History and Production

Ever since placer mining began in Oregon, about 1852, near Jacksonville, the southwestern part of the State has been known as a gold-producing region. Its early history includes the usual period of rapidly succeeding discoveries, gold rushes, and booms, followed by less intense but steadier activity. The smaller units, which at first constituted separate placer mines, were later combined into larger holdings, and the cruder processes of mining gave place to more efficient hydraulic methods. Although less active than formerly, hydraulic mining has continued without interruption to the present time and has exceeded quartz mining as a source of the gold produced. At times in the last 20 years dredging has been attempted, but until the last two years it has not been carried on continuously for any considerable time.

Early in the mining period gold quartz lodes were discovered. Since then lode mining has experienced periods of relative activity and quiet but has never been completely suspended.

Soon after placer mining began cinnabar was observed in the sluice boxes and later traced to its source in lodes. At times small amounts of quicksilver were produced by means of crude furnaces from deposits on Evans Creek, the Applegate River, and elsewhere and sold to the placer miners. Until recently quicksilver mining in southwestern Oregon has been spasmodic, owing to the general low average price of the metal, combined with the fact that the deposits, though large are of low grade. In the aggregate, however, considerable development work has been done, and in the last two years the mining and reduction of quicksilver ore has been carried on continuously at Black Butte.

Copper ore is said to have been discovered in the Waldo district in 1860, but the deposits were not developed until later. During most of the period 1902-1919 copper ores were mined in the Waldo district, and within the last two years the mines have again become active. Until 1908 the ores were smelted at Takilma; since then they have been shipped outside the district for treatment. Considerable copper was produced from ores mined and smelted in the Galice district, and since 1927 copper ore has been shipped from the Silver Peak lode, near Riddle. Subject to market conditions, these and other copper deposits promise continued mining activity.

No records of production were kept during the early part of the mining period, and there is apparently little basis for a satisfactory estimate of the output before 1864. Beginning in 1864 more or less complete records and estimates became available, and for the years since 1882 fairly detailed records are given in the annual volumes of Mineral Resources of the United States, up to and including 1928 (the latest yet issued), published by the Geological Survey until 1925 and by the Bureau of Mines since then. From these sources and including an estimate of the early production of Jackson and Josephine counties by Winchell,[1]

1/ Winchell, A. N., Petrology and mineral resources of Jackson and Josephine Counties, Oreg.; Mineral Resources of Oregon, vol. 1, No. 5, p. 29, Oregon Bur. Mines and Geology, August, 1914.

which the writer has taken the liberty of modifying somewhat with respect to silver, and an estimate for Josephine County by Diller,[2] the total metalliferous production of western Oregon appears to be between $24,000,000 and $40,000,000, distributed among the different metals as follows:

Gold	$22,000,000 to $38,000,000
Copper	1,278,880
Quicksilver	466,344
Silver	325,590
Platinum	59,826
Lead	9,043

[2] Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, p. 47, 1914.

The most productive part of the period for which records have been kept was from 1899 to 1907. During this time the annual yield ranged from $350,000 to nearly $700,000; the greater amount was attained in 1906. At least four-fifths of the total was gold, and the remainder chiefly copper. In this period the placer output was exceeded by that from quartz lodes, the most productive of which were the Greenback, Opp, Granite Hill, and Braden. The Queen of Bronze mine produced a noteworthy amount of copper. After 1906 there was a sharp decline, an incomplete recovery in 1916-1918, due mainly to increased copper production from the Waldo district, and another decline to less than $100,000 in 1927. In 1928, however, as a result of activities in quicksilver and copper mining, the total production jumped to more than $400,000. Incomplete records for 1929 indicate a still larger amount for that year. They also indicate that both quicksilver and copper exceed the gold in value. For many years past the placer output has shown on the whole a gradual decline, evidently due to the depletion of the richer and more accessible deposits. Since 1913 the average annual production has been about $70,000.

Except perhaps during the period of high production from 1899 to 1907, the annual yield of gold from lodes has fluctuated violently, owing to the occasional discovery and subsequent rapid mining of exceedingly rich but discontinuous ore bodies. In 1919 and 1920 lode-gold production almost ceased, as no rich ore was in sight, and increased costs of labor and supplies made mining of the lower grades of ore unprofitable. In 1928, however, the lode-gold production had increased to $61,000.

Although discoveries of rich ore in the upper parts of the lodes will probably continue to be made from time to time, it is evident that most of the districts have reached the stage at which the bulk of future gold production must come from the deeper zones or from low-grade ore bodies or both. The continued production of copper and quicksilver will depend on the successful working of low-grade deposits. It follows, therefore, that in western Oregon the day of crude methods is past and that profitable exploitation will depend more and more on skillful engineering, including the application of geology. Realization of this condition in the State as a whole led to the passage of the State act under which the present investigation is being undertaken.

Metalliferous Deposits

Gold

Gold is rather widely distributed in the southern part of western Oregon and is also found in several places on the western slope of the Cascade Range as far north as the basin of the Molalla River, east of Salem. The southern and principal gold-bearing region, generally referred to as southwestern Oregon, comprises Josephine County, the west half of Jackson County, most of Curry County, and adjoining parts of Douglas and Coos Counties, a total area of more than 6,000 square miles. This region lies mostly in the drainage basin of the lower Rogue River but includes areas drained by the South Umpqua, the Chetco, the South Fork of the Coquille, and the Sixes Rivers. Although gold deposits are found throughout this region they are most numerous in the parts included within Jackson and Josephine Counties, which to date have yielded four-fifths or more of the total gold produced in western Oregon. Here, as in most other gold-bearing regions, the gold occurs both in lodes and in placer deposits.

Lodes

Reports by Diller[3] and Winchell,[4] based on field work done mostly before 1914, describe many of the mines and prospects that have been developed on the gold-bearing lodes. A few additional mines are described by Butler and Mitchell,[5] who examined Curry County in 1915. In the summer of 1929 several lodes, some of which are among those described by the authors cited, were examined by the writer.

3/ Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, 1914.

4/ Winchell, A. N., Petrology and mineral resources of Jackson and Josephine Counties, Oregon: Mineral Resources of Oregon, vol. 1, No. 5, Oregon Bur. Mines and Geology, 1914.

5/ Butler, G. M., and Mitchell, J. M., Preliminary survey of the geology and mineral resources of Curry County, Oreg.: Mineral Resources of Oregon, vol. 2, No. 2, Oregon Bur. Mines and Geology, 1916.

History and Production

From reports by C. G. Yale, J. M. Hill, and V. C. Heikes in the annual volumes of Mineral Resources of the United States and the reports cited above, it appears that the most active and productive period of gold lode mining was the decade 1900-1910. For the later part of that period (1904-1910) the records show that from 20 to 30 mines were operated and that the total yearly production ranged from about $55,000 to $320,000. Since 1910 the activity in gold-lode mining has decreased, and the number of mines operated has fallen at times as low as 5. The yearly production has ranged from $3,000 to $87,000; the low figure represents the output of 1919 and 1920, when the postwar depression adversely affected gold mining as well as many other industries. A jump to $87,000 occurred in 1921, chiefly as the result of mining a rich ore body in the Boswell lode near Holland. High points of production of $59,000 and $43,000, reported

in 1925 and 1926 respectively, were caused by the working of similar ore bodies in the Robertson or Progressive mine, near Galice. In 1928 more than $61,000 in lode gold was produced, a large part of which was contributed by a rich ore body in the Robert E. mine, near Marial. During the intervals between the exceptional years of low and high production mentioned, an average of about 13 lode mines were operated and their aggregate average yearly output was $24,000, or a little less than $2,000 a mine. Figures for 1929 are not yet available, but incomplete reports indicate an activity and production equal to if not greater than that of 1928.

Most of the time since 1913 the value of the ore mined from gold lodes has averaged less than $20 a ton. During the highly productive years 1904-1907 the average value of the ore mined was less than $8 a ton. In 1906 it was only $5 a ton. In 1921, however, the rich ore produced by the Boswell mine caused the average for Josephine County to jump to $225 a ton. In 1925 and 1926, when the Robertson mine was productive, the average was nearly $150 a ton. During the intervals of scanty production the ore has ranged in value from $5 to $50 a ton and averaged about $20.

Diller and Winchell together describe more than 150 mines and prospects in southwestern Oregon that are on lodes valuable chiefly or only for gold. A few additional mines are described by Butler and Mitchell. At least five-sixths of all the lodes described by these authors are quartz veins, including simple and multiple veins, stringer lodes, lenses, and pockets. The remainder are chiefly mineralized shear or fracture zones. Of the vein group about 15 are comparatively large -- that is, they are from 3 to 10 feet or more wide and extend continuously for hundreds of feet along the strike and dip. Among these are the lodes in the Ashland, Greenback, Opp, and Granite Hill mines, each of which contains several thousand feet of underground workings and has produced from $75,000 to $1,000,000 or more. All contained small shoots of rich ore, but the bulk of their production came from bodies 2 to 5 feet or more thick and several hundred feet long and deep that yielded from $5 to $13 a ton.

About 40 of the lodes described are between 1 and 3 feet wide but comparatively large otherwise. The most extensively developed and productive of these are the lodes in the Daisy, Mountain Lion, Golden Wedge, and Braden mines, for which available records show production ranging from $30,000 to $200,000. The ore bodies are mostly 2 or 3 feet thick and from 100 to 500 feet or more long and deep, and their average tenor exclusive of some small rich shoots and bunches is from $8 to $20 a ton.

Of the remaining 100 or more lodes, a few are described as 1 foot or less wide and not continuous very far horizontally or vertically. From the incomplete descriptions of the remainder, it may be inferred that most of them are also small. Despite their small size, some of these lodes have been very productive, particularly those containing the ore bodies known as pockets. The most celebrated example, the Gold Hill pocket, is said to have yielded $700,000. It was a body 15 feet deep and of no great horizontal dimensions. The Steam Boat, Revenue, and Town pockets are credited with $100,000 to $350,000 each. Five or six others produced a few thousand dollars each, and several yielded smaller amounts. A few of the small lodes contain ore shoots that persist to greater depths than the superficial bodies mentioned. Except the rich pockets and shoots the small lodes are of low grade. Extensive underground workings have been made on few of them.

Quartz is the predominant mineral of these lodes. Commonly they contain also calcite and sulphide minerals, which in the aggregate generally do not exceed 2 or 3 per cent. Of the sulphides, pyrite is the most abundant and is found in nearly all the lodes. Several lodes contain one or more of the minerals chalcopyrite, pyrrhotite, sphalerite, and galena, and a few the gold-silver tellurides sylvanite and petzite. Petzite was identified in ore from the Robertson mine. Native gold is abundant in the richer deposits.

The ore is more or less "free milling" -- that is, part of the gold can be recovered by simple crushing and plate amalgamation. The remainder is mostly saved by concentrating the sulphides to a product that generally assays as much as $75 a ton. Many of the lodes are or were at some time equipped with mills or arrastres. Most of the mills are small, being equipped with 1 to 5 stamps or their equivalent in other machinery. A few range from 5 to 20 stamps, and one, at the Greenback mine, contains 40 stamps.

Included in the group of gold-bearing or possible gold-bearing lodes are 30 or more bodies that may be described as mineralized shear zones. Most of them are in the Galice-Kerby region and districts farther west in Curry County. They range in width from a few feet to a hundred feet or more, and some are said to extend for long distances horizontally. Although some productive mines, such as the Jewett, near Grants Pass, include such bodies, the workable ore of those mines comes from lenses or veins separate and distinct from the low-grade zones.

No productive mines are yet known that depend on the low-grade zones for ore. The exploration of a few of them seems to have been mainly incidental to the search for rich pockets or other ore bodies. The low-grade zones are characterized usually by disseminated pyrite and the presence of chlorite and other minerals indicative of rock alteration. Evidence as to their value is scanty and conflicting. A zone that is exposed by the extensive workings of the Almeda mine, at Galice, is from 30 to 60 feet or more wide. It occurs along the west or footwall side of a copper-bearing lode and consists of a dike rock (quartz porphyry or dacite porphyry) that has been more or less altered and replaced by quartz and pyrite. Diller6/ quotes an assay reported by an engineer

6/ Op. cit., p. 77.

for the company, P. H. Holdsworth, that is claimed to represent an average of this zone in the upper levels. It shows 0.14 ounce of gold (equivalent to $2.80) and 6.4 ounces of silver to the ton and 0.3 per cent of copper. Diller also quotes several higher assays reported by Holdsworth, said to represent material from the same zone but not identified as to location. Diller's own observations and sampling, so far as they go, do not confirm the results given by Holdsworth. Diller says: "The only siliceous material I collected was taken from the crosscut west from the 500 level. The assays of these samples (collected near the shaft and 12 feet west of it) show that they contain but very little gold (20 cents a ton) and only a trace of silver. These samples, however, appear to me to fairly represent much of the material lying immediately west of the copper ore."

The Red Elephant claims, on Howard Creek west of Galice, are mentioned by Diller 7/ as containing a mineralized belt several hundred feet wide. He reports

7/ Op. cit., p. 55.

a sample as having assayed 0.023 ounce of gold (equivalent to about 46 cents) to a ton. Samples collected by Diller from other zones contained no gold. Samples from still other zones are said by the owners to assay from $2 to $12 or more a ton.

The annual volumes of Mineral Resources mention 65 lode mines in southwestern Oregon as having been productive at one time or another since 1912. Only 22 of these are included in the list of mines described by Diller and others. The remaining 43 presumably include mines that were known but were inactive before 1912 and mines that were discovered since that date. The productive period of two-thirds of the lodes mentioned in Mineral Resources was 1 year or less. Most of the remainder were operated from 2 to 4 years, and three, the Great I Am, January First, and Gold Ridge, were operated 5 or 6 years each. The largest producers since 1912 are the Boswell, Robertson, and Robert E. In addition to the 65 productive mines, 17 are mentioned in Mineral Resources as being under development but not productive, and one of these, the Millionaire, was being developed through a period of five years. About 10 mines on gold lodes were producing or being developed in 1929. Among these were the Robertson, Robert E., Sylvanite, and Ida.

The available information indicates that many of the larger lodes, such as those in the Ashland, Greenback, and Opp mines, probably contain unexploited ore bodies of good size but mostly of low grade. The prospects for making a valuable mine of the Ashland were considered by Winchell 8/ in 1914 as "very unusually

8/ Op. cit., p. 117.

good." This mine has been inactive for a long time, as a result, it is understood, of litigation. Except for a little development work done in 1927 and 1928 the Greenback mine has been inactive since 1908. The last considerable production of the Opp mine was made in the period 1914-1924.

Placers

As in many other gold-bearing regions, the placer deposits of southwestern Oregon are distributed through the areas of gold-bearing lodes and in addition occur in a fringing zone that extends mainly in the direction of past or present drainage discharge. The origin of the placers from the lodes by erosion is thus indicated.

Since their discovery in 1852 the placer deposits have been mined continuously and have yielded between $15,000,000 and $26,000,000, or more than two-thirds of the total gold produced. Up to 1928 practically all of the placer production had been won by sluicing and hydraulic operations. In that year a considerable part of the output was obtained by dredging.

The output from placer mines has been less variable than that from lodes. Such fluctuations as it has shown appear to be related in general to available water supply -- that is, the annual precipitation for the output has been high in wet seasons and low in dry ones. The lowest average annual production of record, namely, about $27,000, occurred in 1923-1926, which, as shown by the records of the United States Weather Bureau, were years of marked deficiency in rainfall. Since 1905, when a record production of $280,000 was reported, there has been a gradual decline of the placer output. In 1927, a year of nearly normal rainfall, about $40,000 was produced. In 1928, owing largely to the contribution from dredging, the total output increased to $70,500. A further increase from dredging operations is indicated for 1929.

The bulk of the placer production has come from alluvial deposits along the streams and on terraces above them. Deposits on present and ancient sea beaches have yielded a moderate amount, and a little has been won from the mantle of overlying rocks that have decomposed in place. The richer and more easily accessible of the stream, terrace, and beach deposits have been worked out. There remain rather extensive bodies of comparatively low grade, some of which are suitable for dredging and others for large-scale hydraulic operations. A continuing moderate production from these sources may be expected for many years.

Alluvial deposits in the valley of Foots Creek are now being mined successfully by dredging. The location and extent of other bodies that are probably suitable for the same method will doubtless be indicated by further geologic investigation. Extensive low-grade deposits suitable for hydraulic operations remain in the Waldo, Galice, Applegate, and other districts. A few deposits consisting of surface mantle derived from the weathering of gold-bearing rocks in place have been worked in a small way, particularly in an area west of Kerby. Most of these deposits are on divides or other high surfaces, where the available water supply is rather scarce. They do not promise more than a small production, but their working may uncover valuable lodes.

Copper

Although compared to the leading copper deposits of the country, those of Oregon are small, copper lodes are among the more promising of the mineral deposits on which the future metal-mining activity of western Oregon depends. In some districts copper is associated with other metals, and small amounts have been produced from such mixed deposits, particularly in the Bohemia district. The lodes that are valuable chiefly for copper, however, are mostly confined to the southwestern part of the region, more particularly to a belt that extends from Riddle southward to the California line and includes the Galice, Kerby, and Takilma districts. In places the copper-bearing lodes are rather numerous, and most of them occur in greenstone, serpentine, or schist. They are closely related in origin to intrusive bodies of diorite, gabbro, and peridotite.

Distributed irregularly throughout serpentine areas are many lenslike or boulderlike bodies ranging in weight from a few ounces to a ton or more. They are composed mainly of magnetite and copper minerals, including native copper,

which in some of them forms nodular bodies weighing several pounds. Locally these lenses or "boulders" appear to be more numerous along shear zones than elsewhere, but so far as discovered they are not plentiful enough at any place to form collectively an ore body. They are considered to be of deep-seated origin, with later modification by superficial agencies.

In the Galice district larger lenslike bodies, explored by the extensive workings of the Almeda mine, have produced considerable ore composed of chalcopyrite and other copper minerals in a gangue that is mostly barite. These bodies occur in a shear zone that traverses a dike of altered dacite porphyry. They are distributed for distances of several hundred feet along the strike and dip.

Recent development work in the Silver Peak mine, near Riddle, has disclosed ore bodies containing bornite with subordinate amounts of chalcopyrite, tennantite, galena, and sphalerite in a quartz gangue. The mineral association is similar to that of the copper ores at Butte, Mont. Smelter returns show the average value of this ore to be about $25 a ton, chiefly in copper with a little gold and silver. The ore bodies occur in a shear zone a hundred feet or more wide that crosses fine-grained greenstone and porphyry. They are of irregular and lenslike forms and as much as 20 or 30 feet in maximum width.

The largest and most productive copper deposits so far developed in western Oregon are in the Queen of Bronze, Cow Boy, and other mines at Takilma. These bodies are of irregular form and yield from a few tons to as much as 10,000 tons of ore each. They occur along shear zones in gabbro, peridotite, and serpentine and are composed of chalcopyrite, pyrite, and pyrrhotite accompanied by more or less quartz and calcite. Smelter returns show from 5 to 13 per cent of copper and a little gold and silver in ore that has been selected for shipment. Much ore of lower grade remains. The mineralogy of these lodes indicates that they are related in origin to some intrusive rock and that they had a deep-seated rather than a superficial source. They have been explored to a maximum depth of about 300 feet.

The Mammoth lode, near the California line west of Waldo, is inclosed in greenstone and presents a very large and prominent outcrop that is rich in iron oxides. Of several tunnels on this deposit one that reaches a part of the lode below the oxidized zone exposes ore composed of pyrite and chalcopyrite for a distance of 50 feet or more.

In the Squaw Creek district an area of schist contains several zones that are rich in pyrite. Shallow workings on one of them on the Great Eastern claim shows enough chalcopyrite distributed through a width of 15 feet to classify the mass as low-grade ore. Most of the other zones are said to contain copper, but definite information about them is lacking. The extensive workings of the Blue Ledge mine, which is a few miles south of the Oregon boundary, discloses lenticular bodies of chalcopyrite ore distributed along zones in a schist formation similar to that in the Squaw Creek area. In the Blue Ledge mine 110,000 tons of 6 per cent copper ore is reported to be blocked out. 9/

9/ Mines Handbook, 1926, p. 502.

In 1929 preparations were being made to reopen the Banfield mine, near Drew. This mine, which contains rather extensive development workings opened during the last 25 years, is said to have made a small shipment of ore containing 8 or 9 per cent of copper and a little gold. The workings explore a zone of altered rocks 20 or 30 feet wide that contains irregularly distributed grains and bunches of magnetite, chalcopyrite, bornite, and pyrite. Bunches of coarse-textured quartz like that of pegmatitic quartz veins occur here and there. The country rock is an altered basalt or andesite of undetermined but probably Tertiary age.

Quicksilver

Increases in the price of quicksilver during the last few years have stimulated prospecting and development of deposits of that metal in western Oregon, as well as in other regions. Should present prices ($118 a flask May 23, 1930) continue, western Oregon promises a steady production for a considerable time. One of the main factors in maintaining the present price is the reported agreement or cartel among Spanish and Italian producers to limit their output. The life of such an agreement is of course problematic. Aside from that factor, the increased uses of quicksilver developed during the last few years are favorable to the continuance of high prices. The manufacturers of drugs, chemicals, paints, neon and mercury lights, and electrical apparatus are reported to be steady consumers. The use of quicksilver for the manufacture of explosive caps or detonators remains steady. Large amounts that are used for scientific and technical instruments compensate for the declining use of quicksilver in amalgamation. That the demand may even exceed the present visible supply is possible should such an apparatus as the Emmet mercury vapor boiler prove to be of general utility.

In 1928 the different industries in the United States used more than 30,000 flasks of quicksilver, of which less than two-thirds (about 18,000 flasks) was supplied by the domestic producers. 10/

10/ Tyler, P. M., Mineral Resources, 1928, p. 266, U. S. Bur. Mines, 1929.

Very little detailed information as to the quicksilver deposits in western Oregon is available, and further geologic investigation of them may be expected to aid in their development. Cinnabar, the sulphide of quicksilver, is known to be rather widely distributed. It occurs mostly as streaks, films, and specks disseminated through fracture and shear zones. The principal deposits are in an area that extends from Black Butte southward 20 miles or more to Bonanza, another that extends from the vicinity of Tiller southeastward 40 or 50 miles to a point beyond the Rogue River at Trail, and a small area on Evans Creek, known as the Meadows district.

Black Butte - Bonanza area

The Black Butte mine has produced most of the total quicksilver accredited to western Oregon. It is on a wide and extensive fracture zone in andesite tuff, in which the rocks are strongly altered and bleached nearly white. Cinnabar is sparingly and irregularly distributed through the mass. Veinlets, mostly less than 1 inch thick and commonly referred to by the miners as "iron ribs," form a network that marks out the pattern of a coarse breccia. They are composed chiefly of brown iron oxide with more or less pyrite and cinnabar. These minerals are arranged in parallel bands, and the iron oxide as well as the other minerals appears to have been deposited by ascending thermal solutions and not to be the result of atmospheric oxidation. A little marcasite is intergrown with the pyrite. Cinnabar grains and specks with or without accompanying pyrite are scattered through the rock that forms the walls of the veinlets.

Parts of the Black Butte zone rich enough to be workable under present conditions are as much as 40 feet wide and hundreds of feet in their other dimensions. It is understood that the average content of the ore mined in 1929 was between 4 and 5 pounds of quicksilver to a ton. The mine workings aggregate several thousand feet, and all of them are accessible from adit levels. The equipment includes two rotary Gould furnaces, which have a combined capacity of 200 tons a day.

The lodes in the Elkhead, Nonpareil, and Bonanza mines are, like that in the Black Butte mine, zones of broken and altered rock, characterized by "iron ribs" and sparingly and irregularly disseminated cinnabar. Several hundred feet of workings at the Elkhead mine show rather extensive bodies of the cinnabar-bearing material, the quicksilver content of which is evidently low. A considerable production is reported to have been won from this deposit before 1917 by means of a Scott furnace.

Adits and connected workings of the Nonpareil mine aggregate 2,000 feet or more. The ore from a stope 4 to 15 feet wide, 75 feet long, and 150 feet deep (pitch length) is said to have been treated in a Scott furnace and to have yielded 700 flasks of quicksilver. The indicated quicksilver content of the ore treated is thus about 7 pounds a ton. The country rock is Umpqua sandstone (Eocene), and the lode is formed in a crushed zone that trends northeastward and is 50 to 100 feet or more wide.

The Bonanza lode is a zone of crushed Umpqua sandstone adjoining a bed of shale that forms the hanging wall. It was worked several years ago, and the ore was treated in a Scott furnace, but the production is unknown. Several hundred feet of workings turned from adit levels explore the lode to a maximum depth on the dip of 230 feet. Visible specks of cinnabar are sparingly scattered through the mass, and hundreds of samples taken throughout the workings are said to show an average of 3 pounds or more of quicksilver to a ton.

As the deposits in the Black Butte-Bonanza area occupy crushed zones either in Eocene sandstone or in andesite that overlies the sandstone unconformably, their age is clearly post-Eocene. They may have formed during the late Tertiary period of volcanism.

Tiller - Trail area

The Tiller-Trail area contains many quicksilver prospects, most of which are on crushed and altered zones in volcanic rocks of probable late Tertiary age. Streaks and specks of cinnabar are sparingly and irregularly disseminated through the zones, some of which are 30 feet or more wide. In addition, most of the zones show "iron ribs" like those of the deposits in the Black Butte - Bonanza area. Samples reported indicate contents of quicksilver ranging from 2 to 20 pounds or more to a ton, but the extent of the bodies represented by the samples is not known.

Meadows District

The quicksilver deposits in the Meadows district occur in zones of fracturing that cross a variety of rocks, including andesite tuff, sandstone, shale that contains coaly layers, and intrusive granite and porphyry. Within these zones and immediately adjacent to them the rocks have been more or less altered by hydrothermal solutions and partly replaced by chalcedonic quartz. Veinlets and specks of cinnabar accompanied by more or less pyrite and marcasite are irregularly disseminated through the zones.

Several mines are located on the cinnabar-bearing deposits in the Meadows district. The largest, the War Eagle mine, was operated at times before 1920 and is reported to have produced 556 flasks of quicksilver. The ore bodies range from 4 to 6 feet in width and extend several hundred feet along the strike and dip. The ore that was extracted from them averaged 1 per cent or more of quicksilver.

The older workings of the Dave Force mine, the property of the Quicksilver Producers Co., exploited several ore bodies having the form of pipes a few feet in diameter that extend obliquely downward along the lode. The ore from those bodies is said to have been comparatively rich. It was treated in retorts. Newer workings at this mine partly expose a tabular body 6 feet wide in one place that contains streaks and films of cinnabar.

Platinum, Silver, Lead, and Zinc

Small amounts of platinum, usually alloyed with osmium and iridium, occur in many of the placer deposits in southwestern Oregon. It is nowhere plentiful enough to be mined alone, but in places where it is recovered as a by-product of placer gold mining it adds materially to the value of the output. Since 1913 the annual production of platinum has ranged from 4 to 100 ounces or more, most of which has come from the Waldo and Kerby districts and the districts along the ocean beach. The theory that the ultimate sources of platinum are basic igneous rocks, such as peridotite, finds some support in the geology of southwestern Oregon. However, claims that have been made from time to time that platinum has actually been found in lodes or in the rocks of that region are either disputed or remain unverified.

Most of the silver produced in western Oregon has been recovered as a by-product of gold mining. The crude gold of the placer mines is an alloy containing from 1/9 to 1/6 of an ounce of silver to each ounce of gold. The bullion produced from gold lodes also contains silver in a ratio that varies from 1/8 of an ounce to 1 ounce or more of silver to each ounce of gold. The average silver content of lode and placer gold produced since 1913 is about 1 ounce to $3\frac{1}{2}$ ounces of gold. This ratio was used in recalculating the amount of silver produced before 1864, as estimated by Winchell. A moderate amount of silver is recovered from copper ores and from complex base ores such as occur in the Bohemia district.

The lead so far produced in western Oregon has been recovered from complex base ores, and in most of these ores zinc is also an element of considerable potential value.

Deposits of complex base-metal ores on the western slope of the Cascade Mountains.

Veins containing gold, silver, copper, lead, and zinc in the Bohemia district, east of Cottage Grove, are described in reports by Diller 11/ and MacDonald, 12/ based on field work which they did in 1908 and previous years. In 1929 some of the mines were briefly inspected by the writer.

11/ Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, pp. 26, 30, 1914; The Bohemia mining region of western Oregon: U. S. Geol. Survey Twentieth Ann. Rept., pt. 3, pp. 7-36, 1900.
12/ MacDonald, D. F., Notes on the Bohemia district, Oregon: U. S. Geol. Survey Bull. 380, pp. 80, 84, 1909.

MacDonald estimated the production of the district at between $300,000 and $400,000, chiefly in gold. Since his visit, but mainly before 1918, the aggregate production, according to Yale and Hill in the annual volumes of Mineral Resources of the United States, has been about $143,000, distributed as follows: Gold, $131,000; silver, $4,300; copper, $3,200; lead, $4,500.

The veins are distributed through an area of 4 or 5 square miles, in which, as indicated by the fact that about 2,000 claims have been staked, they are fairly numerous. Many of the veins range from 1 to 12 feet or more in width and persist along the strike and dip for hundreds or thousands of feet. A few have been explored to moderate depths by workings accessible through adit levels. The country rock consists of andesite and andesitic tuff of Tertiary age. Below the oxidized zone the veins are composed of quartz and altered country rock with more or less pyrite, sphalerite, galena, and chalcopyrite. Ore bodies in the Champion and Musick veins that range from 2 to 10 feet or more in width and extend several hundred feet along the strike and dip evidently contain noteworthy amounts of the sulphides mentioned. Assays purported to represent these bodies show from 1 to 4 per cent of copper, 2 to 16 per cent of zinc, and 1 to 63 per cent of lead. In addition the ore generally carries $5 or $6 in gold and a few ounces of silver to a ton. Richer ore occurs in spots, and the concentrate from milling operations is said to be worth as much as $75 a ton.

Some of the veins have been oxidized to depths ranging from 100 to 300 feet, and most of their original metallic content except gold and silver has been leached out. The oxidized ore remaining is more or less enriched in gold and is free milling. Such ore was the source of nearly all the gold produced before 1909. Since that date attempts to mine the sulphide ores have been more or less discouraging, owing partly to the somewhat remote situation of the district and partly to the fact that the zinc, which is abundant in most of the veins, was penalized by the smelters. It seems reasonable to expect that flotation may now be adapted successfully to the treatment of these complex ores and thus allow them to be mined profitably. The size and number of the veins in this district indicate the probable existence of a large amount of ore.

In the Blue River district considerable work has been done on the Lucky Boy, Treasure, and some other veins, which together are said to have produced considerable gold. In 1929 this district was inactive, but some preparations toward reopening the mines were under way. In general the formation and the veins are of the same types as those in the Bohemia district. Free-milling gold ore was found in the upper levels. Below the zone of oxidation the ore is of lower grade and characterized by sulphides.

Lodes containing gold, copper, and other metals are reported in the Quartzville and North Santiam districts, on the west slope of the Cascade Range north of the Blue River. Shipments aggregating about 140 tons of crude ore and concentrate are reported from mines in the North Santiam district operated in recent years by the Northwest Copper Co. The crude ore contained from 4 to 11 per cent of copper, 1 to 4 ounces of silver to the ton, and a very little gold. The concentrate contained 20 per cent of copper and 5 ounces of silver to the ton.

Small amounts of gold are said to have been produced from lodes in the Quartzville and Ogle Creek districts, on Fall Creek, and at a few other places. The geology of these areas is not known in detail.

In the southern part of the Cascade Range region production is reported from the Pearl or Buzzard mine, on Elk Creek northeast of Trail, and the Barron mine, southeast of Ashland. The Pearl mine was operated at times between 1913 and 1921. It is on a lode described as a shear zone, in andesite that contains pyrite, sphalerite, and galena with more or less gold. 13/ The Barron mine is

13/ Parks, H. M., and Swartley, A. M., Handbook of the mining districts of Oregon: The Mineral Resources of Oregon, vol. 2, No. 4, p. 179, Oregon Bur. Mines and Geology, 1916.

said to have produced about $10,000 in gold and silver from ore that was in part milled on the ground and in part shipped to a smelter. The underground workings were not accessible when that locality was visited by the writer in 1929. As described by Winchell, 14/ the lode is 16 feet thick in one place and occupies a

14/ Op. cit., p. 123.

fault that cuts volcanic rocks. A sample of ore rich in gold, silver, and zinc, with small amounts of lead and copper, consists of sphalerite, pyrite, galena, chalcopyrite, stibnite, realgar, native copper, and native gold. The maximum depth of development work is 250 feet.

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