crosscut adits driven through sandstone toward a thin lens of serpentine locally altered to

silica-carbonate rock. The upper adit reportedly reached the mineralized zone. Cinnabar and some native mercury occur in the silica-carbonate rock and the sandstone footwall.

Eureka Mine

The Eureka mine comprises four claims and three millsites about 20 miles northeast of Healdsburg at an altitude of 3,500 feet.

The property was located in 1860. Sporadic work to 1943 and during 1951-52 produced a few flasks of mercury.

Inaccessible mine workings include several hundred feet of drifts, crosscuts, and shallow shafts along an easterly striking, southerly dipping ledge of silica-carbonate rock between sandstone and serpentine. Cinnabar and native mercury occur in the silica-carbonate rock.

Jumbo Prospect

The Jumbo prospect includes five claims 16 miles northeast of Healdsburg. The property is an old discovery with a very small production record. Caved mine workings include several short adits and shallow shafts which explore scattered lenses of weakly mineralized silica-carbonate rock along a serpentine-sandstone contact.

Kissack or Amazon Mine

The Kissack, or Amazon, mine is located between the Buckeye and Cloverdale mines.

The property was operated intermittently during 1930-40 and in 1945. Production was small. It was reactivated in 1956 when an exploratory adit was driven along a mineralized bed of Franciscan chert.

Old mine workings include several short adits and open cuts along cinnabar-bearing chert layers.

Last Chance and Young Denver Properties

The Last Chance and Young Denver properties are 16 miles northeast of Healdsburg.

The properties were located during the 1860's. The Last Chance mine produced some mercury in 1902; the Young Denver mine was unproductive. Both have been inactive since the early 1900's. Inaccessible mine workings at the Last Chance prospect comprise about 400 feet of adits on three levels that explore a narrow silica-carbonate body along a serpentine-sandstone contact. Cinnabar occurs erratically in the silica-carbonate rock. The Young Denver workings comprise about 100 feet of drifts on several levels and numerous open cuts, along a shear zone in serpentine. Some cinnabar was exposed, but no significant ore bodies developed.

Lost Ledge and Mercuryville Divide Mines

The Lost Ledge and Mercuryville Divide mines are about 21 miles northeast of Healdsburg. The properties were formerly a part of older mines of the area. Production from a series of open cuts along a ledge of cinnabar-bearing silica-carbonate rock was small.

Mary Hurley Prospect

The Mary Hurley prospect comprises 160 acres about 15 miles northeast of Healdsburg, at an elevation of 2,000 feet. The past history of the property is obscure, but it was probably explored during the 1860's along with other mines in the area. Two short adits were driven toward a silica-carbonate lens, in which cinnabar was erratically distributed. No mercury was produced. In 1956 bulldozer stripping was done along the serpentine-sandstone contact. A 2-pipe inclined gas-fired retort was erected.

Mericoma Mine

The Mericoma mine is about 8½ miles northeast of Healdsburg at an altitude of 600 feet.

The property was located about 1903, and during that year produced a few flasks of mercury. It was abandoned in 1941 and relocated in 1952.

Mine workings include a series of short crosscut adits and drifts extending over a vertical range of about 140 feet, which explore a sandstone-greenstone fault contact in which cinnabar-bearing pods of silica-carbonate rock occur. Some stoping was done.

Rattlesnake Mine

The Rattlesnake mine comprises three claims and two millsites, about 22 miles northeast of Healdsburg, at an altitude of 3,000 feet.

The property was located in 1874. Some mercury was produced during 1874-75, and 1916-18. The property has since been idle.

Rocks in the mine area include sandstone and serpentine. Native mercury occurs disseminated in the sandstone and fault gouge. Mine workings comprise two adits (60 feet apart, vertically, and each about 200 feet long), with a winze extending from the upper to the lower adit and possibly deeper.

Socrates Mine

The Socrates mine is 19 miles northeast of Healdsburg at an altitude of 3,200 feet. The property was located about 1860 and operated intermittently from 1861 to 1943 with a production of about 5,000 flasks of mercury. Operations were resumed in 1955.

Lenses of mineralized silica-carbonate rock occur along a northwest-striking, southwest-dipping contact between serpentine and Franciscan sandstone. Ore bodies occur along and beneath the contact. Native mercury and some cinnabar occur in the silica-carbonate rock and disseminated in the underlying sandstone. Two main oreshoots were mined; one about 70 feet long and up to 15 feet wide, extending to a depth of 400 feet; the other about 160 feet long and 250 feet deep. Apparently, both oreshoots bottomed at depth.

Inaccessible mine workings, reached through three adits comprising about 6,000 feet of openings, include four main drifts and several sublevels over a vertical range of 400 feet. Work during 1956-57 explored the mineralized contact by bulldozer stripping and open cutting.

The concentrating plant to beneficiate the low-grade ore includes a crushing and grinding unit, washer, concentrating table, and retort. Power is furnished by a diesel electric generator.

Sonoma Group

The Sonoma group of seven claims is 16 miles northeast of Healdsburg.

The property was located in 1873 and during that year a small quantity of mercury was produced. A period of inactivity continued until 1904 when further operations yielded several additional flasks. The mine was relocated in 1917 and a small production was made. It remained idle until 1954 when extensive surface exploration was done, and a washing plant-concentrator and a 2-D retort were installed. Production was small. Exploration was done during 1956.

Caved mine workings include nine crosscut adits and about 1,000 feet of drifts on five levels, which explore a northwest-trending ledge of silica-carbonate rock and adjacent sandstone. In 1956 extensive bulldozer stripping along exposures of the silica-carbonate rock was done.

The reduction plant includes a trommel, jawcrusher, cyclone-type washer, three Wilfley tables, circular dryer, and a 2-D oil-fired retort.

Power is furnished by a diesel electric generator.

Truitt No. 1 Property

The Truitt No. 1 property is about 16 miles east of Cloverdale. Recently a program of surface and underground exploration was carried out and a beneficiation plant constructed. A few flasks of mercury have been produced.

Yellowjacket Mine

The Yellowjacket mine is southeast of the Pine Flat area and about 3 miles northeast of Kellog. The mine was located about 1871 and had a small output of mercury during 1871-75. No work has been done since.

Inaccessible mine workings include two shafts and five adits totaling several hundred feet, which explored several lenses of cinnabar-bearing silica-carbonate rock.

Guerneville District Mines and Properties

The Guerneville mining district in west-central Sonoma County has been the largest producing district in the county, with an output of over 100,000 flasks of mercury, entirely from the Mount Jackson and Great Eastern mines.

These mines have a large production potential and could make a significant annual production under high mercury prices. Operations are confined to the deeper levels of the mines. The large ore bodies have been depleted in the upper levels, but based on extensive exploration, it is reasonable to infer that significant reserves exist below present workings. High mining costs, together with a decrease in grade of the ore at depth, will make it a marginal operation under prevailing mercury prices. Production and continued operation can be assured only under more favorable economic conditions.

Sonoma Quicksilver Mines (Great Eastern, Mount Jackson)

The Sonoma Quicksilver mines comprised mainly the Great Eastern and Mount Jackson properties about 4 miles northeast of Guerneville, at altitudes ranging from 400 to 700 feet.

The Great Eastern and Mount Jackson mines have been the largest producers in the county with a combined output of over 100,000 flasks of mercury. The average grade of ore has been about 8.5 pounds of mercury per ton.

The mines were located during the early 1870's and operated during 1875-1906, 1915-19, and 1934-55. Extensive underground exploration was done during 1956; production was resumed in 1957 and was continuous through 1961.

The two mines were operated independently until 1888, then under Great Eastern control until 1906. The 1915-19 operations were from the upper levels of the Great Eastern mine. During 1934 work was resumed at the Mount Jackson mine, which was acquired in 1940 by Sonoma Quicksilver Mines, Inc. The Great Eastern mine was acquired in 1941 by the Magee Mercury Co. and sold to the Sonoma Quicksilver Mines, Inc., in 1942.

A DMEA contract was in force during 1956, and geologically favorable structures west of the mine and below present mine workings were explored. Work was completed at a cost of about $13,600 and included 313 feet of drifting and crosscutting, and 1,303 feet of underground diamond drilling.

The mercury deposits consist of steeply dipping mineralized pipes and tabular bodies, usually within silica-carbonate rock. The oreshoots are controlled by shearing and fracturing along several groups of faults. Cinnabar is disseminated in the silica-carbonate rock and to a lesser extent in the adjacent Franciscan sandstone and fault breccia. The largest ore body is in the Mount Jackson mine and consists of an irregular pipelike shoot which has

been stoped continuously through a vertical range of over 1,000 feet and horizontally from 25 to 200 feet. The Great Eastern ore body was a tabular shoot about 300 feet long, with a maximum width of 10 feet, and was mined along a pitch length of 550 feet.

Underground development consists of the vertical Mount Jackson shaft, which extends from the 60- to the 975-foot level and from which 10 levels were extended. The 500-foot vertical Great Eastern shaft is located 320 feet southeast of the Mount Jackson shaft with which it is connected on 5 levels. Underground workings exceed 16,000 feet in total length. Ore bodies are mined by shrinkage stoping.

The reduction plant includes a primary crusher, a 4- by 64-foot 80-ton-capacity oil-fired rotary furnace, cyclone dust collector, fan, vertical cast-iron pipe condensers, settling tanks, and stack. Soot is treated in mechanical hoeing machines; residue is burned in an oil-fired retort. Calcines drop to concrete bins and are trammed to the waste dump.

Skaggs Springs District Mines and Properties

Skaggs Springs Mine

The Skaggs Springs mine is in Sonoma County, about 15 miles northwest of Healdsburg and about 10 air-line miles north of the Sonoma Quicksilver mines.

The deposit was discovered in 1928 and worked until 1943. Production was 330 flasks of mercury.

Metacinnabarite and some cinnabar, asssociated with a hydrocarbon (curtsite), occur finely disseminated in a massive northeast-striking, southeast-dipping Franciscan sandstone bed beneath a hanging-wall contact of impervious shale and sandstone. The sandstone is bounded by two northwest-trending faults.

The mine was developed by a 135-foot inclined shaft with levels at 16, 50, 73, and 100 feet. A 35-foot inclined winze from the 100-foot level connects with the bottom 135-foot level. Several irregular raise-stopes extend between the levels. The workings total about 1,800 feet in length.

Bulldozer pits were excavated on other mineralized areas.

Oakville District Mines and Properties

The Oakville mining district in western Napa County was intermittently active between 1863 and 1943 with a production of about 3,800 flasks of mercury entirely from the Bella Oak and La Joya mines. Several small prospects in the area were unproductive. It may have a small production potential capable of supporting a continuous operation, but extensive exploration and mine development are necessary prior to a resumption of operations. Reserves have been depleted, but exploration for downward continuations of known ore bodies, and prospecting for additional mineralized areas along the major

controlling faults could be productive. The cost of mine rehabilitation and subsequent exploration would be high, justified only by a relatively high price for mercury.

Bella Oak Mine

The Bella Oak mine comprises two patented claims at an altitude of 500 feet.

The property was discovered in 1868. Intermittent operations with a moderate output of mercury were in progress from 1872 through 1944. Published reports credit the property with a production of 1,792 flasks.

Ore bodies occur in silica-carbonate rock formed from the lower part of a flat southwest-dipping tabular body of serpentine that occupies a northwest-trending thrust fault. Conglomeratic Franciscan sandstone overlies the serpentine, and black shale underlies the silica-carbonate rock. Cinnabar occurs as veinlets and disseminations in the silica-carbonate rock.

Inaccessible mine workings comprise about 6,000 feet of shallow shafts, winzes, drifts, and crosscuts extending over a strike length of about 3,500 feet and to inclined depths of 250 feet.

La Joya Mine

The La Joya mine includes 11 patented claims and 480 acres, 7 miles west of Oakville at altitudes ranging from 1,600 to 1,900 feet.

The property was located in 1865 and was worked intermittently until 1898. Several periods of operation followed from 1915 to 1939 with a reported production of 2,017 flasks. No work, other than sporadic prospecting, has been done since 1939.

Ore bodies occur in brecciated silica-carbonate rock along a steeply dipping, northwest-trending contact fault between serpentine and Franciscan sandstone and shale. Cinnabar occurs as veinlets and disseminations in the silica-carbonate ore bodies.

The mine was developed by about 5,000 feet of workings, including six shafts and three main adits, extending over a strike length of 900 feet, and to a maximum depth of 350 feet. The greater part of the workings is inaccessible.

Petaluma District Mines and Properties

The mercury deposits in the Petaluma mining district, north central Marin County, are a comparatively recent discovery. A small output of mercury has been made from the Gambonini and Edwards mines. Development of the latter property is in progress.

The mines are in an area of interest, but work has not been adequate to determine the production potential. Extensive exploration will be required to develop sufficient ore to support moderate-sized operations.

Edwards or Bentley Ranch Mine

The Edwards or Bentley Ranch mine is about 12½ miles southwest of Petaluma.

The deposit was discovered in 1955 and a few flasks of mercury were produced each year through 1961.

Cinnabar occurs as disseminated crystals and fracture fillings along minor faults, shear zones, and narrow breccia zones in Franciscan sandstone and shale. Mineralized zones are small and discontinuous. Mine workings include bulldozer cuts, several short adits, and a shallow winze.

A reduction plant includes a jaw crusher, a 24-foot by 16-inch, 20-ton-capacity oil-fired rotary furnace, dust collector, fan, vertical pipe condensers, settling tank, and stack. Power is supplied by a diesel electric generator.

Gambonini Property

The Gambonini property is located about 13 miles southwest of Petaluma.

The deposit was discovered in 1945 and leased during 1945-48 to the Cordero Mining Co., who completed an extensive exploration program. The property was idle until acquired in 1955 by Turner and McFarland and a small amount of mercury has been produced yearly since.

Cinnabar occurs in small discontinuous pods in silica-carbonate rock along minor faults in highly fractured sandstone and shale. Mineralization is spotty and erratic. Mine workings include numerous deep bulldozer cuts, test pits, trenches, shallow prospect shafts, and a crosscut adit. Ore is burned in a 500-pound-capacity, 2-pipe gas-fired inclined retort.

Sulphur Springs Mountain (Vallejo) District Mines and Properties

The Sulphur Springs Mountain or Vallejo mining district is in southwestern Solano County. The distrect was active from 1852 to 1943 with a production record of about 17,500 flasks of mercury. Principal output was from the St. Johns mine with small contributions from other properties. Surface exploration was done in the area during 1956.

The district could again become an active producer under favorable economic conditions. Known ore bodies have been depleted and underground openings are inaccessible, but surface exploration has indicated widespread mineralization and the possible existence of a substantial tonnage of submarginal grade material.

It is unlikely that old mine workings could be rehabilitated economically; future underground development would have to be done from new openings, resulting in high startup costs. Some of the deposits may be adaptable to exploitation by open-pit mining, thus permitting lower operating costs and the handling of lower grade ores.

Continued exploration utilizing bulldozer stripping, diamond drilling, and geophysical surveying are necessary to delineate the extent of the mineralization and to permit an accurate evaluation of the deposits.

Borges Prospect

The Borges prospect is about 3½ miles northeast of Vallejo. Cinnabar occurs disseminated in silica-carbonate rock along a serpentine-sandstone contact. Workings consist of bulldozer trenches and open cuts. No production has been made.

Brownlie Property

The Brownlie property is 5 miles northeast of Vallejo.

The deposit was discovered in 1852 and some work was done during the 1870's, when a small output of mercury was made. Intermittent prospecting continued for many years, but there is no record of further production.

Cinnabar occurs in small lenses and pockets erratically distributed in a breccia zone within a northwest-trending, northeast-dipping contact fault between andesite with sandstone and shale. Mine workings include numerous short adits, open pits, and bulldozer cuts extending over a wide area.

Hastings Mine

The Hastings mine, about 4½ miles northeast of Vallejo, has been idle since 1930.

The mine was discovered during the 1870's and operated on a small scale. Further exploration during 1904-05 and extensive underground development in 1917 produced a small quantity of mercury. A period of inactivity followed until 1929 when a crosscut adit driven toward the mineralized zone encountered a heavy flow of acid mine water. A court injunction obtained in 1930 by local ranchers forced abandonment of operations.

Ore bodies occur in a wide northwest-striking, northeast-dipping fault zone between overlying shale and underlying brecciated and silicified shale and sandstone. Cinnabar occurs as irregular masses in fractures within the breccia zone, and along contacts with intrusive andesite dikes.

Inaccessible mine workings include numerous open cuts, drainage adit, and a 1,100-foot crosscut adit which intersects the fault zone at 950 feet and from which two small ore bodies were stoped.

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St. Johns Mine

The St. Johns mine is about 6 miles northeast of Vallejo.

The mine was discovered in 1852. Work was done in three areas--the north side of Mount St. John, Mount Luffman, and in a basinlike depression between the two mountains. Mining was on the north side of Mount St. John during 1855-73. Work was started in the basin area in 1873 and continued until 1880 with an output of about 11,500 flasks of mercury. Some exploratory work was done from 1873 to 1880 on Mount Luffman. Activity continued during 1899-1909 and 1914-18. Work was sporadic since 1918, confined principally to reworking old dumps. In 1956 work consisted of bulldozer trenching and extensive sampling. Total production from the mine has been over 17,000 flasks of mercury. In the basin area, cinnabar occurs as fissure fillings in irregular ore bodies along and in altered andesite dikes which were intruded into a wide northwest-trending fault contact zone between silica-carbonate rock and shale. The fault zone has been extensively faulted and brecciated. The deposits on the north side of Mount St. John occur in a zone of brecciated shale, cut by intrusive andesite, near a sandstone contact. Cinnabar occurs as veinlets along fractures in the shale and sandstone. On Mount Luffman, cinnabar occurs in small pockets and veinlets in silica-carbonate rock.

Mine workings are inaccessible. Data on the old Mount St. John mine are incomplete, but the underground openings are reported to have consisted of adits and shafts extending to a depth of 400 feet. Principal workings in the basin area consisted of an 1,100-foot adit from which a 400-foot shaft was sunk. Three main levels and five intermediate levels were connected with the shaft. Numerous short adits and shallow shafts are also on the property. The extensive workings extended over a vertical range of 650 feet.

Mount Diablo District Mines and Properties

The Mount Diablo district in central Contra Costa County, was intermittently active from 1875 to 1956 with a production of about 11,000 flasks of mercury.

Exploration of the mineralized areas has been thorough, and the more recent work failed to develop significant tonnages of commercial-grade ore. Undoubtedly, small reserves of low-grade ore remain in the mine area and in other geologically favorable sections, but the high cost of extensive exploration and development, in relation to the small tonnage involved, prevents economic consideration under current mercury prices. A small annual yield could probably be made from high-grading operations limited to small bodies of retort-grade ore.

Local landowners object to the acid mine water being pumped from the lower mine workings and flowing through their respective properties. Water disposal is a problem which could result in costly litigation or installation of an expensive water-treatment plant.

Mount Diablo Mine

The Mount Diablo mine is about 4½ miles southeast of Clayton, at an altitude of 1,000 feet.

The property was located during the 1870's. It was active from 1875 to 1877 but remained idle until acquired by the present owner in 1930.

Bradley Mining Co., San Francisco, Calif., operated the mine during 1936-46, its period of greatest activity. Further work comprised extensive underground exploration by lessees during 1952-56. Total production from the mine was about 11,000 flasks from ore which varied in grade from 4 to 12 pounds mercury per ton.

Metacinnabarite and cinnabar occur as fracture fillings in silica-carbonate rock and locally disseminated through silica-carbonate rock and serpentine, within a northwest-trending, northeast-dipping shear zone along a serpentine-sandstone contact. Mining was done on two tabular oreshoots.

Development was confined to two areas--the Rhyne and Jones tunnels, comprising about 1,200 feet of now inaccessible adits and drifts where the earliest work was done, and the Mill workings, located about 1,500 feet to the east, from which the principal production was made. The Mill workings, on 5 levels, include about 3,000 feet of adits, shafts, drifts, winzes, and extensive open pits, which explored the area to an inclined depth of 400 feet.

A DMEA contract in effect during 1953-54, explored the downward extension of the ore zone exposed in the Mill workings. A 330-foot vertical shaft was sunk and a 120-foot crosscut driven on the 300-foot level at a cost of about $44,300.

Ore was treated in a 40-ton-capacity oil-fired rotary furnace plant.

Emerald Lake District Mines and Properties

The Emerald Lake district is in northern San Mateo County. The presence of cinnabar in the area was known many years ago and some sporadic prospecting done, but it was not until 1954, when mercury was found in the topsoil while excavating for an extensive housing development, that production started. The Challenge mine has been the principal producer.

Challenge or Farm Hill No. 2 Mine

The Challenge or Farm Hill No. 2 mine is 2 miles southwest of Redwood City. The Harbor custom mill, which treated the ore from this property is located on Harbor Boulevard, 2 miles east of Redwood City.

Production was started in 1955 and ore was shipped to several custom plants for furnacing. The company's reduction plant was built and put in operation during 1956. Production has exceeded 2,500 flasks of mercury from material varying in grade from 8 to 12 pounds of mercury per ton. Operations were terminated in 1958, and the area was included in a housing development.

The overburden extends from a few to 75 feet in depth and consists of clayey gouge and small boulders of silica-carbonate rock, serpentine, and sandstone. Isolated and erratic concentrations of the mercury minerals were found along a 2,000-foot section of a northwest-trending belt, formed by natural erosion of the nearby hills or comprising a large slump area. Cinnabar, metacinnabarite, native mercury, and several of the rarer mercury minerals occur in vugs and along fracture planes in the silica-carbonate rock. No mineralization was found in the underlying bedrock.

Mine workings include several open pits, most of which have been backfilled, extending to a maximum depth of 75 feet and widths of 50 feet. Mining was done by bulldozers and power shovels.

The reduction plant includes a jaw crusher, a 40-ton-capacity Pacific-type multiple-hearth oil-fired furnace, cyclone dust collector, two banks of vertical pipe condensers, suction fan, settling tank, and stack. Soot is hand hoed; residue is returned to the furnace. Calcines drop to a steel bin and are loaded by bucket elevator into a dump truck and hauled to the waste dump.

Del Puerto and Orestimba Districts Mines and Properties

The Del Puerto and Orestimba mining districts are in western Stanislaus County. Small-scale mercury-mining activities commenced during the 1870's, and intermittent operations have continued to recent years, producing a few hundred flasks of mercury. Principal output was from the Phoenix and Adobe mines; several other properties contributed a minor production.

The district has a small production potential only during periods of very high mercury prices. The deposits are shallow, of limited extent, and contain relatively low-grade ore. During 1955-56, high-grading activity at the Adobe mine yielded a few flasks; however, reserves of retort-grade ore adequate to maintain a stable production could not be developed.

Extensive exploration at several of the properties could encounter new mineralized areas, but in view of the district's past production records and the comparatively low grade of the ore, this work would not be justified except under high mercury prices.

Adobe Mine

The Adobe mine comprises 320 acres in the Del Puerto district, 21 miles west of Patterson, at an altitude of 1,750 feet.

The deposit was discovered during the 1880's with production recorded during 1884-88. The mine was idle until 1940-41 when old workings were rehabilitated and a reduction plant was installed. Operation continued until 1944. It was leased during 1953-56 to various operators and a small amount of mercury was produced. The reduction plant was removed and the mine was idle during 1957. A new retort was built during 1958 and a small amount of mercury has been produced since.

The mine was developed by a now inaccessible 180-foot vertical shaft from which 4 levels were turned, an old inclined shaft, numerous crosscuts, and drifts. Open cuts were excavated along surface exposures of the mineralized zones. The workings explored a series of parallel northerly trending, easterly dipping fissures in Franciscan sandstone, in which cinnabar is erratically distributed. Grade of the ore varies from 2 to 10 pounds of mercury per ton.

Ore was treated in a 16-ton-capacity rotary furnace and a 180-pound-capacity 2-pipe retort.

International Prospect

The International prospect in the Orestimba district, is about a mile southwest of the Orestimba mine. Some work was done during the 1880's, but production was small.

Orestimba Mine

The Orestimba mine includes 22 claims in the Orestimba district, about 25 miles southwest of Crow's Landing.

The mine was first operated sometime prior to 1900. It was idle until 1917-18 when it was reactivated and a 75-foot shaft sunk on a cinnabar-bearing shear zone in silicified shale. Production was small. No work has been done since 1918.

Phoenix Group

The Phoenix group includes 13 claims, millsites, and other property in the Del Puerto district, 26 miles west of Patterson at an altitude of 2,150 feet.

The property was located during the 1870's and worked intermittently during 1901-03 and 1915-16. No work has been done since 1916. Production was about 200 flasks from ore that averaged 5 to 6 pounds of mercury per ton.

The mine is developed by three crosscut adits, all caved, and several raises and winzes which explored three cinnabar-bearing fissures in the footwall of a northerly striking, easterly dipping fault between serpentine and Franciscan sandstone and chert.

Red Acres Mine (Orestimba, Winegar)

The Red Acres mine comprises 1,920 acres in the Del Puerto district, 28 miles west of Patterson.

The property was originally part of the Phoenix group and has been known as the Orestimba or Winegar mine. Mine workings in 1916 included a shallow shaft, an upper crosscut adit from which a drift was driven and along which some raising was done, and a lower crosscut driven to intersect the mineralized

zone. The workings explore a northwest-trending, northeast-dipping fault between chert and sandstone. Cinnabar is irregularly distributed along fractures in a breccia zone in sandstone. No mercury was produced.

The owner was reported to have reactivated the mine during 1956 and to have continued work in the lower crosscut adit.

New Almaden District Mines and Properties

The New Almaden mining district in southwest Santa Clara County has been the source of the greatest production of mercury in California. Mining started prior to 1850 and has continued almost without interruption. Total output of the district has exceeded 1 million flasks of mercury. Principal production was made between 1850 and 1915, but a substantial output has been made since. Recent activity has been on a basis of 1,000 to 2,000 flasks per year. The New Almaden mine, comprising several separate properties, was the largest producer, with a significant production from the Guadalupe mine and a minor output from the many smaller properties.

The large known ore bodies have been depleted and no deep-level mining has been done for many years, but work since 1955 has demonstrated that substantial tonnages of commercial-grade ore remain as remnants of old ore bodies and in mineralized zones in undeveloped areas. Extensive prospecting by bulldozer stripping, and some underground work, disclosed stringers and lenses of cinnabar that are being selectively mined to produce retort-grade ore. This work was done economically under 1956-61 prices and should continue as long as these prices prevail.

Low-grade ores produced during the course of the high-grading operations constitute a significant reserve. Beneficiation practices on some of the ores successfully upgrade them. Additional reserves will undoubtedly be disclosed, and it is also possible that important reserves remain in old mine workings. Several geologically favorable areas at the New Almaden and Guadalupe mines remain unexplored; further work could be productive. The greater part of the underground workings are inaccessible, and the high cost of mine rehabilitation, subsequent exploration, and development of these areas does not appear justified under prevailing prices.

Several other properties in the district, specifically the Chaboya-Hillsdale and Silver Creek mines, contain significant reserves of marginal and submarginal ore which comprise potential sources of mercury under more favorable economic conditions. The many smaller mines and prospects yielded but a small quantity of mercury and can be considered to have only a small production potential.

Bernal Prospect

The Bernal prospect is 10 miles southeast of San Jose. Work prior to 1918 comprised a 200-foot adit on a clay-serpentine contact. No significant cinnabar mineralization was encountered and no production made. The property has been inactive since 1918.

Brainard or James Ranch Prospect

The Brainard, or James Ranch prospect is about 10 miles south of San Jose. Work on the property was done prior to 1918; it included driving two adits, now inaccessible, a short raise, and a shallow winze, which explored cinnabar-bearing clay seams along a serpentine-sandstone contact. No commercial-grade ore bodies were encountered and no production made.

Chaboya-Hillsdale Mines

The Chaboya-Hillsdale mines are 3 miles south of San Jose. The two mines were discovered in 1847 by Mexicans who worked them until 1861 when the mines were purchased by American interests and operated until 1874. Intermittent work continued until 1943, followed by lessee operations during 1943-46. Total output of the mines was several hundred flasks obtained from ore ranging from 5 to 10 pounds of mercury per ton.

Cinnabar occurs in a series of discontinuous lenses or pods of silica-carbonate rock along an easterly trending serpentine-sandstone contact. Ore bodies are localized along steeply dipping north-south and flat-dipping northeast-southwest fractures. Mine workings, the greater part of which have caved, include about 4,000 feet of adits, drifts, raises and winzes, in two separate areas, over a vertical range of 100 feet. Ore was treated in a rotary furnace and in retorts.

Guadalupe Mine

The Guadalupe mine is 10 miles south of San Jose and 5 miles northwest of the New Almaden mine, at altitudes ranging from 400 to 770 feet.

The property, one of the State's largest producers, was discovered during the 1850's, shortly after the New Almaden attained prominence. First production was in 1856. Operations continued until 1875, during which time an estimated 20,000 flasks of mercury was produced. The mine was then sold to the Guadalupe Mining Co. and worked until litigation in 1886 forced suspension of operations. Work, resumed in 1901 by the Century Mining Co., continued until 1922 when litigation again closed the mine. Intermittent small-scale operations were carried out during 1930-36. A lease was acquired in 1937 by the Laco Mining Co., and underground and surface mining was continued until 1947. The Bureau of Mines and the Geological Survey explored the property during 1942-43 by bulldozer trenching, dragline trenching (of old dumps), hand trenching, and diamond drilling. The moderate tonnage of low-grade ore indicated by the work encouraged the company to expand the operations between 1944 and 1947. Intermittent work continued until 1955 when a lease was acquired by the Palo Alto Mining Corp. Total production from the mine has exceeded 113,000 flasks. Grade of ore varied from 3 to 50 pounds of mercury per ton.

During 1957 work under a DMEA contract explored the contact zones of several silica-carbonate bodies exposed in the East Ridge area, which were considered favorable for the localization of cinnabar ore bodies. A total of 3,200 linear feet of bulldozer trenches, with an estimated volume of 12,765

cubic yards, was excavated and 150 feet of churn drilling completed in three 50-foot holes. Approximate cost of the work was $6,000.

Rocks in the area include Franciscan sandstone and shale, which have been intruded by irregular masses of serpentine. The margins of the serpentine were altered to silica-carbonate rock in which the principal ore bodies occur. Ore bodies are in three nearly parallel northwest-trending ledges of silica-carbonate boulders in the fault gouge.

The extensive mine workings, largely inaccessible, include several miles of openings on the northeast and southwest sides of Capitancillos Creek. Original workings in the southwest area included a 625-foot vertical shaft from which six levels were driven, and an inclined winze from the sixth to the ninth level. Continuous flooding of the shaft during wet seasons forced its abandonment, and the 700-foot inclined shaft in the northeast area was sunk. In addition, numerous mineralized areas on the property were developed by shallow shafts, crosscut adits, and open cuts. During 1955-61 work included extensive bulldozer stripping and open-cut mining along mineralized sections of silica-carbonate rock, some underground mining, and washing of stream gravels and tailings.

Sorted ore is treated in 6- and 4-pipe gas-fired retorts. Lower grade ore is beneficiated in a washing and jigging plant on the property or hauled to the company's concentrator on Coyote Creek, about 9 miles east of the mine. This 40-ton plant includes two jaw crushers, vibrating screen, jigs, classifier, and three concentrating tables. Concentrates are treated in a 3-ton-capacity Carlson furnace.

New Almaden Mine

The New Almaden mine includes about 8,000 acres, 8 to 13 miles south of San Jose, at altitudes ranging from 500 to 1,750 feet. The property, owned by the Sexton Estate, Philadelphia, Pa., and leased to Gene Allen, Los Altos, Calif., includes the New Almaden, Enriquita, Senator, and several smaller mines extending over a 4-mile northwest-trending mineralized belt. During the latter part of 1960 the mine area was purchased by the New Almaden Property Holders, Inc.; the various operations under sublease are discussed separately.

Cinnabar was known to occur in the area as early as 1824, but not until 1845 were the fabulously rich ore bodies discovered. Large-scale mining was started in 1850 by Barron, Forbes, and Co. and continued until 1858 when a dispute over land titles forced a suspension of operations. Work was resumed in 1861, and 2 years later the property was purchased by the Quicksilver Mining Co. for a reported $1,750,000. Peak production was reached in 1865 when 47,194 flasks of mercury were produced. The output of high-grade ore continued until 1874 when depletion of the rich ore bodies necessitated reworking mine dumps, mining lower grade deposits, and developing more efficient metallurgical processes. Production was maintained at a rate of about 20,000 flasks yearly until 1890 when a gradual decline started in output which continued uninterruptedly until 1927. The Quicksilver Mining Co. was declared

bankrupt in 1912, and the property was acquired in 1915 by the present owners. Mine dumps were worked intermittently during 1928-39 and in 1940 the New Almaden Corp. obtained a lease on the property. Old mine and surface fills were worked, many of the underground workings rehabilitated, and a modern rotary furnace plant installed. The Bureau of Mines and the Geological Survey explored the property in 1943 by diamond drilling, but no significant discoveries were made. Company operations continued until 1945. Lessees worked over the mine and calcine dumps during 1945-50. Following the outbreak of the Korean conflict the property was leased in 1951 to the Cordero Mining Co., Palo Alto, Calif.

The New Almaden property was explored extensively during 1951-53 under a DMEA contract. The program was based on previous work done by the Geological Survey and was designed to explore four structurally favorable areas. Work included 2,681 feet of diamond drilling from 10 underground stations, 5,080 feet of diamond drilling from 13 surface locations, and reopening 2,745 feet of the Day tunnel. Cost of the work was about $111,500.

Gene Allen acquired a lease on the property in 1955 and work by subleasers has continued since. During 1956-60 production was about 1,000 flasks annually from ore varying in grade from 15 to 60 pounds of mercury per ton. Total production from the property was over 1,050,000 flasks. Grade of ore during maximum production period (1850-90) ranged from 60 to 750 pounds mercury per ton.

The oldest rocks in the New Almaden mine area consist of folded feldspathic sedimentary rocks and altered mafic tuffs and flows that comprise the bulk of the Franciscan Group of probable Jurassic age. Intrusive into these rocks are sill-like bodies of serpentine, locally altered along their margins to silica-carbonate rock, the host rock for the mercury ore bodies. Within the silica-carbonate rock, ore bodies have been found close to the intrusive contact in structurally favorable places, such as at the axes of domes or plunging anticlines, or where the rock is traversed by a series of northeasterly trending fractures. The majority of the ore bodies were formed close to the upper margins of the sills, but some, equally as rich, occurred near the lower surfaces of the sills. In parts of the mine, particularly in the New World-San Francisco area, there are many thin apophyses branching outward and downward from the larger serpentine sills. Where these were extensively mineralized, they formed thin overlapping ore bodies.

The ore bodies occur in silica-carbonate rock on the contact between the serpentine and Franciscan sandstones and other sedimentary formations. The hanging wall is generally well marked by a clay gouge, locally termed alta (hanging wall). Single ore bodies produced up to 70,000 flasks of mercury.

Cinnabar is the principal mercury-bearing mineral, although the occurrence of metacinnabarite and free mercury is not unusual. Pyrite, quartz, calcite, chalcedony, and bituminous material are generally associated with the mercury mineralization.

Ore bodies extended to unusual depths, and it is reported that continuous bodies were followed from the surface to the 1,600-foot level. The deepest workings were 2,450 feet below the top of Mine Hill. More than 18 shafts were sunk, and underground workings reportedly exceeded 100 miles in total length.

During 1956-61 many of the ore bodies of the New Almaden mine were being worked. Twelve retorts were operating, having a combined capacity of about 12 tons that could produce 9 to 12 flasks of mercury daily. The operators were well equipped with mine machinery, trucks, and earthmoving equipment. A steady production was maintained. A description of each operation follows:

Mine Hill.--Bulldozer stripping and trenching followed by open-cut mining along remnants of old ore bodies and exposures of new mineralized areas. Subleasing operations in four areas. Ore sorted, crushed, and treated in small, gas-fired retorts.

Day Tunnel.--Rehabilitating tunnel on 800-foot level and mining the downward extension of an ore body encountered on the 500-foot level. Ore treated in a 2-pipe gas-fired retort.

Deep Gulch Placer.--Small-scale placer operations using a 2-drum slusher scraper and washing plant. Concentrates retorted.

American Mine.--Bulldozer stripping and trenching over old workings to expose mineralized silica-carbonate rock. Open-cut mining on narrow stringers and small lenses. Sorted ore retorted.

La Providencia Mine.--Bulldozer stripping and trenching in old mine area. Mineralized exposures of silica-carbonate rock mined by open-cut methods. Ore treated in 2-pipe gas-fired retort.

San Mateo Mine.--Operated by La Purissima Mining Co., San Jose, Calif. Bulldozer stripping and trenching followed by open-cut mining on exposures of cinnabar-bearing silica-carbonate rock. Ore treated in a 4-ton capacity, 4-pipe inclined gas-fired retort.

San Cristobal Mine.--Rehabilitating a 600-foot adit and 50-foot winze. Mining remnants of an old ore body.

Randol Mine Dump.--Dragline operations on extensive mine dumps. Excavated material washed and concentrates retorted.

Enriquita Mine.--Driving a 550-foot crosscut adit to an area where stope pillars and sections of mineralized zones are reported to remain. Ore treated in a 2-ton-capacity vertical retort.

Senator Mine.--Old mine areas explored by bulldozer stripping. Mining exposed mineralized zones by open-cut methods and driving short adits. Ore crushed, screened, and treated in 2-pipe gas-fired retorts.

New North Almaden or Santa Clara Mine

The New North Almaden or Santa Clara mine is about 9 miles southeast of San Jose.

Original work on the property was done prior to 1906, when a 1,400-foot adit was driven to explore a cinnabar-bearing fracture in sandstone 300 feet below its outcrop. During 1928-30 a 100-foot adit was driven on the mineralized zone, and a small amount of mercury was produced. Further prospecting was done during World War II.

Rianda Mine

The Rianda mine in the southeastern part of the New Almaden district is about 5 miles northeast of Gilroy.

The mine was operated during 1942-44 and a small amount of mercury was produced. Work included driving about 1,000 feet of drifts and crosscuts, sinking a shallow winze, and some stoping. The workings explore a mineralized ledge of silica-carbonate rock in which small ore bodies occur, near a sandstone contact. Grade of the ore varied from 5 to 15 pounds of mercury per ton.

Santa Teresa Prospect

The Santa Teresa prospect is about 3 miles northeast of the New Almaden mine. The property was explored about 1903.

The work included driving several adits and drifts to develop mineralized silica-carbonate rock along a serpentine-sandstone contact. No commercial-grade ore bodies were found. The mine has reportedly been abandoned.

Silver Creek Mine

The Silver Creek mine is about 12 miles southeast of San Jose.

The property was located during the 1890's and operated intermittently during 1893-1904 and 1928-43. Production was a few hundred flasks of mercury from ore varying in grade from 2 to 8 pounds of mercury per ton. The mine is within a broad fault zone in a large isolated mass of shale and limestone that contains smaller masses of silica-carbonate rock. Cinnabar occurs in the silica-carbonate rock and the surrounding sedimentary rocks. Inaccessible mine workings include numerous drifts and crosscuts.

Tilton Ranch Prospect

The Tilton Ranch prospect is about 12 miles southeast of San Jose.

The property was prospected during 1929-30. A 160-foot adit encountered two cinnabar-bearing fracture zones in serpentine. Ore was low grade, and there has been no production.

Wright Property

The Wright property is about 15 miles south of San Jose.

The property was first worked prior to 1903 and produced a small amount of mercury. It remained idle until 1942 when further exploration was done. Development includes two shallow shafts and a short adit which explore an isolated body of silica-carbonate rock in serpentine.

Stayton District Mines and Properties

The Stayton mining district lying at the junction of Merced, Santa Clara, and San Benito Counties has been intermittently active since 1870 with a production of about 2,000 flasks of mercury. Principal output was from the Stayton mine with a smaller production from the Gypsy and Comstock mines.

Although the district has contributed but a very small part of the State's production, it has a small potential under comparatively high mercury prices. Past work indicated the existence of mineralized zones capable of maintaining a small annual production and on which further development, laterally and at depth, appears justified. Selective mining yielded a comparatively high-grade ore. The remaining lower grade material comprises a significant reserve minable under higher mercury prices. Extensive exploration of other geologically favorable but undeveloped areas could also be productive.

Comstock Mine

The Comstock mine is in Santa Clara County, about 17 miles northeast of Hollister, at an altitude of 1,770 feet.

The property was located about 1870; it was worked until 1880 with a production of about 500 flasks of mercury. Sporadic prospecting since 1880 has been unproductive.

The mine is in a northwest-trending belt of serpentine and silica-carbonate rock. A body of cinnabar ore occurs in silica-carbonate rock along the hanging wall of a moderately dipping northeast-striking fault. An inclined shaft, partially inaccessible, extends to a depth of about 250 feet. Short east-west drifts were driven on several levels from the shaft and some stoping was done in the upper section of the mine.

Gypsy Mine

The Gypsy mine is in Merced County, 13 miles northeast of Hollister at altitudes ranging from 2,700 to 2,800 feet.

The deposit was discovered during the 1870's and operated until 1880 with an output of about 500 flasks of mercury, which is included in the output of the Stayton mine. No significant production has been made since. Grade of ore averaged about 10 pounds of mercury per ton.

The mine explores a silicified breccia zone along a northwest-trending, southwest-dipping fault in altered basalt in which cinnabar occurs as vein fillings and fracture coatings. Mine workings include a stope open to the surface extending to an inclined depth of about 100 feet, several drifts, and 2 adits. An old inaccessible inclined shaft is reported to extend to a depth of 40 feet below the workings. The ore body mined was about 50 feet long, 5 to 10 feet wide, and 75 feet deep.

Mariposa Mine

The Mariposa mine is in San Benito County, about 16 miles northeast of Hollister.

The property was located during the 1870's and a small amount of mercury was produced prior to 1903. The mine has been idle for many years.

A wide shear zone in basalt, striking northwesterly and dipping moderately to the northeast, contains sparsely disseminated cinnabar. It has been developed by a 350-foot adit, several short drifts and a raise. About 1,400 and 2,000 feet to the southeast, the same altered zone, reportedly containing stronger mineralization, was explored by three shallow shafts and a drift.

Red Metal or Shriver Mine

The Red Metal or Shriver mine is in Merced County, about 14 miles northeast of Hollister.

The deposit was discovered during the 1880's and was worked primarily for stibnite. Some cinnabar was mined from shallow surface deposits and treated at the adjoining Gypsy mine. No work has been done for many years.

Two adits, with an aggregate length of about 1,200 feet, explored a stibnite-cinnabar bearing vein in basalt. Cinnabar occurs along small fractures and pods in the upper part of the vein.

Stayton Mine

The Stayton mine is in Merced County, about 13 miles northeast of Hollister at an altitude of 2,760 feet.

The property, located in 1870, has been the principal producer of the district. Its first activity was confined to the mining of antimony ores. Mercury production commenced in 1876 and continued until 1880 with a reported output of 1,000 flasks. Intermittent operations during 1917-18, and 1920-47 yielded an additional few hundred flasks. The mine was reactivated in 1955 and a small amount of mercury was produced. Grade of ore mined ranged from 2 to 40 pounds of mercury per ton.

Cinnabar occurs in a series of parallel fractures along a northerly trending, westerly dipping fault zone in basalt. Mineralization persists in the main fault zone to a reported inclined depth of 250 feet. It extends for

about 75 feet into the hanging wall, with ore occurring in comparatively wide low-grade zones and narrow high-grade stringers.

Old mine workings, largely inaccessible, include the main level, driven about 350 feet to the south along the ore zone, and a 250-foot inclined shaft with levels at 70, 150, and 235 feet. The 150 level was reportedly developed by 775 feet of drifts. Extensive raising and stoping was done along the main ore zone and parallel hanging wall fissures. A crosscut adit, driven to intersect the vein 70 feet north of the main adit portal, encountered a small pocket of cinnabar.

During 1956-57, the mine was worked from the adjoining Yellowjacket mine about 500 feet northwest of the Stayton adit. The Yellowjacket adit driven about 600 feet to the south then 100 feet to the east, encountered the main Stayton fault zone about 45 feet below the 70 level. Some lateral development was done. Development ore was sorted and treated in a 2-pipe oil-fired retort having a 1½-ton daily capacity.

Yellowjacket Mine

The Yellowjacket mine in Merced County, adjoins the Stayton mine on the northwest and has been worked in conjunction with the Stayton mine.

Several narrow, weakly mineralized, cinnabar-bearing veins in altered basalt were encountered by the main adit which extends 600 feet southerly and 100 feet easterly to the Stayton ore zone. A 275-foot crosscut, driven southwest through altered basalt, cut a narrow vein 55 feet from the main adit. No significant tonnage of commercial-grade ore was developed.

Central San Benito District Mines and Properties

The Central San Benito mining district is in east-central San Benito and northwest Fresno Counties. Mercury production, starting in 1859, has continued intermittently. Total output is about 5,000 flasks with principal production from the Arrambide (Mercy), Cerro Bonito, Juniper, Lea-Grant, Lucky Strike, and Valley View mines. Many smaller properties have produced small quantities of mercury.

Although the district's production has been comparatively minor, it constitutes a small potential source of mercury under favorable economic conditions. In general, the ore bodies are small and irregular in occurrence and much prospecting and exploration is necessary to maintain a small production. The cost of this work, in relation to the small tonnage produced, is abnormally high and is justified only during periods of high mercury prices. The 1955-57 prices encouraged search for new deposits, and two properties (Dar and El Cajon) were brought into production during 1956, indicating the possibilities of the district are not exhausted.

With the exception of the Lea-Grant and Valley View mines, selective mining of the small ore bodies to produce a retort-grade ore has been generally practiced. Significant reserves of low-grade ore undoubtedly remain in many

of the old mine workings. These reserves, and the probability of new discoveries in undeveloped areas, give the district a small production potential.

Arrambide or Mercury Mine

The Arrambide or Mercury mine consists of 18 claims and 5 millsites in Fresno County, about 25 miles southwest of South Dos Palos, at altitudes ranging from 1,600 to 2,000 feet.

Cinnabar was discovered in the area in 1860 by Mexican miners, and a moderate quantity of mercury was produced during the ensuing few years. The property was idle until 1911 when company operations were started and continued until 1914. Intermittent production by various companies and lessees was recorded during 1918, 1929-34, and 1938-43. The property was reportedly reactivated by A. L. Prichard, San Jose, Calif., during 1956. Total production from the mine has been about 1,700 flasks of mercury.

A creek crosses the property, dividing it in two parts known as the North Hill and South Hill workings. Rocks in the North Hill area consist of zones of altered Franciscan sandstone crossed by northerly trending, easterly dipping quartz veins and a northeast-striking, southeast-dipping breccia zone. Cinnabar occurs in fractures in a quartz vein, locally in the adjacent wall rock, and along the breccia zone. A pipelike ore body in a quartz vein measured 30 feet long and 20 feet wide, at a depth of 140 feet. An oreshoot in the breccia zone was approximately 80 feet long and 4 to 6 feet wide, on the 120-foot level. Inaccessible mine workings include several hundred feet of adits, drifts, and crosscuts.

Rocks in the South Hill area comprise altered Franciscan sandstones. Cinnabar occurs in a northeast-striking, southeast-dipping breccia zone and locally in the adjacent sandstone wall rock. Shoots of high-grade ore are erratically distributed along the zone; the intervening material is low-grade ore. Two oreshoots were mined; the southernmost ore body was 40 feet long, 20 feet wide, and bottomed at a depth of 90 feet; the northern ore body was mined over a length of 160 feet, a width of 20 feet, and a depth of 30 feet. Deeper development indicates its downward continuance. Mine workings, largely inaccessible, include over 1,000 feet of underground openings and an open pit.

Other areas of the property were explored. Cinnabar was found to occur erratically along narrow breccia zones.

Bitter Water Mine

The Bitter Water mine is in San Benito County, 2 miles southwest of Llanada. The mine was active during 1932 and 1938, and a small production of mercury was made. Exploration by bulldozer stripping was reported to have been done during 1955-56.

Mine workings include about 100 feet of underground openings and several open cuts which explore a narrow northeast-trending fracture in Upper Cretaceous Panoche sandstone. Cinnabar occurs along fractures and disseminated in the sandstone.

Butts Property

The Butts property is in San Benito County, about 28 miles southeast of Hollister. The deposit was discovered prior to 1900, but no production was recorded until 1915-19 when a small quantity of mercury was produced. The mine has been inactive since.

Inaccessible mine workings include two open cuts and short adits exploring a narrow northwest-striking, northeast-dipping breccia zone in sandstone and chert. Cinnabar and metacinnabarite are erratically distributed throughout the breccia zone.

Cerro Bonito Mine

The Cerro Bonito mine is in San Benito County, about 2 miles south of Llanada at an altitude of 3,000 feet.

The property was located in 1873, and production through 1876 was an estimated 800 flasks of mercury. Grade of the ore mined averaged 10 to 20 pounds of mercury per ton. Sporadic work since 1876 yielded no significant production. Recent work comprised sorting dump material and retorting sorted ore.

Extensive mine workings explore a narrow northerly dipping body of serpentine whose upper part was altered to silica-carbonate rock. Cinnabar is erratically distributed in the silica-carbonate rock and locally concentrated along the sandstone contact. The upper workings include numerous open cuts and shallow pits in silica-carbonate rock. A lower adit 600 feet below the upper workings and reportedly connected with the upper section of the mine, was driven southerly through serpentine and easterly along the serpentine-sandstone contact. Another adit was reported to have encountered cinnabar mineralization in the Franciscan sandstone along its contact with silica-carbonate rock.

Crystal Quartz Prospect

The Crystal Quartz prospect is in Fresno County, near the Arrambide mine. The property was located in 1953, and a few flasks of mercury were produced. No work has been done since.

Several surface cuts were excavated along a cinnabar-bearing quartz vein in sandstone.

Dar Prospect

The Dar prospect in San Benito County, about 8½ miles southeast of Llanada, was discovered in 1956.

Cinnabar occurs as disseminations and narrow veinlets along a shear zone in Panoche sandstone and shale. Bulldozer stripping and open-cut mining along the mineralized zone resulted in a small production of mercury. Sorted ore was treated in a 2-pipe retort.

El Cajon Mine

The El Cajon mine comprises 20 claims in San Benito County, about 9 miles southwest of Llanada, at altitudes ranging from 1,800 to 2,800 feet. The property was discovered in 1955, and a small quantity of mercury was produced during 1956-57, from ore which averaged 15 pounds of mercury per ton.

The mine is on a northwest-trending, northeast-dipping fault zone which forms a breccia as much as 200 feet wide between Panoche sandstone and shale and footwall Franciscan graywacke and shale. Cinnabar occurs in the breccia zone and the altered sandstone hanging wall. Small irregular ore bodies are localized along northeast-trending cross faults within the breccia zone.

Workings consist of a bulldozed area about 300 feet long, 200 feet wide, and from 1 to 20 feet deep. Numerous trenches and open cuts were excavated in the stripped area. Ore is trucked to the New Idria mine for furnacing.

El Rey Mine

The El Rey mine is in San Benito County, about 2 miles northwest of Llanada.

The property was discovered in 1940, and operations to 1943 produced a small quantity of mercury. Intermittent work during 1949-56 produced an additional few flasks. Recently, underground exploration was continued.

Mine workings include several short adits and drifts along an easterly trending, northerly dipping thrust fault in Franciscan sandstone. Cinnabar occurs in small disconnected bodies along the fault zone. Sorted ore is treated in a 2-pipe oil-fired retort.

Juniper Mine

The Juniper mine is in San Benito County, about 9 miles southeast of Llanada, at an altitude of 1,400 feet.

The property, formerly the Lily and Neva sections of the Lea-Grant group, was discovered in 1940. The output of mercury during the 1946-56 period of operations was substantial. Grade of ore varied from 5 to 60 pounds of mercury per ton.

Mine workings include about 1,000 feet of crosscuts, drifts, and raises on steep, narrow, northwest-trending cinnabar-bearing fault zones in hydrothermally altered Panoche sandstone. A 65-foot shaft was sunk from the main adit on a fault zone and stoping done from a sublevel 25 feet below the collar of the shaft. Ore was treated in 1- and 2-pipe gas-fired retorts. Recent operations consist of open-pit mining followed by wet screening and retorting of the fines.

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Lea-Grant Group

The Lea-Grant group comprises the Wild Turkey and Toothache mines in San Benito County, about 8 miles southeast of Llanada.

The property was discovered in 1940, and operated until 1944 with an output of over 700 flasks from ore which averaged 2 to 8 pounds of mercury per ton. It was reactivated in 1954 and intermittent work produced an additional few flasks.

The mines are on an easterly trending, northerly dipping zone of mineralization in altered Panoche sandstone, broken by numerous small faults with little continuity or displacement. Cinnabar is erratically distributed along the ends of the zone. The middle section is apparently barren. Work was most extensive at the Toothache and Wild Turkey mines on the east and west ends of the zone.

The Toothache mine was the more productive. It is developed by adits and open pits over a vertical range of about 100 feet. Cinnabar occurs in small ore bodies along fractures in the mineralized zone and disseminated in the adjacent altered sandstone.

Workings of the Wild Turkey mine consist of adits and drifts exploring a mineralized shear zone in which cinnabar occurs along fractures and impregnated in the sandstone. Sorted ore is burned in a 2-pipe, gas-fired retort.

Lone Oak Mine

The Lone Oak mine is in San Benito County, about 2½ miles north of Llanada. The mine was discovered in 1938, and intermittent work to 1945 produced about 60 flasks of mercury. It was reactivated in 1951, and sporadic operations to 1957 yielded an additional few flasks.

The property is located along mineralized thrust faults in Franciscan sandstone which strike northwest and dip moderately to the northeast. Cinnabar occurs in isolated small pods, or pockets, in the breccia zone, and in narrow high-grade stringers in the sandstone. Mine workings include surface cuts, 2 shallow shafts, and several open pits along a 400-foot section of the fault zone. A mineralized area about 1,800 feet to the northwest on which development is continuing was explored by a 40-foot shaft and a crosscut adit. The Pico Rico area on a fault zone west of the Lone Oak fault, was developed only superficially.

The reduction plant includes a 25-kw diesel electric generator, jaw crusher, 2- by 25-foot 20-ton-capacity oil-fired rotary furnace, vertical pipe condensers, dust collector, settling tank, and stack. Soot is hand hoed, and residue is retorted. Calcines drop to a cooling bin and are trammed to the dump in mine cars. A 6-pipe retort for treating high-grade ore completes the plant.

Lucky Strike Mine

The Lucky Strike mine includes two claims in San Benito County, about 3 miles northwest of Llanada.

The mine was discovered in 1940 and operated until 1944. An estimated 200 flasks of mercury was produced from high-grade ore, averaging over 60 pounds of mercury per ton. It was reactivated in 1954, and a few flasks were produced from ore encountered during exploration.

The claims are on a thrust fault in Franciscan sandstone marked by a zone of echelon shears which strike northwesterly and dip from vertical to about 45° northeast. Ore bodies occur along the strongest shears. Cinnabar is impregnated in fault gouge and forms high-grade veins in the sandstone wall rock.

Mine workings on two levels aggregate about 1,500 feet over a lateral distance of about 170 feet and a vertical range of 130 feet. Ore is treated in a 2-pipe gas-fired retort.

Mitchell Prospect

The Mitchell prospect is in San Benito County, about 8 miles southeast of Llanada. The deposit was located in 1942 and operated until 1945. Its output was several flasks from ore which averaged 7 to 15 pounds of mercury per ton. The mine has been inactive since.

Cinnabar occurs in cross fractures, along bedding plants, and locally disseminated in Panoche sandstone. Small ore bodies are erratically distributed along the mineralized zone. Mine workings include a short adit and numerous open cuts.

Parker-Carlson Prospect

The Parker-Carlson prospect in San Benito County, 2 miles northwest of Llanada, has been inactive since 1941.

The deposit was discovered in 1941, and a few flasks of mercury were produced. Scattered surface cuts explore a northerly trending, easterly dipping thrust fault in Franciscan sandstone containing small, shallow pockets of cinnabar.

Valley View Mine

The Valley View mine is in San Benito County, about 2 miles north of Llanada at an altitude of 1,600 feet.

The mine was located in 1935 and operated until 1943 with a production of over 300 flasks from low-grade ore. Further work during 1946-47 and 1951-52 yielded additional mercury. Ore mined during the latter periods averaged 4 to

5 pounds per ton. The property was reactivated in 1956, and underground exploration was carried out.

Metacinnabarite and cinnabar occur along a flat-dipping silicified thrust fault in Franciscan sandstone and shale. Ore is localized at fault intersections between the main fault and branches that extend upward from it.

Mine workings, largely inaccessible, include about 1,600 feet of shallow underground openings and numerous surface cuts along the breccia zones. Short adits and open cuts, west and north of the main workings, explore lateral extensions of the mineralized faults.

Yturriarte Mine

The Yturriarte mine is in San Benito County, about 2 miles northwest of Llanada. The deposit was discovered in 1940, and during 1941-43 a few flasks of mercury were produced. No work has been done since.

Mine workings include several adits, totaling about 400 feet, which explore a wide breccia zone along a thrust fault in Franciscan sandstone and shale. Cinnabar is disseminated in the breccia and along the adjacent sandstone contacts.

New Idria District Mines and Properties

The New Idria mining district in southeast San Benito County and western Fresno County, is the State's second largest mercury producing district with an output since 1854 of over 500,000 flasks. Most of this output came from the New Idria mine, with a small but significant production from the many smaller properties.

Although the original large rich ore bodies of the New Idria mine have been depleted, the property has been able to maintain a stable production by a program of aggressive and intelligent exploration and development. This work developed extensions of known ore bodies and encountered new deposits in geologically favorable areas in undeveloped sections of the mine as well as in adjacent properties. The company's 2,500- to 3,000-ton monthly production rate should be maintained, although this is dependent on the character and grade of mineralization encountered during mine development and on the assumption that operating costs will not increase disproportionately. Higher mercury prices would allow the cutoff grade to be lowered, permit the utilization of marginal-grade ores, and increase the mine's potential reserves.

The numerous other properties in the district have a combined small production potential that could, with adequate exploration and development, maintain a limited production. Recent mercury prices have not encouraged increased activity, and small-scale leasing operations have been confined to the high-grade sections of the deposits. Surface prospecting has been thorough, but it is possible that intensive underground exploration would be productive and add substantially to the district's ore reserves.

Alpine Mine

The Alpine mine is in San Benito County, about 40 miles northwest of Coalinga and 5 miles southwest of the New Idria mine, at an altitude of 3,600 feet.

The mine was discovered in 1910 and operated intermittently until 1943. Principal production was during 1912-17 when several hundred flasks of mercury were produced. During 1956, road building and mine rehabilitation were done.

Cinnabar and native mercury occur in small, disconnected lenses and isolated bodies of silica-carbonate rock along a northwest-trending, northeast-dipping fracture zone in serpentine. Inaccessible mine workings include a main adit, several shorter adits, crosscuts, and raises, totaling about 1,400 feet, which explore the mineralized zone to an inclined depth of 230 feet. Ore is hauled to the New Idria mine for furnacing.

Anita Prospect

The Anita prospect is in Fresno County, about 28 miles northwest of Coalinga.

The property was worked sporadically from 1941 to 1954, with a small production of mercury. Grade of ore averaged about 10 pounds of mercury per ton. During the period 1956-58, low-grade ore was intermittently mined from open cuts and trucked 10 miles to New Idria for furnacing. Sorted ore was treated in 2-pipe retorts. Workings include numerous open cuts and short adits along fractures and faults in sandstones and shale in which cinnabar occurs as small blebs and isolated bunches.

Archer Mine

The Archer mine includes seven claims in Fresno County, 24 miles northwest of Coalinga and 10 air-line miles southeast of the New Idria mine, at an altitude of 3,300 feet.

The claims were located in 1904, and intermittent operation by the owner continued until 1943 when the mine was leased to Archer Enterprises, Los Angeles, Calif. Company operations continued recurrently until 1953, and leasing operations have been in progress since. Total production was over 1,000 flasks from ore which ranged in grade from 3 to 24 pounds of mercury per ton.

The mine is on a northeast-trending, southeast-dipping fault contact between underlying serpentine and overlying indurated Panoche shale. Cinnabar and metacinnabarite occur in the northwest- and northeast-trending shear zones that cut the indurated shale. The zones range from 1 to 15 feet in thickness.

Mine workings are on two levels, 205 feet apart. The upper level includes 520 feet of drifts, crosscuts, several raises, and winzes; the lower level consists of a 640-foot crosscut adit and a 1,000-foot drift parallel to the upper

level. About 450 feet of raises extend from the lower level, one of which connects with the upper workings. Ore bodies are mined by square-set stoping methods.

Sorted ore is treated in a 2-pipe wood-fired retort. An 80-ton-capacity oil-fired rotary furnace formerly treated the lower grade ore.

Aurora Mine

The Aurora mine is in San Benito County, about 72 miles southeast of Hollister and 5 miles south of the New Idria mine at an elevation of 4,000 feet.

The property was discovered in 1853 and worked intermittently until 1911. Further work was done in 1915 and 1917 and during 1930-43. Operations by lessees have been in progress since 1946. Total production has been over a thousand flasks. Grade of the ore ranged from 2 to 10 pounds of mercury per ton.

The main deposit is on a northwest-trending, southwest-dipping fault in serpentine. It occupies a zone about 400 feet long and 100 feet wide in which several large irregular bodies of silica-carbonate rock occur. Cinnabar and metacinnabarite form irregular veins and bunches along fractures in the silica-carbonate rock. Minable ore bodies are found where the mineralized fractures are closely spaced.

Mine workings, largely inaccessible, include 5 adits, a glory hole, numerous drifts, and crosscuts extending about 400 feet laterally over a vertical range of 100 feet. Surface exposures along the mineralized area were explored extensively by a series of open cuts. Work since 1955 was on a small, isolated cinnabar-bearing lens of silica-carbonate rock, south of the main workings, which is developed by open cuts and shallow underground openings. The low-grade ore produced is sorted and treated in retorts.

Breen Group

The Breen group, comprising the old Don Juan, Don Miguel, Cody and Niesen properties, is in San Benito County, about 30 miles northwest of Coalinga at an altitude of 2,750 feet.

The deposits were discovered during the 1870's and 1880's. Some sporadic prospecting was done during that period and again during 1933. No production was recorded. Mine workings comprise about 300 feet of adits along mineralized fractures in altered Panoche shale. Cinnabar is disseminated in the fault gouge, but apparently too sparsely to form minable ore bodies.

Del Mexico Mine

The Del Mexico mine includes three claims in Fresno County, about 28 miles northwest of Coalinga, and 12 miles by road southeast of the New Idria mine at an altitude of 3,700 feet. The mine was discovered in the 1860's and has been worked intermittently. Production has been small.

Cinnabar occurs in a series of irregularly spaced, nearly parallel fractures in indurated Panoche sandstone, varying in width from one to several inches. The veins are often high grade with values up to 20 pounds of mercury per ton. The mine workings, which are partially inaccessible, include about 800 feet of adits and drifts, and several open cuts.

Flint Group

The Flint group includes the Andy Johnson, Clear Creek, Fourth of July, and Red Rock properties, in San Benito County, 31 to 35 miles northwest of Coalinga, at altitudes ranging from 3,000 to 4,400 feet.

The several mines comprising the group were discovered prior to the 1880's and prospected sporadically. Information on these early operations is obscure. Lessees worked the properties at various times during 1933-57, but production was small.

Cinnabar and native mercury occur in irregular bodies of silica-carbonate rock along a northwest-trending, southwest-dipping shear zone in serpentine. Ore bodies are discontinuous and relatively shallow. Mine workings include several exploratory adits, aggregating about 1,500 feet, and numerous open cuts.

Florence Mac Mine

The Florence Mac mine consists of six claims in San Benito County, about 27 miles northwest of Coalinga, at an altitude of 3,000 feet. The claims were located in 1904 and worked intermittently until 1939 with a small production of mercury. Lessees worked on the property in 1957.

The mine is on a northwest-trending, southwest-dipping fault between Panoche shale and underlying Panoche sandstone. Cinnabar occurs along northeast and northwest-striking shears that cross the indurated shale. Inaccessible mine workings include about 900 feet of drifts and crosscuts and numerous bulldozer cuts and trenches.

Koski Group

The Koski group of four claims is in Fresno County, about 25 miles northwest of Coalinga.

Cinnabar-bearing shear zones in indurated shale were explored sporadically, and a small production of mercury was made. Workings include several open cuts and short adits.

New Idria Mine

The New Idria mine, including the Idria, San Carlos, Molino, Sulphur Springs, and Creek properties, is in San Benito County, about 67 miles southeast of Hollister, at altitudes ranging from 2,500 to 5,200 feet. The properties comprise 240 acres of patented mining claims and 4,200 additional acres of patented land owned by the New Idria Mining and Chemical Co., Idria, Calif.

Cinnabar deposits in the area were discovered by Mexican prospectors in 1853. Large-scale operations soon followed, with an estimated output of 17,455 flasks of mercury in the period between 1854 and 1865. The mine soon became the second largest producer in the State, exceeded only by the New Almaden mine. Yearly production records, starting in 1866, indicate an average yield of 11,330 flasks for 1867-69 followed by a period of gradual decline to 792 flasks in 1891. Ownership of the property changed, and an increase in production started in 1892, reaching a high of about 11,000 flasks in 1910 and 1917. The 1916-18 average yearly production was 10,845 flasks. Most of the ore produced during this period came from old mine dumps and open-cut operations. In 1920 a fire destroyed part of the reduction plant, and the mine was shut down for the first time in its long history.

The property was purchased by the New Idria Quicksilver mines in 1922. Old workings were rehabilitated and production resumed, continuing at an annual average rate of 4,261 flasks through 1931. A drastic curtailment in operations caused by depressed economic conditions during 1932-36 decreased yearly production to an average of 490 flasks. The New Idria Quicksilver Mining Co. acquired the property in 1936. The higher grade ore bodies had been depleted, so mining was confined to lower grade ores, dumps, and stope fills.

The Bureau of Mines and the Geological Survey explored the property in 1941-42 by diamond drilling. Information obtained regarding ore structures proved valuable to the operators in planning underground prospecting and led directly to the discovery of high-grade ore.

Intensive company exploration in 1942 encountered new ore bodies, averaging 15 to 20 pounds of mercury per ton. Output increased to 13,785 flasks in 1943 and 12,201 flasks in 1944.

Following World War II production declined and remained comparatively small until 1951, when the Korean conflict and higher mercury prices stimulated increased activity.

Starting in 1952 and continuing to 1958, three DMEA contracts have been in force. The first contract, started in 1952 and completed in 1958, explored for mercury ores in the West Idria area along the Idria thrust. Underground exploration comprised 8,449 feet of drifts, crosscuts, raises, and winzes and 1,375 feet of diamond drilling. The work cost $337,219.

The second contract started in 1955 and was completed in 1958. Work was designed to explore the Molino zone, a mineralized area in Panoche shale on the footwall side of the Idria thrust fault between the Idria and San Carlos mines. Exploration, consisting of 2,867 feet of drifting, raising, and crosscutting, was completed at a cost of about $112,690. The third contract was in force from 1957 to 1959 and explored the Sulphur Springs area in the eastern part of the New Idria mine. Work done included rehabilitation and 1,022 feet of drifting and raising, at a cost of $38,919.

The Government's share of all DMEA cost was repaid by the company through royalties from production.

During 1956-61 the mine was the largest mercury producer in California. Ore, averaging 6 to 12 pounds of mercury per ton, is produced from underground workings at the rate of 2,500 to 3,000 tons per month. Lessee operations and custom ore provide additional tonnage.

The area consists of a large oval body of strongly sheared serpentine rimmed by Franciscan sandstone and the Upper Cretaceous Panoche Formation and later sediments. The structure is that of an asymmetric anticlinal dome marked on the northeast flank by overturned beds and by an irregular thrust fault (termed the New Idria fault) along or near the Franciscan-Panoche contact. Except for the contacts along this thrust fault and the tear (local usage) faults that offset it, the serpentine-Franciscan and Franciscan-Panoche contacts around the remainder of the dome are marked by high-angle faults that encircle the core and generally dip away from its center. In all cases, the fault-bounded serpentine and Franciscan rock core of the dome has been raised in relation to the enclosing Panoche sedimentary rocks.

The mercury deposits consist of cinnabar, with very little metacinnabarite and native mercury, and occur as veins and stockworks that occupy late fractures or fracture zones in altered rocks. The ore bodies' greatest development lies in Panoche rocks beneath the New Idria thrust fault and includes the New Idria and San Carlos as well as several promising but hitherto unproductive deposits. Several deposits of economic importance lie close to the faults around the south and west sides of the dome. Other deposits occur in silica-carbonate rock along shear zones in the northwest part of the serpentine mass, and a few are in altered sandstone of the Franciscan formation.

Oreshoots vary greatly in size. Those of the New Idria and San Carlos mines are measured in hundreds of feet, but only a few other ore bodies are more than 50 feet in greatest dimension. Grade of ore is also variable. All known deposits are in places where abundant openings were formed during faulting. Abrupt changes in strike of the New Idria fault, due to tear faults or to bends, exerted the most important structural control on rock alteration and ore deposition, but some ore bodies are definitely related to changes in angle of dip.

During 1955-61 a large part of the production was from a deposit in the Franciscan Formation in which ore occurs in narrow fissure veins interlayered with calcite and dolomite or disseminated in the wall rock. These veins occupy a complicated system of tear faults similar to the type found elsewhere in the mine. Cinnabar is not continuous within the vein and occurs in irregular concentrations along the plane of the vein. Ore bodies vary from 3 to 50 feet in width.

The New Idria mine is extensively developed by a series of adit levels, sublevels, drifts, and crosscuts, connected by raises and winzes, exceeding 30 miles in total length, and a large open pit and glory hole. Underground

operations are from the No. 10, or main haulage, level. Principal production was from the main ore zone comprising a lens that outcropped 1,200 feet long, 550 feet wide, and extended downward for 1,500 feet. Its width on the No. 10 level was about 150 feet. This large mineralized zone was developed from 14 main levels and is essentially mined out down to the 1,450-foot level. It contained many very large ore bodies and numerous smaller ones scattered through the lens in the Panoche sandstone and shale. The larger ore bodies were mined by square-set stoping, with back filling to support the heavy ground. Stull-stoping methods were used for the narrow veins.

Mineralized sections are explored by drifting and raising. Diamond drilling and long-hole drilling did not prove successful in locating new ore. They were useful in guiding exploration headings by locating the hanging wall or other structures, thereby eliminating the use of more costly crosscuts or raises. Raises are used along exploration headings to follow stringers of cinnabar, especially where added structural information is required.

The San Carlos deposit was developed originally by extensive underground workings, including both adits and a shaft, to a vertical depth of about 500 feet, over a horizontal distance of about 1,500 feet. Underground workings were later abandoned and operations were then by open-cut mining along the northwest and southeast ends of the deposit.

Exploration at the Molino mine includes driving an adit southeasterly toward, and under, the San Carlos workings, and subsequent development of small mineralized zones encountered during the work.

In 1961 110 men were employed at the New Idria mine and 11 men on the San Carlos operation.

Furnacing methods are as follows: Mine-run ore is crushed to 2-inch size, conveyed to feeder bins, and fed by shaking or grasshopper feeders to four oil-fired rotary furnaces. Each furnace has a capacity of 100 tons per 24 hours and uses No. 7 gravity fuel oil, heated electrically and atomized by compressed air. Air used in the furnaces is preheated by passing it through the concrete calcine bins. Oil consumption ranges from 5 to 7 gallons per ton.

Burned ore drops into concrete storage bins and is trucked to the calcine dump. The mercury-laden gases pass from the furnaces to 12-inch cyclone-type dust collectors. The collected dust drops into cone-shaped hoppers and is washed by water into the trap collecting system. The gases are drawn by fans through steel flues to a manifold ahead of the condensing system, consisting of 2 banks of vertical pipe condensers, each containing 34 cast iron pipes, 16 inches in diameter and 24 feet high. Pipe bottoms with cast iron hoppers extend into circular concrete dust-collecting trays about 3 feet deep and filled with water.

The mixture of dust and water is stirred continuously in the concrete trays by alloy steel paddles attached to vertical rotating shafts, extending from the hoeing machines through the bottom of the trays. The paddles move

the sludge to a circular steel hopper from which it is fed through a hand-operated valve to the hoeing machine. This machine, designed by the management, is a double-bottom slightly concave steel pan about 15 feet in diameter, with water in the lower part heated electrically. Lime is added to the sludge and the drying mixture is stirred by four sets of hinged blades and a roller attached to arms extending from the central shaft. Mercury is freed, runs toward the center of the machine and flows by gravity through a pipe to the cleaning and bottling room. The residue, which still contains some mercury, is returned to the furnace for retreatment. A recovery of over 95 percent of the mercury in the ore is obtained.

Excess water from the settling trays and from washing the concrete floor beneath the hoeing machines flows to a series of traps and a settling tank where a small amount of mercury is recovered.

Exhaust gases from the condensers pass through two wooden junction boxes and a wood flue to a third wooden junction box and a wood side-hill flue connected to a wooden stack.

The furnace plant is operated on a 3-shift-per-day basis. One kiln boss on day shift and a fireman and helper on each shift comprise the 7-man operating crew.

North Star Mine

The North Star mine is in San Benito County, about 4 miles southwest of the New Idria mine.

The deposit was discovered in 1946 and worked intermittently through 1955 with a production of several hundred flasks from ore which varied in grade from 5 to 9 pounds of mercury per ton. A shear zone in serpentine containing disseminated cinnabar has been developed by an open cut. Selectively mined and sorted ore is trucked to New Idria for furnacing.

Picacho Group

The Picacho group, including the Benta, Bonanza, and Hernandez properties, comprises 10 claims in San Benito County, about 30 miles northwest of Coalinga.

The property was discovered prior to 1870 and worked intermittently until 1906 with a small output of mercury. The present company acquired the mines in 1913 and operated them until 1916. Sporadic operations were recorded during 1938-40, 1952-54, and 1957-59.

Cinnabar occurs in small, shallow lenses of silica-carbonate rock erratically distributed along a northwest-trending, southwest-dipping shear zone in serpentine. Mine workings include a 3,000-foot adit, driven to intersect downward extensions of cinnabar-bearing outcrops, and several shallow, inclined shafts and open cuts, excavated on small high-grade stringers.

Santa Margarita Mine (Edna Bell, New Tirado)

The Santa Margarita, Edna Bell, or New Tirado mine is in San Benito County, about 28 miles northwest of Coalinga.

The deposit was discovered in 1938 and worked sporadically until 1944. It was reactivated in 1954 and has since been worked by lessees. A small production of mercury has been made.

Mine workings consist of several short adits and open cuts along cinnabar-bearing shears in indurated Panoche shale that forms the hanging wall of a northwest-trending, southwest-dipping fault zone between shale and sandstone. Ore is sorted and treated in a 2-pipe retort.

Spanish Prospect

The Spanish prospect is in San Benito County, about a mile southwest of the New Idria mine.

The property was prospected in 1954 and a few flasks of mercury produced. Cinnabar and native mercury occur in fracture planes along shear zones in sandstone. Workings include a short adit and several open cuts.

Tirado Prospect

The Tirado prospect consists of two claims in San Benito County, about 2½ miles northeast of the Alpine mine. The property was located in 1914 and worked intermittently until 1919, then again in 1942. Production was small. Cinnabar occurs in a small body of silica-carbonate rock along a shear zone in serpentine. Mine workings include a few shallow open cuts.

Tirado and Shear Prospect

The Tirado and Shear prospect is in San Benito County, about 2½ miles southwest of the New Idria mine. Cinnabar was discovered on the property in 1925 and subsequent prospecting yielded one flask of mercury. No work has been done since.

Small isolated bodies of cinnabar-bearing silica-carbonate rock occur along shear zones in serpentine. Workings consist of several shallow open cuts.

Wonder Mine

The Wonder mine consists of six claims in San Benito County, about 1½ miles southwest of the New Idria mine.

The mine was discovered in 1908 and worked intermittently until 1942 with production of a few hundred flasks of mercury. It was reactivated in 1951, and since then lessee operations have been continuous. Cinnabar occurs along fractures within a crushed zone in Franciscan sandstone. Ore varies in grade

from 3 to 9 pounds of mercury per ton. Mine workings comprise several hundred feet of underground openings and open cuts. Sorted ore is retorted.

Parkfield District Mines and Properties

The Parkfield mining district is in Kings County, southern Fresno County, and southeastern Monterey County. It consists of two separate areas about 10 miles apart, known as the Patriquin and Table Mountain areas, which have produced about 4,000 flasks of mercury since 1873. Principal production was from the Patriquin, Kings, and Dawson mines; the first two properties are active and operating on a small-scale basis. Operations have been intermittent, dependent on high mercury prices, and production has been small in comparison with other California mercury districts. Known ore bodies are largely depleted, but favorable geologic conditions justify continued exploration that could develop new reserves adequate to maintain a small production.

Dawson Mine

The Dawson mine is in Kings County, about 14½ miles east of Parkfield, at an altitude of 2,300 feet. Operations started in 1918 with principal production between 1918 and 1922. Sporadic operations during 1923-45 and 1957-61 resulted in a small output of mercury. Total production is over 1,000 flasks.

The mine is in a landslide mass of serpentine and silica-carbonate rock. Cinnabar and metacinnabarite occur in veinlets and fractures in the silica-carbonate rock. Mine workings which developed a shallow ore body, include a glory hole and several hundred feet of inaccessible underground workings about 30 feet below the glory hole. Grade of the ore ranged from 6 to 10 pounds of mercury per ton. Narrow rich stringers of high-grade ore reportedly averaged over 40 pounds of mercury per ton. Sorted ore was retorted.

Gillette Prospect

The Gillette prospect is in Monterey County, 10 miles north of Parkfield, at an altitude of 1,700 feet. The property was worked in 1917 and from 1937 to 1940 with a production of a few flasks of mercury. Mine workings include several short adits and open cuts which explore mineralized blocks of silica-carbonate rock within a landslide mass.

G.W.D. Mine

The G.W.D. mine is in Monterey County, about 9 miles north of Parkfield, at an elevation of 2,700 feet. During 1937-41 several flasks of mercury were produced.

Cinnabar is erratically distributed along narrow mineralized zones in blocks of silica-carbonate rock within a landslide mass. Mine workings comprise shallow open cuts and several short adits.

Kings or Fredana Mine

The Kings or Fredana mine is in Kings County, about 14 miles east of Parkfield, at an altitude of 3,100 feet. It has been the most active property in the area with a record of intermittent operations from 1902 to 1957 and total production of over 1,500 flasks.

The mine is in a landslide area along a crushed zone of serpentine, sandstone, and shale. Cinnabar and native mercury occur in rich veinlets and stringers in the serpentine, and as disseminated bunches in the sandstone. Grade of the ore varies from 3 to 8 pounds of mercury per ton. Old mine workings, largely inaccessible, include an adit and a 60-foot shaft from which short levels were driven. New workings consist of an open pit and a 150-foot adit.

Ore is treated in a 24-ton-capacity rotary furnace designed and constructed by the lessees. Power is supplied by a diesel generator.

Patriquin Mine

The Patriquin mine in Monterey County, about 9½ miles north of Parkfield at an altitude of 3,000 feet, was the principal producer of the area. The mine has been operated intermittently by various owners and lessees since 1873 with principal production during 1915-20, and last production during 1956-59. Total production is over 1,500 flasks.

The mine is on a mineralized zone beneath a northwest-trending, northeast-dipping fault between serpentine and silica-carbonate rock. Cinnabar occurs in veinlets and stringers in the silica-carbonate rock and to some extent in sheared serpentine. Two ore bodies were mined. Grade of the ore varied from 6 to 20 pounds of mercury per ton. Mine workings include a glory hole and extensive (inaccessible) underground openings, several open cuts, and trenches.

Poppy Prospect

The Poppy prospect is in Monterey County, south of the Patriquin mine. A very small quantity of mercury was produced in 1932. Shallow mine workings explored narrow discontinuous cinnabar-bearing mineralized zones in remnants of silica-carbonate rock.

Sommer's Property

The Sommer's property is in Monterey County, about 8 miles north of Parkfield at an altitude of 3,000 feet.

Several short adits explore a weakly mineralized fault between serpentine and silica-carbonate rock, and the underlying sandstone. No production was made.

White Property

The White property is in Monterey County, about 14 miles east of Parkfield. A few flasks of mercury were produced in 1916 and with the exception of occasional prospecting, the mine has since been idle.

Inaccessible mine workings include several crosscut adits and drifts which explored a mineralized zone beneath a low angle fault between serpentine and silica-carbonate rock. Grade of the ore ranged from 2 to 10 pounds of mercury per ton.

Bryson and San Carpoforo Districts Mines and Properties

The Bryson mining district in southwest Monterey County, and the San Carpoforo mining district in southwest Monterey and northwest San Luis Obispo County, comprise two minor mercury-producing districts that have been active intermittently since 1870. Production was about 500 flasks of mercury, principally from the Polar Star mine.

Both districts have a small production potential and favorable geologic conditions suggest that further exploration might develop reserves adequate to maintain small operations. Past work indicates low-grade mineralization at the Bryson mine and comparative high-grade mineralization at the Polar Star property. Under present prices, it is apparent that only high-grading operations can be expected. Increased prices would permit greater flexibility in operations and the possible mining of lower grade ores.

Bryson Mine

The Bryson mine is in Monterey County, about 8 miles northwest of Bryson, at an altitude of 1,100 feet. The deposit was worked intermittently for several years prior to 1941 with a small production of mercury.

Mine workings consist of numerous open cuts and several short adits which explore a northeast-trending, northwest-dipping fault zone between Cretaceous shale and sandstone. The zone varies in width from 10 to 50 feet. Cinnabar is widely distributed along fractures in the fault breccia.

Dutra Property

The Dutra property is in Monterey County, about 20 miles north of San Simeon. The deposit was discovered in the 1870's and worked intermittently until 1900. A few flasks of mercury were obtained from reportedly low-grade ore.

Inaccessible mine workings include a shallow shaft, short adit, and an open cut that explored a wide, northwest-trending fault zone containing large bodies of silica-carbonate rock. Cinnabar is erratically distributed in the silica-carbonate and sandstone country rock.

North Star and Sunset View Prospects

The North Star and Sunset View prospects are in San Luis Obispo County, about 15 miles north of San Simeon. The prospects were discovered in the 1870's and explored intermittently to 1900. No mercury was produced.

Several open cuts explore a mineralized breccia zone in graywacke and shale. No commercial ore bodies were found.

Polar Star Mine

The Polar Star mine consists of nine claims, in San Luis Obispo County, about 13½ miles north of San Simeon, at an altitude of 500 feet. Mineral rights on the property are owned by Kenneth Emigh, Santa Cruz, Calif. Surface rights are owned by the Sunical Land and Livestock Division, Hearst Corp., San Simeon, Calif.

The mine was discovered in 1870 and explored intermittently between 1870 and 1900 and during 1915. Production was small. Further work during 1935-46 produced several hundred flasks of mercury. The property was reactivated in 1955 and operated until 1958.

Rocks in the area consist of graywacke and shale. Isolated pods containing cinnabar occur along a breccia zone and range in size from a few inches to 30 feet in width. Mine workings, mostly caved, include several crosscut adits over a vertical range of 340 feet. Upper workings consist of an open pit, a crosscut adit, and an inclined shaft with short levels at 26 and 41 feet. The most recent work consisted of bulldozer stripping and trenching. Ore was treated in a 2-pipe retort.

Pine Mountain District Mines and Properties

The Pine Mountain mining district in northwest San Luis Obispo County, which has had a production of less than 1,000 flasks of mercury, contains many small prospects and mines that were operated at various times since the 1870's. Principal output was from the Keystone, Ocean View, Buckeye and Quien Sabe mines, with small contributions from other properties.

Past work was not sufficient to determine the potential of the district, and although its production record is small, the district is of interest. Widespread mineralization is indicated over a large area not yet systematically explored or developed. Narrow rich veins and small bunches and disseminations of cinnabar were mined at several properties with little attention paid to the development of lower grade ores. Intelligent exploration for extensions of known mineralized zones and for new ore bodies in geologically favorable but undeveloped areas could develop significant reserves of commercial-grade ore adequate to permit a small but stable operation. This work, together with mine rehabilitation, would be justified only under high mercury prices.

Hamilton Mine

The Hamilton mine is 11 miles northeast of Cambria at an altitude of 1,000 feet. The deposit was discovered during the early 1900's and explored prior to 1915. Production was very small.

The mine is on a broad, steeply dipping, northwest-trending fault in sandstone and shale, in which small lenses of silica-carbonate rock occur. Cinnabar is disseminated in the silica-carbonate rock and fault breccia. Inaccessible mine workings include seven adits, each 100 to 500 feet long, that extensively explored the deposit.

Keystone Mine

The Keystone mine is about 13 miles northeast of Cambria at an altitude of 2,000 feet.

The property was located during the 1870's and operated in 1875 with a reported production of 60 flasks of mercury. Further exploration in 1916-17 and high-grading operations during 1954-55 produced an additional few flasks. Grade of the ore varied from 10 to 20 pounds of mercury per ton.

A moderately east-dipping vein of silica-carbonate rock within a broad northwest-trending fault zone, contains small veins, bunches, and disseminations of cinnabar. Mine workings include the main 300-foot adit, now caved, from which a 50-foot inclined winze was sunk, and several open cuts and short adits. Sorted ore was treated in a 2-pipe retort.

Pine Mountain Group

The Pine Mountain group, including the Buckeye, Ocean View, Pine Mountain, and Little Almaden properties, is 16 to 18 miles northeast of Cambria at altitudes ranging from 2,800 to 3,000 feet.

The mines were discovered in the 1870's and operated intermittently through 1903 with a moderate output of mercury. With the exception of the Buckeye mine, operated on a small scale during 1943-44, no work has been done since 1903.

The properties are located along a strong northwest-trending fault zone in sandstone, shale, and serpentine, containing large erratically distributed bodies of silica-carbonate rock. Cinnabar occurs in siliceous veinlets and disseminations in the silica-carbonate rock. The selectively mined and sorted ore varied in grade from 8 to 20 pounds of mercury per ton.

The Ocean View mine was the principal producer. Inaccessible mine workings include a 1700-foot adit, several short adits, shallow shafts, and crosscuts, that explored the mineralized zone over a vertical range of 170 feet. The Buckeye workings include a 350-foot adit, a raise from the drift to surface, and several open cuts. The Pine Mountain mine was explored by a 200-foot adit, several short adits, and open cuts. The Little Almaden property was prospected by a series of open cuts.

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Quien Sabe and Doty Mines

The Quien Sabe and Doty mines consist of five claims about 16 miles northeast of Cambria. The deposits were discovered about 1905. Sporadic work during 1905-17 produced a small amount of mercury. Lessee operations were in progress during 1955-56.

A narrow lenticular body of serpentine, in many places altered to silica-carbonate rock, lies between two northwest-trending faults in serpentine and sandstone. Cinnabar occurs as small bunches and disseminations in the silica-carbonate rock.

The Doty workings on the northwest end of the serpentine body include two short adits and several open cuts. The Quien Sabe workings, at the southeast end, comprise a 100-foot shaft, a 200-foot crosscut adit, and several open cuts.

Warren Prospect

The Warren prospect is located 11½ miles northeast of Cambria. The property was active in 1940. Several open cuts were excavated on a body of brecciated chert, within a northwest-trending fault zone, in which cinnabar is sparsely disseminated. No production was made.

Williams Prospect

The Williams prospect, about one-half mile east of the Keystone mine, was prospected superficially in 1915 and 1940. No production was made.

Cinnabar occurs in a shallow lens of silica-carbonate rock along a northwest-trending fault zone. Workings include a series of open cuts.

Cambria-Oceanic District Mines and Properties

The Cambria-Oceanic mining district in northwest San Luis Obispo County was the county's largest producer with an output since 1865 approaching 50,000 flasks of mercury. The greater part of the production was made prior to 1938. Principal production was from the Oceanic mine; the Cambria mine made a significant yield, and the several smaller properties contributed a minor output. Production has been small since 1938.

The large known ore bodies in the principal mines are depleted and underground openings are largely inaccessible. During 1954-57 surface exploration was done along several favorable sections of the mineralized zones. The relatively high mercury prices during 1954-58 failed to encourage large-scale activity.

Although significant reserves undoubtedly remain in downward extensions of the productive mineralized zones and in possible parallel zones, the condition of mine workings prohibits extensive rehabilitation, and the high cost of driving new openings to permit deep-level exploration would be warranted

only under increased mercury prices. The large area between and adjacent to the Cambria and Oceanic mines, containing several small properties and prospects, was extensively prospected, but the possibility exists that further work, with modern exploration techniques, would encounter new mineralized sections along and below surface outcrops.

The potential reserve of the Oceanic mine lies in the downward extension of old ore bodies and possible parallel deposits. Work during 1955-57 developed a small productive surface ore body. The Cambria mine offers possibilities of additional reserves along lateral extensions of known ore bodies. Several prospects, partially developed by high-grading operations, deserve further consideration.

Cambria Mine

The Cambria mine, 10 miles northeast of Cambria at an altitude of 1,750 feet, has been inactive since 1940.

The deposit was discovered in 1903 and operated extensively from 1905 to 1908. Depletion of the ore bodies forced suspension of operations. Further work was done in 1915-16 and the mine dumps were reworked during 1932-34. In 1940 some mercury was produced from leasing operations, and in 1961 production was also reported. Total output of the mine is about 4,000 flasks. The ore reportedly averaged 7.6 pounds of mercury per ton.

The mine is located on a wide mass of serpentine, cut by northwest-trending, northeast-dipping faults. Cinnabar occurs as disseminations and fracture fillings in silicified serpentine, and as rich bunches and small veinlets in silica-carbonate rock.

Mine openings, largely inaccessible, include the upper and lower workings along two mineralized faults. The upper workings comprise about 2,100 feet of openings that developed a silica-carbonate-type zone; the lower workings include about 1,800 feet of openings along a zone of silicified serpentine. An ore body in the lower workings, mined by square-set stoping, was reported to be 180 feet long, 8 to 40 feet wide, and 150 feet high. Ore was treated in a 50-ton Scott furnace and a 4-pipe retort.

Fitzhugh Ranch Prospect

The Fitzhugh Ranch prospect is about 8 miles east of Cambria. The property was explored in 1915 and 1933. Production was very small.

A weakly mineralized zone in serpentine contains small and erratic concentrations of cinnabar. Development includes an 800-foot adit and several short adits.

Marquart Prospect

The Marquart prospect is about 1½ miles northeast of the Oceanic mine. The area was prospected in 1917.

Lenses of weakly mineralized silica-carbonate rock occur along a fault in sandstone and shale. No commercial ore was encountered.

Oceanic Mine

The Oceanic mine consists of three patented claims about 5 miles east of Cambria at altitudes of 1,000 to 1,300 feet.

The mine was the largest producer in the county with an output to 1946 of about 39,000 flasks of mercury. It was located in 1865. Large-scale operations started in 1875 and continued until low prices of mercury forced suspension of operations in 1882. Work was resumed in 1902, continuing intermittently to 1926 when the property was acquired by H. W. Gould. During 1926-30, the mine was developed to the 750 level and a modern rotary furnace plant installed. Work by several owners was in progress during 1930-38, followed by sporadic leasing operations from 1940 to 1946. Activities were resumed in 1954. A mineralized area northwest of the old mine workings was developed.

During 1955-57 work under a DMEA contract explored at depth a mercury-bearing serpentine and silica-carbonate contact zone. Cost of the work was about $6,600 and comprised about 2,000 cubic yards of surface stripping and 684 feet of diamond drilling. Small-scale open-pit operations were discontinued in 1958.

The mine is located along a belt of northwest-trending Miocene conglomerates, sandstones, and shales intruded by diabase dikes, which are in fault contact on the northeast with a series of Franciscan sandstones, shales, and serpentine. The fault, which strikes N 45°-60° W and dips steeply to the southwest with local variations to the northeast, cuts across the ore body and limits its extent to the southeast. The main ore shoot strikes about N 65° W, has a nearly vertical dip, and pitches about 45° to the southeast. It was developed to a vertical depth of about 750 feet, over a maximum horizontal extent of 600 feet, and widths of 15 to 40 feet.

Two distinct types of ore occur in the main ore zone. The high-grade type comprises cinnabar disseminated in medium-grained Miocene sandstone; the lower grade type consists of almond-shaped nuggets of cinnabar, replacement of fossil shells by cinnabar, and some native mercury, in a fine-grained sandstone. Ore in the open cut consists of veinlets and disseminations of cinnabar in silica-carbonate rock.

Old mine workings, largely inaccessible, include an open cut and over 2½ miles of underground openings. The main haulage level, or 400-foot adit, is about 350 feet below the outcrop. A 2-compartment vertical shaft extends from this level to the 750-foot level. The top-slicing method of stoping was generally used, although square-set methods were employed for mining isolated sections of the ore body and pillars.

Ore from the new open-pit operations is treated in a 4-pipe gas-fired retort. The rotary furnace has been removed.

Vulture Prospect

The Vulture prospect is about 10 miles east of Cambria. The property was located about 1915 and worked during 1915 and 1933. Production was small. Caved mine workings include two short adits and several open cuts along a cinnabar-bearing fault breccia zone in serpentine.

Wittenberg Property

The Wittenberg property is about 5 miles east of Cambria. The prospect, discovered about 1900, was explored sporadically until 1955, and a few flasks of mercury were produced. Several open cuts were excavated on small, high-grade cinnabar stringers in a sloughed section of silica-carbonate rock.

Adelaide District Mines and Properties

The Adelaide mining district in northwest San Luis Obispo County has been active since 1862, with intermittent operations producing over 40,000 flasks of mercury. Principal production was from the Klau mine with a substantial output from the Buena Vista, La Libertad, and Little Bonanza properties. A small yield came from the numerous other small mines and prospects.

The district has a small-to-moderate production potential under high mercury prices. Extensive exploration at the Buena Vista mine in 1956, stimulated by relatively favorable mercury prices, led to the discovery of a new ore body and stabilized the operation. This discovery encouraged search for new deposits in other geologically promising areas.

Underground workings at the principal mines are largely inaccessible, requiring extensive and costly rehabilitation to permit underground exploration and access to possible marginal grade ore remaining in stope fills, pillars, and unmined sections of the oreshoots. This work would be warranted only during sustained periods of high mercury prices.

Based on past production performance records and the character and grade of mineralization, it is apparent that the district could, under more favorable economic conditions, again become one of the State's major mercury producing areas.

Buena Vista or Mahoney Mine

The Buena Vista or Mahoney mine is about 16 miles west of Paso Robles, at an altitude of 1,300 feet.

The property was located in 1874 and operated intermittently between 1900 and 1948. Principal production was during 1942-48. The mine was reactivated in 1953. Exploration under a DMEA contract during 1956-57, in an undeveloped area south of the old mine workings, led to the discovery of a new mineralized zone. The work consisted of 3,504 feet of rotary drilling in 12 holes at a cost of about $5,800. Development is continuing and open-pit operations are in progress. Production is about 25 to 35 tons per day. Total output has

exceeded 15,000 flasks from ore which ranged in grade from 5 to 20 pounds of mercury per ton.

The old mine is on the extension of the wide easterly striking, southerly dipping fault breccia zone of the adjoining Klau mine. The ore consists of cinnabar that fills fractures in the Franciscan shale and sandstone breccia and pore spaces in altered graywacke. Ore bodies range in size from small pods to as much as 10,000 tons.

Inaccessible underground workings consist of a series of adits driven southerly into the hillside from which several thousand feet of drifts, crosscuts, winzes and raises extend over a strike length of about 700 feet and a vertical range of 300 feet.

The new mine is on a fault zone in sandstone and shale. Cinnabar occurs in high-grade stringers, pockets, and disseminated in the sandstone. Mine workings comprise a large open pit.

The 30-ton-capacity reduction plant includes a jaw crusher, a 3- by 42-foot oil-fired rotary furnace, cyclone dust collector, fan, two banks of vertical cast-iron pipe condensers, settling tank, and stack. Soot is hand hoed; residue is treated in a 1-pipe retort. Calcines are trammed to the waste dump.

Cypress Mountain Prospect

The Cypress Mountain prospect is about 20 miles west of Paso Robles at an elevation of 2,500 feet. The property was discovered about 1900 and prospected intermittently for several years. There was no production of mercury. Shallow mine workings reportedly explored a weakly mineralized fault zone crossing shale and sandstone.

Kismet Prospect

The Kismet prospect is about 1¼ miles southeast of the Cypress Mountain claims. Three claims were located during the early 1900's. Some sporadic prospecting was done, but there was no production. Cinnabar is sparsely disseminated in outcrops of silica-carbonate rock along a fault zone in shale and sandstone.

Klau Property and Capitola Mine

The Klau property, including the Capitola mine, consists of five claims, 17 miles west of Paso Robles at altitudes ranging from 1,100 to 1,300 feet.

The claims were located in 1868. Production commenced in 1874 and continued until 1879 with an output of 4,277 flasks of mercury. Declining mercury prices and depletion of ore reserves forced suspension of operations. Extensive mine development started in 1895 and continued to 1899. New owners acquired the mine in 1901 and produced 3,300 flasks during 1903. Large-scale operations continued until 1905, followed by a gradual decline in production,

terminating in 1912. Leasing operations during 1915-17 were followed by intermittent company operations from 1920 to 1935. The Capitola mine was worked intermittently from 1913 to 1934. The H. W. Gould Co. acquired the mines in 1934 and operated them continuously until 1940 and again during 1943-47. Company work terminated in 1947. Small-scale leasing operations have since been in progress. Total production has been about 24,000 flasks from ore which contained from 5 to 30 pounds of mercury per ton.

The mine is located on a broad easterly striking, southerly dipping fault breccia zone which attains a width of about 1,000 feet, and consists mainly of Franciscan shale with minor amounts of sandstone, chert, and silica-carbonate rock. Mine workings generally follow a series of nearly parallel minor shear planes that trend northwest and dip steeply to the northeast. Ore occurs in stockworks or networks along the shears, forming definite ore shoots in which crystalline cinnabar occurs in fissure fillings and fractures. The ore shoots apparently pinch out both laterally and vertically.

Extensive open pits are accessible. Inaccessible underground workings include about 5 miles of openings on three main levels, reached by a series of crosscut adits and inclined shafts, which develop an area about 500 feet long, 200 to 300 feet wide, and with a vertical extent of about 300 feet. The Capitola mine on a southeast split of the fault zone was developed through a crosscut adit. Ore bodies were mined by open and square-set stoping methods.

Furnace plants, mine equipment, and surface facilities have been removed.

La Libertad Mine

The La Libertad mine is about 22 miles west of Paso Robles at an altitude of 1,750 feet.

The property was located in 1901 and worked until 1903. Further operations were during 1915-16, 1935, and 1947-48. The mine was reactivated in 1952. Latest operations were on a 15-ton-per-day basis. Total production was about 1,100 flasks from ore which averaged 7 to 8 pounds of mercury per ton.

The mine is on a wide steeply dipping, northwest-trending fault breccia zone in Franciscan sandstone and shale cut by numerous easterly trending, northerly dipping cross fractures. A pipelike body of cinnabar-bearing silica-carbonate rock, within a major cross fracture, pitches steeply to the east, varies from 1 to 30 feet in thickness and from 40 to 60 feet in length, and was developed over a pitch length of 290 feet. Other cross fractures contain cinnabar and stibnite.

Development includes four adits, numerous drifts, raises, and winzes, aggregating about 1,800 feet. Recent work was from the lower adit level, about 150 feet vertically below the surface. A 60-foot winze, sunk from this level, developed the ore body over a length of 50 feet and a width of 20 feet.

The reduction plant includes a 10- by 12-inch jaw crusher, a 15-ton-capacity 3- by 22-foot oil-fired rotary furnace, dust collector, fan, vertical

cast-iron pipe condensers, redwood tank and stack, and a single D retort. Power is generated by Butane gas-driven electric generators.

Little Bonanza Group

The Little Bonanza group, including the Little Bonanza, Alice, and Modoc properties, is about 20 miles west of Paso Robles at an altitude of 2,000 feet.

The property was discovered in 1862, and a small quantity of mercury was produced prior to 1900. Operations from 1900 to 1906 produced about 1,000 flasks of mercury, and intermittent work by lessees from 1915 to 1940 yielded an additional small production. Grade of ore produced varied from 3 to 10 pounds of mercury per ton. No work has been done since 1940.

The mine is on a wide steeply dipping, northwest-trending fault breccia zone in Franciscan sandstone and shale containing easterly striking, northerly dipping veins of silica-carbonate rock and brecciated chert. Irregularly shaped ore shoots in the veins pitch to the east. Cinnabar occurs in rich bunches and veinlets in the silica-carbonate rock and on fracture surfaces in brecciated chert.

Inaccessible mine workings on the Little Bonanza claim comprise about 3,000 feet of drifts, crosscuts, and raises on three levels, extending over a vertical range of 260 feet. The three main ore bodies were mined from the 600-foot adit. Short adits and small stopes develop several minor ore bodies. Caved workings on the Alice claim were reported to include five adits, totaling about 750 feet in length, and a shallow shaft.

Madrone Mine

The Madrone mine is about 20 miles west of Paso Robles and one-half mile southeast of the La Libertad mine. The property was worked about 1900 and a small production made. Some work was done in 1956 and 1958.

Cinnabar occurs in masses of silica-carbonate rock erratically distributed within a northwest-trending fault breccia zone. Workings include a 50-foot adit, a 125-foot shaft, and several open cuts. Ore is treated in a 2-pipe retort.

Tamney Group

The Tamney group consists of three claims adjoining the Little Bonanza group on the north. The property was prospected many years ago, but there was no production.

Mine workings comprise two short adits, a raise, and a 30-foot drift that explore lenses of mineralized silica-carbonate rock within a northwest-trending fault breccia zone.

William Tell Prospect

The William Tell prospect, about one-half mile west of the Klau mine, has been idle for many years. The property was located about 1900 and explored sporadically with no production recorded. Caved mine workings include short adits and open cuts on exposures of mineralized silica-carbonate rock in the western extension of the Klau fault zone.

Rinconada District Mines and Properties

The Rinconada mining district in south-central San Luis Obispo County, a considerable distance southeast of the county's principal mercury producing districts, has been active intermittently since 1872. Several thousand flasks of mercury were produced. Principal production was from the Rinconada mine; a small output came from the Deer Trail mine.

The district has a moderate production potential. Past work at the Rinconada mine was confined to the development of several oreshoots within a comparatively small section of the property. Extensive exploration indicated several promising areas, containing lower grade ore, that could be productive under higher mercury prices.

Further exploration at the Deer Trail mine could encounter extensions of known oreshoots and new deposits. The cost of this work in relation to the small tonnage involved would be abnormally high.

Deer Trail Mine

The Deer Trail mine comprises two claims and a millsite about 20 miles east of Arroyo Grande. The mine was located in 1915 and operated through 1916. It was reactivated in 1928 and worked intermittently until 1940 and again during 1951. Production was about 200 flasks of mercury.

Cinnabar occurs in thin seams and vugs in easterly striking brecciated calcite veins in metamorphosed sandstone. Mine workings include three adits, connected by winzes, and numerous drifts and crosscuts extending over a strike length of 450 feet and a vertical range of about 200 feet. Short adits explore adjacent mineralized zones. Ore is treated in retorts.

Rinconada Mine

The Rinconada mine consists of eleven claims 11 miles southeast of Santa Margarita at altitudes ranging from 1,500 to 2,000 feet.

The property was discovered in 1872 and worked until 1883. It was idle until a small production was made from high-grading operations in 1897. In 1915 intermittent operations by various companies and lessees commenced and continued until 1937. Further work was done during 1943-44. The mine was reactivated in 1951 and has since been operated by several lessees. During 1959-61 work was in progress in the mine area and on a mineralized zone southwest of the main workings. Total production was about 3,000 flasks of mercury.

Rocks in the mine area include Franciscan sandstones, shales, and altered volcanics which have been thrust over Cretaceous rocks along a northwest-trending thrust fault dipping at low angles to the southwest. The Franciscan rocks have been cut by a series of irregular-dipping, northerly trending minor fractures. On its southwest side the Franciscan block is in fault contact with Lower Cretaceous rocks. Ore deposits are generally confined to large bodies of silica-carbonate rock in remnants of a serpentine sheet capping the Franciscan. Two of these bodies are in the mine area, and a third body is south and west of the mine workings. Smaller lenses of silica-carbonate rock are distributed over the property. Mineralization is widespread with cinnabar and metacinnabarite occurring in cracks and fractures in the silica-carbonate rock. Grade of the ore varies from 2 to 5 pounds of mercury per ton.

The extensive mine workings comprise about 7,000 feet of adits, levels, sublevels, raises, and a glory hole, over a strike length of about 500 feet, and a vertical range of 200 feet. Open cuts and trenches explore other mineralized areas.

The reduction plant includes a jaw crusher, a 40-ton-capacity 4- by 54-foot oil-fired rotary furnace, dust collector, fan, two banks of vertical cast-iron pipe condensers, redwood settling tanks, tile flue, and stack. Soot is hoed by hand; residue is treated in a single D retort. Calcines drop to the waste dump.

Cachuma District Mines and Properties

The Cachuma mining district is in central Santa Barbara County. Intermittent operations from 1867 to 1946 produced about 3,500 flasks of mercury, with principal production from the Red Rock mine and a small output from the adjoining Lion Den mine. The district has a small production potential. Ore reserves in the two mines have been depleted, but exploration for downward continuations and possible lateral extensions of the major ore bodies could be productive. Extensive mine rehabilitation and high exploration and mining costs, in relation to the small tonnage involved, justifies the work only under exceptionally favorable conditions.

Lion Den Mine

The Lion Den mine, about 17 miles northeast of Santa Ynez, is at an altitude of 3,250 feet.

The original Santa Rosa claim was located prior to 1917, and some prospecting was done. The Lion Den claim was located in 1933 and worked by various operators through 1937. Intermittent operations continued during 1938-44. Total mine production was about 330 flasks from ore which varied in grade from 5 to 10 pounds of mercury per ton. Last reported work, in 1956, was confined to concentrating cinnabar-bearing creek gravels below the mine workings and retorting the concentrates.

The mine is located along the northeast extension of the fault zone in the adjoining Red Rock mine. The small, shallow ore bodies, occurring along

the intersections of the main northeast-trending fault, with easterly and southeasterly trending faults, are discontinuous and erratic in occurrence.

Inaccessible mine workings, comprising about 1,300 feet of openings over a vertical range of 120 feet, consist of an inclined shaft, three main levels, a sublevel, and a major stoped area. Several short adits explore other mineralized sections.

The 20-ton-capacity reduction plant includes a jaw crusher, arrastre, 20-inch by 30-foot oil-fired rotary furnace, cyclone dust collector, fan, and a series of vertical pipe condensers. Power was furnished by a diesel-electric generator.

Red Rock Mine (Cachuma Eagle)

The Red Rock mine consists of six claims and two millsites, about 16 miles northeast of Santa Ynez at altitudes ranging from 2,800 to 3,300 feet.

The property was located in 1867 and a small production made. Intermittent operations were in progress from 1905 through 1921 and during 1932-39. The Cachuma Mining Co., a subsidiary of the Seeley-Mudd Corp., acquired the property in 1941 and operated it through 1943 with a production of about 1,200 flasks of mercury. The mine was sold to the present owner in 1944 and work continued to 1946. It has been idle since. Total production from the mine was over 3,000 flasks from ore varying in grade from 2 to 10 pounds of mercury per ton.

Rocks in the mine area consist of siltstone interbedded with shale, and sandstone of the Knoxville Formation (late Upper Jurassic). The formations are crossed by three sets of mineralized faults. The first set comprises three parallel north-south striking, easterly dipping fault zones, the second group consists of easterly trending, southerly dipping flat faults, and the third set comprises the major northeast-striking, southeast-dipping fault zone, which offsets the other faults in the mine. Ore bodies occur along the northeast fault zone at its intersection with other faults. The richest oreshoot was pipelike in shape, located at the intersection of a strong north-south fault with the northeast-striking fault, and was developed from surface to the eighth level. Several large tabular bodies along the faults have been extensively developed. Cinnabar occurs in open spaces, fractures and shears in the fault breccia, and disseminated in the fault gouge.

Mine workings, largely inaccessible, extend from surface to a maximum vertical depth of about 500 feet, over a strike length of 1,300 feet. The workings consist of four adit levels, with workings aggregating about 7,000 feet, connected by raises and winzes. Extensive stoping was done between the seventh level and surface. The eighth level partially developed downward continuations of several ore bodies.

The reduction plant includes a 3- by 50-foot 50-ton-capacity oil-fired rotary furnace, cyclone dust collector, a series of vertical pipe condensers, redwood settling tank, and a D retort. Two old wood-burning pipe retorts remain near the upper mine workings. Power was supplied by a diesel generator.

Los Prietos District Mines and Properties

The Los Prietos mining district is southeast Santa Barbara County has been intermittently active since 1860 with a production exceeding 4,000 flasks of mercury. Nearly all this production was made at the Gibraltar (Falcon) mine.

The district has a large production potential based on comparatively low-grade ore. A wide mineralized zone has been extensively developed, and further exploration could indicate its lateral and downward continuation. Ore reserves in the Falcon mine area are not depleted, but their low grade makes them marginal under present mercury prices. Geologic conditions appear favorable for a similar type of mineralization on several undeveloped localities.

Gibraltar Mine (Falcon, Santa Ynez, McAvoy-Millburn)

The Gibraltar (Falcon) mine comprises the Santa Ynez group of claims, subsequently known as the McAvoy-Millburn group. They are on the south side of the Santa Ynez River about 2 miles east of the Gibraltar dam and about 18 miles north of Santa Barbara at an altitude of 1,500 feet.

The claims were relocated in 1908, following the settlement of a title dispute, and were held by location for many years. Considerable work was done and a small production was made during 1913-18.

Activity during 1937-44 included extensive development, installation of the present furnace plant, and a substantial output of mercury. The Gibraltar Mining Co. acquired the property in 1955, rehabilitated the camp and furnace plant, started extensive mine development, and commenced open-pit mining. Production in 1956 was on a 50-ton-per-day basis. Total production from the mine has exceeded 3,000 flasks.

Cinnabar occurs as disseminations, veinlets, and bunches in a northwest-striking, southwest-dipping lens of silica-carbonate rock between overlying serpentine and underlying black shale and sandstone beds of the Knoxville group. The entire section is overturned at the Gibraltar mine. The silica-carbonate lens varies from a few feet to over 100 feet in width. Ore bodies in the silica-carbonate rock are localized by faults and cross fractures. The higher grade bodies were reportedly found near the serpentine contact and in fault gouge; the lower grade bodies occur near the shale footwall. Grade of the ore averages 2 to 4 pounds of mercury per ton. A second, unmined, silica-carbonate lens is found about 100 feet higher in the Knoxville section of rocks.

Mine workings consist of the upper and lower adits, about 60 feet apart vertically, driven southeasterly along the mineralized sandstone for about 500 feet. Extensive stoping was done from both levels. Stopes from the upper adit extend to surface and form an irregular-shaped glory hole several hundred feet long and up to 200 feet in depth. Open cuts excavated along the ore zone are located 300 to 400 feet above and 600 to 900 feet southeast of the lower adit portal.

The furnacing plant includes a jaw crusher, three rotary furnaces (including two 30-inch by 40-foot, 35-ton-capacity oil-fired furnaces), cyclone dust collectors, suction fans, vertical pipe condenser systems, settling tanks, and stack. Soot is hoed by hand; residue is treated in an oil-fired double-D retort. Calcines drop into concrete cooling bins and are trammed to the dump. The jaw crusher is driven by an 85-hp gasoline engine. Power for the plant is furnished by a 70-hp diesel engine that also drives a 3-kw light plant.

Los Prietos Mine

The Los Prietos mine includes the Juniper group of claims and those claims later known as the Snow Group. They include those workings near the west end of the Santa Barbara Reservoir north of the Santa Ynez River.

Mercury was discovered here in 1860 and several deposits were worked sporadically until 1874. Large-scale operations were in progress from 1874 to 1876, followed by a decline in production and a suspension of operations in 1877. The mines were reopened in 1878 and closed in 1883. Work was resumed during 1911-1916. In 1918 it was reported that the Snow Group and the McAvoy-Millburn claims south of the river were united and controlled by the Los Prietos Quicksilver Mining Co.

A period of idleness intervened until 1930. Production was next reported from the Los Prietos mine during 1930-32 and again during 1935-39. Total production from the Los Prietos mine has been probably between 500 and 1,000 flasks.

Diamond Creek District Mines and Properties

The Diamond Creek mining district in north-central Del Norte County adjoining the California-Oregon border is a minor mercury district with a very small production record. Principal work was at the Big Boy mine where unsuccessful attempts were made to recover cinnabar by sluicing the soft altered mineralized diorite. Although mineralization occurs over a wide area, it is extremely low grade, submarginal under 1961 economic conditions.

Big Boy Cinnabar Group

The Big Boy Cinnabar group, comprises 16 claims about 15 miles southwest of O'Brien, Oreg., at an altitude of 2,150 feet.

The deposit was located about 1920, and between 1920 and 1933 several attempts were made to mine the soft cinnabar-bearing, placer-type deposits of diorite material by ground sluicing. A small quantity of mercury was reportedly produced, but the work was unsuccessful. No production was made since 1933. Extensive sampling and testing has been done by the present owner.

Cinnabar occurs along fine joint fissures in a large mass of highly altered diorite. Mine workings include numerous comparatively shallow open cuts and pits.

Sunny Brook Prospect

The Sunny Brook prospect includes four claims about 4 miles southwest of the Big Boy mine.

The deposit was discovered about 1850, but no records are available regarding early production. The property was relocated in 1916, and intermittent work to 1933 produced a small quantity of mercury. No work has been done since.

Mine workings, largely inaccessible, include a shallow shaft, lower adit and crosscut, and an open cut, exploring small cinnabar-bearing quartz veins and steep, northerly trending mineralized fissures in the serpentine. Native mercury is also present. The grade of the ore retorted reportedly averaged about 10 pounds mercury per ton.

Patrick Creek District Mines and Properties

The Patrick Creek mining district in north-central Del Norte County has been a small, intermittent producer of mercury since 1940. Its entire output came from the Webb mine. The potential of the area is undetermined, but geologic aspects favor continued exploration that could develop ore sufficient to maintain a small operation.

Webb, Schultz, or Simbro Mine

The Webb, Schultz, or Simbro mine consists of nine claims about 7 miles north of the small settlement of Patrick Creek, at an altitude of 2,750 feet. The property has been operated intermittently by various lessees since 1946 and over 200 flasks have been produced.

Cinnabar, metacinnabarite, and native mercury, associated with pyrite, occur in small bodies of silica-carbonate rock, breccia zones, and clay gouge and also along fractures in serpentine, near minor intrusions of andesite. The mineralized zones are small, irregular in occurrence, and apparently limited in lateral and vertical extent. Grade of ore treated in the furnace and retorts reportedly varied from 10 to 20 pounds of mercury per ton.

Mine workings include numerous trenches and open cuts and about a thousand feet of underground openings. Underground openings comprise three adits, 100 to 500 feet long, a 40-foot shaft, and several crosscuts and drifts, that explore the mineralized area to a vertical depth of about 125 feet.

The reduction plant includes a 9-inch by 12-inch jaw crusher, a 25-ton capacity, 30-inch by 30-foot, oil-fired rotary furnace, blower, dust collector, ten 16-inch by 24-foot vertical pipe condensers, and a 4-pipe retort.

Klamath River District Mines and Properties

The Klamath River mining district in northern Siskiyou County contains several widely separated mercury-bearing areas that have been explored to a

varying extent. Principal activity was at the Great Northern mine, which produced over 500 flasks of mercury during intermittent operations from 1929 to 1943. Minor activity, with a negligible output of mercury, was in progress at various intervals in the Ivanhoe and Horse Creek areas. The properties have, with the exception of sporadic prospecting, been inactive since 1943.

The district was a minor contributor to the State's mercury production, and it has a small production potential under favorable economic conditions. Ore reserves at the Great Northern mine are depleted, but further exploration in geologically favorable areas could be productive. The tenor of the ore in the Ivanhoe area requires high mercury prices to justify further work. The Horse Creek property, and other prospects in the area, are undeveloped and extensive exploration is necessary to determine their potential.

Great Northern or Empire Canyon Mine

The Great Northern mine in the Empire Creek area includes 17 claims about 24 miles northwest of Yreka, at an altitude of 3,200 feet.

The property was located in 1905 and operated intermittently by various owners and lessees until 1943. Its greatest period of activity was during 1929-43 when over 500 flasks of mercury were produced.

Cinnabar and native mercury occur in a series of northeast-trending, northwest-dipping fissures and shear zones in metamorphic rocks near their contact with granodiorite. The relatively small ore bodies are erratic in occurrence.

Mine workings are in three areas along a horizontal distance of about 1,400 feet. Principal workings near the center of the area comprise a series of adits, drifts, and crosscuts, aggregating several thousand feet on two levels, about 160 feet apart vertically, and several stopes and open cuts. Fringe area workings comprise exploratory adits.

Several reduction plants were built and operated, including a flotation concentrator and retorts and a 24-ton-capacity multihearth furnace. A single D retort remains.

Horse Creek Prospect

The Horse Creek prospect is about 37 miles northwest of Yreka.

Cinnabar in the form of nuggets in the creek gravels was discovered in 1878, and a small recovery was made during subsequent gold dredging operations. The deposit along the west bank of Horse Creek was located about 1916 and has been explored several times since.

Workings include several short adits, which are inaccessible, and bulldozer cuts that explored a series of steeply dipping cinnabar-bearing fractures and fissures in hornblende schist. No production of mercury has been reported.

Ivanhoe Group (Cowgill)

The Ivanhoe group of four claims, formerly known as the Cowgill mine, is about 35 miles northwest of Yreka, at an elevation of 3,600 feet. The property was located prior to 1917 and operated during several periods between 1917 and 1939. Production was small.

Cinnabar occurs erratically in the soil cover and along a series of narrow fractures and shears in altered mica schist. The mineralized areas are explored by open cuts and short adits.

Alturas District Mines and Properties

The Alturas mining district in eastern Modoc County contains several mercury-bearing areas. No recorded production has been made. Mineralization is generally low grade, although occasional small pods, or stringers, of higher grade material were encountered. Past work failed to develop tonnages of commercial ore adequate to support small operations. The mineralized zones are discontinuous and much exploration is needed to permit evaluation of the deposits.

Brown Prospect

The Brown prospect comprises five claims about 6 miles east of Likely, Calif. The property was explored during 1939-40, but no production was made. Narrow northwest-trending, northeast-dipping ribs of opalite and silicified volcanic tuff occur in the area. Cinnabar is sparsely disseminated within them, but local concentrations are not of sufficient size to form minable ore bodies. Caved mine workings include several short adits and open cuts.

Deep Creek or Silvertown Prospect

The Deep Creek or Silvertown mercury prospect comprises five claims about 5 miles southwest of Cedarville at elevations ranging from 5,000 to 5,500 feet. Cinnabar was discovered in the area during the 1930's followed by intermittent exploration to 1941. Company operations were in progress during recent years but no production of mercury was recorded.

Cinnabar is erratically distributed in small, discontinuous ore bodies occurring along the footwall of a steeply dipping, northwest-trending shear zone that crosses flat-lying andesite flows, agglomerates, and tuffs. The shear zone has been partially developed by numerous open cuts and two shallow prospect shafts.

Selectively mined ore was crushed, screened, and treated in a company-designed continuous-feed oil-fired horizontal retort. No production was reported.

Red Hawk Mine

The Red Hawk mine includes three claims in the Willow Ranch area about 40 miles northeast of Alturas at an altitude of 5,200 feet. The deposit,

discovered in 1917, has been explored intermittently. No production has been made.

Cinnabar is distributed erratically along fissures and cross fractures in silicified tuff, rhyolite, and altered andesite. Mine workings include several short adits and a large open cut along a wide breccia zone.

Altoona District Mines and Properties

The Altoona mining district in northeast Trinity County is the largest mercury-producing district in California outside of the main Coast Range belt, with an output since 1871 of approximately 34,000 flasks of mercury. Maximum production was made prior to 1901. The Altoona mine was the principal producer, with a small yield from several adjoining properties. Intermittent leasing operations have been in progress since 1901. The reactivation of the Altoona mine should prove a stimulus for revived interest in the district.

The district has a moderate production potential under high mercury prices. Exploration and development at the Altoona mine during 1955-57 was encouraging, and further work in geologically favorable areas could be productive. The isolated location of the area, adverse winter weather conditions, high transportation and labor cots, and deep-level mining result in higher operating costs.

Altoona Mine

The Altoona mine comprises three claims and timberland about 24 miles northwest of Castella, at an altitude of 4,600 feet.

The mine has been the largest producer in the district with an output of nearly 34,000 flasks of mercury. The ore varied in grade from 10 to 50 pounds of mercury per ton, and averaged 20 pounds per ton. The property was discovered in 1871, and by 1880 when it was closed by litigation, it had produced over 10,000 flasks of mercury. The mine was reopened in 1894 and continued in operation until 1901. The main shaft was sunk to the 450 level, and a vertical winze sunk from the 450 to the 600 level. Production during this period was about 20,000 flasks. The heavy flow of water in the lower levels, prohibitive costs, and failure to obtain a right-of-way for a deep-level drainage tunnel forced suspension of operations in 1902. Sporadic work by lessees on mine dumps and along surface workings continued from 1902 until 1921 with a small production of mercury each year, except 1914 and 1915. No production was reported from 1921 to 1928 inclusive.

In 1929 the shaft was reopened to the 132 level and small-scale mining on the 50 and 100 levels continued until 1943. The shaft was unwatered to the 350 level in 1944, but falling prices forced a curtailment of operations and the mine was shut down in 1945.

During 1955-57 the Castella Corporation, under a DMEA contract, unwatered and rehabilitated the mine and explored for the possible downward continuation of cinnabar-bearing shear zones in altered diorite. The work comprised

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unwatering the 450-foot shaft and 150-foot winze and rehabilitating 780 feet of mine workings. A total of 928 feet of drifts and crosscuts was driven and nine diamond drill holes, aggregating 954 feet, completed. Cost of the work was about $93,000.

The Altoona ore bodies are narrow tabular lenses, about 5 feet in thickness and locally attaining lengths and depths exceeding 200 feet. They occur along steeply dipping faults in altered diorite. Ore minerals are cinnabar and minor amounts of native mercury.

Mine workings include about 10,000 feet of underground openings, (largely inaccessible above the 450 level), extending to a vertical depth of 600 feet over a strike length of about 1,600 feet. The workings are reached from a 2-compartment vertical shaft which extends from surface to the 450 level, and a vertical winze extending from 450 to the 600 level. Six levels were driven from the main shaft and two from the winze. The 132 level was driven 885 feet to surface and used as a drainage tunnel.

Carr Prospect

The Carr prospect, comprising one claim, lies east of the Altoona mine. Some sporadic surface exploration was done prior to 1918, but no significant discovery was made.

Integral Property

The Integral property comprises two patented and two unpatented claims adjoining the Altoona mine. A small production of mercury was made during 1902-03. Subsequent exploration yielded a few flasks.

Cinnabar occurs in small ore bodies within an altered zone of diorite porphyry. Inaccessible mine workings include a 180-foot shaft and five levels containing several hundred feet of drifts. A 130-foot winze connects the bottom level with the lower Castella development tunnel. Extensive surface cuts and trenches explore surface outcrops.

Munko Prospect

The Munko prospect consists of one claim about 22 miles northwest of Castella, at an altitude of 5,000 feet.

The property was located in 1939. Several open cuts explore a cinnabar-bearing fault along a serpentine-diorite porphyry contact. No production was made.

A 5-ton-capacity retort near Castella is used for retorting ore and table concentrates produced by several lessees in the district.

Shasta Lilly Mine

The Shasta Lilly mine includes one claim about 22 miles northwest of Castella, at an altitude of 4,000 feet. The property was operated intermittently since 1937 with a small production of mercury.

Cinnabar occurs along a vertical, northwest-trending mineralized zone in serpentine, developed by a shallow shaft, adits, and open cuts. Ore is treated in a single D retort.

Trinity and Taggart Group

The Trinity and Taggart group is adjacent to the Altoona mine. The property was explored sporadically, but no production was recorded.

Cinnabar occurs erratically along mineralized faults in altered diorite porphyry.

New River District

The New River mining district is in the Trinity Alps area in northwest Trinity County, about 21 miles northeast of Denny, and 47 miles northeast of Willow Creek. Mining was predominantly for gold. The discovery of cinnabar led to intermittent prospecting in 1918 and during 1931-35, and 1939-41. The Overland claims were located in 1918, with a subsequent location of several other prospects. A few flasks of mercury were produced.

Cinnabar occurs in small discontinuous pockets along shear zones in serpentine. Work was inconclusive and did not determine the potential of the district. The isolated location of the deposits, their comparative small size, and the extensive exploration necessary make for high operating costs and permit consideration only during periods of high mercury prices.

Mill Creek District

The Mill Creek district located in northeastern Humboldt County, has had no sustained production from any of several locations. The most prominent occurrence is the Humboldt Almaden, where a mercury-bearing zone along a dike has been prospected by short adits and surface panning. It is said that the dike contains mercury for a distance of 3 miles.

The property is owned by the Mill Creek Mining Co., of which J. S. Woods is the Secretary. Mr. Woods was also the discoverer of the property which he claimed in 1928.

Clover Creek District

The Clover Creek mining district is in Shasta County, about 24 miles northeast of Redding. Intermittent prospecting for mercury between 1898 and 1915 failed to encounter commercial-grade ore.

Minute crystals and isolated specks of cinnabar occur in fractures along a shear zone in silicified basalt. Numerous test pits, several shallow shafts, and drifts explore the mineralized zone.

Occident District

The Occident mining district in southeast Mendocino County contains the Occident mercury property located about 7 miles southwest of Hopland.

Old records indicate the mine was located prior to 1875 and worked intermittently until 1907. Recorded production was over 60 flasks of mercury. Caved mine workings explored cinnabar-bearing breccia zones in serpentine.

Nashville District

The Nashville mining district in southwest El Dorado County was formerly the center of extensive gold-mining operations. Mercury was discovered during the 1860's at the Bernard property, 2 miles west of Nashville. Intermittent operations to 1903 produced a few flasks of mercury.

Cinnabar occurs along a wide mineralized zone in slates and quartzitic rocks. Mine workings include a 75-foot vertical shaft connected to a lower adit.

Mogul District

The Mogul Peak prospect in the Mogul mining district, northeast Alpine County, was discovered and explored in 1939. A few flasks of mercury have been produced.

Cinnabar occurs in a series of narrow, steeply dipping fissure veins in andesite. Mineralization is low grade and erratic in occurrence.

Bridgeport District Mines and Properties

The Bridgeport mining district in northern Mono County includes several mercury deposits in widely scattered areas. Exploration was sporadic with principal activity during 1941-44. Production was small, comprising a few flasks of mercury from the Calmono and Paramount properties.

The production potential of the district is dependent upon high mercury prices. Mineralization is widespread but too low in grade to permit economical operations. No significant commercial concentrations were encountered. It is possible that further work under favorable economic conditions would be productive.

Alta Plana Prospect

The Alta Plana prospect comprises nine claims, about 10 miles east of Bridgeport, at altitudes ranging from 8,800 to 9,500 feet. The deposit was discovered and explored in 1942, but no production was made.

A wide zone of alteration in opalized rhyolitic tuff and agglomerate, containing erratic distributions of cinnabar, was explored by a series of bulldozer trenches.

Calmono or Old Timer Mine

The Calmono or Old Timer mine, 10 miles southeast of Bridgeport, is at an altitude of 7,400 feet. It was worked during 1923 with a reported production of 10 flasks of mercury. Intermittent exploration since then has been unproductive.

A zone of cinnabar-bearing opalized rhyolitic tuff was developed by an 80-foot inclined shaft and extensive bulldozer cuts and pits.

Loughlin Prospect

The Loughlin prospect, about 4 miles west of Bridgeport, was explored prior to 1943. No production was made.

Fractures in altered sandstone containing sparsely disseminated cinnabar were explored by a short adit and three shallow shafts.

Paramount Mine

The Paramount mine consists of 26 claims, about 11½ miles east of Bridgeport, at an altitude of 8,600 feet. The property was discovered in 1941 and explored by various operators during 1942-44. A small production of mercury was made. Grade of ore varied from 1.5 to 5.0 pounds of mercury per ton.

Cinnabar occurs erratically as coating along cracks and seams in opalized rhyolitic tuff and agglomerate. It is also found in the overlying detritus. Underground workings, aggregating several hundred feet, include an upper and lower adit, about 40 feet apart vertically, several drifts, and a shallow winze.

Coso District

The Coso mining district in southwest Inyo County includes three hot springs deposits intermittently operated during 1929-45. The Bureau of Mines explored the deposits in 1941 by rotary bucket drilling, hand auger, and channel sampling, with favorable results. The work indicated a moderate reserve of ore averaging 2 to 3 pounds of mercury per ton, that could possibly be augmented by further exploration. The property is part of the U.S. Naval Ordnance Test Station, Inyokern, Calif., and is not open for private exploitation.

The deposits are distributed over a wide area about 10 miles east of Little Lake, at an altitude of about 4,000 feet. Mercury was discovered in 1929, and several unsuccessful attempts were made to operate the deposits. Several hundred flasks of mercury were produced from retort and furnace operations.

The known occurrences are in the Devil's Kitchen, Nicol, and Wheeler areas of the district. Several minor unexplored areas also exist. Country rocks consist of rhyolite, granite, volcanic tuff, and other bedded volcanic rocks, highly altered by solfataric action. Cinnabar and metacinnabarite occur in random distributions along the sinter vents of the hot springs. The escaping hot gases also contain small amounts of mercury. Mine workings include numerous open cuts, trenches, and shallow shafts.

Tehachapi District Mines and Properties

The Tehachapi mining district in south-central Kern County has been a minor producer of mercury since 1916. Production from intermittent operations has been about 1,500 flasks, principally from the Walabu mine.

The district has a small production potential. Reserves are depleted, but further exploration in geologically favorable areas could encounter additional ore bodies with a tonnage adequate to maintain a small operation. Extensive exploration and development are justified only during sustained periods of high mercury prices.

Fickert-Durnal Property

The Fickert-Durnal property is about 1½ miles east of the Walabu mine. The deposit was discovered in 1917 and worked during that year with a small yield of mercury. Some exploration was done in 1956, but no production was reported.

Several short adits and a shallow shaft explore a cinnabar-bearing rhyolite dike in granite.

Walabu or Cuddeback Mine

The Walabu or Cuddeback mine is about 7½ miles west of Tehachapi, at an altitude of 3,300 feet.

The property was discovered in 1916 and operated intermittently by various lessees until 1936, when it was acquired by the Walabu Mining Co. Work since then included continuance of company operations to 1939, followed by several periods of sporadic exploration during 1939-56. Production has exceeded 1,300 flasks of mercury recovered from ore which reportedly averaged 7 to 10 pounds of mercury per ton.

A DMEA contract was in force during 1953-54. Work included one-half mile of access-road construction and 2,264 feet of surface diamond drilling to explore for downward and lateral continuations of the mineralized zones. Cost of the work was about $17,400.

Rocks in the mine area comprise several rhyolite dikes crossing granite country rock. Small ore bodies occur along a northeast-trending dike, close to contacts with the granite. Cinnabar is erratically distributed within the ore bodies and occurs along fractures and in small breccia veins. It occurs to a lesser extent as disseminations in the more altered rhyolite.

Mine workings, largely inaccessible, include a 140-foot inclined shaft, about 2,500 feet of underground openings, several small stopes, and seven small glory holes.

Tustin District Mines and Properties

The Tustin mining district in north-central Orange County contains minor occurrences of mercury from which a small production was made from 1927 to 1929. The mineralized area is now part of a housing development.

Red Hill Mine (Tustin)

The Red Hill or Tustin mine, about two miles east of Tustin, was the district's only producer.

Occurrences of cinnabar were known as early as 1892, but the first recorded production was during 1927-29. Sporadic operations were in progress during 1932-33 and again in 1939, but no production was reported from them. Total output from the mine was small.

Mine workings comprised several short adits which explored native mercury and cinnabar-bearing barite veins in Tertiary sandstone.

San Bernardino County Mines and Properties

Several occurrences of mercury are reported from San Bernardino County but no significant production has been made.

Bimetallic (Desert Mercury)

The Bimetallic (also known as the Desert Mercury), is located about 12 miles northeast of Danby, a station on the Atchison, Topeka and Santa Fe Railway. Several flasks were produced in 1940, but there has been no other report of production.

A series of roughly parallel quartz-porphyry dikes occur in granitic gneiss. Cinnabar mineralization has taken place in a breccia zone along the quartz-porphyry contacts and on small fractures in the gneiss close to the contact.

Idria Quicksilver Group

The Idria Quicksilver group is 5 miles south of Goffs, a station on the Santa Fe Railway. No production has been reported from these claims.

At this occurrence, numerous parallel veins traverse the floor of the canyon in a hornblende granitic gneiss. The ore occurs along the main fractures and joints in the brecciated wall rock. The wall rock has been greatly altered along these veins, principally by silicification, in places showing as much as 4 feet of solid chalcedony, through which cinnabar is disseminated in minute particles. The veins vary in width from a few inches to eight feet.

High individual assays are reported, but as no production has been made, the amount of good grade material is apparently very limited.

Workings consist of surface trenches and two 25-foot deep shafts.

Miscellaneous Occurrences

The Economic Mineral Map of California also shows occurrences in areas 10 miles southwest of Needles, 4 miles south of Ivanpah, and 1 mile north of Hodge. No sustained production came from any of these locations.