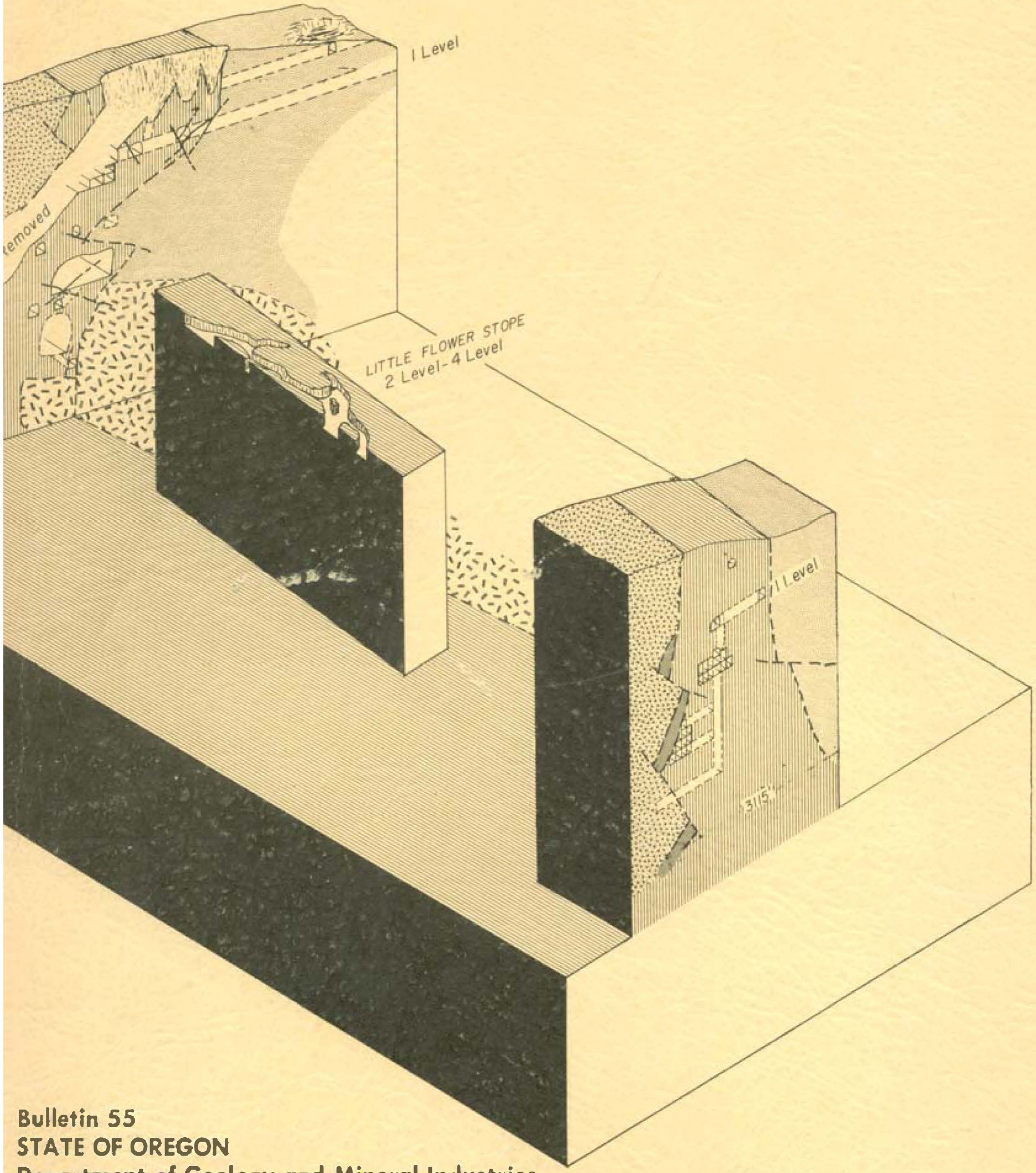
QUICKSILVER
IN OREGON



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QUICKSILVER IN OREGON

By

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Geologist

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FOREWORD

Oregon's metal-mining industry in recent years has essentially been one of strategic mineral production. A major contributor to the state's mineral production and a strategic mineral is quicksilver. The liquid metal is more widely distributed in the state than any other valuable metallic mineral. This is probably because of the close association of quicksilver with volcanism and, as is generally known, Oregon has a greater area of volcanics than any other state except Hawaii. Several major mining districts at widespread places have been delineated, and five mines have produced important quantities of metal. The prospects for further mining of quicksilver and the discovery of new ore deposits appear to be good.

Strategic minerals are those which are absolutely necessary for production of metals needed to give special properties to steel (for armor, jackets for armor-piercing shells, for tools and dies, and the like) and for other uses for which there are no satisfactory substitutes. These minerals are required for the successful conduct of a war - either hot or cold. Unavailability of strategic minerals, even those which are needed in relatively minute amounts, can have serious national consequences out of all proportion to their dollar value.

It has been the custom of the United States to rely on imports of the strategic minerals during times of peace or periods of relative economic stability, but during war time, when sea lanes are closed or hazardous, to offer incentive prices for supplies from domestic sources. The result has been a market price for the "strategics" that has fluctuated widely. The author of this bulletin has referred to this situation as a "yo-yo policy." Many times the fluctuations vary rapidly, with the result that greater investments are made in exploring for or developing the strategics than the market can reasonably support (in the case of a rapidly rising price), or it is impossible to amortize investments (in the case of a rapidly dropping market). The long-range result of this is three-fold. The prospector finds it difficult to know where to concentrate his efforts in his search for minerals and therefore becomes frustrated and loses interest; the responsible mining company cannot justify a domestic exploration program or long-range investments and therefore avoids the strategic field; and the investor views the strategics as a long-shot gamble and therefore shows little interest, or he requires returns or security far greater than the usual investment, with the result that little money is available.

The answer, of course, is a National Minerals Policy that will bring some stability to this "Achilles heel" in the national economy. But, surprisingly and inconceivably, this has never been forthcoming even though it has been repeatedly urged by the mineral industry and the Western Governors Conference. The only precaution that the Federal planners have ever taken to insure a continuing supply of strategic minerals was in the 1950's, when a national stockpile, based largely on imports, was accumulated. And now we see the domestic suppliers to the stockpile called before Congressional committees and subjected to various investigations! They also must face the threat of having the stockpile accumulations dumped on an already depressed market.

The result of this, of course, is a dead strategic minerals industry in the United States with a complete dependence on overseas sources. A by-product is the discontinuance of prospecting and developing and a loss of any ore that might have been left at the time a mine was forced to close.

Of all the strategics, none has had a more spotty history than quicksilver. Today the market is depressed and there are only four mines operating in all of the United States. It seems likely that two of these will close before the year is out. Oregon has not had a major producer in operation for over a year and prospecting is at a standstill. But history has taught us that a time will come when the demand for quicksilver will become critical. Then this bulletin will prove invaluable. It could well be that this record may stimulate interest even now, since it is a compendium that deserves study. There is the possibility also that works such as this will encourage the Federal Government to enunciate a National Minerals Policy.

Hollis M. Dole
Director

February 14, 1963

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QUICKSILVER IN OREGON

By

Howard C. Brooks

Part I. Economics and Geology of Quicksilver

Introduction

Purpose and scope of study

This bulletin was prepared to replace Bulletin 4, "Quicksilver Deposits in Oregon," which was published by the Oregon Department of Geology and Mineral Industries in 1938. Since that time many other quicksilver deposits have been found and additional information obtained regarding the geologic occurrence and distribution of deposits. This has necessitated the compilation of a new volume on Oregon quicksilver.

Bulletin 55 is in two parts. Part I discusses the economics of quicksilver in general and the distribution, production, and geology of quicksilver in Oregon. Part II describes the geology and history of individual areas and mines. For purposes of presenting the material in Part II, the state has been divided arbitrarily into six regions: Chapter 1, Southwestern Oregon; Chapter 2, Northwestern Oregon; Chapter 3, North-central Oregon; Chapter 4, South-central Oregon; Chapter 5, Southeastern Oregon; and Chapter 6, Northeastern Oregon.

The information for Bulletin 55 was compiled by the writer during the four-year period of 1957-1960. Most of the deposits described were examined and an exhaustive search was made of all known published and unpublished data. Several of the quicksilver districts and mines are described in reports by the U.S. Geological Survey and other agencies (see bibliography). Reference is made to these publications and much of the material contained in them has been summarized. This bulletin, however, is not intended to replace the more detailed accounts, but to supplement them by bringing together in one volume an over-all picture of the quicksilver industry in Oregon, together with brief descriptions of each deposit.

Acknowledgments

The writer wishes to thank the many persons who helped in the compilation and publication of this bulletin. Particular gratitude is extended to Howel Williams and Robert R. Compton of the U.S. Geological Survey for permission to use their unpublished manuscripts and maps of several southwest Oregon quicksilver districts and mines, and to their colleague, Edgar H. Bailey, for making this information available.

Staff members, both past and present, of the State of Oregon Department of Geology and Mineral Industries contributed materially to this bulletin. Much assistance came in the form of mine-file reports and published data of past department investigations. More current assistance came from staff geologists who aided the writer in the field and who offered constructive criticism concerning the manuscript. Other personnel helped immeasurably by performing chemical assays, locating source material, drafting maps, and editing and preparing the manuscript for publication. To all of these the writer is exceedingly grateful.

The author wishes to thank the many quicksilver miners, prospectors, and mine operators and owners throughout the state who gave freely of their time, knowledge, and hospitality. Without their help completion of this work would have been virtually impossible. Although mention of all of them cannot be made in the space allowed, special thanks are due to Bert Avery and Tom Bidwell at the Bonanza mine; F. E. Lewis and Clarence McClain at the Horse Heaven mine; the Eickemeyer brothers at the Maury Mountain mine; Paul Sorensen and Roy Hickman at the Bretz mine; Daniel I. Mills, at the Black Butte mine; Ed Staley, Dayton Glover, David Westbrook, and Frank Reid, Prineville; Al Bartell and R.R. Whiting, Portland; Marion Hewlett, Baker; Stuart and James Chisholm, Rogue River; A.G. Rodgers, Trail; David Crispen, Milo; the late C. C. Kubli, Jacksonville; and Harry and Donald Alexander, Fields, Oregon.

A. J. Kauffman, Clara Hutchison, Norman S. Petersen, and Kenneth Baber of the Albany office of the U. S. Bureau of Mines aided greatly in making available production statistics. Much historical information about the multitude of corporations which have contributed to the development of Oregon's quicksilver industry came from the files of the State Corporation Department.

Economics of Quicksilver

Properties of quicksilver

Mercury, or "quicksilver" as it is more popularly called by men of the mining industry, is a heavy (specific gravity 13.6 at 0° C), silver-white shiny metal that is liquid at ordinary temperatures. It solidifies to a malleable solid at -40° C and boils to a colorless vapor at 358° C. Mercury is the only metallic element (except gallium) that is liquid at ordinary temperatures. Its volume expands or contracts uniformly over a wide range of temperature; it does not wet glass, iron, or steel; it is highly stable in air under ordinary conditions; it is an excellent conductor of heat and electricity; it unites or mixes readily with many other metals to form amalgams; and it forms toxic compounds for use in many agricultural and pharmaceutical preparations.

Uses of quicksilver

The use of quicksilver and cinnabar (mercuric sulphide), the chief mineral from which it is recovered, is mentioned in records dating back to the fourth century B.C. Early writings indicate that quicksilver was known by the ancients to be effective in recovering gold and silver from ores, but its principal uses were for medicinal purposes and for gilding amalgamable metals. Cinnabar was used in cosmetics as rouge, and in the arts as vermilion ink and paint.

More important industrial applications of quicksilver began when the Patio process for the recovery of silver by amalgamation was invented at Pachuca, Mexico, in 1557. The mercury barometer was invented in 1643 and the mercury thermometer in 1720. Mercuric fulminate for detonating explosives was invented in 1797. Since these simple beginnings, increasing consumption of quicksilver has paralleled industrial and scientific advancements.

The first substantial industrial use of quicksilver in the United States was in the amalgamation process for the recovery of gold and silver from ores. With the development of the cyanidation and flotation processes in 1890 this use of quicksilver began to diminish. Furthermore, since little gold is being mined in the United States today, only a very small percentage of the United States' mercury supply is now consumed in its recovery.

Mercury has many applications because of the unusual properties of the metal, its vapor, and its compounds. Because it is of high density and an excellent heat conductor, mercury metal is used for many industrial and control instruments such as barometers, compensating clock pendulums, gas pressure and tank gauges, flow meters, high-vacuum diffusion pumps, weightometers, gyroscopes, and clutches or seals on small electric motors or other apparatus. As an excellent conductor of electricity, mercury is particularly suited to electrical apparatus, including mercury switches and fuses, relay tubes, mercury-arc rectifiers and oscillators, mercuric oxide batteries, various vapor lamps, and the cathodes used in the electrolytic processes for the manufacture of chlorine and caustic soda from salt.

Mercury amalgamates readily with many metals: copper, bismuth, cadmium, lead, sodium, tin, and zinc in addition to the classic examples, gold and silver. A notable exception is iron. Mercury amalgams are used for dental applications, bearings, solders, and type. Mercury vapor is employed effectively in electric power generation in areas deficient in hydro-electric power and low-cost fuels; it is also used for process heating and temperature control, and for sensitizing photographic film.

Except for mercurous chloride and the mercury sulphides, most mercury compounds are extremely toxic. Mercury, therefore, serves as a base material in fungicidal and insecticidal compounds in agriculture and in antiseptic, medicinal, and germicidal preparations. The oxide is used in antifouling paint for ship bottoms. Mercury fulminate is an explosive used in munitions and blasting caps.

Large quantities of mercury are required for the initial installations of mercury-vapor boilers in power generating units and plants for the electrolytic separation of chlorine and caustic soda. However, once the metal is added to these systems it is not dissipated and may be reclaimed if the plants are dismantled. Requirements for a new installation range from one to several thousand flasks.

Relatively little mercury is recovered from most of the articles in which it is used. Mercury scrap has been available in too small quantities to have much commercial interest. The quantity of secondary mercury produced in the United States during the years 1953-57 was only about 12 percent of the amount consumed.

Extraction processes

The extraction of quicksilver from its ores is a comparatively simple process and nearly every mine has its own extraction facilities.

The simplest and most efficient method of recovery is to roast the ore in order to volatilize the quicksilver, then collect the metal in a condensing system through which the volatiles are conducted. Roasting temperatures are ordinarily maintained in excess of the boiling point of quicksilver, 1,076° F. These basic principles, used almost exclusively in the extraction of quicksilver, have been employed since early times, although the techniques involved have been improved considerably.

Processes have been devised whereby quicksilver is leached from its ores and the metal precipitated electrolytically. However, the costs involved in this method of quicksilver reduction have proven in most instances to be higher than the simpler method of reduction by distillation and it has been used very little. In some instances hand sorting or screening methods of upgrading an ore before it is roasted may prove beneficial. Gravity methods of beneficiation such as jigging and tabling are sometimes used prior to roasting but recovery of ore minerals is generally poor. Flotation, another method of beneficiating cinnabar ores, has been used to advantage at the Bretz mine.

Quicksilver ores are roasted either in mechanical furnaces or retorts. In furnaces, the ore is exposed directly to the flame and is charged and discharged more or less continuously by mechanical means. Retorting is a batch process; the ore is heated indirectly in a closed container that is intermittently charged and discharged, usually by hand.

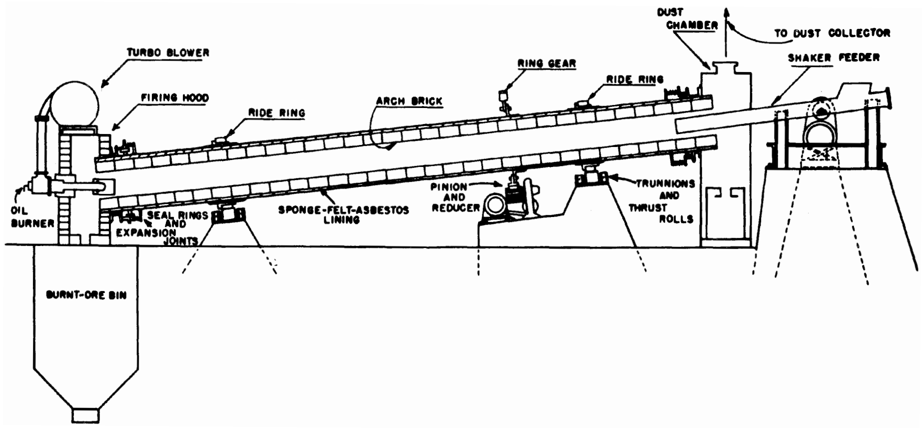
Furnaces are used at most of the mines where relatively large quantities of ore are available. They are capable of economically treating much lower grade ore than are retorts, and under exceptionally favorable conditions small profits have been realized from treatment of ores averaging less than 3 pounds of quicksilver per ton on recovery. According to U.S. Tariff Commission statistics, however, the average recovery per ton of ore treated in the United States between 1936 and 1960 ranged from a low of 5.1 pounds in 1941-42 to a high of 12.5 pounds in 1947. The ore treated in 1959 averaged 8.6 pounds per ton and that treated in 1960 averaged 9.7 pounds per ton.

Retorts are generally small and comparatively inexpensive to install, but because they are indirectly fired and manually charged and discharged intermittently, fuel and labor costs per ton of ore treated are higher than in furnace operation. Retorts are used to advantage at small mines where the ore bodies are of high grade but too small and widely distributed to supply feed economically for the continuous operation of a furnace, or where the quantity of ore available is considered too small to amortize the cost of constructing a furnace. Retorts may also be used to treat selected high-grade ore in early stages of the development of prospects. This helps to defray costs of further development of the mine and installation of a furnace. Purchase of a retort for use during the early stages of mine development will, of course, cut the ultimate profits of the operation if a furnace is eventually installed. More than 90 percent of the total mercury produced at mines in the United States in recent years has been recovered with furnaces and the balance with retorts.

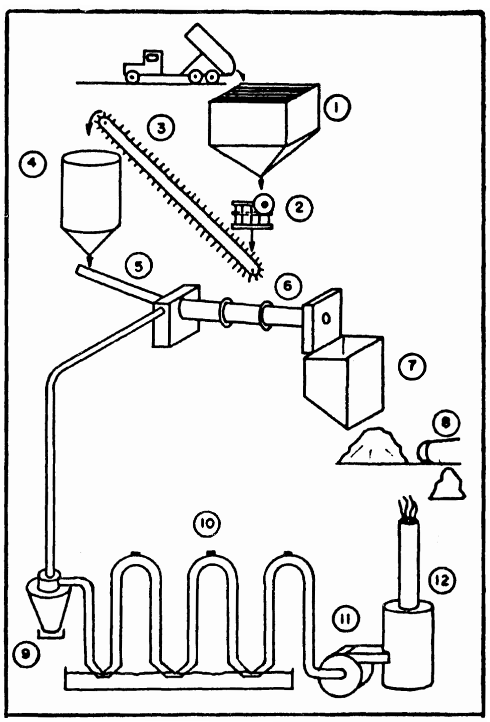
Types of furnaces: Many types of furnaces are used throughout the world, but in the United States ores are treated chiefly in the horizontally inclined rotating kiln or multiple-hearth vertical furnace. The capacity of most of these furnaces ranges between 15 and 75 tons per day but larger and smaller sizes are in use. Oil, fed through pressure burners, is the usual fuel; consumption ranges from 4 to as much as 14 gallons per ton of ore treated, but averages about 6 gallons. Ore fed to the multiple-hearth furnace is commonly crushed to $1\frac{1}{4}$ inches or less in size, while the rotary kiln can handle material as large as 3 inches in diameter. The size is determined mainly by the size of the feeder.

The rotary furnace is essentially a tubular steel shell lined on the inside with fire brick or other refractory material and set on a slope of $\frac{1}{2}$ to $1\frac{1}{2}$ inches per foot (figure 1). While the kiln rotates, generally one to two times per minute, ore is fed into the upper end of the furnace from a regulatable feeder and moves countercurrently toward the heat source at the lower end where it is discharged.

The multiple-hearth or Herreshoff furnace consists of a series of circular hearths of fire brick, enclosed one above the other, in an upright cylindrical metal shell lined on the inside with fire brick (figure 2a&b). Ore enters the furnace through the top hearth, which is usually used to dry the ore, and passes downward successively from hearth to hearth. Heat may be applied at any desired number of hearths. A series of rabbles attached to a rotating vertical shaft running through the center of the furnace draws the ore toward openings through which it



a. Section through a rotary furnace (U. S. Bureau of Mines Inf. Circ. 7941).



1. Coarse ore bin, 75-ton
2. Crusher 8" x 16"
3. Bucket elevator
4. Fine ore bin, 50-ton
5. Feeder
6. Rotary furnace 30" x 30'
7. Calcine soaking pit
8. Calcine scraper
9. Sirocco dust collector, 8"
10. Condensers - 44 pipes 8" x 16'
11. Stack fan
12. Redwood stack

b. General layout of the rotary furnace plant used at the Horse Heaven mine in north-central Oregon.

Figure 1. Section and layout of a rotary furnace plant.

falls to the hearth below. The roasted ore or calcines are discharged into a bin from the bottom hearth.

The condensing system for each type of furnace is essentially the same. From the upper parts of either furnace, mercury vapor, the gases of combustion, and dust produced by the abrasion of the ore are drawn through a cyclone dust collector and then through a series of vertical pipes joined alternately at the top and bottom with U-shaped connections. Gas flowage through the dust collector and condensers is stimulated by a suction fan. Mercury vapor, rapidly cooled, condenses on the pipe walls and along with a little dust and soot is collected under water from openings in the lower U connections. Other gases are discharged to the atmosphere. The product from the condensers, commonly known as "mud," is agitated with lime, thus causing the finely divided mercury particles to coalesce. The liquid mercury is collected, filtered, and then bottled for market. At some mines the final residue is treated again in a retort but common practice is to put it back in the furnace.

Types of retorts: Retorts most commonly consist of either cylindrical or D-shaped iron castings placed singly or in sets over a fire box, the whole being enclosed in fire brick or other masonry (figure 3). Installations may range from one or two pipes for the D-tube retorts to 12 units or more for the round pipes. The practice of employing large banks of cylindrical pipes has been discontinued, however, in favor of the mechanical furnace. In size, the D-shaped pipes ordinarily range from 20 to 24 inches across, 10 to 15 inches in height, and 8 to 12 feet long. The round pipes or "tubes" are usually 10 to 12 inches in diameter and 7 to 9 feet long. The condensing apparatus typically consists of a cast-iron pipe, one end of which is attached to the back end of the retort, with the other end submerged in a tank or bucket of water into which the quicksilver is discharged.

Only those volatiles that are released from the ore pass into the condenser. Since no oxygen can enter the retort, lime is added to combine with the sulphur and so liberate the quicksilver. The sulphur combines with the calcium of the lime to form calcium sulphide and calcium sulphate. In an iron retort, if no lime were added, the sulphur would attack the iron to form iron sulphide.

Retorts having a D-shaped cross section are installed horizontally with the flat side downward (figure 3). The D-shape permits ore to be placed in the retort in rectangular iron pans thus speeding up the charging and discharging processes. The cylindrical pipes may be set horizontally or at angles varying from 30° to 45°. The horizontal pipes are commonly known as Johnson McKay retorts and the latter as Rossi retorts. The advantage of the Rossi retort is that it can be charged at the top and discharged at the bottom. Oil, coal, gas, or wood may be used as fuel for retorts. The capacity of retorts varies with the size of the pipe, the type of ore treated, and the kind of fuel employed. In practice, however, D-tube retorts are typically charged with from 300 to 500 pounds of ore per tube every 12 hours. Cylindrical pipes have capacities of from 200 to 300 pounds per tube in 12 hours.

Revolving retorts have also been designed and have been used at several small mines particularly in central Oregon. Although employed, possibly for the first time, in Texas this type of retort was intoduced into central Oregon by A. J. Champion and hence is commonly referred to there as the Champion rotary retort. It consists of an iron cylinder 8 feet long and about 30 inches in diameter, mounted on trunions and rotating within a masonry shell. The condenser pipe is connected to the retort by means of a stuffing box. Capacity of the retort is about 800 pounds every 6 hours. Most of the ore produced at the Maury Mountain mine in southern Crook County was treated in a Champion retort.

Marketing of quicksilver

"Prime virgin quicksilver," the product of the mines, is shipped to market in cylindrical steel or iron flasks containing 76 pounds each. Most of the metal thus entering the market is about 99.9 percent pure and more than 80 percent is used without further refining. Redistilled, electrolytically refined, or otherwise purified mercury is packed in smaller containers, usually less than 10 pounds, and sold under various names for special purposes.

World production and its effect on the domestic industry

Quicksilver ranks tenth in quantity in world output of non-ferrous metals. It is a relatively rare metal whose unit value among those in common use is exceeded only by that of gold and silver. In most of its applications small amounts suffice, consequently the monetary value of the contained mercury has little effect on the ultimate cost of most articles in which it is used. Prices paid for the raw metal in the domestic market tend to fluctuate widely, due to erratic demands and the highly adverse effect of market saturation. Fluctuations in price are generally followed closely by a corresponding increase or decrease in domestic production (see figure 4 and table 1).

An unusual and desirable combination of chemical and physical properties that make it indispensable to all

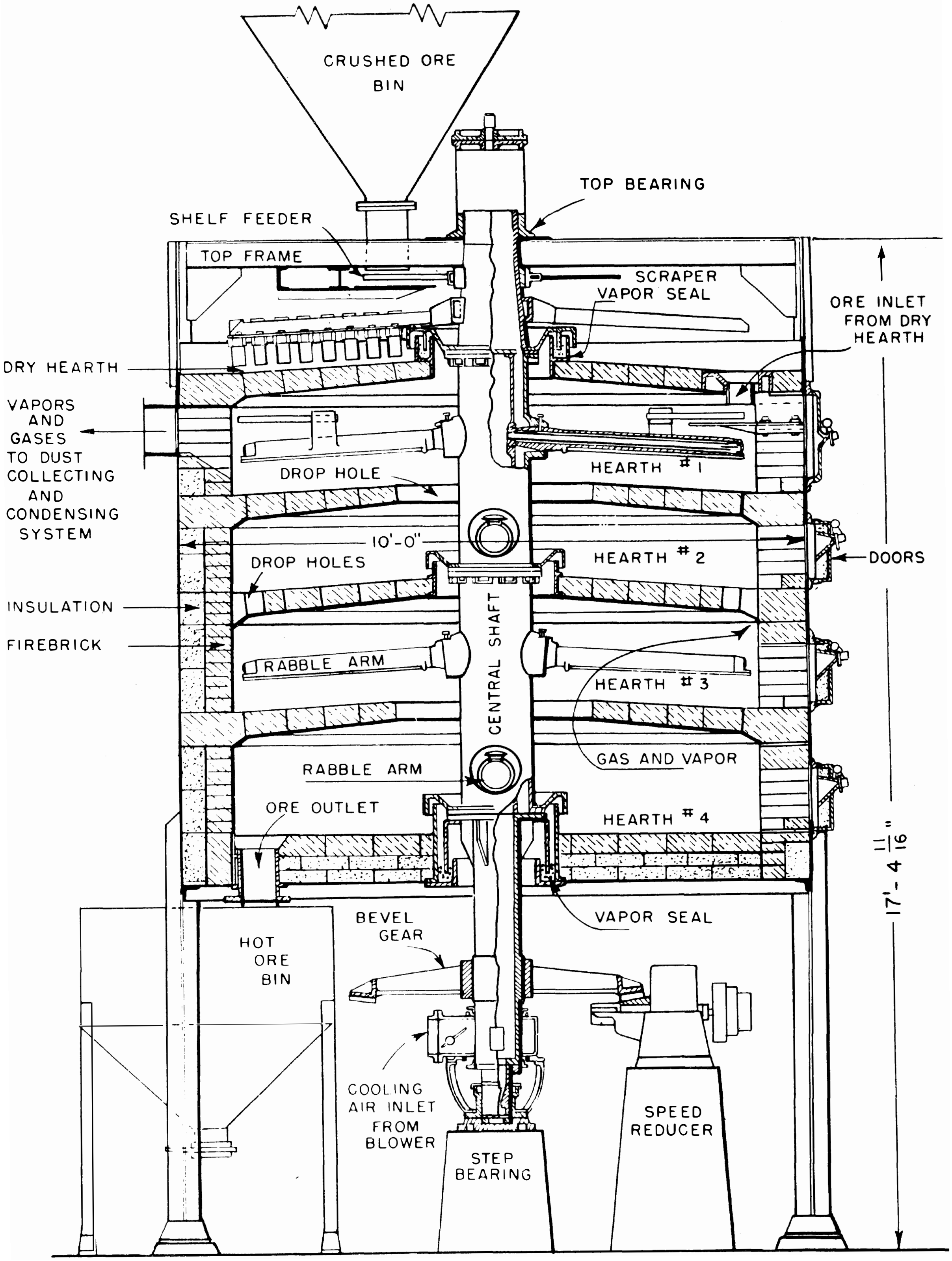


Figure 2a. Section through a multiple-hearth furnace (U.S. Bureau of Mines Inf. Circ. 7941).

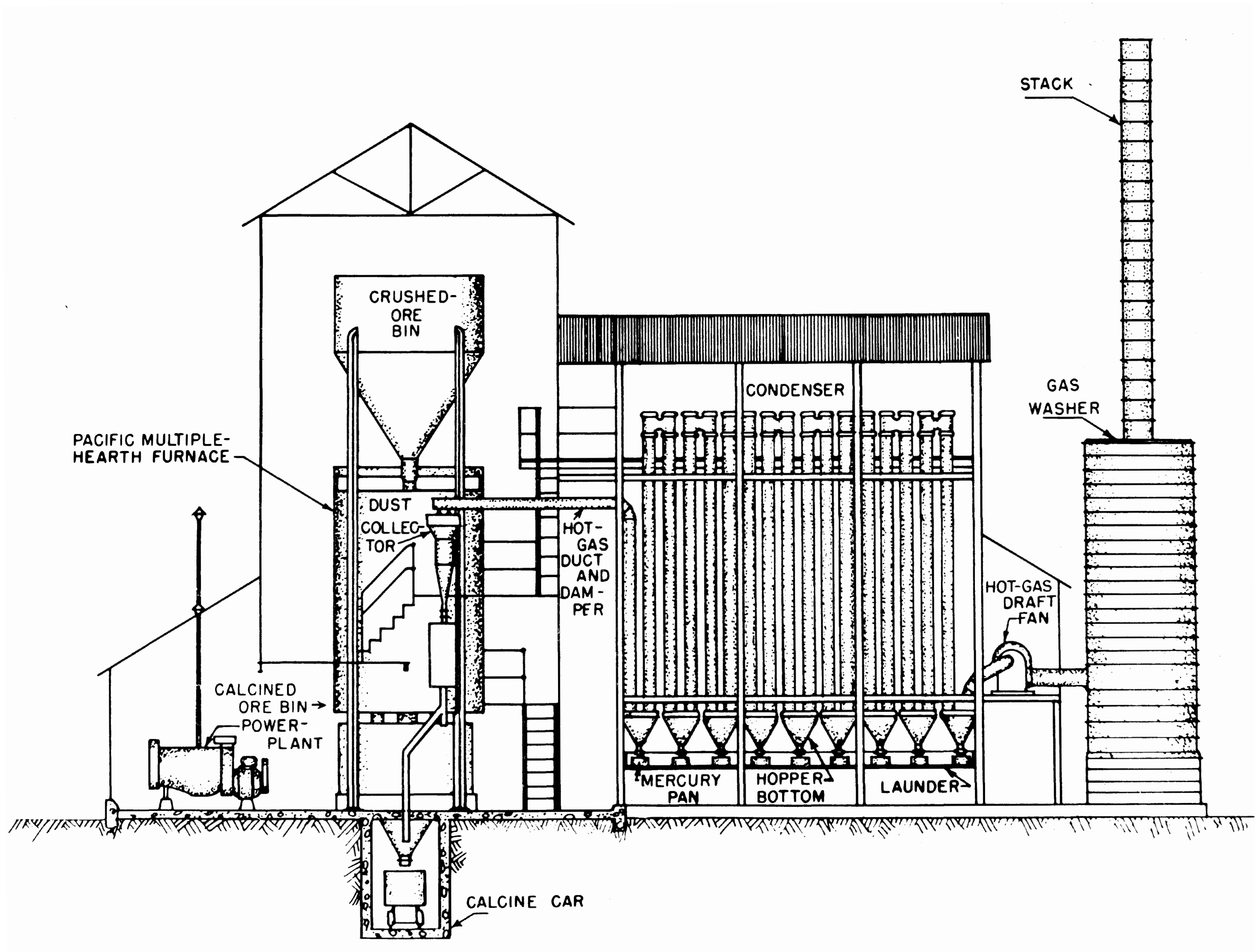


Figure 2b. Layout of a multiple-hearth furnace plant (U.S. Bureau of Mines Inf. Circ. 7941).

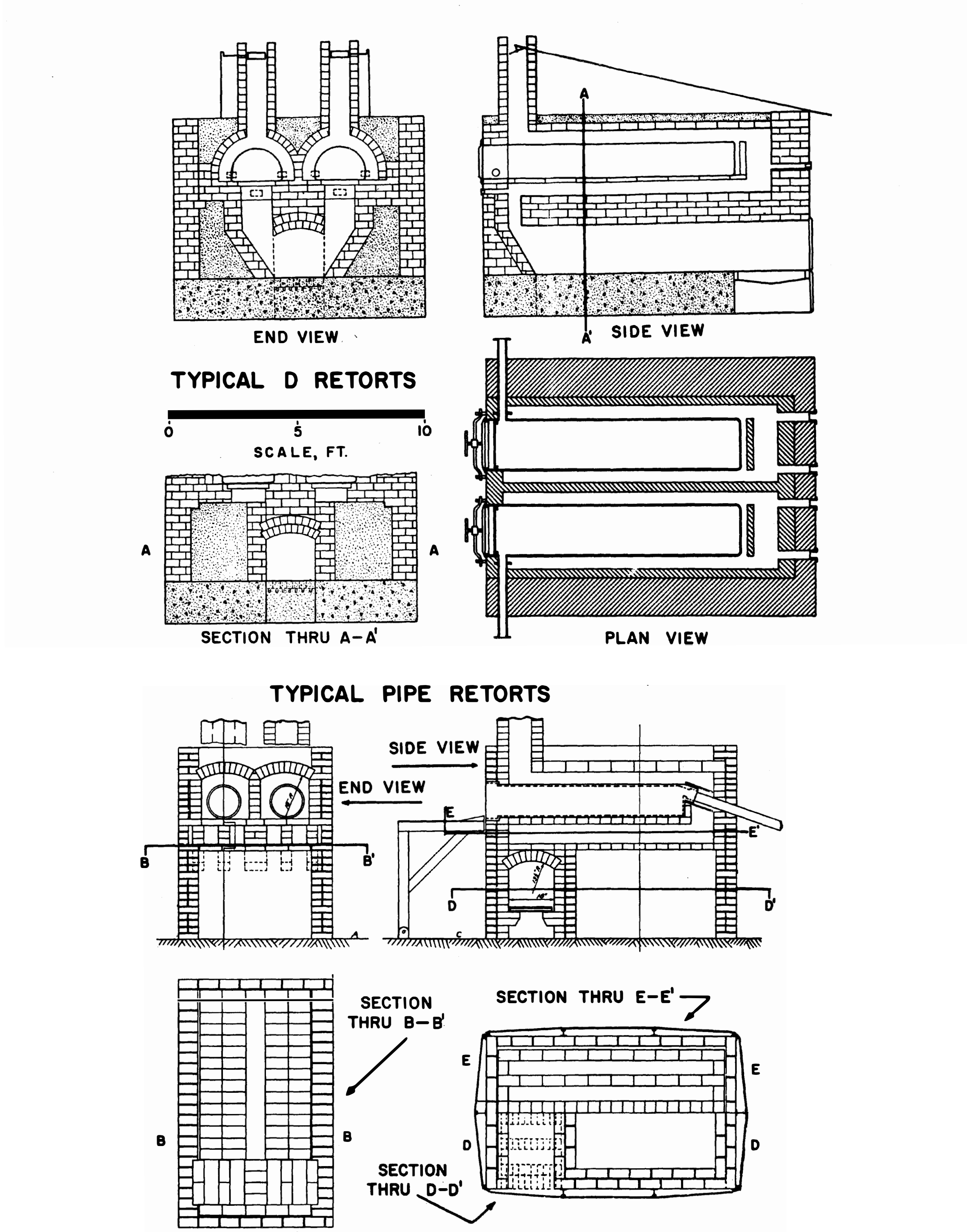


Figure 3. Sections through typical D retorts and pipe retorts.

nations, and unequal distribution of the world's sources of supply give quicksilver an industrial and military importance far out of balance with the small physical size of the domestic producing industry. In normal times none of the great industrial powers of the world today produce more than a part of its own requirements. The United States, which during the latter half of the 1800's more or less dominated world production, has since 1915 produced on the average about 60 percent of apparent annual consumption. When considered on an annual basis, the ratio of production to consumption varies widely, ranging from lows of 23 percent, 35 percent, and 7 percent in 1926, 1933, and 1950 respectively, to highs of more than 100 percent in 1916-17, 1931, and 1940-42.

World production is dominated by Spain and Italy, whose combined production accounts for about half of world output in recent years. Nearly all of the Spanish production comes from a single large mine, the Almaden. Italian yield is credited mainly to two large mines and several smaller ones in the Monte Amiata area. Most of the remaining production comes from the United States, Mexico, Japan, Yugoslavia, the U.S.S.R., China, and the Philippines. Because the principal Spanish and Italian deposits are larger and richer than the others and production costs are much lower, these two countries have long been able to control prices in the world quicksilver market.

According to U.S. Bureau of Mines statistics (figure 4), ores produced in the United States from 1927 through 1960 ranged from 5.1 to 12.5 pounds quicksilver per ton and the record production in this country in 1943 was extracted from ore averaging 6.3 pounds of recoverable quicksilver per ton. Italian ores average about 15 pounds of quicksilver per ton and the grade of ore at the Almaden mine in Spain, the world's largest producer, is 3 to 5 times higher.

Because the world's quicksilver resources are unequally distributed and demands are erratic, the balance between world supplies and demand is disturbed easily and quite often. As a result the domestic industry for many years has been shrouded in an unhealthy, often precarious, atmosphere. For example, at times when wartime industrial demands force consumption to abnormal heights or when foreign supplies are curtailed either militarily or by price manipulation, the demands upon domestic production increase. Prices rise, allowing profitable expansion of the domestic production. As such crises end, however, the quicksilver market is rapidly surfeited. The return to more normal conditions of supply and demand has several times in the past dealt a severe blow to the domestic quicksilver industry. Declining prices progressively discourage exploration and development work to replace deposits exhausted by mining, and curtail maintenance of machinery and equipment. Continued production requires the mining of progressively higher grade ores with the result that the exhaustion of known reserves is greatly accelerated. In many instances the remaining low-grade ore is left in such a condition that it is lost. The end result is a shut-down mine with no proven ore reserves, worn-out equipment, and caved or caving workings. These conditions brought the United States quicksilver industry to near extinction three times since World War I. Present trends indicate that it will do so again in the near future.

Following World War I, prices fell from the 1916-19 average of \$113.59 per flask to a low of \$46.07 in 1921. Production dropped from a high of 35,683 flasks in 1917 to a low of 6,256 in 1921. Output failed to increase appreciably for the next 5 years. Thus while production exceeded consumption in 1916 and 1917, about 70 percent of the apparent consumption was imported during the years 1921-26. About 77 percent was imported in 1926, even though the market price was double that of 1921.

In 1927 prices rose to an annual average of \$118.16 as a result of consumer reaction to rumors of the impending establishment of a cartel between Spanish and Italian producers, who at the time controlled 80 percent of the world's quicksilver. (Only three times prior to 1927 had recorded domestic quicksilver prices exceeded \$100 per flask. These were in the years 1850, 1874, and during the war years of 1916-18.)

Beginning its functions in October 1928, the aims of the cartel were to control the sale of all Spanish and Italian quicksilver at prices and amounts fixed in advance. Prices remained in excess of \$100 through the early months of 1931. Unfortunately, prices set by the cartel proved too high to maintain adequate balance between world supply and demand. U. S. production increased rapidly and by 1931 exceeded consumption. In 1931, instead of buying large quantities from Europe as was customary, United States firms began exporting small quantities, taking advantage of higher European prices. Ultimately domestic prices began to drop, reaching a low for the year of \$66 per flask in December. The European cartel, in order to regain its normal share of the U.S. market, was forced to reduce its prices drastically. In October 1932, the European price in New York duty paid was \$52.00 per flask, a price considerably below the cost of production at most American mines. Domestic production declined from 24,947 flasks in 1931 to 9,699 in 1933 and the United States returned to its former position as an importer. If employment had been readily available elsewhere and had there not been a coincident depression in production costs brought about by national economic conditions, it is probable that the U. S. quicksilver industry would have been as severely crippled by the 1931-33 collapse in the quicksilver market as it was following World War I.

With the outbreak of World War II, the Spanish-Italian cartel forced quicksilver prices to unprecedented heights, and, although a ceiling price of \$191 per flask was imposed on domestic producers, world prices rose

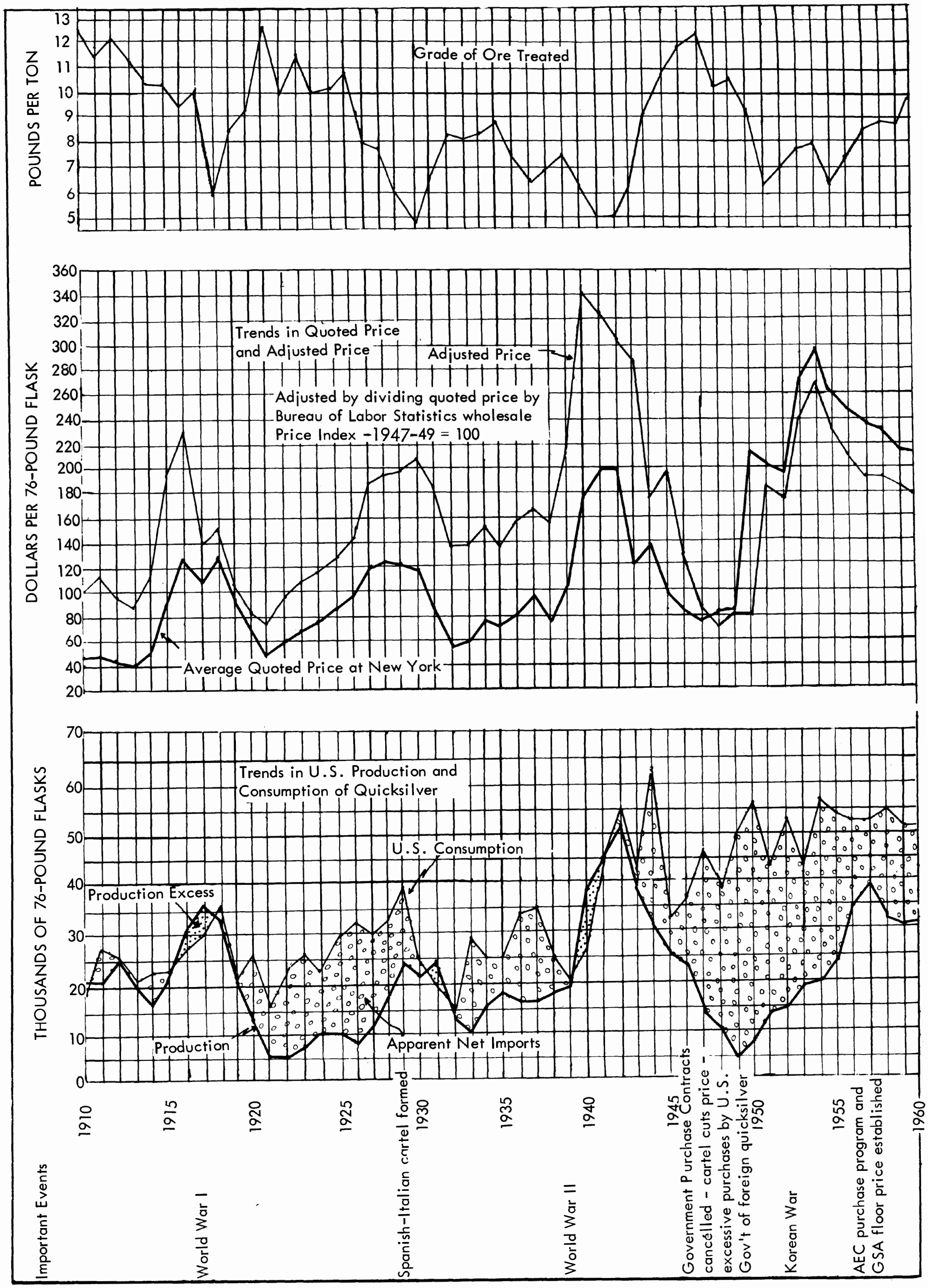


Figure 4. Trends in production, consumption, quoted price, adjusted price (1947-49 = 100), and grade of ore treated in the United States 1910-60 (based on U. S. Bureau of Mines statistics).

more than $100 above that. Under the impetus of high prices without increased costs, domestic production rose rapidly. In 1940, domestic mines produced 37,777 flasks and by 1943 production had risen to 51,929 flasks. From 1940 through the end of 1942, domestic mines produced more than enough to meet the demands of this country and some was shipped to allied nations. Foreign supplies purchased during these years became surplus stock at the end of the war. In late 1943, domestic purchase contracts were canceled and American producers were informed that mercury reserves were ample. Nonetheless, in 1943 and 1944 large amounts of foreign mercury were purchased by the government. The result was a disastrous crash in the mercury market which began in early 1944. New supplies foreign and domestic, exceeded consumption by 55 percent in 1946 and some United States producers are believed to have operated at a loss. United States production decreased from 51,929 flasks from 146 mines in 1943 to 4,535 flasks from 16 mines in 1950. This was the smallest output since the beginning of recorded production in 1850. Domestic production in 1950 constituted only 7 percent of the total United States supply; 93 percent was imported.

During World War II the cartel lost its control over the world market. Germany and Japan, formerly large consumers, were almost completely out of the market because of extensive damage to their war industries. The United States' requirements were supplied largely by domestic producers. Consequently, immediately following the war the cartel dropped its prices to as low as $45 a flask. The purpose of this was to obtain United States dollar credit and to get rid of a considerable stock. Much of the metal was probably sold at prices below costs.

With the phenomenal rise in the average price of mercury to $210.13 per flask in 1951, domestic production increased to only 7,283 flasks. Owing to the shortage of men and materials during the war years, the upkeep of many of the mines and the development of future reserves were neglected. Consequently the reopening of inactive mines required outlays of considerable capital, and producers were slow to expand production without some assurance of market stability. Also, when compared with pre-inflation mercury values and production costs, the 1951 average price was considerably lower than the prices paid during the early years of World War II (figure 4).

In 1951, the Defense Minerals Procurement Agency considered it unnecessary to allow government aid in the expansion of domestic mercury production. World supply was then adequate for world demand. However, since the United States was then producing only a small part of its consumption requirements, dependence on foreign sources led to the establishment of a strategic stockpile of mercury. Mercury was also included with minerals eligible for exploration aid through the Defense Minerals Exploration Administration.*

Following the 1951 increase, prices remained at about the $200 level until mid-1954, when purchases for the Atomic Energy Commission created a shortage which forced prices to a peak of $330 in October. A mercury procurement program enacted by the General Services Administration in July 1954 had the effect of establishing a floor price of $225 on domestic mercury for the $4\frac{1}{2}$-year period ending December 31, 1958. Although the market price remained considerably above the government price until mid-1958 and little quicksilver was purchased under the stockpile program, the floor price tended to stabilize the market and encourage the revitalization of the quicksilver industry. The program as enacted in July 1954 and extended in 1957 called for total procurement of 155,000 flasks of domestic and 95,000 flasks of Mexican quicksilver. Deliveries accepted through January 31, 1959 totaled 26,891 flasks of domestic and 3,274 flasks of Mexican metal. These 30,165 flasks were eventually transferred to the Atomic Energy Commission.

Since 1959 there has been a slow but continuing decrease in the price of quicksilver, accompanied by increasing production costs.

*Under the authority of the Defense Production Act, the government offered assistance in the exploration of quicksilver deposits. Between mid-1951 and mid-1958 the program was administered by the Defense Minerals Exploration Administration and since 1958 by the Office of Minerals Exploration. When the program was initiated, the government was authorized to loan as much as 75 percent of allowable exploration costs. Since October 1957, this limit has been lowered to 50 percent. The loan, plus interest, is repayable on a royalty basis from production from reserves developed as a result of work done under the contract.

TABLE 1. Salient Mercury Statistics (Flasks)

(U.S. Bureau of Mines Minerals Yearbook, 1960)

Year	United States						World production	United States (percent of world total)
	Production	Imports for consumption	Exports	Apparent consumption	Price			
					Average per flask at New York	Adjusted by wholesale index [1]		
1910	20,330	9	1,898	18,441	[2] $47.69	$104	107,053	19
1911	20,976	6,209	287	26,898	[2] 47.16	112	120,423	17
1912	24,734	1,088	306	25,516	[2] 43.03	96	120,650	21
1913	19,947	2,259	1,125	21,081	[2] 40.07	88	117,465	17
1914	16,330	8,090	1,427	22,993	[2] 48.95	110	108,601	15
1915	20,756	5,551	3,328	22,979	[2] 88.17	195	112,871	18
1916	29,538	5,585	8,763	26,360	[2] 127.16	229	101,544	29
1917	35,683	5,138	10,636	30,185	[2] 107.72	141	115,087	31
1918	32,450	6,631	3,057	36,024	[2] 125.12	147	99,256	33
1919	21,133	10,495	8,987	22,641	[2] 93.38	104	89,940	23
1920	13,216	13,982	1,533	25,665	[2] 82.20	82	84,470	16
1921	6,256	10,462	388	16,330	[2] 46.07	73	61,916	10
1922	6,291	16,697	287	22,701	[2] 59.74	95	91,819	7
1923	7,833	17,836	314	25,355	[2] 67.39	103	93,040	8
1924	9,952	12,996	205	22,743	[2] 70.69	111	89,138	11
1925	9,053	20,580	201	29,432	[2] 84.24	125	103,344	9
1926	7,541	25,634	114	33,061	[2] 93.13	143	115,969	7
1927	11,128	19,941	(3)	[4] 30,900	118.16	191	149,905	7
1928	17,870	14,562	(3)	[4] 32,300	123.51	196	149,083	12
1929	23,682	14,917	(3)	[4] 38,500	122.15	197	162,699	15
1930	21,553	3,725	(3)	[4] 25,200	115.01	205	108,985	20
1931	24,947	549	[5] 4,984	20,512	87.35	184	99,069	25
1932	12,622	3,886	[5] 214	16,294	57.93	138	82,644	15
1933	9,669	20,315	(3)	[4] 29,700	59.23	138	59,828	16
1934	15,445	10,192	(3)	[4] 25,400	73.87	152	76,939	20
1935	17,518	7,815	(3)	[4] 25,200	71.99	138	100,261	17
1936	16,569	18,088	263	34,400	79.92	152	123,878	13
1937	16,508	18,917	454	35,000	90.18	161	133,136	12
1938	17,991	2,362	713	19,600	75.47	148	150,000	12
1939	18,633	3,499	1,208	20,900	103.94	207	145,000	13
1940	37,777	171	9,617	[6] 26,800	176.87	346	215,000	18
1941	44,921	7,740	2,590	[6] 44,800	185.02	326	275,000	16
1942	50,846	[7] 38,941	[7] 345	[6] 49,700	196.35	306	265,000	19
1943	51,929	[7] 47,805	[7] 385	[6] 54,500	195.21	291	236,000	22
1944	37,688	19,553	750	[6] 42,900	118.36	175	163,000	23
1945	30,763	68,617	1,038	[6] 62,429	134.89	196	131,000	23
1946	25,348	13,894	907	[6] 31,552	98.24	125	154,000	16
1947	23,244	13,008	884	[6] 35,581	83.74	87	168,000	14
1948	14,388	31,951	526	[6] 46,253	76.49	73	107,000	13
1949	9,930	103,141	577	[6] 39,857	79.46	80	121,000	8
1950	4,535	56,080	447	[6] 49,215	81.26	79	143,000	3
1951	7,293	47,860	241	[6] 56,848	210.13	183	147,000	5
1952	12,547	71,855	400	[6] 42,556	199.10	178	151,000	8
1953	14,337	83,393	546	[6] 52,259	193.03	175	160,000	9
1954	18,543	64,957	890	[6] 42,796	264.39	240	180,000	10
1955	18,955	20,354	451	[6] 57,185	290.35	262	185,000	10
1956	24,177	47,316	1,080	[6] 54,143	259.92	227	221,000	11
1957	34,625	42,005	1,919	[6] 52,889	246.98	210	246,000	14
1958	38,067	30,196	320	[6] 52,617	229.06	192	251,000	15
1959	31,256	30,141	640	[6] 54,895	227.48	190	233,000	13
1960	33,223	19,488	357	[6] 51,167	210.76	176	254,000	13

[1] Quoted price divided by Bureau of Labor Statistics wholesale price index (1947–49=100.)
[2] Quoted price for 75-pound flask calculated to equivalents for 76-pound flasks.
[3] Not separately classified for 1927–30 and 1933–35.
[4] Estimated by Bureau of Mines.
[5] From a special compilation, Bureau of Foreign and Domestic Commerce.
[6] Actual consumption.
[7] Large quantities reexported in 1942 and 1943 are included in imports but not exports.

Oregon's Quicksilver Industry

Distribution and production

Quicksilver deposits are widely distributed in Oregon, but the greatest number and the most productive lie in the southwestern, north-central, and southeastern parts of the state (see figure 5). Each shaded area in figure 5 represents a group of deposits, some or all of which have produced at least a few pounds of quicksilver. Plate 1 (in pocket) shows the location of all known quicksilver mines and prospects in Oregon.

The production from Oregon quicksilver mines, as recorded by the U.S. Bureau of Mines, to the end of 1961 is 103,562 flasks valued at 14.5 million dollars. Of this amount 100,354 flasks have been produced since 1927, when continuous production began in the state. Table 2 shows the annual production reported by the U.S. Bureau of Mines. Plate 2 shows the distribution of annual production by mine and county. For some of the larger mines, owner-operator records of production for certain years are at variance with U. S. Bureau of Mines statistics. Where these discrepancies exist, the owner-operator records were used. Consequently, for several different years Oregon's total annual quicksilver production as given in Table 2 differs slightly from that shown in Plate 2.

Most of Oregon's quicksilver production has been contributed by five mines: the Bonanza and Black Butte mines in the Bonanza-Nonpareil and Black Butte areas in southwestern Oregon, the Horse Heaven mine in the Horse Heaven area in north-central Oregon, and the Bretz and Opalite mines in the Opalite area in southeastern Oregon. The Bonanza mine is the largest producer with 39,488 flasks. Yield from each of the other four major producers ranges between 12,000 and 17,500 flasks each. No other mine has furnished more than 1,000 flasks.

Relationship to other producing states

Oregon is one of only 10 states in the nation that are known to have produced quicksilver. California has always been the largest producer, and accounted for virtually all of domestic production during the latter half of the 1800's when the United States dominated world production. Texas provided important quantities during 1899-1918 and 1938-44 . From 1936 through 1944 Oregon ranked second among the producing states, yielding that place to Nevada in 1945. In 1957 Alaska became the third ranking producer, with Oregon and Idaho since vying for fourth place. During the 6 years 1956-61 when United States production averaged 32,158 flasks, five states accounted for 99 percent of the total with California producing 53 percent, Nevada 22 percent, Alaska 13 percent, Idaho 6 percent, and Oregon 5 percent. Other states that have been the source of small amounts of quicksilver are Arkansas, Arizona, Washington, and Utah.

History of production

In Oregon, quicksilver was probably first found with gold in the placer mines of Jackson County, which were discovered about 1852. During the next 30 years many quicksilver deposits were located in Jackson and Douglas Counties and some quicksilver was recovered with crude reduction equipment and sold locally to the gold miners. The first production of which there is any known record was 50 flasks made in 1882 by mines in the Bonanza-Nonpareil and Elkhead areas of Douglas County.

In north-central Oregon quicksilver was discovered in 1899 near the present site of the Mother Lode mine. Initial output from this small mine was in 1906. Most of the other known occurrences in north-central Oregon, including the Horse Heaven mine, were discovered during a quicksilver prospecting "boom" that occurred in the late 1920's and early 1930's. The Bretz and Opalite mine deposits in southeastern Oregon were discovered in 1917 and 1924 respectively.

Except for a few flasks produced by the Mother Lode mine, all of Oregon's recorded quicksilver production of 3,208 flasks prior to 1927 was contributed by mines in Lane, Douglas, and Jackson Counties. More than two-thirds of it was produced by the Black Butte mine in Lane County; the remainder is attributed chiefly to the War Eagle and Elkhead mines. About 42 percent of the pre-1927 production occurred during the four-year period from 1916 to 1919, when demands brought about by World War I forced prices to unprecedented average heights ($113.00 per flask).

The real development of Oregon's quicksilver industry began in 1927 under the impetus of high prices brought about by the impending establishment of the Spanish-Italian Mercury Cartel. The 2,055 flasks produced that year, a figure just short of equaling the total previous production, came largely from the Black Butte and Opalite mines. Continued productivity from these mines stimulated prospecting elsewhere and by 1937 all of Oregon's five major producers were in operation. The Bretz mine came into production in 1931, the Horse Heaven in 1934, and the Bonanza in 1937. In addition many smaller deposits were developed.

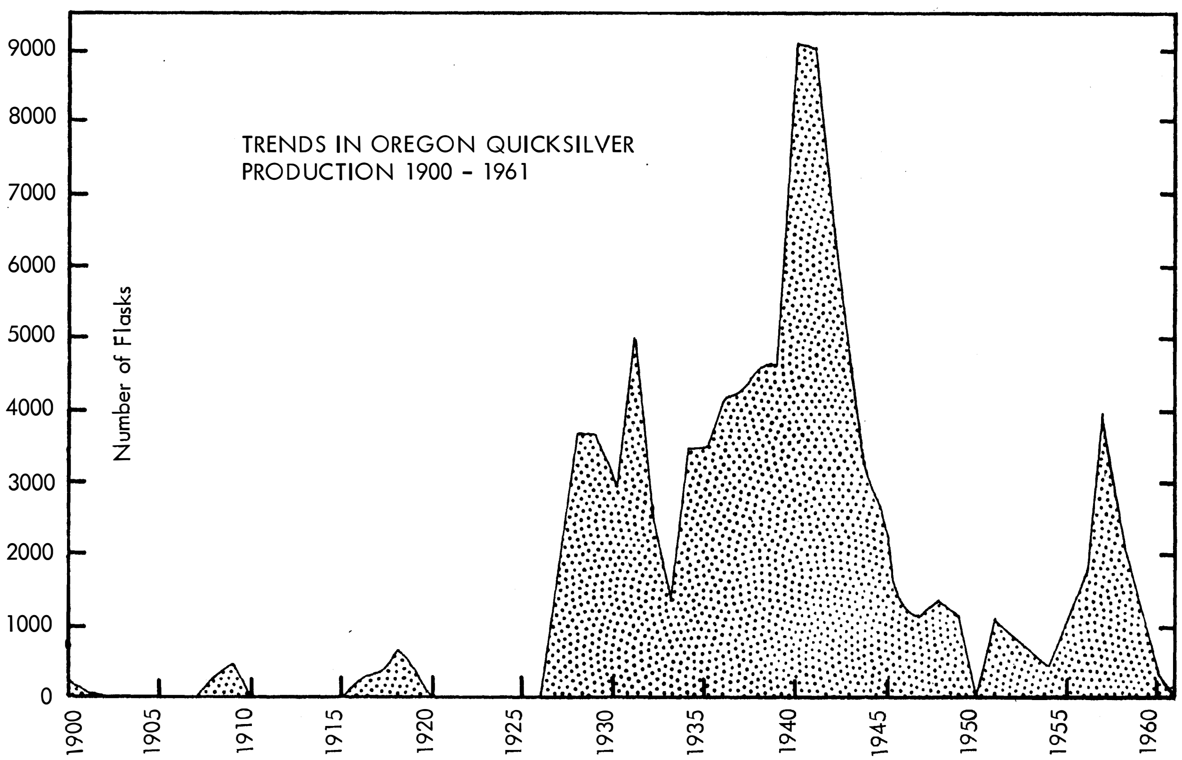
The yearly average of Oregon quicksilver production from 1927 through 1945 was about 4,265 flasks. The

TABLE 2. Oregon Quicksilver Production Statistics and Trends, U.S. Bureau of Mines

Year	Number of producing mines	Production in flasks	Average price per flask at New York	Value*
1882	1	50		
1883-86		none		
1887	2	65	42.37	2,754
1888	1	32	42.50	1,360
1889	1	20	45.00	900
1890-99		none		none
1900	1	200	44.94	10,010
1901	1	75	48.46	3,539
1902-04		none		none
1905	1	43	36.22	1,677
1906	1	3	39.50	109
1907		none		none
1908	2	341	44.17	15,570
1909	1	487	45.45	21,575
1910-14		none		none
1915	1	3	88.17	240
1916	3	299	127.16	38,145
1917	2	383	107.72	40,864
1918	2	693	125.12	82,485
1919	3	429	93.38	39,276
1920	1	24	82.20	1,912
1921	1	11	46.07	500
1922	1	2	59.74	116
1923	1	38	67.39	2,601
1924	1	10	70.69	695
1925-26		none		none
1927	3	2,055	118.16	242,761
1928	4	3,710	123.51	458,147
1929	5	3,657	122.15	446,684
1930	7	2,919	115.01	335,711

Year	Number of producing mines	Production in flasks	Average price per flask at New York	Value*
1931	5	5,011	87.35	437,716
1932	7	2,523	57.93	146,145
1933	5	1,342	59.23	79,483
1934	11	3,460	73.87	265,573
1935	10	3,456	71.99	248,798
1936	13	4,126	79.92	329,750
1937	14	4,264	90.18	384,527
1938	13	4,610	75.47	347,917
1939	14	4,592	103.94	477,293
1940	23	9,043	176.87	1,599,436
1941	21	9,032	185.02	1,671,101
1942	23	6,935	196.35	1,361,687
1943	16	4,651	195.21	907,922
1944	8	3,159	118.36	373,899
1945	6	2,500	134.89	337,225
1946	6	1,326	98.24	130,226
1947	3	1,135	83.74	99,232
1948	1	1,351	76.49	103,338
1949	2	1,167	79.46	92,703
1950	1	5	81.26	406
1951	4	1,177	210.13	247,323
1952	4	868	199.10	172,819
1953	5	648	193.03	125,048
1954	9	489	264.39	129,287
1955	7	1,056	290.35	306,610
1956	13	1,893	259.92	492,029
1957	8	3,993	246.98	986,191
1958	7	2,276	229.06	521,340
1959	4	1,224	227.48	278,435
1960	5	513	210.76	108,120
1961	5	138	197.60	27,269
		103,562		$14,536,409

*Value calculated from annual average New York prices which are generally a few dollars higher than those paid to the producer.



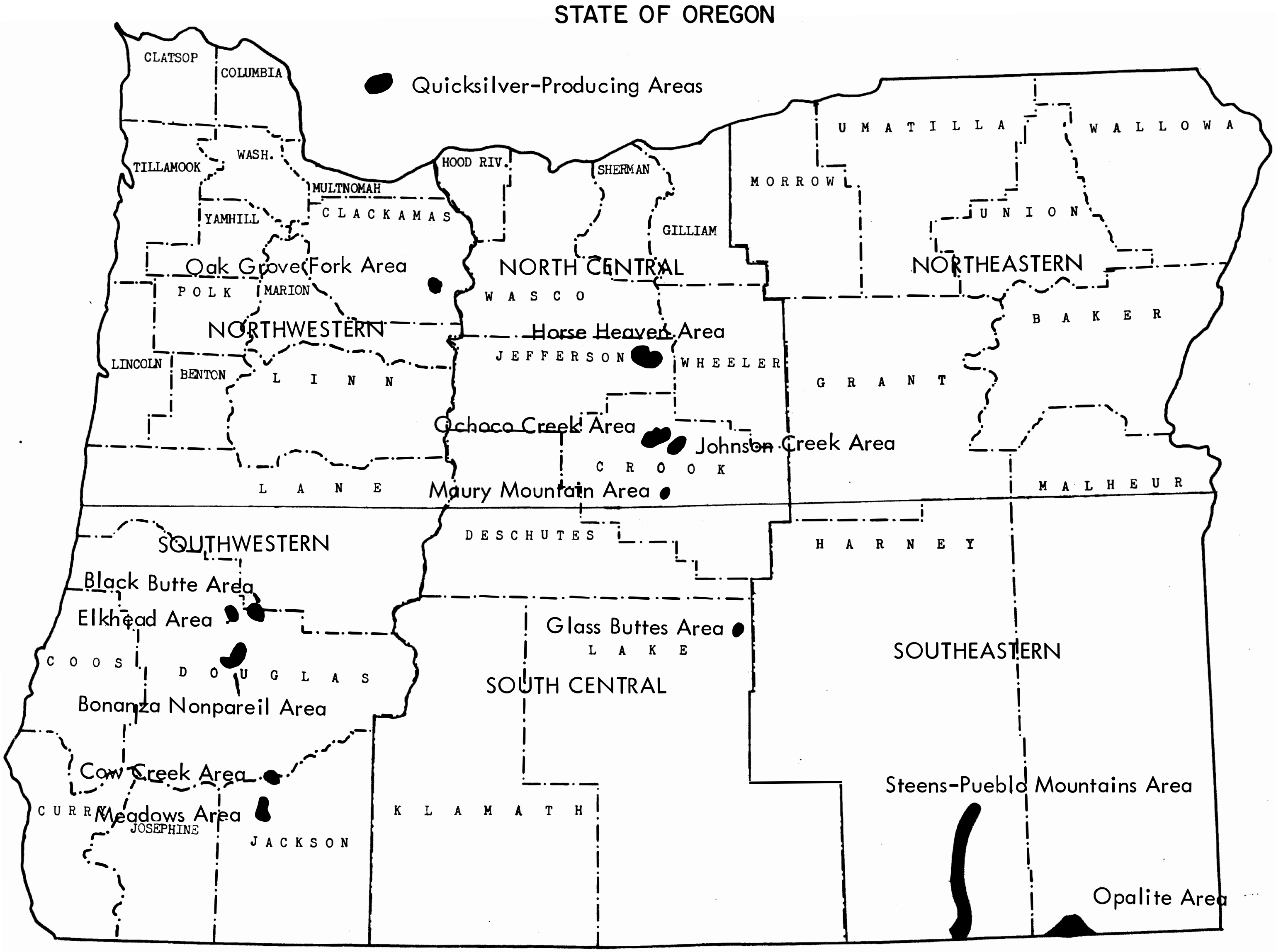


Figure 5. Index map of Oregon showing the six divisions of the state as used in the text and the areas that have produced more than 50 flasks of quicksilver.

greatest production was made in 1940-1941 when at least 20 mines contributed to a total of more than 9,000 flasks each year for an average price of $180.95 per flask. From 1936 through 1944, Oregon ranked second only to California in annual output.

Because of the shortage of men and materials during the early years of World War II, the development of reserves at many domestic mines, particularly those in Oregon, did not keep pace with production. Consequently, although United States production increased steadily until 1943, Oregon production decreased sharply after the 1940-41 surge.

By 1945, the Bretz, Opalite, and Black Butte mines had closed as reserves minable under existing conditions were depleted. In 1944, the surface plant at the Horse Heaven mine was destroyed by fire, and existing reserves did not warrant the expenditure required to rebuild even had war-directed labor and materials been available. Consequently it too closed, leaving the Bonanza as Oregon's only major producer still in operation. When World War II ended in 1945, mercury played its familiar role of reacting rapidly to changed economic conditions and was soon in oversupply. Continued purchases of foreign quicksilver after the war ended saturated the domestic market, and prices lowered while production costs rose.

In 1950, when quicksilver prices averaged only $81.26 per flask and all but 16 mines in the United States were closed, including Oregon's Bonanza mine, Oregon produced only 5 flasks. The total United States production that year was but 4,535 flasks.

With the phenomenal rise in the average price of mercury to $210.13 per flask in 1951, the Bonanza mine was reactivated and accounted for nearly all of Oregon's production for the next 4 years. In 1955 the Horse Heaven mine was reopened but production costs proved too high to allow extensive exploration and development work. Consequently, after accessible pillars and broken ore left in the mine since 1944 had been removed, the mine was closed in April 1958. The Bretz and Black Butte mines were reactivated and came into production again late in 1956; however, operations at the Black Butte lasted only a few months. At the Bretz mine, a new ore body adjacent to the old workings was discovered, a 150-ton flotation plant and small furnace were installed, and an annual production of several hundred flasks was made through 1960. In October 1960 the Bonanza mine, whose production accounts for about 38 percent of Oregon's total, was closed, dismantled, and offered for sale.

Future of the industry

At present the outlook for quicksilver mining in Oregon is not bright. Reserves minable under current economic conditions have been virtually exhausted and the continuing increase in exploration and production costs leaves little incentive to search for or develop new deposits.

While the bulk of Oregon's past quicksilver production is attributed to five mines, more than 60 other deposits have produced between one and 1,000 flasks and at least that many more non-productive occurrences scattered throughout the state have had some exploratory work done on them. No doubt a majority of these small producers and non-productive occurrences are of little or no economic merit; however, several deposits appear to the writer to warrant further development. Since the incentive to explore for new deposits is directly proportional to the price of quicksilver, and in view of the worsening condition of the market, few miners with the necessary capital and technical background care to venture.

That some small mines could become major producers is illustrated by the history of the Bonanza mine, Oregon's largest producer of quicksilver. Cinnabar was discovered there before 1870 and even though numerous attempts were made to develop it into a paying mine, there was almost no production until 1937. The Black Butte mine also failed to sustain profitable operation before 1927, although some 15,000 feet of development work was done and the ore body well blocked out prior to 1908.

If and when the economic climate becomes favorable, there is little doubt that Oregon will again produce substantial amounts of quicksilver.

Mineralogy and Geology of Oregon Quicksilver Deposits

Ore minerals

General: Cinnabar, the red mercuric sulfide, is the only mineral of commercial significance in quicksilver ores in Oregon. More than 25 other minerals are known to contain quicksilver and of these, native quicksilver, metacinnabar, schwatzite, terlinguaite, eglestonite, and calomel have been recognized in Oregon. In some cinnabar ore bodies they add slightly to the tenor of the ore.

Cinnabar: Pure cinnabar contains about 86 percent mercury and 14 percent sulfur. It can be recognized by its cochineal-red color, scarlet streak, high specific gravity, and adamantine luster. Cinnabar can be scratched very easily with a knife and is transparent to opaque. It crystallizes in the hexagonal crystal system; however, well formed crystals of appreciable size are rare. In hand specimens, particularly of low grade or finely disseminated ore, the color of cinnabar is often masked by other minerals, particularly the oxides of iron. Hematite, the red oxide of iron, is the mineral most commonly mistaken for cinnabar. When exposed to sunlight, cinnabar darkens to a brownish red or, where finely divided as in opalite, a purplish gray or black. Under desert conditions the color of cinnabar contained in an exposure of opalite ore was noted to have changed from red to purple in less than a year. This discoloration of cinnabar is only superficial and fresh exposures show the true red color.

Secondary cinnabar, or cinnabar that has been dissolved and transported away from its place of original deposition and redeposited, is probably of little significance to the quicksilver miner.

Native quicksilver: Native mercury is a common but rarely abundant associate of cinnabar in many quicksilver deposits in Oregon. It generally occurs as silvery globules in vugs and other small open spaces. When it is very finely divided it may resemble dark gray soot. Native quicksilver is heavier than cinnabar and can generally be collected in a gold pan as fluid droplets but occasionally when extremely fine and dirty (floured) it tends to float. Presence of quicksilver in a gold placer deposit can raise the suspicion of its having been lost by previous placer miners.

Metacinnabarite: Metacinnabarite is a black mercuric sulfide which has the same composition and approximately the same specific gravity as cinnabar. The mineral gives a black powder and streak and is generally found only in association with cinnabar. Metacinnabarite is a rare mineral whose abundance tends to be exaggerated because of its close resemblance to several other black minerals. Nowhere in the state is it known to occur in economic quantities, although it has been reliably reported from several localities, including the Bonanza and Horse Heaven mines.

Schwatzite: The mercurial tetrahedrite, schwatzite, is a common constituent of many of the deposits in the Steens-Pueblo Mountains area. In several of the deposits it is the only primary mercury-bearing mineral. Schwatzite, $(Cu,Hg,Zn,Fe)_{12}(Sb,As)_4S_{13}$, on fresh surfaces is medium gray and resembles ordinary tetrahedrite or "gray copper." The mineral contains sufficient arsenic in place of antimony to approach the composition of mercurian tennantite, and locally the arsenic content is sufficient to make retorting difficult. An analysis of schwatzite from the Blue Bull mine given by Ross (1942-b, p. 241) shows 10.68 percent mercury, 33.16 percent copper, 11.03 percent antimony, and 6.94 percent arsenic. Williams and Compton (1953, p. 39) further relate "The mineral is partly replaced, particularly in the cores of the grains, by covellite and chalcocite. This, coupled with the fact that enargite (Cu_3AsS_4) is invariably concentrated in the cores, suggests that the schwatzite is zoned, its copper content diminishing outward as the content of mercury increases."

Livingstonite: Livingstonite is a lead-gray, mercury-antimony sulfide ($HgS_2Sb_2S_3$) that resembles stibnite in form, but has a reddish-brown streak. Its specific gravity (4.8) is only slightly more than half that of cinnabar. A small amount of this mineral occurs at the Red Jacket mine in the Horse Heaven area of north-central Oregon.

Mercury chlorides and oxychlorides: The mercury chloride calomel (HgCl) and the mercury oxychlorides terlinguaite (HgClO) and eglestonite (Hg_4Cl_2O) have been identified in a few Oregon deposits. Terlinguaite is said to have added to the economic tenor of the ore at the Opalite mine. Elsewhere in the state these minerals have been of little or no economic importance. Terlinguaite and eglestonite are soft, heavy, powdery minerals that rapidly turn greenish, then nearly black on exposure to sunlight. Calomel is a heavy, soft, waxy mineral, shiny white to yellowish to greenish-gray in color. It commonly forms minute tabular crystals.

Gangue minerals

Iron sulfides and oxides: The iron sulfides, pyrite and marcasite, are almost always present as gangue minerals, and in some deposits are abundant. Mixtures of the oxides and hydrous oxides of iron are also common constituents of most quicksilver deposits, and are in large part responsible for the red, yellow, and brown colors of the altered host rocks. Because these products of the oxidation and leaching of iron-bearing minerals are commonly composed of several minerals that are not easily segregated and identified, the term "limonite" is used for them throughout this bulletin. The term "limonitization" refers to the oxidation process. "Limonitized" indicates that the contained iron-bearing minerals have been oxidized.

Antimony and arsenic: Antimony and arsenic sulfides and oxides are reported to occur in small quantity in several of the world's quicksilver deposits. Their volatilization temperatures are near that of cinnabar so that the clean recovery of quicksilver from ores containing appreciable quantities of antimony and arsenic is difficult with ordinary furnacing procedures. Only at the War Eagle mine in Jackson County have such ores been reported in Oregon. Here, arsenic is believed to be chemically combined with the iron sulfides. A greenish mineral tentatively identified as the hydrous ferric arsenate, scorodite, is also present in small quantity.

Copper minerals: Chalcopyrite, malachite, azurite, chrysocolla, and tenorite occur in small quantities in many of the quicksilver deposits of the Steens-Pueblo Mountains. Elsewhere copper minerals are scarce or absent.

Tungsten: Scheelite has been found in small amounts at the Murphy and Mocks Gulch prospects in the Upper Applegate area of southwest Oregon. There appears, however, to be no genetic relationship between the scheelite and quicksilver mineralization.

Clay minerals: Clays result from the chemical breakdown of rock-forming minerals, a process considerably aided by the crushing and grinding of the rocks along faults. Of the clay minerals identified in Oregon deposits, kaolinite and montmorillonite are probably the most abundant.

Silica: Chalcedony is generally the most abundant silica mineral, although quartz or opal predominates in a few deposits. Evidence suggests that the introduced silica in many instances was originally deposited as opal and that the other forms of silica now present were derived from it through dehydration, crystallization, or replacement. It is probable that part of the silica introduced was leached from the host rocks and redistributed.

Carbonate minerals: Calcite is usually the most abundant carbonate mineral, although dolomite, siderite, and ankerite are also common. The carbonate minerals are almost universally present in Oregon quicksilver deposits, but are scarce in those in which the rocks have been extensively silicified. The carbonate minerals may have been derived in part from the alteration of the host rocks.

Miscellaneous nonmetallic gangue minerals: Chlorite and gypsum occur in many deposits but rarely in abundance. Barite is common in many of the deposits in the Steens-Pueblo Mountains area and is occasionally found in a few other deposits. At the Nisbet mine in Clackamas County, part of the cinnabar is contained in a vein composed largely of one of the zeolite minerals (heulandite-stilbite). A little native sulfur was found in the Axehandle deposit in Jefferson County. A bituminous substance commonly called "gilsonite" by local prospectors occurs in small quantity in several deposits in north-central Oregon but has not been reported elsewhere in the state.

Origin, depth of formation, and age

Quicksilver deposits are the result of deposition of cinnabar from ascending hydrothermal solutions which are probably the end products of the cooling and differentiation of magmas. According to current theory, primary cinnabar is deposited in an alkaline environment. Essentially all of the world's major quicksilver deposits are confined to regions of Tertiary and Quaternary orogeny and volcanism. This suggests that the hydrothermal solutions are genetically related to magmas that give rise to volcanism rather than to deep-seated igneous activity. It is also inferred that these solutions are genetically related to many hot springs.

Laboratory research, plus independent field studies by many geologists, indicates that quicksilver deposits are formed nearer the surface and at lower temperatures and pressures than the deposits of most other metals formed from residual magmatic solutions. This would account for the small amount of metallic minerals other than cinnabar in quicksilver deposits.

Most of the world's quicksilver has come from depths of less than 1,000 feet and Oregon's deposits conform to this. In this state the deepest mining occurred at the Black Butte mine. A little ore was mined from the lowest level, which is about 1,300 feet below the highest point or the surface trace of the ore zone. The greatest quantity of ore produced at the Black Butte mine was above 870 feet. Ore bodies at the Bretz and Opalite mines in southern Malheur County have yielded little or no ore from depths greater than 100 feet. The near-surface character of quicksilver deposits is shown at several deposits where cinnabar mineralization faded out at depth and yet other characteristics of the ore zone were essentially unchanged. Examples of this are seen at the Horse Heaven and Bretz mines.

All of the important deposits of quicksilver in Oregon were formed in middle to late Tertiary time. It is probable that deposits of quicksilver were formed during pre-Tertiary periods of volcanism and orogeny but because of formation near the surface they have been destroyed by erosion. Several minor deposits, such as the Murphy and Steamboat prospects in the pre-Tertiary rocks of southwestern Oregon and the Roba-Westfall property in northeastern Oregon, are remote from centers of Tertiary volcanism and may represent the roots of old deposits. Considering the wide-spread distribution of Tertiary quicksilver deposits, however, it seems more likely that these occurrences in older rocks are also of Tertiary age.

Host rocks

General: The appearance of quicksilver deposits in a wide variety of rocks indicates that the chemical composition of the host rock is less important than its physical properties. The one condition that seems most essential is that at the time of mineralization the rocks were permeable and easily invaded by the solutions.

Because the bulk of the cinnabar forms in pre-existing open spaces rather than by replacing earlier minerals, the most favorable host rocks are those that are capable of providing maximum open space by being both porous and readily shattered by structural stresses. Thus sandstones, lavas, or any other type of rock that is relatively brittle are structurally more favorable than shales and other clayey rocks that tend to yield plastically to structural stress. Also sandstones and other open-textured rocks favor diffusion of the cinnabar through voids in the rock adjacent to the feeding fissures, rather than restriction of deposition to the fissures themselves.

In layered rocks of varied kinds, some beds or layers are more porous or more readily shattered than others and are thus more likely to receive quicksilver mineralization. A fissure passing from brittle sandstone into yielding shale may become tightly compressed or disappear. This is well displayed at the Bonanza mine.

Most cinnabar-bearing fracture zones are made up of a multitude of subparallel and branching fissures, breccia pockets, and crushed zones. Planes of movement are often marked by layers of gouge. Between the planes much shattering of the rocks, with little disturbance of the fragments, has taken place. No important deposits have been found along major faults, perhaps because they are too tightly compressed or too full of gouge to allow ingress of quicksilver-bearing solutions.

Ore bodies commonly occur where the rocks are most shattered. There is evidence in several deposits in Oregon that cinnabar has concentrated at fault intersections where open spaces were more numerous. This suggests that zones with small fractures that provide a large total surface area are more favorable than zones with large fractures and a small total surface area.

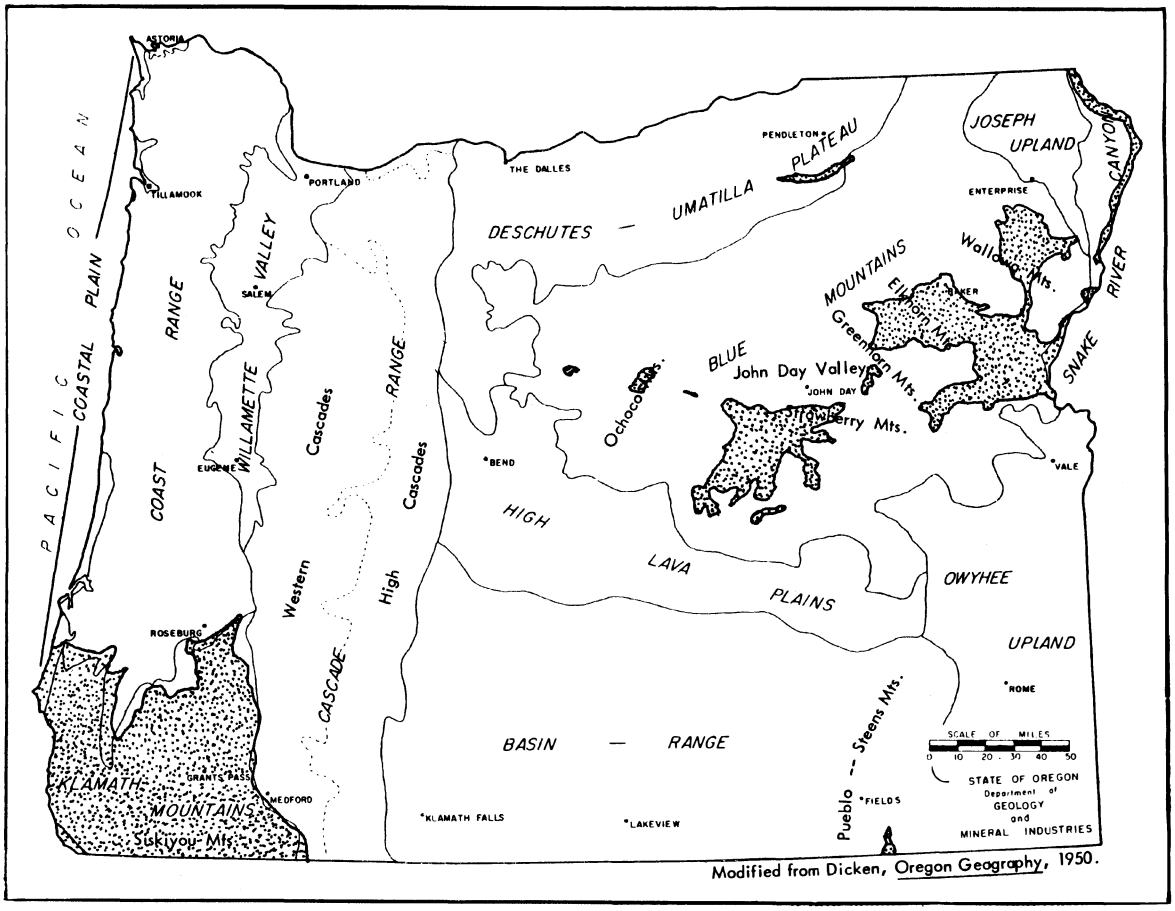
Alteration: Alteration of the rock prior to the introduction of cinnabar may be important. In many deposits the rocks have been completely changed in composition and appearance by such intense and often repetitious fracturing and hydrothermal alteration that their original character is indeterminable. All gradations can be observed from unaltered rock, to rock completely replaced by silica, to rock in which only quartz phenocrysts remain in a matrix of clays or carbonates or a mixture of both. The alteration is nearly always accompanied by a change in color and the altered rocks are commonly either harder or softer than the enclosing rocks.

The type and degree of alteration appears to have been governed to a large extent by the kind of rock and the availability of openings. Loose, porous rocks that were originally high in silica, such as rhyolitic tuffs, ash, and tuffaceous sediments, are the most likely to become extensively silicified. The maximum effect of this type of alteration is the formation of large masses of intermixed opal and chalcedony hundreds of feet across. The Opalite mine is the type locality for this form of alteration. Less siliceous rocks that have been altered are typically more rich in carbonates and clays than in silica. In the Steens-Pueblo Mountains area, and in a few other places, elongate, resistant reefs were formed by the silicification of andesitic lavas along faults.

Alteration is usually intensified by the oxidizing and leaching effect of downward-percolating groundwater. The oxidation of iron-bearing minerals often gives the rocks a blotchy reddish to yellowish appearance.

The aureole of alteration varies greatly in width from one deposit to another. At Black Butte, for example, solutions rising along the main fault were diverted through an infinite number of interconnected minor faults and fractures. In this manner a tremendous mass of rock was altered. While the effects of the alteration were most intense adjacent to the main fault, rocks several hundred feet away were bleached and softened. At the other extreme, the solutions which formed the Rainier vein at the War Eagle mine were largely confined to a single, well-defined fissure less than 10 feet wide.

Tertiary rocks: More than 99 percent of Oregon's recorded quicksilver production has come from deposits in Tertiary rocks of Eocene, Oligocene, and Miocene age. These Tertiary host rocks include volcanic flows, plugs, breccias, and agglomerates; massive and bedded tuffs; tuffaceous lake beds; and marine and non-marine sandstones. The rocks of volcanic origin are predominantly of andesitic to rhyolitic composition. Although a



Modified from Dicken, Oregon Geography, 1950.

Figure 6. Map showing the geomorphic divisions of Oregon and the distribution of pre-Tertiary rocks (stippled) and Tertiary and younger rocks (white).

few quicksilver deposits occur in basaltic rocks along the western edge of the Cascade Range, the plateau-forming basalts that cover so much of the state east of the Cascades are remarkably unmineralized.

Pre-Tertiary rocks: Numerous quicksilver occurrences have been found in rocks of pre-Tertiary age in the Klamath Mountains of southwestern Oregon, the Blue Mountains of northeastern Oregon, and the Pueblo Mountains of southeastern Oregon. Few of these have been productive, however. The occurrences are confined largely to greenschists, amphibolites, and quartz-mica schists derived from low-to-medium grade metamorphism of andesitic lavas and pyroclastics, and medium-to-coarse grained tuffaceous sandstones and graywackes. Quicksilver mineralization in serpentine, plutonic intrusives, and limestone is rare in Oregon and production has been very limited. The bulk of recorded production from deposits in pre-Tertiary rocks has come from the War Eagle mine in the Meadows area of southwestern Oregon.

Figure 6 shows the distribution of pre-Tertiary rocks in Oregon and the geomorphic divisions. Figure 7 shows the relative productive ranks of the Tertiary and pre-Tertiary host rocks.

Localization

Quicksilver deposits occur in fractured or porous rocks and are the result of a complex process requiring a long period of time, during which the host rocks are repeatedly fractured, altered, and mineralized. A general sequence of events for the introduction of cinnabar to form quicksilver deposits would be as follows: (1) fracturing of the rocks, as the result of folding, faulting, or intrusions, to provide conduits for the mineralizing solutions; (2) introduction of the mineralizing solutions; (3) alteration of the rocks with the attendant formation of clay, silica, and carbonate gangue minerals; (4) recurrent fracturing to reopen the conduits or to provide new ones; and (5) introduction of additional gangue minerals and cinnabar. In detail, the process is very complex. Many deposits exhibit evidence that fracturing was relatively continuous throughout the mineralizing process and that mineralization did not proceed uniformly. In most deposits the bulk of the cinnabar was deposited during a late stage in the alteration of the rocks, but commonly several generations of gangue minerals can be distinguished in a deposit, and in some the formation of cinnabar and the various gangue minerals obviously overlapped. Variations in the order of deposition from place to place in an individual deposit are common and probably indicate that, during the several stages of the mineralizing process, only parts of the zone provided suitable openings for the passage of solutions.

The localization of cinnabar deposits appears to have been induced principally by variations in the permeability of the invaded rock and in the size and shape of the conduits. Chemical reactions brought about by a commingling of the mineralizing solutions with water percolating downward from the surface may also have had an important influence on the localization of some deposits.

Especially rich ores often occur where the rise of the solutions was impeded by less pervious materials, for example, shales or fault gouges, or by abrupt changes in the attitude or size of the conduits. In some deposits, ore bodies were formed in fractured rocks beneath impermeable cappings such as the shale overlying the Bonanza deposit and the clay-soil horizon overlying parts of the Horse Heaven mine ore bodies. In other deposits, such as the Black Butte mine, no impervious capping exists. Schuette (1931) suggested that this was the reason the Black Butte ore was of relatively low grade. Here, however, as in many other mines, it is evident that clay gouge which developed along faults locally dammed the rising solutions and thus promoted concentrations of cinnabar.

Types of deposits

Oregon's quicksilver deposits, particularly the larger ones, differ from each other mainly in the kind of host rocks for the quicksilver mineralization and the manner in which the host rocks responded to orogenic movements, intrusion, and alteration (Figure 8). A classification of deposits, therefore, can be established by summarizing the main characteristics of the principal mining districts. Six types have been set up as follows:

Type (1) - Deposits localized along inclined bedding plane shear zones in sandstone beneath strata of relatively impermeable shale: In this type of deposit, space to accommodate the mineralizing solutions was provided by bedding-plane shears and subordinate faults. An impervious shale capping confined the solutions to the faults. Ordinarily the deposits are lens-shaped, with the longest dimensions parallel to the shear zone beneath the shale-sandstone contact. The ore bodies may lie immediately beneath the shale or several feet below. Most of the deposits of this type are found in the Bonanza area of southwestern Oregon.

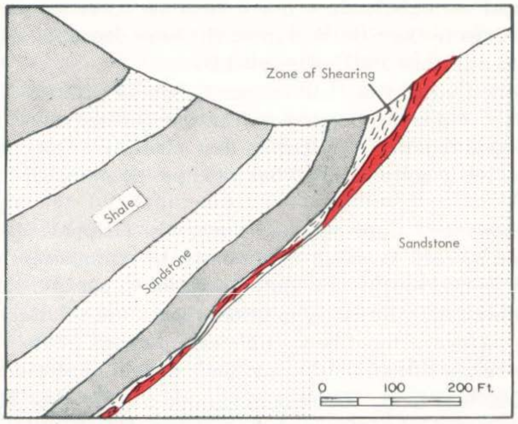
Type (2) - Deposits formed along fault zones in lavas, pyroclastics, and tuffaceous sediments: In this type of deposit, the ore zone lies along a principal zone of fissuring, with ore extending into subordinate, subparallel, and inter-connecting branch faults and fractures distributed through the hanging wall and footwall of the main fault. Cap rocks are generally not apparent. Localization of cinnabar was controlled primarily by the faults and fractures and is often concentrated beneath layers of gouge and at fault intersections. The majority of the quicksilver deposits in Oregon are in this category, the most notable being the Black Butte deposit in andesitic lavas and the Bretz deposits in tuffaceous lake beds. Also in this class are the several deposits in the Meadows area that occur in fresh-water sandstones and lignitic coal seams.

Type (3) - Deposits formed in zones of shearing and brecciation at the borders of volcanic plugs and the intruded rocks: In this type there is a close relationship between the force creating the space to receive the mineralizing solutions and the source of the solutions. The intrusive plugs range from rhyolite at the Horse Heaven mine (the type example), to andesite at the Axehandle mine, to basalt at the Maury Mountain mine. The intruded rocks are lavas, tuffs, and volcanic sediments. The plugs were apparently intruded in a semi-viscous condition so that the overlying rocks were intricately fractured and locally converted to breccia. At the Horse Heaven mine, the confining of the quicksilver-bearing solutions to the intrusive-fractured rocks was aided by a clay-soil horizon into which the plug was intruded. Other areas for ore deposition were formed in brecciated zones within the intrusive and at the margins of the intrusive. At the Maury Mountain mine cinnabar deposition was restricted to fractures in the bedded rocks bordering the intrusive basaltic plug.

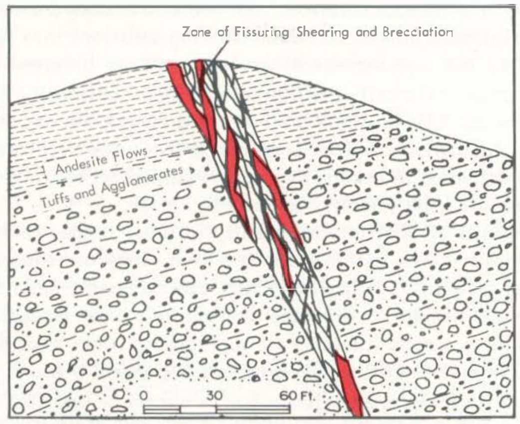
Type (4) - Deposits in opalite: As used in this bulletin, the term "opalite" refers to a rock composed of a mixture of opal, chalcedony, and sometimes quartz. Opalite is hard, brittle, milk white to dark grey in color, and is the result of almost complete replacement of volcanic rocks - mainly tuffs, ash, and tuffaceous sediments. Yates (1942) suggests these stages in the formation of opalite ores: (a) siliceous solutions converting the rocks

		SOUTHWESTERN OREGON	NORTHWESTERN OREGON	NORTH-CENTRAL OREGON	SOUTH-CENTRAL OREGON	SOUTHEASTERN OREGON	NORTHEASTERN OREGON	Approx. percent of total production
TERTIARY	Miocene	Andesitic tuffs, breccias, and flows, with intercalated basalts, rhyolites, and conglomerates of the Western Cascades volcanic series.	Columbia River Basalt	Rhyolite and andesite intrusions. Varicolored tuffs and tuffaceous shales, with some basalt flows and tuffaceous sandstones of post-Clarno age.	Mainly a complex of interrelated acid volcanics including plugs, flows, and breccias, commonly opalized.	Andesite, rhyolite, and dacite flows and tuffs in the Steens-Pueblo Mountains area. Tuffs and tuffaceous lake beds (in part opalized) in the Opalite area.	Dacite, rhyolite, and tuffaceous sediments.	59 percent
	Oligocene							
	Eocene	Sandstones and shales in part tuffaceous, with intercalated lavas, tuffs, and coarse conglomerates of the Umpqua Formation.		Andesitic lavas, tuffs, breccias, some basalt and rhyolite flows, and interbeds of tuffaceous sandstones and shales of the Clarno Formation.				40 percent
PRE-TERTIARY		Folded and faulted metavolcanic and metasedimentary rocks invaded by a wide variety of intrusions.				Folded and faulted metavolcanic and metasedimentary rocks invaded by dioritic intrusions.	Folded and faulted metavolcanic and metasedimentary rocks invaded by a wide variety of intrusions.	1 percent

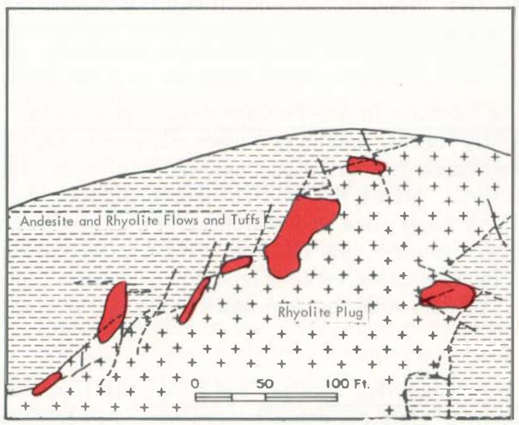
Figure 7. Chart showing general character, stratigraphic relationships, and productive rank of rock units that contain quicksilver deposits in Oregon.



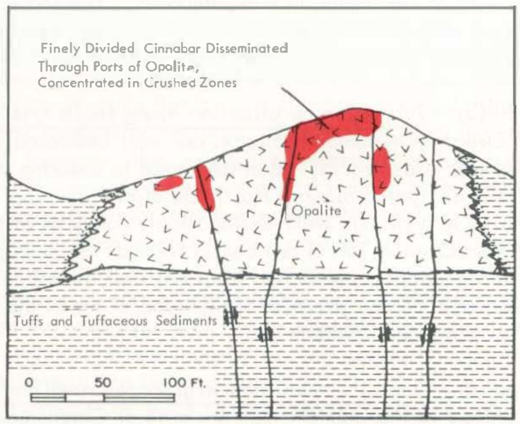
Type 1. Deposits localized along inclined bedding plane shear zones in sandstone beneath strata of relatively impermeable shale.



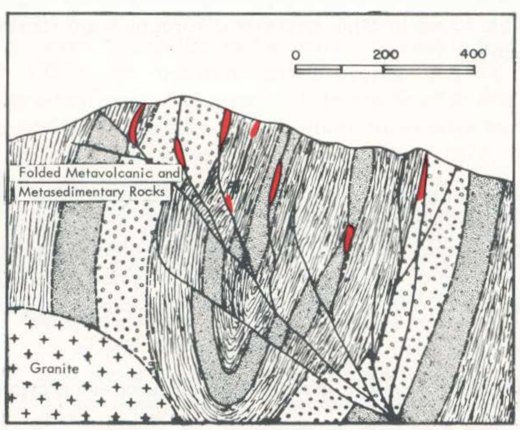
Type 2. Deposits formed along fault zones in lavas, pyroclastics, and tuffaceous sediments.



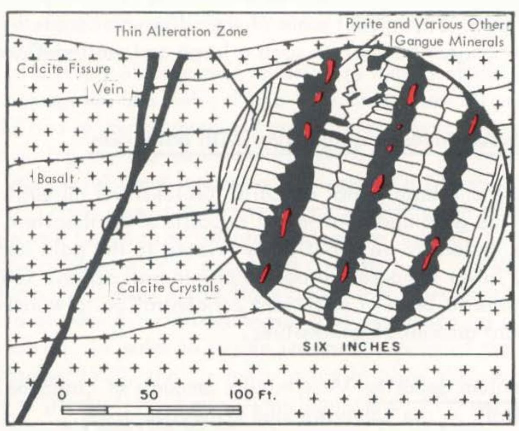
Type 3. Deposits formed in zones of shearing and brecciation of the borders of volcanic plugs and the intruded rocks.



Type 4. Deposits in opalite.



Type 5. Tertiary mineralization along faults and minor fractures in pre-Tertiary metamorphic rocks.



Type 6. Deposits associated with large crustified veins of calcite, zeolite, and silica.

Figure 8. Illustrations of the six types of quicksilver deposits. Ore bodies are shown in red.

Figure 8. Diagrammatic cross sections illustrating the characteristic features of different types of quicksilver deposits in Oregon (ore shown in red).

into opal; (b) dehydration and crystallization of the opal into chalcedony and quartz, resulting in brecciation; (c) entry of siliceous solutions that replace undehydrated opal with chalcedony and extend the silicified zone; and (d) introduction of cinnabar-bearing solutions into openings in the silicified rocks (in some deposits, such as the Bretz, the cinnabar-bearing solutions were diverted into adjacent unsilicified rocks).

In opalite deposits the cinnabar is in an extremely finely divided state and intimately mixed with the silica. The cinnabar fills or coats fractures and forms pink to reddish, cloudlike or streaky dispersions in the unfractured rock. Generally both fractured and unfractured rock are found together, indicating that mineralization and brecciation occurred in recurrent stages. Cinnabar-bearing opalite is quite colorful but because the cinnabar is so finely divided the quantity is actually small.

Deposits of opalite vary greatly in size, shape, and frequency. They may be numerous or isolated. If several deposits occur within a limited area, they are separated by rock in which the intensity of replacement diminishes gradually. Opalite masses are commonly mound-like and roughly elongated parallel to but of much greater width than the fracture or fracture system through which the silicifying solutions rose. The solutions appear to have spread laterally through porous rocks near the surface without benefit of well-defined fractures. The thickness of most opalized masses is generally found to be considerably less than their lateral dimensions. The Opalite mine ore bodies occur in a mass of opalite 1,200 feet long, 800 feet wide, and a little over 100 feet in maximum thickness. Although the Opalite mine is the typical example of this kind of deposit, fairly large masses of opalite are found elsewhere, for example, in the Quartz Mountain area in Lake County, and smaller bunches are not uncommon in many deposits. Therefore, the term "opalite" finds additional use as a descriptive prefix when reference is made to narrow veinlets, nodules, and small, irregular masses of silica contained in otherwise unsilicified or only partially silicified fault and breccia zones.

Type (5) - Tertiary mineralization along faults and minor fractures in pre-Tertiary metamorphic rocks: Most of Oregon's metamorphic rocks are well indurated, tightly folded, and have a great many fractures of small displacement. Such rocks, when subjected to shearing stress, rarely fracture along well-defined zones. Instead the stress is dissipated along a multitude of pre-existing fractures. Where the quicksilver-bearing solutions could be confined to a strong, well-defined fault zone, as at the War Eagle mine and elsewhere in the Meadows area of southwest Oregon, small ore bodies formed. In most places, however, the solutions were dispersed along so many interconnecting shears and fractures that the cinnabar became scattered over broad areas without formation of an ore body. Many deposits of this type occur in the pre-Tertiary rocks in southwestern and northeastern Oregon. Few have been productive.

Type (6) - Deposits associated with large crustified* veins of calcite, zeolite, and silica: This type of deposit is unique to the Oak Grove Fork area of Clackamas County. Here the deposits were formed in open, well-defined fissures; calcite and subordinate quantities of other gangue minerals and cinnabar were deposited in alternating layers crust upon crust until the fissures were filled. The veins range from 6 inches to more than 6 feet in width. No doubt some of the silica-carbonate veinlets found in other deposits in Oregon were formed in the same manner but not on such a large and well-defined scale.

Minor occurrences of quicksilver with other ores

Gold and base-metal deposits: Quicksilver minerals occur in small quantity in, or closely associated with, some of the gold and base-metal deposits of northeastern and southwestern Oregon. In places, the quicksilver minerals appear to be genetically related to the gold and base-metal minerals. In others they clearly represent a later, lower temperature period of mineralization. Only in some of the latter type of deposits have the quicksilver minerals been of sufficient concentration to warrant exploration, and none of these have produced any significant amount of quicksilver.

Uranium deposits: Very minute amounts of cinnabar have been found in association with uranium prospects, particularly in the Lakeview and Prineville areas.

* Bateman describes "crustified" as follows: "Generally, however, successive crusts of different minerals are deposited upon the first one, perhaps with repetition of earlier minerals, until the filling is complete, and this gives rise to crustification; if the cavity is a fissure, a crustified vein results." A. N. Bateman, "Economic Mineral Deposits," 2nd edition, John Wiley & Sons, Inc., p. 108.

Prospecting guides

General: The most likely place to prospect for cinnabar is in and adjacent to areas where the mineral has been previously mined. It is entirely possible that important deposits await discovery in the areas of mines having the largest production, namely, along the western front of the Cascade Range in southwestern Oregon, in the Ochoco Mountains in north-central Oregon, and in the White Horse Mountains in extreme southeastern Oregon. Other parts of the state should not be overlooked, particularly those areas where cinnabar is known to exist, even though in minor amounts.

Quicksilver deposits occur in a wide variety of geologic environments, but those of a particular environment, no matter how distant from each other, usually have many characteristics in common. Thus it is well for the prospector to acquire knowledge about the geology of the area to be prospected and the characteristics of the deposits known to occur in that geologic environment.

Most of the important quicksilver deposits in Oregon have been found along fault and breccia zones in tuffaceous sandstones, and in volcanic flows, plugs, breccias, and tuffs of andesitic to rhyolitic composition of Eocene and Miocene age.

Because the rocks enclosing most quicksilver deposits are extensively altered, the best areas to prospect are those in which the soil and rock rubble indicate that the underlying rocks have been abnormally altered. Unfortunately, though all quicksilver deposits are intimately associated with altered rock, only a few zones of altered rock contain quicksilver even in areas where important deposits have been worked.

The soil overlying hydrothermally altered zones differs in appearance from that of adjacent unaltered rocks, but the distinction is generally vague and can be applied only after considerable experience. On the other hand, float (broken pieces of ore or cinnabar scattered through the soil) is an invaluable aid in prospecting. Cinnabar float is ordinarily soft and is rarely found far from a deposit.

The surface expression of a zone of altered rock varies with the type of alteration. Silicified rocks commonly protrude slightly above the surrounding rock, whereas clay alteration products are more easily eroded and may form depressed areas. However, such topographic expressions often go unnoticed until the fault zone is detected by other means. In southwestern Oregon many of the quicksilver deposits are characterized by introduced silica and carbonate minerals which commonly occur as veinlets in softened rock and therefore result in narrow, iron-stained ribs on weathered surfaces.

Geophysical surveys: Stephenson (1943) conducted detailed geophysical surveys in north-central Oregon in the vicinity of the Blue Ridge mine, the Taylor Ranch mine, and the Maury Mountain mines. A similar survey was made by Bath and Cook (1949) at the Mother Lode and Independent mines. Concerning the value of the surveys, Stephenson concludes:

"...Because of the physical nature of cinnabar and the small size of the ore bodies, the successful use of geophysical methods in finding cinnabar deposits depends on the detection and delineation of geologic bodies or structures associated with the ore. In the Ochoco District, many of the rocks are paramagnetic, and detailed magnetometer surveys, supplemented by resistivity measurements, were made in order to map the ore-bearing fault systems.

"The surveyed areas are magnetically variable and show many magnetic anomalies. Some of the anomalies appear to depend on differences in type of rock; but groups of definite magnetic patterns are found that, in the light of available geologic information, appear to be largely determined by the fault systems."

Little underground development work has been done in the areas covered by Stephenson since the surveys were made. Consequently, no new ore bodies have been found as a result of his work, but it is probable that the structural patterns indicated by the surveys would be an aid to any future prospecting.

Geochemical prospecting: Field colorimetric tests for mercury have been developed by the Geochemical Branch of the U.S. Geological Survey (Ward and Bailey, 1958). These tests are relatively involved and have about the same sensitivity as the willemite screen test, or about 2.5 parts per million or 0.1 ounces per ton, so have not supplanted it.

Russian geochemists have developed a mercury detector using air samples with a detection limit well below one part per million. With this device they have been able to outline mercury halos (Ginzburg, 1960) around both mercury and base metal deposits. Variations of this technique have been used by Hawkes and Williston (1962), who have increased the sensitivity of the air-sampling method. By this technique they have been able to delineate several known mercury deposits and have shown the existence of mercury halos around base metal deposits.

From the present state of knowledge, it seems this air-sampling technique will probably supplant most other methods of prospecting for mercury.

Qualitative tests for cinnabar: Except in opalite ores in which the cinnabar crystals are so minute as to be practically inseparable from their siliceous gangue, the best method of testing for cinnabar is to pan the crushed or disintegrated rock in the conventional manner, searching for the bright, cochineal-red crystals which, because of their higher specific gravity, will "tail" behind the common gangue minerals. It is probable that most of the cinnabar deposits known today were discovered initially by the prospector tracing float or pannings uphill to their source. This is still the best method of prospecting for new cinnabar deposits.

If doubt exists that the concentrate from the pan or the red mineral in a piece of float is cinnabar, one of the following simple tests can be made. These tests will also detect quicksilver in most of the other quicksilver minerals.

(1) When the dry mineral powder is mixed with four parts of dry sodium carbonate and heated slowly in a test tube, mercury will appear as a gray sublimate or as small globules on the walls of the tube. If heated without sodium carbonate in the tube, most mercury minerals volatilize without decomposing.

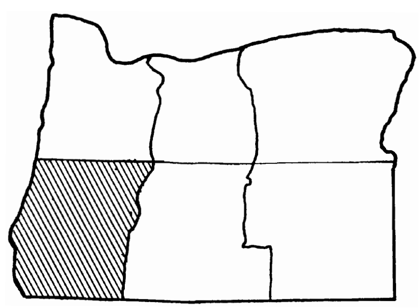
(2) Most compounds of quicksilver, if moistened with hydrochloric acid and rubbed on a piece of bright copper, will impart a bright silvery coating to the copper. In this test quicker results are usually obtained if the mineral is powdered.

(3) An ultraviolet light and a willemite-coated screen can be used to detect even small amounts of mercury in a sample. In this method, the powdered sample to be tested is placed between the ultra-violet-light source and the screen and heated sufficiently to volatilize any contained quicksilver. Mercury vapor will appear as a dense, dark cloud or shadow of smoke against the screen. Without the presence of mercury vapor the willemite screen will fluoresce a uniformly strong green over the entire surface. Ordinarily smoke or water vapor will not give a shadow. This is a quick, easy test and its main drawback is its high sensitivity; even trace quantities will show a slight "smoke."

PART II DESCRIPTIONS OF THE QUICKSILVER DEPOSITS

CHAPTER 1

SOUTHWESTERN OREGON



Chapter 1. SOUTHWESTERN OREGON

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Part II. Descriptions of the Quicksilver Deposits

CHAPTER 1

Southwestern Oregon

Southwestern Oregon is considered here as including southern Lane County and all of Douglas, Jackson, Coos, Curry, and Josephine Counties, or all of the area in Oregon that is south of the 44th parallel of latitude and west of the High Cascades (see figure 5, Part I). The areas known to contain quicksilver deposits are indicated on figure 9. Also shown in figure 9 are the principal geologic divisions of this part of the state.

General Geologic Setting

GEOMORPHOLOGY

Southwestern Oregon includes parts of three geomorphic provinces, the Cascade Range, the Coast Range, and the Klamath Mountains (see figure 6, Part I), all of which contain quicksilver deposits.

The Cascade Range is divisible longitudinally into the High Cascades and the Western Cascades. The High Cascades include the many volcanic peaks, cinder cones, and relatively undissected Pliocene-Pleistocene and Recent lavas which form the picturesque crest of the range. The Western Cascades are composed of older volcanic rocks extending in age from Eocene through Miocene. The region is structurally more deformed than the High Cascades and much more deeply dissected. Summit elevations lie between 2,000 and 6,000 feet.

The Coast Range, in the areas of quicksilver deposits, is characterized by wide valleys separated by smoothly rounded, elongate hills rising to an average elevation of 1,500 feet above sea level. The region is underlain by folded marine sedimentary rocks and basalt flows of Eocene age.

The Klamath Mountains province, which includes the Siskiyou Mountains, is a region of rugged topography with elevations ranging from sea level to 7,500 feet. Streams are numerous, canyons deep, and ridges narrow. The province is underlain predominantly by a thick sequence of Mesozoic rocks which are in part metamorphosed. The rocks are tightly folded, faulted, and intruded by large masses of plutonic rock. Paleozoic schists lie along the Oregon-California boundary in the Siskiyou Mountains.

STRATIGRAPHY

Paleozoic rocks

The oldest rocks known in southwestern Oregon are a series of deformed schists of probable Paleozoic age (Peck, 1961). These rocks are exposed along the California boundary in extreme southern Jackson County. They consist mainly of highly foliated, medium-to-dark green, quartz-epidote-chlorite schists which were derived from volcanic and sedimentary rocks rich in ferromagnesian minerals. Mica schists and graphitic schists

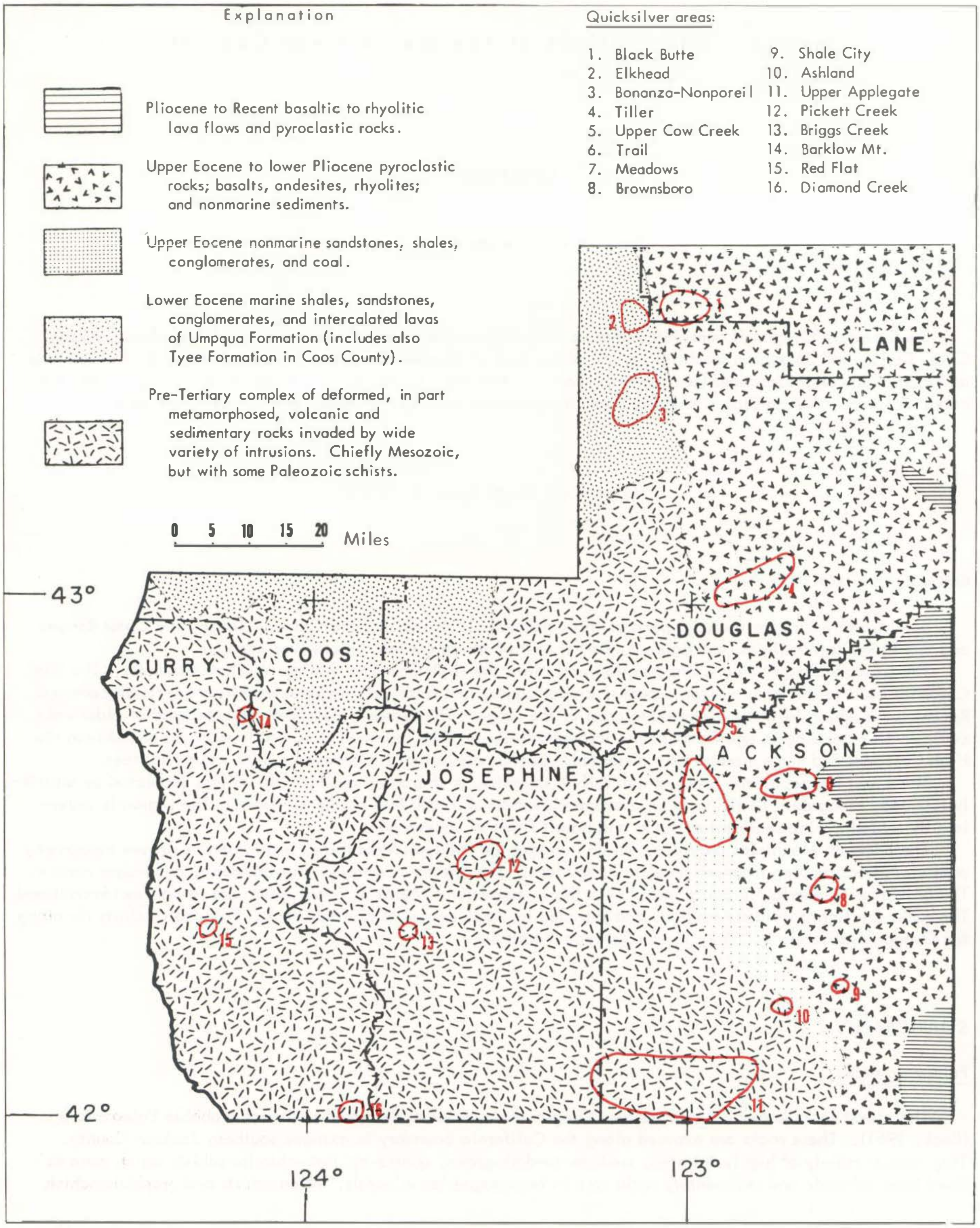


Figure 9. Geologic sketch map of southwestern Oregon showing location of quicksilver-bearing areas.

are also included. Because of the high degree of metamorphism, original textures and composition are indeterminable.

Mesozoic rocks

Applegate Group: Unconformably overlying the schists is a thick sequence of folded and metamorphosed volcanic and sedimentary rocks of Upper Triassic (?) age called the Applegate Group. The May Creek Schist, mapped as Paleozoic in the Riddle quadrangle by Diller and Kay (1924) and in the Butte Falls quadrangle by Wilkinson and others (1941), has since been shown by Wells and others (1949) to be part of the Applegate Group. Rocks of this group consist mainly of andesitic to basaltic lavas and tuffs with lenticular interbeds of argillite, chert, quartzite, conglomerate, and limestone. A name commonly used for these rocks is "greenstones" because of the pale green to greenish gray color resulting from the introduction of epidote and, in places, chlorite. Many of the quicksilver deposits in southwestern Oregon occur in rocks of the Applegate Group.

Dothan, Rogue, and Galice Formations: Unconformably above the Applegate Group is a thick series of sedimentary and volcanic rocks which were deposited in a rapidly subsiding trough during Middle or Late Jurassic time. The Jurassic rocks have been subdivided into three formations from oldest to youngest, the Dothan, Rogue, and Galice Formations. The Dothan Formation consists mainly of massive, indurated graywacke sandstone with interbedded, highly contorted shales, and lenses of chert and conglomerate. The Rogue Formation is composed of intermediate to basic lavas, tuffs, and some agglomerates. The lavas are chloritized and some of the tuffs indurated by silicification. The rocks of the Galice Formation consist of a thick sequence of shales and siltstones with some lavas and pyroclastics and, more rarely, conglomerates.

Myrtle Group: The Myrtle Group of Late Jurassic to Early Cretaceous age consists of locally fossiliferous sandstones and siltstones, with interstratified lenses of conglomerate, which were deposited during uplift of the Klamath Mountains. The rocks are steeply folded but not metamorphosed. Only one quicksilver deposit is known in the Myrtle Group; it is the Olson and Needham prospect in Curry County.

Late Cretaceous rocks: Locally fossiliferous fine-grained sandstone with lesser amounts of mudstone and conglomerate occurs in patches in Jackson County and along the coast in Curry County. Rocks are only moderately deformed. No quicksilver deposits are known in these rocks.

Cenozoic rocks

Umpqua Formation: The Umpqua Formation of lower to middle Eocene age is the oldest Tertiary formation in southwestern Oregon. As originally described by Diller in early U.S. Geological Survey publications, it includes both marine and terrestrial sedimentary rocks and volcanics. The formation is locally more than 12,000 feet thick.

North of Roseburg in the Bonanza-Nonpareil and Elkhead quicksilver areas the Umpqua Formation is largely of marine origin. As described by Brown and Waters (1951), it consists of two parts: the lower composed principally of arkosic sandstone, siltstone, and shales containing occasional lenses and interbeds of tuff; and the upper made up largely of volcanic rocks, particularly pillow basalt and palagonite tuff, interstratified with irregular lenses of conglomerate. Structurally the formation here is characterized by broad northeast-trending open folds with dips in the more competent members of 20° to 65°.

To the south, in the Sams Valley and Medford areas, are non-marine sediments consisting of massive, light-colored, medium to coarse-grained sandstones in part tuffaceous, with heterogeneous conglomerate lenses, rythmically bedded shales, and seams of low-grade coal. These rocks were formerly assigned to the Umpqua Formation by Wells (1956), but have recently been assigned to the late Eocene (Peck, 1961) on the basis of fossil plants (Brown, 1956).

Tyee Formation: The Tyee Formation of middle Eocene age is composed chiefly of rythmically bedded micaceous sandstones that unconformably overlie the Umpqua Formation in the Coast Range province. No quicksilver deposits are known to occur in these rocks.

Western Cascade volcanic series: This series of nonmarine lavas and pyroclastic rocks in the Western Cascades rests in part unconformably on the Umpqua Formation. The series ranges in age from upper Eocene through lower Miocene and locally may be as much as 15,000 feet thick. In the quicksilver areas along the lower western flanks of the Cascades, these rocks are mainly pyroclastics including a heterogeneous assemblage of tuff, tuff breccias, and conglomerates, with interbedded rhyolitic to basaltic flows, lenses of water-laid tuffaceous sediments, and pebble to boulder conglomerates. In general these rocks dip gently eastward. Since most of the lithologic units have restricted areal extent, stratigraphic differentiation is difficult to make. Fossil floras similar to the Clarno flora (upper Eocene - lower Oligocene) and John Day flora (Oligocene-Miocene) of central Oregon have been recognized in some of the tuffaceous rocks (Wells, 1956; Peck, 1960).

Formational names have been applied to these rocks in certain areas. In the Black Butte area, the name

Calapooya Formation was proposed by Wells and Waters (1934, p. 11) for rocks of late Eocene to early Oligocene age; however, Hoover (1959) has since shown that the Calapooya Formation is a southward extension of similar late Eocene to early Oligocene rocks in the Eugene area that Schenck (1927, p. 45) had already named the Fisher Formation. In the Medford area, late Eocene rocks are assigned the name Colestin Formation. Overlying these formations is an Oligocene-Miocene unit referred to as Mehama Volcanics by various workers in the Western Cascades. In the Medford area, these rocks are called the Little Butte Volcanic Series.

High Cascades volcanic series: Rocks forming the High Cascades are dominantly basaltic andesites and olivine basalts of Plio-Pleistocene and Recent age. Some rhyolite and obsidian flows are present. Pumice blankets large areas. Pliocene lavas locally extend westward overlapping and, in particular, filling canyons in the Western Cascade volcanic series. Except where disturbed by faulting, the dips of the High Cascades lavas are original. Rocks of the High Cascades are not known to contain quicksilver deposits.

Intrusive rocks

During Late Jurassic and Early Cretaceous time, the older formations of southwestern Oregon were intruded by a large variety of rocks ranging from peridotites and serpentines to granite. Of the granitic rocks, quartz diorite, diorite, and granodiorite are the most common. True granites are rare. In size the exposures range from small dike-like bodies to masses several miles across. Pegmatites are widespread and numerous in the rocks bordering some of the granitic intrusions. They are particularly abundant in the vicinity of the Mountain King mine in the meadows area. Dikes, sills, and plugs ranging in composition from basalt to andesite and more rarely rhyolite are common in the Tertiary rocks.

Structure

Each of the principal geomorphic divisions of southwestern Oregon exhibits a characteristic type of structure. The main structural trends are northeasterly. The rocks of the Klamath Mountains have been tightly folded and uplifted along northeast-trending lines and, regionally speaking, become younger to the northwest. Broad northeast-trending folds characterize the structure of the Coast Range in the Roseburg area.

The Cascade Range can best be described as a great pile of heterogeneous volcanic rocks in which unconformities and lateral lithologic variations are so common as to obscure structural details. In general, however, the rocks of the Western Cascades dip gently eastward.

The contact between the Upper-Triassic Applegate Group and the overlying Tertiary lavas and sediments along the western flank of the Cascades is rarely well exposed. In most places where it has been observed it appears to be depositional. In the Meadows area, however, it is marked by a broad zone of faulting several miles in length.

Distribution of Quicksilver Deposits

Most of the quicksilver deposits in southwestern Oregon occur in scattered groups in a belt 20 to 25 miles wide that extends along the western edge of the Cascade Range from the vicinity of Black Butte in southern Lane County southward through central Douglas and western Jackson Counties to the California state line, a distance of about 110 miles (figure 9). This mineralized belt follows the north-trending boundary between Tertiary volcanic rocks of the Western Cascades on the east and folded earlier Tertiary marine sediments of the Coast Range to the northwest and pre-Tertiary metamorphic and igneous rocks of the Klamath Mountains to the southwest. All of the deposits within this belt that have recorded significant quicksilver production lie north of the Rogue River.

North of Roseburg the mineralized belt includes the Bonanza and Black Butte mines, which together account for about half of Oregon's total recorded quicksilver production. In addition there are two small producers, the Nonpareil and Elkhead mines, and several prospects. The Bonanza, Nonpareil, and Elkhead deposits lie within the Coast Range province in marine sediments of the Umpqua Formation. The Black Butte deposit is in the Calapooya Mountains, a west-trending spur of the Cascade Range, in terrestrial volcanics of the Calapooya (Fisher) Formation.

From Roseburg south to the Rogue River, several small producers and undeveloped prospects lie close to and on both sides of the boundary between the Tertiary volcanics of the Cascade Range and pre-Tertiary metamorphic rocks of the Klamath Mountains. In this part of the belt most of the recorded quicksilver production has come from deposits in the Meadows area west of Trail, where the deposits indiscriminately cross the boundary between the older and younger rocks.

Within the Klamath Mountains most of the known deposits in the quicksilver belt occur in rocks of the Triassic Applegate Group. Exceptions are one deposit in granite, one in sheared serpentine, and various minor occurrences in Paleozoic schists of the Siskiyou Mountains.

West of the quicksilver belt, in Josephine and Curry Counties, quicksilver deposits are widely scattered and of minor importance. They occur chiefly in Jurassic or Cretaceous volcanic and sedimentary rocks. In the Red Flat area of Curry County, cinnabar is associated with peridotite and serpentine.

Description of the Quicksilver Deposits

BLACK BUTTE AREA

The Black Butte area is in southern Lane County in Tps. 22 and 23 S., R. 3 W., near the head of the Coast Fork of the Willamette River (figure 10), about 17 miles by road south of Cottage Grove on the north slope of the Calapooya Mountains. The area is covered by the topographic map of the Anlauf quadrangle. Located therein are the Black Butte mine, the Woodard prospects, and the Hobart Butte deposit.

Rocks underlying the area are predominantly hypersthene-augite andesites of the upper or dominantly lava facies of the Calapooya Formation (Wells and Waters, 1934, p. 11), which has been shown to be the equivalent of the Fisher Formation (Hoover, 1959). The quicksilver deposits follow normal faults along which andesites have been extensively altered over broad areas by hydrothermal solutions. Rugged crags, sustained by thickly massed veinlets of silica-carbonate and deposits of silicified rock commonly mark the fault zones. On the surface, brown iron ribs produced by weathering of silica-carbonate veinlets are almost omnipresent, increasing in number near the faults. Recorded production from the area has been 16,094 flasks, all from the Black Butte mine.

BLACK BUTTE MINE

Location: The property consists of about 1,000 acres in secs. 8, 9, 16, and 17, T. 23 S., R. 3 W. The workings are in the NW$\frac{1}{4}$ sec. 16 and enter the northwest slope of Black Butte, which is a sharp-crested hill of 2,800 feet elevation.

Owner: Quicksilver Syndicate, Daniel I. Mills, Pres., Black Butte, Oregon.

Production: U. S. Bureau of Mines production figures are shown in table 3.

History: The Black Butte mine, Oregon's fourth largest quicksilver producer, was discovered in 1890 by S. P. Garoutte. Although a 40-ton-per-day Scott-Hutner furnace was installed, little development work was done until 1897, when the Black Butte Quicksilver Mining Co. was organized and took over the property. By 1908, under the direction of W. B. Dennis, some 15,000 feet of development work was done on 100, 200, 300, and 400 foot levels. Dennis also increased the capacity of the Scott-Hutner furnace with an artificial downdraft system.

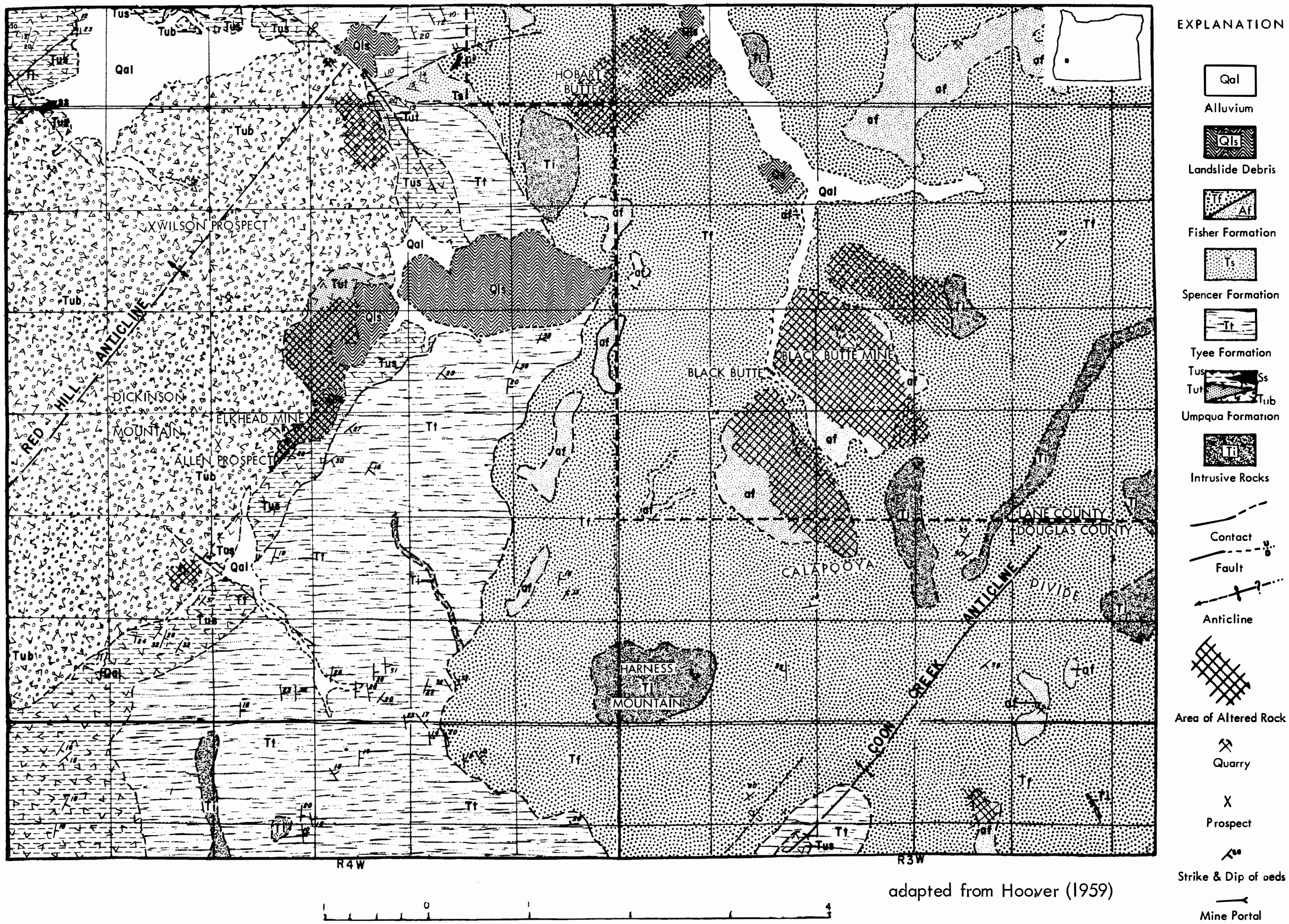
From 1909 until 1916 the mine was closed, owing to the depressed price of quicksilver.

World War I saw rising prices and the mine was reopened by a New York company under the management of Earl B. Crane. A flotation unit and a redesigned Scott furnace were used from 1916 to 1919. After the war, declining prices forced a shutdown.

In 1927 the property was purchased by the Quicksilver Syndicate controlled by Robert M. Betts. By 1929 two 4-by-60-foot rotary furnaces had been installed, giving the mill a capacity of 150 tons per day. The Black Butte was operated more or less continuously from 1927 to 1942 by the Quicksilver Syndicate. During this time levels were established at 500, 600, 900, 1100, 1300, and 1600 feet. After retreating old furnace tailings, the mine was closed in March 1943 and remained idle until 1956.

In 1956 and 1957 the mine was under lease to the Mercury & Chemicals Corp. of New York. With the assistance of a DMEA loan they explored, developed, and furnaced ore from the 900 and 1,100 foot levels.

Development: The Black Butte mine has been developed by 8 adit levels distributed over a vertical distance of about 1,300 feet (see plate 3 in pocket). The principal ore shoot of the mine has been worked from surface



adapted from Hoover (1959)

Figure 10. Geologic map of the Black Butte and Elkhead areas.

outcrops to the 1,100-foot level, a vertical distance of about 850 feet. The apex of the ore zone is 1,500 feet in elevation above the furnace level.

The workings required no timbering except in manways and chutes and when visited by the writer in the summer of 1959 most of the mine workings were still open, even though little maintenance work has been done since 1943. Ore was mined from large shrinkage stopes from adit levels, making mining costs much less than at most other quicksilver mines (see figure 11).

Before 1927, ore was carried to the mill by an aerial tramway from the 400-foot level. In 1927 the tramway head house was moved to the 900-foot level and a raise was driven to the 500-foot level. This tramway had 110 buckets and each bucket carried 90 pounds of crushed ore. The aerial tramway was abandoned in 1939 and ore was brought down inside the mine to the Dennis Creek (1,600) level, crushed, and trammed in mine cars to the furnace plant.

Table 3. Recorded Production of the Black Butte Quicksilver Mine*

Year	Treated Furnace (Short Tons)	Flasks
1900	-	200
1901	-	75
1905	-	42
1908	4,100	323
1909	231	486
1916	5,746	282
1917	12,726	380
1918	-	382
1919	-	210
1927	8,841	150
1928	26,248	999
1929	39,901	1,312
1930	49,419	1,549
1931	45,439	1,618
1932	28,667	912
1933	20,455	607
1934	23,086	1,273
1935	22,345	919
1936	21,075	788
1937	19,637	895
1938	19,701	803
1939	17,456	540
1940	18,767	439
1941	19,733	292
1942	2,678	208
1943	2,282	38
1951)	-	26
1951)	-	4
1956	2,284	45
1957	7,752	297
	418,569	16,094

*Source: U. S. Bureau of Mines

<u>Geology</u>: The following descriptions of the geology and the ore shoots and the suggestions for future exploration are quoted from Waters (1945).

Geology at the Black Butte Mine

"Black Butte is composed of andesitic lavas, tuffs, and breccias of the Calapooya Formation (Tertiary). At a few places in the mine these volcanic rocks have been injected by dikes and irregular intrusive masses of basalt and andesite. A single felsite dike is exposed in the lowest adit.

"The top of Black Butte coincides roughly with the trace of a normal fault which, though containing warps and irregularities, strikes approximately N. 70°W. and dips about 58° NE. Roughly parallel with this fault are numerous smaller faults, distributed through a considerable zone both on the hanging wall and footwall sides of the main fault.

"Hydrothermal solutions, rising along these faults and along bedding planes, joints, and other permeable zones in the volcanic rocks, have profoundly altered the andesitic lavas and pyroclastics. Much of the rock of the mountain has been so bleached and softened that its original character is almost unrecognizable. In most areas the altered rock is composed largely of carbonates and clay minerals, with variable amounts of chalcedony and quartz, and minor amounts of opal, chlorite, sericite, pyrite, and marcasite. Irregular veinlets composed of chalcedony and carbonates cut the altered rock, and are particularly numerous near the faults. The veinlets contain abundant siderite and some iron sulfides. Since the cinnabar was introduced during the last stages of silicification, the iron-stained rubble derived from the oxidation of the veinlets is a guide in prospecting.

"Locally the rock has been completely silicified. Fault breccia and gouge along the main fault have in many places been replaced by solid masses of chalcedony. These silicified rocks occur not only along the main fault but large bodies of silicified, bedded tuffs also occur in the Smoky Stope area more than 100 feet north of the main fault. The silicified rock is ore-bearing in many parts of the mine.

"During the last stages of mineralization, much calcite was introduced as veinlets and impregnations. A large body of vein calcite was deposited along the main fault between the western part of the 900 level and the 1,550 or Dennis Creek level, this body of coarsely crystalline vein calcite is over 30 feet thick and has been mined and marketed for chicken grits.

"Though the main epoch of faulting preceeded the hydrothermal alteration and ore deposition, there has also been some post-mineral movement, particularly along the main fault. The post-mineral movement has in many places polished fault surfaces that are well exposed as "walls" in the drifts and stopes.

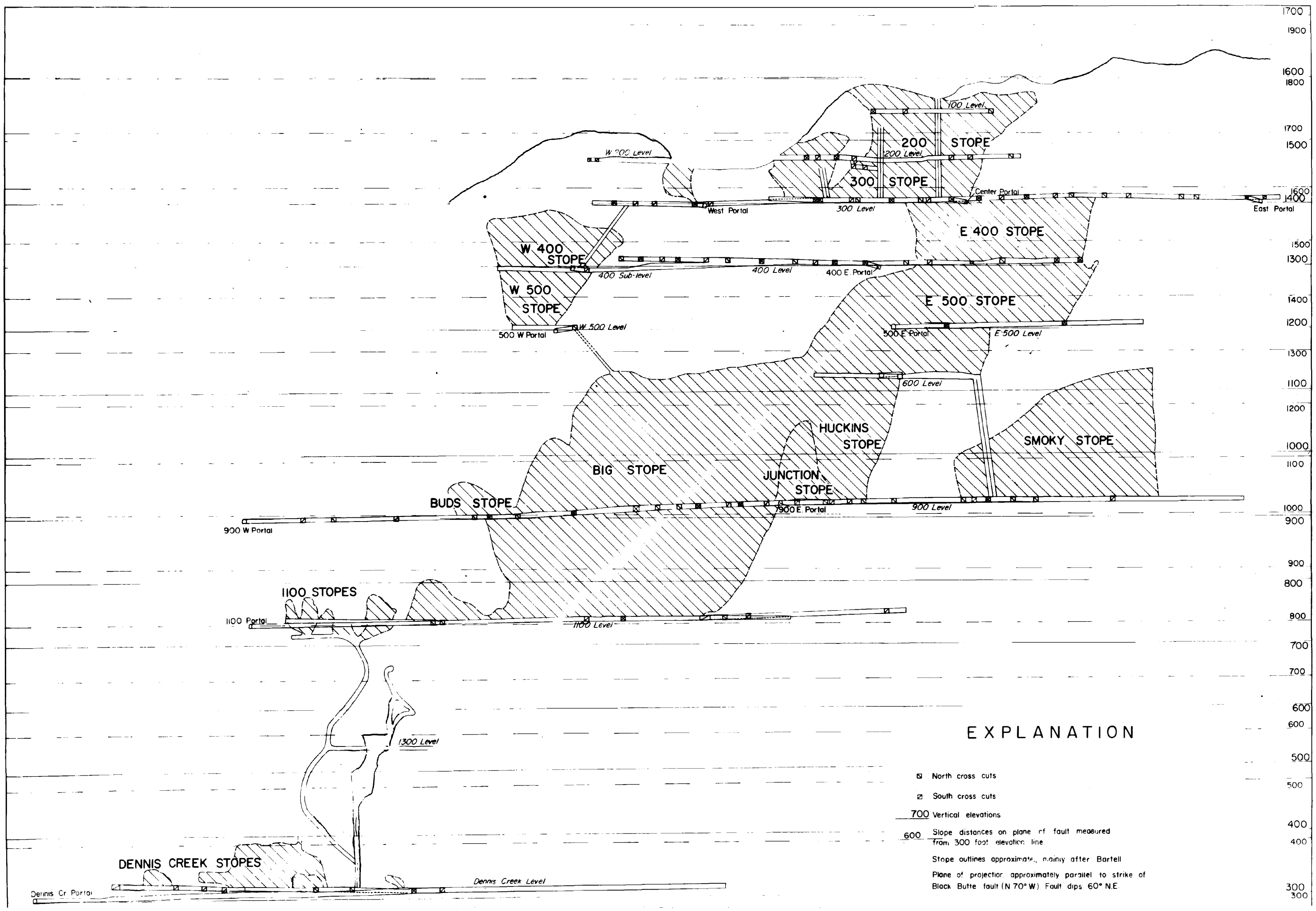


Figure 11. Vertical longitudinal projection of the Black Butte mine.

Ore Shoots of the Black Butte Mine

"Ore shoots along the Black Butte fault: Most of the production of the Black Butte mine has come from a single continuous ore shoot along the Black Butte fault. This ore shoot has been exploited by the Big stope, and by stopes in the eastern part of the mine above the 600 level. Ore was mined from the top of the mountain to the 1,100 level, a vertical distance of 850 feet. The ore shoot, which has indefinite walls, rakes to the northwest. The greatest dimension of the stopes, measured on the fault surface in the direction of rake, is about 1,200 feet. The width of the mined area, taken at right angles to the rake, varies greatly but averages about 300 feet. The ore shoot is from 3 to 40 feet thick.

"Within this ore shoot, cinnabar and small amounts of metacinnabar and native quicksilver occur as specks, blebs, and short discontinuous veinlets in and adjacent to the brecciated and altered rock along the Black Butte fault. The tenor of the ore varies erratically; in general it is richest in the more thoroughly silicified rocks of the fault zone, where it occurs chiefly as discontinuous veinlets and blebs. Some silicified rock, however, is almost barren. After silicification, renewed movement shattered the silicified rock locally and left other parts relatively unfractured. Cinnabar and accompanying minerals were then deposited in the openings of the shattered rock. Minable ore also occurs locally in the clayey and carbonatized but unsilicified rocks in and adjacent to the fault. Here the cinnabar is chiefly disseminated in minute specks through the altered rock, though some is in short veinlets associated with siderite and chalcedony.

"Although some very rich ore has been mined, especially from the highly veined parts of the silicified rock, most ore was of very low grade. The average grade of rock mined from this ore shoot appears to be not more than 4 pounds per ton. Permeable zones, due to shattering of the silicified rock, were obviously the favored sites for ore deposition.

"The stope that extends above and below the west end of the 400 level is on the Black Butte fault, in ore of the same nature as that in the ore shoot just described. Unmined low-grade ore of the same general character lies between the two stopes on the 400 level. This ore was not extracted because the raise connecting the 400 level with lower levels was plugged.

"Ore shoots in bedded tuffs: The Smoky stope, at the east end of the 900 level, and the stopes at the west end of the 1,100 level have been opened in ore shoots that lie in bedded tuffs more than 100 feet northeast of the Black Butte fault.

"The Smoky stope ore shoot lies at the contact between two tuff beds. The upper one is a coarse, purple to red-brown, andesite tuff containing fragments up to 1 inch in diameter. The fragments are pumiceous andesite set in a lighter-colored matrix of fine andesite fragments and pumice dust. Associated with this tuff in the west end of the Smoky stope, about 40 feet above the 900 level, is a lava flow which has been converted into a beautiful replacement breccia by hydrothermal solutions. Similar altered lava at the east end of the 900 level drift may also be a part of this unit, but its exact relationship is obscured because it is separated from the rest of the main Smoky stope area by a northeast-trending cross fault, which forms the east end of the Smoky stope.

"The basal portion of the purple-brown tuff has been thoroughly silicified locally, especially along the 900 level, and the best ore occurs in and directly beneath the silicified purple-brown tuff.

"The purple-brown tuff is underlain by a highly altered white to light-buff tuff. This white tuff, which is composed largely of carbonates and clay in the Smoky stope, is more silicified toward the west and eventually passes into a hard, cream-colored, sugary-textured rock composed largely of chalcedony. The cinnabar gradually diminishes and disappears westward as the silicification increases.

"The ore-bearing contact between the white and purple-brown tuff strikes about N. 80° W. and dips 30° to 35° NE. However, the overall inclination of the ore-bearing zone, both in the mined-out portion above the 800 level and in its downward projection as determined by drilling, is 45° to 50°. This discordance is due to the fact that the ore-bearing contact is repeatedly broken and offset by small faults with downthrow to the northeast. Some of these faults are premineral, others postmineral.

"The stopes at the west end of the 1,100 level have been opened in partially silicified, fine-grained tuffs interstratified between coarse volcanic breccias.

"Ore shoots along vertical fractures in andesite: The Dennis Creek level is mainly in a thick flow of porphyritic andesite. This andesite is cut, 250 to 300 feet north of the Black Butte fault, by a series of steeply dipping fractures that strike roughly parallel with the fault. For some distance from each fracture the lava is irregularly altered, and cinnabar has been deposited as veinlets and disseminations in the altered rock. The ore is of very low grade.

Suggestions for Future Exploration

"Except for a limited area of blocked-out ore on the 400 level, the stope area along the Black Butte fault appears to be exhausted of all but submarginal ore. On the other hand, the downward continuation of the ore in bedded tuffs below the Smoky stope has been indicated by drilling. The four holes drilled have delimited the western limit of the ore body at depth, but have not delimited either its eastern limit or its bottom. Above the 900 level, the Smoky ore shoot ends on the east against a prominent cross fault that shows postmineral movement. The ground to the east of the cross fault has not been well prospected. Drilling to the east would establish whether or not the same contact (purple-brown tuff--white altered tuff) is also mineralized.

"Very little exploration has been done along the continuation of the Black Butte fault to the east of the Big stope. The zone of hydrothermal alteration continues in this direction for at least half a mile, as shown by float and an occasional outcrop of silicified rock. Inclined drilling into the ridge in this area would test not only the possibility of a second ore shoot along the Black Butte fault, but also the possibility of bedded ore shoots, such as the Smoky ore shoot in the hanging wall.

"Although the hanging-wall area has been well explored by numerous adits in the main area of the mine, only a few short crosscuts penetrate the footwall. The possibilities of the footwall area could be thoroughly tested by drilling flat to low-pitching holes to the southwest from the 900 and 400 levels."

WOODARD PROSPECTS

Location: Secs. 17, 20, 21, and 28, T. 23 S., R. 3 W., on Little Baldy Butte and Cinnabar Mountain, which flank Black Butte on the south and southwest.

Owner: J. F. Woodard.

Production: None.

Development: Development includes many pits and trenches, four adits containing more than 600 feet of workings on the north face of Little Baldy Butte, and a 200-foot adit on Cinnabar Mountain. Most of this work was done by Woodard during many years of prospecting the area. Of 287 samples taken from these many prospects by the U.S. Bureau of Mines in 1942, none contained more than a trace of quicksilver. Woodard reports, however, that assays in excess of 15 pounds per ton of quicksilver had been obtained.

Geology: Jagged crags and high, steep-walled outcrops of altered rocks similar to those forming the crest of Black Butte are well developed on Cinnabar Mountain and Little Baldy Butte. The numerous workings explore altered andesitic lavas that mark the outcrop of a fault zone trending N. 15° to 35° W. According to Wells and Waters (1934, p. 33), this fault zone is at least 2 miles long and a quarter of a mile wide.

HOBART BUTTE

Cinnabar is occasionally reported as occurring in the high-alumina clay deposit on and near Hobart Butte. From the principal quarry, lying near the crest of the Butte in the SW$\frac{1}{4}$ sec. 31, T. 22 S., R. 3 W. and about 3 miles airline northwest of the Black Butte mine, 12,000 to 15,000 tons of clay were shipped to a brick plant at Willamina during the 1930's (Oregon Department of Geology and Mineral Industries 1951, p. 90-91). A substantial tonnage of the clay was blocked out by a joint drilling program of the U.S. Bureau of Mines and U.S. Geological Survey in 1943 (Allen, Loofbourow, and Nichols, 1951). Quicksilver was not reported in any of their analyses. It is thought that perhaps realgar, the arsenic sulfide which is rarely found in the clay, has, on occasion, been mistakenly identified as cinnabar. On the other hand, cinnabar may reasonably be expected to occur here, since the Butte lies within a district of rather widespread hydrothermal alteration and cinnabar mineralization.

The rocks from which the clay has derived are thought to have been volcanic breccias, tuffs, conglomerates, lava flows, and mud flows of the Fisher Formation.

ELKHEAD AREA

The Elkhead area extends along Elk Creek south of Scotts Valley in T. 23 S., R. 4 W., Douglas County, about 4 miles west of the Black Butte area (see figure 10). The topographic map of the Anlauf quadrangle covers both areas.

Quicksilver deposits include the Elkhead mine and the Thompson, Wilson, and Allen prospects. The Elkhead mine and the adjoining Thompson prospect lie within a zone of shearing along the contact between amygdaloidal basalt and overlying sandstone of the Umpqua Formation. The Wilson prospect, about 3 miles to the northwest, and the Allen prospect, three-quarters of a mile west, are along small faults in the basalt. Production, which is probably much greater than the 71 flasks recorded by the U.S. Bureau of Mines, is all credited to the Elkhead mine.

ELKHEAD MINE

Location: NE¼ sec. 21, T. 23 S., R. 4 W., about 5.5 miles by road up Elk Creek from U. S. Highway 99 at Scotts Valley and about 5 miles airline west of the Black Butte mine in northern Douglas County.

Owner: Blaine Hovey estate.

Production: 71 flasks recorded; probably more (see History).

History: Development of the Elkhead mine began about 1870. Newland (1904, p. 311) states that $30,000 worth of quicksilver was produced prior to 1903, but production records for these years are otherwise very meager. It is known that during the early 1880's the mine was operated by Todd Emerson & Co. and that a small amount of quicksilver was produced in 1882. Production of 50 flasks was recorded in 1887. In 1888 and 1889 production of 32 flasks and 20 flasks respectively were credited to mines in Douglas County. Perhaps part or all of this was produced by the Elkhead mine. A 20-ton Scott furnace, which was erected during these early years, remains on the property.

In 1916, after many years of inactivity, the mine was reopened and some development work was done. According to Floyd Morin, who was employed in revamping the Scott furnace and later operated it, the mine was taken over in 1918 and worked through 1919 by J. O. Anderson. Some quicksilver was produced but no statistics are available. In 1931 development work was done by the Elkhead Quicksilver Mining Co. under the management of J. W. Wenzel, and in 1932, C. O. White of Seattle installed an upright gravity-feed furnace of his own design which was doomed to failure. Two 30-foot by 30-inch Lacey rotary furnaces were installed in 1934 and 1935, and 16 flasks were produced. In 1940 one of the furnaces was moved to the Red Cloud mine in Douglas County from whence it was moved in 1957 to the Angel Peak mine in Lake County. The other furnace was cut in two and half of it moved to the Platner mine in Crook County. In late 1956 the mine was purchased on contract by Ore Mines, Inc., headed by R. M. Falk. The furnace plant was revamped using the remaining half of the furnace and 2 D retorts, and 5 flasks were produced in 1957. In early 1958, Moneta Porcupine Mines, Ltd., optioned the property and considerable exploratory work and sampling was done during the year. The mine was idle during 1959. In April 1960 the mine was leased to the Washington Mining Corp. Under the management of Bert Avery, former superintendent of the Bonanza mine, exploration of the ore zone at depth was carried on until June 1961. More work is planned for the future when and if quicksilver price conditions improve sufficiently to justify the expense.

Development: The Elkhead mine is developed by at least 1,800 feet of workings distributed among 6 adits (figure 12). Adit 2, which contains about 1,000 feet of drifts and crosscuts, is connected by raises to two glory holes at the surface. The workings explore the ore zone through a vertical range of about 150 feet. Most of the ore mined on the property is said to have come from the glory holes and from small stopes near the portals of adits 4 and 5. A sixth adit located a few feet below adit 5 has been largely destroyed by trenching operations.

Geology: The country rocks are amygdaloidal basalt overlain by a series of interbedded sandstones and shales of the Umpqua Formation. The glory holes lie along the contact of the basalt and an overlying layer of tuffaceous sandstone. The contact is sinuous and trends northeastward with dips of 70° to 80° S.E., flattening somewhat both northeast and southwest of the mine. Both the basalt and the sandstone are intensely fractured, hydrothermally altered, and cut by numerous thin iron ribs. Alteration is more intense in the sandstone and silica-limonite veinlets more abundantly developed. The veinlets appear to have been originally composed of intermixed silica and siderite, but, owing to oxidation of the siderite, only limonite and silica generally remain.

A little cinnabar can be seen in and around the glory holes as disseminations and occasional veinlets in the altered sandstone. A series of 10 channel samples each about 5 feet long taken from the west wall of the westernmost glory hole is reported to have averaged 4 pounds per ton quicksilver. The results of panning several samples indicate that nearly all of the sandstone within 25 or 30 feet of the contact in the vicinity of the glory holes contains a little cinnabar, although most of the samples would probably assay less than 1 pound per ton

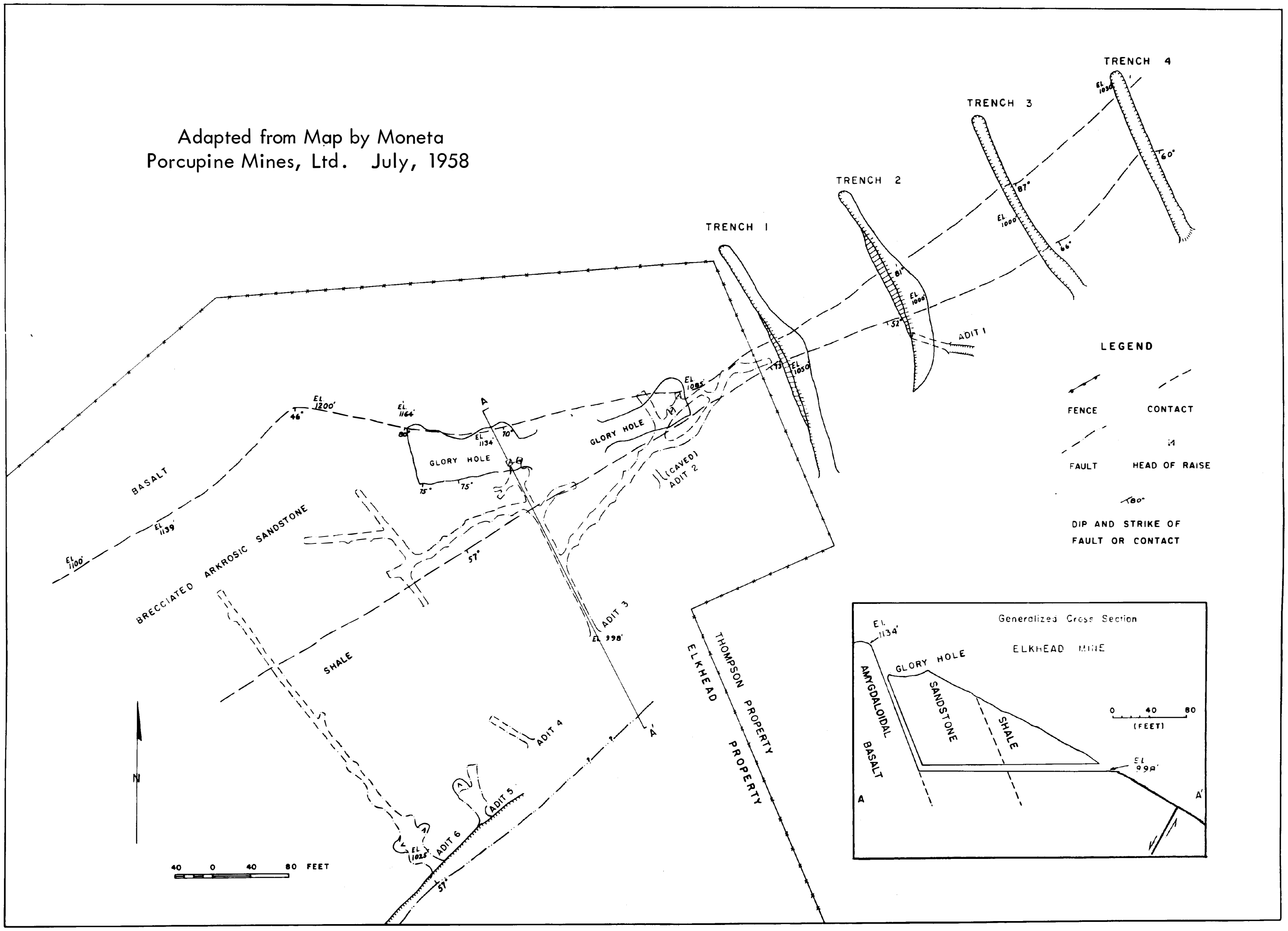


Figure 12. Plan and section of the Elkhead mine and Thompson prospect.

quicksilver.

The tuffaceous sandstone overlying the basalt ranges from 30 to 200 feet in thickness and is in turn overlain by shale. The sandstone-shale contact roughly parallels that of the sandstone and basalt and dips 55° to 75° S.E.

Adjacent to the mill building a bulldozer trench several hundred feet long explores a fault zone that trends N. 50° E. and dips 55° to 60° N.W. This fault roughly parallels the trend of the sandstone-basalt contact but dips in the opposite direction. Small pods of ore have been found in the fractured sandstones and sandy shales in the hanging wall of the fault and a little ore has been stoped near the portals of adits 5 and 6. Where well exposed, the fault zone contains 2 to 3 feet of carbonatized clay gouge and intensely brecciated rock that is locally silicified. The walls of the fault are badly fractured and impregnated with limonite.

Cinnabar was probably deposited from solutions rising along the basalt-sandstone contact and diverted along fractures into the overlying sandstone. The shale horizon apparently acted as a dam to the rising solutions. In most places the shale capping was so far from the main channel of migration that cinnabar was widely scattered through the intervening sandstone and little ore of minable grade was formed. The fault zone adjacent to the mill building is of interest in that it dips toward the basalt-sandstone contact. Perhaps the cinnabar distributed along the fault was also deposited from solutions diverted along it from its intersection with the basalt-sandstone contact. If so, it is conceivable that an ore body might lie in the vicinity of this intersection. The work of Washington Mining Corp. is intended to explore this possibility. If the dips of both the fault and the basalt-sandstone contact remain constant, they should intersect at a depth along the fault of about 450 feet.

THOMPSON PROSPECT

Location: SW¼ sec. 15, T. 23 S., R. 4 W., adjoining the Elkhead mine property on the northeast and once part of it.

Owner: Marvin Thompson.

Production: None.

General description: Development consists of a short adit, a shallow shaft, and four bulldozer trenches each 250 to 300 feet long. The trenches were dug by Moneta Porcupine Mines, Ltd., during 1958 to explore the northeastern extension of the basalt-sandstone contact at the Elkhead mine. Although the sandstone exposed in the trenches is badly fractured, alteration is less pronounced than in the glory-hole area of the Elkhead mine. Only traces of cinnabar were found. (See Figure 12).

WILSON PROSPECT

Location: North central part of the N½ sec. 8, T. 23 S., R. 4 W., about 3 miles northwest of the Elkhead mine.

Owner: Harry Paselk.

Production: None.

General description: The prospect was discovered by Floyd Morin in the late 1930's. An opencut explores a narrow, west-trending fault zone in basalt of the Umpqua Formation. A 10-foot adit nearby is caved. In the opencut, the basalt is sheared through a width of a foot or two and weakly argillized. Cinnabar occurs as disseminated specks and as thin coatings on fracture surfaces. Samples contain less than one pound per ton of quicksilver. Not enough work has been done to determine the continuity of the fault zone or amount of mineralization along it.

ALLEN PROSPECT

Location: N½SW¼ sec. 21, T. 23 S., R. 4 W., about three quarters of a mile west of the Elkhead mine.

Owner: Unknown.

Production: None.

General description: The prospect was not visited by the writer. The workings, consisting of a short adit and two or three small pits, are said to be caved. Floyd Morin, the discoverer, reports finding cinnabar scattered along a narrow fault zone in altered basalt. A sample submitted to the Department in 1940 assayed 26 pounds per ton of quicksilver.

BONANZA-NONPAREIL AREA

The mines and prospects of the Bonanza-Nonpareil area in northern Douglas County are distributed along a discontinuous linear zone of structural disturbance and associated hydrothermal alteration that extends in a northeasterly direction from the Sutherland prospect in sec. 30, T. 25 S., R. 4 W., through the Longbrake prospect, the Bonanza mine, and the Nonpareil mine, to the Butte prospects in sec. 26, T. 24 S., R. 4 W. (see Figure 13).

Geology, history, and development of the Bonanza-Nonpareil area have been treated in two U.S. Geological Survey publications for which field work was done in 1930 (Wells and Waters, 1934) and in 1942 and 1944 (Brown and Waters, 1951). Figure 13 is adapted from the geologic map prepared by Brown and Waters.

The mines and prospects of the area lie in a region of smoothly rounded hills and broad valleys underlain by marine sandstones and shales of the lower Eocene Umpqua Formation. The rocks, from oldest to youngest, include: (1) well-cemented buff to dark gray arkosic sandstone that is generally massive but locally interlayered with thin beds of siltstone and shale; (2) lenses of light-colored tuffaceous sandstone occurring in the upper portions of the arkosic sandstone; and (3) interbedded black to dark gray siltstone and shale.

Structurally the area represents the east limb of a broad anticline striking about N. 25° E. and dipping 20° to 65° SE. Differential movement during the folding developed fractures in the more competent rocks, some of which were later mineralized. The discontinuous line of structural disturbance along which the mines and prospects are distributed roughly follows the stratigraphic horizon of the tuffaceous sandstone lenses but locally cuts stratigraphically higher or lower rocks (Figure 13).

The Bonanza mine or bodies were formed along bedding-plane shear zones in the tuffaceous sandstone close beneath a layer of relatively impervious shale which is thought to have aided in localizing the mineralizing solutions. At the Nonpareil mine where the shear zone cuts tuffaceous sandstone stratigraphically lower in the section, the ore bodies were localized primarily by cross faults.

BONANZA MINE

Location: SW$\frac{1}{4}$ sec. 16, T. 25 S., R. 4 W., about 8 miles east of Sutherlin. The principal workings enter the eastern slope of a brush-covered hill that rises approximately 600 feet above the adjacent valleys. The property consists of 113 acres of deeded land, two mining claims held by location, and 143 acres of land under lease.

Owner: Bonanza Oil & Mines Corp.

Production: The recorded production of the Bonanza mine is shown in Table 4.

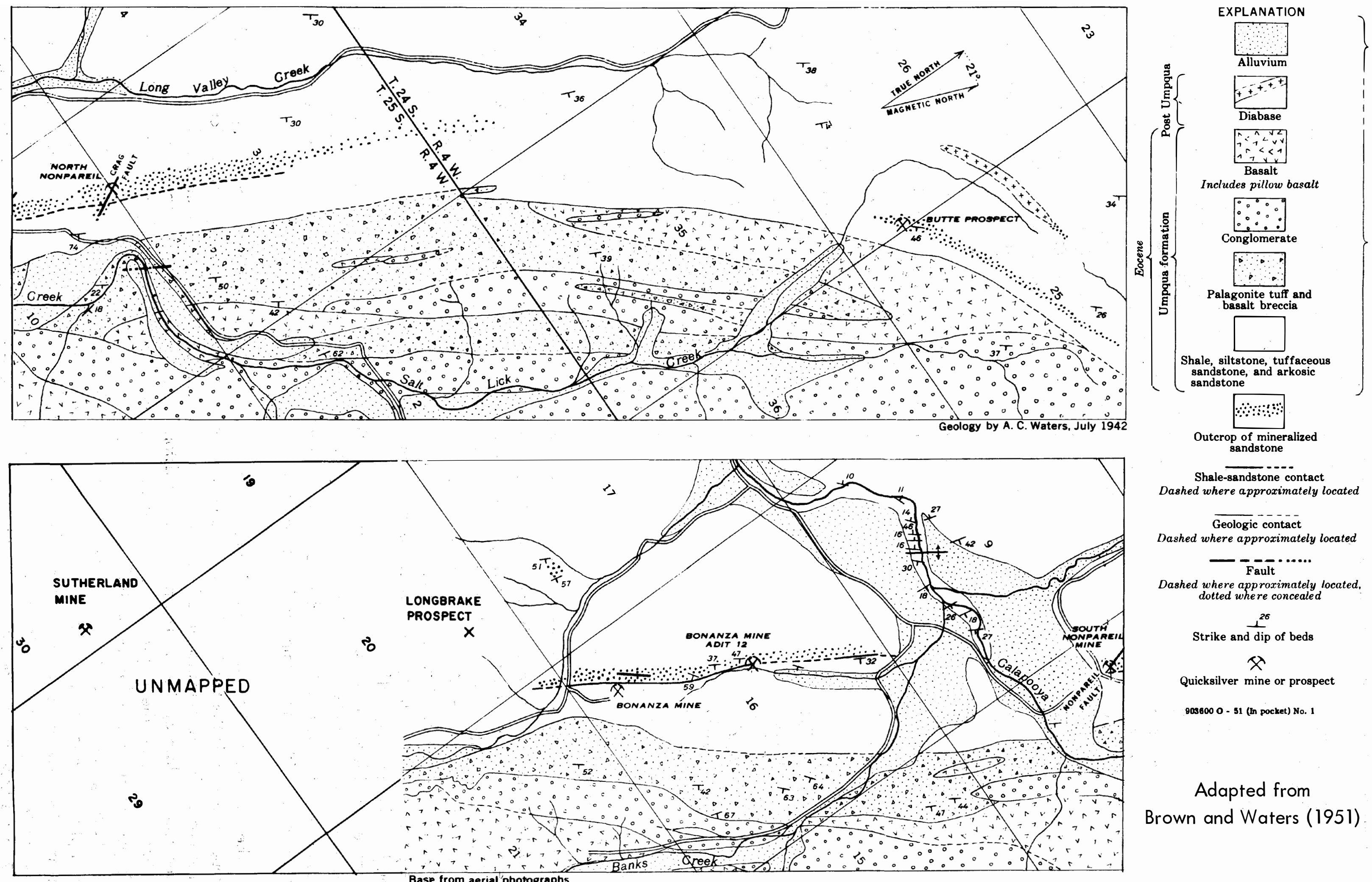
History: The history of the Bonanza mine dates back to the early days of mining in Oregon. Cinnabar is said to have been discovered there some time during the 1860's. Some of the early development was done by the Bonanza Quicksilver Mining Co., which was organized in 1878. This company reportedly installed the Scott furnace, parts of which are still on the property. Following these activities, the property passed through the hands of several individuals and groups, none of which succeeded in putting the mine on a paying basis. A production of 15 flasks was recorded in 1887. No other production records exist for the years prior to 1937. According to Parks and Swartley (1916, p.218-9), the Sutherlin Quicksilver Mining, Refining & Development Co. was organized in 1916 to operate the Bonanza mine, and a small mill was installed to concentrate ore before retorting.

In 1928 the property was acquired by J. W. Wenzel, F. S. Skiff, and C. Scherer, who organized a second Bonanza Quicksilver Mining Co. An extensive sampling program indicated a large tonnage of low-grade ore but no production was made.

Most of the early operations were confined to float and surface ore mined from a glory hole in the outcrop of the north or main ore body and from several short adits all less than 250 feet long.

In 1935 the mine was acquired by H. C. Wilmot, who organized Bonanza Mines, Inc. (renamed Bonanza Oil & Mines Corp. in 1951), and development of a small ore body that lay several hundred feet to the south was started. A 5-deck Herreshoff furnace of 50-tons-per-day capacity was installed and in late 1937 production began.

Continued underground exploration led to the discovery of a large body of ore in the north hill in 1939 just as the south ore body was playing out. As a result, two 100-ton-per-day Gould rotary furnaces were added to the treatment plant. Discovery and development of the rich ore body had come at a period when war-time demands were forcing quicksilver prices to record highs, and for the year 1940 the Bonanza mine ranked second



Adapted from Brown and Waters (1951)

Figure 13. Geologic map of the Bonanza-Nonpareil area (in two parts; left edge of upper part joins with right edge of lower part).

TABLE 4. Recorded Production Bonanza Quicksilver Mine*

Year	Treated Furnace (short tons)	Flasks
1887	-	15
1937	2,215	148
1938	14,914	1,183
1939	15,560	2,199
1940	49,863	5,733
1941	54,245	5,548
1942	40,950	3,940
1943	-	3,294
1944	15,547	2,426
1945	12,580	2,350
1946	8,188	1,261
1947	7,233	1,182
1948	8,119	1,351
1949	-	1,161
1950	-	-
1951	-	1,160
1952	16,115	846
1953	-	593
1954	-	383
1955	10,731	604
1956	11,903	977
1957	15,278	1,434
1958	10,204	795
1959	9,855	722
1960	3,236	183
Total		39,488

*Source: United States Bureau of Mines

among the quicksilver producers in the United States with a production of 5,733 flasks. The Bonanza mine was the only major quicksilver mine in Oregon to continue operations through the war years.

In the summer of 1942 one of the rotaries was dismantled and moved to the company's property at Hermes, Idaho. For several years prior to closure of the mine only the remaining rotary furnace was used.

The mine was closed from late 1949 through early 1951 and for a short time during 1954 as a result of low quicksilver prices. Otherwise it was in constant operation from 1937 until October 1960, when it was again forced to close as reserves minable under present economic conditions were exhausted.

Development: Development at the Bonanza mine extends from the surface to an inclined depth of 1,450 feet involving a large system of drifts along the ore zone spaced 70 to 130 feet apart (Plate 4, in pocket).

Prior to encountering the north ore body in No. 11 adit crosscut in early 1939, all of the ore produced by Bonanza Mines, Inc., was extracted from the south ore body with most of it through No. 9 adit. The No. 11 or 370 level adit has since been the main access and haulage level of the mine. An access adit was driven on the 200 level but ore from above was passed through chutes to the 370 level, part of it being mined by open pit.

The 500, 630, 700, and 830 level drifts were turned from short crosscuts connecting to the main incline, a two-compartment winze sunk in the footwall of the ore zone from the 370 level (Figure 14). The 40 winze, sunk from the 830 level about 500 feet northeast of the foot of the main incline, gives similar access to the 960, 1,050, 1,150, 1,260, and 1,450 levels. Thus ore from the lower levels must be hoisted up the 40 winze to the 830 level, trammed 500 feet to the main incline, hoisted again to the 370 level, and from there trammed to the furnace plant.

Ore is mined above the levels from open stopes ordinarily supported by stulls and head boards. Exploration raises are closely spaced. Preliminary exploration below established levels was done by diamond drilling from crosscuts driven into the hanging wall.

The company entered into an exploration contract with the Defense Minerals Exploration Administration in early 1953, and during 1953, 1955-56, and 1958, more than 2,000 feet of exploratory drifting, raising, and crosscutting was done on the 830, 1,050, and 1,150 levels. Practically all of the Government's share of the expenditures has been repaid by the company through royalties from production.

Geology: The ore bodies at the Bonanza mine are in the form of irregular lenses scattered along a zone of shearing that roughly parallels the bedding in a tuffaceous sandstone horizon of the Umpqua Formation. Above the 700 level the ore bodies are confined to a lens of tuffaceous sandstone of variable thickness underlain by arkosic sandstone and overlain by shale. The tuffaceous sandstone thins downward and at about the 700 level apparently pinches out. Below the 700 level the ore bodies lie in part in stratigraphically lower sandstones and siltstones and in part within isolated lenses of tuffaceous sandstone.

The zone of shearing has an average dip of about 45° SE. It approximately parallels the bedding in the sandstone, but in places transects it, particularly where flexures occur. The shearing was probably caused by reverse movement of the rocks along bedding planes during folding. The bedding plane shears are commonly intersected by less steeply dipping subparallel thrust faults that are probably drag faults produced by friction. Most of them lie in the hanging wall and converge with the bedding plane shears (Figure 15). Movement along

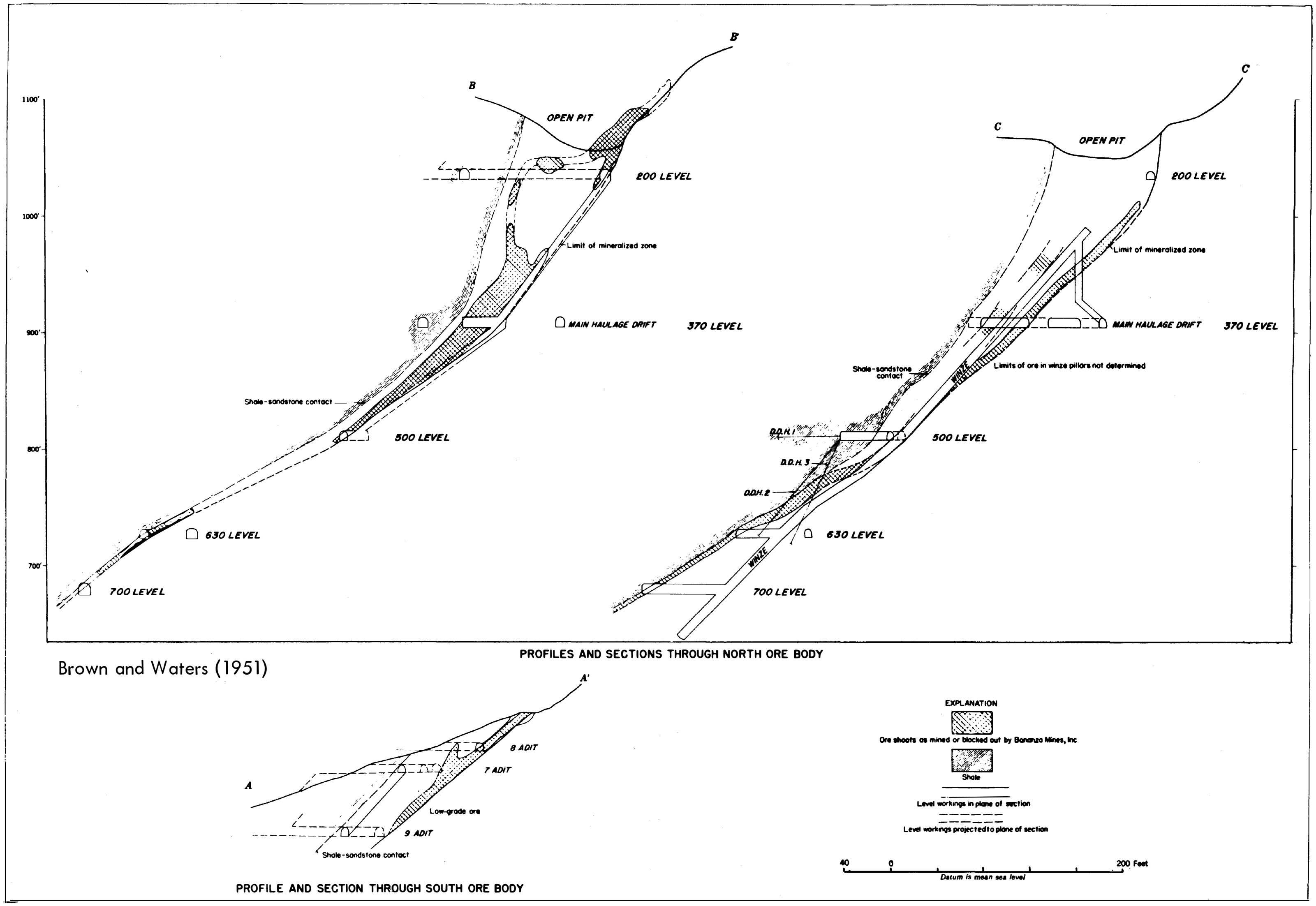


Figure 14. Profiles and sections through the Bonanza mine (above the 830 level).

all of these various fault systems appears to have been reverse. Cross faults, most of them small, intersect and in places offset the shear zones. Some are premineral and some postmineral. A cross fault, that was apparently younger than the bedding plane shears but older than the mineralization, offsets the shear zone an unknown distance at the north end of the 1,150 and 1,260 level drifts. Ore was formed in the crushed zone along the cross fault. In a few places premineral cross faults form one wall of ore bodies contained in the bedding plane shear zones.

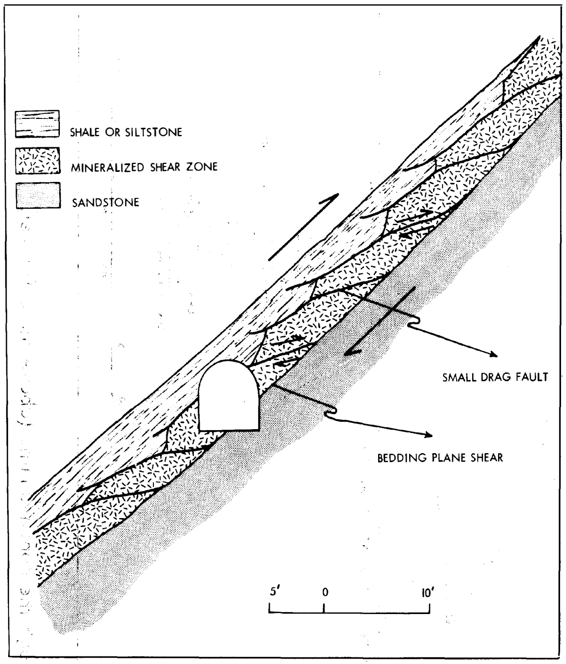


Figure 15. Diagrammatic section illustrating drag faulting caused by differential movement along bedding planes at the Bonanza mine.

The ore bodies consist almost entirely of sheared and argillized sandstone which is veined and impregnated with calcite, siderite, chalcedony, quartz, and cinnabar. Metacinnabarite and native quicksilver are present in the upper workings, but are of little economic importance. Marcasite is only locally abundant. Arsenic and antimony sulphides are extremely rare.

The altered and mineralized rocks in the shear zones are bleached nearly white in contrast to the drab gray and grayish black of the unaltered wall rocks. On long exposure the altered rocks assume a rusty brown color due to oxidation of the siderite. Locally the shear zones contain dark chocolate-colored gouge.

In places both the upper and lower limits of the ore zones are marked by distinct and often slickensided surfaces, beyond which the rocks are relatively unaltered. In others, even though such surfaces may be present, cinnabar has impregnated the wall rocks along small fractures and the exact limits of the ore must be determined by assay or panning.

Where first encountered on the 370 level, the principal ore body of the mine proved to be about 600 feet long and as much as 60 feet thick. This ore body tapered both laterally and downward, pinching to a width of about 4 feet and a length of 150 feet on the 700-foot level. It was feared in 1944 that mining below the 700 level would prove unprofitable. Fortunately nodal extensions and subsidiary lenses were encountered by continued drifting, sinking, and raising along the zone of shearing. Throughout much of the deeper part of the mine, the shear zone is thin, indistinct, and difficult to follow. For long distances it contains from an inch to 2 feet of gouge and altered rock of non-minable width or is marked merely by irregular, discontinuous fault surfaces along which little or no evidence of movement or mineralization exists. Locally and unpredictably it widens to form the lens-shaped zones which contain the ore bodies. Ordinarily the ore bodies end laterally between converging shear planes, although in some places distinct premineral cross faults form the lateral barrier.

Parallel ore bodies separated by barren rock are uncommon; however, Brown and Waters (1951, p. 240) state:

> "On the 370-foot level, the entire shear zone was minable ore, but on the north end of this level the ore body split into a distinct hanging-wall ore shoot and a footwall ore shoot. Above the 370-foot level the hanging-wall ore shoot grades out, and on the 200-foot level it is replaced by a flat-lying, tabular ore shoot between the hanging wall and the footwall. The footwall ore shoot continued upward above the 200-foot level to the surface, where it was mined in an open pit. Distinct footwall ore shoots occur, also, below the 370-foot level at a few localities. Raise 30 on the 500-foot level had a high-grade hanging-wall ore shoot and a low-grade footwall ore shoot; raise 24 on the 500-foot level showed high-grade ore on both walls and lower-grade ore between. These two ore shoots merged into a single hanging-wall ore shoot below the 500-foot level and continued as one ore shoot below the 630-foot level."

The mineralizing solutions are believed to have risen along the bedding-plane shears. Localization of the ore was influenced primarily by the pervious nature of the fractured sandstones in the shear zones and the damming action of the overlying shales or fault surfaces. The distance between the mineralized shear zones and the lower contact of the shale varies. In the upper levels of the mine the upper limit of the shear zone, and hence of the ore bodies, lies along or a very few feet below, the shale-sandstone contact. Below the 700-level, in most parts of the mine, siltstones form the hanging wall of the ore, and the shales are so far distant that they have rarely been encountered in the workings.

Nowhere in the mine did the ore solutions significantly penetrate the shale horizon, although in places, particularly in the northern part of the mine, the shear zone passes into the shales. In the lower levels, thin shaly interbeds in sandstone are occasionally mineralized.

Several ore bodies in the lower levels of the mine are capped by a complex en echelon arrangement of short, interjoining drag faults below which the mineralizing solutions were confined (see figure 15).

Reserves: Mr. Avery of the Bonanza states (written communication, 1962): "The ore reserves at the Bonanza mine as of this date are extremely low. Five hundred tons of 5-pound ore is exposed on the upper levels only. There is 50,000 tons of 2-pound rock lying between the 370 level and the 630 level, but under present conditions can be discounted. Lying below the 1,400 level, particularly north of No. 40 winze, core drilling indicated 20,000 tons of commercial ore outlined by drilling from two stations 400 feet apart. It is reasonable to believe this ore will average 6.0 pounds per ton and that the values will continue for a much greater distance below the 135-foot elevation below the 1,400 level as most of the holes were in ore when stopped."

NONPAREIL MINE

Location: Property encompasses two principal systems of workings lying about 2,000 feet apart in T. 25 S., R. 4 W. -- the South Nonpareil in the NW$\frac{1}{4}$ sec. 10 and the North Nonpareil in the SW$\frac{1}{4}$ sec. 3. The mine workings are on the southeast slope and near the crest of a northeast-trending ridge between Calapooya and Long Valley Creeks (see figure 16).

Owner: Nonpareil Quicksilver Co.

Production: Production records are scarce. On the basis of existing workings and assays of samples taken from the stopes and an old ore bin, Brown and Waters (1951) estimated that about 3,000 tons of ore carrying approximately 7 pounds of quicksilver to the ton has been mined and treated. This would place the total production of the mine at about 340 flasks.

History: The Nonpareil mine was discovered between 1865 and 1870 at about the same time as the Bonanza mine. Records at the Douglas County courthouse show that several quicksilver claims which encompassed the present site of the Nonpareil mine were located by a group of individuals in April 1875. The property was originally known as the New Idrian mine. A Scott furnace was erected and, according to Brown and Waters (1951), 33 or 34 flasks were produced before 1880. Remains of the furnace stand near the South Nonpareil mine. In 1881 the Oregon Cinnabar & Silver Mining Co. was organized to operate the mine. In 1882 production of 50 flasks was recorded (Becker 1888, p. 36) from mines in the Bonanza-Nonpareil district. Probably all of it came from the Nonpareil. In 1884 both the Bonanza and Nonpareil mines were being operated by the Bonanza Quicksilver Mining Co. From then until 1925 the history of the mine is unknown.

In 1925 several flasks of quicksilver were produced from retort operations. The Nonpareil Quicksilver Co. acquired the property in 1928 and leased it to C. M. Everett. Everett, after an unsuccessful attempt to work the original South Nonpareil mine, commenced development of the North Nonpareil by driving 12 adits into the east slope of the ridge between 1,800 and 3,500 feet northeast of the old workings. In 1931 a 4-deck 10-foot diameter Herreshoff furnace was erected on the property, and 61 flasks of mercury were produced in 1932. Apparently, however, the grade and quantity of ore developed did not allow further operation in view of dwindling prices, and soon after the death of Everett in 1932 the mine was closed. The furnace and other equipment were sold and moved to a southern California property.

In 1944 exploratory drilling was done at both the North Nonpareil and South Nonpareil mines by the U.S. Bureau of Mines. In 1956 and 1957 an exploratory adit was driven at the South Nonpareil and some drilling was done by Bonanza Oil & Mines, Inc.

Development: Development at the South Nonpareil mine is distributed among four adits and an opencut and totals more than 3,000 feet. Distribution of the workings is shown on figure 16. About 2,000 feet of interconnected drifts, raises, and stopes on three levels explore an area about 165 feet in vertical height over a length of 520 feet in length. Ore has been mined from five stopes in this system of workings. The North Nonpareil is developed by at least 12 short adits, two shallow shafts, and several opencuts. Three of the adits are between 250 and 300 feet long; the rest are 10 to 30 feet long. Ore has been mined from an isolated pocket in adit 5N.

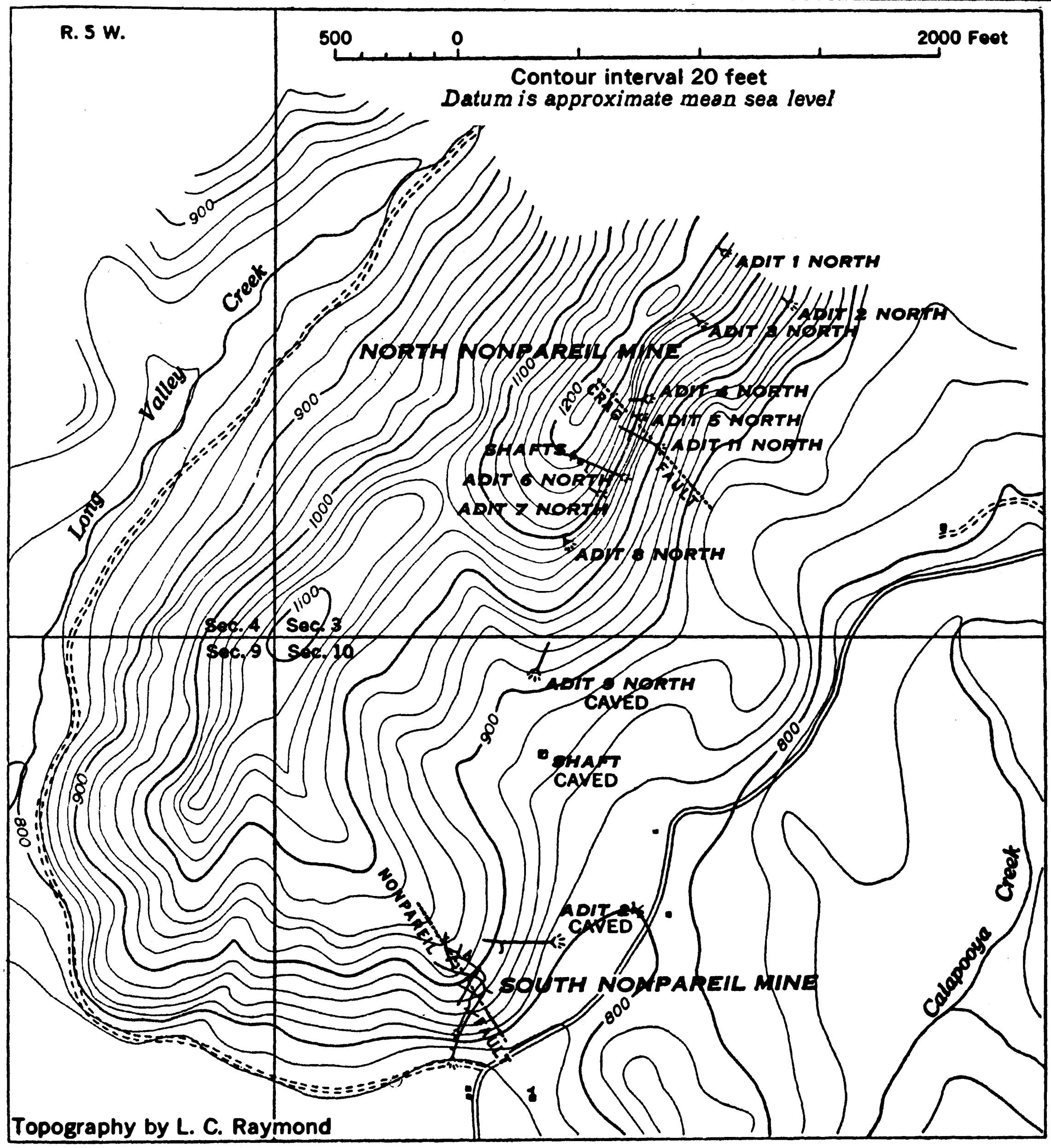


Figure 16. Topographic map of the Nonpareil mine. Reprinted from Brown and Waters (1951).

Geology: The rocks at the Nonpareil mine are similar to those at the Bonanza mine. The ore bodies, however, were formed along northwest-trending crossfaults in tuffaceous sandstone some distance stratigraphically below the shale horizon that aided in localizing the principal ore bodies at the Bonanza mine.

Ore deposition was primarily controlled by the Crag fault at the North Nonpareil and by the Nonpareil fault at the South Nonpareil. Both appear to be of small displacement but are marked for several hundred feet by zones of brecciation and intense hydrothermal alteration of the included sandstone. The Crag fault zone is made particularly conspicuous by a line of crags sustained by silicification of the sandstone.

The Nonpareil fault zone trends approximately N. 25° W. and dips 65° to 75° SW. The Crag fault strikes N. 45° W. and dips 70° SW. to vertical. At the South Nonpareil some of the ore bodies were confined to crushed zones produced by the Nonpareil fault. Others extended away from the crossfault for short distances along lens-shaped shear zones. The shear zones roughly parallel the bedding. The isolated ore shoot developed in Adit 5N at the North Nonpareil mine lay along the intersection between the Crag fault and a bedding plane shear and thus pitched to the southeast at a low angle.

The shale-sandstone contact which played such an important role in the localization of the Bonanza mine ore bodies was not explored prior to the U.S. Bureau of Mines' exploration project in 1944, either because of ignorance of its existence or because of its unfavorable location under a heavy mantle of landslide debris near the base of the ridge. The drilling in 1944 explored the areas at the intersection of the Nonpareil and Crag faults with the shale-sandstone contact, but results were not favorable. In 1956 and 1957 a 270-foot-long crosscut adit driven by Bonanza Mines, Inc., penetrated the projected intersection of the Crag fault with the shale-sandstone contact but failed to disclose any appreciable amount of mineralization.

BUTTE PROSPECTS

Location: Sec. 26, T. 24 S., R. 4 W., about 2½ miles northeast of the Nonpareil mine.

Owner: Giles Hunt.

Production: None.

General description: The prospects were discovered many years ago. Wells and Waters (1934, p. 38) state: "The principal tunnel has caved, but material collected from the dump is a broken and brecciated tuffaceous sandstone cemented by iron ribs. A short tunnel nearby exposes the same rock in place. No cinnabar was seen. The zone of altered rock in which the prospects are located is little more than 100 yards wide, but it is nearly a mile long." Brown and Waters (1951, p. 249) report that the shale and siltstone member of the Umpqua Formation appears either to have become sandier or to have thinned, as rocks stratigraphically higher than the shale-siltstone member are closer to the mineralized zone than at the Bonanza or Nonpareil mines.

LONGBRAKE PROSPECT

Location: NE¼ sec. 20, T. 25 S., R. 4 W., on the east slope near the crest of the ridge about three-quarters of a mile southwest of the Bonanza mine.

Owner: The property consists of 80 acres. The surface rights are owned by Darrell C. Longbrake, Sutherlin, and the mineral rights are owned by Douglas County.

Production: None.

Development: The prospect is developed by a 360-foot crosscut adit and a small opencut. Most of the work was done in 1956 by Darrell Longbrake, Lawrence Longbrake, Floyd Norris, Ike Norris, Don Norris, and Gale Norris.

Geology: The prospect is on the southwest extension of the mineralized belt which includes the Bonanza mine. The rocks consist of well-bedded sandstone containing thin interbeds of shale. The beds strike roughly N. 25° E. and dip 35° to 40° SE. In the opencut a fault crossing the beds at almost right angles records at least 4 feet of vertical movement. Little evidence of cinnabar mineralization was observed, although thin, irregularly distributed iron ribs are plentiful and the sandstone is locally softened and iron stained. A sample of the altered sandstone from the opencut assayed a trace of mercury. The adit was driven to meet this weakly mineralized zone about 180 feet below the level of the opencut. Nothing of recognizable significance was encountered.

SUTHERLAND PROSPECT

Location: Sec. 30, T. 25 S., R. 4 W., at the west end of the mineralized zone and about 1½ miles southwest of the Bonanza mine.

Owner: Unknown.

Production: None.

General description: The prospect was not visited by the writer as little or no work has been done since it was inspected by Wells and Waters (1934, p. 41), who report: "The Sutherland prospect is developed by a

30-foot tunnel driven N. 15° W. from a small gully. . . . The surrounding surface is covered by a rubble of iron ribs, which have been formed in a coarse tuffaceous grit, most of which seems to be little altered, as grains of quartzite are clearly visible in the silica cement. The tunnel is in fine-grained sandstone that has been slightly altered and cut by a few iron ribs. No cinnabar was seen."

TILLER AREA

Several small quicksilver deposits occur in the South Umpqua River drainage northeast of Tiller in T. 29 S., Rs. 1 and 2 W., and T. 28 S., R. 1 E. The South Umpqua River Road east from Tiller gives access to roads and trails to the deposits. Base maps for the area are the Tiller, Red Butte, and Quartz Mountain quadrangles.

All of the deposits in the Tiller area are in Tertiary lavas and pyroclastics of the Western Cascades volcanic series, except at the Buena Vista mine, where older Tertiary sedimentary rocks of the Umpqua Formation are in fault contact with the volcanics. Cinnabar is concentrated in veinlets of calcite and chalcedony within zones of shearing and hydrothermal alteration.

Recorded production from the area has been 9 flasks of quicksilver, all from the Buena Vista mine. It is probable, however, that the Buena Vista yielded more than this amount and that the Maud S. mine also produced a few flasks.

BUENA VISTA MINE

Other names: Umpqua mine.

Location: North-central part of sec. 34, T. 29 S., R. 2 W., high on the south flank of Deadman Creek and about 8 miles north by mountain road from a point on the South Umpqua River Road 6.5 miles east of Tiller.

Owners: Steve Cooper and Bernard Young, Roseburg.

Production: 9 flasks recorded; probably a few more.

History and development: Development of the Buena Vista mine was begun by W. S. Webb in 1918. Much of the existing work was done during the 1920's and early 1930's. Local informants state that between 1928 and 1930 many flasks of quicksilver were produced by the Oregon Mercury Co. with a bank of Johnson McKay retorts but only 4 flasks were recorded, all in 1929. In 1930 the property was owned by Guy Cordon, H. E. Rogers, and H. A. Jensen. In 1932 it was leased to the Umpqua Mining Co. Under the management of E. D. Perrin a 40-ton rotary furnace was installed and 2 flasks were produced in 1934. A small amount of ore was treated in the furnace in 1936-1937 but there is no record of production. The Tiller Development Co. attempted unsuccessfully to operate the mine on a sublease from the Umpqua Mining Co. in 1940. In 1943 Associated Metals, Inc., produced 3 flasks. The property was eventually acquired by P. A. Nichols and then was taken over by the present owners in 1954 along with the adjoining Maud S. Mine (figure 17).

The main Buena Vista workings consist of three levels distributed over a vertical range of 65 feet (see figure 18). The levels are connected to each other by various raises and a stope, and to the surface by a 325-foot crosscut adit on the lower level and a drift adit on the upper level. Lineal footage of drifts totals 350 feet on the lower level, about 60 feet on the intermediate level, and 100 feet on the upper level. At the time of inspection, a 36-foot winze below the main level was flooded and a stope above it, which is said to extend to the surface, was caved. There are several caved opencuts and a 100-foot adit above the upper level.

Geology: The country rocks include conglomerates, sandstones, and siltstones of the Umpqua Formation in fault contact with the stratigraphically higher andesites, tuffs, and tuff breccias of the Western Cascades volcanic series. Rock fragments in the Umpqua conglomerates are as large as 8 inches in diameter and include granitic rocks, schists, slates, quartzites, and metavolcanics. Bedding planes of the Umpqua Formation strike east and dip about 45° N. The volcanic rocks dip gently eastward.

Mine workings explore displaced blocks and slivers of carbonatized and kaolinized andesite and tuff breccias lying along the fault contact between the Umpqua Formation and the volcanic rocks. In the mine area the fault zone strikes N. 65° to 70° E. and dips about 80° N. What is believed to be the same fault is exposed for more than 1,000 feet both northeast and southwest of the Buena Vista adit.

The lowermost rocks exposed in the main crosscut south of the fault are unstratified tuff breccias composed of angular to sub-rounded blocks of andesite and pumiceous rhyolite set in a matrix of tuff. The tuff breccia is heavily charged with fragments of older rocks including slates and water-worn pebbles of plutonic and metamorphic rocks. Above the intermediate level the tuff breccias are overlain by a series of porphyritic and amygdaloidal

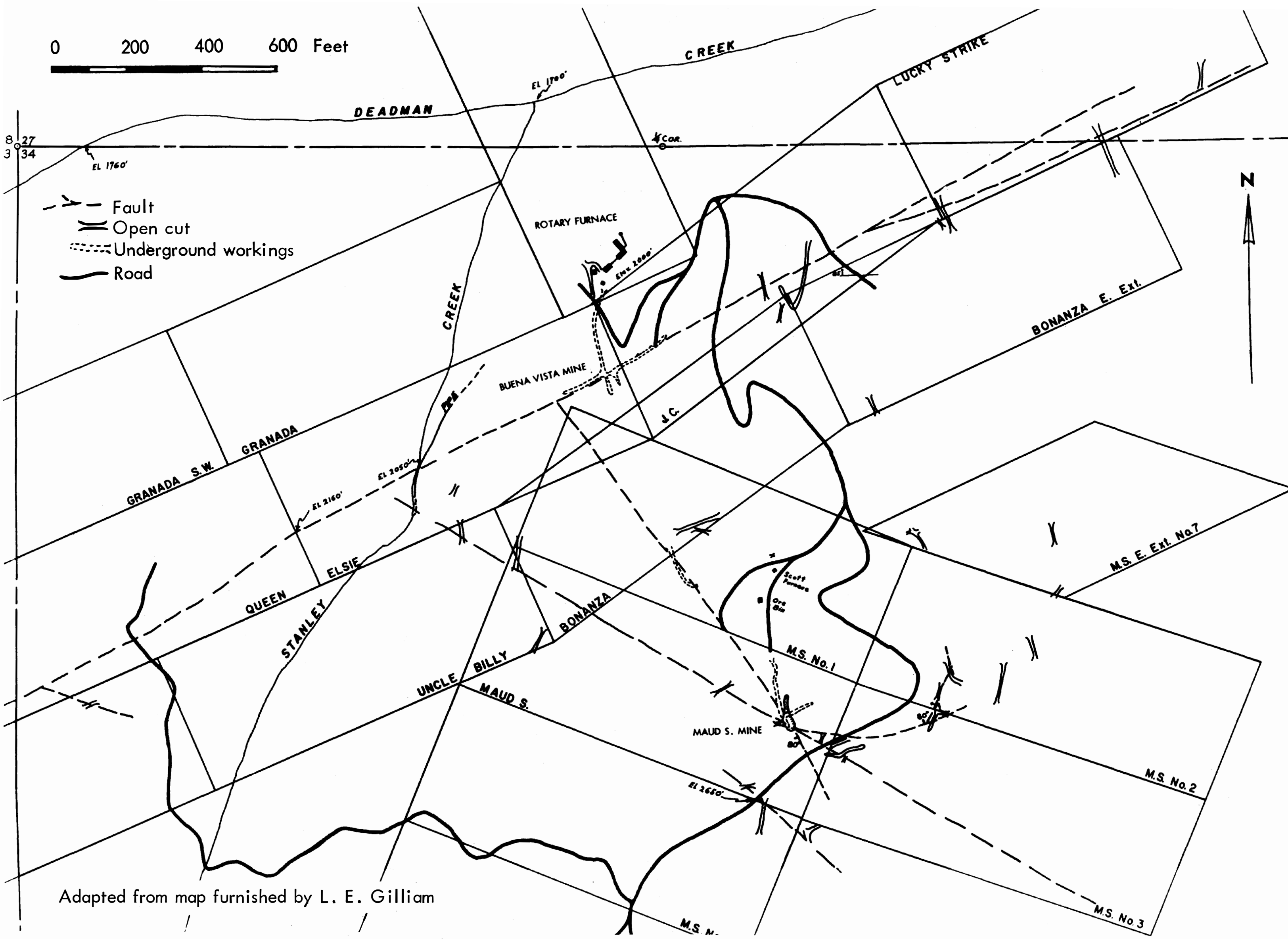


Figure 17. Map of the Buena Vista and Maud S. mine properties, showing distribution of the workings.

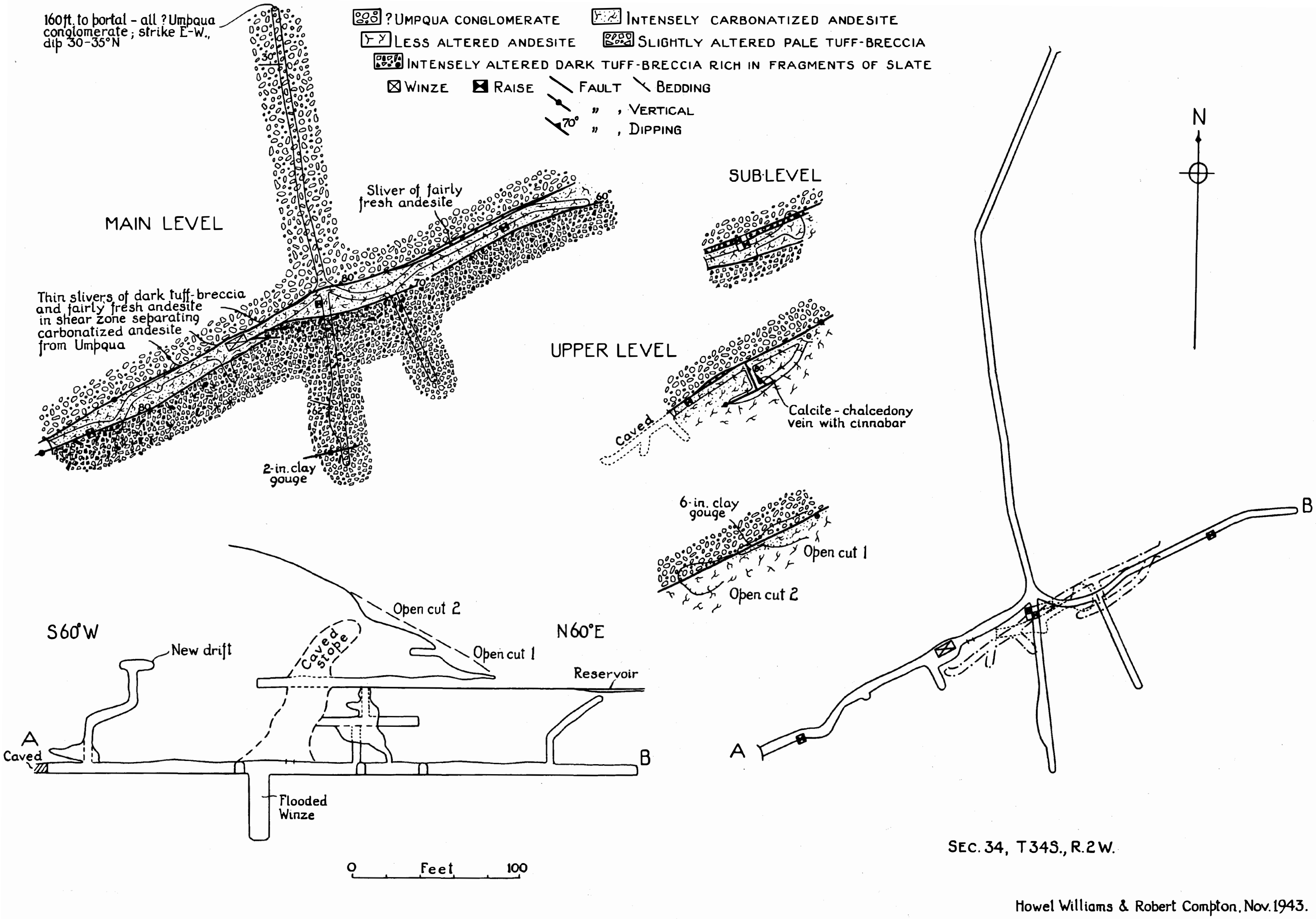


Figure 18. Geology, plan, and section of the Buena Vista mine.

andesites. For several feet south of the fault zone the andesite and tuff breccias are altered and cut by small faults and fractures, many of which are filled with calcite or banded calcite and chalcedony. On the lower or main level of the mine a down-faulted block of andesite is bounded on the north by the conglomeratic series and on the south by tuff breccias. Above the intermediate level the andesites continue to the south.

Where exposed by underground workings, the fault zone ranges from 5 to 17 feet in width. Although slight post-mineral movement is indicated, the principal movements are older. Locally, seams of wet clayey gouge as much as 2 feet thick lie along the contact between the andesite and the conglomeratic series to the north and along main fractures in the andesite. Evidence of movement along the southern or tuff-breccia contact is less conspicuous. The andesite and local slivers of tuff-breccia lying between the walls of the fault zone have been subjected to shearing and limited brecciation. The principal shears are either vertical or dip northward at steep angles. Hydrothermal alteration is intense and locally the andesite is bleached nearly white and thoroughly softened. Much of the andesite is carbonitized, some so thoroughly that the original porphyritic texture is obscured. Calcite and calcite-chalcedony veinlets are locally numerous.

Ore mineralization is spotty and confined mainly within the fault zone, although a little cinnabar occurs locally along transverse fractures in the wall rock. Very little cinnabar remains in sight. It was observed as narrow seams in veinlets of calcite and banded calcite-chalcedony and is most abundant adjacent to the gouge seam along the north wall. Locally, bands of marcasite and pyrite alternate with cinnabar. Elsewhere they occur together, the iron sulphides surrounding the cinnabar. Vertical transverse fractures are said to have been associated with the best ore pockets. It is probable that these transverse fractures were originally joints along which movement occurred during the faulting. Some of them were later mineralized.

A stope was carried from the intermediate level to the surface, but how much of the material was ore is indeterminable. According to Wells and Waters (1934, p. 45), the ore retorted in 1929 and 1930 indicated that parts of the lode as much as 5 feet wide may have averaged from 1 to 2 percent quicksilver.

MAUD S. MINE

Location: North central part of sec. 34, T. 29 S., R. 2 W., high on the south flank of Deadman Creek and about 8½ miles north by mountain road from a point on the South Umpqua River Road about 6.5 miles east of Tiller. The Maud S. mine is about 1,600 feet S. 25° E. of the Buena Vista mine and is part of the same property (see figure 17).

Owners: Steve Cooper and Bernard Young, Roseburg.

Production: None recorded; probably a few flasks.

History and development: Development of the Maud S. mine was begun in 1927 by H. L. Pennell, J. W. Gilpin, Josie Gilpin, and Ralph Young. During 1928-1930 the mine was operated by the Oregon Mercury Co. in conjunction with the Buena Vista mine and according to local informants a few flasks were produced. During the period 1934-36, a small Scott furnace was erected by Christie Brothers of Klamath Falls. From the size of the calcine dump it is judged that about 100 tons of ore was subsequently treated. P. A. Nichols acquired the property in about 1938 and sold it to the present owners in 1954.

The principal development on the Maud S. group of claims consists of about 900 feet of workings distributed among three adits with connecting raises and, on the surface, a glory hole that cuts into the upper adit. The intermediate adit, now caved, is 60 feet above the lower adit and 30 feet below the upper adit and floor of the glory hole. The plan of the workings is shown by figure 19.

Geology: The country rocks are tuffs, tuff breccias, and andesites of the Western Cascades volcanic series. The upper and intermediate levels are in andesite. The lower level lies mainly in the tuffaceous rocks. In the crosscut on the lower level, tuffaceous rocks to the west are in contact with andesites to the east along a fault trending N. 25° W. and dipping 65° E.

The upper adit and glory hole developed a small ore body lying along a fault trending N. 25° W. and dipping 70° W. This fault continued to the intermediate level but mineralization along it was weak. The lower adit drifts along one, then another, of several faults and fractures that branch and diverge in a northwesterly direction and dip from 60° to 80° W. The crosscut to the east intersects several faults of similarly variable trends. Within the fault zones, which range from a few inches to 4 or more feet in width, the volcanics are intensely sheared and carbonatized. Veinlets of calcite and silica-limonite ribs are common both in the fault zone and in the wall rocks. Cinnabar is sparsely distributed along some of the faults. The richest zone lay just south of the crosscut in the main drift, where the cinnabar occurs along a grouge-filled fault zone trending N. 45°W. and dipping 65°W. The ore lies in the hanging wall of the fault and is associated with veinlets of calcite.

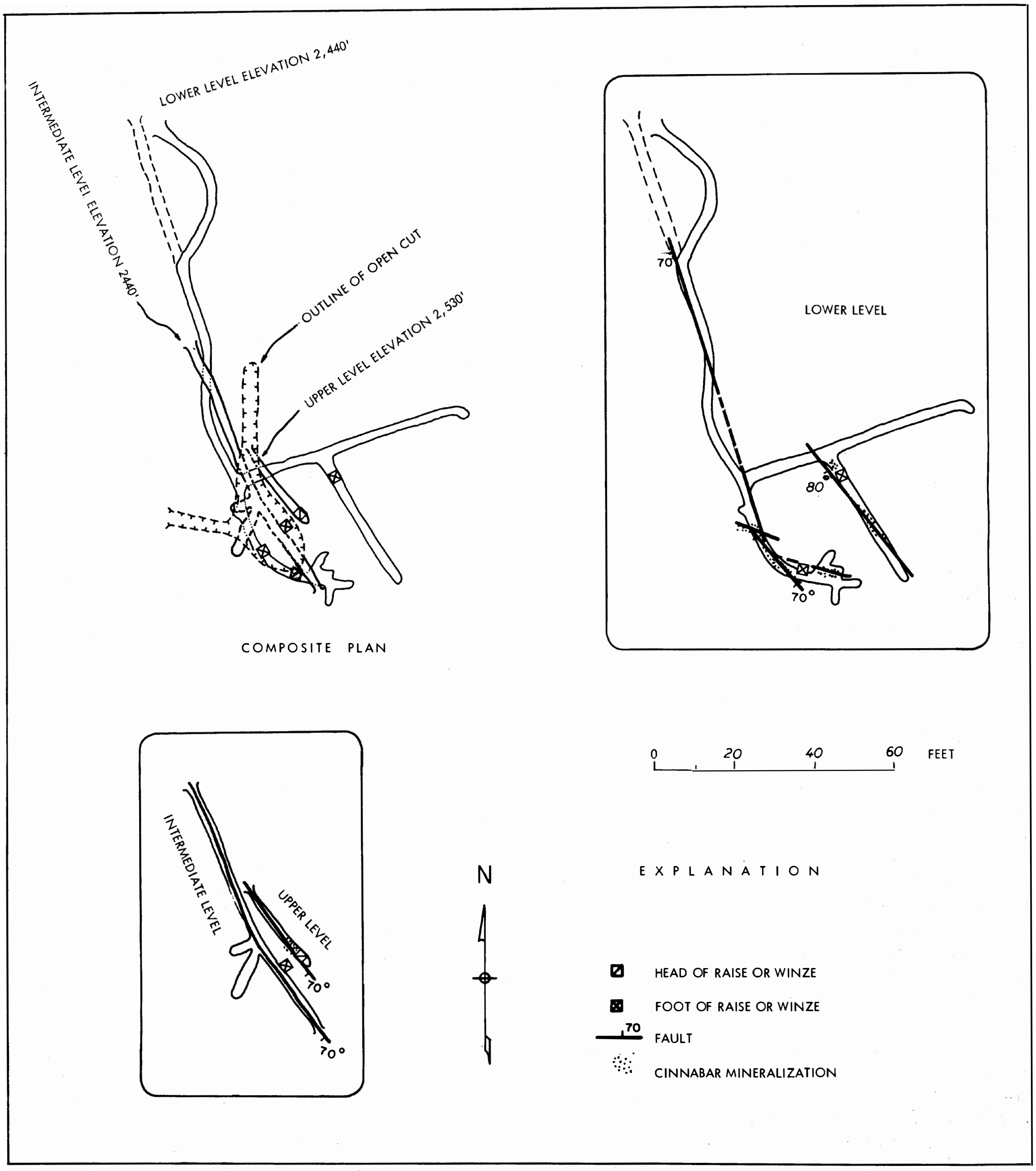


Figure 19. Plan of workings of the Maud S. mine.

Discontinuous veinlets of cinnabar one-quarter inch thick were observed; however, the overall tenor of the ore is low. A chip sample across the raise assayed 1.3 pounds per ton quicksilver. This zone may be a downward continuation of the shoot mined from the glory some 90 feet above.

Another adit lies downslope about 600 feet from the Maud S. workings. It is 220 feet long, curves slightly, but trends generally southeast in andesite and andesite agglomerate. This adit cuts several narrow faults that strike north 10° to 45° W. and dip steeply east or west. A small amount of cinnabar in calcite was seen in a short raise at the face.

JAMES R. GROUP

Former name: Pollanz prospect.

Location: Secs. 34 and 35, T. 29 S., R. 2 W., a short distance southeast of the Maud S. mine.

Owner: Unknown.

Production: None.

General description: The discovery claims were located by J. L. Pollanz in 1927. R. A. Schircliff of Tiller later relocated the property as the James R. group.

Several adits and opencuts were driven to explore veinlets of calcite and chalcedony associated with small faults cutting altered andesite lavas and tuffs. Wells and Waters (1934) mention two adits trending a few degrees east of north -- the lower 140 feet long, the upper several hundred feet higher and 80 feet long. It is said that very little cinnabar was found in either of these adits or in the several other shorter adits and opencuts, all of which are now caved.

GOPHER MINE

Location: Sec. 11, T. 29 S., R. 1 W., about 1½ miles northwest of Boulder Creek Bridge and about half a mile west of Boulder Creek. Elevation of the property is about 2,000 feet.

Owner: Unknown.

Production: None.

General description: The property was not visited by the writer. The Oregon Dept. Geology and Mineral Industries (1940, p. 124) reports that the prospect was located in 1936, and was owned in 1938 by Guy Pennell. The geology is described as follows: "Country rock is rhyolite, and it is reported that cinnabar can be panned over a distance of 1,000 feet. Four samples taken -- two from the discovery tunnel and two from an open cut about 600 feet NE of the discovery tunnel -- all ran a trace."

LAUREL GROUP

Location: SW¼ sec. 24, T. 28 S., R. 1 E., on the southwest side of a steep knob about one mile N. 25° E. from Flagstone Peak. It may be reached from the Quartz Mountain road by walking southeast along a ridge for two miles.

Owners: C. L. Hartley, Tiller, and H. J. Dean, Sutherlin.

Production: None.

Development: One shallow opencut.

Geology: As described by Len Ramp (unpublished Oregon Dept. Geology and Mineral Industries mine-file report, 1960), the area is underlain by volcanic rocks consisting of tuffs (in part sedimentary), basalts, and rhyolite. The prospect is on a mineralized zone in a rhyolite dike or plug. The zone, which is 3 feet wide, strikes northwest, is nearly vertical, and can be traced for about 30 feet in the discovery cut. It contains narrow seams of barite crystals with lesser quantities of goethite, pyrite, and minor amounts of cinnabar. Of two samples assayed by the department, one contained 0.8 pounds of quicksilver per ton and the other, 0.5 pounds per ton.

MILLS PROSPECT

Location: Sec. 15, T. 29 S., R. 1 W., about $1\frac{1}{2}$ miles by trail up Dumont Creek from the South Umpqua River Road.

Owner: Unknown.

Production: None.

General description: The property is developed by several pits and short adits, one of which is 42 feet long with a 35-foot winze at the end. Most of the work was done by L. O. Mills during the late 1930's and early 1940's. The workings explore a north-trending fault zone cutting andesites and tuffs. Cinnabar is scarce, occurring in veinlets of chalcedony and calcite, within the fault zone.

POOR BOY PROSPECT

Former name: Monte Carlo Claims.

Location: On Budd Creek in the $S\frac{1}{2}$ sec. 16, T. 29 S., R. 1 W., about 14 miles by road northeast of Tiller via the Straight Creek road, which branches from the South Umpqua River Road 10.7 miles northeast of Tiller.

Owners: W. E. Belcher, Emmett Belcher, and others of Tiller.

Production: None.

History and development: The prospect was located by Dave Crispen and associates around 1927 and was relocated by the present owners in 1954. The property is developed by two short adits. One enters the west side of the Straight Creek road about 100 feet north of Budd Creek. The other enters the north bank of Budd Creek near creek level about 2,000 feet west of this point. There is a small cabin adjacent to the portal of the latter adit.

Geology: Rocks in the area include andesite flows, tuffs, and agglomerates of the Western Cascades volcanic series. The adit in the road cut is 48 feet long and was driven N. 48° W. along one of several narrow subparallel faults that make up a shear zone about 20 feet wide. Most of the individual faults dip 55° to 75° NE. Striae on several of the fault planes pitch 5° to 10° NW. The faults are marked by up to a foot of limonitized clayey gouge cut by veinlets of chalcedony and calcite. The intervening rocks are altered, partly to clays and limonite, and mildly silicified. Pannings from the gouge zones show a few minute crystals of cinnabar and pyrite. The adit near the cabin drifts along a fault zone trending N. 35° W. for 33 feet, then turns N. 50° W. for 37 feet. At the turn a drift 25 feet long trends N. 25° E. exploring a series of narrow, closely spaced fractures that dip 40° S. At the intersection of the two fault zones the rocks are considerably brecciated and softened by alteration. Toward the portal several fractures, whose walls are limonitized and kaolinized, are exposed. The alteration generally extends less than 4 inches from the fractures but occasionally lenses out to more than one foot. Pannings from the fault intersection and from several of the kaolinized fractures failed to show more than half a dozen minute cinnabar crystals and a little pyrite.

UPPER COW CREEK AREA

The Upper Cow Creek area includes a group of mines and prospects situated along the slopes of the East Fork of Cow Creek in secs. 16 and 21, T. 32 S., R. 2 W. In this group are the Red Cloud mine and adjacent Nivinson and Thomason prospects in Douglas County and the Elkhorn prospect in Jackson County. The area lies in the Tiller quadrangle. It is about 7 miles by dirt road west of the Divide Guard Station, which is on Oregon Highway 227 approximately 11 miles north of Trail.

Figure 20 shows the approximate distribution of workings in the area. Also shown are the various claim groups as they existed in 1946. It is very likely that property boundaries have changed, but little additional development work has been done and the various groups of workings are best known by the names given on the map.

Rocks in the area comprise massive to schistose amphibolites and quartz mica schists of the Triassic Applegate

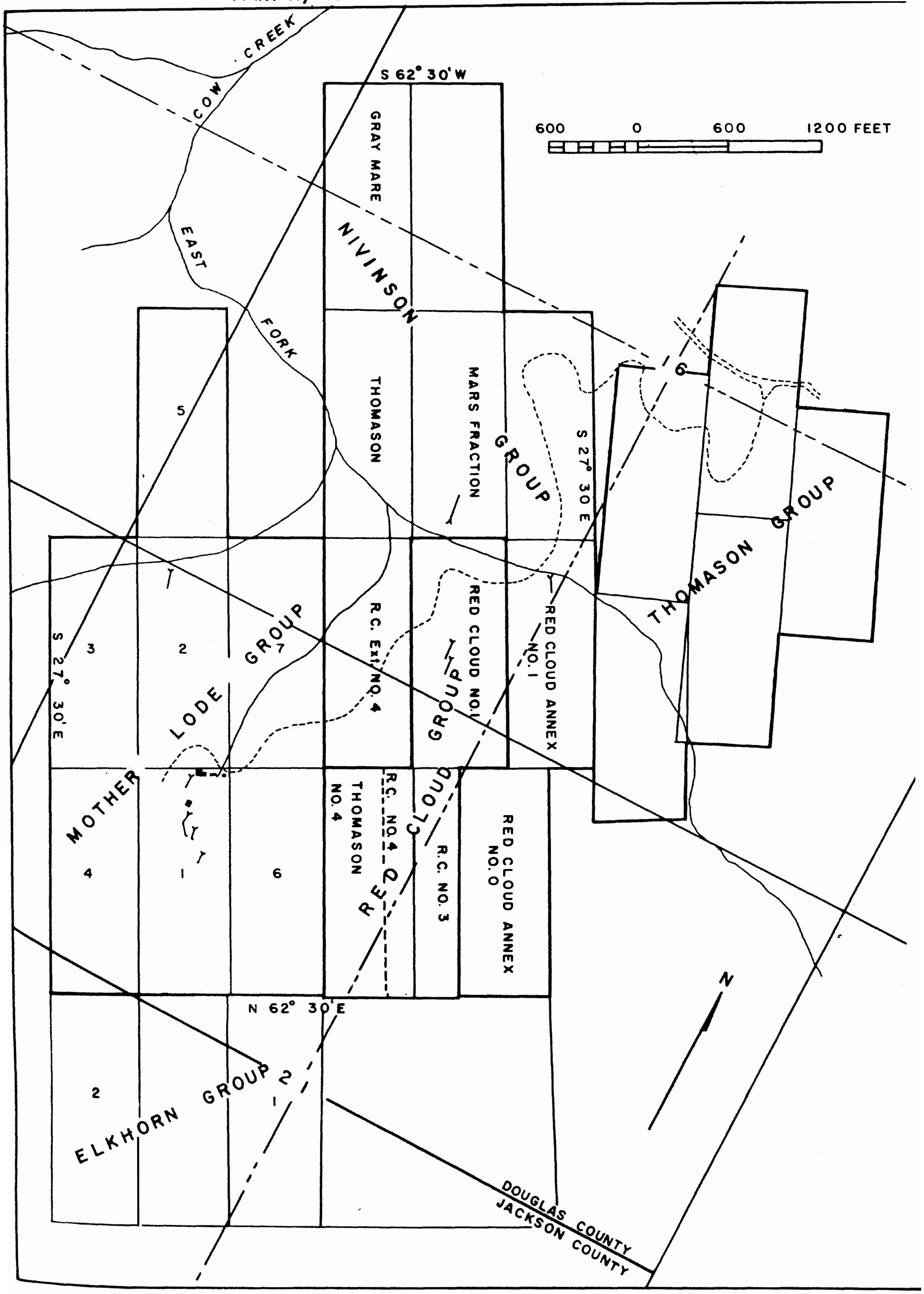


Figure 20. Sketch showing approximate distribution of workings and claim boundaries in the Upper Cow Creek area (surveyed in early 1940's, author unknown).

Group locally overlain by Tertiary lavas. Because of the scarcity of exposures, the general attitude of cleavage laminae in the older rocks could not be confidently determined. Several nearly vertical shear zones have been exposed by mine and prospect workings. Most of them trend N. 20° to 40° W., although a few have a northeasterly trend.

Only at the Red Cloud mine is any appreciable amount of cinnabar known to have been found in place, although it occurs as float and pannings in the surface mantle of many parts of the area. The fact that the many other workings penetrated barren or only weakly mineralized rock suggests that the float was probably derived from numerous occurrences which alone are too small and widely scattered to permit profitable exploitation.

RED CLOUD MINE

Former name: Mother Lode mine.

Location: Near the center of the NW$\frac{1}{4}$ sec. 21, T. 32 S., R. 2 W.

Owner: Mrs. B. E. Hanson.

Production: 6 flasks recorded; probably 63 produced.

History: Cinnabar was discovered in the area in 1907 by R. W. Thomason, Lewis Thomason, and William Sasse. Some development work was done between 1908 and 1911 by the Scotia Development Co. No production was made and the prospects lay idle until 1932. The Research Mining Co. operated the mine from 1932 through early 1934, producing 39 flasks with a small 3-pipe retort. In 1935 the property was purchased by Dr. Russell Kaizer. During 1936-38 at least 14 flasks were produced from his operations and from those of subsequent lessees.

In 1940 the property was acquired by the Red Cloud Mining Co., headed by Chas. H. Greely, and during 1940-41,10 or 12 flasks were produced with a newly installed 20-ton rotary furnace. Ownership was later transferred to J. A. Jaeckel, C. S. McDowell, A. A. Headrick, Horace White, and B. E. Hanson. In 1946 the property was leased to J. R. Davies, but there is no record of production from his operations. Assessment work has been kept up in recent years by Mrs. B. E. Hanson. In 1957 the furnace and other servicable equipment were moved to the Angel Peak mine in the Quartz Mountain area in Lake County.

Development: The mine is developed by several adits and open cuts. The uppermost adit of the three shown in figure 21 was open for about 170 feet when visited. The other workings are caved.

Geology: The following information on the geology is based on inspection of the open workings by the writer, supplemented by earlier reports by Williams and Compton (1943) and Dole (unpublished Oregon Dept. Geology and Mineral Industries mine-file report, 1946).

The Red Cloud mine workings explore a fault zone cutting rocks of the Applegate Group consisting of dark green, massive, fine-grained amphibolites alternating with quartz hornblende and quartz mica schists. Contacts between the various rock types appear to be gradational.

The fault zone contains a series of sub-parallel veins or mineralized shear zones that trend N. 25° to 35° W. and are either vertical or dip eastward at angles in excess of 70°. The trace of the fault zone is marked by a shallow ravine, along which the workings are distributed.

The shear zones generally contain soft masses of limonitized and carbonatized clay gouge; enclosed lenses of sheared but relatively less altered amphibolite are also common. Numerous branching veinlets and small bunches of calcite and minor amounts of quartz cut both the gouge and the sheared amphibolite and locally penetrate the wall rocks. Pyrite is sparsely distributed through the gouge and in the adjacent wall rocks. Some of the shear zones are as much as 12 feet in width but the average width is 4 or 5 feet. Cinnabar was observed as paint-thin coatings on fractures and as faint disseminations in the gouge. A sample taken across 4 feet of gouge in the west drift of the upper adit assayed 0.4 pounds of quicksilver per ton. It is said that the better ore is associated with concentrations of calcite in the clay gouge. Cinnabar also occurs with pyrite in calcite veinlets cutting the wall rocks. Specimens of fractured calcite containing cinnabar veinlets half an inch wide were observed on the dump of the upper adit.

ELKHORN CLAIMS

Location: Sec. 21, T. 32 S., R. 2 W. about a quarter mile south of the Red Cloud mine.

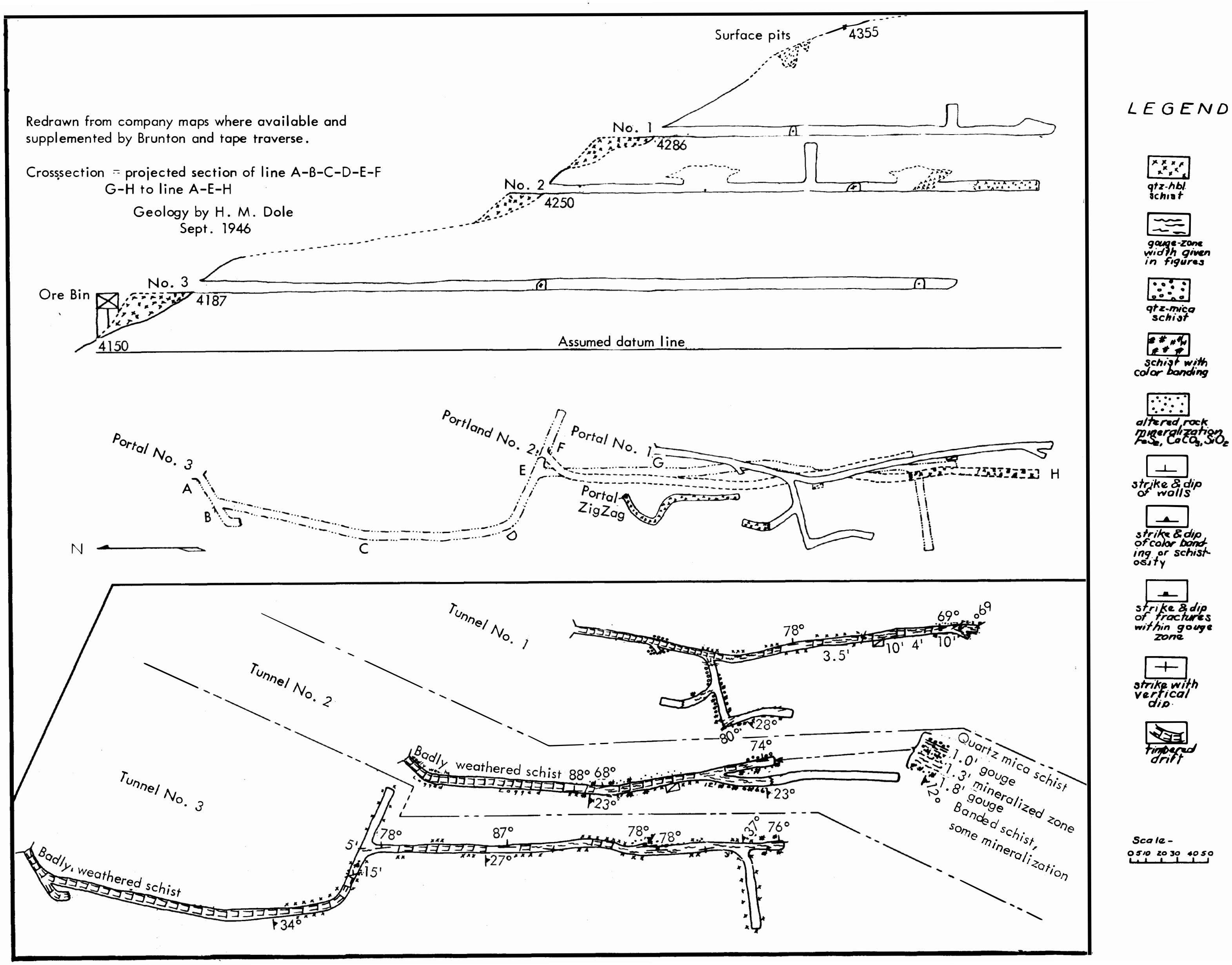


Figure 21. Geology, plan, and section of the Red Cloud mine.

Owner: Carl Bergman.

Production: None.

General description: The prospect was discovered a number of years ago by Lew Thomason. Development consists of several opencuts and short adits, most of which have been destroyed by logging operations.

The rocks are mica schists and amphibolites of the Applegate Group. An adit about 10 feet long has been driven S. 55° W. following a shear zone that dips 40° W. The shear zone contains about 3 feet of amphibolite that has been mildly altered to clays and limonite. A sample of the material assayed 0.5 pound of quicksilver per ton. About 50 feet above the adit a shallow dozer trench exposes another sheared zone of similar width that strikes N. 35° - 55° W. and dips about 60° S. Two samples taken from it panned a few crystals of cinnabar and a little pyrite.

NIVINSON PROSPECT

Location: SW$\frac{1}{4}$ sec. 16, T. 32 S., R. 2 W., near the bridge crossing the east fork of Cow Creek on the old mine road about three-eighths of a mile north of the Red Cloud mine.

Owner: John Adams, Salem.

Production: None recorded.

Development and geology: The property is developed by several short adits and opencuts. Most of the work was done prior to 1929 by Henry and Frank Nivinson. One of the adits enters the south bank of the creek just above the old bridge. Another enters the north bank of the creek a short distance below the bridge. Neither was accessible when visited by the writer. Material on the dumps indicates that bedrocks encountered were amphibolite schists cut by veinlets of calcite. Pannings from the dumps contain traces of cinnabar. Before passing into the bedrock the lower adit apparently penetrated several feet of bouldery terrace material, from which local historians report pieces of high-grade cinnabar float were obtained.

Other short adits and opencuts are scattered about the north bank of the creek above the lower adit. They are reportedly caved and were not visited. Wells and Waters (1934, page 47) state: "Two of the adits are at the same altitude and within 15 feet of each other; the third is 200 feet farther up the slope. The adits are 30, 40, and 48 feet long. They are all in mica schist and follow for parts of their courses fractures that strike N.27° E. A few small stringers of calcite were seen, but no indications of cinnabar. Farther up the ridge a few shallow pits were examined, but none of these was sufficiently deep to pass below the weathered zone."

THOMASON GROUP

Location: SE$\frac{1}{4}$ sec. 16 T. 32 S., R. 2 W., a short distance northeast of the Nivinson prospects.

Owner: Unknown.

Production: None.

Development and geology: Development consists of at least 4 bulldozer trenches, each about 100 feet long, and several shallow shafts and pits all of which were dug by Lewis Thomason more than 20 years ago. Thomason is said to have also dug about 500 auger holes to depths of 6 or 8 feet, reporting favorable "pannings" over several acres. However, few of the holes penetrated below the mantle of soil and broken rock consisting mainly of decomposed schists. Several narrow fault zones having approximately the same trend as those at the Red Cloud mine were exposed by the trenching operations, but none contained an appreciable amount of cinnabar.

TRAIL AREA

The Trail area includes at least 7 small quicksilver deposits scattered along both sides of the Rogue River east of Trail in Ts. 33 and 34 S., Rs. 1 E. and 1 W., Jackson County. Topography of the area is given on the Trail and Butte Falls quadrangles.

Figure 22 shows the geology of the area, as adapted from Wilkinson and others (1941), and the distribution of the deposits. Like the deposits northeast of Tiller, those in the Trail area lie in gently dipping volcanic rocks of the Western Cascades. No large or persistent fractures have been found and all veins are of low grade. Cinnabar is concentrated in veinlets of chalcedony filling minor fractures in altered flows and tuffs. Although no records of production from the district exist, it is said locally that a little quicksilver was recovered from the Ash and the Poole and Pence prospects.

The prospects in the Trail area are described by Williams and Compton (1943), and some of the following information is taken from their unpublished manuscript.

ASH PROSPECTS

Location: NW$\frac{1}{4}$ sec. 1, T. 34 S., R. 1 W., on the steep western flank of Bear Mountain east of Brush Creek and south of the Rogue River. The prospects lie about 1$\frac{1}{2}$ miles east of Trail and are reached from Shady Cove by county road along the south bank of the Rogue River. A jeep road ascends Brush Creek and Bear Mountain to the uppermost workings at about 700 feet above the Rogue River.

Owners: E. C. Tams and John Carter, Medford.

Production: None recorded; a few tons of ore were retorted.

History and development: The workings, which are widely scattered, include three adits having an aggregate length of 335 feet, a 35-foot shaft, and several trenches and opencuts. Most of the work was done by E. E. Ash prior to 1930 (Wells and Waters, 1934, p. 48). A tram line was built across the Rogue River near the mouth of Brush Creek in 1930 by the Cinnabar Mountain Mining Co. The present owners relocated the property in 1957.

Geology: The country rocks are nearly flat-lying rhyolite flows and, less commonly, rhyolitic tuffs and breccias overlain by porphyritic basalt. The known prospects are confined to the rhyolitic rocks which over a wide area have undergone a high degree of minor fracturing and silicification. Most of the underground workings, though not maintained for many years, remain open. Cinnabar, commonly associated with small amounts of chalcedony and limonite, and, occasionally, thin seams of clay gouge, is sparsely distributed along small discontinuous fractures.

The 50-foot adit (No. 4) of Wells and Waters, which is near the end of the mine road at an elevation of about 2,175 feet, has been extended irregularly southeastward and is now 176 feet long. A crosscut, 106 feet from the portal, extends southward for 12 feet, then S. 10° E. for 20 feet. From the portal nearly to the crosscut the adit follows a vertical fault trending S. 63° E. The fault dies out near the crosscut. Along the fault the rhyolite is fractured, locally brecciated, and silicified. Cinnabar occurs sporadically as paint-thin coatings on fracture surfaces. In and beyond the crosscut, the massive rhyolite is strongly jointed and impregnated with veinlets of chalcedony and limonite. The joints are locally coated with cinnabar.

On top of the ridge, about 50 feet above this adit, a shaft 35 feet deep containing a 12-foot drift from its foot explores a fault zone that strikes N. 35° W. and dips 80° E. About 250 feet below the shaft a second adit enters the southeast flank of the ridge, trending N. 38° W. for about 80 feet. A third adit lying at 1,700 feet elevation near the base of the slope trends S. 80° E., following a series of fractures dipping 80° S. for about 50 feet. No cinnabar was visible in the shaft or in the two lower adits.

DONALDSON PROSPECT

Location: West of the Ash prospect on the opposite side of Brush Creek in the SE$\frac{1}{4}$ sec. 35, T. 33 S., R. 1 W., and the NE$\frac{1}{4}$ sec. 2, T. 34 S., R. 1 W.

Owner: Unknown.

Production: None.

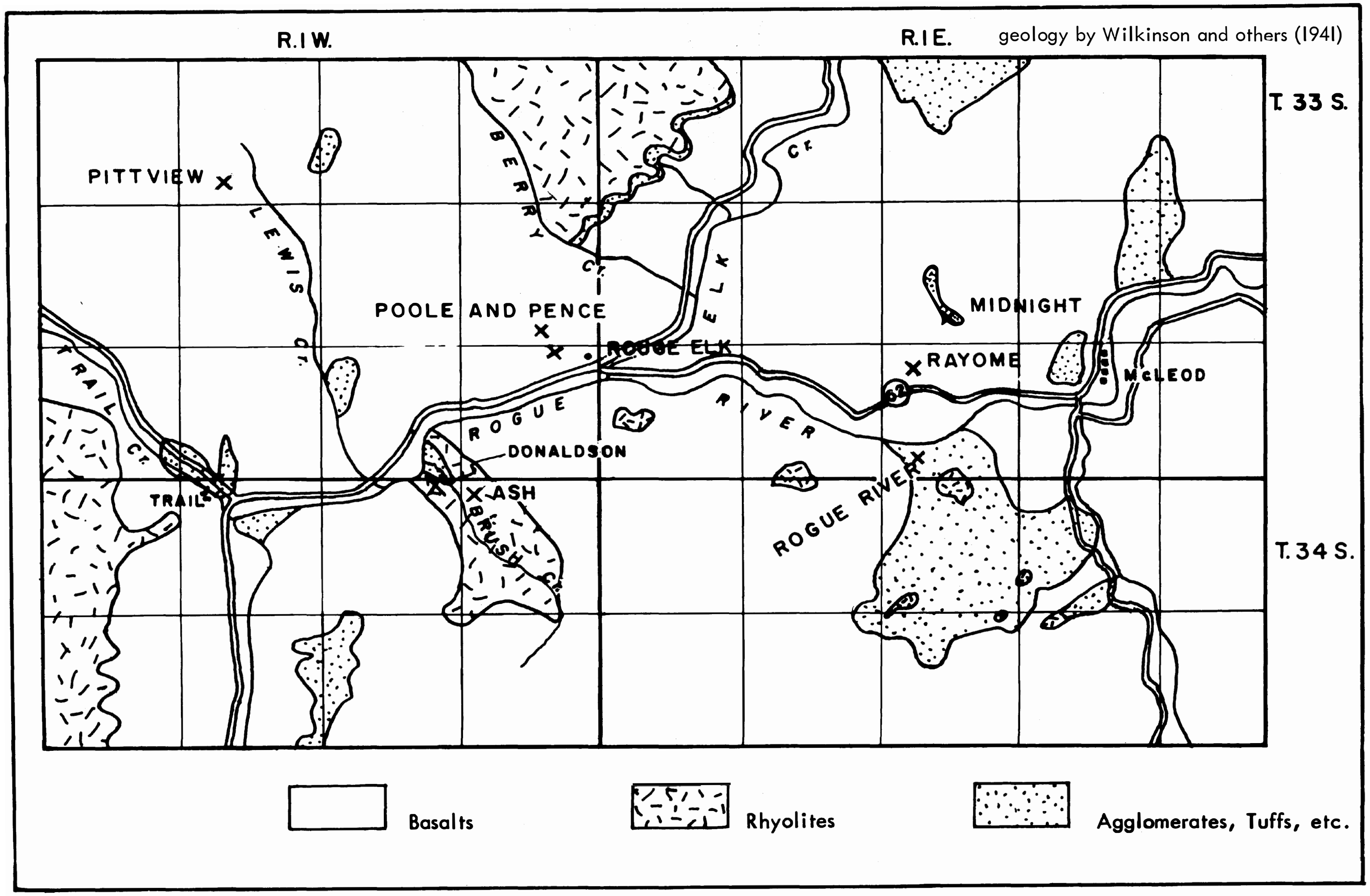


Figure 22. Geologic sketch map of the Trail area, showing location of quicksilver deposits.

Development: Most of the work here was done by Paul Donaldson during 1940-41. Development includes an adit 60 feet long and several opencuts scattered along the crest of the ridge that flanks Brush Creek on the west.

Geology: The country rocks are rhyolite flows and intercalated tuffs that have been silicified and in many places are cut by limonite-stained chalcedony veinlets. The rocks have been irregularly fractured. Some of the fractures are filled with seams of gouge an inch or so thick. Cinnabar is visible in only a few places, occurring as specks in the limonite-chalcedony veinlets and as fine crystals in gouge.

MIDNIGHT PROSPECT

Location: South-central part of sec. 28, T. 33 S., R. 1 E. about half a mile northeast of the Rayome prospect.

Owner: Unknown.

Production: None.

Development: Development includes a series of 8 or 10 opencuts along a north-trending ridge. This work was done by O. H. Peterson and Thomas Madden around 1940.

Geology: The trenches expose gently dipping, interbedded basalts and tuff breccias. The latter are bleached and softened and cut by chalcedony veinlets, some of which are limonite stained. Cinnabar is sparsely distributed in and along the edges of some of the veinlets.

PITT VIEW PROSPECT

Location: SW$\frac{1}{4}$ sec. 22, T. 33 S., R. 1 W., on the west bank of Lewis Creek about 3 miles by road north of Crater Lake Highway.

Owner: T. P. Adams.

Production: None.

Development: Workings consist of a caved adit 35 feet long and several shallow pits and trenches, most of which were dug about 1940 by T. P. Adams of Trail.

Geology: The country rocks are andesitic lavas and agglomerates; thick soil and overburden mask the structural relations. A small amount of cinnabar and native quicksilver can be panned, both from the soil and from the decomposed andesite on the adit dump.

POOLE AND PENCE PROSPECTS

Location: South-central part of sec. 25, and NE$\frac{1}{4}$ sec. 36, T. 33 S., R. 1 W., a quarter to half a mile north of Crater Lake Highway near Rogue Elk.

Owner: G. R. Moore, Rogue Elk.

Production: None recorded; a few hundred pounds of ore were retorted.

History: Most of the work on the property was done by J. L. Poole and later by Ed Pence. A. G. Rodgers prospected the area during the early 1940's. Little work has been done since.

Workings and geology: The Poole prospect consists of a series of small pits and trenches in the adjoining eastern parts of secs. 25 and 36. The cuts expose small veins trending roughly north and cutting altered basalt. The veins, at least one of which is about 1 foot in maximum width, are composed of brecciated and silicified basalt cemented by chalcedony. The walls of the vein for a distance of a few inches to several feet are softened to a mealy consistency and cut by many veinlets of limonite. Poole is reported to have exposed small quantities of cinnabar in some of the pits. None was seen by the writer.

Two short adits driven by Ed Pence lie in the south-central part of section 25 about a quarter of a mile west of the Poole prospect. A small retort was once erected nearby. An old road, now almost impassable, leads to these workings. The uppermost of the two adits trends N. 58° E. for 72 feet through altered basalt. Near the portal the tunnel exposes a fault zone 2 feet wide in basalt. Shear planes strike N. 10° E. and dip 75° W. Slickensides pitch gently south. At the face of the adit a fault striking N. 5° E. and dipping 45° W. contains as much as a foot of crushed basalt and clay gouge. The lower adit, 200 feet to the south, trends N. 45° E., also through altered basalt. Intersecting fractures are numerous. Some contain a little clay but no evidence of displacement was observed.

No cinnabar was seen along the walls of either of the adits; however, a sample taken from the upper adit dump panned a few small crystals. Several cuts in altered basalt and andesite are scattered about the slope above the upper adit, two of which show a little cinnabar along siliceous veins in basalt. According to Rodgers, a shaft about 40 feet deep sunk on a siliceous vein lies a few hundred feet west of the Pence adits. This was not visited by the writer.

RAYOME PROSPECT

Location: NW$\frac{1}{4}$ sec. 33, T. 33 S., R. 1 E., a third of a mile north of Crater Lake Highway from a point 1.8 miles east of Rogue Elk.

Owner: Unknown.

Production: None.

Workings and geology: The prospect was not visited by the writer. Williams and Compton (1943) report as follows:

> "The chief workings are on the Flashlight Claim, extending 300 yards east from a point 200 yards up the creek from Rayome's cabin. They include five open cuts, 12 to 50 feet long and up to 10 feet deep, and two pits about 5 feet deep. Other smaller pits and trenches reveal nothing but soil mantle.
>
> "The country rocks are basaltic lavas and breccias. Two parallel, vertical shear zones, 40 feet apart and striking 60° to 65° W. are explored by the main cuts. They vary in width up to 18 inches and carry seams of gouge up to 3 inches across. Adjacent to the fractures the rocks are bleached a pale cream color and are charged to varying degree with limonite, kaolin, and silica. Cinnabar paint occurs in two or three of the cuts and values up to a fraction of a pound per ton were panned from the shear zone exposed in one of the pits. The limonite ribs developed along an older irregular set of fractures appear to be entirely barren."

ROGUE RIVER PROSPECT

Other names: Red Chief prospect; Steel Head prospect.

Location: SW$\frac{1}{4}$ sec. 33, T. 33 S., R. 1 E., on the south bank of the Rogue River about 3 miles east of Rogue Elk. A private dirt road passing through the yard of the first farm south of the McLeod Bridge leads downriver 1$\frac{1}{2}$ miles to the workings.

Owner: A. C. Van Galder, Jacksonville.

Production: None.

History and development: The property is developed by two adits and several small opencuts (see figure 23). None of the opencuts penetrate below the mantle of soil and broken rock. A small frame cabin and a 1-tube retort in poor repair are on the property.

The lower adit is about 100 feet above the river level. It contains about 260 feet of workings, including a drift about 180 feet long and three crosscuts each about 25 feet long. The upper adit 42 feet above and about 50 feet southwest of the lower is 23 feet long.

Little is definitely known about the history of the property. Wells and Waters (1934, p. 49) report that in 1930 the property was owned by G. C. Cottrell, William Cottrell, and Sprat Wells. During 1939, and possibly for several years thereafter, the property was owned by A. G. Rodgers, now living in Rogue Elk, Oregon.

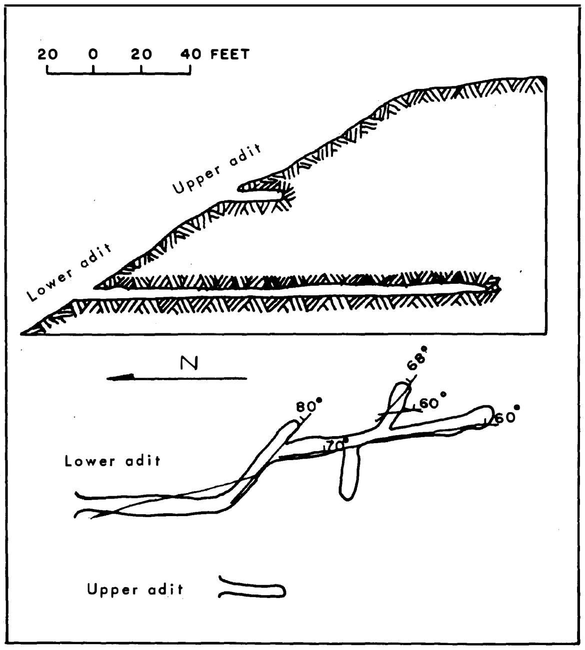


Figure 23. Plan and section of the Rogue River prospect (country rock is altered basalt).

About 50 feet of work was done by hand in the lower adit by Rodgers in 1940. Little work has been done since that time, although the property has apparently changed hands several times. According to Rodgers, John Walker and Associates relocated the property in 1956. A 1-tube retort was erected and about 1,000 pounds of rock were treated but little or no development work was done. The property was acquired by Van Galder in the summer of 1959 and is now called the Steel Head Mine. There is no record that any quicksilver has ever been produced from the property.

Geology: Rocks in the vicinity of the workings have been profoundly kaolinized, limonitized, and silicified, and appear to have been basalt flows. Veinlets and nodules of chalcedony, some of which are stained with limonite, are common. Some calcite is present and limonite veinlets are widespread. Narrow layers of gouge follow fractures in or adjacent to fault zones. Several faults and fractures are exposed in the workings.

The first 60 feet of the lower adit appears to be devoid of ore. At that point the tunnel turns along a fault striking S. 50° E. and dipping 80° NE. The fractured and brecciated rocks along the fault contain only traces of cinnabar. At a point 76 feet from the portal the adit turns along a fault which strikes N.10° W. and dips about 70° E. The width of the fault varies from a few inches to about 4 feet. A slickensided fault surface locally forms the west wall of the adit. The basalt here is brecciated and locally silicified. Seams of gouge have formed in the fractures. Cinnabar occurs as fine, disseminated crystals in the siliceous breccia and as paint-thin coatings on fractures. Of six channel samples taken across the width of the drift from the first crosscut to the face, none assayed less than 0.2 pound per ton and none more than 1.5 pounds per ton. Small samples could be obtained, however, which would run as high as 20 pounds to the ton.

The southernmost crosscut into the hanging wall intersects a minor north-trending fault which shows some cinnabar. It then follows parallel shears trending N. 78° W. and dipping 68° N. in mildly altered basalt. Wilkinson (1940, p. 2) quotes a report from Rodgers that 8 percent ore was obtained from this crosscut. No significant amount of cinnabar is presently visible. The northern crosscut into the hanging wall appears to be barren as is the crosscut into the footwall. The footwall here is an amygdaloidal, porphyritic basalt, slightly kaolinized and calcitized and seamed with limonite.

The upper adit was driven S. 10° E. for 23 feet along a shear zone 30 inches wide and dipping 75° E. Slickensides rake 20° S. No cinnabar was visible. Soil and loose rock in the opencuts above the adits are said to show fair color when panned.

MEADOWS AREA

All of the quicksilver deposits of the Meadows area, except the Bonita mine, are scattered through the timbered hills bordering the "Meadows" of Evans Creek (Figure 24). The Meadows lie in the south-central part of T. 34 S., R. 2 W., Jackson County, about 25 miles from either Medford or Gold Hill. Short side roads give access to most of the mine and prospect workings. The Bonita mine lies about 8 miles by road northwest of the Meadows in T. 33 S., R. 3 W. The Trail quadrangle map gives topographic coverage for the area.

History of the Meadows area

Quicksilver was discovered in the Meadows area in 1878 (Schuette 1958, p. 81). By 1884 claims had been taken, deposits examined, and metal produced (Walling, 1884, p. 321) for use by the local placer-gold miners. Stafford (1904), reporting on his visit to the area in 1903, stated "...the Rogue River Quicksilver Mining Co. (incorporated August 5, 1901), having Dr. J. M. Keene of Medford as one of its major stockholders, had sunk

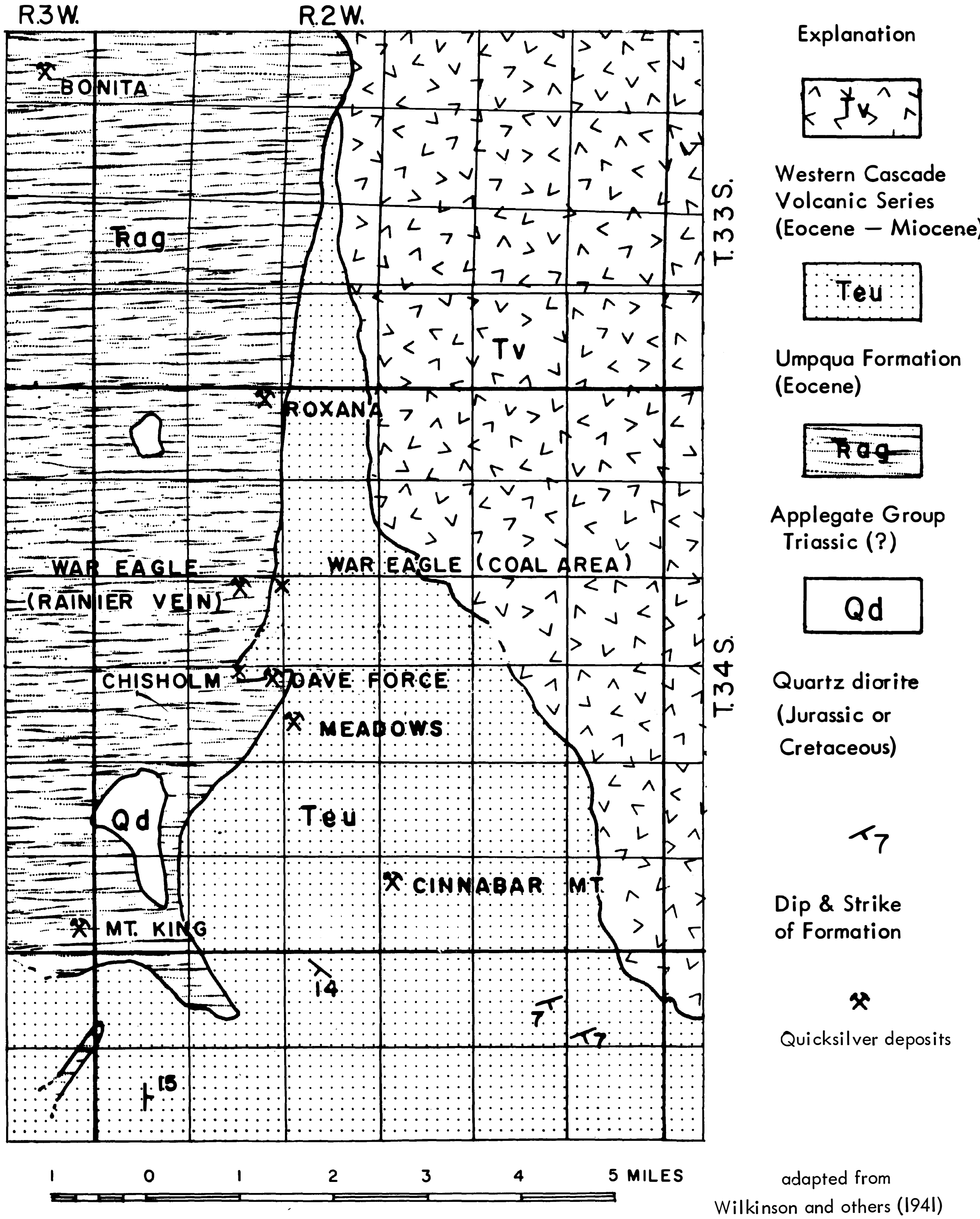


Figure 24. Geologic sketch map of the Meadows area showing distribution of the quicksilver occurrences.

a 55-foot shaft and started a tunnel 150 feet below; Reed and Fletcher had sunk a shaft 118 feet in depth; and the Mayfield property was said to have had a large body of ore carrying one percent mercury."

There are no records of where work was done either by the Rogue River Quicksilver Mining Co. or by Reed and Fletcher. The Mayfield property later became part of the Chisholm claims.

World War I demands for quicksilver stimulated activities and led in 1916 to the first recorded shipments from the area. By the end of 1919 when quicksilver prices began to decline, recorded production from the area stood at 546 flasks, 532 of which had come from the Rainier vein of the War Eagle mine. Since World War I, recorded production from the area has been small and sporadic, amounting to 282 flasks, of which 160 flasks were produced during the World War II period (1939-45) from the Mountain King, Cinnabar Mountain, War Eagle, and Roxana mines.

Geology of the Meadows area

The quicksilver deposits of the Meadows area lie within a broad zone of minor normal faults adjacent to, and on both sides of, the contact between rocks of the Upper Triassic (?) Applegate Group and Eocene sedimentary rocks of the Umpqua Formation (Fig. 24). Welded rhyolitic tuff and basalt flows of the Western Cascades volcanic series crop out on the ridge east of the Meadows but these rocks are not known to contain any important quicksilver deposits.

The Applegate Group in this area includes schistose amphibolites with subordinate biotite schists and quartzites. These rocks were called the "May Creek formation" by Wilkinson and others (1941). Unconformably overlying the older rocks is the Umpqua Formation consisting of arkosic sandstones, in part tuffaceous and in part conglomeratic, interbedded with shales and lignitic coal. Locally these rocks are cut by diabase dikes and, near the War Eagle mine, by a massive quartz-rich intrusive. The Umpqua sediments become increasingly tuffaceous upward and appear to grade into the Western Cascade volcanic series.

Planes of schistosity in the Applegate Group have wide variety, but the majority strike N. 20° to 60° E. and dip SE. at angles in excess of 30°. Attitudes in the Umpqua Formation are also highly variable, but dips rarely exceed 15° in any direction. The variation in attitude of the Umpqua Formation is probably due to faulting.

Both north and south of the Meadows area the contact between the Umpqua sediments and the underlying schists appears to be largely depositional. Within the area, however, faulting has occurred along the contact and thick accumulations of gouge are exposed in several of the excavations on the Chisholm and Palomar groups of claims.

The quicksilver deposits are associated with subordinate faults of divergent trends cutting the rocks on either side of the contact, or are confined within diabase dikes which themselves were probably intruded along zones of weakness produced by the faulting. No quicksilver mineralization has been found along the contact, perhaps because the accumulation of gouge was sufficient to prevent access to quicksilver-bearing solutions.

WAR EAGLE MINE

Location: Two groups of workings about half a mile apart: the Rainier workings near the north edge of sec. 17, T. 34 S., R. 2 W.; and the Coal area workings in the NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 16, T. 34 S., R. 2 W.

Owners: Rainier workings are on property owned by Timber Products Co., Medford. Coal area workings are on property held in trust by E. W. Steinbeck for a group of stockholders in Illinois.

Production: 657 flasks.

History: The Rainier vein of the War Eagle mine was discovered by Carl Bertelson in 1916. During that year 35 claims were acquired by location or purchased from other owners and the Utah Quicksilver Co. was incorporated to operate the property by Alex Nibley, H. D. Norton, and Samuel Bertelson. Four flasks were produced during the year. In 1918 the Rainier Quick Silver Co. was organized and took over the property, producing 311 flasks using a Johnson McKay retort of 3-tons-per-day capacity. The mine was operated by the latter company until August 1918 when it was leased to R. S. Jamison.

In 1919 the property was acquired by the War Eagle Mining Co., which operated the mine through 1924, producing 292 flasks, 217 of which were produced during 1919. A 25-ton Scott furnace was built on the property in 1920.

According to Schuette (1938, p. 114), "By 1926 the affairs of the War Eagle Mining Co. had become so involved that the property was sold under foreclosure to satisfy debts and claims against it. It was bought by

Burtelson, Harder, Kidd, and Hilsinger. They turned the property over to the Medford Reducing & Refining Co. for stocks and bonds of this company. The Medford Reducing & Refining Co. was capitalized at $1,500,000 and an issue of $160,000 first mortgage bonds was put out. This company appears to have been largely a promotion scheme and the property passed into the hands of a receiver in the spring of 1928. The mine then became the property of the bondholders."

During the period of 1936-37, George Schumacher recovered 11 flasks from cleanup. He discovered cinnabar in the vicinity of the Coal area workings and explored the new prospect with a short, inclined shaft and a drift about 60 feet long. In 1937 the property was acquired by Mineral Mines, Inc., which, during the next few years, did most of the existing work in the Coal area. A 6-cell flotation plant was installed to concentrate the ore before retorting, and a total of 25 flasks of quicksilver was produced between 1939 and 1946. Use of electrolytic cells for the reduction of the concentrates was attempted unsuccessfully.

In 1953 and 1954, J. H. and J. A. Holtzclaw and S. A. Edwards cleaned out part of the Rainier workings which had been inactive since 1924 and installed a small retort. One flask was produced in 1953 and three in 1954.

In 1960 David W. Chase leased the property, installed a 20-ton rotary furnace, and began cleaning out the old workings on the Rainier vein. The furnace, manufactured by Chase, had formerly been at the Bonita mine.

Geology of the War Eagle mine area: The mine area is underlain by rocks of the Applegate Group and the Umpqua Formation (see Plate 5). Rocks of the Applegate Group consist of dark gray to greenish medium-grained schists composed of plagioclase, biotite, and amphibole. Also present are subordinate quartz-bearing biotite schists and, locally, massive light-colored quartzites. Adjacent to the Rainier vein the schists strike N.45° to 60° E. and dip 15° to 30° SE. On the ridge above the Rainier workings there are bold outcrops of a massive light-colored, quartz-rich intrusive.

The Umpqua Formation consists of fresh-water arkosic sandstones, siltstones, and shales, with subordinate layers of lignitic coal and lenses of conglomerate. The sediments in the vicinity of the coal area workings lie nearly flat. East of the mine, toward the contact with the schists, the dip is to the northeast and markedly steeper.

The contact between the Umpqua Formation and the schists is not exposed. Float and soil color changes suggest its position and indicate that it is a fault in that it holds a nearly straight line bearing slightly west of north, irrespective of changes in topography.

Geology and workings of the Rainier vein: The geology and development of the Rainier vein is shown on Plate 5.

The Rainier vein occupies a well-defined normal fault fissure that strikes N. 70° W. and in general dips from 75° NE. to vertical but in places dips steeply southwest. The fissure is from 3 to 10 feet wide but averages about 4½ feet and is filled with brecciated material consisting mainly of angular fragments of dark gray-to-white microcrystalline quartz and silicified pieces of wall rock. The interstices of the fragments, which rarely exceed 3 inches in diameter, are in places sealed with either crystalline marcasite or a mixture of clays and limonite. In still other places the open spaces between fragments remain void. Cinnabar, generally always associated with marcasite, occurs in the open spaces in the breccia. Scorodite and perhaps other arsenical minerals are present. Analysis also shows considerable arsenic in the marcasite.

Several periods of movement and mineralization are recorded. It appears that, following the inception of movement along the fault, the broken schists were silicified. Renewed movement brecciated this material, allowing access of solutions bearing cinnabar and marcasite, with the cinnabar slightly preceding marcasite in the order of deposition. Further movement developed thin layers of gouge between the vein and the wall rocks and locally "smeared" the cinnabar. Slickensides in the gouge on both walls of the fissure pitch 30° to 45° E. Most of the mineralizing solutions were confined to the vein, whereas the relatively impervious wall rocks were little affected. The vein is very difficult to trace on the surface, particularly beyond the ends of the workings.

The Rainier vein is developed on two levels by drifts driven from crosscut adits. Ore has been mined from two shoots that rake to the east and lie entirely within the shear zone. A large proportion of the ground in the ore shoots was not mined. One of the shoots explored from near the middle of the lower level is 200 feet long; the other, at the west end of the upper level, is 175 feet long. The average tenor of quicksilver was 15 pounds to the ton. With the exception of one or two small pockets and occasional small clusters of cinnabar, most of the drifting in the upper level east of the adit appears to have been through low-grade rock. A sulphide body in the east end may represent the upper portion of the ore shoot which was stoped out from the central part of the lower level. The central ore shoot occurred in the portion where the vein change in strike. Both were located where the vein was nearly vertical.

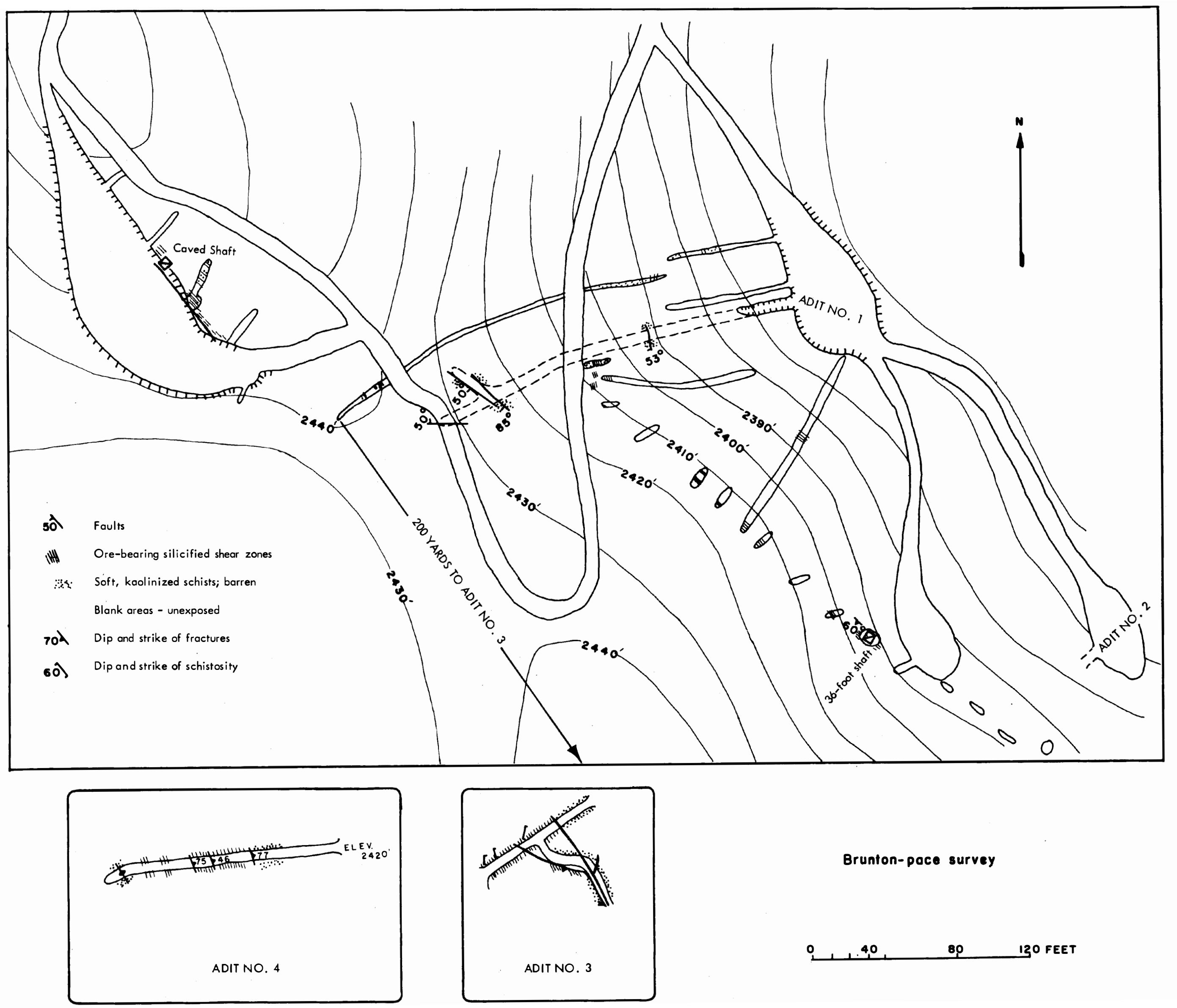


Figure 25. Sketch map of the Roxana mine.

Geology of the Coal area workings: These workings were caved at the portal and entirely inaccessible when the property was visited by the writer. The plan of the workings shown in Plate 5 and the following description of the geology are adapted from the unpublished report of Williams and Compton (1943).

The Coal area workings explore fractured and mineralized coal seams in the Umpqua Formation. Two and, in some places, three coal seams are exposed. Aggregate and individual thicknesses of the two upper seams are shown in Plate 5. The thickness of the lower seam was not determined.

The southern limit of the mine workings coincides with a complex fault zone trending N. 50° W. and dipping north. This fault zone in turn coincides with the margin of the original coal basin. Not only do the coal beds thin rapidly toward the fault, but in that direction they are increasingly separated by partings of shale. The dominant strike of the sediments, like that of the fault, is N. 50° W. About 50 feet away from the fault the beds dip 15° to 20° SW; adjacent to the fault, however, they dip 30° to 40° NE, so that a cross-sectional trace of an individual bed is trough-shaped. The principal drift coincides roughly with the axis of the trough, and crosscuts rise in opposite directions along the bedding planes.

Cinnabar mineralization is confined virtually to the coals, occurring along minute bedding-plane cracks and discontinuous cross fractures. Few of the seams exceed 1/8 inch in thickness. Locally they are accompanied by a small amount of marcasite. Silicification is sporadic and mild. Available assays indicate that the material is of very low grade.

ROXANA MINE

Location: E$\frac{1}{2}$ sec. 5, T. 34 S., R. 2 W., on the crest and upper flanks of the northwest-trending ridge which separates Morrison and Evans Creeks.

Owner: Paul Matson, Grants Pass.

Production: 7 flasks.

History: Location of the 5 claims which constitute the property began in 1919. Much of the early work was done by B. O. Force, H. H. Sharp, and E. W. Hewitt. In 1941 a two-tube retort was installed on the east bank of Morrison Creek and 6 flasks were produced. The property was subsequently leased by several individuals and groups, and ownership was acquired by Matson. In 1956 Steve Elko and associates produced one flask. There are no further records of production. David Chase of Medford now holds the property on a lease-purchase agreement.

Development: About 0.8 mile northwest along the Round Top Mountain road from its junction with the Evans Creek road, a short spur leads to a low saddle where the principal group of workings is located. These workings, which are distributed over an area about 650 feet wide and 250 feet long, include many hand-dug trenches all less than 4 feet deep, two adits, two shallow shafts, and a large bulldozer cut. A topographic and geologic sketch of these workings is shown on figure 25. A third adit lies about 200 yards south along the ridge from the saddle. A fourth adit and several opencuts lie about 1,500 feet farther to the south. Geologic sketches of the latter two adits are also shown on figure 25. Many other pits and trenches are said to be scattered about the claims but were not visited.

Geology and workings: The Roxana prospects are in rocks of the Applegate Group, which here consist dominantly of dark schistose metavolcanics presumably derived mainly from basaltic and andesitic lavas and tuffs and to a lesser extent from rhyolite. Minor alternations of mica schist and rocks having a gneissic appearance are included, as are also small local injections of pegmatite. In general the planes of schistosity strike N. 20° to 40° W. and dip 40° to 70° NE. In a strip more than 2,500 feet long and 100 to 300 feet wide along the crest and upper flanks of the ridge, the rocks are cut by numerous short discontinuous shears and fractures that trend N. 20° to 50° W. and dip steeply east or west. The fractured rocks have been more or less altered by hydrothermal solutions. Where the fractures are particularly plentiful the rocks have been silicified or, in places, reduced to soft masses of limonite, clays, and carbonates.

In and about the saddle where the principal group of workings is located, many short lenticular bands and stringers of chalcedony cut kaolinized and limonite-impregnated metavolcanics. The bands and stringers of siliceous material are numerous and closely spaced but are individually short, and few exceed 2 feet in width. The silicified zone exposed at the collar of the 36-foot shaft (figure 25) is about 8 feet wide but it pinches rapidly both laterally and downward. Small, widely spaced pockets of coarsely crystalline cinnabar occur in the chalcedony, and cinnabar is finely disseminated in the closely adjacent altered rocks. No significant amount of ore-grade material was observed but some very nice specimens of cinnabar in chalcedony are obtainable.

Adit No. 1 and the opencut leading to it were driven for most of their length in softened, kaolinized, and limonite-impregnated metavolcanics practically devoid of cinnabar mineralization. Several northwest-trending fractures and narrow siliceous bands were crosscut and a short drift was driven N. 50° W. along a fault zone dipping 50° SW. Rock in the fault zone is brecciated and softened to a mealy consistency but is not much silicified. Pannings of the material show only traces of cinnabar. Adit No. 2, which is said to be about 100 feet long, has been destroyed by a small landslide.

North of the saddle a bulldozer trench about 50 feet wide and 12 feet in maximum depth extends northwest along the west side of the ridge for about 180 feet. Most of the rocks exposed by the cut are intensely altered, softened, and limonitized. A fault zone near the southern end of the cut contains a conspicuous fault plane and a series of subparallel fractures which strike about N. 20° W. and dip about 75° SW. An intersecting system of fractures has a similar strike but dips 55° NE. A panned sample of the crushed and altered rock from the intersection showed a few small crystals of cinnabar.

A reef of silicified rock commences just south of the saddle and extends S. 20° E. along the crest of the ridge for several hundred feet. Poor showings of cinnabar may be found at intervals along it. Adit No. 3, which is 70 feet long, was driven through the ridge at shallow depth. Near the middle of the adit, a drift extends southeastward for 50 feet. According to Schuette (1938, p. 121), ore was found both at the east portal and at the intersection of the tunnel with the drift, but none was seen in place. The drift ends in soft, kaolinized schists. The principal shears strike west of north and are inclined to the primary schistosity.

Adit No. 4 enters the east slope of the ridge, about 1,500 feet southeast of Adit 3 and trends S. 80° E. for 132 feet (see figure 25). For the first 50 feet it passes through pale, kaolinized, feldspathic schist and amphibolite; beyond, there is a thin zone of fracturing and silicification and what may be a vein of altered pegmatite a few inches thick which carries a small amount of visible cinnabar. Farther on, the adit cuts decomposed amphibolitic schists with veinlets of kaolinized pegmatite. Locally, indefinite zones of denser, more silicified rock are present, some of which show traces of cinnabar when panned. No ore was observed in two opencuts a short distance north of Adit No. 4.

CHISHOLM PROPERTY

Location: Adjoining eastern parts of secs. 17 and 20, T. 34 S., R. 2 W., along the crest and eastern slope of a north-trending ridge. Includes the Little Jean, Palomar, Mrs. Dewey, and other small scattered groups of workings.

Owners: The property has been divided in recent years by relocation. Ownerships are given under descriptions of individual properties.

History and production: Development of the property by Dr. Chisholm began with the purchase of the Mercur Claim from William Mayfield about 1915. Shortly thereafter several adjoining claims were located. Recorded production for the ensuing years is given below. According to Stuart Chisholm, several flasks were also produced during the late 1930's and early 1940's. Most of the production was made with a bank of Johnson McKay retorts.

Quicksilver production from the old Chisholm property.
(U. S. Bureau of Mines)

1916	W. P. Chisholm	9*
1917	W. P. Chisholm	3
1919	W. P. Chisholm	2
1930	Wm. M. Miller	3
1931	W. P. Chisholm	1
1932	W. P. Chisholm	6
1933	W. P. Chisholm	2
1934	W. P. Chisholm	4
1935	John A. Chisholm	1
	Total recorded	31

*Includes one flask produced from Mrs. Dewey claim by S. H. Hubbard.

Geology: The many adits, pits, and shallow shafts scattered about the several claims explore mineralized fault zones cutting the Umpqua Formation east of and within a few hundred feet of the north-trending contact with metamorphic rocks of the Applegate Group. Some of the workings explore the contact zone for short distances and locally pass beyond into the schists. Where exposed the contact dips eastward at angles between 25° and 50° and is marked by several feet of intensely sheared gouge. Cinnabar is rarely found in the sheared contact, although small amounts are reported to occur in one of the adits of the Little Jean workings. Perhaps one reason for this is that the shear zone, because of its soft, wet condition, is difficult to explore and as a result has received little attention. More likely, however, cinnabar-bearing solutions were unsuccessful in permeating the zone to a significant extent. No ore has yet been found in the adjacent metamorphic rocks.

Cinnabar, with occasional metacinnabar and native quicksilver, is sparsely distributed along many small fault zones that cut the adjacent Umpqua sediments, diverging in strike only slightly from the trend of the contact. Only in a few small and widely scattered places, however, have the quicksilver minerals been found in sufficient concentration to be considered ore.

The Little Jean and adjacent prospects: Most of the quicksilver produced from the Chisholm claims was recovered from the Little Jean workings, which are scattered along the crest and upper flanks of a small spur ridge extending eastward along the line between sections 17 and 20. At least 300 feet of underground work had been done here by 1918. Caved pits and shallow shafts on the crest of the ridge are said to have yielded pockets of rich ore, and several adits were subsequently driven into the spur from both sides with the hope of tapping similar ore bodies at depth. Most of these workings are now included in the Quinalt and Jackson claims held by James Chisholm and Charles Pierce. At the time of visit, Chisholm and Pierce were reopening a vertical shaft on the ridge crest but had not yet passed below the level of old workings at a depth of 60 feet.

On the south side of the spur an adit 180 feet long, trending N. 50° E., is said to have encountered near its portal a small ore body along the Umpqua-Applegate contact. A short distance to the southeast another adit trends northward for about 100 feet in altered sandstone containing little cinnabar. On the north side of the spur an adit extending in the direction of the shaft trends S. 53° E. at its portal. According to Williams and Compton (1943) the adit is 150 feet long, at which distance there is a winze 15 feet deep and a crosscut runing N. 38° W.

Palomar prospects: The Palomar prospects now included in 2 claims, one owned by Frank Fink and the other by Stuart Chisholm, lie along the east slope of the main ridge from a third to a half mile northeast of the Little Jean workings. The first work on these claims may have been done by early owners of the War Eagle mine and later by Doctor Chisholm. In about 1938 the two claims constituting the Palomar group were located by Stuart Chisholm. In 1942 E. L. Morris and E. E. Hamrick leased the claims and hired James Chisholm to install a 2-tube D retort and do some development work. Little or no quicksilver was produced. The claims then lay idle until relocated by the present owners in 1954. A small cabin and the retort remain.

In addition to many opencuts, there are at least three adits on the Fink claim with a total length of approximately 380 feet. One contains a drift about 125 feet long on a shear zone trending northeasterly and dipping 55° to 60° SE. The other two adits contain only short drifts. About 200 yards south of the old cabin, an adit has been driven sinuously northward for about 150 feet. The face of the adit lies in a heavy gouge zone forming the contact between the Umpqua Formation and the metamorphic rocks of the Applegate Group. No cinnabar was seen in the gouge.

Mrs. Dewey claim: Adjoining the Palomar prospects on the west are two claims: the Ripper 1 and 2 held by Vola Tolman. These claims encompass the Mrs. Dewey claim, from which S. H. Hubbard obtained one flask of quicksilver in 1916. Development includes several pits and trenches and two adits, one of which is inaccessible. The other contains 240 feet of workings including a drift 140 feet long that follows a fault zone trending N. 25° to 30° E. and dipping 50° to 75° SE. in sandstone of the Umpqua Formation.

The fault zone, as exposed in the drift and a nearby trench, contains from 2 to 6 feet of sheared sandstone and gouge, locally silicified. Cinnabar is very sparsely distributed in the broken rock.

CINNABAR MOUNTAIN MINE

Other names: Webb and Tainor and Lucky Strike.

Location: SW$\frac{1}{4}$ sec. 34, T. 34 S., R. 2 W. about half a mile west by a mine road that branches from the East Meadows county road. The mine workings are on the east slope of a hill that borders the Meadows on the southeast. Figure 26 shows the topography of the area and distribution of workings.

Owner: W. B. Webb, Medford.

Production: 38 flasks recorded by the U.S. Bureau of Mines; probably a few more as indicated below.

History: Although local residents report this to be one of the oldest quicksilver mines in the Meadows area,

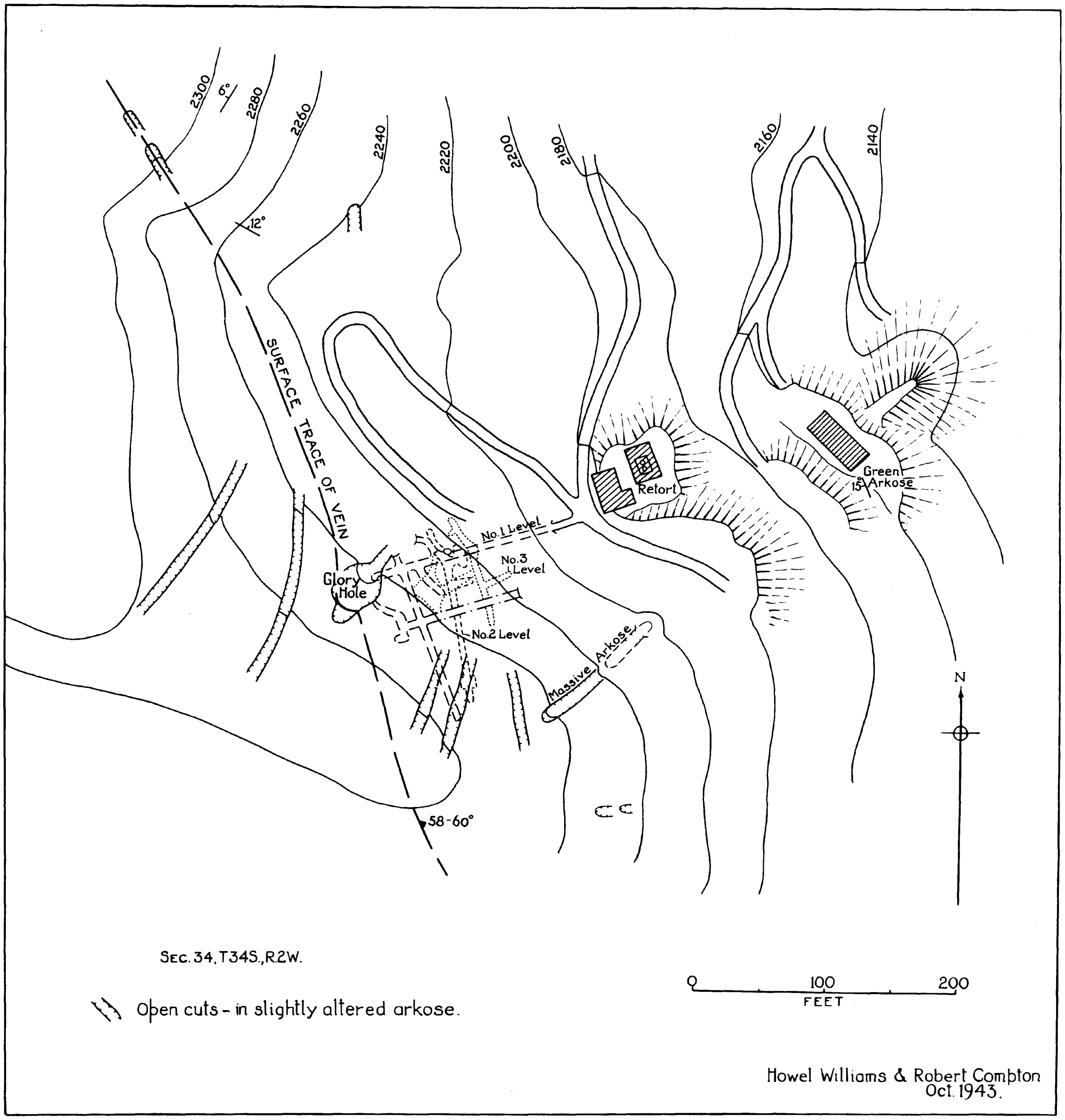


Figure 26. Topographic map of the Cinnabar Mountain mine.

no details of its history are known prior to its acquisition by M. B. Webb and O. F. Tainor in 1928. Webb and Tainor installed a homemade 3-tube retort and according to Schuette (1938) produced 15 flasks up to 1938. Williams and Compton (1943) report that according to Tainor another 21 flasks were produced prior to 1941. Between September 1940 and October 1941 the property was operated by the Cinnabar Mountain Mining Co. under management of H. V. Henrickson. Production of 11 flasks was recorded for 1940. Late in 1941 the property was taken over by Pacific Syndicate Co. A Herreshoff furnace was installed and production of 25 flasks and 2 flasks was recorded in 1942 and 1943 respectively. Their lease was dropped in early 1943 and the furnace and other equipment removed. There is no record of production or any significant amount of development work since.

Development: Development consists of a crosscut adit 143 feet long driven at an almost right angle to a drift on the vein from which an incline 150 feet deep has been sunk. Three drifts spaced about 50 feet apart and ranging in length from 60 to 200 feet have been turned from the shaft. Two raises have been driven to the surface from the adit level, one for ventilation, the other connects with a glory hole in the vein. At the time of the writer's visit, the crosscut adit was caved 110 feet from the portal. Figure 27, showing the principal workings, was adapted from Williams and Compton (1943).

Geology: The country rocks are sediments of the Umpqua Formation, consisting principally of buff and greenish arkosic sandstones, in part tuffaceous, with minor lenses of conglomerate, shale, and lignitic clay. The strike of the beds is variable and the dips are low, but measurements are too scattered to determine details of the structure.

The workings explore a broad irregular zone of faulting, shearing, and hydrothermal alteration whose footwall is marked by a smooth surface of sticky gray and black clay. The footwall plane strikes N. 20° W., dips 55° to 60° E., and forms the floors of the main incline and of the principal stope and glory hole. The sandstones and conglomerates above are cut by several small faults and minor fractures, some of which are roughly parallel to the footwall; others diverge at angles as much as 45°. The rocks in this complexly faulted zone have been sheared, locally crushed, and more or less altered to masses of clay, limonite, and carbonates depending upon their nearness to a fault. Lenticular masses of soft, clay-rich gouge lie along the larger faults, often between much less altered walls of sandstone and conglomerate. Silicification of altered rocks is noticeable in only a few places. Marcasite and pyrite occur locally as thin, scattered veinlets.

Cinnabar is confined largely to bodies of crushed limonite-impregnated sandstone. It occurs both as thin veinlets and as fine disseminations in the sandstone. There is little cinnabar in either gouge rich in clays or in sandstone that has not been intensely broken.

The principal cinnabar occurrences lie immediately above the smooth footwall of the fault zone, but small amounts of ore have also been recovered from some subordinate faults far out in the hanging wall. The principal ore body of the mine lay adjacent to the footwall between the No. 1 and No. 2 level drifts. About 1,100 tons of ore were mined and treated from an irregular stope in this ore body in 1942 and 1943. The stope ranges in width from 3 to 9 feet. The ore averaged less than 2 pounds per ton on recovery, but no doubt some high-grade pockets were included. A small amount of ore has also been recovered from the Tainor winze, which lies about 80 feet from the portal of the crosscut adit. The winze was sunk on a branch fault that strikes N. 40° W., dips 75° E., and is marked by clay gouge as much as 3 feet wide. The cinnabar occurs in the fractured sandstone adjacent to the gouge.

According to reports of local prospectors, small bodies of ore were also encountered in the glory hole at the surface and in the two raises which connect the glory hole to the No. 1 level.

DAVE FORCE MINE

Other names: Quicksilver Producers mine.

Location: NE$\frac{1}{4}$ sec. 20, T. 34 S., R. 2 W., just north of Evans Creek road.

Owner: Unknown.

Production: A few flasks, but none recorded by U.S. Bureau of Mines.

History and development: Nothing of significance has been done on the property since it was visited by Wells and Waters (1934, p. 51). The following information is taken from their report.

The original claims were staked by D. S. Force, who is reported to have obtained several flasks of quicksilver from surface workings. In 1924 the Quicksilver Producers Co. was incorporated and took over the

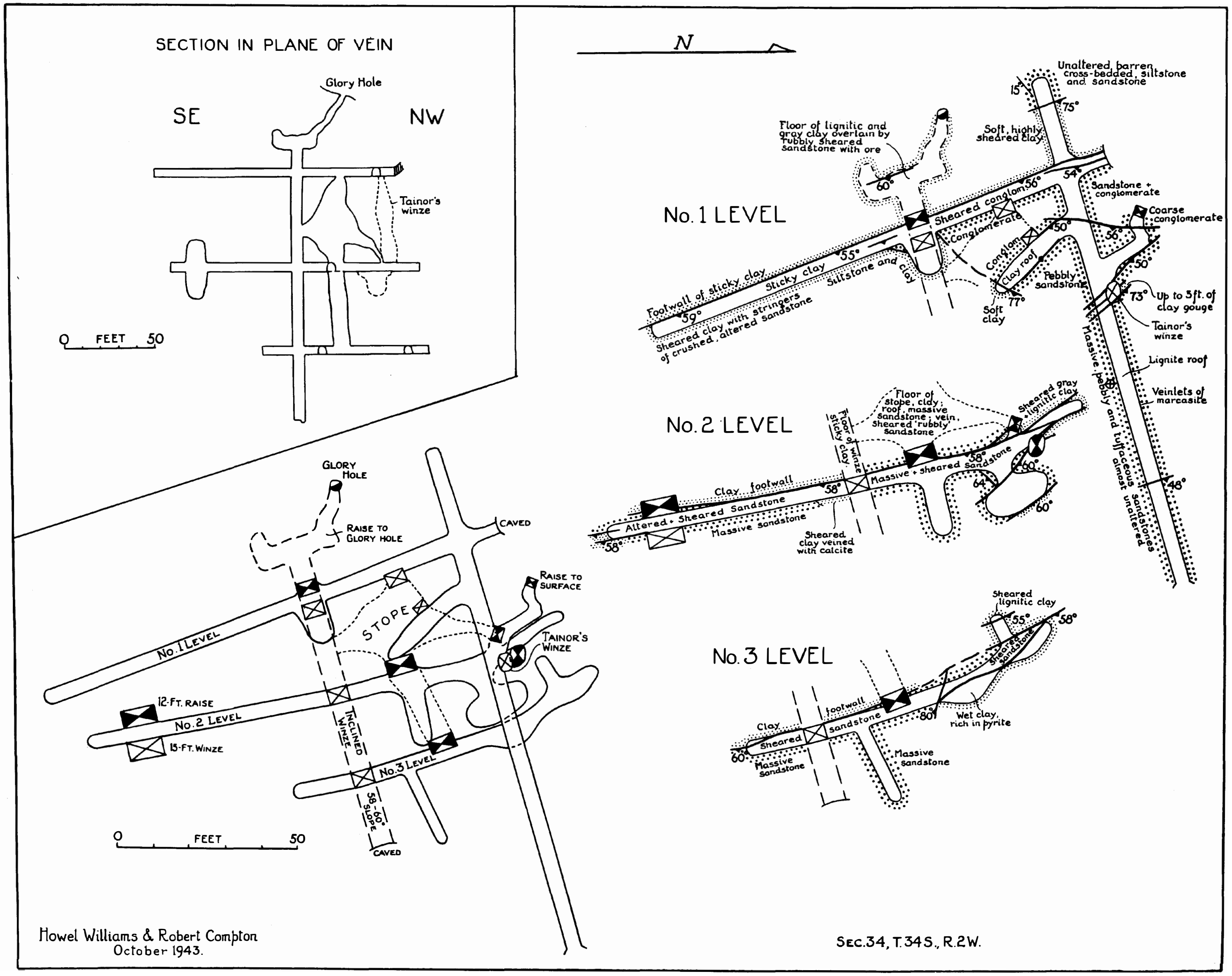


Figure 27 Geology, plan, and section of Cinnabar Mountain mine.

property, operating it until about 1930. Development consists of 2,110 feet of tunnel distributed among three adits: 1,375 feet on level 3; 430 feet on level 2; and 305 feet on level 1. Level 2 is 64 feet above level 1, and the two are connected by a 30° inclined raise. Level 3 is 119 feet above level 1. From level 3 two raises formerly extended to the surface, but both are now caved. A winze 20 feet deep was sunk from level 3, and a small stope 10 feet long and 15 feet high was mined from this level.

Geology: Rocks penetrated by the workings include tuffaceous sandstone with intercalated shales of the Umpqua Formation, a diabase dike, and quartz diorite. The Umpqua sediments dip gently northwest. The diabase dike, a fine-grained porphyritic rock, is about 80 feet wide, strikes N. 50° W. and dips 59° NE. The quartz diorite is coarse grained and thoroughly decomposed. It is cut by many pegmatite dikes half an inch to 6 inches in width made up of coarse feldspar, quartz, and much-altered mica.

The rocks are cut by a zone of normal faults that trends roughly N. 54° W., dips 34° NE., and contains 2 or more feet of breccia and gouge. Several small slips diverge from this zone. In places the fault belt contains a siliceous breccia composed of and cemented by chalcedony. In other places the fault zone is marked by fractured and altered diabase cut by thin discontinuous silica-carbonate veinlets that are rarely more than 1 inch thick and 3 feet long, but may branch and converge.

Quicksilver mineralization is confined to the diabase dike and is associated with a fault which branches N. 20° W. from the main fault. Cinnabar occurs as seams in the silica-carbonate veinlets and as fine dispersions in the chalcedony breccia. Iron sulfide minerals are scarce.

Little cinnabar remains to be seen. All of the ore retorted from the property is said to have come from a small stope 10 feet long and 15 feet high above the upper or 3 level and from surface cuts immediately above this stope.

MEADOWS PROSPECT

Location: $S\frac{1}{2}NW\frac{1}{4}$ sec. 21, T. 34 S., R. 2 W., on the south bank of Evans Creek.

Owner: August Singler.

Production: None.

History and development: Development of the prospect was begun in 1954 by Herman Gerhardus, Gene Arnold, and Floyd Estes. Later work was done by Gerhardus and the Holtzclaw brothers. Development consists of two shafts about 100 feet apart: one is 18 feet deep and vertical, the other is 15 feet deep on a 36° incline.

Geology: The workings explore a fault zone trending N. 30° to 40° W. and dipping 35° to 40° E. In the inclined shaft the footwall of the fault is a hard, highly silicified sandstone containing a little pyrite. Fractures are locally filled with crystalline barite. The hanging wall is brecciated and silicified argillite. A layer of brecciated fragments and clay gouge about one foot wide separates the walls of the fault and forms the smooth back of the incline. No cinnabar was visible in the shaft, but a 5-foot channel sample of the gouge assayed 0.3 pounds quicksilver per ton.

No argillite is exposed in the northern shaft. The fault zone here consists of several fractures, some of which contain local lenses of brecciated rock. The majority of the fractures roughly parallel the trend of the fault zone. Cinnabar was seen as very thin coatings on some of the fracture surfaces.

BONITA MINE

Location: Sec. 13, T. 33 S., R. 3 W. The Bonita mine may be reached from Trail by traveling 8 miles north on Oregon Highway 42 to the Divide Guard Station, thence $9\frac{1}{2}$ miles west and south on the Railroad Gap-Round Mountain road, thence $1\frac{1}{2}$ miles west on a side road to the mine.

Owner: H. S. Musson, Central Point, Oregon.

History and production: The property was discovered in 1930 by J. Henderson. The following year it was acquired by Harry S. Musson. In 1939 or 1940 six flasks of quicksilver were recovered with a 3-tube retort. Since that time little underground development has been done. In 1956 the property was leased to David W. Chase, Medford. Installation of a small rotary furnace 18 feet long and 24 inches in outside diameter was completed by mid-1957. Production of one flask was recorded in 1960.

Development: Development consists of 3 adits and numerous opencuts which expose the vein at intervals for a linear distance of 2,000 feet. The northern adit trends S. 15° E. and follows the shear zone for 110 feet. About 300 feet southeast of this is another adit which trends southwest and west to intersect the vein 75 feet from the portal at a vertical depth of about 150 feet. Most of the ore produced in 1937 was taken from the south adit, which follows the vein for about 130 feet. Near the end of this drift several small high-grade pockets and shoots of ore were mined from an irregular stope 60 feet long, 45 feet high, and 8 feet in maximum width.

Geology: The workings explore a well-defined shear zone cutting massive to schistose amphibolites of the Applegate Group containing abundant stringers of pegmatite.

The shear zone, which roughly parallels the planes of schistosity, trends N. 10° to 25° W., is nearly vertical, and averages about 4 feet in width. The walls are sharply defined. The amphibolite of the shear zone contains abundant limonite and calcite. In general, only partings in the rust-colored sheared amphibolite are filled with clay gouge, but locally the clay gouge fills the entire shear zone. Occasional slickensides found on the walls of the zone pitch steeply southward. Cinnabar occurs as disseminations and fracture coatings in the clay gouge and as finely divided crystals in some of the numerous irregularly distributed calcite veinlets. Three channel samples taken at 50-foot intervals across the vein exposed by the surface stripping above the south adit level assayed 0.4, 1.7, and 0.5 pounds of quicksilver per ton.

MOUNTAIN KING MINE

Location: NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 36, T. 34 S., R. 3 W., near the head of a steep tributary canyon entering Ramsey Canyon from the south. Ramsey Creek flows northwestward into Evans Creek. A forest road in poor repair branching northward from the Sams Valley-Evans Creek road 6 miles north of Sams Valley leads 1$\frac{1}{2}$ miles to the mine. The topography at the mine is shown on Plate 6. The mine is included within 800 acres of patented land.

Owner: All of sec. 36, T. 34 S., R. 3 W. is deeded land owned by Elizabeth Whipple and Charles H. and Josephine H. Bay, Costa Mesa, California.

Production: 95 flasks recorded.

History: Development of the mine probably began in the early 1900's. By the end of 1915, a 700-foot tunnel had been driven and a 6-tube retort installed. Considerable work was done during 1916 and in July 1918 workings consisted of 8 or 10 tunnels said to have a total length of 2,500 feet. There is no record of production in these early years. James Holtzclaw reports that during 1937 and 1938 he recovered several flasks from high-grade ore treated in the 6-tube retort. He also reports that during this time and in 1939 several of the tunnel portals and about 500 feet of the old workings were reopened.

In 1940 the mine was acquired by the Western Mineral Products Co. of Vancouver, Washington. Most of the old workings were reopened. Additional work was done on No. 1 and No. 2 levels and an intermediate level was driven to tap the east vein below No. 1 level. Installation of a 20- to 25-ton Herreshoff furnace was completed in October 1942 and 95 flasks were produced from ore mined mainly from No. 1 level stopes. So far as is known the mine has been idle since October 1943. During 1947 and 1948 the Holtzclaw brothers cleaned up around the furnace plant and report that 17 flasks were recovered. The furnace was moved to the Amity mine near Priveville in 1948. There is no mining equipment on the property.

Development: The mine is developed by more than 2,000 feet of workings distributed between 6 levels and one sub-level (see plate 6). No. 1 level is 292 feet vertically above No. 5, and No. 2 level is 180 feet below No. 1. On the surface a short adit and numerous opencuts are distributed along the principal vein 60 feet above No. 1 level. Much of No. 1 level was open but the rest of the underground workings were caved at the portals when visited in 1958.

Geology and workings: The mine workings explore mineralized fracture zones in metamorphic rocks of the Applegate Group into which abundant irregular veins, dikes, and small masses of pegmatite and diorite have been intruded. Some mica schists are present, but the principal rocks are schistose to locally massive quartz-plagioclase amphibolites. Veins and small masses of granitoid rock as much as 6 feet wide are abundant in the metamorphic rocks exposed in the mine area. Silicification is prominent along the edges of some of the pegmatites. The trend of the principal cleavage in the schistose rocks varys considerably within a small area, indicating that the rocks have undergone rather complex folding.

Cinnabar deposition was controlled by two strong northeast-trending fault zones. One, known as the eastern vein, strikes N. 25° E. and dips 75° to 80° E. The other, or western vein, strikes roughly N. 45° E. and dips 70° to 80° SE. A crossfault striking N. 45° to 55° W. and dipping 50° to 70° N. intersects both of these fault zones but is said to be barren of ore minerals except where it intersects the northeast-trending fault zones. Along all three of the fault zones the rocks have been extensively sheared and in places thoroughly crushed. On No. 1 level, where most severely crushed, these rocks have been altered to a mealy gouge rich in calcite, clays, and limonite, moderately silicified and impregnated with pyrite and/or marcasite and, locally, cinnabar. Elongate fragments of sheared but relatively unaltered country rock are commonly distributed through the gouge. Irregular veinlets and small bunches of silica and calcite are plentiful.

Cinnabar occurs as small irregular veinlets, clots, and specks scattered through the altered rocks and as paint-thin coatings on fracture surfaces. Locally, minute globules of native quicksilver are associated with the cinnabar. The better ore is associated with the most thoroughly crushed and altered zones. The strongest cinnabar mineralization found was localized along the eastern fault zone which is developed by about 450 feet of drift and a series of stopes on No. 1 level. The fractured zone is about 10 feet wide where it was intersected by the No. 1 level crosscut adit, but the ore was confined to a much narrower zone.

A series of interconnecting stopes commences near the junction of the adit with the drift and extends northward for about 160 and southward for about 115 feet (plate 6). The stopes average about 4 feet in width and extend to the surface, a distance of about 60 feet. Only about half of the material in the stoped area was mined. In addition a little ore was mined from a short sub-level about 30 feet below No. 1 level and from several short winzes. A total of about 2,000 tons of ore was treated in recovering 95 flasks. The ore thus averaged about 3.6 pounds on recovery. Most of this mining was done during 1942 and 1943. Beyond the stoped area the fractured zone pinches so severely that drifting was discontinued.

Because all of the workings below No. 1 level were caved at the portal when visited by the writer, the following information is taken from the report by Williams and Compton (1943).

The intermediate level crosscut completed in 1943 intersects the eastern vein about 235 feet from the portal and 95 feet below the No. 1 level. The shear zone is $3\frac{1}{2}$ to 4 feet wide, but brecciation is less intense than in the higher level and the tenor of ore is only 3 to 4 pounds per ton.

The western vein exposed by 315 feet of drift on the No. 2 level trends roughly N. 45° E. and dips 70° to 80° SE. Although this fracture zone resembles that of the eastern vein, mineralization is spotty and low grade. Assays reveal no distinct ore shoots but at least two branch fractures trending about N. 35° E. carry values of 4 to 6 pounds per ton over widths of 2 or 3 feet. Little ore has been mined from the western vein. Other fractures of the N. 25° to 45° E. system are exposed in the workings, but none is as strong as those just described and little ore has been mined from them. Ten feet from the portal of the powder adit of No. 2 level, a vein striking N. 28° E. and dipping 85° E. has been developed by short drifts. The ore zone here is 12 inches wide and averages 3 pounds per ton. On the surface immediately above, several tons of high-grade ore were mined from an open cut developed along the same shear zone. A vein striking N. 33° E. and dipping 85° E. cuts massive amphibolite on No. 3 level, 60 feet from the portal. It averages 20 pounds per ton across 7 inches. The only vein developed south of the crossfault was revealed in a 85-foot opencut west of the portal of No. 2 level. This vein is said to have contained some rich pockets and stringers in a crushed zone 1 to 3 feet wide.

The crossfault which trends roughly N. 55° W., intersecting the N. 25-45° E. system of veins and fractures, has been exposed over a length of 440 feet on No. 2 level. It dips from 50° to 70° N. This same shear is exposed along the last 30 feet of No. 5 level. Here it trends N. 45° W. Throughout the exposed length of the fault zone, walls of massive amphibolite enclose a gouge of sticky clay, 2 to 6 feet thick, containing elongate horses of crushed amphibolite and veins of somewhat drusy calcite. Locally the calcite veins are more than a foot thick and contain euhedral pyrite and/or marcasite. At the assumed intersection with the eastern vein they also contain cinnabar and native mercury. There is doubt as to whether the east drift on 2 level has actually intersected the east vein. No fracture trending N. 25° E. to intersect the crossfault has been exposed, but a mineralized fracture trending N. 10° E. is exposed and quicksilver values increase sharply near it. Perhaps continued exploration to the east would expose the N. 25° E. vein.

BROWNSBORO AREA

STANLEY and BROWN PROSPECTS

Other name: Brownsboro Clay & Quicksilver.

Location: $E\frac{1}{2}NW\frac{1}{4}$ sec. 11, T. 36 S., R. 1 E., on a small butte about 3 miles southeast of Brownsboro in Jackson County. The area is included in the Butte Falls quadrangle.

Owner: Unknown.

Production: None recorded.

History and development: The Stanley prospect, on the crest of the butte, was discovered in 1902 by W.M. Stanley and J. Rogers and is developed by several pits and trenches. The Brown prospect, developed by an adit 107 feet long with 30 feet of crosscuts and a shaft 30 to 40 feet deep, lies near the northwestern base of the butte. Most of the work on the latter was done by Frank Simpson around 1920. The property was then owned by George B. Brown. Simpson is credited locally with producing 2 or 3 flasks.

Geology: Rocks forming the butte are mainly andesitic flows and tuffs of the Western Cascades volcanic series. The workings explore a steeply dipping fault zone that passes through the crest of the butte trending N. 45° to 55° W. The course of the fault zone is marked locally by low, resistant crags of sheared, kaolinized, and mildly silicified volcanic rocks cut by thin, irregular veinlets of dark gray chalcedony. Cinnabar occurs as splotchy aggregates and thin stringers associated with the chalcedony veinlets. The ore produced by Simpson from the Brown adit and shaft was hand-sorted from small, widely spaced pockets.

SHALE CITY AREA

Shale City, a ghost village, is in the $S\frac{1}{2}SE\frac{1}{4}$ sec. 9, T. 38 S., R. 2 E., northeast of Ashland in Jackson County. Several small and scattered cinnabar occurrences are included in three different groups of claims located in section 9, north and west of Shale City. The area lies in the Lakecreek quadrangle.

Cinnabar was discovered here by K. J. Khooery in about 1951. Development of the prospects consists of scattered pits and trenches. No production has been made. Rhyolitic to dacitic pyroclastic rocks of the Little Butte volcanic series of Oligocene age underlie much of the area (Wells, 1956). A little andesite agglomerate was also seen. The cinnabar prospects occur in scattered masses of opalite derived from the hydrothermal alteration of the pyroclastic rocks. Distribution of the cinnabar is typical of the opalite type deposit.

MAMMOTH PROSPECT

Location: $NW\frac{1}{4}NE\frac{1}{4}$ sec. 9, T. 38 S., R. 2 E., about $1\frac{1}{2}$ miles north and west by road from Shale City.

Owner: R. A. Myers.

Production: None.

History and development: The prospect was discovered about 1951 by K. J. Khoorey and was relocated by R. A. Myers in 1960. It is developed by several bulldozer trenches and small pits.

Geology: Cinnabar occurrences are scattered along the crest and north flank of a broad, low ridge underlain by pyroclastic rocks of the Little Butte volcanic series, which have here been opalized. The extent of the opalization could not be fully determined because of inadequate exposure, but scattered outcrops and boulders of opalite occur over an area about 1,500 feet long and from 100 to 400 feet wide. In one of the bulldozer trenches the rocks have been converted largely to clays and elsewhere lenses, bands, and pockets of clay and altered pyroclastic rocks are scattered through the opalite. In the present state of development, cinnabar appears to be confined to the opalized rocks, occurring as fine dispersions in the unbroken rock and as coatings on fracture surfaces.

During a series of traverses, fragments of opalite were gathered from the soil or chipped from outcrops at regular intervals and mixed. Of 5 large samples taken in this manner, none assayed more than 0.3 pounds per ton quicksilver and none less than 0.2 pounds. Near the middle of the mass along its northern edge a small pit exposes cinnabar in brecciated opalite. A selected sample of high-grade ore assayed 9.1 pounds quicksilver per ton. From allegedly similar occurrences scattered about the claims the owners report that four assays ranging from 2.8 pounds to 4.6 pounds quicksilver per ton have been taken. Very little work has been done on the property.

HOPELESS PROSPECT

Location: N½SW¼ sec. 9, T. 38 S., R. 2 E., at the apex (5,275 feet elevation) of a steep-sided northeast-trending ridge about half a mile northwest of Shale City.

Owner: R. A. Myers and Marcel Klimek of Medford.

Production: None.

History and development: The property was located in September 1960 by the present owners. Development consists of a bulldozer cut about 50 feet in diameter with a maximum depth of 6 feet.

Geology: The peak on which the prospect occurs is composed largely of opalized tuff of the Little Butte volcanic series. Near the middle of the bulldozer cut a little low-grade cinnabar-bearing brecciated opalite is exposed. The zone is about 15 feet long and 1 foot wide and is cut by a series of nearly vertical fractures that trend N. 85° W. Elsewhere in the cut the opalite is fractured and jointed but virtually barren of cinnabar.

LUCKY 13 PROSPECT

Location: SE¼NW¼ sec. 9, T. 38 S., R. 2 E., about three-quarters of a mile northwest of Shale City. It lies on the west edge of the ridge crest between the Hopeless and Mammoth prospects.

Owners: Bob and Lloyd Ferns and Martin and Henry Schnack.

Production: None.

History and development: The prospect was located in September 1960 by the present owners. Development consists of a pit 8 feet deep and a trench that failed to penetrate the surface mantle.

Geology: The pit was sunk in an exposure of opalized tuff of the Little Butte volcanic series. Many boulders and small fragments are scattered through the soil in the immediate vicinity of the pit. Within the pit the opalite has been brecciated at the intersection of a series of fractures trending N. 60° W. with another series trending nearly due north. Cinnabar occurs as fine dispersions in the opalite and coats breccia fragments. The cinnabar-bearing zone is about 14 inches wide near the top of the pit but pinches out near the bottom.

ASHLAND AREA

Cinnabar occurs about 3 miles northwest of Ashland in the vicinity of the old Forty-Nine Diggings gold placers and at the Phillips mine. Both deposits are included in land owned by members of the Phillips family, descendants of Eli K. Anderson, who is believed to have been the original owner of the Forty-Nine Diggings. Bedrocks at both of the deposits are metavolcanics of the Applegate Group. Local residents claim that other small cinnabar occurrences are known in this area but reportedly have received little attention; they were not visited by the writer. The Ashland and Talent quadrangle maps provide topographic coverage for the area.

FORTY-NINE DIGGINGS

Location: Sec. 31, T. 38 S., R. 1 E., at the Forty-Nine Diggings gold placers about 2½ miles northwest of Ashland at the north end of the ridge between Wagner and Ashland Creeks.

Owner: Phillips Estate, Ashland.

Production: No quicksilver.

General description: The property has been extensively developed as a gold placer, but little attempt has been made to exploit the cinnabar, which is said to be widely distributed in the alluvial material and also in silica-carbonate veinlets in the underlying bedrocks.

PHILLIPS MINE

Location: NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 36, T. 38 S., R. 1 W., about 2 miles southeast of Talent and an equal distance northwest of Ashland. The mine is about 0.8 mile east by unimproved road branching from the old Ashland-Medford Highway.

Owner: Phillips Estate, Ashland.

Production: None recorded; possibly a few flasks (see History).

History: Very little is known of the history of this deposit. The Metal Mines Handbook for Jackson County (Oregon Dept. Geology & Mineral Industries, 1943, p. 34) refers to the property as the Meridian prospect and states that according to informant, W. G. Davis, the property had been opened by a 40-foot shaft and some ore had been removed in 1940. In April 1941, Milo Shier, Harry O. Brown, and Allison Moulton formed the Mercury Mining Corp. to operate the property. Earl Annes, consulting engineer from Grants Pass, who performed some engineering work for the group, stated that Milo Shier, George Jackson, and associates mined a small ore shoot from the vein and transported it to a California reduction plant, recovering several flasks of quicksilver. Two 1,000-pound capacity retort tubes were installed in 1941, but were apparently little used and have since been removed. According to R. C. Treasher (unpublished department mine report, 1943), no underground development work had been done since 1941, and there was no equipment on the property.

Development: The workings, located near the base of a northwest-facing slope, include 275 feet of crosscuts divided among 3 adits, a 100-foot shaft with connecting short drifts and small stope on the vein, and a 300-foot bulldozer cut along the vein. The lowermost adit connects to the foot of the shaft about 180 feet from its portal. The intermediate adit, about 70 feet above the lower level, is connected to the shaft by a 35-foot stope (see Figure 28). Two short drifts extend southeast from the shaft at depths of 50 and 68 feet respectively. The upper adit, lying 100 feet east of the shaft collar, crosscuts 55 feet into the footwall of the vein.

Geology: The workings explore a narrow vein enclosed within a broad zone of shearing and intense hydrothermal alteration cutting altered basalts of the Applegate Group. The vein and a majority of the fractures in the adjacent wallrocks strike N. 25° W. and dip 85° W. Many small fractures dip to the east, some at lower angles. For several tens of feet on either side of the vein the wall rocks have been intensely sheared and altered to a rubbly mixture of calcite- and limonite-impregnated clays and softened rock interspersed with veinlets, nodules, and irregular patches of calcite and a little chalcedony and opal. Near the vein, alteration increases until the original character of the rock is obliterated. The vein, which ranges in width from a few inches to about 5 feet, is composed of discontinuous veinlets, nodules, and boulder-like masses of limonite-impregnated chalcedony and coarse calcite set in a matrix of calcite-rich clay gouge. Where cinnabar was seen on the property it was associated with masses and veinlets of limonite-bearing chalcedony. Little was found in the calcite or in the softened matrix of the vein or its walls.

UPPER APPLEGATE AREA

The Upper Applegate area includes the upper drainage of the Applegate and Little Applegate Rivers in the Klamath-Siskiyou Mountains of southwestern Jackson County. Several small quicksilver prospects of minor commercial significance are scattered among the pre-Tertiary rocks of the area (see Figure 29). Most of the known prospects were discovered prior to 1940. None has a recorded production of more than a few pounds of quicksilver, although it is said that the Brick Pile mine produced a few flasks during the early days for use in the nearby gold fields.

The area is one of extremely rugged terrain. Roads have been built to most of the prospects, although some are accessible only on foot. Many can be reached only during the summer months. The area is covered topographically by the Ashland, Ruch, and Talent quadrangles.

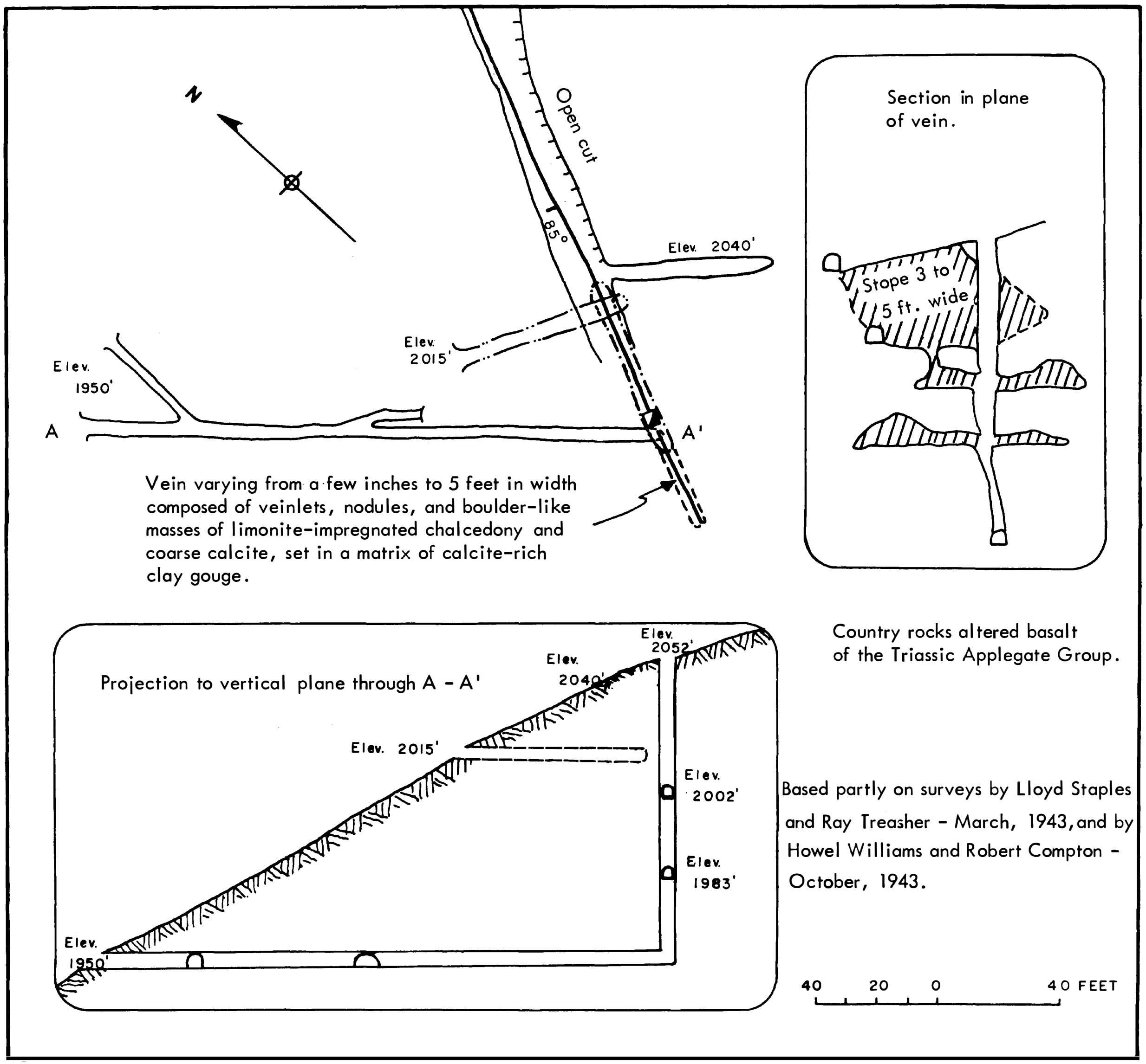


Figure 28. Geologic plan and section of the Phillips mine.

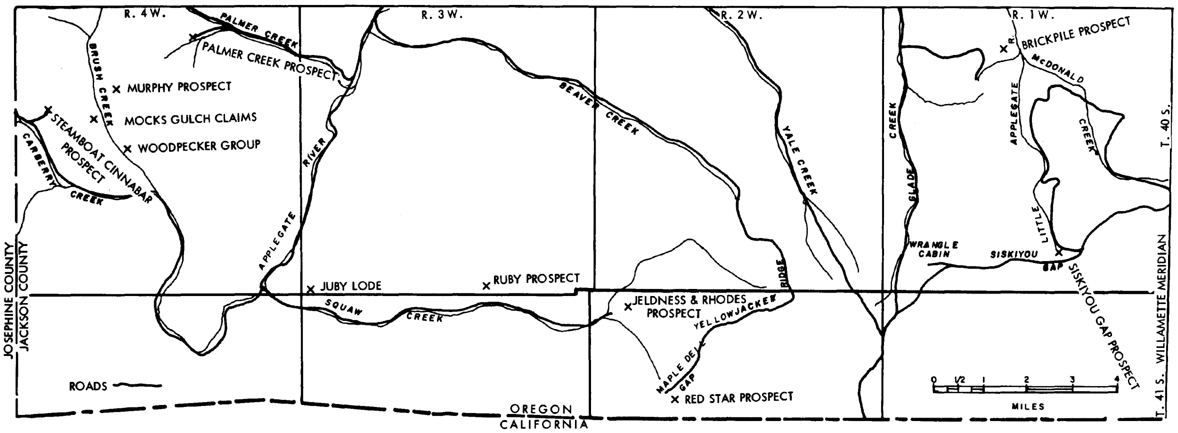


Figure 29. Index map of the Upper Applegate area, showing distribution of the quicksilver deposits.

The majority of the deposits lie in metavolcanics and tuffaceous metasediments of the Applegate Group. A few occur in schists of probable Paleozoic age. At least two deposits have been found in altered serpentine and one in quartz diorite. The rocks in the vicinity of most of the quicksilver occurrences are cut by numerous small, irregular, and discontinuous faults, shear zones, and other minor fractures that are related to the intense folding and uplift of the region as a whole. As a result the cinnabar-bearing solutions were so widely dispersed that no accumulations of ore of minable size and grade were formed.

The larger fractured zones commonly contain layers of gouge and small, discontinuous veins and bunches of calcite and quartz. The major concentrations of cinnabar occur as crystalline aggregates in the calcite and quartz and as disseminations and fracture fillings in the associated breccia and gouge. In addition, cinnabar is widely but very sparsely distributed along joints, schistose partings, bedding planes, and other minor fractures in the wall rocks.

Native quicksilver is locally associated with the cinnabar. In two of the prospects, the Murphy and Mock Gulch, small quantities of scheelite are associated with the cinnabar; however, there appears to be no genetic relationship between the two minerals.

STEAMBOAT CINNABAR PROSPECT

Location: NW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 18, T. 40 S., R. 4 W. The Thompson Creek-Carberry Creek road is followed 12$\frac{1}{2}$ miles south and west of Applegate to the mine road which leads eastward up Swamp Gulch 0.7 mile to the workings. The prospect is about 32 miles from Grants Pass.

Owner: Edward W. Kubli, Jacksonville.

Production: None recorded; possibly a few flasks.

History and development: Local historians report that work was done on the property during World War I by the partners, Swinden & McFadden. During 1933 a 6-ton revolving retort was installed, a blacksmith shop and drill equipment were set up, and about 90 feet of tunnel was driven. Between 1934 and 1936 the property was operated by J. H. Blair, George Hammersley, E. W. Morris, and C. W. Martin. As disclosed by recent operations, early development consisted of 4 tunnels having an aggregate length of about 350 feet, a raise about 60 feet long, and a 15-foot shaft. Although no records exist, it is believed locally that a few flasks of quicksilver were produced. The property was relocated by W. D. Curl and D. E. Serry in mid-1954, and was sold to the Kubli brothers in 1956.

During 1956-57 a large excavation 100 feet long, 80 feet wide, and 25 feet in maximum depth was dug with a bulldozer cutting out parts of two adits and the upper part of a raise from the lowest adit. At present only one tunnel, trending N. 5° E. for 15 feet, is visible. The others and the raise are buried by excavated rubble. About 50 feet below and 70 feet south of the southern edge of the cut, an old tunnel containing 210 feet of workings was reopened. During the summer of 1957 the property was leased to Rex Thompson and Bill Likee. Erection of a 2-tube inclined retort was begun but not completed.

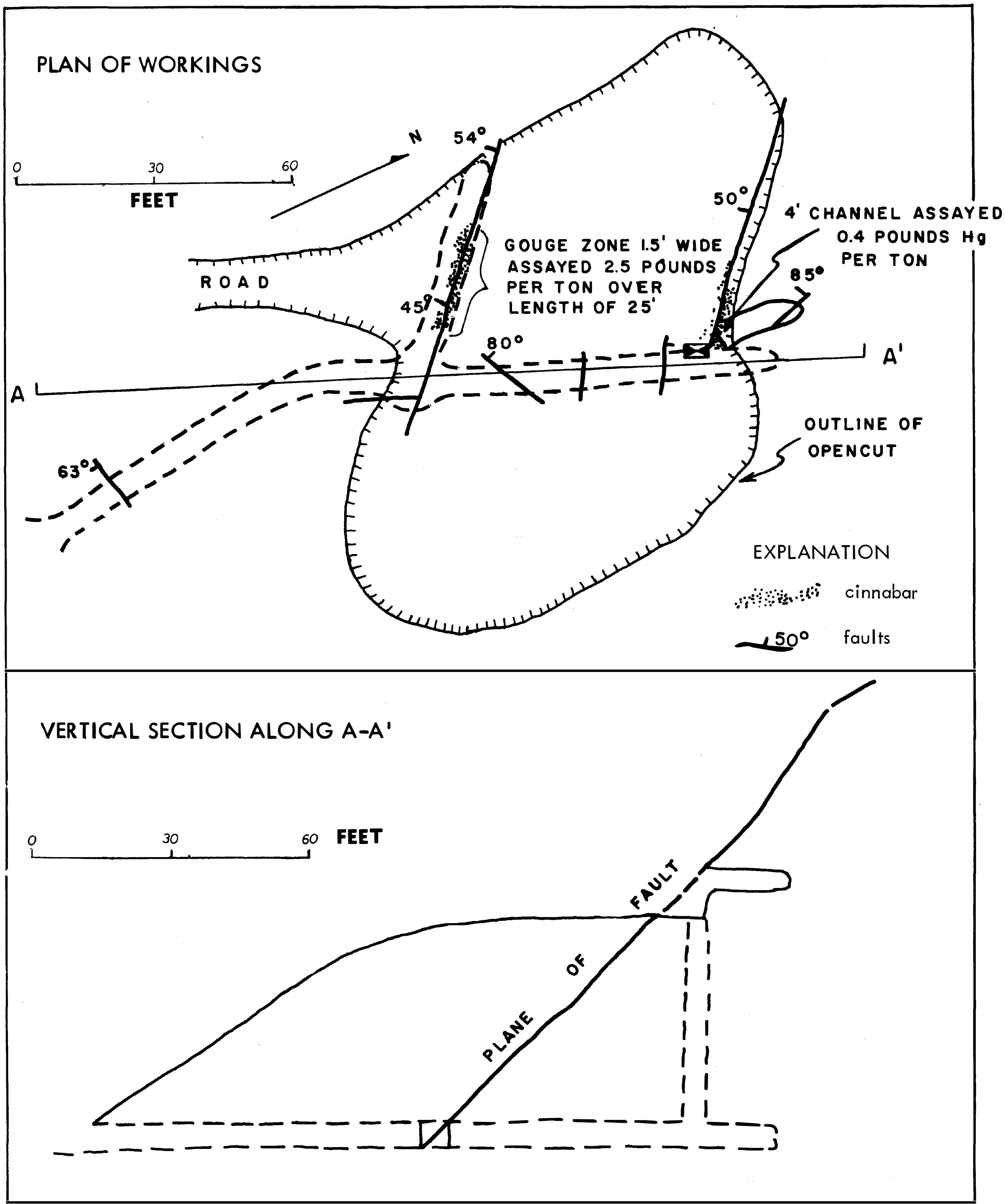


Figure 30. Plan and section of the Steamboat Cinnabar prospect.

Geology: The country rocks are highly fractured argillites and sandstones of the Triassic Applegate Group. The more prominent set of fractures strikes roughly eastward and dips about 65° N. The rocks are cut by many faults and shear zones of diverse trend. Quicksilver mineralization appears to be associated with a fault striking N. 48° W. and dipping 50° to 55° S. The footwall plane of this fault forms the northern face of the opencut. A drift from the lower adit (Figure 30) follows the fault zone northwesterly for 50 feet. In the drift the fault zone contains about 2 feet of limonitized breccia and clayey gouge in which a little disseminated cinnabar and native quicksilver are visible. A 50-pound sample taken over a length of 25 feet and quartered down assayed 2.5 pounds per ton of quicksilver. Near the west end of its exposure in the opencut above the tunnel, the fault contains $2\frac{1}{2}$ to 3 feet of gouge but no visible cinnabar. A sample taken from the fault zone near the portal of the 15-foot adit in the north face of the opencut assayed 0.4 pounds of quicksilver per ton. In the footwall of the fault, cinnabar occurs along a series of north-trending fractures near their intersection with a fracture trending N. 75° E. Alteration is slight and the cinnabar is confined to the fractures. The zone as exposed is about 6 inches wide and 4 or 5 feet long. Chester Kubli reports that other similar zones have been found immediately beneath the main fault. In the opencut, cinnabar has been found in the fractured rocks bordering either side of the fault, but the largest concentrations have been in the footwall. A stockpile amounting to possibly 200 or 300 tons of material selected from the fault zone contains cinnabar, as indicated by the panning of several samples, but the tenor is low.

MURPHY PROSPECT

Former names: Rattlesnake Group; Murphy and Noe prospect.

Location: SW$\frac{1}{4}$ sec. 9, T. 40 S., R. 4 W., about a quarter of a mile east of and 600 feet above Brush Creek.

Owner: Robert Wells, Applegate, Oregon.

Production: None.

History and development: Development of the prospect began in 1935 by Milton Murphy and E. S. Noe, who located 5 claims in the SW$\frac{1}{4}$ sec. 9 and 6 claims in the NE$\frac{1}{4}$ sec. 8 respectively. Minor occurrences of cinnabar and occasionally scheelite are said to have been discovered by panning and test pitting on most of the claims. However, development centered in the SW$\frac{1}{4}$ sec. 9, where a total of about 650 feet of underground work was done from 5 adits. Some of this work was accomplished by the Horse Heaven Mining Co. during late 1942 and early 1943, by Robert Wells during 1945 and 1946, and by a group of lessees during the summer of 1958. The present owner acquired the property by relocation in 1952.

Geology: Rocks in the vicinity of the prospect are highly fractured metavolcanics of the Applegate Group. Thin interbeds of metasediment are exposed nearby. The metavolcanic rocks, consisting mainly of basaltic and andesitic lavas, are generally fine grained and greenish gray on weathered surfaces. The more conspicuous partings in the rocks strike N. 15° to 35° E. and dip from 50° E. to vertical. Several shear zones, varying considerably in attitude and ranging from a few inches to several feet in width, are exposed in the workings. These shear zones commonly contain narrow seams of gouge and numerous veinlets and irregular concentrations of calcite and, more rarely, quartz. Where shear zones intersect, the rocks are often crushed and thoroughly altered to soft masses of clays, limonite, and calcite. In places the crushed rocks are mildly silicified. Sheared but uncrushed rocks below the zone of weathering are darker green than the surrounding rocks, probably because of more intense chloritization, and are slick along fracture surfaces.

The principal exposure of quicksilver mineralization occurs in the Cinnabar adit (see Figure 31). This adit, 95 feet long and containing 5 crosscuts each about 15 feet long, drifts roughly S. 70° E. along a series of shear planes dipping 70° to 80° N. A fault surface of this attitude forms the north wall of the drift for about half of its length. In the first 65 feet of the adit the rocks are considerably broken, particularly where cross fractures cut the shear zone, and intensely altered. Thorough sampling by various individuals and companies indicates that all of the rocks in the first 65 feet of the drift contain some cinnabar. Five large samples taken by the writer assayed from 1.5 pounds to 11.5 pounds of quicksilver per ton.

The best sample was obtained from a lens of limonitized, carbonatized, and mildly silicified breccia occurring in the back of the drift and commencing about 45 feet from the portal. The lens as exposed is about 20 feet long and 3 feet in maximum width and contains both cinnabar and native quicksilver, a little pyrite, and manganese oxides. In cross section the lens is wedge shaped. Its hanging wall is probably the fault plane forming the north wall of the drift and dipping 80° N. Its footwall is a fault surface dipping 40° N. and intersecting the hanging wall near the north floor of the drift. A short crosscut driven into the footwall exposed little

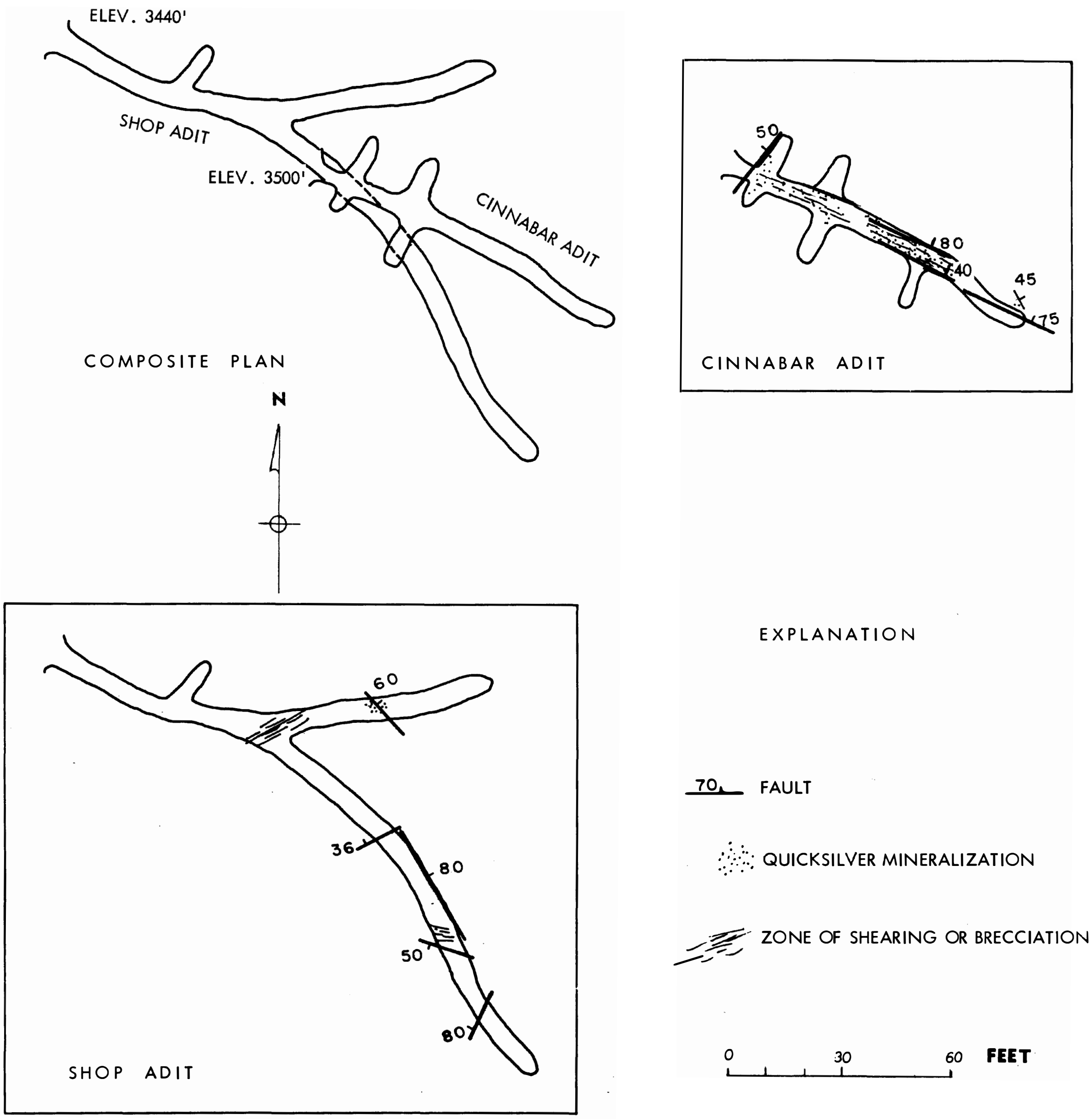


Figure 31. Geologic sketch of the Cinnabar adit and Shop adit of the Murphy prospect.

mineralization. If the assumptions concerning the limits of the lens are correct, the ore body will probably not continue far below the drift level. Samples from the shear zone at the surface above the drift are of low grade. Beyond the lens the drift turns slightly to the south following a narrow calcitized fracture zone about 10 inches wide. At the face, the zone is cut by a set of subparallel fractures striking N. 30° W. and dipping 45° NE. Cinnabar and a little pyrite occur on the slick surfaces of the cross fractures which lie in the hanging wall of the vein.

Scheelite occurs in a narrow stringer extending about 15 feet along the floor on the northeast side of the Cinnabar adit and is said to occur in small amount at other places on the property. Evidence proves conclusively that the cinnabar formed after the scheelite and that the two have no genetic correlation.

The Shop Adit, trending about S. 65° E. for 85 feet, then about S. 35° E. for an additional 100 feet, passes beneath the portal of the Cinnabar adit at a depth of about 60 feet. In addition the adit contains two crosscuts, one 35 feet from the portal and trending N. 42° E. for 15 feet, the other 60 feet from the portal and trending N. 78° E. for 65 feet (see figure 31). Little quicksilver mineralization was observed in these workings, although shearing has occurred in several places. Many of the shear zones contain breccia, occasional gouge, and veinlets of calcite and quartz. That part of the adit which trends S. 35° E. follows for a short distance along a fault plane striking S. 30° E. and dipping 70° N. The 65-foot crosscut to the northeast exposes a small northwest-trending shear zone containing visible globules of native quicksilver.

A 40-foot crosscut adit, driven N. 40° W. from the edge of the road about 200 feet south of the Cinnabar adit portal, cuts a shear zone about one foot wide striking N. 60° W. and dipping 35° S. A little cinnabar is exposed in the 15-foot drift on the shear zone. Below the road a short distance farther south is an adit trending N. 10° E. for 40 feet, exposing numerous calcite and occasional quartz stringers.

An adit driven during the summer of 1958 lies about 0.4 mile by road south of the Cinnabar adit. It trends N. 82° E. for 138 feet. Three samples taken from the more prominent of several quartz-and gouge-impregnated shear zones of variable width and attitude assayed less than 0.2 pound of quicksilver per ton. Some of the quartz obtained in the adit has been brecciated, indicating recurrent movement along the faults.

In an exposure along the edge of the road near the 1958 adit, cinnabar occurs as thin fracture coatings. The exposed fractures are about 2 inches apart, strike S. 70° E. and dip 80° E. These fractures are intersected by another set striking N. 15° E. and dipping 65° to 70° E. The zone is cut by several irregular calcite seams.

MOCKS GULCH PROSPECT

Location: SW¼NE¼ sec. 17, T. 40 S., R. 4 W., on the west side of Brush Creek at an elevation of about 3,400 feet.

Owner: Unknown.

Production: None.

History and development: The prospect was owned for many years by Russell Mitchell and D. A. Wright of Jacksonville. It was held on option for a short time during the early 1950's by a Nevada tungsten mining company. Development consists of several cuts and a short adit which was inaccessible when visited. Most of the work has been directed toward the development of scheelite occurrences. No production of either tungsten or quicksilver has been made.

Geology: Exposures are scarce because of a heavy cover of soil and brush. Rocks exposed by the excavations are mainly metavolcanics of the Applegate Group. Planes of schistocity trend northeasterly and dip steeply northwest.

Local informants state that the adit develops a scheelite-bearing shear zone about 3 feet wide. The vein strikes nearly due east and dips 70° S. Cinnabar occurs as paint-thin coatings on fracture surfaces in some of the open cuts and also, according to reports, in the walls of the scheelite vein.

WOODPECKER GROUP

Location: SW¼ sec. 16, and NW¼ sec. 21, T. 40 S., R. 4 W., on the slopes of Brush Creek.

Owners: Unknown.

Production: None.

General description: The group consists of four claims (Woodpecker Nos. 1, 2, and 3 and the Circle Park claim) located in 1941 by Valorie Haskins and Paul Seidel, Jacksonville. Development work done shortly after discovery consists of an opencut leading to a 35-foot adit and several scattered test pits. The geology of the deposit is similar to that of the Murphy prospect to the north.

PALMER CREEK PROSPECT

Former names: Hyde prospect; Davison prospect; Doodlebug prospect.

Location: SE¼ sec. 3, T. 40 S., R. 4 W., on the southeast-facing slope of Bailey Gulch, a tributary of Palmer Creek. It is reached from the McKee Bridge by 2 miles of graveled road up the west side of the Applegate River, and about 3 miles up the Palmer Creek road to Bailey Gulch. Total distance from Ruch is 11 miles.

Owners: Valorie Haskins, Wallace Haskins, Ivan McDonough, and Marion Dunlap.

Production: None (?)

History: Alluvial gold in the bed of Palmer Creek received considerable attention from the early miners and it is probable that the associated cinnabar was traced to its source in section 3 many years ago. The Gold Pan group of 8 gold claims located in 1919 is thought to have covered the area of present cinnabar development. It is reported by the Haskins brothers that several test pits and short adits were dug and that small high-grade gold pockets were recovered along the banks of Palmer Creek, but the total production is probably small. George A. Hyde, who was operating the property during the late 1930's and possibly earlier, may have been the first to attempt exploitation of the cinnabar. Hyde set up a placer operation on the creek and attempted to obtain both gold and cinnabar. The quantity of cinnabar proved too small to be economically recoverable. In 1940 the property was acquired by R. T. Davison, who erected a 2-tube retort and did a little underground development work but apparently produced no quicksilver. For a short time during 1942 and 1943, the property was under option to Horse Heaven Mines, Inc., which at that time was also exploring the Murphy prospect on Brush Creek.

In 1954 the present owners relocated the property. In May 1957 the claims were leased to Chester C. and Edward W. Kubli and Charles Stearns. The property was later subleased to Archie Adams of Adams Mining & Exploration Co. Adams drilled 4 vertical holes to an average depth of 225 feet and several shorter angle holes. Core recovery is said to have been good, but nothing was found to justify further development work. Adams relinquished his sub-lease in June 1958 and the property reverted to its owners.

Development: Development consists of many trenches, test pits, and short adits, most of them dug in the search for gold. Most of the old workings are caved. Two adits driven into the north bank of the creek were examined and mapped by Len Ramp (Figure 32). The lower adit is in a gulley tributary to Bailey Gulch at an elevation of about 2,825 feet and is approximately 80 feet long. The upper adit, which is about 40 feet west and 15 feet higher, is 50 feet long. About 200 feet northwest of the adits is a large, horseshoe-shaped opencut about 80 feet across and 15 feet in maximum depth.

Geology: The adits and opencut expose several small faults of diverse trends cutting metavolcanics of the Triassic Applegate Group. Within the fault zones the metavolcanics are sheared and locally crushed. Partings are commonly filled with gouge and several contain calcite and quartz veinlets as much as 3 inches thick. One of the more prominent fault zones exposed in the west wall of the pit is about 3 feet wide, trends N. 75° W., and dips 60° S. Coarsely crystalline cinnabar is strikingly displayed as fracture fillings in the quartz and calcite veinlets and as thin fracture coatings and nuggets as much as a half inch in diameter in the intervening altered rock. According to the owners, this mineralized zone extends across the floor of the opencut. Unfortunately, material considered to be ore had been piled on top of the zone in the floor of the opencut, preventing examination. This material, consisting of about 20 tons of altered metavolcanic rock and a little calcite and quartz, contained possibly 0.5 percent cinnabar in the form of nuggets and as fracture fillings and thin coatings on fracture surfaces. In the wall of the cut this fault zone is intersected by a series of fractures trending N. 35° E. and dipping 80° S. Presumably this same fracture zone is exposed in the northeast wall of the cut. Here it contains about 4 inches of fault breccia but little or no cinnabar. Of the several other faults and shear zones exposed in the walls of the cut, only traces of cinnabar and occasional nuggets have been found.

The principal mineralized zone exposed in the adits lies within an irregular zone of shearing having an overall northwesterly trend, although within the shear zone fracture lines trend in several directions.

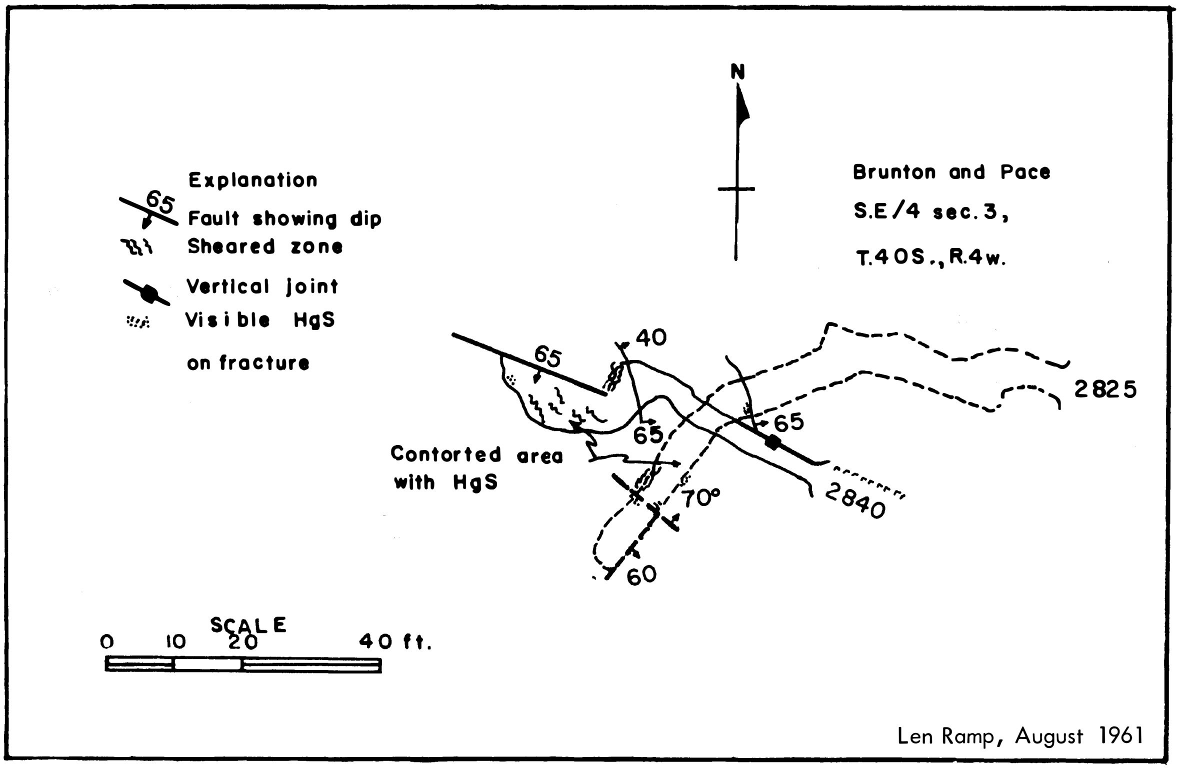


Figure 32. Sketch of the underground workings of the Palmer prospect.

JUBY LODE

Location: SW¼ sec. 31, T. 40 S., R. 3 W., less than half a mile north of Squaw Creek.

Owner: Wade Crawford, Medford.

Production: None.

History and development: Most of the development work, which consists of three short adits and several opencuts, was done by Crawford in the 1930's.

Geology: In the prospect area amphibolites of the Applegate Group have been intruded by dikes of quartz diorite which range in width from 1 inch to 30 feet. The amphibolites are considerably fractured and cut by numerous irregular stringers and small veins of quartz and calcite. Cinnabar occurs as thin veinlets, fracture coatings, and occasional nuggets distributed along fractures in the amphibolite and as crystalline specks in the quartz and calcite. The lateral limits of the cinnabar mineralization have not been determined nor has any structural feature capable of localizing appreciable amounts of cinnabar been found.

RUBY QUICKSILVER PROSPECT

Other names: Red Feather; Jeldness prospect.

Location: SE¼ sec. 34 and SW¼ sec. 35, T. 40 S., R. 3 W. between 3,600 and 3,700 feet in elevation on the north side of Squaw Creek, a tributary of the Applegate River. The prospect is about 35 miles south of Medford.

Owner: Arthur Jeldness.

Production: A few pounds.

History: The property, consisting of 5 claims, was owned by D. R. Luper in 1938 and probably earlier. In 1940 it was leased to Ruby Mines, Inc., a Washington corporation. This company built about 2 miles of road to the property from the Squaw Creek road and did a little development work but produced no quicksilver. In 1945 the claims were relocated by Andrew Jeldness, father of the present owner. In 1953 Arthur Jeldness erected a 2-tube retort on a mill site in the SW$\frac{1}{4}$SE$\frac{1}{4}$ sec. 34. In 1956 about 60 pounds of quicksilver was recovered from selected high-grade ore treated in the retort.

Development: Development consists of at least 4 short adits, 2 shafts, and several opencuts distributed along the mineralized zone for about 1,500 feet. None of the underground workings, except an inclined shaft about 35 feet deep,were accessible when visited by the writer.

Geology: The country rocks consist of small interfingering bodies of serpentine and granodiorite that have been intruded along the east-trending contact between highly foliated Paleozoic mica schists to the south and metavolcanic rocks of the Applegate Group to the north. A major fault, trending N. 45° to 70° E. and dipping 35° to 45° NW., roughly follows the contact between the intrusive rocks and the schists to the south.

Cinnabar mineralization is confined largely to zones of intensely sheared and brecciated serpentine lying within 5 or 10 feet of the contact with the footwall schist. Locally within these zones of intense shearing the serpentine silicified. Cinnabar is sparsely distributed as disseminated specks and smeared fracture coatings in the sheared serpentine and silicified rock. The schist and the granodiorite, even where most strongly affected by the movement and hydrothermal alteration along the fault, appear to be virtually barren although it is reported that the granodiorite contains a little cinnabar in places. Cinnabar prospects are said to be scattered along the fault for at least 1,500 feet but only a few of those thus far discovered have been of sufficient promise to encourage development.

JELDNESS and RHODES PROSPECT

Location: NE$\frac{1}{4}$ sec. 6, T. 41 S., R. 2 W., on the crest and south slope of a wooded ridge between the forks of Squaw Creek about a quarter of a mile northeast of the end of the Squaw Creek road.

Owner: Clarence Stevens.

Production: None recorded; about one flask produced.

History and development: Nothing is known of the early history of the prospect except that it is thought to be one of the many discovered by Andrew Jeldness during almost a lifetime of prospecting in the area. C. W. Rhodes held an interest in the property along with Jeldness during the early 1940's.

The property is developed by a 240-foot adit, which is caved, a shaft about 40 feet deep, two shafts 10 feet deep, and several opencuts. The shafts and opencuts are clustered in an area about 300 feet long and 100 feet wide. The portal of the caved adit lies about 250 feet down the flank of the ridge to the southeast.

Geology: The workings on the crest of the ridge explore intensely fractured and altered ferromagnesian rocks adjacent to their contact with relatively unaltered Paleozoic sericite schists. The ferromagnesian rocks are buff or "buckskin" in color, grading to grayish green in less altered places, and are cut by an intricate network of small fractures filled with a dark brown mixture of limonite and clay. The fractures appear to have random orientation and none could be traced for more than a few feet. Minor brecciation has occurred along some of them and the walls are heavily coated with limonite. A few contain discontinuous quartz veinlets. Cinnabar occurring as small pockets, narrow seams, and fracture coatings was observed in some of the large fractures and also in smaller fractures cutting the adjacent wall rocks. At the time of visit several hundred pounds of "high grade", composed partly of limonite-impregnated nuggets of cinnabar, had been placed in a box near the collar of the 40-foot shaft. Presumably this material was recovered from the shaft but the bottom was flooded and lagging above the water level prevented examination. According to the owner, several hundred pounds of similar material was retorted at the Ruby prospect in 1957 and about 60 pounds of quicksilver was recovered.

About 100 feet north of the shaft two shafts about 10 feet deep have been sunk along northeast-trending fractures. Two roughly parallel fractures about 4 feet apart and trending N. 65° to 70° E., along which minor brecciation has occurred, are exposed in the eastern shaft. A single fracture trending about N. 50° E. is exposed in the western shaft about 15 feet away. No cinnabar was visible in either shaft but samples of limonitized clay and brecciated rock contained in the fractures were panned and found to contain traces of cinnabar.

The adit, said to penetrate the area beneath the shaft, trends about N. 35° W. at the portal. Difference in elevation between the shaft collar and the adit is about 115 feet. The surface of the dump consists mainly of epidote-rich rocks thought to belong to the Paleozoic schists. Crystalline cinnabar was found on the dump in rock fragments cut by veinlets of calcite and quartz. Many of the slip surfaces are coated with hematite.

RED STAR PROSPECT

Location: W$\frac{1}{2}$NW$\frac{1}{4}$ sec. 17, T. 41 S., R. 2 W., about 300 yards southeast of Maple Dell Gap along the Wards Fork Gap trail, which branches from the Yellowjacket Ridge road.

Owner: Donald O'Brien.

Production: None.

History and development: It is reported that quicksilver used by an early-day placer miner was obtained from this occurrence. Evidently the amount was small. The present claims were located on November 18, 1938, by Eugene Mee and John O'Brien, father of the present owner.

Development consists of a 20-foot opencut leading to an 8-foot adit and, about 15 feet lower, a 25-foot adit. The opencut is nearly filled with caved rubble. Several small prospect pits are scattered about the immediate area.

Geology: The country rock is a coarse-grained foliated-to-massive chlorite-epidote schist. The opencut and two tunnels extend northward into the hill along an ill-defined fault trending N. 5° E. and dipping steeply westward. The rocks exposed in the lower tunnel are distinctly foliated, whereas those in the workings above are not. Rock on both sides of the fault is cut by numerous discontinuous veinlets of calcite and a few of quartz. The largest exposed veinlet is composed of calcite and is about 3 inches in maximum thickness and trends nearly normal to the fault.

Evidence that faulting has occurred exists largely in the difference in attitude of the foliation and minor fracturing on opposite sides of the fault. Foliations in the lower tunnel trend N. 70° W. and dip 21° N. on the footwall side and on the hanging wall side nearly parallel the fault. Narrow fractures on opposite sides of the fault in the upper workings dip toward each other. Brecciation has occurred along some of the fractures and occasionally they are filled with narrow calcite veinlets. Hydrothermal alteration of the wall rocks is slight.

Very little cinnabar was observed in the workings; however, in several pieces of broken rock piled near the entrance to the opencut, crystalline cinnabar is strikingly displayed in the calcite seams and also in the rock immediately adjacent to the calcite.

BRICK PILE PROSPECT

Location: Secs. 4 and 9, T. 40 S., R. 1 W., on the north-facing slope of the ridge north of Cinnabar Gulch, which enters the Little Applegate River from the west. The prospect is accessible only on foot, and may be reached by walking half a mile down the slope from a spur off the Glade Creek road.

Owner: Timber Products Co., Medford.

Production: None recorded; a few flasks probably produced.

History: Dennis (1903) reports that cinnabar was discovered in this area in 1868. In 1871 a Mr. Mullin constructed a crude furnace and attempted, in a primitive way, to reduce the surface ores. For a short period he succeeded in supplying the local demand of the placer miners, but the escape of mercurial fumes from his rudely constructed furnace soon salivated his men and the project was abandoned. In 1899 these claims were relocated and in 1901 the property was acquired by a Montana company which did considerable development work. Other claims are said to have been located in the same area by other interests.

The property was acquired by the Oregon-Montana Mining, Milling & Manufacturing Co. in 1914, and by the Timber Products Co. of Medford, Oregon, in 1938. In 1941 about 600 feet of old workings were cleaned out by a group of lessees. Other than this, no significant work is known to have been done since the time of the Dennis report, and all of the workings are caved.

Development: Remains of an old brick furnace lie near creek level at the southern edge of a graveled terrace about a third of a mile west of the Applegate River. The mine workings are up the hill to the south and west. A short distance downstream from the furnace, an old road leads up the ridge for about half a mile to the caved portal of a tunnel, which from the size of its dump may contain 400 to 600 feet of workings. The Oregon Dept. of Geology and Mineral Industries (1943) reports the existence of another adit about 200 feet in elevation above this tunnel, and the dump of perhaps a shallow shaft lying still higher.

Geology: The rocks of the area include weakly schistose to massive amphibolites and siliceous metasediments. Little is known about the distribution and occurrence of cinnabar. Dennis (1903) states, "The cinnabar of this district occurs in very fine crystals saturating a gangue of granular calcite; the veins have nearly a north and south strike and dip at an angle of 48° W." The Oregon Dept. of Geology and Mineral Industries (1943) reports as follows:

> "In the uppermost adit, at the portal, there is a shear zone that trends S. 43° W. and dips 37° NW. As this trend is similar to the underground workings, it may be that this shear zone defines the hanging wall of the ore body. The ore is in a silicified portion of the country rock. Numerous quartz stringers cut the rock which is well silicified. Oxidized portions have a rust-brown color; the prevailing color is buff. The cinnabar occurs as small crystals, averaging about 1/8 inch in length although there is some evidence of 'paint.' Some specimens are regularly spotted with cinnabar. A few very small grains of sulphides were seen."

SISKIYOU GAP PROSPECT

Location: NE$\frac{1}{4}$ sec. 34, T. 40 S., R. 1 W., about 1,500 feet airline northeast of and about 300 feet below the level of Siskiyou Gap at the head of the Little Applegate River.

Owner: Gordon Mehl.

Production: None.

Development: Development consists of a 50-foot adit and an opencut 12 feet deep which connects with the face of the drift. All of this work is said to have been done by Ray Elliott and associates during 1957.

Geology: The country rock is a medium-grained hornblende quartz diorite. Several quartz-feldspar pegmatite veins of random orientation are exposed in the workings. The largest seen was 6 inches thick. The opencut and the last 10 feet of the adit explore a zone, 2 to 3 feet wide, of crushed and thoroughly altered quartz diorite trending N. 55° E., dipping 80° NW., and lying within a shear zone at least 20 feet wide. The gouge zone consists almost entirely of varicolored clays and limonite. The wall rocks have been altered, though not so intensely, along numerous closely spaced subparallel fractures. A spring issuing from the slope above and penetrating the fractured rock is probably responsible for part of the alteration.

No cinnabar was visible in any of the workings; however, samples of both the gouge and the fractured but less altered wall rocks were panned and found to contain a small number of fine cinnabar crystals. A small amount of pyrite was also found in pannings of the wall rock.

PICKETT CREEK AREA

The Pickett Creek area lies about 12 airline miles northwest of Grants Pass in the center of Josephine County. The area is bisected by Pickett Creek, which heads in the vicinity of Onion Mountain and flows westward about 5 miles to the Rogue River at Robertson Bridge. Topographic coverage for the area is given on the Selma quadrangle map.

The area includes six quicksilver prospects, but only three are described below. The others (Contact, Postem, and Wolfe prospects), in which only traces of quicksilver were reported, are listed in Table 5 at the end of the section on southwestern Oregon. Quicksilver production totals 42 pounds, all of which was produced at the Pickett Creek mine in 1932. The host rocks are sandstones, shales, and mildly metamorphosed volcanic rocks of the Jurassic Galice Formation.

EMPIRE MINE

Location: NW¼ sec. 3, T. 36 S., R. 7 W. about 13 miles west of Grants Pass and on the Shaw Creek side of the divide between Pickett and Shaw Creeks. It is accessible via a side road branching from the Shaw Creek road.

Owner: Lela Briggs.

Production: None.

History and development: Four claims, including the prospect, were located by Lester R. Briggs in 1931. Underground work, most of which was done prior to 1940, consists of two short adits, one above the other, and a shallow shaft. These workings, now caved, are scattered along the course of a shallow northeast-trending draw. The upper adit is reported to be about 80 feet long, the lower about 45 feet long, and the shaft about 35 feet deep. In recent years a large opencut about 200 feet long, following the contour of the hill, destroyed the portal of the upper adit. A small retort and two ore bins in complete disrepair remain on the property.

Geology: The country rocks are massive to schistose metavolcanics, and where exposed by the opencut are considerably oxidized. A small part of the rock on the upper adit dump is dark green and has a slick, shiny appearance, probably caused by the presence of considerable chlorite. A sample of the upper adit dump assayed 0.30 pounds quicksilver per ton. A sample of several tons of oxidized rock remaining in the ore bins assayed 0.50 pounds per ton.

PICKETT CREEK MINE

Other names: Carnegie mine; Duvall and Powell prospects.

Location: Sec. 33, T. 35 S., R. 7 W. about 3.2 miles west by road up Pickett Creek from Robertson Bridge and 300 yards south by trail along a small tributary of Pickett Creek. The workings are nearly concealed by underbrush. On the opposite side of Pickett Creek from the mouth of the tributary are two dilapidated cabins and a small pile of bricks, presumably the remains of a small retort.

Owner: Frank Melvin.

Production: 42 pounds.

History and development: Claims presumably covering this prospect were located in 1931 by J. M. Farmer and E. T. Carnegie. J. C. Wilson acquired the property in 1932 and, according to records, produced 42 pounds of quicksilver during that year using a small rotary retort. In 1938 the property was operated by J. C. Hirchfeld and associates but no production was made. The property was held for a time during 1954-55 by E. F. Duvall and Grant Powell and was relocated by Melvin in July 1956.

Development includes a shallow shaft, several small pits, and three short crosscut adits, all lying within a 100-foot-square area along the western edge of the creek.

Geology: The country rocks are contorted sandstones and shales of the Jurassic Galice Formation. The two southernmost adits, which are connected by a drift, which is in turn connected to a raise to the surface and to a 5-foot winze, are in fractured and altered medium-grained sandstone containing crumpled lenses of shale. The drift and connected workings explore a northerly trending shear zone wherein the sandstone is altered, locally silicified and cut by irregular lenses and veinlets of quartz. The northernmost adit lies almost entirely in highly contorted black shale cut by numerous veinlets and small bunches of quartz. The shaft, collared in sandstone near the portal of the northern adit, is full of water but is said to be about 20 feet deep. No cinnabar was observed in any of the accessible workings.

RED LEDGE CINNABAR

Location: Center of south edge of sec. 1, T. 36 S., R. 8 W., near head of Pickett Creek, about 1¼ miles airline northeast of Onion Mountain Lookout. From the southeast base of Onion Mountain a road leads northeast about three-quarters of a mile to a small cabin on the property.

Owner: J. E. Hamlin, Grants Pass.

Production: None.

History and development: Along the crest of the ridge south of the cabin are several short tunnels, shafts, and opencuts which were dug by Hamlin and various lessees over a period of many years in search for gold. These workings lie in a mass of serpentinized peridotite.

The principal cinnabar development lies about half a mile by trail east of the cabin. Here two claims, the Red Ledge and the Mercury King located in 1931, lie end to end and extend roughly N. 45° W. across the northeast-facing slope of a steep ridge. Development consists of two or three hand-dug opencuts. The only one visited by the writer was near the middle of the Red Ledge claim. It was about 10 feet across and 8 feet deep.

Geology: Rocks exposed in the vicinity of the opencut consist of massive greenish to greenish-gray chloritized tuffs and andesites of the Jurassic Galice Formation interrupted by a layer of thin-bedded maroon-red tuff. The red tuff band, which is about 10 feet thick, is exposed at intervals along the hillside for several hundred feet in a northerly direction. In the opencut, chloritized tuffs below the red band contain scattered, finely crystalline particles of pyrite in various stages of oxidation. Cinnabar occurs locally along fracture surfaces, which were probably produced mainly by jointing, since little evidence of movement was observed. The rocks are well indurated and apparently were impregnated by the cinnabar-bearing solutions only along the joints.

BRIGGS CREEK AREA

The Briggs Creek area, which is primarily one of gold and chromite, includes three cinnabar prospects in west-central Josephine County; one in T. 36 S., R. 9 W., and two in T. 37 S., R. 9 W. The prospects lie in the drainage of Briggs Creek, a tributary entering the Illinois River from the northeast. Very little work has been done on any of the prospects and no production made. All are in rocks of pre-Tertiary age. The area is covered by the Selma topographic quadrangle.

LAST CHANCE GROUP

Location: Sec. 15, T. 37 S., R. 9 W., on Soldier Creek, a tributary of Briggs Creek and the Illinois River.

Owners: Unknown.

Production: None.

History: According to Treasher (unpublished department mine-file report, 1942) the area was prospected many years ago in search of gold. Cinnabar was known to be present but was not exploited until July 1941, when the claims were relocated by J. A. Hance. E. H. Messenger and Fred Linkhart were given an interest to help develop the property. A few shallow pits were dug, but these were caved and full of water at the time of Treasher's visit in July 1942. There is no record that any further work has been done on the property. The present writer found all workings in accessible and was unable to locate any local resident familiar with the prospect.

Geology: Treasher reports: "The overburden is quite heavy and rock outcrops are scarce. The trail to the property is on a granitic rock probably diorite, but this changes to a gneissic rock with the development of considerable hornblende and some biotite. This material may be a contact auriole. Serpentine covers the rest of the area. The 'cinnabar ledge' appears to be along the contact of the serpentine and the gneiss. The contact zone is several feet wide, is intensely sheared and thoroughly softened. The soil overlying the ledge contains cinnabar that can be seen by panning. The grade is low. It is reported that soft, decomposed serpentine contains up to 8 pounds per ton of quicksilver."

LIGHTNING RIDGE PROSPECT

Location: Near the north edge of sec. 24, T. 36 S., R. 9 W., on a sharp-crested ridge. The prospect is about 20 miles from Galice via the Chrome Ridge Road.

Owners: Lester Smith and Paul Baird, Canyonville.

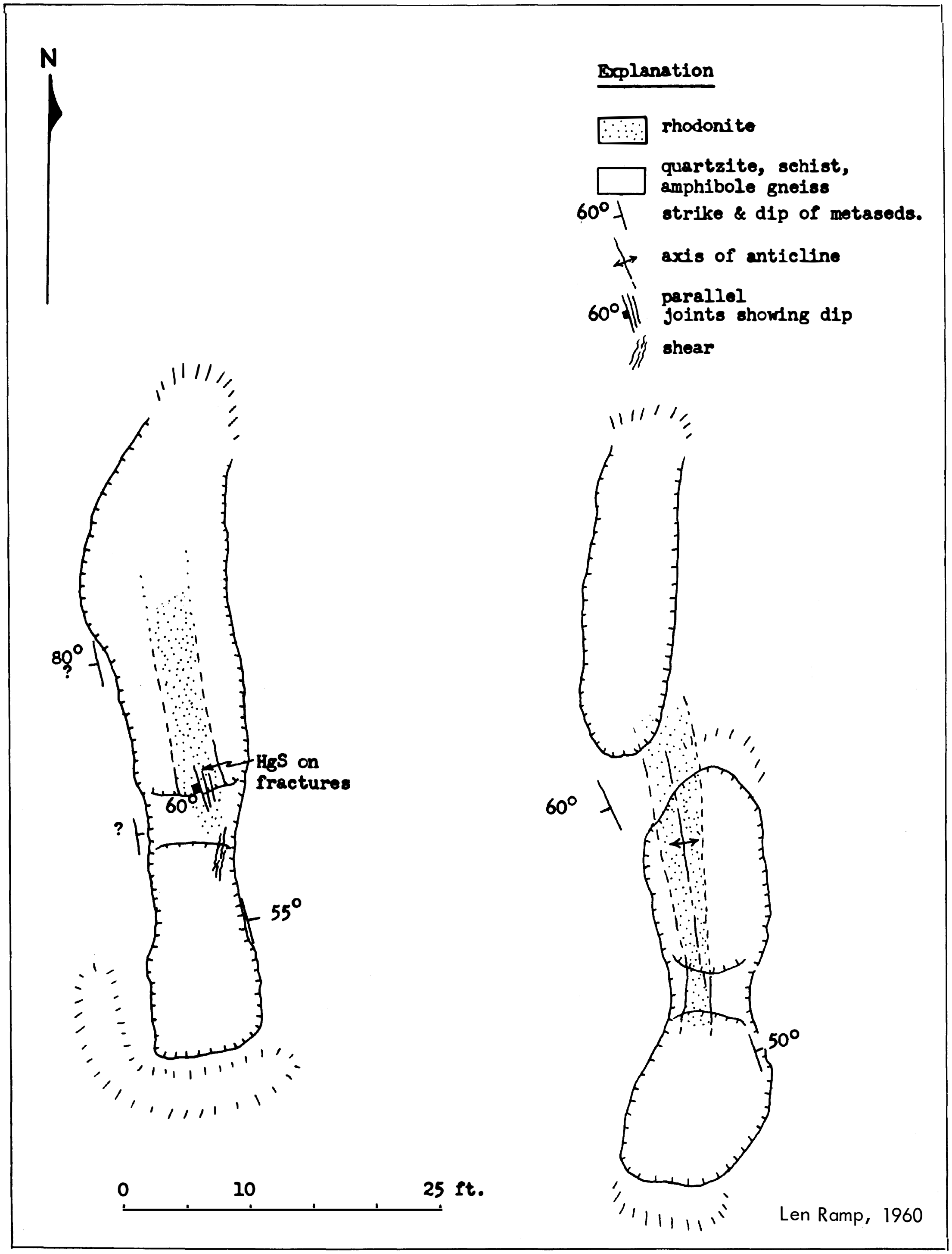


Figure 33. Sketch of the Lightning Ridge prospect.

Production: None.

General description: The following is from reports by Appling (1958) and Ramp (unpublished department mine-file report, 1960). The prospect is developed by two pits 5 feet deep and a trench 3 to 6 feet deep (see Figure 33). The country rocks consist of tightly folded quartzites, mica schists, and amphibolites that appear to be wholly gradational. Small pods of rhodonite, mixed manganese oxides, quartz, and a little garnet occur along the crests of small folds. The pods are associated with bedding-plane fractures that strike N. 10° W. to N. 25° W.

Cinnabar occurs along fractures in the manganese minerals in one of the pods. Of two samples assayed by the department, one contained the equivalent of 3.30 pounds of quicksilver per ton, and the other 16.7 pounds per ton. The deposit appears to be of very limited size.

SWEDE BASIN PROSPECT

Location: NW$\frac{1}{4}$ sec. 1, T. 37 S., R. 9 W., about one mile west of Swede Basin and a third of a mile southwest from the end of the Onion Creek road.

Owner: Jack Eggers.

Production: None.

History: John W. Eggers, father of the present owner, located the property in 1926 and prospected it sporadically until his death in 1948. In 1958 the 4 claims were relocated by Jack Eggers, George Eggers, and Jack Wilson.

Development: Development consists of an inclined shaft and several pits and bulldozer trenches. The shaft, now caved a few feet below the collar, is said to be about 36 feet deep on a 45° incline.

Geology: The country rocks are felsitic and amygdaloidal metavolcanics of the Galice Formation of Jurassic age. The shaft explores a shear zone, which is about 3 feet wide and strikes N. 75° W., in altered and softened light-colored metavolcanics. Within the shear zone the rocks have been reduced to a dark red mixture of clays and iron oxides. A sample of this material from the shaft dump contained only a trace of cinnabar.

Alluvium in a swampy area lying a few hundred yards south of the shaft yields small amounts of cinnabar on panning. Several cuts and auger holes have failed to disclose the source of the float.

BARKLOW MOUNTAIN AREA

The Barklow Mountain area lies in the northeastern part of Curry County at the head of Sixes River in T. 32 S., R. 13 W. It was not visited by the writer. The only known quicksilver deposit is the Harmony prospect. The following report was compiled from notes taken by A. O. Bartell in October 1940 and from information furnished by the present owners. The area is covered by the Powers topographic quadrangle.

HARMONY PROSPECT

Location: Sec. 35, T. 32 S., R. 13 W., about 300 feet up the south bank of Benson Creek. It is accessible by about 6 miles of trail leading westward over Barklow Mountain from the Johnson Creek road.

Owners: Daniel D. Keohane, A. C. Schafer, B. P. Harmon, D. B. Harmon, and Joe Knox.

Production: None.

History and development: The two original claims, the Fixus and the Crystal, were located about 1937 by J. A. Olson and D. E. Needham. Succeeding Olson and Needham as owners of the property were Bob Harrison, Walt Marion, Joe Knox, and Art Train. The property was relocated by the present owners about 1950. Development consists of four or five small opencuts and a short adit. There is no record of production or of installation of any reduction equipment.

Geology: The country rocks consist of a greenish and partially serpentinized sandstone conglomerate in contact with a steeply dipping layer of shale. Both are probably of the "Myrtle formation" of Cretaceous age. The strike of the contact is approximately N. 35° E., and its dip is steeply northwest. Cinnabar occurs in the conglomerate immediately adjacent to the steeply dipping shale hanging wall. The cinnabar occurs both as disseminations and as thin coatings surrounding the pebbles. Traces of cinnabar can be found along the contact for more than 1,000 feet. An 8-foot channel sample from one of the cuts assayed 0.2 pounds of quicksilver to the ton. Another channel sample 5 feet in length assayed 3.05 pounds per ton. Another assayed 0.15 pounds per ton.

RED FLAT PLACERS AREA

Red Flat is a semi-level area adjacent to the North Fork of Pistol River in T. 37 S., R. 13 W., Curry County, about 17 miles by road east of Gold Beach. The map of the Gold Beach quadrangle gives the topography of the area.

Placer operations to recover both gold and quicksilver from the residual soils of the flat were begun in the early 1930's. Since that time, several large groups of placer claims have been located and there has been considerable prospecting activity. Concentrating equipment and small retorts have been erected, but there is no record of production. Present ownership and property boundaries are not accurately known. Organizations and individuals involved over the years have been The Red Flats Association or Red Gold Mining Co. headed by Mary Smedberg and J. A. Walsh, both of Gold Beach; Red Ridge Mining Co., represented by Harry Hedderley of Gold Beach; The Glade Creek Placer Association; and numerous others.

Most of Red Flat appears to be underlain by various types of peridotite which has been serpentinized to varying degrees. Red clayey soil, a product of weathering, interspersed with loose boulders of serpentine and peridotite, form the surface mantle. Since the terrain is fairly level, the products of weathering are only slowly removed. At least one prospect hole sunk to a depth of 30 feet failed to penetrate bedrock. Both cinnabar and native quicksilver occur locally in the soils of the flat but nowhere are representative samples known to have been taken that assayed more than a small fraction of a pound of quicksilver per ton. Parts of the deposit have been sampled for nickel by the department (Libbey and others, 1947) and by the U.S. Bureau of Mines (Hundhausen and others, 1954). Drill-hole samples tested for nickel were also assayed for quicksilver, but results were not favorable.

DIAMOND CREEK PLACERS AREA

The Diamond Creek placers are on the North Fork of Diamond Creek in the extreme southeastern corner of Curry County. The deposits, at an elevation of about 2,150 feet, extend southward along the creek into California. Those in Oregon lie in sec. 16, T. 41 S., R. 10 W., in the Chetco Peak quadrangle. Present ownership is unknown. The property was equipped with hydraulic equipment in 1929 and a small amount of ground has since been sluiced by various owners and lessees. Little work has been done for many years. The geology and development are described by Cater and Wells (1953, p. 126-7) as follows:

> "The cinnabar is scattered along fine joint fissures in a mass of propylitized diorite. The feldspar in this rock has been completely altered to kaolinite and sericite, and the amphibole has been altered to limonite. The altered diorite is exposed over the top of the ridge west of the camp and farther west is in contact with, or continuous with, the dikes passing near the Sunny Brook prospect. A tongue of serpentine crops out to the north, and to the east less altered rocks occur, including either a fresh hornblendite or gabbro containing inclusions of serpentine.
>
> "The original locator, John Griffin, dug a ditch along the top of the ridge and ground-sluiced what was originally a small slide. The water was run through a 10-inch sluice box equipped with Hungarian block riffles. The concentrates were retorted in two 4-inch pipes. Later equipment, installed by the J. I. L. Dredging Co. of Spokane, which leased the property was essentially a refinement of the above. A 3-inch giant was operated in the slide and the material run through a series of sluices in an attempt to concentrate the heavier cinnabar crystals by gravity separation. The process was extremely inefficient, operations were abandoned, and the property has been idle a number of years."

Table 5. Miscellaneous Quicksilver Occurrences in Southwestern Oregon.

PROSPECT NAME	Sec.	Twp.	Rge.	LOCATION	CHARACTER OF DEPOSIT	DEVELOPMENT	DISCOVERER & DATE	INFORMATION SOURCE	SAMPLE INFORMATION Date	Description	Assay lb./ton
COOS COUNTY											
Fuller Quicksilver prospect	10	32S	10W	Near head west fork of Cow Ck. 2 miles east Eden Guard Station.				(1)	9-12-41	10-ft. channel sample	0.1
CURRY COUNTY											
Clarno prospect	9	35S	14W	On Euchre Ck. about 1 mile east of Ophir.	Quicksilver and cinnabar in gold placer.			J. W. Pressler Grants Pass			
Rhyolite claim	30	32S	10W		Unknown	Shallow open cuts.	M.J.Carmichael 1936	Dept.Bull.14-C Vol. 1, p. 79	1939	None	None
DOUGLAS COUNTY											
Abeene property	18	25S	4W		Unknown			(2)			
Baldwin prospect	7	29S	8W	About 3 mi. n. of Camas Valley	Unknown			(1)	8-11-41	None	0.3
Banfield mine	34	31S	2W	On tributary of Drew Ck. about 6 mi. south of Drew.	Cinnabar reported with copper in greenstone.	3500' of underground workings. 5 adits.	H.Banfield (1900)	Dept.Bull.14-C Vol. 1, p. 128/9			
Chaney prospect	S½	28S	4W					(2)			
Drew prospect	SE11	31S	2W	¼ mi. east of Drew.	Traces of cinnabar in altered fault zones in Tertiary tuffs & basalt.	25-foot adit & 15-foot shaft.	Dave Crispen (about 1925)	Examined by writer			
Glide prospect	23, 26	26S	4W	On east slope of Jack Mtn. about 3 mi. SW of Glide.	Cinnabar along fractures in mildly altered basalt.	Short adit and small pits.	Tom Neil (about 1930)	Examined by writer			
Harkins prospect	22	31S	2W	About 3 mi. south of Drew.	Cinnabar in small fracture zones in schist & amphibolite.	Prospect pits.		Dave Crispen Milo, Oregon	3-16-42		0.7
Lucky Cuss claims	31	30S	2W	High on south wall of South Umpqua River canyon 3 mi. west of Tiller.	Traces of cinnabar along fractures in schist.	2 bulldozer cuts.	Dave Crispen (about 1925)	Examined by writer			
Manning prospect	2, 3	25S	4W		Unknown.			(2)			
May prospect	27	30S	2W		Unknown.			(1)	1-23-40	Quartz with cinnabar	5.8
Morris prospect	6	31S	4W		Unknown.			(1)		Fault gouge with free quicksilver	2.8
Ross claims	17, 18	29S	1W	On ridge n. of Budd Ck. 1 mi. w. of Poor Boy prospect.	Chalcedony veinlets with cinnabar in altered Tertiary volcanics.		Dave Crispen (about 1930)	Dave Crispen Milo, Oregon	3- 1-40		3.2
Rowe prospect	16	30S	4W	2½ mi. south of Days Ck.	Cinnabar along small fractures in Tertiary basalt.	None.	Albert N. Rowe (1942)	Albert N. Rowe Days Creek, Ore.	1- 6-42	Iron-stained quartz	0.5
Victory placer	33	32S	7W	Few miles west of Glendale.	Native quicksilver & cinnabar in gold placer.			W. R. Purvine Glendale, Ore.			

JACKSON COUNTY											
Booth prospect	3	36S	3W		Unknown.			(1)	8- 2-41		0.1
Copus prospect	2	40S	3W		Unknown.			(1)	4- -40	Quartz & pyrite	5.7
Frost claims	20	34S	2W	Adjoins Chisholm Group on south in Meadows area.	Cinnabar along fractures in schist & amphibolite	Opencuts		James Chisholm Rogue River, Ore.			
Jolly prospect	8	37S	3E	On north wall of South Fork of Little Butte Ck. Canyon, 9 mi. east of Lake Ck.	Cinnabar in chalcedony veinlets in 6-inch fracture zone in basalt.	One small pit.	Byron Jolly (1941)	Examined by writer	10-29-41	Reddish chalcedony	0.1
Long Branch mine	24	34S	2W	West edge of Meadows area.	Chalcedony veinlets in altered Tertiary volcanics with pyrite & cinnabar.	Caved adit.		Schuette 1938			
Mammoth lode	28,29	32S	2W	2 mi. south of Red Cloud mine.	Massive pyrite & chalcopyrite in amphibolite. (3)	Adit containing about 200' of workings.		Examined by writer			
No Name prospect	20	40S	4W	Short distance S. of Murphy prospect, Upper Applegate area.	Probably typical of others in Upper Applegate area.			Wells (1939)			
Seventy Three group	1	35S	3W	Adjoins Mtn. King mine on south.	Cinnabar along fractures in schists.	Small scattered pits.		Dept. Bull. 14-C, Vol. 2, Sec. 2, p/108			
Shull prospect	13	34S	2W		Clay alteration of Tertiary volcanics with pyrite & cinnabar.			(1)	3-21-41		34.0
Table Mtn. prospect					Writer unable to locate.			(2)			
JOSEPHINE COUNTY											
Centennial mine	25	35S	5W	On Louse Ck. about 10 miles NE. of Grants Pass.	Cinnabar reported with gold in granite.	Two adits & opencuts.	Unknown (prior to 1940)	Dept. Bull. 14-C Vol. 2, Sec. 1, p. 68			
Contact group	28	35S	7W	On the divide between Panther and Pickett Cks.	Gold, silver prospect in "slate" & greenstone. (3)	4 adits & opencuts.	E.T. Carnegie (about 1930)	Dept. Bull. 14-C Vol. 2, Sec. 1, p. 68			
Copper Queen mine	15	34S	6W		Massive pyrrhotite & chalcopyrite in altered sediments of Galice Formation. (3)			Dept. Bull. 14-C Vol. 2, Sec. 1, p. 99			
Eggers and Hance prospects	15	41S	9W			Small prospect pits.		John Eggers Cave Junction, Ore.		Greenstone	0.4
Postem prospect	36	35S	8W		Unknown.			(1)	10-27-41	Altered serpentine	0.1
Wolfe prospect	16	35S	7W		Unknown.			(1)	10- 3-41	Serpentine with cinnabar.	6.0
Young prospect	6	33S	5W		Unknown.		George D. Young (1940)	(1)	5- -41	Schistose greenstone	2.2
LANE COUNTY											
Pitcher prospect	26	21S	1W	Few miles northwest of Disston.		Pits & short adit.	Ben Pitcher, 1935 Disston, Oregon	Frederick file report, 1943	4- 2-40	Quartz & altered felsite with small amount of cinnabar	0.3

(1) Information available is limited to that given on forms submitted with samples for assay.
(2) Listed by Frederick (1945); no other information available.
(3) Frederick (1945) indicates that quicksilver minerals are also present. No assays or other information available.

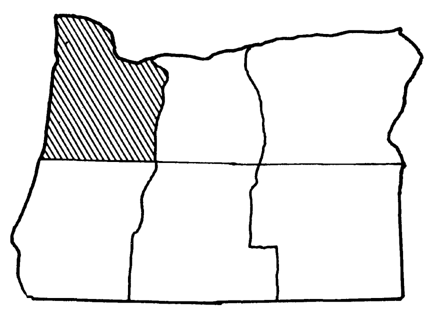
MISCELLANEOUS OCCURRENCES

Listed in table 5 are a number of quicksilver occurrences which, because of their minor importance, have been omitted from plate 1 (locality map of quicksilver deposits in Oregon). Some of these occurrences are of doubtful existence, but since they have been either reported to the department or included in the literature, the available information about them is summarized in table 5. Certain of these deposits are known only through data given on assay forms by prospectors who submitted samples to the department for chemical analysis. The writer attempted to visit each of these reported occurrences or in some way verify their existence, but could not confirm all of them.

PART II DESCRIPTIONS OF THE QUICKSILVER DEPOSITS

CHAPTER 2

NORTHWESTERN OREGON



Chapter 2. NORTHWESTERN OREGON

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CHAPTER 2

Northwestern Oregon

Northwestern Oregon includes all of the area of the state lying north of the 44th parallel and west of the High Cascades (Figure 34). Its only productive quicksilver deposits are the adjoining Nisbet, Kiggins, and Ames properties on the Oak Grove Fork of the Clackamas River. Nonproductive occurrences include the North Fork prospect on the North Fork of the Clackamas River, the Portland Tunnel locality in Multnomah County, and the Watrous prospect near Manhattan Beach in Tillamook County.

Geology and Distribution of the Quicksilver Deposits

All of the quicksilver deposits occur in volcanic rocks of Tertiary age. The deposits in the Oak Grove Fork area occur in veins filling fractures in Columbia River Basalt of middle Miocene age. The North Fork occurrence, 17 miles to the northwest, is in the Rhododendron Formation of Miocene age, overlying Columbia River Basalt. Distribution of these formations in the Clackamas River area has been discussed and mapped by Peck (1960, 1961) and by earlier workers (Barnes and Butler, 1930; Sheets, 1932). The quicksilver occurrence in Portland is in Columbia River Basalt, whereas the Watrous deposit is associated with sediments intruded by a basalt dike.

Description of the Quicksilver Deposits

OAK GROVE FORK AREA

KIGGINS, NISBET, and AMES-BANCROFT GROUPS

Location and ownership

Three adjoining groups of claims known as the Kiggins, Nisbet, and Ames-Bancroft groups, lie along the Oak Grove Fork of the Clackamas River in secs. 4 and 5, T. 6 S., R. 7 E. The principal workings of these claim groups are scattered along the steep southwestern bank of the river immediately below the Three Lynx Dam (also known as Lake Harriet Dam) of the Portland General Electric Co. The mines lie 31 miles southeast of Estacada and are reached via heavy haulage roads up the Clackamas River and the Oak Grove Fork. The High Rock quadrangle gives topographic coverage.

The Kiggins mine workings are about a quarter of a mile below the Three Lynx Dam and about a third of a mile upstream from the Nisbet mine. The principal workings of both the Kiggins and the Nisbet mines lie within 300 feet of the river's edge, a short distance from roads on either side of the river. The adjoining Ames-Bancroft prospect lies farther up the slope. No road affords access to any of the tunnel sites. Materials are transported from the north side of the river by tramline. Topographic relief is high. The southwestern river bank, along which most of the development work has been done, is precipitous. Elevations here range from 1,800 to 2,100 feet above sea level. Rock outcrops are scarce except along the banks and bed of the river.

The Nisbet group of claims is owned jointly by the estate of George Nisbet, deceased, and A. O. Bartell. The Kiggins group, owned by D. E. Kiggins, is at present under lease to Bartell. The Ames-Bancroft group is owned by Elizabeth Ames and E. A. Bancroft.

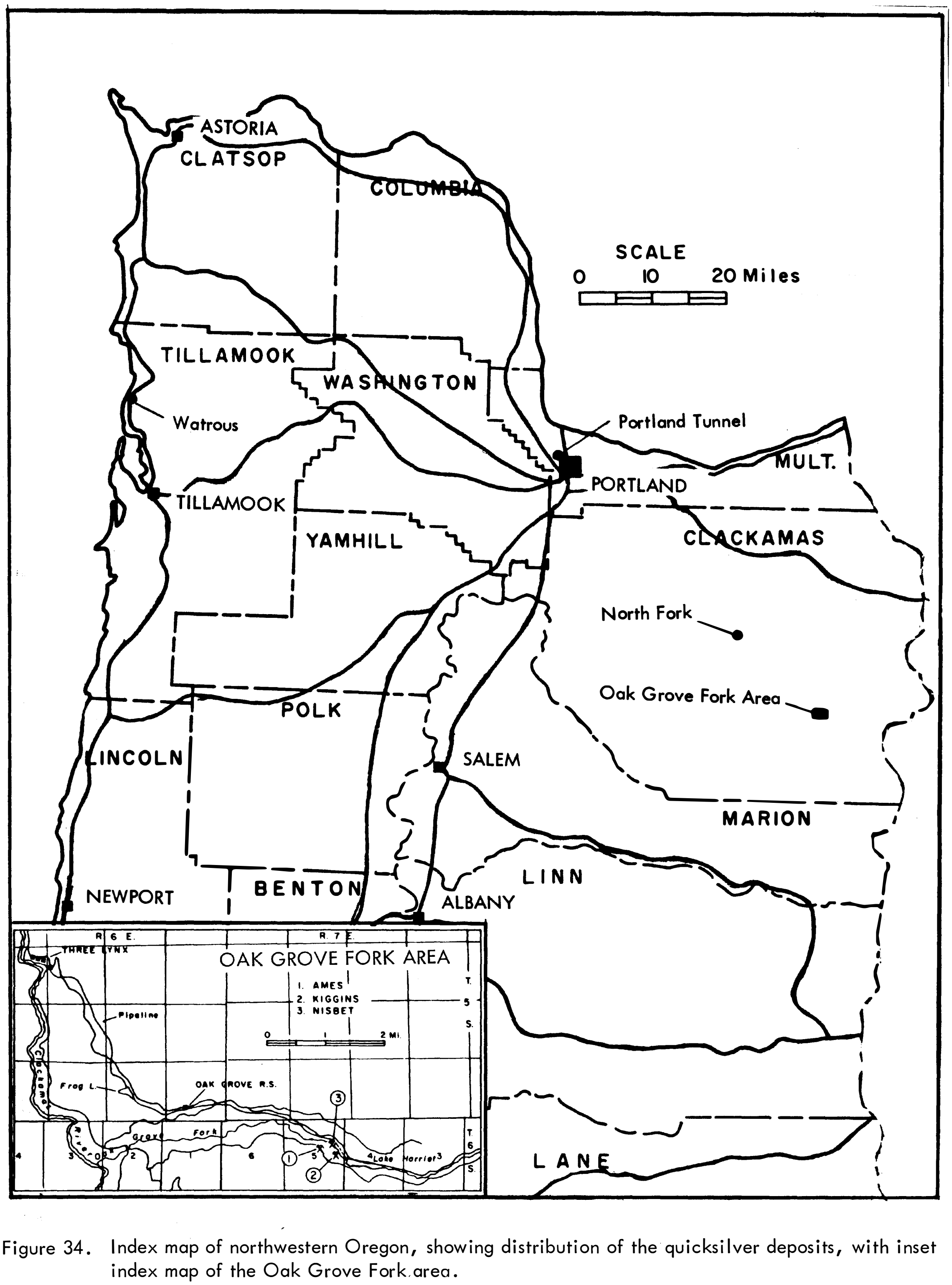


Figure 34. Index map of northwestern Oregon, showing distribution of the quicksilver deposits, with inset index map of the Oak Grove Fork area.

History and production

Cinnabar was first discovered in the Oak Grove Fork area by George Nisbet, who located the Vermilion group of claims in 1923-24, and the Oak Grove group two years later. In 1927 D. E. Kiggins was given a one-eighth interest in the claims and the two men worked as partners until 1938, when Nisbet gave his interest in the Vermilion group to Kiggins and took ownership of the Oak Grove group for himself. During these early years, ore was treated in a more or less continuous shaft-type furnace constructed by Nisbet in 1925 or 1926. To construct the furnace, Nisbet built a concrete wall across the open side of a chimney-like opening in a rock cliff. A wood-burning firebox was built into the bottom of the furnace by placing two large fire tiles in a roof shape across the inside of the furnace near the bottom. The fire tiles kept the ore mass from crushing out the wood fire and allowed the burned ore to pass on both sides, reuniting beneath the firebox. When the furnace was in operation on a continuous basis, a wheelbarrow-load of burned ore was withdrawn through a chute opening at the bottom and a charge of new ore was added from a hopper at the top. In 1939 a cylindrical shaft-type furnace with a capacity of about 15 tons per day was erected on the Oak Grove group of claims.

In 1940 an option was given on the Kiggins claims to Horse Heaven Mines, Inc., and the Nisbet claims were leased to Oregon Quicksilver, Inc., headed by George S. Barton of Eugene. After driving adit No. 3 to what is apparently the intersection between the Falls vein and the Vermilion vein and finding only minor mineralization, Horse Heaven Mining Co. failed to exercise its option to lease the Kiggins group and the property reverted to its owner. During 1940 and 1941, Oregon Quicksilver, Inc., produced 66 flasks from the Nisbet property using the cylindrical shaft furnace. In 1942 E. O. Emil produced 3 additional flasks from the Nisbet claims.

The latest recorded production from the Kiggins claims was made in 1941 and from the Nisbet claims in 1943. Little other than annual assessment work was done on either property until recent years. In 1960, Bartell received an OME loan and began a drilling program to explore the property at depth. This work is still in progress.

The Ames-Bancroft group of claims was located by A. G. Ames, who had been hired by Nisbet to do surface trenching on the Oak Grove group of claims for annual assessment work. Ames found cinnabar at the side line of the Oak Grove claim. The vein extended into the adjoining Clackamas claim, which Nisbet had located but had not recorded. Nisbet gave the Clackamas claims to Ames and Kiggins. Ames later acquired sole ownership of the claim and proceeded through the following years to locate other claims in the area. An interest in the claim group was later acquired by E. A. Bancroft. Production of 7 flasks from sorted high-grade ore was recorded in 1932. Ore was evidently treated in the crude furnace on the Vermilion claim. There is no record of any further production. Production as recorded by the U. S. Bureau of Mines for the Ames, Kiggins, and Nisbet groups of claims is given in Table 6. Information obtained from Nisbet by Mr. Bartell indicates that the total production may be around 300 flasks.

	Ames		Kiggins		Nisbet	
	Flasks	Tons of Ore	Flasks	Tons of Ore	Flasks	Tons of Ore
1932	7	?				
1934			20	?		
1935			16	?		
1936			12	?		
1937					18	60
1938			5	20	7	25
1939			9	64	5	25
1940			5	28	57	619
1941			4	31	9	68
1942					3	25
1943					3	Cleanup
			71		102	822

Table 6. Production from Ames, Kiggins, and Nisbet mines.

Geology

The deposits are in basalt or basaltic andesite flows, probably Columbia River Basalt of Miocene age. The rock is dark gray to black. The structure ranges from columnar to blocky to massive, and the texture is fine grained to glassy. In the mineralized area the basalt is cut by numerous calcite veinlets of random orientation. These veinlets increase in number near the larger mineralized veins.

Cinnabar occurs chiefly in fissure veins constituted mainly of banded calcite, although one of the most productive veins on the Nisbet claims consists principally of the mineral stilbite, a low-temperature zeolite. Cinnabar is said to occur also as narrow fracture fillings in the basalt adjacent to the veins.

The cinnabar-bearing calcite veins explored by the workings range from about 6 inches to about 6 feet in width. Locally the individual veins converge to form mineralized zones 10 to 15 feet wide. The calcite veins appear to have been introduced into open fractures in the basalt. Displacement along the fractures is evidently slight, although locally the basalt adjacent to the veins is brecciated and has been altered by hydrothermal solutions to a dark, gray-green rock which contains considerable clay and is locally stained by limonite.

The calcite veins commonly have a banded structure. Thin sections furnished by Mr. Bartell clearly show that the calcite is a mass of coalescing crystals deposited in successive stages, one band upon the other, until the opening was completely filled. Open spaces between the terminal faces of one band of calcite and the base of the next and also open spaces between some of the calcite crystals are commonly filled with chalcedony containing felted mixtures of quartz; opal; a zeolite which is either heulandite or stilbite; calcite; and locally ilsemanite, jordisite, and cinnabar. The mixture ranges in color from red to white to black, depending upon how much cinnabar or pyrite, ilsemanite, and jordisite might be present.

In places the zone of oxidation is pronounced. The calcite has been leached away leaving the cinnabar intermixed in the remaining soil and rubble. A large part of Nisbet's production is said to have been made by hydraulicking rich residual material overlying the Sluice vein and the Oak Grove vein and recovering it on sluice boxes and a homemade shaking table. Because sloughed material and vegetation cover parts of the sluiced area, and because the reject from the concentrators went into the creek and was carried away, there is little evidence of the amount of ore treated in this manner.

Description of the veins and workings

Part of the workings on both the Kiggins and Nisbet properties was inaccessible at the time of visit by the present writer. Fortunately, the mines had been examined and a report and maps compiled by Brown and Walker (1943) when most of the workings were open for inspection. Figures 35 and 36 were adapted from their maps and part of the following information was taken from their unpublished report. In addition, much helpful information came from a report made by Mr. Bartell concerning the property.

Kiggins mine: The Kiggins mine includes 330 feet of drifts and stopes and about 200 feet of crosscuts divided among three adits. All the workings are near the same altitude on the back edge of a river terrace. The Vermilion, Stope, and Falls veins are exposed. They vary in attitude by several degrees, but all lie in the northwest quadrant and dip to the northeast. The Falls vein is exposed in the bed of the river and has been worked very little.

The Vermilion vein is developed by three adits. The No. 1 adit explores the vein from the portal for 180 feet northwestward, at which point the vein dies out and ends against a steep, westward-dipping mineralized cross fault which shows both premineral and postmineral movement. Exploration north and west failed to discover the vein extension. The vein is irregularly mineralized with cinnabar for the entire distance, but only one ore shoot contains minable ore. This is near the portal of the No. 1 adit and extends downward to the No. 2 adit, with a pitch to the east of 50 degrees. The amount of cinnabar in the vein decreases westward. The thickness of the vein similarly decreases westward from a maximum of 4 feet at the portal of the No. 1 adit to less than 2 feet at the cross fault zone.

The southeast extension of the Vermilion vein is explored by the No. 3 adit, 320 feet southeast of the No. 1 adit. The vein in this adit dips 35° northeastward and splits into two steeper diverging veins, only one of which is mineralized with cinnabar. Cinnabar in the vein decreases eastward from the portal. The part of the vein between the two adits lies at the base of the cliff and is covered by vegetation and numerous driftwood logs.

The Stope vein north of the No. 1 adit is stoped westward for 30 feet and upward for 17 feet. The vein is 8 inches thick and assays about 6 pounds of quicksilver per ton of vein material. It probably joins the Vermilion vein at greater depth (Fig. 35).

The Fall vein crops out in the channel of the Oak Grove Fork of the Clackamas River for a distance of 250 feet from a point a short distance downstream from the furnace to a point opposite the No. 3 adit. The vein is $1\frac{1}{2}$ to 2 feet thick and is nearly vertical. The river channel follows the vein, which erodes more easily than the enclosing basalt. As the result, the vein lies in a narrow trench from 3 to 5 feet wide and from 10 to 20 feet deep in the river bed. Part of this vein was mined opposite the No. 3 adit, but work can be done only during low-water stages of the river or when the dam upstream releases little water. Numerous boulders and blocks of cinnabar-bearing calcite are strewn for more than half a mile downstream as the result of erosion of this vein.

Nisbet mine: The Nisbet mine is developed by about 500 feet of underground workings distributed among 5 adits and an inclined shaft. There are also several opencuts (Fig. 36). The Oak Grove vein is developed by two adits and surface trench; the Sluice vein by an adit and a surface trench; the Ben vein by one adit and a small stope; and the Zeolite vein by an adit and inclined shaft, both caved, and by a stope only partly accessible. Most of the production of the mine has come from the Zeolite vein.

The Oak Grove vein strikes east, dips 70° to 80° N., and is explored for a horizontal distance of 100 feet and for a vertical distance of 100 feet by two adits and a surface trench. It ranges from 6 inches to 6 feet thick. At the west face of the lower adit the Oak Grove vein consists of three shears, each of which is mineralized with cinnabar, calcite, and silica. The vein is of stoping width where these mineralized shears are near each other. In the upper adit the vein is a foot wide at the portal and well defined, but westward it splits into three

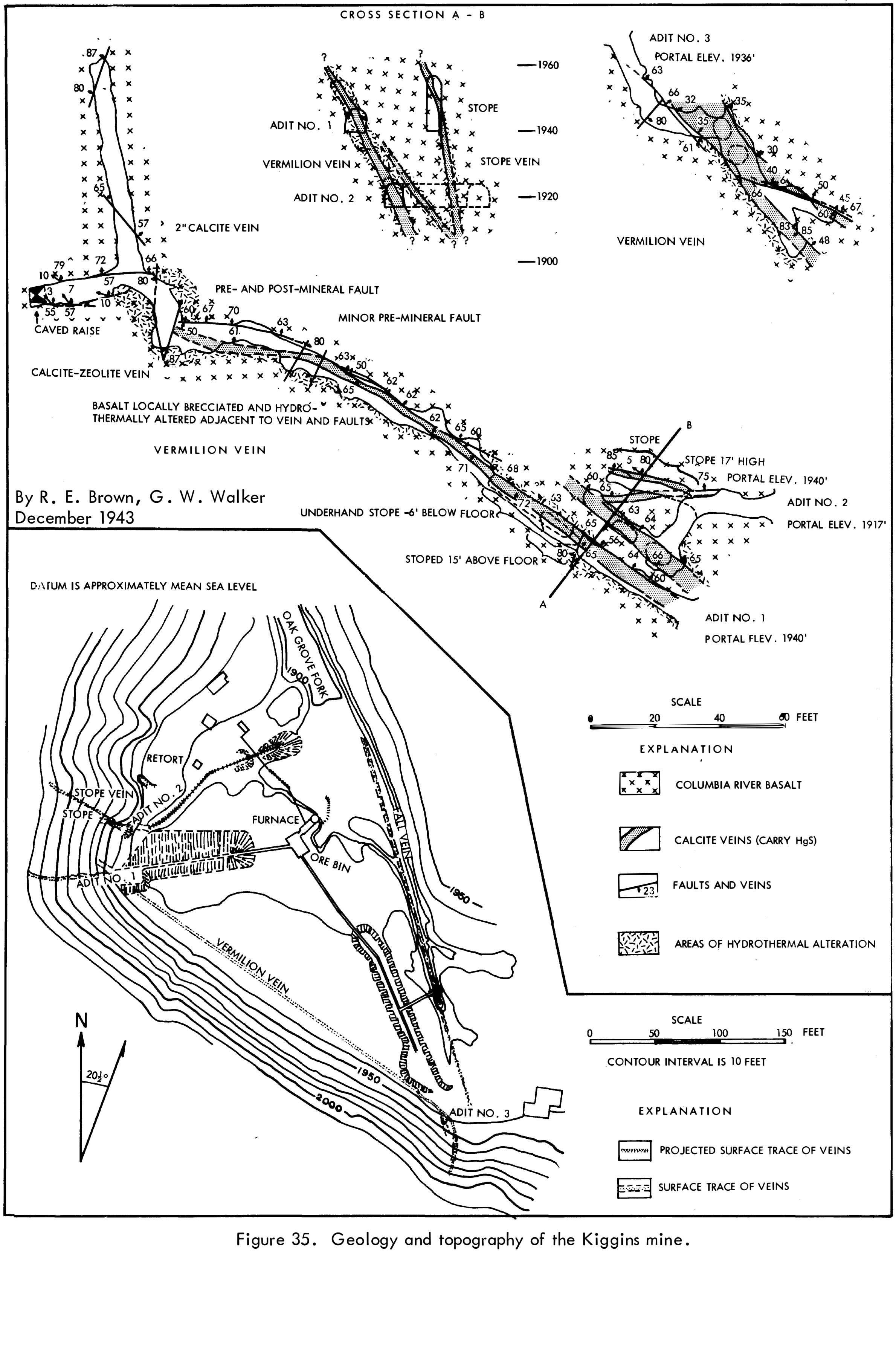


Figure 35. Geology and topography of the Kiggins mine.

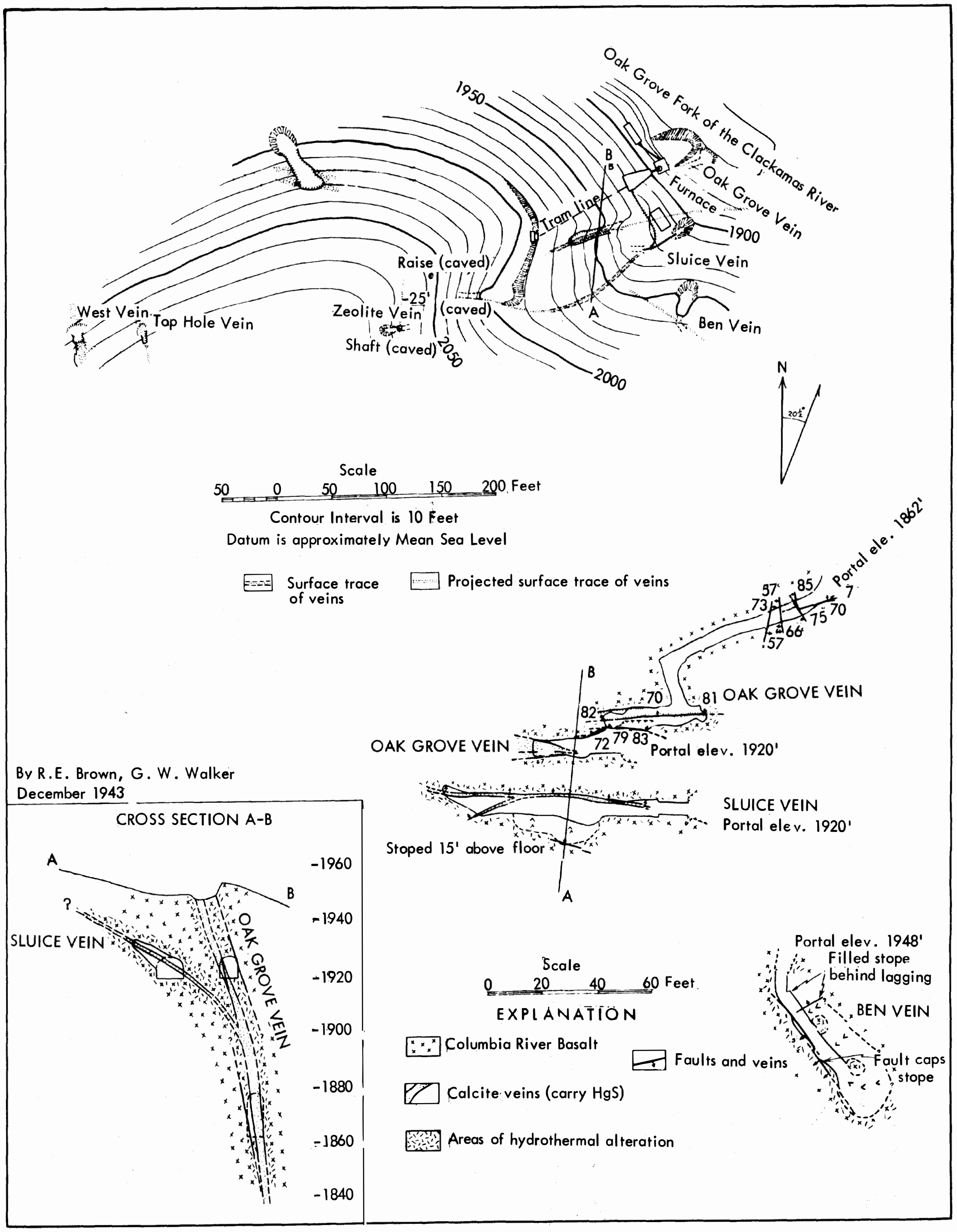


Figure 36. Topography and geology of the Nisbet mine.

minor mineralized shears which diverge westward. The Oak Grove vein produced about 5 flasks of quicksilver, most of it from the lower adit. The average grade of vein material mined is about 9 pounds of quicksilver per ton.

The Sluice vein strikes east and dips 30° to 50° N. It ranges from 6 inches to 2.5 feet in thickness, and probably joins the Oak Grove vein about 20 feet below the upper Oak Grove adit. The vein was stoped for 50 feet along the strike of the vein and 20 feet up the dip from the drift. Production was probably about 10 flasks.

The Ben vein has an irregular ore body about 1 to 3 feet thick which follows the trace of the intersection of two faults. One fault strikes N. 60° E. and dips 15° NW. The other, which terminates the ore body on the west and partly caps the stope, strikes N. 40° W. and dips 55° SW. This fault is premineral, but a small amount of postmineral movement has occurred. The line of intersection of the two faults strikes N. 50° W. and dips 14° NW. Production from the stope is estimated at about 20 flasks.

The Zeolite vein strikes N. 5° E. and dips 22° E., and averages 2 feet thick. The enclosing basalt has been altered by hydrothermal solutions to a mealy, soft, limonite-stained clay, which was mineralized a short distance from the vein so that the ore body averaged 3 to 4 feet thick. The stope is about 40 feet on the strike and 60 feet long on the dip of the vein. It was stoped nearly to the surface. The Zeolite vein consists principally of the zeolite mineral stilbite, with smaller amounts of calcite and silica. Cinnabar occurs in the zeolite and calcite in stringers, seams, interbanded streaks, and small pockets, and is disseminated in the basalt near the vein.

To the east the zeolite vein ore body terminates against a fault which strikes N. 52° W. and dips 80° W. to vertical. No accessible workings cross this fault so the relationship between the vein and fault cannot be determined. The absence of major postmineral faulting in the area indicates that the steep fault is premineral and that the Zeolite vein was mineralized by solutions which rose up it. At least one small postmineral normal fault offsets the Zeolite vein. It strikes N. 30° E. and dips 65° NW. and displaces the vein 1.5 feet. Production from the Zeolite vein is probably about 100 flasks of quicksilver.

Cinnabar was also found and mined in the opencuts on the West vein, the Top Hole vein, and an unnamed vein. About 175 tons of ore were mined from the large opencut and 10 to 15 flasks of quicksilver were probably produced. The structure in these cuts is obscure, but the mineralization follows shear zones which may be the surface characteristic of calcite veins at greater depth. The basalt is highly weathered and altered to a structureless, soft, limonite-stained clay.

Ames property: Workings on the Ames property consist of scattered opencuts, all of which are caved. Little information could be obtained from them. It is presumed they explore calcite veins that are similar to but not as well mineralized as those on the Nisbet and Kiggins properties.

Other veins: Four calcite veins 2 to 4 feet wide crop out in the river channel between the main workings of the Kiggins and Nisbet mines. The veins diverge slightly in attitude, but all of them strike northwest; three are vertical and the fourth dips steeply north. Small amounts of cinnabar have been observed in two of the veins.

MISCELLANEOUS QUICKSILVER OCCURRENCES

NORTH FORK CLAIMS

Location: Secs. 7 and 8, T. 4 S., R. 5 E., 8 miles by road southeast of Estacada on the North Fork of the Clackamas River, in the Fish Creek Mountain quadrangle.

Owner: Jacob Hauck, Oregon City.

Production: None.

General description: The property was located in 1934 by Mr. Hauck. Development consists of a 30-foot adit and scattered opencuts. Workings are in agglomerate and tuffs of the Rhododendron Formation. The rocks show little evidence of mineralization, and, although assays of more than 26 pounds of quicksilver per ton have been reported, only traces of cinnabar were contained in several samples taken by J. E. Allen in 1941 (Oregon Dept. Geology and Mineral Industries, 1951, p. 21).

PORTLAND TUNNEL OCCURRENCE

Location: Near center of S$\frac{1}{2}$ sec. 30, T. 1 N., R. 1 E., in the City of Portland on the northeast side of the Tualatin Mountains, about half a mile west of the Montgomery Ward store.

Owner: City of Portland.

Production: None.

General description: The history of the prospect is unknown. According to the Oregon Dept. of Geology and Mineral Industries (1951, p. 141), a tunnel, which is now caved at the portal, was driven due west for 960 feet in nearly horizontal lavas of the Columbia River Basalt. Agglomeratic and bouldery interbeds in the lavas are common in this area and make up a large portion of the tunnel walls. The rocks have been more or less altered and in several places have been largely replaced by hematite. Silica has been deposited in some of the open spaces. The relatively unaltered basalts are cut by widely spaced hematitic seams striking a little east of north. Eleven samples taken from the altered rocks and hematitic seams assayed from a trace to one pound of quicksilver per ton.

WATROUS PROSPECT

Location: E$\frac{1}{2}$ sec. 20, T. 2 N., R. 10 W., in the Nehalem quadrangle.

Owner: Unknown.

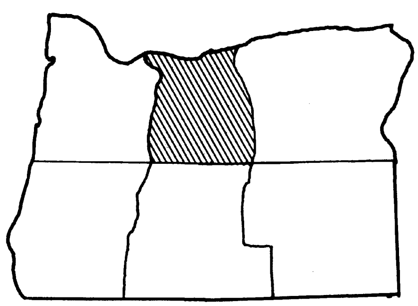
Production: None.

General description: The prospect was not visited by the writer. A department mine file report compiled in 1943 states that F. L. Watrous, then of Manhatten Beach, had found native quicksilver in the area and that a little exploratory work had been done in a small landslide area. The rocks are described as shale and sandstone with basaltic dike intrusions.

PART II DESCRIPTIONS OF THE QUICKSILVER DEPOSITS

CHAPTER 3

NORTH-CENTRAL OREGON



Chapter 3. NORTH-CENTRAL OREGON

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CHAPTER 3

North-Central Oregon

North-central Oregon includes all or part of eight counties north of the 44th parallel. The quicksilver deposits are limited, however, to the southeast corner of this region in Jefferson, Crook, and Wheeler Counties, and all are within 35 miles of Prineville (see figure 37). The most productive grouping of quicksilver deposits has been the Horse Heaven area near Ashwood in Jefferson County, where the Horse Heaven mine rates as the second largest producer in the state. Important contributions have also been made by mines in the Ochoco Creek, Johnson Creek, and Maury Mountain areas in Crook County. Small amounts of quicksilver have come from the Bear Creek and Kidnap Springs areas and from the Barnes Butte deposit, also in Crook County. The Marks Creek area in Wheeler County and the several isolated deposits in Jefferson and Crook Counties have had little or no production.

General Geologic Setting

GEOMORPHOLOGY

North-central Oregon includes parts of three geomorphic provinces, namely, the Deschutes-Umatilla Plateau extending across the northern half; the High Lava Plains jutting up into the Bend-Sisters-Redmond area; and the western end of the Blue Mountains in the southeastern part of the region. Since all of the quicksilver deposits in north-central Oregon occur in the Blue Mountains, only this province will be considered here.

The western part of the Blue Mountains province, generally called the Ochoco Mountains, is composed largely of volcanic rocks. The topography is fairly rugged, but in places has plateaus and broad upland basins. Elevations range from 6,926 feet on Lookout Mountain to 2,863 feet at Prineville. The northern part of the Blue Mountains is drained by the John Day River, and the southern part by the Crooked River and its tributaries.

STRATIGRAPHY

The area is underlain chiefly by Tertiary volcanic rocks and terrestrial sediments, with a few small pre-Teriary windows. The geology of the area as a whole has been mapped by Hodge (1941), the Round Mountain quadrangle by Wilkinson and others (1940), the Bear Creek area by Lowry (1940), the Horse Heaven area by Waters and others (1951), the Bend quadrangle by Williams (1957), and the Mitchell quadrangle by Wilkinson and others (1959).

Pre-Tertiary rocks: Pre-Tertiary rocks consist of deformed Jurassic and Cretaceous shales, sandstones, and conglomerates of marine origin. These rocks are of small exposure and are not associated with any known quicksilver deposits.

Clarno Formation: The Clarno Formation of late Eocene to early Oligocene age (Wilkinson and others, 1959) represents the oldest Tertiary rocks in the area. Most of the quicksilver deposits in north-central Oregon are associated with these rocks. The Clarno Formation is composed of a thick accumulation of lavas, tuffs, tuffaceous sediments, volcanic breccias, agglomerates, and mud flows. Included are waterlaid sedimentary interbeds, some of which contain fossil vertebrates and plants. The lavas are predominantly andesitic, but basalts and rhyolites are locally abundant. Most of the volcanic material of the Clarno Formation was extruded from local vents, hence unconformities within the formation are common and lithologic units grade laterally into one another. In some places a clay soil zone, formed by alteration of pyroclastic material, marks the unconformity between the Clarno Formation and younger rocks.

Post-Clarno rocks: Unconformably overlying the Clarno Formation is a sequence of lavas, pyroclastics, and

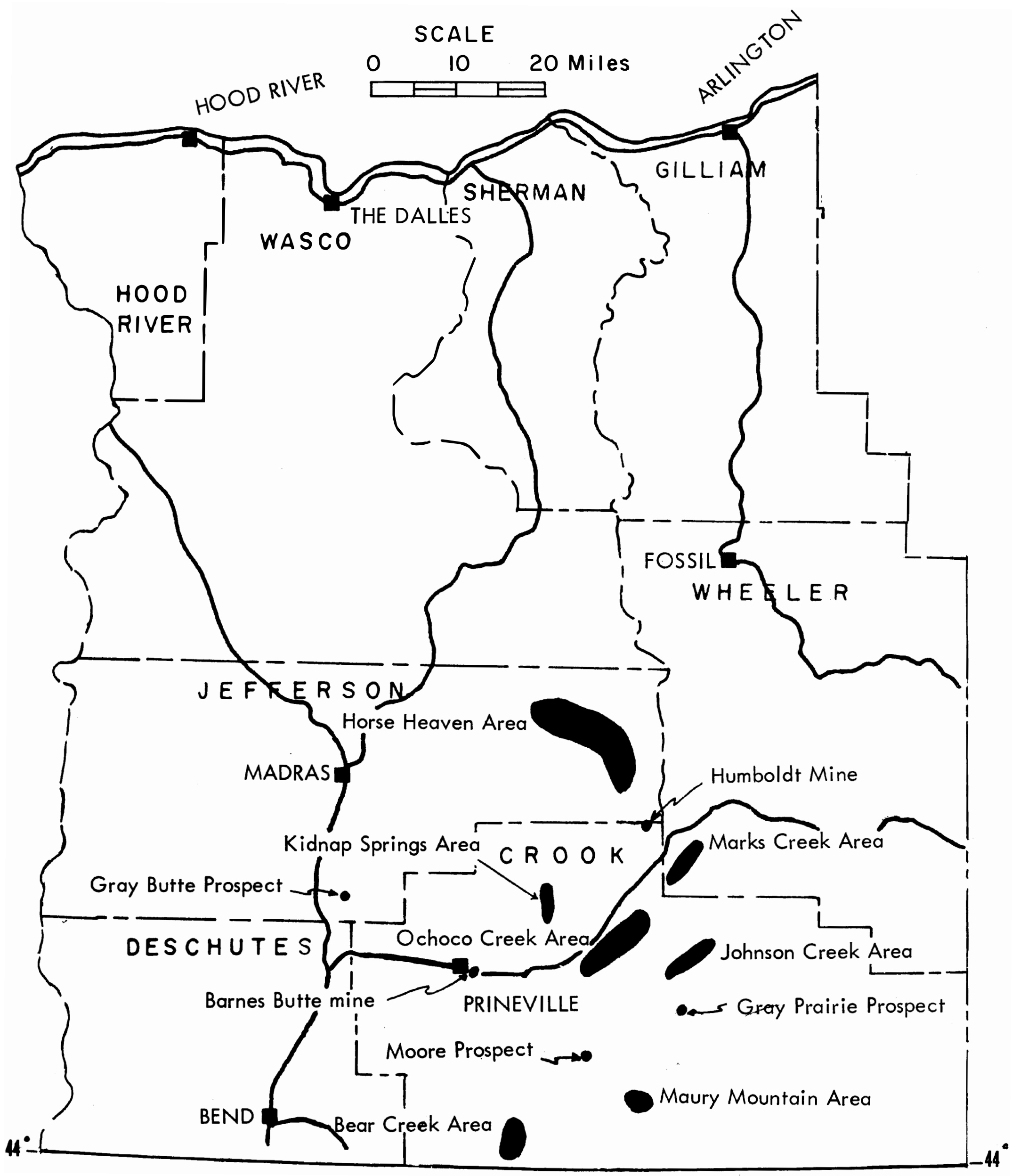


Figure 37. Index map of north-central Oregon showing the distribution of the quicksilver deposits.

tuffaceous sediments that are probably correlative with the John Day, Columbia River Basalt, Mascall, and Rattlesnake Formations recognized by Merriam (1901) and later workers in the John Day Basin to the east. These and other formations, ranging in age from late Oligocene through Pliocene, have been mapped in the area under discussion by various workers. In many places, however, the mapping is subject to varied interpretations, because of the similar lithologies in rocks of widely differing ages, the discontinuity of deposits, and the lack of diagnostic fossils. Some of the quicksilver deposits are probably associated with the lower units of this complex series.

Intrusive rocks: Numerous plugs and dikes, ranging in composition from basalt to rhyolite, intrude both the Clarno and post-Clarno rocks, adding to their structural complexity. Many of these intrusions are visible as erosional remnants that rise conspicuously above the surrounding terrain. Less resistant plugs and dikes of more basic composition have been exposed by mine and prospect workings. Hydrothermal solutions related to the intrusions may have been the source of the quicksilver deposits.

Distribution of the Quicksilver Deposits

All of the known quicksilver deposits in north-central Oregon occur in rocks of Tertiary age. The deposits in the Horse Heaven area occur within and along the margins of rhyolite and andesite plugs intruded into rocks of Clarno and post-Clarno age. In the Kidnap Spring area, cinnabar occurs in fractured tuffs bordering a rhyolite plug. Deposits in the Ochoco Creek, Johnson Creek, and Marks Creek areas are scattered along northeast-trending zones of faulting and hydrothermal alteration in rocks of the Clarno Formation. Occurrences in the Maury Mountain area are scattered along faults in Clarno tuffs bordering a basaltic andesite plug. In the Bear Creek area, cinnabar is sparsely distributed along small normal faults cutting Clarno lavas and tuffs. Here some of the faults are marked by prominent reefs due to silicification of the wall rocks. Among the isolated quicksilver deposits scattered through the region, only the Barnes Butte occurrence has been productive (Fig. 37). This deposit occurs in fractured tuffaceous sediments near a rhyolite plug.

Description of the Quicksilver Deposits

HORSE HEAVEN AREA

The Horse Heaven area, dominated by the Horse Heaven mine, the second largest quicksilver producing mine in Oregon, lies in eastern Jefferson County (see figure 38). A well-maintained gravelled road passes through the area connecting with U. S. highway 97 at Madras to the west and with U. S. highway 26 near Mitchell, to the southeast. The small settlement of Ashwood is situated at the west end of the area, about 29 miles east of Madras. In addition to the Horse Heaven mine, there are at least 9 other occurrences.

The area contains several early-day gold, silver, and base-metal prospects. The Oregon King mine, lying about 4 miles northwest of Axehandle Butte, has been worked intermittently for gold, silver, copper, lead, and zinc. It is probable that the presence of quicksilver in the district was known to the early prospectors, but until the discovery of the Horse Heaven deposits in 1933 no attempts were made towards its exploitation. Of the total recorded production from the area of 17,364 flasks, 17,214 were produced from the Horse Heaven mine and 150 from the Axehandle mine. There has been no production from the district since mid-1958, when the former was closed.

The geology of the Horse Heaven mine has been described by Waters and others (1951), who show that the known quicksilver deposits occur in or near volcanic plugs intruded into rocks of Clarno and post-Clarno age. The Clarno Formation rocks in the area consist mainly of andesite flows, tuffs, and tuffaceous sediments. The northward-tilted Clarno rocks are separated from younger formations by an angular unconformity, marked in many places by a thick layer of clayey soil. This clay horizon played an important role in localizing the quicksilver ore bodies.

The post-Clarno rocks in the area consist, in ascending order, of basaltic andesite flows, cone-forming pumiceous tuffs, platy rhyolite flows, and andesite flows, all of local extent. Numerous rhyolite to andesite plugs were intruded during both Clarno and post-Clarno periods of volcanism. Because of differential erosion, many

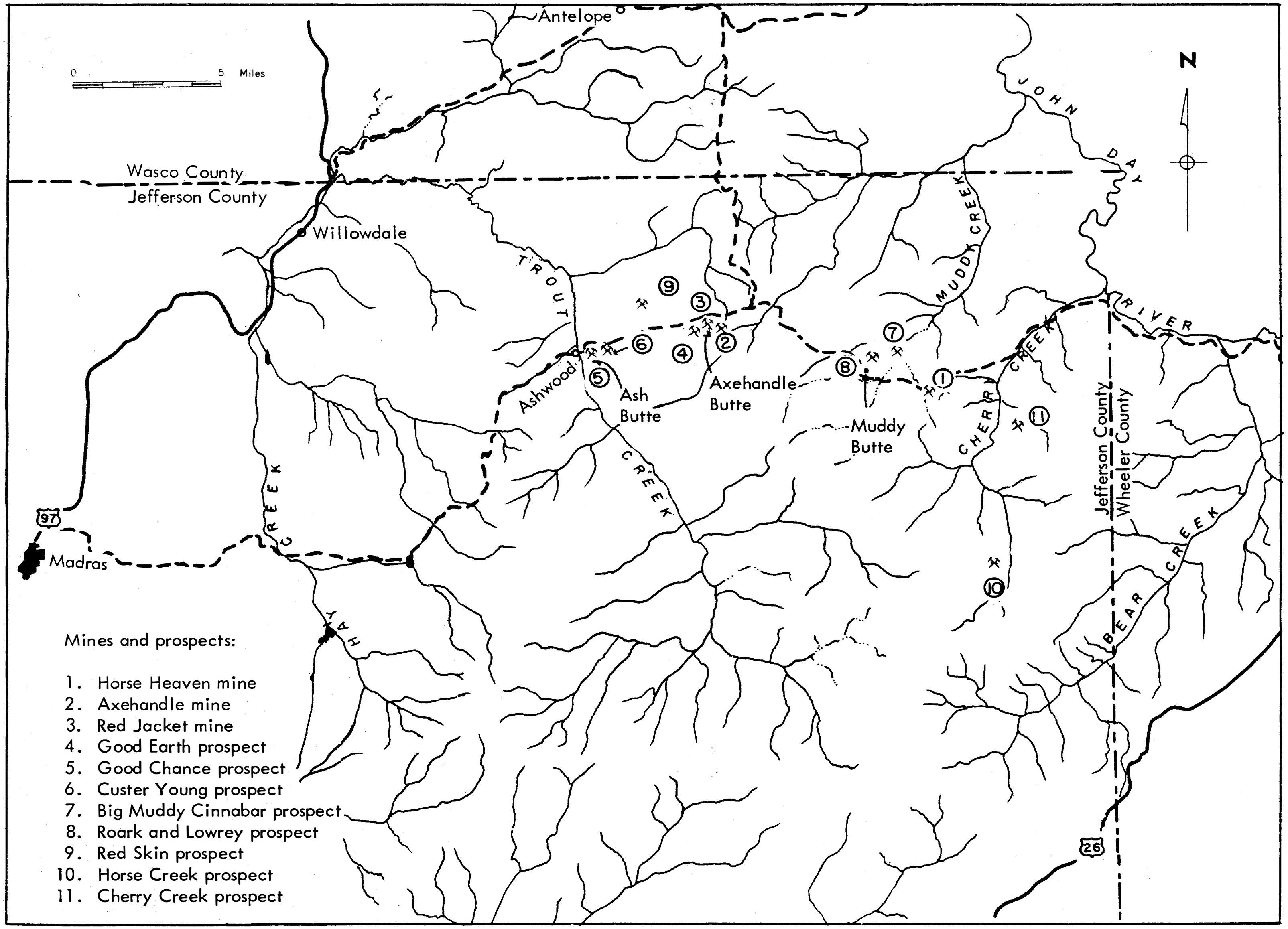


Figure 38. Index map of the Horse Heaven area showing the location of quicksilver mines and prospects.

of the plugs stand in bold relief above the softer tuffs and sediments. The altered plugs, which are more likely to contain cinnabar deposits, are much less conspicuous because of the softening effect of hydrothermal alteration.

Ore bodies generally occur in autobrecciated portions of the plugs and along faults in the adjacent enclosing rocks. Most of the ore bodies thus far found in the area, including the Horse Heaven deposit, are associated with plugs of biotite rhyolite. An exception is at the Axehandle mine, where the quicksilver is associated with a plug of andesite.

HORSE HEAVEN MINE

Location: NE$\frac{1}{4}$ sec. 12, T. 10 S., R. 18 E., about 17 miles east of Ashwood and 46 miles east of Madras.

Owner: Cordero Mining Co.

Production: During its two periods of productive activity, from 1934 through 1944 and from April 1955 to April 1958, when minable reserves were completely exhausted, the mine produced 17,214 flasks of quicksilver (table 7).

History: Art Champion and Grover Keeton traced cinnabar float to the saddle below the present site of the Horse Heaven mine in April 1933. Being unable to find the mineral in place, Champion and Keeton sold the prospect to R. R. Whiting and C. C. Hayes. Ray Whiting, Jr., and Harry Hoy soon discovered cinnabar in ledges of altered platy rhyolite a short distance above the saddle and work was begun a little lower on the hillside on what is now the Number One level of the mine. A body of high-grade ore was discovered, and after the installation of a four-hearth, 10-foot diameter Herreshoff furnace, production began in September 1934. During the next 2 years, approximately 2,200 flasks were produced.

In 1936 the property was sold to the Sun Oil Co. and a subsidiary company, Horse Heaven Mines, Inc., was formed to operate the mine. Operation was continued with little interruption for the next 8 years, increasing the total production to 15,097 flasks of quicksilver. In November 1944 the Herreshoff furnace, power plant, and other structures were destroyed by fire.

At the time of the fire, ore reserves were limited, consisting mainly of pillars containing vital accessways and thin layers of ore left to help support the upper edges of some of the stopes. In view of rising mining costs and the sharply decreasing value of quicksilver, no immediate plans were made to rebuild the plant. In 1945, after the recovery of 74 flasks from cleanup operations, the mine closed; however, development and exploration continued on a very limited scale.

With marked improvement in quicksilver values, production was resumed in April 1955, using a newly installed 30-ton rotary furnace plant. Mining was directed primarily toward the recovery of broken ore and pillars left from the earlier operation. Considerable exploratory work was done during the early stages of operation, but little new ore was developed.

Table 7. Quicksilver rroduction from the Horse Heaven Mine (U.S. Bureau Mines Records)

Year	Tons Furn.	Flasks
1934	2,457	176
1935	5,856	781
1936	6,054	1,781
1937	6,375	2,107
1938	7,168	2,190
1939	9,601	1,668
1940	16,591	1,626
1941	16,788	1,940
1942	15,179	1,243
1943	9,393	911
1944	4,929	674
1945	Cleanup	74
1950	Cleanup	($2\frac{1}{2}$*)
1955	6,380	349
1956	9,355	744
1957	9,483	749
1958	2,607	201
Total	128,216	17,214

*Not recorded by U.S.B.M.

Development: The ore-bearing zone of the Horse Heaven mine is approximately 1,300 feet long, trending northwest (figure 39). The northwestern half of this zone is developed by 10 levels and several sub-levels, which are connected by numerous raises, winzes, and open stopes. The vertical distance from the upper level or Lost Mine adit to the lower level, level 10, is only 383 feet. The levels are 20 to 56 feet apart. The main adit, which leads to level 1, enters the hill just above the furnace plant at a floor elevation of 3,250 feet. The elevation of level 10 is 2,962 feet. The principal accessway to the lower levels was an inside incline that extended from level 1 to level 6, cutting through some of the best ore in the mine. In 1942 the Manway shaft was sunk near the northwest end of the ore zone and thereafter the bulk of the ore from the lower levels was drawn through it and trucked to the mill. The southeastern end of the ore zone is developed by only level 1 and short sublevels connected to two winzes. Relationship of the geology to the workings is shown by block diagram in plate 7 (in pocket). During the 1955-58 period of operations, the pillars supporting the major stopes and the main inside incline were removed. As a result, the central and most productive part of the mine is now caved and inaccessible.

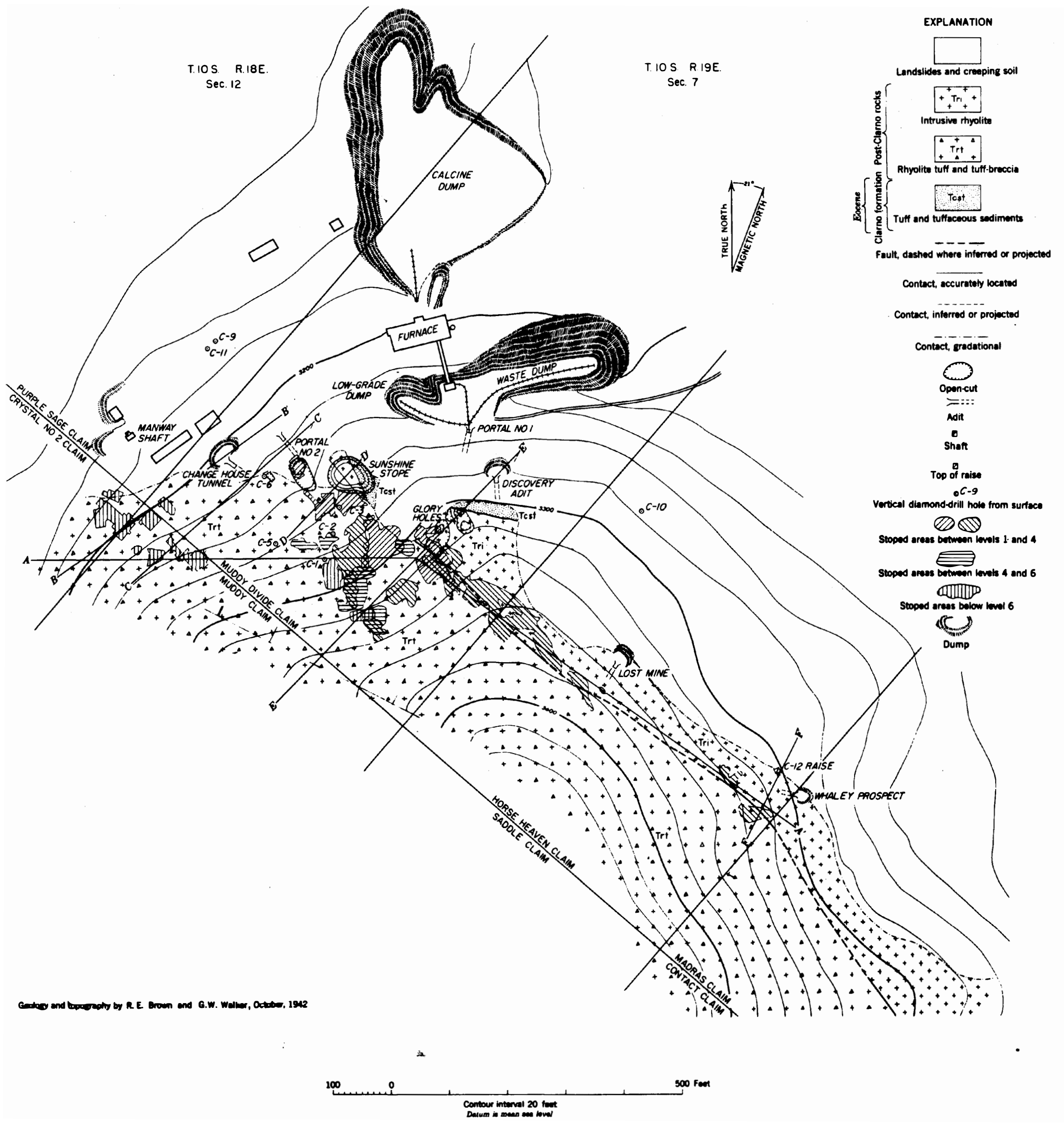


Figure 39. Geologic map of the Horse Heaven mine (reprinted from Waters and others, 1951).

Geology: The Horse Heaven ore bodies are associated with a highly autobrecciated biotite rhyolite plug and its subsidiary dikes and protrusions which have invaded volcanic rocks and tuffaceous sediments and clays of Clarno (Eocene) and post-Clarno age (Waters and others, 1951). The main or central part of the plug, as delimited by mine workings, is crudely circular in plan and above level 6 is about 250 feet in diameter; below level 6 it widens in all directions.

The longer dimension of the ore zone coincides with two prominent dikes which extend from the plug in opposite directions, one to the southeast, the other to the northwest. The southeastern dike has been exposed for a linear distance of 600 feet on level 1 and for a much shorter distance on levels 2 and 4 and in the Little Flower stopes. Where both walls are exposed by crosscuts on level 1, the dike varies between 35 feet and 80 feet in thickness. The northwestern dike, which is well exposed in levels 3, 4, 6, 7, and 8, is similar in general character to the southeastern dike but thinner and shorter. It ends within 250 feet of the edge of the plug, and in the deeper levels of the mine is but 15 to 20 feet thick.

The host rocks into which the plug was intruded can be subdivided as follows in ascending order: (1) tuffs and tuffaceous sediments of the Clarno Formation; (2) altered andesite flows of the Clarno Formation; (3) a layer of clay derived from underlying Clarno rocks that lies at the unconformity between the Clarno Formation and overlying rocks; (4) biotite rhyolite tuff, probably from a local eruption of post-Clarno age.

The rhyolite intrusive was probably emplaced in highly viscous or almost solid condition. In most places there is obvious evidence of mechanical movement along its walls. As it rose, the overlying rocks were domed and both the rhyolite and the wall rocks were intricately fractured and locally converted to breccia. These fractures are short, have little displacement, and trend in all directions, although many tend to parallel the irregular edges of the intrusive. In addition, many parts of the rhyolite itself were highly autobrecciated, probably as a result of differential movement within the viscous mass.

The southwestern margin of the plug, although highly irregular in detail, has an over-all dip of roughly 50° SW. Because of the movement and extensive hydrothermal alteration which has developed along it, this portion of the plug has been called the "Horse Heaven fault." It is not a true fault, however, but a series of small, irregular fractures developed along the border as the plug intruded the host volcanics. A layer of clay, which developed at the surface of unconformity between the Clarno Formation and the overlying pumiceous tuffs, is often in contact with the thin margin of the plug.

The largest and most productive ore bodies were formed in zones of autobrecciation within the plug and in bodies of breccia along its southwest margin. Many of the ore bodies end upward against the clay of the unconformity or beneath clay gouge along flat or gently dipping faults. Beneath these cappings the ore was especially rich. Relatively low-grade ore bodies were formed locally in the tuffs overlying the plug, and in the lower parts of the mine a few rich ore shoots were formed in andesite.

In the central part of the plug, most of the ore bodies above level 5 lay directly beneath the Clarno-post-Clarno unconformity clay soil horizon. From level 5 to level 7 the ore continued downward almost vertically, having no recognizable hanging wall barrier. While there are no apparent changes in the characteristics of the rhyolite with depth, no minable ore was found below level 7 in the central part of the plug. The principal stopes in the lower levels are located along the crest and in the wall rocks just above a small protrusion on the west side of the plug. A particularly rich ore shoot above level 9 was produced in the intrusive rhyolite directly beneath the unconformity clay horizon. Where this ore body was encountered just above level 9, it was about 150 feet in extreme length and about 15 feet thick. It grew smaller upward, finally pinching out about 20 feet above level 6. The soft condition of the clay hanging wall required the use of square sets. This, plus the narrow width of the ore, made costs excessive.

The Sunshine stope extends along the northwestern dike. Here the ore occurred mainly in brecciated rhyolite of the dike, but part of it came from the tuff on the southwest or hanging wall side. In much of this area the unconformity clay horizon was not in evidence. The upper part of the Sunshine stope ore body was mined by open pit.

Most of the ore found associated with the southeastern dike occurred in the Little Flower stope, which nearly adjoins the ore zone of the main plug and extends southeastward along the dike for about 350 feet. The Little Flower ore body was 20 to 25 feet wide and 10 to 30 feet thick. Most of the ore lay in the dike.

Near the southeast end of level 1 and about 250 feet southeast of the end of the Little Flower stope, a small ore body was developed by an incline from which three short sublevels 40, 60, and 110 feet below level 1 were extended. A square set stope was carried from the 40-foot level up to a few feet above level 1.

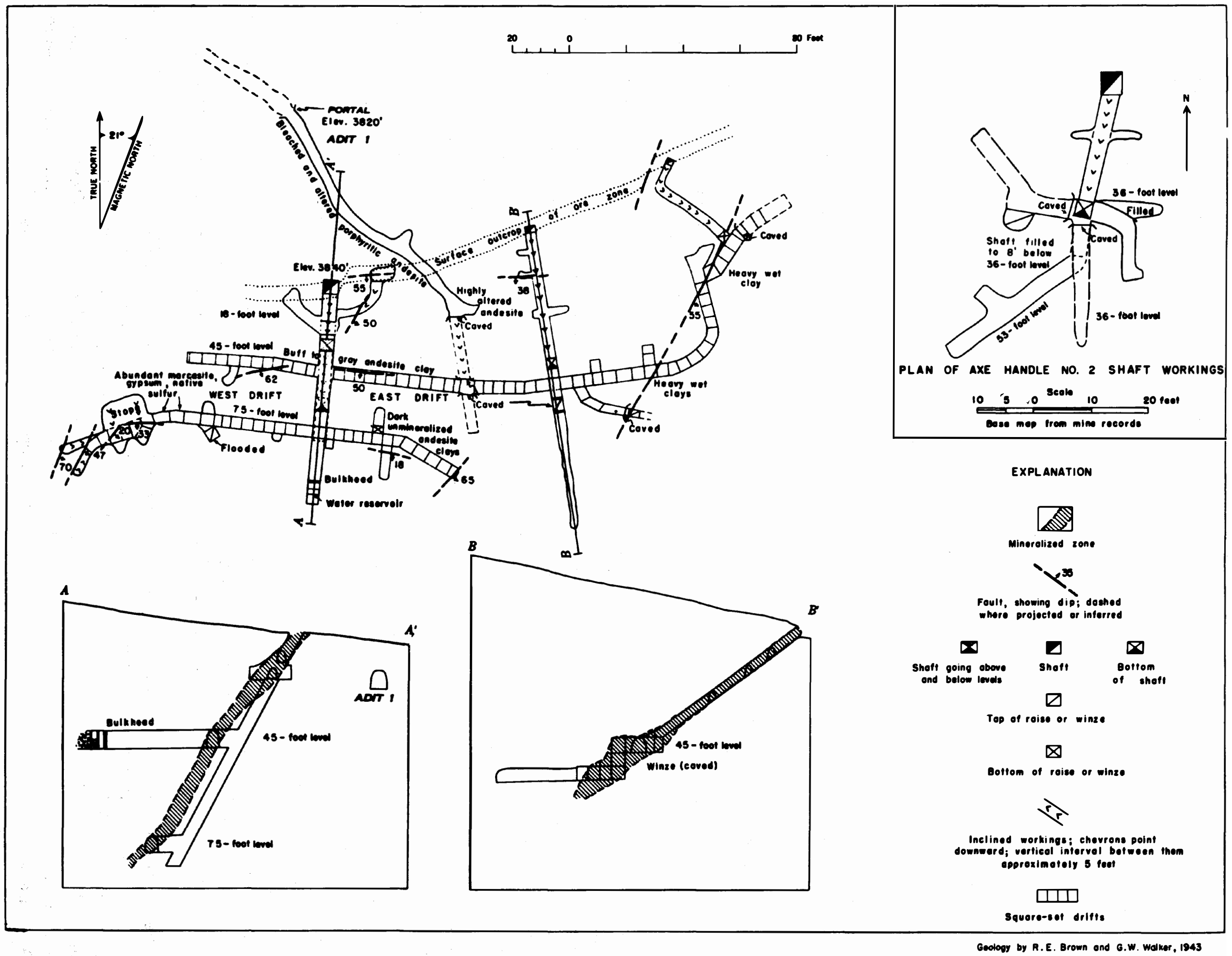


Figure 40. Plan and sections of shaft 1 workings and plan of shaft 2 workings at the Axehandle mine.

(Reprinted from Waters and others, 1951)

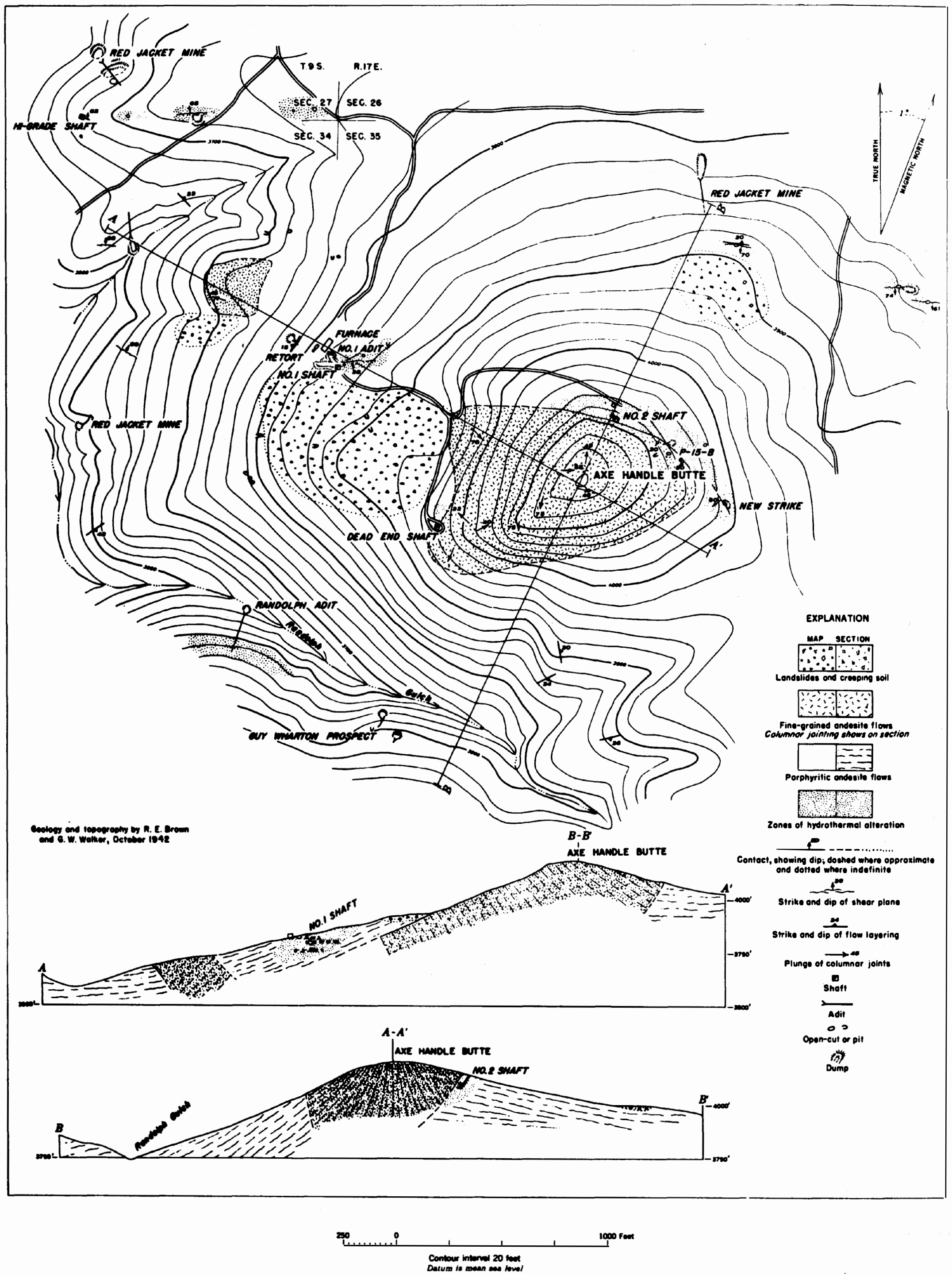


Figure 41. Geologic and topographic map of the Axehandle mine area.

(Reprinted from Waters and others, 1951)

AXEHANDLE MINE

Location: Sec. 35, T. 9 S., R. 17 E., on Axehandle Butte about 12 miles west of the Horse Heaven mine and 4 miles east of Ashwood.

Owner: Dan Swanson, Mrs. Lavoy Swanson, Mrs. Francis Johnson, Guy Wharton, and Tom Autzen.

Production: 150 flasks.

History: Development of the Axehandle mine was begun by Charles and Lavoy Swanson in 1936. A Champion rotary retort was installed and several flasks of quicksilver were produced each year from 1937 through 1943. The property was operated by Horse Heaven Mines, Inc., from mid-1938 to the end of 1939, during which time ore was trucked to the Horse Heaven furnace. In 1940 a 20-ton Lacey rotary furnace was installed, but it was used for only a short time. Dan Swanson recovered two flasks from surface ore in 1955. In 1956 the property was leased to the International Engineering & Mining Co. of Santa Barbara, California. Extensive surface stripping was done and in 1957 a DMEA loan for 2,000 feet of exploratory drilling was obtained. John B. Hoffman assumed the lease in April 1958 and initiated the drilling under the DMEA contract. Results are said to have been discouraging, and the property has been idle since that time.

Development: Distribution of the mine workings is shown in figure 40. The principal ore body lay in the No. 1 shaft area on the northwest slope of the butte. It is developed by three inclined shafts 50 to 70 feet apart and a crosscut adit. The three shafts and a winze from the crosscut adit are connected by a drift on the ore zone on the 45-foot level. From the westernmost shaft there is a drift on the 75-foot level. Ore was also mined from the P-15-B shaft and the No. 2 shaft on the northeast slope of the butte. The No. 2 shaft is 60 feet long with workings on the 36- and 53-foot levels. The P-15-B shaft is 80 feet long. Both are inclined. The Dead End shaft on the west slope of the butte is 40 feet deep.

Geology: Cinnabar mineralization occurs along the altered contact of an andesite plug forming the central core of Axehandle Butte and along altered shear zones cutting the extrusive andesites into which the plug was intruded. The shear zones are more or less parallel to the edges of the plug and probably were formed as a result of stresses developed during its implacement. The andesites bordering the plug are intensely altered, particularly along the shear zones. Alteration of the plug was largely confined to its edges. Adjacent to the contact the extrusive andesite has been silicified locally. Geology of the workings is shown in Figure 41

Cinnabar mineralization occurs mainly along the shear zones, but some ore was also found along the contact in both intrusive and extrusive andesite. In the No. 1 shaft area, mineralization was confined to a shear zone trending N. 85° E. and dipping 62° to 18° S., with an average dip of about 45° S. The ore body was somewhat larger where the zone flattened. This mineralized shear zone is cut and offset by faults striking N. 30° E. and dipping 50° to 70° SE. Four cross faults intersect the ore zone. One of them offsets the ore zone about 40 feet. Offset along the others is negligible. Cinnabar occurs in seams and veinlets and locally impregnates the clays. Marcasite and gypsum are abundant. A little native sulfur occurs in the ore.

The margins of the gently westward-pitching plug vary greatly in dip, and in the No. 2 shaft area mineralization was concentrated in extrusive andesites beneath an overhanging protrusion of the plug.

RED JACKET MINE

Location: Secs. 27 and 34, T. 9 S., R. 17 E., about 1,600 feet northwest of the No. 1 adit and furnace building of the Axehandle mine.

Owners: Mike Dragish, Ben Laughlin, and Charles Epply.

Production: None recorded; probably a flask or two.

History: The area was prospected for gold and silver about 1900 and traces of these metals are said to have been found. During the late 1930's, Charles and Lavoy Swanson leased the property for a short time and attempted to exploit small, scattered pockets of livingstonite which had long been known to occur here. Dan Swanson reports that several flasks of quicksilver were produced from high-grade ore treated at the Axehandle mine.

Development and geology: Development consists of a 25-foot shaft and several pits. The workings explore a broad, northwest-trending shear zone in porphyritic andesite. The rocks have a reddish-brown color and are hard and brittle as a result of silicification. The shaft was sunk in a zone of shearing and fracturing 3 to 5 feet wide. Most of the shear planes dip steeply north, although the intervening rock is intersected by numerous small, irregular fractures. Open spaces are lined with limonite, clay, and sometimes a little stibnite, pyrite, and marcasite. In some of the more intensely fractured zones, small masses of livingstonite occur with traces of cinnabar, which is probably secondary after the livingstonite. The small pods of ore are reported to have been of very high grade but too widely separated to permit profitable exploitation.

GOOD EARTH PROSPECT

Location: NW$\frac{1}{4}$SE$\frac{1}{4}$ and NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 34, T. 9 S., R. 17 E., on the west slope of a small rounded hill about three quarters of a mile southwest of Axehandle Butte, and about one mile south of the Madras-Ashwood-Mitchell county road.

Owners: Eighty acres of deeded land owned by Fenton Wharton. Dan Swanson and Gerald Thornton each hold a portion of the mineral rights through an agreement with Wharton.

Production: None.

History and development: The prospect was discovered in 1954 by Dan Swanson. A small amount of exploratory trenching was done by the Horse Heaven Mining Co. during the fall of 1956. Development consists mainly of a trench about 80 feet long and as much as 25 feet deep.

Geology: The workings expose cinnabar mineralization along an intensely altered shear zone in gently dipping andesite flows. The shear zone is about 4 feet wide and strikes approximately N. 40° W. and dips 40° NE. The rock within the shear zone and for several feet on either side has been altered to a white-to-buff clay. Cinnabar occurs in small clots and veinlets within the sheared rocks and is generally associated with lenses of grayish wet clay that parallel the fracture surfaces. Five grab samples taken from the shear zone averaged 2.2 pounds of quicksilver per ton.

GOOD CHANCE PROSPECT

Location: SW$\frac{1}{4}$ sec. 6, T. 10 S., R. 17 E., about a quarter of a mile east of Ashwood in a northwest-trending dry wash along the southern base of Ash Butte.

Owner: Dan Swanson, Ashwood, Oregon.

Production: None recorded; probably 2$\frac{1}{2}$ flasks.

History and development: The deposit was discovered in 1937 by Lavoy Swanson and Charles Swanson. About 2$\frac{1}{2}$ flasks were recovered from sorted ore during 1938-39. The ore was treated at the Axehandle mine. Development consists of a bulldozer trench 150 feet long in the gully bottom and a shaft about 50 feet deep.

Geology: The prospect is in porphyritic andesite bordering the biotite-rhyolite plug which forms Ash Butte. In the shaft and northeast wall of the trench, the andesite is cut by many small and irregular veinlets of marcasite, calcite, silica, and gypsum. The veinlets range from the thickness of paper to about 1 inch. Some of the calcite veinlets contain finely disseminated cinnabar. All of the ore produced by the prospect came from a narrow ore shoot exposed during the sinking of the shaft. According to Swanson, the shoot was associated with a nearly vertical vein of calcite 3 to 4 inches wide and striking N. 45° W. No ore remains.

CUSTER YOUNG PROSPECT

Location: S$\frac{1}{2}$ sec. 6, T. 10 S., R. 17 E., on the north slope of a low hill about half a mile east of Ashwood.

Owner: Custer Young, Ashwood, Oregon.

Production: None recorded; probably 2 flasks.

History and development: Development of the prospect was begun by Charles and Lavoy Swanson in 1937. About 20 tons of selected ore was hauled to the Axehandle mine and treated in the rotary furnace. According to Dan Swanson, 2 flasks were recovered. Young acquired the property in 1956. Workings include three adits, two of which are caved, and a bulldozer trench about 300 feet long.

Geology: The prospect is in nearly flat-lying andesite that is widely fractured and altered. The open adit enters the south wall of the trench and trends southward for 80 feet, crosscutting several east-trending veinlets of calcite, quartz, and gypsum. A small amount of marcasite and traces of cinnabar are occasionally associated with the veinlets. Toward the end of the adit the andesite becomes increasingly silicified, and the quantity of cinnabar appears to increase. Assays, however, would indicate very low-grade ore.

BIG MUDDY CINNABAR PROSPECT

Former names: Crosby Mercury Claims, Yates Prospect, and Degner Prospect.

Location: N½ sec. 2, T. 10 S., R. 18 E., on the west side of Muddy Creek. A road to the prospect leads down Muddy Creek for about one mile to the northeast from the Ashwood-Horse Heaven road, which crosses Muddy Creek about 2½ miles west of the Horse Heaven mine.

Production: None recorded; possibly 2½ flasks.

Owners: Ella Degner and Norman Crowley hold the mineral rights by location.

History: The prospect was discovered by E. G. Degner in 1935 and was operated for a short time by Degner, Maurice Thiebault, and Ray Whiting, who are said to have produced 2½ flasks from a shallow shaft. The property was held for a short time in 1936 by Horse Heaven Mines, Inc. Some trenching was done and two holes were drilled, but little record of the results is available.

In recent years intermittent development work has been done by Norman Degner. During 1956, 1957, and 1958, several hundred feet of trenches were cut by bulldozer, and four holes for a total footage of 105 feet were drilled. In 1959 the property was leased to Oregon Cinnabar Mines, Inc. An OME drilling program was begun during the summer and continued into 1960. The results are unknown.

Development: When the property was last visited in 1958, development consisted of about a dozen bulldozer trenches of an aggregate length of more than 1,000 feet; a caved shaft 40 feet deep containing a 35-foot drift from its foot; a 25-foot adit; and a 10-foot shaft. According to Norman Degner, son of the original discoverer, the 2½ flasks of quicksilver said to have been produced were recovered from about one ton of ore recovered from the drift at the bottom of the 40-foot shaft. This shaft has been filled by later operations and its exact location is unknown.

Geology: The prospect area as mapped by Waters and others (1951) consists of an elongated tongue of stratified tuffs of Clarno age, unconformably overlain by a thick series of post-Clarno basaltic andesite flows and andesitic tuffs. Prospect development has revealed a small body of rhyolite, part of which is probably intrusive, included in the tuffs. Small lenses of altered perlitic rhyolite border the rhyolite on the east. The glassy rhyolite exhibits a thin banding that has an overall northeasterly trend and a steep easterly dip. Cinnabar occurs along thin fracture seams that roughly parallel the banding. Assays as high as 30 pounds per ton have been taken from the 10-foot shaft sunk in the zone. About 250 feet north of the shaft a narrow, nearly vertical gouge zone cutting the post-Clarno tuffs in a northeasterly direction contains disseminated cinnabar.

ROARK and LOWREY PROSPECT

Location: Sec. 3, T. 10 S., R. 18 E., about a quarter of a mile north of Muddy Butte.

Owner: Unknown.

Production: None.

General description: The Roark and Lowrey prospect was located by E. D. Lowrey in 1941. Work on the prospect was later done by the Roark Brothers. Development consists of a caved shaft 55 feet deep and scattered pits. The country rocks are lapilli tuffs and andesite that have been altered, presumably, by hydrothermal solutions related to the intrusive plug of biotite rhyolite forming Muddy Butte. The shaft is said to explore a narrow stringer of cinnabar-bearing calcite. Rocks adjacent to the shaft contain traces of disseminated cinnabar.

REDSKIN PROSPECT

Location: SW¼NE¼ sec. 29, T. 9 S., R. 17 E., about 1 mile northwest of Ashwood.

Owners: The prospect is on private land owned by Ben Taylor. Permission to develop the prospect was given to Dan Swanson and Byron Friend.

Production: None recorded.

History and development: The prospect was discovered by Dan Swanson in 1954, and half a flask of quicksilver was recovered from 150 pounds of sorted ore. Development consists of three small pits and a bulldozer trench about 50 feet long. Some drilling was done in 1956 with a small rotary, but the results are unknown.

Geology: The rocks in the pits and in the walls of the trench are altered andesite flows and tuffs. The upper part of a small mass of rhyolite is exposed in the floor of the trench. Cinnabar was seen in the north wall of the trench where it occurred as thin veinlets immediately beneath a tuffaceous clay layer about 1½ feet thick. More work will need to be done before the merits of this prospect can be determined.

HORSE CREEK PROSPECT

Location: W½ sec. 9, T. 11 S., R. 19 E., at an elevation of 3,500 feet on the west side of the steep ridge between Horse Creek and Cherry Creek.

Owner: Unknown.

Production: None.

General description: The prospect was worked by Bert Roark and Glenn Stephenson during the mid-1930's. The workings consist of two adits and scattered opencuts. They lie in biotite rhyolite, which forms this part of the ridge. The rhyolite exposed in the workings is cut by numerous small fractures, altered largely to clays and locally silicified. The upper adit trends S. 10° E. for 20 feet and contains a raise to the surface from the face. Thin, sparsely distributed veinlets of cinnabar are visible in a few places. The lower adit, 65 feet below the upper, trends S. 55° E. for 176 feet without showing a trace of cinnabar.

CHERRY CREEK PROSPECT

Location: S½ sec. 16 and N½ sec. 21, T. 10 S., R. 19 E., on the east side of Cherry Creek, about 3 miles east of the Horse Heaven mine.

Production: None.

Owner: Parr Norton.

General description: Two mineral rights claims were located in April 1943 by Glenn Stephenson, Bert Roark, and Glenn Frier, after cinnabar float had been panned up the hill from Cherry Creek. It is said that a small pocket of high-grade ore was found in one place, but after several shallow test pits and a short adit failed to reveal either additional ore or a structural lead, the prospect was abandoned.

In late 1949, Norton and Roy Shrum cut a series of trenches across the area of the original work. Scattered irregular stringers of cinnabar were found in narrow fractures in maroon and yellowish clays derived from tuffs and andesites. All of the workings are badly caved and geologic interpretation would be difficult even if warranted.

KIDNAP SPRING AREA

The Kidnap Spring area includes a group of quicksilver deposits lying along the crest of the ridge between Lemon and Dry Creeks in secs. 14 and 23, T. 13 S., R. 17 E. (see figure 42). The area is about 18 miles by road northeast of Prineville. It is heavily timbered and topographically rugged. Elevations range from about 4,300 feet at the Allison prospect at the south end of the area to about 5,200 feet at the Strickland Butte mine at the north end. The prospects are generally inaccessible during winter months. The Ochoco Reservoir quadrangle gives topographic coverage.

Cinnabar was discovered in the area by J. E. Staley about 1930. Production amounting to 11 flasks from retort operations was recorded by the U. S. Bureau of Mines in 1940-41: 10 from the Strickland Butte mine and 1 from the Watson prospect. Reports by owners indicate that about 8 additional flasks were produced. Sporadic activity has continued to the present time, but there has been no production since 1941.

The deposits occur in tuffs, andesite flows, and agglomerates of probable Clarno age. At the Strickland Butte mine, cinnabar occurs in fractured rocks adjacent to a rhyolite plug. The conditions controlling the localization of deposits at the southern end of the area are not clear. It is possible that the small, widely scattered occurrences of cinnabar are the result of emanations penetrating fractured Clarno rocks overlying plugs similar to that at the Strickland Butte mine but not yet exposed by erosion.

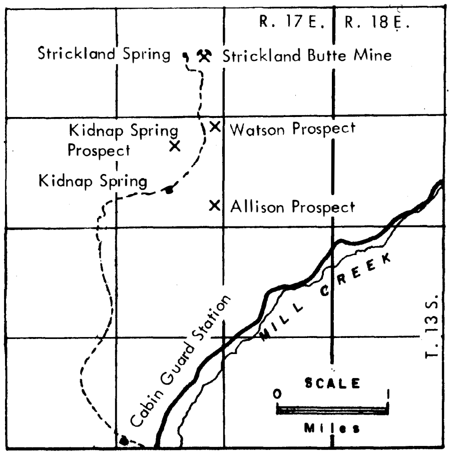


Figure 42. Index map of Kidnap Spring area.

STRICKLAND BUTTE MINE

Location: $SW\frac{1}{4}NE\frac{1}{4}$ sec. 14, T. 13 S., R. 17 E., near Strickland Spring, about a mile and a half north by road along the ridge from the cabins at Kidnap Spring.

Owners: R. S. and M. L. Page, Prineville, Oregon.

Production: 10 flasks.

History: The prospect was located by the Page brothers and C. S. Carnagey in 1940. A Champion rotary retort, 800-pound capacity, was installed during the summer of 1940 and 9 flasks were produced in 1940 and 1 in 1941. Carnagey later relinquished his interest to the Page brothers, who have continued to explore the property.

In 1950 two churn drill holes were sunk to depths of 130 feet and 153 feet respectively, encountering little or no cinnabar mineralization. During 1953 many hundreds of feet of dozer trenching was done under a DMEA loan contract.

Development: Underground development consists of five adits containing an aggregate of at least 500 feet of workings (figure 43). Four of the adits are caved. A small cabin and the retort remain on the property.

Geology: At the Strickland Butte mine there is a prominent, fine-grained, light-gray-to-buff rhyolite plug surrounded by rhyolitic and andesitic tuffs and tuffaceous clays. The plug is several hundred feet in diameter and rises as much as 100 feet above the surrounding terrain. Flow banding is highly developed in the plug and varies from horizontal to extremely contorted. In places the rock cleaves readily into thin plates. Small masses of perlite lie adjacent to the plug contact. At least one rhyolite dike was exposed in the prospect workings. The tuffaceous rocks flanking the plug strike about N. 50° E. and dip 10° to 20° SE. They are cut by several small faults that strike roughly east and dip steeply toward the plug. These appear to be normal faults with their downthrown sides nearest the contact. Cinnabar occurs as thin fracture fillings and fine disseminations in the altered tuffs along or slightly above the upper contact of a dark-red tuffaceous clay. From all indications, the clay is conformably interbedded with the enclosing rocks and where exposed ranges from 2 to 5 feet in thickness.

The ore bodies are small and scattered, but assays of from a trace to two or three pounds of quicksilver per ton have been taken from many places in the altered tuffs immediately above the red clay. Cinnabar mineralization rarely extends to more than 3 feet above the contact.

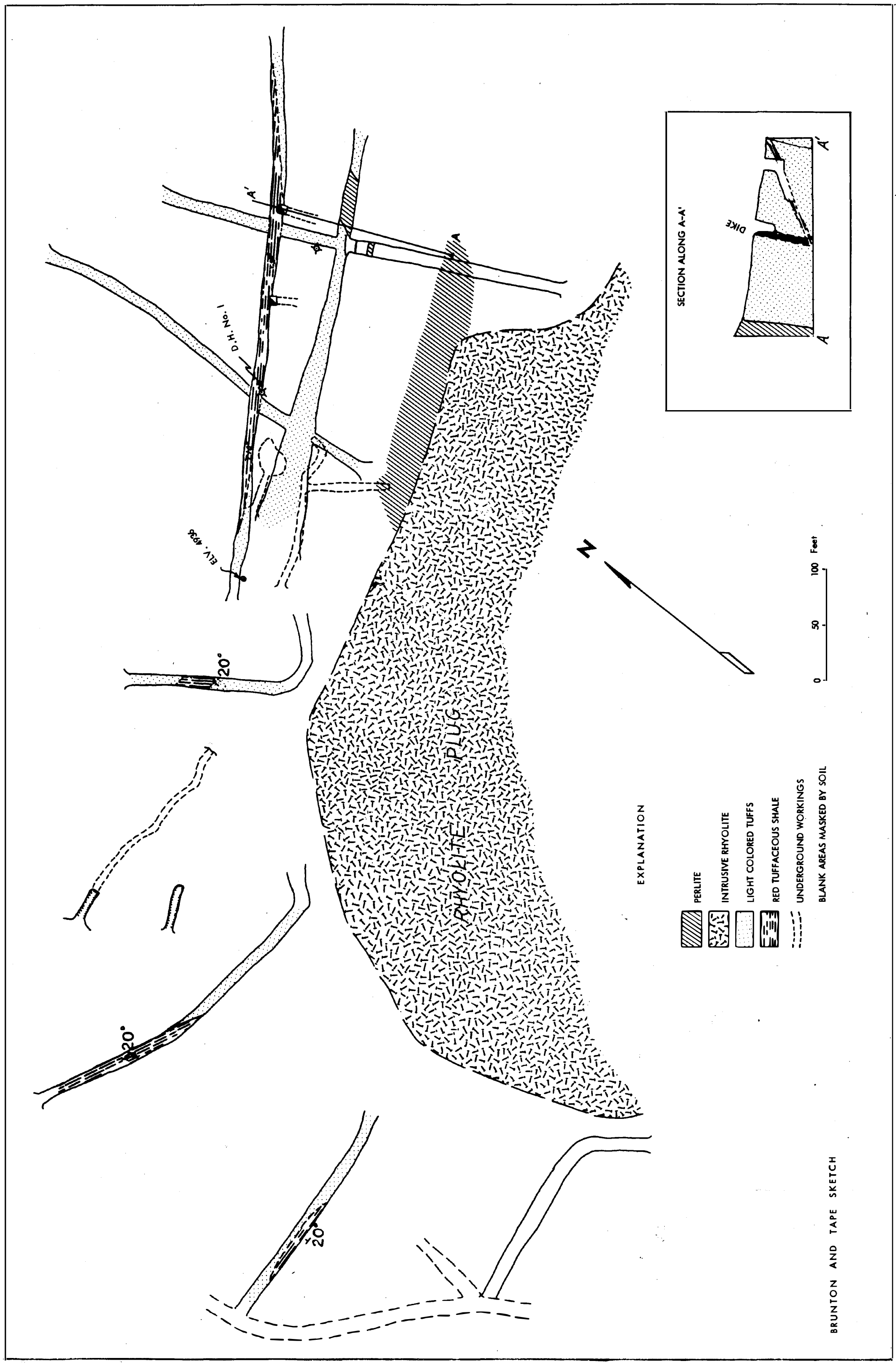


Figure 43. Geologic sketch of the Strickland Butte mine (based in part on survey by F. E. Lewis).

Most of the ore treated was mined from a small ore body about 120 feet east of the Champion retort. The ore body was stoped to the surface from a short adit. The adit and stope are caved. The ore treated is said to have averaged between 35 and 40 pounds per ton. Little ore-grade material was encountered during the DMEA exploration program. A small kidney assaying 22 pounds of quicksilver per ton over a width of 30 inches was exposed in trench No. 7 about 250 feet east of the retort. A winze, sunk to a depth of 28 feet along the contact, which here dips 20° SE., failed to develop more than a few hundred pounds of ore.

KIDNAP SPRING PROSPECT

Other name: Wild Rose mine.

Location: NE$\frac{1}{4}$ sec. 23, T. 13 S., R. 17 E., about 200 yards downslope from the road and half a mile north of the cabins at Kidnap Spring.

Owners: Dayton Glover and Walter Lidstrom, Prineville, Oregon.

Production: None recorded; possibly 5 flasks produced.

History: Three claims covering the prospect were located on April 25, 1931 by Asa Battles, R. R. Hunter, and J. H. Rosenburg. In 1938 these three claims were deeded to C. A. Wilkes, C. S. Carnagey, W. J. La Porte, and J. E. Staley. La Porte's interest was later acquired by Harry De Bord. In 1953 half interest in the claims was acquired by Walter Lidstrom and the other half by Carnagey. In 1958 Carnagey's interest in the property, now totalling 9 claims, was acquired by Glover.

Development: The principal development work was done by Staley and Carnagey during the fall of 1938. An inclined shaft about 40 feet deep was sunk on a high-grade vein about 1$\frac{1}{2}$ inches thick. According to Staley, 3 2/3 flasks were recovered from about 1,000 pounds of this material treated in a small, two-pipe retort erected near the shaft. The shaft was abandoned because the veinlet failed to widen and could not be mined profitably in spite of its high tenor. Another 1 1/3flasks was recovered from one ton of sorted ore from an opencut lying about 250 feet west of the shaft.

Other development work consists of a 50-foot shallow adit and numerous opencuts. The adit is caved and the shaft, covered by a dilapidated shed, is filled with water to within 10 feet of the collar. In recent years several additional surface cuts have been made with a bulldozer south and west of the shaft and the old opencut west of the shaft has been enlarged. The retort has been moved to the Allison prospect on the east side of the ridge.

Geology: The country rocks consist of rather intensely altered andesitic flows, tuffs, and agglomerates, presumably of the Clarno Formation. These rocks are locally overlain by flows of a platy andesite that is much less altered and probably younger. Cinnabar mineralization is confined to the older altered rocks and in one place occurs beneath a capping of the platy andesite. Cinnabar is sparsely scattered through an area at least 250 feet long and 50 feet wide, occurring both in the soil mantle and along small fractures of widely divergent trends. The shaft was collared in massive andesite, which is somewhat less altered than that exposed in surrounding opencuts. A gouge-filled fracture in the east wall of the shaft strikes N. 35° E. and dips 65° NW. A series of joints in the west wall strikes N. 40° E. and dips 65° NW. In the pit west of the shaft the majority of the cinnabar veinlets have a northwesterly trend.

No large fault or other structural feature to which the fracturing might be related has yet been found. It seems possible that a plug similar to that at Strickland Spring, but as yet unexposed, underlies the area and that the fracturing and mineralization are related to its intrusion.

ALLISON PROSPECT

Other names: Carnagey claims, Viles prospect.

Location: SE$\frac{1}{4}$ sec. 23, T. 13 S., R. 17 E. on the east side of the ridge about half a mile southeast of the Kidnap Spring prospect.

Owner: Melvin Viles.

Production: None recorded; possibly 3 flasks produced.

History and development: The property was located in May 1931 and held through 1950 by G.W., W.H., and B.L. Allison. It is said that during the 1930's these men recovered 3 flasks of quicksilver from selected ore hauled to their ranch at Powell Butte and retorted. The property was relocated in 1954 by Carl and Tom Carnagey and sold on contract to Melvin Viles in 1957.

Development consists of several shallow pits and trenches and an adit containing 85 feet of workings. There is a single-tube Johnson-McKay retort in poor repair near the adit portal and a small cabin about 150 yards to the southwest.

Geology: The country rocks consist of altered and softened andesite flows and agglomerates of probable Clarno age. Exposures are poor and fracturing and alteration has been so intense in the vicinity of the prospect workings that the attitude of the rocks was not determinable.

Penetrating altered andesite for most of its length, the crosscut trends N. 10° W. for 53 feet at which point two faults were encountered, one striking N. 40° W. and dipping vertically and another striking east and dipping 70° N. A drift was driven along the N. 40° W. fault for approximately 30 feet. The walls of the fault are separated by 1 or 2 feet of grayish cheese-like clay gouge. Coarse andesitic agglomerate is exposed in the north wall of the drift 58 feet from the adit portal. The walls of the crosscut expose narrow fractures of diverse trend, the majority of which strike easterly and dip steeply north. A narrow limonite-filled fracture 15 feet from the portal strikes N. 15° E. and dips 60° W.

No cinnabar was seen in the adit. Three closely spaced pits lying above the tunnel contain small quantities of cinnabar as fracture fillings and fine crystal disseminations in the altered andesite. One of the fractures in which cinnabar was found strikes N. 45° W. and dips 80° S. The plane of the fault encountered in the adit below is not exposed in the pits, but alteration near its projected location is intense.

WATSON PROSPECT

Location: Sec. 23, T. 13 S., R. 17 E., northeast of the Kidnap Springs prospect.

Owners: Walter Lidstrom and Dayton Glover, Prineville, Oregon.

Production: 1 flask.

General description: Most of the work here was done by Oscar Watson, who, together with Carl Carnagey, produced one flask of quicksilver from selected ore in 1940. The ore was treated in a two-pipe retort which remains on the property.

Development consists of two adits and several shallow pits. The country rock is mainly andesite agglomerate. One of the adits trends N. 45° W. for 140 feet, then branches, one branch trending N. 10° E. for 30 feet and the other south for 10 feet and containing a raise presumably to the upper adit lying about 35 feet above. The upper adit is caved, but the dump indicates that it is much shorter than the lower.

No cinnabar was seen in place anywhere on the property. According to Carnagey, the ore produced was recovered from small fractures in some of the caved pits.

OCHOCO CREEK AREA

The Ochoco Creek area lies about 18 miles east of Prineville in the central part of the Ochoco Mountains (see figure 44). The area extends along Ochoco Creek for about 6 miles in T. 14 S., R. 18 E., and Ts. 13 and 14 S., R. 19 E. In addition to a number of prospects, the area includes four productive deposits which, from west to east, are the Byram-Oscar, Staley, Champion, and Taylor Ranch mines.

The old Ochoco Highway, which branches from U.S. highway 26 about 15 miles east of Prineville, extends through the area. Short side roads give access to the deposits, which are scattered along both sides of Ochoco Creek. Elevations range from 3,500 to 5,000 feet above sea level. Topographic coverage for the area is given on the Ochoco Reservoir and Lookout Mountain 15-minute quadrangles. All but the extreme western end of the area is covered by the Round Mountain 30-minute quadrangle which, although not a topographic map, has been geologically mapped by Wilkinson (1940).

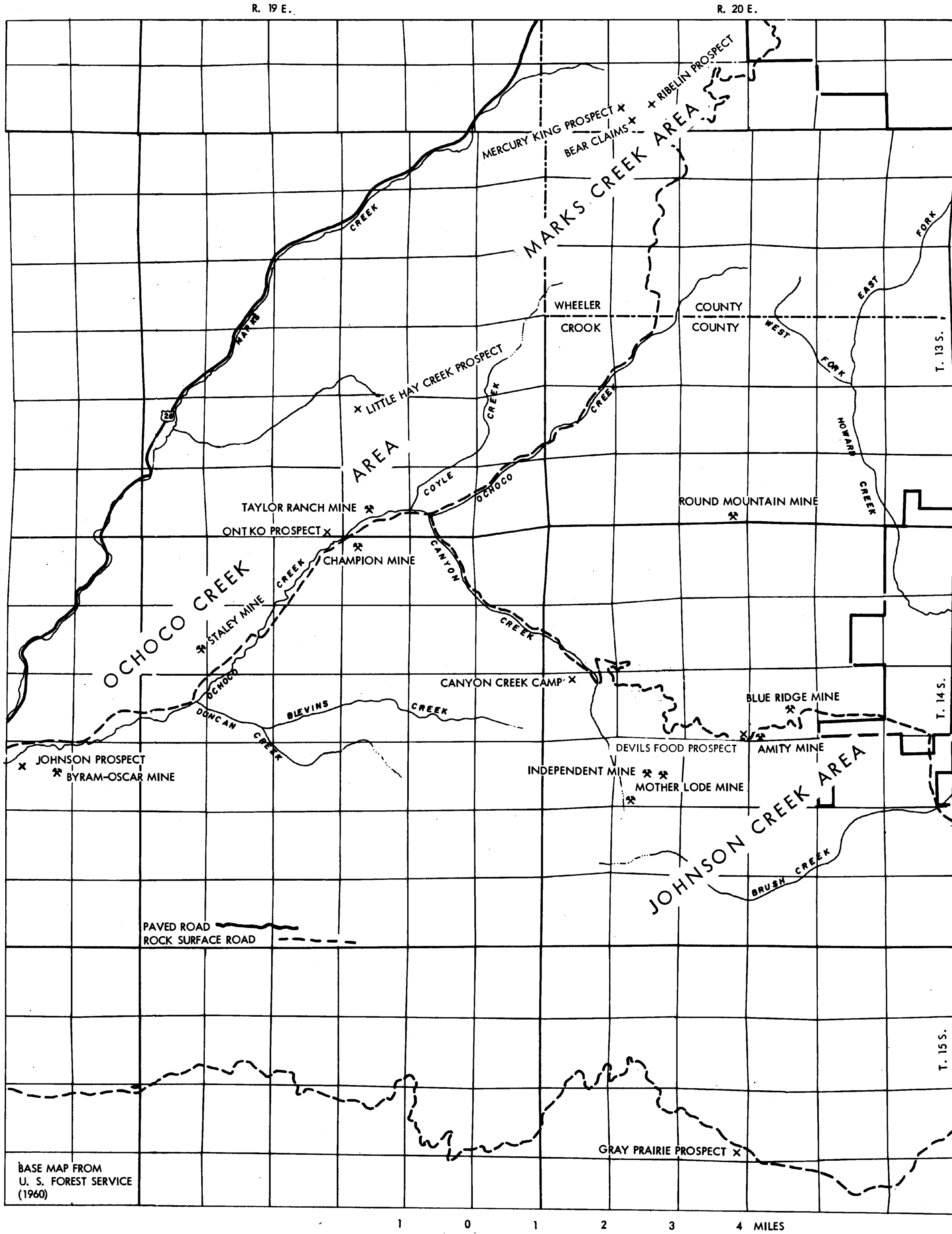


Figure 44. Index map showing the location of quicksilver mines and prospects in the Ochoco Creek, Johnson Creek, and Marks Creek areas and of the isolated Gray Prairie prospect.

History and production

The initial discovery of cinnabar in the Ochoco Creek area was made at the present site of the Staley mine in 1927. This mine was more or less active until 1942, becoming the largest producer in the area, although it changed hands many times. Production from the Byram-Oscar and Champion mines was recorded at intervals during 1935-36 and 1934-41 respectively and from the Taylor Ranch mine during 1939-43. The total recorded production from the area is 796 flasks. Since the end of 1942 little or no development work has been done in the area except at the Champion mine, where assessment work has been kept up but no production made. Only a small part of the workings at the Staley and Champion mines are accessible. Elsewhere all of the underground workings of the various mines in the area are caved.

General geology

The quicksilver mines and prospects of the Ochoco Creek area are distributed along a broad northeast-trending zone of faulting, hydrothermal alteration, and mineralization that extends along Ochoco Creek for 6 or 7 miles. The deposits in the Johnson Creek area about 6 miles to the southeast and in the Marks Creek area to the northeast occur along similar northeast-trending zones of faulting and mineralization. The three zones appear to be structurally related to the complex, large-scale deformation of the Clarno Formation in this part of the Ochoco Mountains. Because the Ochoco Creek and Johnson Creek areas, and to a lesser extent the Marks Creek area, are geologically similar, the general picture of their stratigraphy, structure, and ore deposits is combined.

Stratigraphy: The rocks in the Ochoco Creek, Johnson Creek, and Marks Creek areas consist predominantly of a complex series of andesitic to basaltic tuffs, flows, and agglomerates mapped by Wilkinson (1940) as part of the Clarno Formation; in places rhyolite flows and associated tuffs and tuffaceous sediments are included. Locally these rocks are unconformably overlain by relatively unaltered basaltic lavas tentatively called the "Ochoco lavas" by Wilkinson and dated by him as upper Pliocene or later. The Ochoco lavas are exposed at various places but while they lie in close proximity to some of the quicksilver deposits they are not known to contain cinnabar.

Most of the Clarno rocks exposed in the mine and prospect areas have been considerably altered by hydrothermal solutions and are deeply weathered. Exposures are scarce because of the thick accumulations of altered surface rock, stream deposits, and vegetation, consequently the stratigraphic relationships of the various rock types are difficult to determine. Dikes and other small irregular bodies of basalt and possibly andesite intrude the Clarno rocks. In at least three of the mines, the Staley mine in the Ochoco Creek area and the Mother Lode and Amity mines in the Johnson Creek area, basalt dikes parallel the principal northeast-trending system of fractures governing the distribution of the cinnabar and in places lie adjacent to quicksilver ore zones. This suggests that at least some of the dikes were intruded after, or more probably during, the deformation of the Clarno rocks.

Structure: The predominant structural features of the Clarno Formation in this area are anticlines and synclines having sub-parallel, northeast-trending axes and faults or fault zones that parallel them. The quicksilver deposits occupy broad zones of faulting, fracturing, and hydrothermal alteration that reflect these structural trends. Intensity and distribution of faulting varies considerably from place to place. Because of the extensive alteration and softening of the rocks within the zone, individual faults are rarely traceable except by mine and prospect excavations.

The quicksilver deposits along Ochoco Creek and Johnson Creek fall close to lines bearing N. 50° E. and N. 60° E. respectively. Those in the Marks Creek area, though more widely scattered, may lie on an extension of the Ochoco Creek fault zone. The principal system of faults approximately parallels the length of each zone. However, in each, additional sets of faults complicate the structure. These several sets of fractures probably represent various stages in the recurrent deformation of the Clarno Formation.

Ore deposits: The cinnabar ore bodies are generally contained in extensively crushed, hydrothermally altered fault breccia and gouge rich in clays, carbonates and silica. In general, the material has a wet, meal-like consistency, is quite permeable, and forms heavy, dangerous ground for mining. Carbonates and silica, mainly in the form of chalcedony, generally occur as discontinuous veinlets and impregnations in the fault breccia and gouge and fill joints and other cavities in the adjacent rocks. Locally the wall rocks, particularly those of the footwall, are partially silicified. Pyrite or marcasite is widespread but only rarely abundant. The black, lustrous hydrocarbon often, though perhaps erroneously, called gilsonite, is locally present as small blebs and stringers. Some of the individual gouge zones are as much as 20 feet wide but most are less than 5 feet in width. Along many of the faults the thickness of breccia and gouge varies greatly in short distances.

Cinnabar occurs as fracture fillings in the silica-carbonate veinlets and also as disseminations, narrow veinlets, and thin coatings in the gouge. Ore bodies are small, and widely scattered. Those thus far exploited have been small pods and more or less vertical shoots having small lateral extent.

In the past, profitable mining has been hindered by several factors, the most important of which are the limited size of the ore bodies and their erratic and unpredictable distribution. Also, because of very heavy ground, most of the underground workings within zones of faulting had to be timbered and lagged throughout and constantly maintained to prevent caving. At present all of the important underground workings are caved and inaccessible. During the past few years some mining and prospecting has been done on the surface, particularly in the Johnson Creek area.

BYRAM-OSCAR MINE

Location: NE$\frac{1}{4}$ sec. 23, T. 14 S., R. 18 E., in the hills bordering Ochoco Creek valley on the south. The mine is on the east side of the hill about 1,500 feet airline northeast of the old millsite, which is on the east bank of Camp Branch Creek.

Owner: The deposit is on deeded land owned by Ernest Grubbe.

Production: 63 flasks recorded.

History and development: Development of the deposit was begun by A. J. Champion and Grover Keeton in 1932. In the same year, the property was sold to H. F. Byram and Ray Whiting. Whiting's interest was acquired by George Oscar in early 1933. The ranch was later sold to Grubbe.

In 1933 a stationary continuous-feed, vertical-tube furnace of unique design was installed but proved to be unsatisfactory. The furnace was erected on the west side of the hill in order to obtain water for the condenser system. In 1935, Grubbe and Byram produced about 13 flasks of quicksilver from 125 tons of ore with the furnace. According to Grubbe, differential expansion and contraction of the furnace joints caused considerable gas leakage. In addition, the wet ore stuck in the tube on occasion.

In 1936 W. J. Seufert leased the mine and, hauling the ore to a 30-ton Selway rotary furnace at the Staley mine, produced 50 flasks during the year from 400 tons of ore which had been blocked out during the Byram-Oscar operations. Little or no work has since been done on the property and no usable equipment remains.

According to information furnished by Byram and Grubbe, the main workings consist of a 95-foot vertical shaft with 4 connecting drift levels. The uppermost drift level is connected to the surface. During the Seufert operations, ore was stoped from the lower level nearly to the surface. The ore zone ranged from 2$\frac{1}{2}$ to 7 feet in width and averaged about 35 feet in length. Several trenches and pits are scattered about the hillside nearby.

Geology: The workings are caved but a little of the ore zone as exposed in the adit level drift is still visible. Here andesite flows and tuffs have been cut by a shear zone that strikes N. 55° to 60° E. Most of the shear surfaces dip steeply southeast. The rocks in and adjacent to the shear zone have been intensely altered, softened, and bleached to various shades of yellow and brown. Cinnabar is visible in a few places in the caved material as narrow veinlets and disseminated specks. According to Grubbe, the ore from the lower levels contained much pyrite. The shear zone has been offset a short distance west of the shaft. Little effort has been put forth to locate its continuation to the west.

JOHNSON PROSPECT

Location: W$\frac{1}{2}$ sec. 23, T. 14 S., R. 18 W., west across Camp Branch Creek from the Byram-Oscar mine.

Owner: Unknown.

Production: None.

General description: Most of the development work was done by James Johnson during the early 1930's. One group of workings, consisting of at least two adits, lies at the north end of the ridge about a quarter of a mile southwest of the mouth of Camp Branch Creek. Three other adits and several opencuts lie along the summit and east slope of this ridge about half a mile to the south. All of the workings are caved and little could be seen by the writer. Rocks on the dumps indicate that the north workings penetrated hard, barren andesite. The south or upper workings were driven into andesite and tuff. The dump of the uppermost adit showed traces of cinnabar on panning.

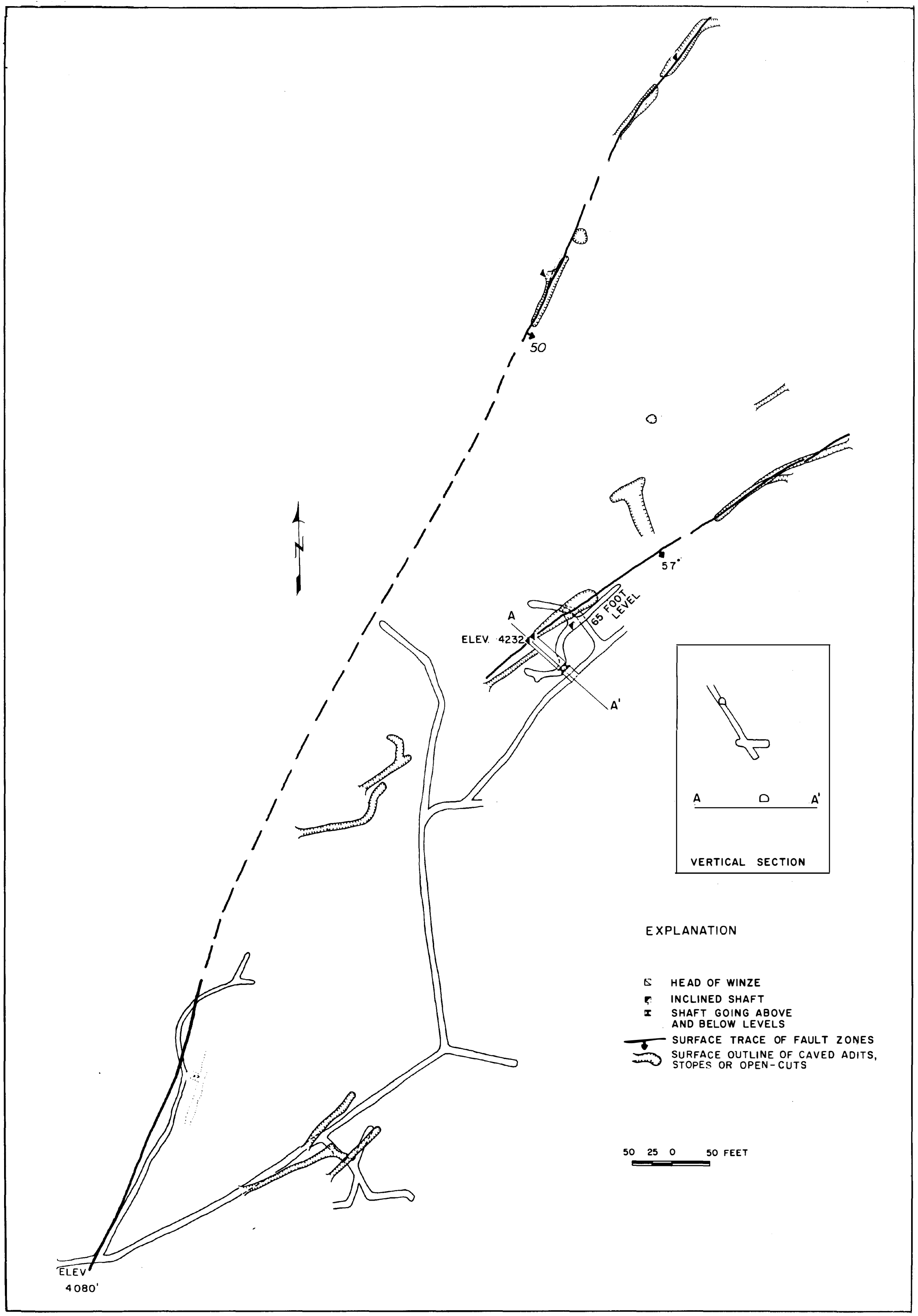


Figure 45. Map of the Staley mine (adapted from map furnished by J. E. Staley).

STALEY MINE

Other names: Barney and Staley mine; Jimmy Ann mine.

Location: E$\frac{1}{2}$ sec. 7, T. 14 S., R. 19 E.

Owner: John Hudspeth.

Production: 448 recorded; probably a few more as indicated below.

History: Cinnabar was discovered here in November 1927 by A. J. Champion and the property, consisting of 160 acres of deeded land, was purchased from a Spokane financial firm by the discoverer and his partners, J. E. Staley and A. L. Barney. Two Johnson-McKay pipes were installed and 40 flasks were produced in 1928 and 40 in 1929. Champion sold his interest in the property to Barney and Staley in June 1929. The property was then leased to Cinnabar Mines, Inc., which, according to Schuette (1938, p. 105) continued operations to the summer of 1933, producing an additional 51 flasks. This latter production was not recorded by the U.S. Bureau of Mines. The lease was then terminated, and during the remainder of 1933 and 1934 the mine was operated by Staley and Barney. Production of 8 flasks was recorded by the U. S. Bureau of Mines in 1934 and 50 in 1935. (Schuette reports that a total of 18 flasks was produced during 1933 and 1934, but makes no mention of the 50 flasks in 1935.) In September 1935 the mine was taken over by the Ochoco Mines Corp. headed by W. J. Seufert of The Dalles, and a Selway rotary furnace 30 inches in diameter and 30 feet long was installed. Between September 1935 and June 1937 a total of 206 flasks was produced. The mine was then leased to C. W. Cramer, who produced 35 flasks between October 1937 and May 1939. This production was made with the Johnson-McKay pipes. An additional 4 flasks were produced during the summer of 1939 by Staley and his son. The rotary furnace was moved to the Axehandle mine in 1940. In the spring of 1940 Barney's interest in the mine was purchased by R. L. Culbertson. A Champion rotary retort was installed and 89 flasks were produced through 1941. Culbertson purchased Staley's interest in the property in the spring of 1942 and, after installing a small Cottrell rotary furnace purchased from Werner at the Platner mine, continued operations until fall, producing 26 flasks. The mine has since been idle and ownership has changed several times.

Development: Development (see figure 45) consists of about 1,600 feet of drifts and crosscuts distributed between two diverging adits having adjoining portals; an inclined shaft 125 feet long with connecting adit and about 120 feet of drifts with a winze below and stopes above extending from its foot; and many opencuts, shallow shafts and adits. About 450 feet of workings from the easternmost of the two main adits is accessible. The remainder of the underground workings is caved.

Geology: The country rocks are andesitic flows, tuffs, and agglomerates of the Clarno Formation intruded by basalt dikes. Exposures are poor and no attempt was made to determine the relationships of the various rock types. These rocks are cut by two strong faults and many minor faults and fractures.

The two prominent faults intersect immediately west of the main inclined shaft. One strikes N. 50° to 60° E., and, according to Staley, dips 50° SE. from the surface to a depth of about 40 feet, then steepens to about 65°. The other, a younger crossfault, strikes N. 25° E., dips 50° SE., and apparently offsets the older fault a considerable distance, because its position west of the crossfault is unknown. Many of the smaller faults and fractures approximately parallel one or the other of the two faults, particularly the one trending N. 50° to 60° E., and most of them are pre-mineral.

The largest ore body, that mined from the inclined shaft and interconnected workings, lay along the fault trending N. 50° to 60° E., near its intersection with the crossfault. Caved stopes, surface cuts, and shallow adits mark its course from the incline eastward for about 500 feet. Gilluly (1933, p. 124) states:

> "Along this zone the rock has been intensely and almost entirely altered to a slickensided clay, chiefly a ferriferous montmorillonite, with some kaolin and nontronite. Impregnating this clayey zone and roughly following the most promiment shear are cinnabar, pyrite, calcite, opal, and chalcedonic quartz. These minerals occur both as veinlets in the altered rock and as discrete particles sporadically developed in it. It can hardly be said that any vein system is present; the mineralized body seems to be a crushed zone. However, the best ore seems to occur rather constantly along the most prominent fault wall. In the stope from which the retort ore was being extracted at the time of visit, just west of the shaft on the 45-foot level, a stringer of cinnabar-bearing material about 4 inches wide occurred along this wall, from which the cinnabar seemed to fade out in smaller and smaller veinlets into the

clay walls. Cinnabar occurred across the entire face of the drift, about 5 feet wide, but only the high-grade streak was being sent to the retorts."

The next most productive ore body lay along the cross fault about 500 feet north of the inclined shaft. During 1940 and 1941 Staley and Culbertson recovered 89 flasks from the shallow inclined workings. The ore averaged about 55 pounds of quicksilver per ton on recovery. The western adit drifted for much of its length along the southward extension of this fault. Small amounts of ore were recovered from the underhand stope indicated on figure 45 and from a surface cut just south of the adit portal. Although cinnabar is said to have been distributed along some of the many faults cut by the eastern adit, apparently very little was of minable grade.

On the ridge between the adit portals and the inclined shaft, several small faults and shear zones are exposed in a series of opencuts. Here the rocks are partially silicified and form a low, resistant rib. Crystalline cinnabar occurs as fillings in the fractures along with silica, limonite, clays, and occasionally gilsonite.

On the point of the hill east of the main incline, cinnabar, associated with calcite and chalcedony stringers, occurs in fractured andesite along the west edge of a basalt dike trending N. 15° E.

CHAMPION MINE

Location: NW$\frac{1}{4}$ sec. 3, T. 14 S., R. 19 E., 0.6 mile south of Ontko's Store on the old Ochoco Highway.

Owners: David A. and George L. Johnston.

Production: 37 flasks recorded.

History: The property was located originally in 1930 by A. J. Champion and Mr. and Mrs. Bert Tolladay. It was acquired under lease and option by W. W. Elmer in 1931. The Ochoco Mercury Corp. was organized by David A. Johnston, Frederic F. Wolfer, and Harold G. Brown to operate the property. A small Joshua Hendy rotary retort was installed but was little used. A large part of the development work in the mine was done by the corporation under the direction of W. W. Elmer, but there is no record of production. In 1934 Champion resumed operation, erected a Champion Rotary retort, and mined ore developed in part by the former operators. Production of 7, 12, and 6 flasks was recorded in 1934, 1935, and 1936 respectively. In 1937 David A. Johnston and George L. Johnston acquired the property, receiving a quit-claim deed in 1938. Elmer was again retained as operator, and production of 5, 2, and 5 flasks was recorded in 1937, 1938, and 1941, respectively. Both retorts remain on the property.

Development: Development consists of an adit about 90 feet long leading to a caved drift, which is said to connect with a raise on the vein that holed through near the top of the ridge about 180 feet northeast of the adit portal. In addition, a two-compartment inclined shaft passing over the adit but connected to it by a crosscut branching off about 40 feet from the adit portal has been sunk on the vein to a reported depth of 120 feet and drifts have been driven each way from the bottom. Ore was hoisted to the surface in one compartment of the incline and dumped down the other to the adit level. Of all the underground workings, only the 90-foot adit was accessible when visited by the writer. According to Wilkinson (1940) the underground workings total about 700 feet.

Geology: The country rocks include andesite flows, agglomerates, tuffs, and tuffaceous sediments. Structural conditions are presumably similar to those throughout the Ochoco Creek area. The workings explore a gouge zone trending about N. 60° E. and, as indicated by the inclination of the inclined shaft, dipping about 50° S. Where exposed in the surface cuts and reportedly throughout the workings, the mineralized zone consists of from 1 to 3 feet of soft, meal-like gouge impregnated with limonite and cut by small veinlets and bunches of chalcedony and calcite. Ore is said to have been mined from small pockets and shoots scattered along the gouge zone.

About 400 feet N. 35° E. of the adit portal are several pits aligned over a distance of about 100 feet along a narrow fault zone trending N. 20° E. A little cinnabar was panned from the dump of the northernmost pit but none was seen in place.

ONTKO PROSPECT

Location: Sec. 33, T. 13 S., R. 19 E., about a third of a mile north of the old Ochoco Highway.

Owner: Andrew Ontko.

Production: None.

History and development: The prospect was discovered by the owner in the early 1930's. Development is said to consist of a tunnel about 50 feet long, a winding shaft of unknown depth, and a large open cut. All of these workings are caved.

Geology: Country rocks consist of Clarno andesites, tuffs, and agglomerates. Cinnabar can be panned from the soil and decomposed rock in the vicinity of the workings where, according to Wilkinson (1940), high-grade stringers were exposed. The structural relationships could not be positively determined, but it is believed that they are similar to the relationships found in the other quicksilver deposits along Ochoco Creek.

LITTLE HAY CREEK PROSPECT

Other names: Flag Creek Prospect, Miller Flat Prospect.

Location: NW$\frac{1}{4}$ sec. 27, T. 13 S., R. 19 E., about 1,000 feet east-southeast of the section corner near the head of Little Hay Creek.

Owner: Unknown.

Production: None recorded; probably 3.5 flasks.

History and development: The prospect was discovered by A. J. Champion, and claims were located by Champion and Bert and Zelma Tolladay in the fall of 1930. In about 1936 the property was leased to the Gilkinson brothers who, according to Tolladay, produced approximately 3.5 flasks of quicksilver from sorted high-grade ore. Development includes a drift about 30 feet long, a shaft 20 feet deep, and scattered pits and trenches. None of the underground workings is accessible.

Geology: The caved workings are distributed along the crest of a low ridge for about 100 yards. A shear zone trending approximately N. 70° E. and dipping steeply south coincides with the crest of the ridge. Another shear zone, which is exposed at the top of the caved shaft, strikes N. 35° W. and is nearly vertical. The rocks near the shaft are intensely altered, softened, and limonitized. Locally they are cut by veinlets and small clots of chalcedony, calcite, and a little cinnabar. Neither the dimensions of the cinnabar-bearing zone nor the grade of ore contained could be determined, owing to inadequate exposure.

A several-hundred-pound stockpile of obviously high-grade ore remaining near the old shaft contains cinnabar as nuggets and fracture fillings in altered andesite.

TAYLOR RANCH MINE

Location: SE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 34, T. 13 S., R. 19 E., about half a mile north of the old Ochoco Highway. The shaft collar and dumps lying a few feet above creek level on the north edge of Ochoco Creek valley, about half a mile west of the Ochoco Creek guard station, are visible from the highway.

Production: 248 flasks, 620 tons of ore treated.

Owner: John Hudspeth; deeded land.

History: The deposit was discovered in 1938 by A. J. Champion, and in 1939 was acquired by R. R. Whiting. A small Champion rotary retort was installed to treat development ore and production was begun in January 1940. Production by Whiting totalled 82 flasks in 1940, 95 flasks in 1941, and 57 in 1942. In October 1942 the lease was sold to E. C. Cantril, who continued production through the early part of 1943, producing an additional 14 flasks. No work of significance has been done since. The workings are caved and no equipment remains on the property.

Development: The mine is developed by a 130-foot shaft from which drifts were extended on the 45-foot, 80-foot, and 130-foot levels. Workings on the 80- and 130-foot levels are shown on Figure 46. About 100 feet of drifting and crosscutting is said to have been done on the 45-foot level.

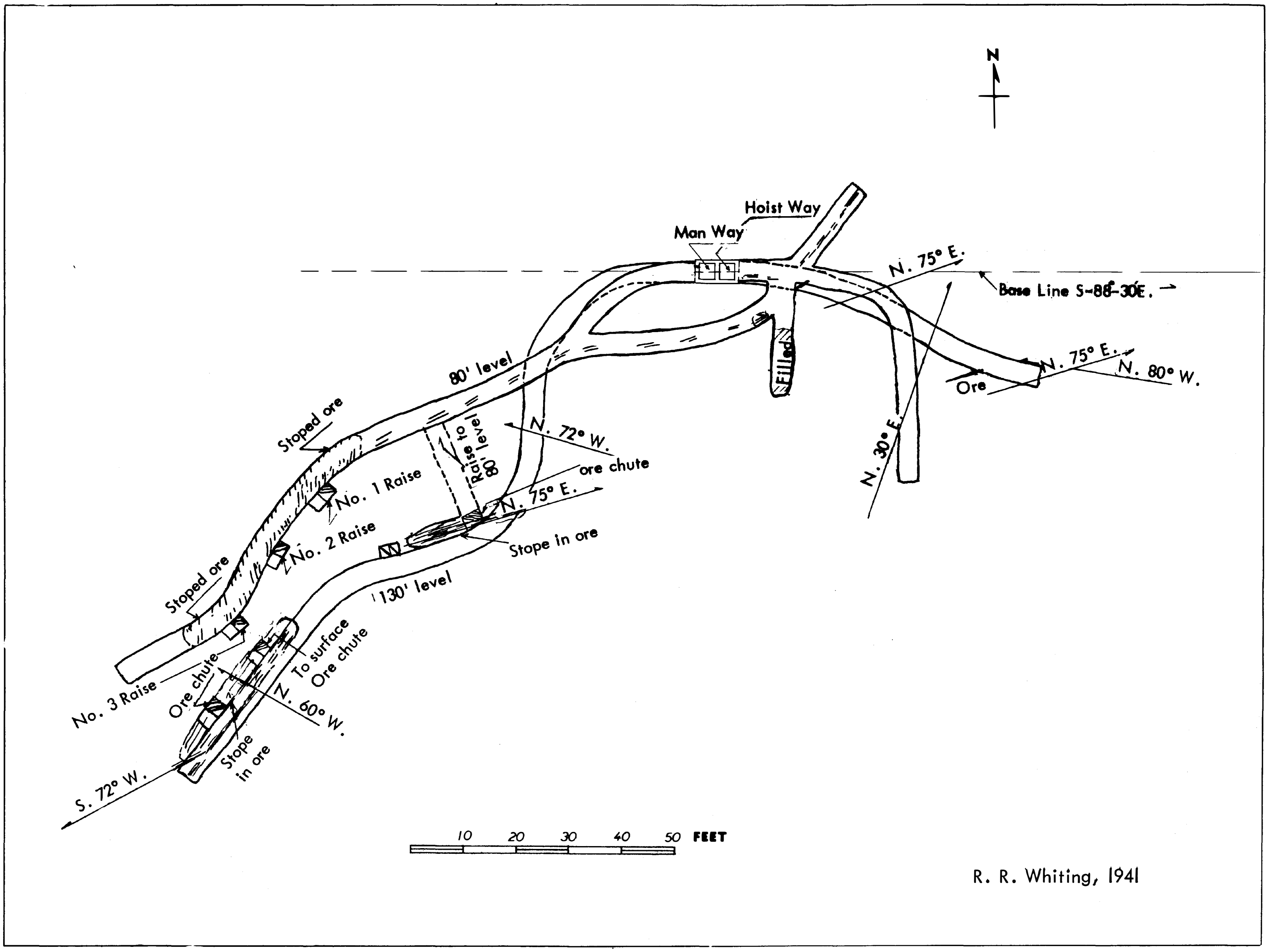


Figure 46. Map of the Taylor Ranch mine.

Geology: Few rock exposures occur in the vicinity of the shaft. The following was obtained partly from the report by Stephenson (1943) and partly from maps and notes compiled by Whiting. The country rock in all of the underground workings is an andesite porphyry. A dense black basalt, probably intrusive, forms a small knob about 600 feet northeast of the shaft. The andesite porphyry explored by the workings is cut by two well-defined fracture systems, one striking N. 31° E. and the other N. 75° E. Faults of both of these groups dip about 70° SE. The andesite along the faults is highly altered and bleached to a light gray color. These faults are intersected by many other faults and fractures of less definite trend. Stephenson (p. 85) reports that most of the ore occurs in or very close to the fault zones and much of it is associated with fractures of the N. 31° E. trend. He states, "Post-mineral movement has occurred along one or more of the major faults of the N. 75° E. group, and has offset faults and ore bodies of the N. 31° E. trend, although the former trend also existed at the time of mineralization....In general, ore deposition was probably localized at intersections of the several fault groups, but the exact role played by each group is uncertain."

Maps by Whiting suggest that because of the slight offsetting of the N. 31° E. faults by those of other trends the overall trend of the cinnabar-bearing zone developed by drifts on both the 80-foot and 130-foot levels is, though variable, about N. 40° E.

According to a Whiting map, supplemented by his comments, the main stope of the mine commencing about 75 feet southwest of the shaft was about 48 feet long on the 80-foot level and tapered upward to within about 20 feet of the surface. The stope ranged from 8 to 10 feet in width and the ore body raked steeply to the southwest. Two smaller stopes, about 70 feet and 120 feet southwest of the shaft and about 33 feet and 23 feet long, respectively, on the 130-foot level, were extended upward for a short distance. The ore body 70 feet southwest of the shaft is reported to have lain along a strong fault striking N. 75° E. and dipping 70° S. The grade of ore mined is said to have decreased appreciably below the 80-foot level.

Little, if any, ore was mined from drifts northeast of the shaft. Whiting's map suggests that the ore zone is offset about 45 feet to the east on the north side of a fault striking N. 75° E. Stephenson refutes this conception on the basis of his magnetic data, which indicate that the main ore zone has been offset about 45 feet westward on the north side of the fault. If Stephenson is correct in this interpretation, the cinnabar-bearing fault zone in the drifts on the 80-foot and 130-foot levels northeast of the shaft is not the northeast extension of the ore zone mined in the stopes southwest of the shaft.

JOHNSON CREEK AREA

The Johnson Creek area, formerly included in the "Ochoco quicksilver district" of Stephenson (1943), lies about 6 miles southeast of the Ochoco Creek area in the center of T. 14 S., R. 20 E., Crook County (see figure 44). The mineralized area is about 4 miles long and extends from the base of Lookout Mountain in section 20 across Johnson Creek to Big Summit Prairie in section 15. Mines and prospects fall on a line that trends approximately N. 60° E. The productive mines, from west to east, are the Mother Lode, Amity, Number One, and Blue Ridge. In addition there are a number of minor occurrences.

Access to the Johnson Creek area is by way of the Summit Prairie road, a graveled Forest Service road, which leaves the old Ochoco Highway near the Ochoco ranger station. Summit Prairie road follows up Canyon Creek, crosses Lookout Mountain divide, and descends Johnson Creek. The distance by road from Prineville is about 34 miles.

Elevations range from about 4,800 feet at the Blue Ridge mine near the east end of the area to about 5,900 feet at the Mother Lode mine near the west. Lookout Mountain rises above the area to an elevation of 6,926 feet. The Johnson Creek district lies wholly within the Lookout Mountain 15-minute quadrangle, and like the Ochoco Creek district is covered by Wilkinson's (1940) geologically mapped Round Mountain 30-minute quadrangle.

History and development

Cinnabar was discovered in the Johnson Creek area at the present site of the Mother Lode mine in 1899; initial production of 3 flasks was made from this mine in 1906. The discovery of cinnabar deposits along the northeasterly extension of the zone on the opposite or north side of Johnson Creek caused a small rush to the area in the spring of 1930. Many claims and claim groups were located, leases were arranged, and by the end of the year work was begun on the properties now known as the Amity, Number One, and Blue Ridge mines. W. J. Wesserling, who with his wife, Ida, located claims in each of the original groups, is generally credited with discovery of these deposits. However, several local informants have stated that the initial discovery of cinnabar in the area was made by A. J. Champion in the winter of 1929. The total recorded production of the Johnson Creek area is 955 flasks.

The four productive mines (Amity, Blue Ridge, Mother Lode, and Number One) have changed hands many times. Few operators have maintained production for more than two consecutive years and none for more than four, although production from one or more was recorded annually from 1927 to 1943.

With the exception of the Amity mine, no underground work has been done in the area since 1943 and nearly all of the workings are inaccessible. Underground development work in the Amity mine continued sporadically until 1957 and a little quicksilver was occasionally produced. Other than this, production from the area since 1943 has been recovered from small, primarily opencut operations.

Geology

Mines and prospects of the Johnson Creek area, as in the Ochoco Creek area, are distributed along a northeast-trending zone of faulting, hydrothermal alteration, and mineralization in the Clarno Formation of Eocene age. The geology of the area is discussed under the Ochoco Creek area heading.

MOTHER LODE MINE

Location: SW$\frac{1}{4}$ sec. 20, and NW$\frac{1}{4}$ sec. 29, T. 14 S., R. 20 E. near the head of Canyon Creek on the north slope of Lookout Mountain.

Production: 347 flasks recorded.

Owners: Frank Reid, Roger Golliard, Earl Zimmerman, and Keith Parkinson.

Lessee: Werdenhoff Mining Co.

History: Development of the Mother Lode mine as a gold and copper prospect was begun by H. S. Cram in 1899. In 1900 quicksilver was discovered and in July 1901 the American Almaden Quicksilver & Gold Mining Co. was organized to operate the mine. A small Scott furnace was erected and production was first recorded in 1906. Since that time, intermittent production has been made by several corporate groups, none of which continued productive operations for more than two consecutive years. Following is a list of known operators and their production as recorded by the U. S. Bureau of Mines.

Operator	Year	No. of Flasks
American Almaden Quicksilver & Gold Mining Co.	1906	3
Same	1908	18
Central Oregon Mining Co.	1915	3
Pacific Quicksilver Co.	1927	24
Consolidated Quicksilver Co.	1928	41
Same	1929	24
Senter Construction Co.	1930	23
Crams, Inc.	1932	3
Same	1935	52
Same	1936	47
Champion Mining Co.	1939	35
Same	1940	60
Gilkey Brothers	1942	2
Same	1943	4
Canyon Creek Mining Co.	1954	2
Werdenhoff Mining Co.	1959	6
Same	1960	5
Total		352

G. W. Tillotson and C. A. Patterson are said to have produced a small amount of quicksilver in 1917 with a battery of 8 retorts, but there is no record of the amount. Much of the work on the Consolidated adit level was done during 1928-30 by the Consolidated Quicksilver Co. Ore from these operations was treated in a Gould rotary furnace of 12 tons per day capacity. When Crams, Inc., took over operation in 1931, work was confined to the No. 4 adit level. In 1936 the mine passed into the hands of the Reconstruction Finance Corp. in lieu of repayment of a $12,000 development loan. During 1939 much open cutting was done above the old stopes and farther to the northeast by the Champion Mining Co. Small ore bodies exposed with a bulldozer were selectively mined and treated in the 12-ton furnace. In 1942 and 1943 the Gilkey Brothers erected a plant utilizing jigs in an attempt to concentrate large tonnages of low-grade ore. The property then lay idle until 1954, when the claims were relocated by the present owners, who organized the Canyon Creek Mining Co. A few tons of surface ore was treated in the Herreshoff furnace at the Amity mine in 1954. The property was leased to the Werdenhoff Mining Co. late in 1958. Since the rotary furnace had been removed from the property, a double D-tube retort was erected and 6 flasks were

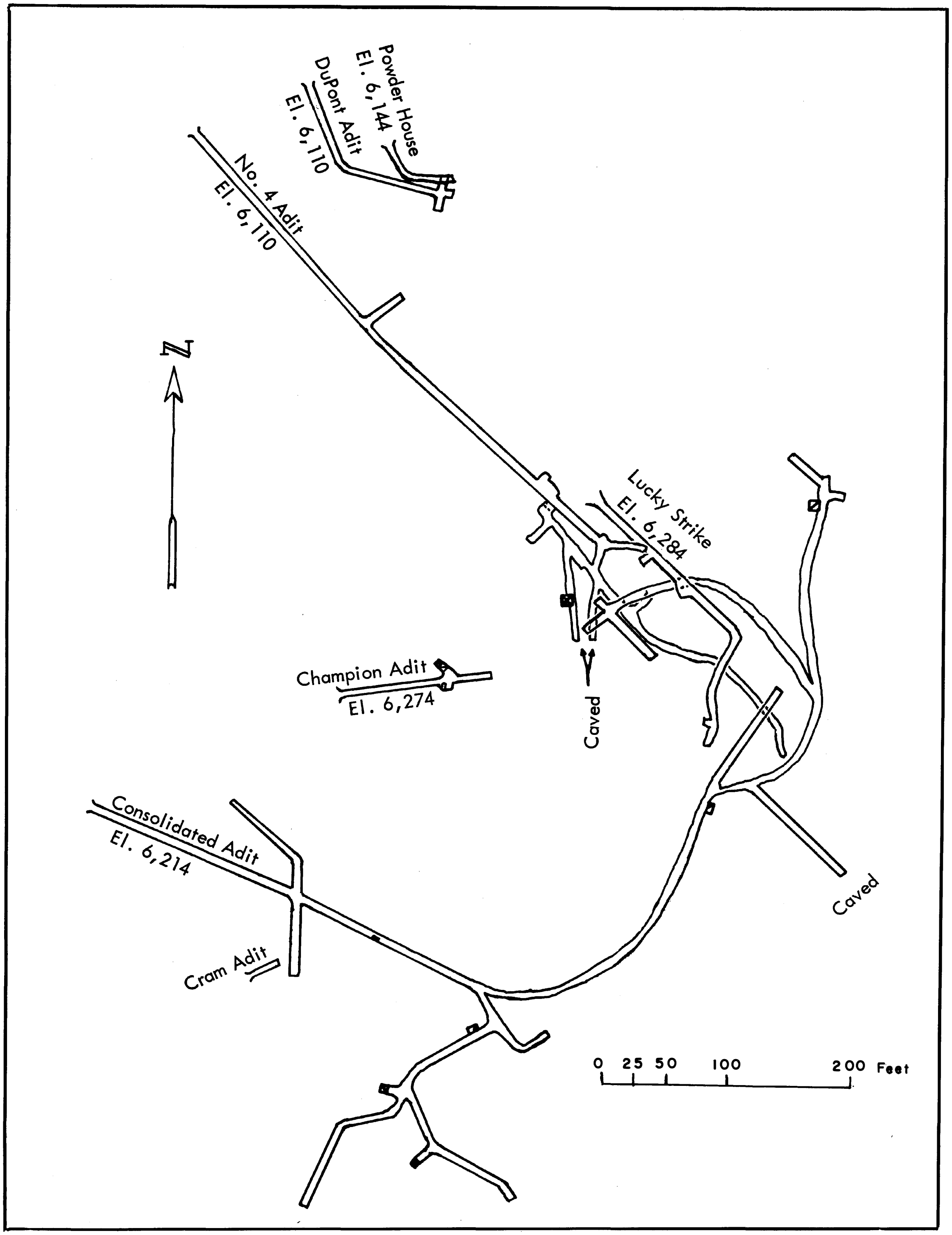


Figure 47. Map of underground workings of the Mother Lode mine.

produced from surface ore in 1959. Erection of a Herreshoff furnace of 50 tons per day capacity was completed late in 1960, but the furnace has been little used.

Development: According to old maps and reports, at least 3,000 feet of underground work has been done from 6 adits. Figure 47 is a compilation of several maps of the workings. The principal adits are the Consolidated adit and the No. 4 adit, both of which enter the east bank of Canyon Creek a short distance above creek level. No underground work has been done on the property since the early 1940's and all the adit portals are caved. Much open pit exploratory work has been done by the Werdenhoff Mining Co.

Geology: The Mother Lode mine is the southwesternmost of the quicksilver deposits scattered along the Johnson Creek fault zone. Rocks exposed in the mine area consist predominantly of andesite flows, tuffs, and agglomerates intruded by dikes and irregular bodies of basalt. Unconformably overlying "Ochoco lavas" are exposed on the hillside above. On the basis of geophysical surveys, Bath and Cook (1949) determined that the main workings of the Mother Lode mine lie between two basalt dikes that trend approximately N. 60° E. The northwesternmost dike is exposed in several places north and east of the portal of No. 4 adit.

Structural conditions at the Mother Lode mine are similar to those throughout the Johnson Creek area; however, ore depositional controls appear to be somewhat different. Northeast of Johnson Creek, cinnabar was deposited primarily along faults trending N. 60° E., concentrating where these faults were cut by crossfaults. In the Mother Lode mine, most of the cinnabar now exposed and, presumably, much of that occurring underground was deposited along crossfaults. The more important sets of localizing crossfaults trend approximately N. 40° to 45° W., N. 10° to 15° W., and N. 5° to 10° E.

Gilluly, Reed, and Park (1933) describe the ore shoots in the Consolidated adit workings as consisting commonly of small branching irregular stringers and seams. They state:

> "Locally the stringers tend to follow stronger controlling fissures and send out branches from these in all directions. One vein that had been worked just prior to the visit strikes N. 45° W. and stands vertical. This vein or lode is apparently controlled by a shear surface and ranges in width from 3 inches to about 1 foot. Many narrower stringers branch from it into the northeast wall, but the southwest wall, in the exposed workings, seems to be less mineralized. These stringers range in thickness from a knife-edge to about half an inch, but most are less than one-eighth inch thick.
>
> "...Considerable stoping has been done near the end of the northeast drift, a stope there in gougy basalt being about 40 feet high and 15 to 20 feet wide. A little cinnabar remains in the clay of the walls. Several other stopes have been worked; one, near the junction of the southwest branch with the main drift, is about 50 feet long and follows a vein that strikes N. 60° E. and dips steeply south. This stope extends to the upper level. Much of the old work in the mine is caved, so that the extent of the other stoping was not determined.
>
> "The tenor of the ore is unknown, but to judge from the material exposed in the mine it must be rather low. It would be difficult to select any considerable tonnage carrying more than one-half of 1 percent of quicksilver; probably even this limit would be hard to maintain."

According to old maps of the workings (figure 47), the downward extension of the N. 45° W.-trending ore body was later encountered on the No. 4 adit level about 400 feet from its portal and 105 feet below the Consolidated adit level. Perhaps all or most of the ore from which 99 flasks were produced by Crams, Inc., during 1935 and 1936 was recovered from several small stopes on this ore body above the No. 4 adit level.

Most of the development work performed on the property by the Werdenhoff Mining Co. has been confined to the enlargement of an open pit exploring the surface extensions of this same ore body. An old stope or raise from the Consolidated adit level has been cut into and parts of the Lucky Strike and Champion adits destroyed. During 1959, ore from several small ore shoots scattered about the pit was selectively mined and treated in the retort. Since that time, the pit has been considerably enlarged.

The principal ore shoots exposed in the open pit in 1959 were contained within northerly trending fracture zones. Cinnabar was observed in one ore shoot as thin films on fracture surfaces and as narrow veinlets an eighth of an inch thick trending in all directions but lying within a zone about 2 feet wide trending N. 10° W. and cutting sheared and silicified andesite. The ore shoot had an exposed length of about 15 feet. A sample taken across the strike assayed 10.1 pounds per ton. A similar roughly parallel body was exposed about 40 feet away. Here the ore lay within and adjacent to a gouge zone from 1 to 3 feet wide trending N. 5° E. Most of the ore produced by the Werdenhoff Mining Co. came from these shoots. It is estimated that the ore treated must have averaged about 30 pounds of quicksilver per ton, although small pods of considerably higher grade were recovered.

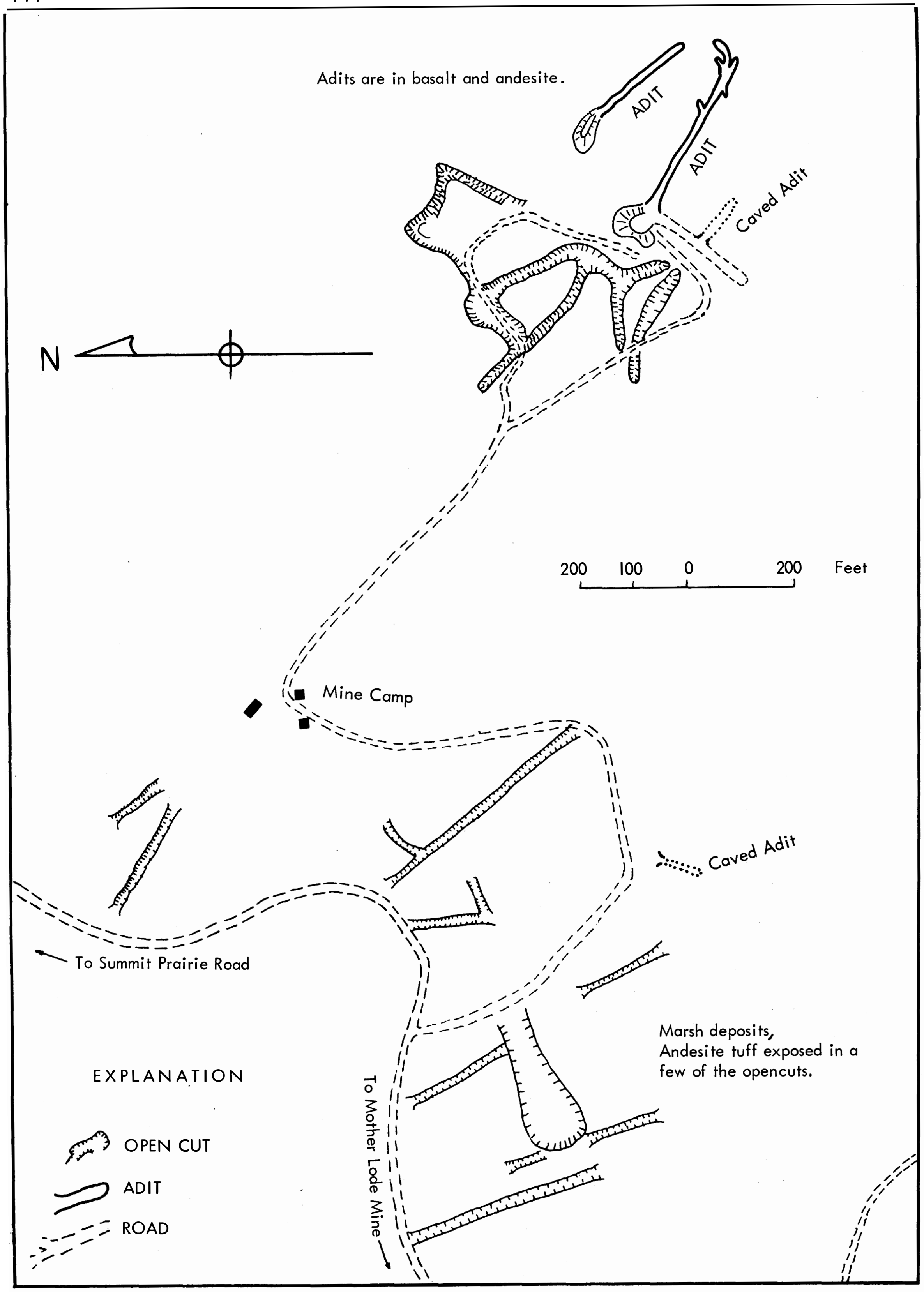


Figure 48. Plan of workings of the Independent mine.

INDEPENDENT PROSPECT

Location: Center of sec. 20, T. 14 S., R. 20 E., at the head of Johnson Creek on the northeast slope of Lookout Mountain. The property adjoins the Mother Lode mine property on the northeast.

Owners: Independent Quicksilver Co.; Lloyd Bartlett, Salem, secretary-treasurer.

Production: None.

History: The prospect may have been worked initially by early owners of the Mother Lode mine. The present company, which was organized by George A. Dreis, acquired ownership in 1930 and has done nearly all of the existing work.

Development: Prospecting efforts have been concentrated in two areas about 1,500 feet apart (figure 48). Both areas have been explored by many hundreds of feet of bulldozer trenches and by several drill holes. The eastern area also includes three adits, one of which is caved. The other two contain, collectively, about 600 feet of workings. A small gravity mill was installed on the property in 1959.

Geology: The west workings are in and along the western edge of a grassy meadow at the head of Johnson Creek. The meadow, which is roughly 200 yards across, is underlain largely by stream and marsh deposits consisting of crossbedded sand and clayey silt. Outcrops are scarce and several of the trenches failed to penetrate the alluvium. Rocks exposed within the meadow and along its periphery include andesite flows, tuffs, and breccias of the Clarno Formation. Dips where ascertainable are of low angle. Along the southeast side of the meadow in the vicinity of the east workings these rocks are overlain, apparently unconformably, by porphyritic andesite.

Within the meadow, cinnabar is sparsely but widely scattered through the alluvium. Its source was not determined by the writer; however, the owners report that, as a result of drilling, several small occurrences of cinnabar have been found in the underlying andesites. Weathering and erosion of the upper parts of such bodies could have contributed the cinnabar.

The two accessible adits of the east workings penetrate hard andesite, crosscutting at irregular intervals some narrow faults. The faults contain from a few inches to a foot of crushed andesite and gouge. Some are impregnated with a little calcite and silica. Cinnabar, though present as fracture coatings and small disseminated crystals, is scarce. One of the opencuts immediately below the adits exposes the varicolored clays and gouge characteristic of shear zones in the Johnson Creek area. Because of inadequate exposure, neither the width nor the attitude of the shear zone could be ascertained. A sample taken from the floor of the cut showed a little cinnabar and pyrite when panned.

DEVIL'S FOOD PROSPECT

Former name: Westbrook prospect.

Location: SE$\frac{1}{4}$ sec. 16, T. 14 S., R. 20 E., a few hundred feet west along the ridge from the Amity mine.

Owners: David Westbrook and Jack Campbell, Prineville.

Production: None recorded; possibly 1 flask.

History: The prospect was first located by J. H. Shelton and Robert Osborne in 1932. Between 1933 and 1943 it was owned by William Endicott, who claims to have produced one flask of quicksilver from selected ore. Owen Pigmon relocated the prospect in 1954 and later sold it on contract to the Orion Mining & Development Co. During 1957 considerable bulldozer trenching was done by this company under a Defense Minerals Exploration Administration contract.

Development: Development consists of bulldozer trenches spaced 40 to 100 feet apart over a linear distance of about 1,000 feet and an adit 130 feet long with connecting crosscut and a raise to the surface. The underground work, all of which was done by Endicott, is caved.

Geology: The workings explore a part of the Johnson Creek fault zone, which here has an over-all trend of

N. 70° to 80° E. and dips about 80° S. Several N. 10° E.-trending cross faults have been exposed. The rocks are mainly altered andesite flows, tuffs, and agglomerates of the Clarno Formation. Near the middle of the series of trenches a dike of dense, relatively unaltered basalt forms the footwall of the fault zone for about 100 feet. Along the dike the andesite has been intensely sheared through a width of from 3 to 12 feet, kaolinized, and impregnated with calcite and chalcedony. Pyrite is widely scattered but not plentiful. Cinnabar fills fractures and is disseminated through the altered rocks in a few places. Two or three small pockets of high-grade disseminated ore assaying as much as 90 pounds of quicksilver per ton were encountered during the excavation, but on the whole the material presently exposed is very low grade.

The dike is virtually barren of cinnabar although the first few inches along the contact have been fractured and silicified. Beyond the ends of the dike the fault zone as exposed in the trenches is less mineralized, but locally contains a little cinnabar.

AMITY MINE

Other name: Johnson Creek mine.

Location: W$\frac{1}{2}$SW$\frac{1}{4}$ sec. 15, T. 14 S., R. 20 E., on the steep north wall of Johnson Creek. The Summit Prairie road crosses the property.

Owner: Homestake Mercury Mines, Inc., Seattle, Washington.

Production: 332 flasks recorded; probably more as indicated below.

History: Development of the Amity mine was begun in 1930 by the Johnson Creek Mercury Co. headed by Martin Paulsen and Ivan Sayler. According to U. S. Bureau of Mines records this company produced 17 flasks in 1930 and 166 flasks in 1931. Schuette (1938) indicates that an additional 67 flasks were produced in 1932. A bank of 8 D-tube retorts was used to treat most of the ore. The Johnson Creek Mercury Co. was dissolved in 1933 and the property reverted to W. J. Wesserling, Ida Wesserling, and Emma Larson, to whom ownership had been transferred in April 1931. The property was acquired by the Homestake Mercury Mines, Inc., in mid-1937. Lessees Florence Cochran, Robert Olson, and Lewis Mills produced 2 flasks in 1942 with a small retort. In 1944 the property was leased to J. E. Morris, A. R. Morris, and E. B. Benson, who later organized the Amity Mining Co. Between 1944 and 1951 much development work was done and a 25-ton per day Herreshoff was installed in 1949. This company produced a total of 18 flasks.

In 1952, A. R. Erspamer of Seattle purchased the mine equipment, took an assignment of the lease from the company, and together with E. B. Benson began operations in 1953 as the Ochoco Mining Co. Owen Pigmon of Prineville was employed as manager until November 1954. Pigmon then acquired the property on a sublease from the Ochoco Mining Co. Between June 1954 and July 1955, 122 flasks were produced. In addition, 7 flasks were produced by Pigmon in 1956 before legal proceedings involving ownership caused the mine to close.

During the fall of 1958, the Herreshoff furnace, retort, and other equipment were removed from the property. Several cabins remain.

Development: Underground workings accessible at the time of visit in 1958 consisted of two crosscut adits lying below the Johnson Creek road. These are shown on figure 49 as adits A and B. Drifts from these crosscuts were only partly accessible.

Several caved workings are scattered about the slope above the Johnson Creek road. Various informants report that these upper workings include two adits 125 and 150 feet long respectively, a glory hole, and a shaft about 50 feet deep. The collar of a 250-foot raise from Adit A is located near the top of the ridge. Most of the work in Adit A was done by the Amity Mining Co. That in Adit B was done by the Homestake Mining Co., the Ochoco Mining Co., and Owen Pigmon.

Geology: Rocks explored by the Amity mine workings are mainly dark gray to black andesite flows, breccias, and agglomerates. Crosscut Adit B ends in dense black basalt. Andesite flows exposed at the north edge of the road cut above Adits A and B dip 5° to 10° SW. A narrow basalt dike exposed in the same cut roughly parallels the general trend of the Johnson Creek fault zone.

Two subparallel fault zones lying 30 to 40 feet apart have been explored by drifts branching from crosscut Adit A. The southern fault zone strikes N. 70° E. and dips 70° to 80° S. In the small amount of drift that was open for inspection, the fault zone was seen to contain 2 to 3 feet of wet, light-colored, meal-like gouge containing numerous porcelain-textured clay seams, veinlets and small bunches of chalcedony, calcite, limonite,

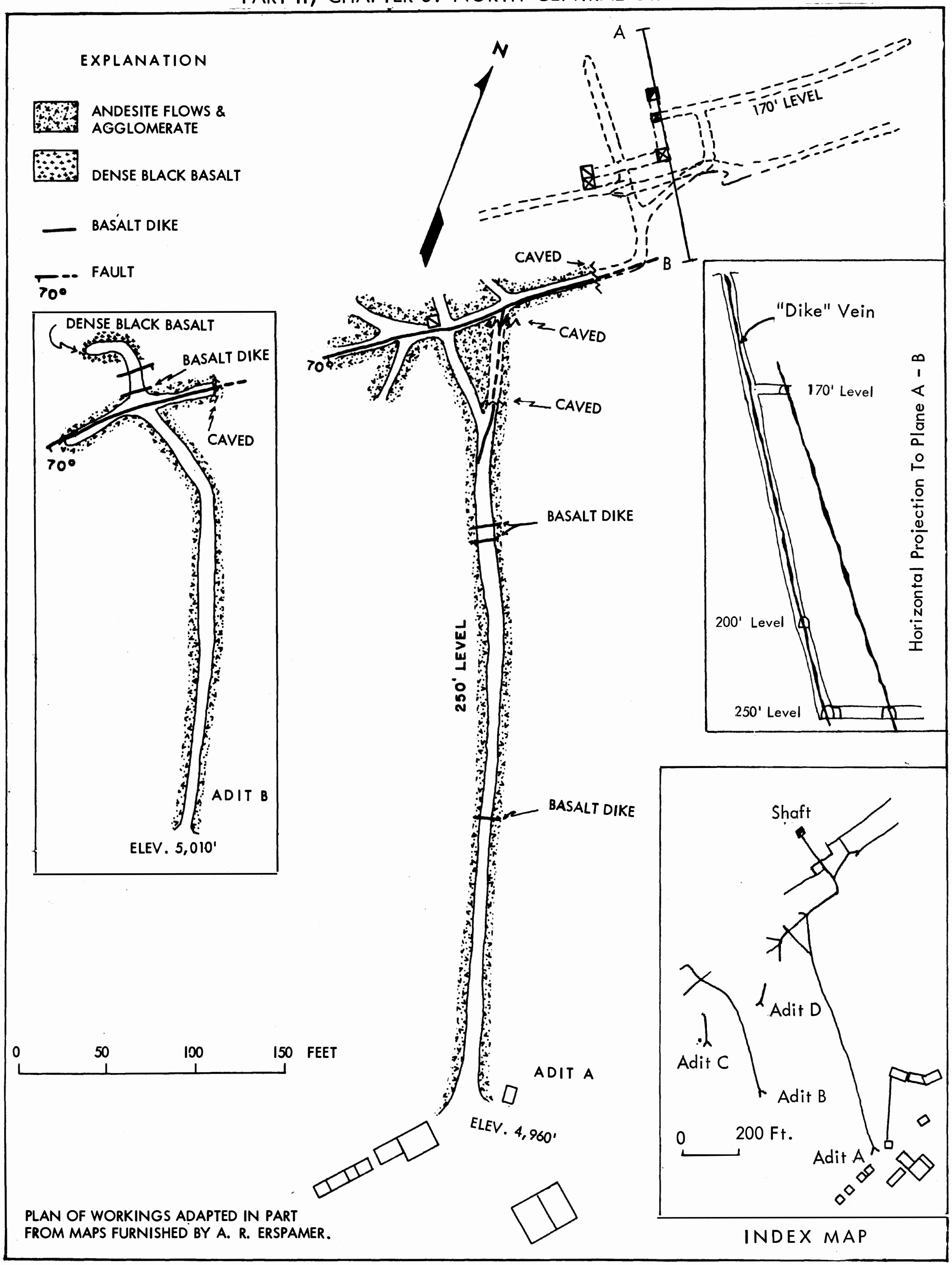


Figure 49. Geologic map of the Amity mine.

scattered marcasite, and occasional small blebs and thin veinlets of "gilsonite." Cinnabar occurs in minor amounts as disseminations and fracture fillings in the silica and calcite and as thin veinlets and fracture coatings in the gouge. Marcasite is locally abundant. Both walls of the gouge zone are sheared and altered over a width of several feet.

Local prospectors report that the northern gouge zone lies within a basalt or andesite dike. If this is true, it is the only intrusive in either the Johnson Creek or Ochoco Creek areas that is known to contain more than a trace of cinnabar. The gouge zone is said to range from 3 to 6 feet in width and to be of similar composition to that of the southern zone, except that its walls are more altered and less stable.

From a drift on the so-called "dike vein" a raise was driven up the dip to the 50-foot level, where it was lost in bad ground. A drift was then driven a short distance northeast from whence the raise was completed to the surface, 250 feet above the adit level. Drifting was done on both veins on the 170-foot level. Small amounts of ore are said to have been encountered at various places in the drifts but little production was made from any of the Adit A workings.

Adit B crosscut intersects a prominent gouge zone about 250 feet from its portal. About 70 feet of drift was accessible at the time of visit. Here the gouge zone is 2 to 3 feet wide, strikes N. 64° E. and dips 75° S., and is of similar composition to that of the southern gouge zone in Adit A and may be a continuation of it. A large part of the ore recovered from the Amity mine is said to have been taken from a small, high-grade shoot lying about 130 feet northeast of the Adit B crosscut-drift intersection and extending from the surface to 15 feet below the level of Adit B. According to record, the ore from the shoot averaged about 25 pounds of quicksilver per ton.

Continuing into the footwall of the gouge zone, the crosscut passes through about 2 feet of sheared andesite, a basalt dike about 2 feet wide cut by irregular calcite veinlets, then again into sheared andesite. About 15 feet beyond the gouge zone, the crosscut intersects a 3-foot zone of brecciated andesite. Perhaps this is a continuation of the so-called "dike vein" explored in Adit A. Beyond this brecciated zone the crosscut passes into massive, relatively unaltered basalt containing occasional calcite veinlets.

In some of the surface cuts north of the road above Adits A and B, occasional cross faults are seen to cut the main fracture trends. Most of the visible cross faults trend nearly north. Gilluly, Reed, and Park (1933, p. 120) mention a fault that trends north, dips 75° W., and contains a quartz vein 8 inches wide.

The gully at the west edge of the workings follows the course of a fault zone trending about N. 40° W. Cinnabar is exposed along this fault in a dozer trench just above the road.

BLUE RIDGE MINE (including NUMBER ONE MINE)

Location: N$\frac{1}{2}$SE$\frac{1}{4}$ sec. 15, T. 14 S., R. 20 E., about one mile by road east of the Amity mine. The Blue Ridge group of 9 claims includes the principal workings of both the Blue Ridge mine and the adjoining Number One mine, which originally consisted of two separately owned and operated properties.

Owner: Roy C. Stanton, Springfield, Oregon.

Production: From combined workings: 271 flasks recorded; possibly 301.

History and development: Location and development of both the Blue Ridge and Number One mines was begun in 1930, following discovery of cinnabar in the area by W. J. Wesserling. The property originally enclosing the Blue Ridge mine consisted of 8 lode and placer claims located by W. J. and Ida Wesserling, W. J. La Porte, Edna Reichen, and Lloyd Barney. The Blue Ridge Mercury Co. was organized to operate the property, and 7 flasks were produced with a small retort in 1930. An Allis-Chalmers rotary furnace 4 feet in diameter and 40 feet long was installed and was placed in operation in August 1931. Production increased to a total of 17 flasks. Late in 1931, the property was leased to Western Resources, Inc. This company produced 26 flasks in 1932 under the management of William Endicott, to whom a deed to the property was given in January 1933. Early development included a large opencut east of the Blue Ridge shaft from which ore was mined with a steam shovel. The present 8- by 16-foot shaft was sunk to the 100-foot level and drifting was done.

Oregon Cinnabar, Inc., leased the property in 1935. Two 10-pipe banks of retorts were installed and 2 flasks were produced in 1936 and 15 flasks during the summer of 1937. W. S. Shenker of Portland acquired the property in November 1937. C. T. Takahashi acquired the property in 1938 and Central Oregon Quicksilver Mines, Inc., was organized as the operating company. During the 3 years 1938-40, production of 92 flasks was recorded. The ore was treated at various plants in the area, including those at the Horse Heaven, Mother Lode, and Taylor Ranch mines. The Allis-Chalmers rotary furnace was still on the property during this time, but there is no evidence that it was used.

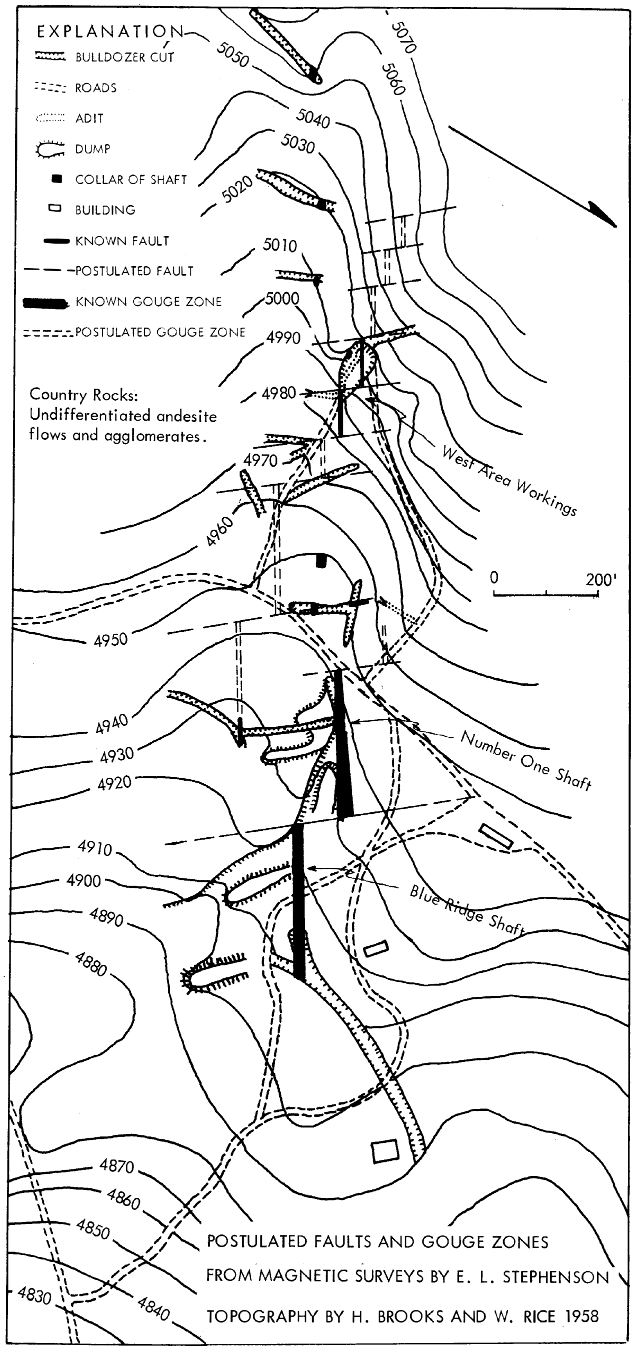


Figure 50. Topographic and geologic map of the Blue Ridge mine.

The 9 claims originally enclosing the Number One mine were located by Hal La Porte, W. H. Higgins, A. N. Whealdon, and others. W. F. Whitely and Donald W. Green of Portland leased the claims in November 1930. In 1931 the lease was reassigned to the Number One Mining Co. and R. R. Whiting was retained as manager and engineer. A map prepared by Whiting shows that in August 1932 the Number One inclined shaft had been sunk to a depth of 110 feet and drifting had been done on the 26-, 57-, and 110-foot levels. According to Whiting, about 30 flasks were produced with two D-tubes during 1930-31. Robert Osborne produced 1 flask from the mine in 1934. Subsequently the company maintained assessment work on the property and during 1939 and 1940 Whiting produced 11 flasks from ore trucked to his retort at the Taylor Ranch mine.

Cinnabar Mines, Inc., J. A. Maller vice-president, was organized in 1941 to work both the Blue Ridge and Number One mines. A 75-ton Gould rotary furnace and condenser system was installed, but after producing 81 flasks in 1942 and 9 early in 1943 from the combined workings, the company ceased operations. The furnace and other equipment were removed from the property in 1944. In that year the Gilkey Brothers cleaned up around the plant site, producing 3 flasks. The Number One Mining Co. property was subsequently taken over by the Central Oregon Quicksilver Mines, Inc., and included in the Blue Ridge group of claims. In 1952 the property was acquired by Roy C. Stanton, and in 1953 was leased to Fred Weber who installed jigs and, later, a washing plant and concentrating tables. Fourteen flasks were produced during 1954-55 from concentrated surface ore treated in a small retort.

In 1957 the property was leased to Mia Mines, Inc., headed by Frank Reid and Dick Toole, who erected a small gravity concentration mill. There is no record of production from their operations, although some ore was treated in the mill. The property reverted to Stanton in late 1958 and the mill has since been moved to the Independent mine.

Figure 50 shows the distribution of the workings; figure 51 gives a plan and sectional view of the Blue Ridge and Number One shafts and also shows the principal stopes. Both shafts are caved at their collars. Additional underground work not shown in figure 51 consists of a 300-foot adit (now caved) in the West adit area.

Geology: The Blue Ridge mine is the northeastern-most of several mines and prospects scattered along the Johnson Creek fault zone. Rocks in the mine area include andesitic flows, agglomerates, and possibly pyroclastics of the Eocene Clarno Formation locally intruded by dense, black, porphyritic basalt. In parts of the surrounding area and for several miles to the east the Clarno Formation is capped by the much younger Ochoco

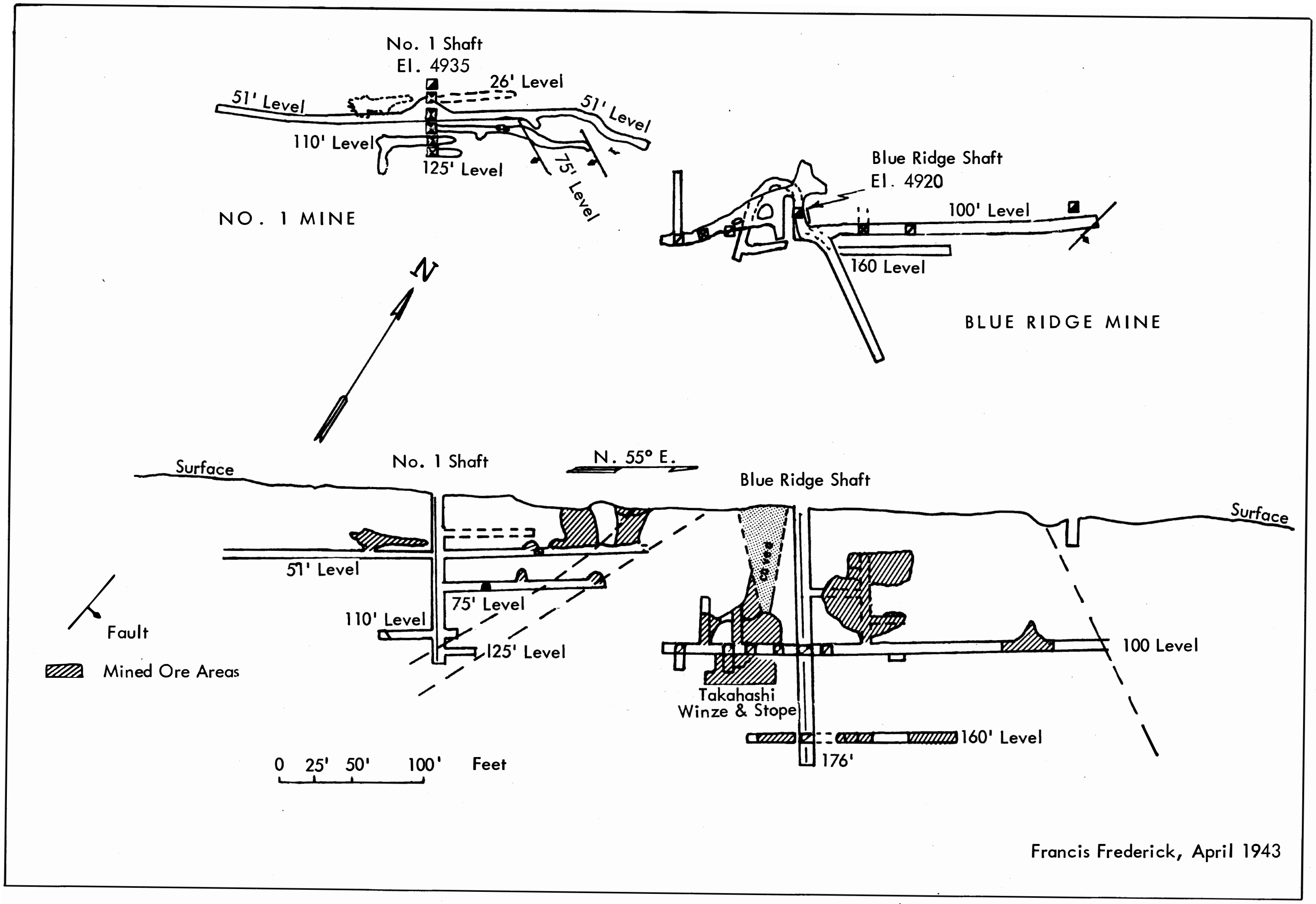


Figure 51. Plan and longitudinal projection of the Blue Ridge shaft and Number One shaft workings.

Lavas. Most of the workings lie in a topographically low area where water stands within a few feet of the surface. The rocks, having been extensively altered and softened by hydrothermal solutions and by ground waters, are in many places unidentifiable. Mining is made difficult by the soft, wet condition of the mineralized zones.

The rocks of the Clarno Formation in the mine area are cut by a series of faults and fractures that roughly parallel the N. 60° E. trend of the Johnson Creek fault zone. In this area they are cut and progressively offset to the northwest by faults that strike N. 40° W. Gouge zones as much as 20 feet wide have developed along some of the faults of the N. 60° E. trend, and it is in these gouge zones that the quicksilver ore bodies thus far developed are largely confined. Locally, however, the cinnabar mineralization extends into the walls of the gouge zones along fractures trending N. 10° W. The horizontal offsets in the gouge zones produced by the N. 40° W. faults are not large, and measured displacements are not more than 80 feet. Most of the movement along these faults is thought to have been horizontal and to have occurred after cinnabar was deposited. Cinnabar occupies only a very small part of the gouge zone, occurring as narrow veinlets and fracture coatings and as disseminated particles in thin, nearly vertical shoots.

The Number One shaft was sunk on a gouge zone which is about 10 feet wide at the shaft collar. It widens to the east to a maximum thickness of about 20 feet. The Blue Ridge shaft was sunk on an offset extension of this gouge zone. In recent years a bulldozer trench has been cut both northeast and southwest from the Number One shaft, exposing the gouge zone over a length of about 200 feet. In the process, the shaft collar was destroyed and the shaft partially filled. Another bulldozer trench has been cut to a depth of about 20 feet on the gouge zone exposed in the West adit area. In both the Number One shaft and West adit areas the north or footwall side of the gouge zone is silicified and hence harder and more resistent than the gouge or its hanging wall. Only locally are the silicified portions of the footwall noticeably expressed topographically.

Wilkinson (1940) indicates that the Johnson Creek fault zone cuts the younger Ochoco lavas northeast of the Blue Ridge mine, but no cinnabar has been found in these rocks.

Part of the ore stoped from the Blue Ridge and Number One shaft areas was very high grade. According to old records, nearly half of the 54 flasks produced in 1940 was recovered from ore averaging about 300 pounds of quicksilver to the ton. On the whole, however, the average recovery was about 18 pounds to the ton.

ROUND MOUNTAIN PROSPECT

Location: $NE\frac{1}{4}NE\frac{1}{4}$ sec. 4, T. 14 S., R. 20 E., at the eastern base of Round Mountain and about 3 miles by road north of the Blue Ridge mine.

Owners: Frank Reid, Dick Toole, Keith Parkinson, and George Rackstraw.

Production: 2 flasks.

History: The prospect was discovered and 10 claims were located in 1933 and 1934 by William Wesserling. The subsequent history is somewhat obscure. It is said that an interest in the prospect was held for a time by D. M. Field of Bend and that the property was acquired by H. M. Rosen during the late 1930's. The prospect was relocated by the present owners in 1954.

Development: Development includes several opencuts and three adits containing more than 450 feet of workings. It is said that the Round Mountain Road was built across some old workings, including a shaft about 30 feet deep.

Geology: Rocks in the area are andesites and basalts that have been mapped by Wilkinson as part of the Clarno Formation. Exposures are poor and important workings are badly caved.

Cinnabar can be panned from several of the old dumps scattered about the flat, but, since most of the workings that are claimed to have exposed cinnabar are caved and outcrops of rock containing cinnabar were not found, little was learned concerning its occurrence. Near the middle of the flat south of the road a timbered opencut was driven northwesterly for at least 60 feet. The cut is caved. Pannings from the dump of yellowish altered andesite show a few cinnabar crystals. A band of maroon clay about 6 inches wide exposed in the bottom of one of the opencuts and trending N. 5° E. also pans a little cinnabar.

One of the three adits lies in a shallow draw at the north end of the flat about 100 yards from the road. This adit, now caved, trends S. 40° E. at the portal and the size of the dump indicates that it contains at least 50 feet of workings. The dump of altered andesite, consisting in part of maroon clay, pans traces of cinnabar. About 200 feet to the south another adit has been driven southward in massive andesite. An east-trending fault zone was encountered about 170 feet from the portal. A drift to the east along the fault zone is caved. No cinnabar was seen.

About 500 yards to the south, the third adit enters the west bank of the north fork of Cram Creek. It trends S. 88° W. for 64 feet, then S. 75° W. for 24 feet, then S. 72° W. for 100 feet. From here it branches, one branch trending S. 35° W. for 25 feet and the other trending N. 50° W. for 35 feet.

This adit was driven in relatively unaltered basalt or possibly andesite in part agglomeratic and in part vesicular. At the portal, bedding planes dip northward at angles of less than 10°. Locally the basalt is cut by narrow calcite veinlets. A fault zone striking N. 35° W. and containing a calcite veinlet about an inch thick is exposed in the northwestern branch of the adit. No cinnabar was seen.

MARKS CREEK AREA

The Marks Creek area embraces several small quicksilver occurrences in the southern part of T. 12 S., R. 20 E. (figure 44) in southwestern Wheeler County. The deposits occur along zones of northeast-trending fracturing, alteration, and cinnabar mineralization. The zones are relatively small and scattered but appear to be representatives of the same structural deformation that formed the Johnson Creek and Ochoco Creek fault zones. Rocks in the prospect areas include andesitic to basaltic flows and tuffs and tuffaceous sediments of the Clarno Formation. Most of the work in the district was done during the early 1930's. No production has been recorded.

BEAR CLAIMS

Location: SW$\frac{1}{4}$ sec. 32, T. 12 S., R. 20 E., on a low, timbered ridge bordering the southern edge of an open meadow about one mile northeast of Corral Flat.

Owner: Unknown.

Production: None.

History and development: The original discovery was made by J. E. Staley. Claims were located in early 1930 by Carl Fisher and G. L. Brazee, who in the course of two or three years sank an inclined shaft about 40 feet deep on the crest of a low ridge and dug several shallow test pits along the edge of the meadow. Bert Tolladay reports that a few hundred pounds of ore was recovered from these workings but was never retorted. The property has since been held by various other interests, the last of which, in 1955, cut several bulldozer trenches south and east of the shaft.

Geology: The shaft sunk by Fisher and Brazee is almost completely caved and little could be seen. Rock on the dump is mainly kaolinized and limonitized andesite, containing bits of quartz, amorphous silica, and calcite. According to Gilluly, Reed, and Park (1933, p. 123) the shaft was sunk on a 4-inch quartz vein, striking N. 55° E. and dipping 65° N. The andesite walls within one foot from the vein were said to have been impregnated with cinnabar and pyrite, both along branching veinlets and in the massive rock.

About 300 feet N. 30° E. of the shaft, a bulldozer trench exposes a broad zone of highly sheared and altered andesite. Shear planes are of various attitudes, but the more prominent ones strike N. 20° to 30° E. and dip gently east. Included in the sheared material are clays, limonite, small stringers and "knots" of chalcedony, and a black, sooty hydrocarbon. Another trench about 100 feet to the northeast cuts a nearly vertical fault striking N. 20° E. The zone of shearing and alteration is about 4 feet wide. Pannings from these fault zones contained only traces of cinnabar.

MERCURY KING PROSPECT

Location: S$\frac{1}{2}$ sec. 31, T. 12 S., R. 20 E., near the base of a south-facing slope about half a mile west of the Bear Claims.

Owner: Unknown.

Production: None.

General description: The history of the prospect is unknown to the writer. Development consists of several caved pits and trenches. The country rocks are andesites and tuffs of the Clarno Formation. Samples taken from some of the pits pan traces of cinnabar, but geologic conditions related to the mineralization were not determined because of caving.

RIBELIN PROSPECT

Location: W$\frac{1}{2}$ sec. 32, T. 12 S., R. 20 E., on the east flank of the ridge at the head of the draw northeast of the Bear claims.

Owner: Unknown.

Production: None.

General description: The prospect was discovered and worked by George Ribelin around 1930. Development consists of several shallow pits. The country rock is mainly andesite, although tuffaceous lake sediments are exposed in one of the pits. A prominently exposed rhyolite plug forms the crest of the ridge a short distance south of the prospect. One of the pits lying a short distance east of the ridge crest exposes a 2- to 4-inch vein of chalcedonic quartz striking N. 80° W. and dipping steeply north. A little cinnabar is contained in the quartz and in the adjacent altered wallrocks. A short distance to the northeast another pit exposes altered and brecciated andesite. Breccia fragments are partially recemented by silica and limonite. A grab sample from the open pit assayed 0.5 pounds of quicksilver per ton.

BEAVER GUARD PROSPECT

Location: Secs. 27 and 28, T. 12 S., R. 20 E., 2,000 feet south of Beaver Guard Station.

Owner: Unknown.

Production: None.

General description: This prospect was developed to its present state during the early 1930's. According to Wilkinson (1940), workings consist of several opencuts, a 10-foot shaft, and a tunnel about 35 feet long. These workings are now caved.

The country rock is a light-colored tuff. Andesites occur nearby. Calcite veins, accompanied by limonitic stain, were observed trending northeasterly, but no cinnabar was found in place. Cinnabar can be panned from the soil and altered rock near some of the caved workings.

Mc TIMMONDS RANCH PROSPECT

Location: NE$\frac{1}{4}$ sec. 15, T. 12 S., R. 20 E., on the north slope of a steep-sided butte about 2 miles southward along the old Ochoco Highway from its junction with U. S. Highway 26.

Owner: Robert E. Woodward.

Production: None.

General description: The prospect was discovered by Norman Misner in 1938. Development consists of two crosscut adits, both caved but said to be about 80 feet long, a combined opencut and shaft about 30 feet deep, and a 40-foot crosscut trench. All of these workings are in an area about 300 feet across. The country rock is a dense, reddish rhyolite. Cinnabar is very sparsely distributed as paint-thin coatings on fractures in a nearly vertical fault zone that strikes N. 68° E. The fault zone is 2 to 4 feet wide and traceable for about 120 feet. The rhyolite is fractured and locally brecciated, but there is little evidence of hydrothermal alteration.

MAURY MOUNTAIN AREA

The Maury Mountain area lies in the northern foothills of the Maury Mountains in southwestern Crook County. The area, enclosing two adjoining mines and a prospect in sec. 10, T. 17 S., R. 19 E., is about 38 miles southeast of Prineville and about 5 miles southeast of Post. A narrow but well maintained, gravelled road leads southward to the mines from a bridge crossing the Crooked River about half a mile east of Post. Elevation at the mines is about 4,200 feet. Topography is shown on the Post 15-minute quadrangle.

The Maury Mountains, as mapped by Wilkinson (1940) consist of gently folded volcanic rocks of the Clarno Formation of Eocene and lower Oligocene age overlain in part by the John Day Formation of middle Oligocene to lower Miocene age and, overlying both formations is the Columbia River Basalt of Miocene age. Many andesitic to basaltic plugs and dikes intrude the Clarno and John Day Formations. The quicksilver deposits lie wholly within rocks of the Clarno Formation. Wilkinson states that the Maury Mountain mines lie just east of the crest of a "gentle anticline which disappears north and south under the Columbia River Basalts. The axis of this fold strikes south just west of the Maury mine, and the dip on the east limb increases to 7°."

Quicksilver was discovered in the area in 1930. The total production is 766½ flasks.

MAURY MOUNTAIN MINES

Location: SE¼ sec. 10, T. 17 S., R. 19 E., on the north-facing slope of the Maury Mountains about 5 miles south of Post. The Maury Mountain mines comprise the Maury Mountain or Eickemeyer mine and the adjoining Lost Cinnabar No. 1 or Towner mine.

Owners: The Eickemeyer property, consisting of 320 acres of deeded land and 8 claims held by location, is owned by H. W. Eickemeyer, who resides at the mine, and the estate of his brother, Fred C. Eickemeyer. The Towner property, consisting of one claim held by location, is owned by Selby Towner, Towner Motor Co., Prineville, Oregon.

Production: Eickemeyer workings, 585½ flasks; Towner workings, 181 flasks.

History: Cinnabar was discovered in the Maury Mountain area and 5 claims were located in the summer of 1930 by J. E. Staley and Frank Towner. H. Corbett and W. L. Castleton organized the Maury Mountain Mining Co. to operate the claims owned by Staley. Installation of a 4-hearth, 10-foot-diameter Herreshoff furnace was completed in May 1932 and 51 flasks were produced during the remainder of the year. The mine was then closed and remained idle through 1933 because of low quicksilver prices and the fact that the type and distribution of the ore bodies prevented economic operation of so large a reduction plant. After recovering 16 flasks in 1934, the furnace was moved to the Horse Heaven mine. The Eickemeyer brothers, who had contracted the development work for the company, then took over the Staley claims, producing an additional 8 flasks during the remainder of 1934. The Eickemeyers' production from 1934 through 1937 was recovered from workings on the Staley claim. In 1938 the Eickemeyer brothers discovered high-grade ore on deeded land about a quarter of a mile northwest of the early workings. The land was purchased from Joe Gibson, and development through 1942 was concentrated on this property. In 1942 a Reconstruction Finance Corp. loan was obtained and work was begun on the Drainage adit, from whence all of the ore subsequently treated by the Eickemeyers has been mined.

Production from the Towner property was started in 1934 by Frank Towner and Selby Towner. All of the production has been recovered from workings on the Lost Cinnabar No. 1 claim. Nearly 100 flasks were produced from one small ore body.

Development: About 5,000 feet of underground development work has been done (plate 8). Development consists of two principal groups of workings called the Upper workings and the Lower workings. The Upper, indiscriminately crossing the line between the Towner claim and the Eickemeyer property, consist of four adits with connecting raises and winzes, a glory hole stope, and an open cut. The Lower workings, lying entirely within the Eickemeyer property, consist of two principal adit levels (the Shaft adit and Drainage adit) with sublevels, raises, winzes, and stopes connected by a steeply inclined shaft, a vertical shaft, and several nonproductive adits and opencuts.

Water for domestic purposes is available. In addition to plant and shop facilities, four well-constructed and maintained frame buildings are on the property. Since the removal of the Herreshoff furnace in 1934, ore from the Eickemeyer workings has been treated in a rotary retort of about 3 tons per day maximum capacity. The retort is 24 inches in inside diameter and 6 feet long. Towner treated his ore in a similar retort until 1941, when a 10-ton-per-day rotary furnace was installed and the retort was sold and moved to the Barnes Butte mine near Prineville. This furnace proved unsatisfactory, however, and saw little use. In 1951 the retort was returned from the Barnes Butte mine.

Geology: The country rocks consist mainly of Clarno tuffs and tuffaceous sediments intruded by a poorly exposed basaltic andesite plug. An andesite flow unconformably overlies the Clarno tuffs in the vicinity of the Drainage adit. Dips in the mine area are gentle but variable, and mostly away from the plug.

The Clarno tuffs and tuffaceous sediments bordering the northern and eastern edges of the plug are intricately fractured, and faults and fractures of almost any attitude may be found in the various workings. However, most of them lie in a broad zone that in overall plan forms a crudely semi-circular arc paralleling the exposed edges of the plug. Some of the more continuous faults assume a curvature similar to that of the arc. Most of the faults and fractures are normal, dipping away from the plug, and vertical movement on any one fault was probably not much more than 10 feet. With the exception of the Drainage adit fault, which is continuous for more than 400 feet, single fault surfaces can rarely be traced for more than 100 feet.

At least three periods of fracturing occurred. Following the initial stage, the rocks were partially altered to clays, silicified, and carbonatized. The rocks were then refractured allowing the introduction of quicksilver. During the third stage of fracturing, cinnabar was smeared along fracture surfaces and in places mineralized faults were slightly offset. Some of the later faults are very low angle. The silicified fractured rocks, being more resistant, stand as ridges bordering the plug.

The small but extremely high-grade ore bodies are unique among Oregon quicksilver deposits. They formed in small, widely scattered pockets, lenses, and kidneys in various places such as fault junctions and fault intersections, points where attitudes in fault surfaces change, brecciated zones along faults, and transverse fractures between faults. No quicksilver has been found in the intrusive andesite and little ore occurs in the altered tuffs adjacent to the faults. Most of the ore bodies thus far exploited were discovered by exploratory drifting along the larger faults. The ore is generally associated with a small amount of silica as chalcedony and fine-grained quartz. The altered tuffs are commonly impregnated with calcite. Pyrite and "gilsonite" occur locally. The ore treated has averaged over all about 12 percent quicksilver on recovery. From one of the ore bodies, 22 flasks were recovered from 3 tons of ore.

EICKEMEYER PROSPECT

Location: SW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 10, T. 17 S., R. 19 E., about half a mile north of the Maury Mountain mines.

Owner: Herbert Eickemeyer.

Production: None.

General description: The workings, consisting of a dozer trench and shallow pits, are in an altered andesite flow, unconformably overlying andesitic tuffs. Cinnabar occurs as disseminated specks in loose pieces of calcite. Although occasional narrow veinlets of barren calcite and chalcedony cut the andesite, the source of the cinnabar-bearing calcite is unknown. Workings which penetrate the flow have failed to expose cinnabar mineralization. The source may be in the underlying but topographically higher tuffs exposed about 100 feet to the south.

BEAR CREEK AREA

The Bear Creek area lies in southwestern Crook County in Ts. 17 and 18 S., R. 17 E., and T. 17 S., R. 16 E., about 25 miles south of Prineville. It includes seven quicksilver occurrences (see figure 53). Elevations of the deposits range between about 3,300 feet and 4,500 feet above sea level. Most of the deposits lie within the bounds of the Eagle Rock quadrangle 15-minute topographic map.

All of the quicksilver occurrences in the Bear Creek area are in rocks mapped by Lowry (1940) as part of the Clarno Formation or, as in a part of the Platner mine, in dikes intruding these rocks. The Clarno rocks in the vicinity of the deposits include heterogeneous conglomerates or mudflows made up of volcanic ejecta as large as 1$\frac{1}{2}$ feet in diameter; fine-grained to coarsely porphyritic andesite flows; lithic tuffs; bedded and locally stratified tuffs; and tuffaceous sediments ranging in grain size from clay to coarse sand. The dikes are of andesitic composition. In general, the bedded rocks of the Clarno Formation dip to the southwest at angles of from nearly

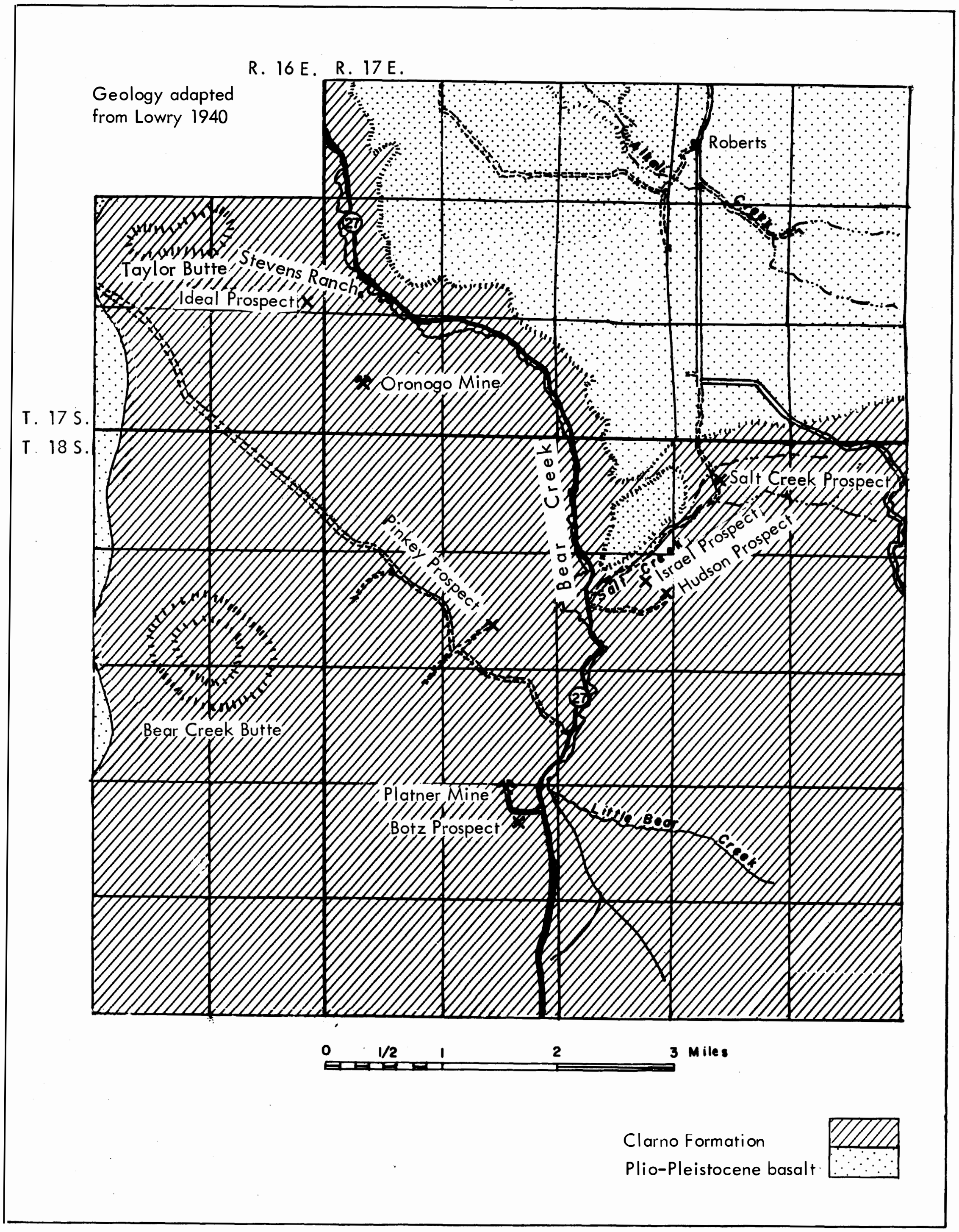


Figure 53. Geologic map of the Bear Creek area showing location of the quicksilver deposits.

horizontal to 20°. Locally, however, dips vary considerably in direction. Overlying the Clarno Formation in the area are very small remnants of the John Day Formation and Columbia River Basalt.

The quicksilver deposits are in altered, silicified, and carbonatized fault zones which appear to be of small displacement. In places the fault zones are marked by siliceous reefs which project above the surrounding terrain.

Records indicate that active prospecting for quicksilver began in the area during the late 1920's, when claims were located by Lloyd F. Wiltsie, Claude C. Dunham, members of the Botz family, C. E. Hamilton, W. A. Beaver, and others. The total production of the area as recorded by the U. S. Bureau of Mines is 30 flasks, of which 24 were produced at the Platner mine and 6 at the Oronogo mine. Production from both of these mines probably exceeds that recorded by the U. S. Bureau of Mines.

PLATNER MINE

Other names: Bear Creek mine.

Location: Secs. 17 and 20, T. 18 S., R. 17 E., an eighth of a mile by road west of the Bear Creek road. The workings are scattered about the crest and west slope of a steep, north-trending ridge. The mine is on the same mineralized fault zone and about 1,500 feet north of the Botz prospect.

Owner: Hugo Dobler, Helena, Montana.

Production: 24 flasks recorded; probably about 45 flasks produced.

History: Cinnabar was discovered in the area by Mrs. Frank Platner in 1930 and several claims were located by Mr. and Mrs. Platner and Lloyd Wiltsie. Mrs. Platner reports that on the Wiltsie claims, which lay northwest across the draw from the Platner workings, only a few opencuts and a short adit were dug shortly after discovery, exposing no mineralization of consequence.

Gilluly, Reed, and Park (1933, p. 138-9) report that in August 1930 the Platner mine was developed by several opencuts and a short crosscut tunnel driven through the lode. In 1931 a small amount of development work was done by Alfred Aya and associates. The property was then leased to the Pacific States Mines, Inc. By the end of 1933 (Mining Journal, Sept. 15, 1933) much of the work in Adit 1 (see figure 54) had been done. In 1939 the mine was leased to J. A. Werner, who, with associates, assumed the name Bear Creek Mercury Co. According to department records, 15 flasks were produced by Werner prior to the erection of a 19-ton Selway rotary furnace completed in April 1940. An additional 16 flasks were produced in early 1942 before the furnace was moved to the Staley mine. Most of this production was recovered from ore mined from Adits No. 2 and No. 3. Six flasks were produced by LaVorne Taylor in 1954. From 1956 to 1958 William J. Holly and Joe Thompson operated the mine as the Platner Mining Co., producing, according to Holly, about 6 flasks of quicksilver. Production from the Platner mine as recorded by the U. S. Bureau of Mines amounts to 10 flasks in 1940, 7 in 1941, 6 in 1954, and 1 in 1958.

Development: Drifts from three crosscut adits and one drift adit explore about 1,000 feet of the fault zone. Numerous pits, cuts, and dozer trenches are scattered about the surface (see figure 54). A combined bunkhouse and mess hall remains on the property.

Geology: Rocks exposed in the area from oldest to youngest consist of heterogeneous mudflow deposits, stratified and lithic tuffs, and porphyritic andesites mapped by Lowry (1940) as part of the Clarno Formation of Eocene age. The mine workings lie in the tuffs and lower part of the porphyritic andesite. Dips of the bedded rocks range from nearly flat to 15°. Direction of dip is highly variable. An andesite dike whose surface exposure is about 85 feet wide is explored by approximately 250 feet of drift-level workings, several winzes, and a caved raise at the northern end of the Lower Adit drift. The dike strikes nearly N. 30° W. and dips steeply east.

The mine workings explore a silicified fault zone whose surface trace coincides with the crest of an elongate ridge more than a mile in length extending from a quarter of a mile north of the Platner workings to a quarter of a mile south of the Botz workings. The overall surface trend of the fault zone, though it contains minor warps and irregularities, is approximately N. 10° W. In the Platner mine area the stike is about N. 5° E. Dips of the principal fault planes are to the west and range from 50° to nearly vertical. The average dip of the fault zone is about 65° W. Innumerable subordinate shears and fractures within the fault zone vary considerably in attitude, but tend to parallel the principal faults. Several short auxiliary faults trending N. 40° W. and S. 40° E. branch from the main fault and at least two of them are now represented by short spur ridges.

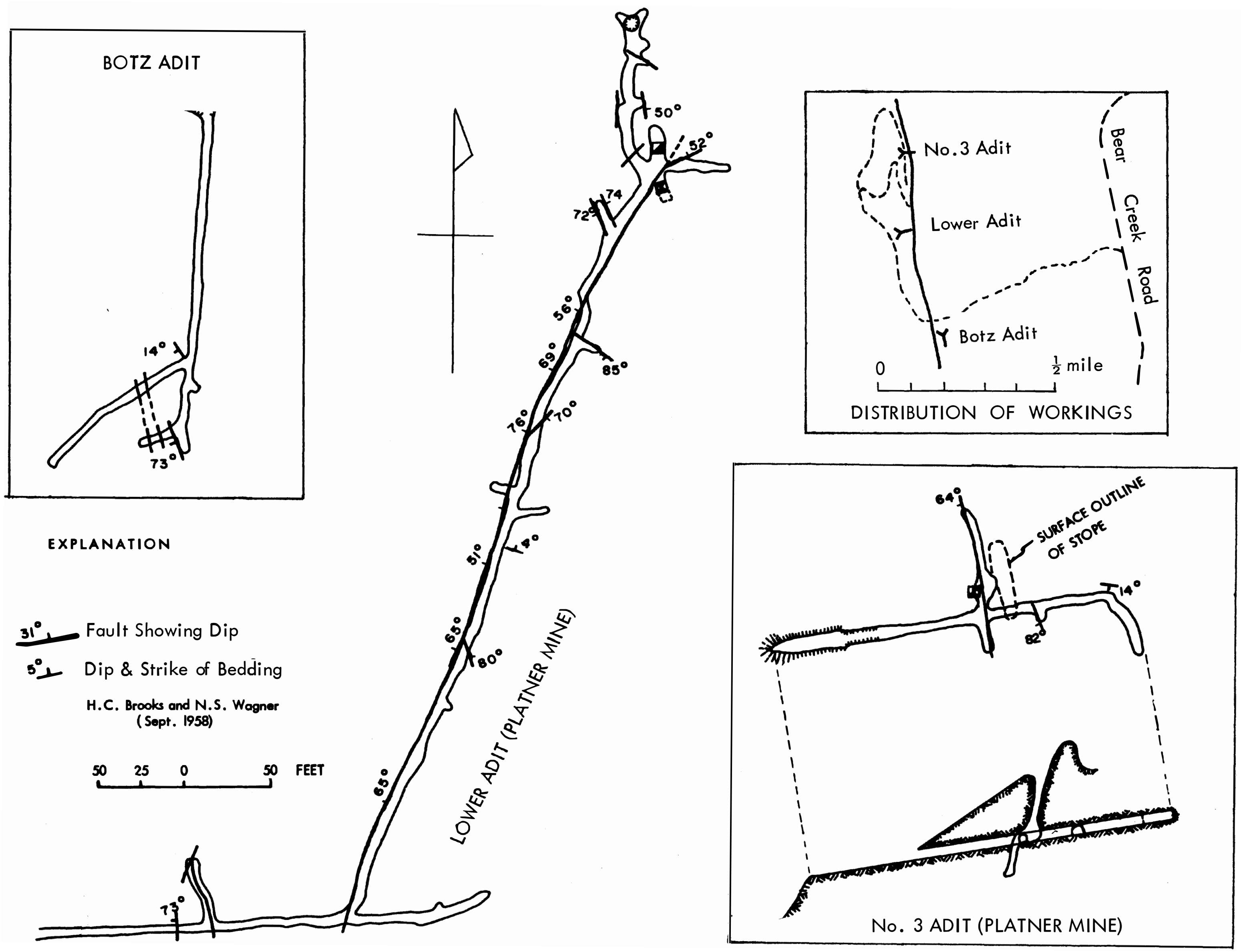


Figure 54. Map showing distribution, workings, and geology of the Platner mine and the Botz prospect.

The fault zone generally ranges from 5 to 10 feet in width and consists commonly of a principal fault bounded by numerous subparallel shears and fractures. The fault plane forming the west wall of the Lower Adit drift can be traced, with short interruptions, for 350 feet. Movement along the fault was probably normal. Slickensides pitching 10° to 20° S. indicate that some strike-slip movement occurred.

Rocks in the fault zone are altered, limonitized, and extensively silicified. Reticulating veinlets of carbonate and silica are common, the latter occurring mainly as chalcedony and to a lesser extent as quartz. Many of the fractures are filled with clay gouge admixed with limonite and often silica.

Cinnabar occurrences are sparsely distributed along the fault zone for about 3,000 feet, but ore has been mined in only three places. Judging from the size of the mined areas, the ore bodies were small, with their longest dimension paralleling the dip of the fault zone. The largest ore body, that mined from the stope and winze in Adit 3, lay at the fault contact between a hanging wall of bedded tuff and a footwall of porphyritic andesite. At the surface the stope is about 50 feet long and 10 feet wide and tapers to 10 feet in length and 5 feet in width at the drift level. A winze, about 8 feet long and 4 feet wide, continues to a depth of at least 15 feet below the drift level. How much of the stope and winze was ore is unknown.

BOTZ PROSPECT

Location: Near the center of sec. 20, T. 18 S., R. 17 E., about 1,500 feet south of the Platner mine on an extension of the same silicified fault zone.

Owner: Charles W. Sullivan, Butler Road, Bend, Oregon.

Production: None.

History and development: According to Mrs. Frank Platner, the prospect was located originally as part of the Platner property, but was later sold to J. A. Botz. Development, nearly all of which was done during the 1930's, consists of about 380 feet of drifts and crosscuts driven from two adits and several small opencuts. A small cabin remains on the property.

Geology: The Botz prospect lies in the lower part of the section exposed in the Platner mine area. The lower adit (see figure 54), driven S. 5° W. for 200 feet in the mudflow deposit, lies east of and roughly parallel to the Platner mine fault. At points 145 feet and 185 feet from the portal, crosscuts were driven southwestward, cutting the fault zone and a stratigraphically higher series of bedded tuffs. Here the fault zone contains a displaced block of red, tuffaceous clay about 20 feet wide. An adit 55 feet long on the west side of the ridge lies largely in this horizon. Cinnabar occurs in several of the surface pits along the fault zone, but none was seen underground. Below the surface the fault zone contains abundant limonite, gypsum, and a little marcasite, but silicification is less prominent than at the surface or in the Platner mine workings.

PINKEY PROSPECT

Former names: Ideal prospect, New Deal prospect.

Location: Sec. 8, T. 18 S., R. 17 E., about one mile west of Bear Creek.

Owner: John McManman.

Production: None.

History: The prospect was worked first by Lloyd Wiltsie during the early 1930's and later by C. E. Hamilton, J. W. Rubow, and C. G. Compton. The latter are said to have recovered 9 pounds of quicksilver with a small hand-made pipe retort, the ruins of which remain on the property. About one ton of rock was treated.

In 1954 the property was relocated by John McManman and B. R. Bayley. A small DMEA loan was granted to McManman in October 1954 and remained in force through early 1955. No development work has been done since the expiration of the loan.

Development: Development work, most of which was done under the DMEA contract, consists mainly of a 55-foot shaft from the bottom of which a 90-foot drift was driven S. 60° E. and a crosscut 40 feet long was driven S. 35° W. A crosscut trench intersects the shaft at a depth of 12 feet. Other work includes a 17-foot shaft and several small pits scattered along the course of the mineralized zone to the northwest. Immediately to the southeast of the shaft, an area about 300 feet long and 150 feet wide has been stripped with a bulldozer.

Geology: The rocks are gently dipping, varicolored andesites, lithic tuffs, and minor mud-flow deposits of the Clarno Formation. The workings explore a silicified fault zone that trends N. 60° W., dips 70° S. to nearly vertical, and for more than 1,200 feet coincides with the crest of a broad, low ridge that slopes gently southeastward. Toward its southeastern end, where most of the development work has been done, the fault zone is marked by an almost continuous "rib" of brecciated and silicified rock which ranges from 20 feet to more than 40 feet in width. Veinlets of chalcedony and a little calcite cut the silicified rock. Seams of limonite and gouge are also common. In the vicinity of the deeper shaft the rocks along the north or footwall side of the zone have been intensely sheared, bleached, and altered but not noticeably silicified. Farther to the northwest, the course of the fault zone is marked by relatively thin, elongated outcrops of silicified rock and piles of silicified rock rubble.

Minor amounts of cinnabar occurring in minute, disseminated grains associated with chalcedony and as thin coatings on fracture surfaces have been found in several places along the fault zone, particularly in the vicinity of the deeper shaft. It has been reported by local prospectors that assays of more than 10 pounds of quicksilver per ton have been obtained; however, no material of this grade was observed by the writer except possibly in small selected specimens.

SALT CREEK PROSPECT

Location: Sec. 3, T. 18 S., R. 17 E., about a mile and a half by road up Salt Creek northeastward from its junction with Bear Creek.

Owner: Unknown.

Production: None.

History and development: The prospect was located by W. A. Beaver and Earl Hale in October 1940. During the next few years several trenches, shallow shafts, and short adits were dug and a small, one-pipe retort was erected. A small quantity of rock was treated but there is no record of production. The Herreshoff furnace employed at the Mountain King mine in Jackson County until 1942 was later moved to the Salt Creek prospect but was never used. It was removed to the Amity mine in 1948.

Geology: The prospect occurs in a gently dipping flow of porphyritic andesite which, in the prospect area, is intruded by a glassy andesite dike striking N. 10° E. and dipping steeply southeast. Cinnabar is sparsely distributed along fractures in a broad zone of shearing that strikes N. 50° W. and dips steeply south. The porphyritic andesite in the shear zone has been brecciated, altered, and impregnated with chalcedony, quartz, and calcite. A little cinnabar is also visible in brecciated and altered andesite along the edges of the dike.

HUDSON PROSPECT

Location: $E\frac{1}{2}NE\frac{1}{4}$ sec. 9 and $W\frac{1}{2}$ sec. 10, T. 18 S., R. 17 E., one mile by road east of the Bear Creek road.

Owner: William C. Hudson and Dayton Glover, Prineville, Oregon.

Production: None.

History and development: The original Hudson claim was located in 1939. Adjoining claims were located a short time later by Wells and Gervais. The several claims were incorporated and held as a group known at one time as the Gervais prospect, although nearly all of the development work was done on the Hudson claim. Various lessees have done small amounts of work but no reduction equipment has been installed. Aside from a small cabin constructed recently, no equipment is on the property. The Wells and Gervais claims have lapsed.

Development consists of a 40-foot shaft completely lagged and still open but partly filled with water; two shallower shafts; and several opencuts.

Geology: The workings are scattered across the south and west slopes of a small hill composed of an andesite flow and an underlying series of coarse-grained lithic tuffs. Both the flow and the tuffs are part of the Clarno

Formation.

The andesite-tuff contact, which is probably conformable, dips gently westward and crosses between the 40-foot shaft and the workings farther down the slope to the southwest. The 40-foot shaft was collared in andesite, but, according to Mr. Hudson, brecciated and mineralized tuffs were encountered a few feet below the surface. Hydrothermally altered tuffs containing cinnabar were found on the dump, but because the shaft is completely lagged the attitude of the mineralized zone could not be determined.

About 140 feet southwest of this shaft, another shaft has been sunk to a depth of 20 feet, exposing a vein of calcite about 18 inches wide bounded on both sides by at least 3 feet of brecciated and altered tuff, containing veinlets and small bunches of quartz and calcite. The zone trends N. 10° E., dips 75° E., and can be traced north of the shaft for at least 150 feet. Cinnabar was not noted in the calcite, but occurs locally as fine crystal particles in the silicified and calcitized wall rocks. One sample from the hanging wall assayed 3.2 pounds of quicksilver per ton. Several other samples have been panned which contained small quantities of cinnabar. A second and approximately parallel vein of similar width is exposed at the top of a caved shaft about 50 feet to the west. Neither of the calcite veins is exposed south of a small gully a few feet south of the shafts, but more work must be done to determine if they have been offset by faulting or merely die out.

ISRAEL PROSPECT

Location: NE$\frac{1}{4}$ sec. 9, T. 18 S., R. 17 E., on a steep hillside about a quarter of a mile east of the Bear Creek road.

Owner: Unknown.

Production: None.

General description: The prospect, discovered by J. H. Israel in 1931, is developed by a shaft about 20 feet deep, an adit 15 feet long, and a small opencut. These workings are in andesite of the Clarno Formation and explore the intersection of a poorly defined zone of small sub-parallel faults that trend northwest and a fault that trends north. The andesite is altered to clays and limonite and mildly silicified and carbonatized. Traces of cinnabar are found by panning.

ORONOGO MINE

Former name: Dunham Ranch mine.

Location: SW$\frac{1}{4}$ sec. 31, T. 17 S., R. 17 E., about 1 mile by road southwest of the Stevens ranch house.

Owners: Max Stevens and Claude C. Dunham. Dunham formerly owned the ranch, and when selling it to Stevens maintained an interest in the mineral rights. The land on which the Oronogo mine workings are situated was homesteaded in part prior to 1916 and in part after that date, so that the mineral rights are held in part by deed and in part by location.

Production: 6 flasks recorded.

History: Cinnabar was discovered in the area by Dunham and Lloyd Wiltsie in or before 1927. According to department records, Dunham produced three flasks of quicksilver in 1937. Oronogo Mercury Mines, Inc., managed by R. E. Coombs, produced 9 flasks in 1940-41 from retort operations. Only the 1940 production of 6 flasks was recorded by the U. S. Bureau of Mines. In the summer of 1955 the property was leased to John McManman, who in turn subleased it to Tom Ray and Associates from San Francisco. Ray built roads to the tunnel sites and installed a small rectangular pipe retort. One flask is said to have been produced from surface ore but was not recorded. The jaw crusher and the retort remain on the property.

Development: The mine is developed by 5 adits which include 260 feet of underground drifts and crosscuts, a 35-foot winze and 40-foot shaft, and several small opencuts (figure 55).

Geology: Workings of the Oronogo mine are distributed along the crest and southwest slope of a low hill consisting of gently westward-dipping andesite flows of the Clarno Formation. Most of the workings explore a northwest-trending shear zone that coincides with the crest of the hill. Adit No. 2 was driven toward the shear

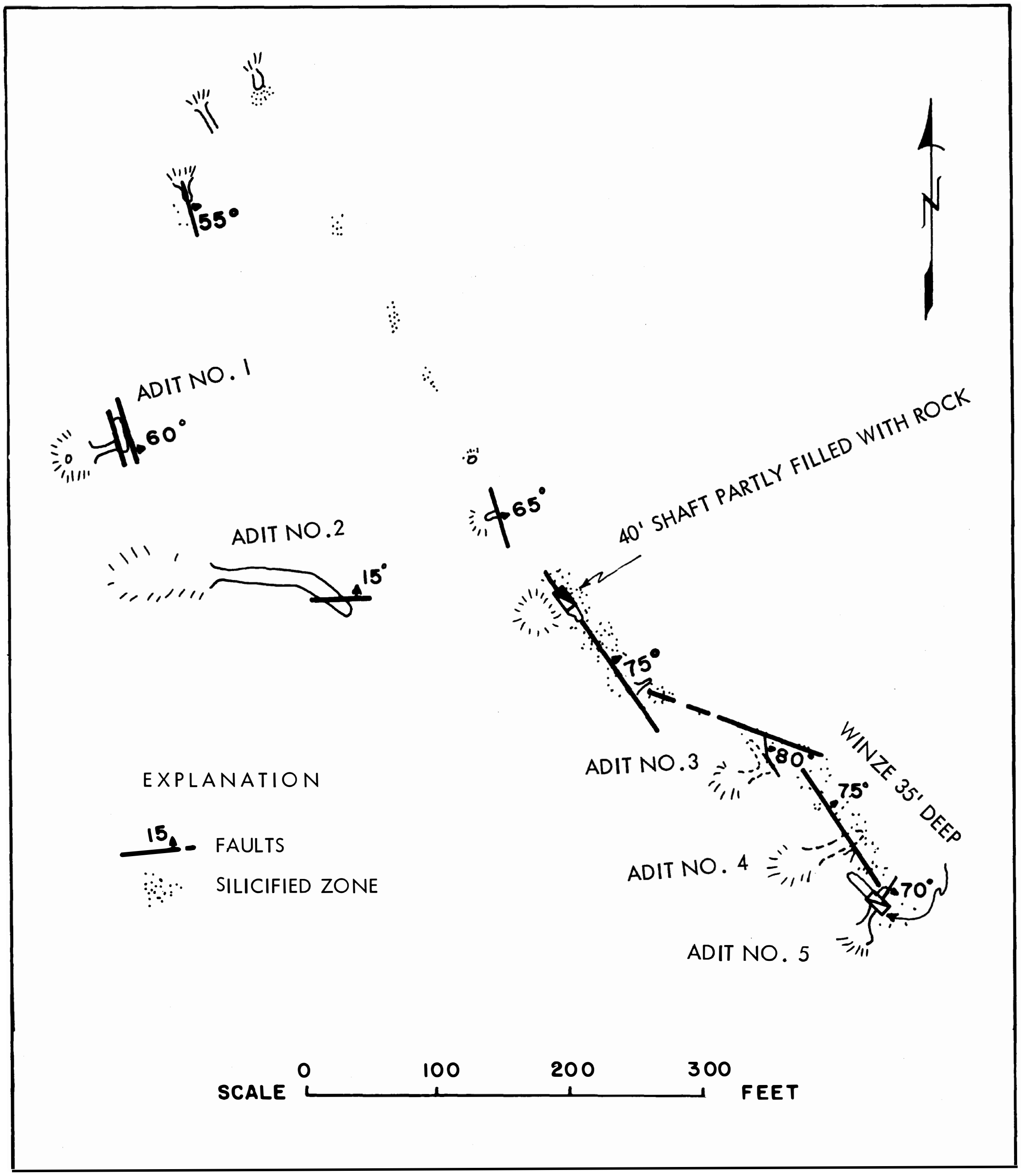


Figure 55. Plan of workings of the Oronogo mine.

zone but ends about 200 feet short of its downward projection. Adit No. 1 developed a small ore body about 250 feet west of the northwestward projection of the shear zone. The shear zone becomes increasingly better exposed toward its southeastern end, where the sheared and altered andesite has been silicified locally and many of the fractures are filled with chalcedony, carbonates, clays, and limonite. Most of the shear surfaces which are individually short, trend N. 25° to 35° W. and dip 60° to 80° E. The shear zone is cut by numerous small faults and fractures of diverse trend and in one place appears to be offset along a fault which, though poorly exposed, is presumed to strike N. 70° W.

Cinnabar occurs locally as thin, irregular stringers and seams associated with veinlets of silica and carbonates. It also fills fractures and other open spaces in the andesite, where it is commonly admixed with clays and limonite. "Gilsonite" is rarely present.

The small ore body developed by Adit No. 1 lies between two faults which strike N. 25° W. and dip 60° E. and are 2 to 3 feet apart. The andesite between the two faults is intensely sheared and altered. A few thin veinlets of cinnabar not over an eighth of an inch thick remain. Most of the ore produced by the mine came from a small stope in Adit No. 1 and from the winze in Adit No. 5.

IDEAL PROSPECT

Location: Sec. 25 and 36, T. 17 S., R. 16 E., about a mile and a half northwest of the Oronogo mine.

Owners: H. W. Carter, H. J. Campbell, R. H. Miller, and C. E. Hamilton.

History and development: The four Ideal claims were located by the owners in late 1955. Development consists of an adit about 25 feet long and several dozer cuts and small pits. A small log cabin has been constructed.

Geology: The andesitic country rocks dipping gently westward are cut by a poorly defined shear zone striking N. 40° E. and dipping 70° NW. The shear zone extends along the crest and upper south slope of a northeast-trending ridge for about 800 feet. Cinnabar is said to occur in minute grains associated with limonite in the fractured rocks. None was seen by the writer; however, a small amount of soot remaining in a small tube retort 2 feet long and 6 inches in diameter contained a few beads of quicksilver from what appeared to be a single test run.

ISOLATED QUICKSILVER OCCURRENCES

HUMBOLDT MINE

Location: $S\frac{1}{2}$ sec. 35, T. 11 S., R. 19 E., about a quarter of a mile north of Bear Creek in the southeast corner of Jefferson County. It may be reached by traveling about 10 miles westward from Mitchell on U. S. highway 28, thence north and west along a country road for 7 miles to Bear Creek. At this point a dim road turns north and leads to the mine workings. The property adjoins the Stephenson Ranch operated by James Stephenson, brother of the discoverer.

Owner: Bert Hayes, John Day.

Production: 5 flasks.

History: The property was discovered in 1935 by Glenn Stephenson. Norman Misener later acquired an interest in the property and after sporadic development a 24-inch Champion retort was installed in 1937. Shortly thereafter Stephenson's interest was purchased by P. J. O'Brien and small quantities of quicksilver were produced by Misener, O'Brien, and Charles Carrol, and later by O'Brien and James Page. In 1940 the property was acquired by the Humboldt Metallics Corp., but in 1942 it reverted to O'Brien. In 1943 it was being operated by Fred Hunter and Ross McFarlane. Since that time, little other than assessment work has been done on the property.

Development: Development consists of about 220 feet of workings on two interconnected adit levels and at least a dozen shallow pits and several short adits. More than a mile of unsurfaced road has been built to various parts of the property, but much of it is now impassable. Of the two main adits, the upper is about 60 feet long and is connected near its portal to a glory hole by a 10-foot raise and to a short sublevel by a 10-foot winze. The lower adit, now largely inaccessible, is 100 feet below the upper and is said to be about 140 feet long. Nearly all of the ore produced on the property was recovered from the upper adit glory hole and winze.

Geology: The workings explore dark, fine-grained to porphyritic andesite. Deeply weathered pyroclastics overlie these rocks a short distance up the slope. The andesite is cut by numerous narrow faults, most of which strike northwesterly and dip to the west. The upper adit and connected glory hole developed a small body of ore contained in a fault zone that trends N. 25° W. and dips 60° W. The fault zone contains about 2 feet of soft, buff-colored, brecciated andesite impregnated with chalcedony, calcite, and limonite. Cinnabar is readily panned from the breccia, but is only rarely visible as films on fracture surfaces and as disseminated specks. According to the owner, small amounts of cinnabar occurring in narrow fractures can be seen in the lower adit and in some of the other caved workings.

GRAY BUTTE PROSPECT

Location: SE$\frac{1}{4}$ sec. 13, T. 13 S., R. 13 E., about a mile and a half north of Gray Butte and 7 miles by dirt road west of U. S. highway 26, in Jefferson County.

Owners: Adrian Rodman, Fred Lyons, and Larry Lyons.

Production: None.

History and development: The prospect was discovered by J. E. Staley in June 1942. Bulldozer stripping and trenching have been done in two areas about 200 yards apart.

Geology: The prospect occurs in lava flows and tuffs of the John Day Formation (Williams 1957) near their contact with overlying flows of Columbia River Basalt. Cinnabar is sparsely distributed along an east-trending zone of faulting which can be traced for about 1,000 feet. At the west end of the area the fault zone is expressed by a rib of silicified tuff from 2 to 6 feet wide protruding in places as much as 8 feet above the surface. The rib is bordered on the north by a 2-foot wide zone of mildly silicified gouge and brecciated tuffs. Cinnabar is visible as fracture coatings along the north edge of the silicified rib. The east end of the fault zone is not so prominently expressed, but has been exposed at intervals by dozer cuts. No cinnabar was seen in the cuts.

BARNES BUTTE MINE

Location: SE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 28, T. 14 S., R. 16 E., on Barnes Butte about a mile and a half airline northeast of Prineville, in Crook County.

Owners: John McKenzie, Ralph Cunningham, and Homer Chapin.

Production: 29 flasks.

History: The prospect was discovered and development begun by the owners in early 1940. Sorted ore was treated in a 3-tube retort purchased from the Oronogo mine until a Champion rotary retort was installed in 1941. No production has been made since the fall of 1942 and no equipment remains.

Development: Development consists of 4 adits containing about 325 feet of drift and crosscuts, two inclined shafts, at least one of which contains a short drift from its foot, one vertical shaft, and several opencuts (figure 56). These workings, none of which reach vertical depths of more than 40 feet, extend westerly for about 700 feet from a saddle at the crest of the butte.

Geology: Barnes Butte covers about 2 square miles and rises some 300 feet above the alluvial plain of Prineville valley. Rocks composing the northern and northwestern part of the Butte include light-colored, well-bedded tuffs and tuffaceous lake beds that dip 15° to 35° SE. and an irregular mass of rhyolite that appears to have intruded the bedded rocks. On the southern and southwestern parts of the Butte, similar tuffs and lake beds are overlain conformably by reddish brown tuff. The bedded rocks may prove to be part of either the Clarno or the John Day Formation, probably the former.

A fault striking N. 65° to 70° E. and dipping 65° S. extends through the saddle at the top of the Butte.

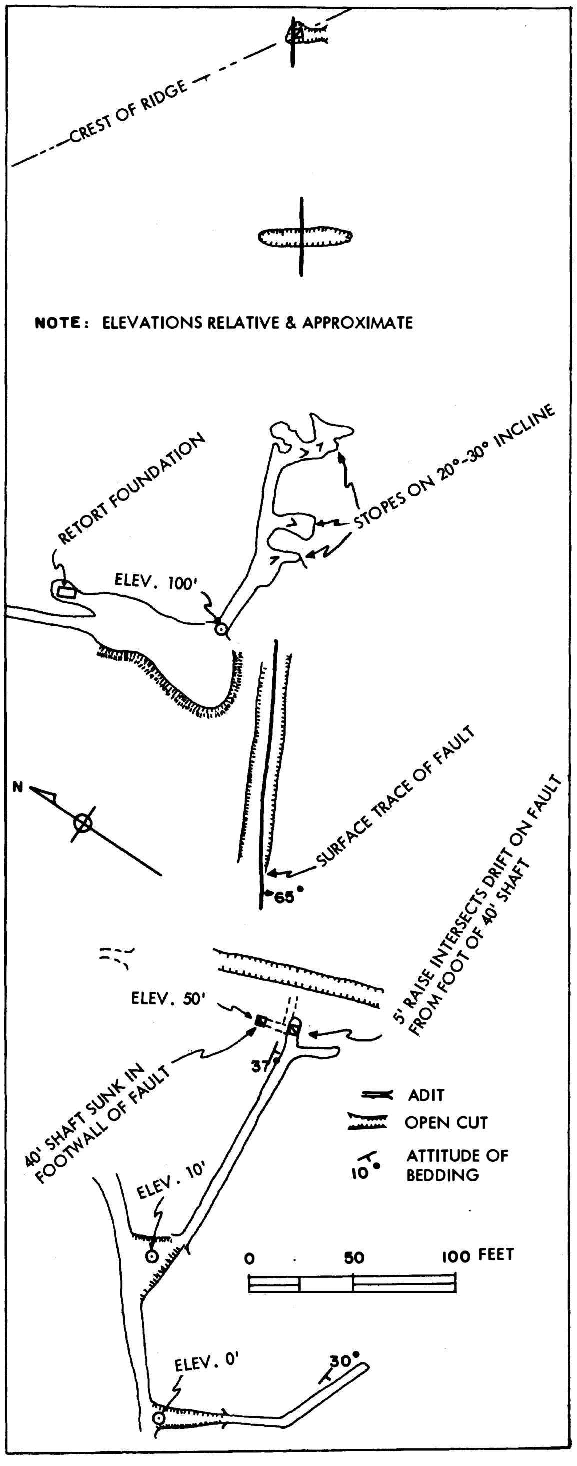


Figure 56. Map of Barnes Butte mine workings.

Tuffs and lake beds to the north are in fault contact with flows to the south. Where exposed in the underground workings, the fault is marked by a few inches to 2 feet of soft, reddish-brown to chocolate-colored clay gouge. Gently dipping slickensides indicate that some horizontal movement occurred. The bedded rocks in the footwall close to the fault are cut by numerous auxiliary fractures, many of which strike northwest and dip steeply southwest. Other small faults dip gently southwest and in places roughly parallel the bedding in the tuffs. Hydrothermal solutions which probably rose along the main fault and were diverted along these auxiliary fractures altered the tuffs and lake beds and locally deposited veinlets, nodules, and bouldery masses of chalcedony and opal and in places a little cinnabar.

Cinnabar was concentrated along bedding planes, joints and other small fractures beneath some of the more gently dipping faults. Most of the ore occurred as small lenses as much as a foot thick. McKenzie stated that some of the quicksilver produced was recovered from boulders of opalite sorted from the surface mantle, one 700-pound boulder yielding 35 pounds of quicksilver.

MOORE PROSPECT

Location: $S\frac{1}{2}$ sec. 15, T. 16 S., R. 18 E., on the east-facing slope of Wickiup Creek, in Crook County.

Owner: Unknown.

Production: None.

General description: The property was owned by Mrs. Pearl Moore in 1939, and most of the development work, which consists of scattered pits and trenches, was done about that time. Traces of cinnabar occur in a north-trending fault zone in porphyritic andesite agglomerate. The fault zone contains from 1 to 3 feet of crushed andesite that has locally been silicified and impregnated with calcite veinlets.

GRAY PRAIRIE PROSPECT

Location: $SE\frac{1}{4}$ sec. 16, T. 15 S., R. 20 E., on the southern edge of Grays Prairie, in Crook County.

Owner: Bert Tolladay and Dayton Glover, Prineville.

Production: None.

History and development: The prospect was located by Bert Tolladay and Roy Mattson in the early 1930's. Development consists of a 30-foot shaft, about 250 feet of bulldozer trenches, and more than 50 hand-dug pits scattered over several acres.

Table 8. Miscellaneous Quicksilver Occurrences in North-Central Oregon.

	Sec.	T.	R.	Location	Character of Deposit	Development	Discoverer and Date	Information Source
CROOK COUNTY								
Beale Prospect	18	13S	17E					*
Blevins Prospect	13	14S	18E	About ½ mile north of old Howard School.	Sheared, altered, and locally silicified tuffs, veined and impregnated with calcite. Little cinnabar observed.	25-foot adit and 20-foot winze (caved).	Ike Blevins (1931)	Examined by writer.
Ochoco Mines	30	13S	20E	On south flank of Ochoco Creek canyon, 28 miles northeast of Prineville.	Epithermal gold deposit in altered andesite and tuffs. **	Many hundreds of feet of drifts and crosscuts.		Department file reports
Peaslee Creek Prospect	18	14S	20E	On Peaslee Creek from ¼ to ½ mile east of junction with Canyon Creek.	Cinnabar in alluvium along banks of creek.		Unknown (1930?)	Examined by writer.
Red Warrior	23, 26	13S	17E					*
Viewpoint Prospect	27, 28	12S	19E					*
Wesserling Prospect	14	14S	20E	About ½ mile southeast of Blue Ridge mine.	Cinnabar float in soil and decomposed andesite rubble.	Several hand-dug prospect pits.	W.J.Wesserling (1930)	Examined by writer.
JEFFERSON COUNTY								
Opal Creek Prospect	25	11S	18E		Iron oxide rich chalcedony nodules and veinlets.**		A.J.Champion (prior to 1940)	Bert Tolladay Prineville, Oregon
Opal Mountain Prospect	35	11S	18E		Iron oxide rich chalcedony nodules and veinlets.**		A.J.Champion (prior to 1940)	Bert Tolladay Prineville, Oregon
Prospect	36	9S	17E					*
Roark Prospect	22 or 27	11S	19E	About 1½ miles northwest of Humboldt mine.	Clay alteration of andesite tuffs with traces of cinnabar.	Several hand-dug prospect pits.		Glenn Stephenson Mitchell, Oregon
WHEELER COUNTY								
Gage Ranch Prospect	Near SW cor.	11S	21E	About 3/4 mile north of McTimmonds Ranch prospect	Unknown.	Unknown.	Louis Bierl (prior to 1940)	J. E. Staley Prineville, Oregon
Howard Ranch Prospect	10	12S	20E					*

* Listed by Frederick (1945); no other information available.
** Frederick (1945) indicates that quicksilver minerals are also present. No assays or other information available.

Geology: The rocks are fine grained, well indurated tuffs and tuffaceous sediments. A small body of gray, silicified tuff containing small pyrite crystals but no cinnabar crops out about 200 feet south of the shaft. Most of the cinnabar found in the area was panned from the soil and was widely scattered. The small amount of cinnabar exposed in the bedrock occurs in an apparently unsystematic arrangement of narrow, widely spaced veinlets. Limonite and occasional marcasite or pyrite are associated with the veinlets. Structural features capable of localizing appreciable mineralization have not been found.

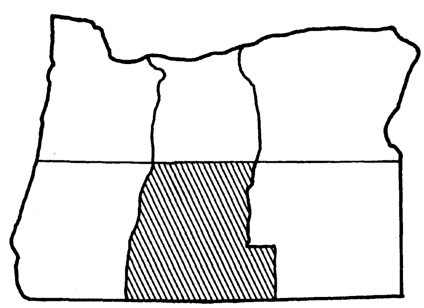
MISCELLANEOUS OCCURRENCES

Listed in table 8 are a number of quicksilver occurrences about which very little is known. Some of these are of doubtful existence, but since they have been either reported to the department or included in the literature, the available information about them is tabulated here. The writer attempted to visit or in some way verify the existence of these reported occurrences, but could not confirm all of them. Because of their minor importance, they have been omitted from plate 1 (locality map of quicksilver deposits in Oregon).

PART II DESCRIPTIONS OF THE QUICKSILVER DEPOSITS

CHAPTER 4

SOUTH-CENTRAL OREGON



Chapter 4. SOUTH-CENTRAL OREGON

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CHAPTER 4

South-Central Oregon

South-central Oregon includes all of Klamath and Lake Counties and those parts of Deschutes and Crook Counties that lie south of the 44th parallel. With the exception of the Givan Ranch prospect in Klamath County, all of the deposits are in Lake County (see figure 57). Of the total recorded quicksilver production for the region of 129 flasks, 92 came from the Glass Buttes area in the northeast corner of Lake County and 34 from the

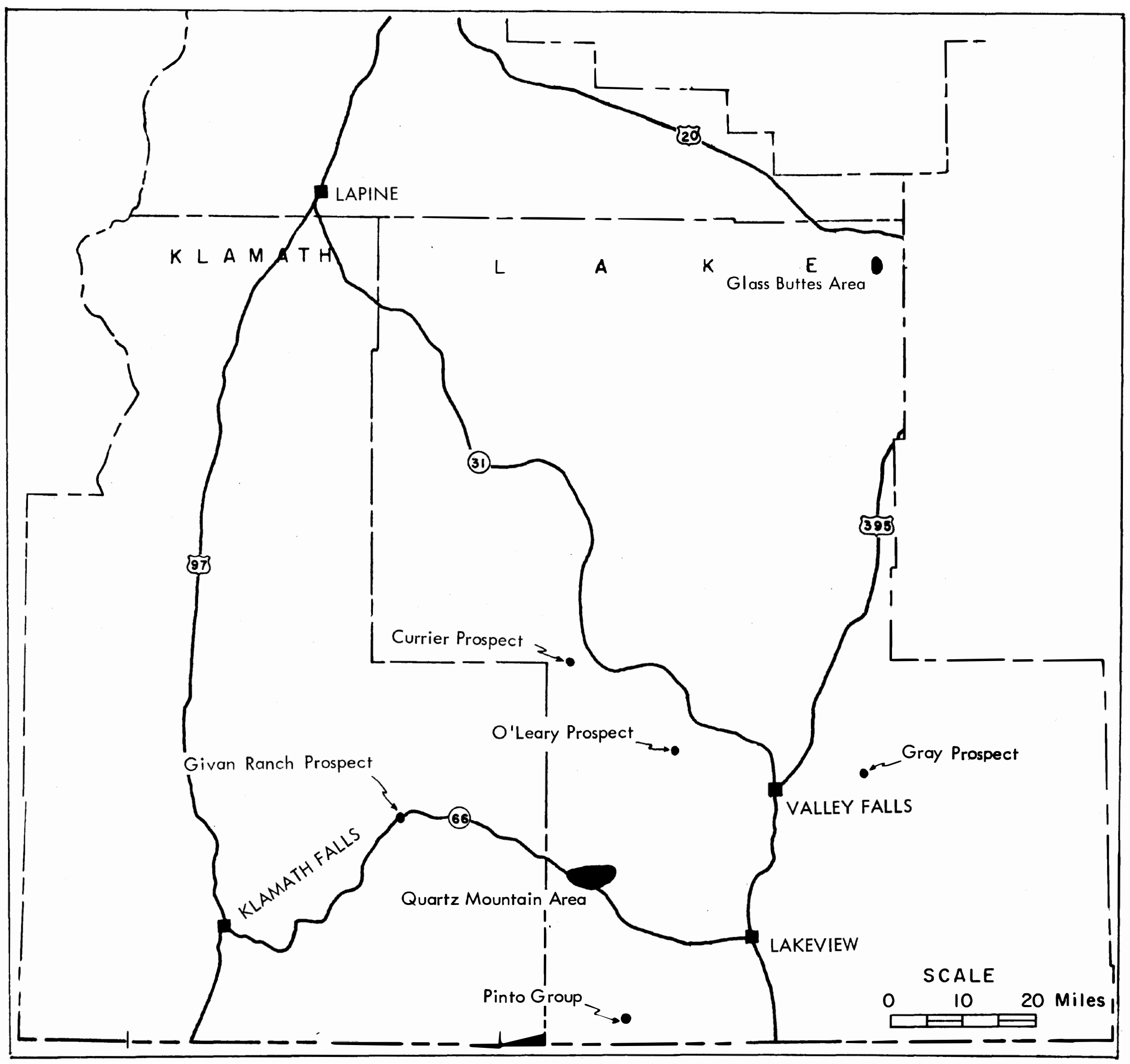


Figure 57. Index map of South-Central Oregon, showing distribution of the quicksilver deposits.

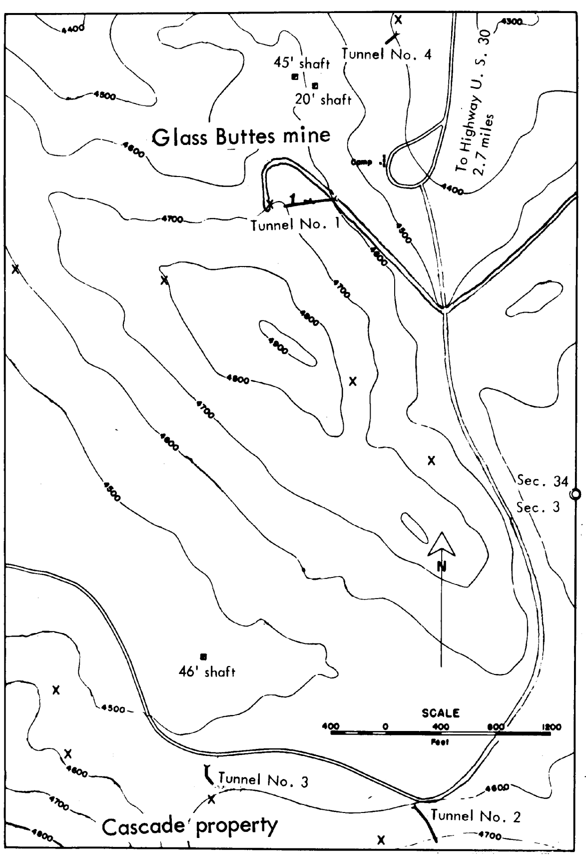
Quartz Mountain area west of Lakeview. The remaining 3 flasks were produced by the Gray prospect north of Plush. Lesser deposits in Lake County are the Currier and O'Leary prospects and the Pinto group. Five prospects (not shown in figure 57), for which information is meager, are listed under "Miscellaneous occurrences" at the end of the section on south-central Oregon.

General Geologic Setting

This section of the state lies within the Basin-Range province and the High Lava Plains. The region is characterized by young fault-block mountains separated by broad graben valleys with interior drainage. Shallow alkaline lakes and playas are the remnants of much larger Quaternary lakes. The region is underlain by a thick sequence of Tertiary rhyolite, andesite, and basalt flows with interbedded tuffs and tuffaceous sediments. These rocks are blanketed to the north and west by Quaternary lavas, pumice, and cinders. All of the quicksilver deposits occur in Tertiary volcanic rocks, and most of them are the opalite type.

Description of the Quicksilver Deposits

GLASS BUTTES AREA



Base map furnished by H. A. Miller

Figure 58. Topographic map of the Glass Buttes area, showing the distribution of the workings of the Glass Buttes mine and the Cascade property (map adapted from Reed, 1946).

The isolated, sagebrush-covered hills known as Glass Buttes lie in the extreme northeastern corner of Lake County. Figure 58 shows the topography of the area and the distribution of workings as they existed in 1940. Much surface exploration and development with bulldozers has since been done. There are two principal areas of development: the Glass Buttes mine in the northern part of the map area and the Cascade property in the southern. The Glass Buttes mine is in sec. 34, T. 23 S., R. 23 E. The Cascade property is in the adjoining part of sec. 3, T. 24 S., R. 23 E.

The Glass Buttes area is underlain by three groups of lava flows (Waters, 1927, p. 441-452), the upper and lower of which are basaltic. The intermediate series of flows, which is more than 400 feet thick and composed of andesitic rocks, perlite, obsidian, and vitrophyre, makes up the greater part of the Buttes. The volcanic rocks forming Glass Buttes have been arched into a broad anticline broken by many normal faults of varying trends and magnitude.

The quicksilver deposits were formed in rocks which originally consisted almost entirely of flow-banded glass. The glassy rocks have been opalized along broad zones of northwesterly trend. Silicification was evidently effected by hydrothermal silica-bearing solutions along northwest-trending fractures. Near the close of the silicifying activity, movement was renewed along many of the northwest-trending faults, with the result that the hard, brittle opalite was fractured and in places thoroughly crushed. Silica, locally admixed with finely divided cinnabar, was subsequently deposited in the innumerable open spaces. The cinnabar consists of clusters of sub-microscopic particles that appear to be suspended in the silica. Individual particles are rarely distinguishable under the microscope.

The silica-cinnabar mixture occurs as fracture filling, often almost completely healing the fractures, and as pulverulent coatings on breccia fragments. In zones of intense crushing, where the principal ore bodies occur, the breccia locally is completely recemented by silica mixed with cinnabar. In several breccia pockets, cinnabar is so extensively distributed as to give the impression that the fragments are bound in a matrix of cinnabar. However, the gravity of the material only slightly exceeds that of the silica and assays rarely exceed 10 pounds of quicksilver per ton. Close examination shows the material to be largely crushed opalite fragments and clays thinly coated with cinnabar. A few breccia fragments contain more cinnabar than does the cementing material, indicating that some brecciation followed the advent of the cinnabar mineralization. The depositional relationship between the cinnabar and silica has not yet been established. Their occurrence as an intimate mixture suggests that the two were deposited simultaneously or at closely alternating intervals.

GLASS BUTTES MINE

Location: Sec. 34, T. 23 S., R. 23 E., about 3 miles south of U. S. Highway 20 from a point about 50 miles west of Burns.

Owners: Verne E. Ryan of Coos Bay, Oregon, holds 34 claims; W. H. Justrom of Coos Bay and John McManman of Bend hold 5 claims. The relative distribution of the two groups of claims is unknown to the writer.

Production: 93 flasks.

History: Cinnabar was discovered in the area in 1933 by P. L. Forbes. The property was later taken over and held until some time during the late 1940's by C. E. Miller of Bend. Much of the existing development work was done under his direction. Harold Olsson and E. W. Pringle relocated most of the area of interest in 1954 and organized the Glass Buttes Mercury Association to promote further development of the property. Considerable exploratory work was done by Kennemetal, Inc., during late 1954 and early 1955. In 1956 Max Stalnaker and Elmer Surratt produced 3 flasks with a small retort. In 1957 a 20-ton-per-day rotary furnace was installed by the Oregon Uranium Corp. and about 1,300 tons of ore yielded 87 flasks. Two additional flasks were produced by Ray Eslinger in 1958. The property was then placed in ownership litigation and lay idle until relocated by the present owners in 1960. Ryan produced one flask in 1961.

Development: Underground development consists of tunnels 1 and 4 and two shafts, 44 and 20 feet deep respectively (figure 58). Opencuts and trenches are widely scattered about the property.

Tunnel No. 1 (Figure 59) contains a 380-foot crosscut adit, about 450 feet of lateral workings, a 48-foot winze, and a 100-foot raise to a glory hole at the surface. Most of the lateral workings crosscut the mineralized zones. All of the ore treated in the furnace by the Oregon Uranium Corp. was mined from the glory hole and pushed into the raise with a bulldozer. Use of the bulldozer no doubt resulted in considerable dilution of the ore.

Geology: Most of the workings in the area expose small amounts of cinnabar in brecciated opalite, but only in Adit No. 1 has sufficient work been done to permit determination of ore controls.

Tunnel No. 1 crosscuts several zones of brecciated opalite, some containing cinnabar. The principal zone of cinnabar mineralization is an irregularly brecciated zone about 15 feet wide striking generally N. 55° to 65° W. and dipping steeply northeast. The zone has been developed by crosscutting to a length of 170 feet and by raising and sinking to a depth below the outcrop of about 150 feet. Mineralization within the zone occurs in several subparallel shoots or pockets ranging from 2 to 5 feet in width. Assays taken from various parts of the ore shoots yielded a maximum of 10 pounds of quicksilver per ton. The average quicksilver content of a minable width of any of the shoots now exposed is probably less than 3 pounds per ton.

Ore mined from the glory hole and raise lay adjacent to a curving fault surface that may form the hanging wall of the mineralized zone. This fault surface is exposed for about 100 feet, strikes N. 58° W. at the eastern end of its exposure and N. 80° W. at the western end. Its dip is approximately 70° at either end, becoming somewhat shallower near its central point. Thus the curving fault forms a cap-like structure which, because of its possible damming effect on rising mineralizing solutions, may account for the ore localization. The ore occurs largely within a 5-foot zone adjacent to the fault, but scattered mineralization and high-grade breccia pockets are found at least 15 feet into the footwall zone. Four narrower breccia zones, ranging from 3 to 10 feet wide, were crosscut in the first 130 feet of Adit 1. These also strike northwesterly and dip northeast.

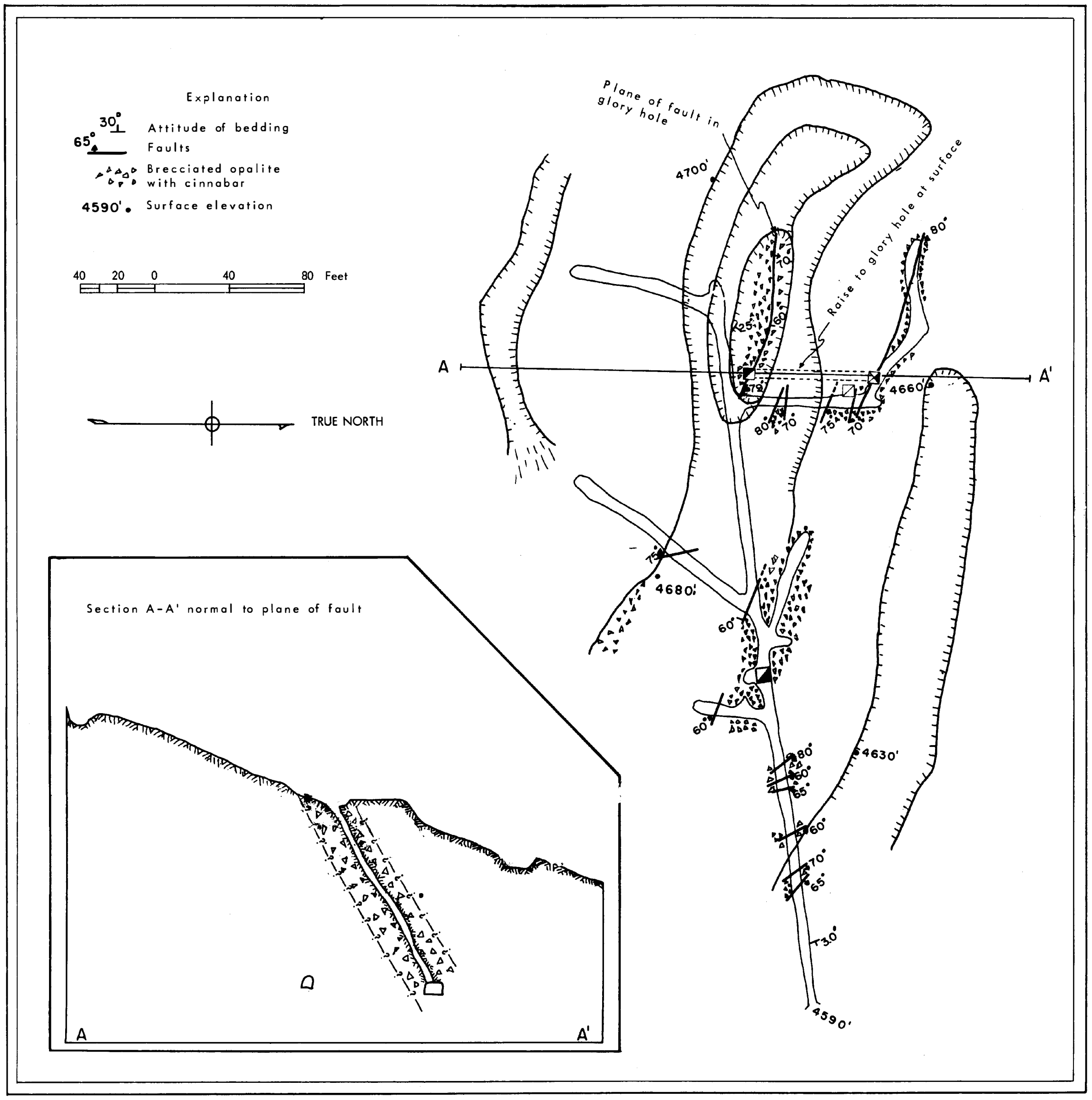


Figure 59. Geologic map and section of Adit No. 1, Glass Buttes mine.

CASCADE PROPERTY

Location: Sec. 3, T. 24 S., R. 23 E., about one mile south of the Glass Buttes mine.

Owner: Elmer Surratt of Salem, Oregon, and associates.

Production: None.

History: The 24 claims of this property were acquired by Elmer Surratt and Max Stalnaker in 1957. In that same year the claims were leased to the Cascade Mining Co. Two small experimental retorts and a large frame cabin have been erected.

Development: Underground work, most of which was done prior to acquisition of the property by the present owners, consists of tunnels 2 and 3 and a 46-foot shaft (figure 58). Many hundreds of feet of opencutting and trenching has been done near No. 2 tunnel and on the hillside to the south.

Geology: Ore controls here are similar to those at the Glass Buttes mine to the north. Cinnabar is widely scattered in small amounts, but the main concentrations are in zones of brecciated opalite along northwest-trending fractures. In places, some of the opalite contains enough cinnabar to average a few pounds of quicksilver to the ton, but nowhere has an ore body of commercial size been developed. The more impressive cinnabar occurrences were observed in No. 2 tunnel in a zone of brecciated opalite about 20 feet wide.

QUARTZ MOUNTAIN AREA

Quicksilver deposits in the area around Quartz Mountain lie north of the Lakeview-Klamath Falls Highway (Oregon 66) in Ts. 37 and 38 S., Rs.16 and 17 E., about 30 miles west of Lakeview, Oregon. The area is topographically rugged and some of the ridges rise to over 6,500 feet in elevation. The western part of the area is covered by the Fishhole Mountain quadrangle topographic map. The geology and quicksilver deposits of part of the area, particularly sections 26, 27, 34, and 35, T. 37 S., R. 17 E., was studied by Johns (1949).

The date of the first discovery of quicksilver in the district is unknown. The earliest work of which there is any record was done in 1936 by the Sun Oil Co. Following abandonment of these claims about 1940, the district received little attention until a prospecting "boom" began in 1957, with the result that many claims and claim groups have since been located in the area. The total recorded production from the area of 34 flasks was recovered from the Angel Peak mine between July 1958 and July 1959.

The area is underlain by a structurally complex series of interrelated acid volcanics, including restricted flows, plugs, and both intrusive and extrusive breccias of Tertiary age. These rocks occur in a northwest-trending belt about 5 miles wide and 12 miles long. They are surrounded by younger bedded tuffs and thin, light-gray olivine basalts that are Pliocene or possibly Pleistocene in age. In places broad zones within this northwest-trending belt of glassy rocks have been highly silicified and some large areas have been completely opalized. The cinnabar deposits of the area occur in these silicified rocks.

ANGEL PEAK MINE

Location: $NW\frac{1}{4}NW\frac{1}{4}$ sec. 32, T. 37 S., R. 17 E., about 6 miles north of Quartz Mountain Lodge via the Ewauna Camp and Drews Creek roads. The workings explore the top of a hill locally known as Angel Peak.

Owners: Lynn Tomlin, G. B. Johnston, and D. V. Morrison.

Production: 34 flasks.

History and development: Development of the property was begun in 1956 by the owners. In the fall of 1957 a group of stockholders of Atomic Metals, Inc., leased the property and later organized as Western Minerals, Inc. During the winter, a 30-foot by 30-inch rotary furnace was obtained from the Red Cloud mine in Douglas County, revamped, and installed on the property. Production from the operation, all open pit, between July 1958 and July 1959 amounted to 34 flasks. Only exploratory development work has been done since. During 1959, silicified material from the open pit was used as road metal.

Geology: On the crest of Angel Peak an area about 100 yards in diameter has been stripped of overburden. Much of the rock exposed has been opalized, though some parts of it have been altered to a soft, powdery mixture of silica and alunite. Identifiable rocks in the opalized area and along its edges include rhyolites, tuffs, tuff breccias, and a glassy andesite. Along the west edge of the opalized area the glassy rocks are interlayered with the opalized material.

Controls for the localization of the cinnabar are obscure. No persistent fracture trends were noted. Cinnabar is concentrated along poorly defined fractures and coats fragments in brecciated zones within silicified parts of the rock. Small amounts also occur as fine dispersions in the silica. Most of the ore mined was recovered from a mineralized zone about 40 feet long, 20 feet wide, and 10 to 15 feet deep. Small pods of ore that assay from one to two percent quicksilver were included, but the over-all grade of ore probably would not exceed

0.15 or 0.2 percent quicksilver. Outside this mineralized zone only scattered bunches of cinnabar were found.

CRONE PROSPECT

Location: NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 34, T. 37 S., R. 16 E.

Owner: Norman Crone.

Production: None.

History and development: The property was first located by a group of individuals in 1936 and was shortly thereafter deeded to the Sun Oil Co. In August 1938 the 5 claims were deeded to subsidiary company, Horse Heaven Mines, Inc. Only a small amount of exploratory trenching and shallow shaft sinking was done. These workings are all caved or sloughed full. In 1958 Norman Crone located 7 fractional claims covering the prospect, cut several trenches with a bulldozer, and in 1959 installed a small propane-fired retort.

Geology: Most of the cinnabar found in the area occurs as fine dispersions and fracture coatings in opalite cobbles and boulders. In the places examined, bedrocks were not exposed. During his trenching operations, Crone sorted out several tons of the cobbles and boulders in anticipation of retorting them. However, the grade of the material appears to be much too low to sustain so small an operation.

The opalite fragments have the appearance of float, but instead may be remnants of a mass of rock that had been partially silicified and partially reduced to clays, the clayey material having since been largely removed, leaving the resistant opalized portions of the rock more or less in place.

MANZANITA GROUP

Location: In the adjoining western parts of secs. 26 and 35, T. 37 S., R. 16 E., about three airline miles east of the Angel Peak mine.

Owners: Ross Foster, Dean Lange, and Don Tracey.

Production: None.

General description: The Manzanita group of 9 claims was located in 1956 by the owners. In December 1956 the property was taken over by Atomic Metals, Inc. An area about 500 feet long and 300 feet wide has been stripped to depths of from 2 to 15 feet. The rocks exposed by this operation are partially silicified tuffs and ash, locally converted to clay. Cinnabar is visible in a few places as paint-thin coatings on fracture surfaces.

ROSALITE PROSPECT

Location: Sec. 5, T. 38 S., R. 17 E., on the crest of a west-trending ridge about one airline mile S. 20°E. from the Angel Peak mine.

Owners: E. H. Rosborough, Wayne Neihaus, H. C. Smith.

Production: None.

History: The Rosalite property, consisting of at least 4 claims, was located by the owners in May 1957.

Development: Development consists of several bulldozer cuts in an area more than 200 feet in diameter in soft, friable, and brilliantly white-to-cream-colored tuff. Reddish iron oxide, sparsely distributed through small fracture zones in the tuffs, was originally mistaken for cinnabar. Two samples of this material taken by the writer contained no quicksilver.

ISOLATED QUICKSILVER OCCURRENCES

CURRIER PROSPECT

Location: Sec. 36, T. 32 S., R. 16 E., on the W. M. Currier ranch, about 12 miles northwest of Paisley and a few hundred feet east of the Lakeview-Bend highway. It lies close to the base of Winter Ridge and just above the marshy flats bordering the southwest side of Summer Lake.

Owner: W. M. Currier.

Production: $2\frac{1}{2}$ flasks, not recorded.

History and development: The prospect was discovered about 1934 and the first work was done by W. M. Currier and a nephew. Currier reports that a short time later $2\frac{1}{2}$ flasks were produced by a lessee named Bobbett with a small hand-made retort. During 1940, A. M. Seits and Dr. E. W. Howard leased the property and performed most of the development work that has been done to date. A Lacey upright furnace of 35- to 40-ton capacity was installed but only a few pounds of quicksilver were produced during their operations.

The property is developed by an adit about 100 feet long driven nearly due west and containing a shallow winze. On the surface, 65 feet vertically above, dozer cuts and small pits expose about 200 feet of the mineralized zone. In 1958 M. E. Weatherly extended an opencut across the portal of the adit, cutting part of it away.

Geology: The workings explore a zone of multiple shearing, brecciation, and hydrothermal alteration at least 50 feet wide, cutting a nearly horizontal andesite flow. A short distance above the mine the andesite is conformably overlain by basalt. The shear zone, made up of a series of discontinuous sub-parallel faults and fractures, trends nearly due north. The more persistent fracture planes dip easterly at moderate to high angles. Within the shear zone the andesite bordering the larger fissures is commonly intensely brecciated, more or less completely reduced to soft, purplish clays and limonite, and locally silicified. In places the breccia fragments are recemented by the silica, mainly chalcedony. Discontinuous lenses as much as a foot wide of altered rock, almost completely replaced by chalcedony and a little quartz, were noted.

Cinnabar occurs mainly as fracture filling and splotchy aggregates and coatings on fracture surfaces in the siliceous material and in the altered but relatively unsilicified adjacent wall rocks. Small amounts of calcite, barite, and pyrite are locally present. A little native quicksilver has also been reported.

Of several samples taken from the adit none showed encouraging amounts of cinnabar, although some high-grade material is reported to have been taken from the winze. On the surface near the old furnace several small pockets of cinnabar have been exposed. Ross (1941) reports that from one of the pits two samples, one cut across a highly silicified seam a foot wide and the second from a cut $5\frac{1}{2}$ feet long across the entire lode, contained 13.0 and 13.8 pounds quicksilver per ton.

GRAY PROSPECT

Former name: Windy Hollow mine.

Location: Secs. 14 and 15, T. 35 S., R. 23 E. in the Coyote Hills. The prospect is 11 miles northwest of Plush in the Camp Loftus area of the old Lost Cabin Gold Mining district. The area was the site of considerable activity during the early 1900's, though gold production was small.

Owners: Glenn Gray, Lynn Gray, and Zane Gray, Lakeview, Oregon.

Production: 3 flasks recorded; possibly 7 produced.

History: The prospect is said to have been discovered by Art Champion in 1934. In November 1936 four claims were located by Mr. and Mrs. R. R. Whiting. Stanley Gray, father of the present owners, acquired the property in 1940 and according to U.S. Bureau of Mines records produced 2 flasks during 1941 from 50 tons of ore and 1 flask during 1942 from 4 tons of ore. Zane Gray reports that production from 1941 through 1943 was 7 flasks. The ore was treated in three 12-inch by 6-foot tubes.

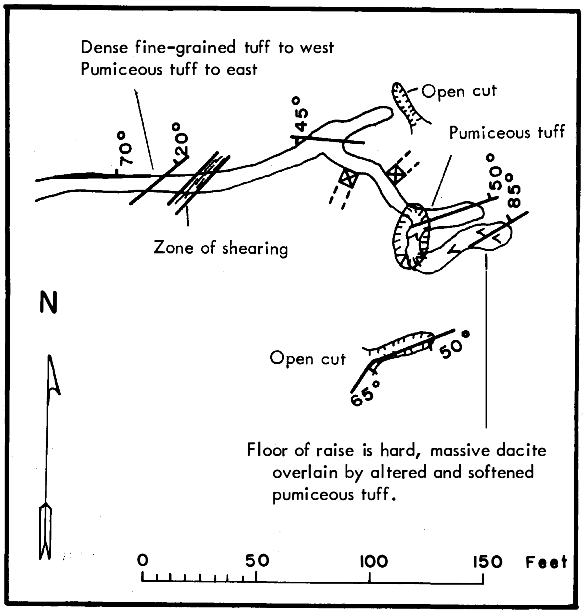


Figure 60. Geologic map of the Gray prospect.

Development: Development consists of a 230-foot adit (figure 60) containing a winding raise about 40 feet long, several opencuts along the slope above the adit, and a shallow dozer trench about 200 yards to the east.

Geology: The mine area is underlain by nearly flat-lying andesitic to rhyolitic flows, coarse agglomerates, fine-grained tuffs, and pumiceous tuffs of Tertiary age. Several masses of dacite protruding at the surface appear to be intrusive and may be parts of an underlying plug. The workings explore irregularly fractured, altered, and locally mineralized volcanics lying adjacent to one of the dacitic masses. The adit was driven for part of its length along a fault trending N. 80° E. and dipping about 70° N. Other faults trend N. 35° to 45° E. Fractured and altered rocks along the faults locally contain traces of cinnabar. The last 30 feet of the adit drifts along a sulphidized fault zone trending N. 75° E. and dipping steeply north. A winding, inclined raise 40 feet long was driven upward along this fault.

The footwall of the fault is a hard, massive, relatively unaltered dacite that may be intrusive. The adjacent tuffs and agglomerates have been intensely fractured, more or less altered to clays and limonite, and locally impregnated with fine pyrite and cinnabar. A selected sample from the top of the raise assayed 16.5 pounds quicksilver per ton. It is said that 6 flasks of quicksilver were recovered from a small opencut on the surface above this raise. An opencut a few feet to the south exposes an altered but apparently barren fault zone that curves from N. 45° E. to N. 85° E. Dips on the fault change from 65° SE. to 50° SE.

About 600 feet S. 70° E. of and 80 feet higher than the adit portal, a shallow dozer trench exposes a narrow zone of opalized tuff. A small lens of perlite lies adjacent to the opalite. The maximum exposed width of the opalized zone is about 12 feet. It is locally bordered on either side by softened tuff. At the northern end of the trench the opalized zone appears to trend about N. 10° E. To the south it turns to N. 50° E. Cinnabar occurs as thin films on fracture surfaces and as fine disseminations in the opalite. A sample of the opalite and the adjacent altered tuff assayed 0.4 and 0.2 pounds of quicksilver per ton respectively.

PINTO GROUP

Location: South edge of sec. 6, T. 41 S., R. 18 E., about 30 miles by road southwest of Lakeview.

Owners: Dan Morrison, Gordon Huntley, George Batman, and George Johnston.

Production: None.

History and development: Six claims were located and development of the prospect was begun by the owners in 1959. Development consists of several bulldozer cuts, a hand-dug shaft, and a short tunnel about 25 feet long.

Geology: The prospect was visited in 1959 by N. V. Peterson of the department, who reports that it lies along the crest of a north-trending triangular shaped ridge consisting of pumice lapilli tuffs, fine-grained clayey tuffs, and tuff breccias. The rocks are extremely sheared and contain scattered zones of intense alteration, iron-staining, and local silicification. Boulders of chalcedony are widely scattered and locally are abundant. Cinnabar is occasionally found as fine disseminations in the chalcedony boulders. In places, cinnabar occurs as thin coatings along fractures and as sparse disseminations in the altered tuffs.

The many widespread dikes and irregular masses of rhyolite scattered throughout the area are believed to have been responsible for the widespread shearing and alteration of the tuffs. Hydrothermal solutions carrying small amounts of cinnabar apparently permeated the whole ridge top. Chalcedony fills irregular fractures in the tuffs and locally completely replaces the tuffs.

O'LEARY PROSPECT

Location: Sec. 5, T. 35 S., R. 18 E., 10 miles south and east of Paisley via the Clover Flat and Avery Pass roads.

Owner: Jerry O'Leary, Paisley.

Production: None.

General description: The prospect, discovered by Art Champion about 1940 and later worked by Charles Connors, is developed by three small hand-dug pits. Rocks in the area include andesite flow breccia and massive rhyolite. The andesite breccia strikes N. 25° to 50° W. and dips about 30° NE. The breccia is cut by a series of small vertical fractures that trend N. 15° to 25° W. Cinnabar occurs as thin veinlets and coatings on some of the later fractures. No structure capable of localizing appreciable cinnabar was observed.

GIVAN RANCH PROSPECT

Location: NE$\frac{1}{4}$ sec. 25, T. 36 S., R. 12 E., on the west flank of Medicine Mountain about 3 miles southeast of Beatty.

Owner: D. G. Givan, Beatty, Oregon.

Production: None.

General description: Information on the prospect was obtained by N. V. Peterson of the department, who visited the property in 1960. Peterson reports that several opencuts expose bedded rhyolite breccias that have been locally opalized. The bedded rocks strike about N. 35° E. and dip 15° NW. The zone of opalization appears to trend northeast. No cinnabar was positively identified in any of the cuts or outcrops, although one piece of opalite float containing cinnabar was found. The owners report that samples have assayed as high as 16 pounds of quicksilver per ton.

MISCELLANEOUS OCCURRENCES

Listed below in table 9 are a few quicksilver occurrences about which very little is known. Some of these are of doubtful existence, but since they have been either reported to the department or included in the literature, the available information about them is tabulated here. The writer attempted to visit or in some way verify the existence of these reported occurrences, but could not confirm all of them. Because of their minor importance, they have been omitted from plate 1 (locality map of quicksilver deposits in Oregon).

Table 9. Miscellaneous Quicksilver Occurrences in South-Central Oregon.

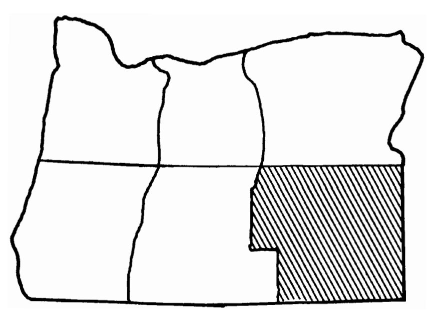
Name of Prospect	Sec.	T.	R.	Location	Character of Deposit	Development	Discoverer and Date	Source of Information
LAKE COUNTY								
Adel		39S.	24E.		Unknown			*
Batman	4	41S.	18E.	About one and one-half miles east of Pinto Group.	Unknown		Charles Batman (prior to 1940)	Dan Morrison Lakeview, Oregon
Chewaucan River	9, 16	34S.	18E.	On bank of Chewaucan River near Benfield dam site.	Unknown	Short adit.	Jack Barham (about 1935)	L. A. Johnson, Paisley, Oregon
Hart Mountain		36S.	25E.		Unknown			*
Kingwell	32	32S.	19E.		Unknown			*

* Listed by Frederick (1945); no other information available.

PART II DESCRIPTIONS OF THE QUICKSILVER DEPOSITS

CHAPTER 5

SOUTHEASTERN OREGON



Chapter 5. SOUTHEASTERN OREGON

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CHAPTER 5

Southeastern Oregon

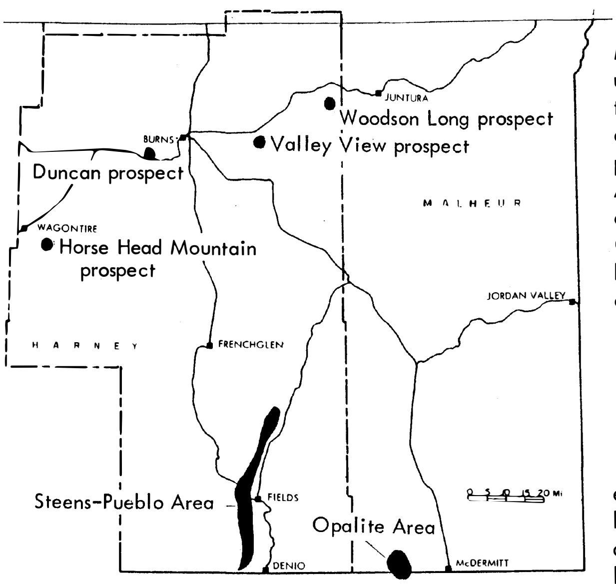


Figure 61. Index map of southeastern Oregon, showing distribution of the quicksilver occurrences.

Southeastern Oregon includes all of Harney and Malheur Counties south of the 44th parallel (see figure 61). The principal quicksilver occurrences are in the Opalite area of southern Malheur County. This area contains two of Oregon's largest quicksilver-producing mines, the Bretz mine and the Opalite mine. A multitude of small deposits lies along the east edge of the Steens-Pueblo Mountains in southern Harney County, but production from this area has been small. In addition, there are small isolated occurrences of cinnabar in the northern part of Harney County.

General Geologic Setting

Southeastern Oregon is considered to be the northern border of the Great Basin, on which typical fault-block structures trending northeast and northwest are developed. The eastern edge of this region is bounded by the Snake River graben, which has been filled with late Tertiary to Quaternary terrestrial sediments and intercalated lavas. Most of southeastern Oregon is underlain by middle to late Tertiary basalts, rhyolites, and associated pyroclastics interbedded with lake and stream deposits. Recent unweathered volcanic cones and flows occur in central Harney County near the town of Diamond and in east-central Malheur County near Jordan Valley. In the southern part of Harney County, near the Nevada border, a small body of pre-Tertiary schist, greenstone, and granite is exposed near the base of the Steens-Pueblo Mountains fault scarp.

Descriptions of the Quicksilver Deposits

OPALITE AREA

The Opalite area lies about 15 miles west of McDermitt, Nevada, and straddles the Oregon-Nevada state boundary (figure 62). The area contains three major quicksilver-producing mines: the Opalite and Bretz mines in Malheur County, Oregon, and the Cordero mine in Humboldt County, Nevada. The quicksilver deposits occur near the margins of the broad graben valley of McDermitt Creek, which flows eastward draining the area. Elevations range from 4,400 feet on the valley floor to more than 7,500 feet in the higher reaches of the White Horse Mountains to the north. The deposits lie in an area of low, rounded hills of 5,000 to 5,500 feet elevation.

In addition to Opalite, Bretz, and Cordero mine deposits, many minor occurrences of cinnabar are scattered through the district.

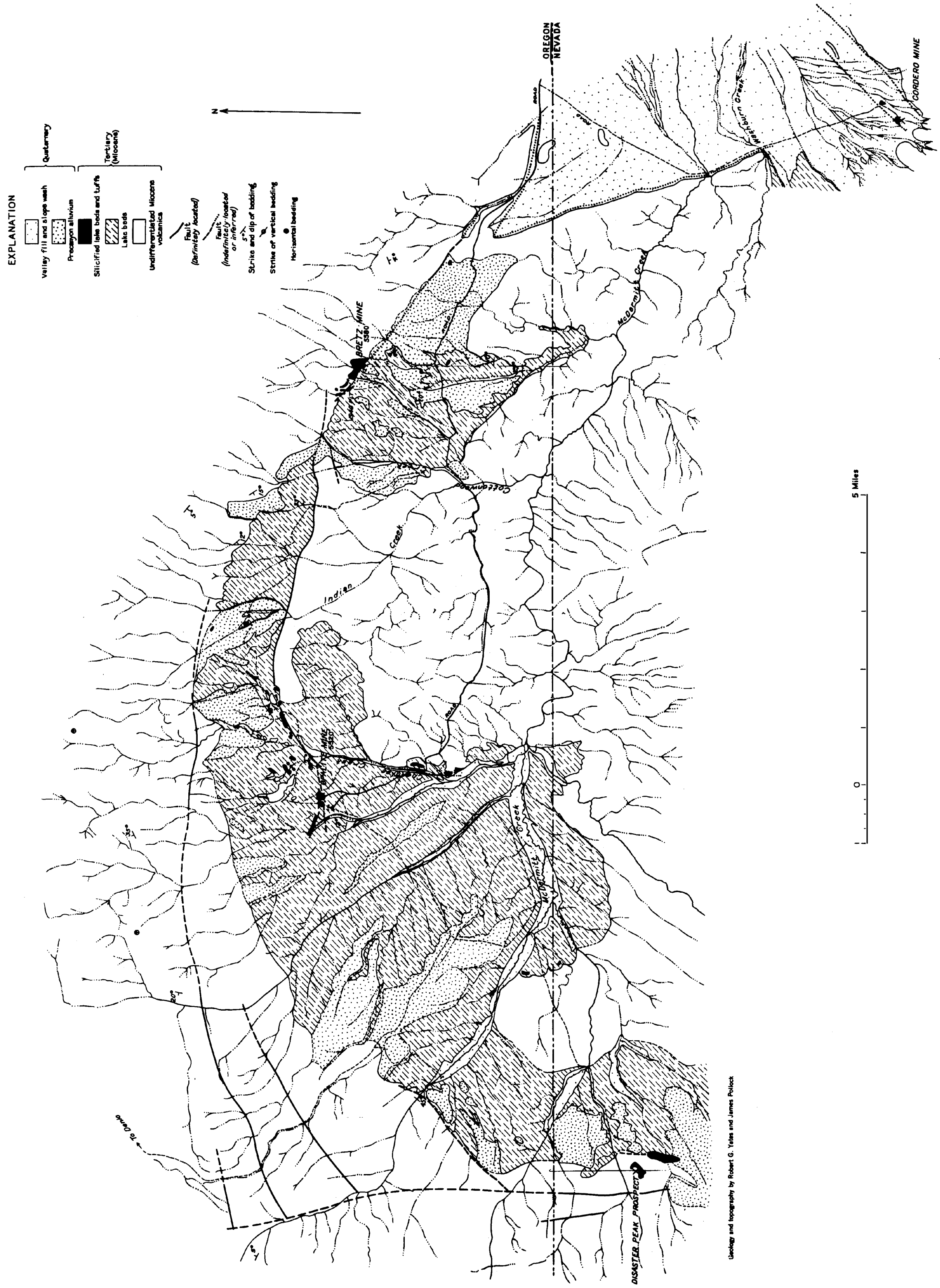


Figure 62. Geologic map of the Opalite area (reprinted from Yates, 1942).

History

Cinnabar was discovered in the vicinity of the Bretz mine by William S. Bretz in 1917. For many years assessment work was confined largely to exploration of low-grade "opalite" outcrops revealing little ore, although some mercury may have been recovered with a small retort operated by Bretz and his brother.

Bretz continued to prospect the surrounding country, and in 1924, with a partner named Murphy, discovered the Opalite ore body 7 miles to the west. The Opalite property was sold to the Mercury Mining Syndicate, organized in April 1925 by F. W. Bradley. Construction of a rotary furnace 5 feet in diameter and 70 feet long was completed late in 1926. The furnace would handle from 80 to 100 tons per day of the hard opalite ore and was then the largest furnace of its type.

Operations at the Opalite mine were discontinuous. Severe winters caused the mine and plant to be shut down for as much as three months, and in December 1938 the furnace buildings burned and the plant was closed until early 1940. However, between 1927 and 1944 the Opalite mine produced 12,333 flasks from ore averaging approximately 6 pounds of mercury per ton. Production since 1944 has been confined to cleanup operations by lessees and amounts to about 25 flasks. The Bradley Mining Co., which succeeded the Mercury Mining Syndicate about 1931, continues to hold the property.

In 1931, Bretz discovered high-grade ore in the soft lake beds near his original location. This property, now known as the Bretz mine, was leased to the Bradley Mining Co. and was worked in conjunction with the Opalite mine. The ore was mined from open pits with a 3/8-yard shovel and trucked 11 miles to the Opalite furnace. Between 1931 and 1936, 7,751 flasks of mercury were recovered from 33,058 tons of ore. In 1936, reserves minable under existing conditions were exhausted and the property reverted to Bretz on expiration of the Bradley lease.

The sharply rising price of quicksilver immediately prior to World War II stimulated search for new ore and in 1940 a discovery was made some 2,000 feet northwest of the 1931-36 workings of the Bretz mine. Production from 1940 through 1942 from the new ore body amounted to 2,531 flasks. Little more was produced before final abandonment by the Bradley Mining Co. in 1944. This was the last major work at the Bretz mine until 1955. Total production for the two early periods of the mine's activity amounted to 10,309 flasks from ore averaging 18.8 pounds of quicksilver per ton.

Encouraged by rising quicksilver prices and the government stockpiling program initiated in 1954, John Ruiz, a rancher from McDermitt, relocated several of the old Bretz claims and attempted to interest capital in additional exploration. In October 1954, Ruiz leased the property to the U.S. Mercury Corp. of New York. Jay A. Carpenter, Reno, Nevada, former director of the Nevada Bureau of Mines, acted as intermediary and manager of initial development. In April 1955 drilling of the property began and application was made for a Defense Minerals Exploration Administration loan. In July 1955 a contract for 4,000 feet of drilling was granted to the Shawano Development Corp., which had, in May 1955, absorbed the U.S. Mercury Corp. In 1955 additional ore was discovered in the western part of the Bretz mine.

Under the terms of an operating agreement drawn up during 1956, Samuel S. Arentz, mining engineer of Salt Lake City, Utah, agreed to construct a treatment plant and to equip and operate the Bretz mine for a half interest in the property. Arentz, retaining the right of management, obtained a portion of the necessary capital for the venture through an agreement with the Comstock Uranium & Oil Co., also of Salt Lake City. This operating combine was known as the Arentz-Comstock Mining Venture. A flotation plant designed to concentrate the ore before roasting was placed in operation in late 1956. Production from that time through 1961 totals 3,699 flasks.

Geology

The geology of the area has been described by Schuette (1938) and by Yates (1942). Figure 62, a geologic map of the area, was adapted from the Yates report.

The rocks of the Opalite area consist of more than 3,000 feet of nearly flat-lying Miocene lavas overlain by upper Miocene tuffaceous lake beds. These lake beds, which in places are more than 200 feet thick, contain the Bretz and Opalite ore bodies. Quaternary alluvium is locally present. Intrusive rocks appear to be scarce, but southwest beyond the district lavas rest on an eroded surface of a granitic complex.

The lavas range from basalt to rhyolite. The siliceous lavas locally associated with tuffs range from obsidian to porphyritic rhyolite, and in general exhibit well-developed flow banding. The darker basaltic and andesitic lavas are characterized by vesicularity, columnar structures, flow brecciation, and porphyritic texture. Individual lava flows are from a few feet to more than 100 feet thick and are horizontal or nearly so, except locally, where they have been tilted by faulting. The lake beds consist mainly of well-bedded tuffs, shales (including clayey, carbonaceous, tuffaceous, and diatomaceous varieties), and sandstone, but include small lenses of conglomerate. The constituent fragments are dominantly of volcanic origin. Age dating of the lake beds is based

Table 10. Annual Production of Opalite and Bretz Mines.

	Opalite		Bretz	
	Tons Treated	Flasks	Tons Treated	Flasks
1926	2,172	-		
1927	19,316	1,889		
1928	26,550	2,655		
1929	31,040	2,276		
1930	29,712	1,323	2	4
1931	7,836	516	8,535	2,414
1932	7,569	1,280	839	226
1933	165	143	4,908	618
1934			9,205	1,957
1935			7,021	1,628
1936	5,970	286	4,429	904
1937	20,129	928		
1938	3,370	285		
1939	32	35		
1940	673	40	4,947	819
1941	13,265	434	4,862	498
1942	146	14	12,880	1,214
1943	2,180	218	36	21
1944		11		6
1945				
1946		16		
1956		6		104
1957		8	36,950	1,413
1958			38,207	1,258
1959			17,287	480
1960			8,370	322
1961		4	2,848	122
Total	170,125	12,367	161,326	14,008

Figures furnished by the Bradley Mining Co. and Arentz-Comstock Mining Venture.

on fossil plants and fresh-water gastropods. The Quaternary rocks include two ages of deposits--an older precanyon alluvium composed of angular rock fragments capping eroded surfaces of the lake beds in interstream areas and a younger alluvium occurring as valley fill and slope wash within the present stream valleys.

The Miocene rocks are cut by steep normal faults. The larger ones are responsible for much of the relief in the area. Smaller faults occur in all the mineralized areas. Locally the soft lake beds are inclined as a result of drag along faults, and possibly such structures were in part responsible for the localization of the cinnabar. Some of these faults acted as channelways for rising hydrothermal solutions and in places the adjacent tuffs and lake beds were silicified into lenticular masses of opalite. The silicification was accompanied by kaolinization, but while both the lavas and lake beds were silicified, only the lake beds were kaolinized.

All the ore bodies are either in or in contact with silicified rocks. The Opalite mine ore body occurs in a mass of chalcedony, some 1,200 feet long, 800 feet wide, and more than 100 feet in maximum thickness. During a late stage in the hydrothermal activity responsible for the silicification, finely divided cinnabar accompanied by silica filled open fractures in the chalcedony. At the Bretz mine, several small, but relatively high-grade, bodies occur in unsilicified shales and sandstones along the south side of an east-trending fault. Masses of chalcedony lie along the north side of the fault directly opposite the ore bodies. Since the quicksilver solutions are believed to have followed the same channels as the silicifying solutions, it seems probable that fracturing similar to that at the Opalite deposit did not exist or that earth movements were insufficient to hold them open during the time cinnabar was being deposited. Consequently, the solutions were diverted into adjacent unsilicified rocks.

OPALITE MINE

Location: Sec. 33, T. 40 S., R. 40 E., about 20 miles by road west of McDermitt and about 7 miles west of the Bretz mine.

Owner: The property, consisting of several patented mining claims, is owned by the Bradley Mining Co.

Production: Production figures are shown in Table 10.

History: The history of the mine is given on previous pages.

Development: The Opalite deposit was developed by the glory hole method. Tunnels were driven beneath the ore body some 100 feet below the outcrops and raises were driven through to the surface (figure 63). Ore from surface pits and from various sublevels was drawn down through the raises to haulageways and trammed to the furnace stockpile. Had the near-surface nature of the deposit been recognized, the mining would probably have been done by open pit. No mining of consequence has been done at Opalite since the Bradley Mining Co.

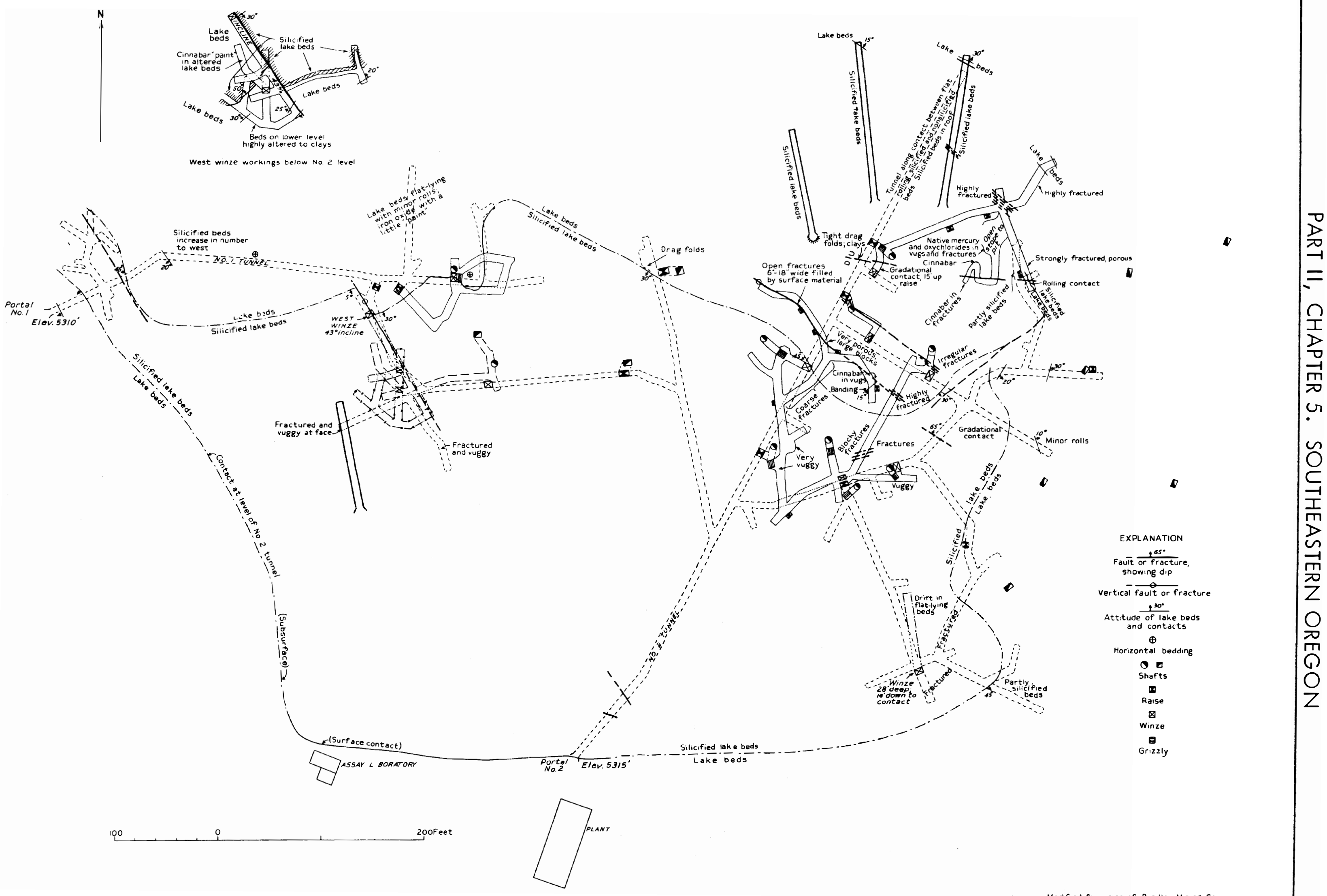


Figure 63. Plan of workings of the Opalite mine.

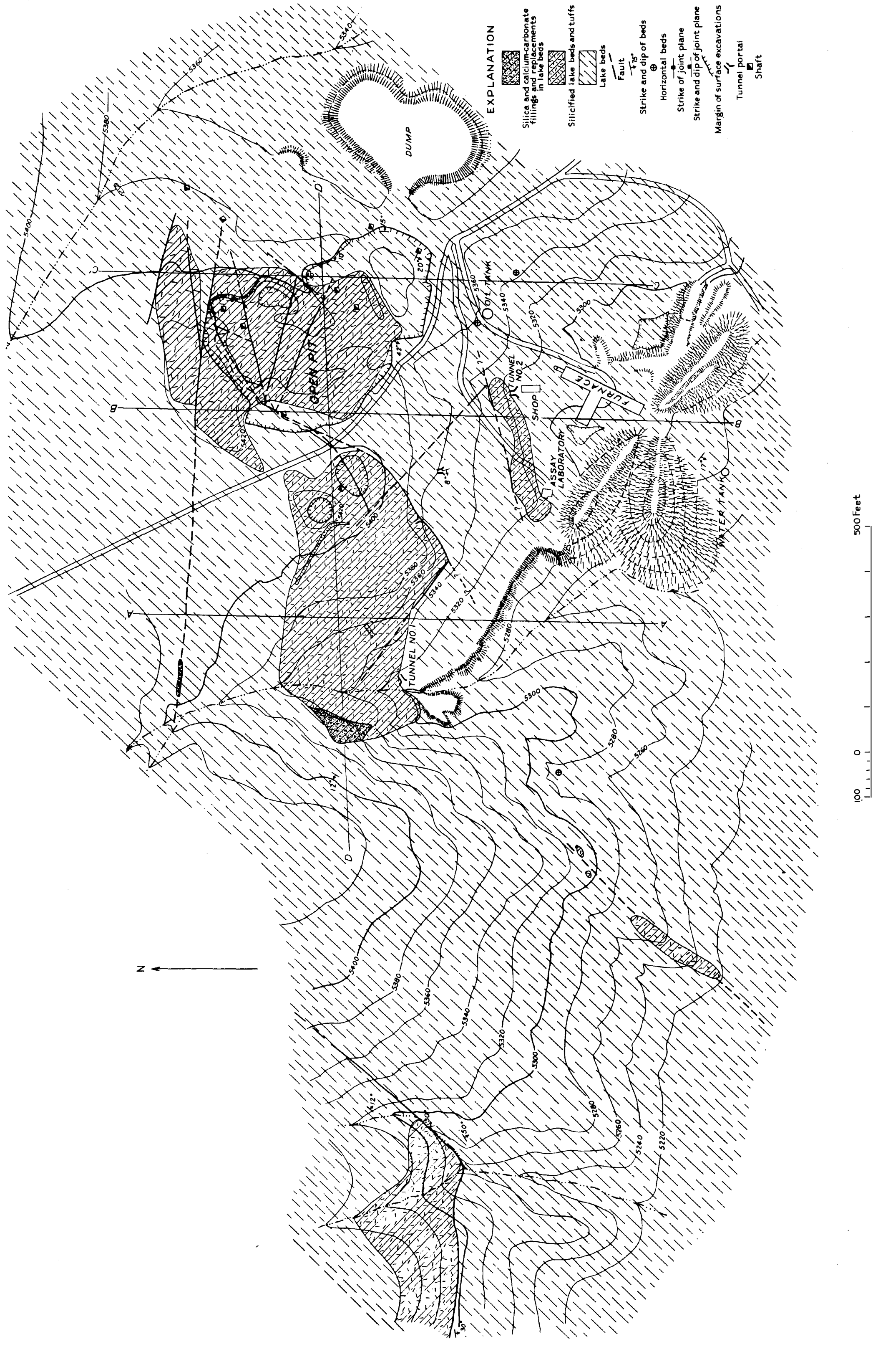


Figure 64. Geologic map of the Opalite mine (reprinted from Yates, 1942).

ceased operations there in 1942. Since that time, several flasks of quicksilver have been recovered from clean-up and high-grading operations.

Geology: The Opalite ore body occurs in a mass of chalcedony some 1,200 feet long, 800 feet wide, and more than 100 feet in maximum thickness (figure 64). Yates, who reported on the mine about the time it closed, states:

> "The lower workings (tunnels 1 and 2) follow, in general, the contact between the unsilicified beds and the overlying chalcedony. There are traces of cinnabar in the chalcedony of these lower workings (figure 63), and a little low-grade ore has been stoped from the soft lake beds on the southeast side of the west winze, which was sunk on a northwest-striking fault. The pulverulent cinnabar here present may be of secondary origin; if so, it will probably not prove to be extensive.
>
> "The main ore body was in the northern part of the east pit, and in general the present borders of the pit coincide with the limits of this ore body. The chalcedony is much brecciated and the best ore occurs where the brecciation is most intense. Ore from the Opalite mine has averaged a little less than 6 pounds of quicksilver to the ton. Some high-grade ore, which contained native mercury and the oxychloride in addition to cinnabar, yielded as much as 40 pounds of quicksilver to the ton, but the rest of the ore produced in the past cannot have averaged more than 4 pounds to the ton.
>
> "Most of the ore has been removed from the east pit, but the former presence of two ore shoots to the west is indicated by the two glory holes represented in figure 64. These two ore shoots did not extend to the lower level, and the chalcedony east of the surface workings contains only traces of cinnabar."

BRETZ MINE

Location: Sec. 3, T. 41 S., R. 41 E., about 13 miles by road west of McDermitt and 7 miles east of the Opalite mine.

Owner: Arentz Mining Venture, Salt Lake City, Utah.

Production: Production figures are shown in Table 10.

History: The history of the mine is discussed in the preceeding pages.

Development: The Bretz mine includes two principal areas of development nearly half a mile apart, known as the "east area workings" and the "west area workings" (see figure 65). All mining has been done by open pit, although some exploratory underground work was done. Ore has been mined from 6 different zones, the locations of which are marked by the east pit and west pit in the east area and pits "A", "B", "C", and "D" in the west area.

Geology: Rocks in the Bretz mine area include rhyolite flows and tuffs and thin-bedded shales and sandstones. Ore bodies apparently were formed only in the shales in the east area, but ore has been mined from both shales and tuffs in the west area. Masses of silicified tuff lie north of the mine workings. The east area workings lie along a northwest-trending fault. Pits "C" and "D" in the west area probably lie along a northwest extension of the same fault. Pits "B" and "A" are transected by a branch of this fault. The faults were probably the channelway for the ore-forming solutions and the solutions that silicified the rocks to the north.

In contrast to the Opalite mine deposit, practically all of the ore occurs in unsilicified shales and tuffs adjacent to masses of silicified rock. Cinnabar occurs as thin, discontinuous veinlets and fracture coatings in the shales and also as disseminations in the coarser sandstones and in the tuff. In places small lenses and boulders of opalite are scattered through the ore zone in pits "C" and "D." Some contain cinnabar, but because the rock is so hard and the cinnabar so finely divided this material is not amenable to treatment in the present plant. Finely disseminated pyrite occurs in most of the mineralized zone and in a few places, particularly in the tuffs, is concentrated enough to give the rocks a grayish-blue color. The mineral is much more widespread than cinnabar. Oxidation of the pyrite gives the rocks a typical limonite coloration which, with the silicification, serves as a guide to exploration.

East area workings: In the east area workings, the rocks south of the fault are mainly thin-bedded shales with occasional sandy layers. Some of the shales contain abundant angular to sub-rounded fragments of porous

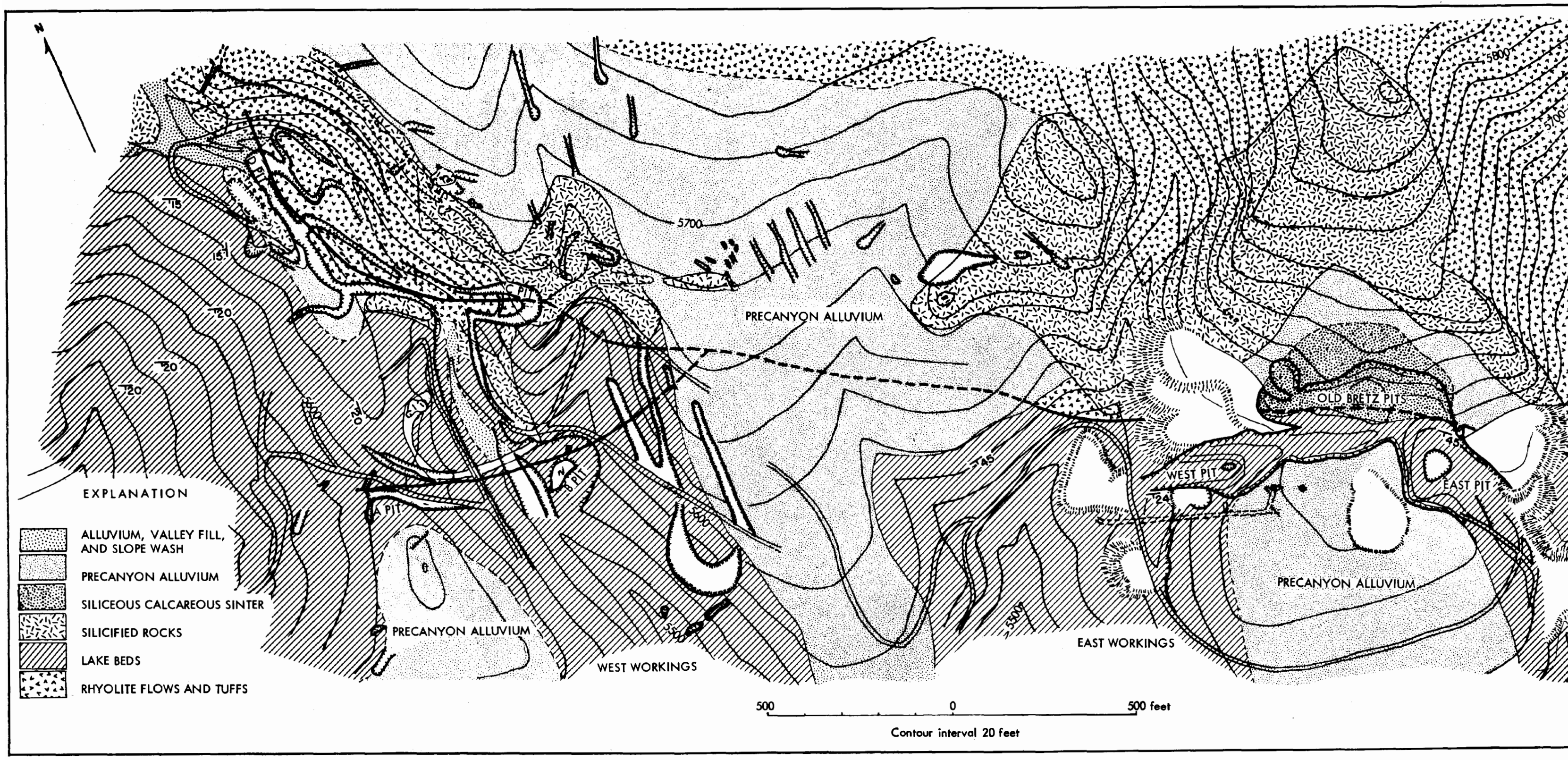


Figure 65. Geologic map of the Bretz mine. (Topography and geology adapted in part from Yates, 1942.)

chalcedony and occasionally rhyolite. The fragments range from pea size to about 2 inches across. Closely spaced bands of iron oxide roughly parallel the bedding in the shales. Silicified tuffs and rhyolite border the fault on the north. Within the fault zone the rocks are much broken and considerably altered. Ore deposition was apparently confined to the shales in the hanging wall of the fault.

A large body of siliceous calcareous sinter, exposed in the cut between the east and west pits, is said to have been intersected by a tunnel 75 feet below the rim of the cut. One exposure was seen to contain cinnabar loosely adhering to the walls of vugs. Exploratory drilling and sampling of the material indicates that it does not constitute ore.

No mining has been done in this area since the Bradley Mining Co. exhausted the two known ore bodies in 1936. Several old dumps of low-grade ore that were piled at the west edge of the workings were treated by the present operators during 1958-61.

West area workings: Ore has been mined from 4 pits in the west area workings (figure 65). Pits "A" and "B" are in soft, thin-bedded shales and in conglomeratic sandstone which underlies the shale. Pits "C" and "D" are in massive- to thick-bedded tuffs that in places contain coarse pumice lapilli. The fault along which the "C" and "D" ore bodies were formed is well exposed in the north end of the "D" pit, where it has swung around until it strikes N. 10° E.

STEENS-PUEBLO AREA

An abundance of small quicksilver deposits occurs in southern Harney County in a belt about 40 miles long and half a mile wide, extending northward from the Nevada state line along the lower eastern flanks and foothills of the Steens and Pueblo Mountains (figure 66). Total production from this area has been about 75 flasks of quicksilver.

General geology: A comprehensive report on the stratigraphy and structure of Steens Mountain was written by Fuller (1931). A preliminary investigation of the quicksilver deposits in both the Steens and Pueblo Mountains was made by Ross (1941). In 1943, a more detailed study of the deposits was made by Williams and Compton (1953). Both of the latter reports contain geologic maps of the eastern flanks of the southern half of the range where the quicksilver deposits occur.

Mining activity has been small in the area since the Williams and Compton report was compiled and, although most of the deposits were re-examined by the present writer, little new information was obtained.

The Steens and Pueblo Mountains form a north-trending range nearly 100 miles long and 25 miles in maximum width. Broadly speaking, the two mountains are parts of an enormous fault block tilted gently westward and bounded on the east for much of its length by a high, precipitous fault scarp. Two ages of rock assemblages are exposed along the scarp. Pre-Tertiary metamorphic rocks, largely metavolcanics and acid to intermediate plutonic rocks, occupy the eastern flank of the Pueblo Mountains. Overlying these older rocks and composing the bulk of both the Steens and Pueblo Mountains is a varied succession of Tertiary volcanic rocks, including the Pike Creek Volcanic Series, the Steens Mountain Volcanic Series, and the Steens Basalt. The lower eastern flanks of the Pueblo Mountains, for a distance of about 15 miles, are covered by alluvial deposits which are younger than the youngest lavas, but older than the lacustrine and alluvial deposits on the floor of Alvord Valley (figure 66).

The major north-trending faults separating the Steens-Pueblo Mountain range from its counterpart, the Alvord graben, are buried beneath the alluvium bordering the range. However, countless subsidiary fractures are exposed farther west along the range front. Most of these minor fractures roughly parallel the range, but a few trend northwestward, particularly those traversing the broad lowland northwest of Fields.

The quicksilver deposits are associated with these subsidiary fractures. There are two distinct types of quicksilver deposits in the area. These can be delineated to a certain extent geographically. At the northern end of the quicksilver belt (figure 66) cinnabar occurs in small pockets, seams, and fracture coatings associated with narrow fault and breccia zones in rhyolitic and dacitic rocks of the Pike Creek Volcanic Series. The chief representatives of this type of deposit are the Steens Mountain mine and the Alexander mine, which together have produced more quicksilver than all of the other deposits in the district.

The second type of deposit occurs between Andrews and Denio. Here minor amounts of cinnabar, and schwatzite and other copper minerals, are erratically distributed along narrow elongated reefs of brecciated and silicified Tertiary lavas, mainly andesite of the Steens Mountain Volcanic Series. These reefs were formed by silicification of the andesite along small faults. Being more resistant than the enclosing rocks, the reefs form prominent ridges as much as 25 feet wide and half a mile or more in length. A few of the reef deposits are in metamorphosed

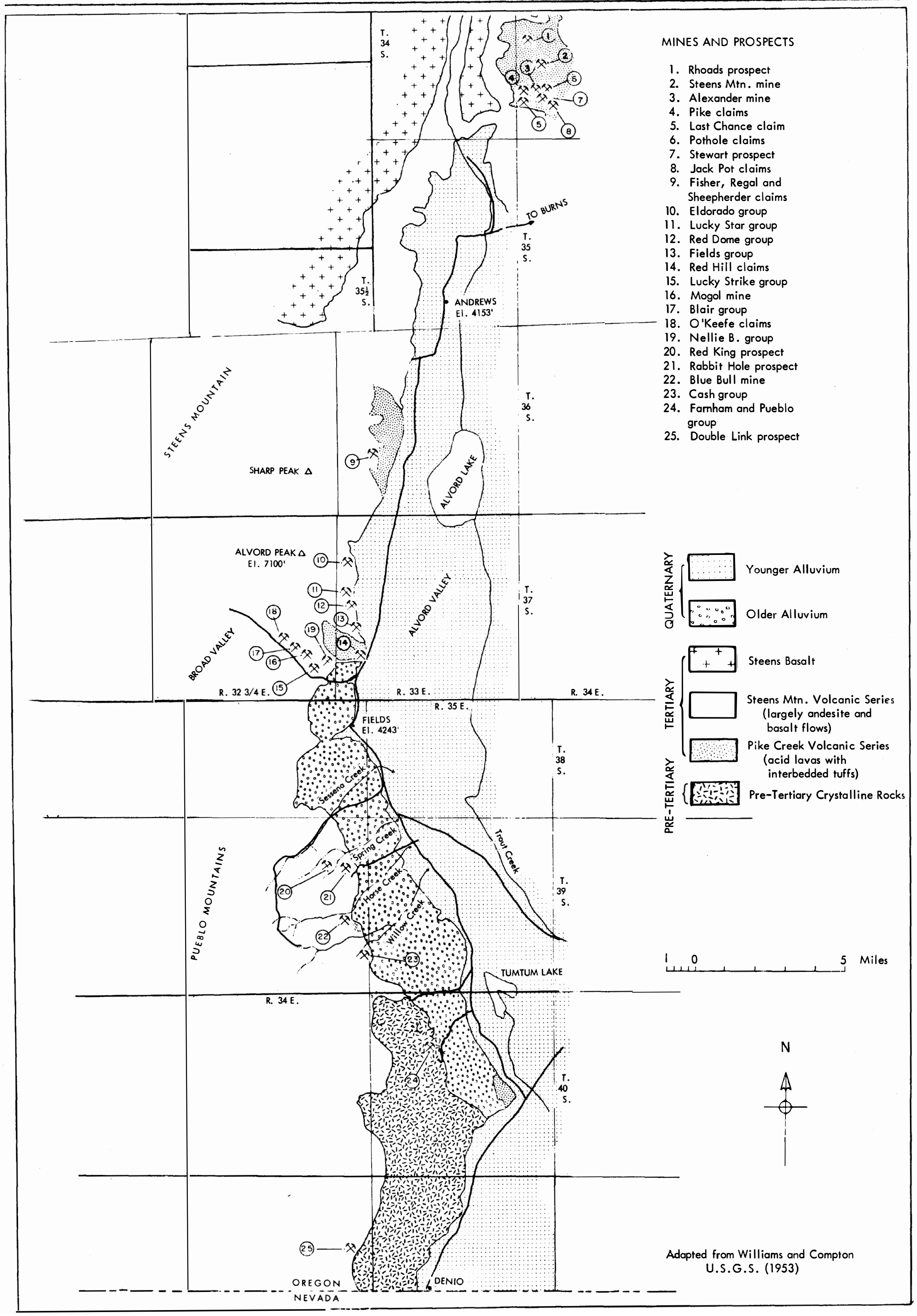


Figure 66. Geologic map of the Steens-Pueblo area, showing distribution of the quicksilver occurrences.

volcanics and sediments of pre-Tertiary age. The only deposit of the reef type known to have produced more than a flask of quicksilver is the Mogul, which yielded 30 flasks from a small pocket of open breccia ore. Adjacent to the reefs, where the rocks have been altered mainly to clays and limonite, ore minerals appear to be absent or too low in concentration for profitable exploitation. As stated by Williams and Compton (1953, p. 46):

> "The reefs are well exposed over long distances, and erosion has bared them to considerable depth, yet none of the surface indications hold promise of important reserves. Admittedly, exploration thus far has been almost wholly by shallow pits and trenches, the deepest working extending no more than 160 feet below the surface. Development, however, has been sufficient, where the showings are most favorable, to indicate that large deposits of high-grade ore are not likely to be discovered. Likewise, though a little cinnabar is disseminated in the soft kaolinized rocks bordering some of the reefs, supplies of low-grade ore adequate to justify large-scale operations are definitely not in sight and cannot be expected."

RHOADS PROSPECT

Location: Sec. 18 (?), T. 34 S., R. 34 E., on the south wall of Pike Creek canyon, about 200 yards above creek level and about one mile from the canyon mouth.

Owner: Lester Rhoads, Andrews, Oregon.

Production: None.

General description: The prospect was discovered by the owner in early 1958. Two small opencuts about 20 feet apart have been dug by hand along the contact between rhyolite of the Pike Creek Volcanic Series and the eastern edge of a basalt dike. The dike is about 40 feet wide and trends nearly north. Both the basalt and rhyolite have been fractured through widths of 2 feet and mildly altered. The rhyolite has been silicified locally. A little barite was observed. Cinnabar was seen in both of the cuts as fine disseminations in the altered basalt and as thin coatings along fractures in the rhyolite. Of three samples taken for assay none contained more than the equivalent of 1 pound quicksilver per ton.

STEENS MOUNTAIN MINE

Location: Secs. 19 and 20, T. 34 S., R. 34 E., on the north bank of Toughey Creek about 1 mile by trail north of the Alexander mine.

Owner: R. A. Officer and R. W. White, Andrews, Oregon.

Production: 36 flasks.

History and development: The property was located by Glenn Stephenson and Bert Roark in early 1938 and shortly thereafter was leased to Horse Heaven Mines, Inc. This company performed the bulk of the existing development work. In late 1940 the property reverted to Stephenson, R. A. Officer, and Efeard Bradley, who, during 1941 and 1942, produced 26 flasks of quicksilver with a small retort. The present owners produced 10 flasks in 1961. The principal development is an adit containing 270 feet of drifts and crosscuts, two short winzes, and an underhand stope (figure 67). Several trenches and pits are scattered about the surface.

Geology: The workings cut flow-banded rhyolite of the Pike Creek Volcanic Series. The banding is somewhat variable in attitude but in most places strikes northwest. Parting parallel to the banding is common. Cinnabar mineralization is related to two sets of fractures, one trending N. 20° E., and the other N. 20° to 30°W.

The adit cuts at a very small angle across a series of short disconnected fractures that strike N. 20° E. and dip steeply east. Some of these fractures contain thin seams not over 3 inches wide of cinnabar-bearing clay gouge, which in places has been silicified. Little cinnabar is presently visible, but according to Ross (1941, p. 250) 1,800 pounds of ore from a series of these stringers near the adit portal yielded 6 flasks of quicksilver.

The 30-foot underhand stope and adjacent 10-foot winze in the northwest drift were sunk along a narrow fault zone that strikes N. 20° to 30° W. and dips 65° to 70° E. Along the fault the rhyolite has been brecciated, partially altered to clay and limonite, and locally silicified through a width of 6 to 12 inches. Cinnabar occurs as coatings on breccia fragments and as fine crystals in small masses of clay and limonite. A few flasks of

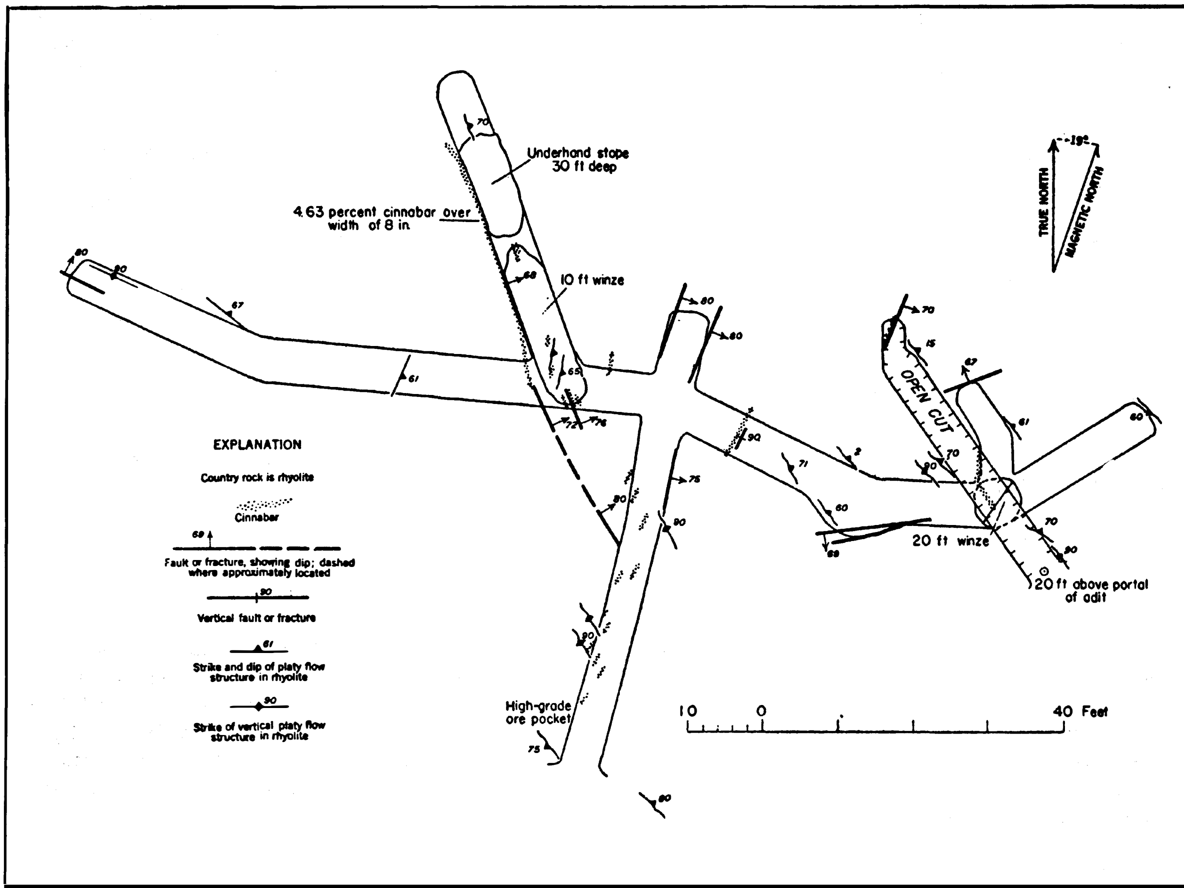


Figure 67. Geologic map of the Steens Mountain mine. (Reprinted from Williams and Compton, 1953).

quicksilver were recovered from a high-grade lens near the top of the underhand stope.

A small amount of ore was also mined from the winze in the east branch of the adit and also from an opencut on the surface directly above. Here the cinnabar was scattered along discontinuous fractures of the N. 20° to 30° W. trend.

ALEXANDER MINE

Location: NE$\frac{1}{4}$ sec. 30, T. 34 S., R. 34 E. on the broad divide between Indian and Toughey Creeks. A dirt road leads up Indian Creek about 2 miles, then turns north to the mine.

Owners: Harry Alexander and Donald Alexander, Andrews, Oregon.

Production: 6 flasks recorded; probably a few more produced.

History and development: Development of this property was begun by the present owners in 1941. A retort was installed and production of 6 flasks was recorded in 1941-42. According to the owners, several more flasks were produced prior to 1946. Workings include a branching adit about 250 feet long, two inclined shafts 30 feet and 50 feet deep respectively, and an opencut 40 feet long (see figure 68). There is a small cabin and tool shed on the property. The retort has been dismantled.

Geology: The country rocks are rhyolites of the Pike Creek Volcanic Series intruded by a basalt dike. The workings explore a fault zone that, though variable, has an overall trend of N. 10° E. and dips 65° to 80° E. The lower adit drifts along the fault for about 150 feet. Here the fault cuts both the rhyolite and basalt as shown

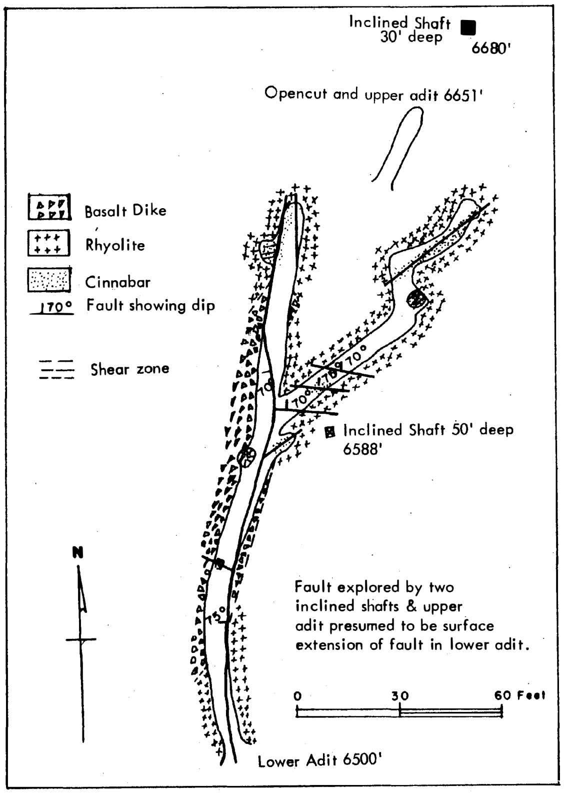


Figure 68. Geologic map of the Alexander mine.

on figure 68. Both the rhyolite and basalt have been brecciated and seams of gouge have developed along some of the fractures. In places, particularly in the rhyolite, the breccia has been strongly silicified. The northeast branch of the adit intersects several small faults of diverse trends. The last 30 feet drifts along a nearly vertical fault zone about 8 inches wide. Places where cinnabar was observed in the adit are shown in figure 68. Most of the cinnabar coats fractures that lie at an angle to the main fault.

In the two inclined shafts and opencut on the hillside above the adit, the fault cuts only rhyolite and interbedded tuff and is somewhat wider. Most of the ore produced by the mine came from these workings. Here the fault zone contains from 18 inches to about 5 feet of coarse, rubbly breccia. Brecciated chalcedony and fragments of silicified rhyolite are in places cemented to the footwall of the zone. Cinnabar occurs in 4-inch seams of sticky, iron-stained clay and as films on fracture surfaces.

PIKE CLAIM

Location: Sec. 30, T. 34 S., R. 34 E., about a third of a mile southwest of the Alexander mine.

Owner: Andrew Shull, Andrews, Oregon.

Production: None.

General description: Two opencuts about 10 feet long explore the contact between rhyolite and the southwest extension of the basalt dike at the Alexander mine. The contact strikes N. 20° W. and dips 70° W. The dike has been altered largely to clay and limonite and in places contains thin, irregular veinlets of chalcedony and a little cinnabar. The rhyolite within a foot from the dike has been fractured and silicified, and some of the fracture surfaces are glazed with silica. Traces of cinnabar and native quicksilver occur along fractures in the altered rhyolite.

LAST CHANCE CLAIMS

Location: Sec. 30, T. 34 S., R. 34 E., on the south wall of Indian Creek about three-quarters of a mile southwest of the Alexander mine.

Owners: Unknown.

Production: None.

General description: A short adit and two opencuts explore a 2- to 3-foot wide zone of brecciated rhyolite that lies along a fault trending N. 60° to 65° W. and dipping steeply southwest. The prospect lies near the same basalt dike that extends northeastward through the Indian Creek and Alexander properties. The broken fragments of rhyolite along the fault have been recemented by chalcedony. Quartz and calcite are also present. Cinnabar is sparsely distributed along fractures in the breccia.

POT HOLE CLAIMS

Location: Sec. 29, T. 34 S., R. 34 E., about half a mile east of the Alexander mine.

Owners: Harry Alexander and Donald Alexander, Andrews, Oregon.

Production: None.

General description: The area is underlain by boulders of brecciated rhyolite in which the fragments have been firmly recemented by silica. Crystalline cinnabar occurs along fractures in some of the boulders. The boulders are scattered over an area several hundred feet across, but since development is limited to a few scattered pits, the source of the boulders and their abundance could not be determined.

STEWART PROSPECT

Other name: Aile Rouge Claim.

Location: SE¼ sec. 30, T. 34 S., R. 34 E., on the crest of a low ridge north of Indian Creek and a quarter of a mile east of the Alexander mine.

Owner: Unknown.

Production: None.

General description: Most of the development work was done by W.B. Stewart during 1942 and early 1943. In late 1942 he installed two retort tubes 12 inches in diameter by 10 feet long. These were little used and were later moved to the Alexander mine. Workings consist principally of a short opencut leading to an inclined shaft about 40 feet deep. The opencut follows a narrow fracture zone trending N. 40° W. and dipping steeply north. The shaft is inclined 40° to the N. 25° E. and follows a fault zone about 20 inches wide containing kaolinized and limonitized breccia lying between clearly defined walls of massive biotite dacite. The fault zone dips about 80° E. Crystalline cinnabar is associated with a 1-inch veinlet of red ocher in the lower part of the shaft, and cinnabar has been panned from several small pockets along both of the fault zones.

JACK POT CLAIMS

Location: Sec. 30, T. 34 S., R. 34 E., about half a mile southeast of the Alexander mine.

Owner: Glenn Stephenson.

Production: None.

History and development: The prospect was discovered by Glenn Stephenson in December 1954, and is developed by a 106-foot crosscut adit and several shallow hand-dug trenches.

Geology: The area is underlain by a series of rhyolite flows and interbedded tuffs of the Pike Creek Volcanic Series. The trenches are distributed along a small silicified shear zone about 2 feet wide that trends about N. 30° W. and is nearly vertical. The rhyolite in the shear zone has been bleached almost white in contrast to the bluish gray of the wall rocks.

Chalcedony veinlets not over a few feet in length and rarely more than three-quarters of an inch in width fill several of the fractures. Cinnabar is associated with these veinlets. In some places it is finely divided and intimately mixed with the silica, giving it a reddish color. In other places, the veinlets are barren but cinnabar occurs as disseminated flecks in the adjacent silicified rhyolite. The 106-foot adit was driven in an attempt to crosscut the fault zone but stops short of its downward projection. The crosscut follows a fault along which the rocks are soft and almost completely altered to clay and limonite. Mere traces of cinnabar have been found along this fault.

FISHER, REGAL and SHEEPHERDER CLAIMS

Location: Secs. 32, 29, and 17, T. 36 S., R. 33 E., about 9 miles north of Fields and one mile west of the Fields-Andrews road.

Owner: Steens Mountain Mining Co., Andrews, Oregon.

Production: A few pounds.

History and development: Development of cinnabar occurrences in the area was begun by Clay T. Fisher in the late 1930's and was continued intermittently through the early 1940's by Fisher, members of the Doan family, and Warren McLean. Workings include several cuts, pits, and a 40-foot adit. In 1940 about 20 pounds of quicksilver was recovered from $1\frac{1}{2}$ tons of selected ore carried to the Rabbit Hole prospect and retorted. The present owners acquired the property through relocation.

Geology: The area is underlain by dacite and andesite flows and tuffs and basalt. A broad series of discontinuous reefs extends for nearly 2 miles along the southwest slope of a ridge that is shaped like a spear pointed southeast. The ridge is a fault block bounded on the east and west by faults that converge to the south. Quicksilver occurrences are confined to the reefs. In the pit from which the ore retorted in 1940 was mined, the ore zone is from 3 to 5 feet wide and consists of brecciated, kaolinized, and silicified andesite cut by narrow veinlets of chalcedony that contain a little schwatzite and cinnabar along with chalcopyrite, malachite, azurite, and chrysocolla. Little of this material remains. Quicksilver minerals were observed elsewhere but nowhere did there appear to be more than a few hundred pounds of low-grade ore available.

ELDORADO, LUCKY STAR, RED DOME, and FIELDS LODE GROUPS

Location: West edge of T. 37 S., R. 33 E. These several contiguous groups of many claims extend northward in a belt from the north edge of Red Hill for about 4 miles along the low foothills bordering the west edge of Alvord Valley.

Owner: Harry Alexander and Don Alexander, Andrews, Oregon.

Production: None.

History and development: The Eldorado group was first located by Warren McLean, Andrew Shull, and Ben O'Keefe in 1938; the Lucky Star group by Ike Kusisto and Andrew Shull in 1939; and the Fields Lode group by Ike Kusisto in 1939. The original locators of the Red Dome claims are unknown. The claims were relocated by the present owners during the later 1950's. Prospect workings along the belt are limited to scattered pits and opencuts except on the Lucky Star group, where an inclined shaft 45 feet deep has been sunk.

Geology: An almost continuous series of sub-parallel and branching reefs and veins extend nearly the full length of the claims. The belt has an overall northerly trend, but the individual reefs branch and converge through a wide range.

Workings on the Eldorado group of claims at the north end of the zone explore a siliceous reef which forms the sharp crest of the first low ridge west of the Fields-Andrews road. The reef trends northward and is about 700 feet long and 20 feet wide. Near its mid-point a thin branching reef trends southeast, pitching toward the floor of the valley. Another reef similarly occupies the crest of the next ridge south. Cinnabar has been found at various places along the northern reef. It occurs intimately mixed in chalcedony and occasionally on fracture surfaces. It is locally associated with schwatzite and chrysocolla. Near the highest point of the reef, a 10-foot shaft has been sunk along a series of roughly parallel fractures which dip steeply west. Many of the fractures are filled with chalcedony or limonite. One 4-inch vein of chalcedony shows evidence of having replaced the host andesite. This vein contains small quantities of finely divided cinnabar.

The Lucky Star group of claims includes an inclined shaft which, when the property was last visited in 1959, was about 45 feet deep with a short drift to the north near its foot. One of the main reefs crossing the property lies about 350 feet east of the shaft and trends N. 10° W. The shaft, inclined 65° to the southeast, has been sunk on a poorly defined shear zone which branches from the mid-part of the reef and trends N. 50° W. About 10 tons of material containing barite, copper oxides, and cinnabar in a gangue of brecciated, kaolinized, limonitized, and silicified andesite were stock-piled while the shaft was being sunk. Several specimens of this material have been selected in which barite rhombs a quarter of an inch long are encrusted with azurite, malachite, and cinnabar. Harry Alexander reports that the stockpile of ore was recovered from small lenses encountered in the shaft from its collar to the drift level. Above the drift level only traces of copper oxides and cinnabar are presently visible. On the drift level a small amount of the material remains in the walls and in the back. A few minute specks of schwatzite occur in the material.

Occasional bunches of barite, malachite, azurite, and a little schwatzite and cinnabar are to be found in the siliceous reef east of the shaft. About 300 yards east of the main reef an 8-foot shaft has been sunk on a series of parallel fractures cutting soft, kaolinized porphyritic andesite. Narrow lenses of silica carry blotches of cinnabar and copper oxides. Approximately a quarter of a mile northward along the east edge of the reef is an opencut about 12 feet long which exposes parallel fractures striking N. 80° W. and dipping 60° N. One of the fractures is filled with a $1\frac{1}{2}$-inch vein of calcite. About 2 tons of secondary copper ore has been recovered from the opencut.

Farther south on the Red Dome claims a number of pits explore 3 reefs which cross the property. One of the reefs strikes N. 10° W., the other two strike N. 60° W. In a few places the fractures contain narrow veinlets of chalcedony accompanied by barite and locally are stained with chrysocolla and azurite. Traces of cinnabar were seen mixed with limonite in cavities and as "paint" along fractures.

At the southern end of the belt on the Fields Lode group of claims no quicksilver minerals were observed.

RED HILL CLAIMS

Location: Sec. 30, T. 37 S., R. 33 E., on the east edge of Red Hill about 3 miles north of Fields.

Owner: Harry Blair, Fields.

Production: None.

General description: The prospects in this area were located by Ben O'Keefe and members of the Doan family in the early 1940's. Workings consist of scattered trenches and pits, some of which expose small fracture zones of northeasterly trend cutting the rhyolite-dacite that composes Red Hill. Along the fracture zones the rock is locally sheared, and in places is altered to clays and limonite and in others is silicified. Cinnabar coats fractures in some of the silicified rocks, but nowhere were significant quantities of the mineral observed.

LUCKY STRIKE CLAIMS

Location: $S\frac{1}{2}$ sec. 25, T. 37 S., R. 32 3/4 E., about 4 miles northeast of Fields and one mile southeast along the same series of reefs which pass through the Mogul mine and the Blair and O'Keefe claims.

Owners: Unknown.

Production: None.

General description: This property was located in 1929 by Pete Cachenaut, Ora and Robert Doan. Development consists of two shafts, 12 feet and 15 feet deep respectively, and scattered pits and trenches. Many prominent reefs of silicified andesite, most of which trend N. 50° to 60° W., are scattered through the area. The intervening rocks are extensively altered. One shaft is near the end of a prominent reef. Here cinnabar coats fractures in mildly silicified lava. The other shaft, which is about 700 feet to the southeast, exposes cinnabar along fractures in lava that has been largely altered to clay and limonite. Elsewhere no cinnabar was seen.

MOGUL MINE

Location: Sec. 26, T. 37 S., R. 32 3/4 E., 4 miles northwest of Fields and half a mile north of the Fields-Frenchglen road.

Production: 30 flasks.

History and development: The four claims of the Mogul group were located by C. M. Doan and Pete Cachenaut in August 1939. Roy H. Elliott of San Francisco leased the property in early 1941 and developed the mine to essentially its present status and produced 20 flasks of quicksilver prior to relinquishing his lease in February 1942. During February and March of that year, C. M. and R. E. Doan recovered 10 additional flasks of quicksilver.

The Mogul mine is developed principally by two inclined shafts and workings on three levels (see figure 69). The discovery shaft, collared in the mildly altered lavas forming the northeast or hanging wall of the reef and sunk on an angle of about 45°, penetrated the hanging wall of the reef at a depth of about 110 feet below its outcrop. Drifting was done on the 120-foot level to develop a small ore body. An inclined raise was driven up the footwall of the reef to the surface. It served as the main access and haulage way and was later sunk to the 180-foot level, where a small amount of drifting and crosscutting was done.

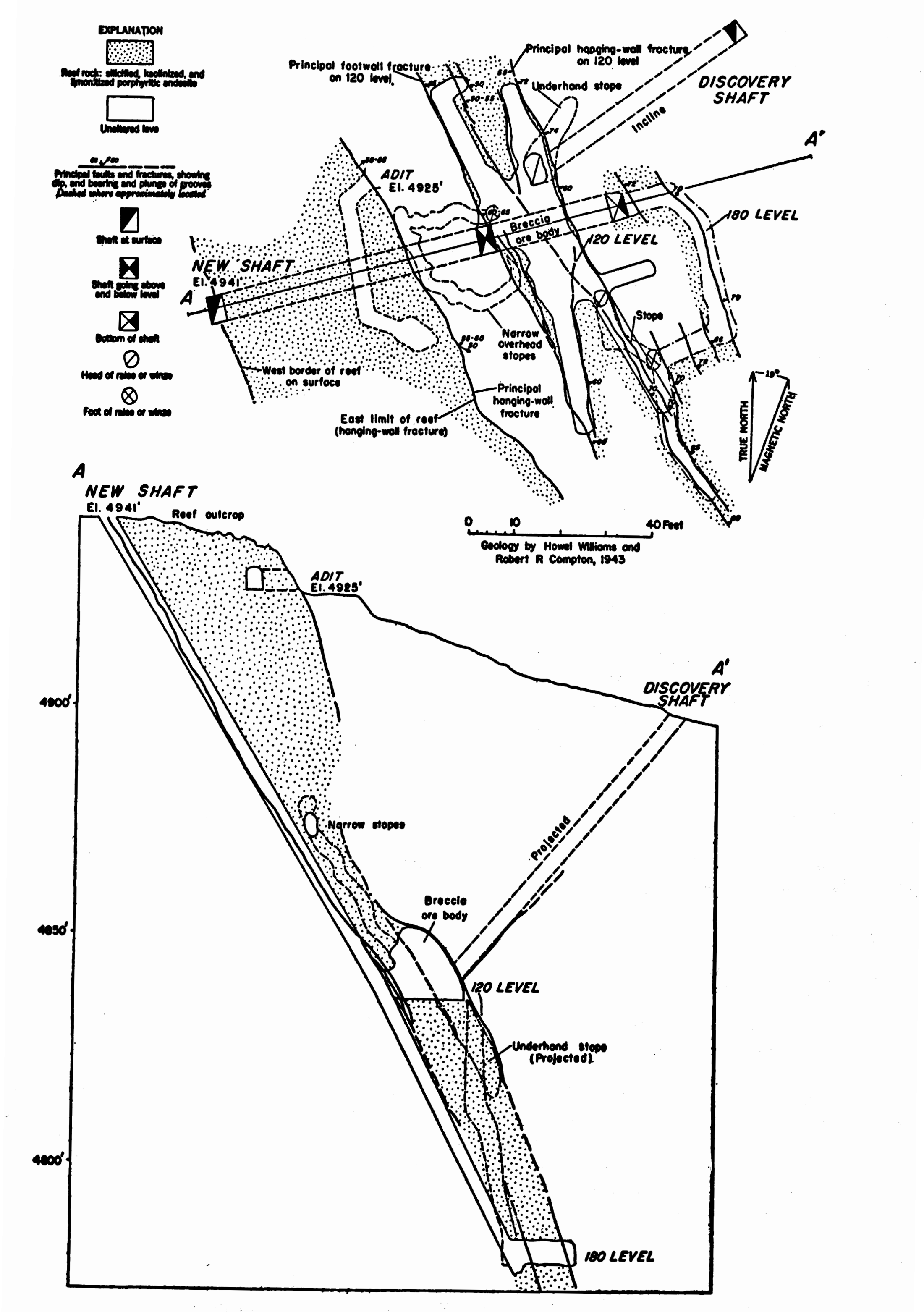


Figure 69. Geologic map of the Mogul mine. (Reprinted from Williams and Compton, 1953).

Geology: The reef explored by the workings trends N. 35° W., dips 50° to 60° E. It is composed principally of sheared, silicified, kaolinized, and limonitized porphyritic andesite and is about 25 to 30 feet thick. Most of the many fractures exposed throughout the workings approximately parallel the trend of the reef. However, on the 120-foot level the principal hanging wall fracture is markedly flatter and at one point two other fractures converge beneath it to form a small pocket of open-fault breccia in which the principal ore body of the mine was formed. Ore has been mined from a stope about 30 feet long, 15 feet wide, and 20 feet high. In addition, small irregular stopes and winzes follow narrow shoots of mineralized breccia that lead away from the pocket for a few tens of feet. A small amount of ore was also mined on the 180-foot level from a 3-foot-wide zone along the hanging wall fracture.

In contrast to the other reef-type deposits in the area, the only ore mineral recognized in the Mogul mine is cinnabar. It occurs mainly in veinlets of barite.

BLAIR GROUP

Location: N½ sec. 26, T. 37 S., R. 32 3/4 E. about half a mile northwest of the Mogul mine.

Owner: Rube Blair, Fields, Oregon.

Production: None.

History and development: The prospect was located by the owner in 1940. Development consists of two adits, 25 feet and 12 feet long respectively; a corkscrew-shaped shaft 12 feet deep with a 12-foot drift from its foot; and two opencuts.

Geology: The workings are scattered along a reef that trends N. 50° W. This, and an apparently barren reef lying about 800 feet farther north, are part of the series of reefs that passes through the Mogul mine area and continues on to the northwest through the O'Keefe claims. The shaft follows a prominent shear striking about N. 35° W. and dipping steeply to the southwest. Traces of cinnabar "paint" occur along fractures, but secondary veinlets of opal-chalcedony are rare. The shorter adit also contains cinnabar "paint" along several slickensided fracture planes, but the rock shows little silicification. The longer adit contains a lense of opalite 8 inches in maximum width but locally pinching to almost nothing. According to a department file report, a sample taken in 1939 across 2 feet of the shear zone, including this lens, assayed 14 pounds of quicksilver per ton.

O'KEEFE CLAIMS

Location: NW¼ sec. 23, T. 37 S., R. 32 3/4 E., about one mile northwest of the Mogul mine and about half a mile northwest of the Blair claims.

Owner: Unknown.

Production: None.

History and development: Development of the O'Keefe claims, most of it done around 1940 by Ben O'Keefe, includes several shallow pits and bulldozer trenches.

Geology: Two poorly exposed belts of sheared kaolinized and locally silicified andesite trend northwest across the property. The two fracture zones are the northwesternmost exposure of the series of reefs that contain the Mogul mine. On the O'Keefe claims the reefs do not form prominent outcrops. Some of the cuts and trenches expose stringers and lenses of chalcedony and silicified breccias which rarely attain one foot in width. In a few places cinnabar occurs as fine dispersions and as fracture coatings in the opalite, but representative assays would be very low. A little barite, schwatzite, chalcopyrite, malachite, and chrysocolla are also present.

NELLIE B. GROUP

Former names: Crimson Rose, White Pick, and Blue Boy groups.

Location: Sec. 25, T. 37 S., R. 32 3/4 E. About one mile east of the Mogul mine.

Owners: Fred Ladd and Nellie B. Ladd.

Production: None.

History and development: Much of the development work on these claims was done by Cris Purvis, members of the Doan family, D. W. Wheeler, and C. Sturgeon during the 1930's and early 1940's. In 1956 the present owners staked a large group of claims covering most of the old workings. A number of short adits, bulldozer trenches, and pits are scattered through the area.

Geology: The claims enclose a broad series of reefs that lie at a slight angle to those that pass through the Lucky Strike, Mogul, Blair, and O'Keefe properties on the opposite or southwest side of the draw. The workings are distributed along a ridge that trends N. 15° W. Near its southeastern end the crest of the ridge is marked by a prominent reef from which smaller reefs branch and diverge. Toward the north, the main reef feathers out into a broad series of smaller reefs about 150 feet wide.

Near the south end of the ridge an adit about 100 feet long has been driven into the west slope, apparently in an attempt to cut the main reef at depth. The adit cuts only kaolinized and locally softened andesite. About 200 feet north along the crest of the ridge a small pit in the reef exposes a little schwatzite, malachite, and azurite associated with a series of narrow fractures filled with chalcedony. Farther on along the ridge crest a shaft 40 feet deep has been sunk in mildly altered lava. Rock on the dump shows an occasional speck of schwatzite and pyrite. At the north end of the ridge are several pits, trenches, and a short adit. In one of the trenches small amounts of schwatzite, cinnabar, and malachite were seen.

RED KING PROSPECT

Location: S½ sec. 11, T. 39 S., R. 34 E., near the head of the south fork of Spring Creek and about 5 miles by road west of the Fields-Denio road. A dirt access road about one mile in length leaves the Sesena Creek road about 4 miles west of the highway.

Owner: Andrew Shull.

Production: None.

History and development: Development of the prospect was begun by Glenn Stephenson, Andrew Shull, and Bert Roark in April 1939. Early development consisted of 3 shallow shafts, an adit about 176 feet long, and several shallow pits. Since 1954, when Shull acquired the property, more than 300 linear feet of bulldozer trenching has been done.

Geology: The prospect workings explore cinnabar showings found in and along the edges of a reef of brecciated and silicified andesite that trends N. 20° W. and dips 50° E. Two shallow shafts about 190 feet apart have been sunk in the reef. Each shaft exposes a small lens of schwatzite and chalcopyrite in a quartz-rich gangue. The sulfides have been partly oxidized to azurite, malachite, limonite, and cinnabar. A 17-foot shaft lying about 50 feet east of the reef exposes barren kaolinized andesites.

According to Stephenson, the adit was driven westward for about 100 feet on a gentle incline to intersect the reef at a depth of about 50 feet. After intersecting the footwall, a drift was driven 75 feet southward through the wet, clayey material adjacent to the reef. Because of the large amount of water encountered along the reef, the work was soon abandoned. The inclined tunnel is now caved to within 25 feet of the portal.

RABBIT HOLE PROSPECT

Location: Sec. 12, T. 39 S., R. 34 E.

Owner: Andrew Shull, Andrews, Oregon.

Production: About one flask, not recorded.

History and development: The Rabbit Hole prospect was located by Ora Doan, C. M. Doan, and D. E. Wheeler in 1940. During that year about one flask of quicksilver was produced from 3 or 4 tons of sorted ore. Workings consist of a 63-foot inclined shaft with a 30-foot drift on the 48-foot level, a 25-foot adit, and several small opencuts and trenches. A two-tube inclined retort remains on the property.

Geology: The rocks are andesite and tuffs of the Steens Mountain Volcanic Series. The shaft and connecting drift explore the junction of two reefs. They follow a poorly defined, nearly vertical zone of silicification 4 inches to 4 feet wide that strikes N. 40° W. The adit about 200 feet southeast of the shaft was probably started with the intention of intersecting the zone at depth, but the work was not completed. No cinnabar was seen in the shaft, although the mineral occurs in a few fragments of opalized andesite on the dump.

BLUE BULL MINE

Location: Sec. 24, T. 39 S., R. 34 E., near the crest of the ridge immediately south of Horse Creek.

Owners: Claude Wright and Vern Bossuot.

Production: None.

History and development: The Blue Bull prospect was located by M. M. and Ora Doan in August 1929. Development consists of a 45-foot inclined shaft with a 40-foot drift on the 20-foot level.

Geology: The prospect workings are contained in a small exposure of pre-Tertiary meta-andesite, which is overlain to the east by Plio-Pleistocene alluvium and to the west by Tertiary basalt. A Tertiary(?) rhyolite dike is exposed about 100 feet north of the shaft. The shaft and connecting drift follow a 3-inch to 15-inch vein of fractured opal-chalcedony that strikes N. 10° E., dips 55° to 65° E., and in places contains a little schwatzite, malachite, azurite, chrysocolla, and cinnabar. Some narrower branching veinlets are also similarly mineralized.

CASH GROUP

Location: Sec. 25, T. 39 S., R. 34 E., on the north side of the south fork of Willow Creek.

Owner: Unknown.

Production: None.

General description: The prospect was discovered by M. M. Doan in 1931. Workings include an adit 130 feet long and scattered pits. The rocks are andesite and tuffs of the Steens Mountain Volcanic Series cut by a prominent north-trending reef that dips 25° to 40° E. The adit trends N. 70° W. toward the reef, cutting for 110 feet through altered and softened andesites. For its last 20 feet the adit penetrates silicified tuffaceous shales and sandstones showing a little copper stain along fractures. Pyrite, chalcopyrite, and copper oxides are present in a few places along the reef, but no quicksilver minerals were observed.

FARNHAM and PUEBLO GROUPS

Location: Secs. 8 and 17, T. 40 S., R. 35 E., on the east face of Pueblo Mountains.

Owner: Unknown.

Production: A few hundred pounds; not recorded.

General description: These adjoining properties are gold and copper prospects which were developed to their present state between 1919 and 1939. A few hundred pounds of quicksilver are said to have been recovered from the Farnham ground, which is the northermost of the two properties. Parts of an old gold mill remain.

DOUBLE LINK PROSPECT

Location: Sec. 13, T. 41 S., R. 34 E., on Denio Creek about 3 miles west of Denio.

Owners: Vestus Tiller and Myron Woodley, Baker, Oregon.

Production: None.

History and development: The property, originally located and held for many years by Jack Brady, was relocated by J. B. Fine and B. T. Fiscal in 1940. The present owners acquired it during the 1950's. Development includes two short adits, a shallow shaft, and several opencuts.

Geology: Workings are scattered along a poorly defined zone of shearing and alteration cutting Tertiary andesites and basalts within a few hundred feet of their contact with pre-Tertiary rocks. The mineralized zone, which contains occasional veinlets and small lenses of chalcedony and inconspicuous ribs of silicified rock enclosed in kaolinized lavas, is traceable along Denio Creek in a northwesterly direction for nearly half a mile. Near the northwest end of the mineralized belt, on the west bank of the creek, an adit 50 feet long has been driven roughly N. 35° W. along a narrow fracture zone filled with broken and silicified andesite containing irregular veinlets and small lenses of opal and chalcedony. The zone ranges in thickness from a few inches to nearly 2 feet. At the adit portal the footwall of the fracture zone is crystalline basalt containing occasional plagioclase laths an inch or more in length. Its contact with the porphyritic andesite of the hanging wall dips 70° N. Fractures in the andesite dip 45° and 60° N. A little cinnabar occurs as coatings on fracture surfaces in the silicified andesite and as faint dispersions in the opal-chalcedony matrix. A sample taken near the face of the adit assayed 1.0 pounds quicksilver per ton. No copper-bearing minerals were detected. On the surface the zone dies out about 250 feet northwest of the adit portal.

About 100 yards southeast of the adit on the east bank of the creek, a trench and 26-foot adit expose altered and locally silicified lavas cut by thin veinlets of quartz and chalcedony. Minor amounts of cinnabar, malachite, and chrysocolla, and very little schwatzite are locally present on fracture surfaces.

About 300 yards farther to the southeast, a shaft 35 feet deep follows a zone of fracturing and silicification that trends N. 55° W. and dips 65° E. to nearly vertical. Thin veinlets of chalcedony cutting the silicified lavas contain traces of cinnabar.

ISOLATED QUICKSILVER PROSPECTS

VALLEY VIEW PROSPECT

Location: Sec. 11, T. 23 S., R. 33 E., in Harney County, about 14 miles by dirt road northwest of Crane.

Owner: Don Robbins.

Production: None.

General description: The prospect was discovered in 1941 by Aubrey Harkey and L. B. Tudor. Several pits and small trenches are distributed on the crest and upper flanks of a long, low hill rising about 250 feet above the eastern edge of Harney Valley. The country rocks are undifferentiated rhyolitic lavas, tuffs, and tuffaceous sediments of Tertiary age. In scattered places these rocks have been hydrothermally altered to clays and irregular bouldery masses and veinlets of opal and chalcedony. Many "geodes" have been removed from the surrounding area by rock collectors. Cinnabar occurs near the crest of the hill as faint dispersions in the opal-chalcedony and as minor impregnations in the adjacent altered rocks, but nowhere have economically significant quantities of the mineral been found.

WOODSON LONG PROSPECT

Location: Secs. 10 and 11, T. 21 S., R. 36 E., in Harney County, on the crest and northwest slope of the northeast-trending ridge about a quarter of a mile south of the junction of Riverside Road with U.S. highway 20.

Owners: Woodson C. Long, Allen J. Long, and associates.

Production: None.

History and development: The prospect was discovered by the owners about 1953. The property has since been developed by more than a dozen dozer trenches scattered about the crest and northwestern slopes of the ridge. Following the writer's visit, a homemade furnace was installed a short distance east of the area.

Geology: The country rocks consist of tuffs and lake beds of Tertiary age. The crest of the ridge is occupied in part by a reef of brecciated and silicified rock. The reef apparently lies along a fault zone several hundred feet long trending N. 60° E. and presumably nearly vertical. To the northeast, beyond a slight depression in the ridge, the fault zone is marked by several siliceous sub-parallel ribs trending N. 40° to 50° E. and dipping 50° to 60° S. The lake beds north of the fault zone are considerably fractured and limonite veinlets are common. Most of the development work has been done along the northwest slope of the hill adjacent to the rib where the lake beds have been fractured, partially altered, locally silicified, and veined with limonite. One large sample taken from the cut immediately north of the reef assayed 1.2 pounds of quicksilver per ton. A similar sample from the next lower cut assayed 0.9 pounds per ton. The owners claimed to have obtained several samples from surface exposures which assayed between 2 and 14 pounds per ton.

DUNCAN PROSPECT

Location: Sec. 26, T. 23 S., R. 29 E. in Harney County, about 2 miles north of U. S. highway 20 from a point about 5 miles west of Hines.

Owner: Unknown.

Production: None.

General description: The property was first worked for gold, then abandoned. In 1939 cinnabar was discovered and an option was taken by Robert M. Duncan and G. Earl Hagey. The prospect has been idle since the early 1940's. Development consists of several caved cuts and a shaft said to be about 25 feet deep and to contain a 20-foot crosscut to the east from its foot.

The country rocks are gently eastward-dipping acidic tuffs and flows. Cinnabar mineralization is associated with small bodies of opalite. Conditions responsible for the localization of the mineralizing solutions are obscure.

HORSE HEAD MOUNTAIN PROSPECT

Location: Secs. 30 and 31, T. 27 S., R. 25 E., on the north slope of Horse Head Mountain about 10 miles east of Wagontire.

Owner: Fred Mewhinney and Arthur Johnson, Lakeview, Oregon.

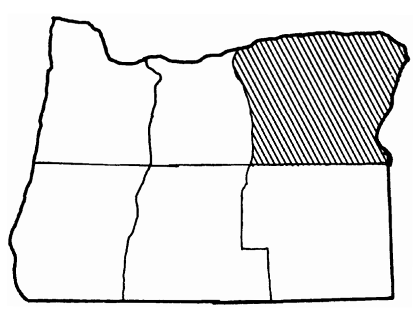
Production: None.

General description: N. V. Peterson, department geologist, who visited the property in 1958, reports that shallow hand-dug pits expose cinnabar in an area about 15 feet in diameter in a northeast-trending zone of opalized tuff. The mineralized opalite is finely brecciated. A wide variety of pyroclastics and flows, probably of the Danforth Formation, make up the surrounding rocks. Samples assaying 12 pounds of quicksilver per ton have been taken, but very little ore of this grade is visible.

PART II DESCRIPTIONS OF THE QUICKSILVER DEPOSITS

CHAPTER 6

NORTHEASTERN OREGON



Chapter 6. NORTHEASTERN OREGON

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CHAPTER 6

Northeastern Oregon

Northeastern Oregon, as shown in figure 70, is bounded on the west by Morrow and Grant Counties and on the south by the 44th parallel. All of the quicksilver occurrences lie in the southern part of the region in Grant, Baker, and Malheur Counties. Quicksilver has long been known in this part of the state (Lindgren, 1901), but no important deposits have yet been developed. The only production has come from the Roba-Westfall mine in the Murderers Creek area in Grant County (fig. 70). The Cinnabar Mountain mine in Grant County, the Paramount prospect in the Greenhorn area, and the Morton prospect in the Mormon Basin-Clarks Creek area are said to have produced small but unrecorded amounts of quicksilver.

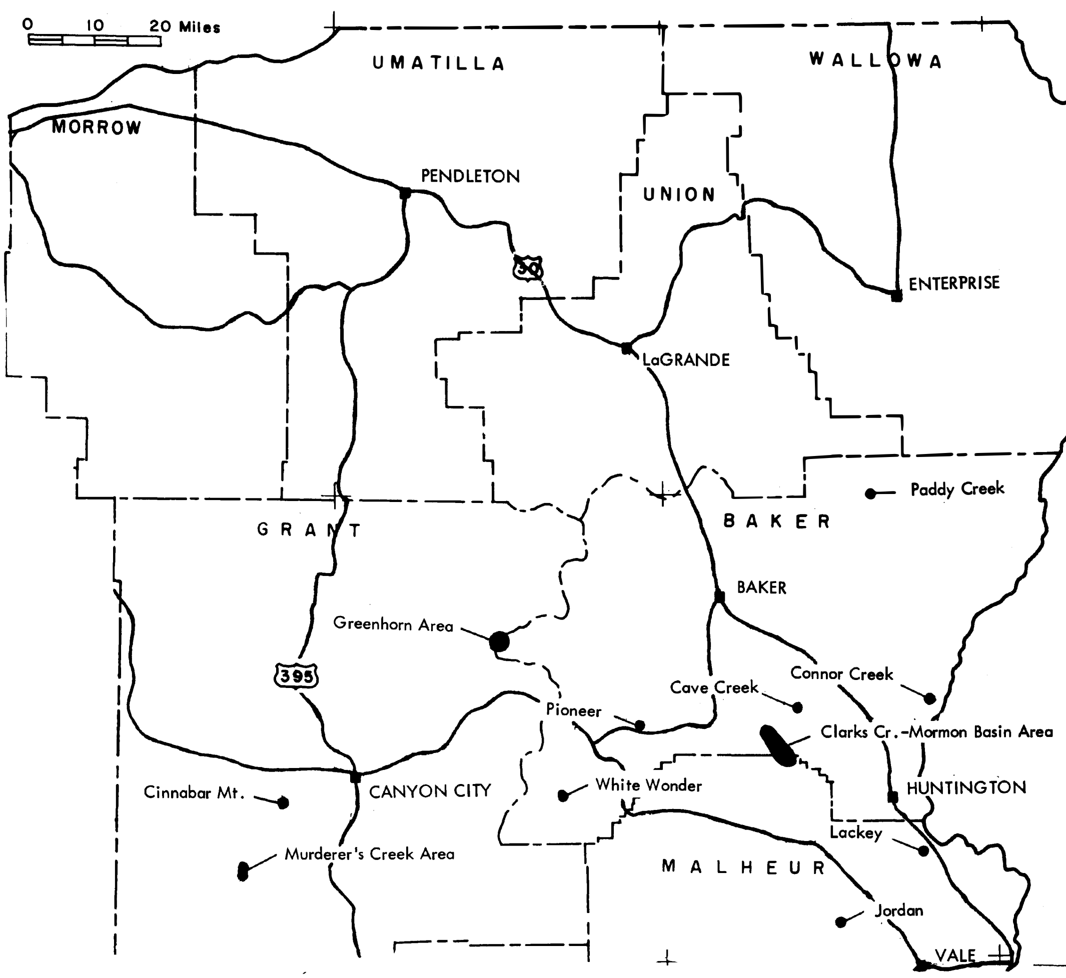

Figure 70. Index map of northeastern Oregon showing distribution of the quicksilver occurrences.

General Geologic Setting

All of the known quicksilver occurrences lie within the Blue Mountains geomorphic province. This complex region of mountains, canyons, plateaus, and basins is made up of a wide variety of rock types ranging in age from Paleozoic to Recent. A core of Cretaceous granitic rock is intrusive into folded, and in places metamorphosed, marine sediments, greenstones, and basic intrusives that range in age from Devonian to Cretaceous. Predominant among these are Triassic and Jurassic marine sedimentary rocks. In many places the pre-Tertiary rocks occur as islands surrounded by Tertiary lavas and pyroclastics. The Tertiary rocks are warped by large, broad folds, and major faults are common.

The majority of the quicksilver occurrences are in pre-Tertiary rocks in gold-producing districts. Although some appear to be genetically related to the gold-bearing quartz veins, most are of later origin. Only two occurrences, neither of which has been productive, have been found thus far in rocks of Tertiary age.

Descriptions of the Quicksilver Deposits

MURDERERS CREEK AREA

The Murderers Creek area includes two quicksilver deposits in the northwest corner of T. 16 S., R. 29 E., Grant County. The properties are about 38 miles southwest of John Day in a timbered and topographically rugged area.

The deposits occur in graywackes and shales mapped as of Upper Triassic age by Wallace and Calkins (1956). Recorded quicksilver production totals 8 flasks, all from the Roba-Westfall mine.

ROBA-WESTFALL PROSPECT

Other names: Deer Creek Prospect.

Location: SW$\frac{1}{4}$ sec. 6, T. 16 S., R. 29 E., about three-quarters of a mile north along the Burma Road from its junction with the Deer Creek road.

Owners: Lawrence H. Roba and V. M. Westfall, Canyon City, Oregon.

Production: 8 flasks recorded; possibly 12 produced.

History and development: The prospect was discovered by Roba in 1947. Four flasks were produced from development rock in 1951, three in 1952, and one in 1953. The ore was treated in a 30-inch by 8-foot rotary retort obtained from the Bear Creek mine in Jefferson County.

In early 1953 a DMEA development loan was obtained and under this contract, which expired in February 1955, the shaft was extended on an 80° incline to a depth of 125 feet and levels containing about 20, 195, and 100 feet of workings were turned at depths of 25, 60, and 120 feet respectively. No production has been made since 1953 and no work, other than assessment, has been done on the property since expiration of the DMEA contract. Water stands in the shaft to within 35 feet of the collar.

Geology: The country rocks are graywackes and shales of Upper Triassic age. Bedding planes commonly strike a few degrees east of north and dip 45° to 65° east. The rocks are cut by small faults and shear zones of diverse trend, although the majority lie within a few degrees of paralleling the bedding planes.

Cinnabar occurs both as disseminations in narrow gouge-filled fractures and as thin films along fractures and bedding planes. Several small cinnabar occurrences have been disclosed by panning and test pitting. The occurrences are aligned in a north-south direction for nearly 1,000 feet, which suggests that they may lie along a north-south fault or shear zone. However, exposures are too limited to prove this.

The shaft was sunk on one of the better showings and all of the ore treated was mined from the shaft above the 25-foot level. At the collar of the shaft the ore zone was about 18 inches wide. The shaft was collared in a zone of shattered and iron-stained shale. Below the 25-foot level the intensity of fracturing, oxidation, and cinnabar mineralization decreased. Workings on the 60-foot level include a drift about 110 feet long on a sinuous, branching shear zone that trends eastward and dips, generally, about 75° S. The fault and bordering shatter zone contain scattered pyrite but is almost barren of cinnabar.

BROADWAY PROSPECT

Other names: York prospect, Rannels prospect.

Location: Sec. 7, T. 16 S., R. 29 E., about 1½ miles by road southwest of the Roba-Westfall prospect.

Owners: Homer York, Prineville; Cecil Rannels, Canyon City; and Stanley Reffett, John Day.

Production: None recorded.

History and development: The prospect is said to have been discovered by Rannels and York about 1940; Reffett obtained an interest in recent years. About 2,000 pounds of ore from the shaft was treated at the Roba-Westfall retort during the early 1950's, and about 21 pounds of quicksilver were recovered. The property is developed by a shaft about 25 feet deep and several nearby dozer trenches and small pits.

Geology: The country rocks are Triassic graywackes, in which quartz is the predominate mineral but kaolinized feldspar is also present. The rocks are cut by fractures of diverse trend, the most prominent of which may be bedding planes striking N. 50° to 60° E. and dipping about 30° SE. Clay seams and lenses of brecciated and highly altered sandstone about a foot wide are common. Some of the fractures are filled with calcite. Two calcite veins are exposed in the shaft, one of which is about 1 foot wide, strikes northwest, and dips about 10° W. Present exposures do not indicate that the cinnabar mineralization is localized along any particular fault or shear zone. Cinnabar occurs in thin films on fracture surfaces over a rather wide area.

N. S. Wagner of the Department of Geology and Mineral Industries obtained two large samples from the shaft at a depth of 12 feet in 1953. One of the samples was selected from the numerous narrow seams, and the other consisted of large chunks of rocks with seam material along one face. Assay results were 5.90 pounds per ton for the selected fines and 4.50 pounds per ton for the lump rock, indicating that some cinnabar must be contained within the body of the rock itself in addition to that showing on the fractured surfaces. In the autumn of 1954, F. E. Lewis of the Horse Heaven mine took a 5-foot channel sample across the shaft at a depth of 20 feet. The sample assayed 2.4 pounds of quicksilver per ton.

GREENHORN AREA

Quicksilver occurrences in the Greenhorn gold-mining district lie in the central part of T. 10 S., R. 35 E. on both sides of the Baker-Grant County line from 0.5 mile to 2 miles southwest of the old town of Greenhorn, which was abandoned long ago except for summer residents. The area is topographically rugged, and it is inaccessible during winter months.

Rocks in the area consist mainly of upper Paleozoic meta-argillites and greenstones intruded by Mesozoic granodiorite and more or less serpentinized pyroxenites, dunites, and gabbros and by early Tertiary porphyritic dikes. The bedded rocks are tightly folded and intensely sheared. Quartz veins and lodes sometimes containing gold and silver and sulphides of iron, copper, lead, zinc, and silver are abundant in certain areas and are apparently associated with the early Tertiary dikes. Gold and silver are the only metals of commercial interest in the veins and lodes. Several of the gold mine and prospect workings southwest of Greenhorn are said to have encountered cinnabar, but the cinnabar is not contained in the gold-base metal-quartz veins or lodes. The Paramount prospect is the only place where exploitation of the cinnabar has been attempted and is the only deposit described here. Two gold mines said to contain cinnabar are the Diadem and IXL.

PARAMOUNT PROSPECT

Other name: Golden Fleece group.

Location: Sec. 16, T. 10 S., R. 35 E., about one mile west of Greenhorn.

Owner: I. Helmer, Baker, Oregon.

Production: None recorded; possibly 3 flasks.

History and development: Development of quicksilver occurrences on the claims was begun by Helmer about 25 years ago. In 1940 the property was leased to W. C. Fellows and Don Kempfer, who erected a Champion rotary retort and, according to Helmer, produced 3 flasks from selected ore. Only assessment work in scattered places has been done since.

The cinnabar occurrence is developed by an adit about 150 feet long and an adjacent opencut lying about 100 yards up the hill north of the retort. Workings of the old Banzett gold mine enter the slope a short distance below the retort. An adit northwest of the retort is said to explore a gold prospect.

The country rocks are serpentine, argillite, and greenstone with scattered exposures of unserpentinized ultrabasic rock. Disseminated chromite is exposed in a small pit about 200 yards northwest of the retort. Cinnabar mineralization occurs along the sheared contact between serpentine on the east and argillite and greenstone on the west. Part of the adit drifts along a fault trending N. 10° E. and dipping 55° E. A fault exposed in an opencut on the surface above strikes N. 20° W. and dips 50° W. Within the shear zone the rocks, particularly the argillite, are badly fractured and more or less altered to clays and limonite. Fractures are commonly filled with thin seams of limonitized gouge. Chalcedony veinlets, generally less than half an inch thick, are locally abundant and in places the fractured rocks are silicified.

Cinnabar occurs as scattered grains and impregnations in the chalcedony veinlets. It also occurs as small pockets and disseminations in gouge-like limonite-filled seams and as thin coatings on fracture surfaces. Cinnabar is sparsely distributed and obviously of very low grade except in small selected specimens.

MORMON BASIN-CLARKS CREEK AREA

The Mormon Basin-Clarks Creek area includes the Mormon Basin gold mining district, which straddles the Baker-Malheur County line and extends northwestward along Clarks Creek to its confluence with Burnt River. The area lies in Ts. 12 and 13 S., Rs. 41 and 42 E.

The country rocks include a broad assemblage of metamorphosed pre-Tertiary sediments and volcanics, altered ultrabasic intrusives, and granodiorite overlain in places by Tertiary lavas and pyroclastics (Gilluly, Reed, and Park, 1933).

The Mormon Basin gold mining district contains several inactive gold mines that attained considerable stature during the early days. Coincident with the working of gold placers, much cinnabar float was found, particularly in the area near the head of French Gulch, which drains southward, and Log Town Gulch, which drains northward, from the ridge dividing Baker and Malheur Counties. In later years attempts were made to locate the source of the float, and as a result cinnabar was found in place at the Quicksilver and Easy Money prospect and at the Morton prospect. No quicksilver production has been recorded from either.

During the late 1930's and early 1940's many claims and claim groups were located and considerable prospecting for quicksilver was done along the lower slopes of Clarks Creek to the north. It is said by local prospectors that scattered occurrences of cinnabar and a little native quicksilver were found in both pre-Tertiary metamorphic rocks and in Tertiary volcanics. Very little work was done in any one place and the locations of prospects reported to contain cinnabar are obscure and unknown to the writer. Only the better known prospects near the head of Clarks Creek and in the Mormon Basin district to the south are described below.

QUICKSILVER and EASY MONEY CLAIMS

Location: Sec. 11, T. 13 S., R. 41 E., near the head of Log Town Gulch.

Owner: Racey brothers, Hereford, Oregon.

Production: None.

General description: The prospect was owned and worked by a Mr. Longstreth during the 1920's. Little has been done since. Development includes an adit about 150 feet long and several cuts. The adit is caved and the cuts are sloughed.

The Metal Mines Handbook (Oregon Department of Geology and Mineral Industries, 1939, p. 81) reports that the country rock is a fine-grained diabase or gabbro intruded by hornblende trachy-andesite along which mineralization occurred. The rock is highly altered for a distance of at least 10 feet from the surface, and is soft and highly iron stained. Assays show a trace of cinnabar in the red material.

MORTON PROSPECT

Location: Secs. 18 and 19, T. 13 S., R. 42 E., near the head of French Gulch.

Owner: Mineral rights, Carl C. Morton; surface rights, Racey brothers, deeded land.

General description: A small cinnabar showing on the property has been developed by a shaft and several small pits, all of which are caved. The inclined shaft is said to have been about 20 feet deep. About 18 tons of ore recovered from the shaft and pits was concentrated at the old Humboldt gold mine mill. There is no record that the concentrates were retorted.

ISOLATED QUICKSILVER OCCURRENCES

CINNABAR MOUNTAIN MINE

Other names: Viewpoint prospect, Hacheney-Johnson prospect.

Location: SE$\frac{1}{4}$ sec. 18, T. 14 S., R. 30 E., in Grant County, on the northwest slope of Cinnabar Mountain about 5 miles airline southwest of Mount Vernon. A road leaving the John Day Highway about 2$\frac{1}{2}$ miles west of Mount Vernon extends up Riley Creek about 4 miles to the base of Cinnabar Mountain. The prospect is about 1 mile south and a little east of the end of the road, at an elevation of about 5,700 feet above sea level.

Owner: Unknown.

Production: None recorded.

History and development: Parks and Swartley (1916, p. 55-56) reported that the vein "was prospected in the early placer days and the best grade was retorted in crude appliances and used by the placer miners of Canyon City and vicinity in catching their gold in the riffles. The deposit was abandoned for many years following the decline of placer operations, but the high price of mercury in 1915-16 caused them to be relocated and some development has been done by drifting to search for commercial grades of cinnabar." In late 1936 the "Viewpoint" claim, which presumably covered the old workings, was located by F. C. Hacheney and H. J. Johnson. In 1937 development consisted of an adit tunnel 110 feet long, a shallow shaft, and several opencuts, as reported by D. K. MacKay (department mine-file report, 1937).

Geology: The country rocks consist of well-bedded siltstones and shales and massive fine-grained graywacke which Thayer (1956) places in the Upper Triassic. The beds strike about N. 50° W. and dip from 75° NE. to the vertical.

The deposit occurs in the zone of shearing along a fault trending N. 10° to 15° E. and extending, according to Thayer (1956) for several miles to the north and south. Two calcite veins about 200 feet apart and trending N. 15° E. are said to have been developed by the workings. These veins dip 60° or more to the west. The westernmost vein is about 6 feet wide where exposed at the collar of a caved shaft. The calcite here is barren of cinnabar and no cinnabar was seen on the dump. The only known occurrence of cinnabar in the area is contained in the easternmost vein, where it is exposed in a small opencut. Reportedly it was from this opencut that the early-day production was made. According to Mackay, the 110-foot tunnel was driven roughly parallel to, but in the wall rock east of the vein. Only thin calcite seams distributed throughout the country rock and containing no cinnabar were exposed.

WHITE WONDER PROSPECT

Location: SE$\frac{1}{4}$ sec. 35, T. 9 S., R. 35$\frac{1}{2}$ E., in Baker County, about one mile by road north and east of a point on the Whitney-Olive Lake road, 8.2 miles northwest of Whitney. The mine road passes near a small log cabin standing about 100 yards north of the Whitney-Olive Lake road. The total distance from Baker is about 45 miles.

Owners: Langdon Rand and Charles Mulkey.

Production: None.

History and development: The prospect was discovered and two claims, the White Wonder and Red Jacket, were located in the spring of 1942 by Charles Mulkey. A one-half interest in the claims was then deeded to Langdon Rand. Late in 1942 the property was optioned to "Bud" Van Kirk, lessee of the Cougar Independence mine, and Tom Lydon, his engineer. Three bulldozer trenches from 250 to 300 feet long and about 200 feet apart were cut in a north to northwesterly direction across the supposed course of the mineralized zone and a 12-foot shaft was sunk in the bottom of the middle trench. Since 1942, little other than annual assessment work has been done.

Geology: The area is thickly timbered and outcrops are scarce. The country rocks exposed in the trenches consist of, presumably, a narrow intra-canyon fill of light-colored Tertiary (?) tuffs elongated in a northeasterly direction and bounded on both sides by undifferentiated pre-Tertiary metavolcanics, metasediments, and a coarse-grained gabbroic rock. The tuffs, reaching a maximum width of about 80 feet in the middle trench, are relatively unaltered. Fine crystalline cinnabar, generally invisible in the hand specimen, can be panned from the tuffs in several places. No cinnabar has been found in the metamorphosed rocks.

In the middle trench, where the principal showing occurs, cinnabar is associated with a nearly vertical fault zone trending about N. 25° W. The fault zone is about 2 feet wide and contains much meal-like limonitized gouge and narrow seams of wet clay. Assays rarely exceed one pound quicksilver per ton.

PIONEER PROSPECT

Location: NE$\frac{1}{4}$ sec. 20 and NW$\frac{1}{4}$ sec. 19, T. 12 S., R. 38 E., in Baker County, in the low but rugged foothills flanking Burnt River valley on the north and about two miles west of Hereford. Wood Gulch crosses the property.

Owners: James Anderson, James Dickerson, Albert Smith, and Jack Pittman.

Production: None.

History and development: Owners of the property found cinnabar in the area in early 1958 as a concomitant of prospecting several scattered antimony occurrences. Most of the development work has been done in two areas about a quarter of a mile apart on opposite sides of Wood Gulch. On the east side of the gulch, development consists of three bulldozer trenches, a 15-foot shaft, and several small hand-dug pits. On the west side of Wood Gulch several small dozer trenches and test pits are scattered along the eastern periphery of a marshy meadow-like area occupied by a bog containing an active hot spring. The boggy area, which lies in the bottom of a draw, is several hundred feet wide and more than a quarter of a mile long. Most of the trenches were dug during the exploration of stibnite occurrences. "Pannings" of mud from a few places along the north edge of the bog contain crystalline cinnabar.

Geology: The area is underlain by dense, light-gray to buff colored porphyritic dacite of Tertiary age (Pardee, 1941). Workings on the east side of the gulch explore a nearly vertical fault trending roughly N.75°W. Between the walls of the fault which, as exposed in the shaft, are a maximum of about 3 feet apart, the rock has been broken into angular blocks ranging from a few inches to a foot or two in diameter. Alteration has been slight, consisting mainly of small clay lenses and narrow veinlets and incrustations of limonite. Many open spaces exist among the wedged fragments. Small amounts of both earthy and finely crystalline cinnabar are locally associated with the limonite. Several channel samples taken across the fractured zone averaged about 0.5 pounds quicksilver.

In another trench about 220 feet to the northwest, crystalline cinnabar is sparsely associated with thin clay and limonite-filled joint fractures the majority of which trend N. 20° W. and dip 37° E.

CAVE CREEK CINNABAR PROSPECT

Location: Secs. 4, 5, and 9, T. 12 S., R. 42 E., in Baker County, about 2½ miles up Cave Creek from its confluence with Burnt River.

Owners: Robert J. Hulin and Carl D. Bowman.

Production: None.

History and development: The prospect was located by the owners in 1959. Development consists of several hundred feet of bulldozer trenches and several shallow hand-dug pits. There is no equipment on the property.

Geology: The prospect occurs in the Burnt River Schist, consisting of a thick series of schists, phyllite, quartzite, and limestone of indefinite pre-Tertiary (possibly pre-Carboniferous) age. In the vicinity of the deposits the formation consists principally of greenstone schist with minor phyllite and quartzite and a lens of limestone. Principal partings in the schist strike N. 45° to N. 70° E. and dip 30° to 50° SE.

Small amounts of cinnabar have been found in several places along a fault trending N. 80° to 85° E. and dipping steeply south. The fault zone is traceable for at least half a mile. Toward its eastern end a prominent reef of silicified schist 40 feet wide and 20 feet high marks the crest of a ridge. The reef is cut by numerous veinlets of quartz and chalcedony, and locally the schist is almost completely silicified. Quantities of cinnabar can be panned from the soil in places along the slope immediately north of the eastern portion of the reef. The owners have been financially unable to explore the reef at depth.

A dozer cut and shallow pit about 100 feet beyond the east end of the reef exposes cinnabar occurring as fracture coatings on rock fragments contained in a rubbly mixture of broken and partially silicified schist intermixed with clays and limonite and cut by discontinuous silica veinlets. A number of samples taken by various individuals have assayed between 0.5 and 2.5 pounds of quicksilver per ton. A 10-foot channel sample from the northern edge of this exposure assayed 0.8 pounds per ton. A small trench at the east end of the reef exposes a thin veinlet of cinnabar in silcified schist. Near the mid-point of the reet a dozer cut about 50 feet in diameter exposes a rubbly, altered zone similar to that beyond the east end of the reef, although cinnabar is less plentiful. Within the more prominently exposed parts of the reef no cinnabar has yet been found. Although no ore has yet been procured from the property, the size of the fault zone and the quantity of cinnabar contained in the soil along the north edge of the reef may justify a limited amount of well-planned prospecting at depth.

JORDAN PROSPECT

Other name: Hope Butte prospect.

Location: E½ sec. 21, T. 17 S., R. 43 E., Malheur County, on the north slope of Hope Butte, 16 miles by road northwest of Vale and 4 miles north of the Bully Creek School.

Owners: B. E. and R. L. Jordan, Vale, Oregon.

Production: None.

History and development: The prospect was discovered by the owners in 1951, and in 1955 was leased to John Stringer and H. K. Riddle. In mid-1956 a DMEA loan was obtained by Riddle after approximately 4,600 linear feet of trenching and 850 feet of underground work in 3 adits had been done. Work completed under the DMEA contract consisted of 19 wagon drill holes for a total footage of 792.5 feet and 3 diamond drill holes for a total footage of 244 feet. The deepest holes were 93 feet and 136 feet respectively. Because of the fractured condition of the rocks, drilling was difficult and the sample recovery poor. An additional 2,500 linear feet of trenching was done mainly in the form of three northeast-trending parallel cuts less than 200 feet apart (Figure 71). Since expiration of the DMEA contract, little work has been done.

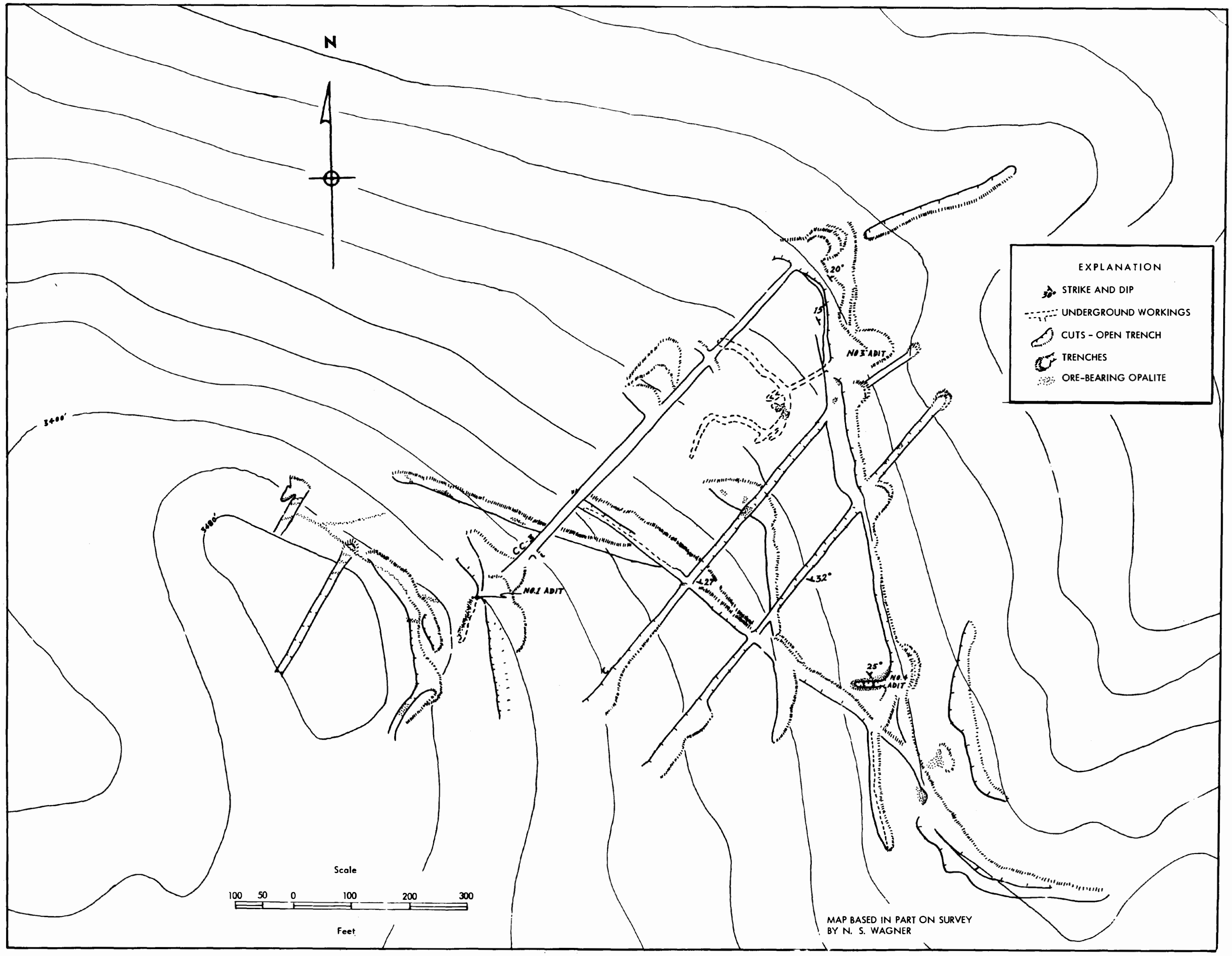

Figure 71. Plan of workings of the Jordan prospect.

Geology: The rocks underlying the upper parts of the prospect area consist mainly of buff to gray, iron-stained, and predominantly massive tuffs and probably a few flows of rhyolitic composition. Lower on the northern flank of the butte, tuffaceous pebble conglomerates, sandstones, and shales are interbedded with the tuffs. Small isolated outcrops of basalt occur in the surrounding area. Carlat (1954) has mapped the tuffs and lake beds as part of the Idaho Formation of Pliocene age and the basalts as part of the Owyhee Formation. Meager evidence gathered from scarce outcrops indicates that the tuffs and lake beds dip generally from 10° to 20° NE.

The tuffs and lake beds are cut by an intricate network of small fractures and at least one prominent northwest-trending fault. The fault zone passes near the crest of the butte and is crudely expressed topographically for more than a mile. Several opencuts and Adit No. 1 explore the zone near the crest of the Butte. A smaller fault of similar trend is exposed in Adit No. 3. Discontinuous opalized masses in both the tuffs and lake beds are erratically distributed over much of the upper part of the butte. The zones vary from narrow veinlets that are often closely grouped to veins and irregularly shaped pods or kidneys up to 10 feet wide. In length some of the larger veins extend for at least 200 feet, but most of them are much shorter. Openwork breccia is common in the opalized zone. Cinnabar occurs as an intimate mixture in the opalite and as void fillings and coatings in both the opalite and the adjacent altered tuffs and lake beds. Although samples containing one percent quicksilver have been taken from isolated places in this area, no minable concentrations of ore have yet been found. In Adit No. 3, containing about 690 feet of underground workings, 45 samples were taken during the DMEA program at intervals of 5 feet. The average quicksilver content of these samples was less than 2 pounds per ton. Very few of the samples contained as much as 3 pounds per ton.

LACKEY PROSPECT

Location: SE$\frac{1}{4}$ sec. 22, and NE$\frac{1}{4}$ sec. 27, T. 15 S., R. 45 E., Malheur County, about one mile south of the Huntington-Weiser branch of U. S. Highway 30.

Owner: Unknown.

Production: None.

General description: Five claims were located in 1941 and early 1942 by Fred and Allie Lackey, Dr. W. J. Weese, and George Sherard. The prospect has been explored by means of two inclined shafts 30 and 25 feet deep and several surface trenches. All these workings caved long ago.

Rocks in the area consist of lacustrine and fluviatile sediments of the undifferentiated Payette and Idaho Formations (Washburne 1911, p. 27). According to a departmental report by L. C. Richards (August 1942), cinnabar occurs as minor fracture fillings and as minute grains in clays. A 3-foot layer of clay exposed in one of the shafts assayed 0.5 pounds per ton. Gypsum was also noted in irregular veinlets 3 inches in width.

CONNOR CREEK PROSPECT

Location: SE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 34, T. 11 S., R. 43 E. on the east bank of Dry Creek about 0.7 mile north of its confluence with Connor Creek, in Baker County.

Owner: Frank Butchart, Portland.

Production: None.

Development and geology: Development of the prospect was started in 1940 by H.D. Lackey and was continued at intervals by various individuals and groups. It consists of a caved adit said to be about 100 feet long, an opencut about 100 feet long, a second adit about 30 feet long driven into the face of the opencut, and a bulldozer trench about 50 feet long. The longer adit was driven under the management of L. K. Requa during 1941. Development of the opencut was begun by Ken Steck and Lee Thorsen in 1947. During recent years, the cut was enlarged and the shorter adit driven by L. C. Richards and Marion Hewlett.

The prospect occurs in a small lenticular mass of altered gabbro or similar basic rock that intrudes schistose pre-Tertiary argillites. The gabbro has been altered almost entirely to magnesian carbonates and is locally impregnated with veinlets of an unidentified bright green mineral and occasional well-formed pyrite pseudomorphs.

The opencut and shorter adit penetrate blocky landslide debris along a steep, west-sloping hill and expose a fault zone striking N. 30° E., dipping 50° N., and containing from 1 to 3 feet of bluish-gray clay gouge. A small amount of cinnabar occurs along fracture surfaces in the hanging wall of the gouge, but none was seen in the gouge. A bulldozer trench cut across the projected dip of the vein a short distance north exposes the upper edge of a body of andesite intruded into argillite and greenstone. Because of insufficient exposure and the fracturing that has occurred along the edges of the andesite, it could not be determined if the cinnabar-bearing fault zone exposed in the opencut extends to this point. No cinnabar was detected in the andesite or along its edges.

PADDY CREEK PROSPECT

Location: S½ sec. 35, T. 6 S., R. 44 E., in Baker County, near the head of Paddy Creek and about half a mile north of the old Amalgamated gold mine.

Owner: Culley Trickle, Baker.

Production: None.

General description: Cinnabar is said to have been discovered by Trickle while he was exploring a gold prospect. The cinnabar occurs at creek level near the north end of a bulldozer trench about 100 feet long. The country rocks are altered and softened greenstones and metasediments of Triassic age. They dip about 30° NW., and in the vicinity of the trench are cut by many small fractures. The cinnabar occurs in a poorly exposed zone of brecciation, the attitude and width of which was not determinable. Both gold and cinnabar can be panned.

MISCELLANEOUS OCCURRENCES

There are a few quicksilver occurrences in northeastern Oregon about which very little is known. These are listed in table 11, but because of their minor importance they have been omitted from plate 1 (locality map of quicksilver deposits in Oregon). Some of the occurrences are of doubtful existence, but since they have been either reported to the department or included in the literature, all available information about them is tabulated here. The writer attempted to visit or in some way verify the existence of these reported occurrences, but could not confirm all of them.

Table 11. Miscellaneous Quicksilver Occurrences in Northeastern Oregon.

	Location				Character of Deposit	Development	Discovered	Information Source
	Sec.	T.	R.					
BAKER COUNTY								
Columbia Gold mine	5	9S	37E	On Fruit Ck. about 8 miles northeast of Sumpter.	Gold-quartz veins in black argillite. Cinnabar & schwatzite locally present.	One of Oregon's largest gold mines.		Lindgren (1901, p. 664)
Hiller Chrome-Cinnabar mine	9	14S	36E	On east flank of Barney Creek.	Altered peridotite impregnated with chalcedony & a little cinnabar.		Ed Hiller (prior to '40)	Ed Hiller, Unity, Oregon
Sumpter placer		9S	37E	On Cracker Creek.	Gold placer (2)			
GRANT COUNTY								
Dead Horse Creek prospect	30	14S	30E					(1)
Gray prospect	29	13S	28E					(1)
Haight prospect	33	14S	31E					(1)
Red Boy mine	10	9S	35E	5 miles west of Granite.	Gold-quartz veins in argillite. Cinnabar & native quicksilver locally present.	One of Oregon's largest gold mines.		Lindgren (1901, p. 683)
Susanville placer					Gold placer with occasional quartz-cinnabar float.			Lindgren (1901, p. 708)
Wild Cat Basin prospect	N½	15S	33E	Near head middle fork of Canyon Creek.			R.L.Martin ('27)	George Dustin, John Day, Oregon

(1) Listed by Frederick (1945) no other information available.
(2) Frederick (1945) indicates that quicksilver minerals are also present. No assays or other information available.

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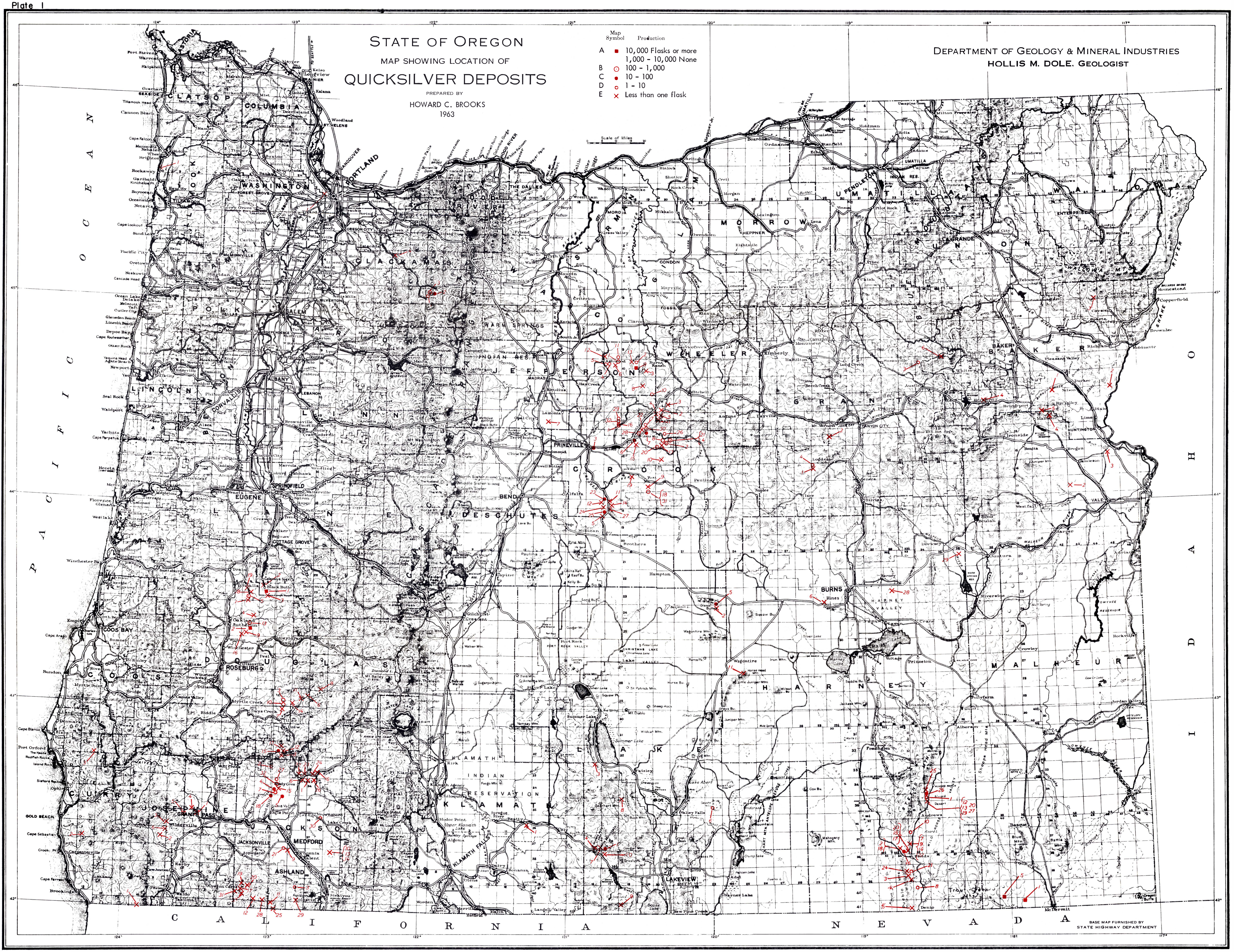
Index of Quicksilver Areas, Mines, and Prospects

Plate I



Map No.	Mine or Prospect Name	Production Class
	BAKER COUNTY	
1.	Cave Creek Prospect	E
2.	Connor Creek Prospect	E
3.	Paddy Creek Prospect	E
4.	Pioneer Prospect	E
5.	Quicksilver & Easy Money Claims	E
6.	White Wonder Prospect	E
	CLACKAMAS COUNTY	
1.	Ames Mine	D
2.	Kiggins Mine	C
3.	Nisbet Mine	B
4.	North Fork Claims	E
	CROOK COUNTY	
1.	Allison Prospect	D
2.	Amity Mine	B
3.	Barnes Butte Mine	C
4.	Blue Ridge Mine	B
5.	Botz Prospect	E
6.	Byram-Oscar Mine	C
7.	Champion Mine	C
8.	Devils Food Prospect	D
9.	Eickemeyer Prospect	E
10.	Gray Prairie Prospect	E
11.	Hudson Prospect	E
12.	Ideal Prospect	E
13.	Independent Prospect	E
14.	Israel Prospect	E
15.	Johnson Prospect	E
16.	Kidnap Springs Prospect	D
17.	Little Hay Creek Prospect	D
18.	Maury Mountain Mine	B
19.	Moore Prospect	E
20.	Mother Lode Mine	B
21.	Number One Mine (Blue Ridge) (4)	
22.	Ontko Prospect	E
23.	Oronogo Mine	D
24.	Pinkey Prospect	E
25.	Platner Mine	C
26.	Round Mountain Prospect	D
27.	Salt Creek Prospect	E
28.	Staley Mine	B
29.	Strickland Butte Mine	D
30.	Taylor Ranch Mine	B
31.	Towner Mine	B
32.	Watson Prospect	D
	CURRY COUNTY	
1.	Diamond Creek Placers	E
2.	Red Flat Placers	E
3.	Harmony Prospect	E
	DOUGLAS COUNTY	
1.	Allen Prospect	E
2.	Bonanza Mine	A
3.	Buena Vista Mine	D
4.	Butte Prospects	E
5.	Elkhead Mine	B
6.	Gopher Mine	E
7.	James R. Group	E
8.	Laurel Group	E
9.	Longbrake Prospect	E
10.	Maud S. Mine	D
11.	Mills Prospect	E
12.	Nivinson Prospect	E
13.	Nonpareil Mine	B
14.	Poor Boy Prospect	E
15.	Red Cloud Mine	C
16.	Sutherland Prospect	E
17.	Thomason Group	E
18.	Thompson Prospect	E
19.	Wilson Prospect	E
	GRANT COUNTY	
1.	Broadway Prospect	E
2.	Cinnabar Mountain Mine	D
3.	Paramount Prospect	D
4.	Roba Westfall Prospect	D
	HARNEY COUNTY	
1.	Alexander Mine	D
2.	Blair Group	E
3.	Blue Bull Mine	E
4.	Cash Group	E
5.	Double Link Prospect	E
6.	Duncan Prospect	E
7.	Eldorado Group	E
8.	Farnham and Pueblo Groups	D
9.	Fields Lode Group	E
10.	Fisher Regal and Sheepherder Claims	D
11.	Horse Head Mountain Prospect	E
12.	Jack Pot Claims	E
13.	Last Chance Claims	E
14.	Lucky Star Group	E
15.	Lucky Strike Claims	E
16.	Mogul Mine	C
17.	Nellie B. Group	E
18.	O'Keefe Claims	E
19.	Pike Claim	E
20.	Pot Hole Claims	E
21.	Rabbit Hole	D
22.	Red Dome Group	E
23.	Red Hill Claims	E
24.	Red King Prospect	E
25.	Rhoads Prospect	E
26.	Steens Mountain Mine	C
27.	Stewart Prospect	E
28.	Valley View Prospect	E
29.	Woodson Long Prospect	E
	JACKSON COUNTY	
1.	Ash Prospects	E
2.	Bonita Mine	D
3.	Brick Pile Prospect	D
4.	Chisholm Property	C
5.	Cinnabar Mountain Mine	C
6.	Donaldson Prospect	E
7.	Dave Force Mine	D
8.	Elkhorn Claims	E
9.	Forty-Nine Diggings	E
10.	Hopeless Prospect	E
11.	Jeldness and Rhodes	E
12.	Juby Lode	E
13.	Lucky 13 Prospect	E
14.	Mammoth Prospect	E
15.	Meadows Prospect	E
16.	Midnight Prospect	E
17.	Mocks Gulch Prospect	E
18.	Mountain King Mine	C
19.	Murphy Prospect	E
20.	Palmer Creek Prospect	E
21.	Phillips Mine	D
22.	Pitt View Prospect	E
23.	Poole and Pence Prospects	E
24.	Rayome Prospect	E
25.	Red Star Prospect	E
26.	Rogue River Prospect	E
27.	Roxana Mine	D
28.	Ruby Quicksilver Prospect	E
29.	Siskiyou Gap Prospect	E
30.	Stanley and Brown Prospects	D
31.	Steamboat Cinnabar Prospect	E
32.	War Eagle Mine	B
33.	Woodpecker Group	E
	JEFFERSON COUNTY	
1.	Axehandle Mine	B
2.	Big Muddy Cinnabar Prospect	D
3.	Cherry Creek Prospect	E
4.	Custer Young Prospect	D
5.	Good Chance Prospect	D
6.	Good Earth Prospect	E
7.	Gray Butte Prospect	E
8.	Horse Creek Prospect	E
9.	Horse Heaven Mine	A
10.	Humboldt Mine	D
11.	Red Jacket Mine	D
12.	Redskin Prospect	E
13.	Roark & Lowrey Prospect	E
	JOSEPHINE COUNTY	
1.	Empire Mine	E
2.	Last Chance Group	E
3.	Lightning Ridge Prospect	E
4.	Pickett Creek Mine	E
5.	Red Ledge Cinnabar	E
6.	Swede Basin Prospect	E
	KLAMATH COUNTY	
1.	Givan Ranch Prospect	E
	LAKE COUNTY	
1.	Angel Peak Mine	C
2.	Cascade Property	E
3.	Currier Prospect	E
4.	Crone Prospect	E
5.	Glass Buttes Mine	C
6.	Gray Prospect	D
7.	Manzanita Group	E
8.	O'Leary Prospect	E
9.	Pinto Group	E
10.	Rosalite Prospect	E
	LANE COUNTY	
1.	Black Butte Mine	A
2.	Hobart Butte	E
3.	Woodard Prospects	E
	MALHEUR COUNTY	
1.	Bretz Mine	A
2.	Jordan Prospect	E
3.	Lackey Prospect	E
4.	Morton Prospect	E
5.	Opalite Mine	A
	MULTNOMAH COUNTY	
1.	Portland Tunnel	E
	TILLAMOOK COUNTY	
1.	Watrous Prospect	E
	WHEELER COUNTY	
1.	Bear Claims	E
2.	Beaver Guard Prospect	E
3.	McTimmonds Ranch Prospect	E
4.	Mercury King Prospect	E
5.	Ribelin Prospect	E

PLATE 2. TABLE SHOWING ANNUAL PRODUCTION OF INDIVIDUAL QUICKSILVER MINES IN OREGON 1882 - 1961

			1961	1960	1959	1958	1957	1956	1955	1954	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938	1937	1936
CLACKAMAS COUNTY																												
Ames mine	7	7																										
Kiggins mine	71	71																					4	5	9	5		12
Nisbet mine	102	102																			3	3	9	57	5	7	18	
CROOK COUNTY																												
Allison prospect		3																								(3)		
Amity mine	332	409						7	46	76				5	6	(2)	2	(8)	4	1		2						
Barnes Butte mine	29	29																				8	19	2				
Blue Ridge mine	259	259							8	6										3	9	81		54	8	30	15	2
Byram-Oscar mine	63	63																										50
Champion mine	37	37																					5			2	5	6
Devils Food prospect		1																										
Kidnap Spring prospect		5																								(5)		
Little Hay Creek prospect		3																										(3)
Maury Mountain mine	575	589		2			1	3	36		45	8	9					21	66	36	14	4	17	24	24	55	30	101
Mother Lode mine	352	352		5	6					2											4	2		60	35			47
Number One mine [a]	12	42																						7	4			
Oronogo mine	6	13																					(4)	6			(3)	
Platner mine	24	45				1				6												(16)	7	15#				
Round Mountain prospect	2	2						2																				
Staley mine	448	509																				26	75	14	15	16	95	119
Strickland Butte mine	10	10																					1	9				
Taylor Ranch mine	248	248																			8	63	95	82				
Towner mine	181	181					1	1	4	6	8	11						12	5	2	2	10	14	30	31	9	6	27
Watson prospect	1	1																						1				
DOUGLAS COUNTY																												
Bonanza mine	39,488	39,488		183	722	795	1434	977	604	383	593	846	1160		1161	1351	1182	1261	2350	2426	3294	3940	5548	5733	2199	1183	148	
Buena Vista mine	9	9																			3							
Elkhead mine	124	124[b]	1				5																					
Nonpareil mine	90	90[c]																										
Red Cloud mine	6	63																					(4)	6			(8)	
GRANT COUNTY																												
Paramount prospect		3																						(3)				
Roba Westfall prospect	8	8									1	3	4															
HARNEY COUNTY																												
Alexander mine	6	6																				5	1					
Fisher group		1																						(1)				
Mogul mine	30	30																				10	20					
Rabbit Hole prospect		1																						(1)				
Steens Mountain mine	36	36	10																			5	21					
Undistributed	2	2															1	1										
JACKSON COUNTY																												
Bonita mine	1	7		1																					←(6)→			
Chisholm property	31	31																										
Cinnabar Mountain mine	38	63																			2	25		11	(10)			
Mountain King mine	95	95																			75	20						
Roxana mine	7	7						1															6					
Stanley and Brown prospects		3																										
War Eagle mine	657	657								3	1							4	1		1	5		1	13		8	3
JEFFERSON COUNTY																												
Axehandle mine	150	152							(2)												43	44	24	4	6	23	6	
Custer Young prospect		2																								(2)		
Good Chance prospect		2																								(2)		
Horse Heaven mine	17,214	17,216				201	749	744	349					(2)					74	674	911	1243	1940	1626	1668	2190	2107	1781
Humboldt mine	5	5																								2	3	
LAKE COUNTY																												
Angel Peak mine	34	34			16	18																						
Glass Buttes mine	93	93	1			2	87	3																				
Gray prospect	3	3																				1	2					
LANE COUNTY																												
Black Butte mine	16,074	16,074					297	45					4								38	208	292	439	540	803	895	788
Musick mine	2[d]	2																				2						
MALHEUR COUNTY																												
Bretz mine	16,057[e]	14,008	122	322	480	1258	1413	104												6	21	1214	498	819#				904
Opalite mine	10,541[e]	12,367	4				8#	6										16#		11	218#	14	434	40#	35	285	928	286
Undistributed	2	2				1				1																		
TOTALS	103,562	103,665	138	513	1224	2276	3995	1893	1049	483	648	868	1177	7	1167	1353	1185	1323	2500	3159	4646	6951	9040	9050	4608	4622	4275	4129
	(U.S.B.M.)	(All sources)	138	513	1224	2276	3993	1893	1056	489	648	868	1177	5	1167	1351	1185	1326	2500	3159	4651	6935	9032	9043	4592	4610	4264	4126

	1935	1934	1933	1932	1931	1930	1929	1928	1927	1924	1923	1922	1921	1920	1919	1918	1917	1916	1915	1909	1908	1906	1905	1901	1900	1889	1888	1887	1882
CLACKAMAS COUNTY																													
Ames mine				7																									
Kiggins mine	16	20																											
Nisbet mine																													
CROOK COUNTY																													
Allison prospect																													
Amity mine				(67)	166	17																							
Barnes Butte mine																													
Blue Ridge mine			26		10	7																							
Byram-Oscar mine	13																												
Champion mine	12	7																											
Devils Food prospect		(1)																											
Kidnap Spring prospect																													
Little Hay Creek prospect																													
Maury Mountain mine	18	24#		51																									
Mother Lode mine	52			3		23	24	41	24										3		18	3							
Number One mine [a]		1			(10)	(20)																							
Oronogo mine																													
Platner mine																													
Round Mountain prospect																													
Staley mine		8	(10)		←(51)→		40	40																					
Strickland Butte mine																													
Taylor Ranch mine																													
Towner mine		2																											
Watson prospect																													
DOUGLAS COUNTY																													
Bonanza mine																												15	
Buena Vista mine		2					4																						
Elkhead mine	16																									20	32	50	
Nonpareil mine				40																									50
Red Cloud mine	(6)	(9)	(30)																										
GRANT COUNTY																													
Paramount prospect																													
Roba Westfall prospect																													
HARNEY COUNTY																													
Alexander mine																													
Fisher group																													
Mogul mine																													
Rabbit Hole prospect																													
Steens Mountain mine																													
Undistributed																													
JACKSON COUNTY																													
Bonita mine																													
Chisholm property	1	4	2	6	1	3									2		3	9											
Cinnabar Mountain mine						(15)																							
Mountain King mine																													
Roxana mine																													
Stanley and Brown prospects														(3)															
War Eagle mine										10	38	2	11	24	217	311		4											
JEFFERSON COUNTY																													
Axehandle mine																													
Custer Young prospect																													
Good Chance prospect																													
Horse Heaven mine	781	176																											
Humboldt mine																													
LAKE COUNTY																													
Angel Peak mine																													
Glass Buttes mine																													
Gray prospect																													
LANE COUNTY																													
Black Butte mine	919	1273	607	912	1618	1549	1312	999	150						210	382	380	286		487	323		43	75	200				
Musick mine																													
MALHEUR COUNTY																													
Bretz mine	1628	1957	618#	226#	2414#	4																							
Opalite mine			143	1280#	516#	1323#	2276#	2655#	1889#																				
Undistributed																													
TOTALS	3462	3484	1436	2592	4786	2961	3656	3735	2063	10	38	2	11	27	429	693	383	299	3	487	341	3	43	75	200	20	32	65	50
	3456	3460	1342	2523	5011	2919	3657	3710	2055	10	38	2	11	24	429	693	383	299	3	487	341	3	43	75	200	20	32	65	50

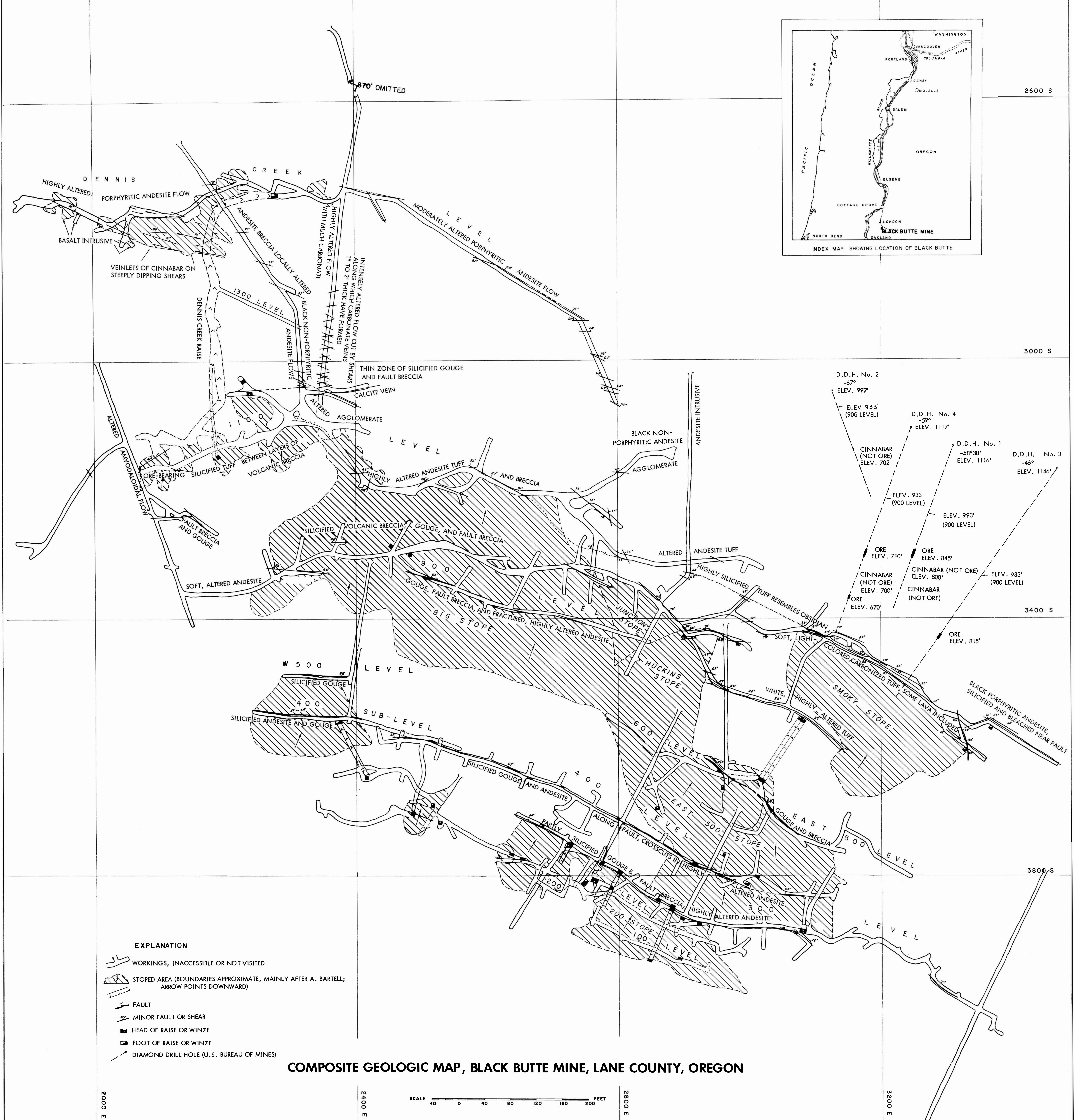
* Unless otherwise indicated, yearly figures were taken from U. S. Bureau of Mines records with the permission of mine owner or operator. Only mines with known production of one flask or more are included. Several mines that are thought to have produced small amounts of quicksilver have been deleted from the table because statistics were not available.

() Production not recorded by U.S. Bureau of Mines. Sources include: previous publications and manuscripts listed in bibliography, department mine file reports, and mine owners and operators.

Owner-operator production figure differing from that recorded by U.S. Bureau of Mines.

a. Production after 1940 combined with Blue Ridge Mine. b. Total production probably amounts to several hundred flasks. c. Based on amount of ore mined, Brown and Waters estimated production to be about 340 flasks. d. Reclaimed from gold mill. e. Annual figures for Opalite mine and for years 1930-45 for the Bretz mine furnished by Bradley Mining Co. U.S. Bureau of Mines total for Bretz mine includes production from Opalite mine. Rather wide discrepancy between U.S. Bureau of Mines and Bradley Mining Co. totals is unexplained.

PLATE 3



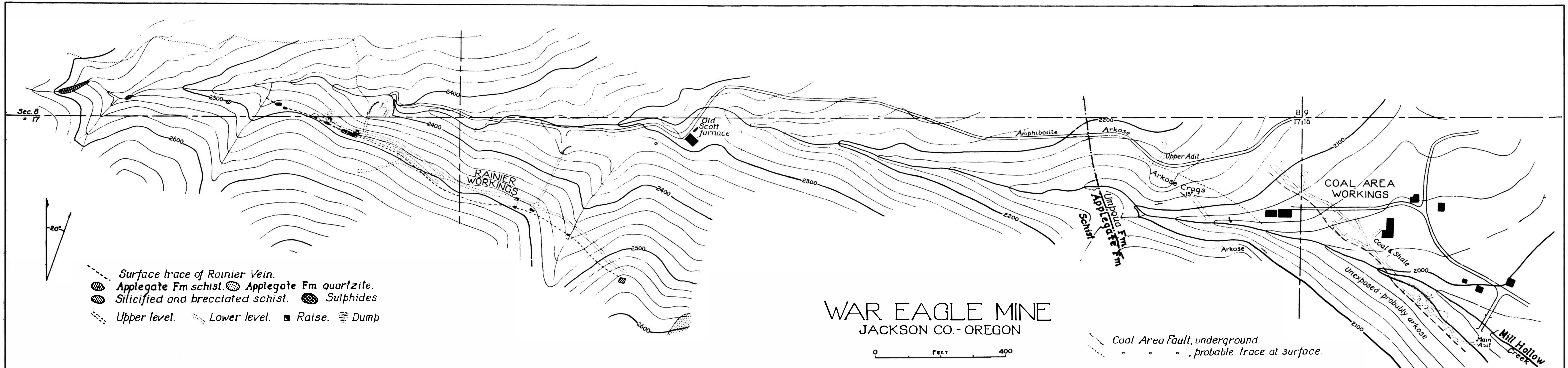
COMPOSITE GEOLOGIC MAP, BLACK BUTTE MINE, LANE COUNTY, OREGON

MAP AFTER A. C. WATERS, U.S.G.S.

Plate 4

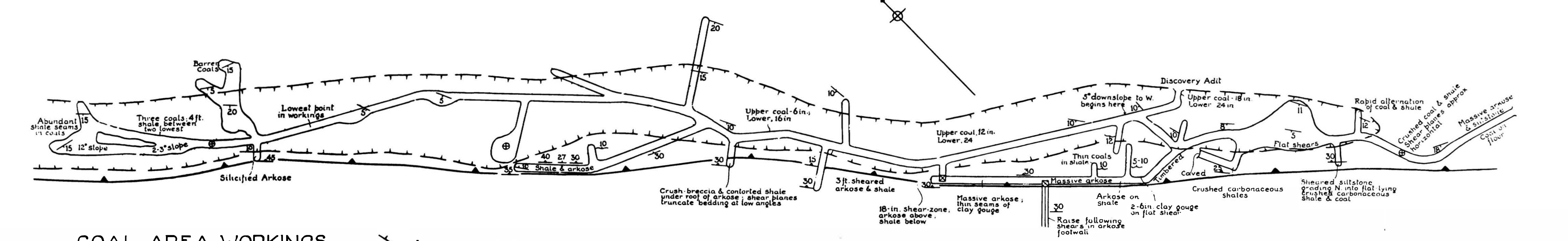
GEOLOGIC MAP OF THE BONANZA MINE

Plate 5



Topography and geology of Rainier workings by P.E.Hotz and P.W.Richards; Coal Area topography from company maps; geology and workings by Howel Williams and R.R.Compton. Nov., 1943.

DATA FURNISHED BY U.S. GEOLOGICAL SURVEY



COAL AREA WORKINGS
WAR EAGLE MINE

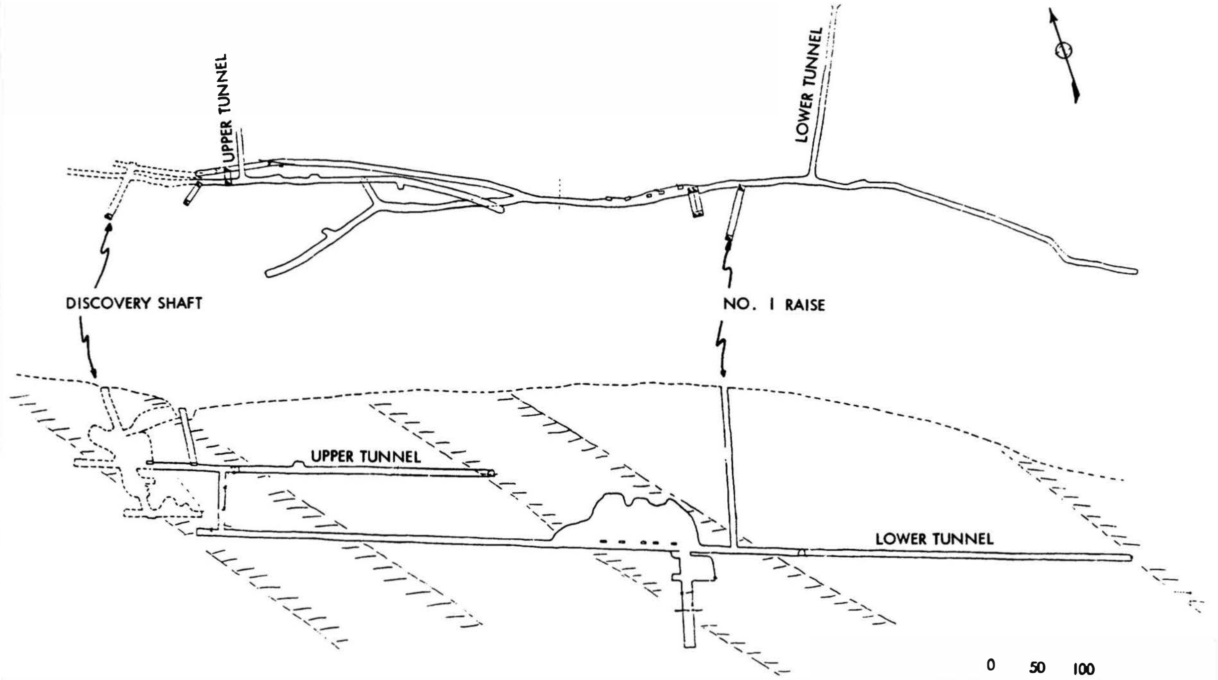
LIMITS OF ORE-BODY
MAIN FAULT
30 DIP AND STRIKE OF FRACTURES
10 " " " " BEDDING

0 Feet 100

South of fault, almost entirely arkose; north of fault almost entirely shales and coals, latter thickening northward.

Howel Williams & Robert Compton - Nov. 1943.

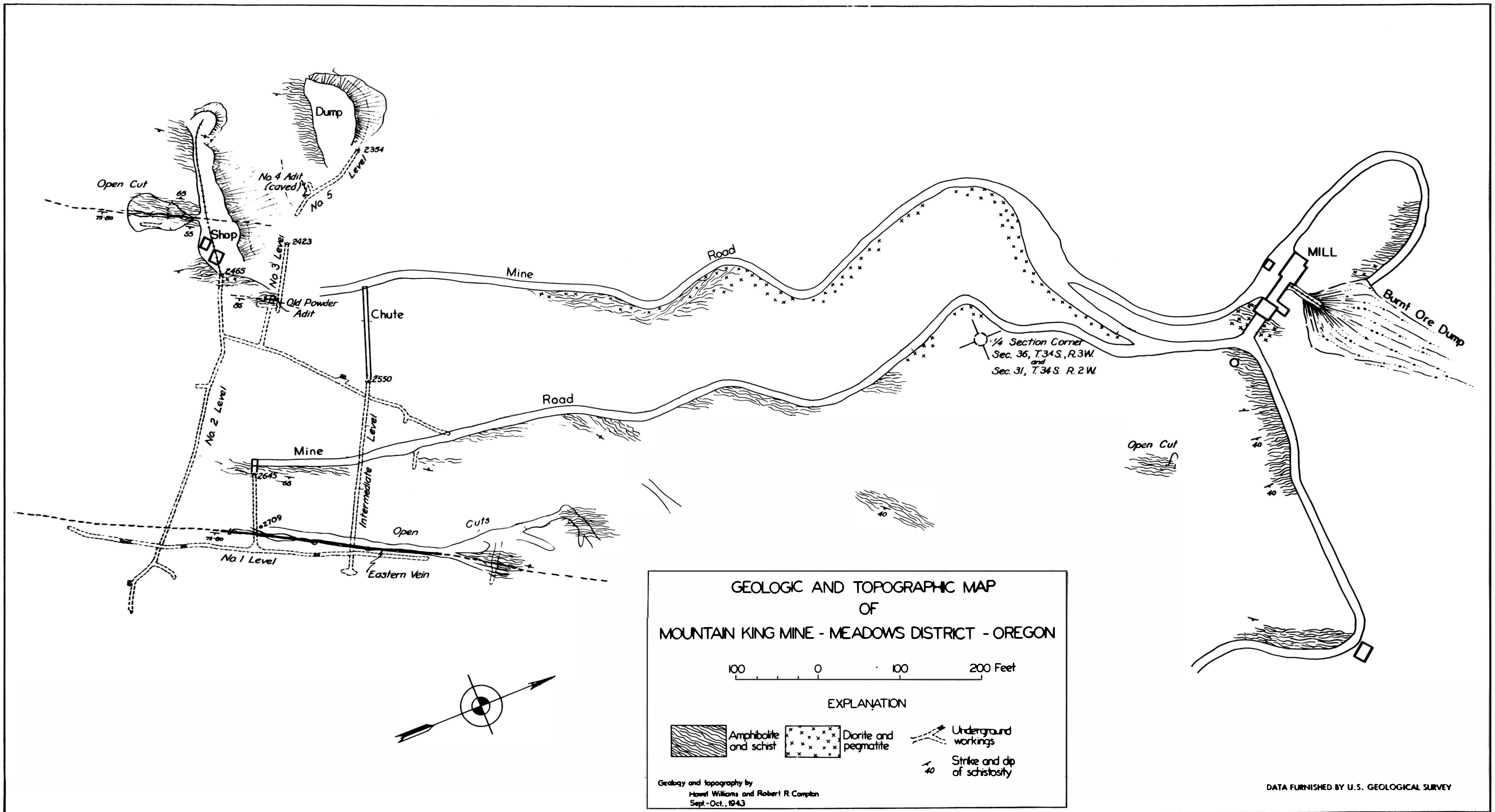
Data furnished by U.S. Geological Survey

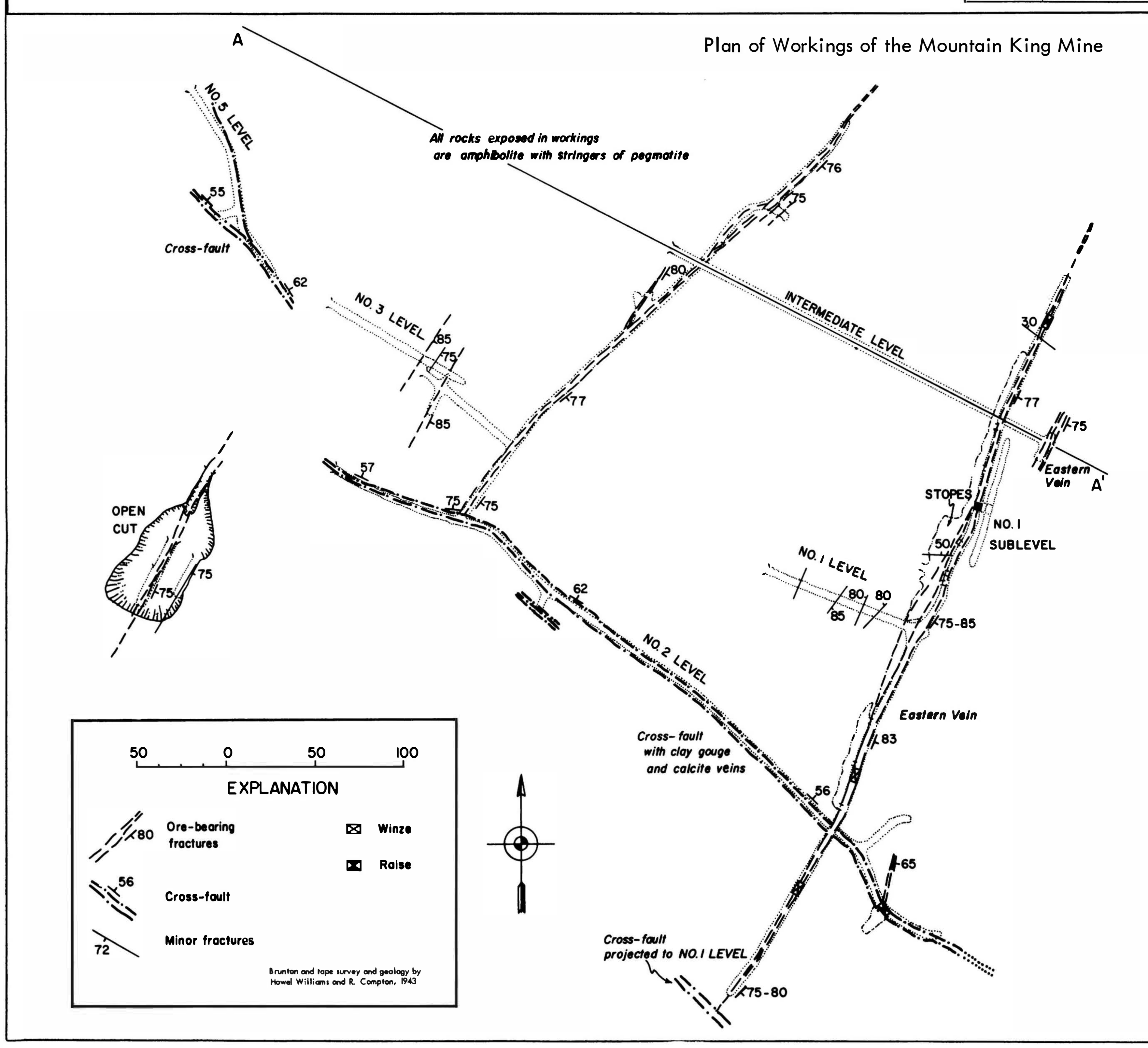


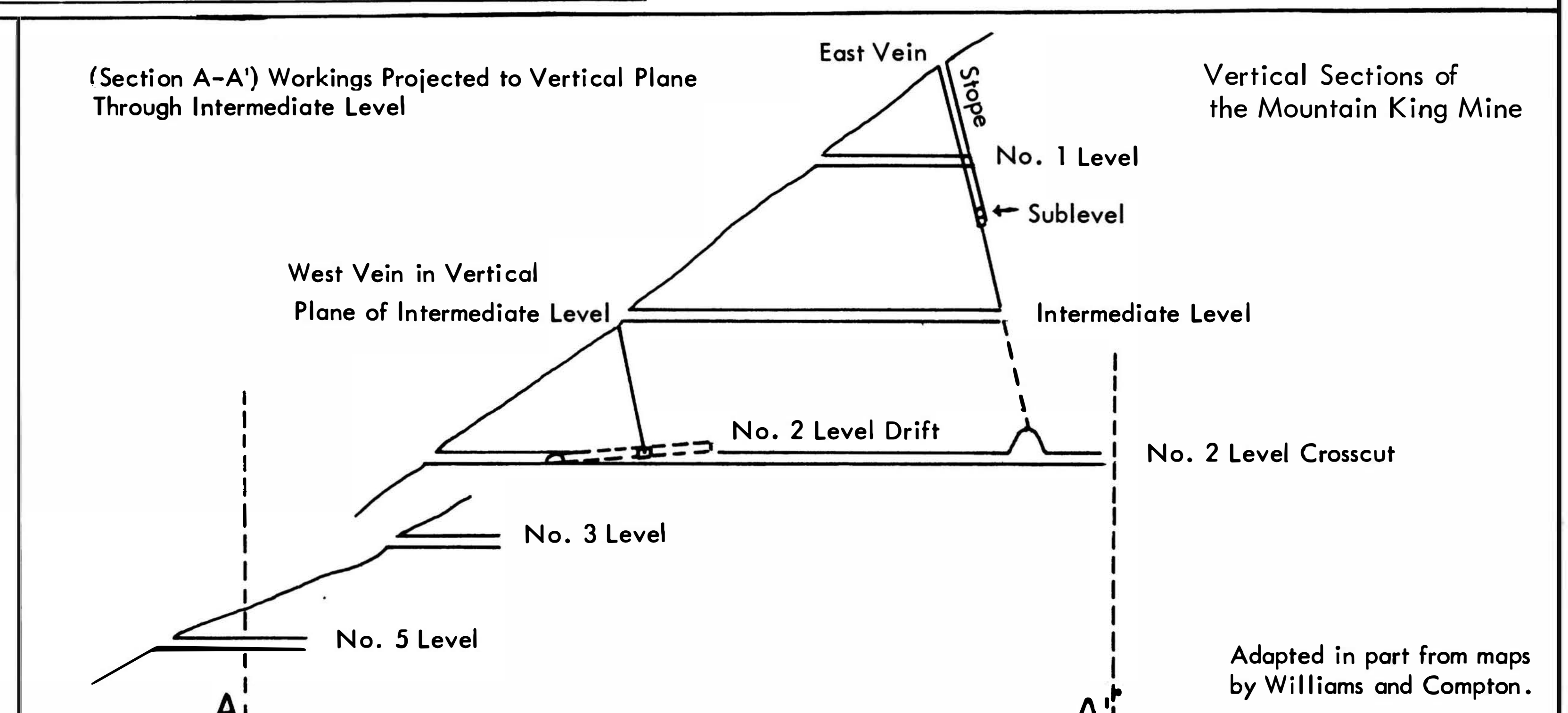
Plan and section of the Rainier vein, War Eagle Mine

FROM C. N. SCHUETTE, BULLETIN 4, OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Plate 6


GEOLOGIC AND TOPOGRAPHIC MAP
OF
MOUNTAIN KING MINE - MEADOWS DISTRICT - OREGON
100 0 100 200 Feet
EXPLANATION
Amphibolite and schist
Diorite and pegmatite
Underground workings
Strike and dip of schistosity
Geology and topography by Howel Williams and Robert R. Compton Sept.-Oct., 1943
DATA FURNISHED BY U.S. GEOLOGICAL SURVEY
Dump
Open Cut
No. 4 Adit (caved)
No. 5 Level
Shop
No. 3 Level
Old Powder Adit
Mine Road
Chute
No. 2 Level
Intermediate Level
Mine Road
Open Cuts
No. 1 Level
Eastern Vein
1/4 Section Corner Sec. 36, T.34S., R.3W. and Sec. 31, T.34S. R.2W.
MILL
Burnt Ore Dump
Open Cut
2354
2423
2465
2550
2645
2709


Plan of Workings of the Mountain King Mine
A
A'
All rocks exposed in workings are amphibolite with stringers of pegmatite
NO. 5 LEVEL
Cross-fault
NO. 3 LEVEL
INTERMEDIATE LEVEL
OPEN CUT
STOPES
NO. 1 SUBLEVEL
NO. 1 LEVEL
Eastern Vein
NO. 2 LEVEL
Cross-fault with clay gouge and calcite veins
Cross-fault projected to NO. 1 LEVEL
50 0 50 100
EXPLANATION
Ore-bearing fractures
Winze
Raise
Cross-fault
Minor fractures
Brunton and tape survey and geology by Howel Williams and R. Compton, 1943


(Section A-A') Workings Projected to Vertical Plane Through Intermediate Level
Vertical Sections of the Mountain King Mine
East Vein
Stope
No. 1 Level
Sublevel
West Vein in Vertical Plane of Intermediate Level
Intermediate Level
No. 2 Level Drift
No. 2 Level Crosscut
No. 3 Level
No. 5 Level
A
A'
Adapted in part from maps by Williams and Compton.

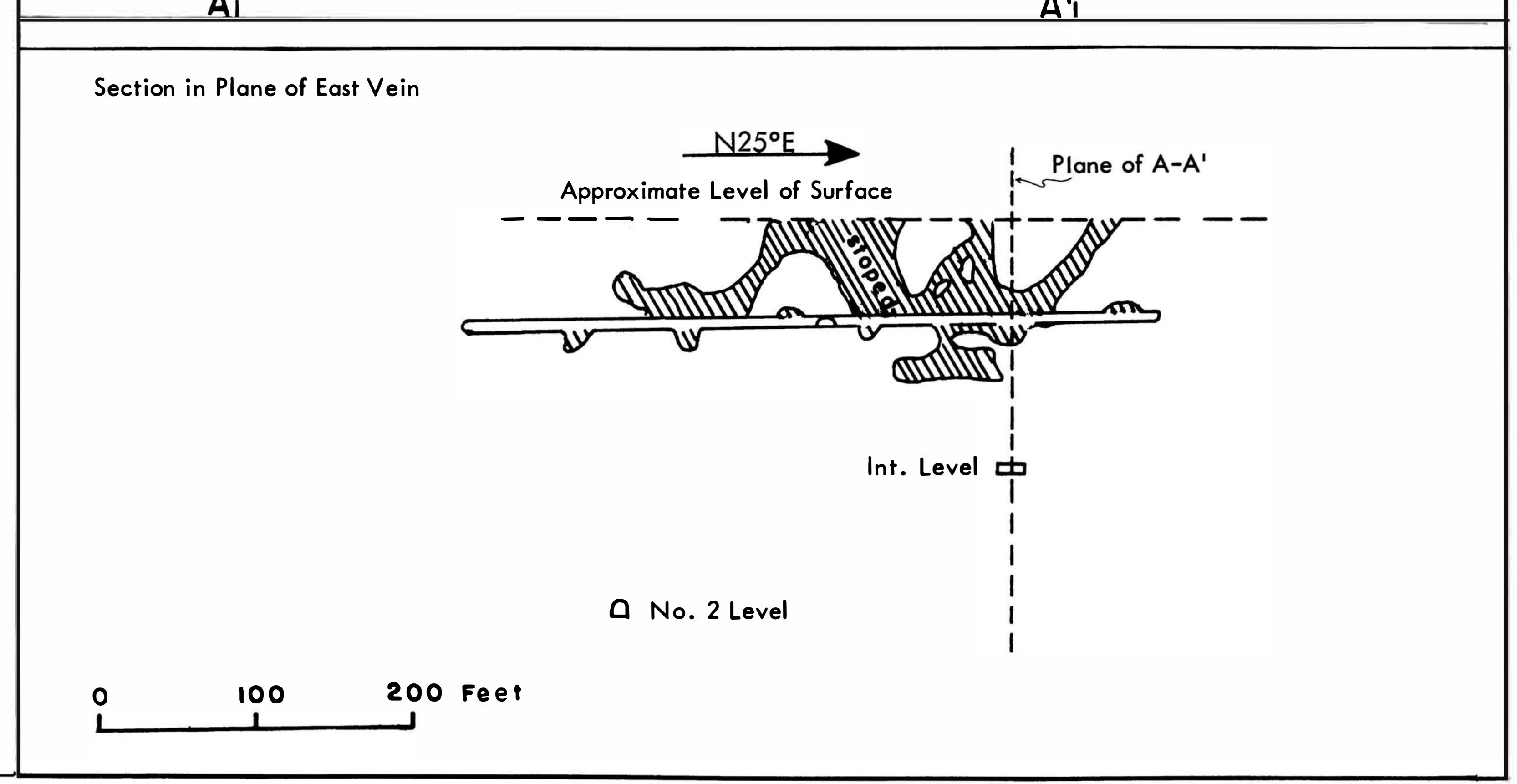
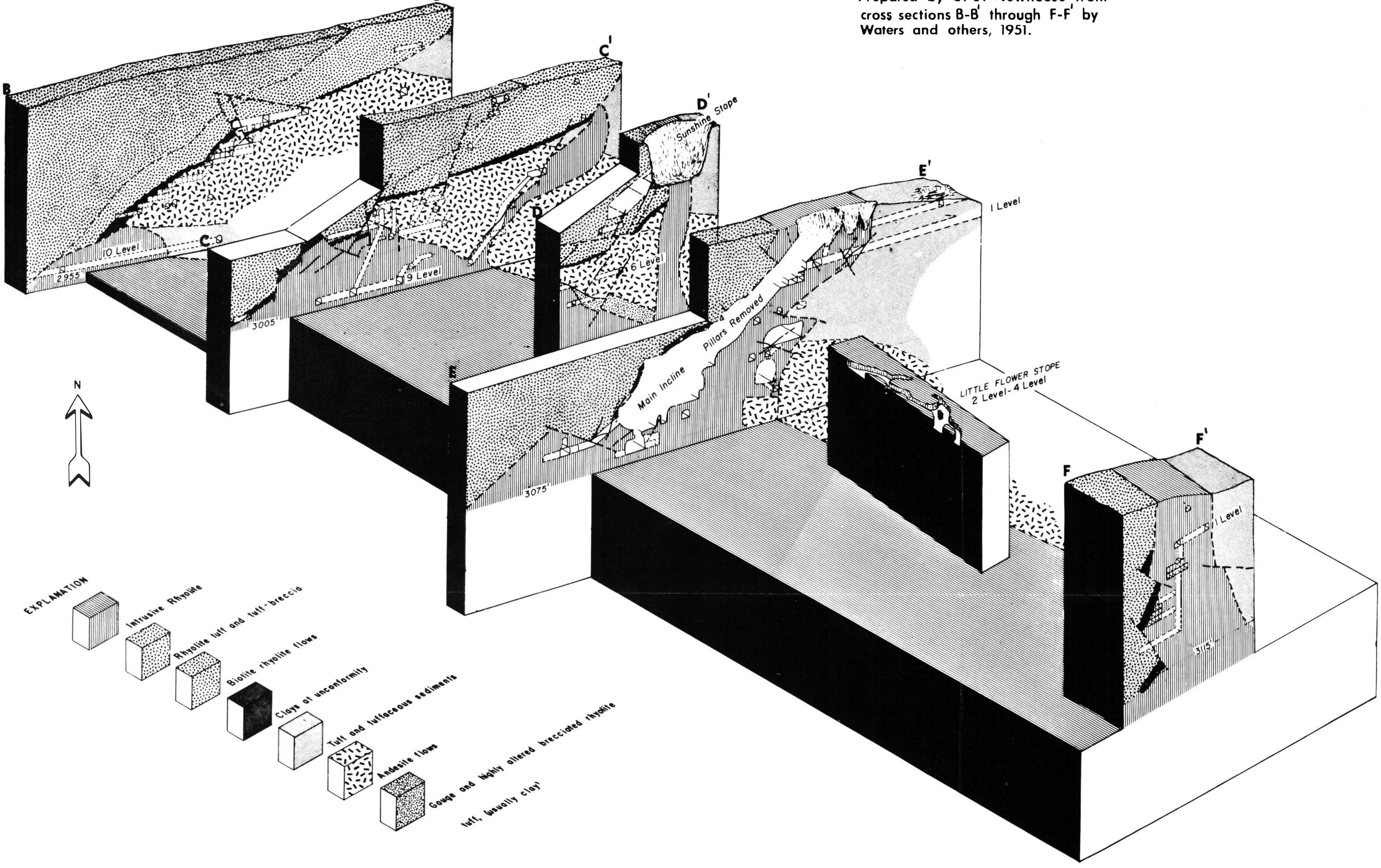
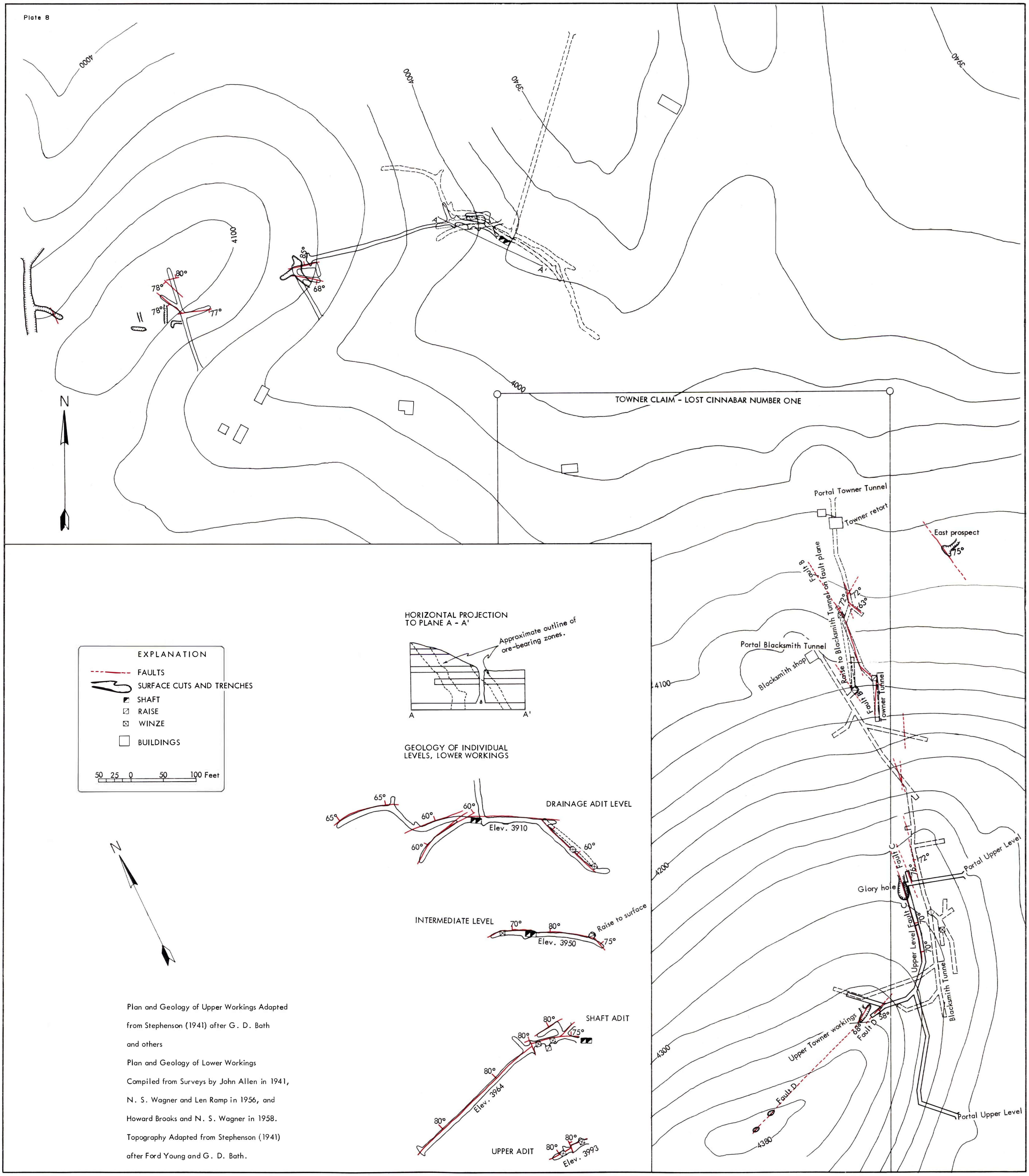

Section in Plane of East Vein
N25°E
Plane of A-A'
Approximate Level of Surface
Stope
Int. Level
No. 2 Level
0 100 200 Feet

PLATE 7

BLOCK DIAGRAM
HORSE HEAVEN MINE

Prepared by C. J. Newhouse from cross sections B-B' through F-F' by Waters and others, 1951.





TOPOGRAPHY AND WORKINGS OF THE MAURY MOUNTAIN MINE