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MINERAL RESOURCES OF THE GRANTS PASS QUADRANGLE AND BORDERING DISTRICTS, OREGON.

By J. S. Diller and G. F. Kay.

GEOGRAPHY AND GEOLOGY.

By J. S. Diller.

INTRODUCTION.

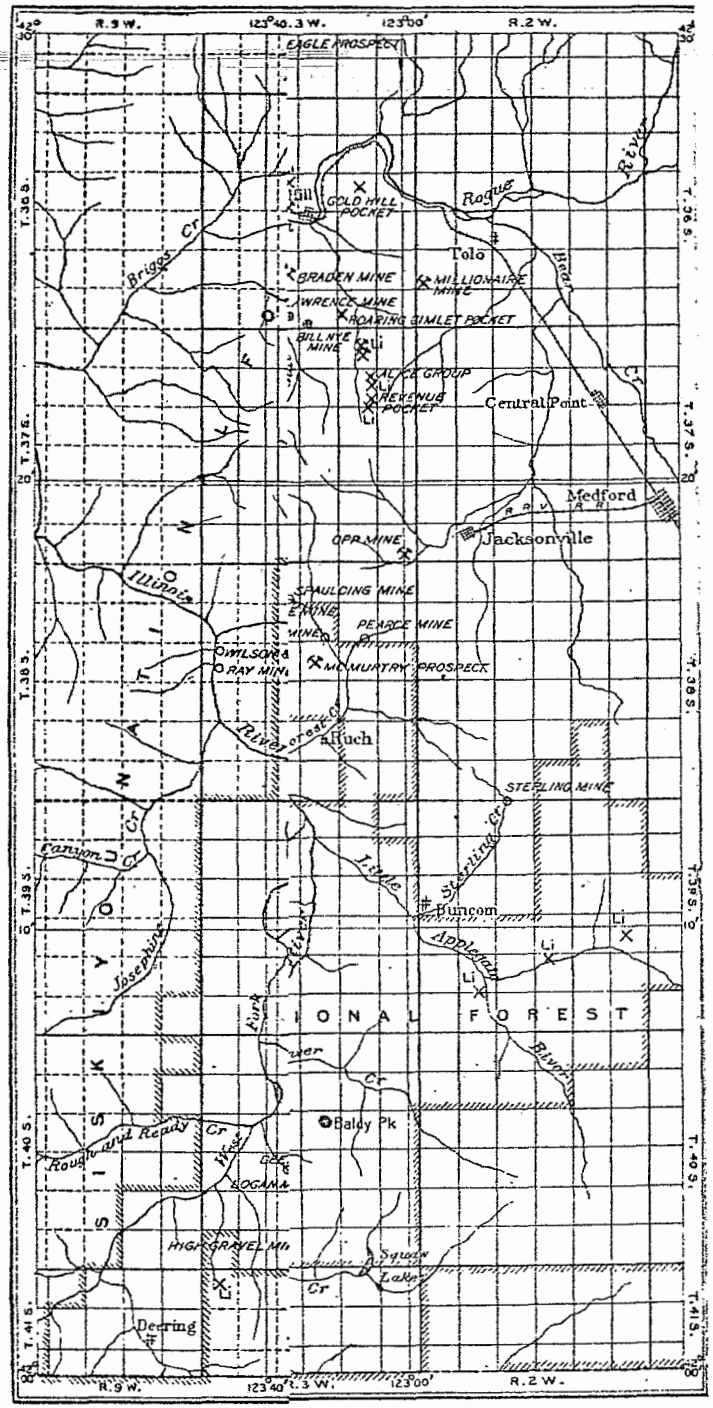
The region considered in this paper is in southwestern Oregon. As shown on the accompanying map (Pl. II), it extends from the neighborhood of Grants Pass on the north to the State line on the south, and from Illinois River on the west nearly to Jacksonville on the east. It is mainly the country drained by Applegate River, and may be conveniently referred to as the Applegate region. It has an area of approximately 1,000 square miles.

Although the principal line of travel across the area had been previously examined, by far the greater part of the work, on which this paper was based, was done in the summer of 1908. I studied the general geology, assisted by James Storrs, who searched for fossils, and Prof. G. F. Kay examined the mines which he describes in the second part of this report.

For the Grants Pass quadrangle we had a good topographic map on the scale of about 2 miles to an inch, but for the border land on the east, west, and south the available maps were on a much smaller scale. On account of the large size of the area to be covered and its complicated structure it was not possible to examine the region in sufficient detail for final mapping.

GEOGRAPHY.

The Siskiyou Mountains of southwestern Oregon and the Salmon, Trinity, South Fork, and North Yolla Bolly Mountains of northwestern California all belong to the same group, to which some years ago the late Maj. J. W. Powell, then Director of the United States Geological Survey, gave the name Klamath Mountains. This is not only a very convenient but an appropriate term and is coming into general use. The Klamath Mountains lie at the meeting point of the



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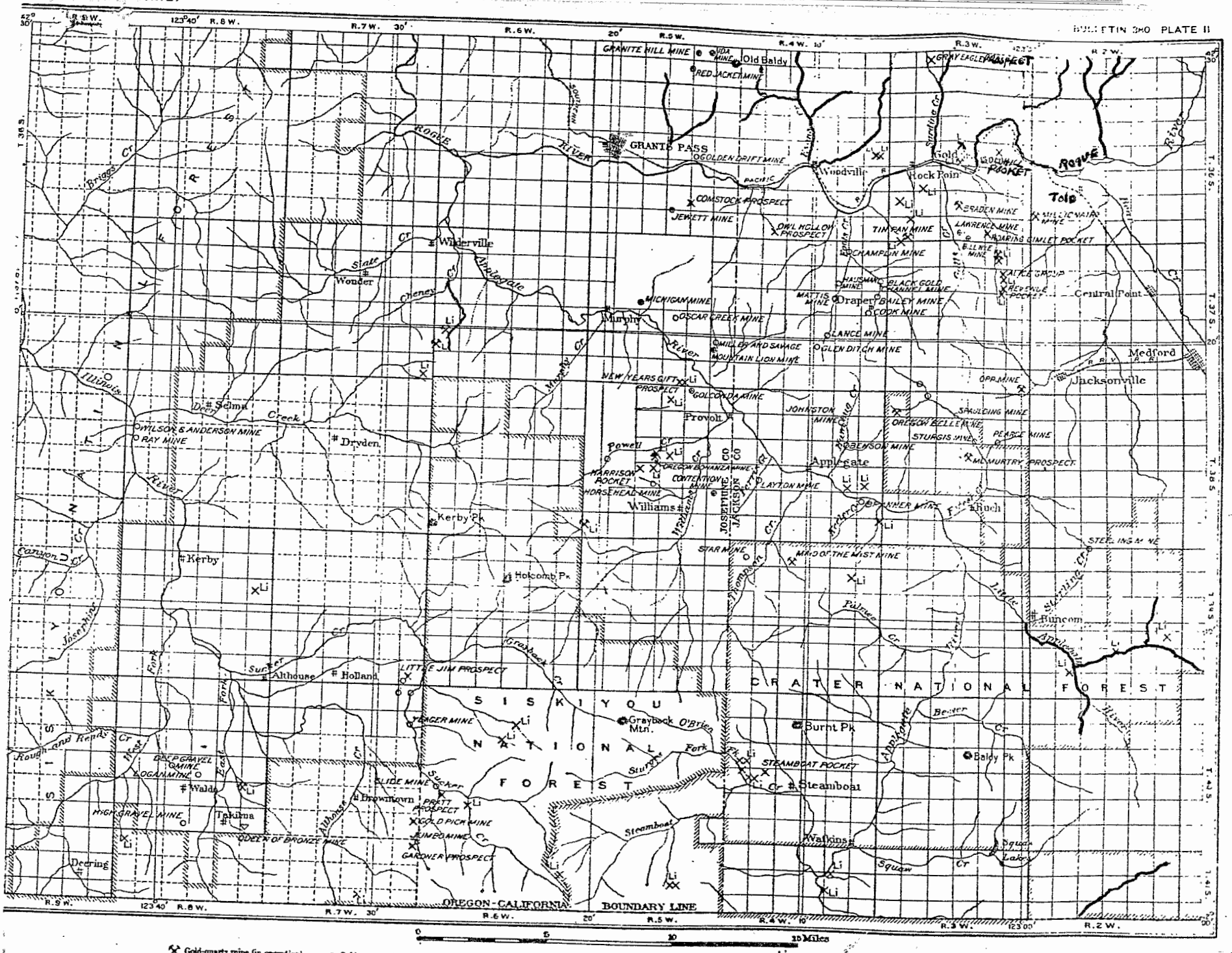
MAP SHOWING...ERING DISTRICTS, OREGON.



MAP SHOWING LIMESTONE DEPOSITS IN SOUTHWESTERN OREGON

Sierra Nevada, the Cascade Range, and the Coast Range. They are most closely related in position and structure to the Coast Range, but the kinds of rocks of which they are made up are like those of the Sierra Nevada.

The region under consideration lies within the Klamath Mountain group and extends from the crest of the Siskiyou Mountains northward to Rogue River, where the stage road and the Southern Pacific Railroad afford a convenient outlet for transportation. Applegate River, which heads in the Siskiyou Mountains, has carved out an irregular but in many places broad and fertile valley across the region. A stage mail route follows the Applegate to the crest of the Siskiyou Mountains in California, but there is no outlet to the south.

The region is mountainous and ranges in altitude from about 871 feet to over 7,043 feet above the sea. The fertile valleys are farmed and the mountains are generally well forested, especially in the southeastern portion, which belongs to the Siskiyou National Forest.

GEOLOGY.

GENERAL OUTLINE.

The rocks of the Applegate region include both sedimentary and igneous rocks of various types and ages. They are arranged in irregular elongated patches or bands running northeast and southwest diagonally across the Grant Pass quadrangle, and the igneous rocks occupy by far the larger portion of the area.

The sedimentary rocks are mainly Paleozoic (Devonian, probably with some Carboniferous), though there are a few of Tertiary age and some of Cretaceous. Besides these there is a mass of mica schists near the crest of the Siskiyou Mountains that appears to be older than the Paleozoic rocks of the same region.

The igneous rocks are in part intrusive, but many of them, possibly the greater portion, are volcanic.

MICA SCHIST.

Mica schist appears to be among the oldest rocks of this portion of Oregon. It occurs in a large area about Squaw Lake, in the southeast corner of the Grants Pass quadrangle, where it is associated with hornblende and chlorite schists. The last two are probably derived from the alteration of ancient igneous rocks, but the origin and age of the mica schist here referred to are not definitely known. Its nearness to the large mass of granodiorite that forms the core of the Siskiyou Range suggests that it may be due to the contact metamorphism of Paleozoic sediments by the granodiorite. However, the absence of andalusite and other characteristic contact minerals favors the view that the mica schist is older than the Paleo-

zoic rocks of that region and lies unconformably beneath them. It is typical mica schist for the most part, with numerous leaves and veins of quartz and locally considerable pyrite.

PALEOZOIC ROCKS.

Kinds of rocks.—The Paleozoic sediments consist of clay slates, dark, siliceous, locally banded slates, and greenish slates, interbedded with tuffs and lentils of limestone. Near the contact with granodiorite they are locally metamorphosed into fine-grained mica schist, which usually contains characteristic minerals, such as chiastolite and staurolite.

Distribution of limestone.—Limestone is one of the most important Paleozoic sedimentary rocks of the region from an economic point of view, especially on account of its relation to the cement industry, and more of it occurs in the Grants Pass quadrangle than in any other quadrangle of equal size in western Oregon.

Measured directly across the strike the area occupied mainly by Paleozoic rocks, both sedimentary and igneous, in the Applegate region has a width of nearly 30 miles, in which there are four more or less clearly defined belts of limestone containing about 50 masses, most of which are located on the accompanying map as quarries or prospects. The largest outcrop is not over one-third of a mile in length and 200 feet in thickness.

The first belt of limestones includes prominent ledges 3 miles southeast of Kerby, as well as several on Cheney Creek, where they occur under favorable conditions for handling and getting to Grants Pass by a haul of 12 miles.

The second belt is less regular. It extends from the vicinity of Gold Hill southwestward by the Oregon Bonanza mine to the Oregon Caves and beyond into California.

The third belt, with several readily accessible ledges on Kane Creek, appears to the southwest on Applegate River, on Steamboat Creek, and in the vicinity of Whisky Peak, where the belt enters California.

The fourth belt of limestone appears on Little Applegate River, and possibly also on Applegate River near Watkins, where a prominent limestone ledge occurs close to the mica schist, which it appears to overlie.

Age of limestone.—The limestones at a number of points are fossiliferous, but the fossils are too poorly preserved to permit definite determination. In two lots—one from the Happy Camp trail, 10 miles south of Waldo, and the other from sec. 19, T. 37 S., R. 6 W., about 10½ miles southwest of Grants Pass—corals are abundant, and among them E. M. Kindle recognizes with doubt forms that he compares with *Favosites nitella* and *Cladopora robusta*, as well as a gasteropod resembling *Loxonema bella*. Mr. Kindle remarks that if these determinations are correct the beds represented are of Devonian age. It thus appears that the Cheney Creek and Gold Hill belts of limestone (the first and second noted above) are of Devonian age. A striking feature that occurs locally in some of the limestone ledges of the second belt is the inclosure of vesicular volcanic fragments, which indicates that volcanic eruptions occurred in the region at the time the limestones were forming.

In the third belt of limestone, which outcrops along Kane and Steamboat creeks, the only fossils found were fragments of round crinoid stems; the fourth belt, on Little Applegate River, contains both round and pentagonal crinoid stems well preserved. The general absence of other fossils from these two belts suggests a difference in age from the Devonian, and it is probable that they are either Carboniferous or Triassic.

Composition of the limestones.—For the purpose of showing the adaptability of these limestones to the manufacture of cement the following analyses were made by R. C. Wells in the chemical laboratory of the United States Geological Survey at Washington:

Analyses of limestone from Grants Pass quadrangle, Oregon.

	Sec. 19, T. 37 S., R. 6 W.	Carter's quarry, sec. 2, T. 37 S., R. 7 W.	Householders' quarry, sec. 2, T. 37 S., R. 7 W.	Ridge 1 mile south west of Gold Hill, sec. 2, T. 36 S., R. 3 W.	Marble southwest of Williams, sec. 31, T. 38 S., R. 5 W.	Sec. 7, T. 41 S., R. 4 W., on Applegate River south of Watkins.	Three miles S. 70° E. of Kerby.
Specimen No.	7015A.	7017A.	7017B.	7021	7027	7015	7024
Calcium oxide (CaO)	55.28	55.71	55.31	41.82	55.55	55.05	55.38
Carbon dioxide (CO_2)	43.57	43.54	43.23	32.57	43.63	43.25	43.51
Water (H_2O)	.50	.37	.56	.46	.26	.50	.10
Silica (SiO_2)	.23	.37	.31	23.86	.15	.52	.18
Alumina and iron oxide ($Al_2Fe_2O_3$)	.29	.20	.41	.32	.28	.52	.62
Magnesia (MgO)	.03	.01	.03	Trace.	None.	Trace.	Trace.
	98.80	100.20	99.91	99.01	99.95	99.84	99.79

With the exception of No. 7021, these limestones are nonmagnesian and pure, and are well suited for the manufacture of cement. Shales that appear to be suitable to combine with the limestone to make cement occur convenient to the railroad in the Bear Creek portion of the Rogue River valley.

Relation of Paleozoic to adjacent rocks.—The succession of sediments included in the four belts of limestone and associated rocks, to judge from their attitude and distribution, appears to be conformable throughout, although these strata are apparently unconformable not only with the underlying mica schists but also with the overlying Jurassic rocks.

JURASSIC ROCKS.

The Jurassic rocks of this region consist mainly of shales and thin-bedded sandstones in variable proportion. Small beds of fine siliceous conglomerates are rarely present. The shales are dark, locally black, but weather gray, yellowish, or brown, and here and there are decidedly slaty. The sandstones are gray and hard. Locally in the sandstones quartz veins are abundant, but usually they are scarce or absent. The fine conglomerate of quartzose pebbles contains, on its weathered surface, small cavities from which soluble pebbles have disappeared. Near the contact with granite these rocks are, in places, altered to mica schist. They occupy only a small portion of the region under consideration, in the vicinity of the stage road from Wilderville to Kerby, and their distribution indicates that they unconformably overlap the Paleozoic rocks.

CRETACEOUS ROCKS.

The Cretaceous rocks are comparatively soft conglomerates, sandstones, and shales that once formed a conspicuously unconformable blanket-like covering over a large part of the region, but erosion has removed all of it excepting a few small patches that cling on the older rocks in the neighborhood of Jacksonville and Waldo, where the conglomerate at the base is locally auriferous and mined as a placer.[a]

That these auriferous conglomerates are Cretaceous (Horsetown and Chico) is clearly shown by the fossils contained in the overlying sandstones and shales.

TERTIARY ROCKS.

The Rogue River valley contains a mass of soft sandstone of Tertiary (Eocene) age. It is decidedly arkose near the base and, lying between the Cretaceous strata on the west and the lavas that make up the Cascade Range on the east, it contains the beds of coal best exposed in the vicinity of Ashland and Medford.

IGNEOUS ROCKS.

In the Applegate region igneous rocks are much more abundant than sedimentary rocks and are of comparatively few types, embracing greenstone, serpentine, granodiorite, dacite porphyry, and augite andesite.

The rocks included under the general term greenstone are of several different kinds, but for the most part they agree in being

[a] Lindgren (Am. Jour. Sci., 3d ser., vol. 48, 1894, p. 275) describes an auriferous conglomerate of Jurassic age in the Sierra Nevada of California, and Turner notes one of Chico age in Oregon.

much altered and greenish in color. When fresh and fully crystalline the greenstone is commonly like a gabbro composed essentially of pyroxene and lime-soda feldspar, but it may contain hornblende and resemble diorite, or have ophitic structure and pass into diabase, or be compact like basalt. Much of the greenstone, too, is locally vesicular and this feature, occurring in rock associated with beds of fragmental volcanic material, shows clearly that a large part of the fine-grained greenstone is of volcanic origin, and its relation to the fossiliferous limestones noted above indicates that the volcanoes from which it came were active, some in the Paleozoic era and others in the Mesozoic. These volcanic greenstones of various ages have been cut by numerous dikes and irregular masses of intrusive rocks of the same kind, and the whole has been so crushed and veined by later earth movements in the process of mountain building that it would be very difficult to map these rocks in detail separately.

A few irregular masses of serpentine cut the older greenstones. For the most part they have resulted from the alteration of peridotite or pyroxenite, but some may have come from a basic phase of the greenstone.

Granodiorite similar to that which covers a large area in the vicinity of Grants Pass forms irregular masses and dikes at a number of places. It is composed chiefly of plagioclase feldspar, quartz, and hornblende, generally with more or less mica and orthoclase feldspar, and with the increase of hornblende it varies in color from fine gray to greenish black.

The dacite porphyry is a light-colored rock which in composition and origin is closely related to the granodiorite. It forms dikes, and, though widely distributed, is not abundant. Some of it is decidedly porphyritic, with phenocrysts of feldspar and quartz.

The augite andesite is a dark-colored rock that occurs in a few small dikes cutting all the other igneous rocks as well as all the sedimentary rocks up to the top of the Horsetown.

The relative age of the igneous rocks, aside from the Paleozoic and Mesozoic greenstone lavas, is fairly well established. The greenstones are the oldest, followed in order by the serpentines (peridotites), granodiorite, dacite porphyry, and augite andesite. Although some of the greenstone lavas, and perhaps, also, some of the intrusive greenstones, are Paleozoic, the bulk of the intrusive rocks, including greenstones, granodiorite, peridotite, and dacite porphyry, belong about the close of the Jurassic. The augite andesite is the only igneous rock in the region under consideration that cuts the Cretaceous sediments.

STRUCTURE.

The strike of the strata older than the Cretaceous is generally northeast and southwest, parallel to the rock belts, and their dip for the most part is to the southeast, though in many places they are vertical. To judge from the position of the strata alone it appears that those in the northwest portion of the Grants Pass region should be the oldest, and that they should decrease in age to the southeast. Just the reverse, however, is the case. The youngest rocks (Jurassic) are on the northwest, and the oldest (mica schist) on the southeast, with the Paleozoic between. This apparent reversal of the natural order is due either to folding and overturning of the strata or to faulting, by which the older rocks are made actually or apparently to overlie the younger. It is very probable that both folding and faulting have contributed to the complex structure of the region, but the part played by each is practically unknown and can be determined only by detailed investigation.

The most probable line of faulting noted in the region is one which crosses it from northeast to southwest in the vicinity of Waldo and Kerby, where the Jurassic strata appear to pass beneath the Devonian. A similar line of displacement may occur in the southeastern portion of the Applegate region, between the Paleozoic rocks and the mica schists; but the evidence thus far observed is not conclusive. Both of these supposed lines of faulting have been traced by Hershey southward through the Klamath Mountains, and are shown on the geomorphic map of the California earthquake commission.

METALLIFEROUS MINERAL RESOURCES.

By G. F. Kay.

INTRODUCTION.

The mineral resources of the area under consideration are chiefly gold and copper, the former occurring in gold-quartz veins and in placer deposits. Small amounts of silver are associated with the gold, and from the placers some platinum is obtained. Stibnite, josephinite, and cinnabar have been found, but not in sufficient quantities to be profitably worked. The region in which these minerals occur lies within Jackson and Josephine counties, and covers considerably less than half of their area. The mineral production of these two counties in 1907 had a value of $443,370. Of this amount about 75 per cent came from the mines of the area here described. For that year the value of the production of the copper mines was greater than that of the gold-quartz mines but less than that of the placers.

GOLD-QUARTZ MINES.

GENERAL DESCRIPTION.

The most productive gold-quartz mines which were in operation in this area during the summer of 1908 were the Braden and the Opp.[a] The Granite Hill and Mountain Lion mines, although not now being worked, have also been fairly important producers within the last few years. There are many mines and prospects on which work is not now being done, some of which have never produced, some of which have produced values of a few hundred dollars, and a few of which have produced values of several thousand dollars. At present some development is in progress on new prospects and on mines which were until recently closed. The total gold production of the gold-quartz mines of the area in 1907 was about $70,000.

The gold-bearing quartz is widely distributed and occurs in small veins, veinlets, and brecciated zones, in several kinds of rock. Most of the mines and prospects are in the greenstones, but some are in the granodiorites, some in metamorphosed sediments, and a few prospects in peridotites or their decomposition product, serpentine. The ores are found in several relationships in these rocks. In some places they occur in greenstones at considerable distances from other kinds of rock; in others, they are in the greenstones but at the contact with or near to granodiorites and related rocks. Some veins are parallel to the schistosity in the greenstones. Again, some veinlets are in both greenstones and sediments, and in such occurrences, it is not unusual to find rich ores near the contact of these rocks and closely related to dikes which cut them. This relationship of the rich ore to dikes is also shown where the veinlets are in sediments only. In the peridotites some of the veinlets are at the contact with or near to dikes related to granodiorites.

Many of the veins and veinlets have never produced important bodies of ore but only "pockets," some of which, although filling but small spaces, were remarkably rich, the gold usually having been coarse. In general, the main part of the gold in these pockets has been taken from depths less than 25 feet from the surface.

The veins and veinlets run in all directions. However, a comparison of the more persistent of them showed that more lie in an east-west direction than in a north-south direction. The dips of the veins vary greatly; most of them have fairly high dips, but some are nearly flat and some are vertical. The widths of the veins are usually less than 1 foot; a great many are considerably less, and in some places they form an intricate network of stringers. On the other hand, there are veins with widths of more than 10 feet; in such veins

[a] The Opp mine was not examined.

either "horses" are present, separating the vein into several parts, or there is a decided brecciation of the materials.

The vein filling consists mainly of quartz, which is usually of a milky-white color. In many of the veins the quartz has crystals with perfect outlines, indicating that the deposition took place in open fissures. Calcite is frequently found with the quartz, and subordinate amounts of sulphides, chiefly iron pyrites, but not uncommonly arsenopyrite, chalcopyrite, and galena are also present. A few of the veins contain pyrrhotite. The sulphides rarely exceed 3 per cent of the ores. At the Jewett mine, near Grants Pass, and the Homestake prospect, on Lightning Gulch, a branch of Canyon Creek, gold tellurides occur.

A study of the fillings of the veins in different kinds of rock suggests that the nature of the country rock has not, to any appreciable extent, influenced the contents of the fissures. The gold is present as free gold in the quartz and also associated with the sulphides and tellurides, the concentrates at times being rich.

Few values have been found in the country rocks adjacent to the veins. These rocks are in some places only slightly altered, but in other places they have been chloritized and in still others the products of alteration consist of carbonates, albite, quartz, and pyrite. The presence of albite rather than sericite, a mineral frequently found in the wall rocks of the gold-quartz mines of California,[a] is, no doubt, due to the fact that the Oregon rocks, as indicated from the analyses thus far made, are considerably richer in sodium than in potassium.

The lower limit of the zone of oxidation is in general less than 100 feet below the surface, but in places it exceeds 200 feet.

The evidence suggests that the gold-bearing veins are younger than the early Cretaceous and older than the Eocene, but some of the veins associated with the Paleozoic rocks may be pre-Cretaceous.

DESCRIPTIONS OF THE CHIEF MINES AND PROSPECTS.

BRADEN MINE.

The Braden mine is in the SE. ¼ sec. 27, T. 36 S., R. 3 W., about 3 miles from Gold Hill. It is now owned by C. R. Ray, of Tolo, but during the past year it has been leased to the Opp Mining Company, of Jacksonville. I am indebted to E. W. Liljegran, mines manager for Mr. Ray, for information with regard to this property.

This mine was located about twenty-five years ago by B. A. Knott, of Gold Hill. He began development, the ores being treated in an arrastre. The ownership of the mine passed in succession to several persons, one of them being Dr. James Braden, after whom the mine is named. He sold to Mr. Ray in 1900. The greatest production

[a] Lindgren, Waldemar, Trans. Am. Inst. Min. Eng., vol. 30, 1901, p. 665.

of this mine for any one year was in 1907, when the value of the output was more than $30,000.

The equipment of the mine consists of a 10-stamp mill, one giant crusher, four Johnston concentrating tables, one air compressor, and machine drills. The plant is equipped with an electric power system, the power being brought from Tolo, on Rogue River, a distance of about 5 miles. The property has been developed mainly by drifts along the vein and by winzes and upraises from these drifts. The vein outcrops along the southeastern slope of a hill and dips southeastward. The angle of dip of the vein is greater than the angle of slope of the hill; hence the lower drifts on the vein are at greater depths below the surface than those higher up on the vein. There are four main drifts, one above another. The aggregate length of these drifts is nearly 3,000 feet, and the greatest depth below the surface—less than 250 feet—is in a winze from the lowest of these drifts. The longest drift is the lowest on the vein. It has a length of more than 1,200 feet, and considerable high-grade ore has been taken from the winzes and upraises made from it.

The rocks in which the ores are found are fine grained and of a dark-gray color; in hand specimens small crystals of feldspar may be seen. Under the microscope the rock appears distinctly porphyritic, the groundmass being microcrystalline. The phenocrysts are mainly plagioclase feldspar, but a few crystals of hornblende, probably secondary from augite, are also present. This rock is related to the greenstones, a large area of which lies in a northeast-southwest direction in this part of Jackson County. The area widens rapidly toward the south. The main part of this large area of greenstone is thought to be volcanic rocks interbedded with Paleozoic sediments. The evidence in favor of these rocks being volcanic consists of the presence, in many places, of amygdaloidal and tuff-like characters. Where such characters are absent it is difficult to distinguish those greenstones which are of volcanic origin from those which are fine-grained intrusives.

The vein in which the ores are found strikes about N. 30° E. The average width of the vein is not more than 2 feet; in places it pinches entirely; in other places, instead of one distinct vein with definite walls, there is a brecciated zone, which varies from a few feet to more than 15 feet in width. Within this zone the aggregate width of the quartz veinlets does not exceed 3 feet. In general, the dip of the vein is about 25° SE., but in some places it is nearly flat and in others the angle of dip is high. There are several faults, but they are of small throw—usually from 1 foot to 3 feet, rarely as much as 20 feet. These faults are approximately parallel to one another.

The vein filling consists chiefly of quartz and sulphides; a very subordinate amount of calcite is present. The most abundant sul-

phide is pyrite, but arsenopyrite, chalcopyrite, and galena occur in small quantities. The best values are found in those parts of the vein which are richest in sulphides; where the quartz is comparatively free from sulphides, the gold content is low.

During 1907 the average yield of concentrates was 1 ton from every 12.2 tons of crude ore; these concentrates had an average value of $26 a ton. The average gold and silver content of more than 3,700 tons of ore treated in 1907 was worth about $9 a ton; the silver content was worth only about 22 cents a ton. About 65 per cent of the values of the ores was saved by amalgamation and about 25 per cent by concentration; the remaining values were lost in the tailings. The concentrates were shipped to Selby and to Tacoma.

The main part of the production of the mine has come from two shoots, which are nearly 600 feet apart on the lowest drift of the mine. One of the shoots extended along the vein in this drift for about 55 feet, but in a winze its width increased to about 80 feet, below which it narrowed rapidly. The direction of the shoot was the same as that of the dip of the vein. The other shoot had a length along the strike of the vein of 75 feet; in a winze from it the length increased to 125 feet; at the bottom of the winze, which was run 200 feet below the drift, the values were low. The direction of this shoot was about S. 50° E. Usually the best values were found along the foot wall of this shoot, although in places the values were uniformly distributed across the vein, which here had an average width of about 18 inches.

The zone of oxidation does not extend to a depth greater than about 100 feet below the surface, and in parts of the vein sulphide ores are found at depths considerably less. Along the fault planes the ores show enrichment.

GRANITE HILL MINE.

The Granite Hill mine is in sec. 29, T. 35 S., R. 5 W., near the north boundary of the Grants Pass quadrangle. A good wagon road runs from Grants Pass to the mine, a distance of about 9 miles. At the time of my visit (July, 1908) this mine had been closed for several months and all the workings were filled with water. From Mr. C. M. Morphy, the former superintendent, many of the following facts were obtained. The mine is now owned by the American Goldfields Company, which also owns the property in the vicinity, including the Red Jacket and Ida mines, on which several hundred feet of development work has been done. The present owners obtained the Granite Hill property in 1901, and almost all the development work has been done since that time. During the years 1904 to 1907 the value of the production was more than $65,000, the largest output having been in 1905.

The mine is equipped with a 20-stamp mill, which has a capacity of 100 tons a day; a crusher, concentrating tables, engines, compressors, hoists, machine drills, and a Worthington mine pump. Electric power was used. When the mine was in operation as many as 50 men were employed.

The mine was developed by workings which aggregate nearly 3,000 feet. A vertical shaft of 420 feet intersects the vein at a depth of about 120 feet. From depths of 200, 300, and 400 feet on the shaft crosscuts were run to the vein and drifts made along the vein. The profitable ore between the levels was stoped out and raised through the shaft to the surface.

The country rocks are related to the granodiorites, a narrow tongue of which extends southward into the Grants Pass quadrangle from a larger area of these rocks in the Riddles quadrangle. To the east of the granodiorites is greenstone; to the west, serpentine. At the Granite Hill mine the values have been found only in the granodiorite, but at the Red Jacket and Ida mines they occur in the greenstone.

The vein runs in an east-west direction and has an average width of about 5 feet. In places the vein is brecciated, the fractured zone having a maximum width of about 20 feet. The dip of the vein is about 70° S. The vein filling consists of quartz, pyrite, chalcopyrite, and galena, carrying gold. The sulphides comprise about one-half of 1 per cent of the ores, and as concentrates they yield about $75 to the ton. The average gold value of all the ores treated in 1907 was about $5 a ton.

Mr. Morphy stated that the richest ores were found in shoots, of which there were three, each having a length along the vein of about 150 feet and a direction of dip to the west of south.

The zone of oxidation extends to a depth of more than 200 feet from the surface, and from the oxidized ores the best values were obtained.

MOUNTAIN LION MINE.

The Mountain Lion mine is in the western part of sec. 1, T. 38 S., R. 5 W. It was discovered in 1889 by the Messrs. Bailey, who, with Messrs. Davidson, Jewell, and Harmon, are the present owners. No work has been done on the property for several months. The equipment consists of a 5-stamp mill, with concentrating tables, compressor, and engines. When the mine was in operation, as many as 25 men were employed.

The property has been extensively developed, there being about 8,000 feet of crosscuts, drifts, and other workings. Work has been done on two veins, which are in greenstone and slates and which are close to the contact of these rocks, with an area of granodiorite. The

slates occur as narrow lenses in the greenstones, and the best values of the veins have been obtained near the contacts of the greenstones and the slates. The better-defined vein of the two has a direction of N. 80° W. and dips 65° S. It averages about 1 foot in width and is faulted at many places. The vein filling consists chiefly of quartz, calcite, and sulphides, the sulphides constituting about 1 per cent of the whole. Owing to the prevalence of faults the vein has been difficult to follow.

TIN PAN MINE.

The Tin Pan mine is in the SE. ¼ sec. 31, T. 36 S., R. 3 W., on the divide between Galls Creek and Foots Creek. The property was located many years ago. It is now owned by the Pacific American Gold-Mining Company. T. T. Barnard was superintendent during the summer of 1908.

The mine is equipped with a 10-stamp mill, a Blake crusher, and two concentrating tables. No large body of profitable ore has been found, although more than 1,200 feet of drifts, shafts, and other workings have been made on the vein.

The country rocks in which the ores occur are slates, limestones, and greenstones, the greenstones apparently being intrusive in the sedimentary rocks, although some of them may be volcanic. The direction of strike of the sediments is about N. 13° E. The strike of the vein is between northeast and east, and the dip is nearly vertical. The width of the vein varies from less than 18 inches to more than 6 feet of solid quartz between definite walls, which are usually but slightly altered. In places there is a gouge from 1 to 3 inches in width. This material is clay like, but it contains carbonates and sulphides. The chief values of the vein are in the sulphides, which run about $60 to the ton. The sulphides are pyrite and galena, which together constitute less than 2 per cent of the ores. Some faulting has occurred.

The zone of oxidation reaches a depth of more than 100 feet.

STAR MINE.

The Star mine is in sec. 6, T. 39 S., R. 4 W., west of Thompson Creek and about 4 miles from Applegate post-office. This property was located in 1896 by J. J. Kunutzen. Very little development work was done until 1904, when E. B. Hawkins and Harry N. Morse became the owners. They spent about $20,000 in development. Thus far only about 800 tons of ore has been milled. The gold content was low, running only from $2 to $4 a ton.

The ore was quarried from an area of fine-grained greenstone in which there were numerous small stringers of gold quartz running in various directions. No distinct vein was found.

MAID OF THE MIST MINE.

The Maid of the Mist mine is in sec. 4, T. 39 S., R. 4 W. It is owned by William Wright, who did considerable work on the property during 1906, but suspended operations in May, 1907. During the summer of 1908 it was bonded by the South Oregon Mines Company, and preparations were being made to conduct extensive developments. More than 500 feet of work, mainly in shafts and drifts, had already been done, and compressors and hoists were being installed.

The country rock is greenstone. The gold-bearing quartz occurs in veinlets, which run in various directions. One of the most persistent of these runs N. 85° W. and dips 55° S. The values are irregularly distributed through the quartz, which is fairly free from sulphides. Of the sulphides, arsenopyrite appears to be more prevalent than pyrite. Calcite is subordinate.

JEWETT MINE.

The Jewett mine is close to the boundary between secs. 27 and 34, T. 36 S., R. 5 W., about 4 miles from Grants Pass. It was discovered about 1880 by Thomas Jewett. It now belongs to the estate of Benjamin Healy, of San Francisco. During the summer of 1908 no work was being done, but J. T. Hoare, the superintendent, stated that development was soon to be resumed. A short distance from the mine is a 5-stamp mill. There are seven claims, on which more than 1,500 feet of work has been done.

The country rocks are intrusive greenstones closely related to gabbro. Near the workings a dike of granodiorite cutting the gabbro was observed. The ores do not occur in a vein with definite walls, but in small stringers in a brecciated zone, which is irregular both in direction and in width. The most pronounced direction is about N. 20° W. In places the width of the zone of brecciation is more than 20 feet. The filling between the fragments of the breccia consists chiefly of quartz and calcite, the latter being subordinate. Irregularly distributed through the quartz is a small amount of pyrite, pyrrhotite, and a glistening steel-gray mineral, which when boiled with concentrated sulphuric acid gives the purplish-colored reaction characteristic of a telluride. The properties of the mineral correspond to those of sylvanite. It was found without difficulty in several tons of ore on the dump.

HOMESTAKE PROSPECT.

The Homestake prospect is on the main branch of Lightning Gulch, a tributary of Canyon Creek, which flows into Josephine Creek about 4 miles above its junction with Illinois River. It was formerly owned

by the Lewis and Clark Gold Mining Company, but is now owned by the Homestake Mining Company, of which E. A. McPherson, of Kerby, is manager.

The chief development on this property is a tunnel about 180 feet long. The country rock is a somewhat siliceous greenstone, which is in places decidedly schistose. Veinlets parallel to the schistosity contain quartz and calcite, with which are associated native gold, gold telluride, and iron pyrites. The values are irregularly distributed, some of the ores being rich. The strike of the schistosity is north and south; the dip is 65° E.

OTHER MINES AND PROSPECTS.

Not far from the Homestake are other prospects from which gold tellurides are reported. Of these the Booth prospect, on the west fork of Lightning Gulch, and the Challin & Finch prospect about 1½ miles from the head of Canyon Creek, are the most important.

There are several other mines and prospects which might be described, but they would present no new features. Among such may be mentioned the Michigan mine, Bill Nye mine, Lawrence mine, McMurtry mine, Alice group, Gold Pick mine, Gardner prospect, Pratt prospect, Millionaire mine, Oregon Bonanza mine, Oregon Belle mine, Gray Eagle prospect, and Owl Hollow prospect. On the first seven of these no work has been done for some time; on each of the others a small amount of development is being done. Chief among the "pockets" of ore that have been found within the area are the Gold Hill, the Roaring Gimlet, the Revenue, the Steamboat, and the Harrison. The locations of these are shown on the map.

CONCLUSIONS.

The gold-quartz veins and veinlets of this area are in all important features similar to those of the Riddles quadrangle, which were described in Bulletin 340 of the Survey. Of the many veins and veinlets on which work has been done few have developed into profitable mines, and the outlook for profitable gold-quartz mining in the region is not encouraging. This unpromising condition is due to the structural features of the rocks of the area. These rocks, previous to the mineralization, had been so fractured and fissured by earth movements that later, when precipitation took place from the gold-bearing solutions passing through the rocks, the gold was widely disseminated and not concentrated into definite lodes such as are favorable to gold-quartz mining. Moreover, the difficulties of mining have been increased by faulting subsequent to the formation of the veins. To the widespread distribution of the values, however, is due the fact that placer gold is found in so many of the streams of this part of the country. The veins and veinlets carrying the gold have been undergoing erosion for many thousands of years, and during this time the gold has been carried by water and by gravity into the stream beds, from which it has been and is being mined.

PLACER MINES.

GENERAL OUTLINE.

The placer mines of Jackson and Josephine counties produced in 1907 gold to the value of $229,575, of which $107,722 came from Jackson County and $121,853 from Josephine County. More than 75 per cent of the production of Jackson County and more than 30 per cent of that of Josephine County came from the area described in this report. The chief districts contributing to this production are the Gold Hill, the Foots Creek, the Applegate, and the Jacksonville districts, in Jackson County; and the Althouse and Sucker Creek, the Williams Creek, the Waldo, and the Kerby districts, in Josephine County.

The gravel deposits that are being mined in these districts vary in thickness from a few feet to more than 50 feet. The average thickness of the gravels of all the important mines is more than 20 feet. The material of the deposits ranges from fine clay with but few bowlders to gravels that contain bowlders weighing several tons. The bowlders are, as a rule, fairly well rounded where the gradients of the streams are steep, but where the gradients are flatter, they are subangular and even angular. The predominating bowlders in the gravels are greenstone, but the kinds of bowlders vary in the different stream beds in accordance with the various kinds of rock in which the valleys have been cut. In many of the deposits the coarsest material is at or near the bed rock, but in some the bowlders are somewhat uniformly distributed throughout the section of the gravels.

With but one exception the placers are in gravels closely associated with the present streams, the deposits being either in the present stream beds or on terraces not many feet above them. The exception is at the High Gravel or Allen Gulch mine, near Waldo. Here the gravels are of Cretaceous age and lie on the divide between the east and west forks of Illinois River.

The gold content of the gravels varies greatly. In some of the best mines the average value is from 20 to 40 cents a cubic yard. The best values have usually been found at or near the base of the deposit. Much of the gold is fine, but nuggets are frequently found.

Many of the placer deposits have a bed rock of greenstone, which is in places considerably decomposed, fractured, and fissured, many of the fissures being filled with veinlets of quartz. But the gravels containing the gold are by no means confined to areas of greenstone.

Some of the placers have a bed rock of granodiorite, some of serpentine, and some of slate. In the Waldo district gravels are being mined which lie on Cretaceous conglomerates and sandstones. Much of the material of the deposits has been transported for considerable distances, and hence its origin bears no immediate relation to the rock on which it now lies. As the greenstones are the most widespread rocks of the region and as from them much of the gold of the quartz mines has come, it is reasonable to conclude that much of the placer gold has come from the veins and veinlets of the greenstone areas. But inasmuch as gold-bearing quartz is found also in other kinds of rock in this region, these have, no doubt, contributed gold to the placers. The usual slope of the bed rock is about 150 feet to the mile.

Placer mining is carried on chiefly during the first half of the year, when the supply of water is most abundant. A few mines are so equipped that there is sufficient water to operate them for a greater part of the year. Only one mine, the Champlin, on Foots Creek, is equipped for dredging; the other important mines are equipped for hydraulicking. The ground-sluicing method is used only in the small mines.

In many of the mines from three to five men are employed, but as many as fifteen are employed in some of the larger mines during the mining season.

GOLD HILL DISTRICT.

In the Gold Hill district there are no large placer mines. The most important is the Blockert mine, on Galls Creek. On the same stream work is being done on a few other properties. The gravels worked are in the present stream bed. The hydraulic method is used. On Sardine Creek also some mining is being done.

It is of interest to note that during the summer of 1908 preparations were being made to mine, by electric dredge, deposits to the south of Kane Creek, in the SW. ¼ sec. 36, T. 36 S., R. 3 W. The Electric Gold Dredging Company, of which H. A. Mansfield, of Indianapolis, is manager, had already begun work. The electric power shovel to be used is equipped with three motors, one for hoisting the dipper, one for swinging the crane or boom, and one on the crane or boom for crowding the dipper into the bank. The capacity of the shovel is about 500 cubic yards in ten hours. The electric power is brought from the Ray dam on Rogue River, 2 miles away. The water to be used in washing the gravels is obtained from reservoirs on the small stream which flows through the property. The material of the deposit is fine-grained clay and gravel having an average thickness of about 18 feet; very few bowlders are present. The bed rock is slate with a strike of N. 55° E. and a dip of about 70° SE. The slates have been considerably altered.

FOOTS CREEK DISTRICT.

There are several placer mines on Foots Creek. Of these, the chief producer is the Champlin mine, located on the creek just below the forks. The other mines are the Black Gold Channel and Cook, on the Left Fork, and the Lance and Glen Ditch on the Right Fork. For the notes on the mines on the forks I am indebted to Mr. Diller.

CHAMPLIN MINE.

The Champlin mine is on Foots Creek, about 2 miles from its junction with Rogue River. It is owned by the Champlin Dredging Company, of Chicago, which bought the property in 1903 from Mr. Lance, of Gold Hill. In the same year the company constructed a bucket dredge equipped with steam power. In November, 1905, electric power was installed, the cost of mining being thereby reduced about one-half. Thirty-six buckets are used, each of which holds 8 cubic feet of material.

The average depth of the pay gravel is about 35 feet, but deposits to depths of 46 feet have been mined without reaching bed rock. Much of the material is less than 5 inches in diameter, but bowlders of large size are numerous. The best values are found in a bluish gravel, which is generally reached at a depth of about 12 feet. This gravel is from 8 to 18 feet in thickness. Below it is a fine plastic clay, which is difficult to handle, and which carries practically no gold. In the present workings this clay is not being mined. The property contains more than 1,200 acres of placer ground, much of which has been thoroughly prospected and found to carry gold.

BLACK GOLD CHANNEL MINE.

The Black Gold Channel mine is on the Left Fork of Foots Creek, in sec. 12, T. 37 S., R. 4 W. It is leased at the present time. In the bank is exposed about 15 feet of unstratified gravels, coarsest below, and containing bowlders up to 18 inches in diameter. There is very little fine material; the bowlders, which are almost all of greenstone, are subangular to fairly well rounded. The large bowlders are handled by a derrick. Two giants are used under a head of several hundred feet. The gravels are forced upward for 15 feet over an elevator, but the sluice takes the material 2½ feet above bed rock. The mine pit of the present workings has an area of 1½ acres. A large area down the stream has already been worked over. The bed rock is slate cut by dikes of greenstone. The strike of the slates is N. 10° E.; distinct joints run about N. 70° W. Numerous small veins are present, and have a general northeast-southwest direction.

COOK MINE.

The Cook mine is in the S. ½ sec. 13, T. 37 S., R. 4 W. The pay gravel is, in places, plainly stratified, and consists mainly of fine gravel and clay. The stream bed has been mined for one-fourth of a mile. The bed rock is made up of greenstone and slates cut by numerous greenstone dikes. It has been greatly sheared and faulted. One fault runs N. 75° W. and dips 31° N.; another runs N. 53° E. and has been traced for nearly one-fourth of a mile.

LANCE MINE.

The Lance mine is on the Right Fork of Foots Creek, in the SE. ¼ sec. 22, T. 37 S., R. 4 W. It is owned by the Lance Brothers, but is leased at present. The bank has in places a thickness of 20 feet; much of the material is fine. The bed rock consists of lenses of limestone in slates, which are cut by dikes of greenstone. The bed of the stream has been mined for about one-third of a mile, and there is still considerable good ground to be mined.

GLEN DITCH AND OTHER MINES.

The Glen Ditch mine is near the head of the Right Fork of Foots Creek. It is owned by Boling Brothers. The stream bed has been followed for some distance, but much good ground remains to be worked. The gravels are about 15 feet thick.

Other small producers on the Right Fork are the Mattis and Hausman mines.

APPLEGATE DISTRICT.

The chief mines of the Applegate district are located on small streams flowing into Applegate River. The most important are the Layton mine, on Ferris Gulch; the Johnston and the Benson mines, on Humbug Creek; and the Brantner mine, near the mouth of Keeler Creek.

LAYTON MINE.

The Layton mine is part of the estate of J. F. Layton. The average thickness of the gravels is about 25 feet and the width, from rim to rim of the pay channel, is more than 200 feet. In much of the material the pebbles are less than 6 inches in diameter and are usually subangular. The largest bowlders are in the bottom of the deposit and in places they are considerably decomposed. The best values are found in an old channel about 15 feet below the level of the present stream bed. In this channel the fall is about 4 feet in 100 feet. The gold is usually in small flakes, but nuggets are also found. The bed rock is greenstone, which in places is distinctly vesicular and greatly fractured and veined. Some of the veinlets are as much as 4 inches in width. Narrow bands of slaty rock are interbedded with the volcanic rocks, which have a strike of about N. 40° E. and dip to the southeast.

Mining is carried on each year from February until September. The early miners had a small ditch with a head of 100 feet, but Mr. Layton put in two ditches, the upper of which is 21 miles long and the lower 18 miles. The water of both ditches comes from Williams Creek. Two giants are used under a head of about 300 feet. Five men are generally employed, and the amount mined off each year is somewhat more than 1 acre. The property was secured by the present owners in 1877 and since that date mining has been carried on each year. A considerable area of good ground remains to be washed.

JOHNSTON MINE.

The Johnston mine is in sec. 11, T. 38 S., R. 4 W., at the junction of the west branch with the main Humbug Creek. The present owner is W. H. Johnston. The bank averages about 8 feet in thickness and contains considerable clay, in which the main values are found. Bowlders of greenstone and granodiorite, from 6 inches to more than 8 feet in diameter, are present. Much of the mining has been confined to the bed of the stream. The bed rock consists of fine-grained greenstone, much fractured and veined. The mine is equipped for hydraulicking, the waters being brought from Humbug Creek. The supply of water is so scanty that, in general, the mine can not be operated for more than three months each year. Mining has been done on this stream for more than thirty years, during which time more than 30 acres has been mined.

BENSON MINE.

The Benson mine is on Humbug Creek in sec. 14, T. 38 S., R. 4 W. It is owned by S. L. Benson. The property consists of about 1 mile of the stream bed. The gravels are about 20 feet in thickness and contain many large angular and subangular bowlders, which are rather uniformly distributed throughout the section of the deposit. The gold is found mainly in the bottom. The bed rock is greenstone. This mine has been in operation for many years, but was not equipped for hydraulicking until the spring of 1908.

BRANTNER MINE.

The Brantner mine is on Applegate River, near the mouth of Keeler Creek. It is owned by D. H. Mansfield. In the present workings the sands and gravels have a thickness of 30 to 35 feet and show

distinct stratification. Many large angular and subangular bowlders are found at and near the base of the deposit. All the material above this is fairly well rounded and contains few bowlders. The bowlders are chiefly of greenstone and are comparatively unaltered. The surface of the terrace now being worked is about 40 feet above Applegate River. The bed rock is decomposed greenstone. The mine is equipped for hydraulicking, the water used having a pressure of about 100 feet. The large bowlders are handled by derrick. There is sufficient water to operate the mine for about three months of each year. Altogether, more than 20 acres have been mined, and considerable good ground remains to be washed.

JACKSONVILLE DISTRICT.

In the Jacksonville district is the Sterling mine, the most productive placer mine of southwestern Oregon; also the Old Sturgis, the Spaulding, and the Pearce.

STERLING MINE.

The Sterling mine is on Sterling Creek, a branch of Little Applegate River, and is about 8 miles from Jacksonville. It is owned by the Sterling Mining Company, of which J. D. Heard is manager. The property includes about 2,000 acres, extending from a point below the mouth of Sterling Creek to the head of Sterling Creek and over the divide to Griffin Creek. The gravel bank on the west side of the present workings is more than 40 feet in thickness, but on the east side it is only about 20 feet thick. The section consists of gravel and bowlders, the latter being rather uniformly distributed throughout the section. Many of the bowlders are small, but some are more than 2 feet in diameter and a few exceed 8 feet. They are mainly of greenstone.

Much mining has been done on Sterling Creek by the present company. The main stream was mined up from its mouth for more than 3 miles, then a channel to the east of this stream was followed for about half a mile. Here a channel, which is named Bowlder Channel, was struck, and this has been followed for about a quarter of a mile to the present workings. The bed rock of these workings is a little higher than the present stream bed and is about 100 yards east of it. The values are found across a width of nearly 200 feet. The gold is of medium coarseness and is usually well rounded, although angular nuggets are also present. The average thickness of the gravels in the Bowlder Channel is about 40 feet. It is of interest to note that in these gravels the tusks and jaws of a mammoth, as well as other mammalian bones, have been found. The bed rock at the mine is greenstone, in which are patches of slaty tuffs. These rocks have been considerably sheared and veinlets of quartz are present. The strike of the slaty rocks is N. 8° E., the dip about 60° W. In the present workings is a dike running N. 20° E., containing cross veins which do not extend beyond the dike. The slope of the bed rock is about 2 feet in 100 feet. In 1908 mining was in progress from March until August, during which time about 1 acre was mined. The value of the gravels was about 40 cents to the cubic yard.

The mine is well equipped with ditches, giants, and flumes. The longest ditch is about 27 miles in length. The water enters the ditch from Little Applegate River about 12 miles above the mouth of Sterling Creek. At the mine the head of the water is now only about 80 feet. A pipe line is being planned to carry water from Squaw Lake to the mine, a distance of 17 miles. The mine has been equipped for hydraulicking for about thirty years. The Sterling Mining Company was incorporated in 1872. There were issued only 40 shares of stock, which have been held by a very few shareholders. The total production of the mine is said to exceed $3,000,000.

SPAULDING MINE.

The Spaulding mine is on Forest Creek in sec. 4, T. 38 S., R. 3 W. The maximum thickness of the deposit in the present workings is more than 40 feet, but the average thickness does not exceed 25 feet. The lowest 10 feet consists of gravels containing bowlders; the upper part of the deposit is hardpan. Even in the lower part there are but few bowlders, and these are usually less than 1 foot in diameter. They are rounded or subangular and are usually of greenstone, although some are of granodiorite. The mine is equipped for hydraulicking.

OLD STURGIS MINE.

The Old Sturgis mine is on Forest Creek in sec. 10, T. 38 S., R. 3 W. It is now owned by the Sterling Mining Company. G. L. Jones is the foreman. The deposit has an average thickness of about 30 feet; the maximum thickness is about 60 feet. In the lowest 10 feet are gravels and sand containing rounded and subangular bowlders, which are chiefly of greenstone, although some are of granodiorite. The upper part of the deposit is hardpan, which has a reddish to buff color. The gold is fine, and the best values are near the bottom. The richest ground is said to run as high as $12,000 to the acre. The bed rock is greenstone much fractured and veined; in places it is very slaty, the strike being N. 30° E. and the dip 48° SE. In the mine pit the bed rock is about 8 feet above the stream bed and the slope is very gentle. The water supply is such that the mine may be operated from one to four months each year. The

main ditch is about 1½ miles in length. The mine is equipped with giants, and a derrick is used for handling the bowlders. About 1 acre a year is mined. From 8 to 12 men are employed. The property contains about 900 acres, a large part of which is placer ground. For many years the mine was owned by the Vance Mining Company.

PEARCE MINE.

The Pearce mine is on the east fork of Forest Creek in sec. 11, T. 38 S., R. 3 W. The gravels have an average thickness of about 12 feet, but in places they have been 45 feet thick. Where recent work has been done the bank is about 25 feet thick. In the lowest 6 feet of the deposit there are many large undecomposed bowlders, but above this zone the material is gravel and sand not very strongly cemented. The best values are at and near the bottom. In general the gold is rather fine. Some of the ground has run as high as $7,000 to the acre. The bed rock is greenstone, the slope of which is not more than 2 feet in 100 feet. The mine is equipped for hydraulicking, three giants being used. The pressure of the water is only about 85 feet. The water is brought 1½ miles from the upper part of the stream on which the mine is located. A derrick is used for handling the bowlders. The property consists of 240 acres, a large part of which remains to be worked.

In addition to the mines on Forest Creek already described, there are some other small producers. In the early days of placer mining in Oregon, Forest Creek was among the most productive streams.

ALTHOUSE AND SUCKER CREEKS DISTRICT.

From the gravels of Althouse and Sucker creeks a large amount of gold was washed in the early days of placer mining in Oregon, but for several years the production has not been great, as the best ground was worked many years ago. During 1907 the production of the streams of this district probably did not exceed $6,000. There are no large mines, but numerous small ones. Among these are the Jumbo, the Mountain Slide, the Slide, and the Yeager, on Sucker Creek and its branches. On Althouse Creek some work is being done on the Layman property, and recently the Klamath Development Company acquired eight claims near Grass Flat, on which considerable work is to be done. Some new ground was also being opened at the mouth of Portuguese Gulch, a small branch of Althouse Creek near its head.

WILLIAMS CREEK DISTRICT.

The chief placer mines in the Williams Creek district are the Horsehead mine, on a branch of Williams Creek, the Miller & Savage mine, on Miller Creek, and the Oscar placer, on Oscar Creek.

HORSEHEAD MINE.

The Horsehead mine is in the SE. ¼ sec. 21, T. 38 S., R. 5 W., and is owned by Alexander Watt. The gravels vary in thickness from a few feet to 30 feet, with an average of about 18 feet. The deposit contains many angular and subangular bowlders considerably more than 1 foot in diameter. These are somewhat uniformly distributed throughout the section. Many of the bowlders are greenstone, but some are granodiorite. The finer materials are of a grayish to reddish color. The values are distributed through the gravels and as a rule the gold is fine. The bed rock is granodiorite, which has been fractured and crushed and in places has been disintegrated and decomposed to a depth of more than 10 feet. An area of more than 10 acres has been mined. The property is equipped for hydraulicking. The water is brought from Munger Creek, the ditch being 8 miles long.

MILLER & SAVAGE MINE.

Miller & Savage's mine is on Miller Creek in sec. 25, T. 37 S., R. 5 W. The gravels vary in thickness from 6 to 30 feet, with an average of about 18 feet. Many bowlders exceeding 1 foot in diameter are present, the largest of these being at the bottom of the deposit. The gold is mostly fine, but nuggets of large size have been found. The largest of these was found several years ago and is said to have weighed more than 13 ounces. The mine is equipped for hydraulicking. The present owners have mined each year since 1904, and considerable good ground remains to be washed.

OSCAR CREEK MINE.

The Oscar Creek mine is on Oscar Creek, a small stream which flows into Applegate River. The property comprises more than 300 acres. The gravels have an average thickness of about 12 feet and contain many rounded bowlders of medium size. The materials are not strongly cemented. The gold is found in flakes and in nuggets. The equipment consists of two giants, 1,100 feet of pipe, 300 feet of flume, and 3 miles of ditches. The supply of water is sufficient to carry on operations for about four months of the year. It is said that the property has produced more than $35,000.

WALDO DISTRICT.

In the Waldo district there are three important placer mines, the High Gravel or Allen Gulch mine, the Deep Gravel mine, and the Logan, Simmons & Cameron mine.

HIGH GRAVEL MINE.

The High Gravel mine is about 1 mile south of Waldo on a ridge which forms the divide between the east and west forks of Illinois River. The summit of the ridge is about 1 mile from the east fork and is more than 300 feet above it. The chief workings are at the head of Allen Gulch, on the east slope of the ridge. The most recent workings, however, are on the west slope of the ridge. Of the summit of the ridge a width of only about 100 feet remains to be mined.

This mine is of unusual interest in that the deposits do not belong to the present stream bed or adjacent benches but are conglomerates which are, according to Mr. Diller, who has made a study of the geology of the region, of Cretaceous age.

The deposits mined on the west slope run parallel to the ridge. They are more than one-eighth of a mile in length and have an average width of about 100 feet. The conglomerates do not extend down the slope but constitute only a remnant which here has escaped erosion, as is true of other areas of conglomerate in the region. No conglomerate remains on the summit of the ridge a short distance to the north of the present mine pit. The surfaces on which the conglomerates were laid down were uneven, and hence the thicknesses of the conglomerates vary. The maximum thickness exposed is more than 60 feet. The conglomerates have a purplish tint. They are not strongly cemented and the bowlders are rather uniformly distributed throughout the section. Much of the material is less than 1 foot in diameter; a few bowlders are more than 3 feet. Distinct joints are present in the conglomerates, and a few small veinlets occur. The bed rock is a fractured, fissured, decomposed, and veined greenstone, which, owing to the presence of iron oxides, has a decidedly purplish tint.

The workings on the east side of the ridge extend down Allen Gulch to the east fork of Illinois River, but only those gravels which are near the summit of the ridge are of Cretaceous age. These conglomerates extend along the ridge in a north-south direction. At the south end of the workings they are more than 50 feet in thickness; at the north end and close to the summit of the ridge they are only a few feet thick, and a little farther on they have been completely eroded. The best values are said to be near the bed rock, but some gold is found higher up in the deposit.

These Cretaceous conglomerates are shore deposits, derived from older rocks, similar to those on which they now lie. As stringers carrying values are fairly widespread in these old rocks, some gold is probably present in much of the conglomerate which has been derived from them. But whether or not these values are sufficiently concentrated, as at the High Gravel mine, to be profitably mined can be determined only by prospecting.

It is of interest to note that some placer mines in northern California are in conglomerates of Cretaceous age.[a]

DEEP GRAVEL MINE.

The Deep Gravel mine is about 1 mile northwest of Waldo. The property comprises about 560 acres in secs. 20, 21, and 28, T. 40 S., R. 8 W. It is owned by the Deep Gravel Mining Company. The main workings are in Butcher Gulch and its tributary gulches. The gravels of these gulches are included in a bench which extends from the head of Butcher Gulch to the west fork of Illinois River. The upper limit of the bench is about 1½ miles from the west fork and about 125 feet higher than the bed of this stream. The most recent workings are in Joe Smith Gulch, an eastern tributary of Butcher Gulch, where an area of more than 10 acres has been mined. At the upper end of these workings the gravels are about 12 feet in thickness; at the lower end they are more than 60 feet and the bank consists of gravel and sand containing practically no bowlders except in the lowest 10 feet, and even there few of them exceed 1 foot in diameter. Stratification is well shown. The bed rocks in Joe Smith Gulch consist of purplish conglomerates of Cretaceous age, similar to the conglomerates that are being mined at the High Gravel mine. As these conglomerates of the Deep Gravel mine have not yet been well prospected, their gold content is not known.

The mine pit of Joe Smith Gulch is 1,500 feet from the west fork of Illinois River. The elevation of the bed rock in the mine pit is more than 30 feet below the stream bed of the west fork, a fact that has greatly increased the difficulties of mining, necessitating the use of a hydraulic elevator. The elevator is situated at the lower end of a sluice with riffles. The pay gravel from the bank is first washed through the sluice, the coarse gold being caught on the riffles. Then the material including the fine gold is carried up 46 feet by the elevator, the water pressure used being about 200 feet. At the head of the elevator is a 4-foot flume, 400 feet in length, in which are wooden riffles placed about 1¼ inches apart and parallel to the length of the flume. A beveled steel strip is attached to the upper surface of each riffle. These steel strips are slightly wider than the riffles and, when they are set in place, are about three-fourths of an inch apart.

A clean-up is made about once a month. The gold is saved by amalgamation and is very fine. The concentrates are sold for their values in platinum, osmium, and iridium. Mr. Wimer, the presi-

[a] Eng. and Min. Jour., vol. 76, pp. 653–654.

dent of the company, stated that the average value of the pay gravels during the last five years had been about 25 cents to the cubic yard.

The water used in the pit and in the elevator is brought by two ditches from the east fork of Illinois River. The longer of the two ditches is about 4 miles in length. There is on the property a race about 7,000 feet long that was used for many years when the gravels being mined were at an elevation greater than that of the outlet of the race. At present only the lower end is used.

The history of the Deep Gravel mine dates back for more than thirty years. The first owners were George and Walter Simmons. In 1878 Wimer & Sons bought a half interest and in 1888 they secured all rights to the property. In 1900 the Deep Gravel Mining Company became the owner. Mr. Wimer stated that about $130,000 has been expended on the property and that the output of the mine has been about $250,000.

LOGAN, SIMMONS & CAMERON MINE.

The Logan, Simmons & Cameron mine is northeast of Waldo, the present workings being in sec. 22, T. 40 S., R. 8 W. J. M. Logan is manager. The recent workings are on French Flat, where about 3 acres has been mined. Here the bank consists of gravel, sand, and clay, with a thickness varying from a few feet to 15 feet. Much of the material is fine; only a few bowlders are present, nearly all of which are less than 6 inches in diameter. The bed rock is purplish Cretaceous conglomerate, which has been fractured, fissured, and to some extent veined. The slope of the bed rock is very gentle.

An elevator which raises the material 38 feet is used. There are three ditches. The water from one of these has a pressure of 325 feet and is used in the elevator; that from another is used in two giants in the pit; and that from the third ditch is used in forcing the tailings from the end of the sluice at the head of the elevator. Mining is carried on for about eight months of the year.

The old workings on this property are in Carroll Slough, more than a mile north of the present pit on French Flat. The gravels have been mined in a north-south direction for more than a mile; the average width is about one-eighth mile, the average depth about 18 feet. The gold content was about 12½ cents to the cubic yard. The bed rock is made up in some places of serpentine and in others of Cretaceous conglomerates and sandstones.

This mine has been operated for about twenty-five years, but not until the last season was work begun on French Flat, where there is a considerable area of auriferous gravels. The present owners have operated the mine for the last eight years. Mr. Logan stated that during that time the value of the output has been about $50,000.

KERBY DISTRICT.

The chief placer mine of the Kerby district is the Anderson & Wilson property on Illinois River about 6 miles from Kerby. Other producers are the Ray mine, which adjoins the Anderson & Wilson mine on the south, and, on Josephine Creek, the Flintlock mine, Morrison Brothers' mine, and the Josephine and Illinois Gold Mining Company's mine.

ANDERSON & WILSON MINE.

Anderson & Wilson's mine is on the east bank of Illinois River above the mouth of Deer Creek. The gravels are in benches adjacent to the river. The bed rock of the workings farthest down the stream is but little higher than the bed of the river. The gravels are about 20 feet thick and in places have been mined for a distance of about one-eighth mile back from the stream, where the slope rises steeply and the limit of the bench is reached. The sand and gravels are of a buff color and are well stratified. The largest bowlders are in the lowest 6 feet of the deposit.

The most recent work has been done on gravels lying south of those just described, about 50 feet above the level of Illinois River. The workings run parallel to the river for about 200 yards and extend back from it for about 150 yards. The gravels vary in thickness from a few feet to 25 feet. The upper part of the deposit is rather fine sand and gravel; below this there are many bowlders. Stratification is well shown.

The bed rock is serpentine. The water is brought from Fidler Gulch, a branch of Josephine Creek. It is conveyed across the Illinois at the mine in a large pipe.

OTHER MINES.

The Flintlock mine, Morrison Brothers' mine, and the Josephine and Illinois Gold Mining Company's mine are all equipped for hydraulicking. Their combined output in 1907 had a value of a few thousand dollars.

COPPER MINES.

According to returns from the smelters, Oregon produced 545,859 pounds of copper in 1907. Of this amount, by far the larger part was derived from the ores of Josephine County and the remainder from the ores of Grant County. The entire output of Josephine County came from one mine, the Queen of Bronze, in the Waldo district. Some good ore had been taken from several small mines adjacent to this one, but operations on these mines have been suspended for some time. During the summer of 1908 very little work was being done at the Queen of Bronze mine, but preparations were being made for more extensive developments.

QUEEN OF BRONZE MINE.

The Queen of Bronze mine is located in sec. 36, T. 40 S., R. 8 W., about 6 miles from Waldo and 2 miles from Takilma. It is owned by the Takilma Smelting Company, of Colorado Springs, Colo., and was superintended by C. E. Tucker.

The rocks with which the ores are associated are gabbros, peridotites, and serpentine. These rocks are widespread in southwestern Oregon. The peridotite, which consists chiefly of enstatite and olivine, is in many places intruded in the gabbro; in other places the peridotite and gabbro appear to be products of differentiation of the same magma, there being no sharp line between those rocks which are rich in olivine and pyroxene but have no feldspar and those which are olivine gabbros and gabbros, the last named containing chiefly plagioclase feldspar and pyroxene but no olivine. Locally the peridotite grades into pyroxenite. The compositions and field relationships of these rocks clearly indicate that they are closely related genetically. In some places the peridotites and related rocks are fairly free from decomposition, but over large areas they have been altered to serpentine, which usually has a greenish-yellow color and shows slickensided surfaces. At a few places the serpentine is itself undergoing decomposition, one of the products of alteration being magnesite. The peridotites, gabbros, and serpentine almost everywhere shows the effects of earth movements. They are fractured, fissured, and jointed, and in many localities are decidedly brecciated. The soil formed from these rocks is in general of a reddish color and supports a scant vegetation.

The outcrops of the ore deposits consist of gossan, the oxidized materials varying in depth from a few feet to more than 100 feet. The ore bodies have no definite form but occur as irregular masses in the gabbro, the peridotite, and the serpentine. These masses or pockets of ore appear to have no definite relationships to one another but occur irregularly in the fractured and fissured rocks. Most of the ore bodies, however, that have been found on the Queen of Bronze and adjacent claims lie in a zone that extends for several miles in a north-south direction and has a width of less than 1 mile. The largest single body of unoxidized ore mined at the Queen of Bronze mine contained about 10,000 tons. Practically all of it came from a depth of less than 30 feet. Other masses of unoxidized ores have been taken from depths of about 100 feet. Although depths of about 300 feet have been reached in the workings, no important body of ore has been found below 125 feet. Several occurrences of slickensided ores were observed, and in some places the ore contains small veinlets of calcite.

The unoxidized ore is chalcopyrite, with which are associated pyrite, pyrrhotite, and subordinate amounts of quartz and calcite. In the low-grade ores pyrite and pyrrhotite are the most abundant minerals. In addition to the copper content, the ores carry some gold and silver.

The oxidized ores are malachite, azurite, cuprite, tenorite (?), and chrysocolla. Of these the black ores, containing tenorite or chalcocite, are most abundant. Several thousand tons of oxidized ore has been mined. The average content in copper was more than 10 per cent. The lower limit of the oxidized ores is usually less than 90 feet from the surface, but some have been found at greater depths. In a small opening about 105 feet below the surface black oxide and small amounts of native copper were observed. The zone of oxidation is invariably deeper where the rocks have been serpentinized than where the country rocks are fairly fresh.

These ore bodies are apparently the result of precipitation from mineral-bearing solutions which entered the rocks after they had been fractured and fissured by earth movements. Whether these solutions were set free from cooling magmas as they solidified to form igneous rocks or whether they were of meteoric origin it is impossible to determine. Although dikes cutting the peridotite and gabbro were not observed in the vicinity of the mine, their presence in other areas of these rocks would suggest that the solutions may have been associated with the magmas from which the dikes were formed. In places in the serpentine below the zone of oxidation chalcopyrite with slickensided surfaces has frequently been found. The chalcopyrite appears to have been subjected to all the movements which accompanied the process of serpentinization. This indicates that the ores are older than the serpentine.

The mine is more than 20 miles from Grants Pass, which is the most accessible point on the railway. The only means of transportation between Grants Pass and the mine is by wagon; consequently the rates for hauling machinery, provisions, and other materials for the mine and coke for the smelter have been high. This fact has been unfavorable to the development of the property. The mine is situated on the slope of a ridge. The smelter is at the base of the slope 500 feet below the mine and 1½ miles from it. The ores, when taken from the workings, are trammed to bins, from which they are transferred to wagons and hauled to the smelter.

The equipment at the mine consists of three boilers, an air compressor, a hoist, and two machine drills. The mine has been developed by tunnels, drifts, and open cuts. The chief workings are related to two gossan-covered areas on the claim. The northern and more extensive workings are near the north boundary of the claim; the other workings are about 1,200 feet farther south.

The northern workings consist of two tunnels, from which considerable drifting has been done, and a large open pit. The upper tunnel, which is about 400 feet long, enters the west slope of the ridge and runs eastward beneath an area of decomposed and brecciated gabbro, in which are oxidized ores. At no place does this tunnel have a vertical depth of more than 90 feet from the surface. In this tunnel and in drifts and winzes from it some large irregular-shaped masses of chalcopyrite, but practically no oxides, were obtained. From the tunnel an upraise was made to the oxidized ores. This upraise was then used as a chute. The oxidized ores were mined to the surface by overhand stoping, passed through the chute, and carried out by tram through the tunnel. Several thousand tons of oxidized ores were mined in this way, the large open pit thus formed having an area of about 120 by 120 by 80 feet. Where the tunnels and other workings were in the serpentine, great care had to be taken in timbering. The lower tunnel also enters the west slope and is about 190 feet below the upper tunnel. In it and in drifts from it more than 1,100 feet of work has been done. Only a small amount of ore was found in these workings.

The southern workings consist of a large open cut, a tunnel, which runs underneath this cut, and a 106-foot shaft. From the open cut about 10,000 tons of unoxidized ore, carrying about 7 per cent of copper, was taken. The zone of oxidation was only a few feet in depth. The ores mined were passed through a chute from the bottom of the pit to the tunnel and then trammed to the bins. From the tunnel and the shaft only a small amount of profitable ore was mined.

All the ores that have been mined have been smelted at the Takilma smelter, which is under the same ownership as the mine. The smelter is of the pyritic matte type and has a capacity of 100 tons a day. The charge used was about 1,500 pounds of ore, 350 pounds of limestone, and 200 pounds of coke. The limestone used had to be hauled about 2 miles. The matte from the ores smelted in 1907 contained about 40 per cent of copper.

The Queen of Bronze property was acquired in 1903 by the present owner. Only a small amount of development had been done on the property previous to its acquisition. In all about 30 claims are owned by the company. Including the cost of the smelter, more than $150,000 has been spent on the properties. Mr. Tutt, the president of the company, stated that more than 20,000 tons of ore had been smelted and that the average copper content had been about 8½ per cent. The gold content of the ores has been worth more than $3 a ton, the silver content about 17 cents a ton. Ore was first smelted from this property in 1904. The greatest production was in 1907.

OTHER COPPER MINES.

As already stated, there are several small mines adjacent to the Queen of Bronze mine, and owned by Mr. Tutt and his associates. Considerable development has been done on these properties, and from three of them—the Cow Boy, the Lyttle, and the Mabel—about 4,000 tons of ore has been smelted. The characters of the ores, their modes of occurrence, and their associations are similar to those of the Queen of Bronze mine.

Some distance to the northeast of the Queen of Bronze mine is a prospect owned by Doctor Spence. On this property considerable work has been done and some good ore has been found.

PROSPECTS OF STIBNITE, JOSEPHINITE, AND CINNABAR.

Within the area here described stibnite, josephinite, and cinnabar have been found in small quantities.

A stibnite prospect is located in the SE. ¼ sec. 24, T. 40 S., R. 4 W., about 3 miles north of Watkins, on Applegate River. It is owned by C. M. Buck, of Watkins. The ore occurs in the fractures of a fine-grained brecciated greenstone. From a trench about 50 feet long and a tunnel about 25 feet long several tons of good ore has been mined. Where the ore is exposed the antimony sulphide is being changed to antimony oxide.

The mineral josephinite has been found only in the placers of Josephine Creek, in Josephine County. It is an alloy of iron and nickel, containing 60.47 per cent of the latter.[a] When the mineral is polished it has the appearance of metallic iron or nickel. Although it has not been found in the rocks, the mineral in the placers has probably come from the serpentine through which the stream has cut its channel.

A small prospect of cinnabar, the sulphide of mercury, is located on Palmer Creek, a western branch of Applegate River. Although a considerable amount of the mineral is reported to have been found with the gravels of the stream, very little has yet been found in the surrounding rocks.

[a] Am. Jour. Sci., 3d ser., vol. 43, p. 509.

NOTES ON THE BOHEMIA MINING DISTRICT, OREGON.

By Donald Francis MacDonald.

INTRODUCTION.

The Bohemia mining district is in Lane and Douglas counties, west-central Oregon. It lies on Calapooya Mountain, in the western foothills of the Cascade Range. The district is about 30 miles southeast of Cottage Grove, a small town on the Southern Pacific Railroad. The Oregon and Southeastern Railroad runs from Cottage Grove to Disston, within 12 miles of the mines, which are reached by stage.

In August, 1908, the writer made a short stay in this district and incidentally to other work visited some of the larger mineral properties. For some of the data presented herein he is indebted to Mr. J. S. Diller, of the United States Geological Survey, who made a reconnaissance of the region in 1898,[a] and for many courtesies to Messrs. L. D. Ryan, F. J. Hard, W. W. Warner, and other mining men of the district.

PHYSIOGRAPHY AND GENERAL GEOLOGY.

The relief of the district is pronounced. Several peaks are more than 6,000 feet high, and the elevation of the lowest valleys is less than 2,000 feet. This bold relief is the result of mountain glaciation and stream erosion. The luxuriant vegetation due to the humid climate has somewhat masked the geologic features of the region. Great forests clothe the mountain slopes and the region is notable for its timber value.

The rocks of the district are andesitic lavas and tuffs of Tertiary age, which are cut by dacite porphyry and probably by basalt. The andesites are the most abundant rocks. Seven consecutive flows, aggregating 500 feet in thickness, appear on the south face of Bohemia Mountain. They vary from light to dark gray in color and in hand specimens show small elongated phenocrysts of feldspar and very small greenish crystals of pyroxene or chlorite. In weathering the rock assumes a light-gray to buff color, the feldspars becoming white and powdery. Good exposures of andesite are shown on Bohemia, Elephant, Fairview, and Grizzly mountains.

[a] The Bohemia mining region of western Oregon: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, pp. 7–64.

The tuffs, in the main, are of andesitic composition and at many places are interbedded with andesite flows. A tuff composed of coarse fragments occurs near the White Ghost claim on City Creek. Fine tuff interbedded with lava is shown in the crosscut to No. 2 level in the Noonday mine. The slope east of Horseheaven Creek shows a considerable area of light-gray stratified tuffs. Fine gray banded tuffs were seen on the slopes below Judson Rock. These tuffs are contemporaneous with the andesites, particularly with the later flows.

A light-gray rock, probably dacite porphyry, cuts the darker andesites and tuffs in many places. This rock on fresh fracture shows minute aggregations of quartz, larger crystals of feldspar, and small dark crystals of pyroxene and hornblende. The fine groundmass between the large crystals is gray to slightly greenish, the green tinge being due to the presence of chlorite. This dacite porphyry cuts andesites and interbedded tuffs at several places along the road about halfway between Disston and Orseco. It also occurs within half a mile of the Musick mine, both to the northeast and to the southeast.

Basalt occurs in one or two small outcrops. It is a fine-grained, dark lava, best shown on the south edge of Bohemia Mountain. Its small outcrop suggests that it is intrusive in the andesite.

ORE DEPOSITS.

The ore deposits of this district are fissure veins, which cut the andesites and tuffs. Small sulphide impregnations also occur in the vicinity of altered diabasic dikes, but they have no economic value. The general strike of the veins is north to northwest, with a dip of 60° to 85°. They vary from 1 foot to 12 or 15 feet in width. Some are single veins; others consist of two or more parallel veins, separated by a few inches to a few feet of highly altered country rock. At the Musick mine there are three parallel veins, 1 to 4 feet in width, separated by thin walls of altered country rock. Only the fissure veins which have suffered postmineral fracturing have produced profitable ore. These veins, because of their oxidized and easily workable condition, gave good returns in free gold in their upper workings. Veins which have not been fractured since they were mineralized, or which are situated in regions of maximum erosion, such as old glacial cirques, show sulphide ores at the surface. They are tightly cemented and relatively impermeable and represent the conditions of mineralization that prevail in all the veins below the oxidized zone. The minerals which they contain are sphalerite, pyrite, a little galena, and very little chalcopyrite, with a gangue of quartz, altered country rock, and some calcite. So far these veins have not been found profitable, because their sulphide ore can not be cheaply treated, the tightness with which the ore is cemented makes mining more expensive, and the gold tenor is less than that of the oxidized material.

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HYDROTHERMAL METAMORPHISM.

In the vicinity of the veins the mineralizing solutions have greatly altered the country rock. Several hundred feet distant from a vein the dark color of the rock is in many places changed to a greenish tinge, while close to the deposit it is gray to buff in color, has a clayey appearance, and crumbles easily. The pattern of the rock is fairly well preserved, however, the outlines of the feldspar phenocrysts being clearly visible, though the feldspar material has been changed to a white or yellowish powder.

Under the microscope it is seen that the basic feldspars have altered into sericite, calcite, and quartz, the quartz, however, being in relatively small quantity. The ferromagnesian minerals have been changed to calcite and the iron in them appears now as limonite or hematite. Farther away from the vein, where metamorphism was less intense, these minerals have reached only the chloritic stage of alteration. In many veins soft disintegrated country rock forms a considerable part of the vein matter. An examination of this material showed that near the surface it is composed essentially of very fine granules of quartz with considerable iron-stained kaolin. At greater depth the same rock contains an abundance of sericite and calcite with very little kaolin.

SECONDARY ALTERATION AND ENRICHMENT.

Some of the veins were brecciated after they were filled, and as a result oxygenated surface waters were able to percolate downward along the fractured zone. The ores were thus oxidized and sulphides leached out to depths of 100 to 300 feet, depending on the degree of brecciation and the rate of erosion. The gold occurred as threads and filaments included in the pyrite. The pyrite was leached away, leaving the relatively insoluble gold and some iron oxide occupying a part of the small cavity left in the vein material. This process brought about an association of free gold with iron-stained, spongy quartz and enriched the ore by leaching out the valueless sulphides. It also rendered the ore soft and porous, so that it is much more cheaply mined and milled than the unaltered ore.

Small local enrichments of free gold occur at the junctions of fissures, pyrite being abundant at these junctions, as shown by the mass of iron oxide left. It is probable that the smaller particles of gold were dissolved from the upper parts of the vein by the ferric sulphate solutions of oxidized pyrite and were precipitated by the local masses of pyrite below.

Some secondary sulphides were observed, but these are of no commercial value. They consist of pyrite crystals deposited in cracks in primary pyrite and of very small masses of sphalerite and galena. Other secondary minerals noted were calcite and, rarely, cerusite.

MINING DEVELOPMENT.

Gold was first discovered in Bohemia in 1858. In 1875 the first mill, a five-stamp battery, was built on the Knott claim. From 1877 to 1891 little was done in the district. In the nineties the Musick, Champion, Noonday, Vesuvius, and several other mines became active, and mills aggregating 35 or more stamps were built. At the time of visit, in August, 1908, no ore was being milled in the district, nor had any milling been done since the previous summer. Several companies, however, had men employed in prospecting and development.

Figures for the total output of the camp are not available. As nearly as can be judged from the statistics published in "Mineral Resources of the United States," and from verbal reports, the total product is probably between $300,000 and $400,000, mainly in free gold. Although some rich shoots occur locally, the average tenor of the ore is low, generally running $3 to $5 a ton. The soft, spongy, iron-stained vein material is cheaply mined and milled. The cost of mining is from $1.50 to $2 a ton, and of milling little over 50 cents a ton. The concentrates range in value from $20 to $70 a ton and consist in the main of auriferous pyrite, with silver and a little lead and copper. Values less than $25 a ton can not be profitably shipped because of present high freight rates.

The principal mines of the region which have produced values are the Musick, Champion, Vesuvius, Noonday, Helena, and California, and there are others of lesser note. The Musick leads in development, with about a mile of drifts along six 50-foot levels. Of these, levels 4 and 6 are reached by short crosscuts which tap the vein from the basin at the head of City Creek. About 2,000 feet to the west, on the other slope of the divide, a portal from one of the lower drifts opens out close to a good stand of mining timber. A shaft 80 feet deep connects directly with the two upper levels and through various stopes with most of the lower workings, thus giving good ventilation to the mine. Most of the ore was hauled out at the lower level, which attains a maximum depth of about 300 feet.

The Champion, Vesuvius, and Noonday have each about half a mile of workings. In the Champion most of the development work has been done on two levels, the lower of which attains a maximum depth of about 200 feet and is reached by a crosscut a few hundred feet in length through which all the ore is brought out. A considerable amount of stoping has been done, particularly where the greatest oxidation occurred. The lower workings here show considerable amounts of primary sulphides. The Vesuvius has been worked from several levels to a depth of about 300 feet and has many stopes. The steep slope on which it is situated has facilitated

its development by tunnels and has afforded a gravity transfer for the ore from stope to mill, as well as good ventilation and drainage for all the workings. The Noonday has three principal levels, all tapped by crosscuts from the steep slope of the Horseheaven basin; the lowest level attains a maximum depth of about 300 feet. Considerable stoping was done and the ore from the stopes was sent down to the mill on an aerial tramway about one-third of a mile in length. The Helena has more and the California somewhat less than 1,000 feet of workings. Both are developed by tunnels which will attain 100 to 300 feet of depth. The Helena has two levels and has produced some very rich specimen ore.

The ore from the Musick mine was hauled over a practically level electric tramway about a mile in length and dumped into the ore bins of the Champion mine. Thence the ore of both mines was sent down to the mill on a steep incline, 3,400 feet long. Haulage was effected by an endless cable to which the mine cars were attached by means of an automatic grab, the loaded cars going down pulling the empties up. The Musick-Champion mill, the largest in the district, has 30 stamps and is run by a water-driven electric generating plant located on Frank Bryce Creek, 7 miles below the mine. It handled the ore from both the Musick and Champion mines. The electric plant was designed to develop 300 horsepower and to operate the stamp mill, a small sawmill, and a local electric-light plant and to furnish mine power. A small auxiliary steam plant is provided for use in case of need. Other milling plants in the district are a 10-stamp mill at the Vesuvius mine, a 5-stamp mill at the El Calado property, and a 20-stamp mill on the Noonday group.

SILVER AND COPPER PROSPECTS.

The Riverside and Oregon-Colorado claims are promising copper prospects which show some good chalcopyrite ore and are located on strong veins. The Combination property covers a somewhat extensive lode, consisting of one large vein and some smaller veins, and is said to have produced ore which assayed more than 25 ounces of silver to the ton.

FUTURE OF THE DISTRICT.

The Bohemia district contains many well-defined veins and lodes. Many of those which show on the surface have not yet been explored, and no doubt many more are obscured by the dense vegetation which covers a large part of the district. It seems reasonable to suppose that other mines will yet be opened, and will find workable gold ore at least in the upper and oxidized portion of the veins. Workable bodies of copper and silver may possibly be discovered in the district.

FAULTING AND VEIN STRUCTURE IN THE CRACKER CREEK GOLD DISTRICT, BAKER COUNTY, OREGON.

By J. T. Pardee.

INTRODUCTION.

The Cracker Creek mining district is situated in the northwestern portion of Baker County, Oreg. It is a small integral part of the Blue Mountain gold belt, which has been described by Lindgren,[a] and as generally understood comprises the drainage basins of Cracker and Fruit creeks. The town of Bourne, 6 miles north of Sumpter, is the principal settlement within the district. The principal mines are the North Pole, Eureka and Excelsior, Columbia, and Golconda, all located, from northeast to southwest in the order named, on one persistent fissure, the North Pole-Columbia vein, or "mother lode," as it is locally designated. At present the Columbia is the only producing mine in the district, but the suspension of operations in most of the others is believed to be temporary and not caused by exhaustion of the ore bodies. In addition to those above mentioned, there are a number of smaller mines and prospects on which annual assessment and considerable development work is being done. Time in which to visit all the mines was not available, but in November, 1908, during the progress of field work in the Sumpter quadrangle, in the northern part of which this district lies, advantage was briefly taken of opportunity to visit the underground workings of the Columbia and North Pole mines, to the managers of which, Mr. Frank S. Baillie and Mr. Emil Melzer, respectively, acknowledgment is gratefully made for courtesies extended.

The aggregate production of the mines on the "mother lode" is estimated to be at least $7,000,000.

TOPOGRAPHY.

All of the district is mountainous. The streams have rather steep gradients and flow through valleys which are for the most part V-shaped, but some of which are U-shaped in their upper courses.

[a] Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 2, 1901, pp. 551–776.

The dividing ridges are steep and rugged, with narrow, somewhat serrate summits. The minor details of the sculpture express the variations in the hardness of the underlying rocks. Down cutting of the stream beds appears to be generally still in progress. The average depth of the valleys is from 1,000 to 2,000 feet. The altitude of Bourne is 5,400 feet; that of the junction of Cracker and Silver creeks, the lowest point in the district, 5,000 feet; that of the peak at the head of Rock and Sardine creeks, the highest point in the district, 8,400 feet.

The principal topographic features of the area dealt with in this paper are shown in somewhat generalized fashion in figure 3. The spur trending south-southwestward from Elkhorn Ridge and terminating at Bourne has the local name of North Pole Hill. The ridge dividing Cracker and Fruit creeks is locally named at its southern extension Columbia Hill, and this name may be conveniently extended to the whole ridge.

GEOLOGY.

STRATIGRAPHY.

The rocks most extensively developed about the Cracker Creek mines are argillaceous and siliceous sediments, nonfossiliferous so far as known, and very fine grained throughout. The composition of the beds varies from that of chert consisting almost wholly of silica to that of highly aluminous blue-black slate. These types, however, are rarely found in complete purity; they grade one into the other, and are at many places interlaminated, the cherts in particular being divided into thin sheets and lenses by argillaceous partings. Seen in distant views, the weathered outcrops of the sediments everywhere appear rather dark in hue and more or less rusty with oxide of iron. The impression conveyed by a cursory examination is one of monotony and of a lack of sharp lithologic distinctions. Only long-continued and careful observation made it possible to recognize lithologic subdivisions of the stratigraphic column, a task which it was necessary to accomplish before the structure could be deciphered. The series appears to be conformable. It is exposed over the greater portion of the district in the form of a salient surrounded by intrusives. (See fig. 3.)

The rocks of igneous origin are intrusive granodiorite, surrounding the sedimentary area on the north and northwest; some dikes, observed to cut both the argillite and the granodiorite, varying in thickness from a few inches to 20 feet or more, that appear to be mainly altered feldspar porphyries; a few aplitic dikes; some small masses of serpentine; and a greenstone, probably an interbedded lava or intrusive sill. This last-named rock is most conveniently considered in connection with the sedimentary rocks, which are probably of Paleozoic age.[a]

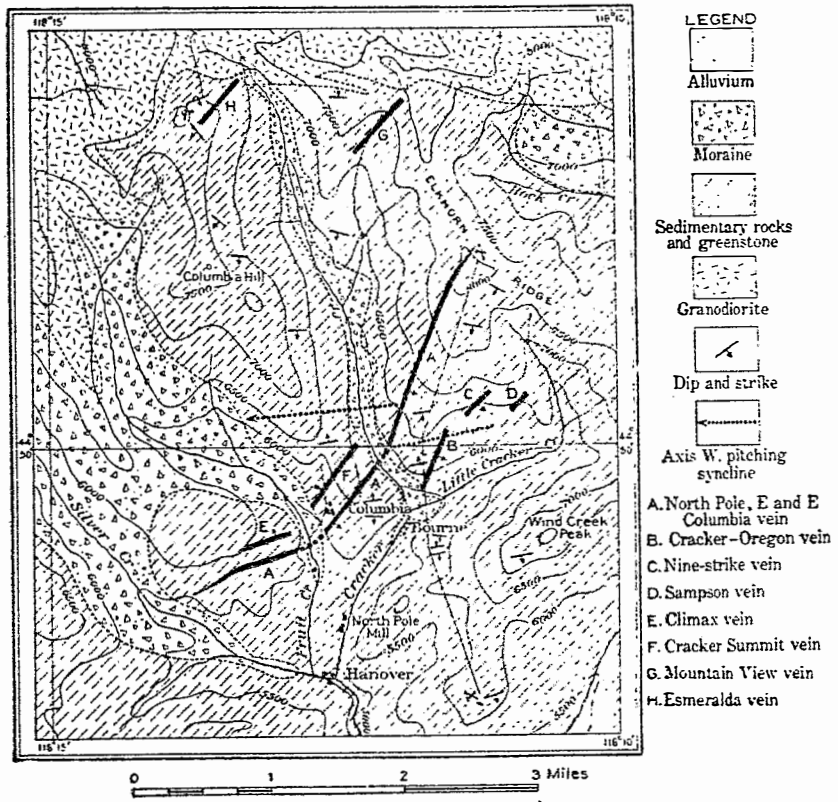

FIGURE 3.—Geologic sketch map of part of Cracker Creek mining district, Baker County, Oreg. Topography from Sumpter atlas sheet.

The following measurements are provisional and subject to correction:

Section of sedimentary rocks and greenstone in Cracker Creek mining district.

[Beds numbered in order of age.]

	Feet.
8. Light to blue-gray siliceous shale. Laminæ 1 to 5 inches thick, irregularly swelling and pinching, separated by very thin dark partings. On weathered surface numerous lighter-colored spots are etched, forming slight depressions and giving outcrops a mottled appearance. Prominent outcrops	100
7. Dark-gray, thinly laminated, rather siliceous argillite, locally mottled as in No. 8 above. Middle portions black with slaty cleavage. Inconspicuous outcrops	600

[a] Lindgren, Waldemar, op. cit.

	Feet.
6. Blue-gray, indistinctly bedded siliceous shale, locally mottled on weathered surface. Moderately conspicuous outcrops	150
5. Dark-gray to black argillite, thinly laminated, conspicuously mottled. Very subordinate outcrops	700
4. Greenstone, a hard, tough, heavy, greenish, massive crystalline rock, of varying texture. Exposed surfaces usually etched, showing irregular rough "warty" prominences of dark-green hornblende, between which are light-gray depressions, these features here and there so arranged as to faintly suggest bedding. Prominent cliffy outcrops	600
3. Black, slaty, thinly laminated argillite with some indistinctly bedded, rather siliceous layers, having mottled weathered surfaces. Inconspicuous outcrops	350
2. Light to warm gray, almost purely siliceous sediments. Laminæ 1 to 3 inches thick; otherwise as in No. 8; prevailingly mottled at top. Forms prominent outcrops	100
1. Prevailingly siliceous, gray to dark-gray sediments, rather indistinctly bedded as a rule, but containing a few beds 4 to 10 feet thick and one 80 feet thick, closely resembling No. 2 above, except that mottling is less conspicuous or absent. Contains also a few thin argillaceous beds. Weathered surfaces gray brown in upper portion to red brown in lower. Prominent outcrops	400+
	3,000

STRUCTURE.

FOLDING.

The most readily noticeable structural feature of the more siliceous of these beds consists of the contortions and small close folds they everywhere exhibit. The black argillites have a slaty cleavage that as a rule coincides with the bedding. Some of them are closely folded also, but as their bedding is less distinct than that of the siliceous rocks their structure is more obscure. The thickening due to small folds has not been estimated, and is therefore not eliminated in the tabular section. As a rule the strike of the beds is N. 80° E. in the southern portion of the district, gradually changing to northwest in the northern portion. The dips are prevailingly south, with local exceptions caused by a westward-pitching syncline exposed in the southern portions of North Pole and Columbia hills. (See figs. 3 and 4.)

FAULTING.

The most noteworthy structural feature is faulting of an extreme distributive type, which is developed throughout the district. This faulting is so common that portions of the district, as for instance the

northern half of Columbia Hill and Elkhorn Ridge, from the summit of North Pole Hill northward to the intrusive contact, may be said to resemble huge fault breccias. The dimensions of the faults descend to the microscopic, and nearly every joint and cleavage plane shows polishing or striæ as evidence of movement.

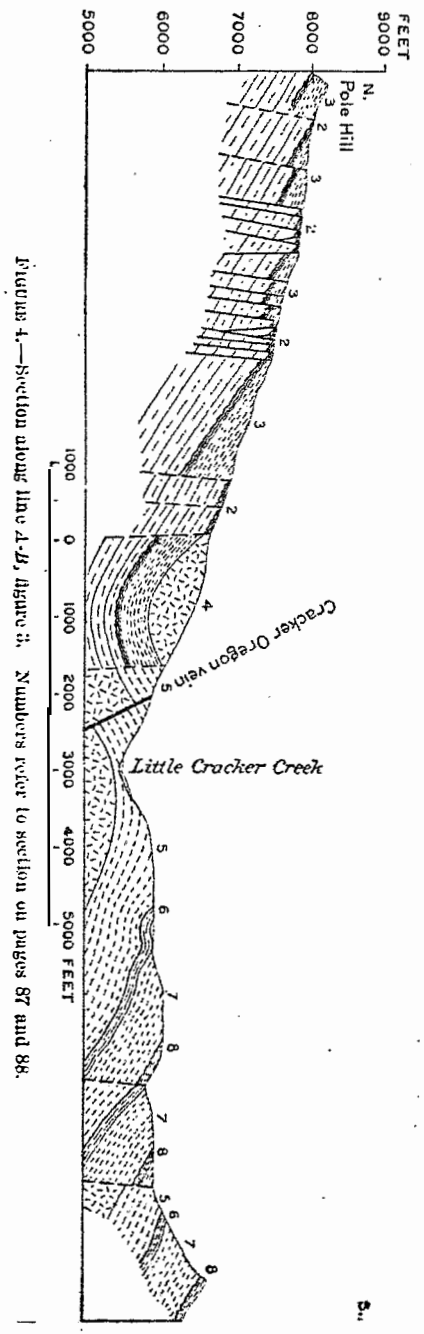

Figure 4.—Section along line A-B, figure 3. Numbers refer to section on pages 87 and 88.

The observed indications of faulting are the following: (1) Beds are in contact out of their normal sequence. The satisfactory identification of the different beds in this district, where sharp lithologic distinctions are lacking and discontinuous exposures the rule, requires careful scrutiny, and the definite location of fault contacts is best effected by carefully following the more prominently cropping siliceous beds. (2) There are numerous fault breccias, the fragments of which, usually distinguishable from other products of disruption by their polished or striated surfaces, are generally distributed in the surface mantle and, where found in place or nearly so, as on some ridge summits, indicate the positions of faults. (3) Notches, trenches, ravines, and offsets in ridges commonly indicate the positions of faults in this district. (4) Many fault planes may be directly observed on cliff faces and in drifts, pits, etc.

All faults in the district whose attitude has been determined are normal, and steep dips are the rule. Most of them may

be grouped, as regards strike only, in an approximately north-south system; an east-west system, observed in some instances to displace the former; and a northeast-southwest system that includes the quartz veins. In the first two of these groups the movement on any one fault plane may commonly be measured in inches, and the maximum observed does not exceed 100 feet. The sum of these small movements is, however, considerable. For instance, the faults of the east-west system on North Pole Hill within a horizontal distance of 1 mile effect an aggregate downthrow to the north of approximately 2,000 feet. (See fig. 4.) But this summation, it should be noted, takes no account of the horizontal component, which, as shown by the pitch of striæ, enters into the movement in nearly every fault plane.

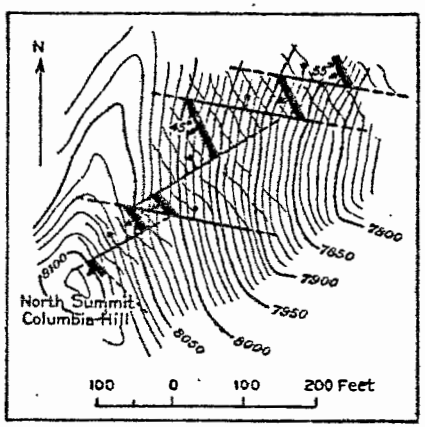

FIGURE 5.—Detail of faulting northeast of Columbia Hill, Baker County, Oreg.

The detail of some of the less complex fault zones may, in favorable places, be mapped, and one near the north summit of Columbia Hill is shown in figure 5. Many of the fault zones are composed of smaller units than this one. An example is one of the east-west faults just south of the lower summit of Columbia Hill. Its aggregate vertical displacement (the horizontal movement not having been estimated) is 400 feet, distributed along a large number of parallel planes, lying 1 inch to a few feet apart, through a horizontal distance of 600 feet.

VEIN SYSTEM.

Only the most superficial observations were made on the smaller veins, the locations of some of which are indicated in figure 3. The Cracker Oregon vein is 4 to 8 feet wide and dips steeply to the southeast. The Cracker Summit vein is 4 to perhaps 12 feet wide and dips 50° to 70° NW. Both are said to have produced pay ore; their vein filling resembles that of the "mother lode" and their walls bear evidence of movement. The Cracker Summit vein has at several points been displaced by faults of the other groups, but the exact details of the faulting have not yet been worked out.

The "mother lode" stands out as a most prominent economic and structural feature. It is a normal fault extending beyond the limits of the district. The portion of it here particularly referred to is that extending from the Columbia shaft to the limit of the North Pole stopes, a distance of 7,500 feet. On this portion of the vein are

located the Columbia, Eureka and Excelsior, and North Pole mines, from southwest to northeast in the order named.

The displacement along this fracture, which in the North Pole dips 70° SE. and strikes N. 34° E., was approximately determined where it crosses Columbia Hill. Here bed No. 4 of the section on pages 69–70 forms the hanging wall and is in contact with bed No. 2 on the foot wall, indicating a vertical displacement of at least 400 feet. But in addition to the vertical throw the fault causes a horizontal displacement of approximately 1,800 feet. This estimate is obtained from the present relative positions of the detached portions of the syncline briefly referred to above and indicated in figures 3 and 4, which the fault cuts nearly at right angles to its axis. The axis of this trough trends approximately east and west and was originally continuous. At present the intersection of the axial plane of the North Pole Hill half of the trough with that of the vein lies about 1,800 feet south-southwest of the intersection of the corresponding plane in the Columbia Hill portion of the trough with that of the vein. This estimate is subject to modification by more careful measurements, but not sufficiently so to disprove the statement that there has been a horizontal displacement of considerable magnitude. The horizontal movement is further indicated by striæ within the vein, as described below. The vein may be said to divide the district into two fault blocks. With respect to the northwestern or Columbia Hill block, the southeastern or Bourne block has settled and moved southwest by south, or along a line lying in the plane of the vein and pitching gently to the southwest.

The large amount of development work that has been done on the "mother lode" offers excellent opportunity for investigation of the structure due to complex movements within the vein.

The Columbia mine is opened by three adit levels and a 900-foot vertical shaft with which crosscuts and drifts connect at each 100 feet. The aggregate of development is stated by Mr. Baillie to be, in drifts and crosscuts, 19,470 feet; in shaft, raises, and stopes, 29,274 feet; total, 48,744 feet.

The shaft is sunk in the hanging wall 45 feet from the vein, which it penetrates at a depth of 800 feet, thus showing the dip of the vein here to be about 86½° SE. Its strike is N. 34° E. Northeast of the shaft the vein is well defined and 20 to 100 feet wide. The ore shoots, 3 to 8 feet in width, are found on the foot wall in all but the upper (adit) levels, where they have crossed to the hanging wall. The pay ore is usually separated from more barren quartz by walls lined with thinly-laminated black gouge. The laminæ are mostly striated. In many places the striæ on one side of the lamina pitch at variance with those on the other side. The directions of movement thus indi-

cated vary from vertical to horizontal, the horizontal component usually predominating. The ore body itself is separated into overlapping wedges or thick lenslike masses by seams of black, laminated, striated gouge. About 200 feet south of the shaft the vein loses its identity in a zone characterized by a great number of faults, most of which strike southwest to west and dip 45° N. or S. The gouge linings of these faults nowhere fail to exhibit evidences of movement as above described. Within this zone isolated masses of ore are found.

The North Pole mine is not at present in operation, having closed down last August. It is developed by five adit levels and one intermediate level, aggregating 12,500 feet, and a large extent of crosscuts and stopes. At 1,800 feet from the mouth of tunnel No. 1 a fault, whose course is N. 18° W. and dip 60° W., displaces the ore shoot 45 feet to the southeast. On following this fault for about 500 feet to the intermediate level, the displacement is noted to be small, and the slip appears to coincide with a flat wall forming the lower boundary of the ore shoot for a distance of about 1,200 feet farther on. This ore body widens above, attaining a maximum of 25 feet just under tunnel No. 3, where a cross section of the vein is as follows:

Section of vein of North Pole mine.

	Feet.
Foot wall: dark-gray siliceous shale.	
Brecciated quartz in black gouge	3
White quartz	40
Finely brecciated unconsolidated ("sugar") quartz	15
Low-grade vein quartz	15
Ore	25
	98

These divisions are separated by polished or striated walls approximately parallel to those of the main vein and bearing abundant, black, laminated, obliquely striated gouge. This ore body abruptly ends to the northeast against a fault plane, striking N. 80° W. and dipping 45° S., which does not penetrate the main hanging wall. Neither does the foot wall appear to have been displaced where the drift turns to it about 120 feet farther on. From this point northeastward for about 400 feet to the face of the drift the foot wall carries small masses of ore that usually exhibit a tendency to branch and disappear in seams leading obliquely upward toward the opposite wall. In the main stope just referred to the ore lies on either wall or occupies intermediate positions. In some places the ore is observed to cross from one position to another on transverse, southwestward-dipping, obliquely striated fault planes that do not pass without the vein.

PRACTICAL CONCLUSIONS.

The results of structural study in the Cracker Creek district indicate that the "mother lode" is not notably displaced by transverse faults. Within the vein itself, however, there are faults which affect the ore bodies. Some of the smaller veins have been offset by faulting. The fact that the faults of known attitude are normal, and that in the movement upon them the horizontal component is commonly as important as the vertical one, should be taken into account in the development of such of the ore bodies as have been displaced.