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# THE MINERAL RESOURCES OF OREGON

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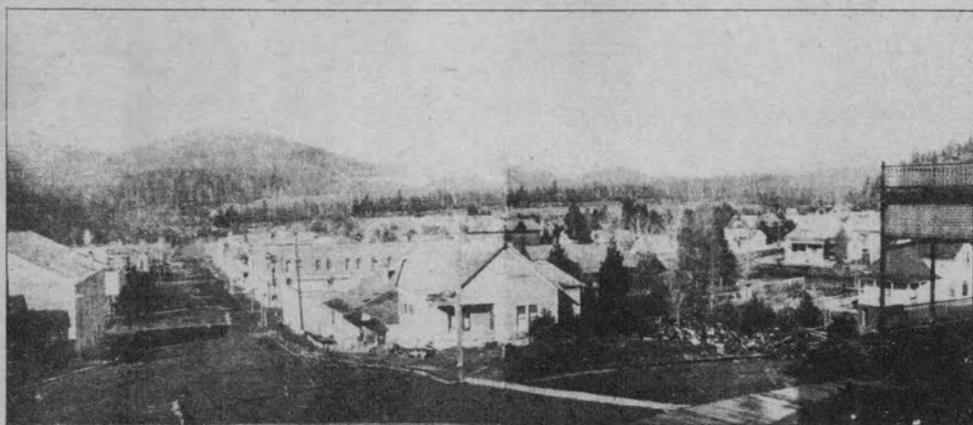


Fig. 3. Sumpter Oregon.

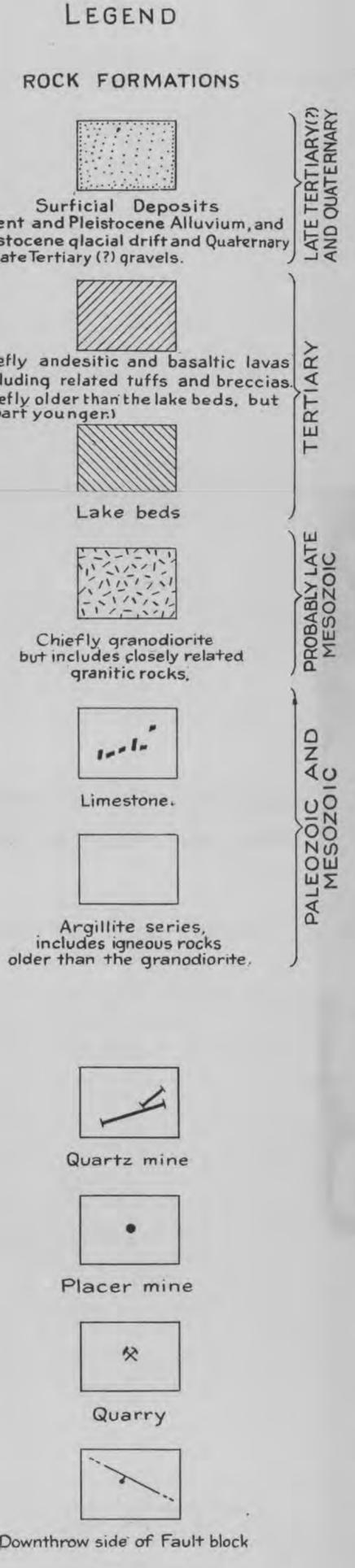
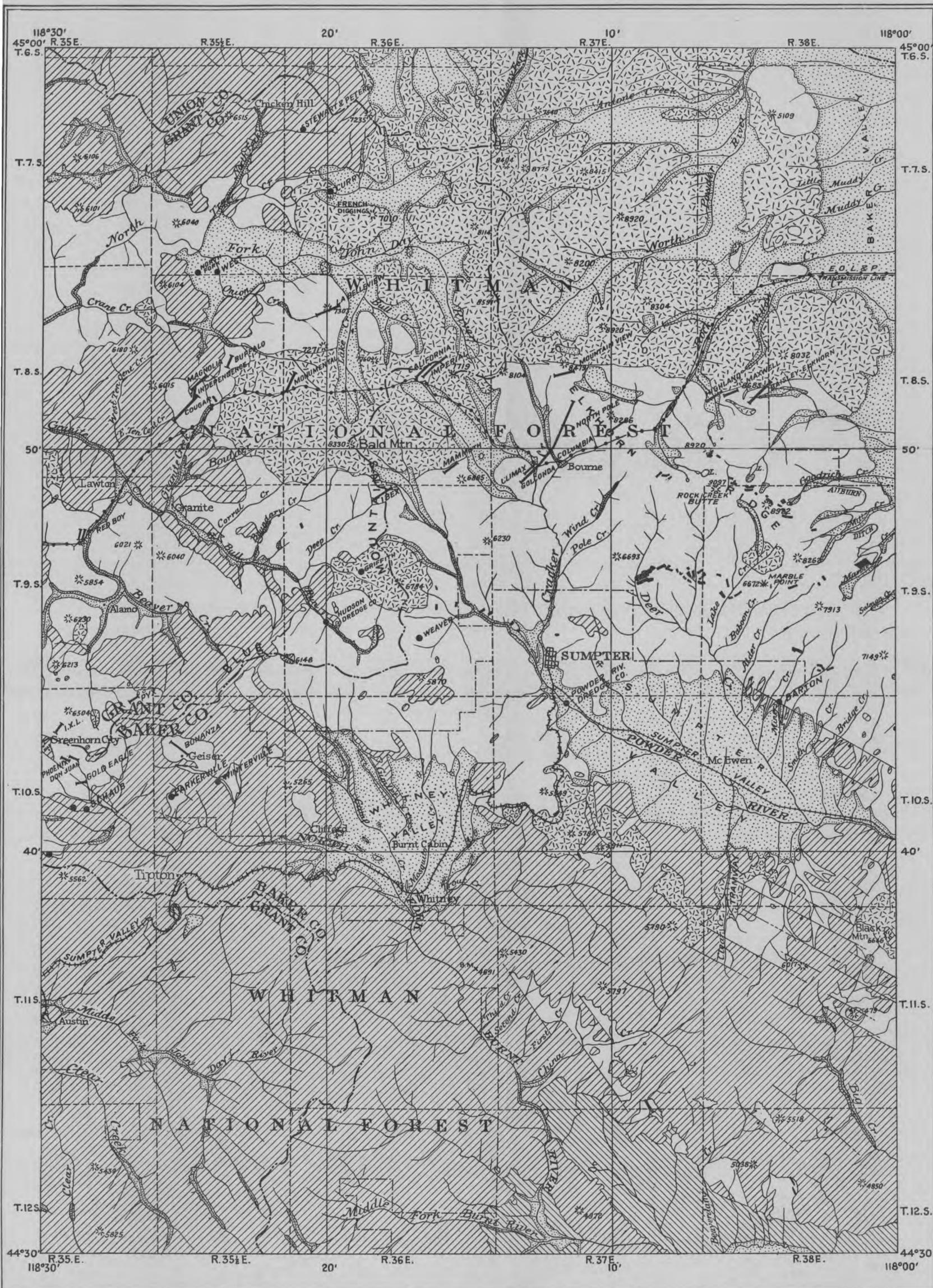
## Geology and Mineral Resources of the Sumpter Quadrangle

By J. T. PARDEE and D. F. HEWETT

## Preliminary Report on the General and Economic Geology of the Baker District of Eastern Oregon

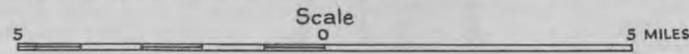
By U. S. GRANT and G. H. CADY

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**GENERALIZED GEOLOGIC MAP OF SUMPTER QUADRANGLE, OREGON.**

Base from Sumpter  
topographic sheet,  
U.S. Geological Survey.



Areal and Economic Geology  
by J. T. Pardee, D. F. Hewett,  
F. J. Katz and T. H. Rosencranz.

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1914

**THE GEOLOGY AND MINERAL RESOURCES OF THE  
SUMPTER QUADRANGLE, OREGON**

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OCTOBER, 1914

# THE MINERAL RESOURCES OF OREGON

*A Periodical Devoted to the Development  
of all her Minerals*

PUBLISHED MONTHLY AT CORVALLIS BY  
THE OREGON BUREAU OF MINES AND GEOLOGY  
H. M. PARKS, Director

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## GEOLOGY AND MINERAL RESOURCES OF THE SUMPTER QUADRANGLE, OREGON

By J. T. PARDEE and D. F. HEWETT.

### SCOPE OF THE REPORT

It is perhaps well to emphasize the fact that the present report is preliminary and makes no attempt at exhaustive treatment of the geology and mineral resources of the Sumpter quadrangle. As but a small part of the data gathered in the field has been studied, it is possible to describe only the most salient features of the quadrangle in generalized fashion, and the present summary is therefore incomplete and essentially provisional in character.

### FIELD WORK AND ACKNOWLEDGMENTS

The field work upon which this preliminary report is based was started by the United States Geological Survey during the seasons of 1908 and 1909, and completed by the Survey under a cooperative agreement with the Oregon Bureau of Mines and Geology in 1913 and 1914.

During the fall of 1908 and the summer of 1909 the north-central portion of the quadrangle was mapped by J. T. Pardee under the supervision of F. C. Calkins. Thanks are due Mr. Calkins for many suggestions during the early stages of the investigation and for the microscopic examination of many of the thin sections.

A portion of the Elkhorn range east of Sumpter was mapped by

F. J. Katz in the fall of 1913, and the remaining areas covered by J. T. Pardee and D. F. Hewett in 1914, with the efficient assistance of T. H. Rosenkranz. During this period H. C. Hawley served as cook and teamster.

It is a pleasure to record that the mining men of the region cheerfully responded to requests for information and aided the writers with every consideration and courtesy.

In making any statements about the geology of this region, and particularly those pertaining to the economic resources, the writers have been keenly conscious of great indebtedness to the earlier thorough work of Lindgren. The attempt has been made from place to place to make this acknowledgment, but it has been difficult if not impossible at all times to clearly recognize the extent to which their conceptions are based upon the observations of Lindgren, and to what extent upon their own. Some conclusions are briefly outlined in this report that differ appreciably from those reached by Lindgren, but it will be apparent that they explain certain observations and relations which he recognized as conflicting. The facilities for making several kinds of observations pertaining to the mines were obviously better in 1900 than in 1914. In other respects the writers have from place to place had the benefit of the results of 14 years' additional work on the veins.

It has not been possible in preparing this preliminary report to give reference to original sources of contributions to fact or theory that have been used in this report. In the final report these references will be given freely.

The writers have collaborated to a greater or less degree in the treatment of all the subjects discussed in the report, although the pages describing the geology, physiography and closely related subjects were written chiefly by Mr. Pardee, and those relating to the ore deposits and mineralogy are principally the work of Mr. Hewett.

## HISTORY

The history of the Blue Mountain region in general has been briefly summarized up to the year 1900 by Lindgren\* from whose report the following extracts are quoted:

"While the gold fields in the southwestern part of Oregon were discovered about 1852, those of the Blue Mountains remained unknown until

\*Lindgren, Waldemar, *The gold belt of the Blue Mountains of Oregon*: Twenty-second Ann. Rept., U. S. Geol. Survey, pt. 2, pp. 563-564, 1901.

about ten years later. In the fall of 1861 a prospector named Griffin, with a party of men, discovered what is known as Griffin Gulch, a tributary of Powder River, a few miles southwest of Baker City. At that time the only settlement in the Blue Mountains was that of some cattle raisers in Grande Ronde Valley. Early in the spring of 1862, D. Littlefield and a party of four or five men were prospecting in the same neighborhood and discovered the rich placers of Auburn. In a very short time miners came pouring in from all directions, and the town of Auburn, laid out in June, 1862, grew rapidly, until in less than a year it contained 5,000 inhabitants. In those days the Blue Mountains were difficult of access, supplies having to be brought in from The Dalles, a distance of 300 miles. The mines of Auburn were found to be extremely rich, and from this center exploring parties penetrated the surrounding region in all directions. Prospectors from Auburn discovered the Boise Basin and the Owyhee mines in Idaho. The placers of Sumpter, Canyon, Mormon Basin, and Rye Valley were also discovered by men from the same camp, so that by 1864 practically all of the mining districts of the Blue Mountains were known. The yield per man was at least \$8 per day, and any gravels containing less than this were not considered by the early prospectors....About 1870 the richest placers were exhausted and a gradual decline in the production began, which may be said to have continued until the present time."

Within the Sumpter quadrangle the first mining is said to have been done by Eph and Sant Day who discovered gold on Granite creek in the fall of 1861. The following autumn, so it is reported, a party of five southerners discovered gold on the present site of the town of Sumpter, and named their settlement Fort Sumpter. Placer mining was the main industry for several years thereafter. The first quartz claim located is said to have been the Mammoth, which was staked out in 1866. In 1874 the Monumental and in 1877 the La Belleview mines were discovered; rich ore is said to have been shipped from the latter at this early date by pack train a distance of several hundred miles to Umatilla on the Columbia river. In the same year the Eureka and Excelsior claims were located on the now famous "Mother Lode" and shortly thereafter the other claims that have since become well-known producers were staked out. The real beginning of quartz mining, however, dates from the completion of the Oregon Railroad and Navigation Company's railroad to Baker City in 1886. This gave rise to extensive lumbering operations in the Blue mountains, and the Sumpter Valley railroad, built primarily for logging, was completed to Sumpter in 1896. The next 6 or 7 years witnessed a material growth of quartz mining and the opening of most of the large producing mines. Sumpter grew from a small hamlet of a few hundred population to a town of 3,000 or more, and a boom, similar to those through which most mining camps pass, culminated in 1902 or 1903. From 1904 to 1908 a smelter, erected by the Oregon Smelting and Refining Company at Sumpter, operated

on ores produced mainly within the quadrangle, yielding more than \$1,000,000. The plant closed down in 1908, owing, it is said, to financial difficulties, and is now the property of the Northwest Smelting and Refining Company. Since 1908 the mining industry in the Sumpter quadrangle has declined to a low stage of activity.

### PRODUCTION OF GOLD AND SILVER

During the most active period of placer mining in the Sumpter quadrangle, records of production were seldom kept. Therefore the exact yield from this source is not known. It is possible, however, to estimate approximately the amount that must have been produced to have made operations profitable. Such an estimate gives the minimum possible production of a mine or district and not the true total, which would usually be higher. In the present instance this estimate is based mainly upon two factors: (1) the method of working, whether by shoveling, ground-sluicing, or hydraulicking; and (2) the cost of labor at the time. For example, ground worked in the early 70's by shoveling must have contained at least \$1.00 to the cubic yard, because wages were then at least \$5.00 a day, and one man ordinarily handles about 5 yards of gravel a day. On the other hand, gravel banks fortunately situated for hydraulic operations, may be profitably worked when the gold content is as low as 5 cents a cubic yard. In a very few instances authentic records of production were obtained and were used for the mines they represent in arriving at the totals. The cubic contents of the principal placer excavations in the quadrangle were estimated to aggregate approximately 21,500,000 cubic yards, the minimum yield of which was computed to be \$5,231,000, or an average of about 25 cents a cubic yard.

The *minimum yields* computed for the various districts are as follows:

North Fork drainage basin.....	\$ 893,000
Granite Creek .....	1,033,000
Sumpter district .....	1,691,000
Greenhorn district .....	1,140,000
Bonanza .....	396,000
Minersville District .....	36,000
Whitney Valley .....	32,000
Scattering .....	10,000
<b>Total .....</b>	<b>\$5,231,000</b>

The actual placer production of the quadrangle is doubtless much larger than the total arrived at. Miners and others familiar with the

region invariably make higher estimates than those given, in some instances estimating more for a single district than the total for the whole as given above. As nearly as can be ascertained the portion of silver alloyed with placer gold ranged from 5 to 30 per cent and probably averaged 17 per cent, equivalent to a gold fineness of 830 or value of \$17.15 an ounce. Assuming the gold and silver values combined in the total given, it is calculated that of the total amount about \$30,000 was silver.

The greater part of the deep mine production of the quadrangle has been made since 1900 and for this period authentic records show an output of \$8,943,486 from 53 of the mines, only eight of which exceeded \$100,000 production. Some of the records are incomplete, however, and for some of the mines no reliable records are available. This additional production, as based on estimates believed to be fairly reliable, amounts to \$800,000. Prior to 1900 few records are available but estimates which seem to be reasonable place the production for that period at \$1,600,000. Thus it appears that the total deep mine production of Sumpter quadrangle is not far from \$11,350,000 in gold and silver. Of this amount probably about 5 per cent, or \$565,000, has been derived from silver.

From these records and estimates, which are believed to be under rather than over the actual amount, the production of the quadrangle from both placer and deep mines is placed at \$15,986,000 in gold and \$595,000 in silver.

## CONDITION OF THE MINING INDUSTRY

### PLACER MINING

All of the easily worked placer deposits of the quadrangle have been exhausted. In the summer of 1914 one large dredge was in successful and continuous operation, one smaller dredge of a different type was under construction, and eleven hydraulic and sluicing mines were being worked on a small scale.

The area has been so thoroughly prospected that important new placer discoveries are hardly to be expected. The ground yet to be worked consists of some large low-grade gravel banks that require hydraulic methods for some of which little water is available, and certain flat-lying gravels that require dredging. Because of the definite limits of the placer gravels, the future of this industry may be foretold with some certainty. At the present rate of progress the

dredging ground in Sumpter valley will have been exhausted in about ten years. It is possible that the gravel deposits of Crane creek and upper Bull Run creek may sometime be profitably dredged, but the extent of these gravels is not great. The large gravel banks along North Fork of John Day river will outlast a generation at the present rate of working, which, however, makes only a small production annually, and employs only a few men. Likewise the remaining smaller mines may be expected to operate intermittently for a considerable time, but at the end of another decade placer mining in this area will have little importance.

#### DEEP MINES

The Columbia was the only steadily producing deep mine in the Sumpter quadrangle in 1914, although there were five intermittent producers, the North Pole, Golden Eagle, Imperial, Belle of Baker, and Last Chance. At this time development work was being prosecuted on a moderate scale at three mines, the Independence, Buckeye, and Maid of Oregon, and annual assessment work was being done upon at least 40 or 50 prospects. Contrasted with the activity of former years, the present relative depression is very noticeable.

An ideal condition of the mining industry in any locality is attained when its mines are judiciously worked to their fullest capacities. So numerous are the obstacles to be overcome, such as uncertain ownership, lack of capital and engineering skill, incompetent management, etc., that few mining districts reach or maintain the ideal condition. Although knowledge of the Sumpter region is far from exhaustive, the facts that have been ascertained lead to the conclusion that, aside from possible new discoveries, if a few of the larger idle mines were added to the list of producers it would enjoy about the ideal condition described. If the principal lodes only are considered, it appears that 80 per cent of their bonanza ore bodies occur within perhaps 300 feet of the surface and that with one or two exceptions these parts have been exhausted. Here and there, however, shoots of rich ore extend to considerably greater depths although the deeper ores are of much lower grade and are not as a rule free milling. There is an important tonnage of good grade ore known in the mines of the quadrangle and a larger amount of possibly profitable ore. Some of the larger mines that are now idle have no ore in sight although there is a strong probability that further exploration will develop commercial ore in some of them,

and some others have considerable ore in sight that possibly may be worked at a profit.

The continued life of the mining industry in the quadrangle depends upon new discoveries and the continuation in depth of the known ore shoots. There is no reason to suspect that the low grade ores do not persist to considerable depth, but whether they can be profitably extracted can be proven only by a careful study of costs for each individual deposit. As an occasional new discovery of importance may be expected, the conclusion is drawn that a healthy degree of mining activity can be maintained in the Sumpter quadrangle for several years to come.

#### LITERATURE

Prior to Lindgren's examination in 1900 little except statistical reports had been published concerning the metalliferous deposits of the area included in the Sumpter quadrangle. The following list includes the principal publications that describe the general and economic geology of the quadrangle or of the region that includes it:

- Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: Twenty-second Annual Rept., U. S. Geological Survey, part 2, pp. 551-776, 1900.
- Lindgren, Waldemar, Rare minerals in gold quartz veins of eastern Oregon: Mining and Scientific Press, vol. 82, p. 252, 1901.
- Condon, Thomas, The two islands and what came of them. Portland, Oregon, 1902.
- Stafford, O. F., Mineral Resources and mineral industries of Oregon: Univ. of Oregon Bull., vol. 1, No. 4, 1903.
- Jensen, C. A. and MacKie, W. W., Soil survey of Baker City area, Oregon: U. S. Dept. Agric., Bur. Soils, 5th Rept., pp. 1121-50, 1904.
- Pardee, J. T., Faulting and vein structure in the Cracker creek gold district, Baker county, Oregon: Bull. 380, U. S. Geol. Survey, pp. 85-94, 1909.
- Pardee, J. T., Placer gravels of Sumpter and Granite districts, eastern Oregon: Bull. 430, U. S. Geol. Survey, pp. 59-65, 1910.
- Melzer, E., North Pole mine, Baker county, Oregon: Eng. & Min. Journal, vol. 89, pp. 868-869, 1910.
- Parks, H. M., The economic geologic resources of Oregon: Bull. 2, Ore. State Bur. Min., 1912, Corvallis, Oregon.



Fig. 1. Sketch map showing location



of areas treated in this number.

## GEOGRAPHY

### AREA AND LOCATION

The Sumpter quadrangle, situated in northeastern Oregon, is a rectangular area almost 35 miles in length from north to south, and a trifle more than 25½ miles in width from east to west, thus embracing a little more than 854 square miles. It comprises portions of Baker, Grant and Union counties, bounded by the meridians of 118° and 118° 30' west longitude, and the parallels of 44° 30' and 45° north latitude. The gold belt of eastern Oregon is approximately an area 30 miles wide that extends from Snake river at the mouth of Powder river in a course slightly south of west to the center of Grant county. Sumpter quadrangle, situated in the west-central part of this area, comprises about a quarter of it and includes the Baker or Baisley-Elkhorn, Cracker creek, Cable Cove, Granite, and Bonanza mining districts. That portion of the Greenhorn district east of Greenhorn City also lies within the quadrangle's boundaries. The town of Sumpter is 2½ miles east of the exact center of the quadrangle, whose southwest and southeast corners are near Austin and Hereford, respectively. Its northeast and northwest extremities are out in the Baker valley near Bulger hill and on the divide between Grande Ronde and John Day rivers.

### SETTLEMENTS AND INDUSTRIES

Sumpter\*, (Fig. 3—front cover) the most important town in the quadrangle, is situated picturesquely at the head of Sumpter valley, and is the chief supply point for several mining districts and a limited agricultural and lumbering area. The Sumpter valley railroad, with narrow gage track, extends from Baker, the junction with the Oregon-Washington Railroad and Navigation Company's line, via Sumpter, to Prairie City.

Bourne, Granite, and Greenhorn City are small mining camps. Whitney and Austin are lumbering settlements situated on the Sumpter valley railroad. From Sumpter, Whitney, and Austin systems of good roads and trails make nearly every portion of the quadrangle accessible.

The principal industries of the area are gold mining which is confined chiefly to its northern and western portions, lumbering which is carried on in the southern half, grazing within the National Forest, and agriculture in the lower valleys. A smelter, now idle,

\*Population estimated at 650 in 1914.

equipped with one stack of about 75 tons daily capacity, is situated at Sumpter.

#### SOILS

Interest in this nearly universal land covering is not limited to the farmer for, though the prospector may not be particularly concerned about its use, anyone engaged in the study of the rocks and minerals is forced to depend more or less upon the soil for information. Even in mountainous lands, like those of Sumpter quadrangle, nine-tenths or more of the rock surface is soil-covered, and the prospector or geologist will examine it often to learn about the quartz lodes and rock formations that concern him. Usually each type of rock formation decomposes to a soil characteristic of it. This is especially true of the Tertiary lavas and lake beds of the area under consideration. Both produce abundant clay soils so soft and sticky when wet that the traveler in passing onto them from an area of granitic rocks, for instance, is impressed forcibly with the fact that he is crossing a geologic boundary. The granitic rocks decay to a sandy soil that is not inclined to be muddy, while the argillites pass into one that has intermediate characteristics. The soils of the glacial and alluvial formations change in accordance with the rocks from which they are derived. The character of the soils of this region is in places modified by a fine white dust which has been brought by the wind from an outside source and has settled over the quadrangle. In very recent times, geologically speaking, a layer of this material at least a foot thick was deposited. Afterward much of it was washed away, but some remained in saddles on mountain spurs and other protected places, and much of it was heaped up by rain wash in the form of cones at the mouths of small gullies. In many places this material has become incorporated with the original soil. Microscopic examinations show it to be made up of extremely minute and sharp splinters of glass. It is therefore to be classed with the products known usually as volcanic ash, and was produced by the explosive eruption of some distant crater. Soils composed largely of this material are fertile and not muddy, but in places they yield disagreeable dust in dry weather, as for instance along the stage road that crosses the divide between Sumpter and Granite.

The muddy clay soils of the Tertiary formations are usually deep and fertile and support an abundant vegetation. Where conditions admit of cultivation, these lands produce large crops of grains and

grasses. The soils derived from the granitic rocks are perhaps equally fertile but suited better to fruit and vegetable growing, especially in the lower valleys where a mild climate prevails. The soil cover of the argillite areas is apt to be thin and stony, and in these areas the richest farm lands usually are the alluvial borders of the streams. In a rude way then, the geologic map in a measure serves as a soil map of the lands of the quadrangle.

#### CLIMATE AND VEGETATION

The climate of Sumpter quadrangle varies according to the elevation, which ranges from 3,500 feet in Baker valley to 9,000 feet or more at the summit of Elkhorn range. Along the foothills of Baker valley the climate is one in which apples and similar fruits flourish, while the higher mountains experience almost Arctic severity. For most of the region, however, a cool temperate climate prevails; the summer days are comfortably warm and the nights apt to be frosty. The winters are comparatively long but not severely cold as a rule. Throughout most of the year the air is clear and bracing, and during the summer season at least the climate is delightful.

Precipitation varies greatly with the elevation. According to available records, Baker valley receives an average of about 13 inches of rainfall a year. No records were ascertained for other portions of the quadrangle, but it seems not unlikely that about 20 inches is the average rainfall of Sumpter and similarly situated valleys, while the higher mountains must receive a precipitation fully double that amount. The most arid portion of the quadrangle is the valley and foothill region of Burnt river near the southeast corner.

A large part of the Sumpter quadrangle is forested. Within its boundaries the only considerable areas naturally devoid of timber of some sort are the lands of Baker and Burnt river valleys, in the extreme northeast and southeast parts of the area.

A magnificent growth of yellow pine originally covered Sumpter valley. A similar forest still stands in Whitney valley and in general clothes most of the lower mountain slopes. Lumbering, having practically cleared the timber from Sumpter valley, has extended to the vicinity of Whitney and Austin. However, the operations have made comparatively small in-roads on this source of wealth, which, under the protective administration of the National Forest will remain indefinitely one of the chief assets of this region.

About 5,500 feet in elevation the yellow pine gives place to smaller



Fig. 4. Panorama of Sumpter Valley from smelter. Tailings dumps of Powder River Gold Dredging Company in the foreground. Town of Sumpter in left background. Elkhorn Ridge in extreme background.

conifers which often form thick stands difficult to penetrate. Forests of the latter kind prevail in the basin of the North Fork of John Day river, to the practical exclusion of any considerable body of large timber. On dry south slopes in the southeast quarter of the quadrangle the pines thin out and scattered growths of mountain mahogany appear: the lowest slopes are covered only with sagebrush. The yellow pine forest is generally free of underbrush, but some of its higher groves, as well as those of the smaller conifers, usually are impeded by small shrubs, the most conspicuous among which is the mountain laurel or "slick-leaf."

Above 7,000 feet the timber is dwarfed and patchy. Here the surface is usually well covered with grass as are also most of the lower south-facing slopes.

Except in Baker valley, where the mild climate permits fruit growing, the agricultural products of the quadrangle are practically limited to hay and grain. Natural meadows, and to some extent logged-off lands, are successfully cultivated in the principal valleys. Lumbering is further increasing the tillable area which will, however, because of the mountainous character of the quadrangle, never form more than a small per cent of its total area.

#### DRAINAGE

Approximately the eastern two-thirds of Sumpter quadrangle drains through Powder, Burnt, and Grande Ronde rivers to Snake river, the remaining third draining directly into the forks of John Day river which, like Snake river, is a tributary of the Columbia. The watershed between Snake and John Day rivers crosses the quadrangle in a general north-south direction, forming a very sinuous divide which bends east and west in long curves about the headwaters of opposite flowing streams. Most of the streams of the quadrangle are perennial and many maintain strong flows throughout the year. Records from the gaging station of the United States Geological Survey on Powder river at Salisbury, a short distance east of the quadrangle, show a mean average flow of 20 cubic feet a second during the four driest months of the year, for the period from 1904 to 1912. No measurements are available for the other streams of the quadrangle, but by comparison it is estimated that those which descend the northeast slope of Elkhorn range maintain a greater average flow than Powder river at Salisbury, and the tributaries of North Fork of John Day river are nearly if not entirely as large. As practically all the dry sea-

son flow descends from the highest mountains, it is largely available for power. Effective heads that aggregate about 1,500 feet are shown for upper Powder river, from which the estimate is made that approximately 3,000 horsepower could be developed. The effective heads of the North Fork tributaries and of those streams descending the northeast slope of Elkhorn range aggregate at least 1,500 and 2,000 feet respectively. From these observations it is estimated that the waterpower capable of being developed along streams draining the Elkhorn range is not less than 10,000 horsepower. Utilization of a small part of this power has been made by several of the mines and by the Eastern Oregon Light & Power Company. The latter corporation operates power plants situated on Rock creek near the east side of the quadrangle and near the Red Boy mine. The two plants are connected by a high-power transmission line that supplies current to local consumers and to Baker and other points outside of the quadrangle. Practically all of the water that escapes eastward from Sumpter quadrangle during the dry season is utilized for irrigation and domestic purposes. Towns within the quadrangle and adjacent to it depend upon streams from Elkhorn range for pure water, the National Forest Service maintaining protective watersheds for the domestic supplies.

## GENERAL GEOLOGY

### HISTORICAL OUTLINE

In Paleozoic time the present site of Sumpter quadrangle was submerged by a sea contemporaneous and probably connected with similar seas known to have existed in northern California and British Columbia. During a long period fine clay and sandy muds settled on the sea bottom. At a certain epoch the waters became temporarily clearer, and limestones, built in part of shells of Carboniferous foraminifers, corals, and brachiopods, accumulated. At times volcanoes, situated either within the sea or on nearby lands, emitted lavas and tuffs that over wide areas became interbedded with the muds and limestones. A like sedimentation continued into the early Mesozoic era, until beds aggregating several thousand feet in thickness had been deposited. About the close of this great period of deposition molten rock magmas that hardened into gabbro and peridotite were forced between the sedimentary layers and into fissures that crossed them. In middle Mesozoic time sedimentation ceased, the sea disappeared, and the region became an elevated rugged land. During this transformation

great changes took place in the rock, the horizontal layers being bent, broken, and forced to assume steep dips. So severe was the pressure they underwent that certain rock layers were crushed to fragments and others made to flow like plastic clay. Great masses of igneous magmas invaded them from below and cooled to become granitic rocks. The cooling magmas gave off vapors and solutions that penetrated the adjacent rocks altering them to schists, hornstones and marbles, and depositing in them ores of gold and other metals. Next a period of erosion lasting well into Tertiary time cut deeply into the metamorphosed and mineralized rocks and all but leveled the mountains. The middle Tertiary was essentially a time of volcanic activity in which the surface received a thick lava cover. In the late Tertiary and Quaternary periods deformative forces again became active. The mountains were re-elevated and the surface sculptured to its present form.

#### PHYSIOGRAPHY

The origin of the hills and valleys of any land is a fascinating study. In the Sumpter quadrangle this study has an added interest in that the history of the gold deposits is in many ways bound up with the growth of the hills.

The Sumpter quadrangle lies near the central part of the Blue mountains of Oregon, a region about 15,000 square miles in area which extends from Snake river well out into the central part of the state. The general direction of the belt, which is about 75 miles wide and 200 miles long, is a little south of west, but the individual ranges trend, as a rule, northwest-southeast. The region is one of rugged mountains, broad valleys, and hills and canyons without number. Elkhorn ridge and the mountains with which it merges north of Rock creek butte, all of which may be called Elkhorn range, occupy most of the northern half of the quadrangle, and form the bold and rugged skyline west of Baker valley. Southwest of Elkhorn range, beyond Sumpter and Whitney valleys, rises Greenhorn range, only the eastern shoulder of which is within the quadrangle. To the southeast across Sumpter valley fairly high mountains again appear, beyond which the broad valley of Burnt river extends. In general to the south of Elkhorn range the landscape comprises an almost unbroken panorama of rounded, thickly-timbered hills. Viewed broadly and without regard to their smaller details, the larger valleys are oval northwest-southeast basins whose bordering slopes curve into the level bottom lands.

Geology recognizes no truth in the phrase "everlasting hills." Instead, such is the great length of geologic time that "fleeting" or "short-lived" hills would more nearly express the truth. It is indeed literally true that hills grow, become mature, and wither away. A main cause of the growth of hills is compression or tension, which forces the earth's crust to wrinkle and warp, or to crack and slip. Another is vulcanism which may heave or even fold the crust by the pressure of great molten masses from below, or build it up by matter ejected upon the surface. The sculpturing and final destruction of mountains are almost wholly the work of water, ice, wind and changes in temperature. The mountains of Sumpter quadrangle as they now appear are the results of all the processes enumerated, of which, however, the folds and warps have so far played the most prominent part. There is evidence to show that these movements ceased but recently, if indeed they have yet entirely done so, and, therefore, that the mountains have just about attained their growth. When the gradual uplifting of mountains ceases, erosion, always wearing them down, attains the upper hand and, if unopposed, finally destroys them. The multitude of canyons (Fig. 7) and smaller valleys in Sumpter quadrangle indicates that much wearing down already has been accomplished. However, the larger basin-like valleys, as for instance those of Sumpter and Whitney, have had a different origin. Although it is true that erosion has modified these basins, it is plainly evident that they were mainly formed either by warps, folds, and faults that depressed them or that they were left as lowlands while the adjoining mountains grew. Folding was undoubtedly the most important process, but slips along cracks which broke the crust aided materially in the mountain and valley building. In fact, the part played by faults is probably not yet fully appreciated because of a lack of detailed information concerning them.

As the Blue mountains grew their history was recorded in the rocks and many of the records are still preserved. Because of the protection afforded by lavas that covered them, certain soils and stream gravels, relics of a very old surface, still exist in part. As these deposits are easily washed away they can now be seen only in areas recently stripped of the lava cover, as near the present margins of the lava sheets, especially in the southeast quarter of the quadrangle north of China creek. Here a very red-colored soil is seen on close inspection to be the residuum of the underlying rock which is deeply weathered and so thoroughly decomposed that its comparatively indestructible

elements only, such as cherty layers, preserve their original characteristics. The formation of such a soil mantle necessarily requires a long period of undisturbed weathering. Its red color, due to thorough oxidation, implies a scanty vegetation and fairly dry climate.

The former stream gravels are likewise now to be found only where recently stripped of the lava cover. As some of them contain gold in paying quantities they have been worked as placer mines. The exposure thus made at Parkersville, Winterville, Buck gulch, Griffith Diggings, French Diggings, and other places, give evidence that the gravels are old. Boulders of granodiorite and greenstone that must have been solid and firm when the stream rounded them are now so far rotted that when dug out they fall apart of their own weight. Only the most dense and siliceous varieties of boulders remain firm. It is further observed that the bed-rock which in many places had been polished by the streams and must therefore have been hard at the time, is now soft and friable.

The lavas that still cover a large part of the area consist in part of fragments ranging in size from fine sand to boulders six feet in diameter that were ejected from craters and fell over the land as showers. Later the sand and smaller fragments were stratified by running water. In part the lavas are sheets of solid rock that flooded the surface when in a molten state. At the time these diverse layers came to rest they must have been level or nearly so; now they are tilted at angles too steep to have been assumed by liquid flows or to represent angles of deposition of waterlaid sands. Moreover, the layers are observed to be broken and their continuity interrupted by cracks on which their severed parts have been moved up or down.

The high mountains in the northeastern part of the quadrangle are now practically free from the lavas which underlie a large part of the surface elsewhere, and no evidence that they were ever completely covered has been obtained. It is further observed that as the flows approach the higher mountains from the south and west, although they extend well up the slopes, they become thin and disappear one at a time, the lowermost first. The conclusion drawn is that at the time the lava was extruded relatively high land existed in the northeast quarter of the quadrangle which the igneous floods failed to submerge entirely.

All the evidence noted proves the region to have been formerly a land of gentle contour that, after receiving a volcanic cover, was warped, cracked and upheaved to approximately its present form.

Since the upheaval, erosion vigorously attacking the highlands has succeeded in wearing away much of the lava cover and trenching deeply what would otherwise have been comparatively smooth slopes.

To form an idea of the progressive evolution of the Blue mountains so far as available facts permit, the reader may imagine the valleys of recent erosion filled by putting back the materials removed from them, and the surface flattened until the lava sheets regain their former horizontality and finally the surface stripped of the lavas, exposing the old topography as it appeared in early Tertiary time. Sumpter quadrangle was then practically a plain diversified only by shallow valleys and groups of low hills, the largest group of which occupied the present site of Elkhorn range. Streams flowed out from this group and from the other smaller highlands west and south of them. Along their courses these streams deposited gravels in which fragments of trees and stems of giant ferns that grew near by were buried. The gravels were in part made up of granodiorite cobbles and in places they contained quartz and fine particles of gold. Therefore the great masses of intrusive rock had already solidified and the gold-bearing lodes had been formed. Furthermore, as the texture of this granitic rock can be produced only by crystallization of molten matter beneath a heavy cover, and the cover was gone, it appears that the hills were but the remnants of still earlier mountains that had been worn down by erosion. Thus at the close of a long erosion period there was a land of gentle slopes, its scantily timbered hills ribbed with gold-bearing quartz and its streams lined with placer gravels. By piecing together the present remnants of these old gravels it is possible to get a vague notion of the old river system. Thus it appears that a stream flowed southward from the present site of Bald mountain across Griffith Diggings, Buck gulch, and the head of Three Cent gulch. Another heading in the hills, which occupied the present site of the Greenhorn mountains, took an easterly course across the present Parkerville and Winterville Diggings, and probably joined the first one. Others headed in the hills which then occupied the present site of Elkhorn range and flowed northwestward over the French Diggings and southeastward past the site of Minersville. Numerous other remnants of old gravels show that the drainage system of this time was probably as extensive as now, but knowledge sufficient for its detailed mapping is not available.

It is reasonable to assume that while the ancient Elkhorn and Greenhorn ranges were being eroded and the upper portions of their

quartz lodes washed away, the chemical changes due to weathering were going on within the lodes and that even the more complex processes that produce downward enrichment were at work. In fact, the rich ore pockets of the Greenhorn district that are now found near the old surface where it has been but recently stripped of the lava cover, are believed to have developed during this ancient erosion period.

This period was suddenly interrupted by a series of extensive volcanic eruptions that overwhelmed the land, destroying whatever life existed, obstructing the stream channels and completely altering the landscape. First came a series of terrific explosions that threw from great craters shower after shower of rocks and sand until the land was buried hundreds of feet deep. Between these showers the streams, endeavoring to re-establish themselves, shifted and stratified much of the finest material and in a feeble way formed even a little placer gravel. Next, separated by intervals of various lengths, came quiet outpourings of molten basaltic and latitic lavas which spread far and wide over the surface. Buried thus beneath a great depth of barren rocks, the land must have been a desolate plain. Like islands in a lake the higher hills still protruded above the general surface.

In addition to the effects already described, the great lava cover at once put a stop to erosion of the old surface, to the weathering of its rock formations and of its quartz lodes. Their wearing away with the accompanying development of placer gravels or enriched ore bodies was arrested. The soil mantle and stream gravels were put in storage as it were for preservation until the events of a later time exposed them to view.

Gently at first, but with increasing force, the land began to crack and heave as if to throw off the incubus that had settled upon it. Evidence placing the beginning of this movement is found in the erosion surface between the rhyolitic and underlying basaltic lava sheets. The fact that the basaltic sheet was channeled by streams as observed for instance north of China creek, implies that it was locally at least, uplifted enough to establish working grades for water. This deformation was not, however, sufficient to prevent the succeeding rhyolitic flood spreading as a sheet over the region generally.

Succeeding the rhyolitic floods, but closely associated with them, are some very interesting formations composed largely of volcanic sand, dust, and pumice. Many of these beds show distinct evidences of having settled from still water. They are now exposed over a considerable area in the foothills of Burnt river valley, and in small de-

tached areas elsewhere. Nor is there any reason to think that they once formed a continuous sheet. Apparently this material accumulated in basins that held lakes into which showers of volcanic ash fell directly and was also washed from the surrounding lands. The lake basins may have been formed in valleys as they were dammed by the rhyolitic floods or have been due to continued deformation of the crust. Probably both causes were responsible but the fact that the deposits occur mainly in structural basins indicates the latter to have been the chief factor concerned. In places abundant fossil leaves have been found inclosed in these rocks and they record that Miocene species of oaks, maples, willows, and even redwoods grew about the basins. While the lakes persisted a group of minute plants known as diatoms grew abundantly in some of them and left their minute siliceous skeletons in such numbers as to form beds several feet in thickness. This return of life to the desolated land was destined, however, to be brief. Soon the region was in great part overwhelmed again by molten floods of basaltic lavas that added several hundred feet more to the already thick cover.

The next great episode in the physiographic history of the area was the building of the Blue mountains of the present day, or at least the portion of them included in the Sumpter quadrangle. As already stated, there is reason to believe that before the great volcanic outbursts had ceased, their growth had begun. But the deformed condition of the later lavas shows that at the time they overspread the surface the work was less than half accomplished. From the hitherto flat surface, great swells slowly rose of which one in the region of the Elkhorn range became the most prominent. In many places the rocks and cracks formed miles in length, on which adjacent blocks were step by step forced past each other for hundreds of feet. If a buried gravel channel lay in the path of a swell or crack, it was raised or lowered, or cut off, and its adjacent portions forced to different levels. In similar manner the quartz lodes were shifted and faulted. It is well indeed for the mining industry that the faulting was relatively less abundant in some of the principal quartz-bearing areas than elsewhere. The old gravels were less fortunate. Practically all these deposits were involved in the folding or cut into blocks that were shifted up or down. Therefore it is readily apparent why they are now found in detached masses, here on top of a ridge, there down in a basin, and elsewhere hanging on some intermediate slope. Likewise, it is now clear why the bed-rock under these gravels may often have steep



Fig. 5. Government trail through forest of lodge pole pine (*Pinus Murrayana*).



Fig. 7. Canyon of North Fork of John Day River below Trail Creek,. Shows extent of post-lava erosion in rocks of the argillite series.



Fig. 6. Yellow Pine Forest (*Pinus Ponderosa*) along the divide on the road between Burnt River and Austin. Shows the abundance of undergrowth characteristic of these forests above 5,000 feet elevation.



slopes, and why the pay-dirt in many places ends abruptly against a wall, perhaps to be found again on top of it.

There remains to be considered the final step of mountain building, namely, the sculpturing. If the work of water had been omitted, the quadrangle today would present a surface of broad alternating swells and basins. Sumpter and Whitney valleys would be oval depressions with no outlets. Their sides would be smooth, continuous slopes except for steep faultscarps that would break them here and there. Instead of a rugged ridge with canyons, Elkhorn range would be a featureless dome-like surface. Likewise the smaller and sharper irregularities elsewhere in the quadrangle would not exist. Furthermore, the volcanic overburden would still conceal most of the known gold-bearing lodes and for the most part the placer gravels would not have come into being. As a matter of fact, once the elevating process began, erosion became active and the two progressed hand in hand so that at no time did the surface present forms of purely structural origin. As the new system of streams deepened their channels and worked through the lavas, they brought to light again the long buried veins and gravels. Again the processes of vein alteration began; the enrichment of the veins, the wearing away of the outcrops and the concentration of placer gravels were resumed. Where new streams cut into the old channels they shifted the gravels and reworked them into richer deposits. During an early vigorous stage of this erosion, gravels were washed into the basins faster than they could be carried out; Sumpter, Whitney, and other valleys were filled to depths that ranged from a few feet to a hundred feet or more. Streams that were depositing gold transported it out beyond the edges of the hills in some places. In this way the bench or bar diggings of Sumpter are believed to have in part at least accumulated. Although erosion was now the dominant process, earth movements had not entirely ceased for gravels of this age in Whitney valley are observed to be slightly faulted and tilted. Afterward the rivers swept away part of these valley accumulations, digging out their wide flood plains, and carving the adjacent gravel terraces to about the form they have today.

Although it is true that erosion had always been more active on the higher lands than elsewhere, owing not only to their steeper slopes, but to a greater rainfall, this inequality was intensified during the succeeding Pleistocene glacial period. About this time the climate changed until the annual snowfall in the high mountains exceeded the waste by melting and a great excess of snow accumulated that by its own

weight was compacted into ice. When a great thickness of ice had formed, it flowed slowly down the mountain valleys precisely as do the glaciers of Alaska and the Alps today. Likewise the glaciers of the Elkhorn range deepened and rounded their valleys and dug them headward into the very heart of the mountains. In this way the rugged cliffs and crags that form so striking a feature of the landscape were produced.

Farther down where the air was warmer the ice melted and dropped the rock debris, scraped and carried from above, to form the irregular but characteristic hillocks or moraines.

From the melting ice-tips floods spread much of the morainal material well out over the lowlands as gravel fans and sheets. The ice accumulated in greater abundance on northerly slopes, and here the glacial deposits are more extensive than elsewhere, as along streams tributary to North Fork of John Day river, and those that debouch along Baker valley. Recurring changes in climate caused the ice to dwindle away and then to accumulate and advance a second time; and finally to disappear. The retreating ice tongues distributed morainal debris irregularly over the valleys as they vacated them. In this way the streams were dammed and the beautiful mountain lakes of the quadrangle produced.

The general absence of placer gravels within the glaciated area is very noticeable. Even the few deposits found near its margins are of low grade. Their absence can not be ascribed to a lack of gold-bearing rock formations from which the streams could draw a supply. Instead, it is likely that placer gravels existed before the ice invasions, but the glaciers brushed them out and diluted them so greatly with barren debris that they became valueless. An interesting exception to this general rule is afforded by the gravels at the North Fork Diggings, which, although made up chiefly of unassorted glacial debris, contain gold in paying quantities. The exceptional nature of the deposit and the probable reasons therefor are discussed elsewhere. Near their lower extremities the ice tongues, weakened no doubt by shrinkage due to melting, appear to have been unable to scrape the bed-rock severely, but in their more vigorous upper portions they were able not only to remove all loose material, but to wear down the solid rock. Thus they carried away the upper portions of any quartz lodes that lay in their paths, often removing the oxidized zones completely, and even tearing away parts of the ore bodies beneath.

Since the ice disappeared the streams have worked to fill up the

lakes with sediment and to repair the damage done to the placer gravels. Up to the present, however, they have succeeded in but a small way so short relatively has been the time.

Thus, if the records have been correctly interpreted, a complete cycle appears in which the ancient mountains of Sumpter quadrangle were nearly leveled and then rose again as the imposing Elkhorn range of today.

#### GLACIATION

The picturesque cirques and mountain lakes, and the bare rounded rock surfaces, some of them grooved (Fig. 8), that abound in the high mountains north of Sumpter, as well as the rocky unassorted debris that lines the mountain valleys, gives indisputable evidence of the former activity of glaciers. At the time of its greatest extent, ice filled all the mountain valleys that dissect the northeast slope of Elkhorn range and the high lands north of Bourne. North of the head of Cracker creek the valley glaciers joined, forming a confluent ice sheet through which only the higher mountain peaks and ridges projected. From this central area ice tongues descended the mountain valleys to 3,500 feet elevation at the edge of Baker valley and even pushed out beyond its margin a mile or more. A large stream descended the valley of the North Fork of John Day river and deposited its terminal moraine (Fig. 9) at an elevation of 5,200 feet upon the remnant of which the North Fork placer mine is located. In contrast to the opposite slopes, those facing south and southwest almost escaped glaciation. Comparatively small ice streams flowed down McCully Fork, Silver, Fruit and Cracker creeks, but none of them reached Sumpter valley. A similar relative distribution of the ice is characteristic of glaciated areas throughout the northwestern states and the relative scarcity of ice on south and southwest slopes was apparently due not wholly to their exposure to the sun but in part to winds that prevailed from the west or southwest. The history of glaciation is briefly summed up in the section on physiography.

All of the glaciated valleys contain irregularly distributed drift that is most abundant along their lower courses, and except Baker valley, the area northeast of Elkhorn ridge and north of the latitude of Bourne and east of Trail creek, covered on the geologic map Fig. — by the pattern representing surficial deposits, are chiefly occupied by glacial debris. The most extensive drift sheets were laid down by the glaciers that occupied the valleys of Rock creek, North Powder

river and North Fork of John Day river. Near the points where these streams leave the mountains the glacial debris is thickest and is piled up in characteristic morainal hillocks several hundred feet high. In some places, particularly at the lower limit reached by the North Fork glacier, the drift contains rusted and decomposed granodiorite boulders. They could not have preserved their forms had they been soft when the ice transported them, indicating that the drift to which they belong has lain undisturbed a long time. Further up stream there is another drift sheet, but in this the boulders are all fresh and firm, indicating a much younger age. Two sheets of drift are distinctly recorded also by the deposits on Cracker creek, but in most of the glaciated areas the younger drift only can be recognized.

## PRE-TERTIARY ROCKS

### GENERAL STATEMENT

The rock formations described in this section are considered in the order of their ages, the oldest being considered first. Their thicknesses are given as preliminary estimates and are subject to correction. The general features only of the rocks are described here, leaving the details of stratigraphy and structure for the forthcoming geologic folio of Sumpter quadrangle, to be published by the United States Geological Survey.

### ARGILLITE SERIES

*Distribution and lithology.* The area shown on the accompanying map, Fig. 2, (in pocket) as occupied by the argillite series, includes the outcrops of fine-grained siliceous argillaceous sediments, which comprise at least 90 per cent of the whole, limestone, rocks of volcanic origin interbedded with both, and some intrusive rocks that take the forms of sills and dikes. These rocks are exposed over a broad belt that crosses the quadrangle from east to west and approximately occupies its middle third. To the north and northeast they abut against granodiorite and to the southwest and northwest they disappear beneath younger formations. Outside of this main belt, however, many small areas of the argillite series appear where the cover has been eroded away. The best exposures of the argillaceous and siliceous sediments are found on the northeast slope of Elkhorn ridge where numerous glacial cirques have eaten into them, and along some of the streams draining the southwest slope, especially Cracker creek, which flows across the

strike of the beds for a distance of about eight miles above Sumpter. Between Sumpter and Pole creek the Cracker creek section shows at more or less regular intervals detached reefs of indistinctly bedded extremely fine-grained light to dark gray siliceous or cherty rocks, the intervening spaces being deeply soil-covered. Above Pole creek the exposures are more nearly continuous and the rocks are seen to be composed chiefly of very fine alternating siliceous and argillaceous layers that range in thickness from a fraction of an inch to several feet. Some of the harder gray siliceous layers resemble chert, and some of the softer argillaceous ones a bluish-black slate. All gradations between the two occur, and as a rule the transition from one to the other is not abrupt. The siliceous sediments occur as indistinctly bedded strata or as layers an inch or two thick that pinch and swell and are separated by thin partings of dark argillaceous material. In places the forms due to alternate pinching and swelling grade into overlapping lenses, and these to detached nodules interbedded in the softer dark material. The black layers are composed of very fine argillaceous material through which carbon dust is distributed. They are usually thin bedded and part readily on bedding planes.

These strata grade upward into poorly bedded, fine-textured, dull gray and green rocks, that are best exposed on the southwest slope of Elkhorn ridge from Rock creek butte southeastward and appear to be developed also in the range south of Sumpter valley. The gray beds are derived from water-laid sediments but most of the green ones have been recognized as interbedded lava flows and tuff.

Although some portions of the series contrast strongly in color with other portions, contrasting beds in most places are separated more or less widely by rocks of intermediate characteristics through which one kind grades almost imperceptibly into another. No well-marked type of beds characterizes any particular part of the series, as gray cherty layers, black beds, and intermediate kinds occur at many different horizons. For the most part the rocks weather readily and only the highly siliceous portions form prominent outcrops. Because of this the relative importance of the latter is apt to be over-estimated, especially in the region south of Elkhorn range, where as a rule outcrops of the cherty beds only can be seen. The Cracker creek section appears to be less affected by folds and contortions than any of the others, but the detached reefs and the polished striated surfaces of the joint and bedding planes of the rocks here indicate that fault displacements are as numerous as elsewhere. In this section the average strike and dip are

east-west and  $39^{\circ}$  south, respectively. Excluding from the section portions affected by folds, the great apparent thickness of 21,000 feet is shown. There is reason to believe, however, that the beds are many times repeated by faults, and that, were these repetitions excluded, the total thickness would not exceed 3,000 feet. This section, however, does not include the interbedded lavas, limestones, and an unknown thickness of siliceous argillite associated with them.

The limestone comprises a relatively small proportion of the volume of the series. Its greatest areal exposures are confined to a belt about half a mile in width that extends from Marble Point westward to Deer creek, although a number of very small outcrops are scattered sparingly elsewhere in the argillite area. The limestone outcrops are rather remarkable because they almost invariably occur as small detached areas that have angular boundaries. Most of them range from 50 to 500 feet in width and from 100 to 1,000 feet in length, and in order to make them plainly visible on a map of the scale used for this report, the dimensions of the smaller ones as shown are considerably enlarged. In color they range from light gray to dark blue and in composition they appear to be generally almost pure calcium carbonate. Many of the masses have been altered to a white crystalline marble. The detached areas that form the principal belt of limestone for the most part are bounded by straight and parallel lines one set of which strikes about  $N. 65^{\circ} E.$  and another about  $N. 50^{\circ} W.$  The largest single exposure of limestone, that of Marble Point, occupies an irregular area about three-fourths of a mile in length from east to west, and half a mile in width. Its vertical extent is 1,000 feet or more. In detail, its boundaries are irregular zig-zag lines and the whole appears to be made up of separate angular blocks.

In general the limestones of this belt have been metamorphosed into fine to medium-grained, white to light-blue marbles. Bedding planes are usually indistinguishable and the rock is traversed by minute fractures healed by thin calcite seams. Weathered surfaces present intricate patterns of etched right lines that separate bluish-gray patches. The small limestone areas scattered elsewhere in the quadrangle are essentially similar to these except that all are not metamorphosed to the same degree. The limestones occur in the upper part of the argillite series, and are interbedded with argillaceous sediments and lie between sheets of eruptive rocks. Owing to the obscurity of bedding planes their thickness is difficult to measure, although it has been estimated to range from 50 to 500 feet.

Meta-gabbro is a heavy, dense, crystalline green rock that in the form of sills, dikes and bosses cuts the sedimentary beds. The largest exposure of the rock extends from the vicinity of Bourne eastward to the boundary of the quadrangle and beyond in a belt from one-quarter of a mile to a mile and a half in width. The rock here occurs as a sill in the lower part of the argillite series, and is characterized by prominent angular outcrops. Several glacial cirques including the large one south of the Highland mine are carved in it. Along the summit of the Elkhorn ridge east of Lake creek and in the vicinity of Greenhorn City the rock forms prominent knobs (Fig. 10). In the vicinity of Bourne the meta-gabbro sill is about 700 feet thick, but it increases to the eastward and attains a thickness of not less than 1,500 feet in the basin south of Highland. Beyond this point the rock occupies large areas whose forms suggest that it occurs mainly as irregular masses and as dikes. Good exposures of the rock on the hills north of the Columbia mine and east of the North Pole mine are dark greenish-gray. Little knobs of dark green hornblende project from the rough weathered surface and light gray interstitial material forms an intricate pattern. In the cirques south of the Highland mine and to the east the rock is lighter in shade and plainly shows a granitic texture. Preliminary microscopic examinations show the rock to be composed essentially of altered plagioclase feldspar and green amphibole such as might form from the alteration of augite.

Peridotite is a coarsely crystalline, heavy, dark-green or black rock composed largely of iron magnesia silicates and is characteristically dark brown on the weathered surface. It intrudes the argillitic sediments and the meta-gabbro in irregular masses whose inconspicuous outcrops occupy small areas along McCully Fork west of Sumpter and occur in the basins of Corral and Boundary creeks. Serpentine, an alteration product of peridotite, occupies considerable areas in the vicinity of Greenhorn city and to the southwest of the Ibex mine. It is characterized by a smooth or soapy feel, a network of fractures that break into small fragments with curved outlines, and varies from light green to black in color.

*Structure.* The argillite series is characterized by steep dips. On Elkhorn ridge and in the area north of Sumpter the prevailing dip is southward at angles that range from 30 to 90° and the strike, locally variable, averages nearly east-west. Elsewhere the strike and dip are more diverse, but the latter is steep as a rule, angles that range from 70° to the vertical being most common. Its contrasting beds are so ill-

defined and its deformation has been so extensive and severe that it is doubtful if the structure of the series can ever be comprehensively worked out. Even where clean exposures abound, as in the glacial cirques of Elkhorn ridge, so indefinite are the boundaries between any two beds and so slight are the color variations and other differences by which one stratum may be separated from another, that the most painstaking efforts to unravel the structural details have succeeded only in showing that in addition to small compressed folds and contortions innumerable small faults exist. Detailed studies in the vicinity of Bourne have shown that locally at least the downthrow is cumulative in one direction, so that the effect produced is as if the displacement of a large fault were distributed over a wide space. The extent and complexity of faults is shown by the distribution and form of the limestone outcrops. It is unreasonable to think that this rock was deposited in the angular detached form it now shows. The blocks are probably parts of one or more formerly continuous beds that have been cut and shifted by faults to a most extraordinary extent. Some notion of the degree to which the rocks have been compressed is had when it is observed that throughout large areas they have been crushed to small fragments and the softer portions caused to flow about the harder ones transforming the mass into a rock that resembles a conglomerate. Good exposures of this pseudo-conglomerate occur in the glacial cirques at the heads of Pine and Goodrich creeks.

The most noticeable of the smaller structures are short, closely-compressed folds and contortions that characterize the thinly bedded cherty strata almost everywhere. Perhaps the best exposures of them occur on the spur east of the North Pole mine and on the slopes near the Buckeye mine. Folds are spaced but a yard or two apart as a rule, and they grade into irregular plications and contortions. A moderately broad openfold that involves the meta-gabbro sill is shown on the North Pole and Columbia hills.

The compressed folds and pseudo-conglomerate, apparently the oldest of the structures exhibited, were for the most part formed at a time when the strata involved were beneath a heavy cover, probably when the ancient Blue mountains were elevated. The distributive faults were, in part at least, later and as they do not appear to affect the granodiorite, the development of these structures probably antedates that formation. Some of the deformation, however, appears to have been caused by the intrusive rock which probably came to place before the mountain building had ceased.



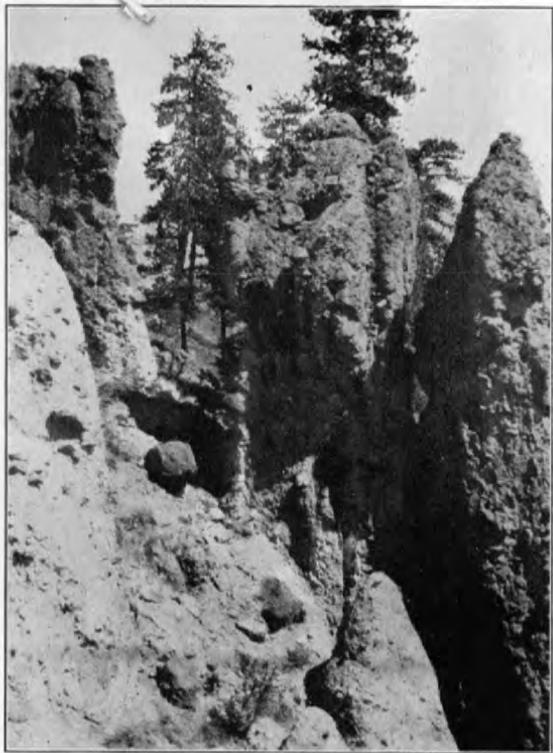
Fig. 9. North Fork Placer Mine. Shows bank composed of glacial drift containing large boulders.



Fig. 10. Outcrops of Meta-gabbro. Summit of Elkhorn Ridge near head of Marble Creek.



Fig. 11. Outcrop of granodiorite. Basin at head of North Powder River. Shows prominent horizontal joints.



Of later date are faults along which the metalliferous lodes of the quadrangle developed. Compared with the others they are more widely spaced and of vastly greater size and throw. As a rule they strike northeast and dip steeply south. For more particular descriptions of them the reader is referred to the paragraphs on ore deposits.

Superimposed upon all of the above-mentioned structures are folds and faults of Tertiary age that have been briefly described in the section on physiography. Only where Tertiary rocks are in contact with the argillite series has it been possible to differentiate the later structures from the extensive and complex older ones. The principal faults that have been determined are indicated on the accompanying geologic map. As regards strike, they form a system of parallel fractures of northwest-southeast trend and variable dip. As a rule, however, they dip southward and cause normal displacements of a few hundred feet.

*Age.* But little definite evidence of the age of the series as a whole has been obtained. The only fossiliferous beds so far discovered are the limestones, and the paleontological collections afforded by them are for the most part small and fragmentary. Here and there the limestone outcrops show indistinct sections of round crinoid stems and fragments of other fossils. At one locality 3 miles due south of Sumpter collections obtained from a small limestone mass exposed by a cut on the Sumpter valley railroad, contain fossil shells of the Carboniferous foraminifer *Fusulina* and of brachiopods and other genera.

A great thickness of sedimentary beds underlies the limestone, however, and how far these descend in the geologic time scale is not known. Likewise above the *Fusulina*-bearing stratum no fossil evidence has been found. In a few places severely deformed conglomerates that contain limestone pebbles occur. If these are derived from erosion of the *Fusulina*-bearing stratum which their composition suggests, they are, of course, younger and support the view that beds of Mesozoic age are included in the argillite series. That such are present in the quadrangle is to be expected, as Triassic rocks are extensively developed in the Eagle creek range, a short distance east of it.\*

#### GRANODIORITE

Granodiorite occupies a large area in the northern portion of the quadrangle forming Bald mountain and the bold rocky summits north

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\*Lindgren, W., The gold belt of the Blue Mountains of Oregon: Twenty-second Ann. Rept. U. S. Geol. Survey, part 2, p. 581. 1901.

of the head of Cracker creek. Smaller areas of this rock outcrop south of Sumpter valley, in the Greenhorn district and elsewhere, as shown on the accompanying geologic map. The larger mass was named by Lindgren the Bald mountain batholith. Outcrops of the rock long exposed to ordinary weather conditions show characteristic rounded forms except on the bare cliffs and pinnacles of the higher mountains where its rapid disruption by frost working along the numerous joint planes causes angular forms. Except in the highlands north of the head of Cracker creek, where ice and stream erosion have been unusually active, rounded rather subdued topographic forms characterize areas of this rock. The granodiorite is cut by three sets of joint planes approximately at right angles to each other, two of which are vertical or nearly so. From place to place, however, the spacing and relative importance of the different joint systems vary. Over wide areas the vertical or steeply dipping joints are closely spaced and prominent (Fig. 12). In other areas they are subordinate to the horizontal fractures. (See Fig. 11). Viewed broadly, the main granodiorite mass of the quadrangle is circular in plan, extends to unknown depths, tends to be enlarged downward, and is therefore of the form to which the term batholith is applied. The smaller masses to the south of it although somewhat more irregular than the main body, are of the same general form and are regarded as off-shoots connected with it in depth. The small granodiorite areas near Greenhorn city and Red Boy are probably the outcrops of off-shoots of the Greenhorn range batholith exposed west of the quadrangle. From the edge of Baker valley to the head of Cracker creek the boundary of the main or Bald mountain batholith deviates but little from a straight line although an uneven topography is crossed, showing that along this course the contact plane is vertical or nearly so. But from the head of Cracker creek to the basin of Fruit creek the trace of this contact plane is an irregular line that descends gradually into the valleys but approaches horizontality, the argillite above, the granodiorite below, showing that here the contact plane dips gently outward, and that the batholith is enlarged in depth. Similar but less striking characteristics of the boundary line that separates the re-entrant mass of argillite of the La Belleview mine from the granodiorite show the former to be a blunt wedge hanging point down, as it were, in the intrusive rock. From Silver creek to Granite creek the trace of the contact plane shows it to range in dip from the vertical to steep angles outward. The contact of the Bald mountain batholith is exposed to view only along its

southern boundary and on Bulger hill in the northeast corner of the quadrangle. In the former localities the invaded rocks dip steeply away from the granodiorite as if it had elevated or domed them during intrusion. The argillite and associated rocks warp around the detached area of granodiorite west of McCully Fork in such a manner as to suggest that the intrusive rock pushed them aside. On the other hand, the granodiorite locally cuts across the strata as in the basin of Fruit creek, or they appear to have settled in the magma, as at the La Belleview mine on Bulger hill and along the edge of Baker valley south of it. It appears, therefore, that the granodiorite magma reached its present position in part by displacing and in part by engulfing the invaded rock.

In its most common occurrence, the granodiorite is a light-gray medium-textured rock that resembles ordinary granite. Its outcrops, as seen from a distance of a few miles, appear nearly white, although the marginal portions of the main mass and the smaller masses south of it are, as a rule, somewhat darker in shade. Representative specimens from Bald mountain and the peaks north of Cracker creek consist chiefly of plagioclase feldspar, quartz, hornblende and biotite, together with noteworthy amounts of orthoclase. The marginal phases of the principal mass and the smaller bodies contain relatively larger proportions of hornblende and biotite and less quartz and orthoclase, and some of them may be properly termed diorite. Throughout most of its area, however, the Bald mountain batholith shows but little variation in composition and texture. Locally the rocks contain dark spots of a few inches diameter caused by the segregation of brown mica or other dark minerals.

Dikes of aplite and pegmatite are sparingly distributed through the Bald mountain batholith. They were observed most commonly in the northern part of the mass where they are generally narrow, and composed chiefly of a flesh pink feldspar, quartz and a long bladed brown mica. Relatively large ones were seen on the Flying Cloud claim near the head of North Powder river where disseminated copper and iron sulphides are closely associated with them. They have not been studied microscopically.

In detail the contact is not ragged except near the La Belleview mine, where the granodiorite and sedimentary rocks interlace in an intricate manner. Apophyses from 100 to 500 feet in width branch from the granodiorite here and there, particularly near the Baisley-Elkhorn and Bald mountain mines; elsewhere they are uncommon.

The rocks crystallized from molted magmas that invaded the argillite series long before the deposition of the Tertiary beds, the lowest of which rests upon its eroded surface. All of the relations observed accord well with Lindgren's conclusion that the invasion took place in late Mesozoic time.\*

#### DIKES

All the formations of Sumpter quadrangle except those of Quaternary age are cut by igneous dikes. They are most numerous in the argillite series and successively younger formations contain fewer of them. The dikes range in width from a fraction of an inch to a hundred feet or more, but as a rule are narrow and non-persistent. In composition they range from ultra-basic to extremely siliceous, but few of their petrographic details are available for the present report.

In the area underlain by the argillite series, the most common variety is a dense fine-textured light-gray rock, indicated by preliminary examination to be a granodiorite porphyry. In certain localities where the bed-rock is free from soil cover, as near the summit of Elkhorn ridge, dikes of this kind are so closely spaced that in places they make up as much as 20 per cent of the mass. Elsewhere their presence is shown by fragments in the surface mantle. In general the granodiorite porphyry dikes differ widely in strike and dip but in the locality of Elkhorn ridge most of them appear to occupy fault fissures that strike northeast-southwest and dip steeply. Similar dikes occur in the mine workings where, as in the Red Boy mine, they cut across the lodes. Others, however, appear to be younger than the vein system. Dikes that range in color from light to dark shades of greenish-gray and in composition from diorite porphyries to pyroxenite are widely distributed. In the granodiorite area dikes of these kinds occur mainly near the contact, but even here they are less abundant than in the areas of argillite. The aplite and pegmatite dikes mentioned in the section on granodiorite are rather sparingly distributed, over the area of that rock, and occur locally in the portions of the argillite series in contact with it.

In the Tertiary volcanic rocks dikes, most of which are porphyritic, are fairly numerous in the area drained by Burnt river east of China creek. Here they pass into the sills and other forms mentioned in the section on tuff breccias. In the main they are dense dark-colored

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\*Lindgren, Waldemar, *The gold belt of the Blue Mountains of Oregon*: U. S. Geol. Survey, Twenty-second Ann. Rept., pt. 2, p. 596, 1901.

basic rocks, but some are light in color and appear to be siliceous in composition. Discussion of their petrographic details awaits the opportunity for detailed microscopic study.

### TERTIARY ROCKS PRE-TUFF-BRECCIA GRAVELS

The pre-tuff-breccia gravels have been briefly described as to origin and history in the section on physiography. They compose a formation of relatively small volume as compared with the other formations of the quadrangle, but the gravels are widely distributed and are of particular interest because they have yielded a considerable percentage of the placer gold production and are still being mined in some places. The best exposures of the formation occur at the Weaver, Griffith, Winterville, and Barton mines, and at the French Diggings. Natural exposures are poor and most of them are confined to areas adjoining the margins of the lava sheet and to localities from which the lava has been recently stripped by erosion. The gravels throughout are characterized by very smooth stream-worn cobbles and boulders of moderate size, composed almost exclusively of the more resistant kinds of rock such as chert, quartz, and dense fine-textured porphyries. The cobbles show signs of having lain a long time exposed to the agents of rock decay, their outer shells being commonly softened and bleached to light-buff or gray tints. The abundant matrix is composed largely of clay and sand, some of which are derived from the decay in place of water-worn cobbles of argillite, greenstone and granodiorite. In many places the gravels contain fragments of silicified wood. The color of this formation is variable, but bright reds and bluish grays are more common than intermediate shades. Locally the gravels contain particles of gold in sufficient abundance to make their extraction by placer mining profitable. The gold is invariably smoothly washed and of high grade, worth from \$17 to \$19 an ounce.

At the upper ends of the extensive pits known as French Diggings, the following section, presented in descending order, is shown.

	Thickness in feet
Eroded surface with 1 to 2 feet of soil	
1. Reddish-yellow gravel composed of a moderate percentage of water-worn cobbles and boulders up to 2 feet in diameter in an abundant red sandy matrix, cobbles chiefly of chert and siliceous argillite..	20
2. Hard arkosic gray sandstone containing abundant fragments of silicified wood .....	3
3. Light bluish-gray gravel composed of cobbles similar to those in bed No. 1 inclosed in a sandy clay matrix .....	15
Total .....	38
Granodiorite bed rock	

Here the formation is cut by at least three faults that strike about north-south and dip steeply to the east. They show normal displacements of 12 feet or more and some of them are accompanied by breccia slightly mineralized with pyrite. The layers, which are locally cross-bedded, range in dip from the horizontal to 10° westward and in width from 200 feet for the lowest to 1,000 feet or more for the highest layer; the general course of the channel is a little west of north.

The section at the Griffith mine shows 40 feet of gravel similar to the upper gravel layer at the French Diggings, beneath which is about 18 feet of gray sand and clay in alternating layers, moderately indurated and resting upon a bed-rock of decomposed granodiorite. At the Weaver mine (Fig. 13) a similar section is exposed and at both localities the smooth bleached ellipsoidal boulders are very noticeable, suggesting great white eggs scattered among the rock piles. The gravels here are also slightly faulted and tilted.

At Winterville a section comprising 6 feet of gray "cemented" gravel, 20 feet of clay and sand, and 2 feet of black carbonaceous shale, is shown beneath the tuff breccias. At Parkerville gray gravels appear to be directly overlain by red gravels, and these covered by the tuff breccias.

#### ANDESITE TUFF-BRECCIAS

Rocks composed of fragments ejected during the explosive eruptions of craters occupy a large area in the Sumpter quadrangle. Andesite tuff-breccia is the prevailing formation in the drainage basin of Burnt river and underlies considerable areas north of Granite creek below the town of Granite and in the vicinity of Chicken hill. The tuff-breccias are composed of angular and subangular fragments that range in size from sand grains to boulders 6 feet in diameter. Portions of the mass are unsorted mixtures of fragments of various sizes but, in many places, beds of coarse and fine texture alternate, the latter commonly showing evidence of stratification by running water. The sandy matrix is light-gray and the fragments range from gray to black; rarely they are dull red in color. As a rule the fragments are hornblende or pyroxene andesites that range from porous to compact in density, and from glassy or crypto-crystalline to coarsely porphyritic in texture. Viewed broadly, these rocks are separable into two groups, the lower and most persistent of which is characterized by several types of pyroxene andesite, and the upper by hornblende andesite with small amounts of the pyroxene varieties. No general vertical

assortment of the various kinds of rock is shown. On the slope northeast of Burnt river below the mouth of Trout creek many alternating beds of coarse and fine material are exposed. In the lower portion of this section the larger fragments are chiefly of a vesicular black lava in which small laths and blades of feldspar are conspicuously developed. Some of the layers consist of closely packed angular fragments that average not more than 2 inches in diameter; others contain boulders as large as 3 feet in diameter; and still others consist almost wholly of fine waterlaid sand.

A section exposed by the slope north of China creek is similar to the one above described except that it is characterized by large fragments of light-gray medium-textured andesite, some of which contain hornblende crystals.

On the south end of Kings mountain, an exceptionally thick section is shown, but only hornblende porphyries are present. The lower part of the section, of which the base is not shown, is 1200 feet thick, and contains angular fragments of drab hornblende andesite porphyry in a matrix of drab tuff. Overlying this portion and probably separated from it by an erosional unconformity are 150 feet of water-worn cobbles which merge upward with 400 feet of breccia. The fragments attain a maximum dimension of 10 feet, but a rude bedding is present throughout. Near the base of the upper portion there are two sills of pale-brown porphyritic andesite.

The cliff on the north side of Granite creek opposite the mouth of Clear creek shows stratified tuff-breccias in which most of the fragments are less than 10 inches in diameter. The abundant sandy matrix is light-gray in color and the cobbles consist of both dense and porous light-gray andesites. On the slope above the cliff there are layers containing many large fragments, some of which are of a red porphyritic rock. Exposures in the basin of the North Fork of Trout creek are essentially similar to those already described but on the south slope of Chicken hill there are deposits in which both the matrix and boulders are brick-red.

In exposed situations, the tuff-breccias tend to form cliffs usually diversified with crags and pinnacles, as is well illustrated at the head of Three Cent gulch (Fig. 14), and on the south slope of Kings mountain. As a rule, however, lands underlain by this formation have smooth contours and a surface strewn with the fragments of all sizes set free by the weathering of the matrix.

In the drainage basin of Burnt river below China creek, sills, dikes

and other forms of intrusive rocks are associated with the tuff-breccias. To the north of Alkali springs and east of Beaverdam creek a dense light greenish-gray porphyritic rock occupies a considerable area. It is an irregular intrusive mass so associated with the tuff-breccias that on the map accompanying this text it has been included with them, although its age is at present in doubt. In places, particularly north of Beaverdam creek and adjacent to Alkali springs, the rock has been hydrothermally altered and locally it has disintegrated to a soft, white, clay-like mass apparently the residuum left by bleaching processes which have extracted its alkaline and iron constituents. A rock of similarly doubtful age occurs along Big creek opposite the mouth of Rattlesnake gulch. It is coarsely porphyritic in texture, is light-gray and pale pink, weathers to rounded forms like granite, and disintegrates readily to a coarse sand. Preliminary microscopic examination indicates that it is dacite. It is associated with the tuff-breccia and may be a sill in the lower part of that formation.

In that portion of the Burnt river drainage basin southeast of China creek the tuff-breccia has been intruded by numerous dikes and sills consisting mainly of dense dark-colored porphyritic rocks of basic composition. They have hardened and otherwise altered the adjacent portion of the adjacent rock with the result that it weathers to the rugged buttes characteristic of the area southeast of China creek.

Provisional estimates of the thickness of the tuff-breccias show them to range from a few hundred feet in the northwest portion of the quadrangle to about 1800 feet in the Burnt river basin.

Remnants of a hornblende andesite flow associated with the lower portion of the tuff-breccias occur along Bull Run creek east of Granite, where the rock has been quarried for building stone (Fig. 15), and on the slope south of Sumpter valley.

#### OLDER BASIC LAVA

After the rocks of the tuff-breccia group were deposited there were extensive flows of basalt and pyroxene andesite. Remnants show that these rocks were probably confined to that portion of the quadrangle lying south of Sumpter valley, and that the aggregate thickness ranged from 100 to 300 feet. In general there is no marked discordance between the attitude of these flows and the dip of the stratified portions of the underlying tuff-breccia group. Locally, rocks closely related to these flows, rest upon an erosional surface of argillite and grano-



Fig. 12. Glaciated basin at the head of Crawfish Creek, a tributary of the North Fork of John Day River. Main divide of Blue Mountains in background. Outcrops show closely spaced joints in granodiorite.

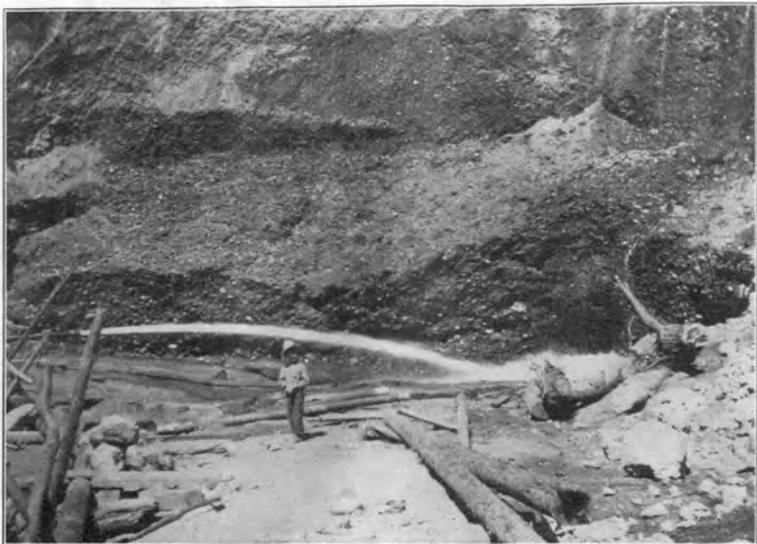


Fig. 13. Weaver Placer Mine. Bank of auriferous gravel of pre-tuff-breccia age.



Fig. 15. Face of quarry along stage road east of Granits. Shows columnar joints in hornblende andesites.

diorite, and there is reason for believing that rocks of the tuff-breccia group were locally eroded prior to the advent of these flows.

Numerous small remnants of the flows cap hills in the southeast quarter of the quadrangle and in the drainage basin of Granite creek. Typical exposures show a dark dense rock which weathers dark brown and resembles basalt to the unaided eye. Vesicular phases are known along the North Fork of Burnt river from China creek to Third creek. The structure is locally columnar and the rock tends to form cliffs, such as Sheep rock.

#### RHYOLITE SERIES

The rocks included under this heading are a group of light-colored lavas and associated tuffs approximately co-extensive with the older basic flows. These rocks appear to have formed a fairly continuous sheet 50 to 200 feet thick, and large remnants form the surface of the northeast slope of Kings mountain, part of the bench lands of Whitney, Sumpter and Burnt river valleys, and along Big creek below Rattlesnake gulch. There is evidence of local erosion of the older basic flows prior to the appearance of the rhyolite flows which also overlapped the earlier rocks on the south slope of Elkhorn ridge. Five distinct phases are present in rocks of the rhyolite series, though they are undoubtedly closely related. The lowest phase is gray, glassy and locally laminated and it is overlain by a lithoidal phase of similar color, with here and there zones of black scoria. The most persistent and typical phase is white to pale red, pumiceous and locally vesicular with here and there a phenocryst of plagioclase feldspar. This phase is succeeded by a darker flow-breccia, in which numerous dark angular scoriaceous fragments are included in a light pumiceous groundmass. The uppermost phase is gray to pale brown and tuffaceous with here and there rounded knots of dark glass.

The series contains a number of striking rock types and it is especially important in the present study, as it furnishes a means for determining the deformation of the bedded rocks of Tertiary age.

#### LAKE BEDS

Tertiary sedimentary rocks of fresh-water origin are widely distributed in the western states. They were deposited during various epochs in basins that held lakes, some of them very large. These deposits are characterized throughout by the prevalence of light colors, usually cream or buff, and by the presence of abundant volcanic sand

and dust. Locally they grade into shades of brown and may contain gravel, clay, marl, diatomaceous earth, and coal. In the southern third of Sumpter quadrangle rocks of this type underlie an area of half a township or more of the bench lands along Burnt river below China creek, and small areas of them occur near Austin, Tipton, and Whitney, as shown on the accompanying geologic map (Fig. 2). The Burnt river area extends south and east beyond the limits of the quadrangle, and aggregates several townships in extent. Because this formation yields readily to stream erosion, lands underlain by it are at first trenched by an intricate system of narrow ravines with light-colored slopes, and at more advanced stage of erosion are characterized by rounded hillocks and wide flat valleys. Both types are well shown in the Burnt river area.

The best exposure of lake beds seen in the quadrangle is along the westernmost cut on the "loop" of the Sumpter valley railroad, 1 mile south of Tipton. Here a nearly vertical face (Fig. 16) about 40 feet high consists of thin-bedded nearly white strata of diatomaceous earth and volcanic sand in alternating layers. The beds dip 8° S. and are overlain by a basic lava flow. They contain abundant fossil leaves of oaks, willows, maples, redwoods and other plants which are stated by Dr. F. H. Knowlton to be of Miocene species similar to those of the Mascall formation of central Oregon. The same species were collected from the exposures west of Austin, and a few fragments of apparently similar leaves were found north of the road down Burnt river below China creek. The latter are too poorly preserved to be identified with certainty, but their similarity to those found near Austin, together with the general lithologic resemblances in the two exposures, suggest strongly that they are of the same age.

In addition to diatomaceous earth and volcanic sand the Burnt river beds contain considerable clay-like material as well as some ordinary sand and gravel. Preliminary estimates indicate that the thickness of this formation is several hundred feet.

#### YOUNGER BASIC LAVAS

The rhyolite was closely followed by quiet eruptions of basic lavas that are indicated by preliminary microscopic examination to be chiefly basalts. These rocks are widely distributed over all but the northeast portion of the quadrangle. They almost exclusively occupy the drainage basin of the Middle Fork of John Day river and some adjacent lands. Considerable areas of them occur in the northwest

quarter of the quadrangle and many small patches are scattered elsewhere. For the most part they are dark-colored fine rocks that range in texture from dense to porous and weather to shades of gray. There are abundant porphyritic phases in which lath-shaped plagioclase feldspars are prominent, and others characterized by phenocrysts of olivine. Over considerable areas the rocks exhibit a pronounced platy structure (Fig. 17), but in others they show the ordinary columnar jointing common to basalts. As a rule, they weather to prominent forms characterized by small cliffs and bare knobs and lands underlain by them are covered with a residual red clay soil. The series appears to be made up of a great number of separate flows local in origin and extent but closely related in age. Eroded volcanic necks that appear to have been sources of some of these lavas have been identified in a hill (Fig. 19) on the divide about a mile due north of Geiser and in the summit at 6106 elevation west of Trout creek in the northwest corner of the quadrangle. For the most part the existing remnants of these flows lie directly on rhyolite, but thin beds of rhyolite pebbles and the absence of the older flows at certain localities, indicate a period of erosion prior to the deposition of the basalt.

#### STRUCTURE OF THE TERTIARY ROCKS

In contrast to the complex deformation of the argillite series, the structure of the Tertiary rocks is relatively simple, is characterized by broad folds and faults of northwest-southeast trend which are broadly reflected by the topographic features. Dips of the lava sheets and associated rocks are moderate, for the most part not exceeding  $20^{\circ}$  from the horizontal. The structure is dominated by large folds that strike northwest-southeast and appear unusually broad as compared to their length. The largest fold occupies Elkhorn ridge and the high lands to the north. To the southeastward it narrows and ends rather abruptly at the sharp bend of Powder river a few miles east of the quadrangle. In the opposite direction it swells to a broad dome that is perhaps widest on a line extending from Cable Cove to Bulger hill, beyond which it decreases in height and width. As the area occupied by this fold has been denuded of the Tertiary rocks, except on a portion of its southeast shoulder and a few places along its southwest flank, its form can be generalized only. A northeast-southwest section near Auburn, about 3 miles east of the quadrangle, shows a broad flat-topped curve with dips of 8 to  $12^{\circ}$  on both sides. A parallel section farther northwest along a line drawn through Bridge

creek shows similar slopes in the lava patches at the foot of the range north of Sumpter valley. To the northeast over the summit and down the Baker valley slope no Tertiary rocks remain, but flats on the summit are underlain by deep residual soils believed to be remnants of the Tertiary surface mantle from which the lavas have been but recently removed. The curve that begins with the dip slope of the flows at the base of the range in Sumpter valley, touches the soil-covered summit and descends along the most prominent spurs to Baker valley, is symmetrical except that its slope is slightly steeper on the Baker valley side. Still farther to the northwest evidence showing the form of the fold is less plain, but generalized profiles across the surface show curves similar in form to those described.

The divide between Sumpter valley and Burnt river is a small anticline that appears to end on the southeast at Clear creek. To the northwest of the wagon road that connects Sumpter and Whitney the anticline appears to branch into a number of small folds of northwest trend that occupy the drainage basins of Bull Run and Beaver creeks. Another parallel anticline is indistinctly shown in the divide between Whitney valley and the Middle Fork of John Day river. The axis of a large anticline rises from Clifford northwestward through the Greenhorn district and the axis of another one descends into the quadrangle from the east in the vicinity of Black mountain. The remaining areas of the quadrangle are occupied by broad basin-like troughs some of which, however, are greatly modified by faults. Sumpter and Whitney valleys are broad short synclines of northwest-southeast trend, as are also the less symmetrical basins of the Middle Fork of John Day river and of Burnt river below China creek. The aggregate result is a warped surface with broad anticlines and synclines extending in a northwest-southeast direction.

The dominant northwest-southeast trend is characteristic of the faults which show but small variations from an average strike of N. 55° W. The dip of the fault planes appears to be steep and the displacements are normal, that is, the hanging-wall has moved relatively downward. In the southeast quarter of the quadrangle faults that have been traced from a mile to six miles on which displacement of one hundred to several hundred feet have occurred, are spaced from half a mile to one mile apart and form a group, the units of which are successively dropped to the southwest. Locally, these faults can be readily traced because of the fortuitous association of contrasting formations. In the area north of Burnt river east of

China creek the displacement caused by these faults has, in the aggregate, had the effect of elevating a section that would otherwise be a broad deep basin.

#### AGE OF THE TERTIARY ROCKS

The Tertiary rocks form a series, individual members of which are separated by no great time interval. Fossil evidence of their ages is confined so far as known to the Lake Bed member and, as already noted, consists of a Miocene flora that is similar to that found in the Mascall formation of central Oregon. A tentative correlation of the Tertiary rocks of Sumpter quadrangle with those of central Oregon is suggested as follows:

Sumpter Quadrangle	Central Oregon
Younger Basic Lavas.....	(?)
Lake Beds and Rhyolite.....	Mascall
Older Basin Flows.....	Columbia Lava
Tuff-Breccias.....	John Day Series
Pre-Tuff-Breccia Gravels.....	Clarno(?)

Lithologically, this correlation involves no recognized difficulty except in the case of the Younger Basic Lavas for which no equivalent appears in the central Oregon section. It is possible, however, that these rocks are restricted in area. The manner of their occurrence in the Sumpter quadrangle suggests that for the most part they followed closely in time the deposition of the Lake Beds. Locally, however, rocks that have been included with them appear to fill recent valleys and may, therefore, be of a considerably later date.

### QUATERNARY ROCKS

#### TERRACE GRAVELS

These gravels were deposited during a period of vigorous erosion immediately preceding the glacial epoch. Similar gravels are widespread in the northwestern states and are generally believed to be of late Tertiary or early Quaternary age. Fossils of determinative value have seldom been found in them. Lindgren\* reports the occurrence of vertebrate remains of early Pliocene age in Rye valley, Oregon, in certain gravels which overlie Tertiary lake beds and appear to be similar in stratigraphic position to the terrace gravels of the Sumpter quadrangle. The latter occur extensively in beds up to 100 feet or more in thickness in Sumpter and Whitney valleys where they

\*Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: U. S. Geol. Survey, Twenty-second Ann. Rept., pt. 2, p. 583, 1901.

underlie the bench lands and form the terraces that border the stream bottoms. Thinner sheets cover Crane Flats, portions of the benches north of Burnt river below Second creek, and form small terraces along Trout creek north of North Fork of John Day river. As a rule these gravels are not coarse and although they contain some smooth cobbles they are largely made up of fragments that have been but partly rounded by stream action. They show evidences of considerable age, a large proportion of their more readily decomposed cobbles being completely decayed. In most places their color is yellowish drab, although shades of red are not uncommon. In Whitney valley the beds dip rather persistently 5° eastward. The upper terraces trend at right angles to this course and appear to be set off in part by faultscarps that repeatedly elevate the beds to the eastward. Locally these gravels contain gold in paying quantities, particularly on Crane Flats and the bars near Sumpter where they have been mined. The precise relations, however, of the bar gravels near Sumpter are in doubt, and their assignment to the terrace gravel formation is tentative. Few good sections of these gravels are known, the partial natural sections made by small ravines that trench the bench lands showing little more than the character of the cobbles.

The gravel bars on both sides of Cracker creek and McCully Fork near Sumpter are thought to be contemporaneous with the terrace gravels. The extensive placer excavation opposite Sumpter on the bar between Cracker creek and McCully Fork shows 50 feet of reddish-yellow gravel that contains a high percentage of cobbles and boulders in a red clay matrix. The lower layers are moderately indurated and although some of the cobbles are smooth, a large proportion of them are subangular. A few of the boulders are decomposed but none were seen having the bleached outer part characteristic of the pre-tuff-breccia boulders.

#### GLACIAL DRIFT

Glacial drift of Pleistocene age covers considerable areas in the north half of the quadrangle. Its distribution and character have been briefly described in the section on glaciation.

#### ALLUVIUM

Under the head of alluvium are included Pleistocene and Recent stream wash, but in the unglaciated areas, as for instance the drainage basins of Burnt river and Middle Fork of John Day river, sedi-

ments of late Tertiary age are probably included. The deposits are confined practically to the valley bottoms and consist of various kinds of gravel, sand, and silt. They form the most valuable agricultural lands of the quadrangle, and in the placer mining districts have yielded most of the placer gold produced. Gravel of Quaternary age is at present being mined near Sumpter by the Powder River Gold Dredging Company.

#### REGIONAL METAMORPHISM

The fine sediments and other rocks that accumulated in the region of Sumpter quadrangle in Carboniferous time have undergone extensive changes during the long periods that have elapsed since they were deposited. The pressure of superincumbent rocks, together with chemical changes incident to long continued burial, have transformed what were probably once clay-shales and fine-grained sandstones into argillite and chert. They have been compacted and their component particles tightly cemented by the development of minerals not present in the original rock. Severe compression incident to mountain building has further altered the argillaceous beds in part to slate and transformed many of the siliceous ones into breccias and pseudo-conglomerates. The limestones have been partially recrystallized and the old lavas, tuffs and intrusive rocks have had their original characteristics largely masked by physical and chemical changes that have altered them to greenstones. Locally these changes have been superseded by other alterations caused by intrusive rocks of later date, as described in the section on contact metamorphism. Detailed discussion of the changes induced by regional metamorphism will be deferred until the final report.

#### CONTACT METAMORPHISM

By contact metamorphism is meant the alteration produced in rock formations by igneous magmas that invade them. The alteration, greatest in the layer next to the magma, decreases outward and at most places in this area is not noticeable at distances greater than a quarter of a mile from the intrusive body. The kind of alteration varies most noticeably with differences in the kinds of rock invaded. Limestones that lie very near the granodiorite have been altered to marble or hornstones depending upon their degree of purity. Argillaceous rocks adjoining the granodiorite have been changed to schists in which mica is abundantly developed and hornblende and

other silicate minerals are common. The siliceous argillites and cherty rocks have been hardened and made to resemble fine-grained quartzites. Where the metamorphic action has been most intense, the finely laminated argillites have not only been altered to mica schists but thin layers of the magma itself have been forced in between the leaves so that the rock now resembles a gneiss. In addition to these readily noticeable features microscopic examination reveals the presence of andalusite, scapolite (?), axinite, and other minerals the relation of which will be discussed in the final report on the district. The argillitic rocks that border the Bald mountain batholith are transformed in this manner for a distance of a quarter of a mile to 2 miles from the contact. Where the metamorphosed belt is much wider than a quarter of a mile, as in the vicinities of Bourne and the La Belleview mine, the granodiorite dips beneath the argillite as is clearly shown by the topographic relations of their contact. The greater areal extent of metamorphic rocks in these localities does not necessarily mean, therefore, that the granodiorite exerted a greater influence here than elsewhere for it is certain that it lies beneath them at a relatively shallow depth. The smaller areas of granodiorite in the mountains south of Sumpter valley and elsewhere are observed to be surrounded by similar but narrower metamorphic collars wherever the argillitic rocks in contact with them are exposed. Here, however, much of the intrusive contact is concealed beneath younger eruptive rocks.

## ECONOMIC GEOLOGY

### METALLIFEROUS DEPOSITS—LODE DEPOSITS—CHARACTER AND DISTRIBUTION

The mineral wealth of the Sumpter quadrangle, though it embraces a number of different materials, lies dominantly in the metal-bearing lodes and the placers derived by their weathering and erosion. Limestone, diatomaceous earth, and stone adapted to building purposes are found at a number of places but they have potential rather than immediate value as it is doubtful whether they can for some time compete with known sources of supply in this general region. A number of minerals, such as chromite, manganese oxides and other unusual minerals are found both in the rocks and in the stream gravels, but so far as known they do not occur in sufficient quantities to warrant exploitation at present.



Fig. 19. Eroded volcanic neck near divide one mile north of Bonanza Mine. Head of Camp Creek.



Fig. 20. Fault scarp in bed-rock of old placer mine at Winterville.



Fig. 16. Exposure of Tertiary Lake Beds overlain by younger basic lava. Railroad cut on the "loop" of the Sumpter Valley Railroad one mile south of Tipton.



Fig. 17. Outcrop of platy lava. Divide between Middle forks of Burnt and John Day rivers.

The metals of greatest importance occurring in lodes are gold and silver though shipments of ore and concentrates from some of the mines have from time to time contained sufficient lead and copper to add considerably to their value. Minerals of mercury occur in a number of lodes and it is reported that at one mine small amounts of this metal were recovered on amalgamating plates in the ordinary milling operation. There are no known lodes, however, from which it could be regarded as the important metal. Zinc blende is a common lode mineral and though its proportion usually exceeds that of galena, no instance of ore or concentrate is known where it could be regarded other than as a detriment. Most of the shipments of the concentrate and many of the ores from lodes in the quadrangle contain considerable arsenopyrite, the arsenic from which, under favorable smelting conditions, could be recovered at a profit, but as usually is the case, the presence of arsenic in the ores detracts from their value.

Though in parts of the quadrangle some lodes appear to bear no definite relation to those near them, viewed broadly, there are few that do not form a portion of an extensive group or system. In fact, compared with many districts having similar geologic associations, the important shoots of ore occur along fissures having evident structural relationships. The most important lode, that near Bourne explored by the North Pole and Columbia mines, is followed nearly continuously for about two and one-half miles by underground workings, and its persistence for another mile on each end is inferred from outcrops and sporadic explorations. Another important lode system, though not clearly a single fracture, extends from the Ibex mine on Deep creek to the Belle of Baker and Mammoth mines three miles northeast. A similar system extends from the Cougar near Granite three miles northeast to the Blue Ribbon and Standard mines. Another system not so clearly aligned, extends from the Highland three miles east to the Baisley-Elkhorn. Each of these groups forms a broad arc concave toward the northwest, and several bear evidence of being zones of faulting with considerable horizontal components of displacement. The veins closely related in character or filling continuous fissures, dip consistently in one direction, generally steeply southeast, but where this relation is not so close, as shown by mineral diversity, dips opposite to the general one are common. Other groups of lodes such as those extending from Quartz gulch north of Robinsonville to the Red Boy mine and around Cable Cove are approximately

parallel in strike but show diversity in dip. The group of lodes around Geiser, of which the Bonanza has been the most important, appear to be isolated, but when it is recalled that they occur in a small area of the argillite group, completely surrounded by post-mineral lavas, it is apparent that they may form a small part of a more extensive group. In fact, any study of the distribution of the lodes particularly in its bearing upon the source of gold in the early Tertiary placers, should consider the possibility of the existence of important lodes under the lava cover.

Though some of the lode systems lie along exceptionally persistent narrow belts, several of the important ones appear to branch at one end. Thus, the North Pole-Columbia lode though sharply defined for 12,000 feet, widens to a broad crushed zone in the Golconda mine. Though complete data regarding the trend of the lodes farther southwest can not be had, it appears that those worked in the Mountain Belle, Amazon, and Bunker Hill mines form a west branch of this system, whereas those in the Mayflower and prospects farther south form an east branch. Similarly, the system of which the Cougar, Independence, Magnolia, and Buffalo veins successively are units, appears to branch, an eastern group extending to the La Belleview mine and a western group to the Grizzly mine on Onion creek.

In considering the geologic association of the lodes it will be noted that most of them occur in the argillite group, though several important mines are wholly in granodiorite. Three important systems, those to which the Cougar, Ibex and Highland respectively belong, pass from beds of folded argillite into granodiorite, without great change in general character or mineral content. So far as known only one minor vein, that explored by the higher Maxwell tunnels, follows the contact of these two rocks. A number of short veins that have yielded pockets of rich ore occur in serpentine. In those areas of serpentine that contain masses of gabbro or its altered equivalent, the fissures do not enter the gabbro, but either terminate or pass around the mass. A few minor lodes only are known within masses of gabbro.

It is a noteworthy feature of this general region that large areas of argillite not interrupted by masses of granodiorite are devoid of important lodes, and this taken with the tendency of the important lode systems to be grouped roughly around the broad contact belt of these two rocks, indicates a close relation between the masses of granodiorite and the deposits of ore. A number of the important

mines extending from the Baisley-Elkhorn on the northeast to the La Belleview on the west may be regarded as lying within a broad belt having the form of an arc concave to the north which follows roughly the contact of the argillite group and granodiorite. In the case of a number of other mines, such as those around Greenhorn, Red Boy and Bonanza, which lie beyond this belt and appear isolated, there are good reasons for believing that the granodiorite mass underlies the surface at no great distance. In the Bonanza district, the proximity of this rock is inferred from the occurrence in the argillite of scapolite, a mineral which in this general region seems to be distinctive of contact metamorphism. Certain broad relations indicate however that the portions of the lodes that contain deposits of metallic minerals of economic value may represent zones of extensive nearly vertical fractures, other and probably deeper zones of which contain a different group of minerals that may have little or no economic value. The belt that follows the contact of these two rocks, as exposed at the surface the exact location of which is largely fortuitous and depends upon details of intrusion and topography, only broadly indicates, therefore, the area within which the economically important minerals are found. This relation will be discussed further under considerations of genesis.

#### CLASSIFICATION AND DISTRIBUTION

In the Sumpter quadrangle, the deposits other than placer, containing gold, silver and related metals, may be grouped as lodes. As used in this report, this term has broad significance and embraces replaced shear and breccia zones as well as veins, which in a restricted sense may be regarded as the fillings of fissures. In this report it seems advisable to use the term vein more broadly, applying it to that portion of the lode which is ordinarily mixed. Chromite forms small irregular masses in serpentine and is found in the detrital material of placers, but will not be considered further in this report. Minerals of manganese occur with several associations but will only be considered under the caption "Mineralogy."

In his discussion of the veins of the Blue mountains, Lindgren recognized five types, four of which he found in the Sumpter quadrangle\*. These may be briefly stated as follows:

a. True veins or filled fissures, not recognized in the Sumpter quadrangle.

\*Loc. cit. pp. 601-602.

b. Replaced shear zones of which the lodes of Cable Cove may be regarded as typical.

c. Normal replacement veins, of which the Cougar vein is typical.

d. Pocket veins, noted in the Greenhorn district.

e. Argillite breccia zones, to which most of the veins of the Cracker creek, Granite and Bonanza districts are assigned.

In the present report, the following classification is suggested.

1. Breccia zones in argillite; silicification meagre. The Cougar vein is typical of this group, but it is also approached by parts of the Highland vein.

2. Breccia zones in argillite, silicification dominant. The North Pole-Columbia lode is the type, but it is found throughout the Cracker creek, Granite and Bonanza districts as well as in the lower Maxwell vein. This corresponds to Lindgren's argillite breccia zones.

3. Breccia zones in granodiorite, observed only in the upper Maxwell vein.

4. Shear-zones in granodiorite, with replacement by quartz and accompanying sericitization. This is the same as Lindgren's "replaced shear zones" and is shown in the mines of Cable Cove, the Monumental and Baisley-Elkhorn mines.

5. Shear-zones in gabbro accompanied by silicification and chloritization, shown in the Listen Lake and Gold Bullion mines.

6. Filled fissures, with meagre alteration of wall-rocks. The veins of dolomite in serpentine near Greenhorn, well shown in the Golden Eagle mine, are typical.

It will be noted that this classification is based largely on structure though genesis is indicated. It is thought there is a close genetic relationship between all these types of veins, the form actually assumed depending upon the physical as well as chemical character of the enclosing rock. Thus, there are a number of lodes that show from place to place two or more of the types outlined, and only a few can be regarded as resembling a single type throughout. In the following discussion of these types, the megascopic relations such as are determinable with hand lens only will be considered. Those detailed relations which are alone revealed by microscopic study will be treated in the final report.

1. Breccia zones in argillite; silicification meagre. The Cougar vein which is the type, fills a fissure with definite walls, and is composed of finely crushed dark argillite, alternate zones or lenses of which show considerable bleaching and meagre silicification. Both replacement of the argillite fragments and cementation of the breccia by quartz occur to a meagre extent. The examination of a number of faces of the vein gives the impression that crushing and attrition of the vein matter by post-mineral movement emphasizes the degree of alteration. Pyrite occurs both in the bleached and dark argillite but it is probable that gold is associated principally with the former. The main shoot of the Highland vein shows similar filling with more silicification but the "Big Silver" shoot possesses the characters shown by the second or North Pole-Columbia type. It also locally contains considerable galena and arsenopyrite. So far as known, veins of this type do not contain the shoots of rich ore showing free gold, roscoelite and tellurides of gold and silver. The ores though amenable to concentration do not yield much gold by amalgamation.

2. Breccia zones in argillite, silicification dominant. These zones are commonly to be regarded as lodes because they attain considerable widths between the limiting walls and though locally the entire width may be mined, it seldom pays to extract more than a half. The lodes show shoots of more or less silicified argillite breccia, which, according to the amount of sulphide minerals present, may or may not pay to mine. The remainder of the lode is sheared or crushed argillite only locally altered. So far as known, in only one mine, the south end of the Eureka and Excelsior, have two parallel shoots separated by a barren zone warranted mining. The argillite fragments are angular and range from one-half to 6 inches in diameter and in places the impression is gained that the size of the largest completely silicified fragments increases with the width of the zone. Microscopic examination shows that though the process of silicification has in some places proceeded from a network of minute cracks in the argillite fragment, gradually recrystallizing the entire quartz content, there are areas showing evidence of recrystallization around centers not connected by cracks. Only rarely are fragments more than three inches in diameter completely silicified. Though commonly silicified, the argillite fragments also from place to place contain disseminated fine crystals of pyrite and arsenopyrite and small patches of mica, both sericite and fuchsite. In the Belle of Baker mine roscoelite has developed by the alteration of small frag-

ments of the argillite. Where pyrite alone is present, the material may or may not be regarded as ore, but if arsenopyrite is present, it is always, so far as known, so regarded. The argillite fragments are enveloped in a matrix of quartz which typically possesses comb structure, and coarse crystals of pyrite and arsenopyrite either interfere with the crystals of quartz or form concentric bands. In some of the richest ore from the Eureka and Excelsior and North Pole mines, this concentric alteration of zones of quartz with pyrite and arsenopyrite is conspicuous. Some ore of ordinary grade from the Columbia mine shows unaltered fragments of argillite enveloped in alternate zones of quartz and roscoelite with minute crystals of pyrite. Another variety of rich ore from the Eureka and Excelsior and North Pole mines shows roughly angular nuclei of fine crystals of pyrite and arsenopyrite in a matrix of minute quartz grains enveloped by a radial growth of quartz crystals. The relations suggest the relatively complete replacement of angular argillite fragments by pyrite, arsenopyrite and quartz.

In a number of mines, such silicified breccias are crushed and cemented by comb quartz and pyrite and one exposure in the Eureka and Excelsior mine shows three stages of deposition of quartz. Material of this character is usually richer in gold than the average. Tetrahedrite has never been found in the altered argillite nuclei, but occurs with one of the later zones of comb quartz. In the Buffalo, No. 1, Mayflower, and Ibex veins, crystals of tetrahedrite are contemporaneous with the comb quartz. In the Mayflower mine basal sections of some crystals of quartz that line a vug containing crystals of tetrahedrite, contain minute grains of tetrahedrite zonally arranged about the axes of the crystals. The relations indicate essentially contemporaneous origin of comb quartz and tetrahedrite. Roscoelite, a vanadium mica, forms little tufts in both quartz and tetrahedrite. Zinc blende was not observed in the nuclei. The relations of galena and chalcopyrite will be discussed in the final report. Fuchsite, a chromium mica, is common in lodes of this type. In the Bonanza, North Pole, Columbia and Maxwell mines, it is characteristically an ingredient of the highly altered argillite fragments enveloped by quartz; in the Golconda and Climax mines it is apparently the source of the bright green color of gouges formed by the attrition and alteration of the argillite; and in the Bonanza mine and prospects on Beaverdam creek it forms scales scattered through relatively unaltered argillite of the walls. In general the fuchsite appears to

have been formed by the addition of chromic oxide to the aluminous portion of the argillite. Calcite and dolomite are not important vein minerals and though they locally form a cement of argillite breccia, are more commonly found in quartz lined vugs.

Lodes of this character contain the shoots of extraordinarily rich gold that have made the mines of eastern Oregon famous. In such shoots, native gold of fineness ranging from 500 (Red Boy mine) to 800 forms ragged wires in close proximity or even contact with roscoelite and tellurides of gold and silver. In the course of the present investigation, a few specimens only of ore of this character were seen in mineral collections and it was observed in one stope in the Belle of Baker mine. All that can be said of this occurrence is that the roscoelite and gold were contemporaneous in origin. Some specimens of rich gold ore from the North Pole and Columbia mines show no roscoelite and the textural relations as well as greater purity of the gold suggest that it may be secondary and produced by downward enrichment, an explanation consistent with its distribution in the mines. One specimen from the North Pole mine shows ragged gold wires of high purity attached to hessite in a matrix of quartz, and vugs of quartz nearby are filled with calcite.

3. Breccia zones in granodiorite and other igneous rocks. The vein explored in the upper Maxwell tunnels occurs in part in granodiorite and in part along its contact with argillite, but possesses the structure characteristic of many veins in argillite. Angular fragments of granodiorite are altered to a mass of quartz, green mica and pyrite and are enveloped by radially disposed crystals of quartz with here and there a cubic crystal of pyrite. Vugs contain flat rhombohedra of calcite. Though the Belcher vein is locally a silicified shear zone in dense pale green andesite, the important shoot is an altered breccia of this rock cemented by dolomite with crystals of marcasite.

4. Shear zones in granodiorite. This type is well illustrated by a number of veins in the main granodiorite mass, from the Monumental and numerous small veins along Granite creek on the west, through Cable Cove to the Baisley-Elkhorn on the east. Not uncommonly there are two or more parallel veins in a narrow belt as in the case of the Monumental mine where in 600 feet six parallel veins have been explored, and three have been the source of ore. In no case is there any way of measuring the displacement along a given fissure though their known extent and sinuous courses indicate that none

are probably faults of the magnitude of some of the important lodes in argillite. The walls are fairly defined and the vein-filling comprises a series of overlapping lenses of altered granodiorite, gouge formed by attrition and alteration of granodiorite, and quartz with sulphide minerals which constitute the ore. Both the wall-rock and lenses included within the walls show the common sericitic alteration of granodiorite with minor carbonation. Even the highly quartzose lenses show patches of sericite, all that remains of the aluminous portion of the granodiorite. Compared with most of the veins in argillite, these veins contain a considerable proportion of the sulphide minerals, pyrite, arsenopyrite, blende, galena, chalcopyrite and pyrrhotite, the ratio of concentration in milling ranging from 3 to 1 in some of the Cable Cove veins to 7 or 10 to 1 in the Monumental and Baisley-Elkhorn mines. The ratio of silver to gold in these veins varies greatly, ranging from 1.7 to 1 in the Baisley-Elkhorn mine to 9 to 1 in the Imperial mine in Cable Cove.

5. Shear zones in gabbro. The character of these veins is known only from superficial relations and observations on material on dumps at two mines, the Listen Lake and Gold Bullion at the head of McNamee gulch. At the former, the shear zone is silicified and contains a small proportion of pyrite and chalcopyrite, whereas at the latter, chloritization is characteristic and pyrite and chalcopyrite form relatively pure masses. These minerals appear to replace the sheared gabbro without development of sericite.

6. Filled fissures. The most important of this type are the narrow dolomite and quartz veins in serpentine worked in the Golden Eagle mine. The dolomite may locally replace the serpentine but it is dominantly a fissure filling. A dolomitic lens in serpentine which was the source of ore in the Don Juan mine and the quartz vein worked in the Phoenix mine nearby are closely related to this type. Chalcopyrite containing gold was the principal sulphide mineral in both of these mines. The dolomite veins of the Golden Eagle mine contain small replacement veinlets of galena as well as gold.

With the local decrease in the proportion of argillite fragments, some of the small veins in argillite approach this type. The Buffalo No. 1 and No. 2 veins and several veins worked in the Buckeye tunnels are locally simple quartz-filled fissures. Both contain a small proportion of tetrahedrite but galena is present in the former and native gold is an important constituent here and there in the latter.

In reviewing the various structural types of veins in the argillite

group, a varying susceptibility to replacement by quartz of the different kinds of argillite is noted. The dense siliceous varieties tend to break into coarse angular fragments and to be more susceptible to replacement than the more argillaceous and carbonaceous varieties. These appear to be less brittle and therefore tend to form smaller, flat fragments or on crushing to yield clay-like gouges, which range in color from lustrous black to gray or white. Apparently, however, the amount of carbon in an argillite needed to make a lustrous black gouge resembling graphite, is small. As the various kinds of argillite do not form thick homogeneous beds, but are intermingled and the veins fill fault fissures along some of which there has been considerable displacement, the source of the argillite or gouge of the vein at any point can not be determined. In the preparation of this report it has not been possible to examine the gouges to determine the kinds of alteration they have undergone, but this will be undertaken in the preparation of the final report. As the argillite group is broadly separable into four units, based upon the predominance of argillaceous, siliceous and carbonaceous ingredients, it can be realized that the characteristics of any lode cutting the several rock units varies from place to place.

#### ORE SHOOTS

Shoots are those portions of lodes or other ore deposits that contain sufficient valuable minerals to warrant mining. Over a given period, however, the parts of a vein that have been stoped are often regarded as coinciding with the shoot, even though the balance between the gross expenditure and return in mining operations does not show a profit. This is equivalent to saying that the stopes represent the known distribution of material having an average value above that which it is commonly expected should yield a profit. Obviously, unless accurately kept assay charts showing the distribution of the valuable minerals or metals proves the opposite, it is probable that in most mines, the stopes include numerous areas that have yielded material of less than average value but which it was necessary to extract in order to search for those portions that yielded more than the average. The stope map of a mine which has been closed through failure to earn a profit is apt to include, particularly around the borders and especially in the lower levels, areas that probably yielded material of lower grade than the average.

In considering the form and extent of shoots in the Sumpter quad-

range attention should be first called to the extent of exploration on the veins. The region is one in which the relief of the surface ranges from 500 to 2,000 feet, and is one, therefore, adapted to mining by tunnels. Most of the discoveries have been made well up on the slopes of ridges or prominent spurs and mining has proceeded as far as encouraging conditions have been found. In an exceptionally small number of instances extensive work has been undertaken below the level of the adjacent gulches. Among these may be mentioned the Eureka and Excelsior, Columbia, Bonanza and Red Boy mines, the shafts of the first three of which attain depths about 700 feet below the nearest gulch line. These statements emphasize the fact that the available information concerning the shoots is derived from a shallow zone which rarely exceeds a vertical depth from the outcrop of 750 feet, and in the case of a number of mines with records of important productions, is less than 500 feet deep.

In comparing the available data of the extent of stopes in these mines with those from several important and generally similar districts, as those extending along the west flank of the Sierras in California, several features are impressive. In the Sumpter region, many important stopes are much longer parallel to the surface, than in pitch length and most are highly irregular in detail. The stopes of only a few mines have the shape of well-defined channels with definite trend. The shoots of the Columbia and the lower levels of the Bonanza may be noted as instances. The stopes of several mines, notably the Red Boy and Baisley-Elkhorn, appearing to have definite trend in the upper levels, have terminated below along a roughly horizontal line. Among the mines having extensive stopes of irregular shape, may be mentioned the North Pole, Eureka and Excelsior and Highland mines.

Tabulating the best available data from 24 veins that have been extensively explored, there is record of a total of 39 shoots that range in stope length from 40 feet to a maximum of 1,100 feet for the main shoot in the Highland vein. The greatest number of shoots on a given vein, considering only those whose continuity is established, is 4. This is the case with the Highland vein which in an explored distance of 3,000 feet, has four shoots aggregating 1,730 feet. This tabulation excludes, however, the North Pole-Columbia lode, which in an explored distance of 14,000 feet contains 4 highly important, though in part poorly defined, shoots in the Golconda, Columbia, Eureka and Excelsior, and North Pole mines. A number of veins that have

received meagre exploration are omitted from this tabulation. The widths of the stopes in the veins of the region range from a maximum of 30 feet in the North Pole and Golconda mines to 15 or 18 inches which in the Highland main shoot is the average width over considerable areas. The stopes of many mines in the quadrangle average in width between 3 and 5 feet.

The preceding statement relates to shoots that have yielded material equal to or above the grade locally regarded as minable in large quantities with profit. Many of the veins have yielded from place to place, high grade ore containing native gold. On account of the present condition of the mines, little exact information concerning the distribution and associations of this ore can now be obtained. Such ore has been found both in the zone of oxidation and probably as much as 400 feet below any evidence of oxidation. Below the zone of oxidation the free gold is commonly associated with roscoelite, and there is good reason for believing that the two are primary minerals in the ore. The shoots of such ore commonly have roughly lenticular shape with the larger axis pitching steeply with the vein. They lie within larger shoots of lower grade material. In several specimens from the zone of oxidation and immediately below it, textural evidence indicates that the gold is younger than the other vein minerals and probably has been formed by later enrichment.

Summarizing the relations of the ore shoots of the quadrangle, a few tentative conclusions may be stated. Several important stopes are so disposed with relation to the surface that the influence of downward enrichment on the vein is suggested. This appears to be the case with the upper part of the Bonanza vein, with part of the North Pole vein and several smaller veins. Though other important veins show defined shoots, most of the shoots are irregular and viewed broadly, are relatively isolated in areas of material too low grade to warrant mining. Though work on many veins has ceased with the exhaustion of a shoot, there is no reason for stating that others do not occur in the vein, either deeper or along the horizontal extension. The possibilities of a vein cannot be regarded as exhausted as long as blocks 300 feet or more in greatest dimension remain unexplored.

#### MINERALOGY OF THE LODES

No attempt will be made at this time to present the distinctive features of the lode minerals nor those detailed relations that serve

to indicate their paragenesis. They are tentatively grouped according to genesis as shown by field evidence.

1. Primary minerals in the lodes.

Native gold  
Pyrite  
Marcasite  
Pyrrhotite  
Galena  
Zinc blende  
Stibnite  
Argentite (?)  
Chalcopyrite  
Arsenopyrite  
Tetrahedrite  
Freibergite  
Schwartzite (mercurial tetrahedrite)  
Pyrargyrite  
Hessite  
Quartz  
Chalcedony  
Magnetite  
Chromite  
Hematite\*  
Ilmenite\*  
Calcite  
Dolomite  
Siderite  
Fuchsite (chromium mica)  
Roscoelite (vanadium mica)

2. Minerals of the oxidized zone.

Limonite, hydrous oxide of iron  
Wad, hydrous oxide of manganese  
Manganiferous chalcedony  
Malachite, basic carbonate of copper  
Calcite

3. Minerals probably formed by downward enrichment.

Native gold  
Native silver

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\*Recorded by Lindgren.

Native copper  
Mercury  
Marcasite  
Cinnabar  
Chalcocite (?)\*  
Pyrargyrite  
Proustite

#### OXIDATION AND ENRICHMENT

Aside from an enrichment of a vein or other metalliferous deposit that may be produced by successive circulations of deep-seated origin, two types of enrichment are commonly recognized. That which was recognized earliest occurs in the zone of oxidation and two phases are distinguishable. A metal-bearing ore may be relatively enriched in one ingredient in the zone of oxidation by the removal in part or completely of other ingredients. Thus the amount of gold in a vein containing considerable sulphide minerals such as pyrite and arsenopyrite may be greatly increased by the oxidation and solution of these minerals. Also certain features may favor definite channels or zones of circulation along which great masses of oxidized minerals accumulate. This phase of concentration has been observed in many copper deposits where masses of the copper carbonates, azurite and malachite, have accumulated, but is not important in gold deposits. A more important type of enrichment began to receive considerable attention about twenty years ago and during the last ten years has been definitely established as a very important factor in many gold, silver and copper deposits. This has become known as secondary sulphide enrichment and more recently as downward sulphide enrichment. The characteristic feature of the process is that metals are dissolved in the zone of oxidation under favorable conditions and deposited at a lower zone in the vein, commonly at or immediately below the limits of the zone of oxidation which tends to follow closely the permanent water level of the region. The criteria by which the operation of this process has been recognized have been grouped by Ransome as geologic, chemical, mineralogic, and textural.

As the result of numerous observations and studies of deposits of gold, it has been recognized that though gold is relatively insoluble, certain substances, such as manganese oxide, aid in its superficial

\*Recorded by Lindgren.

solution. Textural evidence is often available showing the paragenesis of the gold and associated minerals, and where it has been established that the gold fills cracks or follows fractures later than the dominant vein structure, this type of enrichment must be considered as a possible exploration. Mineralogic data in the case of gold are at present not available. Geologic criteria, such as a relation of the important shoots to the surface are often very significant. In the case of silver a great deal is known of the minerals that are characteristically associated with this process, and textural as well as geologic data are commonly important.

In the Sumpter quadrangle the zone of oxidation is relatively shallow. Though its lower limits have been determined to extend locally to points as much as 450 feet below the outcrop, it seldom exceeds 200 feet. In the Belcher tunnel oxidation of the sulphide minerals is complete to a point 350 feet below the surface, and in the North Pole No. 3 tunnel, traces of oxidation were noted at a point 450 feet below the surface. These cases are extreme and are found only where the relief of the surface is great. Where the relief is less accentuated, oxidation is rarely complete 100 feet below the surface.

In considering the extent of the zone of oxidation as bearing on the possible enrichment of gold-bearing veins, it is well to call attention to the fact that the black hydrous oxides of manganese persist to considerably greater depths than the more common brown hydrous oxide of iron or limonite, and that so far as our knowledge indicates at present, solution of gold may take place where acid solutions bearing alkaline chloride come into contact with oxide or hydrous oxide of manganese and gold. In other words, the lower limit of oxide of manganese and not oxide of iron determines the depth to which solution of gold may take place. Obviously, deposition of the gold may take place near the point of solution or at more remote places.

Many of the valleys heading against Elkhorn ridge and Bald mountain have been severely glaciated. In the glaciated portions of these valleys the zone of oxidation is very shallow or practically absent as in that portion of the Highland vein that lies immediately under the gulch. Where evidence of the character of minerals of the zone of oxidation is destroyed by glaciation, those oxidized minerals which form films on recent mine workings are regarded as indicative of the character of those present in the zone of oxidation. Thus in several mines, such as the Highland, where the glaciers have

scoured away the zone of oxidation, or the Ajax or Eureka and Excelsior where the zone of oxidation is wholly inaccessible, the presence of manganese oxides suggests that it was a constituent of the oxidized zone.

In the present investigation there is considerable geologic evidence available, such as the extent of stopes and their relation to the zone of oxidation. There is some textural evidence in the case of both gold and silver though it has not been exhaustively studied at present. Mineralogic evidence relating to silver is available from several mines.

Summarizing the evidence of enrichment of the gold content of the veins of the quadrangle, several tentative conclusions may be stated. The form of the stopes of several of the important mines, such as the Bonanza, seem almost inexplicable under any conception than that downward enrichment of the vein has taken place. The form of the stopes of several others, such as the Red Boy and North Pole mines, though not clearly suggesting this explanation, is not inconsistent with it. In both these mines, as well as several smaller ones, the important stopes have terminated along a roughly horizontal line. Textural evidence is available in specimens of gold ore from the Golden Eagle, Columbia and North Pole mines, and indicates that the gold is younger than the vein structure. There seems to be good reason for thinking that the process of downward enrichment has affected a number of the gold-bearing veins of the region, though the extent to which this has taken place is not always clear. In some cases, such as the Golden Eagle mine in the Greenhorn district, enrichment probably accounts for the extraordinarily high grade of the ore. Enrichment caused by the removal of sulphide minerals, thereby relatively increasing the content of gold, has probably been a small factor in the region, and would only be possible in a few mines such as Baisley-Elkhorn, Maxwell, and the mines of Cobb Cove.

In the case of several silver veins, though geologic evidence is poor, textural and mineralogic evidence is locally good. The rich silver ore of the La Bellview, Monumental in part, Independence, and Ibex mines, specimens from all of which show a tendency for the minerals pyrrargyrite and proustite and native silver to occur along secondary cracks, is undoubtedly to be explained by the process of downward enrichment. Other textural relations from these mines have not been studied in detail. The occurrence of cinnabar along

cracks in ore from the Ibex mine, a mineral which is reported from several other mines such as the Red Boy and North Pole, is indicative of downward enrichment, as there is little doubt of the correctness of Lindgren's observation that it is formed by decomposition of the mercurial tetrahedrite, schwartzite, which has been definitely identified from several mines.

#### AGE AND GENESIS OF THE LODGE DEPOSITS

The broad areal relation of the economically important lodes and veins to the belt roughly following the contact of the argillite group and granodiorite has been indicated. It is not at present possible to state more than approximately the period during which the intrusions of granodiorite took place. Evidence of the Mesozoic age of some of the sediments involved in folds and other structures that antedate the intrusion has been gathered in the Sumpter quadrangle in the course of the present investigation and is available from the earlier work by Lindgren in nearby regions. The evidence of the age of the beds next younger than the granodiorite, the channel gravels which contain gold and underlie the oldest Tertiary beds, is not satisfactory, though further study of field data and fossils may lead to a definite conclusion. One feature is apparent, however; that after the intrusion of the granodiorite, sufficient erosion had taken place to expose that rock and the surface was one of low relief when volcanic outbursts yielded the extensive tuff-breccia group. If the correlation of this group of rocks with the John Day formation of central Oregon, which is regarded as of Oligocene age, is correct, Eocene and a part of Cretaceous time must have been necessary to so thoroughly reduce the region by erosion. The time of intrusion of the granodiorite is tentatively referred to the Cretaceous, and there is at least a chance that it was early in this period.

The evidence of genesis of the lodes may be briefly summarized. The lodes tend to follow extensive systems of fractures, which were in several important cases, faults of considerable displacement. The relation of these faults to the surface of contact of argillite and granodiorite shows that this surface was not one of perceptible weakness but was essentially cohesive and also that the granodiorite was rigid. Beginning with those in granodiorite at the head of Rock creek on the north, the veins of a large area fall into three arc-shaped belts, the first of which contains those characterized by magnetite of contemporaneous origin with quartz and a small proportion

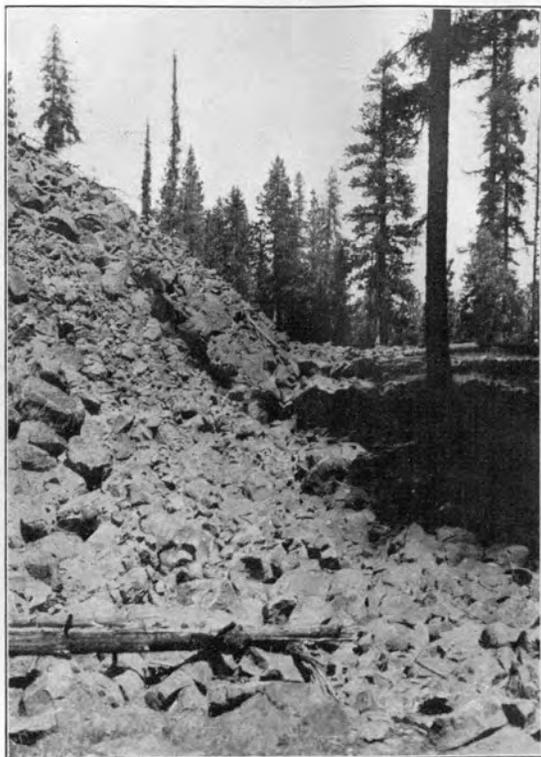


Fig. 18. Heavy talus of younger basic lava, south slope of divide between Whitney Valley and Middle Fork of John Day River. Shows slumping due to the fact that lava is underlain by Tertiary Lake Beds.



Fig. 21. Glaciated basin at the head of Pine Creek. Detached angular masses of limestone imbedded in rocks of the argillite series. Outcrops show complex systems of joints and fractures.

of pyrite and chalcopyrite. The veins of the next belt south contain a high proportion of the sulphide minerals, arsenopyrite and pyrite with minor blende, galena, chalcopyrite and pyrrhotite, and finally the outer belt contains veins with meagre proportions of sulphide minerals, among which tetrahedrite is important. These mineralogic features of the veins suggest, in the light of the genetic relations of the minerals, that the horizontal variations in the mineralogic make-up of the veins implies also a similar vertical variation in the group prior to erosion to the present level. Thus, the belts which cross the areal contact of the granodiorite and argillite suggest that the minerals of the veins in the argillite, as well as in the granodiorite were derived from solutions emanating from the deeper portions of the granodiorite mass.

To what extent the uplift of the region over the granodiorite core accompanied or possibly succeeded the intrusion is not yet determined, and it may have extended over a considerable period of time.

During late Cretaceous and early Tertiary time, erosion was dominant and reduced the region to one of low relief, setting free the gold to form placers along the streams, though probably a part of the gold was dissolved and with the erosion of the outcrop, descended to successively lower zones in the veins. The relation of the important lodes to the surface established at the time of the outburst of the Tertiary volcanoes is yet to be determined as is also the probable amount of erosion accomplished during Tertiary time. Except for the removal of parts of the outcrop by glaciers and the meager erosion since that period, the veins are probably much as they were at the end of Tertiary time.

Glacial and post-glacial erosion have had profound effects upon the distribution and character of the gold-bearing gravels, though probably little new material has been added.

## PLACER DEPOSITS

### DISTRIBUTION

Placer gravels have a much more general distribution in the quadrangle than lodes. Some of them, for instance those of Miners creek, Buck gulch, and Upper Bull Run creek, are well removed from known areas of lode mineralization, but in general the placer deposits form a fringe a few miles in width surrounding the areas containing lode mines. This relation is well illustrated by the placers

along Olive creek and the tributaries near the head of the North Fork of Burnt river, which drain the Greenhorn district; of Bennett creek which drains the Bonanza district; and of Granite creek in whose basin the Monumental, Buffalo, and other mines are situated. The deposits of Miners creek and other localities that are now far removed from areas of bedrock mineralization, are for the most part reworked gravels of an older erosion period whose gold has been shifted several times.

The absence of rich placers in the upper basin of Cracker creek is remarkable in view of the fact that the most extensive lode deposits in the quadrangle are located there. This condition may be explained in part at least by glaciation which is believed to have destroyed the placer gravels, as described in a former report from which the following extract is quoted.\*

“The low-terrace and gulch gravels may be classed according to richness into three minor groups, which are given below with the streams in which each is found:

1. Comparatively rich gravels, in Buck Gulch, Bull Run, Granite Creek, Crane Creek, Olive Creek, and Umpqua Gulch. So far as evidence can be obtained the gravels of these streams have produced the greater part of the gold credited to the area under consideration.

2. Comparatively lean gravels, in Cracker Creek, from Bourne to Sumpter, and McCully Fork, from Sumpter upstream 3 or 4 miles.

3. Practically barren gravels, in Fruit Creek, Silver Creek, Rock Creek, upper course of North Powder River, upper course of North John Day River, Cracker Creek above Bourne, and upper course of McCully Fork, excepting Umpqua Gulch.

The leanness of the last two groups is apparently not due to the poverty of the bed rock eroded, but is to be explained mainly as a result of glaciation, which has affected all these valleys more or less but has been entirely absent from those containing the rich gravels.

The glacial history of this region is briefly as follows :

- (a) An earlier glacial epoch in which ice extended down Cracker Creek to a point within 2 or 3 miles of Sumpter and down McCully Fork somewhat below the Granite stage road crossing. All the valleys of the third or barren group were more extensively glaciated. The effect of this invasion upon the gravels, rich and poor, was to mix them, dilute with other debris, and shift the whole mass down-stream.

- (b) An epoch in which the ice disappeared and the streams to a great extent reconcentrated the jumbled mass left by the glacier. The lean gravels of Cracker Creek are a product of this epoch, as are in great part the low-terrace gravels of McCully Fork.

- (c) A reinvasion of the ice that affected Cracker Creek as far down as Bourne and McCully Fork, within 2 or 3 miles of the glacier's former extension, and again glaciated the valleys of the third group. The effect of this invasion was, within its restricted area, similar to that of the earlier one. The more or less re-sorted stream gravels were again removed and left as unsorted worthless morainal material.

- (d) Disappearance of this later ice and resumption of stream erosion

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\* Pardee, J. T., Placer gravels of the Sumpter and Granite Districts, eastern Oregon: U. S. Geol. Survey Bull. 430, pt. 1, pp. 63-64, 1909.

and reconcentration, continuing to the present time. This is the Recent period of geologic history, which has been relatively so brief that the streams have had time to accomplish little in the way of reconcentrating the moraines and practically no erosion of the bed rock.

The relations of the placer gravels of this area to its glacial history thus impressively bring out the vast length of time required for the concentration of gold by the sluicing action of streams."

#### CLASSIFICATION AND DESCRIPTION

The term placer has been extended to include many kinds of deposits, but in general it means a gravel from which some valuable mineral, commonly gold, may be profitably extracted by simple washing. Placer gravels may be grouped according to their origin, geographic distribution, or textural or lithologic characters, but perhaps the most useful classification of those of Sumpter quadrangle is one based upon age.

Lindgren\* has classified the gravels of Sumpter quadrangle and surrounding areas according to age as:

1. Pre-volcanic gravels of which those of Winterville and Parkerville are examples.
2. Inter-volcanic gravels of which the deposit at Sumpter is given as an example, and,
3. Pleistocene gravels to which the deposits in present stream channels belong.

The more detailed examinations recently made show that gravels of the Winterville age locally lie upon eroded surfaces of old lava. The term pre-tuff-breccia gravels is suggested as being more definite than pre-volcanic. There is reason to think that the deposits of pre-tuff-breccia age include, in addition to those of Winterville and Parkerville, those at French Diggings, Griffith Diggings, Weaver mine, the head of Three Cent gulch, and probably at the Barton mine on Miners creek

As the evidence recently gathered makes it appear that the gravels of Crane Flats and benches near Sumpter were deposited for the most part after the volcanic extravasations had ceased, the term terrace gravels, the age significance of which in the quadrangle is definitely post folding of the lavas, is suggested as a substitute for inter-volcanic. Available evidence indicates that these gravels probably accumulated in early Quaternary, but may also in part date from Pleistocene time.

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\* Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, pp. 635-636, 1901.

For the stream and valley gravels which comprise the deposits that have yielded most of the placer gold produced by Sumpter gravel, Pleistocene and Recent are appropriate.

For descriptions of the pre-tuff-breccia gravels and terrace gravels, the reader is referred to paragraphs under these heads, and for a description of the Pleistocene and Recent gravels to the section under the head of alluvium.

## NON-METALLIFEROUS DEPOSITS

### LIMESTONE

Limestone is fairly abundant in the Sumpter quadrangle, its principal exposure being confined to the area of Elkhorn ridge (Fig. 21). No analyses of these limestones are available, but from superficial examinations it appears that many of them are free from chert or other plainly noticeable impurities and are essentially composed of pure calcium carbonate. Lime has been burned a mile and a half southeast of Sumpter at a small quarry, which has also supplied limestone for flux to the Sumpter smelter. A kiln situated on Marble creek about 1 mile west of the quadrangle's eastern limit has made a small production of lime for domestic purposes. The more extensive limestone outcrops of Marble Point and vicinity have not been developed, but they can readily be made accessible and may be counted as one of the potential resources of the quadrangle.

### IRON ORE

Massive iron oxide occurs in the pass in the divide south of Sumpter traversed by the Sumpter valley railroad on a claim known as the Lazy Jim. During the period from 1904 to 1905, about 100 tons of ore from the Lazy Jim claim were used by the Sumpter smelter for flux. The mine workings consist of open pits that were caved at the time of the recent examination, but their distribution and size indicate that the ledge trends about north-south and is not very extensive. It occurs in altered peridotite and gabbro near an outcrop of limestone, each of these rocks being cut by granodiorite. Specimens from the dumps consist of brown and red iron oxides that show a peculiar fibrous structure suggesting that the iron minerals may be pseudomorphous after amphibole or a related silicate. The geologic associations of the deposit suggest that it is of contact metamorphic origin. Smelter analyses show the ore to have contained from 10 to 15 per cent of silica, from 40 to 48 per cent of iron and

from 0.04 to 0.12 ounces of gold and 0.18 to 0.38 ounces of silver to the ton.

#### DIATOMACEOUS EARTH

Diatomaceous earth, called also infusorial earth and kieselguhr, is a light earthy material that often resembles chalk or clay in its physical properties, but can be distinguished at once from chalk as it does not effervesce when treated with acids. It is generally white or gray in color and is made up of the siliceous tests of minute aquatic plants. Diatomaceous earth, either pure, or mixed with other materials, forms a large percentage of the volume of the Lake Beds of Sumpter quadrangle. White, loosely coherent beds of the pure material are exposed by a cut on a logging railroad at a point 3 miles northwest of Whitney and half a mile north of Irvine's ranch on Burnt river. Here a thickness of 10 feet or more is exposed for a short distance but the lower limit of the formation is not exposed. The westernmost cut on the "loop" of the Sumpter valley railroad south of Tipton shows a face 40 feet high of soft light-colored strata, portions of which are composed almost wholly of diatoms. Similar pure material occurs a short distance west of Austin and along the wagon road south of the Blue mountain ranger station on the Middle Fork of John Day river. At the latter locality, however, the diatomaceous earth is concealed by superficial deposits and is exposed only as fragments on the dumps of badger holes and by a small shaft near the road. In the lake beds of the Burnt river valley no strata of pure diatomaceous earth were seen, but it is highly probable that they occur in that locality also.

Owing to its porosity, diatomaceous earth has great absorptive powers and high insulating efficiency. The hardness, the minute size, and the shape of its grains (Fig. 22) make it an excellent metal-polishing agent. Until recently diatomaceous earth has been largely used as an abrasive in the form of polishing powders and scouring soaps, but now its uses have been considerably extended. Because of its porous nature it is a nonconductor of heat, and this quality in connection with its lightness has extended its use as an insulating packing material for safes, steam pipes, and boilers, and as a fire-proof building material. In 1913\* 6,586 tons of diatomaceous earth, valued at \$69,240, were produced in the United States. Of this amount by far the greatest percentage came from California.

\* Mineral Resources of the United States for 1913, pt. 2, p. 268.

### VOLCANIC ASH

Volcanic sand and dust, commonly known as volcanic ash, consists of more or less finely comminuted fragments of glass produced during explosive volcanic eruptions. In the Sumpter quadrangle this material is widely distributed, enters largely into the volume of the Tertiary Lake Beds, and is the chief ingredient in the fine light-colored top-soil that has been described in another section. For the most part the volcanic ash is mingled with other materials, but certain beds exposed in the Burnt river area appear to be fairly pure. The purest beds are light-gray to white in color, very loosely coherent and consist of minute, angular particles of glass (Fig. 23). Fairly pure layers of the top-soil referred to are exposed in the banks of placer mines along Granite creek, near the Independence mill, along the stage road half a mile below Bourne, and elsewhere.

Volcanic ash is used chiefly as an abrasive, but it also has some value as a building stone where it is sufficiently consolidated. It occurs in many of the western states. Its total production in the United States in 1913, however, amounted to only 24,573 tons, valued at \$55,408.\*

### BUILDING STONE

Although Sumpter quadrangle contains vast bodies of granite and other rocks suitable for ordinary building purposes, they have not been developed except as required by local needs. A small quarry  $1\frac{1}{2}$  miles southeast of Granite along the stage road has supplied the stone for a few buildings in that town and in Sumpter. This rock is a light-gray andesite that dresses readily and looks not unlike granite at a short distance. The quarry is made in an outcrop of steeply pitching columnar andesite (Fig. 15), the columns of which range from 1 to 2 feet in diameter and afford blocks 6 or more feet long free of joints. No use has been made of the volcanic rocks extensively developed in the south half of the quadrangle. The gray tuffaceous beds of the rhyolite group as exposed for instance in some of the benches of Whitney valley appear not unlike the tuff that is quarried at Pleasant Valley, Oregon, and extensively used for building in Baker and elsewhere. In addition the rhyolite group here and there contains layers of very pleasing pink and terra cotta shades that might serve as ornamental building stones.

\*Mineral Resources of the United States for 1913, pt. 2, p. 271.

### ROAD METAL

Roads that traverse areas underlain by the argillite series and the granodiorite have good surfaces and ordinarily require but little repair. In the lands underlain by Tertiary formations, however, the roads in many places are bad in wet weather and difficult to keep in order. In places ordinary stream gravels have been used to surface the roads but as a rule they do not pack sufficiently well to form an ideal road covering. The best natural road metal observed within the quadrangle is the coarse sand produced by the weathering of the dacite, exposed along Big creek opposite the mouth of Rattlesnake gulch. Short stretches of the road up Big creek that had been covered with a layer of this material about 1 foot thick present a smooth hard surface. The sand occurs in abundance below outcrops of the dacite along the road up the east slope of the divide between Big creek and Water gulch, and appears to contain enough binder to produce a hard firm surface that will not wash and at the same time not become muddy. It must be borne in mind, however, that very bad stretches of road need to be treated first with coarse gravel or broken rock before the surfacing sand can be advantageously used on them.

### ROCK SUITABLE FOR TUBE MILL PEBBLES

Heretofore beach pebbles of a tough, hard, flinty rock known as petro-silex, have been imported for grinding pulp in tube mills. Recently, however, experiments by operators of tube mills in many places seem to show that many rocks of local origin can be used with satisfactory results. The material does not need to be water-worn for rock quarried from ledges and prepared for use by breaking to the proper size and rounding the angles by turning in a barrel, has been found to be satisfactory. Apparently any compact rock that is hard and tough will answer the purpose. Rocks of this description are abundant in the Sumpter quadrangle and it seems likely that any tube mill operations in the area can find an abundant local supply of pebble material. Examination of the stream gravels usually shows the presence of some cobbles having the requisite properties, and in most instances these may be traced without difficulty to their parent ledges.

Of the rock species of the quadrangle that appear suitable for tube mill pebbles the most promising are meta-gabbro and granodiorite

porphyry. Both occur as dikes or sills widely distributed in the principal mining districts. Fresh portions of them, free from brecciation, should be selected for use.

## DESCRIPTION OF MINES

### PRELIMINARY STATEMENT

Descriptions of most of the mines of the quadrangle grouped by districts are presented below. In the course of the present investigation numerous additional small mines and prospects have been examined, but descriptions are omitted from this report because they do not present features differing greatly from those of other mines in the quadrangle. Failure to mention a mine or prospect at this time must not be construed as any indication that it lacks merit. The data were gathered largely during the summer of 1914 and descriptions refer to conditions at that time. It has been necessary in describing several important mines to draw freely upon the data recorded in Lindgren's report.

## LODE DEPOSITS

### ELKHORN DISTRICT

*Baisley-Elkhorn mine.*—This mine is situated on the east end of a low spur from the divide between Pine and Rock creeks, near the head of Elkhorn gulch, a tributary of Pine creek valley. It lies 18 miles west of Baker. According to Lindgren, it was discovered in 1882 and a mill was erected in 1889. The mine was sold in 1897 to the Eastern Gold Mining Co. for \$60,000, and, when consolidated later with the adjoining property, the Robbins-Elkhorn, was operated by the United Elkhorn Mines Co. It was closed down in October, 1907, and in September, 1914, was inaccessible. The following description is based upon reports and maps submitted by the present owner, Mr. William Pollman, of Baker, and supplemented by an examination of the surface.

The following statement of production may be incomplete as there is no record of production from 1901 to 1905.

Prior to Jan. 1, 1898.....	\$342,861.07
1898 to Dec. 1, 1900, 26,095 tons crude ore-bullion.....	84,591.64
3,759 tons concentrates.....	239,529.84
472 tons shipped @ \$45.03 per ton....	21,254.04
1905, 20,000 tons crude ore, yielding 3000 tons concentrates....	210,000.00
1907, 7,680 tons crude ore, yielding 1280 tons concentrates.....	38,481.00
1912, (Small production) .....	?
Total .....	\$936,717.59

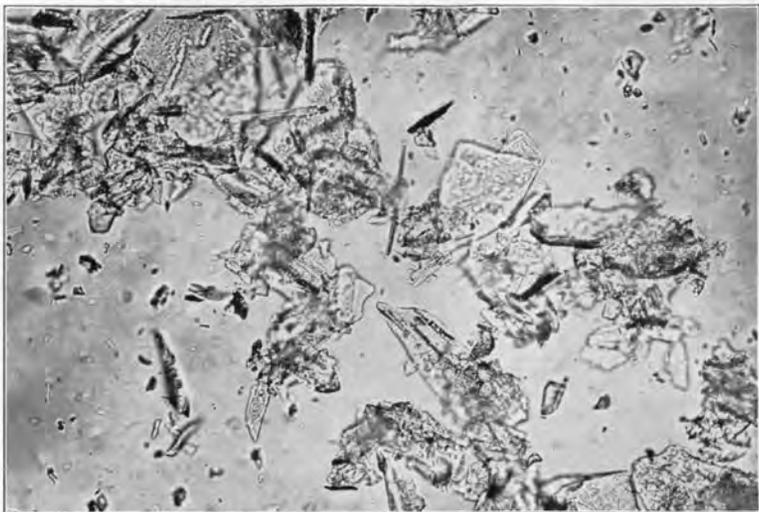


Fig. 23. Volcanic ash, magnified 360 diameters. From an exposure of the Tertiary Lake beds along the wagon road on the north side of Burnt River Valley about 6 miles southeast of China Creek. Shows the minute splinters of glass of which certain layers of this formation are largely composed.

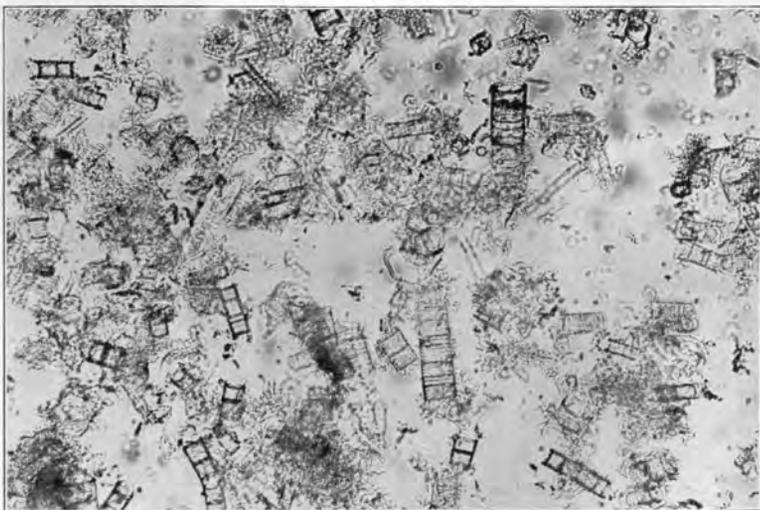


Fig. 22. Diatomaceous Earth, magnified 400 diameters. From cut along Logging Railroad  $2\frac{1}{2}$  miles northwest of Whitney and  $\frac{1}{2}$  mile north of Irvin's Ranch on Burnt River. Shows the siliceous tests of minute aquatic plants of which the material from this locality is entirely composed. To cover a distance of 1 inch, 3,300 of the larger cylinders placed side by side would be required.



Fig. 26. General view of Columbia Mine and reduction plants, looking eastward from Golconda Mill.

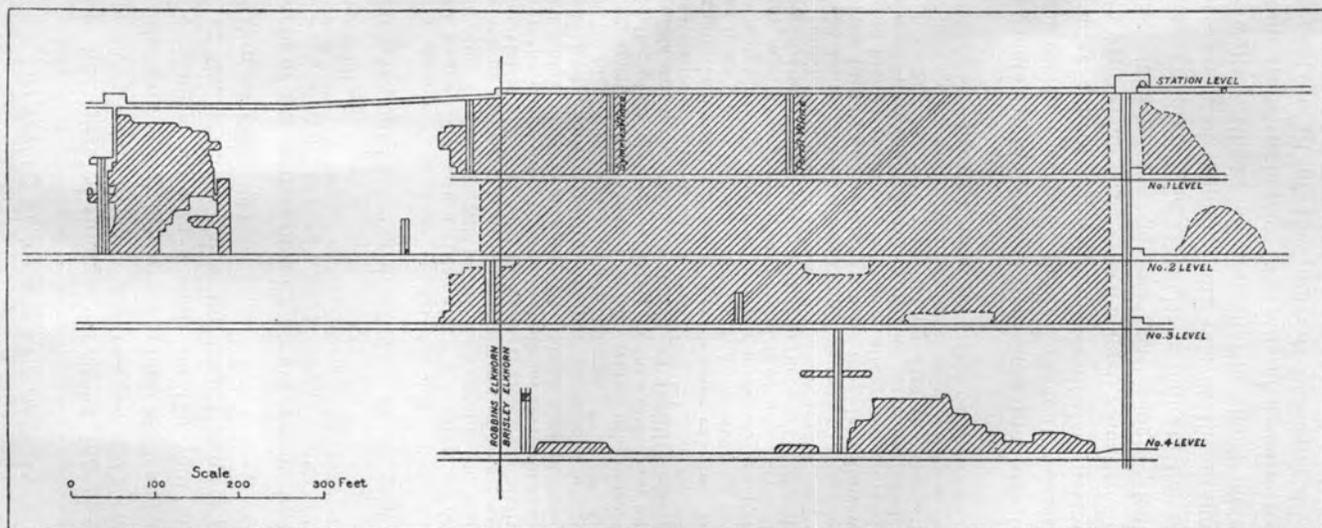


Fig. 24. Stope Map of the Baisley-Elkhorn mine.

The mine was operated through a crosscut tunnel 626 feet long which meets the vein at a point 265 feet below the outcrop. The shoot above the tunnel was exhausted before 1897 and deeper operations were continued through a shaft on the vein 400 feet deep. The extent of the workings below the tunnel level is shown on the accompanying map (Fig. 24).

The course of the vein is broadly an arc convex to the southeast, with an average strike over its known extent of N. 42° E; the dip is nearly vertical.

Lindgren gives the following description of the vein.

“The vein matter is confined between two well-defined walls, covered with polished gouge, but within these there are often subordinate fissures. Striations dipping 20° to 40° N.E. were observed on the walls. Sometimes the whole width of the vein is an altered diorite of small assay values. In the pay shoot the width is from 2 to 10 feet, many gradually fading seams running out on the north side. The ore streak on this width is a soft mixture of coarse sulphides with much crushed diorite and occasional streaks of quartz which show comb structure; in one place a 2-foot ore streak was adjoined by 10 inches of white barren quartz. \* \* \* On the 180-foot level, 700 feet south of the shaft, the vein which otherwise is entirely contained in diorite, gives sign of splitting up into stringers, and a black fine-grained hornfels appears, which is simply an argillite altered by the heat of the diorite cooling close to it. \* \* \*

“The gangue is normal vein quartz with some calcite. In general character the ore is soft and rich in sulphurets, concentrating in the proportion of 7:1. The sulphides, in order of their abundance, are pyrite, black zinc blende, galena, and chalcopyrite, all of which occur in irregular intergrowth with the gangue, the pyrite alone being sometimes crystallized. Ruby silver is occasionally found. The chief values of the ore are in gold which is partly—up to 25 per cent—free amalgamating, occurring in pyrite or intergrown with black zinc blende and calcite in form of pale yellow wires. Some of the brown zinc blende contains 160 ounces silver per ton and no gold, while some of the mentioned black blende contains much gold and no silver. The bullion is 700 to 750 fine. \* \* \* Along with the ore is found some diorite converted to a white mass of sericite, calcite, and with small crystals of pyrite. This metasomatic product as a rule contains no pay.”

The last material to be taken from the mine, reported to be from the fourth level in the shaft, shows lenticular masses of gray and milky granular quartz containing disseminated pyrite, blende and chalcopyrite with which is associated a small amount of pyrrhotite and arsenopyrite. The quartz contains small roughly lenticular aggregates of gray sericite. The associations indicate the replacement by quartz and associated sulphide minerals of the granodiorite which forms the walls. Blocks of granodiorite show, on a small scale, the transition from fresh rock to a zone of sericitic rock along fractures that contain all of the minerals characteristic of the vein. Locally, terminated quartz crystals penetrate lenticular masses of

calcite in such a manner as to show that calcite has filled a quartz-lined vug and was probably the last mineral to be deposited.

The vein is reported to be traceable for 1800 feet on the surface and has been explored for 1400 feet on the second level from the shaft. Within this distance two shoots have been found, the Baisley-Elkhorn 850 feet long, and the Robbins-Elkhorn 150 feet long. Both appear to have pitched directly down the dip of the vein. Though the former was stoped continuously to the third level 515 feet below the outcrop, the fourth level, 150 feet lower, appears to have found only sporadic masses of ore.

The ore produced during several periods has shown a wide range in value. Over the period 1898-1900 the extraction from 26,095 tons averaged \$12.30 per ton, omitting 472 tons of shipping ore which yielded an average of \$45.03 per ton. It would appear that most if not all of this came from the zones between the tunnel and second level in the shaft. The value for 1905 and 1907 was \$7 and \$5 respectively.

*Maxwell mine.*—This property adjoins the Highland. The workings are indicated by a number of dumps extending over a vertical range of 1200 feet, along a narrow ravine at the head of Maxwell basin, which is formed by the junction of two glacial valleys that head against a prominent northward spur from Elkhorn ridge. The most important operations extended over the period from 1900 to 1905, and though there has been no production since 1905, a little work is reported to have been done as late as 1909. The mine is said to have been sold for \$123,000 in 1901.

The developments comprise eighteen tunnels and short drifts reported to aggregate 6,000 feet. The lowest, No. 18, and No. 10, 900 feet higher, were open in 1914, though the sources of ore in the former were not accessible. An aerial tram connects tunnel No. 10 with a mill, now dismantled, in the basin below.

According to J. K. Romig, a former manager, an intermediate tunnel, No. 14, contained the most extensive workings. In this two ore shoots were developed on a vein in argillite, an outer one 250 feet long attaining a maximum width of  $4\frac{1}{2}$  feet, and an inner one 80 feet long, with a maximum width of 6 feet. The oxidized zone was extremely shallow. The material now to be found on the dumps of the lower tunnels contains a high per cent of pyrite, arsenopyrite, blende and galena named in order of abundance. In addition to quartz, the gangue minerals are calcite, siderite, and fuchsite. In

structure this type of ore resembles that found in the Highland vein, which lies a short distance to the northwest. It is reported that though much of this class of ore contains a fair amount of gold and silver, it is not amenable to treatment by concentration, because of the high proportion of sulphide minerals.

Tunnel No. 10, 290 feet long, and several above it that are now caved, explore a vein different in character though lying along the extension of the lower group of tunnels. This vein is a breccia zone, in part in granodiorite and in part along its contact with argillite attains a maximum width of 3 feet and has been stoped over an area 130 feet long by 80 feet high to the outcrop. In contrast with the average strike of about N. 60° E. of the lower Maxwell vein, this vein strikes N. 30° E., and the dip is 80° S. E. The ore occurs as lenses showing angular nuclear masses of fine pyrite, sericite and fuchsite in dense quartz. These nuclei are enveloped in a zone of radial quartz crystals with here and there a coarse pyrite crystal. If arsenopyrite is present, it was not observed. The vugs between these nuclear masses contain calcite crystals. In addition to the quartzose lenses, the vein contains zones of sericitic gouge. This general structure is characteristic of many veins in the quadrangle, but this is the only one seen in granodiorite that showed it. A small amount of manganese oxide occurs in the oxidized ore. Assays as high as \$35 a ton in gold are reported, the ratio of silver to gold seldom exceeding 2 to 1 by weight.

*Highland mine.*—This is one of the few mines of the region whose important development dates since 1906, when the general decline of activity in the region began. The mine buildings and mill are situated in the lower end of Maxwell basin, a mile above the junction of the gulch with Rock creek.

The property contains six claims, the oldest of which was located in 1891. Ore was first discovered in a tunnel near the bottom of the gulch and though most of the early work was done south of it, the important work which began in 1909 has been confined to tunnels on the north side. A small mill was erected in 1905, but this was replaced by a modern 50-ton plant in 1911, which was run continuously until April, 1914. The immediate cause of the cessation of work is reported to be an injunction issued by a local court restraining the operating company from polluting the waters of Rock creek.

The following statement of production is submitted by the company.

1905 .....	\$ 7,781.67a
1909, 330 tons crude ore .....	25,527.06b
1910, 960 tons crude ore.....	43,826.00b
1911, 186 tons crude ore.....	11,129.28b
1912, 1,725 tons concentrates .....	84,014.50b
1913, 2,678 tons concentrates .....	111,472.39b
1914, to April 15th, 443.62 tons concentrates	27,801.78b
	\$311,552.68

a. probably net      b. gross

The mine is developed by six tunnels with an aggregate length of about 5,000 feet. Two tunnels lie south and three north of the gulch line. The sixth is a crosscut 625 feet to the vein, with extensive drifts northeast and southwest. These tunnels explore a well-defined vein at several levels over a total distance of 3500 feet. In September, 1914, three were accessible in part; No. 2 on the north side of the gulch for a distance of 1150 feet, and No. 4 (Highland crosscut or mill level) 240 feet lower, for 1,000 feet along the vein.

The Highland vein is the most persistent of the group comprising the Highland, Maxwell, Baisley-Elkhorn and other associated veins. Beginning at the southwest with the Highland vein, which strikes N. 75° E., the Maxwell and Baisley-Elkhorn are successively offset to the east, and the northernmost or Baisley-Elkhorn strikes N. 40° E. Broadly, the dip of each is nearly vertical, though from place to place the stipes show deviations of a few degrees either to the northwest or southeast. Minor fractures, locally ore-bearing, occur nearly parallel to each of the three main veins. At the southwest limit of exploration, the Highland vein, wholly in dense argillite, is about 500 feet from the main granodiorite contact, but farther northeast this distance decreases and the veins successively approach and finally enter the granodiorite. The Baisley-Elkhorn is largely within this rock.

The Highland No. 4 crosscut tunnel starts in a dense gray siliceous argillite which strikes east and dips 60° to the south. This rock contains zones of irregular narrow quartz-filled fractures and is succeeded by a darker argillite with a few fractures and no quartz veinlets. The rocks forming the walls of the vein range from dark dense carbonaceous argillites to light, coarser siliceous varieties and bedding is rarely determinable near the vein. The character of the vein, as well as the deep narrow furrows on the south wall, inclined at low angles to the northeast, indicate that the vein follows a fault

along which appreciable movement has taken place. The vein material is bounded by well-defined walls from which it breaks freely. Crosscuts locally show a width of as much as 28 feet between the walls, but the more productive portion in few places exceeds 30 inches in width.

The zone of oxidation is very shallow and irregular, probably because the explored portion of the vein crops out within a glaciated area. Films of recently formed hydrous oxide of manganese occur along the walls at a number of places on the lowest drifts.

Four shoots of ore have been found, and though three are fairly defined, the fourth, which has been the source of the richest ore, has been stoped over a very irregular area, and no exact record of its extent has been kept. The most southwestern, or Big Silver shoot, is reported to be 300 feet long, but to contain material of low grade only a small portion of which was stoped. The next or Shelton shoot, is 60 feet long and was the source of some ore of shipping grade in the early history of operations. The main shoot, the source of most of the recent production, extends from a shaft near the bottom of the gulch about 1100 feet northeast.

As the shoot has been explored to a depth of only 360 feet, its attitude in the vein is not known with assurance. The Beckwith shoot, 180 feet long, lies farther northeast and the greatest stope length is about 120 feet.

The vein contains several distinct classes of material, each of which locally has been found by assay to warrant mining, though places are known where each contains but little gold and silver, a condition that requires numerous assays, both during development and actual mining, in order that the grade of the product may be maintained. The richest ore shows bunches or short lenses of sulphide minerals in white quartz, locally showing radial structure. The sulphides noted, in order of importance are fine granular pyrite in which are small patches of dark blende and coarsely crystalline galena; arsenopyrite, chalcopyrite, and tetrahedrite. Locally there are small patches of a greenish mica that may be either sericite or fuchsite. This pyritic material here and there is coherent and has definite structure, but most of it is not coherent and a definite structure cannot be recognized in hand specimens. Tests have shown that some of the more coherent material is merely a breccia of the ore minerals cemented by calcium carbonate, and that some of the quartzose portion is a similar quartz breccia. This is one of several

features showing that considerable post-mineral movement has taken place in the vein. It is reported that this material from the eastern part of the main shoot contains as much as 2.5 ounces of gold and 15.0 ounces silver per ton, but that very similar material farther west is considerably lower in grade.

Another class of filling is found in the Big Silver shoot and the western portion of the main shoot. Here angular fragments of argillite or masses of pale green mica and pyrite that resemble replaced argillite, are embedded in quartz, locally having radial structure. Such material is undoubtedly an argillite breccia more or less replaced by vein minerals and cemented by quartz. This is reported to be low grade.

By far the greater portion of the vein filling is an incoherent mass of crushed argillite, clay, quartz, and ore minerals. The argillite is locally fresh but dominantly silicified, and the clay, which ranges in color from light gray to nearly black, appears to have been formed by the alteration as well as attrition of the argillite country rock. The darker varieties of such clays are uniformly low grade, but otherwise the content in gold and silver varies greatly. It is necessary to mine large quantities of this material in order that the richer portions of the vein may be found, as well as to avoid the necessity of holding it in place in the stopes.

With the exception of the quartz-argillite breccia which usually forms well defined lenses, the other two materials form both definite zones and highly irregular masses, but in each case the limits are walls or slips along which the materials separate freely.

The ratio of silver to gold in the ore ranges for the most part from 5 to 25 of silver to 1 of gold by weight, but in the concentrates the ratio deviates but little from 9 to 1, being approximately 15 ounces silver and 1.80 ounces gold to the ton. Concentrates containing galena show a higher proportion of gold than the normal pyritic concentrates and indicate an association of gold with that mineral. Thus, a concentrate containing 15.5 per cent lead, yielded 5.28 ounces gold and 23.12 ounces silver to the ton. The average recovery from the ore in the present mill has been about 2 ounces silver and .25 ounces gold to the ton. The tailings are reported to contain gold and silver to the extent of \$1.80 to \$2.20 to the ton in value.

#### CRACKER CREEK DISTRICT

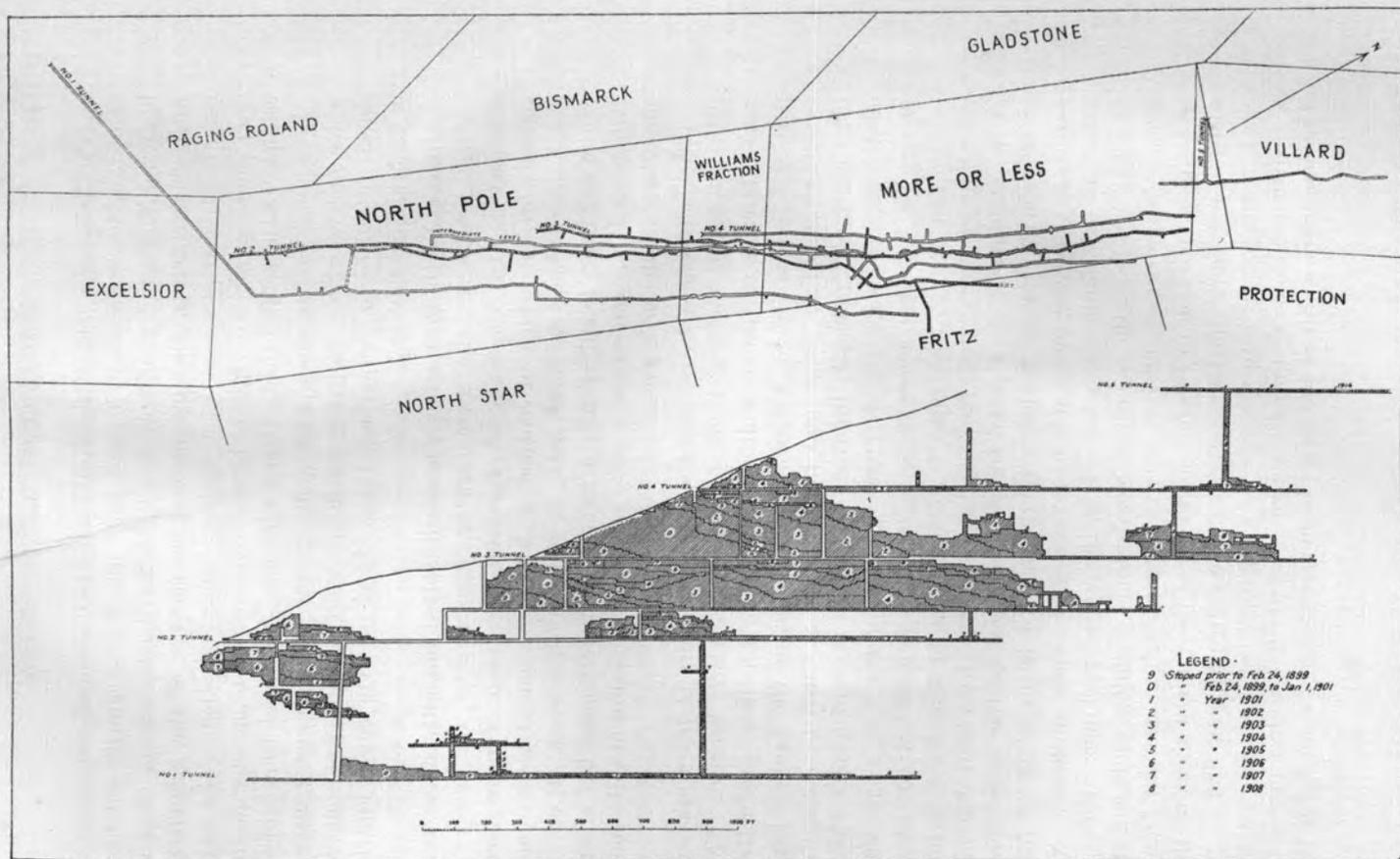
*North Pole mine.*—The northern extension of the famous lode

explored by this mine, has been the source of a small production in the South Pole mine, north of the Elkhorn ridge divide, but the important shoots occur south of it. The claims of the Eastern Oregon Mining Company, which operated the North Pole mine, cover 6,000 feet along the lode and extend from Cracker creek north nearly to the divide. The North Pole claim was located in 1887 but the important production covered the period from 1895 to 1908 when systematic work ceased. The mine has been worked in a small way by lessees and a small production reported from time to time since 1908. When work was stopped in 1908, the production probably exceeded that of any other deep mine in eastern Oregon, but this record has since been surpassed by the Columbia mine which operates the southern extension of the same lode.

The mine is developed by five tunnels and an intermediate level of an aggregate length of 13,000 feet, which attain a maximum depth below the outcrop of 1,300 feet. A plan and vertical section of the workings are shown in figure 25. The tunnels follow the vein, with the exception of the present No. 3 tunnel which is a foot-wall drift with here and there a crosscut to the old stopes. Though most of the tunnels, with the exception of No. 2 were accessible in 1914, the stopes are either filled or caved to such an extent that the vein may be examined at only a few places. It is therefore no longer possible to get data upon which to present a comprehensive study of the vein.

Mr. Emil Melzer, of Baker, who was manager of the mine, submits the following record of production.

Milling ore	Tonnage	Gross value per ton	Gross value
1895-96 .....	2,350.07	\$19.27	\$ 45,331.40
1897 .....	5,508.05	11.04	60,819.93
1898 .....	5,460.86	13.78	75,278.20
1899 .....	8,132.78	8.75	71,146.66
1900 .....	5,133.17	11.17	57,344.48
1901 .....	8,673.19	17.85	154,824.59
1902 .....	9,341.32	23.02	215,058.84
1903 .....	20,045.72	12.38	248,179.60
1904 .....	18,770.33	11.82	221,774.20
1905 .....	23,659.34	11.22	265,658.60
1906 .....	22,341.17	10.77	240,602.80
1907 .....	19,592.13	10.39	203,557.96
1908 .....	8,793.71	7.76	68,258.80
	<u>157,801.84</u>	<u>\$12.216</u>	<u>\$1,927,836.06</u>
Shipping ore			
1897-1908 .....	1,115.556	\$499.45	557,170.90
Total .....	<u>158,917.396</u> tons	<u>15.63</u>	<u>\$2,485,006.96</u>
Recovery .....		12.59	2,000,900.82



**LEGEND -**  
 9 Shaped prior to Feb 24, 1899  
 0 " Feb 24, 1899, to Jan 1, 1901  
 1 " Year 1901  
 2 " " 1902  
 3 " " 1903  
 4 " " 1904  
 5 " " 1905  
 6 " " 1906  
 7 " " 1907  
 8 " " 1908

Fig. 25. Plan and section of North Pole mine.

The lode crops out on the North Pole claim almost continuously from the No. 2 tunnel to a point above the No. 4 tunnel, 800 feet higher. Below the mouth of No. 2 tunnel the outcrop is covered with glacial debris, and judging by the contour of the ground it may have been glaciated to a slightly higher elevation. The outcrop shows a silicified argillite breccia cemented by numerous quartz veinlets and here and there stained with manganese and iron oxides. Above No. 4 tunnel, there is a roughly rounded mass of homogeneous white quartz which attains a maximum width of 300 feet, but as shown in stopes to the surface, the walls of the vein cut it and it is probably pre-mineral.

In the North Pole mine, the argillite is dominantly dense and highly siliceous and the more carbonaceous varieties are meagerly represented. In No. 5 tunnel, the vein cuts a bed of pale green volcanic breccia, which in contrast with the interbedded greenstones noted elsewhere in the quadrangle, is relatively unaltered. Bedding of the sediments is only locally determinable underground but observations on the surface show a locally complex structure broadly synclinal east of the vein zone.

The lode strikes N. 30° E., and the average dip is 78° southeast, though between No. 2 and No. 3 tunnels it is nearly vertical. The zone attains a maximum width of 40 feet in the most productive part and is bounded by well-defined walls, but as the tunnels tend to follow a median course and the walls are explored by crosscuts, their continuity is locally inferred. The large mass of quartz which on the surface above No. 4 tunnel lies west of the vein, is present in the No. 2 tunnel where it lies east of the vein and at one place is 150 feet wide. The relation of the walls to this mass is not clear underground. Both faults and crushed zones have been observed in the workings. At a point 800 feet northeast of the intersection of the No. 1 crosscut tunnel with the vein, it is displaced 40 feet southeast along the north side of a fault that trends southeast. No effect of this fault was observed in the upper workings. Sixteen hundred feet from the mouth of No. 3 tunnel a similar fault cut off the ore in the stopes and it is reported that though no ore was found in a similar position in the vein northeast of the fault, a shoot on the footwall not known farther south, was the source of some ore.

The source of ore in the mine is a quartzose vein which occupies a median position in the lode though it locally lies against one wall. The maximum width of the stopes is 30 feet in No. 3 tunnel, but the

average is between 4 and 6 feet. The extraordinary extent of the stopes is shown in the stope map. The vein was stoped continuously between No. 3 tunnel and the intermediate level for a distance of 1800 feet, and to a point at the lower end that was about 800 feet below the outcrop. So far as can be ascertained, at no place in the mine were two parallel shoots the source of ore. In the accessible stopes, the detailed structure of the vein is complex. The predominant structure, and one common to many of the veins of the region, is characterized by silicified argillite breccia cemented by quartz ordinarily showing comb structure. Commonly, the silicification of the argillite is incomplete and angular nuclei contain a micaceous or carbonaceous residue, as well as pyrite and arsenopyrite. In a less common type the replacement appears to be complete and the nuclei are composed of numerous minute crystals of pyrite and arsenopyrite in a matrix of finely granular quartz. This material is reported to contain more gold than that in which outlines of the argillite fragments are clear, but the gold is difficult to recover. In a stope 1200 feet from the mouth of No. 4 tunnel, similar material, intimately fractured and cemented by radial aggregates of quartz, has a porous texture. Most of the exposures of the vein in the stopes, show quartzose bands or lenses separated from each other by thin bands of argillite gouge. Each presents one of the several stages of silicification above described.

Arsenopyrite appears to be present in greater amount than pyrite, but large crystals of either are rare. Though these minerals dominantly occur in the nuclei of replaced argillite, some specimens of rich ore show zonal layers of minute pyrite crystals and tetrahedrite outside of the envelope of quartz. Tetrahedrite, which has not been observed in the nuclei, either forms grains in the comb quartz or zonal layers with pyrite. Chalcopyrite, galena, blende and cinnabar are reported by Lindgren but were not observed in the course of this examination. Stibnite occurs in calcite from the intermediate level. Gold attached to hessite in quartz was observed in specimens at the office of the company. In the face of No. 3 tunnel, calcite cements a partially silicified argillite breccia but is not a common mineral in the vein.

The condition of the mine does not permit a detailed statement of the extent of the zone of oxidation. Though, according to Lindgren\*

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\* Loc. cit., p. 661.

“partial oxidation has taken place for a distance of 200 or 250 feet from the surface.” Fair evidence of partial oxidation was observed in No. 3 tunnel in 1914 beyond the limits of exploration in 1900. Recently formed manganese and iron oxides are now present throughout the limits of the workings.

The extent of the stopes on the vein is shown in figure 25. Broadly, there are three distinct areas, two of which extend to the surface, whereas the other is well below the limit of oxidation. The striking features of the large stope are the great excess of the stope length or horizontal dimension over the height, and its abrupt termination along the intermediate level, except for the small area above No. 2 tunnel. There is no clearly recognizable relation between this or either of the smaller stopes and the present surface, and though downward enrichment may have affected the vein, the form of the stopes offers no definite data that aid in demonstrating it. So far as prospecting between No. 1 and No. 2 tunnels has gone, it cannot be assumed that there are no shoots of fair size between these levels. The meagre textural evidence available at this time does not afford conclusive proof that downward enrichment has taken place, though the presence of the mineral cinnabar suggests it.

According to Mr. E. Melzer, of Baker, a remarkable shoot of rich ore was mined between the No. 2 and No. 3 tunnels during 1902 and 1903. The shoot was roughly elliptical with a stope length of 250 feet and a maximum height above No. 3 tunnel of 200 feet. It was mined over a maximum width of 5 feet but pinched to a few inches on the borders and appeared to be composed of a series of smaller overlapping lenses. The shoot yielded 1115 tons of ore with an average value of \$500, but some was considerably richer. The gold in this shoot was not characteristically associated with rosceolite.

*The E. and E. mine.*—The Bourne Gold Mining Company, which succeeded the Eureka and Excelsior Consolidated Mining Company, owns claims covering about 3,000 feet along the North Pole-Columbia lode, between the North Pole mine on the north and the Tabor Fraction on the south. It has been extensively worked from a shaft near the bed of Cracker creek and by tunnels of which there are three on the Excelsior claim north of the creek and five on the Eureka claim south of it. The shaft is 760 feet deep and there are drifts on the vein both north and south at six levels, several extending to the limits of the claims. The aggregate length of drifts and tunnels is reported to exceed 17,000 feet. Water stands 100 feet below the

collar of the shaft but all of the tunnels and several stopes were accessible in 1914.

The period of greatest activity extended from 1894 to 1898, but a production is also reported from 1903 to 1905. The immediate cause of the cessation of work in 1906 is reported to have been an extraordinary influx of water on the lower levels from the shaft. There has been no exploration since that date. Comparing the extent of the stopes in 1900 as shown by Lindgren\* the production since that time has come almost wholly from ore mined above the tunnels north of the shaft. Accurate figures of the total production are not available, but it probably does not exceed \$1,250,000.

The outcrop is covered with glacial debris north of Cracker creek but is prominent on the ridge south of it. It shows the typical silicified argillite breccia and near the summit of the ridge, on the Tabor Fraction claim, attains a width of 30 feet. Films of manganese oxide are common throughout the extent of the outcrop, from Cracker creek to Fruit creek.

The tunnels south of Cracker creek tend to follow the foot-wall of the vein zone and though several crosscuts show widths between definite walls as great as 30 feet the ore lies against the foot-wall. A striking feature in the Eureka tunnels is the number of persistent furrows in the foot-wall of the vein zone. These range from 2 to 3 feet wide and are locally 6 inches deep. A few pitch at low angles to the northeast, but most are inclined south  $10^{\circ}$  to  $15^{\circ}$  and coincide with the direction of motion of the walls inferred by the displacement of an important synclinal axis.

The average strike of the vein zone in the Eureka and Excelsior claims is N.  $35^{\circ}$  E., and the dip  $70^{\circ}$  to  $75^{\circ}$  southeast. The argillite is dark and siliceous and the bedding on the surface strikes east and dips north.

The vein has yielded little ore above the lowest tunnel south of the creek, except from small stopes that in higher tunnels are connected with those of the adjoining Tabor Fraction mine. In these stopes the vein ranges from 3 to 6 feet in width, and shows lenses of highly silicified argillite breccia alternating with narrower bands of sheared dark argillite.

The accessible exposures show a low content of pyrite and arsenopyrite. Another shoot of argillite breccia 300 feet long occurs in the

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\* Op. cit. p. 658.

two lower Eureka tunnels and though it has been stoped at one point it is reported to be low grade.

There are extensive stopes above the lowest tunnel on the Excelsior claim north of the creek, but only the inner exposures adjacent to the North Pole claim are accessible. The stopes range in width from 3 to 12 feet, but the average is about 4 feet. In describing the shoot of the Eureka claim, Lindgren quotes Mr. J. Arthur of Baker as follows.

“A surface tunnel on the Excelsior claim disclosed a shoot 200 feet long, the ore still remaining at the face and very likely continuing to the North Pole line 400 feet distant. This shoot is 4 feet wide and contains \$10 per ton in gold. The better grade ore, assaying \$50, was sorted and shipped. This high-grade ore appears as a streak 2 feet wide and 75 feet long in the bottom of the drift and adjoining the milling ore. The shoot next south of this was 400 feet in length and from 1 foot to 15 feet in width, differing from the first in having a wavy character, the thickness changing suddenly and often. The shoot, with an average width of 4 feet, has been mined down to a depth of 160 feet from the surface.”

Argillite breccia, showing several degrees of silicification, occurs in each of the exposures, but when poor in sulphide minerals is low grade. The best ore shows either successive concentric zones of comb quartz and fine pyrite and arsenopyrite crystals, enveloping highly silicified argillite nuclei with the same minerals, or a breccia of similar material cemented by comb quartz or small quartz veins. Most faces show evidence of at least two successive periods of silicification and brecciation with deposition of sulphide minerals, and one face shows three. The attitude of most of the lenses of ore indicates post mineral movement and slickensides in the ore are common.

In addition to pyrite and arsenopyrite, tetrahedrite occurs as grains in the quartz, but was not observed in the silicified argillite. Other sulphide minerals if present are not common. As well as occurring in the outcrop, recently-formed manganese oxide coats the walls of many drifts and crosscuts in the Excelsior claim, and though in the more superficial workings it is associated with limonite, it is abundant in deeper workings where limonite is absent. The zone of oxidation appears to have been shallow, at no place attaining a greater depth than 100 feet. No evidence of downward enrichment has been recognized, but it is noteworthy that those accessible portions of the vein zone that have yielded ore coincide with the workings showing considerable recently formed manganese oxide.

*Tabor Fraction mine.*—This mine explored that portion of the North Pole-Columbia lode covered by the fraction 300 feet wide lying between the Columbia mine on the south and the Eureka and Excel-

sior on the north. The vein was explored through a shaft and considerable ore showing much free gold and roscoelite was extracted, though it is reported that more extensive work was done from the Columbia mine when the claim was under lease to that Company. All of the drifts from the Columbia mine were bulkheaded in 1914 and a single stope was accessible from the Eureka No. 2 tunnel. The character of the ore is the same as that mined from the adjacent portion of the Columbia.

*Columbia mine.*—This mine, which exceeds any other in the quadrangle in continuity of production and total wealth yielded, is situated on Fruit creek, 1 mile west of Bourne. The property embraces about 3,000 feet of the North Pole-E. & E. Columbia lode between the Tabor Fraction and the Golconda mines, and comprises the southwestern slope of the divide between Fruit and Cracker creeks. (Fig. 26.)

Although the conspicuous outcrops of this great lode were noticed by prospectors as early as 1870, the portion now included in the Columbia holdings remained unclaimed until 1887, when it was located by the Cable brothers. The claims were purchased by E. M. Backus and a 10-stamp mill was erected in 1896. The following year the present three-compartment shaft was begun 45 feet south of the vein at an elevation of 5,700 feet. Development was vigorously prosecuted in the succeeding years, and the plant was increased by the addition of 10 stamps and equipment for cyaniding the tailings and the generation of water-power.

The Columbia mine has a record of practically uninterrupted production since 1896. Figures showing the annual and total amounts produced are not available for publication, but it may be said that the total runs into millions of dollars. The average value of the ore milled has been \$11.04 to the ton, but the ore shipped directly to the smelters has averaged \$212.72 to the ton. The shipments made from 1905 to 1907 contained 1.2 per cent of copper, and gold and silver in the ratio of 1 to 3 by weight. A high percentage of the gold and silver is recovered from the ore milled. Of this, approximately 40, 50, and 10 per cent are extracted, respectively, by plates, concentrators, and cyanidation.

The shaft is 918 feet deep and reaches a level about 1,300 feet below the highest outcrop of the vein. Three adit levels above the collar of the shaft and eight levels at 100-foot intervals below it have been driven on the vein, aggregating 17,134 feet in length. There

are also 5,663 feet of crosscuts and raises, making a total of 22,797 linear feet in addition to stopes which have yielded many thousands of tons of ore.

On the slope below 5,850 feet, the elevation near the mouth of tunnel No. 2, the outcrop is concealed by talus and glacial drift. East of that point for a distance of 1,000 feet the outcrop forms a ledge of banded quartz and silicified argillite breccia which ranges from 10 to 45 feet in width and is stained with the oxides of iron and manganese. As shown by the underground workings, the vein has an average strike of N. 34° E. and dips 86½° southeast. The wall rocks are the dark-colored siliceous argillites that prevail in this locality. The walls are well defined, especially the west or footwall, and are only locally less than 25 feet apart. About 300 feet southwestward from the shaft the vein loses its identity in a zone of faulted brecciated rocks that extend for 800 feet or more, beyond which the vein reappears and continues into the Golconda ground.

The vein filling is similar to that in the E. & E. and North Pole mines situated on the same lode, and consists principally of brecciated argillite cemented and partly replaced by quartz. The commercial ore occurs in shoots of irregular extent that range from 3 to 8 feet in width. The shoot penetrated by adit levels Nos. 1 and 2 and extends east beyond the Columbia end line, into the Tabor Fraction claim. On level No. 2 it has a length in the Columbia ground of about 500 feet, and terminates southwestward along a line pitching approximately 50° northeast in the plane of the vein. It has been developed to the 400 level east of the shaft showing a pitch length of at least 700 feet. An irregular shoot that begins near the mouth of adit level No. 2 has a stope length of from 200 to 500 feet and extends downward in a generally vertical course. It is reported to contain high-grade ore as deep as the 800 level. A third shoot about 500 feet long occurs near the surface between the mouth of adit level No. 2 and a point about 100 feet southwest of the shaft. This shoot pitches southwest about 45° in the plane of the vein and appears to end between the 5th and 8th levels against the faulted zone southwest of the shaft.

Below adit level No. 3 the ore shoots lie next to the footwall, but above that point they occupy intermediate positions or cross to the opposite side of the vein. The ore bodies are usually separated from adjacent parts of the vein by an inch or more of gouge which locally is a light-gray or white putty-like material but in most places is black

and made up of thin striated laminae that separate easily. The ore in some places is in fairly large and solid masses but the characteristic type is made up of small overlapping lenses separated by slips; locally it is crushed to such a degree that it readily breaks into small fragments.

*Vein mineralogy.*—The ore normally consists of quartz or silicified argillite that carries a small per cent of sulphides, of which finely divided pyrite is by far the most abundant. Arsenopyrite is characteristic of most of the ore. The following minerals were observed in ores from the Columbia mine by Lindgren.\* Native gold, native copper, pyrite, arsenopyrite, zinc blende, pyrrargyrite, antimonite, cinnabar, chalcopyrite, stibnite and schwartzite, a mercurial variety of tetrahedrite, as ore minerals, and quartz, sericite, fuchsite or maropsite and calcite as gangue minerals. To this list may be added the vanadium mica, roscoelite, which was observed on the 500 level north, and the 600 level south of the shaft. Roscoelite, fuchsite, arsenopyrite, and chalcopyrite, either separately or together appear to be characteristic of the rich ore. On the other hand, their presence does not necessarily indicate high values.

The lower limit of oxidation approaches near to the surface in the vicinity of the shaft and from this locality rises eastward somewhat less rapidly than the surface. Near the east line of the Columbia ground the zone of partial oxidation ranges from 200 to 300 feet in depth.

*Ore reserves.*—A large reserve of ore is wholly or partially blocked out. Most of this is below the collar of the shaft but ore from one of the adit levels is still being milled. Figures showing the exact amount and value of the ore reserves are not available for publication.

About 300 feet southwest of the shaft, level No. 3 follows a series of slips of variable dip that continue with the general course of the vein and contain gouge and quartz. A cross fracture near this point is followed 100 feet to the southeast where a vein with a dip of 60° to the southeast and parallel to the main vein has been drifted on for 300 feet. This vein is a gouge-lined slip that contains disconnected bodies of sparingly mineralized quartz that range in width from 2 inches to 2 feet. One of them, however, widens to an irregular mass 10 feet across that resembles the ordinary filling of the poorer portions of the main lode. A cross section of the vein on level No. 3 north of

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\* Lindgren, Waldemar, The gold belt of the Blue Mountains of Oregon: Twenty-second Ann. Rept., U. S. Geol. Survey, pt. 2 p. 664, 1901.

the shaft reveals an 8-foot layer next the footwall composed of small overlapping lenses of ore in a matrix of gouge and fine quartz-argillite breccia. On the hanging-wall side of this layer, and separated from it by a well-defined slip, is a great thickness of barren quartz. Level No. 5 south crosses the faulted zone for a distance of 800 feet, traversing siliceous argillite and small masses of greenstone and other altered rocks. Locally in this crosscut detached bunches of vein quartz appear, some of which are valuable as ore. For the most part these bunches seem to have been broken from a vein by fault movement but this explanation may not apply to all of them. On the 500-foot level north of the shaft, in a 20-foot section of the vein exposed by a crosscut, roscoelite is fairly abundant in a 3-foot layer next the footwall, where in distinct concretionary structures the quartz crusts are heavily coated with it. On the 600-foot level south a 6-foot breast of milling ore shows similar concretionary structures next to banded quartz on the hanging-wall side. Here kernels or nuclei of argillite that have been almost completely replaced by quartz, contain very fine specks of sulphide minerals and are surrounded by crusts of terminated quartz crystals. Two concentric crusts have been deposited each coated with thin bright green films of the chromium mica fuchsite. Roscoelite was detected in one place as a coating on quartz banded with minute specks of sulphide minerals.

*Golconda mine.*—The Golconda Mining Company was succeeded, in 1902, by the Golconda Consolidated Gold Mines Co., which in addition to other claims, owns two on the North Pole-Columbia lode which adjoin those of the Columbia Mining Co. on the southwest. The period of important production extended from 1897 to 1904, though a small production was reported in 1906 and some exploration was carried out as late as 1911. According to J. A. Howard, of Baker, the total production to 1904 was approximately \$550,000.

An adit 1,300 feet long attains a depth below the outcrop of about 300 feet, but the most extensive work was done from a shaft 500 feet deep near the mouth of the adit. The total extent of the development is reported to be 7,000 feet. Of this, a single crosscut near the mouth of the adit was accessible in 1914. Lindgren has given the following description of underground conditions in 1900.\*

“The developments in the shaft have shown the existence of a very wide mass of crushed argillite. The general trend of this is northeast, the dips in the upper levels are northwesterly at steep angles, while in the fourth level

\* Loc Cit. p. 665.

this is reversed to a southeasterly dip, similar to that of the Columbia and the North Pole. In places this crushed zone is 200 feet wide and traversed by several seams, running across the vein in a northwest-southeast direction, on some of which quartz veins carrying gold appear. The principal shoots are found as streaks 2 to 4 feet wide in this shattered argillite and pursue a rather irregular course. The ore carries but little quartz and is largely a replacement of argillite and some porphyry by finely divided pyrite, marcasite, and arsenopyrite and a very little chalcopyrite and zinc blende."

According to Lindgren, the richest ore contained roscoelite and tetrahedrite. The material on the dump contains considerable bright-green fuchsite formed by the alteration of argillite.

According to a report made for the Company by J. K. McKenzie of Chicago in 1904, three veins in a crushed zone 175 feet wide have been the source of the ore. They strike N. 45° E. but have varied greatly in dip. The west vein dipping steeply northwest was the source of some ore above the adit level, but was not found in the deeper work from the shaft. The intermediate vein, dipping 35° southeast, was stopped in places above the adit level, but, as it was not found in a cross-cut from the 100-foot level in the shaft, it has been assumed that it merged with the east vein. The east vein, which has been the most important, dips 77° to 81° northwest in the upper levels from the shaft, but this is reversed in the lower levels. The shoot in this vein attained a maximum length of 235 feet on the second level where the maximum width was 30 feet; it was not found on the fourth and fifth levels. Within the area of this stope a small shoot of rich ore occurred on the second level. It was 70 feet long and 20 feet wide and yielded about \$97,000 in gold. The average width of the east vein is about 3 feet and the value of the ore has ranged from \$6 to \$8 to the ton. The ore yields about 6 per cent concentrates that contain 2 to 3 ounces of gold and 3 to 6 ounces of silver to the ton.

The extent of the zone of oxidation is not known but it was probably shallow. Manganese oxide was not found in the outcrop nor as a recently formed stain in the accessible workings in 1914.

*Mountain View mine.*—The Mountain View mine, situated at the head of Sardine gulch 2½ miles due north of Bourne, was closed in 1914. Its period of productive activity extended from 1903 to the end of 1907, when its mill was destroyed by fire. The vein occupies a fissure that strikes northeastward in granodiorite and the severely metamorphosed argillite along its border. According to reports, the mine was profitable during the period of its operation and produced a large sum in gold and silver. It is said that its principal ore shoot was worked over a stope length of 200 feet and pitch length of 300

feet or more, and that at the time the mine closed down ore was exposed for 80 feet along the lowest level. Partial records of the mine's production were seen that show a total of \$63,842 in gold and silver. In the crude ore shipped the silver value was comparatively insignificant, the ratio of gold to silver by weight being as 6 to 1.

*Buckeye mine.*—The development of this mine has taken place largely since 1900 and work is now in progress. It is situated on the divide between Little Cracker creek and Rock creek, 2 miles north-east of Bourne. The course of the explored zone is prominently marked by a group of dumps that extend from an elevation of 7,400 feet on the southwest or Little Cracker creek slope over the summit at 8,100 feet to the northeast side. There are five tunnels and some shallow shafts on the southwest and two tunnels on the northeast slope with an aggregate length of about 3,500 feet. A small production is reported.

The workings explore a zone within which there is one relatively persistent and probably several non-persistent veins in dark carbonaceous argillite. The structure of the argillite beds is complex, the strike ranging from N. 60° E. to S. 70° E. and the dip from 30° south to nearly horizontal. Though the dominant fissure cuts across the structure with strike of N. 60° E. and dip of 70° southeast, minor fissures that are essentially bedding-plane faults merge with the main vein and locally contain some quartz. Where the fissure is well defined, the walls are locally as much as 4 feet apart and the vein contains lenses of argillite breccia cemented with quartz in a highly lustrous black gouge. Such portions merge with poorly defined crushed zones in which there are numerous small irregular quartz stringers. Compared with other veins of the argillite breccia type, replacement of the argillite is meagre and pyrite to the extent of a few per cent occurs both in fragments and in the cementing quartz. Sporadic grains of tetrahedrite, only slightly argentiferous, are confined to the quartz. Calcite fills quartz-lined vugs. The gold, so far as noted in unoxidized ore, forms ragged wires in quartz, and specimens showing it freely, are reported from points 250 feet below the outcrop and 150 feet below the zone of oxidation. The only knowledge of the grade of ore in the vein is based upon the yield of small lots of hand-sorted material, some of which shows free gold. Twenty-seven dollars to the ton was returned on one lot of 20 tons though smaller lots have yielded more and it is estimated that the mine has produced free gold specimens worth approximately \$5,000.

The outcrop, particularly on the Rock creek slope, contains considerable manganese, as well as iron oxides, and although it is possible that some of the gold in the superficial portion of the vein is due to downward enrichment, it can not be stated with any assurance that such is the case with the gold found in the deeper portion.

*Ibex mine.*—The claims of this company are the westernmost of a group that extends from the Ibex at the head of Deep creek, 3 miles eastward to the Belle of Baker and Mammoth, and include the Bald mountain, and Grand Trunk mines. It is commonly assumed that a single lode extends the entire distance, and though considerable work has been done along the belt and outcrops are locally persistent, the diverse character of the ore at these mines hardly warrants the assumption.

The Ibex vein is extensively developed over a distance of 3,000 feet and to a maximum depth of 500 feet below the outcrop, by three tunnels from the surface and an intermediate level. The total amount of underground work is about 7,200 feet, of which about 3,800 feet or most of the upper tunnels, were driven prior to 1900. Since 1912 the lower or pyrites tunnel has been extended 2,000 feet. There is, however, no record of production.

The vein, which trends N. 65° E. and dips 72° southeast, crops out prominently near the mine as a reef of argillite breccia cemented by quartz. The argillite is dominantly dark, dense and carbonaceous and observations on the bedding in the lower tunnels deviate in strike but little from N. 60° W. but in dip range from 20° to 50° southwest. These observations indicate a broad crumpling of the beds on the flank of a major fold. A single dike of a green porphyritic rock occurs in the pyrites tunnel and though the vein is displaced 30 feet along one wall of the dike, the continuation, bearing ore, cuts it, so that the dike is pre-mineral and the faulting post-mineral. Toward the northeast end of the mine, the fissure reaches a maximum width of 25 feet but over most of the explored distance averages 5 feet. At the widest part, it contains several quartzose lenses separated by zones of sheared argillite which is rarely bleached and probably but slightly altered, a feature which contrasts strongly with most of the similar veins of the region. The best ore tends to occur in the quartzose lenses adjacent to the hanging-wall and the character of these is only apparent upon close scrutiny. Considered casually, the quartz is mottled gray of several shades and contains angular gray fragments that are obviously silicified argillite, locally surrounded by a zone of

comb quartz. Under the microscope, many of the other gray patches are roughly angular, and though all trace of elastic character is gone, disseminated black dust remains that is apparently carbon retained from the argillite. Some of these contain minute crystals of a metallic mineral that may be an arsenopyrite. With further examination, poorly defined zones may be recognized in the quartzose lenses that are composed of angular fragments of each of the foregoing materials cemented again by comb quartz. Sufficient evidence was obtained to show clearly that this structure indicates two periods of crushing and cementation by quartz. The portion of the volume of the quartzose lenses that was originally occupied by argillite fragments varies greatly from place to place and is locally difficult to estimate, but there is little doubt that it was considerable throughout.

Other than small amounts of pyrite in the zones of sheared argillite, the proportion of sulphide minerals in the vein is low, at no place being over one per cent. Schwartzite, or mercurial gray copper, is predominant and occurs as disseminated grains, having little, if any definite relation to the textural features. Pyrite occurs both as minute crystals in the quartz and as rounded grains in the center of the grains of schwartzite in such a manner as to indicate that this mineral partially replaces pyrite. Cinnabar was observed on cracks at several places below the zone of oxidation and as suggested by Lindgren, appears to be secondary. At one place on the second level, minute crystals of marcasite are associated with cinnabar. Pyrargyrite also forms films on fractures. Native silver is common and is reported 100 feet below the limit of the zone of oxidation. Native gold is reported under similar conditions.

As the vein has only been explored by drifts and raises and no ore has been stoped, the limits of shoots are not known. Other than the quartzose lenses in the eastern end of the mine that are regarded as ore, there is also the so-called "boulder" shoot which has been opened on two levels. This is composed of roughly rounded masses of quartz in dark gouge that is sheared carbonaceous argillite. Assays of samples systematically taken throughout the mine show a wide variation in the ratio of silver to gold and in the amount of these metals. In most of the assays silver is greatly in excess and in one block the average ratio of silver to gold is 30 to 1, by weight. Blocks are estimated to range in value from \$3 to \$6 to the ton, though there is much material of lower grade in the vein.

The zone of oxidation extends about 100 feet below the surface

and manganese oxides are present both on the walls and in crosscuts in the argillite. Recently deposited films of manganese and iron oxides occur throughout the lower tunnel.

From the textural relations of the minerals and their distribution with reference to the limits of the zone of oxidation, it is highly probable that the cinnabar, marcasite, pyrrargyrite in part at least, native silver and possibly part of the gold, have been formed by downward enrichment following the weathering of the superficial zone. The mercurial gray copper, schwartzite, appears to have been the last of the minerals of deep seated origin to be deposited.

*Bald Mountain mine.*—This mine is situated on a broad spur from the ridge east of the Ibex, which separates the waters of McCully's Fork from Deep creek. A mill was erected in 1900 which ran for four months in 1901. The mine was then closed down and except for desultory prospecting in deep crosscut tunnels, no work has been done since. The main work from the shaft was inaccessible in 1914.

*Grand Trunk mine.*—This mine explores for 1,200 feet a vein whose croppings are prominent on the ridge east of McCully's Fork. It is reported that no work has been done on it since 1900.

*Belle of Baker mine.*—The Mammoth Mining Company is the present owner of the Belle of Baker and old Mammoth mines on the divide between McCully's Fork and Silver creek. The latter has been abandoned since about 1902 and the workings are not accessible. On the former there is a 400-foot shaft with drifts at four levels, aggregating about 2,000 feet. Since 1909 work has been confined to the two upper levels, the lower levels being filled with water.

Though a gap of several hundred feet exists between the workings of the Mammoth and Belle of Baker mines, the two appear to explore the same vein. The vein outcrops in granodiorite but argillite locally forms the hanging-wall in the Belle of Baker workings. The outcrop of the explored parts of the vein lies within an area of glaciation and the zone of oxidation is less than 100 feet deep.

In the Belle of Baker mine, the vein has been explored for a maximum distance of 700 feet on the 100-foot level, and trends N. 45° E. with a dip of 68° southeast. On this level a shoot 400 feet long has been stoped to the surface, though on the 200-foot level the length is about 120 feet. The vein attains a maximum width of 35 feet on the 100-foot level but is pinched on the northeast and splits on the southwest end. A hanging-wall fork from the vein known as the "Shoestring," has locally been the source of some rich ore. The main vein

consists of alternating zones of gouge, sheared argillite and lenses of silicified argillite breccia, that are highly irregular and non-persistent. The gouge seams are dominantly sericitized masses of crushed granodiorite and contain pyrite, but little gold. In contrast with most of the other argillite breccias of the region, the zone of comb quartz crystals is thin and the cement is dolomite. An extremely interesting feature of the vein is the narrow zones of rich gold-bearing quartz with which roscoelite is associated. These are highly silicified argillite breccia, and the gold is generally uniformly disseminated as ragged wires in the quartz though as noted by Lindgren\* it also occurs adjacent to small blotches of roscoelite, and on secondary fractures. Textural evidence shows that the roscoelite in part replaces argillite. All that can be stated of the relation of gold and roscoelite at this mine is that the two are rarely in contact, though gold-bearing quartz is usually adjacent or near to zones showing roscoelite. Where associated, both minerals have relations indicating that they were primary constituents of the vein. Pyrite and arsenopyrite are conspicuous in the concentrates, although these do not exceed a few per cent in the ore. The average grade of the ore is low, but small lenses often yield several hundred pounds of ore worth from \$10 to \$50 per pound.

Manganese oxide is present in the superficial zone, but available data do not warrant any statement of the influence of downward enrichment.

#### CABLE COVE DISTRICT

*Imperial mine.*—The property of the Imperial Mining & Development Company comprises several claims situated in Cable Cove district at 6,500 to 7,700 feet elevation on a glaciated slope south of the divide between Silver creek and North Fork of John Day river. The property includes the Eagle, Imperial, Winchester, and some other veins.

Although the Cable Cove veins were known as early as 1872, it was not until the completion of the overland railroad in 1885 that the district was seriously exploited. During 1900, when Mr. Lindgren made his examination, development "was in progress upon a great number of claims and about 10 carloads of ore were shipped to smelting works."

Soon after 1900 a mill was built which was supplanted by a new one in 1909 and milling operations continued intermittently up to

\*Loc. cit., p. 625.

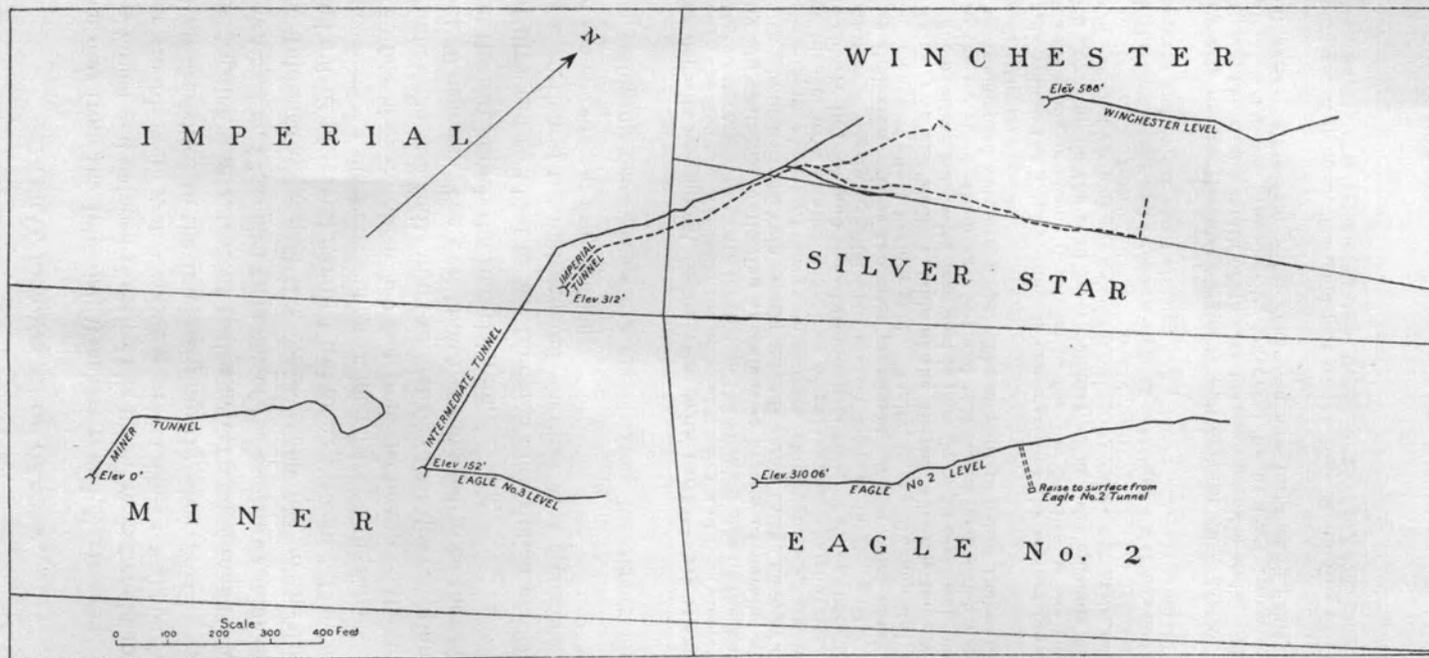


Fig. 27. Plan of the Imperial Mine.

1910 on ores from the Imperial, Winchester, and Eagle veins. Crude ore was mined and shipped to Salt Lake by F. W. Schofield in 1914. Smelter records were seen showing a production of \$50,500 in gold and silver accredited to the Imperial property since 1904.

The location and extent of the principal underground workings are shown by Fig. 27, copied from one of the company's mine maps.

The Intermediate tunnel is a crosscut 500 feet to the Imperial vein and a drift of several hundred feet along the vein. The Imperial tunnel comprises a short crosscut and a long drift on the same vein at a level 152 feet higher. About 550 feet from the mouth of the intermediate tunnel, the vein splits into two branches that diverge at an angle of about 20 degrees. The west branch is supposed to be the Winchester, and the east branch the Imperial vein.

But little can be added to Mr. Lindgren's description of the veins, as only a portion of the underground workings were accessible at the time of the more recent examination.

The following descriptions are quoted from his report made in 1900.\*

"The deposits are normal fissure veins with northeasterly strike. One strong lode, the Eagle, is traceable for at least 2 miles, and dips steeply northwest. Most of the other veins are located on the hanging side of the Eagle and generally dip southeast, following an extensive system of parallel shearing planes. One branch of the vein system extends across to the head of Cracker Creek. The ores consist of heavy sulphurets, chiefly pyrite, arsenopyrite, and zinc blende, with smaller quantities of galena and chalcopyrite. Their value is chiefly in gold, and very little of it is free. Two or three miles to the northwest a nearly parallel vein system appears in the gneiss, among which La Belleview vein is the most prominent. These veins carry a considerable amount of silver besides gold. Finally, in the Monumental, beyond La Belleview vein and really outside of the district, silver is the prevailing metal. The oxidized zone with free gold is only 30 to 50 feet deep, no doubt owing to the ice sheet which once covered this region and which has swept away the decomposed vein croppings. The sulphurets below the water level contain a little free gold.

"Eagle vein.—The Eagle, which is considered as the mother lode of the district, continuing in strong development for 2 or 3 miles, is the first vein met with going up on the road from Sumpter. The developments and production of the Eagle are as yet comparatively very small, but great hopes are placed in it for the future. It is traceable with a north-northeast strike through the Homestake and Oregon Chief. The Oregon Chief has 800 feet of developments and an ore shoot claimed to be 8 feet wide and containing \$12 per ton.

"The vein on the Hereulean claim is well exposed by a surface cut at Silver Creek, showing a width of 15 feet between granitic walls. The vein material is an altered granodiorite, traversed by at least two streaks of arsenical pyrite half a foot wide. The vein now turns more nearly north-

\* Lindgren, Waldemar, *The gold belt of the Blue Mountains of Oregon*; U. S. Geol. Survey, Twenty-second Ann. Rept., pt. 2, p. 673-675, 1901.

east, and on the adjoining claim, the Black Dwarf, preparations were made in 1900 to sink a 300-foot shaft.

"On the northwest side of Silver Creek the Herculean is covered by the Eagle claim, on which a 400-foot tunnel has been driven. In a width of 15 feet of altered granite the vein here contains overlapping pay streaks from 2 to 3 feet wide, reported to average something like \$12 per ton.

"Imperial mine.—The Eagle Consolidated Mining Company owns mine claims in the district, among them the Eagle, Imperial, and Winchester. The latter two have been actively worked during the last two or three years. In 1900, 160 tons of ore, with a value of \$120 per ton, is reported to have been shipped. The developments consist of 1,500 feet of tunnels. The present working tunnel is located one-fourth mile northeast of the old California mill, at an elevation of about 7,200 feet, 250 feet below the gap. Several hundred feet of additional backs can be obtained by a lower tunnel about 1,500 feet long.

"The claims are located on veins in the hanging of the Eagle lode, which is about 800 feet distant. Northwestward from the Eagle a small vein called the Star is the first met with; then follows the Imperial, and a short distance farther the Winchester. Granodiorite is the country rock in which the inconspicuous croppings appear. The strike is N. 35° E; the dip of the Imperial 70° SE., while the Winchester is nearly vertical. The veins are from 3 to 4 feet wide, the vein matter consisting largely of granodiorite slightly crushed and darkened by the spreading of chloritic material. The pay streak is usually on the hanging wall and consists of from a few inches to a foot of nearly massive sulphurets with a small quantity of quartz and calcite gangue. Surrounding the pay streak is a belt of a few inches wide of white, soft granodiorite, thoroughly sericitized and carbonatized. Seams striking in a northerly direction and dipping 70° W. come in on the Winchester from the hanging wall, but do not cut back into the foot wall. They carry circulating water and sometimes contain a little quartz and altered granodiorite. Both vein walls and seams show a horizontal striation.

"The ore, most of which is high grade, occurs in irregular and overlapping lenses. The seams mentioned generally cut off the ore, the latter usually reappearing a few feet farther on. Material with over \$25 per ton is shipping ore. The 160 tons shipped in 1900 are stated by Mr. F. C. Cabell to have contained as high as 6 ounces of gold and 80 ounces of silver per ton. While the principal values are thus found in narrow streaks of rich ore, there are also in places, especially in the Imperial, smaller shoots, a few feet wide, of second-class concentrating ore. The stopes above the tunnel level are 150 feet high.

"The ore minerals are galena, arsenopyrite, chalcopyrite, and pyrite, with a little zinc blende. The galena appears to be the earliest mineral and is often cemented by the others. Massive structure prevails. These sulphurets contain a little free gold, apparently chiefly connected with the galena and the zinc blende. About 10 per cent of the total gold can be recovered by amalgamation. Some nearly pure galena was assayed and contained 0.74 ounce gold and 60.86 ounces silver per ton. The arsenopyrite contained 5.82 ounces gold and 7.08 ounces silver per ton."

Between the Intermediate and Imperial tunnels and above the latter massive sulphide ore occurs in lenses that approach circular form and range from 10 to 50 feet in greatest dimension and from a thickness of 2 inches near their edges to from 8 to 24 inches near their center. Several lenses are grouped to form irregular shoots of which the principal one extends from the Intermediate tunnel at a point about 1,000 feet from its mouth to the Imperial tunnel and above.

It pitches steeply southwest and widens upward. Portions of the vein not occupied by the lenses are filled with granodiorite partially or wholly altered to a mass of sericite, quartz, and calcite in which small amounts of sulphide occur. In places a similar alteration and mineralization extends into the walls a foot or more. Manganese stains were observed above the Imperial tunnel level. According to Mr. F. W. Schofield the assay value of the lenses varies considerably from place to place within them. Representative specimens of sulphide ore from the Imperial tunnel consist of arsenopyrite, galena, zinc blende, and chalcopyrite in variable proportions, with, however, the arsenopyrite in excess, its average ratio to the other sulphides combined being not less than 5 to 1. The minerals enumerated occur, for the most part, in coarse interlocking crystals, but in places banded structure is shown. Quartz is the chief gangue mineral and together with the sulphide minerals appears to have replaced granodiorite in addition to filling open fractures. Calcite occurs in small fractures that traverse the ore and appears to have been the latest mineral deposited. The average ratio of gold to silver by weight in the ores shipped to smelters from 1904 to 1914 is as 1 to 9.

That milling operations have not been successful is, in part at least, because the ores can not be concentrated by ordinary methods to a high grade product. Concentrates produced from 1904 to 1907 averaged \$28.60 to the ton. Ore shipments consisting of almost pure sulphide, averaged, during the same period, about \$32.70 to the ton and in 1914 about \$22.00 to the ton.

*Last Chance mine.*—The vein system of Cable Cove extends from Silver creek northeastward across the divide into the basin at the head of North Fork of John Day river. In a compact area of about 4 square miles more than 50 patented and unpatented mining claims are located on fractures that cut the granodiorite in a general northeast-southwest direction. Except at the Last Chance, which was being developed to a moderate extent, little work beyond that required for annual representation was being done on the North Fork slope in 1914. The Last Chance claim, which is the property of the Blue Mountain Mining Company, is situated near the summit about half a mile northeast of the Imperial mine. The principal development on this claim is an adit level 450 feet long at an elevation of 7,300 feet, driven on a vein supposed to be the continuation to the northeastward of the Winchester vein. The company is testing the ore from the Last Chance vein in a small plant equipped with a Huntington

mill, plate, Wilfley table, and two vanners. The ore milled has ranged from \$7 to \$10 to the ton, chiefly in gold, and has been concentrated in the ratio of about 10 to 1. About 50 cents to the ton is extracted by amalgamation and 34 tons of concentrates of a total value of about \$2,000 have been produced since 1911. The concentrates said to be richest in gold are those produced by the Wilfley table and which contain relatively the largest proportion of galena.

The average strike and dip of the vein is N. 50° E. and 80° S. E., respectively. Its walls are smooth, gouge-lined, and spaced from 1 to 2 feet apart throughout most of the workings, although locally they are in contact. At the face of the main level the vein is cut off by a N. 45° W. fault fissure that contains 4 feet of unoxidized granodiorite breccia. The vein filling consists of altered granodiorite mineralized chiefly with arsenopyrite and subordinately with zinc blende, galena, and an unidentified copper sulphide together with their oxidation products. Manganese stains were observed in several places. A stope 40 feet in length, beginning at a point about 350 feet from the mouth of the level, is made on a partly oxidized ore shoot that ranges from 2 to 18 inches in thickness. In its least altered portions, the ore consists of banded quartz containing arsenopyrite in considerable percentage and small proportions of other sulphides. A shorter but otherwise similar ore shoot is opened above the level at a point about 135 feet from its mouth.

#### GRANITE DISTRICT

*Cougar mine.*—This is the southernmost of a group of mines along a persistent group of veins that extend several miles to the northeast from a point about 3 miles due north of Granite. They trend northeast and, with several exceptions, dip southeast, and though possessing some features in common, they differ appreciably in mineralogy and in details of vein structure. It is doubtful whether any two of the mines are located on the same fissure.

In addition to the mill tunnel 1,200 feet long, and upper work, described by Lindgren in 1900, a new tunnel 500 feet long and 100 feet lower than this work, has been run. Though the greater portion of the lower two tunnels is accessible, little of the vein can be seen and no authentic detailed information of the value of the ore is available. A small production is reported as recently as 1909.

The outcrop of the vein, though not conspicuous, is marked by a number of tunnels, shallow pits, and shafts for a distance of 1,800

feet, throughout which it strikes N. 45° E. and dips 80°-85° to the southeast. There is no local record of the yield of the considerable superficial portion of the vein which has been removed. The material adjacent to the walls and much of the vein-filling is a loosely coherent mass composed of small angular fragments of carbonaceous argillite showing little alteration, though crosscuts show firm, dark siliceous argillite with northwest strike and dip of 75° to 85° to the southwest. Where the argillite contains pyrite and numerous small veinlets of quartz, it is regarded as ore. The vein contains zones of light gouge that is also poor in quartz, a feature that may be regarded as characteristic. In comparison with most of the veins with similar associations, the Cougar does not appear to contain the breccia of silicified argillite cemented by comb quartz, and the sulphide minerals other than pyrite, appear to be notably absent. At several places on the mill tunnel level, narrow decomposed dikes and gouge-bearing fractures in the southeast or hanging-wall are cut off and in one instance appreciably dragged along the course of the vein. The relations indicate that the northwest or foot-wall has moved northeast. The character of the vein filling suggests that a portion of this movement may have been post-mineral.

The mill tunnel explores the vein for a distance of 1100 feet, and though there is a stope above this level, neither its extent nor the distribution of gold and silver in the vein, generally is known. A report made for the company in 1902 contains an estimate of a considerable tonnage of ore valued at \$6.85 per ton, of which a portion in a shoot 140 feet long and 85 feet high above the mill tunnel, is estimated at \$13.71 per ton.

Original oxidation was noted to a depth of 200 feet below the surface but the zone is very irregular. Manganese oxide is present but not abundant.

*Independence mine.*—A mile northeast of the Cougar and on the north slope of the ridge cut by the Cougar vein, lies the Independence mine, also in argillite. The early history of the mine is obscure, though it has been worked within the last few years, and a small production was reported in 1907. The workings comprise two tunnels, an upper 250 feet long, a lower 1020 feet long, and a shaft 210 feet deep, intersecting the second tunnel 440 feet from its portal. A portion of the longer tunnel, wholly in the oxidized zone, was accessible in 1914.

The vein is explored for about 1100 feet along the strike, N. 50° E., and to a depth of 190 feet below the outcrop. The vein dips 65° S. E. Two shoots, 320 feet and 120 feet long, having average widths

of 3 and 2.8 feet respectively, have been developed. The first of these has been stoped to a height of 60 feet above the tunnel, and is known 100 feet lower in a drift from the shaft. In the accessible workings the vein, which contains only a meagre amount of quartz, is composed of sheared argillite and gouge much stained with limonite. Unoxidized ore from the 100-foot level shows altered argillite breccia cemented by dense dolomite with minor quartz. Locally, a breccia of both minerals is cemented by chalcedonic silica. Pyrite and arsenopyrite were observed both in the argillite fragments and in the cement, although tetrahedrite and pyrargyrite appear to be confined to dolomite. Faint stains of proustite occur on fractures. The total content of sulphide minerals does not exceed a few per cent. In the oxidized zone, manganese stains are abundant, both on the walls and in the vein mineral.

According to Mr. Walter Gleason, an owner, the average of a number of assays in the oxidized zone of the longer shoot is 2.66 ounces silver and .43 ounces gold per ton, and in the unoxidized ore, 100 feet lower, the average is 9.3 ounces silver and 1.06 ounces gold. These averages indicate a ratio of silver to gold in oxidized ore of 6 to 1, compared with 9 to 1 below, as well as considerable increase in the value of the ore. The associations of the rich silver minerals strongly suggest that this increase in value is to be attributed to downward enrichment, following the weathering and erosion of the superficial portion of the vein. The extent of exploration on the vein, however, does not warrant a statement of the extent to which ore has been enriched by this process.

Several light decomposed dikes, 2 to 4 feet wide, with southeast courses, have been found in both walls. These terminate against the vein and indicate that it fills a fault fissure, although the amount of displacement has not been determined.

The attempt made in a mill on Granite creek to extract the gold and silver from this ore by an adaptation of the cyanide process is reported to have been unsuccessful.

*Magnolia mine.*—Comparing the present condition of this mine with the description given by Lindgren in 1900, it appears that the only work since then has been the extension of the lower tunnel about 200 feet, though the middle and upper tunnels are not accessible. According to reports, the last work was done in 1904. The tunnels extend northeast along the vein from Lucas gulch, a tributary of Granite creek. A small production is reported.

The vein strikes N. 50° E. and dips 65° southeast cutting dark siliceous argillite, whose bedding strikes northwest and dips steeply southwest. Within the explored portion of the vein, 960 feet, there are three stopes, 205, 155 and 25 feet long respectively. The walls are not continuous between the first two and as the middle shoot terminates on the southwest against a slip, it is possible that the three shoots are not on the same fissure. Near the face of the tunnel the vein is offset 16 feet to the north along a crushed zone.

Much of the material constituting the vein is soft altered argillite with a small per cent of pyrite, but there are also lenses of highly silicified argillite breccia. In this material the sulphide minerals, pyrite and arsenopyrite, are confined to the argillite fragments, though marcasite occurs along secondary fractures. The maximum thickness of the longest shoot is 8 feet, but through the greater portion it averages 4 feet. The ore is reported to be low in grade and the saving in previous milling operations has been poor.

The limit of the zone of oxidation could not be determined and recently-formed manganese oxides were not noted underground.

*Ajax mine.*—The Ajax mine is in Lucas gulch several hundred feet below the Magnolia and explores a parallel vein. The workings include two tunnels, a lower extending 280 feet northeast and an upper, 112 feet above it and about 500 feet long. A small production from a shoot 90 feet long in the upper tunnel, now inaccessible, is reported over the period 1905-1906.

The lower tunnel follows a gouge-filled fissure for 280 feet but the shoot has not been encountered. The material on the dumps resembles that from the Magnolia vein. Manganese oxide was noted along secondary fractures and is reported to have been common in the upper tunnel.

*Buffalo-Monitor mine.*—The veins explored by this mine cross the ridge at the head of Chipman gulch, a tributary of Granite creek, 5 miles north of the town of Granite. The principal period of activity was from 1906 to 1909, and a total production of about \$70,000 is estimated.

The developments are two crosscut tunnels which with drifts, aggregate about 2600 feet. They explore four essentially parallel veins to a maximum depth below the outcrop of 500 feet. A sketch plan of the upper tunnel made by compass traverse is presented in Fig. 28. The productive portions of the veins lie in dense siliceous argillite, though the most eastern enters granodiorite on the south.

Oxidation products were not noted 100 feet below the surface, and manganese oxide was not observed.

The western vein of the group, known as the Monitor, is a broad zone of altered argillite breccia, with here and there a quartz stringer. It attains a width of 45 feet on the lower level where it has been meagrely explored and contains but little gold and silver. The production has come from the Buffalo, Nos. 1, 2 and 3 veins explored in the upper tunnel. These veins trend N. 25° to 30° E. and dip 65° to 75° W., cutting the bedding of the argillite which strikes N. 30° to 40° E. and dips 45° southwest. On each of these veins a single shoot has been developed, the more important on the Buffalo No. 1 vein being stoped for a distance of 300 feet and to a height above the level of 90 feet.

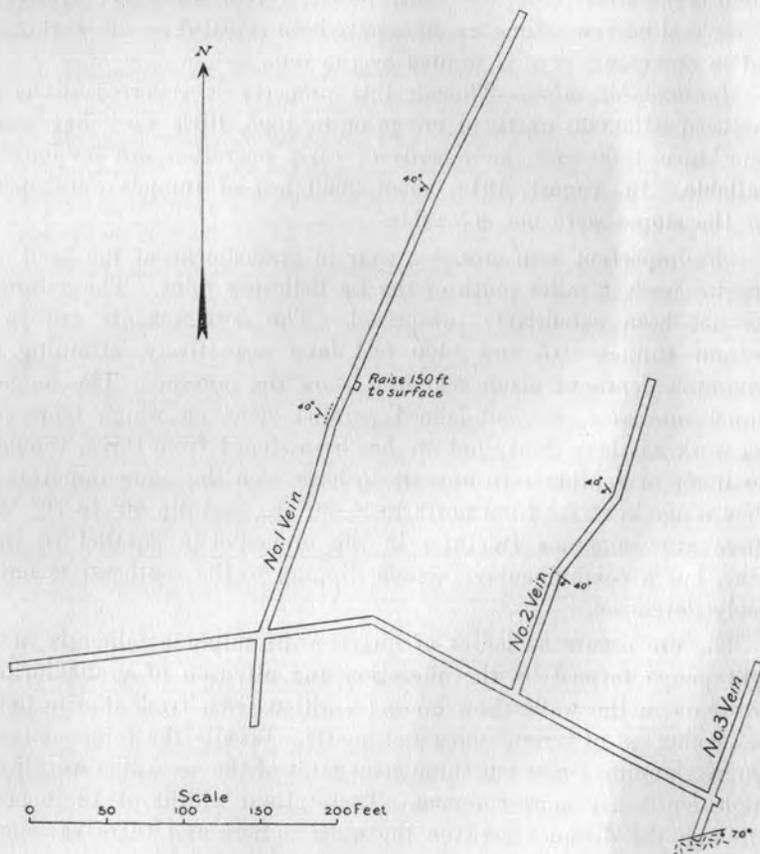


Fig 28. Sketch Map of Buffalo Tunnel.

So far as accessible, these three veins are essentially similar. They are composed of zones of argillite breccia and associated gouge in which the fragments are partially silicified as well as cemented by radial aggregates of quartz crystals. The sulphide minerals in order of abundance are pyrite, galena, argentiferous tetrahedrite, and chalcopyrite, but except in pockets in which galena is dominant, these rarely exceed a few per cent. Stibnite is reported. The relations indicate a contemporaneous origin for these minerals. Ore rich in galena has been known to contain 35 ounces of gold to the ton, but much of the ore that has been shipped contained about 2.5 ounces gold and 40 ounces silver to the ton. The vein in the main shoot of the No. 1 vein attains a width of 30 inches, averaging in the stope, 15 to 18 inches. In comparison with most of the veins of the region, which break freely from the walls, the No. 1 vein is locally "frozen."

Several narrow pegmatite dikes have been revealed by the workings and in one case a dike is faulted by the vein.

*Monumental mine.*—Though this property is reported to have produced \$100,000 worth of ore prior to 1895, little work has been done since 1900 and the records of early operation are no longer available. In August, 1914, about 3000 feet of tunnels were open but the stopes were not accessible.

The important vein crosses a spur in granodiorite at the head of Granite creek, 2 miles south of the La Belleview mine. The outcrop has not been extensively prospected. The developments are two crosscut tunnels 215 and 1400 feet long respectively, attaining a maximum depth of about 600 feet below the outcrop. The longer tunnel intersects six well-defined parallel veins on which more or less work has been done, and ore has been stoped from three, though the inner or southeastern appears to have been the more important. They range in strike from north to N. 30° E., and dip 60° to 70° W. There are numerous fractures in the granodiorite parallel to the veins, but a complimentary system dipping to the southeast is only feebly developed.

The ore occurs as lenses of quartz with sulphide minerals in a light gouge formed by the alteration and attrition of granodiorite. Crosscuts in the walls show every transition from fresh diorite to a rock composed of sericite-mica and quartz. Locally the veins contain two overlapping lenses but throughout most of the accessible workings single lenses are more common. These attain widths of 18 inches, although the distance between the walls is here and there as much

as five feet. The more important shoots were not completely accessible, but two others on an intermediate vein were 30 and 100 feet long respectively.

The ore now found around the mine and mill contains a high percentage of pyrite, arsenopyrite, blende, argentiferous tetrahedrite, and galena, in approximately the proportions of 100 : 20 : 10 : 5 : 1. These minerals occur in quartz that has been formed by the replacement of granodiorite. The richer ore contains silver minerals, of which pyrargyrite and proustite were identified. Though the tetrahedrite appears to be a mineral of primary deposition, the proustite and much of the pyrargyrite occur on cracks and under other associations indicating secondary origin. The depth to which these minerals were encountered is not definitely known, but they are reported from the lower tunnel.

The zone of oxidation attained at one point a depth of 200 feet below the outcrop. Manganese oxides were not found in any of the veins.

The gravels of Granite creek have been extensively washed to within a mile of the Monumental mine, and as only local rock types were noted, a local rather than distant origin is indicated. It seems highly probable that the gold was derived from small veins in the granodiorite, a number of which outcrop prominently on the bare north slopes of Granite gulch. These veins, which seldom exceed a few inches in width, are rich in their superficial oxidized zones, as is attested by numerous exploratory tunnels and shallow shafts near the stream. None of these, however, appear to have found material of sufficient grade to warrant mining.

*La Belleview mine.*—This mine lies within the area of highly metamorphosed argillite that lies along the prominent north spur from Bald mountain. The mine workings extend from the top of the ridge, southwest into the ravine, forming the north fork of Onion creek. Little work has been done since 1907 and the workings on the vein are now inaccessible. This description is based upon an examination of the surface and notes left by the owner, F. E. Cabell, after his death in 1912. Mrs. Cabell permitted the examination of a collection of specimens taken during the operation of the mine.

Quartz biotite schist, in which persistent laminae of biotite separate quartzose bands one-quarter to an inch wide, forms the walls of the vein. The vein trends N. 50° E. and dips northwest. Two types of ore are recognized. The commonest shows rudely alternating

quartzose zones, rich and poor in sulphide minerals, with here and there a lenticular vug. In the richer zones the sulphide minerals, pyrite, arsenopyrite, blende and galena are coarsely crystalline and though dominantly intermixed, are locally in bands. Chalcopyrite and pyrrhotite are sparingly present. In the poorest zones the pyrite is dense and the other sulphides are only sporadically present. The second type of ore shows angular nuclei which may be recognized as mica-schist fragments, more or less replaced by quartz and pyrite, inclosed in masses of quartz crystals, radially arranged. The richer ore shows argentiferous tetrahedrite, probably in primary intergrowth with pyrite and quartz pyrargyrite, possibly proustite, and native silver occur as films along fractures.

According to Mr. Cabell's data, three tunnels contain an aggregate of 6000 feet of work on the vein, over a vertical range of about 600 feet. The vein was opened for a distance of 1800 feet in addition to 600 feet explored in the Wide West claim, which adjoins the La Belleview on the southwest. Within this distance two shoots were found, the larger of which attained a stope length of 280 feet. The lower portion of this shoot yielded material containing 0.40 ounces gold and 15 ounces silver to the ton.

The total production up to 1911 including ore shipped elsewhere or milled in the mill on Onion creek, amounted to 8000 tons, having a gross value of \$200,000. Concentrates averaged 1.20 ounces gold and 55 ounces silver to the ton, and shipping ore was worth \$60 to \$300 to the ton.

*Red Boy mine.*—The most important period of activity of this mine covers the decade 1893 to 1903, though there has been considerable development and from time to time a small production until August, 1914, when the pumps were drawn from the shaft. The successive operators have been Taber and Godfrey, the Red Boy Consolidated Gold Mines Company, and more recently the Red Boy Mines Company. The following estimate of production is submitted by the Company.

Discovery, 1890, to July 1, 1898, estimated 13,600 tons.....	\$150,000.00
July 1st, 1898, to Jan. 1, 1899.....)	64,594.22
1899.....)	135,703.84
1900.....)	186,401.73
1901.....)	129,622.31
1902.....)	55,307.95
1903.....)	31,199.28
1908-1910, estimated.....)	10,000.00
1911.....)	10,408.40
1912.....)	4,612.93
Total.....)	\$777,850.66



and raises have been run, the workings have scarcely attained an increase in depth of 300 feet. A large part of the development has been devoted to the Blaine and Concord veins, west of the Red Boy and Monarch veins. Unfortunately, only the Blacksmith tunnel and superficial workings were accessible in the latter part of August, 1914.

The following description of the underground conditions is given by Lindgren,\*

"The country rock is a black argillite, not very fissile, but showing its stratification fairly plainly. The strata are here unusually flat, dipping about 15° W. The argillite, which changes in character from siliceous to calcareous, is in many places cut by light-gray extremely altered porphyritic dikes, which have the appearance of cutting across the vein and faulting it. It is believed, however, that the veins are really later than the dikes, that the fissures in crossing them were, as often happens, split up in stringers; and that a subsequent movement has occurred along the walls of many of the dikes, so that the veins now appear dislocated by them. The dikes are greatly altered and their original character is in doubt. Probably they were originally granite-porphyrries, but now consist chiefly of quartz, calcite and pyrite. Several of them are seen in the crosscut to the vein, one being 60 feet wide. \* \* \* The outcrops are not very prominent and the pay shoots not conspicuous on the surface. \* \* \* In their general character the veins are similar to those of Cracker creek, though they are not so wide. They consist of a crushed fault zone in argillite from 3 to 15 feet wide, in which the broken rock is cemented by a great number of quartz seams. The two veins converge slightly and nearly meet at a main porphyry dike dipping 60° S., along which they have been sharply cut off by a smooth fault. The veins have not yet been found beyond the dike, though from surface indications it is probable that the northern block has moved, relatively 400 feet to the east. A similar dike, 10 feet wide, faults the Monarch vein 10 feet through all the levels, the throw being in the same direction as that along the big fault. Another dike cuts across the Red Boy horizontally, and still another has produced a sharp twist of the vein in the same direction. \* \* \* The footwall of the Monarch vein is usually smooth and sharply defined, while the hanging is less well marked, a definite wall being often entirely absent. The width between walls varies from 5 to 7 feet. The vein matter is a black crushed slate and sometimes also, masses or bunches of soft porphyry, both containing finely divided pyrite. The vein matter is traversed by a number of small quartz seams, rarely over 4 inches wide. Most of the seams are on the footwall side and produce a banded appearance of the vein. The best pay is contained in the 2 feet on the footwall, though the whole width is mined. In a few places on the Monarch vein, bunches of 5 to 6 feet of solid quartz were found. The seams usually show clearly defined comb structure. \* \* \*

"The Red Boy vein averages from 3 to 6 feet in width and is in general structure similar to the Monarch, though the quartz is apt to form somewhat heavier bodies. It also contains more clay than the Monarch vein.

"The value of the ore appears to be entirely contained in the quartz seams and consists chiefly in free gold alloyed with much silver, the bullion being from 515 to 525 fine. The quartz contains a small amount of sulphides, pyrite with very little chalcopyrite, and arsenopyrite. In some parts of the mine cinnabar and native mercury have also been found. \* \* \* Metallic silver and copper have also been found on the Monarch vein, inclosed in white massive quartz and thus probably primary. The 5 per cent sulphurets contained in the ore are low grade, from \$5 to \$20 per ton, and probably

\*Loc. cit. p. 681.

are largely contained in the slate milled with the quartz. The average ore is reported to run about \$12 per ton."

In addition to the three veins, Red Boy, Monarch, and Blaine explored under the ownership of Tabor and Godfrey, the consolidation in 1902 included the Concord and Congo veins farther west. The Monarch vein has been explored for a distance of 900 feet and a single shoot 800 feet wide has yielded a large tonnage of ore. The vein strikes N. 30° E. and dips 50° to 55° northwest. The greatest length of exploration on the Red Boy is about 1000 feet and the shoot is 800 feet long. The strike is due north and dip 77° to 80° west. As shown on the map these two veins approach at depth and merge on their western extensions. Though explorations on the Monarch attain a depth of 285 feet below the Blacksmith tunnel, the Red Boy vein has not been definitely recognized in the lowest workings. Neither of the veins has been recognized beyond the dike which they meet south of their junction. According to data collected by the Company to January 1, 1902, the combined areas of the stopes on the Monarch and Red Boy veins was 437,500 square feet, and the yield 83,373 tons, indicating an average stoping width of 28 inches. The return from this tonnage was \$666,322.10 or \$8.00 to the ton. On the Chapman and lower level, 600 and 180 feet long respectively, no defined shoots of ore of milling grade have been found. Most of the work of the last few years has been devoted to the Blaine, Concord, and Congo veins, and although these are well defined and locally contain lenses of quartz, no shoots that would pay to mill have been found.

As the old stopes are no longer accessible, the extent of oxidation cannot be ascertained. According to Lindgren, there was no evidence of oxidation in the Monarch vein on the Blacksmith tunnel level, 470 feet below the outcrop. Manganese oxide stains were noted along the outcrop of the Red Boy vein where the slopes reach the surface.

It would not be wise on the slender basis of the information now available, to state definitely that the grade of ore in the shoots of the Monarch and Red Boy veins has been greatly affected by processes of superficial enrichment, though some features of the shoots indicate it. The shoots of both veins have a considerably greater stope length than height. The lower limit of each was essentially horizontal, and several hundred feet at least below the zone of oxidation. Both were overlain by a superficial zone in which no ore was found, though the character of vein filling here is not known.

Within a radius of a mile of the Red Boy mine there has been a great deal of prospecting, principally in the form of long exploratory crosscut tunnels in some of which veins have been found and small amounts of ore extracted. None appear to have maintained production over considerable periods, and many are so far abandoned that assessment work is not kept up.

The Blue Bird mine is developed by a crosscut tunnel 2500 feet long and some short drifts extending under the ridge northeast of the Red Boy mill. The tunnel was not accessible in 1914, but Mr. Walter Gleason, of Baker, states that during 1904 and 1905 about 1500 tons of ore yielding \$5000 was taken from a vein near the portal. The material on the dump shows a breccia of unaltered argillite cemented by comb quartz with minor amounts of pyrite and arsenopyrite.

#### GREENHORN DISTRICT

*Golden Gate mine.*—The Golden Gate Mining Company owns the group of claims including the Golden Gate and Belcher, situated along the west side of the high ridge extending north from Greenhorn. A 10-stamp mill is in process of erection near the mouth of the Belcher lower tunnel. Only a small amount of work has been done on the Golden Gate vein since 1900.

The Belcher vein is explored through two tunnels, an upper 800 feet long, now inaccessible, and a lower 1800 feet long, with 600 feet of crosscuts and raises. This tunnel follows the vein, which strikes N. 30° E., and dips 65° southeast, in slightly altered andesite for about 1400 feet to a fault 250 feet from the face. The fault, trending east and dipping 50° south, brings chert on the south side into contact with the andesite and is probably pre-mineral. The andesite is locally brecciated and is traversed by numerous joints parallel to the vein. It is probably a pre-Tertiary intrusive rock. The north end of the vein zone contains two lenses of quartz, 220 and 60 feet long respectively, with a maximum width of 20 inches of material reported to be low in grade. Farther south, the vein is not well defined, but is a zone of andesitic breccia, cemented by dolomite and minor quartz. The only sulphide mineral noted is marcasite which occurs only in the cement. The material is almost completely oxidized and a shoot 200 feet long with a maximum width of 42 inches is regarded as ore. One lot of 5 tons is reported to have yielded \$7.80 to the ton in gold. The shoot is completely oxidized on the

tunnel level, at a depth below the surface of 350 feet. Manganese oxides are common.

*Royal White mine.*—This mine is situated 2000 feet northeast of the Belcher tunnel, on the north end of the ridge overlooking Quartz gulch. It is of particular interest because intricate faulting is shown and the abundance of manganese oxides suggests that superficial enrichment has taken place.

The principal development is a tunnel which attains a maximum depth of 95 feet below the outcrop. A plan based on compass survey is shown in Fig. 30. The country rock is dense gray, thin-bedded chert, intricately fractured and locally plicated. The bedding trends east and the dominant dip is north, a structure which appears to antedate the fracture followed by the vein.

The vein fills a well-defined fracture, which strikes N. 40° E.

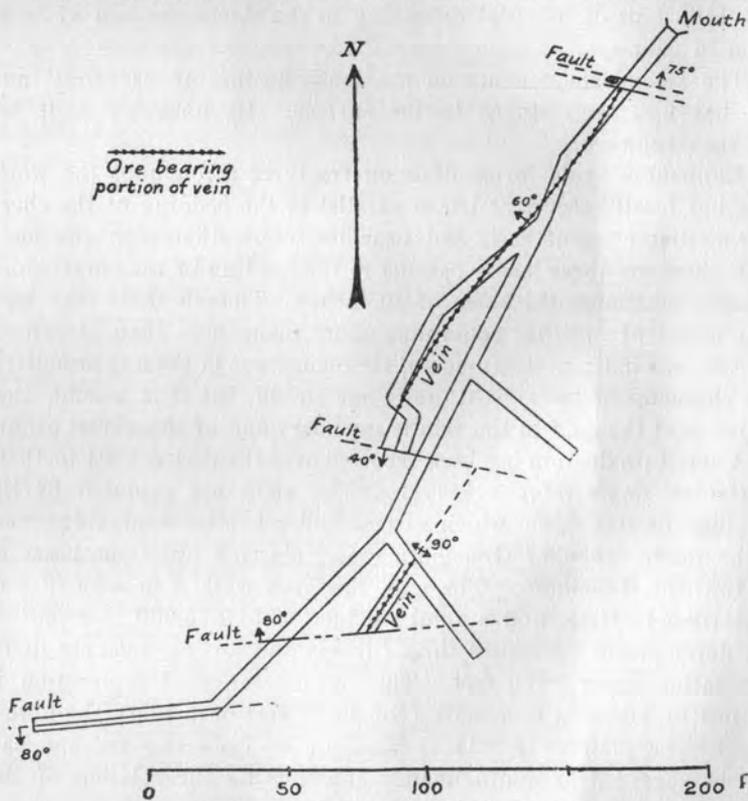


Fig. 30. Sketch Map of Royal White Tunnel.

and dips steeply west, and is composed of chert breccia cemented by dense cream-colored chalcedony, which in vugs is covered with a film of minute quartz crystals. No sulphide minerals have been noted in the vein, though iron and manganese oxides are common throughout the explorations. Two portions of the vein which range in width from 1 to 3 feet, have been worked; a northern 160 feet long, and a southern 30 feet long. The northern end of the longer shoot abuts against a crushed zone 5 feet wide and from this a 2-ton boulder is reported to have yielded \$400 in gold. On the southern end of this shoot, the hanging wall bends over and merges with a fracture trending northwest in such a manner as to indicate that it has been dragged during a post-mineral fault movement. This portion has been explored to the surface, and has yielded several hundred tons of sorted ore containing \$25 to \$28 a ton in gold. It is estimated that 1400 tons of material remaining in the stopes, contain \$7 to \$9 a ton in gold.

The second shoot abuts on the south against an east-west fault and has also been stoped to the surface. Its northern limit has not been explored.

Manganese oxide forms films on fractures throughout the workings, but locally occurs as lenses parallel to the bedding of the chert. In the first crosscut east, and near its intersection with the main drift, there are three lenses parallel to the bedding of the chert which attain a maximum thickness of 10 inches. Though these may have been lenses of argillite containing more manganese than elsewhere, the relations indicate that much of the manganese in them is secondary. The character of unoxidized ore is not known, but it is possible that a portion of the gold in the vein is secondary and of superficial origin.

A small production has been reported over the period 1904 to 1910.

*Golden Eagle mine.*—Several unique veins are explored by the workings of this mine, which extend under a prominent ridge west of the lower canon of Greenhorn creek, about 2 miles southeast of the town of Greenhorn. The mine has been worked in a small way from time to time, and a total production of \$75,000 is reported. The development comprises three tunnels and an intermediate drift, aggregating about 2600 feet. The vertical range of exploration is 175 feet, in addition to a shaft (No. 1) 75 feet deep below the lowest tunnel. The plan (Fig. 31) is based on compass traverse and can only be regarded as approximately representing the relation of the levels.

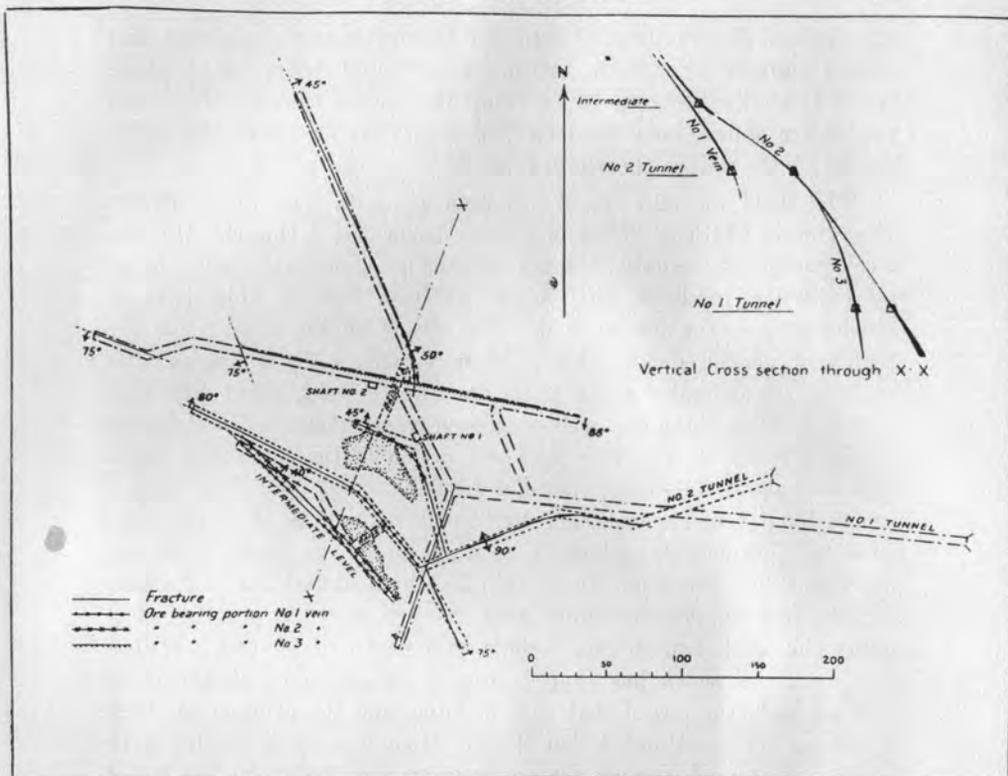


Fig. 31. Sketch Map of Golden Eagle Mine.

The country rock is serpentine derived from peridotite in which there are a number of large blocks of altered gabbro. Evidence elsewhere in the region indicates that the gabbro blocks were caught in the peridotite at the time of its intrusion. Altered gabbro is found only at one place underground. The workings explore a number of non-persistent fissures, three of which are ore-bearing and the others barren. At one place, an ore-bearing fissure terminates against a barren fissure in such a manner as to suggest that the latter is a post-mineral fault. Further consideration leads to the conclusion that all are contemporaneous, though there is other evidence of post-mineral movement. The barren fissures cut the serpentine in an irregular manner, but the three that have yielded ore form a branching system. Of these, No. 2 is the dominant fissure and has been explored almost continuously from the surface to a depth of 200 feet. It trends N. 30° W. to N. 60° W. and dips 40° to 50° northeast. No. 1,

a branch of No. 2, dropped into the footwall between the first and second tunnels, though it has not been found below this tunnel. No. 3 is similar, leaving No. 2 below the second tunnel. The most productive shoots have been on No. 1 and No. 2 above the intermediate level and on the No. 3 vein.

The shoot on vein No. 2 has been a quartz lens which attains a maximum width of 3 feet in a winze below No. 3 tunnel. On this level, the quartz contains a small amount of chalcopyrite and one of its oxidation products, chrysocolla. Fifteen tons of this material yielded \$22 to the ton in gold. The shoots on the other veins are lenses of coarse, cream-colored dolomite with a little galena that replaces the dolomite along small fractures. Gold, about 850 fine, occurs as films along one wall or fills cleavage cracks in the dolomite adjacent to the walls. Free gold is common in the superficial workings and above the No. 2 tunnel a single sheet of gold measuring 4 inches long, 3 inches wide, and half an inch thick, is reported. One showing considerable galena is usually higher in grade than the average. The shoot on No. 3 vein has been stoped for a distance of 130 feet on No. 3 tunnel level, as well as to a point 65 feet above the level, and in No. 2 shaft to a depth of 20 feet. Within this area, the width has ranged from a maximum of 18 inches to half an inch, the lowest that pays to mine, and the average has been 6 inches. It is estimated that the ore from this shoot yielded \$175 to the ton in gold, though the ore from an area 20 by 50 feet below the level yielded \$800 to the ton. A portion of the stope above the level, 35 by 65 feet, yielded \$35,000 in gold. None of the shoots have been found in the drifts from No. 1 shaft, which is 75 feet deep and now filled with water.

It is reported that the presence of manganese oxide, limonite or chrysocolla indicates ore of good grade. Dendritic films of manganese oxide were observed at a number of places in the lowest tunnel including the extreme limits of work and are common in the upper tunnels. Specimens from the face of the intermediate level show angular fragments of dolomite cemented by chalcedony and stained by numerous dendrites of manganese oxide.

The mine is not accessible below the lower limits of oxidation, but from textural evidence it is highly probable that a portion of the gold of the richer ore has been introduced through superficial enrichment.

*Listen Lake and Gold Bullion mines.*—Veins of a type not

observed elsewhere in the Sumpter quadrangle, are exhibited by these adjoining mines near the west end of McNamee gulch, south of Greenhorn. There is a shaft 120 feet deep on the former and numerous shallow shafts on the latter all of which are now filled with water. A small production is reported from the Listen Lake mine.

Both mines lie within an area of altered gabbro which intrudes the argillite series, and the veins bear some resemblance to the "chloritic subtype" of Lindgren,\* noted in the Iron Dyke deposit. At the Listen Lake mine, a silicified shear zone in the gabbro, reported to attain a width of 50 feet, has been crushed and small amounts of pyrite and chalcopryrite have been introduced along fractures. The material on the dump contains a few per cent of copper and is said to contain a fraction of an ounce of gold to the ton. The material from the Gold Bullion vein is less siliceous and more chloritic, sheared nodules rich in chalcopryrite and pyrite occurring in a dark-green chloritic gouge. Water stands within 10 feet of the surface in the shafts and the zone of oxidation is shallow.

#### BONANZA DISTRICT

*Bonanza mine.*—This famous mine is situated on a south spur from a high ridge that extends east from Greenhorn. The settlement of Geiser below the mine, is 8 miles northwest of Whitney. The early history of the mine is given by Lindgren.†

"The first location is said to have been made in 1877 by a pioneer prospector named Jack Haggard who sold it in 1879 for \$350 to the Bonanza Mining Company. In 1892, the mine was bought by Geiser brothers for a reported sum of \$3,000 and worked by them until 1898, when it was sold to the present owners, a Pittsburg, Pa., corporation for a price believed to have been \$500,000. The production before 1892 was inconsiderable though extending over a series of years. Geiser brothers are supposed to have taken out several hundred thousand dollars. When sold, \$300,000 was believed to be in sight. Since 1898 at least an equal amount has been extracted, making the total production well up toward the million-dollar mark."

After its purchase by the Consolidated Bonanza Gold Mines Company, the mine was vigorously exploited until December, 1904, when the pumps were drawn and the workings below the adit allowed to fill with water. The mine has been operated from time to time since that date, ore being drawn from the superficial workings, but at present only a small part of these is accessible.

\*Loc. cit. p. 631.

†Loc. cit. p. 700.

A vertical section of the mine showing the extent of work up to 1903 is presented in Fig. 32. Before work was stopped in the shaft in 1904, considerable work had been done on the 800, 1,000, 1,100 and 1,200 levels, to a depth of about 1,250 feet below the outcrop.

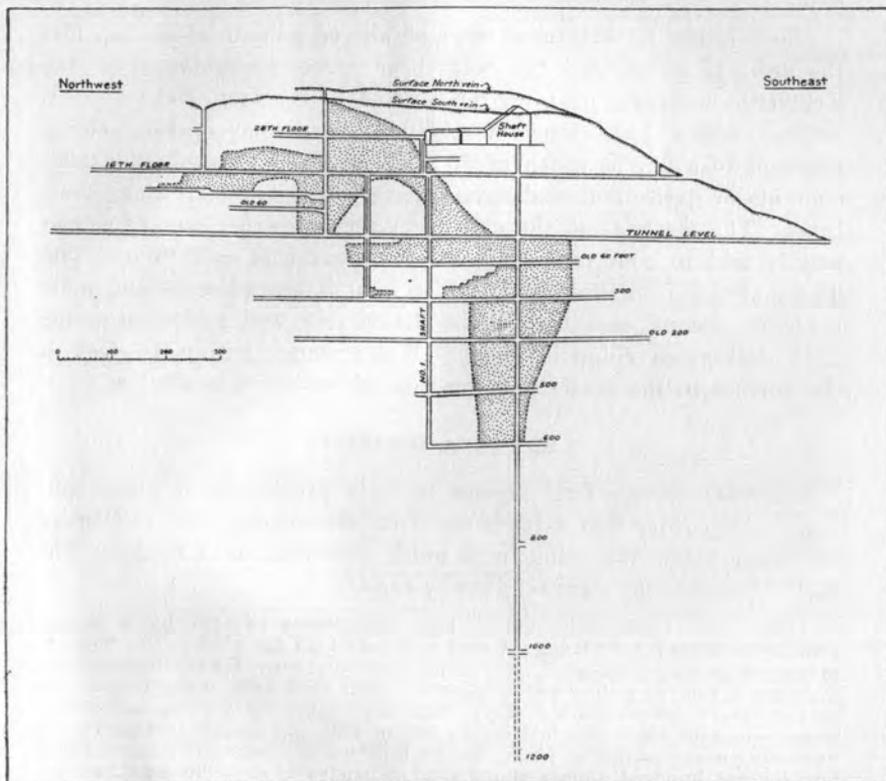


Fig. 32. Stope Map of Bonanza Mine.

A statement of production since 1899 is given.

1899 .....	\$146,419.47 a
1900 .....	175,953.45 a
1901 14,885 tons ore .....	279,556.42 b
1902 5,371 tons ore .....	84,003.08 b
1903 11,495 tons ore .....	202,375.85 b
1904 3,887 tons ore .....	52,315.81 b
	\$940,624.08

a probably net                      b gross

The outcrop lies within an area of argillite and most of the dumps are composed of this material, though serpentine was also

noted. The argillite is dominantly dense and carbonaceous though south of the shaft there are broad zones of cherty layers and thin lenses of limestone. Throughout this area the argillite is metamorphosed and locally is schistose. Observations on the bedding show it to range from east to southeast and dip steeply south. The vein trends N. 55° W. and though nearly vertical in the upper levels, dips 75° S. below the 800 level. Several of the stopes reach the surface northwest of the shaft and show widths as great as 7 feet, but the outcrop nearby is not conspicuous. Manganese oxide was not observed along the outcrop.

According to Lindgren\*:

“The ore body as a whole forms a mass of clay slate traversed by quartz veins and seams of all sizes. The gold is low grade, being about 600 fine or worth \$11.50 per ounce. Something like 70 per cent is free, though it is said that as depth is increased more concentrates and less free gold are obtained. The concentrates are said to vary from \$20 to \$60 per ton, chiefly in gold. The average ore is believed to run from \$7 to \$12 per ton, but lenses of ore 8 to 16 inches wide have been mined which ran as high as \$1400 per ton, and several hundred tons are said to have yielded at the rate of \$100 in free gold per ton. Though the pay streak averages only 5 to 6 feet, it is swelled in places to 40 feet by the appearance of a vast number of quartz stringers.”

The ore now to be seen on the dumps shows a finely brecciated mass of dark argillite, cemented by quartz which contains a few per cent of the sulphide minerals, arsenopyrite, pyrite and blende, and small lenses of dolomite. Most of the argillite fragments are unaltered but some are silicified and the argillite forming the walls adjacent to these breccia zones contains splashes of brilliant green fuchsite. Several associations indicate that this mineral is formed by the alteration of the micaceous portion of the argillite. Marcasite was observed on secondary fractures.

The stopes placed on the map presented herewith are not complete as none below the 600 level are shown. Other data have been obtained showing that the narrow shoot from the 300 to the 600 levels continued and was stoped to the 1,000 level with similar dimensions. Viewed broadly, the shape of the shoot as represented by stoped ground, is unusual. It is essentially composed of a horizontal zone 800 feet long and 300 feet deep, superimposed on a narrow shoot proven to a depth of 725 feet but ranging from 40 to 220 feet long. There is, therefore, a zone parallel to the present surface and another normal to it, features that alone strongly suggest the influence of

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\*Loc. cit. p. 701.

superficial enrichment in the formation of the upper zone. Unfortunately, the extent of oxidation, and the distribution of gold and silver in the vein, factors which might aid in estimating the effect of this process, are not known.

## PLACER DEPOSITS

### GRANITE DISTRICT

*North Fork mine.*—The interesting gravel deposit known as the North Fork or Klopp mine is situated on the south bank of North Fork of John Day river, opposite the mouth of Trail creek. Adjoining it on the east is the placer mine of David West on Onion creek, and to the north across the river are the now idle Dadum placers. All of these mines are situated on parts of the same or similar deposits, and may be conveniently described together.

Mining has evidently been carried on here for many years, the size of the water-supply ditches and of the abandoned portions of flumes and hydraulic equipment showing that some of the former operations were on a large scale. Records of production are lacking but the reports of miners and others familiar with this locality agree that the operations though usually profitable were never richly productive. The volume of gravel worked to date in these mines is roughly estimated to aggregate 6,800,000 cubic yards, which, at a minimum of 5 cents per cubic yard, must have yielded at least \$342,000. During the season of 1914 Glenn and Henderson were operating two 4-inch giants at the North Fork mine, and David West a smaller giant on the Onion creek slope.

The gold-bearing material covers about one square mile in a compact area that lies mainly on the south side of the river. The gravel extends from the river's level about 500 feet up the hills on both sides and is shown by the workings to be 60 feet or more deep in places. In this area most of the top layer and a small per cent of the deeper portions have been mined. The few exposures of the bed rock show it to be very irregular and to contain no well-defined channel.

The gravel bed is a compact unsorted mass of sandy clay and rounded to angular cobbles and boulders. In places the latter comprise 30 or more per cent of the whole. Many of them are very large having dimensions in extreme instances as great as 10 feet. The cobbles and boulders are principally of granitic rocks with a

sprinkling of schists and a small per cent of lavas. In addition a very few small cobbles of unmetamorphosed argillite are distributed through the mass. Although many of the boulders are firm and fresh looking, some are rusty and thoroughly decomposed. Fine particles of gold are distributed through the mass as deeply as it has been exposed, but accounts agree that the thin top layer is proportionately much richer than the rest. The gold is worth about \$14.50 per ounce or is about 700 fine.

This heterogeneous deposit ends about one-fourth of a mile below the mouth of Trail creek, and gold has been recognized in commercial quantities for about three-fourths of a mile above the same point. The same bouldery mass extends up the valley of the North Fork and its main tributaries well into the basins in which they head, but it does not contain gold in commercial quantities.

The deposit is clearly the terminal portion of an old drift sheet laid down by the North Fork glacier. As gold-bearing moraines are very rare and of exceptional occurrence, the presence of gold in this one and its localization at the lower extremity suggest problems of particular interest. Adjoining this glacial deposit on the south is a broad valley known as Crane Flats to which Crane and Onion creeks flow from the vicinities of the La Belleview and Monumental mines. These streams, particularly Crane creek, contain gold-bearing wash that merges into the sheet of gravel covering Crane Flats. This gravel sheet is similar in composition and general characteristics to the terrace gravels of the general region, which are known to be of pre-glacial age. To the northwest across the river along Trout creek there are terraced gravels which are similar in composition and occur at about the same level as those of Crane Flats. Although now separated by the North Fork valley, 200 feet deep, these two deposits are thought to be remnants of one continuous sheet. As is discussed in the following paragraphs it is believed that this ancient gravel sheet is the immediate source of the gold in the morainal deposits of North Fork.

It is observed that all of the various kinds of rock fragments in the North Fork deposits except two, those composed of lava and argillite, can be traced to parent outcrops along the path of the North Fork glacier, and as these exceptions are the most common kinds of rocks in the Crane Flats gravels, the suggestion is had that these gravels supplied the argillite and lava cobbles and the gold as well to the newer deposit.

At the close of the terrace gravel epoch the North Fork is thought to have deepened its valley, separated the Crane Flats and Trout creek gravel sheets, and produced at this point by reconcentration of these gravels a rich placer deposit. Subsequently the glacier descended the valley, plowed up the gravels and incorporated them with its own debris, but failed to render them absolutely unworkable or to sweep them away.

Since the disappearance of the ice, ordinary weathering and erosion have slightly worn down the surface of this deposit enriching its superficial portion by removing barren soil and sand and leaving the gold behind.

*French Diggings.*—French Diggings, known also as the Currey mine, occupies several hundred acres in a compact area that extends from the summit of the divide at 6,800 feet elevation between North Fork of John Day river and Trail creek down to the latter stream at a point about 6 miles above its mouth and at an elevation of 6,000 feet.

This deposit, which was discovered in the "early days," has been extensively worked and is reported to have produced more than a million dollars' worth of gold. Based upon a minimum yield of 10 cents per cubic yard, a rough estimate of the volume of gravel mined shows that the production has not been less than \$387,005. Present operations are confined to the portion of the deposit adjacent to Trail creek, where a small giant is operated by lessees.

Above 6,400 feet elevation the deposit represents an undisturbed part of the Tertiary pre-tuff-breccia gravels but below that level they have been disturbed and modified by glacial action, and have assumed the character of glacial drift. In 1914 a 10-foot bank of gravel containing abundant cobbles and boulders was being worked. About 75 per cent of the cobbles and boulders, some of which are decomposed, consist of granodiorite and the remainder of chert and other rocks characteristic of the Tertiary gravel higher up the slope. The matrix is a compact sandy clay.

The gold, which occurs as small, flat, smooth particles worth \$17 or more per ounce, is said to be practically confined to a 3-foot layer of indistinctly stratified gravel that rests on the granodiorite bedrock. The deposits are said to be worked at only a moderate profit.

## BONANZA DISTRICT

*Winterville and Parkerville Diggings.*—The now deserted camps of Winterville and Parkerville are situated a mile east and a mile south, respectively, of Geiser. At these points deposits of Tertiary pre-tuff-breccia gravels have been mined by hydraulic methods. The total production is unknown but has been estimated, on the basis of 50 cents per cubic yard for the volume of gravel worked, at a minimum of \$145,000. Of late years activity has been confined to the Winterville diggings which have intermittently produced small amounts.

The Winterville deposit is situated on the slopes adjoining Bennett creek. The work at present is being done entirely on the gravels west of the stream, those east of it having been worked out a long time ago. In 1900, when visited by Lindgren, the Winterville mine was being operated on a larger scale than at present, and but little can be added to the following description quoted from his report.

“ The gravels washed at present are found about the level of the creek (Bennett creek) and on its western side. The area which thus far has been hydraulicked comprises about 3 acres, the banks being from 15 to 20 feet high. The bed rock is a serpentinoid greenstone of uneven surface. A north-south fault in the bed rock has been exposed 100 feet long and showing a scarp 30 feet high which dips 60° E. The pay gravel, resting on the red rock, is from 3 to 10 feet thick, not very coarse, and sometimes cemented. It contains pebbles of serpentine, quartzite, slate, and quartz. Above this rest 15 feet of clayey beds with small strata of coaly material. Above this follows 2 feet of hard cemented gravel, covered by andesitic tuffs and breccia. The gold, found chiefly on the bed rock, is extremely coarse, the pieces ranging from 0.05 ounce up to 15 ounces in weight, but at the same time very well washed. Most of the nuggets have an oblong flat shape. The fineness averages 900. This interesting deposit was clearly formed before the time of the Neocene andesitic eruptions and must be of Eocene or early Neocene age.”

Since Mr. Lindgren's examination the pit west of Bennett creek has been worked back a distance of 1,000 feet or more and two other faultscarps have been exposed. One forms a wall 20 feet high that strikes N. 60° W. dips 65° N.E. and crosses near the middle of the pit. The other forms the present south boundary of the workings. It presents a curved wall 40 feet high that varies in trend from east-west to southwest and dips steeply northward. In addition, other small displacements are shown, the net result of all being a rapid elevation of the bed-rock southward and westward, although it dips in these directions.

The Parkerville mine had been idle for some time, and therefore the gravel banks were not so well exposed at the time of the examina-

tion as those at Winterville. Enough was seen, however, to make certain that the two deposits are identical in character and composition. The bed-rock here is cut by faults that dip in the same direction as those of the bed-rock at Winterville and cause displacements in the same manner. The two mines are undoubtedly situated upon portions of the same gravel channel.

The intervening space of about a mile and a half comprises a divide 300 feet high composed of tuff-breccias. If the buried channel remains level or nearly so between the exposed portions it is too deeply buried to allow of any other method of working than by drifting. It is probable, however, that step faults, similar to those observed in the two pits that have been excavated exist in the lands between. If this is true the gravel bed, to some extent at least, ascends the hill from Winterville by steps and descends to Parkerville due to its dip slope.

West of Parkerville this erratic deposit is fully 40 feet thick and dips beneath the tuff-breccias at an angle of  $12^{\circ}$ ; it is not known to appear at the surface farther west.

#### SUMPTER DISTRICT

*Weaver and Griffith mines.*—The following extracts are quoted from a report published in 1910.\*

**Weaver Mine.** "The Weaver mine is situated near the head of the north prong of Buck gulch, in a gravel terrace hanging upon the north slope some 200 feet above the bed of the ravine. Its elevation above sea is 5,550 feet. It extends as an ill-defined bench, having a course approximately east and west, 1,000 feet or more, its western termination not being exposed. In its eastern portion pits 50 to 90 feet wide and aggregating 450 feet in length have been made, exposing a bank 40 feet high. These openings have apparently reached not more than halfway across the deposit. In part the gravel rests unconformably upon loosely consolidated fine sands and silt, which in turn rests upon a bed rock of cherty shale and basic igneous intrusive rocks. The gravel consists of smooth rounded cobbles of an average diameter less than 12 inches, in an abundant sandy matrix that is very loosely 'cemented'....

Gold is distributed throughout the gravel, but is found in greater quantity in the lower layers. It occurs mainly as small half-rounded grains of pin-head size and dust, with occasionally a small nugget. Its fineness is reported as 900 to 940.....

The Weaver property is equipped with a small hydraulic plant and supplied with water through a ditch about 6 miles long that diverts the flow of Grays gulch, a tributary of McCullys Fork. Water in sufficient amount for mining purposes is had only during part of the spring and summer.

This mine has been operated profitably during the past nine years, but a statement of its output and the average yield of the gravel is not avail-

\*Pardee, J. T., Placer gravels of the Sumpter and Granite districts, eastern Oregon: U. S. Geol. Survey Bull. 430, pp. 60-62, 1910.

able for publication. The sluices here yield a considerable amount of 'black sand,' a sample of which was examined in the Survey laboratory. A few specks of platinum were detected in it by D. T. Day. It contained in addition a globule of gold amalgam and a few small flattened particles or 'colors' of rusty gold.

South and southeast of the Weaver mine, on the opposite slope of Buck gulch, and on the divide between it and Mosquito gulch, fragmentary patches of gravels are poorly exposed at elevations of 5,500 to 5,600 feet. They greatly resemble the gravel of the Weaver mine and are thought to belong to the same stream system. On the divide mentioned they are apparently overlain by andesitic tuff."

**Griffith Mine.** "The Griffith placers are in a high terrace about  $3\frac{1}{2}$  miles northwest of the Weaver mine, at an elevation of approximately 5,500 feet, and on the opposite or west slope of the Blue Mountain divide. The portion of the ridge separating the two places is from 200 to 400 feet higher.

Lindgren has described this deposit and records that in 1900 'a hydraulic pit about one acre in extent has been made in the high gravels, and a bank 40 feet high is exposed.' The present area of this pit is about the same. Evidently little or no mining has been done since that time. Early in the past season (1909) operations at a point just west of this old pit were commenced, but after a short time they were suspended because of litigation. The gravel here lies unconformably upon fine sediments very similar to those of the Weaver mine and is thickly bedded, striking northwest and dipping  $12^{\circ}$  N.E.

In its general texture this gravel resembles that of the Weaver mine, and it is likewise affected by normal faults, one of which strikes north, with vertical dip and downthrow of 6 feet on the west.

Considerable 'black sand' is said to collect in the sluices, and a sample of it was obtained from G. T. Pinson. Platinum was detected in this sample by D. T. Day, in greater quantity than in the sand from the Weaver mine, amounting to about  $1\frac{1}{2}$  ounces per ton. (The present market value of refined platinum is \$29 per ounce—in 1914 about \$40 per ounce.) In addition, this sample contained a considerable amount of gold amalgam and a few flat particles or 'colors' of rusty gold. Both this and the sand from the Weaver mine are by the partial examination made shown to be well worth saving. These occurrences of platinum are interesting as being from new localities, and the metal's close association there with serpentinized rocks is in line with its general occurrence elsewhere.

The extent of this deposit has not yet been definitely determined by prospecting. It seems, as noted by Lindgren, to extend northwestward for a mile or more, and apparently disappears under a basalt flow."

A small annual production has been maintained by the Weaver mine since the above was written, but no further work has been done at the Griffith mine.

*Powder River Dredge.*—The Powder River Gold Dredging Company's property is situated along Powder river from the vicinity of Sumpter downstream a distance of 4 or 5 miles. The company is operating a bucket chain dredge, built by the Yuba Construction Company of Marysville, California, having a rated capacity of from 5,000 to 6,000 cubic yards per day of 24 hours. The bucket chain consists of 65 closely connected buckets weighing 2,350 pounds each. The machinery is electrically driven, 460 horsepower being consumed

by seven motors. The dredge has been continuously in operation since January 8, 1913.

The deposit is a belt of gravel that ranges from 300 to 2,000 feet in width and occupies the upper or headward portion of the bottom lands of Sumpter valley. The gravel ranges from 12 to 28 feet in depth, is fairly uniform in size and contains but few large boulders. It is for the most part loosely compacted, only the layer next bed-rock being what is commonly termed "cemented." Above the gravel there is a fairly uniform soil cover about 3 feet thick. The gold content is mostly in the lower strata of gravel, chiefly on or near bed-rock, though small percentages appear up to the soil cover. The average section is stated by Mr. Derby, the manager for the company, to be 3 feet of soil, 10 feet of loose nearly barren gravel, and from  $2\frac{1}{2}$  to  $3\frac{1}{2}$  feet of clayey gravel which contains good pay. According to Mr. Derby, the gold occurs as fine, flat or flaky particles, only about 20 per cent of which exceed 1 mm. in diameter. Nuggets are uncommon, the largest being about one pennyweight in size; rarely small chunks of gold-bearing quartz are found. The average fineness of the gold is 780. To October, 1914, a strip of ground extending from the railroad Y opposite the smelter downstream about one mile, had been dredged. Although the amount produced is not known, the operations have evidently been profitable.

**PRELIMINARY REPORT ON THE GENERAL AND  
ECONOMIC GEOLOGY OF THE BAKER  
DISTRICT OF EASTERN OREGON**

By U. S. GRANT and G. H. CADY

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**INTRODUCTION**

The city of Baker is the county seat of Baker county in eastern Oregon and is near the center of the Baker topographic sheet of the United States Geological Survey. This map includes the area between west longitude  $117^{\circ} 30'$  and  $118^{\circ}$  and north latitude  $44^{\circ} 30'$  and  $45^{\circ}$ . The particular part of the district here described lies mainly in the northwest quarter of the above sheet, but includes some of the region to the east of Baker in the vicinity of the Virtue and Flagstaff mines.

The work on which this report is based was done for the Oregon Bureau of Mines and Geology between June 14 and August 31, 1913. In this work the authors were assisted in the field by Mr. G. E. Goodspeed, Jr., and they have had the advantage of field conferences with H. M. Parks, Director of the Bureau, and with Messrs. J. T. Pardee and F. J. Katz of the United States Geological Survey who were working in the Sumpter district, immediately to the west of the Baker district. Many residents of Baker and vicinity, especially those interested in mining, were uniformly generous in giving information concerning mining properties and in aiding the work in other ways.

The general district of the Blue mountains of eastern Oregon, of which the Baker district forms a part, has not been extensively described in geological literature, except in one paper by Waldemar Lindgren entitled "The gold belt of the Blue mountains of Oregon" published in 1901.\* At the time this report was written Lindgren had made a geological reconnaissance over the whole district and had had an opportunity to visit and to study a large number of the mines which were then in active operation. During the present field season there was very little mining activity in the immediate region of Baker and there was little opportunity to get more detailed information concerning the mines than had been

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\*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 writers have used this excellent paper many times in the preparation of the present report and have not attempted to always give definite references to it.

gathered by Lindgren. In no mine were we able to collect specimens of unaltered ore, nor to study the rocks below the belt of weathering. With these conditions existing it soon became evident that little could be added in a short field season to the results already obtained by Lindgren on the ore deposits of the district. It seemed best therefore to attempt a careful geological survey of the Baker quadrangle, and thus to lay a basis for definite geological conclusions and for a thorough later study of the ore deposits. It was impossible to finish the whole quadrangle with the time available this season, and so the work was confined largely to the northwest quarter of the district, with the expectation that the following season would make it possible to practically complete the survey of the quadrangle. Such opportunity, however, did not offer itself, and it seems unwise, with only partial data at hand and with our inability to get better information on the ore deposits than was had by Lindgren, to write a detailed description of the area at the present time. Aside from the reasons above stated the other duties of the writers prevented them from spending the time necessary to prepare a detailed description of the district.

#### TOPOGRAPHY

The city of Baker is situated on the southeast border of a wide plain, the Baker valley (Fig. 8), which lies between 3300 and 3500 feet above sea level. In the northern part of this plain are two groups of low hills, the hills including Coyote point east of Haines and another group north of that town. On the northeast the plain is bounded by the Farley hills which culminate in Magpie peak, 4561 feet above the sea; and from this peak to the southeast stretches a range of low hills ending in a noticeable elevation, Lone Pine mountain, which is 5077 feet high. From Lone Pine mountain westward the rim of Baker valley is broken only by the gorge of Sutton creek and the more noticeable gorge of the Powder river (Fig. 1), beyond (west of) which the mountains become more rugged and reach an elevation of over 6800 feet at the western edge of the quadrangle. This same mountain mass becomes higher and more rugged in the area immediately to the west of the Baker district where the Elkhorn ridge forms the western border of the Baker valley (Fig. 8).

The main stream of the Baker valley is the Powder river which traverses the valley from south to north. With the exception of

Sutton creek this stream has practically no tributaries from the east, but there are a number of streams which enter the Powder river from the southwest and west, these being fed by the greater precipitation of the Elkhorn ridge area.

#### OUTLINE OF THE GEOLOGY

In the district here studied rock exposures are not always numerous, especially exposures of the older rocks which are frequently covered by hillside wash and which are almost everywhere altered by weathering. The more recent lavas, however, are commonly exposed in great profusion (Fig. 1) and they effectively conceal from investigation large areas of the older rocks.

The different geological formations of the district, following Lindgren, are as follows.

1. An older series of sediments which consist mainly of argillite and chert with smaller quantities of limestone and quartzite. Associated with these are large amounts of igneous material which is in part effusive, in part fragmental, and in part intrusive. The age of this series is probably Carboniferous.

2. Another series of argillite, chert and igneous rocks occurs in the vicinity of Haines and to the northeast in the Farley hills. This series is somewhat similar in lithology to the series noted above, but may be of Triassic age.

3. A few small areas of granite occur in places in both of the above series of rocks, but these granites are quite old and have been subjected to most of the dynamic alterations which have affected the surrounding sediments.

4. A younger granite mass, called the Haines granite, which is practically unaltered.

5. A great series of volcanic rocks, mainly lava flow, of Tertiary age.

6. A series of sands and clays deposited mainly in Tertiary lakes.

7. The recent alluvium, hillside wash, and products of weathering.

#### GENERAL GEOLOGY

##### THE CARBONIFEROUS ROCKS

The rocks referred to the Carboniferous in the area studied occur mainly in T. 9 S., R. 39 E., and compose the mountainous area which

lies west of Baker and south of the Baker valley. In this area these rocks occur everywhere except on the east where they have been concealed by flows of Tertiary basalts. Rocks of similar nature are found in the region between the Virtue mine and Pleasant valley.

The Carboniferous sediments consist of argillites, cherts and limestones. In most places the relation of these three types to each other is not clear, but some exposures show that they are interbedded and it is consequently assumed that they all belong to one conformable system. It has not been possible, however, to work out the stratigraphy definitely because, first, of fewness of exposures, second, of the presence of much igneous material, and third, of the intense faulting and folding to which the rocks have been subjected. To the west in the vicinity of Sumpter and Bourne the structure, which is one of folding and complicated faulting, has been deciphered by Pardee,\* who found a series of argillites, cherts and limestones, that can be traced directly into similar rocks in the Baker district, and conformable one with another.

No evidence has been found in the Baker district to show the definite age of these argillites, cherts and limestones, but in the Sumpter district a few fossils have been discovered in the limestone beds, which fossils indicate the Carboniferous age of the deposits, but do not place the age more definitely than this.

The argillites are black to gray in color, more commonly the former, fine-grained, and more or less fissile, but do not have the cleavage developed in the same direction over large areas.

The cherts are gray, black and in some places green in color. They occur in very massive beds as well as in a finely laminated condition, and they are in places distinctly interbedded with layers of black argillites. Because of the more resistant character of the cherts they are more prominent on the surface than are the argillites.

The limestones are generally black in color; they occur in rather limited areas and thus appear more like lenses than like layers of considerable extent. It is possible, however, that this appearance is due to faulting and that the limestone was originally deposited in rather definite layers. Black limestones occur in the east half

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\*Pardee, J. T., Faulting and vein structure in the Cracker Creek gold district, Baker County, Oregon: Bull. U. S. Geol. Survey No. 380, 1909, pp. 85-93.

of Sec. 7, T. 9 S., R. 39 E.; in the west side of a branch of Salmon creek in the east half of Sec. 18, of the same township; near the center of the west side of Sec. 19; in the south half of Sec. 15; and along the Auburn ditch in the northwest quarter of Sec. 33. Large exposures of limestone occur on the same ditch in Sec. 19, where the rock is distinctly interbedded with black argillite. Gray to white limestones are less common, but some of the darker colored ones weather gray, and there are exposures of a distinctly white limestone on the hill in the southwest quarter of Sec. 13, of the same township.

The igneous rocks of the Carboniferous are grouped conveniently under the term greenstone. They have been largely altered and their pyroxenic constituents changed to hornblende and to chlorite. The most common type of igneous rock is a fine-grained basic tuff, which is usually much silicified and thus stands out in prominent exposures. Surface basic flows are less common and these and the tuffs are thought to be, at least in part, contemporary with the associated sediments. Intrusive rocks, mainly diabases, both fine and coarse-grained, are common and some of these are much later than the rocks they cut for they show no results of the dynamic metamorphism to which the sediments, the tuffs, the flows and some of the intrusives have been subjected.

#### THE TRIASSIC ROCKS

In T. 7 S., R. 39 E., and T. 7 S., R. 40 E., north and east of Haines, another series of argillites and cherts occurs; with these are considerable quantities of igneous rocks. In the area here discussed no fossils have been found in this series of sediments and there is no definite proof of their age, but from the relations of these rocks and their similarity to known Triassic rocks elsewhere in the Blue mountains, Lindgren referred them to the Triassic. This series is in general similar in lithology to the rocks already described under the Carboniferous, but they differ in at least three points. The chert is usually more uniformly massive and not finely laminated; practically no limestone has been found in this area, and the presence of surface and fragmental igneous rocks is not so marked. Still, there remains the possibility that the rocks here called Triassic are of the same age (Carboniferous) as the cherts and argillites west of Baker and southeast of the Virtue mine.

The main area of chert occurs just to the east of Haines and

forms a considerable part of the eastern slope of the group of hills of which Coyote point is the summit. Argillites are, as far as exposures are concerned, much less abundant, although, because of their less resistance to erosion, it is probable that a considerably larger area is underlain by argillite than is at first apparent. Small amounts of quartzite are associated with the cherts and argillites.

The igneous rocks of this Triassic area are not commonly fragmental, but are mainly in the nature of flows and intrusions. As a rule these rocks have been so altered that the name greenstone can be conveniently applied to them. Associated with these greenstones are, however, basic and acid igneous rocks which in places show little alteration and which may thus belong to a later age. With the information at hand it has not been possible to separate these older igneous rocks from all those that are probably of later date. In the main, however, the older rocks are of a basic nature, while the later ones are more acid, that is, they are granites and their finer grained equivalents.

Along the northern border of the Haines granite the older Triassic greenstones have been so metamorphosed by contact action that they have been turned into a series of hornblende schists and hornblende gneisses close to the contact. Exposures of this character are seen on the western slopes of the range of hills just east of Hutchinson.

#### THE OLDER GRANITES

Associated with the Carboniferous rocks and also with those referred to the Triassic, are certain areas of granite whose definite age is unknown. These areas of granite agree, however, in the fact that they are associated with these older rocks and that they have all been subjected to at least some of the intense dynamic forces which have altered and metamorphosed the Carboniferous and Triassic sediments and igneous rocks. Some of these granites are intrusive into the surrounding rocks. In other cases their relationship to these rocks has not been definitely determined.

These older granites vary somewhat among themselves, but in general they are from medium to fine in grain and are quite acid in composition. They originally contained only small quantities of ferromagnesian minerals and these are now so completely altered that their original nature is difficult to determine. In one case, at least, the original dark mineral was biotite. These granites in the main have been crushed and frequently granulated and, with the

exception of those in the Magpie peak district, they do not usually resist erosion more strongly than do the surrounding rocks.

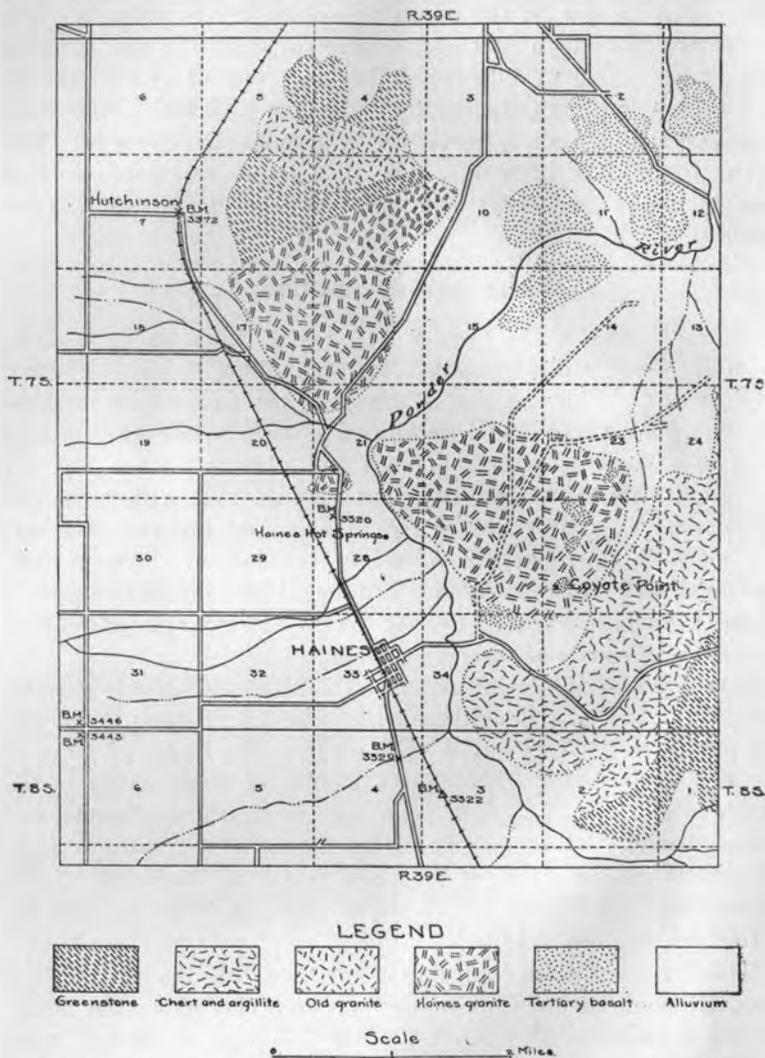


Fig. 9. Geological Sketch Map of the Haines Granite and Surrounding Rocks.

Among the localities where these granites occur the following may be listed. Three small areas in the upper part of the valley of Elk creek in the north half of Sec. 30, T. 9 S., R. 39 E.; another

small area in the section immediately to the west of the last; two areas in the highest part of the hills west of Baker in Sec. 31 of the same township and in the adjoining section to the west; an area of perhaps one and a half square miles in extent in the northern part of the group of hills which lies just east of Hutchinson in T. 7 S., R. 39 E. In the vicinity of Magpie peak and to the north a considerable district is underlain by granites and some of these appear to be of a little later date than those just mentioned; at least in places they have been less subjected to dynamic metamorphism.

#### THE HAINES GRANITE

On both sides of the Powder river north of Haines in T. 7 S., R. 39 E., there is a large mass of fresh, medium to coarse-grained, gray granite. This granite is exposed over an area of perhaps five square miles and it undoubtedly underlies a considerably greater territory under the covering of wash and alluvium. (See Fig. 2.) The granite forms comparatively low rounded hills with numerous irregular knobs of unweathered rock. In general this rock weathers into more or less spherical masses or boulders of disintegration. Compared with the other granites mentioned above the Haines granite is fresh and unaltered except by weathering. It is not crushed nor does it exhibit the results of shearing stresses.

Lithologically the Haines granite is a hornblende biotite granite, but some at least of the hornblende has been derived from the alteration of augite, as fresh augite cores occur in the center of some of the hornblende grains. There are a number of small masses in the granite which are of a dark color and in which hornblende and biotite abound. These may be of the nature of segregations from the granite magma itself, or they may be altered fragments of the surrounding greenstones which have been included in, and recrystallized by, the granite.

The Haines granite is distinctly intrusive into the surrounding rocks, although the evidence of this was seen only along the north-western boundaries of the mass where it comes in contact with the greenstone in the hills east of Hutchinson. At the contact these greenstones have been entirely recrystallized and have been turned into hornblende schists and near the contact into hornblende gneisses.

Associated with the granite are a number of intrusive rocks



Fig. 1. Powder River Canyon cut in flows of Tertiary basalt; south of Baker.



Fig. 2. Weathering of the Haines granite; quarry of the Northwestern Granite Co. near Haines.

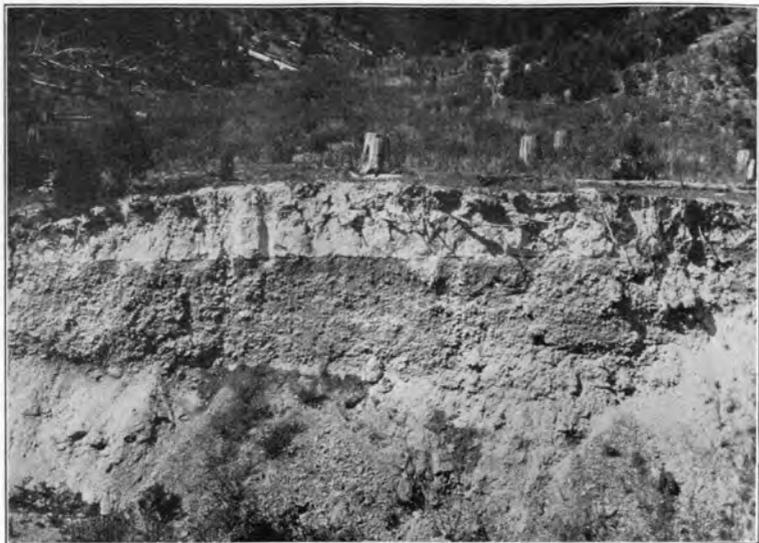


Fig. 3. Section of auriferous gravels overlain by gray volcanic ash; Stices Gulch.



Fig. 4. Section of auriferous gravels; Nelson Placer workings, near Salmon Gulch.

which may be regarded as later products from the same magma. These cut the granite and the surrounding rocks in a number of dikes. In composition these dikes are considerably more basic than the main granite mass and are usually porphyritic in texture, containing large quantities of hornblende and some biotite. Pegmatite was found only in one locality, and one dike of aplitic material was seen cutting the granite.

The time of the intrusion of this granite is not certain, but it is clearly later than the Triassic rocks and also clearly later than most of the stresses to which these rocks have been subjected. It is also much earlier than the flows of Tertiary basalt, for between the time of its intrusion and the extrusion of the basalt the district was highly eroded and the granite thus brought to the surface. The basalt now rests directly upon the weathered surface of the granite.\*

#### THE TERTIARY LAVAS

The most noticeable rocks in the Baker district are the Tertiary lavas which are found capping many of the hills and extending down into the valleys. The most prominent canyons of the district, that is, the Powder river canyon, which is south of Baker and the still deeper canyon of the same river in the northeastern part of T. 7 S., R. 40 E., are both cut in a thick series of basaltic flows of Tertiary time. The prominent hills in Sec. 22, T. 9 S., R. 40 E., just east of Baker, are capped by these lavas which extend westward to the lower elevations within the city limits. A mile and one-half south of Baker is the upper canyon of the Powder river (Fig. 1) which has been cut through a considerable thickness of these flows, and this same area of basalt extends westward to the upper part of Griffin creek and then northward along the east side of Washington gulch. In one place the flows have crossed the latter gulch and in them a precipitous canyon has been cut. The highest land in T. 9 S., R. 39 E. is not, however, covered by these flows. They occur in smaller amounts in the vicinity of Haines where they cap the highest point of the Haines hills, known as Coyote point; and three or four miles to the north they form low flat mesas through which the Powder river has cut a shallow canyon.

The greatest thickness of these flows in the area studied is along the lower canyon of the Powder river in the northeast part of T. 7

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\*For further details concerning the Haines granite see: Parks, H. M., *Mineral Resources of Oregon*, vol. I, Feb., 1914, pp. 18-19.

S., R. 40 E., where there is at least 1000 feet made up of a large series of nearly horizontal sheets piled one on top of another. This area extends south and west to Magpie peak, and from there continues without interruption to the vicinity of the Flagstaff mine. Thus the whole of the eastern side and much of the north and south side of Baker valley are hemmed in by rocks of this character.

The exact age of these lava flows has not been determined in this particular district, but they are known elsewhere to have originated in approximately mid-Tertiary time, that is, in the later Miocene and earlier Pliocene.

In the vicinity of Baker these Tertiary lavas are commonly basaltic in character and of very uniform and monotonous lithology. In a few small areas acid lavas, chiefly rhyolites, are found. Good examples of these acid lavas occur in the hills between Baker and the Flagstaff mine, and they cap a few of the minor elevations on the west side of Washington gulch in Sec. 15, T. 9 S., R. 39 E. Some very characteristic rocks of this type also occur in the district of the Farley hills in the western part of Sec. 7, T. 7 S., R. 10 E. Large areas of the acid lavas are found in the south part of the Baker quadrangle beyond the area of our special work.

The Tertiary lavas were poured out upon an exceedingly irregular surface, and they are found not only on the summits of the hills but also in the bottoms of the valleys. It was due to the damming of the valleys by these streams of lava that many of the local lakes of Tertiary time were formed. Thus many of the main features of the present topography, and even some of the minor features, were in existence before the extrusion of these lavas. The relation of these rocks to the lake beds of the district and to some of the large deposits of gravel, parts of which are auriferous, is not always definitely known; as stated above, however, the presence of at least some of the lakes was due to the damming of the stream valleys by these flows. On the other hand, in certain places the flows are found lying directly upon the old lake beds, as, for instance, in the aqueduct which cuts through the hills just east of Baker in Sec. 21, T. 9 S., R. 40 E. Here a considerable part of the aqueduct appears to have been cut in lake bed deposits which are directly overlain by the flows of basalt that cover the tops of the hills in this section and the still more prominent hills in the section to the east. There are places also where the basalt has been poured out upon a series of gravels. On the whole it must be concluded that the period of volcanism, which was inaugurated

before the formation of the Tertiary lake beds of this district, was continued at intervals during the history of these lakes and even after some of them had received considerable deposits.

One of the most interesting occurrences of the basalt is in the hills just east and north of Haines where the highest point, Coyote point, is capped by a thin sheet of lava, and the remains of this same sheet, which apparently flowed out over a very irregular surface, are found at various elevations to the northeast and also to the southwest. The top of this point is composed of basalt which separates into thin sheets dipping  $20^{\circ}$  to  $25^{\circ}$  towards the northwest. In places these sheets are only one-eighth of an inch in thickness, though they are commonly from one to two inches thick. At the southwestern base of Coyote point, along the road from Haines, this sheeting of the basalt is also prominent and the dip is  $17^{\circ}$  towards the west-northwest. About 75 feet below the summit of Coyote point, and on the south side of the hill, a prospect tunnel some 35 feet in length has been run in on the junction of the basalt and the underlying granite. The section here is as follows, the oldest rock being given below.

3. Black basalt, exposed to a thickness of 15 feet.
2. Old surface zone, two to four feet in thickness, composed of hillside wash which contains boulders of granite, quartzite and diorite and even some of basalt similar to that which overlies it.
1. Decomposed granite; five feet exposed. In this granite is a very much decomposed basic dike, which is evidently much earlier than the material which overlies it.

On the north side of Coyote point prospect pits sunk along this same contact encountered a part of the upper decomposed portion of the granite which is highly charged with hematite.

#### THE TERTIARY LAKE DEPOSITS

The deposits made in these Tertiary (Neocene) lakes are soft and unconsolidated gravels, sands, clays and waterlaid tuffs. Because of their less resistant character they have been easily eroded and are seldom exposed except in artificial cuts. Strata of this kind probably underlie a large part of the Baker valley, but are covered with more recent deposits. Among the points in the vicinity of Baker where the lake beds are known to exist are: (1) along the aqueduct in Sec. 20, T. 9 S., R. 40 E., just east of Baker; (2) in the broad terrace-like flat which runs northward from the first range of hills east of Baker and makes up a large portion of Sec. 15, T. 9 S., R. 40 E. These lake beds probably extend for a distance of two miles to the northeast in

the direction of the Flagstaff mine and their upper surface is not far below 3,600 feet above sea level. Another broad terrace-like flat lying also at an elevation of a little less than 3,600 feet occurs to the south of Baker in Sec. 20 of the same township, and the same deposits probably extend northwestward for two miles along the base of the steep range of hills on which is the water reservoir. Deposits of a similar nature occur also in the higher terrace-like area on the west side of the mouth of Washington gulch in Sec. 10, T. 9 S., R. 39 E.

Along the railroad cuts in Secs. 7 and 15, T. 10 S., R. 41 E., are considerable exposures of the lake beds which show both tilting and faulting. In the southwest quarter of the former section a thickness of 15 feet of these beds is exposed and two faults occur. One fault plane strikes N. 23° W. and hases toward the east 10°. The east side is the downthrow side, and the displacement has been four feet. Another fault 100 yards farther east strikes N. 18° W. and hases towards the west 38°. The west side is the downthrow side and the displacement is 6 feet. Here the beds strike N. 68° W. and dip 24° towards the north. Along both of these faults are minor parallel step faults.

In the southwest quarter of the latter section the lake beds strike N. 83° W. and dip 30° towards the north. Here there are several small faults and two larger ones. Two of the smaller faults are vertical and strike N. 53° W. One of the larger faults strikes N. 78° W. and hases toward the south 23°. The south side is the downthrow side, and the displacement is at least 15 feet. The other larger fault strikes N. 75° W. and is vertical. The south side is the downthrow side and the displacement is 30 feet.

The above exposures are probably typical of many parts of the lake beds. These beds as stated have in places been tilted and faulted, and the same statement can be made of the lava flows. As far as seen these displacements are of the nature of gravity or normal faults, and any careful study of the structural geology (as well as the physiographic geology) may well be based on a detailed examination of a small area of these lava flows in order to determine the character of such displacements.

#### THE RECENT DEPOSITS

Since the time of the Tertiary lake beds a considerable amount of mantle rock has been formed from the decay of all of the older rocks of the district. In addition to this there are extensive areas of river

alluvium, deposited by the widely meandering streams in the flat Baker valley, and large areas are covered by the usual hillside wash common in semi-arid districts. Near the mouths of the steeper valleys or gulches which open into the Baker valley large quantities of sand and gravel derived from the older rocks in the mountains have been deposited. One of the most extensive areas of this nature is in the form of a piedmont alluvium plain formed by the coalescing of a series of alluvial fans at the mouths of the gulches which extend from Washington gulch westward. Within this area are the very extensive workings of the old Nelson placers of Salmon creek.

No glacial drift has been found within the district studied, but Alpine glaciers are known to have existed in the higher parts of the Elkhorn ridge, directly to the west of the Baker quadrangle, and some streams from this highland district obtain their head waters from within the region which contained these glaciers. Some, at least, of the gravels included in the piedmont alluvium fans undoubtedly consist of material brought down by streams flowing from Alpine glaciers. The separation of such material from the ordinary gravels and boulders which are derived solely by stream erosion cannot easily be made, and it is very probable that these alluvial fans, and consequently some of the auriferous gravels of the district, contain deposits made in the various periods from before the era of the Tertiary lava flows down to the present.

The latest deposit which is known in the district is a layer from one to ten feet in thickness of very fine-grained, gray to white, volcanic ash. This is found along several of the streams in the west part of T. 9 S., R. 39 E., and especially along Salmon creek where this fine unconsolidated material occurs overlying some of the gravels in the upper part of the creek and also extending out over some of the Nelson placer district. (Fig. 4.) Along Stices gulch in T. 11 S., R. 40 E., are other deposits of the same character which overlie the most recent stream gravels. (Fig. 3.) It appears that at some very recent time many square miles to the south and west of Baker must have received a layer of volcanic ash; and what is left of this today has been washed from the hillsides and has accumulated in the stream valleys. The point from which this material came is unknown, and no report has, so far as the writers' knowledge goes, been given of very recent volcanic activity in this general district. The ash is very fine and so it may have been carried by the wind for a great many miles from its original source, as similar ash was carried

100 and even 200 miles in the recent eruption of the Alaskan volcano known as Katmai.

### ECONOMIC GEOLOGY

The main mineral products in the Baker district have been gold and silver; in fact, this general district has been the most important producer of these minerals in eastern Oregon, as well as in the whole state. At the present time the producing mines are situated outside of the immediate vicinity of Baker and the special district included in this report. As has been stated before the mines about Baker were not in active operation during the season of 1913, and there was consequently little opportunity to study them. So little more could be added to the knowledge of their geology and ore deposits than had previously been stated by Lindgren. In the following descriptions some information is given concerning a number of these mines and prospects, but no attempt has been made to list all of them, for they—especially the prospects—are numerous and many of them are difficult of access because of the condition of their timbers and the caving of their sides. The mines and prospects noted in the descriptions below are usually the larger ones or those in which points of especial interest were seen.

It is of course impossible, with our necessarily limited knowledge of the mines in this vicinity, to make positive statements as to their value or as to the prospects of their future development. But there are certain features which lead one to suggest that possibly some of the mines may be reopened and worked with profit. The veins are of such a nature that there is no reason to expect that their content of the precious metals will sharply decrease with depth, at least within a few hundred feet below the depths to which they have already been worked. There is also a reasonable possibility that some of the veins which have been worked may have a greater lateral extent than is now known; and the possibility of finding new veins should still be considered. The consolidation of several of the smaller properties in one vicinity so that they can be worked together at less expense will prove to be advantageous, and the advent of electric power at a less cost than was formerly necessary for fuel is a feature favorable to future mining in this district.

### GOLD AND SILVER

The gold and silver deposits, which have made Baker county the most important producer of the precious metals of all the counties of

Oregon, occur both in lode and in placer deposits. The latter were the earlier sources of gold and later the lode deposits became of more importance and have in recent years furnished the chief production.

In 1861 placer gold was discovered on Griffin creek, a few miles southwest of Baker, and the next year the richer placers of Auburn, a few miles farther southwest, became known. This was soon followed by the discovery of other placer districts in the Blue mountains and the consequent rapid influx of miners and prospectors. Lode deposits were discovered shortly after, and the vein at the Virtue mine was one of the earliest, if not the earliest, of these. The production of the earlier years was large, but this decreased as the placers became partially exhausted, and later increased as the lode mines became more extensively worked. Of late years the production has not been up to the average, but the last two years have seen a revival in the mining industry in eastern Oregon and the production of gold in Baker county in 1913 amounted to \$1,373,480, which is an increase of \$889,439 over the yield of 1912.\*

#### LODE DEPOSITS

Gold and silver occur in this district commonly in quartz veins which cut the older complex of Carboniferous rocks and less commonly in similar veins in the Triassic rocks. The wall rock is usually slate or some form of altered igneous rock. The veins are usually in clean-cut fissures, and the vein filling is very largely quartz; occasionally calcite is found; and the metallic sulphides are usually in small amounts. The chief sulphides are pyrite and chalcopyrite, though sphalerite, galena and arsenopyrite also occur. The gold is in large part free, especially in the upper oxidized portions of the veins.

#### VALLEY OF SALMON CREEK

On the high mountainous area in Secs. 19 and 20, T. 9 S., R. 39 E., are a few prospects. One of these is near the summit in the center of the west half of the latter section, and consists of an old excavation 30 feet long and 10 feet deep along a fractured, dark, quartz vein in greenstone; the vein is a foot in width, strikes N. 52° W., and is about vertical. A few rods southwest of the last is a more recent cut, 100 feet long, in a fine-grained, tough greenstone which has been silicified and contains small cubes of pyrite; no vein-like form occurs here.

\*McCaskey, H. D., Gold and silver in 1913: U. S. Geol. Survey, Mineral Resources 1913, pt. 1, 1914, p. 862.

A mile and a half west of the last on the west edge of the Baker quadrangle, near the center of the east half of Sec. 24, T. 9 S., R. 38 E., at an elevation of 6,500 feet, is an old prospect hole on a dike of gray weathering, somewhat rusty, quartz porphyry. This dike is 36 inches wide, strikes N. 47° E., and dips 80° towards the northwest. A tunnel 30 feet in length has been run in on this same dike 25 feet below the above prospect hole. The country rock here is slate which is gray to black in color. Somewhat similar dikes, usually less acid in composition, have been prospected in other localities in the basin of Salmon creek, probably because they contain small quantities of disseminated pyrite which gives an iron stain to the weathered rock.

In other localities prospecting has been carried on in masses or dikes of fine-grained, rather soft, altered greenstone which now contains much calcite disseminated through it in small grains. One such prospect is in the southeast quarter of Sec. 18, T. 9 S., R. 39 E., at an elevation of 4,700 feet, on the west side of the east branch of Salmon creek. At this point there is a crooked tunnel 150 feet long dug perhaps three years ago. The rock is the above described greenstone containing a few small irregular seams of quartz. Another such prospect is 50 feet below the Auburn ditch in the southeast quarter of Sec. 13, T. 9 S., R. 39 E., where there is a tunnel perhaps 250 feet long. This is now locked. The rock thrown out is an oxidized greenstone. Other old prospects in similar greenstone occur near the center of Sec. 8, T. 9 S., R. 39 E., and here some white quartz is found on the dumps.

*Carpenter Hill mine.*—This is one of the larger group of workings which have been established along Salmon creek above the old Nelson placers, evidently with the hope of finding the veins from which the gold of these placers was derived. The mill of this mine is situated on the east bank of Salmon creek in the southwest quarter of Sec. 8, T. 9 S., R. 39 E., contains 5 stamps, and is reported to have ceased operations about eight years ago. The main workings are a tunnel on the east side of a ravine a short distance east of the mill. The ore was carried from the tunnel by cars which dumped into a hopper at the top of the mill. The tunnel represents about 1,200 feet of work and was evidently driven into the hill to intercept certain veins which had been prospected on the east side of this ravine. The tunnel cuts greenstone of several varieties and shows several faults along which a clay gouge has been developed. The strike and dip of some of these are as follows. N. 49° E., dip 46° N. W.; N. 62° W., dip 20° N.;



Fig. 5. General view of the Virtue Mine.



Fig. 6. Lime kiln at Pleasant Valley.



Fig. 7. View of western part of Baker Valley.



Fig. 8. View of southern part of Baker Valley.

N. 53° E., dip 67° N. W.; N. 37° W., dip 30° N. W.; N. 27° W., dip 42° N. E. Several veinlets of quartz occur in this tunnel, and one strikes N. 11° W. and dips 80° W.; this is 6 inches in width and is reported to have widened to 3 feet in places.

*Young America prospect.*—This lies about a quarter of a mile south of the Carpenter Hill mine and between the two are a number of old prospect holes, some of which show considerable amounts of rather pure white quartz. The main work at the Young America has been along a sloping tunnel, now partly caved, in much decayed greenstone. The vein strikes N. 79° E. and dips 33° to 38° S. Its entire thickness is not always exposed, but the maximum thickness is at least 5 feet, and one-half to four-fifths of it is pure white quartz. In one place the vein showed the following section, from above downward.

	Feet	Inches
1. Decayed rock and gouge.....	2	.
2. Sugary white quartz.....	2	.
3. Dark gouge .....	.	½
4. Much decayed greenish rock.....	2	.
5. Dark gouge .....	.	½
6. White quartz with thin wavy bands containing limonite .....	2	.

It is said that this vein, 200 feet down the sloping tunnel, is cut off by a fault which dips to the northeast.

*Barker and Herriman prospect.*—These men have a small ranch and truck garden on Salmon creek near the Carpenter hill mine and have done considerable prospecting along this creek with the hope of finding some of the veins which furnished the gold for the Nelson placers. Their most extensive working is a tunnel 600 feet in length, now partially caved, in greenstone. This tunnel was run to intercept the Young America vein.

*Yellowstone Mining Company.*—This company has a considerable number of prospect holes and tunnels on McCord gulch in the northeast quarter of Sec. 7, T. 9 S., R. 39 E., and a one-stamp Nissen mill run by a gasoline engine. Work was discontinued here about a year ago. The main veins consist of two, known as the Old Soldier and Tom Paine, and the country rock is slate and black limestone cut by a number of decayed greenstone dikes as well as by some more acid dikes. Prospecting along McCord gulch has been carried on to a large extent because of the finding of quartz veins here and because lower down on this gulch some rich placer deposits were formerly worked.

In the bottom of the gulch there are two tunnels on the Old

Soldier vein, one is about 600 feet in length and the other about 60 feet; the latter tunnel is now in shape to be entered. In this the vein is 3 feet in thickness, strikes N. 68° W., and dips 42° S. The vein is about one-third quartz and is much sheared and decayed, as are the adjoining rocks. Below the vein is a thickness of 4 feet of a fine-grained, gray, andesitic (?) rock which carries minute pyrite cubes and is cut by small veinlets composed of quartz and calcite; in some

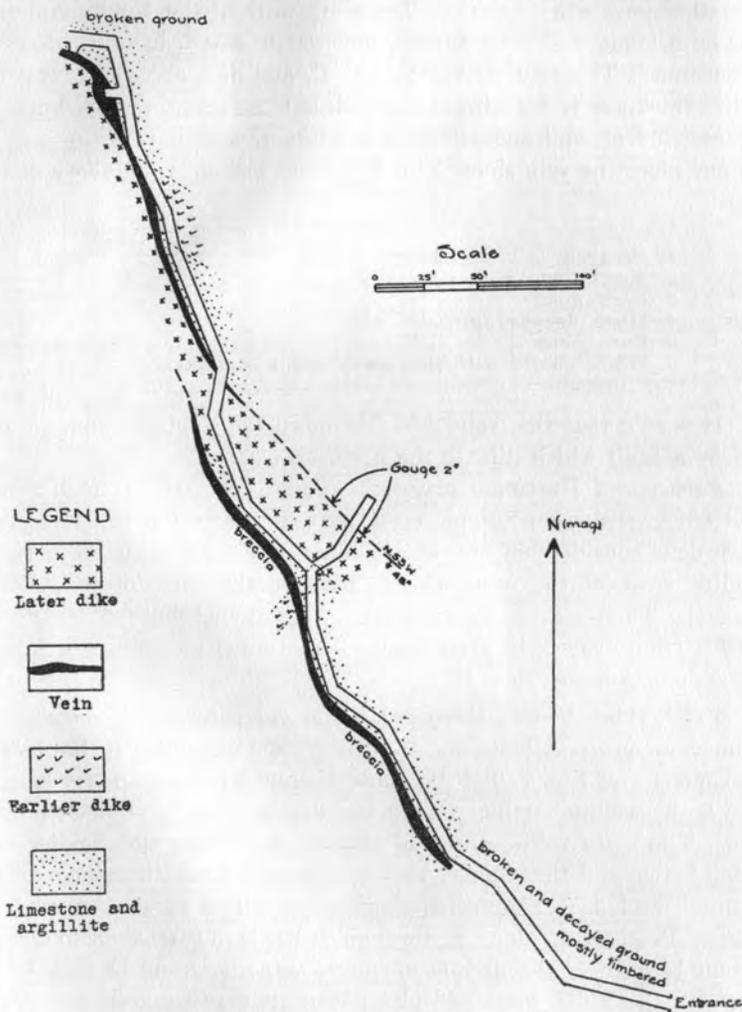


Fig. 10. Map of Tom Paine Vein.

cases the veinlets are bordered by a film of limonite which probably originated from the alteration of pyrite.

The chief workings on the Tom Paine vein are higher up on the west side of McCord gulch. The vein here is from a few inches to 4 feet thick and is mostly of white quartz. The relations of this vein to the adjoining rocks are shown in the accompanying sketch (Fig. 10.) The vein dips to the southwest at angles varying from 30° to 50°, and in the sketch, which is drawn at the elevation of the bottom of the tunnel, is shown to the southwest of the tunnel, although it is exposed on the sides and the roof. The country rock is slate and black limestone. It is decayed in places and in others much brecciated. This rock was cut by two dikes which are older than the vein. They consist of a fine-grained, gray to greenish, rock which becomes spotted on weathering and now contains large quantities of calcite. This rock is similar to many of the greenstone dikes of the district. The vein itself occupies a fissure which displaced the dikes just noted, but the amount of the displacement is not evident. Later another dike was injected in general parallel to the vein, but cutting it at a small angle. This later dike is a fine-grained, light gray rock, much decayed and holding small cubes of pyrite. The rock is probably of the nature of an andesite and possibly is as late as the Tertiary lavas of the district. Dikes of similar rock have been prospected at several other points in the vicinity of McCord gulch, but were not found to carry any important quantities of gold or silver.

#### WASHINGTON GULCH

*Sorbeck prospect*—On the west side of the tributary to Washington gulch near the center of Sec. 27, T. 9 S., R. 39 E., a considerable amount of work has been done in a branching tunnel which cuts various types of rocks—limestone, chert, greenstone, and a black tuffaceous rock. The latter carries a small amount of pyrite which tarnishes to a bright yellow, indicating probably a small copper content. Several small fault zones with clay gouge occur in these workings and one small vein of quartz was noted. A detailed study of this prospect, which contains in all over 1,200 feet of tunnel working, was not made.

*Helgeson prospect*.—In the southwest quarter of Sec. 22, T. 9 S., R. 39 E., on the northwest side of Washington gulch, are a number of prospect holes and tunnels on veins said to have been located by the "forked-stick method." The country rock is greenstone cut by some diorite dikes. One of the veins is composed largely of platy calcite.

*Dale prospect.*—Near the center of the west half of Sec. 22, T. 9 S., R. 39 E., west of Washington gulch, more than 400 feet of tunneling has been done along a vein which strikes N. 23° E. and dips 70° W. The vein carries both quartz and calcite, the latter being of very fine grain and possibly of the nature of aragonite rather than calcite. The foot-wall is distinct and the hanging-wall is less so. In one of the branch tunnels there is a very pronounced fault zone striking N. 67° W., and dipping 65° towards the north. About 100 yards south-east of this locality are old openings in much decayed rock which shows masses of gossan. The largest of these which was seen was about 5 feet in horizontal diameter and 6 feet deep. A little unaltered pyrite was observed in this gossan, which is mainly limonite with small quantities of hematite.

*Kent mine.*—Near the north edge of Sec. 28, T. 9 S., R. 39 E., at an elevation of 4,860 feet, there is a group of buildings belonging to the Kent mine. The largest building includes the plant, consisting of a boiler and a steam engine, a small gasoline engine, dynamo, Blake crusher, ball mill, large revolving roasting furnace (Bruckner type), a Chilian mill, an amalgamation plate, large vanner, and two Wilfley tables. It is said that this property has been closed since the spring of 1912. The ore which was treated in this mill was drawn by team from a tunnel about one and one-quarter miles distant. This tunnel is situated at an elevation of 5676 feet in the southeast quarter of Sec. 20. Judging from the material thrown out from this tunnel it must be something over 300 feet long. The rock is much decayed and consists mainly of greenstone and chert, the latter being frequently brecciated.

#### VIRTUE MINE AND VICINITY

*Virtue mine.*—This mine has been the largest producer of all the mines in the immediate vicinity of Baker and within the area covered by this report. It is consequently of much interest and Lindgren's account of it is here reproduced.\*

As this mine is one of the earliest and largest producers of the whole region described, it may be desirable to outline its interesting history more fully. It is 7 miles nearly due east from Baker City in air line, and is situated in the foothills of the dry and barren ridges which partially fill the big bend of Powder River. The drainage around it is to the northeast into the lower part of the river; its elevation is 3,800 feet.

The discovery dates from 1862, and was due to the tracing up of rich

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\*Lindgren, Waldemar, Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 2, 1901, pp. 722-724.

placers filling the gulches below it. For ten years after its discovery it was known as the Rucker or Union mine. A great deal of work was done in early days, as shown by Raymond's report of 1870. From 1871 to 1878 it was worked nearly continuously, largely by Brown and Virtue. In 1878 it was sold to Grayson & Co., of San Francisco, and up to 1884 was worked in a more or less satisfactory manner. From 1884 to 1893 the mine was idle, but in the latter year work was resumed and continued with excellent results until 1898, when, after a short period of idleness, it was sold to the Consolidated Virtue Mine Company, of Montreal, Canada, also owners of the adjoining Collateral mine. After a short period of work in the upper parts of the mine, it was again closed on August 1, 1899. When visited, the mine was, unfortunately, shut down. The property is equipped with a 20-stamp mill.

The production up to 1878 was \$1,250,000. From 1878 to 1884 \$200,000 is the estimated amount. From 1893 to 1898 the production was \$739,000, the maximum being reached in 1896 with \$256,000, and the minimum in 1898 with \$13,100. The total production is thus \$2,189,000.

The earlier developments consisted of three tunnel levels, the lowest of which is 300 feet below the croppings. From the lowest tunnel a vertical shaft was sunk 800 feet deep, and at each 100 feet crosscuts were made to the vein. The levels extend from 200 to 400 feet north and 800 to 900 feet south from the shaft.

The country rock is a greenstone of very fine grain and dull greenish gray color, some of it having a serpentinoid appearance. It is an old volcanic tuff of breccia, probably of the same age as the slates of the White Swan or the gabbro and diorites of Flagstaff. Much of it is so altered that its original character can be recognized only with difficulty. It has no slaty structure.

The vein strikes northwest and dips 45° to 80° SW., its width varying from 6 inches to 12 feet, being on an average 14 inches. Southeasterly it may be traced into the adjoining Virginia mine.

The ore is a white, normal, coarse vein quartz with some drusy cavities. It contains free gold, which often is very coarse and shows imperfect crystallization; it is unusually pure, reaching a fineness of 940. The quartz contains an extremely small amount of sulphurets, consisting of a little pyrite and chalcopyrite. Occasionally the quartz is banded by shearing, and this is considered the best rock. The country rock near the veins contains seams of calcite and pyrite, but ordinarily carries no value. The richest ore occurred near the surface. In 1870 the average yield was \$20 per ton; in 1873, \$40 per ton was reported; in 1875, \$24 per ton. From 1893 to 1898 the ore averaged \$15 or \$16 per ton. Still richer chimneys were occasionally found in the main ore shoot.

From the seventh level up, the ore was stoped for the full distance of the drifts, the ore shoot being practically 1,200 feet long. According to the earlier data in Raymond's report of 1870, the upper part of the shoot above the lowest tunnel level was much shorter. Mr. Grayson states that "no stoping was done between the eighth and the seventh level, as the ledge matter was broken up and carried but slight values." The mine was then abandoned, and since that time it has never been unwatered.

An interesting feature is that the water in the shaft is very abundant and stands a short distance below the collar, that is, a couple of hundred feet above the level of the valley. Moreover, it is warm or tepid, so that it must represent an ascending column of the underground circulation. The high temperature was a serious obstacle to the working of the mine.

The present owners of this property, organized as the Virtue Mines Development Company, now control claims amounting to 480 acres which run for about a mile along the vein, or rather the series of veins

which have been mined here. These claims are said to have had a combined product of over \$3,000,000. The equipment, on the main property, consists of a stamp mill with 4 batteries of 5 stamps each, 5 vanner tables, and 4 cyanide tanks, the latter having been recently installed. The motive power was formerly steam, but now electricity derived from the Eagle river has been brought to the mine. We understand that the Virtue mine has not been unwatered since 1899, but since that date some work has been carried on in the part of the mine above the adit level, and in 1913 a cyanide plant was installed and operated for a few weeks on the tailings left from earlier mining.

Mining on this property was carried on in a series of nearly parallel veins whose strike is from northwest to north-northwest; and they dip at steep angles to the southwest. Eight of these veins have thus far been located, but the larger part of the production has come from the most northeasterly, or the Virtue vein.

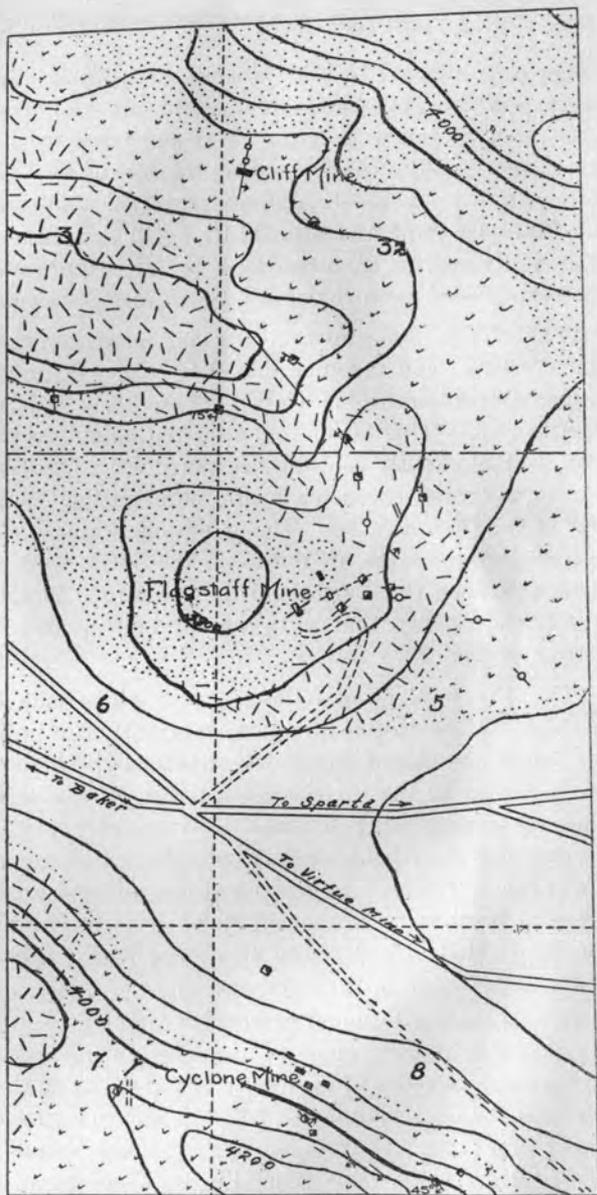
*Norwood mine.*—The Norwood mine is situated a short distance to the northwest of the Virtue mine and it is thought to have the continuation of some of the same veins which are found on the latter property. At the Norwood mine some active developmental work was being carried on in 1913 and a crusher with 5 stamps driven by electric power, were installed.

#### THE FLAGSTAFF MINE AND VICINITY

*Flagstaff mine.*—The Flagstaff mine is situated on the eastern brow of a prominent hill in Sec. 5, T. 9 S., R. 41 E., 6 miles northeast of Baker and 4 miles northwest of the Virtue mine. The mine is controlled by the Flagstaff Mining Company, and work was begun here some twenty years ago. At the mine there is a mill consisting of 4 batteries of 5 stamps each, an amalgamation plate, and a cyanide plant; both steam and electric power are used. In recent years the mine has not been working extensively except for a time in the spring of 1910. The shaft is said to go down 760 feet on the vein which strikes northeast and southwest and dips about 65° towards the southeast.

The accompanying map (Fig. 11) shows the location of this mine and the geology and topography of the district adjacent to it. The map was somewhat hurriedly made and none of the mines were being worked during our visit, so a careful study of the veins was not possible.

The country rock is several varieties—hillside wash, basalt, lake-beds, relatively recent diorite, and an older complex of argillite, green-



Scale  $\frac{1}{4}$   $\frac{1}{2}$   $\frac{3}{4}$  1 Mile

Contour Interval 100 feet.

Fig. 11. Sketch Map of the Vicinity of the Flagstaff Mine.

stone, etc., referred to the Carboniferous. Wash covers much of the surface in the draws and lower elevations. Probable lake-beds outcrop near the junction of the roads and trails in the southeast quarter of Sec. 6 and in the ditch along the base of the basalt about a quarter of a mile to the north. Basalt forms the capping of the hill west of the Flagstaff mine and also occurs north and east of the Cliff mine in Secs. 31 and 32, T. 8 S., R. 41 E. It is quite possible that basalt has been eroded from the area between these two points.

The oldest rocks are argillites and greenstones which have been much mashed and metamorphosed by regional, and possibly also by contact, metamorphism. Cutting these rocks is a mass of younger dioritic rock. This latter underlies the basalt west of the Flagstaff mine and apparently continues eastward for a quarter of a mile or so. Diorite of similar character is also found on the hill about a half-mile west of the Cyclone mine. The greenstone which is cut by this diorite laps around the mass of diorite on the north, west and south. The contact between the diorite and the greenstone complex was observed in only one locality, that is, in the southwest quarter of the southwest quarter of Sec. 32.

The Flagstaff mine follows a vein which cuts the diorite in a northeast and southwest direction, apparently continuing to the southwest below the cap of basalt for at least a short distance. The vein can be traced on the surface about one-quarter mile northeast of the mine, its course being followed by frequently placed test pits and prospect shafts. About one-quarter mile east of the mine on the east side of the diorite area are a series of test pits and prospect shafts with a general north-south alignment which seem to follow a vein or veins running in that direction and at a large angle to the Flagstaff vein.

The Cliff mine in the northwest quarter of Sec. 32 follows a vein which cuts the argillite and greenstone complex in a direction slightly east of north, or at an angle of about  $60^\circ$  to the bearing of the Flagstaff vein. The series of prospect pits and shafts on the south range of hills near the Cyclone mine in 7 and 8 seem to conform to the general type of vein extending from the Cyclone to the Virtue mine along this line of hills. These veins generally run about parallel to the axis of the hills and cut argillite or greenstone. The argillite east of the Cyclone mine is cut by peridotitic, gabbroic, and granitic dikes. West of the Cyclone mine the greenstone lies against the diorite, which is apparently part of the same mass cut by the Flagstaff vein.

Although the veins most prospected seem to run in the directions indicated, other veins cut the country rock at many variations from these directions. No attempt has been made to correlate the different veins, as it would require a greater knowledge of the structure of the region than could be obtained in the short time spent in the field. That there is more than one series of fractures filled by vein material is evident, but the relative ages of these different fractures have not been determined.

#### FARLEY HILLS

The name Farley hills has been applied to the elevation in the vicinity of Magpie peak, which is near the center of T. 7 S., R. 40 E. These hills extend northwestward from this peak to near the northwest corner of the same township. On the lower western slopes of Magpie peak and extending north and northwest to the Buckeye mine in Sec. 6 of this township is a considerable number of prospects. The country rock is chiefly granite and greenstone with small quantities of slate and quartzite, the whole cut by dikes of both acid and basic rocks. The prospecting has been done along certain layers of rock or in masses which contain varying quantities of limonite gossan. The layers of rock prospected consist chiefly of white granular material which in some cases is vein quartz, in others is a fine-grained weathered granitic rock, and in still others is apparently a much silicified tuff. The material thrown out of the prospects is usually highly weathered and sulphides, except occasionally pyrite, are rare. In a few places green stains of malachite were noted.

*Buckeye mine.*—This mine is situated in the northwest quarter of Sec. 6, T. 7 N., R. 40 E., and originally had a considerable equipment. The mine has evidently been abandoned for several years, and the workings are not usually accessible. There are many old pits and tunnels as well as some deeper shafts. From the material thrown out of these workings it is evident that some limonite gossan areas were encountered, and from most of the workings a fine-grained, white-weathering, dense rock was obtained. This contains veinlets of quartz and was evidently regarded as part of the ore. Its exact nature is not clear, but it seems to be, at least in part, a highly silicified tuff. Rock somewhat similar to this was found on the dump from the main shaft, and it is here green in color and unweathered. This rock is highly charged with pyrite, and the pyrite occurs both in disseminated crys-

tals and in veinlets. The masses of gossan seen at the surface probably came from the weathering of such rock.

At the main shaft some ore still remains on the ground. This ore consists of gray to green rock which has been highly silicified so that it is now largely quartz of fine grain. This rock has been minutely fractured and the fractures filled by quartz and metallic sulphides. These sulphides are also disseminated through the rock outside of the fractures. The sulphides are pyrite, sphalerite, and chalcopyrite. The pyrite and sphalerite are especially prominent. Some of the pieces of ore show malachite stains along the cracks.

#### VICINITY OF HAINES

In the hills east and north of Haines a few quartz veins occur, but they are small and have been prospected to only a very limited extent. In one locality, near the northeast corner of Sec. 34, T. 7 S., R. 39 E., at an elevation of 4,625 feet, are several pits and trenches on a vein which is a sheeted zone in the country granite (the Haines granite). The vein is 2 to 6 feet wide and is composed of one-fourth to one-third quartz, and the remainder is crushed granite. The quartz and granite are much oxidized and iron-stained, and the nature of the original metallic minerals is not clear. The vein strikes north-north-west, dips 65° to the west, and is paralleled on the east by a fine-grained greenish dike (probably diorite). In one of the openings at this place the following section was observed in going from east to west.

	Feet	Inches
1. The above mentioned dike rock.....	3	.
2. Sheeted zone, composed of quartz and crushed granite .....	1	.
3. Granite .....	4	.
4. Sheeted zone of quartz and crushed granite..	3	.
5. Granite .....	2	.
6. A nearly vertical dike, composed of soft, fine-grained, highly weathered, porphyritic rock.	0	15
7. Granite .....	8	.

#### PLACER DEPOSITS

The production of placer gold in the Baker district long ago became of small importance. At the present time there is little activity in placer mining, although in a few places a small amount of gold is still recovered from gravels. Recent work of this kind has been done on Salmon creek and in two places in Washington gulch.

Formerly there was much gold produced from placer workings in this district, and practically all of the streams flowing out from that part of the Elkhorn ridge which extends eastward nearly to Baker have furnished auriferous gravels of value. The most extensive placer workings in the area covered by this report were on Salmon creek and just to the west, at the mouth of McCord gulch. On Salmon creek the Nelson placers were worked for a long series of years, even after many of the other auriferous gravel deposits were exhausted.

The future will probably see a local continuance of small workings in these gravel deposits, and the success of recent dredging operations near Sumpter may stimulate further search for dredgable ground on the lower reaches of some of the streams flowing out from the Elkhorn ridge.

#### COPPER

The copper-iron sulphide chalcopyrite is found to a small extent in some of the veins of the district, but in no place have large quantities of it, or other copper-bearing minerals, been reported, except possibly from the Buckeye mine (p. 156). The masses of gossan mentioned in the description of the Dale prospect in Washington gulch (p. 150) and of the prospects in the Farley hills (p. 155) and at the Buckeye mine, may possibly come from rock carrying small quantities of copper sulphides along with large quantities of iron sulphide. Little is known of the original unweathered condition of such sulphide masses in this district, and from the weathered portions of them the copper, if it ever existed in appreciable amounts, has been leached almost completely.

#### IRON

No iron deposits have been reported from the vicinity of Baker. The most suggestive indications of such deposits are small accumulations of iron oxide (hematite) in the zone between the base of some of the basic Tertiary lava flows and the underlying rocks. On the north slope of Coyote point, near Haines, a few prospect pits have uncovered a mass of red material which consists of weathered granite much stained and impregnated by hematite, but not containing a large enough percentage of iron to be called an iron ore. An analysis of this hematite material showed only a trace of phosphorus and of sulphur.

### ZINC AND LEAD

The sulphide of zinc (sphalerite) and the sulphide of lead (galena) occur in small amounts in some of the quartz veins of this district. In no place have they been reported to be abundant except at the Buckeye mine (p. 155) where sphalerite is very common in a small quantity of the ore left at the mine.

### LIMESTONE

The deposits of limestone in the immediate vicinity of Baker City that are of most economic importance, are located from one-half to one mile north of Pleasant valley in Section 18, T. 10 S., R. 42 E. There are three quarries. One is located in the southeast quarter of the southwest quarter; a second in the northwest quarter of the southwest quarter; and a third in the southwest quarter of the northeast quarter of this section.

The rock is bluish-gray in color and of a dense texture. In places, especially in the first mentioned quarry, it appears to have been brecciated and then recemented. It is here also cut by small veins of a darker colored calcite. A great many samples taken from all of the quarries have been analyzed. The analyses show that the limestone is practically pure calcium carbonate containing only about one-half of one per cent of silica, approximately the same amount of iron oxide and alumina, and a very small percentage of magnesia.

Although no fossils are present the limestone should probably be referred to the Carboniferous, on the basis of lithologic and structural resemblance to other occurrences of limestones in eastern Oregon, that are known to be of this age. Other rocks of similar age in the vicinity are cherts, argillites, and greenstones.

The extent and size of the deposits are as follows:

Quarry in S. E.  $\frac{1}{4}$  of S. W.  $\frac{1}{4}$  has an opening about 75 feet long, 30 feet wide, and a face 20 feet in height. The limestone outcrops over an area of about one-fourth of an acre.

The quarry in N. W.  $\frac{1}{4}$  of S. W.  $\frac{1}{4}$  is but a prospect cut, though the limestone is exposed over about 4 or 5 acres. Along the steep hill slope at the south it can be seen to have a thickness of at least 50 feet.

The third quarry referred to has an opening about 100 feet long, 30 feet wide, and a face of 20 feet. The rock is known to cover about 5 acres. In this quarry there is an irregular bed of shaly limestone about 4 feet thick. The dip as measured on this interbedded shaly layer is approximately  $40^{\circ}$  to the northeastward and the strike

N. 25° W. From this it can be seen that the limestone bed is considerably thicker than the 20 feet exposed in the quarry opening.

Formerly the rock from the two quarries that have been worked was hauled to a lime-kiln near the old town of Pleasant Valley, which is about one mile northwest of the present railroad station. Some limestone for this kiln was also obtained from a small deposit located in the southeast quarter of the northwest quarter of Section 12, T. 10 S., R. 41 E.

Transporting the limestone from the quarries to a plant at Pleasant Valley can easily be done with an aerial tramway as the difference in elevation between the two points is about 600 feet. There are volcanic tuff quarries close to the railroad and it has been determined by careful tests that this material can be used with the limestone, replacing shale to a large extent, for the manufacture of Portland cement. The Baker Commercial Club has had such tests made by the Smith Emery Company of San Francisco, also by the Wolverine Portland Cement Company of Coldwater, Michigan, previous to their endorsement of the Intermountain Cement and Lime Works of Baker, which proposes to erect a cement plant in the vicinity of Pleasant Valley. On account of the financial situation due to the European war, the promotion of this company is suspended.

#### BUILDING STONES

The chief building stones used about Baker are the Haines granite and a peculiar gray volcanic tuff from Pleasant Valley, about 12 miles southeast of Baker. The granite has been used in buildings and also for ornamental and statuary purposes. It is of a pleasing dark gray color, polishes well, and is very durable. The volcanic tuff has been used in many buildings. It is of light gray color, is easily worked, is of comparatively light weight, and will probably have an increasing use. Both of these building stones have been described elsewhere.\*

#### ROAD MATERIAL

In very many places throughout the district there are deposits of gravel which can be used for road material. Some such material has already been obtained from two gravel pits in the eastern part of the city of Baker and small amounts of gravel for road dressing have been taken from various localities. Undoubtedly much larger quantities of gravel are available than there is likely to be a demand for.

\*Parks, H. M., Mineral Resources of Oregon, Vol. I, Feb., 1914, pp. 18-19, 37-40.

Many of the harder rocks of the area when crushed will furnish excellent road metal, and two quarries, with crushers, have already been established at Baker for the production of such material. These quarries use the Tertiary basalt. The supply of rock for road metal is far beyond the present or any future demand.

#### POLISHING POWDER

The volcanic ash already described (p. 72) occurs in a few places in quantities sufficient to furnish a supply of material which might be of service as a polishing powder. The purer parts of this ash consist mainly of minute and sharply angular fragments of fresh volcanic glass.

#### WATER RESOURCES

Water for irrigation, for domestic purposes and for medicinal purposes occurs in the vicinity of Baker. Water from the Powder river and some of the other streams is used for irrigation, and the future will probably show irrigation more extensively practiced than at present, for larger supplies of water are available than are now used. In the Baker valley and in the valleys of some of the smaller streams there are wells which furnish good water for domestic use. Undoubtedly more extensive use will be made of this ordinary ground water as the country becomes more thickly populated. The town of Haines gets its supply from a well reported to be 160 feet deep. This well penetrated sand, gravel, and clay, but no solid rock. There is good reason to believe that other deep wells sunk in the floor of the Baker valley will prove to be successful. The city of Baker obtains an abundant supply and an excellent quality of water by means of the old Auburn ditch which crosses and appropriates water from a number of mountain streams such as Marble, Salmon and Elk creeks. The water is taken from this ditch in Sec. 33, T. 9 S., R. 39 E., and carried by means of a pipe line to a large reservoir on the north slope of the hills just southwest of the city.

*Electric Power.*—The Eastern Oregon Light and Power Company's high tension line into Baker from its Rock creek plant is located along the southwestern side of Baker valley. A branch line five or six miles in length would reach the mines in the western part of this quadrangle.

Although a high tension line has recently been built from Eagle river to Baker, a distance of approximately thirty miles, the company is not prepared to furnish continuous service so necessary to mining

companies. This line passes through the Virtue district, but these mines are only from six to twelve miles from Baker. The Eastern Oregon Light and Power Company stand ready to construct branch lines to any points where such expense seems to be justified. They would doubtless do this for each of the above mentioned districts.

#### SOILS

The soils of this district, especially where they can be irrigated, have proved themselves to be well adapted to diversified farming. Large parts of the Baker valley, as well as some of the smaller valleys, have been successfully cultivated (Figs. 7 and 8) for a number of years, and the extent of this cultivated land is constantly increasing. The introduction of dry-farming has caused, within the last two years, a decided advance in the size of the area under cultivation. The soils vary in character, but in large part are formed of not totally disintegrated materials derived from igneous rocks, and so have been leached of the substances necessary for plant growth. Small areas underlain by the recent volcanic ash are said to be especially fertile and particularly adapted to the growth of garden truck and small fruits.