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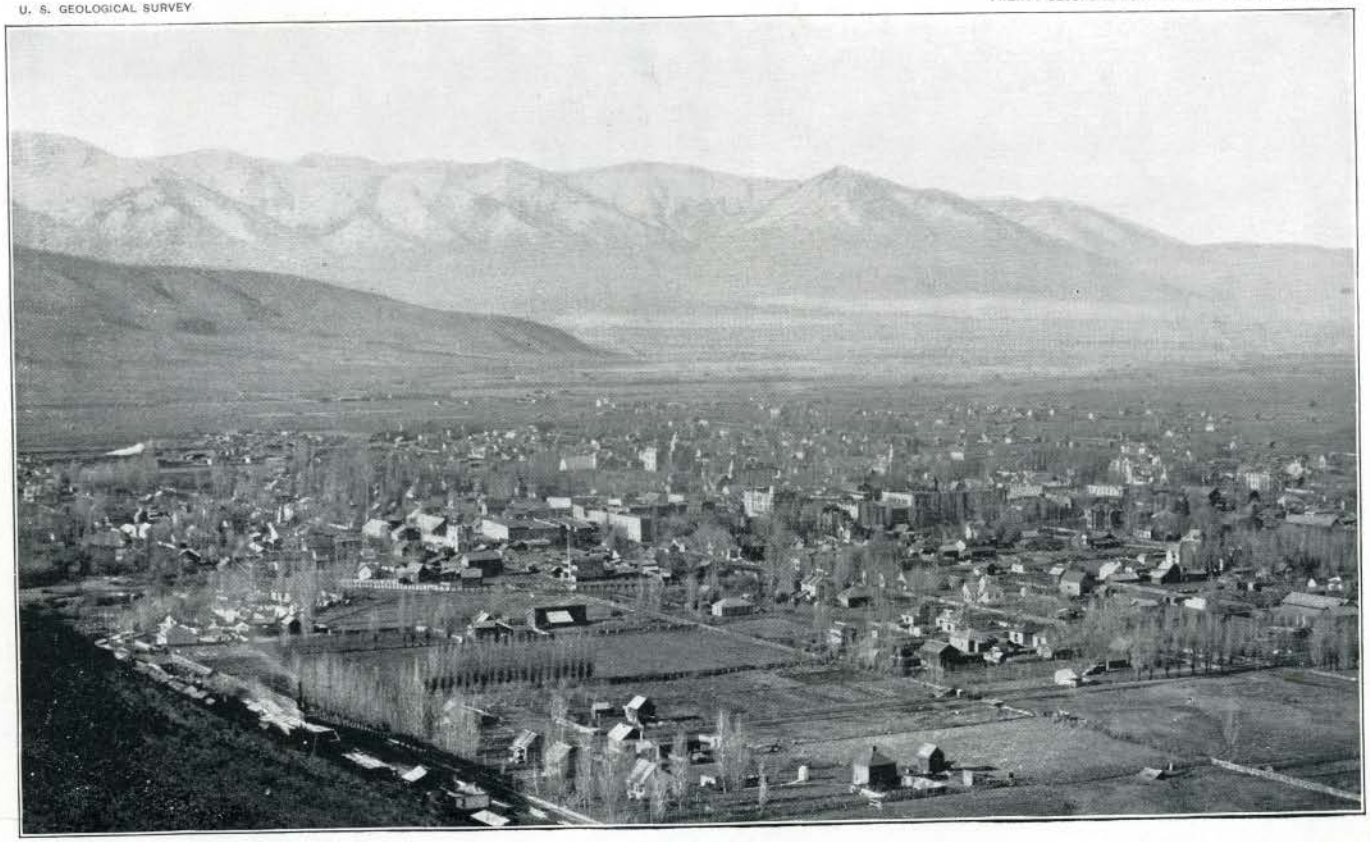
THE GOLD BELT OF THE BLUE MOUNTAINS OF OREGON

BY

WALDEMAR LINDGREN



BAKER CITY.

THE GOLD BELT OF THE BLUE MOUNTAINS OF OREGON.

By WALDEMAR LINDGREN.

CHAPTER I.

INTRODUCTION.

GEOGRAPHIC POSITION, FIELD WORK, AND ACKNOWLEDGMENTS.

The State of Oregon contains several gold-bearing areas, widely scattered over different regions. Practically its whole coast is fringed by a belt of auriferous sands which sometimes are rich in fine gold. A second gold field is situated in the southern part of the State, chiefly in Jackson and Josephine counties, and may be considered as an extension of the gold belt of northern California. A third auriferous region is that of the Calapooya Mountains, extending northward toward the Santiam River and centering in the Bohemia mines.[1] Here the gold and silver appear in veins contained in Neocene andesites and basalts. A fourth mineral-bearing area is reported from the Puebla Mountains, in the extreme southeastern part of the State.

But the most important gold field of Oregon is that of the Blue Mountains. It is situated in the northeastern part of the State, and extends for a distance of about 130 miles westward from Snake River. Its production is at least three-fourths of the total output of the State. The present report deals exclusively with this region, which during the last few years has again assumed the prominent position among the gold-bearing areas of the United States which it held about forty years ago, when gold was first discovered there.

The present report is the result of an examination of the Blue Mountains made during a period extending from August to December, 1900, and undertaken by order of the Director of the United States Geological Survey. It will be conceded that four months is a short time in which to examine such an extensive territory and such a wealth of mineral deposits. The report therefore partakes of the character of preliminary or reconnaissance work, and should be judged

[1] The Bohemia mining region of western Oregon, by J. S. Diller: Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, pp. 7–36.

accordingly. It was not possible to visit all the mines and prospects in the gold belt. The most prominent were naturally selected, but it should be emphasized that the failure to mention any particular deposit in this report is by no means a reflection on it or an indication that it lacks value.

A large proportion of the data concerning mines and mining in this report has, of course, been obtained from the men who are in charge of the mining operations in the Blue Mountains, and to all of them my best thanks are due. With two conspicuous exceptions, permission to visit the mines was cheerfully extended and information readily

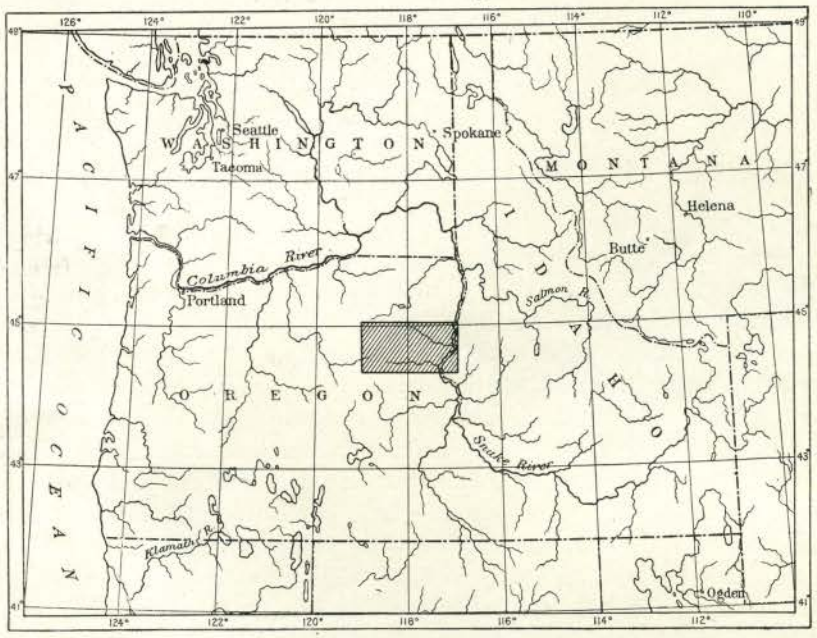


FIG. 79.—Index map of Northwestern States, showing location of special map.

given. Among the many to whom I am under obligations I would specially mention Messrs. E. Melzer, F. R. Mellis, J. Arthur, F. E. Cabell, H. S. McCallum, N. C. Haskell, and J. H. Pomeroy.

THE MAP.

In order to present graphically the distribution of the mineral-bearing areas, the accompanying map (Pl. LXIV) has been prepared. The data contained in it require a few words of explanation. The map is based on the triangulations and the determination of latitude and longitude made by Mr. S. S. Gannett, of the United States Geological Survey. The Sumpter, Baker City, and Weiser (Idaho) atlas sheets of the United States Geological Survey, surveyed by Messrs. L. C. Fletcher, R. H. McKee, and E. T. Perkins, have been reduced to the

scale of the map and used as a basis. The first two sheets include the region extending from latitude 44° 30′ to 45° and from longitude 117° 30′ to 118° 30′. For the country outside of these three quadrangles the base for townships and drainage has been the General Land Office map. The contours drawn at 500 feet vertical interval have been sketched by myself in the field. Excepting in the area of the three atlas sheets mentioned, they are to be regarded as approximate only, but they will serve to give a general idea of the character of the country. In the compilation of the data outside of the special quadrangles the mining map of eastern Oregon, issued by Mr. John Hagel, of Baker City, has been extensively used. Similar maps, issued by the Oregon Railroad and Navigation Company and by Mr. Arthur Philbrick, have also been found of use. As to the mineral veins indicated on the map, their position has been ascertained partly by independent observation, partly from data obtained from the surveyor-general's office, and partly from claim maps of the different regions issued by Mr. John Hagel.

Owing to the hasty nature of the field work, it is with considerable hesitation that it has been decided to indicate the geological areas on the map, but it is believed that the indication of the various rocks will so greatly help the understanding of the problems involved that, although imperfect, it should not be omitted. It must be expressly emphasized, however, that the outlines are only approximate in many cases.

PREVIOUS EXPLORATIONS.

From a geological standpoint, the gold belt of eastern Oregon has practically been an unknown region. The only data available to the student are those contained in Raymond's reports.[1] Though these reports deal more extensively with mining and the production of mines, there are, for instance in the report of 1870, some general notes on the geology of the region.[2] Notes regarding production are to be found in the various reports on the production of gold and silver by the Director of the Mint. The data contained in this report, therefore, to some extent fill a gap in our knowledge of the western United States.

HISTORY AND SETTLEMENTS.

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

[1] Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains, by R. W. Raymond, Washington, 1870, 1871, 1872, 1873, 1874, and 1875.

[2] Notes in regard to the mining industry may also be found in the report of J. Ross Browne on the mineral resources of the States and Territories west of the Rocky Mountains (Washington, 1868).

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.

It was soon seen, however, that profitable mining was dependent upon water supply, and in the next few years much capital and labor were devoted to the construction of ditches. In 1863 the Auburn canal, taking its water from Pine Creek and other gulches in the Elkhorn Range, was completed. The Rye Valley ditch was constructed in 1864. The Sparta ditch, carrying the waters of Eagle Creek down to the dry hills of Sparta, a distance of 22 miles, was completed in 1873. About the same time a project was carried out supplying the Malheur diggings with water from the head of Burnt River. This canal, called the Eldorado ditch, was finished in 1873. Its total length is over 100 miles.

By means of these ditches much ground which formerly was inaccessible or too poor to work became available. 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. From an output of several million dollars in 1870 the product of the placer mines has gradually diminished to something like $200,000 in 1899. During the last years the decline has been very gradual, and it is likely that a production of $200,000 may be kept up for many years to come, as low-grade gravels are beginning to be worked by modern processes of dredging.

While the placer mines declined, another industry, that of quartz mining, gradually developed. We find records of quartz mines being worked in Susanville and at Mormon Basin in 1865 and 1868. One of the first mills was built at Susanville in 1869 and the process used was pan amalgamation. The Virtue mine was discovered soon after 1862, and the Connor Creek mine in 1872, when the first prospecting in the vicinity of Cable Cove was begun and La Belleview and Monumental mines were worked. The ore was shipped on horseback for several

hundred miles. Under such conditions the development of quartz mining was necessarily slow. Its active development dates from 1885, when the country was made accessible by the construction of the transcontinental railroad now traversing it. About 1886 valuable discoveries were made in the Eagle Creek Mountains near Cornucopia. From 1889 a rapid increase in the production was noticed. Quartz mines were worked in various parts of the country and some of them produced heavily. A number of mines in the Cracker Creek district were then, for the first time, considered worthy of exploitation and soon began to add to the annual production. This quiet development continued until 1899, when public attention was drawn to the extremely gratifying results obtained from the quartz mines in the Sumpter, Granite, and Bonanza districts. The West seemed suddenly to become aware that the long-neglected gold fields of the Blue Mountains had far greater value than was commonly attributed to them. In 1899 and 1900 a strong influx of prospectors and miners from all parts of the West took place, and under the stimulus of this new immigration and the introduction of modern methods of mining the country has rapidly developed. Prospectors have penetrated the whole region, searching for gold and silver veins. While this "boom" has probably induced over speculation, and in some cases an exaggerated notion of values, it has served to make the country better known and many valuable mines have been opened as a consequence of it.

The supply point for the largest part of the mining region is Baker City, a flourishing town in the Powder River Valley, having a population estimated at 7,000. The dormant camp of Sumpter was revived during the boom of 1899 and is now a prosperous mining town. Auburn, once flourishing, is now practically deserted. Canyon, in the John Day Valley, still remains a mining town of some importance. Other settlements of note are Union, located 30 miles north of Baker City, from which the camps of Eagle Creek Range largely receive their supplies, and Huntington, 40 miles southeast of Baker City, which is the supply point for the mining camps of Rye Valley, Malheur, Connor Creek, and Mineral. According to the last published census (1890) the population of the three counties, Baker, Union, and Grant, numbered 23,900.

Although the larger part of the area consists either of mountains and forests or dry foothills, there are several agricultural districts of great value. South of the Eagle Creek Mountains are the beautiful valleys of Pine and Eagle, which have a mild climate. Along the lower Powder River a belt of fertile bottom lands extends for a distance of 20 miles. The largest agricultural area is that of Baker Valley, 18 miles long by 10 miles wide. This has a somewhat higher elevation and its climate is a little colder than that of the valleys previously mentioned. West of Baker City extends a vast area of

mountains and canyons, the only agricultural areas of importance being Sumpter and Clifford valleys, which, however, are at elevations over 4,000 feet, and are chiefly used for pastures and hay lands. Very little agricultural land is found on the North and Middle forks of John Day River. On the South Fork of the same river, however, extends the fertile John Day Valley, having a length east to west of about 20 miles and a width up to 10 miles. The John Day Valley is justly celebrated for its excellent fruit and beautiful alfalfa fields. It has an elevation of about 3,200 feet, and is one of the oldest agricultural settlements in eastern Oregon.

Practically all of the agricultural lands of the Blue Mountain must be irrigated if heavy and profitable yield is desired. On certain rich bottom lands it is possible to raise a crop of hay or cereals without irrigation, but this is exceptional. In the Baker Valley are large areas which could be cultivated if water were available, and a project is now on foot to obtain it by storing the flood water of Powder River during the winter and gradually distributing it through the summer.

CLIMATE AN VEGETATION.

Owing to the great diversity in elevation and situation, the climate in the Blue Mountains varies considerably from place to place. Along the Snake River and the contiguous valleys a dry, warm climate prevails, with little rain and snow. At Baker City the average precipitation for a period of ten years was 13 inches, varying from 4.17 to 18.23 inches per annum. The temperature during the last ten years shows variations from $+110^\circ$ in July to a minimum of -17° in the winter. In the mountain region west of Baker City the rain and snow fall increases rapidly with the elevation. Showers during the summer are of frequent occurrence, and the winter snows are from 5 to 15 feet deep.

The vegetation is, of course, largely dependent upon the meteorological conditions. Arid foothills without forest growth, but with a sometimes luxuriant vegetation of grass and sagebrush, extend from Baker City to Snake River. East of Baker City the mountain region is covered with a heavy growth of timber, except the highest, once-glaciated areas, which have been swept bare of soil by the ice streams. The northwestern part of the area described has the greater precipitation and the more abundant vegetation. The southeastern part, sloping toward the great interior valley of Snake River, is dry and destitute of forest growth. Bare foothills extend from Huntington westward over the lower part of Willow Creek and Burnt River. On the whole, it may be said that an elevation of 4,000 feet marks the timber line. Below this elevation there are only scattered groups of trees.

Except for willows and alders along the water courses, the forests consist entirely of coniferous trees. The most important of these is the yellow pine, which attains its best development at an elevation

of from 4,000 to 5,000 feet. Above 5,000 feet the timber is usually of poor quality, consisting largely of black pine and tamarack. The best timber is found on the headwaters of Powder River, Burnt River, and the Middle Fork of John Day, while on the North Fork of John Day the growth appears to be of inferior character.

MINING AND METALLURGY.

In eastern Oregon mining is usually carried on under favorable circumstances. Wood, timber, and water are ordinarily in good supply. The principal drawback is the distance of some camps from railroad lines, and in the highest mining districts the severe climate, as, for instance, at Cable Cove, on the Greenhorn Ridge, and at Cornucopia. No special comment is required in regard to methods of mining. In many cases lack of technical skill has materially increased the difficulties. Men of various professions have been sent out to take charge of mines, instead of experienced mining engineers. At some prospects, and even at some mines, manifestly unsafe shafts and machinery were found. Still, these matters have greatly improved and many of the mines are now models of their kind. The cost of mining may be taken to vary from $1 to $4 per ton in the large mines having considerable bodies of ore 2 to 6 feet wide. According to Mr. J. Arthur, the E. and E. mined their vein from a shaft 200 feet deep, at a cost of $1.85 per ton. The cost of mining at the Columbia mine, hoisting from a shaft 500 feet deep, is supposed to be $3 per ton.

The simplest and most satisfactory ores are those of mainly free milling character, like the Red Boy, Bonanza, and Belle of Baker veins. The cost of milling with plate amalgamation and concentration is rarely over $1 per ton. At the E. and E. mine, according to Mr. Arthur, milling costs $1.05 per ton, giving a total for mining and milling of $2.90 per ton. At the Bonanza the mining and milling are believed to cost from $2.50 to $3 per ton. At the Red Boy the total expenses are said to be a little heavier, possibly reaching $4 per ton. Sometimes it is necessary to subject the tailings to the cyanide process, and this will increase the total cost by at least $1 per ton. When the ore is roasted and subjected to direct cyaniding, as at the North Pole mine, the expense naturally becomes higher. In the mines which produce large amounts of concentrates or sulphide ores, which must be shipped to smelting works, the cost of treatment is, of course, greatly increased, freight and smelting charges amounting to at least $5 each, or a total of $10, besides heavy wagon freight if the mine is situated far from railroad. Anything containing less than $25 per ton is usually not considered shipping ore. Frequently the total charges reach $30 per ton. Last year an attempt was made to run a small smelting plant at Sumpter, but even with the most careful management there are great drawbacks to such an enterprise; the main ones are expensive coke and the absence of large quantities

of suitable copper and lead ores. Smelting of cupriferous pyrite by the pyritic process was for some years successfully carried on at the camp of Mineral, on Snake River.

Regarding the percentage of extraction, exact data are difficult to obtain. It is not probable that any mill at present works closer than 80 to 85 per cent, and many of them fall considerably short of this figure.

The ores from veins in argillite, which in their normal, fresh state consist of hard quartz with finely disseminated pyrite and arsenopyrite, have from the start proved a difficult problem for the metallurgist, and useless plants, erected without due deliberation and preliminary tests, have absorbed a heavy expenditure, which could have been avoided by more skill and care.

It seems that the values are chiefly contained in the fine-grained sulphurets inclosed in the quartz; but besides this there are in the different shoots great variations in the relative percentage of gold and silver, as well as in the state of the gold. The surface ores—that is, down to a depth of 100 to 200 feet below the surface—are partly oxidized. While this frees a part of the gold, another part is still held by the sulphides. The surface ores can therefore usually not be treated by amalgamation and concentration except when, as in the Red Boy and Bonanza, the proportion of free gold is great. The cyanide process has been used for these ores. Even then it is necessary to roast the ore carefully before the cyanide solution is applied, a fact which of course considerably increases the cost. When, as in the case of the base ore of the E. and E., the concentration process was used for surface ore, the extraction only averaged from 50 to 60 per cent, the percentage saved increasing at the rate of 10 per cent for every 50 feet of depth gained.

In cyaniding the similar North Pole ores, on the other hand, the extraction was found to be 85 per cent on ore averaging 0.753 ounce of gold and 0.967 ounce of silver per ton.

In using the plate amalgamation and concentration method on the deep ores the percentage of gold saved on the plates varies from a few per cent up to 60 and above, the highest savings being found in the Bonanza and the Red Boy ores. Successful concentration of these ores depends largely upon the manner in which the crushing is effected. Mr. J. Arthur informs me of the following experiment in this direction: A mill sample was taken for thirty days from the E. and E. ore, when this mine was running, crushing through a 50-mesh screen. This sample assayed $11.50 per ton, and the mill extraction for this month was 51 per cent. The fine slimes from the mill would sometimes run somewhat higher than the ore. Concentrated in gold pan in the laboratory, only 48 per cent was recovered. Ten pounds of this sample were then crushed to one-fourth inch size, and it was found that 28 per cent of the value could be saved by jigging. The tailings from the

jig were then crushed through 10-mesh screen, and 26 per cent again saved by jigging. The tailings from the jig were recrushed through 40-mesh screen and run over vanners. The three crushings resulted in a total saving of 83½ per cent. This would seem to indicate the method to be pursued for disseminated sulphide ores, without free gold. At present the stamp mill usually crushes directly to 50-mesh screens and the pulp is run over vanners. Lately, at the Columbia mine, the tailings have been saved, and it is reported that it has been found practicable to cyanide the tailings, without roasting, with 76 per cent extraction, by a five-day percolation, the cost of the cyaniding being as high as $1.50 per ton.

PRODUCTION OF GOLD AND SILVER IN OREGON.

As by far the largest proportion of the production of the precious metals comes from the Blue Mountains, it may be pertinent to give the figures relating to the production of the State as a whole. During the earlier years statistics were very imcomplete. Gold and silver were not separated, and, indeed, for a number of years the production of Washington was included in that of Oregon. The former did not, however, amount to very much.

The product for the four years from 1862 to 1865, inclusive, is not known, even as an estimate. It would not be surprising if it reached $50,000,000, as the years closely following the discovery marked the high point of production. The product in 1865 is doubtfully estimated at $20,000,000 (J. Ross Browne).

Production of gold and silver in Oregon and Washington from 1866 to 1875, inclusive.

[Compiled from the official reports on the production of the precious metals by J. Ross Browne and W. R. Raymond.]

Year.	Gold and silver.
1866	*a* $8,000,000
1867	3,000,000
1868	4,000,000
1869	3,000,000
1870	3,000,000
1871	2,500,000
1872	2,000,000
1873	*b* 1,376,400
1874	*c* 609,070
1875	*c* 1,246,978
Total	28,732,448

a Estimated by some as high as $20,000,000.
b Estimate of total by Wells, Fargo Express Company; Oregon only.
c Oregon only.

There are no official statistics for 1876, but the production may be roughly estimated at $1,100,000. From 1877 to the present time somewhat more accurate statistics are available, which are given below. It should be stated, however, that the silver production does not appear to be reliable, as in many returns from placer mines the relatively small amount of silver is apparently overlooked. Moreover, as the silver value given is the coining value, or $1.29 per ounce, the returns for the years later than 1884 are misleading, the price of silver having declined to about 60 cents per ounce.

Production of gold and silver in Oregon from 1877 to the present time.

[From the reports of the Director of the Mint on the production of the precious metals.]

Year.	Gold.	Silver (coinage value).	Total.
1877	$1,000,000	$100,000	$1,100,000
1878	1,000,000	100,000	1,100,000
1879	1,150,000	20,000	1,170,000
1880	1,090,000	15,000	1,105,000
1881	1,100,000	50,000	1,150,000
1882	830,000	35,000	865,000
1883	660,000	3,000	663,000
1884	660,000	20,000	680,000
1885	800,000	10,000	810,000
1886	990,000	5,000	995,000
1887	900,000	10,000	910,000
1888	825,000	15,000	840,000
1889	1,200,000	38,787	1,238,787
1890	1,087,000	129,199	[a]1,216,199
1891	1,994,622	296,280	2,290,902
1892	1,491,781	64,080	1,555,861
1893	1,690,951	13,557	1,704,508
1894	2,113,356	10,315	2,123,671
1895	1,837,682	15,192	1,852,874
1896	1,290,964	71,811	1,362,775
1897	1,354,593	109,643	1,464,236
1898	1,216,669	165,916	1,382,585
1899	1,467,379	187,932	1,655,311
Total	27,749,997	1,685,712	29,435,709

[a] Census reports: Gold, $964,000; silver, $23,383; total, $987,383.

The data show a gradual decline in production from the heyday of placer mining in 1862–1866 to less than a million dollars ($663,000) in 1883. From this time quartz mining on a larger scale begins to show its influence, and during the last decade of the century the production

rises to between one and two millions, exceeding the latter amount during two years. The production for the last few years averages $1,400,000, and it is believed the product of 1900 will show a considerable increase over that of 1899.

The total production of gold in Oregon from 1866 to 1899, inclusive, is approximately $59,000,000. Adding to this the production from date of discovery, 1861 to 1865 inclusive, very roughly estimated at $50,000,000, we obtain the whole production of gold and silver in Oregon as $109,000,000. Silver forms but a small fraction of this amount.

PRODUCTION OF GOLD AND SILVER IN THE BLUE MOUNTAINS.

The production of the three counties of the Blue Mountains is very imperfectly known previous to 1880. From that year (except in 1896) detailed statistics have been given in the Mint reports, and in the reports from 1889–1892 individual reports from the separate mines as well. It is much to be regretted that this could not be kept up, the chief difficulty being the objection of the average mine owner to having his production published. In looking over the following compiled tables it becomes apparent that many inaccuracies and discrepancies clearly exist, so that the figures are at best only approximate. Still they serve to give an idea of the relative importance of the counties and the fluctuations in the production. A comparison with the total production of Oregon shows that the largest part of the output is to be credited to the Blue Mountains.

Baker County, containing the most important quartz mines of the central belt, leads in production. The totals, though fluctuating greatly, approximate $1,000,000 per year, and the production is on the whole increasing. Grant County, containing chiefly placer mines, shows a smaller production, between $100,000 and $300,000. The yield was, on the whole, decreasing up to 1898, when a notable increase appeared.

Union County was of less importance as a producer up to 1889, when, owing to the discovery of rich quartz veins at Sanger and Cornucopia, the yield suddenly increased, and in one year (1894) exceeded $1,000,000.

The returns from Malheur County, in which the mining districts of Malheur, Amelia, and Mormon Basin are situated, have, until the last few years, been included in the amounts reported from Baker County.

The grand total of $18,000,000 shows the total production of the mining districts of the Blue Mountains from 1880 to 1899 inclusive.

The Mint reports for the years 1897 and 1898 give also for the State of Oregon the relative amounts of gold and silver contained in placer bullion, mill bullion, and smelting ore, thus furnishing an opportunity to compare the relative importance of placers, free milling, gold-quartz mines, and mines containing base ore. Some very rich ore from gold-

quartz mines may, however, be included in the latter amount. The diminishing importance of the placers is clearly perceived, it being from one-fourth to one-fifth of the total amount.

Source of gold and silver in Oregon for 1897, 1898, and 1899.

[From the reports of the Director of the Mint.]

	Gold.		Silver.		Total.
	Quantity.	Value.	Quantity.	Value.	
1897.	*Fine ounces.*		*Fine ounces.*		
Placer bullion	17,170	$354,931	3,908	$5,053	$359,984
Mill bullion	29,587	611,616	41,302	53,400	665,016
Smelting ores and concentrates	18,772	388,046	39,592	51,189	439,236
1898.					
Placer bullion	14,289	295,381	3,254	4,207	299,588
Mill bullion	24,770	512,040	24,419	31,572	543,613
Smelting ores and concentrates	19,797	409,248	100,653	130,137	539,385
1899.					
Placer bullion	13,887	287,070	2,722	3,519	290,589
Mill bullion	30,954	639,876	13,904	17,977	657,853
Smelting ores and concentrates	26,143	540,432	128,728	166,436	706,868

Production of gold and silver in Baker, Grant, and Union counties, Oreg., from 1880 to 1899.

[Compiled from the reports of the Director of the Mint.]

Year.	Baker.			Grant.			Union.			Total.
	Gold.	Silver.	Total.	Gold.	Silver.	Total.	Gold.	Silver.	Total.	
1880	$226,647	$400	$227,047	$85,400	$543	$85,943	$60,347	.....	$60,347	$373,337
1881	250,000	10,000	260,000	280,000	20,000	300,000	40,000	.....	40,000	600,000
1882	190,000	5,000	195,000	240,000	25,000	265,000	60,000	$800	60,800	520,800
1883	160,000	2,500	162,500	200,000	15,000	215,000	45,000	300	45,300	422,800
1884	160,000	2,500	162,500	200,000	15,000	215,000	45,000	300	45,300	422,800
1885	348,044	.....	348,044	194,600	.....	194,600	7,322	.....	7,322	549,966
1886	396,115	9,005	405,120	198,580	.....	198,580	20,650	.....	20,650	624,350
1887	173,558	5,153	178,711	163,896	11,797	175,693	15,000	.....	15,000	369,404
1888	190,000	5,000	195,000	140,000	10,000	150,000	15,000	.....	15,000	360,000
1889	463,604	7,500	471,104	73,989	9,550	83,539	574,989	1,028	576,017	1,130,660
1890	335,000	127,540	462,540	90,000	129	90,129	400,000	.....	400,000	952,669
1891	873,058	217,833	1,090,891	124,487	4,297	128,784	625,956	3,500	629,456	1,849,131
1892	367,587	3,257	370,844	53,780	40	53,820	753,715	1,900	755,615	1,180,279
1893	728,947	10,454	739,401	198,650	.....	198,650	420,237	3,046	423,283	1,361,334
1894	447,996	2,251	450,247	129,853	.....	129,853	1,059,070	8,100	1,067,170	1,647,270
1895	942,483	7,963	950,446	101,853	.....	101,853	144,800	3,000	147,800	1,200,099
1896[1]	800,000	20,000	820,000	100,000	.....	100,000	300,000	.....	300,000	1,220,000
1897	796,741	50,088	846,829	86,969	4,880	91,841	211,699	36,071	247,770	1,186,440
1898	525,945	42,690	568,635	143,463	32,769	176,232	292,324	67,816	360,140	1,105,007
1899	582,348	55,418	637,766	217,054	86,626	303,680	114,212	19,466	133,678	1,075,124
Total	8,958,073	564,552	9,542,625	3,022,564	235,631	3,258,197	5,205,331	145,327	5,350,648	18,151,470

[1] No product by counties given in mint reports. Figures for this year are only rough estimates.

CHAPTER II.

GEOLOGY.

TOPOGRAPHY.

Relief.—The Blue Mountains are situated in the northeastern corner of the State of Oregon. They form an irregular complex of mountain groups which as a whole may appropriately be regarded as a projecting spur from the great central mountain mass of Idaho. On the east, near the Idaho boundary line, which follows Snake River, high plateaus adjoin the mountains and continue into Idaho. The northwesterly limit is well marked by the broad ridge which swells to elevations of 4,000 to 5,000 feet from the lower plateau of the Columbia River and which continues from the southeastern corner of Washington in a southwesterly direction for at least 150 miles toward the John Day River. The westerly limit may be extended to the Deschutes trough, which separates the Blue Mountains from the Cascades, and the southerly boundary is formed by the deserts of Malheur River and Harney Lake. This area includes a great diversity of lesser ranges in confusing complexity, due partly to displacement, partly to extremely heavy lava flows covering the old and probably structurally more simple ranges. A very irregular drainage, caused by the same lava flows, has cut deep valleys into the heterogeneous mass of mountains.

The northeastern part consists of a lava plateau from 4,000 to 5,000 feet high, above which rise the Eagle Creek Mountains, a circular group with a diameter of about 30 miles and elevations exceeding 9,000 feet. Within this plateau lie fertile valleys, at least one of which is a depressed area bounded by fault lines. About 30 miles west of the Eagle Creek Mountains is the Elkhorn Range. This is composed of older rocks, is continuous in a northwesterly direction for about 40 miles, and reaches an elevation of a little over 9,000 feet. Its western slope is not so sharply defined. A spur extends to Bald Mountain (elevation 8,330 feet), and lower ridges connect this high region of old rocks with the Greenhorn Ridge, which, with maximum elevation of 8,100 feet, continues for 30 miles in a general northwesterly direction. The Elkhorn and Greenhorn mountains form the largest area of old, pre-Neocene rocks in the Blue Mountains, which is surrounded practically on all sides by lava masses rising to irregular plateaus with elevations of 5,000 to 6,000 feet. West of the Greenhorn Mountains

another pre-Neocene ridge, also surrounded by plateau-like lava masses, extends northwesterly from Dixie Butte (elevation 7,700 feet) toward Long Creek. Lastly, south of Dixie Butte lies the deep John Day Valley, and south of this rises, with an abrupt slope suggestive of a fault line, the imposing Strawberry Range, culminating in Strawberry Peak (elevation 8,600 feet). This range has a marked east-west trend, but it is not of uniform geological build, its eastern part being heavily covered with lava flows, while its western end is composed of pre-Neocene rocks.

To such a degree is the older pre-Neocene structure veiled by the lavas that it is difficult to obtain an idea of its probable configuration. It was by no means a unit, for it was separated into several masses by deep depressions and valleys of erosion; but its general trend was surely southwesterly, although folding movements of different age, faults, and extremely active erosion had greatly diversified its features.

Drainage.—With the exception of the few streams which find their way down to the plains of Harney Lake, the whole region drains either into the Snake or the Columbia River. Snake River pursues its course along the eastern border through the lava plateau, in a canyon which for about 50 miles north of Huntington varies from 2,000 to 3,000 feet in depth. In the high basaltic plateau just west of the Seven Devils this canyon is eroded to a depth of 5,000 feet or even more.[1] Near the mouth of the Grande Ronde the bottom is 3,000 feet below the basalt plateau.[2]

The northeastern plateau and the northern side of the Eagle Creek Mountains are drained by the Grande Ronde and Imnaha rivers, both flowing in sharply cut canyons. The former also cuts far back into the region of the northern Elkhorn Range and heads in the great granodiorite area north of Cable Cove, near Sumpter. The southeastern part of the Blue Mountains is drained by Powder and Burnt rivers. Powder River has a very remarkable course. Heading west of the Elkhorn Range, with a southeasterly direction, it soon turns sharply, in a deep canyon, and takes a northerly direction, which it maintains through Baker Valley. At the northern end of this valley is another, smaller canyon, and a still sharper turn to a southeasterly course, which it keeps until the junction with the Snake. Burnt River also heads in the central region near Sumpter, and then traverses a series of canyons and open valleys until, near Huntington, it joins Snake River.

The whole of the western drainage is through the three forks of John Day River. The North Fork heads near Cable Cove, a few miles north of Sumpter, and flows from there westward through deeply cut canyons. The Middle Fork heads near Austins, opposite Burnt River, and traverses the mountains in a deep but rather broad canyon or

[1] W. Lindgren: Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 88.
[2] I. C. Russell: Water-Supply and Irrigation Papers U. S. Geol. Survey, No. 4, p. 25.

valley with a west-northwesterly direction. The South Fork of John Day River also has its source immediately west of the head of Burnt River and continues for 40 miles due eastward, flowing in the broad, open John Day Valley, bounded on the north by sloping basalt flows, and on the south by the abrupt buttresses of the Strawberry Range.

GENERAL GEOLOGICAL FEATURES.

The part of the Blue Mountains represented on the accompanying map consists of several cores of older rocks partly surrounded by floods of Neocene lavas, rhyolites, andesites, and basalts. If the map were extended somewhat farther north it would be seen that the same lavas entirely surround the northern part of the Elkhorn Range as well as the Eagle Creek Mountains. These cores of older rocks form a salient from the great mass of mountains filling central Idaho. The vast granite area which occupies so much space in central Idaho does not extend into Oregon, but ends some miles east of Snake River, near Huntington, against sedimentary rocks and old lavas which are believed to be of Triassic age. West of these beds, which have a general northeasterly strike, appears a series of argillites, strongly developed about Durkee and the Virtue district and equally strongly represented in the Elkhorn Range. These argillites, which have a general east-west strike, would appear, as far as the present incomplete examinations have been carried, to form a large syncline. In the Elkhorn Range the dips are prevailingly to the south, while in the southeastern part of the area northerly dips predominate. The whole series is moderately compressed, and if the structure were examined in detail many minor folds would probably be found. The rocks consist chiefly of argillites, often very siliceous. Coarse sediments are generally absent. Smaller masses of slates of probably the same age are found in the extreme western part of the area. The age of this series of argillites is believed to be Paleozoic and probably Carboniferous.

In the Eagle Creek Range, surrounded on all sides by high lava plateaus, another series of rocks appears which presents much similarity to the strata near Huntington mentioned above. It consists of shales and limestones with large masses of intercalated lavas. The beds lie nearly flat in the foothills, but are tilted, folded, and strongly metamorphosed in the central part of the mountains. Their age is Triassic, as shown by fossils found in several localities. The same Triassic rocks appear in the northeastern corner of the area exposed below the Neocene lavas of the Snake River Canyon.

In many places all of these sediments, the Carboniferous as well as the Triassic, are disrupted and contain larger or smaller intrusive masses of granite, granodiorite, diorite, gabbro, and serpentine. The granodiorite is most extensively developed in the northern Elkhorn

Range. Diorites, diabases, and serpentines prevail in the eastern part of the mapped area.

Baker Valley, in the center of the district, is the largest Pleistocene area. It is bordered on the east by low hills, while toward the west the imposing Elkhorn Range rises to elevations of 9,000 feet. At its base is a fault scarp, excellently exposed at the mouth of Salmon Creek in the Nelson placer mines, which indicates that the valley is largely an area of subsidence.

In its general aspect the region described is of the geological type so frequently found on the Pacific slope, consisting of closely folded Paleozoic and early Mesozoic strata, shattered by large masses of intrusive granular rocks and covered by Neocene lava flows.

THE ROCKS.

ARCHEAN.

The only area of gneiss in the region described occurs northwest of Bald Mountain, about La Belleview mine. The rock is a coarse-grained biotite-gneiss with prominent schistosity and sometimes a little contorted. The reddish-brown biotite forms large anhedral, often ragged foils. A few plates of muscovite are associated with it. Quartz in elongated grains is very abundant. There is only a very small amount of plagioclase and orthoclase. The composition indicates that the rock is of sedimentary origin, but it is far more altered than the ordinary contact-metamorphic slates. Below La Belleview mine the strike is N. 40° E. and the dip 45° W. The rock is usually sharply separated from the granite.

PALEOZOIC SEDIMENTS.

Rocks referred to the Paleozoic system occupy a large area in the lower Burnt River region, about Pleasant Valley, in the southern Elkhorn Range, and on the headwaters of Burnt River and Granite Creek. Smaller isolated areas of clay slate, inclosed in diorites, diabases, and serpentines, also occur near Susanville, in the Quartzburg district, and near Canyon. There is no clew to the age of these, but they are believed to belong to the same Paleozoic series. The prevailing rocks through the whole of this large sedimentary area are dark and very fine grained, ranging from cherts to siliceous argillites and ordinary clay slates. A large proportion of the sediments show no distinct stratification in ordinary outcrops, but in thin sections the carbonaceous streaks which indicate the planes of deposition are readily recognized. In many places, however, the rocks are normal clay slates of fairly fissile character.

In contrast to the heavy limestones of the Trias, this series contains only isolated lenses, ordinarily of no great length. The only large

and persistent belt of limestones known in it is found west of Durkee, as shown on the map.

The cherts are gray to dark gray, and usually consist of extremely fine- and even-grained quartz aggregates. The siliceous argillites are similar, but contain more or less finely divided organic matter, shreds of sericite, and finely divided kaolin. The clay slates are extremely fine-grained rocks with streaks of finely distributed carbon, inclosing lenticular spaces of clearer substance, consisting of microcrystalline to cryptocrystalline aggregates of quartz with kaolin, sericite, chlorite, and calcite, and occasional prisms of tourmaline, rutile, and zoisite. In places the slates are calcareous and contain rounded or lenticular masses of fine-grained calcite. Pyrite and pyrrhotite are generally absent, except in the immediate vicinity of mineral veins. Larger clastic grains are not abundant. Near intrusive granitic rocks the argillites become brownish and somewhat crystalline through a conversion into allotriomorphic aggregates of biotite, quartz, and feldspar. A little magnetite and actinolite are also often present. Such rocks are found all along the main contacts, as, for instance, near the Baisley-Elkhorn vein; they usually extend only a few hundred feet from the contact. In the Present Need tunnel, in the Quartzburg district, a narrow streak of a peculiar dark-gray, almost flinty rock occurs, spotted by irregular black blotches. This consists of an interlocking quartz aggregate filled with sericite and containing bunches and spherulitic aggregates of tourmaline, accompanied by a little calcite. It is inclosed in diabase, and is probably a contact-metamorphic, tuffaceous clay slate.

The strata throughout the region have a well-marked east-west strike. The dip is prevailingly southward and ranges from 40° to 70°. Though the structure has not been definitely worked out, owing to the frequent difficulty of ascertaining strike and dip, it is probably a series of compressed folds. Schistosity is rarely observed, though at a few places in the Elkhorn Range and near Sumpter joint planes and incipient north-south schistosity transverse to the strike may be noted. The strike of the strata is a little north of west near Sumpter and Auburn, while south of Powder River it is from 10° to 20° south of west.

The only place where fossils were found is near the Bonanza mine, at Winterville, where round crinoid stems occur in a small mass of crystalline limestone. The other limestone lenses in the series, though carefully examined, yielded no fossils. Round crinoid stems are most common in Paleozoic rocks; taken in consideration with the fact that the series as a whole has a distinctly older appearance than the Triassic of Eagle Creek, from which it is also petrographically very different, we may with some confidence refer it to the Paleozoic and possibly to the Carboniferous. The series is similar to the Delhi

division of the Calaveras formation in the Sierra Nevada,[1] which is believed to belong to the Carboniferous.

Well-defined Carboniferous fossils have been found by Professor Condon in the Crooked River drainage, in the extreme western part of the Blue Mountains.

PALEOZOIC LAVAS.

Compared to the Trias of Eagle Creek, the Paleozoic section is poor in intercalated lavas of the same age as the sedimentary beds. Greatly altered greenstones, of massive and roughly schistose structure, occur in it at Pleasant Valley, and at Unity, which is a railroad station south of that place; also on the road to Clifford from Sumpter, on McCully Fork, a few miles from Sumpter, and in Quartz Gulch, on Olive Creek. These rocks are so much altered that the original character can hardly be ascertained. They are chiefly tuffs, containing much chlorite, epidote, and calcite.

HUNTINGTON SERIES.

These sedimentary beds are exposed near the mouth of Burnt River and along Snake River below that place, at least as far as Mineral, and are described in detail on pp. 752–762. This series consists of limestones, calcareous shales, clay slates, and volcanic tuffs, of red and green color, resting, with flat dips of from 14° to 60°, on a basement of old volcanic rocks. The latter are well exposed in Burnt River Canyon near its mouth, and in the Snake River Canyon below Huntington. The prevailing rocks are greenish or grayish, massive, and fragmentary igneous rocks, showing no bedding nor schistosity. They seem to be largely old rhyolites and accompanying tuffs. The clay slates and limestones at Connor Creek mine and at Mineral belong to the same series, and there is, as far as could be seen, no line which separates it from the Paleozoic series of Weatherby and Durkee. The line indicated on the map is really arbitrary. The only indication of its age obtainable were a few round crinoid stems from the limestone near the gypsum mine at Huntington. I incline to the belief that this series is Triassic, in spite of the lack of distinct separation from the older rocks, and base this belief on the flat dip and on its association with large amounts of volcanic rocks, so characteristic of the Triassic of this region.

TRIASSIC SEDIMENTS.

The Triassic beds found in the United States may be grouped in two widely differing areas. The first include the Red Beds of the eastern part of the Cordilleran system, and consist of a considerable thickness of sandy strata in which fossils are very scarce and which

[1] Geologic Atlas U. S., folio 66, Colfax, California.

probably are not of marine origin. The Triassic beds of the Pacific slope are of very different character, being distinctly marine sediments and generally containing characteristic fossils. The fauna is similar to that of the Alpine province in Europe. The first marine Trias was discovered by Whitney in California, and was examined by Gabb, who identified it with the upper Trias of the Alps. Soon afterward thick Triassic strata were discovered in the Star Peak Range, Nevada, by the geologists of the Fortieth Parallel Survey; and later, Triassic beds with a thickness of several thousand feet were found by Dr. C. A. White[1] in southeastern Idaho. The Triassic beds of California have been described by Professor Hyatt[2] and J. Perrin Smith.[3] The latter, in a recent article, has given an excellent review of our knowledge of the marine Trias of the Pacific coast and its correlation with European and Asiatic occurrences. The Canadian geologists have also discovered beds of similar age and character in British Columbia. Professor Dawson,[4] in 1899, described an extensive Triassic series associated with surface lavas of the same age from the vicinity of Nicola Lake, and named it the Nicola formation. Further discoveries of marine Trias have been made on Peace River and near Glenora, on the Stikine River. McConnell has found Triassic beds on the Liard River, and Dawson again found Triassic beds on Queen Charlotte Island and several other islands in the Straits of Georgia. Still farther north, in the Copper River region of Alaska, the Triassic has recently been identified by Messrs. Schrader and Spencer.

With widespread Triassic areas in California, Idaho, and Nevada, and with similar areas north of the international boundary line, it seemed strange that no rocks of the same age were found in Oregon or in Washington. This gap has been partly bridged by the discovery of very extensive Triassic beds in the Eagle Creek Range, extending from there across Snake River into Idaho, to the vicinity of the Seven Devils. If the sedimentary rocks in the vicinity of Huntington belong to the same age, as is possible, though by no means certain, the area of the Triassic would be still further extended.

A characteristic feature of the Triassic of the Eagle Creek Range is the occurrence of large masses of limestone and some shale, with an abundance of more or less altered lavas poured out during the time when these beds were being deposited.

The Triassic sediments are best exposed on Eagle Creek. All along the foothills of the lower Powder River the Triassic lavas contain smaller bodies of limestone and shale, but on Eagle Creek, below the forks, the sedimentary series prevails and consists of calcareous shales and limestone in horizontal or slightly inclined position. Volcanic

[1] U. S. Geog. and Geol. Surv. of Terr., 1883, Vol. XII, Pt. I, p. 105.
[2] Bull. Geol. Soc. America, Vol. V, p. 395.
[3] Jour. Geol., Vol. VI, 1898, p. 776.
[4] Descriptive Sketch of the Dominion of Canada, by G. M. Dawson: Montreal, Canada, 1879.

breccias are interbedded with the limestone. The total thickness of the series, including the volcanic beds, is probably several thousand feet. Many of the exposed limestone masses are several hundred feet in thickness. Above the junction, as described on page 735, the limestones become converted into marbles and the volcanic breccias into schists, while the whole series acquires a dip of 60° eastward.

Dr. T. W. Stanton examined fossils collected one-third mile below the mouth of East Eagle Creek, and reports them to consist of numerous specimens of *Halobia* and two indeterminable fragments of an ammonite. The *Halobia* is apparently an undescribed species, but the genus itself is characteristic of the Trias. Another lot, collected from the limestone bluff on East Eagle Creek 2½ miles above its mouth, contains *Pentacrinus* columns with spines and fragments of tests of echinoids. From the Miles placers, 1½ miles below the mouth of East Eagle Creek, I obtained, through Mr. F. R. Mellis, of Baker City, a cast of a gigantic gasteropod found in the limestone bed rock during drifting operations on this claim. Dr. Stanton remarks that it has the form of a very large *Turritella* or *Pseudomelania*. Nothing of this character approaching it in size has been described from the west coast, but similar forms described as *Chemnitzia* and *Pseudomelania* are known from the Trias and Jura of Europe. The total length of this cast is 8 inches and its diameter at the thickest end 3 inches.

Along Snake River Canyon, below the mouth of Pine Creek, Triassic lavas and tuffs are again exposed in the bluff below the Neocene basalt flows which cap the hills. These Triassic igneous rocks contain thin beds of black shales and limestone with imprints of a large species of *Daonella* or *Halobia*. A limestone mass 4 miles below Ballard Ferry contained a *Lima* with fragmentary imprints of a *Halobia* (?), and is also probably Triassic. The last two fossils were obtained from Mr. E. Antz, of Ballard Ferry.

From these data and from what is known of the field relations of the strata it is safe to conclude that a Triassic series is developed on a large scale in this region; but from the paleontological evidence at hand it would not be possible to say which one of the numerous subdivisions of the series is present. The Eagle Creek Mountains offer a most attractive field for future study.

TRIASSIC LAVAS.

Extending from North Powder to Eagle Creek along the foothills of the range are large areas of old basalts, andesites, and tuffs, containing in places small masses of limestone and shales. Though greatly altered, they are as a rule not schistose, except in the central part of the Eagle Creek Mountains. Fine-grained uralitic metabasalts were found in the Farley Hills. Near Copper Butte and the claims of the North American Copper Company dark-green or brownish amygdaloid

metabasalts and tuffs, often full of calcite nodules and veinlets of zeolites, were collected. Similar altered basalts, andesites, and rhyolites, with their tuffs, were found at many places along Snake River below Pine Creek. Some of these are described in more detail on pp. 731 and 750. At the Sheep Rock mine, on East Eagle Creek, below the Triassic limestone, appears a volcanic breccia of metabasalt and other lavas, which also contains fragments of a granitic rock. A few miles higher up this breccia becomes very schistose. Its original character is not apparent to the naked eye, but the microscope reveals it very plainly. The fragments of lava are pressed flat or lenticular, and secondary hornblende and chlorite suffuses the whole rock.

JURASSIC AND CRETACEOUS SEDIMENTS.

Neither Jurassic nor Cretaceous sediments have been recognized in the area described; but from the Crooked River drainage, west of Blue Mountains, a sandstone with characteristic Jurassic fossils was collected by Prof. Th. Condon, of Eugene, Oreg., and examined by Professor Hyatt.[1] The Chico Cretaceous with its characteristic fossils has been found by Professor Condon at many points in the Crooked River drainage and along the lower John Day River.[2] Lately Dr. Merriam has visited the same region and recognized, besides the Chico Cretaceous, beds possibly belonging to the Knoxville or Lower Cretaceous.

NEOCENE SEDIMENTS.

During the Neocene period most important changes took place in the Blue Mountains. The volcanic flows radically changed the topographic features of the lower slopes; the upper river valleys were dammed and filled with silts and gravels; the upper Snake River Valley became a lake, dammed by the lava barriers extending from the Idaho Mountains to the Cascades, and its surface attained a level corresponding to a present elevation of approximately 4,200 feet. This lake has left abundant traces of its existence throughout the Snake River Valley, particularly between Boise and Weiser and on both sides of the Owyhee Range. The rising waters of the lake followed the river valleys draining toward it far into the mountains, where remains of its deposits may still be found. Surrounding the margin of the lakes are many small, basin-like depressions, which in part are certainly of structural origin—that is, caused by depressions along certain fault lines. These basins are usually filled with lake sediments. As the lake gradually receded, accumulations of gravels followed the retreating waters in the old river valleys, and these now form terraces resting on the lake beds.

[1] Trias and Jura in the Western States: Bull. Geol. Soc. Am., Vol. V, p. 395.

[2] Th. Condon, in Raymond's Statistics of Mines and Mining, Washington, 1870, p. 212. J. S. Diller, Bull. Geol. Soc. America, Vol. IV, p. 214.

the west side there are remains of a well-defined bench at an elevation of 3,100 feet. On the north the beds extend much higher up on the slopes of Lookout Mountain, probably reaching 4,000 feet. They are disturbed, dipping gently westward, and are interstratified with rhyclite tuffs and covered in places by small basalt flows.

The divide between Burnt River and Powder River along the railroad shows most interesting relations. At the summit, which has an elevation of 4,000 feet, is a gap 2 or 3 miles wide, bounded on both sides by low slate hills. The rolling hills are covered with shallow, gently folded lake beds, dipping 12° to 30° E. or W.

The gravel slopes on both sides give positive evidence that an elevation of 4,100 or 4,200 feet marks an old and important base-level. I can see no other explanation possible than this: That the Payette Lake once just covered the summit and the basin of Sutton Creek. Whether the Payette Lake also flooded Baker Valley is doubtful. There seems to have existed a very delicately balanced set of conditions which finally caused Powder River to turn northward and excavate the canyon south of Baker City in the basaltic barrier extending across from the Virtue Hills to the Elkhorn Range. This barrier was originally probably just a little higher than the gap through which the railroad runs.

PLEISTOCENE SEDIMENTS.

Older sediments.—As elsewhere in the Pacific States, there is no distinct line separating the Neocene and the Pleistocene sediments. The two periods insensibly grade one into the other. Assuming that the highest level of the Neocene lake in Idaho marks the middle of that period, equivalent to the Miocene, it follows that the excavation of the great Snake River Canyon comprises the late Neocene (Pliocene) and probably a part of the Pleistocene period. It has been assumed, on the basis of paleontological evidence, that the next lower level of the lake, at an elevation of about 3,100 feet, marks the close of the Pliocene and that the erosion of the Snake River Canyon below that level falls into the Pleistocene.[1] The Glacial epoch then merely becomes a part—and a smaller part—of the Pleistocene period. As a result of this reasoning, the gravel bars along the lower courses of Snake, Powder, and Burnt rivers, up to an elevation of several hundred feet above the present bed, may be assigned to the Pleistocene. But as the tributary streams are ascended, erosion has cut down less deeply into their beds, and Neocene gravels may in places be found at 50 feet, or even less, above the present river level—as, for instance, in the upper Burnt River and Powder River valleys. On the John Day side, as would be expected from the lower level of the Columbia River,

[1] Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 101.

erosion has been more active than on the side facing the upper Snake River Valley. Throughout the whole region the rivers and creeks usually flow over gravel-filled beds, indicating a present slow rate of progress of erosion.

To the Pleistocene period belong also the alluvial deposits in Baker, Pine, and Eagle valleys.

The largest Pleistocene area is that of Baker Valley, an elliptical trough 20 miles long and 10 miles wide. Excepting near the foot of the Elkhorn Range, where large and gently sloping débris fans mark the debouchure of the gulches, it is a remarkably level area. Above and below the valley the river flows in canyons. Interesting evidence has been adduced which proves that a fault line exists along the foot of the Elkhorn Range (p. 652) and that the whole valley is probably a field of depression, similar to so many of the basins in the marginal areas of the great Payette Lake. If the erosion of the lower canyon near North Powder did not keep pace with the sinking along the fault line, Baker Valley must, at some time during the Pleistocene, have been a shallow lake. The only definite evidence of this is the fine-grained kaolinic material capping the gravels in the lower reaches of the creeks at the foot of the Elkhorn Range. At Baker City wells are said to have been drilled through sediments to a depth of 600 feet. Carbonized wood and other vegetable remains are reported to have been brought up from that depth. This shows clearly that the Pleistocene of the valley rests in a closed basin.

Glacial deposits.—It has been shown by Prof. I. C. Russell and myself that during a late part of the Pleistocene period, probably during the Glacial epoch, the canyons of Snake and Salmon rivers were again filled with sediments to a depth of about 300 feet and that the erosion since the close of that epoch has been limited to the removal of these 300 feet of sediments, together with an insignificant deepening of the early Pleistocene rock channel. Between Mineral and Connor creeks, in the upper Snake River Canyon, are indications of a similar filling of the eroded canyon by sand to a similar depth, 300 feet. Aside from this there are few gravel bars higher than 50 feet above the present river bed.

INTRUSIVE ROCKS.

Granite.—True orthoclase granites appear to be absent from the area examined. At least no well-marked occurrences of this rock were found. The granitic area of Sparta consists of a normal soda granite in which the orthoclase is almost entirely wanting, its place being filled by albite. The surface of this granite area is extremely decomposed, and fresh rock can be obtained only from shafts and tunnels. A representative specimen from the Gem mine is a greenish-

gray rock, with grains averaging 3 mm. to 5 mm. in diameter. The quartz grains are abundant and large, the feldspars slightly greenish. There are only small amounts of ferromagnesian minerals, mostly chlorite. The thin section shows a very large amount of quartz and a smaller amount of feldspars. Some of these are prismatic crystals, others irregular grains. A number of the feldspars are single crystals; others show a few intercalated lamellæ, the maximum extinction of which in the zone perpendicular to (010) is about 14°, corresponding to albite. No perthite is present. Between the quartz and the feldspar is a little chlorite, probably remains of primary biotite.

A partial analysis of this granite by Dr. W. F. Hillebrand resulted as follows:

Analysis of granite from Sparta.

Constituent.	Per cent.
SiO_2	76.25
CaO	1.70
Na_2O	4.60
K_2O	.59

This indicates a very unusually pure albite-granite containing a large amount of quartz.

In the first foothills west of Sparta and north of Powder River the granite becomes porphyritic by the development of large quartz crystals. This granite-porphyry has a coarsely microcrystalline groundmass of pegmatitic quartz, and much albite and some orthoclase, the latter two in part intergrown in the manner of perthite.

Granodiorite.—The most common granular rock of eastern Oregon is granodiorite. It occupies a large area in the northern part of the Elkhorn Range, including Bald Mountain. It also appears near Cornucopia, in the Eagle Creek Range, and, together with diorite, in the several areas extending from Lookout Mountain to Malheur. The rock is light gray to dark gray in color and its grains are from 2 mm. to 4 mm. in diameter. The quartz grains are gray, the feldspars white; the hornblende, which is usually present, appears in prisms up to 6 mm. long. The biotite, which is always present, forms black scales up to 3 mm. in diameter. Under the microscope the rock has a hypidiomorphic structure. The biotite appears in yellowish-brown, ragged foils, inclosing much magnetite. The most abundant feldspar is a roughly prismatic andesine, embedded in the usual way in anhedral clear quartz and orthoclase. Perthite and microcline are absent. The rock is never schistose and is usually fresh. Only a slight alteration to chlorite and epidote is noticeable in the biotite and hornblende.

A typical rock from near the lake at the northern base of Bald

Mountain, at an elevation of 7,000 feet, was analyzed by Dr. W. F. Hillebrand with the following result:

Analysis of granodiorite from Bald Mountain.

Constituent.	Per cent.
SiO_2	71.23
Al_2O_3	14.61
Fe_2O_3	.93
FeO	1.66
MgO	1.01
CaO	3.29
Na_2O	4.00
K_2O	1.92
H_2O (below 110°)	.17
H_2O (above 110°)	.55
TiO_2	.34
ZrO_2	.02
P_2O_5	.14
MnO	.08
BaO	.08
SrO	.02
Li_2O	Trace.
Total	100.05

The analysis shows that the rock is a normal granodiorite of an acid type, containing a little more quartz than is usual in the granodiorite of the Sierra Nevada.[1] For this reason the other constituents appear with slightly lower percentages than they would have in a rock poorer in quartz. In the small areas and near the contacts of the large areas the rock shows a great tendency to transition into normal diorite. Examples of this may be seen near the Baisley-Elkhorn mine, at the divide between Powder River and Bull Run, on the road from Sumpter to Granite, in the Greenhorn Mountains, and at many other places.

Diorite.—The diorite, which occurs as a facies or local development of granodiorite, is a dark-gray to dark-green granular rock, consisting of andesine or labradorite feldspar, greenish hornblende, and sometimes brown biotite, with magnetite and titanite as accessories. The hornblende is usually roughly idiomorphic, as are, with short prismatic form, the feldspars. Pressed in between the feldspars is frequently a little quartz. Diorites were collected from the Baisley-Elkhorn mine,

[1] Granodiorite and other intermediate rocks, by W. Lindgren; Am. Jour. Sci., 4th series, Vol. IX, p. 277.

from the Coyote Hills near Haines, and from Dixie Creek Canyon above Prairie. Diorites containing some orthoclase were collected from the Powder River Canyon near North Powder.

Gabbro.—The dioritic rocks are sometimes intimately associated with gabbros. It is thus, for instance, in the Robinsonville and in the Virtue districts. The gabbros are greenish-gray granular rocks, composed chiefly of a basic plagioclase and a pyroxene often converted into uralitic hornblende. The gabbros of this region are often irregularly crushed, but rarely schistose. Gabbro areas are found in the Virtue district, in the Elkhorn Range, in the Greenhorn Mountains, and finally near Canyon. In the latter two localities the rock is associated with large areas of serpentine.

A gabbro from the Flagstaff mine, Virtue district, is a mottled, dark greenish-gray rock, much crushed and recemented, but not schistose. The feldspars are saussuritic, of almost flinty appearance. The rock consists of coarse aggregates of light-green amphibole, which also pervades the whole slide in needles and fibers. The originally large grains of plagioclase, which stands between labradorite and anorthite, show extraordinary bends and fractures in their broad twin lamellæ, and are dissolving into new aggregates of basic feldspar. There is no zoisite present. A uralite-gabbro containing much zoisite was collected from the Copper King mine, 7 miles west of North Powder.

One mile below the Little Giant mine, near Alamo, two rocks closely associated with serpentine were collected. One of these is a coarse gabbro crushed almost to a breccia, and containing serpentine and chlorite on the fractures. The other is a fine-grained aggregate of anhedral, light-brownish hornblende, with an andesine or labradorite. At the Virginia mine, Robinsonville, occurs, closely associated with serpentine, a greenish-gray, granular rock of somewhat varying grain, the maximum being 2 mm. The rock originally consisted of colorless augite and basic plagioclase, with typical gabbro structure, but it is extremely crushed, the augites are bent and shattered, and the plagioclase is filled with sericite and traversed by veinlets of calcite and zoisite. At the Great Northern mine, near Canyon, gabbro also appears, associated with diabase and serpentine. The rock is a normal gabbro consisting of broad anhedral grains of augite and basic feldspar; it is greatly altered and filled with chlorite, uralite, and kaolin.

Diabase.—The diabases are granular rocks belonging to the gabbro family and consisting of augite and labradorite feldspar, intergrown with peculiar and characteristic structure. Typical diabases are not very common in this region. Diabases form the prevailing rock of the Quartzburg district and are adjoined on the south, below Comer, by diorites. At the junction of the two forks of Dixie Creek appears a very fresh, dark-green diabase-porphyry, with abundant phenocrysts of uralitized augite and plagioclase in a somewhat finer-grained

groundmass of normal uralitized diabase. Near the Present Need mine coarse diabases are found associated with dikes (?) of diorite-porphyry. Similar uralite-diabases are found at Copperopolis, on the east fork of Dixie Creek.

At the Great Northern mine irregular masses of a very altered diabase occur in the gabbro. The rock is filled with calcite and chlorite, only the lath-like feldspar remaining fresh.

Serpentine.—This rock, which is rarely found in Idaho and Montana, begins to appear in force as the Pacific province of intrusive rocks is reached. It forms large areas in the vicinity of Robinsonville and Bonanza, in the eastern part of the Greenhorn Mountains, at Susanville, and in the Strawberry Range south of Prairie and Canyon. At all these places it is closely associated with gabbros and allied rocks. This is so constant that one is forced to believe that the serpentine is an altered form of gabbro, perhaps also of peridotites, and that in its original state it was intruded simultaneously with the gabbros, diorites, and granodiorites into the sedimentary series.

The serpentine is of the ordinary dull-green appearance, and has not suffered greatly from pressure. Thin sections from Canyon show a normal rock with grate structure, containing abundant magnetite, forming a network in the clear serpentine mass. Chromite is found in the serpentine south of Prairie and near the Winterville placer mines.

The older dike rocks.—The sedimentary series and the granular rocks intrusive in them do not contain many dikes. Between Sumpter and the North Pole mine several greatly altered and partly mineralized dikes, which probably originally were diorite-porphyries, cut the argillites. Aplites are sometimes found near the contact of the intrusives, as are minor dikes of diorite and granodiorite. Porphyry dikes of light color, completely altered, bleached, and softened, occur in the Red Boy mine. In the Coyote Hills the diorite contains pegmatitic dikes consisting of orthoclase, microcline, and quartz, together with some idiomorphic andesine and small grains of augites—a very unusual character of pegmatite. In the same locality were found fine-grained dioritic dikes of the kersantite type of lamprophyres, a class of rocks which otherwise seem very rare in this region. In Idaho it has often been observed that gold-quartz veins follow such narrow lamprophyric dikes. The only similar occurrence in the Blue Mountains is at the Connor Creek mine, where a narrow dike of sericiticized and carbonatized porphyry accompanies the vein.

NEOCENE LAVAS.

General statement.—The Neocene period in the Blue Mountain region, as throughout the whole of Oregon, Washington, and California, was characterized by enormous eruptions of lavas of different

kinds. So far as known the Neocene lavas of the Blue Mountains belong, almost without exception, to the earlier part of the Neocene period—that is, to the Miocene. Late Neocene (Pliocene) and even Pleistocene eruptions are known to have taken place in different parts of the Northwestern States, but in this region it seems as if the Pliocene epoch had been one of quiescence as far as eruptions were concerned. The Neocene lavas surround the Blue Mountains almost completely. They fill the old valleys of a drainage system occupying a lower level than that of the present streams. The highest parts of the Blue Mountains are, as a rule, not covered with these flows, but on the lower slopes they are piled up in numberless sheets, aggregating as much as 2,000 feet in thickness.

The rocks of this series are separated into three groups—the basalts, the rhyolites, and the andesites. The basalts are the most widely distributed of the rocks, but the rhyolites and the andesites also occupy large areas.[1]

Regarding the succession of these lavas, the evidence is not altogether satisfactory. South of Baker City and near Durkee the basalts cover rhyolitic tuffs. On the divide between Powder River and Burnt River, south of Baker City, the basalts also seem to rest against older masses of rhyolite. On the other hand, near Canyon basalt flows appear to be overlain by rhyolite tuffs, and on the flanks of Strawberry Butte a dike of rhyolite apparently cuts the basalt flows.[2] Near Austin basaltic flows seem to cover the andesite. It will be seen that the evidence is somewhat contradictory, but, on the whole, it seems probable that the eruptions were begun by rhyolites, followed by andesites, and closed by the basaltic outbursts. Near Boise, in the adjoining region of Idaho, the rhyolites were the earliest of the Neocene eruptives, and were succeeded by a basalt. In the Silver City district, in southwestern Idaho, on the other hand, the rhyolite is later than the basalt, as is clearly seen in the section of the Trade Dollar mine.[3]

Rhyolite.—The rhyolites are generally absent from the eastern and western parts of the area described. The largest rhyolitic eruption is found south of Baker City, where it builds up the divide between Powder River and Burnt River from a point some miles west of Hereford down to the mouth of Clarks Creek. The hills north of Burnt River consist almost entirely of rhyolite. The same rock continues up

[1] A valuable contribution to the literature of the lake beds and eruptive rocks of the lower John Day River has recently been published by Dr. J. C. Merriam. (University of California, Bull. Dept. Geol., Vol. 2, No. 9, pp. 269-314.) He finds in the John Day River Basin, below Canyon, the following formations: (1) Eocene lake beds, with flows of rhyolite and andesite (Clarno formation); (2) John Day series (Miocene) of tuffs, with several flows of rhyolites; (3) Columbia River lava (Miocene basalts); thickness over 1,000 feet; (4) Mascall formation (probably Miocene) of tuffs and ashes; (5) Rattlesnake formation (probably Pliocene), consisting of gravels, tuffs, and rhyolite, the latter overlying Columbia River basalt; (6) Terraces (Pleistocene) up to 100 feet above the rivers.

[2] These rhyolites of Canyon are evidently identical with those in the Rattlesnake formation of Dr. Merriam, which he regards as of Pliocene age. See footnote 1, above.

[3] Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 140.

to the divide, 2,500 feet above the river, and down the northern slope toward Powder River until at an elevation of 5,000 feet (1,000 feet below the summit) the covering basalt flows are met with. Toward the east this rhyolite gradually thins out, and near Pleasant Valley only a few small areas are found covering the slates. Rhyolite tuffs occur, as stated, near Baker City, on Griffin Gulch and Sutton Creek, also near North Powder, on Wolf Creek, and finally at Canyon.

The rhyolite is of the normal reddish or brownish lithoidal variety, with small crystals of feldspar and quartz contained in a streaky microcrystalline to cryptocrystalline groundmass. The rhyolite tuffs are light-colored, grayish rocks, which usually are easily dressed, and therefore make good building stone. They consist of a mass of rhyolitic fragments, often pumice-like in character, and cemented by a finer mass of the same material.

Dacite.—A few miles north of Hereford, on Big Creek, occurs a flow of light-brownish rock closely associated with the rhyolite. It contains abundant porphyritic crystals of quartz, glassy feldspar, and brown biotite in a hypocrystalline groundmass of trachytic structure. The feldspars are a plagioclase approximating to labradorite in composition, and the rock should therefore be classed as a dacite.

Andesite.—Andesites are practically absent from the whole eastern and northern part of the area described. At Granite and in Bull Run, for a few miles above the town, however, bluffs of hornblende-andesite appear on both sides of the stream, apparently covered by basalt. The thickness attained is only from 50 to 100 feet. The rock is light gray and porphyritic, containing small phenocrysts of feldspar and hornblende in a fine-grained groundmass consisting of plagioclase and hornblende. The structure of the groundmass is trachytic. The feldspar phenocrysts are apparently labradorite. In their largest development the andesites are found on the headwaters of Burnt River and on the divide between that river and the Middle Fork of John Day. They even extend as far west as Prairie, near which place they are apparently covered by later basaltic flows. The andesitic eruptions in the vicinity of Clifford have a thickness of probably not less than 1,000 feet, and form a greatly dissected plateau, the summit of which attains an elevation of from 5,000 to 6,000 feet. To a very large extent the andesites are of fragmental character—that is to say, they consist of tuffs and breccias. On the road from Sumpter to Hereford the divide between Powder River and Burnt River is covered by 300 feet of andesitic tuffs and breccias well stratified, coarser layers alternating with more fine-grained material, almost like sandstones. These tuffs dip 20° N., and at the summit of the ridge have an elevation of 5,500 feet. On the south side of the ridge andesitic breccias prevail down to an elevation of 4,500 feet, when the underlying rhyolites appear, covered by dacite. West of Burnt River the heavy flow

which extends down toward Susanville and Prairie consists very largely of coarse breccias, containing angular fragments of andesites of varying appearance. Some are dark gray; others brownish or black. Many fragments are vesicular. This breccia is cemented by a finer mass of the same material, and the whole forms a well-consolidated mass. The resemblance to the andesitic breccias overlying the auriferous gravels in California is very striking.

The rocks are chiefly normal hypersthene-andesites, containing phenocrysts of labradorite, augite, and hypersthene inclosed in a brownish, glassy groundmass containing small needles and prisms of feldspar. Sometimes fragments of lighter color are present which contain, besides augite and pyroxene, some needles of hornblende.

Basalt.—As is well known, basalt is the predominating rock among the eruptive masses surrounding the Blue Mountains. Basalt flows cover vast areas in the eastern part of the region described, adjoining Snake River, where they form the extensive plateau which almost completely surrounds the Eagle Creek Mountains. Throughout the larger part of this area the basaltic formation consists of a great number of superimposed flows which are well exposed along many sharply incised canyons. The flows are from 50 to 150 feet thick, and slight differences in weathering render them very conspicuous in favorable exposures. East of Cornucopia the basaltic flows reach a total thickness of over 2,000 feet; only rarely are they accompanied by or interbedded with tuffs. This formation, with its characteristic exposures of thin, superimposed beds of dark-brown color, extends over thousands of square miles north, east, and west of the Eagle Creek Mountains. It is the same formation which Prof. I. C. Russell has named the Columbia River lava, and it must be acknowledged that the persistent extent of these beds over such a vast territory deserves to be specially pointed out by a local name. If this name is to be preserved as a distinct formation name, I would suggest that it be restricted to the basaltic lavas of Miocene age. It seems to be the intention of Professor Russell to give it a somewhat wider significance, including under it different kinds of lava of Miocene or Pliocene age. This seems scarcely advisable if the name is to be preserved in the significance given to it above. The Columbia River lava crosses Powder River just south of Baker City and appears on the low hills separating the upper from the lower river. The flows are here very thin, rest on clays, sands, and fine gravels, and slope gently eastward.

Little Lookout Mountain is covered by a succession of basalt flows evidently belonging to the same formation. Similar rocks are exposed in Burnt River Valley, between Weatherby and Durkee, and on the spur between Rock Creek and Snake River. On the Idaho side the characteristic flows descend to river level, showing that the canyon must have been excavated before the period of basaltic flows.

The Elkhorn Range from Auburn north is free from basalts and

other Neocene eruptions, but at its southern end, in the first sharp bend of Powder River, south of Baker City, basaltic flows are piled up to an elevation of 4,700 feet, or a total thickness of about 1,000 feet. Heavy masses of basalt form bluffs on both sides of Granite Creek, below the town of Granite, and extend from here nearly up to the summits of the Greenhorn Range.

Basaltic flows are again noted near Austin and on the lower slopes of the John Day Valley from Prairie to Canyon. They are beautifully exposed on Strawberry Butte, south of Prairie, and it is probable that the headwaters of this river are entirely surrounded by these igneous masses. On Strawberry Butte the total thickness of the flows probably amounts to several thousand feet. As in the southern portion of the area, individual flows are well exposed, appearing as dark-brown strata on the abrupt slopes of the mountain.

In petrographic character the basalts show little variation. They are entirely normal rocks of their kind, with or without olivine, and ordinarily contain a moderate amount of glassy groundmass. Occasionally, however, this glassy base almost disappears, and the rock then is usually somewhat coarser, having the appearance of a diabasic rock. Vesicular and massive flows alternate; the former are usually the more glassy varieties. From near the mouth of Canyon Creek, at the town of John Day, was collected a black, fine-grained basalt of unusual freshness. It contains nearly lath-shaped crystals of labradorite, abundant fresh, small olivine grains, and a brownish augite. These constituents are cemented by a small amount of dark-brown glass containing very beautiful arborescent forms of magnetite. A short distance north of Medical Springs (20 miles north-northeast of Baker City) the rocks are very unusually glassy basalts. Thin sections show them to consist chiefly of glass filled with minute crystals of pyroxene and a few larger phenocrysts of plagioclase. The rocks also contain a few larger prisms of hypersthene.

The question of the manner of eruption of these enormous masses of basalt has always been an interesting one. It is generally believed that the magma was not ejected from volcanoes, but that it poured out in a comparatively quiet manner from large fissures in the crust. This view has been substantiated by the discovery of a large number of basalt dikes at Cornucopia and other places high up on the flanks of the mountain, and in such a position relative to the flows that it is not to be doubted that the foci of the eruption were located at these places. A description of this interesting occurrence will be found under the head of Cornucopia mining district. The rocks collected from dikes prove in all cases to be normal basalts containing a varying but generally small proportion of glass. Basalt dikes were also found at Mineral, Idaho, at Sparta, and on the road from Rye Valley to Mormon Basin; but in no place are they exposed on such a magnificent scale as in the Bonanza Basin, near Cornucopia.

GEOLOGICAL HISTORY.

The oldest rocks of the Blue Mountains are represented by the relatively small area of gneiss embedded in the granodiorite north of Bald Mountain. Undoubted Archean gneiss is not often met with in the Pacific States. Mr. H. W. Turner[1] has described areas of probable Archean gneiss from the Big Trees quadrangle, Calaveras County, Cal. This area is embedded in granitic rocks of much later date. In Idaho, along the Nez Percé trail, north of Salmon River, two large areas of gneiss were found[2]—one near Shoup, the other at Elk City. Both have the appearance of true Archean gneisses and both are shattered by later granites. These isolated occurrences are of much interest, as they indicate the character of the basement upon which the Paleozoic rocks were deposited. The composition of the Oregon gneiss probably indicates a sedimentary origin, but it is completely recrystallized over a large area, which precludes the supposition of contact-metamorphic origin. Unfortunately, no contacts between the gneiss and the sedimentary rocks were observed; but it is likely that the latter were deposited unconformably upon the gneisses.

During the Paleozoic age the sea extended over what is now the Blue Mountains and probably connected with the Carboniferous sea of eastern Nevada and California. The deposits of this sea consisted of argillaceous and siliceous mud, which during long subsequent ages consolidated to argillites, more or less rich in silica. These were the prevailing sediments, but a few interbedded strata of limestone were also formed, the largest appearing now in the hills west of Durkee. The sediments contain interbedded volcanic rocks (tuffs and greenstones) in a few places, but they are not prominent. The only clue to the age is furnished by the round crinoid stems in the limestone of Winterville. This argillite series is undoubtedly older than the Trias of the Eagle Creek Mountains, and may without much uncertainty be referred to the Paleozoic, possibly to the Carboniferous, which is so extensively developed in California. The whole argillite series, from Weatherby to the Greenhorn Mountains, is composed of fine-grained sediments, indicating deposition in deep waters. Sandstones, quartzites, and conglomerates are entirely absent, according to present information.

This probably Paleozoic series is adjoined, toward Huntington, by another series of clay slates, shales, and limestones, with some gypsum. At Huntington these sediments rest with flat dip on heavy masses of old lavas and tuffs, which now are considerably altered, though nowhere schistose. The general character of this series shows much similarity to the Trias of the Eagle Creek Range; on the other hand, toward the northwest these rocks soon change into the steeply dipping argillites

[1] Geologic Atlas U. S., folio 51, Big Trees, California.
[2] Unpublished notes, W. L.

of the Burnt River Canyon above Durkee, which have been considered as Paleozoic. No contact line or unconformity could be observed, and the whole series dips northward. The line drawn on the map is wholly arbitrary and may have to be revised. Indeterminable fossils, some of which seemed to be round crinoid stems, were found in the Huntington series near the gypsum quarry.

The structural features show considerable regularity. The argillites of the Elkhorn Range trend a few degrees north of west and dip about 60° S. South of Burnt River Canyon and as far down as Huntington the strike is southwesterly or south-southwesterly, the dip generally being at steep angles toward the north. Thus it would seem that the sediments are folded, roughly speaking, into one great geosyncline. Strongly marked slaty cleavage is generally absent, though in a few places in the Elkhorn Range are indications of joints and cleavage planes perpendicular to the stratification. In many places the argillites are massive and fail to show the direction of the stratification. The thickness of the argillite series can not be safely estimated at present; it doubtless amounts to several thousand feet.

During the Triassic period the ocean again covered this region, though the abundance of surface lavas and tuffs indicates that the waters were shallow and land masses not far distant.

The Triassic of the Eagle Creek Mountains and Snake River consists of shales and limestones interstratified with a vast amount of more or less altered tuffs and lavas, and is exposed all along the lower Powder River and the upper course of Eagle Creek. There is reason to believe that these Triassic lavas extend as far northwest as the Farley Hills and the greenstone areas west of the North Powder, and they certainly again emerge from below the basalt flows in the canyon of the Snake River, below the Seven Devils. In this canyon they contain smaller strata of shale and limestone with Triassic fossils. Tuffs and old lavas with intercalated sediments and limestones again appear in the mining district of the Seven Devils, on the Idaho side. Along Eagle Creek the little-altered limestones and shales contain *Daonella* and *Halobia*, as well as pentagonal crinoid stems and fragments of ammonites and echinoids. In the foothills the strata sometimes lie nearly horizontal, but in the Eagle Creek Range they quickly acquire an easterly dip and become greatly altered by dynamometamorphism. The limestones change to marbles, the volcanic tuffs to amphibolitic schists. The central parts of the Eagle Creek Mountains are built up of these altered Triassic rocks. Outside of this area the strata and the Triassic lavas show no evidence of compression or traces of schistosity, although the volcanic rocks may have been considerably altered by ordinary hydrometamorphism, producing epidote, chlorite, and zeolites. The thickness of the Triassic beds and accompanying volcanic rocks is considerable, but has not been directly measured. Without doubt the total amounts to several thousand feet.

Though the strata of known Triassic age were at no place observed in contact with the Paleozoic series, it is probable, from the general relations, that there is an unconformity between the two series of strata. This implies that there were pre-Triassic uplift and folding, and that the Triassic beds were laid down on the upturned edges of the Paleozoic strata. It is not unlikely that during this uplift the intrusions of the diorites and gabbros of the Virtue district and the southern Elkhorn Range occurred. Among the volcanic tuffs and breccias of the Trias fragments of quartz-diorites are found.

After the deposition of the Trias followed another and more extensive uplift, probably the same which affected the whole of the Pacific slope. Both the Triassic and the Paleozoic series were folded, though the former in places still lies nearly horizontal. The Trias was violently compressed in the area now occupied by the Eagle Creek Mountains. The uplift was accompanied by very extensive intrusions of granular rocks, and as these now appear in the highest parts of the mountains and as great erosion has since taken place, it follows that the Blue Mountains in Jurassic and early Cretaceous times must have been a range of imposing height. The intrusions consisted of granodiorites, diorites, gabbros, and peridotites, the latter now partly converted into serpentines. They extend over the whole area from the Eagle Creek Mountains to the Elkhorn and the Greenhorn ranges. The time of this great uplift is difficult to fix with exactness from the data at hand. It was certainly post-Triassic and pre-Neocene. Jurassic strata have been found on Crooked River, west of the Blue Mountains, and also near Burns, south of Crooked River,[1] but their relation to the older strata is not known. Sandstones of Chico age, underlain by Knoxville beds, have been found at several places on the lower John Day River,[2] under such circumstances as suggest that they may connect below the lavas of the Cascade Range with the Cretaceous of western Oregon. It seems probable then that, at least as far back as the Chico Cretaceous, the western foot of the Blue Mountains was skirted by the sea, and that the uplift and intrusion of the granular rocks are of pre-Chico age. In the Sierra Nevada the time of similar upheavals has been determined as post-Jurassic and pre-Chico, and thus it becomes probable that the disturbance in the two provinces took place about the same time. Regarding the form of the mountain range after the great uplift, we know little except that it had a general east-west direction. A very active erosion had worked on it for a long time, but had failed to reduce it to anything like gentle topographic outlines. That the pre-Neocene rivers had excavated their channels to a greater depth than the present streams is certain, for the lavas descend to the level of Snake River below Huntington, and that mighty stream flows for many miles on a basaltic

[1] Trias and Jura in the Western States, by A. Hyatt: Bull. Geol. Soc. America, Vol. V, p. 401.
[2] J. S. Diller: Bull. Geol. Soc. America, Vol. IV, p. 214. Oral communication by Dr. J. C. Merriam.

bed. Take away the lava flows which cover the flanks of the Blue Mountains, and you would see rising to imposing heights, almost from sea level, and separated by a lower gap, two great, roughly circular mountain groups—the Eagle Creek Mountains and the Blue Mountains proper. They formed a projecting spur from the great crust-block of central Idaho, but did not connect directly with the Sierra Nevada.

Then, as now, the Blue Mountains were seamed by gold and silver veins, and gold-bearing gravels accumulated in its valleys. The formation of the veins followed the great intrusions of granitic rocks, and may be placed in the Jurassic or early Cretaceous.

Such were the conditions when the great Neocene lava flows began to pour out from numberless fissures on the flank of the mountains. At first came rhyolites and andesites, then basalts in increasing volume. Lava streams covered each other in endless succession. The lower water courses became filled with basalts, damming the headwaters and creating lakes. The sharp slopes became sloping plateaus, and finally the Blue Mountains stood like islands in a basaltic sea, a salient of the Idaho mass, separated from it by the black surface of slowly cooling flows. The rivers had to adjust themselves to these new conditions and lay out their lower courses anew. Hence all these strangely changed river courses and sediment-filled upper basins which form such difficult problems in the geology of the Blue Mountains. The bar of lavas thrown across from the Idaho Mountains to the Cascades resulted in the formation of a great lake in the central Snake River Valley, the waters of which reached elevations of about 4,200 feet. Establishing an outlet through the present course of Snake River, the lake was gradually drained. The Pliocene and the early part of the Pleistocene period were times of active canyon erosion, with many temporary checks, resulting in the formation of benches and bars of gravel high above the present drainage level. One of the most difficult problems is the explanation of the present course of Snake River below Huntington. Certain parts of the canyon must have been excavated before the Neocene period, even if it was largely filled again by local basalt flows. Below the mouth of Powder River the Snake for a long distance flows over basalt, and it seems probable that the old canyon turned somewhat westward and found its way toward the Columbia closer to the Eagle Creek Range. The question is, What caused the post-basaltic river to lay out its course across the high plateau of lava and across the projecting shoulder of the Seven Devils, which attains at least 6,500 feet in elevation, and where the canyon now is correspondingly deep? It would seem as if a much more natural outlet could have been established across the Deschutes gap at the foot of the Cascades, or through the present Baker Valley and down the direction of the Grande Ronde River. Much more detailed examinations are necessary to explain these problems.

After the close of the Neocene, or even during the middle of that

period, followed other orogenic movements of a less violent character. The lake beds of Durkee Valley, of the Sutton Creek Plateau, and of Rye Valley were thrown into gentle folds and also faulted. At Rye Valley undisturbed Pliocene river gravels cover lake beds of Miocene age which form a monocline dipping gently westward. Besides this, there is no doubt that slow epeirogenic movements of the crust took place in eastern Oregon in Neocene and post-Neocene times, but their exact nature and amount are doubtful. The pre-Neocene drainage was cut deeper than that of the present day, and hence it would seem likely that this region has suffered depression of considerable amount. It seems, indeed, impossible that the extrusion of such enormous masses of lavas over such a vast area should not be accompanied by slow continental movements of some kind. To such movements is probably also due the course of Snake River Canyon below Huntington, referred to above.

After the Pliocene and early Pleistocene epochs of erosion, the Sierran period of Le Conte,[1] during which the conditions of the present day were gradually established, followed the Glacial epoch, when the climate became much colder and glaciers covered the higher region of the Eagle Creek, the Elkhorn, and the Greenhorn ranges. But this was of relatively short duration as compared to the period of erosion. The glaciers have disappeared only very recently, not many thousand years ago. Compared to the glaciers of the Sierra Nevada and the Cascade Range, they were of small extent.

There is reason to believe that there is an old fault line located at the eastern foot of the Elkhorn Range and that Baker Valley is essentially an area of subsidence. At some time in the Pleistocene period renewed faulting occurred along this line, as is shown most convincingly by the exposures at the Nelson gravel mine, near the mouth of Salmon Creek (p. 653). What the total amount of this faulting is remains doubtful. A dislocation of at least 200 feet is shown by the exposures.

PHYSIOGRAPHIC PROBLEMS.

The Blue Mountains abound in physiographic problems caused by many changes in river courses due to the lava floods. A few of these have been briefly touched upon in the detailed part of this report and in the paragraph on Neocene sediments; but many of them, and the most important ones, among which is the origin of the Snake River Canyon, are still unsolved, and a rich field here remains for future work. This report, being principally limited to problems of economic geology, is very incomplete in respect to the physiographic branch of geology.

[1] The Ozarkian and its significance in theoretical geology: Jour. Geol., Vol. VII, 1899, pp. 525–544.

CHAPTER III.

THE MINERAL DEPOSITS.

GENERAL STATEMENT.

A great variety of mineral deposits has been found in the Blue Mountains. They contain gold and silver veins, copper deposits, gold-bearing gravels, ores of iron, manganese, and chromium, coal, limestone, and gypsum. Many rocks are used for building stone, and mineral springs with useful medicinal qualities occur in widely separated places. Economically, the placers and the gold and silver veins are the most important and will be most fully treated. The gold and silver veins are so intimately connected that it is scarcely possible to separate them in a description of the region. They may, however, be divided into three groups—the gold veins, the gold-silver veins, and the silver veins.

PRIMARY GOLD AND SILVER DEPOSITS.

GENERAL CHARACTER.

The primary gold and silver deposits are, with few exceptions, normal fissure veins of a simple or composite character, carrying native gold, or sulphurets containing gold or silver or both native gold and sulphurets, in a gangue of quartz, more rarely calcite or dolomite. Sometimes the deposits contain also a notable percentage of lead, copper, or zinc, but ordinarily these metals are present only in subordinate quantities; and, on the other hand, the copper deposits are apt to contain a little silver and gold. Nevertheless, the two classes of deposits maintain their distinctive and separate characteristics.

GENERAL DISTRIBUTION.

Broadly speaking, the gold and silver veins occupy a belt 30 or 40 miles wide, beginning near the State boundary along Snake River and extending in a westerly direction for at least 100 miles. This area roughly coincides with the core of older rocks, the highest parts of the Blue Mountains, rising above the surrounding lava floods and late sediments. The accompanying map covers this area, but does not show quite the full extent toward the west, for gold placers are found on Long Creek and Cottonwood Creek, 18 miles west of Susanville, and isolated occurrences even farther west—as, for instance, at the Spanish Gulch placers, on Crooked River, 66 miles west-southwest of Canyon.

The principal deposits are in Baker and Grant counties, though some are found also in Union County and along the northern boundary of Malheur County.

When the distribution of the veins and vein systems, as shown on the map, is examined in detail, it appears at once that there is no well-defined and continuous belt of deposits extending across the whole auriferous area. What is found is a great number of local aggregations of veins, distributed without clearly apparent rule. In some districts the veins are scattered irregularly; in others there are local belts from 2 or 3 miles up to 15 miles in length. The Cornucopia, Sparta, and lower Burnt River districts may be selected as representatives of the former mode, while the long vein systems of Cracker Creek and Cable Cove show the latter arrangement. The region in which most of the important veins are concentrated extends from the Elkhorn mining district on the east for 35 miles in a west-southwest direction to the Greenhorn Mountains.

DIRECTIONS OF STRIKE AND DIP.

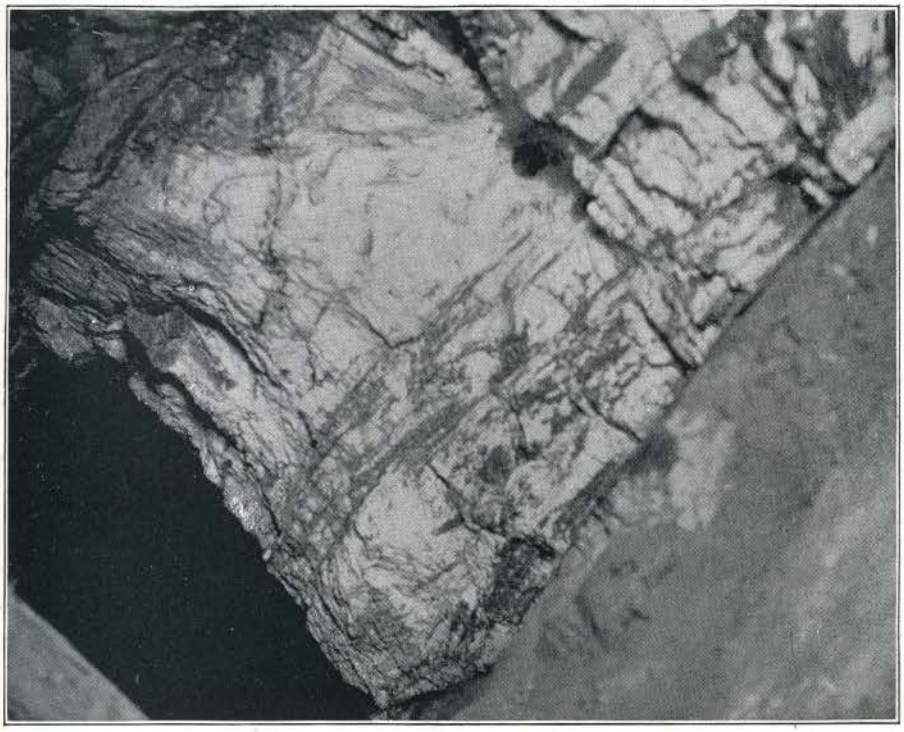
The prevailing direction of the fissures in and along which the precious metals have been deposited is northeast and southwest, sometimes changing to a due east-west direction. This is the strike followed by the great Cracker Creek and Cable Cove system, by the Magnolia, the Greenhorn, the Alamo, the Susanville, and the Quartzburg veins. The prevailing dip is to the southeast or south, at angles from 45° to nearly 90°; but there are exceptions—thus, for instance, the strong and persistent Eagle vein, in Cable Cove, which dips toward the northwest at a steep angle. On the other hand, there are some districts with vein systems striking nearly north and south, or a few degrees east of this direction. Among them is the Cornucopia district, with veins dipping at moderate or steep angles east or west; the Pocahontas district, where flat westerly dips prevail, and the Red Boy, the veins of which dip from 50° to 80° W.

Still rarer is a northwesterly strike, usually coupled with a moderate southwest dip. Such veins are found in the Virtue district, at Connor Creek, Gold Ridge, and in the Bonanza district.

Regarded in a general way, the northeasterly or east-northeasterly strike of the veins is characteristic of the whole gold belt, and also coincides with its extension as a whole; just as much so, in fact, as the north-northwesterly strike is characteristic for the majority of the veins of the California gold belt.

It may not be amiss, in this connection, to call attention to a paragraph and a map in a previous report,[1] in which it is emphasized that

[1] The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho: Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 101.



A. UNION-COMPANION VEIN.

B MONARCH VEIN.

the veins of central Idaho, with few exceptions, strike in a general east-west direction. Similar directions are found in parts of southern Montana adjacent to Idaho—as, for instance, at Butte; and it is now shown that the veins of eastern Oregon adhere to this rule, though it is not quite so exclusively maintained as in central Idaho. It was also pointed out in the above-mentioned report that this constancy in the strike of the fissure systems indicated that at the time they were formed the whole region constituted a solid crust block, which acted as a unit toward the disturbing forces. Nor is there in the Oregon district any evidence militating against the conclusion reached during the examinations of central Idaho that the fissures were formed under the influence of compressive stress acting in the main from north to south.

Wherever extensive vein systems were formed they have the character of linked veins—that is, the fissures are not absolutely continuous, but branches are thrown off at frequent intervals. The most important veins die out at some point and are replaced by other parallel fissures. A very excellent illustration is furnished by the vein system of Elkhorn, Cracker Creek, and Cable Cove, shown on the map. Beginning at the Baisley-Elkhorn with northeasterly strike, the veins continue across Rock Creek with east-west strike; on the divide between Rock Creek and Cracker Creek the direction again turns sharply northeast and the powerful North Pole vein begins. Continuing through the Columbia and the Golconda veins, the direction again gradually turns east-west, and the fissure gradually splits west of the Bunker Hill claim. But a short distance north of this point the exceptionally straight Ibex vein appears and continues without interruption for 2 or 3 miles. Again, parallel east-west veins appear a short distance north of Rock Creek and connect with the extensive fissure system of Cable Cove, which gradually swings around until near its westerly end it closely approaches the Ibex vein.

VEIN STRUCTURE.

In regard to structure, several types may be distinguished among the fissure veins. The most common is that of the simple vein with a quartz filling, continuous over considerable spaces. The adjoining rock is rarely strongly sheeted by shear zones, and there are seldom parallel ore bodies in close contiguity. It is the simplest form of a gold-quartz vein, and is similar in type to many veins along the California gold belt. To this class belong the veins of Cornucopia, Sparta, Lower Burnt River, Pocahontas, Quartzburg, and many of the silver veins of the Greenhorn Mountains. It is illustrated by Pl. LXV, *A*, which shows a stope above the second level in the shaft of the Union–Companion vein, Cornucopia. It is an absolutely continuous filling of massive, coarse crystalline vein quartz with irregularly scattered

sulphurets, 3 to 4 feet thick, between sharply defined and clear-cut walls of somewhat altered granodiorite. The assay value is about $20 per ton across the quartz. In both the upper and lower part the quartz is slightly sheared, as shown by the plate. For comparison a view of the Argonaut vein, Amador County, Cal., is represented in Pl. LXVI. This photograph was taken 650 feet below the surface, by Mr. O. H. Packer, a mining engineer of San Francisco. The vein is of massive quartz, containing some streaks of slate, as shown; it is in a country rock of clay slate and contains in the hanging many stringers of rich quartz; the vein itself is also good ore.

A second structural type occurs in regions of pronounced shear-zones, as, for instance, in the granodiorites of the Cable Cove district. The veins are here more closely spaced and there is more evidence of replacement. The sulphurets are more abundant, and parallel seams with new ore bodies may be found by cross cutting. The veins, however, maintain their individuality over fairly long distances. Some of the silver veins of the Greenhorn Mountains in diorite and granodiorite also show this tendency.

A third type is represented by the Cougar vein, which is a normal replacement vein. The values are contained entirely in the crushed argillite along a single fissure, and the quartz, if present, carries but little ore. The tourmaline-copper-gold vein of Copperopolis, in the Quartzburg district, is also practically a replacement vein, in which the diabase is irregularly altered into ore. On the whole this type is not common

A fourth type is developed in the pocket veins of Canyon. The fairly well-defined quartz veins of these deposits are poor or barren, while the seams accompanying them are filled with quartz or calcite rich in native gold.

The fifth type, and the most interesting, includes the gold and gold-silver veins in the argillite series. Among them are found the richest and strongest of the veins of eastern Oregon; they are chiefly developed in the Sumpter, Cracker Creek, Granite, Alamo, and Bonanza districts. Their peculiarities are due to the action of a strong, dislocating force on the brittle, siliceous argillites, so extensively developed in these districts. In their simplest type, as in the Monarch and Red Boy veins, they form strong and continuous fissures, with well-defined walls 2 to 5 feet apart. The vein filling is, however, not exclusively quartz, but a shattered mass of argillite, cemented by single veinlets or by a perfect network of veinlets with mineral quartz filling, often showing comb structure. Though altered and impregnated with pyrite, the slate does not often carry the pay, which is usually concentrated in the quartz seams. This type is illustrated in Pl. LXV, *B*, from a photograph taken in the Monarch vein, Red Boy mine, in a slope just above the tunnel level south of the crosscut.

ARGONAUT VEIN AT 650 FEET, JACKSON, AMADOR COUNTY, CAL.

In the Ibex and Bonanza veins the same type prevails, but the vein is wider, up to 40 feet, and of the composite type. There are sometimes several parallel walls and parallel masses of ore, consisting of shattered and recemented argillite. Frequent crosscutting is necessary; otherwise important ore bodies may escape attention. Most of the gold is contained in the quartz filling, but part of the ore also consists of a silicified argillite mud, which largely filled the fissures. Sometimes the breasts show a mass of argillite fragments embedded in massive quartz.

This type attains its extreme development in the North Pole vein, upon which some of the most celebrated mines of the Blue Mountains are located. It is a crushed zone, absolutely continuous for at least 4 miles and having a width of from a few feet up to 200 feet, averaging, perhaps, 25 feet. In very few places the walls approach each other within a few feet; no places were seen in which the fissure had locally closed down so as to contain no quartz. The normal developments show two well- or fairly well-defined walls, but no extensive system of parallel sheeting or shear planes. Between these walls lies a mass of quartz-argillite breccia; either of the constituents may locally prevail. Sometimes large bodies of pure, coarse, vein quartz appear, 10 feet to 20 feet in width, with only a few intermixed argillite fragments. Near the North Pole, Golconda, and the Bunker Hill mines enormous quartz croppings appear, measuring 100 and even 200 feet across. Very likely, however, this excessive thickness is deceptive and is caused in part by sliding or settling of the outcrops. At the Golconda mine the vein loses some of its distinctive features, and appears locally as a crushed zone, 200 feet wide, penetrated by irregular seams and veins.

FAULTS.

The veins of the Blue Mountains are very little affected by subsequent disturbances. Faults are not common and, when occurring, are of slight throw. In the Cornucopia district Neocene basalt dikes often cut and fault the veins, and similar conditions were observed in the Sparta district. Strong faulting movement has taken place in the Red Boy and in the Connor Creek mines. In the Cracker Creek and Cable Cove mines faults are not often encountered.

THE ORES.

The ores of these different classes of veins vary so much that they are best described under the types enumerated below. It may be said briefly that the predominating gangue is quartz, nearly always accompanied by a little calcite. More rarely the calcite or dolomite, the latter in serpentine areas, predominates. Accessory constituents are sericite, a chromium-mica (fuchsite?), and roscoelite. The latter two are found in several veins.

Among the ore minerals gold, more or less alloyed with silver, is of almost universal occurrence. The fineness varies from 930 to 500. The quantity amenable to plate amalgamation varies from a few up to 80 per cent. The sulphurets are those usually accompanying gold, viz, pyrite, arsenopyrite, zinc blende, galena, and chalcopyrite, the two latter rarely in large amounts. Arsenopyrite is very frequent, and, next to pyrite, the most common ore. Marcasite also occurs in the veins in argillite. Accessories are cinnabar, which is pretty common in the argillite veins, stibnite, tetrahedrite, mercurial tetrahedrite (schwatzite), pyrargyrite, and tellurides, the latter identified from the Cornucopia and the North Pole mines. A detailed list of minerals found in the area is given on pp. 642–643. The value of the ores milled at the mines ordinarily varies from $8 to $20, chiefly in gold; but considerable quantities of ore containing $40 per ton, or even much more, have been reduced in local mills. Concentrates and ores shipped to smelters vary from $30 to several hundred dollars per ton.

The silver veins carry in part the above-mentioned most common sulphurets; some of them carry also argentite, tetrahedrite, and pyrargyrite, but seldom much galena.

METASOMATIC PROCESSES.

The gold and silver veins contained in granodiorite, diorite, serpentine, and gabbro all show great similarity in the processes of alteration which the rocks have undergone close to the fissures. Excepted from this statement is the small group of tourmaline veins. The process consists in a metasomatic replacement of the ferromagnesian silicates, the feldspars, and to some extent also the quartz, by sericite, calcite, or allied carbonates and pyrite. In the Cornucopia mines and on the Gold Hill in the lower Burnt River district this alteration is particularly intense, but it is equally present in the Elkhorn district, in Cable Cove, and in the silver mines of Greenhorn Mountains. Locally the sericite or the calcite may predominate, and veins in serpentine and allied rocks present an exclusive alteration to dolomite. These abundant carbonates in the country rock stand in sharp contrast to the almost exclusively prevalent quartz filling of the veins.

The great similarity of ores and processes of alteration to the gold-quartz veins of California and of central Idaho, described elsewhere, is extremely striking and forms one of the most important generalizations to be drawn. The gold veins in the three States certainly owe their origin to extremely similar processes. The only difference between the California veins and those of eastern Oregon, as far as contents and alteration are concerned, is that the latter on the whole contain less free gold and more sulphurets than the former. Characteristic for both is the total absence of barite, fluorite, and tourma-

line, as well as of garnet, ferromagnesian silicates, epidote, and iron oxides.

The interrelations of the vein systems prove almost conclusively that the veins in argillite are of the same age and of the same genesis as those in granular rocks, and yet in the more or less siliceous and carbonaceous argillite the metasomatic processes are of a different character. Extensive alteration has not ordinarily taken place, but very frequently the argillite is filled with sharply developed crystals of pyrite and also a little sericite. Where the alteration is intense a silicification has usually occurred, though the process is not widespread and does not affect any rocks outside of the walls, even in the largest veins. Some of the very richest shipping ore in the Columbia and the Golconda is probably a siliceous replacement of argillite.

In many veins two kinds of alteration appear; for instance, in the Badger mine, at Susanville; in the Golconda mine, at Sumpter, and the Connor Creek mine, on Snake River. Feldspathic rocks, whether sedimentary or igneous, are subjected to sericitization and carbonatization, while siliceous clay slates are silicified or impregnated with pyrite. The replacing solutions attack vigorously only the feldspars and the ferromagnesian silicates. Many argillites contain practically none of these minerals, but are composed of quartz and sericite, or quartz and kaolin, and on such minerals solutions of the kind here active are powerless as far as sericitization and carbonatization are concerned. But pyrite is formed, metasomatically, without difficulty, while the cryptocrystalline quartz is also recrystallized in larger and clearer individuals and additional quartz is deposited in every available space. In any rock with a large amount of quartz, mass action becomes a factor of importance when it is under the influence of this kind of solution, and more quartz will be deposited. The solutions contained much carbon dioxide, alkaline carbonates, and silica.

This course of alteration is entirely similar to that in the wall rocks of the California gold-quartz veins, though the reasons for the differences indicated were scarcely fully appreciated at the time the study of the latter deposits was undertaken.

PAY SHOOTS.

As in all gold-quartz mines, only certain parts of the veins contain gold-bearing material of sufficiently high grade to be considered as ore. It is recognized, of course, that the definition of ore is a fluctuating one, dependent upon the cost of mining and milling. Under the general conditions prevailing in eastern Oregon, this varies with the accessibility of the districts and the cost of reduction of the ores. Under favorable circumstances the cost of mining and milling can be estimated at $3 to $4 for free-milling ores, as well as for ores adapted for concentration, provided that a continuous ore shoot with a thick-

ness of at least a couple of feet of ore is available. Theoretically, then, everything over $3 should be considered ore. As a matter of fact, the ores extracted run considerably higher, or at least $7 per ton. The mining and milling of ores of lower grade have not yet been extensively attempted, and when it is necessary to roast and cyanide or chlorinate the ore directly the expense must of necessity be much higher. In narrow veins with rich ore the expense of mining will also necessarily be higher, and in such districts distant from railroads merchantable ore must contain something like $25 per ton.

In most of the mines the development has scarcely progressed far enough to justify an opinion regarding the form of the ore shoots. Sometimes, indeed often, the ore bodies are very irregularly distributed, but in the majority of cases they are apt to form elongated bodies with a well-defined pitch in one direction or another on the plane of the vein. Ordinarily the pay shoots outcrop on the surface; this has been the usual case, many statements to the contrary notwithstanding. It was so in the Cornucopia, the Connor Creek, and the Virtue mines; also in Cable Cove, and in the North Pole, E. and E., and the Columbia mines. The Bonanza vein has been mined up to the grass roots, though the best ore was found only a couple of hundred feet lower. On the other hand, the Monarch pay shoot in the Red Boy mine did not reach the surface, though a few hundred feet below it has lengthened to 800 feet. The Red Boy vein had pay shoot only 100 feet long on the surface, which in depth attained a length of 800 feet. In the Golconda the croppings were very poor, and the ore body was revealed only after the shaft had been sunk. But this is exceptional. Extensive developments have often been undertaken below poor croppings without successful results. The conclusion is that, while good mines may be developed from poor croppings, the chances are against it, here in Oregon as elsewhere, where gold-quartz veins are concerned. The reason, however, why the barren croppings are so much more conspicuous than the rich is that the latter, being usually less compact and more easily oxidized, are very often eroded and covered by soil and detritus.

The quartz between the pay shoots is sometimes entirely barren, but is more apt to contain from a trace to $2 or $3 in gold. In some smaller veins pay appears wherever quartz filling has had an opportunity to form.

In the Union-Companion mine, Cornucopia, the ore shoot, as far as proved, pitches south on a vein dipping west. In the Virtue mine somewhat complete data are available, and the pay shoot has approximately the form shown in fig. 86. It will be noted that on the surface the shoot was only 200 feet long, but that below the first few levels it rapidly widened to 1,200 feet, a width maintained to a depth of 1,100 feet below the surface. On level No. 7 the vein became impoverished

and very little pay was found; on No. 8, though, the vein continued without break. No very decided pitch was noted in the continuous, almost rectangular shoot, which comprises an area of 960,000 square feet. The average thickness was 14 inches, whence followed an average yield per square foot of the plane of the vein of $2.29, or a value per ton of $24.23, the total output being $2,200,000. This is more than the average value of the lower and larger part of the shoot, which was $16 per ton. From this it may be concluded that the value of the ore near the surface was considerably higher than the average in depth. (See below, under the heading "Secondary enrichment.") From the developments on levels No. 7 and 8 it was concluded that the pay shoot was exhausted, and the mine was considered worked out and allowed to fill with water. If the vein, as is stated, really continued unbroken on these levels it may be questioned whether this is a safe conclusion. Barren stretches for 200 feet in depth, or even more, are by no means unknown among gold-quartz veins, and without further and deeper exploration it would be rash to say that the ore deposition really had ceased at a depth of 1,000 feet from the surface.

In the great North Pole vein, in Cracker Creek district, are at least three pay shoots separated by wide spaces of poor quartz (fig. 81). The first is that of the North Pole, continued in the E. and E. mine. It is several hundred feet long measured along the levels, and pitches 20°–30° SW., the vein dipping 70° SE. It has been followed for 2,500 feet along its pitch. Fifteen hundred feet farther southwest is the Columbia shoot, also several hundred feet long, having the same pitch and having thus far been followed for 2,000 feet along this pitch. Two thousand feet farther southwest is the Golconda ore shoot, which has a more irregular outline, and thus far shows no decided pitch. The beginning of another ore shoot has been found northeast of the North Pole and E. and E. shoot in the workings of the former vein.

On the Ibex vein, continuous for 3 miles, a great number of pay shoots have been found, which, however, are usually of less extent along the strike of the vein than those of the North Pole vein, and which also, as a rule, are more irregular and show rapid variations in their tenor. In a distance of 4,500 feet in the Ibex and Bald Mountain mines at least six shoots occur, which, like those of the North Pole vein, pitch southwest on the vein, the latter having a steep southerly dip. The maximum length along the drift is 200 feet; the pitch is much steeper than in the North Pole vein.

An interesting observation is the general coincidence of the pay shoots on the parallel and adjoining Monarch and Red Boy veins in the Red Boy mine. Even the richest placers in the two veins appear to be opposite each other.

The next subject to be considered is the width of the shoots in the composite veins. In the simple veins the whole width of the quartz, or,

in veins poor in quartz, the whole width of the sulphurets, ordinarily constitutes pay ore. A difference is sometimes found, as, for instance, in the Monarch vein (Pl. LXV, *B*), in which the 2 feet next to the foot wall contain the best ore. The whole width is, however, milled. Other instances of similar relations are not wanting. In the Baisley-Elkhorn mine, for instance, a 2-foot-wide body of rich sulphide ore was in one place adjoined by 2 feet of nearly barren quartz. In wide veins in granodiorite, like the Eagle vein in Cable Cove, which consists of 15 feet of crushed rock between well-defined walls, this width contains one or more pay streaks of sulphurets from a fraction of a foot to several feet wide. The pay streaks change from foot wall to hanging wall and occasionally overlap; but wherever there are sulphurets there is also pay.

In the pay shoots of wide, composite veins in argillite other and more complicated conditions prevail. Out of a total width of quartz and quartz-argillite breccia of from 7 to 40 feet, or even more, the pay is usually confined to a streak from 1 to 4 feet in width. This streak may lie on either wall and sometimes crosses diagonally from one wall to another, or it may break up into several stringers of pay ore. The pay streak is often adjoined on both sides by normal quartz, sometimes differing but little in appearance from the ore. Ordinarily, however, to the practiced eye there is a difference, consisting in a looser or more crumbling condition, or in the occurrence of finely distributed pyrite and arsenopyrite in the ore. This suggests at once that the pay streaks may be secondary breaks and fissures enriched by concentration from a great width of lean ore. This should not be understood as meaning concentration under the influence of oxidizing waters or a concentration in any way dependent on surface conditions. If these streaks really are secondary enrichments, they have been effected under the influence of the same kind of solutions that formed the vein as a whole, and may be relied upon to continue in depth. But the question is by no means simple, and much more extended observations than those which could be made on a rapid reconnaissance are necessary to settle the question. In some cases there seems to be no difference in the character of the quartz outside and inside of the pay streaks except in the content of gold in the latter. On the other hand, it is often found, as, for instance, in the North Pole vein, that extensive crushing and brecciating has taken place in the pay streaks and the fragments are recemented by calcite and secondary sulphurets. The cemented fragments are not barren quartz but contain arsenopyrite in unquestionable primary deposition. The argument for secondary concentration is further weakened by the fact that in many places the barren quartz shows a similar brecciation and calcitic cement. The difficulty is to account for deposition of ore in certain streaks

which occasionally cross the vein, while the whole space was filled with metalliferous solutions and deposition of quartz went on throughout. The theory of a secondary concentration is very attractive, but the occurrence of well-defined and parallel pitching ore shoots on the plane of the vein remains to be explained as well on this supposition as on the theory of their direct formation from original deposition.

In some veins, like the Bonanza, and on the Belle of Baker claim, on the Ibex vein, large bodies of high-grade quartz and breccia of quartz and country rock occur with a width up to 40 feet, while parallel and closely adjoining fissures may carry very low-grade quartz. Again, there are some veins in argillite which in a width of 10 to 20 feet carry approximately even values of from $3 to $5 per ton.

Within the great ore shoots it is not uncommon to find smaller bodies of extremely rich ore. Pockets of gold and argentite occur in the Connor Creek mine and similar bunches of coarse, high-grade gold in the Virtue mine. Similar bodies are found in the North Pole, E. and E., Columbia, and Golconda mines, here containing pyrite, chalcopyrite, tetrahedrite, native gold, and sometimes telluride in a gangue of quartz and roscoelite. These rich pockets are small and irregular masses or narrow chimneys. An unusually large mass of this kind in the Golconda mine was 70 feet long and 14 feet wide and pitched flat in a southeasterly direction across the general trend of the vein, which is here a broad, crushed argillite zone with quartz stringers rather than a well-defined fissure. Most cases of this kind are not, I believe, due to a secondary concentration, but bear the ear marks of original deposition.

In conclusion, there is no uniform law as to the form and the pitch of the shoots. In the Nevada City and Grass Valley districts of California it has been shown that the shoots usually pitch to the left of the observer, standing on the croppings and facing in the direction of the dip of the vein. While this corresponds to the general observations in the Cornucopia district, the rule is reversed in the North Pole and in the Ibex veins.

The satisfactory explanation of the ore shoots is one of the most difficult parts of the study of ore deposits. None of the ordinarily advanced theories is entirely satisfactory. Prof. C. R. Van Hise, in a recent paper,[1] believes, in common with some other geologists, that the cause is to be sought in cross fractures carrying different solutions from those found in the main fissure. The ore is precipitated by the reaction of these differing solutions. It can not be said that much evidence has been found in this region to support this view. The only place where cross fractures seem to have any influence upon the ore at all is in the Cable Cove district (see detailed description), and here they locally interrupt the continuance of the ore rather than favor it.

[1] Some principles controlling ore deposition: Trans. Am. Inst. Min. Eng., Vol. XXX, 1901, pp. 27–177.

DEPTH ATTAINED AND THE QUESTION OF PERMANENCY.

The quartz-mining industry in the Blue Mountains is of comparatively recent date, and hence for the most part the mines have not as yet attained great depth. The Connor Creek mine, on Snake River, has reached a depth of 1,000 feet from the croppings, developed by tunnels. Rich ore has recently been found on the lowest level, though the ore shoot is not developed in full force as far as the present explorations go. The Virtue mine is 1,100 feet below the croppings, developed by an 800-foot vertical shaft. The ore shoot, continuous from the surface to a depth of 900 or 1,000 feet, was found to be too poor for working on the deepest level. While the ore in depth was poorer than the oxidized portion, I do not understand that a gradual decrease in the tenor took place. The Cornucopia mines have been worked 500 feet below the croppings with continuous ore shoots. The North Pole has been opened by tunnels to 1,000 feet or more below the croppings; the Columbia by a 500-foot shaft to a point 1,000 feet below the highest croppings on the same claim. The total vertical distance between the highest workings in the North Pole mine and the lowest in the Columbia mine is at least 1,700 feet, and on the deepest levels the ore continues of the same grade as nearer the surface, from the lower edge of the zone of oxidation. The Bonanza mine is opened by tunnels and shaft to a depth of 450 feet below the croppings, good ore being found in the lowest levels.

Regarding the permanency of the veins, there are very good reasons for believing that the strong, well-defined veins upon which most of the important mines are located will continue to the greatest depths yet attained in gold mining. Judging from analogy with other regions, it is also probable that the pay shoots will continue in depth, though the unbroken continuation of one and the same ore shoot should not be relied upon with confidence. It has been the experience of most deep gold-mining enterprises that barren levels will occasionally interrupt the richest and most extensive ore shoots. Smaller fissure veins, members of a great number of veins in close contiguity and which have no great length, are not to be relied upon with as much certainty. But, taken as a whole, the strength of the vein systems and the mineralizing action are important factors in favor of the future of this mining region.

SURFACE OXIDATION.

In eastern Oregon, as in most mining regions, the portion of the veins adjacent to the surface has undergone certain changes, due to the action of oxidizing waters. In late years much attention has been devoted to these phenomena, and the studies of Messrs. Emmons, Weed, and Van Hise have placed the active processes in a much

clearer light. Their importance to the mining industry can not be overestimated, for the future value of a mine depends greatly on the extent of the secondary surface processes and of their certain identification.

In a broad way, the processes of oxidation and the sulphide enrichment accompanying them in greater depths are more active and extensive in an arid climate than in a region of heavy rainfall, where the water level stands high. The Blue Mountain region is essentially one of great precipitation, and has in all probability been so since Neocene time. It is further true, in a general way, that gold-quartz veins are less readily affected than silver and copper veins, due, no doubt, to the more difficult solubility of the gold. Furthermore, some of the districts in this region are located in areas of former glaciation, which has swept away the softer products of oxidation, the limonite and the cellular quartz of the "iron cap."

The general conclusion, then, is that secondary surface enrichment has played a comparatively unimportant part in this region. It is, however, undoubtedly present, as shown by the following examples selected from the detailed descriptions:

From Pedro Mountain near Rye Valley, from La Belleview and the Monumental mines in the Granite district, and from some parts of the Greenhorn Mountains come reports of extraordinarily rich silver ore in the croppings immediately below which poorer ore was found. This is in line with what is known about silver veins elsewhere, and may without doubt be attributed to surface enrichment.

Among the gold veins with coarse sulphides and no free gold the surface, down to 25 or 50 feet, is generally reported to contain limonite with free gold and richer ore than below. Those at Cable Cove and Susanville are examples of this.

Among the gold-quartz veins with much free gold the upper parts of the vein, from the surface to a depth of from 100 to 300 feet, are generally more or less oxidized and richer than the unaltered ore below. At the Sanger mine, on Eagle Creek, the uppermost 100 feet showed a narrow vein yielding $25 per ton, while below the vein widened and the average values were reduced to $12 per ton. At the Virtue mine the upper two or three levels yielded $25 per ton, while the main part of the ore shoot averaged only $16 per ton. Although in a locally arid district, deeper oxidation is excluded in this case, for below the first few levels the mine contained an abundance of warm water, in all probability under ascending pressure.

In the gold veins in argillite of the Cracker Creek and Granite districts the sulphides are generally in very fine distribution and the ore is often quite hard. In connection with a high permanent water level this results in an oxidized zone which, on the steep hillsides of the North Pole claim, extends 200 to 250 feet from the surface. The ore in this

zone is only partly oxidized, and the difference in tenor between it and the deep unaltered ore is surprisingly slight. Average assays of surface ore give 0.968 ounce gold and 0.700 ounce silver per ton, a total of $20.40 per ton. In the fresh ore is very little free gold; in the oxidized ore a little more, but enough is not set free to convert the substance into free milling ore, so that a preliminary roasting is necessary for purposes of the cyanide process. If no great change of volume has taken place during the process, the weathering has had the effect of slightly increasing the gold and decreasing the silver.

The Ibex vein, situated in the glaciated area, shows little evidence of surface decomposition. I believe that the bodies of rich ore, 40 feet wide, found in the Belle of Baker near the surface, as well as in the Bonanza vein 300 feet from the surface, are due to primary deposition, and have not been enriched by oxidizing action.

No decided evidence of sulphide enrichment due to surface waters has been found. The ores should be expected to continue for great depth below the relatively shallow zone of oxidation without notable change in character and tenor.

AGE OF THE GOLD AND SILVER VEINS.

The gold and silver veins of the Blue Mountains with few exceptions consist of a number of very closely related structural and mineralogical types. It is difficult to avoid the conclusion that they are all of about the same age. They occur in argillite, granites, granodiorites, diorites, gabbros, and serpentines. They cut Triassic sediments in the Eagle Creek Mountains; they cut older argillites which with reasonable certainty may be assigned to the Paleozoic age; finally, they never appear in the Neocene basaltic, andesitic, and rhyolitic lavas. The conclusion is that they are post-Triassic and pre-Neocene. The California gold-quartz veins are post-Jurassic and pre-Neocene; we may even fix their age a little closer, for they are doubtless also earlier than the Chico Cretaceous. The vein systems of central Idaho are determined as post-Carboniferous and pre-Neocene. It is very probable that the veins in the three regions date from about the same period, i. e., the early Cretaceous.

A strong mineralization of the Neocene lavas has been noted in Owyhee County, in southern Idaho. The only instance in this region of a post-Neocene mineralization is in the case of a dike of rhyolite 9 miles south of Prairie, which undoubtedly contains traces of gold and silver.

INFLUENCE OF COUNTRY ROCK.

It has been stated that the gold and silver veins appear in almost all of the different rocks of the region, excepting the Neocene lavas; the influence of the country rock upon the character of the ore is next to

be discussed. When smaller districts are examined differences due to the varying character of the country rock may be distinguished; but to a great extent these are effaced when the region as a whole is considered. Most of the big-producing mines are in slate or siliceous argillite; for instance, the Bonanza, Red Boy, North Pole, Columbia, Golconda, and Connor Creek mines; but, on the other hand, the Virtue is in tuffaceous greenstone, and the Baisley-Elkhorn and the Cornucopia mines in diorite or granodiorite. It may perhaps be said that in granite or diorite there is apt to be less free gold and a greater percentage of sulphurets, but this is a doubtful rule, for some of the greatest mines in argillite, like the North Pole and E. and E., contain very little free gold and abundant sulphurets. The same is true of the Badger mine at Susanville. Veins in serpentine are usually narrow and short, with much dolomite gangue and coarse, pure gold.

It would seem that here, as in California, the influence of locality overshadows that of the country rock entirely. That is, if gold-bearing veins are developed at any place, they are likely to be found in any of the various rocks which appear at that place.

No doubt the difference in the character of the fracture in argillite and in granitic rocks greatly influences the deposition. A wide fracture zone is apt to contain a different ore from narrow fissures through which the solutions found their way with difficulty; and the fact that granitic and dioritic rocks are altered in a different way and more easily than the siliceous argillite can hardly fail to make the character of the solutions circulating in the open spaces somewhat different in the two cases. This may account for a relative abundance of sulphides in the granular rocks and a less amount of free gold in them.

VARIATIONS OF THE PAY SHOOTS.

It is an interesting fact that adjoining pay shoots in one and the same vein may differ considerably in the character of the ore. This applies particularly to the North Pole and Ibex veins. The North Pole and E. and E. ore shoots on the North Pole vein contain very little free gold; the sulphurets are of high grade. The Columbia ore shoot contains more free gold and also more silver than the former. The Golconda contains free gold, but the sulphurets are poorer than in the Columbia. These data refer, of course, to the fresh, unoxidized ore. In the Ibex mine three pay shoots show successive variation of the relative proportion of gold and silver. The first shoot contains 90 per cent gold and 10 per cent silver, the last 40 per cent gold and 60 per cent silver.

GEOLOGICAL RELATIONS OF THE VEINS.

While at first glance the veins seem to be scattered irregularly in respect to geological areas, a closer inspection reveals some interesting relations.

Relatively few deposits are contained in the great area of granodiorite of the northern Elkhorn Range, the extensive area of sedimentary rocks of the Eagle Creek Range, or the area of argillites on both sides of the Burnt River Canyon above Durkee.

On the other hand, the veins certainly appear massed near the contacts of sedimentary rocks with granular intrusive rocks. Most conspicuously does this show in the great Elkhorn-Cracker Creek-Cable Cove vein system, which accompanies the contact for many miles—not closely, indeed, for none of the veins follow the actual contact. The veins are now in diorite or granodiorite, now in argillite, continually branching, crossing the contact, and throwing out divergent systems several miles either way from the contact. Near Granite another vein system is developed, crossing the contact. Near the Red Boy, Alamo, and Greenhorn districts another intrusive area of granodiorites, diorite, gabbro, and serpentine begins, and new vein systems appear in them or in the argillites broken by their intrusion. At Bonanza serpentine accompanies the argillite, as it also does at Susanville. At Canyon serpentine and diabase adjoin slate areas. In the southern Elkhorn Range dioritic rocks have shattered the sedimentary series. In the Virtue mining district the veins occur on both sides of a contact between diorites and gabbros and argillite. In the Cornucopia mining district rich veins appear at the intrusive contacts of granodiorite and schists; at Sparta in granite adjoining sedimentary rocks. Finally, the local gold belt of the lower Burnt River, extending from Connor Creek to Malheur, a distance of 30 miles, follows three intrusive areas of diorite and granodiorite—those of Lookout Mountain, Pedro Mountain, and Amelia.

These relations are too evident to be overlooked. It seems certain that the occurrence of rich gold and silver veins in this region is, in some way, connected with the occurrence of intrusive rocks, which more rarely are granites, more commonly granodiorites, diorites, gabbros, or serpentines. This by no means implies that all the veins, nor even a majority of them, are contained in these intrusive rocks. They are just as apt to be found in the sedimentary areas in the vicinity of the intrusive masses. This conclusion is important, as similar evidence has been gathered from so many other regions of auriferous veins.

To fully appreciate this connection and to reach the safe conclusion to be drawn from the facts, a careful comparative study of the auriferous regions of the world must be undertaken. This can not be done at this place, and the probable genesis of these deposits will, therefore, be merely indicated in a few words.

GENESIS OF THE VEINS.

The veins of the Blue Mountains were formed at a relatively remote period, and few traces of the active agents of their formation can be

found now. From data concerning the character of the filling, it is here, as in the case of almost all gold-quartz veins, perfectly safe to conclude that the mode of deposition has been exclusively aqueous. From the fact that they occupy important systems of fractures which doubtless continue in depth to a distance commensurate with their extension in length, and from the fact that as far as followed they exhibit no notable change in the character of their filling, we may feel confident that the fissures were channels conveying currents of ascending waters. Wherever these solutions came in contact with rocks capable of metasomatic alteration, a strong action is noticeable on the latter, most intense nearest to the fissure and gradually fading away at a distance. From the further fact that by this alteration silicates are entirely converted to carbonates and sericite, we conclude that the waters contained a strong percentage of carbon dioxide and alkaline carbonates. All these facts point strongly toward thermal waters, hot ascending currents, as the chief factor in the deposition. Much of the gangue was doubtless extracted from the immediately surrounding country rock. Confirming this is the prevalence of dolomitic gangue in veins in serpentine; but the zone from which this material has been extracted is too limited to make it probable that the gold and silver were extracted from the country rock. Militating against this is also the fact that similar veins are found in most widely differing rocks. It is more probable, perhaps, that the thermal waters obtained their heavy metals from gaseous emanations along the contact of magmas cooling at great depth.

The comparison between the copper deposits and the gold-silver veins, which will be found at the end of the discussion of the former, is most interesting. Conceding aqueous deposition for both classes of deposit, the metasomatic processes and the general structural relations are very different, indicating for the gold deposits a deep-seated origin and for the copper deposits a genesis more closely connected with surface phenomena.

MINERAL CLASSIFICATION OF PRIMARY GOLD AND SILVER VEINS.

GOLD VEINS.

Virtue type.—These are simple fissure veins, with quartz filling, in sedimentary, and, more rarely, in igneous rocks. The ore consists principally of native free-milling gold, often coarse, and always very pure, ranging from 850 to 950 in fineness. The highest grade of gold is found in the Virtue and Connor Creek mines. A very small amount of arsenopyrite, pyrite, and more rarely other sulphurets is present. Occasionally, also, small amounts of tetrahedrite, argentite, and stibnite are found. Besides quartz, a little calcite and occasionally white massive scheelite (Flagstaff, Cliff) occur as gangue. The value is

exclusively contained in the quartz filling, scarcely ever in the altered rock. In slates the alteration is confined to pyritization and occasionally a little carbonatization. In granular rocks there is strong carbonatization with the development of pyrite and a little sericite. Examples are the Virtue, White Swan, Flagstaff, Pocahontas, and Connor Creek mines; probably also the Sanger mines. Specimens from the Connor Creek mine show normal white vein quartz of coarse texture and partly idiomorphic outlines of the grains. It is filled with irregular inclusions and contains, crystallized together with the quartz, coarse idiomorphic arsenopyrite, with which the gold is associated; the latter, of deep-yellow color, either surrounds the arsenopyrite or occurs in intimate intergrowth with it. Most of it is coarse, though it also occurs as fine dust and films through the arsenopyrite. It is observed wholly included in the coarser quartz grains, but also along the contacts of the grains, as if deposited by a secondary migration. Wherever the quartz shows parallel partings or ribbon structure in the specimen evidences of pressure are observed in the sections. The large quartz grains throughout the slides are optically disturbed, and along lines coincident with the "ribbons" extensive crushing appears, with the formation of new quartz aggregates and veinlets of calcite, a mineral which sometimes also occurs in larger grains mixed with the quartz. Along these secondary fractures cubical pyrite has recrystallized and threads of gold are also observed, probably a mechanical deformation of the primary deposit.

The clay slate adjoining the vein is a microcrystalline mosaic of quartz, probably also feldspar, traversed by curved and contorted streaks of carbonaceous matter. It contains cubical pyrite as well as seams of calcite and quartz; calcite also in part replaces the slate.

An extremely altered narrow dike follows the Connor Creek vein throughout. Its structure is porphyritic and its groundmass microcrystalline, consisting of quartz and feldspar. Beyond that it can not be identified. The grayish soft rock contains about 20 per cent each of sericite and calcite, together with a few sharply defined crystals of pyrite. It is cut by a few normal quartz seams.

The quartz of the Virtue mine is similar to that from the Connor Creek, though arsenopyrite is generally absent. The wall rock is a soft, very altered greenstone, probably an old volcanic tuff. The rock is filled with seams of calcite, which also largely replace the rock. The remaining feldspars contain a little very minutely divided sericite. Pyrite and some pyrrhotite are also among the metasomatic developments.

The quartz of the Flagstaff mine is again similar, but contains some grains of brownish calcite intergrown with the primary quartz. This calcite again incloses small prisms of quartz.

Canyon and Robinsonville types.—These two divisions also contain

coarse free gold of high grade, associated with some sulphurets, but they differ somewhat from the Virtue type. Apparently without exception they are contained in serpentine, gabbro, diabase or diabase-porphyry, and rarely have great length or width. The ore usually occurs in rich pockets.

In the Canyon type well-defined, almost barren quartz veins in gabbro or diabase-porphyry are accompanied by complicated systems of seams. Coarse gold is found in rich pockets in these seams and has a tendency to crystalline development. The gold occurs in quartz or in calcite. When in the latter it seems to be later than that mineral and its introduction is accompanied by a shattering of the coarse calcite and a simultaneous deposition of a little quartz (Pl. LXIX, *C*).

The country rock is greatly carbonatized and also contains metasomatic pyrite. The development of the latter along minute fissures and its characteristic calcite rim is illustrated in Pl. LXX, *B*. Sulphurets other than pyrite are generally absent. Veins of the Robinsonville type are also chiefly pockets, but the gold is more confined within the vein and the development shows greater variation. The vein filling is quartz of normal, coarse granular type; the crystals are sometimes (Pl. LXX, *A*) cemented by chalcedony. In serpentine, however, as in the Junebug and Don Juan veins, the gangue is chiefly of dolomite, no doubt derived from the country rock. Both dolomite and quartz contain coarse gold. Among the sulphurets, galena, remarkably enough, often predominates and is directly associated with the gold, but chalcopyrite is also present (Banzett, Diadem). The alteration of the country rock is usually a carbonatization, dolomite being frequently formed.

Cornucopia type.—These are normal, simple quartz-filled fissure veins, containing free gold of a fineness from 870 down to 700. The sulphurets, of which from 5 to 10 per cent is present, are usually rich in gold and sometimes also contain some silver. They consist of pyrite and arsenopyrite, with a little zinc blende, galena, and chalcopyrite. Tellurides are sometimes present. The ores are free milling to the extent of from 30 to 60 per cent. These veins show great similarity to certain California types. The country rock is usually a granodiorite, diorite, or diabase, and is strongly altered to a white, soft substance containing very abundantly calcite, sericite, and pyrite. Examples of this type are found at Cornucopia, Sparta, Gold Hill, and Gold Ridge (Burnt River). It is very similar to the Gold Hill type described from central Idaho.[1]

The quartz from Cornucopia is a normal, coarse vein quartz, greatly crushed and showing optical anomalies in thin section along lines where the ribbon structure appears in specimens. Abundant irregular aqueous inclusions are massed along certain lines. Intergrown

[1] Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 105.

with this quartz are pyrite, chalcopyrite, and a colorless zinc blende. Secondary calcite has been introduced along irregular cracks.

The quartz from the Present Need mine, Quartzburg, shows normal coarse structure and is full of large irregular aqueous fluid inclusions with large bubbles. Between the grains lie anhedrons of pyrite, chalcopyrite, galena, and grayish-yellow marcasite. The pyrite and marcasite are intimately intergrown with native gold.

Cable Cove type.—In this type the sulphurets predominate, and the free gold makes up only a small part of the total value. When it occurs, the free gold is of a low value, from 650 to 750 fine. Among the sulphurets pyrite and arsenopyrite predominate, but zinc blende, galena, and chalcopyrite also occur. Rich silver ores are not uncommon (tetrahedrite and pyrargyrite), and altogether there is more silver than in any of the preceding types. Cinnabar is abundant in the placer mines of Susanville, and may have been derived from veins of this type occurring near by. The gangue, which is not very abundant, consists of quartz, but there is also considerable calcite present.

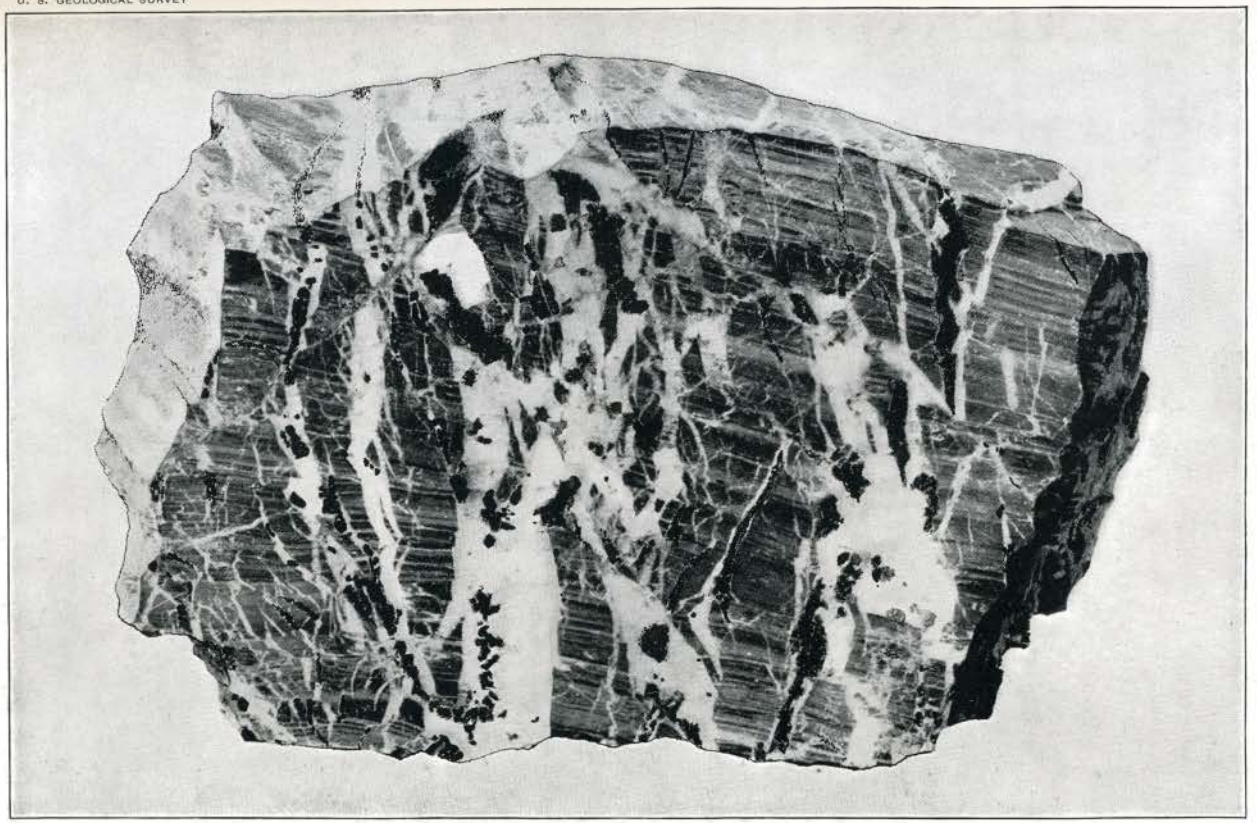
The alteration of the country rock, when of granodiorite or diorite, shows the normal sericitization and carbonatization. When the country rock is slate the veins are accompanied by local and slight silification. A part of the ore is probably formed by replacement of the country rock. Representatives of this type are the Cable Cove mines, the Baisley-Elkhorn, and the Badger mines, at Susanville. This type is somewhat similar to the Willow Creek type from central Idaho.[1]

At the Baisley-Elkhorn the free gold, which amounts to 25 per cent of the total value of the ore, sometimes occurs as wires in a black zinc blende, very intimately intergrown with calcite and a few grains of quartz.

The diorite from the same locality is greatly altered close to the vein. The feldspars are almost completely converted into sericite and calcite, the latter characteristically filling the spaces between the sericite foils. Cubes of pyrite develop in this mass and in the quartz, which otherwise is but little altered. The biotite is partly altered to chlorite, but chiefly to muscovite foils.

In the Cable Cove veins there is less free gold. The vein quartz, when present, is of the normal, coarsely crystalline type (LXIX, *A*), containing well-defined crystals of arsenopyrite and other sulphurets. In a few places a little chalcedony may be noted between the quartz grains. The aqueous inclusions are abundant, but small and irregular, mostly with large stationary bubbles. The granodiorite next to the ore is normally altered to sericite with a little calcite. Fairly pure galena from the Imperial contained 0.74 ounce gold and 60.86 ounces silver per ton, while the pure arsenopyrite from the same mine assayed 5.82 ounces gold and 7.08 ounces silver per ton.

[1] Lindgren, loc. cit.



SPECIMEN OF GOLD ORE, BADGER MINE.

At the Badger mine the coarse pyrite and arsenopyrite is of lower grade, while finer mixtures of these minerals with a little galena, zinc blende, and tetrahedrite contained 1.04 ounces gold and 909.08 ounces silver per ton. The country rock at the Badger mine is a clay slate, developed in at least two modifications. The metasomatic alteration differs correspondingly in an interesting manner. The first is a black, somewhat crumpled, imperfectly fissile clay slate. Under the microscope it has a banded and streaky appearance, due to narrow and curving belts of carbonaceous matter and to streaks of fine aggregates of brown biotite. The clearer parts evidently consist of a very fine microcrystalline aggregate of quartz and feldspar, and contain scattered clastic grains of quartz and twinned feldspars. The clay slate is penetrated by irregularly developed fine-grained aggregates of calcite, accompanied by anhedral pyrite. The calcite very evidently replaces the substance of the clay slate.

The second specimen is a black, fissile clay slate, traversed perpendicularly to the schistosity by a great number of narrow quartz veins containing pyrite, arsenopyrite, and a little zinc blende. The slate is free from sulphides. This clay slate is an almost cryptocrystalline mass, traversed by straight, but not very sharply marked, streaks of calcareous matter. Under highest magnifying powers the substance of the slate is resolved into a fine aggregate of at least two substances of different indices of refraction; many of the larger grains show fibrous undulous extinction. In all probability we have in this rock an intimate mixture of quartz and kaolin. Small and perfect prisms of tourmaline and a few minute sericite foils were noted. The rock is cut by sharply defined quartz veins, in places containing a little calcite and sharply defined crystals of pyrite. They are excellent illustrations of the comb-quartz veins, showing a growth of small crystals next to the walls and then a second generation of coarse crystals reaching entirely across the veinlets. Most of the rock is fresh and unaltered, even when adjoining the veins; but in some places a silicification spreads from the veins in irregular blotches, sometimes following the schistosity. These silicified parts are marked in ordinary light by a replacement of the granulated and dusty argillite substance by a clearer quartz mass, and in polarized light by a coarser, though still fine, aggregate of microcrystalline, interlocking quartz grains and scattered particles of calcite.

These two rocks show that a silicification may take place when the country rock is quartzose and contains no constituents which can easily be acted upon by the solutions. Mass action then becomes predominant, and the solutions containing alkaline carbonates, carbon dioxide, as well as silica, deposit the latter, and some of the kaolin is possibly removed. But when the rock contains feldspars and biotite, chemical reaction between the solutions and the rock produces a deposition of calcite, pyrite, and in most cases also of sericite.

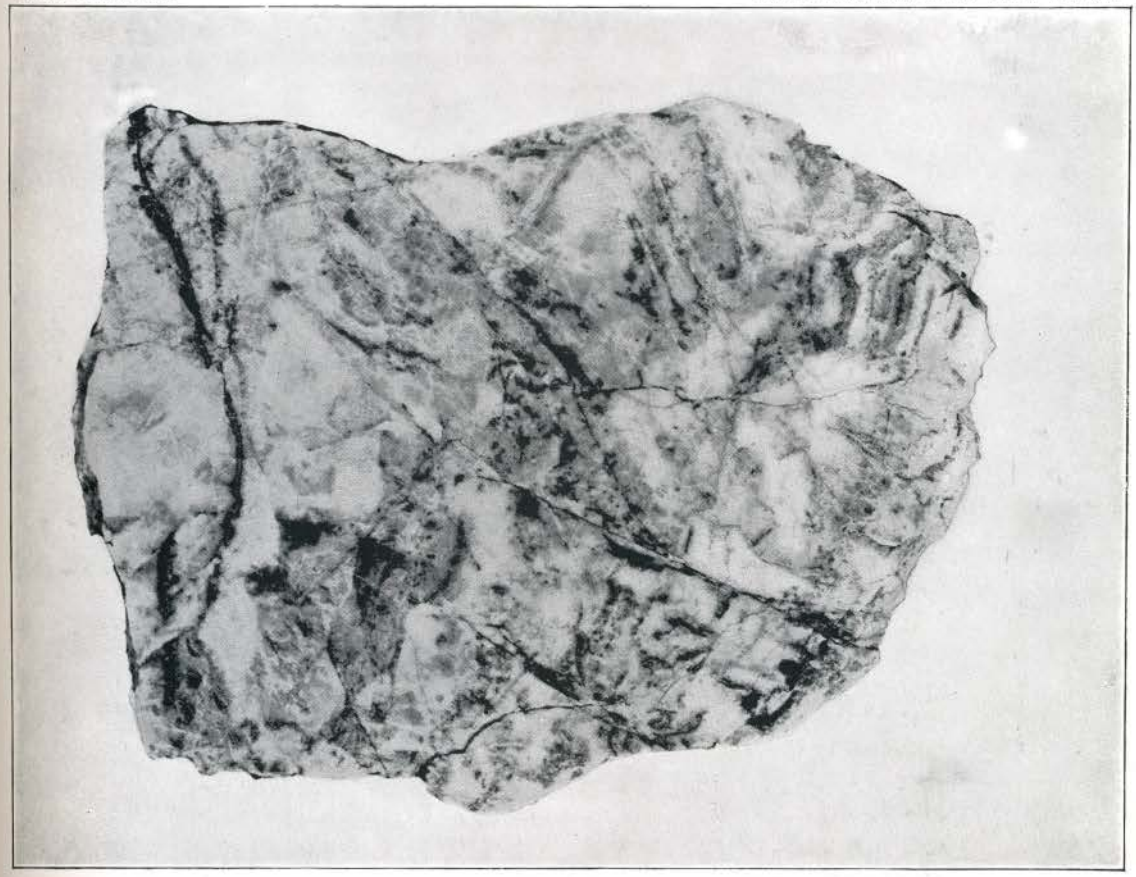
North Pole type.—This division includes the wide, composite veins in argillite and is characterized by a smaller quantity of free gold of rather low grade, together with finely divided sulphurets which usually are rich in gold. The amount of free gold varies from a few per cent up to about 40 per cent. The sulphurets consist chiefly of arsenopyrite and marcasite. Chalcopyrite, galena, and blende are uncommon. Accessory minerals are cinnabar, tetrahedrite, mercurial tetrahedrite, stibnite, and tellurides. The principal gangue is quartz; on secondary seams calcite appears. Chromium mica and roscoelite (vanadium mica) also occur. The ore is usually normal filling, more rarely replaced country rock. The alteration of the slate comprises chiefly a pyritization, occasionally also a silicification; porphyry dikes contained in the argillite are sericitized and partly also carbonatized.

In the North Pole mine the normal ore is a coarse, typical quartz with strong tendency to comb structure. The large crystals show concentric lines of growth upon which the new individuals develop with the same orientation as in the underlying crystals. The comb quartz contains in fine distribution idiomorphic arsenopyrite and less well-developed pyrite. Sometimes the arsenopyrite appears in several sharply defined thin crusts of primary deposition, each generation again covered by comb quartz. Aqueous inclusions of irregular form are common in the quartz. The only difference between barren quartz and ore is in the sulphides contained in the latter.

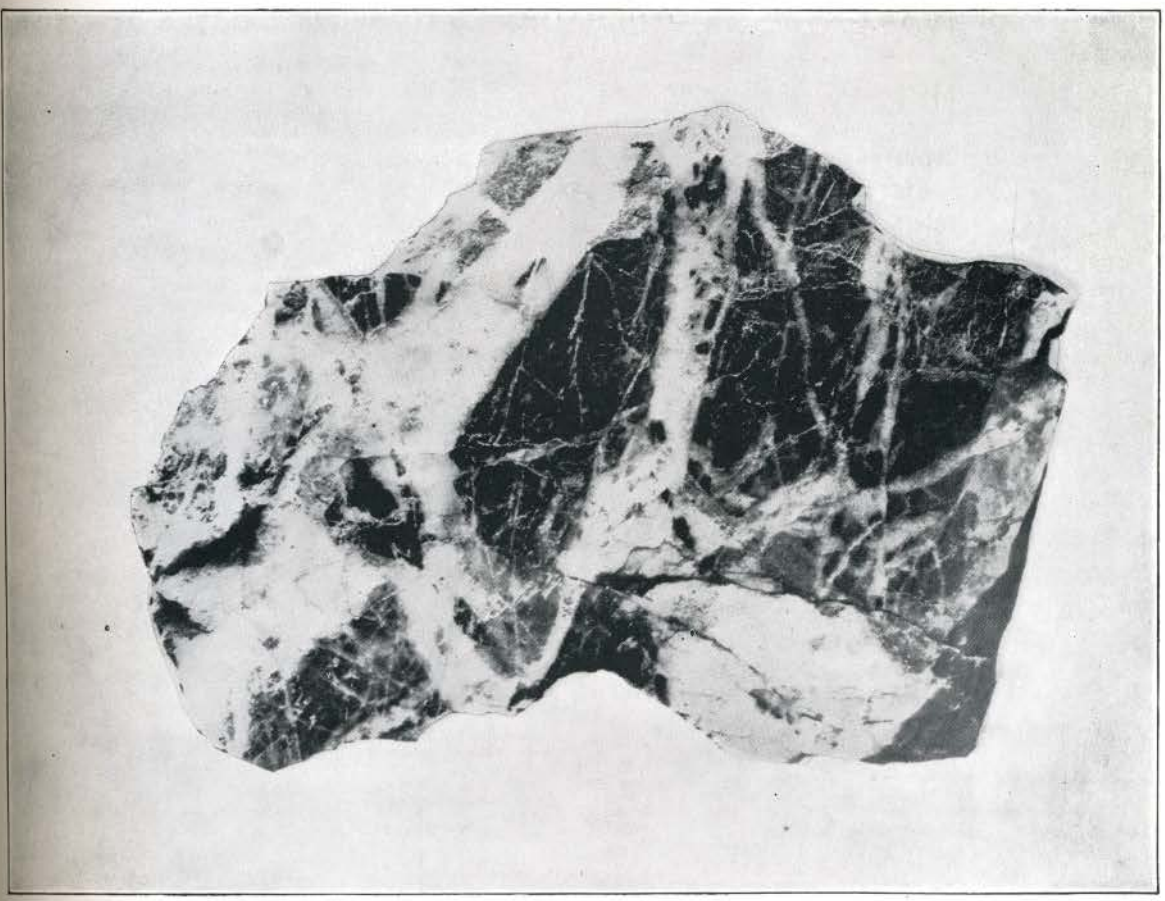
The country rock is siliceous and consists of closely packed, minute, allotriomorphic quartz grains. Between them lie a few fibers of sericite. The planes of the sedimentation are marked by streaks of black carbonaceous material. The principal alteration consists in the development of pyrite in small cubes. This pyrite may in places form larger aggregates, but the latter are always poor in gold and silver.

Secondary changes are frequent in the ore. In many places the quartz shows undulous extinction and is traversed by crushed zones. Whole masses of primary quartz with arsenopyrite in concentric deposition are crushed and recemented by quartz. This produces the peculiar brecciated appearance shown in Pl. LXVIII, *A*, with concentric streaks of arsenopyrite running in many directions and frequently sharply interrupted. In the secondary quartz are scattered sharply defined pentagonal dodecahedrons of pyrite. A third and latest phase of the vein formation is the introduction of calcite along narrow cracks throughout the barren as well as the rich quartz. With the calcite, pyrite and arsenopyrite again recrystallize.

A thin section of rich telluride ore from the North Pole is shown on Pl. LXIX, *B*. The principal mineral is hessite, which is lined with native gold and also contains small masses of another pale-yellow telluride. These minerals occur in apparently primary quartz.



A.



B.

SPECIMENS OF GOLD ORE FROM NORTH POLE AND COLUMBIA MINES.

In the Columbia mine similar relations prevail. The ore is prevailingly a quartz filling showing comb-quartz structure. The argillite is a very fine-grained but clear quartz mosaic, containing abundant streaks of organic matter. Cubes of pyrite are often inclosed in this carbonaceous substance. A slight silicification may have taken place. The argillite is cut by well-defined quartz veinlets, which again show a late infiltration of calcite. Dikes of a very altered igneous rock of doubtful original character are also cut by the vein. A specimen of altered porphyry from the lowest tunnel level consists of sericite fibers, calcite, and a few anhedrons of pyrite.

The rich shipping ore, ordinary specimens of which assayed 245 ounces gold and 166 ounces silver per ton, is a greenish-gray quartz of varying grain. Much of it is very fine grained and almost flinty, and darkened by finely distributed sulphurets. In some places fragments of a greenish-gray altered rock are included in quartz, the color being due to the finely divided roscoelite. Fibers of this mineral are also scattered through the whole rock. The sulphurets consist of pyrite, chalcopyrite, zinc blende, and a black mercurial tetrahedrite, besides much native gold. The latter occurs in intergrowth with the colorless or brownish zinc blende and the tetrahedrite, but not with the pyrite. It also is found intergrown with roscoelite wherever that mineral is abundant. In the prevailing mass of quartz lie small, well-defined inclusions, probably of argillite; these consist of microcrystalline quartz with a little sericite.

The prevailing mineral is a partly idiomorphic normal vein quartz, the grain of which varies considerably. The roscoelite is distributed throughout the quartz in fine aggregates of greenish fibers of strong double refraction. The specimens show no evidence of secondary crushing or deposition.

At the Golconda mine the big quartz vein splits up into stringers, and there is more ore derived from alteration of the country rock than at the other mines. The argillite here approaches normal clay slate, extremely fine grained, with curved streaks of carbonaceous matter. The groundmass seems to consist chiefly of interlocking and very minute quartz grains, together with a little chlorite and isolated crystals of tourmaline and zoisite. The altered rock near the veins contains green spots, due to some chromium mineral, probably fuchsite, besides much pyrite in well-developed crystals. In one specimen were found abundant small and wedge-shaped crystals of marcasite, sometimes also star-shaped, compound crystals of the same. The argillite is cut by veinlets of granular quartz with a little sericite and pyrite.

Dikes of undeterminable porphyries also occur in the mine, and some of them are sufficiently mineralized to be regarded as ore. They are dull grayish, or grayish green, and contain a little pyrite. One

of these, collected from the dump, consists chiefly of sericite in ragged bunches of fibers, and a secondary quartz mosaic, as well as abundant and sharp pyrite crystals. Another dike, from the fourth level, which was considered as ore, consists largely of an extremely intimate mixture of dolomite and quartz, with a little pyrite. Veinlets of quartz, cut again by still later veinlets of some carbonate, traverse the slide. The original rock was probably a basic dike. Possibly the chromium found in the altered rocks is derived from this source.

The rich shipping ore found in the Golconda is similar to that from the Columbia. It consists of a dull-greenish rock of extremely fine-grained quartz, colored by films of roscoelite, and containing pyrite as well as abundant star-shaped marcasite crystals. This rock, which probably is an altered and silicified argillite, contains vugs and veinlets filled with coarser quartz, with native gold, chalcopyrite, pale-brown zinc blende, and probably tetrahedrite. Fine-grained chalcedonic veinlets also cut the rock. Altogether, the ore seems to be a crushed and greatly altered argillite.

In the Mountain Belle the normal quartz filling again appears. The quartz cements fragments of argillite, which is decidedly silicified and contains cubes of pyrite.

The ores of the Ibex vein are composed chiefly of normal quartz filling, the structure giving clear evidence that it was deposited in open space. Fragments of argillite are included in the quartz. These are decidedly silicified and converted to a quartz mosaic coarser than that of the normal rock. Pyrite and small fibers of sericite also appear in it. The ore minerals are finely divided native gold, pyrite, arsenopyrite, and a little pyrargyrite and cinnabar. The latter occurs on secondary fissures in the vein quartz.

The richest ore of the Ibex is a dark-gray breccia of quartz and argillite, the latter composed of microcrystalline quartz and a little sericite, carbonaceous matter, and pyrite. Most of the fragments are sharply defined and cut by quartz veins showing comb structure; but in other places there is an ill-defined mixture of argillite and quartz, strongly suggesting a mud of crushed argillite, between the particles of which the quartz crystallized. In this mixture of quartz and argillite are particles of native gold, together with coarse pyrite and finely distributed arsenopyrite. Several belts of secondary crushing traverse the specimen, and in these is much sooty, fine-grained arsenopyrite, as well as a little gold in fine wires.

Somewhat different from these examples is the Cougar vein, in which there is but little quartz, but much crushed argillite constituting the principal ore. The ore contains a considerable amount of silver, one sample assaying 0.68 ounce gold and 23.88 ounces silver per ton. The ore is composed of argillite, consisting of a very fine-grained and sharply defined quartz mosaic, with a few shreds of sericite and scat-

PLATE LXIX.

PLATE LXIX.

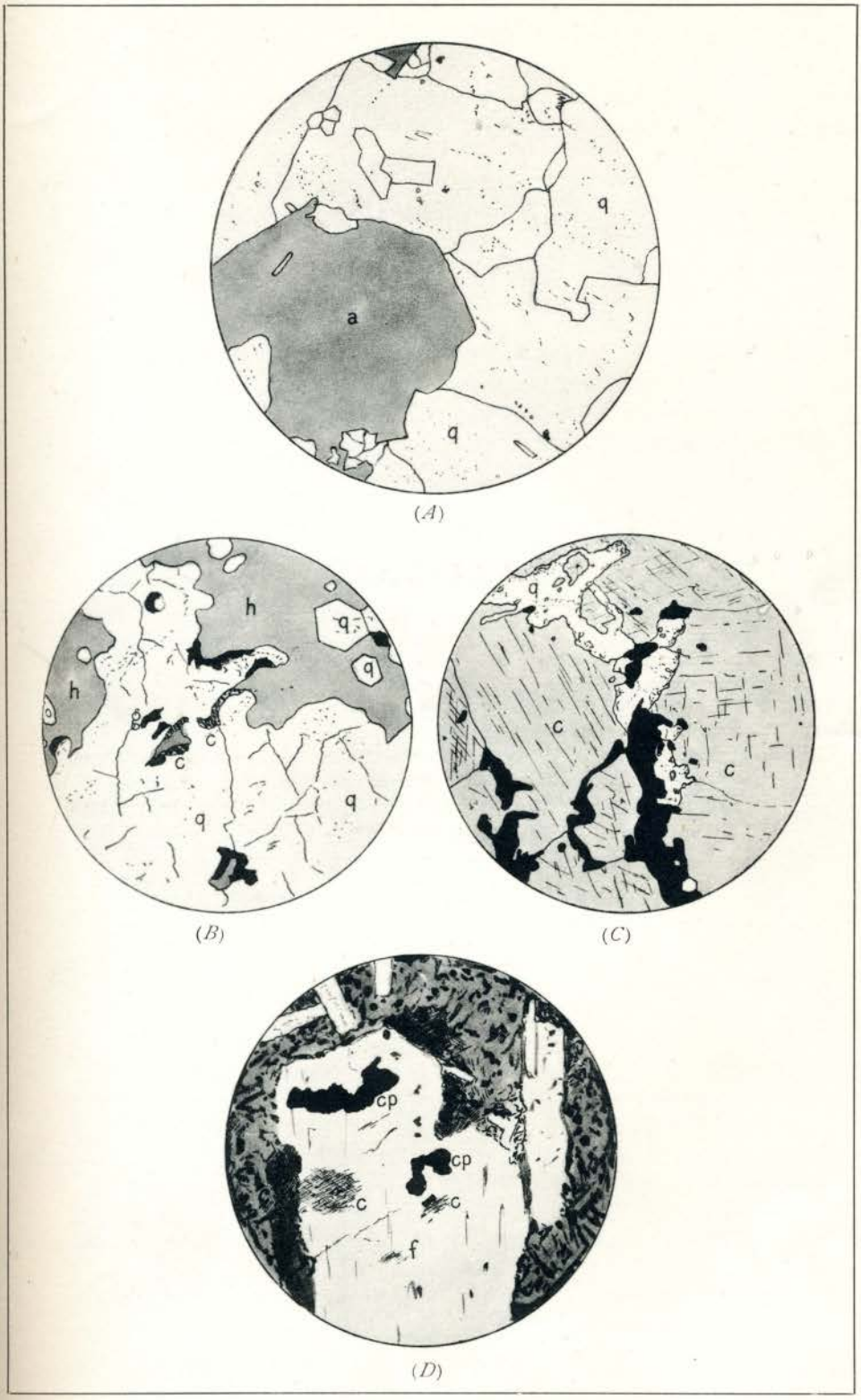
THIN SECTIONS SHOWING STRUCTURE OF ORE.

A. Normal vein quartz with arsenopyrite, from Imperial mine, Cable Cove; q, quartz; a, arsenopyrite. Magnified 16 diameters.

B. Telluride ore from North Pole mine; q, quartz; h, hessite; g, gold; c, calaverite?. Magnified 24 diameters.

C. Coarse gold in calcite with quartz; Great Northern mine, Canyon; c, calcite; q, quartz; gold, black. Magnified 12 diameters.

D. Copper, replacing feldspar in Triassic andesite or basalt. Copper Union, Copper Butte district; f, feldspar; c, chlorite; cp, copper. Magnified 120 diameters.



THIN SECTIONS SHOWING STRUCTURE OF ORE

THE MERIDEN GRAVURE CO.

tered crystals of pyrite and marcasite. Veinlets of quartz, with needles and star-shaped compound crystals of marcasite, traverse the argillite.

Many veins near Alamo belong to this type, and in most of them the ore contains bright-green spots, partly in the quartz, partly in the argillite. This color is due to chromium, and it is believed that the mineral causing it is a very finely divided chromium mica. It is especially prominent in the Little Giant mine, and may be explained by the fact that serpentine, always containing chromium, occurs in close vicinity to the vein; but it is also found in the Quebec, Wilson, and other veins a mile or two distant from serpentoid rocks.

Red Boy type.—This type consists of veins in argillite, similar in their filling to those of the North Pole type, but distinguished by predominant free gold of a low degree of purity. The gold makes up 60 to 90 per cent of the assay value, and varies in fineness from 500 to 600, the rest being silver. Sulphurets amount to 5 per cent at most, and are poor, the concentrates rarely assaying more than $30 per ton. They consist chiefly of pyrite, with a little arsenopyrite and chalcopyrite, or of argillite penetrated by veinlets of quartz, usually with comb structure. The gangue consists of normal vein quartz mixed with fragments of argillite. To this type belong the Red Boy veins, the Bonanza, and the Mammoth. At the Red Boy mine the black argillite seems altered only by the introduction of pyrite, while dikes of a porphyritic rock which can not be identified have suffered alteration to calcite and pyrite, accompanied by microcrystalline quartz.

At the Mammoth mine the country rock is partly granodiorite, partly a siliceous argillite. The latter has suffered no change, except the introduction of some pyrite. The granodiorite is carbonatized to a considerable degree. The ore, which forms thick bodies, consists of brecciated slate and granodiorite cemented by normal vein quartz, containing coarse, pale gold, together with a little pyrite and arsenopyrite. Closely associated with the gold is a dull-green vanadium mica, probably roscoelite. This forms irregular blotches and small aggregates in the quartz, and often surrounds the gold, as shown on Pl. LXX, *D*. There is no reason for believing that the rich ore which occurs near the surface is not due to primary deposition. The rich quartz is traversed by crushed zones and small slipping planes, often coated with gold. Irregular seams of calcite, the latest mineral formed, cut across the quartz. In other parts of the mine the ore is a breccia of sharp argillite fragments. The argillite is very siliceous, appearing under the microscope as a microquartzite. The metasomatic change consists only in the introduction of cubes of pyrite and slender prisms of arsenopyrite or marcasite. The cementing mass is chiefly calcite, coating the argillite in pretty crusts. The calcite contains inclusions of normal vein quartz.

IMPREGNATIONS.

In certain districts in which the vein-forming solutions have been especially active there is another type of deposit which has received little attention because the tenor in gold is usually very small. In this type whole masses of argillite, generally following the roughly defined planes of sedimentation, have been subjected to partial replacement, and no distinct fissures are found. The argillite is somewhat crushed, and quartz has developed on little seams and in nodules. Scattered crystals of pyrite replace the argillite, and there may also be a little dolomite and stains of chromium mica. Strata of argillites several hundred feet thick show these evidences of mineralization and contain throughout traces of gold. Examples of these deposits are found in the Alamo and Granite districts.

The presence of chromium mica in nearly all the veins and deposits of the Alamo district is very remarkable. Serpentine, which always contains chromium, is abundant a few miles from Alamo, but the veins contain this chromiummica whether close to or distant from the contact. I should think it probable that the vein-forming solutions ascended into the argillite from underlying masses of serpentine or peridotite.

SILVER VEINS.

Tempest type.—This type is very similar to the Cable Cove type among the gold veins. It occurs in the granodiorite of the Greenhorn Mountains. The gangue is quartz, forming a normal filling and containing very abundant pyrite, arsenopyrite, and zinc blende. There is little or no galena and no rich silver sulphides. The ore is accompanied by normal, sericitic-carbonatic alteration of the country rock. A little calcite fills secondary cracks in the quartz. In the Carbonate vein, which crops near serpentine, dolomite and a pure chromium mica are abundant.

Greenhorn type.—The deposits of this type are normal, simple quartz veins containing, intergrown with the quartz, tetrahedrite, and, more rarely, argentite and pyrargyrite. Representatives of this class are the Intermountain and Intrinsic veins on Greenhorn Mountain, the Monumental in the Granite district, and the veins of Pedro Mountain in the Rye Valley district.

Mineral type.—The only representatives of this type are the deposits at Mineral, Idaho, near Snake River. They are veins or irregular bodies connecting with fissures and containing pyrite, chalcopyrite, tetrahedrite, galena, and zinc blende, intimately intergrown with one another and with calcite gangue. The ores are in part surely formed by replacement of the country rock, a greenstone or greenstone tuff. The ores are ordinarily not rich in copper or lead. Average good ore

PLATE LXX.

PLATE LXX.

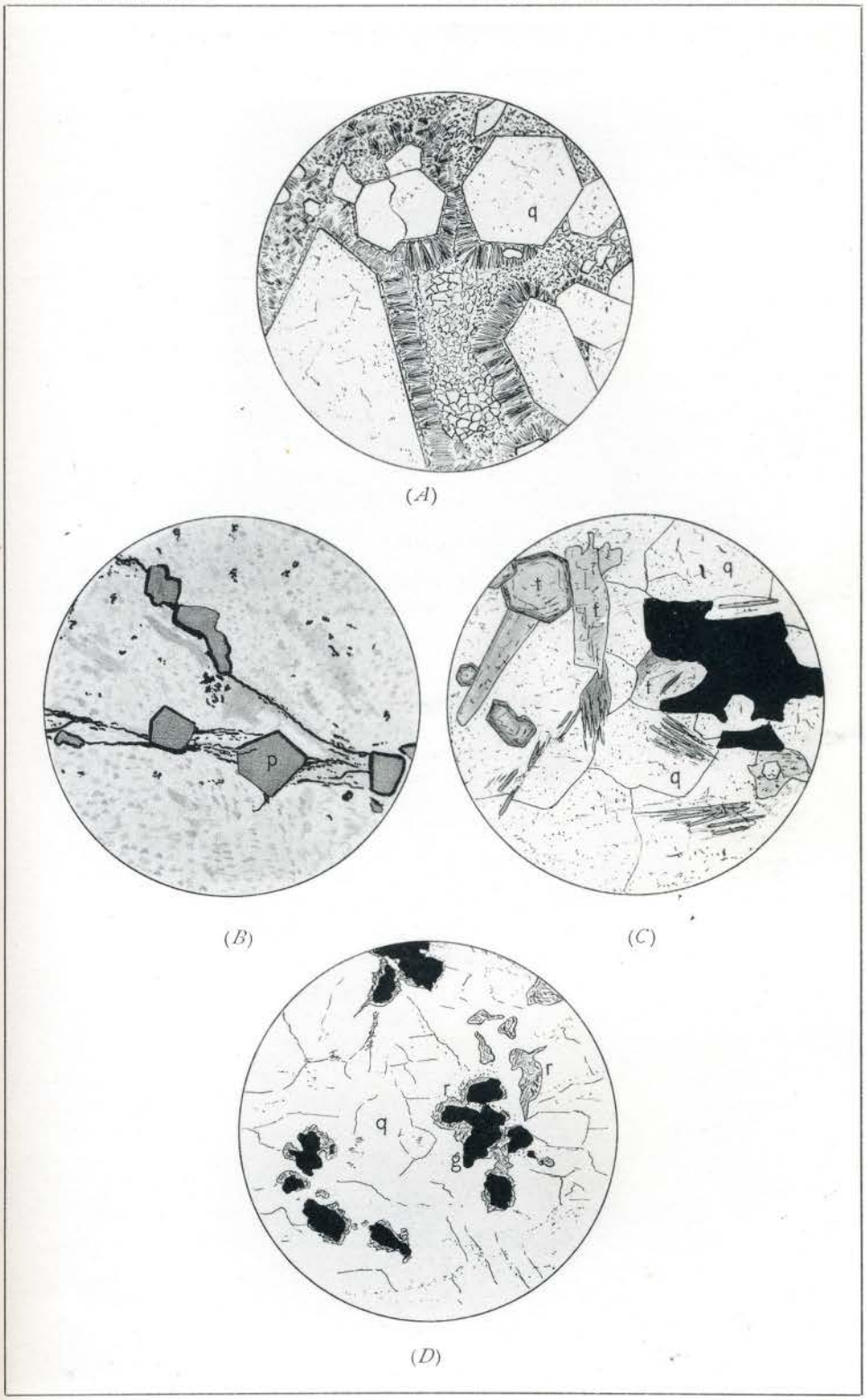
THIN SECTIONS SHOWING STRUCTURE OF ORE.

A. Comb quartz, cemented by chalcedony. Banzett mine, Robinsonville. Polarized light; q, quartz; fibrous and fine-granular aggregates, chalcedony. Magnified 12 diameters.

B. Crystals of pyrite, forming by replacement in chloritic diabase along cracks filled with calcite. Great Northern mine, Canyon. p, pyrite; black, calcite, also lining pyrite crystals; shaded in definite areas, chlorite. Magnified 12 diameters.

C. Tourmaline ore, Copperopolis, Quartzburg district. q, quartz; t, tourmaline; black, chalcopyrite. Magnified 28 diameters.

D. Gold-quartz ore. Belle of Baker, Mammoth mine, Sumpter; q, quartz; r, roscoelite; g, gold. Quartz has normal coarse-grained structure. Magnified 28 diameters.



THIN SECTIONS SHOWING STRUCTURE OF ORE

THE MERIDEN GRAVURE CO.

contains 0.28 ounce gold and 55.92 ounces silver. A peculiar feature is the extremely intimate intergrowth of galena and zinc blende into concentric aggregates.

COPPER DEPOSITS.

GENERAL STATEMENT.

Deposits in which copper constitutes the most valuable metal are rather extensively scattered over the eastern part of the region under discussion. Most of the deposits are contained in Triassic lavas interbedded with sedimentary rocks of the same age. While the gold and silver veins may contain some copper and the copper deposits almost always contain some silver and at least a trace of gold, the copper deposits form a separate class, with well-marked and distinctive characteristics pointing to a very different origin from that of the gold and silver veins. The copper deposits may be classified as follows: The Seven Devils type, the Tourmaline type, and the Snake River type. The first two are of rare occurrence.

SEVEN DEVILS TYPE.

This type includes contact deposits of irregular bodies of chalcopyrite and bornite between limestone and diorite. As gangue appear garnet, epidote, and other contact minerals. This type is represented only by a small prospect near Medical Springs (see p. 731).

TOURMALINE TYPE.

This type is characterized by chalcopyrite and pyrite associated with a gangue of quartz and tourmaline. The deposits form fissure veins or irregular replacements probably connected with fissures. Only two representatives of this type have been found.

The Copperopolis mine, on the east fork of Dixie Creek in the Quartzburg district, is the first. Brown fibrous tourmaline (blue and brown in thin section) is intimately intergrown with quartz (Pl. LXX, *C*), containing very abundant, mostly round, aqueous inclusions. The quartz is in part normal, coarse, vein quartz, in part idiomorphic, in part finer-grained allotriomorphic. The latter as well as the intermixed dirty-brown tourmaline were formed by replacement of the country rock, a diabase. The chalcopyrite is intergrown with quartz and tourmaline.

The Jessie vein in the Mineral district is the second. This is a fissure vein in diorite, accompanied in the hanging wall by a dike of basalt. The vein matter is a black gangue with massive pyrite and chalcopyrite. Thin sections of the ore show a somewhat interlocking, fairly coarse aggregate of quartz, calcite, and dolomite, all in anhedral development. In addition, a mineral which greatly resembles vesuvianite is present, also chlorite and an acicular or prismatic blue or

dirty-brown tourmaline. Thin steel-gray lamellæ of specularite, single and in bunches, are embedded in both quartz and calcite. In translucent light the thin plates are deep red. Pyrite and chalcopyrite are intergrown with quartz, tourmaline, and specularite. The ore has been crushed, and along the cracks calcite has infiltrated.

This mineral combination is very remarkable for fissure vein. Especially is the occurrence of specularite noteworthy. It emphasizes the opinion given in another place[1] that the tourmaline veins are, as a rule, connected with deep-seated processes and formed under higher pressure and temperature than ordinary hydrothermal gold and silver veins.

SNAKE RIVER TYPE.

In general this type is characterized by finely distributed chalcocite or bornite, more rarely chalcopyrite, in Triassic lavas or tuffs. Metallic copper or malachite is sometimes present. The ores carry a little silver, and sometimes also gold. These deposits seem to be largely of metasomatic origin. The distribution of the sulphides is sometimes irregular, but more commonly follows well-defined directions, probably determined by systems of joints. A connection with sharply defined fissures can rarely be observed. The gangue minerals with which the sulphides are associated are quartz, epidote, actinolite, or chlorite, and according to the local prevalence three subtypes may be distinguished.

Epidotic subtype.—In this, chalcocite is associated with epidote in small replacement veins traversing the rock, and native copper occurs as a secondary product. At the North American Copper Company's prospects at Copper Union the ore-bearing rock is a soft, dark-green, very altered Triassic basalt, in places containing small amygdules of calcite. With the naked eye may be seen irregular grains of chalcocite and a little metallic copper, the latter mostly contained in the white veinlets traversing the slide. Under the microscope the basaltic character of the rock is apparent. Phenocrysts of labradorite are contained in a dark groundmass full of small prisms of the same mineral. Chlorite is very abundant in the feldspars as well as in small vesicules throughout the mass. The augite has disappeared completely. Along lines of pressure and deformation small replacement veins of chalcocite inclosed in epidote are noted; no other mineral accompanies the chalcocite. Throughout the section very finely divided metallic copper is distributed, especially abundant is it in little veins filled with zeolite, which corresponds well with natrolite and occurs in fibrous masses with radial structure. Much copper is also contained in the groundmass and in the feldspars of the rock, but it replaces the minerals in which it occurs and is accompanied by chlorite, a little quartz, and a

[1] Metasomatic processes in fissure veins: Trans. Am. Inst. Min. Eng., Vol. XXX, 1901, p. 67.

considerable amount of reddish or brownish limonite or hematite, which seems to surround the aggregates of chlorite near the copper (Pl. LXIX, *D*).

Neither chalcocite nor copper in their present form is a primary constituent of the rock. The chalcocite has been introduced first and the native metal seems a secondary product derived from the sulphide. While a secondary process, the formation of native copper can not justly be said to be due to surface decomposition, for it is clearly connected with the chlorite and the zeolites which may form at great depth. While there is thus no reason why the metallic copper could not occur throughout larger masses of rocks and on a larger scale, the fact seems to be that its occurrence is of subordinate importance to that of the chalcocite. The latter certainly has formed along cracks and joints, but is, nevertheless, not concentrated in well-defined fissure veins.

In the Snake River Canyon many similar deposits occur. Those especially examined were located near Ballards Ferry. The prevailing rock at McDougals camp, 2 miles below Ballards Ferry, is a brownish-gray volcanic tuff, probably of Triassic age. It contains clastic grains of quartz, feldspar, and a variety of fine-grained lavas. The cementing material is a finer mass of the same substances and irregularly distributed chlorite. Amygdules of calcite are common. Some of the prospects have the appearance of small fissure veins with a well-defined filling of white quartz, epidote, and massive chalcocite, the latter especially intergrown with epidote. The larger deposit forms a zone at least half a mile long and from 8 to 30 feet wide, in which an impregnation of calcite is noted. The thin sections show that the rock is fractured and deformed. On these fractures chalcocite, intimately intergrown and inclosed in epidote, has formed as narrow replacement veins. In other places isolated grains of chalcocite are surrounded by irregularly spreading epidote. Malachite appears as a product of decomposition of the chalcocite, but there is no metallic copper. The cryptocrystalline malachite forms veinlets and nests replacing the cement of the tuff.

Actinolitic subtype.—Deposits of this type were examined on the copper claims near the Snowstorm mine, not far from Sanger. The rock is here a dark-green diabase, in which some of the augite still remains, as well as some of the ilmenite, the latter otherwise altered to leucoxene. Throughout the rock light-green needles of amphibole are abundant as a secondary formation; the amphibole occurs throughout the feldspars, and especially along the fractures. Associated with it are irregular grains of chalcocite and bornite. Secondary quartz forms good-sized nodules in the rock and is also intergrown with bornite. Some malachite has formed from the sulphides and occurs intergrown with quartz.

Chloritic subtype.—This is best represented by the Iron Dike

deposit. A large mass of a Triassic greenstone of uncertain original character is here shattered and filled with irregular veinlets of quartz with pyrite and chalcopyrite. Besides being thoroughly filled with chlorite it is certainly also largely replaced by quartz and pyrite, the latter often surrounded by chalcopyrite. Heavy bodies of pyrite and chalcopyrite occur at this place and are in all probability due to a complete replacement of the chloritic rock. This ore contains a little gold and silver, as well as occasionally some galena and zinc blende.

The River Queen deposit should perhaps be referred to this type. It has an irregular, vein-like form, and occurs in an old chloritic rhyolite with phenocrysts of quartz. The ores are cuprite, chalcocite, and pyrite.

The Standard mine, in the Quartzburg district, may also doubtfully be referred to this type. It occurs as a narrow, ill-defined vein, in a chloritic diabase, and is accompanied with small calcite. The ores are chalcopyrite, intergrown with the rare cobalt-arsenide, smaltite, and contain both gold and silver.

COMPARISON WITH GOLD-QUARTZ VEINS.

In the Snake River type of deposits the characteristic association is that of copper sulphides with epidote, amphibole, or chlorite, and in part, also, with quartz. This is in great contrast to the gold-silver veins, where the first three minerals are unknown constituents of the gangue. Further, the copper minerals do not occupy sharply defined and persistent fissures like the gold and silver veins, but appear along joints and small irregular fissures. The ores in their present form are clearly of secondary origin; they are not primary constituents of the rock. They are always, as far as known, associated with the Triassic greenstones, old basalts, andesites, and rhyolites. The difference between these copper deposits and the gold-silver veins is radical, alike in form, substance, and metasomatic processes. They were certainly not formed by the same or even by similar solutions. I would regard them as having probably been formed by a sort of lateral secretion, and by dilute, perhaps cold, solutions belonging to the general circulation of the ground water. The source of the metals was probably in the surrounding old lavas. The active metasomatic processes show a close connection with the general hydrometamorphism, which gradually changes the character of igneous rocks by the formation of amphibole, chlorite, quartz, epidote, and zeolite, while the gold quartz veins are probably due to thermal ascending waters. There is an undoubted parallelism between these copper deposits and those of the Lake Superior region, for both occur in part as replacement veins in amygdaloid rocks. But the Lake Superior veins contain chiefly metallic copper, the sulphides being very rare, while here the reverse is true.

OXIDIZED ZONES OF THE COPPER DEPOSITS.

In most cases the oxidized part of the copper deposits is very superficial, and sulphides, chalcopyrite, as well as chalcocite and bornite, appear immediately or only a few feet below the surface. A little malachite often appears on the surface, but sulphides are usually immediately associated with it. The large sulphide mass of the Iron Dike was covered by a brown shallow crust in which practically no copper was present. Immediately below this pale and partly decomposed pyrite appeared, and the chalcopyrite began only a few feet below the pyrite.

ECONOMIC CONSIDERATIONS.

Among the copper deposits of this region are a vast number of prospects, but thus far no producing mine. Only two or three prospects have made small shipments of high-grade ore. It is, of course, well known that the development of a low-grade copper mine is an enterprise demanding much time and money, differing in this respect from that of an ordinary gold-quartz mine. In the latter a mill adapted to the requirements of the ore and the size of the vein may be rapidly erected and the mine become producing in a short time. For low-grade copper ores very extensive and very carefully planned reduction works are necessary. Ores consisting of coarse pyrite and chalcopyrite with chlorite-quartz gangue, like the Iron Dike, are easy to concentrate and, provided the ore contains enough copper, will prove valuable. Ores containing chalcopyrite and tourmaline will be difficult to concentrate, owing to the high specific gravity of the latter. The majority of the deposits are zones of impregnation with chalcocite in fine distribution. These have been most widely advertised, and presumably ill-informed companies have issued glowing reports apt to mislead the unwary. Copper lodes 4 miles in length and a mile in width, with inexhaustible supply of 4 per cent ore, have been claimed to exist. The fact that ores in the Lake Superior region containing less than 1 per cent of metallic copper have been successfully worked has been duly placed before the public. As a matter of fact, most of these impregnated zones will not contain more than 1 or 2 per cent of copper, and the width ranges from a narrow seam up to 30 feet. The lowest grade of copper ore which can be considered in eastern Oregon, under present conditions, is one containing 3 to 4 per cent of copper, provided that large quantities of it exist. The successful treatment of this ore offers considerable difficulty. Leaching processes can probably not be employed, for the ore contains too much easily dissolved silicates of magnesia, lime, and iron. Concentrating will be difficult and attended with great loss, for fine crushing will be necessary and the chalcocite will form rich slimes. Should

large bodies of ore containing metallic copper be found, these difficulties will be largely obviated, but at present there is no great probability of this. These remarks are not meant to discourage the search for and the development of the copper properties, but only to point out actual facts. Paying copper mines may well be developed in eastern Oregon, but it will be only by careful conservative work by men who understand the problems presented.

PLACER DEPOSITS.

EXTENT.

The placer deposits indicate the extent of the gold belt of eastern Oregon, being widely scattered over the whole area, from the sands of the Snake River on the east to the gravel bars of John Day River on the west. They were the first deposits discovered by the pioneer miners and yielded their millions in early days. Though the output is greatly diminished, the placers are at the present time by no means an unimportant factor in the gold-mining industry of the State. Oregon produces placer bullion to the value of about $300,000 annually; the amount is, however, slowly diminishing. The placers contribute about one-fourth to one-fifth of the total production of gold and silver (see p. 572).

The placer-mining districts are distributed as follows: On the east the Snake River bars still contribute some fine gold. In the Eagle Creek Mountains and at Sparta a small but steady production is maintained. Sparta, especially, was noted for its rich gulch diggings in early times. The belt extending from Connor Creek by Weatherby, Chicken Creek, Rye Valley, Humbolt, Clarks Creek, and Malheur was formerly the most important gold-mining region in the State and still maintains a diminishing production.

The Virtue placers, near Baker City, were long ago exhausted. West of Baker City is the gold belt of the southern Elkhorn Range, with the once celebrated camps of Auburn, Pocahontas, and Minersville. The headwaters of Powder and Burnt rivers, as well as those of Granite Creek, including the districts of Sumpter, Granite, Robinsonville, Bonanza, and Gimlet, may be said to form the central placer-mining region of the Blue Mountains. These placers, while not as extraordinarily rich as some of the others, have maintained a steady though small production, and seem likely to continue to do so for many years. Finally, on the western side are found the isolated districts of Susanville, Dixie Creek, and Canyon Creek, the latter having the reputation of having been the richest placer camp in the State. Both at Susanville and at Canyon a fairly steady production is maintained. Farthest west are the small placers of Fox Creek and Spanish Gulch, on Crooked River, the latter locality 60 miles west-southwest of Canyon.

GEOLOGICAL CHARACTER.

With few exceptions the placers are gravel deposits contained in the beds of the present streams and gulches, or bars and benches deposited by the same water courses at a former higher level; these benches are rarely found more than 200 feet above the present stream bed; most frequently they are 50 to 100 feet above the same. The depth of the gravels seldom exceeds 50 feet and is ordinarily much less. The bed rock may be any one of the formations found in the region, sometimes even Neocene volcanic rocks. The placers are thus not connected with any certain rock; it may be said, however, that they are most abundant in the districts where intrusive diorites, granites, and serpentines break through older sedimentary series. They are, as a rule, absent in the large granitic areas (northern Elkhorn Range) and in extensive areas of old sedimentary rocks. They are also absent in the great Neocene volcanic areas. In mountains which have been covered by glaciers during the ice epoch placers are rarely found. Examples of this are found in the Cornucopia, Cable Cove, and Greenhorn districts. No doubt gold-bearing gravels existed there before the advance of the ice streams, but the latter have dislodged the gravels and scattered the gold among the moraines, and the time since the close of the Glacial epoch has been too short to permit a new concentration of the gold. As a rule, in these districts placers are found below the terminal moraines.

All this means that the placers were chiefly deposited by the present streams at their actual level or at a former higher level. Placers antedating the present drainage system are of rare occurrence. This is not surprising when we consider that the drainage systems of the old mountain areas had been outlined and eroded long before the Neocene period.

According to their geological age the placers may be divided into:

1. *Prevolcanic* (*Eocene or early Miocene*) *gravels.*—Deposits of this age are preserved only when covered by volcanic flows. Owing to the fact that these flows mainly covered the foothills and the lower part of the mountains, and no uplift accompanied by deep erosion has occurred since, these channels mostly lie below the present drainage level. While many of them doubtless are rich in gold, it will be difficult to find them and still more difficult to work them profitably. The only places where these gravels have been worked are at Winterville and Parkerville, on the headwaters of Burnt River. It does not seem altogether impossible that new channels of this character might be found in this vicinity. The great influx of water into inclines and shafts would greatly increase the cost of working. Working placers by means of shafts has been successful only in very rich placer mines. The banks of these pre-Neocene gravels are only about

15 feet high. Most of the gold is coarse and lies on the bed rock. The Winterville pre-Neocene channel was a smaller stream of no great importance. It is sometimes stated that it was part of a large channel which traversed the Blue Mountains. There is no foundation for this view.

2. *Intervolcanic gravels.*—The volcanic outbreaks flooded the lower valleys with lavas. The upper valleys of Burnt River, Powder River, John Day, and probably also Grande Ronde River were thus dammed and accumulations of gravel at once began. These conditions were also favorable for the concentration of the gold, and placers were formed wherever streams from auriferous areas entered the basins. Of this age are the gravel benches of Sumpter and Canyon. In the case of these, the erosion of the main rivers draining the basins has not proceeded far enough to destroy the connection of the Neocene sediments. But in other cases, in the Granite Creek and North Fork of John Day, the volcanic dam has been cut down much deeper, and of the deposits once filling the basin only small fragments are preserved, as in the case of the Klopp placers (p. 687) and the Griffith gravels (p. 688).

As the canyon cutting proceeded, benches were formed at intervals, and some of these gravels remain at various elevations along the present streams. There does not seem to be any exact limit between the late Neocene and Pleistocene gravels. A gradual erosion was continued during the two periods, interrupted occasionally only.

3. *Pleistocene gravels* thus consist of the lowest benches and the deposits in the present channels. These deposits were the first to be mined and are now practically exhausted, as far as ordinary placer mining is concerned. Some of the deep stream gravels can, however, be profitably dredged.

GOLD AND ACCOMPANYING MINERALS.

The gold varies in size from large slugs and nuggets to the finest flour, of which several thousand particles or "colors" are needed to make 1 cent in value. The largest nugget reported is one said to have been found on McNamee Gulch, near Robinsonville, the value of which is said to have been $14,000. Slugs of a value of several hundred dollars have been found at Mormon Basin and at the Winterville placers (upper Burnt River). Pieces worth $200 and $300 were found at the latter place in the clean-up of the fall of 1900. Ordinarily gold is obtained varying in size from that of a mustard grain to a wheat grain. The purity of the placer gold averages, as usual, higher than that from the veins. A fineness of 900 to 990 is obtained from Canyon Creek, the bench gravels of upper Burnt River, and the Winterville placers. At Susanville and Dixie Creek the gold is 860 fine. At Rye Valley and Mormon Basin the gold varies from 650 to 800. At the Nelson placers it is from 700 to 740 fine. On Olive Creek and at Granite it

varies from 680 to 800. The lowest grade is thus about 680, while from a few localities 990 or almost absolutely pure gold is obtained. In a general way, the fineness of gold from one and the same source is apt to increase as the grains grow smaller by attrition, and this has not unreasonably been explained by a gradual dissolving of the silver from the surface of the grains by ordinary surface waters. The flour gold in the bench gravels of upper Burnt River Valley has a fineness of 970, while the coarser gold in the stream bed is only 922 fine. At Canyon the placer gold is 900 fine, but in John Day River, a few miles below the mouth of Canyon Creek, it reaches 990. At Rye Valley the upper benches contain low-grade gold, 750 fine, while the lower benches, the gold of which has been worked over by the stream several times, is 800 fine. Regarding the Snake River gold see pages 759–761.

Platinum should naturally be expected from some placers, especially those in districts with much serpentine, as a connection between this rock and the metal mentioned has often been proved. It has, however, only been reported from one place, viz, Hindman's placers, at the junction of Camp Creek and Pine Creek in upper Burnt River Valley. Mr. Hindman states that a small quantity is found at each clean-up. Magnetite, zircon, ilmenite, and garnet, as usual, accompany the placer gold, the ilmenite often in very perfect, minute crystals. Much cinnabar is reported from Elk Creek, near Susanville. Monazite has not been observed, neither has cassiterite or tin ore been found.

As usual, the gold is largely concentrated on the bed rock, or in the gravels immediately above it, though instances are not wanting of even distribution through 10 or 20 feet of gravels (Nelson placers at Pocahontas). In dredging on Burnt River the top gravel is usually barren and the pay is only obtained from 2 or 3 feet next the bed rock.

The value per cubic yard of gravels in the gravel mines varies greatly. Ordinarily, averaging the content of the whole bank, it ranges from 10 to 35 cents. The stratum on the bed rock is of course much richer. Hydraulic mines working on a large scale may work gravels profitably which average only 2 cents per cubic yard, but such conditions scarcely obtain in this region, where the gravels should at least contain 5 cents per cubic yard. Dredging to a depth of 30 feet may be done for from 3 to 7 cents per cubic yard, but considering the heavy cost of installation and the possibility of losing the pay streaks, gravels for this purpose should ordinarily average 20 to 30 cents per cubic yard. Regarding dredging on Snake River and Burnt River see pages 762 and 766–767.

METHODS OF MINING AND FUTURE POSSIBILITIES.

Placer mining in eastern Oregon has never been carried on upon the large scale prevalent in the California gold belt. The banks are not high, and sluicing or small hydraulic jets throwing at most 500 miner's

inches of water have been chiefly employed. The bench gravels of Sumpter, Rye Valley, upper Burnt River Valley, and Canyon are not exhausted, but will continue to yield moderately for many years. No great increase in the yield may be expected from these sources. It is otherwise with mining by elevators or dredges. At present there is only one dredger at work, at Weatherby, on Burnt River, and one elevator, at Malheur. Gravels, which probably are suitable for dredging are found on John Day River below Canyon, on the Middle Fork of John Day, near Susanville, and at many other places. It is in this direction that the placer-mining industry should be expected to advance, and it is very reasonable to expect that the next few years will see many dredgers in operation.

IRON AND MANGANESE ORES.

Incidental to the erection of the smelter at Sumpter, attempts were made to find a suitable flux of iron or manganese in the vicinity. A deposit of hematite is said to occur on the ridge between Powder and Burnt rivers, about 5 miles south of Sumpter, but nothing is known of its extent.

A soft, black manganese ore, resembling pyrolusite, was found on the same ridge about 4 miles west to southwest of Sumpter, and was used in the smelter during the short time in which it was operated. As far as known no other deposits of iron ore occur in this region.

A large deposit of magnetic iron ore is reported from Iron Mountain, a few miles east of Mineral, in Idaho. This ore contains some copper and is also stated to carry a certain percentage of titanium, which, of course, is not in its favor as far as smelting purposes are concerned. During the short time in which the smelter at Cuprum was in operation some of this ore was sent down the Snake River and hauled up to the smelter. As might have been expected, the material was not a success as a flux.

CHROMITE.

It would be surprising if chromite, so often accompanying serpentine, had not been found in the parts of the Blue Mountains where this rock is abundant. A small mass of chromite is exposed in the serpentine close by Gillespie's sawmill, 7 miles south of Prairie. Associated with it is a small quantity of very fine-grained white material which proves to be practically pure magnesite. Heavy float of chromite was noticed close by the placer mines of Winterville, near Bonanza mine.

The mineral is used in the preparation of pigments and in the production of chrome steel. Recently it has also been used as a basic lining in the furnaces of certain metallurgical processes. It is not

probable that the occurrences in the Blue Mountains will be economically valuable. Delivered in Baltimore, the value of the ore is only from $20 to $25 per ton, and at the mines in California the value is not more than $8 per ton for 50 per cent ore.

LIMESTONE.

All of the sedimentary rocks developed in the Blue Mountains contain more or less limestone of good quality, interbedded with slates, shales, siliceous argillite, and volcanic tuffs. Very large masses are found in the Eagle Creek Mountains. Its quality is excellent, but distance from lines of communication has prevented its utilization.

The series of rocks exposed near Huntington also contains many beds of limestone of good quality. One of the largest of these masses, several hundred feet wide, is exposed 4 miles above Huntington on both sides of the railroad. At this point are extensive works which supply the larger part of the lime used in the State of Oregon. Other heavy strata of limestone are exposed at the head of Connor Creek and on the hills 4 miles southwest of Durkee.

The argillite series, so greatly developed in the vicinity of Baker City and Sumpter, is less rich in limestone. Smaller lenticular deposits occur about a mile north of the railroad at a point 6 miles southeast of Baker City, and also in the hills 3 miles northeast of Pleasant Valley. At both localities lime has been burned, but only the latter is worked at present. The Elkhorn Range contains a few heavy deposits of limestone of thick lenticular form. The most important of these is exposed on Marble Creek at an elevation of 5,500 feet. Lime was formerly burned there, but at present the works are idle. At Sumpter and west of that place limestone is not abundant. A deposit of apparently limited extent is found half a mile north of the city of Sumpter and has locally been used for smelting purposes. At the Winterville placer mines, a short distance below Bonanza mine, another small mass of limestone appears adjacent to serpentine. No work has been done on this. From this point westward no limestone deposits are known to exist in the area under consideration.

GYPSUM.

Beds of gypsum, or hydrous sulphate of calcium, are not uncommon in sedimentary beds, usually occurring as strata or lenses associated with limestone and shales. It is generally regarded as a chemical deposit resulting from the evaporation of shallow inland lakes. In the area here described one deposit of this mineral has been found which is of sufficient extent to be commercially valuable. This occurs about 6 miles north of Huntington, near the summit of the ridge overlying Snake River Canyon. The deposit attains a total

thickness of over 40 feet, and is interbedded with limestone, shales, and volcanic tuffs. Its age is uncertain, though it is not unlikely that it is Triassic.

This is, I believe, the only deposit of gypsum thus far found in Oregon. It is utilized for purposes of fertilizing and for the preparation of plaster of paris. A more detailed description will be found on page 753.

CLAY AND KAOLIN.

Beds of clay suitable for bricks occur in the valley of Powder River and at many other places in the Blue Mountains.

Pure kaolin has been found near the mouth of several of the creeks at the foot of the Elkhorn Range; for instance, on Pine Creek and on Salmon Creek. The deposits, which are from 1 foot to 15 feet deep, cover the gravels of the creek and have the appearance of an extremely fine, almost impalpable white powder, at first glance suggesting an infusorial earth or a rhyolite tuff. Similar kaolin beds were noted in other parts of the region, though not so prominently developed. The origin of this kaolin, which has not been investigated in detail, probably dates from a time when the Powder River Valley was covered by a shallow sheet of water. It is not impossible that this kaolin may be found of some economic importance, if it can be obtained in large quantities sufficiently free from impurities. The mineral is of the nonplastic variety.

COAL.

In the lake beds occurring in many parts of the Blue Mountains thin strata of lignite are occasionally found interbedded with the clays, sands, and tuffs. A long-known occurrence of this kind is at Auburn, near the southern end of the Elkhorn Range. The soft beds underlying the auriferous gravels here contain a thin bed of lignite of poor quality, an analysis of which is given in Raymond's report of 1873. It was made by T. M. Drown, of Philadelphia, and runs as follows: Moisture, 14.68 per cent; volatile matter, 38.95 per cent; fixed carbon, 42.57 per cent; ash, 3.80 per cent; total, 100. The coal is noncoking, and, as the analysis shows, of inferior quality. It is not likely that it will be of economic importance. Another bed of shaly lignite, about 2 feet thick, is found on the southern side of Powder River opposite the mouth of Goose Creek. It is interbedded with tuffs and clays and covered by a basaltic flow. The quality appears inferior and the deposit is probably of limited extent.

Coaly material is also found in the lake beds at the eastern end of Eagle Valley, as well as in lake deposits in the John Day Valley, not far from Prairie.

MINERAL SPRINGS.

Mineral springs occur widely scattered over the area described, but they can not be said to be very abundant. The best-known locality is at Medical Springs, 20 miles north-northeast of Baker City. At this place thermal springs issue from two orifices in a rock belonging to the greenstone series. The aggregate flow amounts to several miner's inches and the temperature is 140° F. The appended analysis is said to show the composition of the waters, which are locally used for medicinal purposes:

Analysis of mineral water from Medical Springs, Oreg.

[Parts per 100,000.]

Constituent.	Parts.
$CaCl_2$	5.552
$MgCl_2$	.466
KCl	.642
NaCl	5.758
Na_2SO_3	.524
Na_2SO_4	50.638
Na_2CO_3	.579
$FeSO_4$	.558
$CaSO_4$	12.175
$CaCO_3$	1.417
SiO_2	9.698
Organic	1.553
Total	89.520

The Virtue mine, in its lower levels, contained a great amount of water of moderately warm temperature. The mine being, unfortunately, closed, no data could be obtained as to the composition of these waters. From the foothills just east of Baker City, near the small stamp mill erected in the outskirts of the city, springs with tepid water are said to issue. Along Snake River a remarkable spring is said to occur at Tartar's ranch, about 8 miles above the mouth of Powder River, where it has formed a considerable deposit of soda.

Hot sulphur springs also exist in the Snake River Canyon on the Idaho side, a mile above Brownlee Creek, and again on the same side a little below Miller Bay.

At the point where the road from Durkee to Rye Valley crosses Burnt River two hot springs issue in the bed of the river just above the water level. The quantity of water is not large, and the water is only moderately warm. It does not seem to be rich in mineral constituents. Just above the bridge calcareous sinter appears and covers

an area of several acres. No doubt this has been deposited by now extinct hot springs. The region of upper Burnt River and upper Powder River seems to contain very few waters which might be classed as mineral. In John Day Valley noted springs of hot water issue 9 miles above Prairie, near the mouth of Reynolds Creek, and are locally used for medicinal purposes. Still another hot sulphur spring is reported from Camp Creek about 6 miles south of Susanville.

On the whole the thermal waters of this region may be characterized as weak mineral waters containing a small amount of salts, together with a little hydrogen sulphide.

MINERALS.

Following is a list of minerals occurring in the Blue Mountains, arranged by mining districts:

List of minerals occurring in the gold belt of the Blue Mountains.

	Elkhorn.	Pocahontas.	Sumpter.	Cable Cove.	Granite.	Alamo.	Greenhorn.	Robinsonville.	Bonanza and upper Burnt River.	Susanville.	Quartzburg.	Canyon.	Virtue.	Copper Butte.	Sparta.	Cornucopia.	Lower Snake River.	Connor Creek.	Mineral.	Lower Burnt River.	Rye Valley.	Mormon Basin, Malheur.
Gold	×	×	×	×	×	×	×	×	×	×	×	×	×	---	×	×	---	×	---	×	×	×
Silver	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---
Platinum	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---
Copper	---	---	×	---	×	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---	---	---
Quicksilver	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Pyrite	×	×	×	×	×	×	×	×	×	×	×	×	×	---	×	×	×	×	×	×	---	---
Marcasite	---	---	×	---	×	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---
Pyrrhotite	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---
Galena	×	---	---	×	---	---	×	×	---	×	×	---	---	---	×	×	---	×	×	---	---	---
Zinc blende	×	---	×	×	---	---	×	---	---	×	×	---	---	---	×	×	---	---	×	×	---	---
Stibnite	---	---	×	---	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---
Cinnabar	---	---	×	---	×	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---
Argentite	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	×	---
Chalcocite	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	×	---	---	---	---	---
Chalcopyrite	×	---	×	×	---	---	×	×	---	×	---	---	---	---	×	×	×	×	×	---	---	---
Bornite	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	×	---	---	---	---	---
Arsenopyrite	×	---	×	×	×	---	×	---	×	×	---	---	---	---	×	×	---	---	×	---	---	---
Tetrahedrite	---	---	---	×	---	---	×	---	---	×	---	---	×	---	---	---	---	---	×	---	---	---
Tetrahedrite mercurial (schwatzite)	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Freibergite	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Pyrargyrite	×	---	×	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---
Hessite	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Sylvanite	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---
Quartz	×	×	×	×	×	×	×	×	×	×	×	×	×	---	×	×	×	×	×	×	×	×
Zircon	---	---	---	---	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---
Opal	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---
Chalcedony	---	---	×	---	---	---	---	×	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Chromite	---	---	---	---	---	---	---	---	×	---	---	×	---	---	---	---	---	---	---	---	---	---
Cuprite	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	×	---	---	---	---	---

List of minerals occurring in the gold belt of the Blue Mountains—Continued.

	Elkhorn.	Pocahontas.	Sumpter.	Cable Cove.	Granite.	Alamo.	Greenhorn.	Robinsonville.	Bonanza and upper Burnt River.	Susanville.	Quartzburg.	Canyon.	Virtue.	Copper Butte.	Sparta.	Cornucopia.	Lower Snake River.	Connor Creek.	Mineral.	Lower Burnt River.	Rye Valley.	Mormon Basin, Malheur.
Specularite (hematite)	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...
Magnetite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...
Ilmenite	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Pyrolusite	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Limonite	×	×	×	×	×	×	×	×	×	×	×	×	×	...	×	×	...	...	×	×	...	...
Garnet	...	...	...	...	...	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...
Vesuvianite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...
Epidote	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...	...	...	...	...
Tourmaline	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	×	...	...	...
Natrolite	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
Erionite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Serpentine	...	...	...	...	...	...	×	×	...	×	...	×	...	...	...	...	...	...	...	...	...	...
Fuchsite or mariposite	...	...	×	...	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Roscoelite	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Calcite	×	...	×	×	...	...	×	×	...	...	...	×	...	...	...	×	...	×	×	×	...	...
Dolomite	...	...	...	×	...	...	×	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Magnesite	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Malachite	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...	...	×	...	×	...	...	...
Calciovolborthite	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
Scheelite	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Gypsum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...
Chalcanthite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...

NOTES TO THE LIST OF MINERALS.

Roscoelite.—This rare mineral is of considerable interest, as it generally has been found closely associated with native gold in gold-quartz veins. First discovered in several small quartz veins near Coloma, Eldorado County, Cal., it has again been found in Boulder district, Colorado, and lately also in Kalgoorlie, western Australia.[1] The mineral belongs to the group of the potassium micas in which the alumina is partly replaced by vanadium. The analyses disagree somewhat, and a definite formula is not as yet established. The original analysis by Genth gave:

Analysis of roscoelite.

Constituent.	Per cent.	Constituent.	Per cent.
SiO_2	47.69	K_2O	7.59
V_2O_3	20.56	Na_2O	.19
Al_2O_3	14.10	H_2O	4.96
FeO	1.67	Total	98.76
MgO	2.00		

[1] T. A. Rickard: Eng. and Min. Journal, Nov. 17, 1900.

This interesting mineral has been found at several mines in eastern Oregon, always associated with rich ore, and ordinarily much free gold. It occurs abundantly in the recently discovered rich shoot of the Belle of Baker, in the rich shipping ore found some time ago in the Golconda mine, and in a similar rich shipping ore lately discovered in the Columbia mine. The mineral has a dull-greenish color, with a tinge of yellow. It occurs intimately intergrown with quartz in yellowish-green microcrystalline aggregates of tufted fibers, generally so fine that its separation from the quartz is almost impossible. The mineral has high double refraction, but the fibers do not seem to be strongly pleochroic. The gold is frequently intergrown with it or surrounded by it, as shown in Pl. LXX, *D*. An attempt to procure sufficient material for analysis failed on account of the impossibility of separating it from the quartz.

Chromium mica.—The argillites and quartz in many of the mines of the Greenhorn Mountains contain greenish spots which have often been mistaken for copper, but which in reality consist of finely divided chromium mica, fuchsite, or mariposite. The same mineral also occurs at Golconda mine, and the stain is somewhat similar to that of roscoelite, but of a slightly more bluish tinge.

Calciovolborthite.—A mineral allied to this species was found in the Little Baby copper prospect near Gilkeson's ranch, about 25 miles northeast of Baker City. It occurs as bright, citron-yellow scales and aggregates with pearly luster on the black, soft argillite in which the copper prospect occurs. Only a small quantity could be obtained for examination. It is, according to Dr. W. F. Hillebrand, essentially a vanadate of copper, but contains, besides, some sodium, and while corresponding approximately as to its percentage of copper and vanadium with the mineral mentioned, it is probably, in fact, a new species.

Scheelite.—This mineral, recently discovered by Mr. C. King, of Baker City, in the Flagstaff and Cliff mines in the Virtue district, is not altogether unusual in gold-quartz veins. It has been found in such deposits near Grass Valley, Cal., Warren, Idaho, and also in New Zealand.

CHAPTER IV.

DETAILED DESCRIPTIONS OF MINING DISTRICTS.

ELKHORN AND ROCK CREEK DISTRICTS.

GENERAL FEATURES.

The Elkhorn mining district is situated 12 miles west-northwest of Baker City, on the eastern slope of the Elkhorn Range, at elevations of from 6,000 to 8,000 feet. This range here rises very abruptly from Powder River Valley, presenting an imposing slope which in 5 miles gains 5,000 feet in elevation. The road enters the range at the mouth of Pine Creek Canyon, which heads at the rocky, dark precipices of Deer Creek Butte and Elkhorn Peak. One mile farther up the road turns and ascends to the headwaters of Elkhorn Gulch, a tributary entering from the north side. North of this gulch is a long, high salient, prominently visible from the valley and commonly called "Old Elk Mountain." This divides the drainage of Pine Creek from that of Rock Creek, incised far back into the heart of the range. A trail leads up Elkhorn Gulch and crosses the Rock Creek divide at a gap the elevation of which is 8,250 feet.

GEOLOGY.

The contact between the granodiorite of the northern and the argillite of the southern part of the Elkhorn Range crosses this mining district from east to west. At the mouth of Pine Creek Canyon black massive argillite crops. Half a mile higher up the rock becomes more crystalline, indicating proximity to granitic masses. Still higher up on the Elkhorn road contorted stratification is visible in the dark-colored siliceous argillite. The actual contact is not well exposed along the road, but runs up the gulch a short distance from the Baisley mine. West of this mine it follows the gulch pretty closely and crosses the Rock Creek divide 100 feet south of the United States mineral monument. The metamorphic rocks are here imperfectly slaty, the schistosity striking east to west, parallel to the contact. For the first 50 feet the rock is a fine-grained brownish hornfels; then dark argillite appears with contorted bands of siliceous cherty rock. Dikes of fine-grained diorite occur in the sedimentary rock 400 feet from the actual contact. Loose fragments of a crystalline limestone were noted 200 feet from the same place. An ill-defined mass of contact-metamorphic

argillite was noted between the Hurdy Gurdy and the Baisley mines, contained in diorite.

The granitic rock near the contact is a diorite of medium grain, sometimes even becoming fine grained very close to the same. Northward from the contact quartz appears, the hornblende becomes less prominent, and the rock shades over into a granodiorite. Locally, as in the Baisley shaft, the diorite develops as a coarse hornblende rock.

The Pleistocene glaciation of the Elkhorn Range is well marked along Pine Creek. A broad débris fan extends over the valley from the mouth of Pine Creek Canyon, which is about 1,000 feet higher than Powder River. Though a few bowlders are scattered over this alluvial cone, there is no good evidence that the glacier reached the valley. But immediately above the narrow entrance of the canyon morainal material is abundant. About one-half mile farther up is a well-defined terminal moraine, and all along above this point the broad bottom is well filled with glacial débris. A partly eroded stratum of white kaolin, an almost impalpably fine powder, covers the bottom of the canyon in places.

QUARTZ VEINS.

The veins of the Elkhorn district contain chiefly gold in an ore rich in sulphurets. About a quarter of the total tenor is usually amenable to amalgamation. Pyrite and zinc blende, with some chalcopyrite, are the principal minerals. The strike of the vein system is northeast to southwest, but individual veins can rarely be traced far. Most of them are contained in diorite, and the mineral belt seems to follow the contact of diorite and argillite. The total production is probably a little above $1,000,000.

Baisley-Elkhorn mine.—At present this mine is the most promising producer in the district. It is located high up on Elkhorn Gulch, a tributary of Pine Creek, the elevation at the mine being 6,700 feet. Its discovery dates from about 1882. Up to 1889 the ore was worked in arrastre; in that year the present mill was erected, consisting of 2 Bryan mills with plates, 6 percussion tables, 4 vanners, and a canvas plant. In 1897, the present owners, the Eastern Oregon Gold Mining Company, bought the mine for $60,000, since which time it has been in constant operation. Data in the Mint reports give isolated figures in regard to production: In 1889, $3,744; in 1891, $89,373; in 1892, $16,500. The total yield up to 1896 is given by Mr. Whittaker, the superintendent, as $535,000. During the last two years the production has been large, attaining from January 1 to August 1, 1900, $94,000.

The developments consist of a 700-foot crosscut to the vein, with drifts for 700 feet south and several hundred feet north. The ore above tunnel level was stoped out before 1897. Two hundred feet south of the crosscut a shaft was sunk on the vein to a depth of 180

feet, and sinking below that level is now in progress. Drifts on two levels in the shaft aggregate over 1,500 feet, the principal developments being on the south side of the shaft.

The country rock is chiefly a normal, granular hornblende-biotite-diorite of dark color. The contact with the somewhat crystalline and contact-metamorphosed argillite is only a few hundred feet distant to the southeast, the black massive croppings of the latter being visible across the creek. 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 by it. Whether this is the main mass or simply a fragment of argillite inclosed in the diorite is difficult to say. At any rate the main argillite area is not far away.

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 value of the ore is in gold, which is partly—up to 25 per cent—free amalgamating, occurring in the 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. The concentrates are shipped to Northport, Wash., freight and charges aggregating $10 per ton. Their ordinary value is said to be $50 per ton, though richer batches are often sent. They contain from 2 to 4 ounces gold and from 10 to 20 ounces silver per ton. The richest ore is hand sorted and shipped; it contains values from 4 to 6.5 ounces gold and from 14 to 21 ounces silver per ton. 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 vein, which is traceable only through two claims, Baisley and Robbins-Elkhorn, has very inconspicuous croppings. The strike is northeasterly, the dip nearly vertical. 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° NE. were observed on the walls. Sometimes the whole width of the vein is an altered diorite of small assay value. In the payshoot the width is from 2 to 10 feet, many gradually fading seams running out on the north side. The ore streak in this width is a soft mixture of coarse sulphides with much crushed diorite and occasional streaks of quartz which may show comb structure; in one place a 2-foot ore streak was adjoined by 10 inches of white, barren quartz.

The pay shoot is rather irregular, but on the whole confined to the southwest end of the claim.

Other mines and prospects.—The Robbins-Elkhorn mine is situated near the Baisley-Elkhorn and covers the southeastern extension of the latter vein. It is not worked at present, but has been a notable producer. The developments consist of a 300-foot crosscut and 1,100 feet of drift. A production of $300,000 is reported, the ore being identical with that of the Baisley mine, and its pay shoot, in the northeast end of the claim, an extension of that of its neighbor. From all accounts it is a promising mine, but for some reason has been permitted to lie idle.

One thousand feet higher up in the gulch and northwest of the Baisley is the Hurdy Gurdy. Located in 1883, earlier than the Baisley, it was worked from 1887 to 1892, and is reported to have produced $80,000. Three carloads were shipped, the rest of the ore being milled in a small Tremain mill. It was opened by a crosscut 378 feet long. The vein is a small one, 20 to 24 inches wide and carries oxidized free-milling ore in diorite.

The Denny group is located near the head of the gulch west of the Baisley-Elkhorn and on the trail leading over to Rock Creek. The Elkhorn Bonanza is supposed to be located on the northeasterly extension of the Baisley-Elkhorn and has been extensively prospected by 3,000 feet of workings.

Rock Creek district.—At the head of Rock Creek about 2 miles due west of the Baisley-Elkhorn mine is a promising district, which, however, was not visited. A trail leads west from the Elkhorn mines to a gap (elevation 8,250 feet), from which a fine view is obtained over upper Rock Creek. The contact of diorite and granite is close by this gap, and it is clearly seen to cross Rock Creek near the Chloride mine and ascend the mountains on the north side. In a general way the veins are near the contact, though they are not parallel to it, and from this prominent place there is noted a series of prospects which follow the contact to the divide between the Middle Fork of Rock Creek and Cracker Creek, a tributary to Powder River. The Maxwell mine, owned by the Pierce Mining Company, covers 11 claims, and has been worked extensively through several tunnel levels for ten or twelve years. It has 4,000 feet of development work, but owing to litigation is not producing at present. A 10-stamp mill is built at an elevation of 6,600 feet, 1,000 feet below the croppings which appear in diorite near the gap mentioned above, but which lower down seem to cut across into the argillite. The strike is northeasterly, the ore similar to that of Baisley-Elkhorn, but carries more silver.

The Chloride mine is located on Rock Creek at an elevation of 5,900 feet. A considerable amount of work has been done on this property, the ore of which contains a great deal of silver, largely in tetrahedrite.

POCAHONTAS, AUBURN, AND MINERSVILLE DISTRICTS.

GENERAL FEATURES.

These three districts, occupying the southern end of Elkhorn Range, are best described together. From the culminating point of Deer Creek Butte (elevation 9,100 feet) the range continues as a narrow backbone for 7 miles southeasterly, until near Auburn a sudden descent occurs. The flanks of the range are 4 to 5 miles wide and present narrow, gradually sloping ridges separated by deeply incised gulches; on the east it sinks below Powder River Valley, 3,500 feet above the sea, while its western base is covered by the gravels of Sumpter Valley at an elevation of 4,000 feet. The foot of the southern end of the range is flooded by basaltic lavas up to an elevation of 4,500 feet and Powder River surrounds it in a semicircle; its canyon, south of Auburn, has not yet cut through the lavas, so that it is evident that before the eruptions the southern slope was more prominent than at present.

Heavy timber covers the middle slopes of the range, while the upper ridges and peaks are often bare and rocky. Southeast and east of Auburn the rolling foothills covered by lava and gravel support no forests.

GEOLOGY.

The two principal terranes which build up the southern end of the Elkhorn Range are a sedimentary series of dark-gray argillite and a dioritic rock intrusive in the former. The argillites predominate, but no detailed mapping was made of the two formations.

The age of the argillite is in doubt, as no fossils have been found, but it is believed that they are older than the Triassic series of the Eagle Creek Mountains. As, on the other hand, the strata are continuous with those of Sumpter and Bonanza in which imperfect fossils have been found, they must be post-Algonkian and are most probably of Carboniferous age. The strike and dip are often very difficult to ascertain, as most of the heavy strata consists of massive siliceous argillite without schistosity or bedding. The prevailing strike of the bedding, conforming with the structure of the whole region, is N. 70° to 80° W. and the dip 60° S.

On Marble Creek, at an elevation of 5,400 feet, is a large limestone mass embedded in the black siliceous argillite, and rising as a steep wall 300 feet above the gulch. At Pocahontas, in the foothills, the rock is very much decomposed, but on the tunnel dumps there is black fissile argillite with small lenses of limestone and sometimes sharply defined cubes of pyrite. At the mouth of Salmon Creek, one-half mile above the Nelson placers, a greenish-gray massive rock crops, showing on weathered surface outlines of fragments of probably volcanic rocks; this is evidently a tuffaceous argillite. In Washington Gulch, Griffins

Gulch, and Elk Creek, black, siliceous, sometimes cherry, argillites prevail, but contain interstratified some calcareous rocks, as well as some fissile slates.

At Auburn the series is more markedly stratified, striking N. 70° W. and dipping 60° S. A jointing, striking northeasterly and dipping 70° NW. was also noted. The rocks consist of alternating, siliceous, and fissile argillite, the former often in lenses and curved streaks. Occasionally small masses of limestone occur.

At Minersville a similar formation is shown. The rounded foothills occupied by this formation are deeply decomposed and the surface is covered with small fragments of chert or siliceous argillite.

The intrusive rock mentioned above is a light to dark greenish-gray diorite, sometimes approaching a gabbro, of medium to fine grain. Nearly always this rock is also irregularly crushed and traversed by small white seams, and is, in fact, identical with the diorite and the gabbro of the Virtue district. It is very different from the fresh and massive diorite and granodiorite of the northern part of the range and is certainly older, having participated in some of the mountain-building movements. Heavy masses of this crop on Goodrich Creek, on Marble Creek below and above the limestone, high up on Salmon Creek, and finally in the high range above Minersville. The rock is clearly intrusive in the argillite formation.

Traces of glaciers are found in most of the gulches heading close to the main range, but nowhere did they reach the valley, and none of them approached the Pine Creek glacier in size (see Elkhorn district).

The origin and structure of this range offer many as yet unsolved problems. We can not doubt that its great features were carved out long before the Miocene lavas flooded its southern foot, although many modifications in its form and structure have occurred since then. The bold front of the range facing Powder River Valley suggests an old fault line, emphasized by comparatively recent orographic movement. That such a fault plane really exists and that movements have taken place on it in Pleistocene time will be shown in the description of the Nelson placers. This direct evidence is of the highest importance, and in the light of it Powder River Valley appears as an area of recent subsidence.

GOLD-QUARTZ VEINS.

Though, as will be shown below, nearly every creek and gulch heading in this part of the range has carried more or less placer gold and a few have been enormously rich, there is throughout a very marked absence of important vein systems to which the origin of these placers could be attributed. In part this may be due to insufficient prospecting, but in most cases I believe that the placer gold was here rather derived from small seams and veinlets than from prominent fissure veins.

A few prospects have been discovered on Pine Creek and on Goodrich Creek. At the limestone mass on Marble Creek the black argillite contains some auriferous pyrite; but no mines of importance are found until the Pocahontas district is reached, in the foothills between Marble and Salmon creeks. Discovered in early days, it is mentioned in Raymond's report for 1872 and has been intermittently worked, in a small way, since then, the total production exceeding $100,000.

The veins strike nearly north and south and dip 20° to 35° W. They are 1 to 3 feet wide, the vein matter consisting of clay with streaks of white quartz. The gold is very high grade, being worth $18 to $19 per ounce, and said to be free milling. The country rock is a very decomposed calcareous argillite. Of the different veins the Tom Paine has been the principal producer, one small chimney producing $70,000 of coarse gold about eighteen years ago. It has been developed by several tunnels, the lowest, in Nelson Gulch, having an elevation of 4,200 feet. This tunnel is 225 feet below the croppings. A winze 60 feet deep was sunk in it. No work is done on the claim at present. The quartz is reported of sugary texture, mixed with clay. Some adjoining claims, notably the Old Soldier, were prospected in 1900. The Old Soldier is on the east side of the Tom Paine, and shows in several inclines and tunnels as a 1 to 2 foot vein of clay with streaks of quartz. Some of this ore was worked, with reported good results, in an arrastre erected in Salmon Creek.

In spite of the rich placers of Salmon Creek, no quartz veins of any importance have been located on it. In the exposed bed rock of Nelson's placers many veins are exposed which strike northeast and have a steep dip; from 1 to 2 feet wide, these veins consist of soft, crushed rock with little stringers of quartz, all of which are said to contain gold, though usually only a very small amount. Veins of this type are probably the source of the placer gold.

A few quartz prospects are located on Washington, Griffin, and Elk gulches, but have not been developed. Three miles west of Baker City, in the lowest foothills, is the Big Buffalo claim, opened by a 300-foot crosscut, and showing a mass of black argillite traversed by seams of quartz, calcite, and a little pyrite.

At Auburn several quartz claims are located north and northeast of the settlement. They have been known since early days and are mentioned in the early Raymond reports. Most of them appear to be small seams rather than well-defined veins. All of these seams, however, are said to carry gold.

At Minersville prospecting for quartz has proceeded actively during the last year. Several narrow mineralized streaks in black slate have been opened by short tunnels, and from higher up on the range a 2-foot vein of quartz with chalcopyrite is reported.

PLACER MINES.

Nearly every gulch of the south end of Elkhorn Range has been worked on a more or less extensive scale for placer gold, though few localities have been exceedingly rich. Though the bulk of the gold was extracted shortly after the discovery, in 1862, some work is yet going on at several of the old diggings, showing that the gravels are not yet exhausted.

At the northern end of the eastern slope small placers have been worked on Marble Creek, near the limekiln. On Salmon Creek the placers are of much greater importance. This creek was worked with success for about one mile upward from the mouth of the canyon. The gravels were 4 to 10 feet deep and covered by 10 to 15 feet of an exceedingly fine, brilliantly white kaolinic material. The bottom of the canyon was originally filled with deposits to a width of one or two hundred feet. Working downstream, the placer miners at the mouth of the canyon gradually discovered a very remarkable deposit, called the Nelson placers. These have been worked successfully for thirty years by the hydraulic process, and are by no means yet exhausted. The working season extends from April to September, 1,000 miner's inches of water being used. The yearly production has generally been from $20,000 to $30,000. In the Mint reports for 1889 the production is given as $77,000; in 1890, $19,000. The total production is believed to be over $400,000. For one period of six years the production is said to have reached $214,000. As the available grade is small, it is proposed to use a hydraulic elevator for mining below the level of the permanent sluice.

The mouth of Salmon Creek Canyon is marked by a low spreading débris fan. The Nelson placers are working the gravels of this fan in a pit covering 40 to 50 acres and from 20 to 100 feet deep. At the top of the bank the elevation is 3,750 feet. The gravel is subangular, many fragments reaching 1 foot in diameter, and consists of argillite and diorite, very little quartz being present. There are two layers. The upper stratum has a bluish-gray color, is 10 to 20 feet thick, and contains, evenly distributed, most of the gold. The lower stratum is yellowish-brown and its rocks are more decomposed. This also contains gold, though in lesser amount, and its bottom has never been reached. Covering the top layer, near the mouth of the canyon, is the same white kaolin which covers the gravels of the creek. The gold, which is worth only $14 to $16 per ounce, is ordinarily fine, though nuggets up to $10 in value occur. To the rough pieces quartz sometimes adheres.

Most interesting are the relations immediately at the mouth of the canyon, for here the hydraulic work has disclosed the presence of a continuous fault scarp 100 feet high and dipping 40° E. It is smooth

now, but when first exposed it is said to have been almost polished and in places covered with a clayey gouge. The direction is northwesterly, but with occasional bends and bulges. The exposed fault line extends completely across Salmon Creek for a distance of 1,500 feet, and the same line, less well exposed, is seen in the Baisley diggings, one-fourth of a mile northward, and in the Carpenter placers, half a mile southeasterly.

A shaft has been sunk in the bottom of the hydraulic pit near the foot of the scarp, but no bed rock was found at a depth of 90 feet. A minimum vertical throw of 200 feet is here shown, the valley side having sunk relatively to the mountains (fig. 80). The upper blue gravel probably was accumulated during the Glacial epoch, while the lower dark-brown gravel is more likely to antedate that time; whether any very recent movement has taken place could not be decided.

Small placers have been worked in Washington Gulch, and the same applies to Griffin Creek and Elk Creek. The Griffin Creek placers are the oldest in eastern Oregon, having been discovered in the fall of 1861.

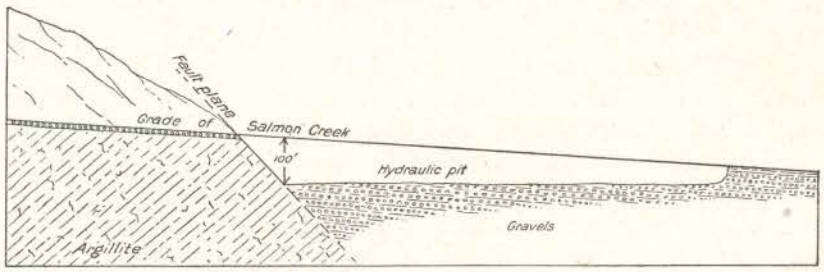


FIG. 80.—Section of Nelson placer mine, showing fault at foot of Elkhorn Range.

The workings are 6 miles southwest of Baker City and at an elevation of 4,750 feet above where the creek enters the lava hills. Some work was in progress in 1900. On the divide between Griffin and Washington creeks is a small area of high gravels which is said to contain gold in paying amount.

Most important were the placers of Auburn, in Blue Canyon, a tributary of Powder River. The diggings were discovered in 1862, and in a short time a town of several thousand inhabitants had grown up. For many years Auburn was the most prominent place in eastern Oregon; but the gold yield gradually diminished and the camp was given over to the Chinese. At the present time hydraulic mining is carried on by two or three white companies. The total production of Auburn is difficult to determine, but it did not nearly reach that of Canyon and the richest placers were soon exhausted. A small and rather steady production is maintained. The Mint reports give $12,000 for 1889, $2,600 for 1890, $8,900 for 1891, $3,000 for 1892. The important Auburn ditch was completed in 1863. It takes water

from the head of Pine Creek and other water courses and carries it down to Auburn, a distance of over 30 miles; its capacity is 1,000 miner's inches.

Auburn is located in a wide basin-like valley at an elevation of about 4,000 feet. The argillites of the mountains here dip below the lava floods of the foothills. On both sides of the town the lava reaches up to elevations of 4,500 feet. The lavas cover soft, clayey, and loamy lake beds containing some coaly layers and impressions of deciduous leaves. On top of the eroded lake beds in the wide gulch rest subangular gravels 8 to 15 feet thick; the latter have been washed both in the gulches and on the flats. Near the town the depth to bed rock is not great; but farther down the valley the thickness of the sediments increases rapidly. The gravels are thus later than the lavas and have accumulated during the erosion of the present valley.

West of Auburn, on the road to Sumpter, several gulches with old placers are passed, Poker Gulch and California Gulch being next to Blue Canyon.

The deposits next in importance are found at Minersville, situated at an elevation of 4,300 feet on one of the small tributaries of Deer Creek. This is also an old placer camp, though not as rich as Auburn. Nearly all of the creeks flowing into Deer Creek from the east have yielded more or less placer gold. Miners Creek is worked at present on a small scale at the point where the stream leaves the old rock and enters the gravel deposits of Sumpter Valley. The gravel is coarse, with many heavy bowlders, and the gold is likewise coarse. Three short gulches southeast of Minersville, heading only 600 feet higher than the town, have been worked all the way up, and the gold contained in them is evidently of very local origin. In spite of this the gulches contain but little quartz.

SUMPTER AND CRACKER CREEK DISTRICTS.

GENERAL FEATURES.

The area described under this heading practically includes the upper Powder River Valley. South of Baker City Powder River cuts through the basaltic plateau at the southern end of the Elkhorn Range in a wide semicircle, and for about 12 miles flows in a narrow canyon. Going up the river, the canyon opens, at an elevation of 4,000 feet, into the wide Sumpter Valley, an alluvial bottom flanked by broad, gently sloping, forested benches. Beyond these the snowy summits of the Elkhorn Range rise abruptly eastward, while toward the west a heavily timbered ridge, of moderate elevation, separates the valley from the Burnt River drainage basin. A little above Sumpter a canyon again begins. The river forks into Silver Creek, Cracker Creek, and McCullys Fork, all heading among the high ridges leading to Elkhorn Range or Mount Baldy.

GEOLOGY.

The older rocks are very similar to those of the Elkhorn Range; there is no geological break between that range and the country west of it. The predominant rocks are argillites, cropping in the canyon below the Sumpter Valley, near the Burnt River summit south of McEwen's, at Minersville, all along the Elkhorn Range, and, finally, above Sumpter until the contact with the Bald Mountain area of granodiorite is reached. The argillites appear in great variety: Some of them are black and fairly fissile, forming almost normal clay slates; another and very common variety shows little stratification and is a dark-brown to black, dense, fine-grained rock, containing more silica than the ordinary clay slates. The siliceous argillite is often interbedded with the clay slate as nodules and lenses, sometimes contorted and elongated. Transitions into black or gray chert are also common. Occasionally the argillites are calcareous, but limestones are not abundant. One limestone lens crops about half a mile north of Sumpter in a low saddle, but it is not very large and is not traceable far. Interbedded fine-grained greenstones and their tuffs were noted at several places, though on the whole the series does not contain much volcanic material. Extremely altered tuffs appear on the road leading to Clifford, and also on the lower part of McCully Fork. The stratification is more clearly marked than in the Elkhorn Range. The whole series strikes east to west or a few degrees north of west. The dip is steadily southward at angles of 45° to 80°. In places a schistosity, or jointing, striking northward and dipping steeply westward, is noted. There is rarely a strong fissility developed parallel to the original dip.

The age of this argillite formation is in doubt, as no fossils of any kind have been found. Not unlikely the rocks may be of Carboniferous age; and if so, they would occupy a position very similar to that of the Calaveras formation in the gold belt of California.

Few dikes or intrusive masses are found south of the great area of granodiorite of Bald Mountain. Near Bourne small dikes of aplitic rock have been noted. Between Sumpter and Cracker Creek two dikes of very much altered igneous rock were noted crossing the road, one below and the other above Halfway House. Both were probably originally diorite-porphyries, but they now contain so much sericite, calcite, and pyrite that their original character is obscured. One of them is accompanied by small quartz veins, and doubtless contains a little gold. Similar extremely sericitized dikes were observed in the Golconda and the Columbia mines.

The general course of the upper Powder River was evidently laid out before the Neocene outbursts of Columbia River lava began. Great basaltic eruptions flooded the valley south of Baker City to a height still clearly indicated by the flat dissected tables above the river. By

these flows the upper river was dammed to a height of 4,600 to 4,700 feet above the sea, and this barrier created Sumpter Valley. Accumulations of coarse gravels at once began and filled the valley to an elevation of 4,600 feet, and these old gravels may still be seen leaning against the older rocks—at Sumpter and Minersville, for instance. As the lava barrier was gradually cut through, lower terraces were developed. These gravel flats must be considered of late Neocene (Pliocene) age. At present the river has cut down to a depth of 700 feet below the top of the lava flows at the lower end of Sumpter Valley. The alluvial flats which follow the river should be referred to the Pleistocene period.

PLACER DEPOSITS.

The Sumpter placer mines were discovered in 1862, and have been worked more or less actively since that time. The first area of placers begins a short distance below Sumpter and extends up to the point where the Cracker Creek vein system cuts across the creek. Another mining district, the placers of which are mentioned under the heading "Minersville district," is situated on Deer Creek a few miles east of Sumpter. Several of the smaller creeks north of Minersville draining the western side of the Elkhorn Range and emptying into Deer Creek also contain placer gold. Placers have also been worked in several gulches above Sumpter and tributary to Powder River, such as Buck Gulch, Mammoth Gulch, and others.

The mining has been done largely by Chinese companies, and it is not believed that the diggings were very rich, compared with those of Auburn, Canyon, Mormon Basin, and similar places. It is impossible to ascertain the total output. At present the bench gravels are worked only in two places adjoining Sumpter—the Downie and Ellis mines. The annual yield of the Sumpter placers probably varies from $10,000 to $20,000. The present river bed, from 50 to 300 feet wide, and the low bars were worked during early days for a few miles above Sumpter, but the diggings are now abandoned. A short distance below Sumpter the gravels in the present bed contain fairly coarse gold, it is claimed, and the possibility of dredging has been suggested, though the depth is far too great to reach bed rock by such machinery. More detailed tests must decide whether this is possible.

The gravels of most importance for present operations are the bench deposits, from 30 to 100 feet above the stream channel. These deposits connect directly with the Pliocene gravels skirting the base of the hills all around Sumpter Valley. Near Sumpter the auriferous veins above have enriched them sufficiently to make them available for placer work. Between Sumpter and McEwen's many shallow gulches cut in these gravels have been profitably mined. Sumpter itself stands on these bench gravels, which have a depth of 15 feet or more. At the electric-

light plant a shaft was sunk 80 feet through sandy strata with two streaks of gravel which prospected well. Bed rock was not reached. The old channel probably underlies the bench gravels on the northeast side of the river, and from all indications it had a steeper grade than the present river. Most of the bench gravels lie on the narrow point opposite the town, between Cracker Creek and McCully Fork, on which the gravels reach a height 60 feet above the stream. The junction of two forks is here evident. The Pliocene equivalent of Cracker Creek is covered by the 200 acres of the Ellis mine, the principal workings of which are north of the Granite road where it crosses the gravel point. Several acres have here been hydraulicked, the banks being up to 80 feet high. The well-washed gravels, fairly coarse, contain the rocks which crop above. The gold occurs in medium fine particles and the yield is reported as up to 16 cents per cubic yard. The bed rock is not exposed until a few hundred yards above Sumpter, where the large gravel areas dwindle into small benches lining the banks of Cracker Creek. A considerable amount of gravel remains, though much of it is not accessible without elevators, on account of lack of grade. The water is supplied by ditches aggregating 10 miles and carrying 1,000 miner's inches. In past years these diggings have been leased to Chinese companies.

The Downie placer mines, 1½ miles from Sumpter, are working on gravels representing the Pliocene McCully Fork, and comprise about 140 acres. The Downie channel is higher than the one just described, and forms a distinct depression on the east side of the creek. The trough is 200 feet wide and contains well-washed gravel 50 feet deep. The bed rock is 40 feet above the present creek. Going downstream, the bed rock descends rapidly, and where the Granite road crosses the point between the forks, mentioned above, no bed rock is seen. The mines dispose of a good supply of water from 6 miles of ditches, carrying 1,000 miner's inches. Operations can be carried on until late in the fall. Two giants are usually operated by Chinese leasers, and the annual yield is reported to be about $9,000.

Rich placers with coarse gold are located in Buck Gulch, a tributary to McCully Fork, near the Granite road and 4½ miles from Sumpter. Scarcity of water restricts the operations.

LIMESTONE AND IRON ORES.

An outcrop of crystalline limestone of good quality occurs in the argillite half a mile north of Sumpter. It could not be traced far either way in the direction of the strike of the rocks, but it may be continuous for a greater distance than is apparent, as the rocks on the hillside are not well exposed. The outcrop is 10 to 15 feet across, and a small quantity has been quarried for the smelter which was in operation for a short time during 1900.

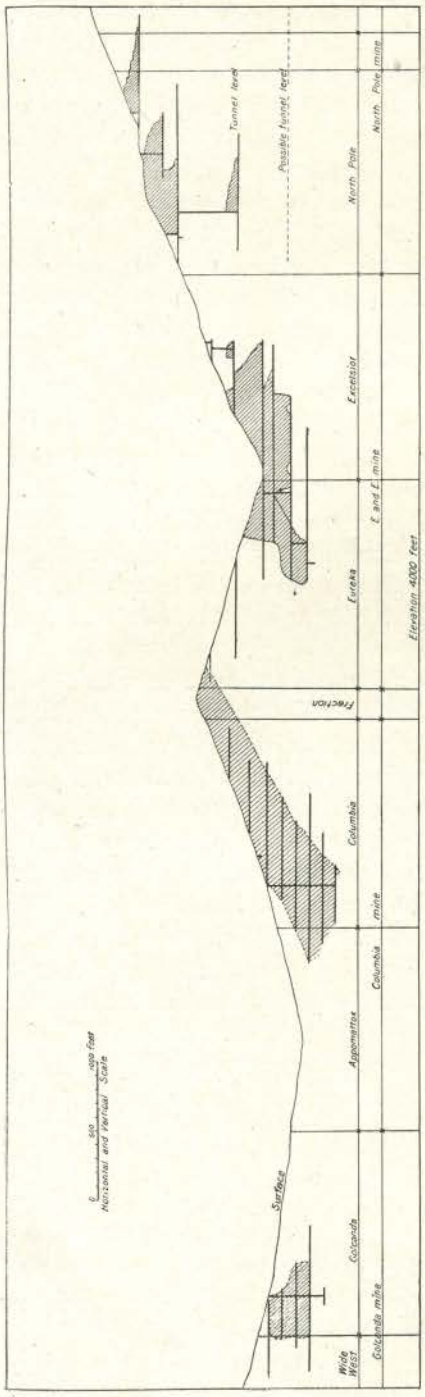


FIG. 81.—Vertical section following the vein from the North Pole mine to the Golconda mine. From data by Emil Melzer. Shaded areas indicate stoped ground. For Columbia and Golconda mines the data are only approximately correct.

A mass of hematite of no great extent has been found in the argillite on the Burnt River divide, 5 miles south of Sumpter. Three miles southwest of Sumpter a small deposit of a black earthy manganese ore occurs. It is near the Bonanza trail, also on the Burnt River divide. It was used in the smelting operations as a substitute for iron.

QUARTZ VEINS IN GENERAL.

Many small veins and indications of mineralization are found near Sumpter, but the big vein systems occur 7 miles above this place. There is practically one continuous vein system, beginning at the Baisley-Elkhorn mine and continuing across to Cracker Creek, with a strike varying from east-west to northwest-southeast, and some of the most important mines in eastern Oregon are comprised in it. The part of the vein system tributary to Sumpter begins at the North Pole mine and continues westward through the E. and E., Columbia, Golconda, Amazon, and Bunker Hill mines. In this distance of 5 miles the vein continues strong and unbroken, but gradually changes its strike from northeast-southwest to east-west. The country rock is, throughout, argillite, and the vein is of the composite

type; that is, it is found as a wide, shattered zone, though ordinarily with well-defined walls. The gangue is quartz throughout, containing gold and sulphurets. The width is from 5 to 100 feet. It is easily the most strongly defined and persistent vein in the Blue Mountains.

A short distance northward is the Ibex vein, which is continuous for at least 3 miles and is nearly parallel to the North Pole vein. It resembles the latter greatly, except that it is usually narrower. There are many other smaller veins and branches thrown off from the two large veins.

The veins of Sumpter were known as far back as 1870, but active exploitation was not attempted until about twenty years ago. The earliest mill was erected on the Mammoth claim about this time.

North Pole mine.—The most northeasterly of the important mines on the big vein comprises two full claims, the North Pole and the More-or-Less. It is located on the mountain slope northeast of Cracker Creek, and ascends to a height of 2,000 feet or more above that stream. The extent and workings will be seen from fig. 81. The elevation of the lowest tunnel is about 5,800 feet. The North Pole claim was located in 1887, croppings of rich ore being found near the surface. The following year the claim was sold to A. Baring, of London, for a reported price of $10,000. The adjoining claim and fraction was acquired for $14,000 in 1897. Though operated since 1887, the most active work on the property has been prosecuted since 1895. The total production is not known, but during the last four years 13,400 tons have been treated, the assay value of which approximated $15 per ton.

The mine is equipped with a cyanide plant provided with two Bruckner roasters, which have a daily capacity of 20 tons. This plant works the zone of semioxidized ores only, and in spite of fine crushing to 1 mm. by ball mills, it is necessary to roast the ore very slowly and carefully. The cyaniding is done in 50-ton tanks, percolation lasting fifteen to twenty days. The extraction by cyanide is stated by Mr. Melzer to be 84.9 per cent of the assay value. For purposes of working the unoxidized ore a 10-stamp mill and a Huntington mill with concentrators have recently been added, making a total capacity of 80 tons per day.

The North Pole is developed by means of three main tunnels, shown on fig. 81, the upper two starting on the vein, the lower one being a crosscut for 1,000 feet. The upper tunnels are, respectively, 450 and 750 feet above the main adit, the total vertical distance on the vein opened by the workings being 850 feet.

Throughout the mine the country rock is the normal, black, hard, siliceous argillite, without clearly visible stratification. In the long crosscut a jointing shows in several directions, the most prominent

being flat or dipping gently east or west. There is no jointing or parting parallel to the vein. The strike of the vein is N. 25° E., and its dip 70° to 80° SE. The croppings are distinct and in some places carry good values. On More-or-Less claim a large mass of quartz crops along the line of the vein, measuring almost 200 feet across. Where the main crosscut meets the vein the latter is 22 feet wide; in places it bulges out to 40 feet, and again contracts to 7 feet, but never thins out entirely. The walls are fairly well-defined fault planes, especially the foot wall. The vein matter is composed of rock of all gradations between crushed argillites seamed by quartz and pure white massive vein quartz. On the whole, there is a large amount of solid vein quartz extending for several feet across the vein and for long distances parallel to it. Other parts of the vein form an intimate mixture of quartz and small leafy or irregular inclusions of argillite, sometimes indistinctly defined from the quartz and giving the impression of a mass of argillite mud partly silicified and cemented by quartz. On the whole, there are no such large and sharply defined inclusions as mark the vein in the lower tunnel of the Columbia. Comb structure is frequently seen on a small scale, though most of the quartz is massive. The argillite in and just outside of the vein is often filled with coarse cubical pyrite of low assay value. Outside the pay shoots the quartz is white and barren of sulphides. The pay quartz is characterized by arsenopyrite, and also by pyrite in minute grains and slender crystals, rarely over 1 mm. in length. In the center of the pay shoots richer lenses are occasionally found, containing up to $150 per ton, and sometimes also a little native gold with tellurides rich in gold and silver. The ordinary ore rarely contains any sulphurets other than arsenopyrite and a little pyrite; sometimes also chalcopyrite. Native gold is seldom seen, though a little, about 6 per cent, may be caught on amalgamating plates. The chief value is in the sulphurets. The average sulphide ore contains 0.688 ounce of gold and 1.200 ounces of silver per ton, or a total average value of $14 per ton. The white quartz outside of the pay shoots carries only small values. Very frequently a peculiar arrangement of the sulphides is noted in the pay shoots. The quartz is here full of small curved and concentric streaks of arsenopyrite, in general not parallel to the walls and frequently sharply cut off. The detailed examination shows that this irregularly concentric structure is due to crustification, but that by subsequent motions the crustified mass has been broken and recemented, in places forming a real breccia (see Pl. LXVIII, *A*). The quartz is free from calcite, but the latter mineral occurs on all little secondary slips and fractures which brecciated the original crust. On these secondary fractures arsenopyrite is also found.

The pay does not include the whole width of the vein, but when present occupies a space of 2 feet up to a maximum of 12 feet, appear-

ing along one wall or the other, or in the middle of the vein, adjoined by barren quartz on both sides. Usually the form is that of a number of lenses which sometimes overlap. The pay shoot, ordinarily on the foot wall, may break across in stringers and streaks and follow the hanging wall for a distance. It is stated that in general the pay has a tendency to follow the seams of gouge found in the vein. As a whole, it has a flat southwesterly dip, as in the Columbia and E. and E. mines, and may in fact be continuous with one of the E. and E. shoots. A large amount of ore is unquestionably in sight; thus, for instance, it is stated that there are 600,000 tons between the short intermediate and the uppermost tunnel level. Besides the pay shoot following the slope of the hill, there are others exposed in the lowest and middle tunnels.

A partial oxidation has taken place for a distance of 200 or 250 feet from the surface. The changes in values are, probably owing to the hardness of the quartz and the fineness of the sulphides, much less marked than is usual in gold veins. According to Mr. E. Melzer, the oxidized ore is but very little richer than the deep ore, though its physical condition has changed so that the same metallurgical processes are not applicable. Average assays of surface ore give 0.968 ounce of gold and 0.700 ounce of silver, or $20.40 per ton, while the sulphide ore assays 0.688 ounce gold and 1.2 ounces silver, or $14.40 per ton, the gold having thus increased slightly and the silver decreased during the process of oxidation.

Eureka and Excelsior mine.—The mine owned by the Eureka and Excelsior Consolidated Mining Company comprises the two claims on the North Pole vein having the above names, and is usually known as the E. and E. It was bought as a prospect in 1888, and from this time up to 1898 it has been worked. In 1900 it was idle and the underground works were not accessible. For most of the data regarding it I am indebted to Messrs. E. Melzer and J. Arthur, of Sumpter. A 20-stamp pan amalgamation mill was erected in 1889 for $200,000, which proved utterly unsuited to the ore, and for several years the mine was worked with indifferent success. The doubtless incomplete Mint reports give the production as $500 for 1889, nothing in 1890, $135,000 in 1891, and nothing in 1892. In 1895 the mine was leased to Mr. J. H. Longmaid for three and one-half years. The lessee put vanners in the mill, and in three years mined and milled 75,000 tons of ore, valued at $900,000. Since the expiration of the lease the property has been idle except for a little surface work, but it is said will soon be reopened. If worked in a rational manner the property will doubtless maintain its reputation as one of the best mines in Oregon.

The total production may be estimated as $800,000, the mine thus possessing the record production among the new mines in the Sumpter district.

The developments consist of between 7,000 and 8,000 feet. There are two small tunnels on the hill northeast of Cracker Creek, 200 and 350 feet above its bed; two tunnels on the southwest side of the water course; a main level at creek level, at an elevation of about 6,500 feet; a shaft 200 feet deep sunk from this tunnel; and still another shaft sunk 100 feet below the 200-foot level in the first shaft (fig. 81). The mining methods employed were crude and faulty, the evident plan being to extract as much as possible without regard to even the immediate future of the mine.

The country rock is the usual black, siliceous argillite. The vein, directly continuous with that of the North Pole on the northeast and the Columbia on the southwest, strikes N. 34° E. and dips 60° to 70° SE. The croppings are well defined, and the vein seems to have paid from the grass roots down for a distance along the surface of 1,300 feet. The vein appears to be identical in character with that of the adjoining claims, being a shattered zone in argillite, in some places as much as 30 feet wide. The milling ore carries pyrite and arsenopyrite in quartz similar to that of the North Pole. It rarely contains free gold. The concentrates amount to 8 to 10 per cent and assay from $100 to $200 in gold, with a little silver. The 70,000 tons of ore extracted by the lessee averaged $12 per ton by assay value. There was also a certain quantity of rich shipping ore yielding from $80 to $240 per ton. Some surface ore extracted in 1898 yielded $8 per ton.

There are four pay shoots in the mine, which may be said to partly connect, forming a body dipping southwest at a gentle angle, like the shoots of the North Pole and the Columbia. In fact, the shoot of the E. and E. may be considered as the continuation of that of the North Pole. Mr. Arthur says: "A surface tunnel on the Excelsior claim disclosed a shoot 200 feet long, the ore still remaining in 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.

The shoot south of this is on the Eureka claim and is said to be 200 feet long and 4 feet wide. From these stopes came most of the shipping ore and a higher grade of milling ore, showing some free gold, not found in the other stopes. This shoot was mined out to the 260-foot level. There is another shoot still farther south which is imperfectly known, but from surface cuts and tunnels it should be 600 feet long and one-half foot in width, averaging from $5 up in gold."

While the deeper ore is fresh, that from the surface down to 100 feet below is more or less oxidized. Regarding the character of this oxidized ore see North Pole mine.

Columbia mine.—This mine is situated on Fruit Creek, at an elevation of about 5,600 feet, between the Golconda and the E. and E., and comprises two claims on the North Pole vein, called the Columbia and the Appomattox. It is owned by the Columbia Gold Mining Company, who also possess a number of other claims in the vicinity. The mine was sold to the present company in 1895 by Cable Brothers, but during the first few years there was but little gold produced. During the last three years the mine has been in active operation. The total production is not known, but is supposed to be in the vicinity of $300,000. There is a 10-stamp mill with six concentrators on the property, capable of crushing 28 tons per day. The tailings are saved, and during 1900 a cyanide plant was built to work them. Ten additional stamps are to be erected. Besides the milling ore, smaller rich chimneys are met with. This ore is shipped to smelters, one car of 20 tons containing about $1,000 per ton. The developments are extensive and comprise in all over 8,000 feet. There are three tunnels on the vein in the steep hill which rises 500 feet above the shaft house, the lowest being at the level of the latter. There is also a 500-foot vertical, 3-compartment shaft with five levels, from which drifts extend several hundred feet each way. Admittance below tunnel level was refused.

The country rock is the usual black argillite, rarely showing stratification or schistosity.

The surface croppings, which can be traced continuously from the E. and E., are very strong, showing a width of from 70 to 100 feet. The vein strikes nearly due northeast and has a southeasterly dip of 60°. Its general character is similar to that of the North Pole. It is a zone of fracture in the brittle siliceous argillites, with a width of about 40 feet, the walls being fairly well defined. Outside the walls there is no strong mineralization. The structure is well shown in the lower tunnel level. The zone consists of quartz, more or less completely filled with inclusions of argillite, from 3 feet in diameter down to the smallest fragment. These inclusions are cemented by normal, white vein quartz, clearly deposited in open fissures and sometimes showing drusy comb structure. The fragments are often so isolated by the quartz that though very abundant they could not have filled the space before the advent of the quartz. Still the quartz is certainly not derived from replacement, and often extends solid over spaces of several feet. This character of vein continues throughout the mine, I am informed, for a long distance, vertically and laterally, without closing down. The foot wall is smooth, hard, and extremely well defined. The hanging wall, though not so well marked, is formed of

argillite impregnated with pyrite. The argillite contains pyrite, and has in places been somewhat silicified, and is sometimes filled with metasomatic sericite. Some doubtful rocks also occur which are probably altered diorite-porphyry, and now filled with pyrite, calcite, and sericite.

The ore consists of quartz carrying up to 8 per cent of sulphurets, chiefly pyrite and arsenopyrite, though the altered slate may also show fair tenor. The solid white "bull quartz" and the sugary quartz carry no values. The average value of the ore is $10 and over per ton, chiefly in gold. About 40 per cent of the gold is caught on the plates, the bullion containing 702 parts gold and 277 parts silver. The concentrates are rich, carrying from $100 to $175 per ton, of which a considerable proportion is silver (Au: Ag = 1:15, by weight). Occasionally some coarse gold is seen in the ore. Smaller chimneys furnish rich ore, which is shipped, often containing 11 ounces gold and 39 ounces silver, or about $250 per ton. This consists of fragments of sericitized argillite cemented by vein quartz and containing native gold and sulphides.

A number of interesting minerals occur on this vein. They comprise native gold, native copper (tunnel level), pyrite, arsenopyrite, zinc blende (rare), pyrargyrite, cinnabar, antimonite, chalcopyrite (sometimes several per cent in shipping ore), stibnite (tunnel level), also an unidentified telluride.

In the shipping ore there occurs also a black tetrahedrite with brown streak, which, upon examination by Dr. Hillebrand, proved to be a mercurial variety, or schwatzite, not previously known from the United States. Among gangue minerals are to be noted quartz, sericite, fuchsite or mariposite (in the rich ore), and also a little calcite. The latter mineral seems to be of very late introduction, traversing quartz and argillite in minute and irregular seams.

As will be seen from fig. 81, the pay shoot as a whole occupies the southwestern slope of the ridge between Fruit and Cracker creeks and dips about 20° SW. on the plane of the vein, similarly to the pay shoots of the North Pole and the E. and E. mines. It is believed that the shoot as a whole is continuous from the top of the ridge to the bottom of the shaft, thus extending over a vertical interval of 1,000 feet. Within this shoot are found smaller chimneys of very rich ore. The pay does not occupy the whole width of the vein, but appears in streaks from 2 to 4 feet in width, following either wall or crossing from one wall to another. On the tunnel level the principal shoot follows the footwall, but throws out three ore splits, one of which carries much free gold and cinnabar and finally crosses over to the hanging wall.

The ore worked at present from the shaft is not altered by surface influences. Above the tunnel level a partial oxidation appears and

A. GOLCONDA MINE AND MILL.

B. RED BOY MINE.

the ore is no longer suitable for concentration, being apparently similar to the North Pole surface ore, which is roasted and cyanided. Much of this oxidized ore remains as yet untouched.

Golconda mine.—This part of the North Pole vein was located as the Golconda claim in 1887 and sold for a reported sum of $24,000 in 1897, there being at that time only 250 feet of development. The Golconda Mining Company at present owns, besides this claim, 8 others adjacent, which are said to cover 2 parallel veins. The Golconda and the Wide West are located on the North Pole vein. In 1898 a large bromination plant, of a capacity of 100 tons per day, was erected but soon found unsuited to the character of the ore. A 20-stamp mill and a Bryan roller mill, together with 18 concentrators, were substituted, giving a total capacity of over 100 tons per day. Crushing was begun in January, 1900, and the mine has consequently not as yet any great production to its credit. In the fall of 1899 a rich ore chimney was struck, 20 tons of which yielded $10,000 in the mill. Still richer ore was shipped to smelting works. In September, 1900, 15 stamps were running. At present there are 2,500 feet of developments, including a 400-foot double compartment perpendicular shaft and 4 levels, the opening of the fourth having just begun; also a 650-foot tunnel running southwest on the ledge.

The country rock is the usual black siliceous argillite, sometimes showing schistosity, but oftener massive. Occasionally this contains light-gray, very much altered dikes of an igneous rock which originally may have been a diorite-porphyry. The croppings of the main vein can be followed from the Columbia for at least part of the distance. A statement is made by some that there is a fault between the two mines; whether this is true is not certain; at any rate the vein holds its general direction well enough. The croppings are not very conspicuous except on the hill southwest from Golconda shaft, where they are marked by a very heavy mass of quartz similar to that above the North Pole. The outcrops carry low values throughout, rarely over $1 per ton.

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 on the fourth level 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 pay 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. The average value is believed to be from $8 to $15 per ton. The ore is in part free milling, containing from 40 to 50 per cent of gold which can be caught on the plates. The sulphurets are stated to be of comparatively low value, the percentage contained in the ore being from 7 to 14.

On the second level the crushing and the irregularity seem to have reached a maximum. On the fourth level the lode contracts to less than 100 feet and the ultimate walls are fairly well defined. The whole mass between them consists of crushed argillite with replacing sulphides and traversed by small quartz veinlets. The pay streak is from 2 to 3 feet wide. It is to be expected that more regularity will be found in depth, and it may also be expected that there will be somewhat less free gold. The pay shoots in general follow the trend of the vein, but a very rich chimney, alluded to above, did not follow this rule. It occurred on the second level, cutting across the general direction of the vein and dipping 30° SE. The shoot was 70 feet long and 14 feet wide; it did not extend far above or below the level. Only a part of it was rich in native gold. The ore consisted of an argillite colored greenish by roscoelite and containing arsenopyrite and pyrite. The native gold, accompanied by tetrahedrite, occurred chiefly in little seams and fractures filled with normal vein quartz. The drifts and crosscuts on the four levels run very irregularly owing to the difficulty in following the pay shoot in such a wide crushed zone.

Mountain Belle mine.—This adjoins the Golconda property on the southwest and is located on the same vein, which here crosses Silver Creek. The Mountain Belle is as yet not a producing mine, but extensive prospecting has been done during the last two years. The vein is developed by a perpendicular shaft in the country rock 300 feet deep, with crosscuts and drifts from the levels. The shaft is located on the northeastern side of Silver Creek, 175 feet above the stream, and at an elevation of about 5,450 feet. The country rock is the usual siliceous argillite without clearly defined stratification. The vein, which shows on the surface in big outcrops of mixed quartz and argillite, strikes N. 60° E. and has, contrary to the ordinary direction for this vein, a northwesterly dip. As on the other properties on this vein, the character is that of a crushed zone between two usually clearly defined walls, the width of the zone being from 20 to 50 feet. The foot-wall half of the vein consists largely of crushed argillite cut in all directions by quartz veinlets, sometimes with comb structure. The quartz often contains minutely divided pyrite and arsenopyrite; the argillite is often filled with pyrite. The hanging-wall part is almost massive quartz, but full of little fragments of silicified and pyritic argillite. In other parts of the mine the whole vein is a quartz-seamed argillite. Again, the whole mass may consist of crumbly

quartz. The values thus far developed are said to be low and much of the quartz is entirely barren.

Amazon, Analulu, and Bunker Hill claims.—The North Pole vein continues clearly marked across Silver Creek and through the above-mentioned claims. The Amazon has over 1,000 feet of tunnels on a vein said to be entirely similar to the Mountain Belle. On the Analulu also a considerable amount of development work has been done. On the Bunker Hill the vein shows quartz croppings of enormous extent; the developments here also exceed 1,000 feet, and the quartz is said to assay from $3 to $7 and over. Three claims, the Bunker Hill, Myrtle, and Lilac, are owned by a Canadian company. The vein where struck by the 300-foot crosscut is said to be 25 feet wide.

The great fracture, now traced for almost 4 miles, has gradually swung around from north-northeast to east-northeast. Beyond the claim last mentioned its continuation is not definitely known, but it is possible that it here splits into several branches. Already, near the Golconda and Columbia, important stringers leave the main ledge and continue somewhat divergent from it. These have not yet been traced out in detail. On one of these the Free Coinage claim is located, the place of principal workings being on Silver Creek, one-third mile above the Mountain Belle. Some 500 feet of work has been done and preparations have been made to sink a shaft. The vein is inclosed in black argillite, much crushed and filled with pyrite and stringers of quartz. Satisfactory ore is reported to have been found.

Ibex mine.—The group of three claims, Ibex, Nachez, and Pyrites, comprising this mine is located on the high divide separating McCully Fork of Powder River from the waters running into Granite Creek and the North Fork of John Day. The elevation at the shaft is 6,270 feet. Through openings in the forest a fine view is obtained across the heavily wooded Granite Creek Basin toward the Greenhorn Mountains. A short distance northward Bald Mountain rises to 8,330 feet. The property was bought a couple of years ago for a sum reported to be $60,000. Since then a great deal of development work has been done, consisting chiefly in a shaft 300 feet deep, with two tunnel levels, as well as a third and lowest tunnel level 800 feet long and driven 500 feet below the shaft on the Pyrites claim. Total development work, 3,000 feet. There is as yet no mill on the property.

The country rock is the usual black, hard argillite, sometimes, as at the Pyrites tunnel, showing the stratification very plainly. At this place its strike is nearly east-west and it dips steeply. A short distance northward the contact with the granodiorite of Bald Mountain begins. The vein is very strongly marked with large outcrops of mixed argillite and quartz. Its strike is E. 25° N. and its dip 60° SE. on top of the hill, increasing to 80° in the bottom of the shaft. The croppings are said to be poor, but in one spot the quartz showed free

gold and a considerable amount of pyrargyrite. The vein is from 6 to 10 feet wide and shows great similarity to the North Pole–Golconda vein. In general it consists of a zone of crushed black argillite between two usually well-defined walls. The argillite is filled with irregular quartz seams, sometimes showing plain comb structure. In other places the argillite occurs as inclusions in the quartz and is partly silicified and filled with pyrite. The pay is contained in the white quartz and is chiefly in the sulphides, which consist of pyrite and arsenopyrite. The gold, when occurring, is of rather pale color and worth only $13 per ounce. Pyrargyrite and cinnabar have been found, the latter in several places as apparently secondary seams in the quartz.

The mine is reported to contain three shoots: The first, struck near the mouth of the second tunnel, 150 feet below the shaft, and called the Boulder shoot, carries no free gold nor sulphurets, but the ore cyanides well after roasting. This ore is said to carry 95 per cent of its value in gold. The next shoots nearer the shaft lie on the hanging wall and are from 3 to 5 feet wide. The second shoot contains 60 per cent gold and 40 per cent silver, and includes as a smaller, 8-foot long lens, the coarse gold chimney, known from the surface and the second tunnel level. Finally, the most easterly shoot is said to carry 60 per cent silver and 40 per cent gold. The pay in this vein is believed to be rather irregular and pockety, but is thought to possibly average $10 per ton.

Bald Mountain mine.—This is located east of the Ibex, on the same vein. It is high up on the summit of the ridge, dividing McCully Fork of Powder River from the drainage basin of the North Fork of John Day River. The elevation at the shaft is 6,300 feet.

The mine has been developed but recently, though the vein has been known and slightly prospected for many years. The intention is announced to shortly erect a 20-stamp mill on the property.

Most of the following data regarding pay shoots and development were kindly furnished by the manager, Mr. H. S. McCallum.

The Bald Mountain Mining Company owns 38 claims, of which two, the Bald Mountain and the Midnight, are on the Ibex vein, taking in 3,000 linear feet of this. The principal vein is developed by a tunnel 500 feet long and by a perpendicular shaft at the mouth of this tunnel. Two levels are turned from this shaft, at 100 and 200 feet, and sinking is in progress below the latter level.

The country rock is a hard, black siliceous argillite, often massive, more rarely showing a stratification, the strike of which is nearly due east-west, the dip being 60° S. The vein is exceedingly strong and well defined. It is a typical fissure vein, showing a width from 1 to 30 feet and averaging several feet. Its strike is N. 60° to 65° E. and its dip averages 70° S., the vein thus cuts the stratification in strike and dip.

The gangue is throughout a white massive quartz, such as normally occurs as filling in fissure veins. The vein is sometimes filled with solid quartz, though more commonly, especially in the wider portions, much of the vein matter is a shattered argillite cemented by auriferous quartz. The vein shows in its structural feature a great resemblance to the Ibex, of which it is the extension. Besides free gold and a very small percentage of pyrite the quartz occasionally contains bunches of cinnabar.

Secondary changes apparently have had little influence except for a distance of 25 to 50 feet from the surface. Several ore shoots are known. All of them carry a certain proportion of free gold and appear to pitch steeply southwest on the vein. The first shoot near the mouth of the tunnel continues for 60 feet, carrying 50 per cent of free gold and equal quantities (by weight) of gold and silver. The vein is from 8 to 10 feet wide and the tenor of the ore is stated to be from $8 to $10 per ton. A second pay shoot, 75 feet long, of lower grade is met 190 feet from the mouth of the tunnel. A third shoot, 300 feet from the mouth, is 200 feet long, the width varying from 4 to 30 feet, and the value from $6 to $50 per ton.

On the first shaft level the first pay shoot was found a short distance from the shaft, its width of 8 feet gradually decreasing to 18 inches. Thirty per cent of the gold is here free. After cutting through this shoot the drift follows the partially pinched vein for 210 feet in quartz with low values of from $1 to $3 per ton. The second and third shoots have not yet been reached. To the east this level continues in ore for 14 feet.

On the second level the first shoot was met 100 feet from the short crosscut to the vein. To the east on this level there is another ore shoot 80 feet from the shaft that has been drifted on for 60 feet. It is proposed to open the vein by means of a 1,500-foot long crosscut lower down on the slope, giving backs of 900 feet, the mill to be placed at the mouth of this adit.

A short distance north of the main deposit are two strong veins, said to carry good ore, which may be offshoots of the principal fissure. They are called Fairview No. 1 and No. 2. In a small tunnel on the latter granite forms both walls, this being probably a dike or smaller intrusive mass in the prevailing argillite.

On the same strongly marked vein as the Ibex and the Bald Mountain, and half a mile eastward from the latter, is the Grand Trunk, on which the Ibex Company had a bond in 1899. Some 1,200 feet of development work was done. The vein is said to be similar in character to those of the two mines already described.

Mammoth mine.—The Mammoth mine is located near the head of the creek of the same name, at an elevation of about 6,300 feet. The gulch, which is a tributary to McCully Fork of Powder River, widens

near the mine. Thick timber covers the region, and down Mammoth Creek an excellent view is obtained over the southern part of the Blue Mountains. In the upper part of the gulch is evidence of extensive placers. The mine itself is one of the oldest in the district, having been worked by means of a primitive hand mortar, arrastre, and mill as early as 1881. A considerable amount of gold has been produced, stated by some to be as high as $150,000. The mine owned by the Bald Mountain Mining Company consists of the Mammoth and the Belle of Baker claims, both on the same vein, supposed to be an extension of the Ibex vein. In 1900 this mine was reopened, with excellent results. It is at present equipped with a 5-foot Bryan mill and four concentrators. The developments consist of an inclined shaft on the Mammoth 300 feet deep and a tunnel with drifts and crosscuts on the Belle of Baker, the latter on the west side of the creek.

One-half mile from the mine toward Sumpter the main granite contact is passed, and the prevailing rock at the Mammoth is a granodiorite. It contains, however, in places masses of argillite strongly contact metamorphosed. A contact between the two may be seen in the creek just below the mine. Most of the workings are in granodiorite, though occasionally argillite appears, as in the foot wall of the vein on the second level.

The vein, which without much doubt is continuous from the Ibex, has an east-northeast direction and a steep southeast dip, similar to the other principal veins in the vicinity. In the shaft from the upper part of which the old bonanza was extracted the vein is very wide—up to 20 and 40 feet—and consists of a crushed zone of rock, traversed by several gouge seams parallel to the ultimate walls, which are fairly well defined. The ore consists of crushed country rock cemented by quartz. Some of it is a very pretty breccia of argillite, which contains a little metasomatic pyrite and arsenopyrite, and which is cemented by crusts of calcite. The calcite again contains veinlets and druses of quartz. Neither calcite nor quartz contains any sulphides. The gold is of pale color and only 500 to 600 fine, the rest being chiefly silver. On the first level in the shaft the ore was poor, but in the second a good, though spotted, free-milling pay shoot was found containing from $6 to $12 per ton. The third level had not yet been developed.

Late in 1900 an important and rich pay shoot was found in the Belle of Baker tunnel. This was run as a crosscut for several hundred feet. The vein, when struck, proved to be 35 feet wide and to contain a 12-foot-wide ore body of crushed rock, with cementing quartz stringers and sulphurets, but no free gold. This body seemed to cut across the vein, making for the hanging wall. From this place a gouge streak in the vein was followed for 200 feet without showing any notable values. Crosscutting toward the foot wall, however, disclosed a large body of ore with much coarse gold, containing $25 to $400 per ton. At the present end of the drift a crosscut showed 16 feet of ore;

70 feet from the breast it had widened to 45 feet. A crosscut 170 feet from the breast and 50 feet from the place where the vein was first struck disclosed no ore, but an 18-foot upraise caught it 5 feet wide, so that the dip of the shoot would seem to be to the southwest. The ore consists of soft, gray granodiorite containing much calcite, and traversed by irregular seams of white vein quartz inclosing pale-colored free gold, together with a little arsenopyrite and pyrite. The gold, while to some extent directly in the quartz, seems by preference accumulated in a soft greenish roscoelite which looks much like chlorite and which is contained in spots and bunches in the quartz. Numerous smooth slips with polished surfaces of gold traverse the ore. Between the tunnel and the surface there is estimated to be between $200,000 and $300,000 in sight. This find is of interest as illustrating the necessity of crosscutting in these wide lodes. It is similar to the case of the Bonanza mine, inasmuch as a drift was long run parallel to the ore body without suspicion of its presence.

CABLE COVE DISTRICT.

GENERAL FEATURES.

The Cable Cove district is situated 10 miles in an air line north-northwest of Sumpter, on the high backbone which separates the drainage of Powder River from that of the North Fork of John Day River. The road from Sumpter follows Silver Creek, the principal fork of Powder River. For some miles above Sumpter the canyon is narrow, but soon widens and assumes the broad U-shaped form characteristic of glaciated valleys. Near Cable Cove the road emerges from the thick timber in the bottom of the valley. The head of the creek appears as a wide amphitheater with steep slopes, sparsely timbered. Westward the ridges of Bald Mountain rise with bare, light-gray, glaciated outcrops. Eastward a number of sharp and high granite peaks meet the eye in the continuation of the Elkhorn Range (Pl. LXXII). The elevation at the California mill is 7,000 feet; the high hill back of it attains 7,900. The gaps east and west of this hill are 7,500 feet in elevation. From the summit long ridges extend northward between the heavily timbered valleys of Big Limber Creek, Bull Creek, and the North Fork of John Day. The summits of Cable Cove culminate a couple of miles southwesterly in Bald Mountain (elevation 8,330 feet), so prominently visible from Sumpter. It is a bare granitic ridge, sloping abruptly northward and here inclosing a glacial amphitheater in the center of which is a small lake.

GEOLOGY.

The geological features are very simple. Cable Cove is situated in a large area of granodiorite, which begins a short distance north of the Free Coinage mine, the actual contact being covered, and which con-

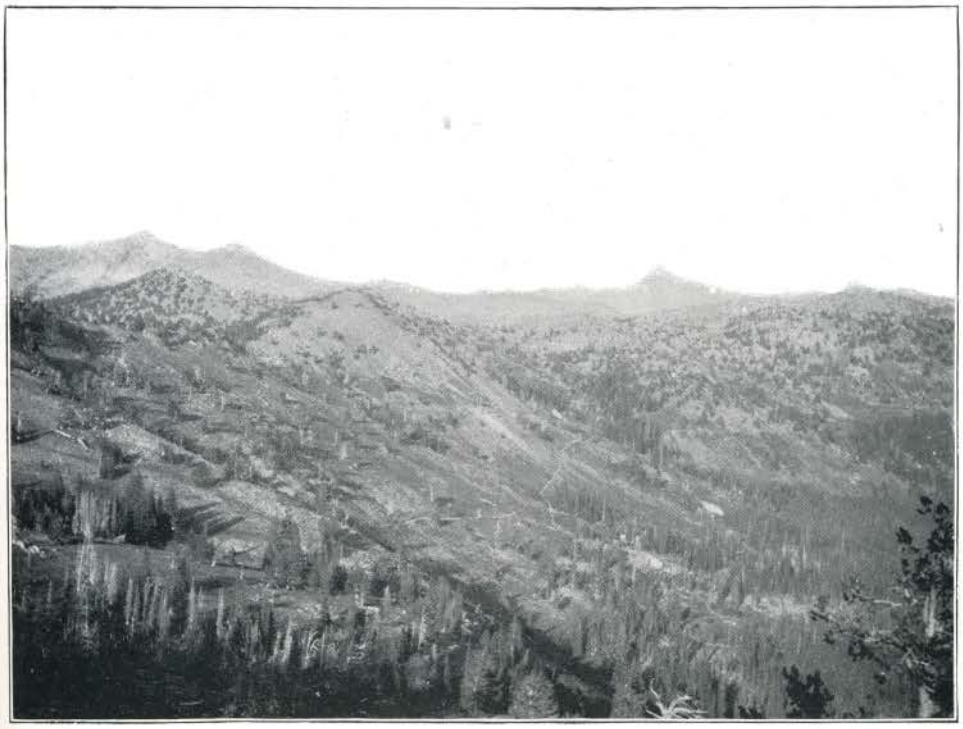
tinues for many miles northward. This rock, very similar to granite, is light gray, granular, and consists of quartz, andesine, orthoclase, biotite, and hornblende. For analysis and detailed description see page 587. Glaciated outcrops seem nearly white, while on the lower slopes the sandy decomposed rock appears light yellowish. Very few dikes of any kind were noted, the exceptions being small sheets of aplite. The granitic area culminates in a series of white, high, and jagged peaks situated between the headwaters of John Day and North Powder rivers.

Beginning a short distance north of the Crown Point claim and extending for several miles northwesterly on both sides of Big Limber Creek is an area of gneiss. The rock is usually sharply defined and separated from the granite and is certainly not a dynamo-metamorphic or sheared granite; neither is it a contact-metamorphic rock. It is coarse grained, very plainly schistose, sometimes contorted, consists of biotite, quartz, and a little plagioclase, and has the appearance of an Archean gneiss. At the Grizzly claims, below La Belleview mine, the strike is N. 40° E. and the dip 45° W. This occurrence is remarkable, because no rocks similar to it have been found in any other part of the area examined.

The whole summit region from Bald Mountain to the high country at the head of North Powder River bears clear evidence of having been glaciated. The higher peaks and ridges are bare, and sometimes polished surfaces are seen, though the rapid disintegration of the rock is apt to soon destroy any such marks. Silver Creek, below Cable Cove, contains morainal material as far down as the junction of the Mammoth road below the Mountain Belle mine, the elevation here being 5,400 feet. McCully Fork, joining Silver Creek near Sumpter, was also occupied by a glacier reaching down to an elevation of 4,700 feet. How far the glacier of the North Fork of John Day descended is not certain, but it pretty surely reached the mouth of the canyon at the road crossing, where the elevation is 5,200 feet.

GOLD-QUARTZ MINES.

General statement.—The mines of Cable Cove are among the earliest discoveries in the Blue Mountains, being found in 1872 by the Cable Brothers. Some rich ore was shipped in these early years, but the great expense rendered this impracticable for the ordinary run of ore. The development of the district was slow, owing to its inaccessible location. When the overland railroad was completed, about 1885, new activity followed and many claims were worked. Shipments of ore continued at intervals, and one concentrating mill was erected. During 1900 there was more activity than at any previous time. Development work was in progress upon a great number of claims and about ten carloads of ore were shipped to smelting works. Deeper exploration will soon determine the value of the district. At present



A. CABLE COVE, LOOKING EAST.

B. LOOKING SOUTHEAST FROM CABLE COVE.

ore is hauled to Sumpter, the distance being 14 miles, and sent by rail from that point.

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 (Pl. LXIV) 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 Herculean 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 northeast, 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 nine 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 a few inches wide of white, soft

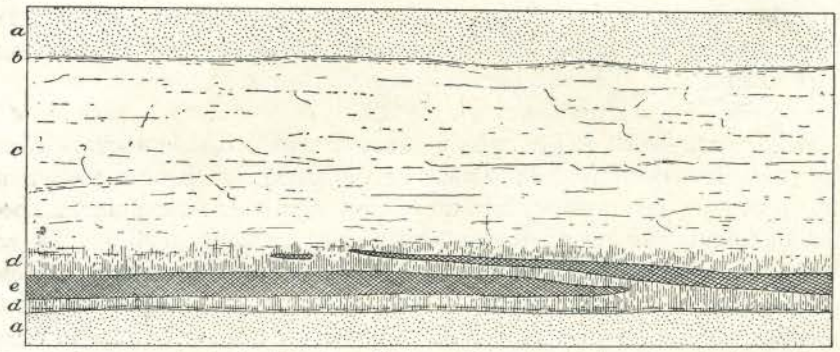


FIG. 82.—Structure of vein in Cable Cove district; width, 4 feet; horizontal projection; *a*, fresh granodiorite; *b*, hanging wall with clay gouge; *c*, crushed granodiorite; *d*, altered (sericitized) granodiorite; *e*, sulphurets with little quartz and calcite.

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 (fig. 82). 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.

California mine.—The California claim is 1,200 feet to the northwest of the Eagle vein, and is one of the oldest mines in eastern Oregon. It was located in 1873, and in 1876 the upper tunnels were begun. At that time there were only two other quartz mines in operation, the Monumental and the Virtue. In 1878 half a ton of ore, assaying $500 per ton, was packed on horseback to Umatilla and thence shipped to San Francisco. In 1896 a shipment of 5½ tons is reported to have yielded $105 per ton. Further shipments were made in 1893 and 1894 of ore assaying $60 to $80 per ton, and in 1897 several carloads were produced.

In 1897 a 10-stamp concentrating mill was built and run with unsatisfactory results for a short time. It is claimed that the whole width of the vein was milled, thus reducing the grade of the ore too much. During 1900 five cars, or 100 tons, are reported to have been shipped. The total production is not known, but probably does not exceed $40,000. The developments consist of 2,000 feet of drifts and crosscuts divided among six tunnels. The lowest working tunnel from which ore was extracted in 1900 is located on the steep slope 400 feet below the croppings. Its elevation is about 7,200 feet, its length 635 feet. A new crosscut, to be 900 feet long, is now in progress 400 feet lower down, 1,300 feet below the summit of California Mountain and 800 feet below the croppings.

Similar to the other veins northwest of the Eagle, the California shows inconspicuous croppings in granodiorite, strikes northeasterly, and dips steeply southeasterly. There is also on the property another parallel vein on which little work has been done. The ore is similar to that of the Imperial, consisting of heavy sulphurets in a gangue of little quartz and still less calcite. The ore seems principally of the shipping order, forming narrow streaks in a 3-foot-wide vein.

Other claims.—Above the mines just described California Hill is traversed by a great number of shearing planes, along nearly all of which more or less ore has accumulated. The developments are generally confined to short tunnels and small shafts. The extension of the Imperial is probably found in the Last Chance on the John Day side of the hill. From a tunnel on that claim some arsenical ore has been shipped. The probable continuation of the California is found

in the Ivy May. In the gap toward Bald Mountain is the Crown Point (elevation of croppings, 7,500 feet), which shows on the surface as a rusty belt of granitic rock traversed by seams of quartz and pyrite. An 800-foot crosscut tunnel is now being driven on this claim.

On the ridges between Bull Creek and John Day River, 1½ miles north of the California, is a group of veins with an east-northeast strike to which much attention has been directed lately. Among them is the Baby McKee vein, which is now being tapped by a 2,000-foot-long crosscut tunnel.

Other groups of veins extend with a northeast or east-northeast direction to a point 3 miles east-northeast of the California. Near the head of Cracker Creek, 2½ miles above the North Pole vein, this vein system crosses the contact of granodiorite and argillite. At least two veins enter the dark-gray, somewhat contact-metamorphic argillite. The Silver King, at an elevation of 7,000 feet, is developed by a tunnel 200 feet long and shows comb quartz with cubical pyrite; the width of the vein is 5 feet. Another vein, south of the Silver King, the Emma, is opened by a tunnel on creek level at an elevation of 6,400 feet; it strikes about east to west and dips 60° S. The width is 2 to 3 feet between walls, with a 6-inch pay streak of quartz, calcite, pyrite, and arsenopyrite. The principal value is in gold. This locality is called Quartz Basin, and some years ago a 5-stamp mill was erected here. The ore proved only partly amenable to amalgamation.

Out on the long ridges between Bull and Lake creeks are other veins which have been prospected recently. Having the same easterly to northeasterly strike, these veins are inclosed in a normal biotite-gneiss, which begins near the Rob Roy claim and continues several miles beyond La Belleview mine.

CAMP CARSON DISTRICT.

The mountainous and heavily timbered country north of Cable Cove does not contain extensive mineral deposits. Camp Carson, 20 miles in an air line north of Sumpter, is the principal mining district known in this region. Lying at the western foot of the high granite peaks of the Elkhorn Range near the head of the Grande Ronde River, it is accessible only by wagon road via Granite and Woodley, or by going up the Grande Ronde Valley from the town of Hilgard. This district was not visited; the following notes were obtained from Mr. Imhaus, of Baker City:

The formation is reported as granite. Near Hunters, 3½ miles below Camp Carson, on the Grande Ronde, are prospects on gold-quartz veins containing much sulphurets. Among them are mentioned the Royal, 6 miles south of Woodley. The vein is said to be

7 feet wide and to contain chalcopyrite and galena rich in gold. From the Pay Boy, 1½ miles southwest of Woodley, two carloads of ore are said to have been shipped. From the Muir zinc blende and galena, with good silver value, are reported.

Old placers have been worked in the Grande Ronde below Camp Carson, and also on Limber Jim Creek, 6 miles northward. Camp Carson itself is located at the head of Tanners Gulch, 1,200 feet above Grande Ronde River. These high placers contain a large body of well-washed, cemented, coarse gravels, presenting a bank 2,500 feet long and generally 15 to 20 feet high. This body of gravels is not exactly situated on the divide, as there are granite hills rising behind them; but it is apparent that they must have been deposited by a river system at very different level from that of to-day, and it is probable that they should be placed in the same category as those of the Griffith claims below Bald Mountain (p. 688).

While the gravels contain gold, their cemented nature interferes with the normal hydraulic process. A French company bought the deposits some years ago and installed hydraulic works, but the enterprise did not succeed well and the property was recently sold at auction.

GRANITE DISTRICT.

GENERAL FEATURES.

Under the Granite mining district will be described the headwaters of the North Fork of John Day River, Granite Creek, and its various tributaries above the town of Granite. The North Fork heads among the granite peaks of the northern Elkhorn Range, near Cable Cove, and flows in a general westerly direction for 20 miles. At this distance from its source it receives the tributary of Granite Creek, the different branches of which head in the gulches scoring the flanks of Bald Mountain and the ridge extending southeasterly from it toward Sumpter. From Bald Mountain northward the headwaters are among high and bare peaks, once glaciated, with elevations of about 8,000 to 8,500 feet. But the whole western part of the drainage area is a maze of deep gulches and moderately sharply cut canyons, separated by long timbered ridges which rarely attain elevations over 6,000 feet. The elevation at Granite is 4,680 feet. The region embraces old placer mining districts worked since 1863, and, as well, some of the most promising quartz mines developed in the last few years. The old mining town of Granite, which has recently acquired new life, is in the center of the area. A new town, called Lawton, has recently been started 2 miles below Granite. The region is splendidly watered and heavily forested, though there is but little yellow pine. The quality of the timber is not nearly so good as in Burnt River Valley and on the Middle Fork of John Day.

GEOLOGY.

Among the older rocks the argillites of the sedimentary series are the most extensively developed formation. They form a large area extending from the granodiorite of Bald Mountain westward until, below Granite, they are covered by basaltic flows. South of the Sumpter–Granite road they are especially prominent. The dark siliceous argillites prevail, but fairly fissile, black, and normal clay slates are not absent. No limestone was noted, neither have any fossils of any kind been found, so that the age of this formation is an open question. It is, however, clearly the continuation of the series developed at Sumpter and, like those series, may provisionally be regarded as Carboniferous. The strike and dip of the strata are not always easy to determine, on account of the massive character of the siliceous argillites; on the whole the strike is a few degrees north of west and the prevailing dip is southerly at steep angles. But in the vicinity of intrusive granodiorite or diorite this strike is frequently deflected. Thus the strike follows the contact of the Bald Mountain granitic area with northwesterly direction and dips of from 60° to 80°, and again near Alamo a northwesterly direction and northeasterly dip of 60° to 70° obtain. At Red Boy mine the clay slates appear in a very exceptional flat position dipping 15° W. These deviations are doubtless explained by the presence of intrusive diorites just west of these localities. Near the Bald Mountain contact the slates are contact metamorphic and schistose, while the alteration near the diorite of Greenhorn Mountain is less conspicuous.

The intrusive rocks include granodiorite and diorite. The granodiorite area of the northern Elkhorn Range and Bald Mountain projects southward from the latter peak along the ridge separating the drainage of Powder River from that of John Day, and it extends a little south of the point where the Granite–Sumpter road crosses that ridge. The rock is here coarse grained and dark; in fact, approaches closely to a normal diorite. Diorites of more basic character and closely connected with gabbro and serpentine appear west and southwest of Red Boy mine. Again, 8 miles north of Granite, on the north side of John Day River, a medium-grained, dark diorite appears rather extensively. The canyon below Klopp's placers is cut in this diorite, which often is irregularly crushed and recemented like the rocks described from the Virtue mining district and the southern end of the Elkhorn Range.

On Onion Creek and Lake Creek, north of Bald Mountain, an area of normal gneiss appears, which has already been described under the heading "Cable Cove" (p. 672).

The Neocene volcanic rocks are represented by andesite and basalts, which, however, do not cover as large areas as farther south; but

there is reason to believe that the basalts occupy vast areas north and northwest of Granite, down the North Fork, and on the Grande Ronde. Rhyolites are apparently not represented. A gray, in part tuffaceous hornblende-andesite fills the bottom of Bull Run from 5 miles above Granite to a point on Granite Creek a short distance below the town. The thickness of the flow is from 50 to 100 feet. The same rock also appears on Granite Creek, 4 miles above the town. Post-andesitic erosion has almost cut through the flow, so that narrow bluffs remain on both sides of the creek. The rock is compact and easily dressed, and can be used with advantage as foundations for machinery and boilers. Whether the andesite is older or younger than the basalt is not definitely settled. It certainly has the appearance of being covered by basalt, and this would correspond to the sequence established in the Burnt River drainage.

Normal olivine-basalts cover small areas near the Powder River divide where crossed by the Sumpter-Granite road. A small patch was also found at the Griffith placer mine, north of that road. Again, on the road leading by the Magnolia mine to Klopp's placers, on the North Fork, basalt begins near the divide at an elevation of 5,600 feet and continues northward over Crane's flat toward Klopp's placers and eastward as far as the Grizzly mine, on Onion Creek, below La Belle-view. Over this area the flow, which appears to be rather thin, is largely covered by clays and gravels.

The largest basaltic area is that which begins just below Granite and extends high up on the hills north and south of the creek. Bluffs of basalt line the creek at least down to 4 miles below Granite, and their elevation is not less than 5,000 feet, or 700 feet above the stream bed. On the south side these basalt flows connect with the large areas surrounding the headwaters of Desolation Creek and Olive Lake. The points of eruption of this basalt must have been located on the higher slopes of the Greenhorn Mountains.

It is clear that these basaltic flows dammed Granite Creek, and probably also the North Fork, to an elevation of at least 5,000 and possibly 5,500 feet, creating even more favorable conditions for the accumulation of sediments than in the upper Powder River and Burnt River valleys.

This damming explains many peculiarities in the upper drainage of Granite Creek. Soft sediments, similar to lake beds, are found in many places, and, resting on them, auriferous gravels which could not possibly have attained such positions except through a considerable elevation of the base-level (see description of Griffith's placers, below). The erosion has proved more active on this side than on the southern side of the mountains, which, indeed, was to be expected, as erosion has cut down much lower on the northern side. The barrier has been almost entirely cut through and the greater part of the sedi-

ments swept away. If we place the accumulation of the beds behind the barriers in the late Neocene (Pliocene), it is probably correct to refer the cutting of the canyon in the basalt to the early pre-Glacial part of the Pleistocene period.

The Pleistocene deposits are confined to the present river beds and the low benches, as well as to the moraines. The bottoms of Granite Creek and Bull Run as far as 4 or 5 miles above Granite are filled with gravels, forming a continuous flat up to a few hundred feet in width. For several miles below Granite the creek bottom continues several hundred feet wide and filled with tailings. Gravel benches sometimes occur along the banks from 25 to 50 feet above the creek.

Moraines are not extensive in this district. The gulches leading down from the north slopes of Bald Mountain were filled with glaciers, and it is probable that the moraine extended down to Klopp's placers (elevation, 5,200 feet).

Another center of former glaciation is in the Greenhorn Mountains. On their northern slope smaller glaciers descended as far as Olive Lake.

GOLD-QUARTZ VEINS.

General statement.—The important veins in the Granite district are chiefly contained in the argillites, and present in general a similarity to those of Sumpter and Cracker Creek districts. There are two prominent vein systems: The first extends from the Cougar mine in a northeasterly direction toward the Magnolia and Buffalo, and the veins dip southeast at steep angles. The second is developed near the Red Boy mine, the veins having a northerly strike and dipping west at angles of from 50° to 70°.

Red Boy mine.—This well-known property is situated on Clear Creek 15 miles in an air line west-northwest of Sumpter and 4 miles from Granite. The elevation of Clear Creek at the mill is 4,610 feet (by level), and the tunnel level is only about 60 feet higher. Heavily forested ridges surround the mine. The Red Boy for many years was worked intermittently and with indifferent results. Two mills were erected on it, each failing to achieve success. After that, Messrs. Taber and Godfrey, the present owners, built a small Crawford mill, which did excellent work for some time. Finally, in October, 1898, the present 20-stamp mill was installed, which has run uninterruptedly and successfully until the present time. As is so often the case, data regarding the total production were not obtainable, but as the mill is currently credited with turning out from $12,000 to $27,000 per month, it may be presumed that the total production since 1898 has not exceeded $300,000. The property is equipped with a 20-stamp water-power mill with amalgamating plates and 8 vanners. The low-grade concentrates are treated without roasting in a small cyanide plant, the

percolation extending over thirty days. This would indicate that value is in free gold adhering to the sulphurets.

The developments on the adit level consist of a main crosscut 1,200 feet long, 470 feet below the summit of the croppings, and drifts aggregating 3,000 feet. At present sinking is in progress on a vertical shaft located on the surface a short distance above the tunnel (Pl. LXXI, *B*).

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 so greatly altered that their original character is in doubt. Probably they were originally granite-porphyries, 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.

There are three veins, the Blaine, Red Boy, and Monarch, all of them having an approximate northerly strike and a varying westerly dip. The Red Boy dips 80°, the Monarch 50° to 60°. The outcrops are not very prominent, and the pay shoots not conspicuous on the surface. The general structural relations are diagrammatically shown on fig. 83. The Blaine is located 300 feet west of the Red Boy, and has not yet been struck in the crosscut. It appears on the surface as a wide vein with fair values. 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 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 structure of the vein is well shown on Pl. LXV, *B*, which is drawn from a photograph of a stope on the Monarch vein a short distance above the tunnel level and near the northern end of the shoot. The foot wall of the Monarch 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. This vein matter is traversed by a number of small quartz seams, rarely over 4 inches wide. Most of the seams are on the foot-wall side and produce a banded appearance of the vein. The best pay is contained in the 2 feet on the foot wall, 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,

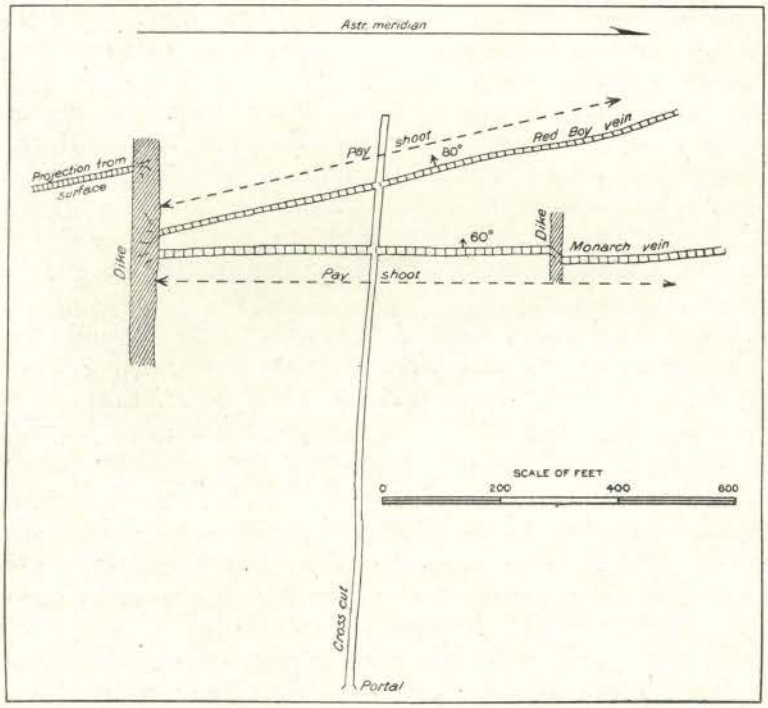


FIG. 83.—Approximate plan of Red Boy mine on tunnel level.

the crystals projecting from both sides of the seams meeting in a median line. There is no evidence of surface oxidation of the Monarch on this level.

The Red Boy vein averages from 3 to 6 feet in width and is in general structure similar to the Monarch (fig. 84), 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. This is given on authority of Mr. J. Arthur, an assayer at Sumpter, who also states that at one time, when the Crawford mine was running, more mercury was obtained from the amalgam than had been added. 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 are largely contained in the slate milled with the quartz. The average ore is reported to run about $12 per ton.

The ore shoots on the two veins almost coincide in extent, and it is said that even the richest places in them correspond. On the surface, however, the pay shoot of the Red Boy was only 100 feet long, and that of the Monarch did not reach the surface at all. The horizontal extent on the tunnel level is 800 feet. North of this the Monarch vein consists of crushed slate with small stringers of quartz. Considerable ore bodies still remain above tunnel level.

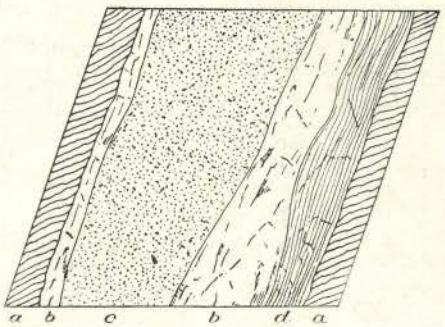


FIG. 84.—Vertical section of Red Boy vein in stope 100 feet above tunnel level; *a*, slate; *b*, quartz; *c*, soft altered porphyry; *d*, clay.

Claims near the Red Boy mine.—Among the many more or less developed claims near the Red Boy is the May Queen, which is about one-fourth of a mile distant, and, with four claims, covers the northerly extension of the Red Boy veins. The developments on the May Queen and adjacent claim consist of about 1,600 feet of tunnels and crosscuts, opening the vein to a depth of 350 feet below the croppings. In general character the ore issimilar to that of the Red Boy. A mill was erected during the winter of 1899–1900, but was run only a short time.

The Concord group of four claims adjoins the Red Boy on the west, and a considerable amount of prospecting work has been done here also.

Cougar mine.—About 4 miles north of Granite and only a short distance from the Magnolia is the Cougar vein. The elevation is 5,300 feet, and, like the Magnolia, it is not far from the main divide between Granite Creek and North Fork of John Day. Its discovery is of comparatively recent date. During 1900 it was actively worked, and a small cyanide plant had just been erected. The treatment of the ore seems to offer some difficulties, like that of the Magnolia.

The developments extend over a vertical distance of 200 feet and

consist of several smaller tunnels and shafts. The lowest tunnel, on mill level, strikes the vein after a short crosscut and follows it for 900 feet. The country rock is a black, siliceous argillite of imperfect fissility. Its strike near the tunnel is N. 80° E., and the schistosity nearly vertical. The outcrops are not conspicuous, and show plainly only on top of the ridge. The strike is due northeasterly and the dip 60° to 70° SE. The Cougar vein forms a sheared zone in the argillite from 2 to 10 feet in width, and is marked by two not very well-defined walls and several subordinate slips. There is a little quartz with some pyrite, but this is said to generally carry low values. The ore streak is formed by the soft, whitish gouge of varying width which follows the vein. Some of this is stated to be very rich, and the whole length of the main tunnel is claimed to be in ore. The values gradually shade off toward the outside, so that it would seem that, in contrast to many other slate veins, this is a typical replacement vein. The gouge, and also to some extent the slate adjoining the vein, carries finely divided pyrite and marcasite, and probably also a very small amount of arsenopyrite. There is no free gold even in the surface ore, and the concentrates are poor, running from $5 to $7; consequently, considering the value of the ore, it was believed that the cyanide process might be applicable. A sample of the soft gouge said to constitute the best ore yielded 0.68 ounce gold and 23.88 ounces silver per ton. Half a mile to the southwest is the South Cougar, supposed to be located on the extension of the Cougar vein.

Magnolia mine.—This is located about 5 miles north-northwest from Granite. The road leads up Granite Creek for 4 miles and then up a narrow gulch for 1½ miles. The elevation at the mill is 5,300 feet. Ascending some hundred feet farther brings one to the summit of the divide between the North Fork of John Day and Granite Creek.

The Magnolia mine was bonded in 1899 by English capitalists and a 10-stamp mill erected. Work was discontinued after a short run, and in the summer of 1900, when visited, the mine was idle and a large pile of concentrates heaped up outside the mill.

The developments consist in three tunnels, the lowest, at mill level, being 760 feet long, giving a depth on the vein of 286 feet. The two upper tunnels aggregate 550 feet in length.

The country rock is black argillite or clay slate. At Granite Creek below the mine the slates are distinctly contact metamorphosed, indicating the proximity of the granite contact. The slates near the mine show distinct fissility, strike N. 35° W. and dip 60° SW.

The vein strikes northeasterly and is said to show from 3½ to 14 feet of mixed quartz and slate. In tunnel No. 1 two pay shoots are reported, 190 and 140 feet long; and in the middle tunnel is another pay shoot, 400 feet long. In all about 30,000 tons of low-grade ore are said to be in sight. The richest ore is found in the upper tunnel.

It is stated that during the short run 2,000 tons of ore, with a value of $9 per ton, were treated. Only a small percentage of the assay value was saved. The ore contains a considerable amount of pyrite. The concentrates were found to assay 0.94 ounce in gold and 1.38 ounces in silver per ton.

Blue Ribbon and Buffalo mines.—These are located in slate on the main ridge a couple of miles northeast of the Magnolia, and may be considered as in the extension of the Cougar-Magnolia vein system. The claims are developed by tunnels aggregating 800 feet on each and said to show good ore bodies. The Buffalo is opened by a crosscut 300 feet below the croppings, and 300 feet of drifting along the vein has been done.

Monumental mine.—This is one of the oldest locations in the district, being discovered in 1874 by Mr. Burnham. Fourteen tons of ore, shipped the same year to San Francisco by pack train, netted $500, the ore containing much silver and no gold. Some ten years later the mine was sold to an English company, who erected a silver mill to treat the ore. At present it is idle, the last work having been done in 1894. The surface vein crops in granitic rock and has a northeasterly strike. It was 18 inches wide and showed a 4-inch pay streak extremely rich in ruby silver and argentite.

The development consists chiefly in a tunnel 1,400 feet long, 600 feet below the croppings. This tunnel is said to cut 16 veins, generally small and contained in hard rock. The southeasterly vein dips very steeply northwest, the others dipping 35° against it, so that they would eventually join. Higher gold values are found in depth than on the surface.

La Belleview mine.—This is also one of the oldest locations, being claimed in 1877 by Mr. F. E. Cabell, to whose kindness the following notes are due. In early days considerable ore was shipped by pack train to Umatilla, and thence by water to San Francisco. A Huntington mill of a capacity of 35 tons per day with concentrators was erected in 1897 and run until 1899. The veins, on which about 7,000 feet of development work has been done, crop in a normal biotite-gneiss, and are located on a main ridge projecting from Bald Mountain toward Granite. The elevation is 6,500 feet; the summit of the ridge above the mine is 7,303 feet. There are two parallel veins with a northeast strike and with a steep northwest dip on the surface, changing to a similar southeast dip in depth. The gangue is quartz with a little calcite. The ore minerals are pyrite, chalcopyrite, galena, pyrrhotite, and strongly argentiferous zinc blende. Among rarer minerals occurring are native wire silver, argentite, tetrahedrite, stephanite and freibergite, the latter containing 1,000 ounces silver per ton.

The ores contain up to 7 per cent lead and ½ per cent copper; shipping ores run from $60 to $600 per ton, one-third of the value being

gold, lately increasing with depth to one-half. The concentrates contain $60 per ton.

In the canyon leading down from La Belleview mine to the North Fork of John Day are several veins cropping in gneiss. One of these, the Grizzly, is located 2 miles below La Belleview mine and has a north-northeast strike. It is developed by three tunnels and shows on the surface with wide rusty croppings. The gangue is quartz accompanied by much low-grade pyrite in heavy masses.

PLACER MINES.

The placers of Granite have been worked since 1862, but were scarcely as rich as those of other celebrated districts. A large part of the mining has been done by Chinese. In 1870 there were 40 white men and 200 Chinese in this district (Raymond's report, 1870). The production is not mentioned. In 1882 the Granite placers produced $20,000, in 1889 $20,000, in 1891 $8,500, in 1892 $28,800 (Mint reports). The present placer production is apparently fairly steady, a number of small mines having been worked for many years with constant output. The total output does not exceed $20,000 per annum.

The gravels in the stream beds of Granite Creek, Bull Run, and Clear Creek have been worked, chiefly by Chinese, for several miles above Granite; and below that place Granite Creek has also been worked. The gravels averaged 9 feet deep and from 50 to 300 feet across. Low gravel bars 30 feet above the river were also washed. Work on these gravels ceased about ten years ago.

The North Fork of John Day has been worked from a point 7 miles northwest of Granite, where Thornburg's placers are located, up to Klopp's placers, where the Grande Ronde road crosses the stream. But little gold was found above Klopp's. Thornburg's placers, which were not visited, have been worked steadily for many years, and with an annual output of several thousand dollars.

The Black Pine placers are situated on a small flat at an elevation of 4,800 feet, a mile below the Cougar mine. They have been worked recently on a small scale. The gravels, of coarse argillite cobbles, rest on a bed rock of volcanic breccia. Johnson placers, on Crane Flat, have been worked successfully for many years. A system of ditches and reservoirs supplies water for a long season. Two hydraulic giants are operated. The gravels are said to be unusually rich. The mines are situated a short distance north of the divide separating Granite Creek from the North Fork and at an elevation of 5,500 feet, 5 miles north of Granite. Going up the steep gulch in which the Magnolia mine is situated, one crosses a small basalt flow at the divide. From here down to the North Fork extends strongly contrasting, gently sloping ground with clayey and gravelly soil, covered with poor forest and a succession of flats and meadows. The clays are

covered by thin gravels, which are washed and which probably derive their gold from the Buffalo and Blue Ribbon veins, situated a short distance above on the main ridge.

Klopp's placers are situated on the North Fork, 2 miles north of Crane Flat, the river here having an elevation of 5,200 feet. These diggings have been worked for many years on a moderate scale and are said to have regularly produced from $3,000 to $6,000 per year. The deposit is certainly one of the most remarkable that has come under observation.

The clays and sands of Crane Flat continue down to the river and the workings extend in irregular pits up to 130 feet above the stream. There is, as a rule, no bed rock visible, though the sediments lean against a high western rim of diorite in which the river has eroded a narrow canyon; but in one place a projecting point of argillite laid bare by the hydraulic work appears in the diggings, and at another place a small knob of basalt occurred below the gravel. The pay dirt is a most peculiar mixture of sand, fine, well-washed gravel, and heavy, partly rounded bowlders of granodiorite and diorite, and also of basalt and slate. The bowlders are irregularly mixed in the clayey sand and the gravel, which rarely shows any stratification. In one place, however, strongly pronounced fluviatile bedding was noted in a bank of sand underlying 12 feet of heavy bowlders mixed with sand. The gold is well washed and generally fine. The gravels are not rich, but the gold seems equally distributed through the mass.

The explanation of this deposit is probably to be found in the damming of the river by Neocene basalt flows to a level of 5,500 feet, and a simultaneous accumulation of gravels in the basin thus produced. There does not seem to be any deep channel through which the North Fork could have found an outlet toward Granite Creek, but the clays and gravels probably do cover the auriferous channel of an old tributary to the North Fork coming down from the vicinity of La Belle-view and Buffalo mines. To judge from the granitic bowlders so abundantly scattered over this deposit it seems probable that the moraine of the glacier which once filled the upper valley of the North Fork reached down to this elevation and that the Neocene deposit has been worked over by glacial agencies.

Throughout the upper drainage basin of Bull Run above Granite many observations show that, in this watershed also, a damming by basalt flows similar to that below Granite has taken place and that the whole basin once was a lake which received fine sediments and along the margin of which, during its highest stand and during its gradual recession by canyon-cutting, the streams deposited their auriferous gravels. The best evidence of this is found at the Griffith placer mine, located 6 miles northwest of Sumpter. The road from Sumpter to Granite passes over a low gap (elevation 5,800 feet) in the ridge

separating Powder River from the Granite Creek drainage basin. Descending the slope toward Granite, one finds that the diorite of the dividing ridge soon disappears, and at an elevation of 5,300 feet the gentle slopes and small flats are covered with a clayey material with scattered, well-washed gravel. Nearly all the gulches in this vicinity have been worked with more or less success. Two miles below the summit a roads leads off to the north, crosses Beagle Creek, and ascends Canal Creek some distance. The latter contains a considerable amount of auriferous gravel still available for placer work.

Griffiths Camp is situated a short distance above Canal Creek, at an elevation of 5,289 feet, or 860 feet above Sumpter. To the west rises the main dividing ridge of granodiorite, about 700 feet above the placers. About the mines there is gently sloping ground, a sort of an ill-defined bench, below which the ground falls rapidly toward Bull Run. The gravel forms a small body on the north slope above Canal Gulch and extends, apparently resting on the slope of the hill, for 1¼ miles in a northwesterly direction. Back of it is high bed rock, but in front the downward slope of the country is unbroken. A hydraulic pit about 1 acre in extent has been made in the high gravels, and a bank 40 feet high is exposed. The gravel is fairly fine, sandy, extremely well washed, and shows fluviatile stratification. On the bed rock lie coarser cobbles of slate and porphyry, also well washed. The continuation of this body in a northwesterly direction is not well exposed, but it seems to lie on a slope, and the extent and depth are difficult to estimate. Although a part of the gravel doubtless rests on diorite, the portion exposed in the pit lies on well-stratified beds of clay, with coaly layers dipping 30° toward the main divide. Thirty feet of these clayey beds are exposed, resting on granitic bed rock. The gold in the gravels is fairly coarse, but it is not probable that the material is very rich, though it may well pay for washing. On the slopes below the deposit and in Canal Gulch the gold has been reconcentrated, and these gravels are much richer. A small area of basalt covers a hill rising 150 feet above the gravels and seems to directly overlie the latter.

The water supply is taken from Canal and Boundary creeks, on the western slope of Bald Mountain, the ditches aggregating 9 miles in length.

ALAMO DISTRICT.

GENERAL STATEMENT.

From the Red Boy to Alamo, a distance of about 4 miles, the argillite continues, no igneous rocks being seen. Near the town of Alamo Clear Creek receives two branches, Olive and Beaver creeks. On all three creeks above Alamo good prospects occur and all of the veins crop in argillite. On Beaver Creek several promising properties are

said to be located, but this part of the district was not visited. The claims described below are situated on Clear Creek and Olive Creek. The creeks have been extensively worked for placer gold, Olive Creek and its upper tributary, Quartz Gulch, being especially rich. A belt of diorite, serpentine, and gabbro begins a short distance west of the Red Boy and continues south, crossing Clear Creek some miles above Alamo. Higher up on its tributary, Spring Creek, at the Little Giant mine, the argillite again appears. The slates near the head of Olive Creek contain strata with detritus of igneous rocks, chiefly surface lavas erupted simultaneously with the deposition. The slates are of the usual character, black clayey argillites, alternating with dark siliceous and cherty rocks. At Alamo the strike is north to northwest, the dip east at angles of 60° to 70°.

QUARTZ VEINS.

Alamo claim.—This is located on the ridge between Olive and Clear creeks, three-fourths of a mile west of Alamo, 650 feet above the latter and at an elevation of about 5,550 feet. It was located in 1899 and as yet is not greatly developed. The country rock is a soft, decomposed argillite, in part siliceous. The vein strikes N. 25° E. and dips 60° ESE. The general character is that of the usual type of composite veins. A maximum width of 20 feet is attained, the vein matter being a brown, soft, decomposed mixture of quartz and argillite. On the well-defined hanging wall is a 4-foot pay streak panning well in free gold, while the whole width prospects more or less. Certain parts of the rock outside of the hanging wall also show good values. On the foot wall lies a 5-inch streak of black decomposed sulphides. The developments consist of a 90-foot crosscut about 70 feet below the croppings, and a 70-foot winze sunk on the pay shoot below this level. The prospect seems promising, although it is probable that the ore will become more base as the present workings are deepened.

Quebec claim.—The ridge between Clear Creek and Olive Creek contains many strong quartz veins. About 3 miles west of Alamo is the Quebec, which is rather extensively developed and is said to be a very promising property. It has recently been sold to a company that proposes to erect a mill on the same. The Quebec is developed by three tunnels, the uppermost being 750 feet above Clear Creek, and drifted 240 feet on the vein; the second tunnel, 120 feet lower, is run on the ledge for 500 feet; while the lowest is a crosscut, just started, 400 feet below the croppings. The vein, which crops prominently and strikes northeasterly, consists of the usual brecciated argillite, cemented by quartz, which often shows pronounced comb structure. The width is 10 feet, sometimes increasing to 30 feet. In the vein matter of altered argillite occur spots and streaks of a green, earthy mineral, which is

finely divided chromium mica (fuchsite or mariposite). It is claimed that there is a pay shoot, 4 feet wide, of good milling ore, containing, in places, bunches of richer ore with visible gold; some of the latter ore is reported to have been shipped.

Other claims.—Near the Quebec is the mine of the Scandia Tunnel Company, which is working on a long crosscut tunnel running in under the ridge to top ledges cropping near the summit. On the north side of the creek, near the junction of Clear Creek and Lightning Creek, is the Wilson vein, its croppings showing prominently 100 feet above the creek. The croppings, which are traceable for several hundred feet, with a direction of N. 35° E., consist of the usual zone of crushed argillite cemented by quartz. Green stains of chromium mica are common in the slate inclosed in the vein. The developments consist of a tunnel giving a depth of 70 feet.

On the south side of Clear Creek, at Alamo, a 450-foot tunnel, 25 feet above the creek, has been driven by the St. Anthony Mining Company. In this distance the management claims to have crosscut four large lodes, 60, 50, 152, and 35 feet wide. It appears very clear that these "lodes" are nothing but slightly mineralized strata of the argillite cut about perpendicular to the strike. The croppings above the tunnel show nothing but heavy benches of siliceous argillite with northwesterly strike and steep southwesterly dip. The rock throughout the tunnel is soft, crushed, and decomposed—a light-gray argillite filled with light-green streaks of earthy chromium mica, and in places cut by seams of quartz, calcite, and pyrite. A great number of assays have been made, and all are said to show a minute quantity of gold. The occurrence is of interest as showing an extensive impregnation of the country rock by auriferous solutions.

Conditions similar to these appear to occur in Nevin's claim, near the town of Granite, where a 200-foot tunnel has disclosed soft slate filled with little bunches and lenticular masses of quartz and calcite and small seams of pyrite; also the same chromium-stained green spots in the slate so often noted from this region. This is probably also a case of impregnation along certain strata of argillite. Small assay values are constantly obtained.

Strasburg claim.—This is located 1 mile above Alamo, on the west side of Olive Creek. The developments consist of several shorter tunnels and a 500-foot crosscut from the creek level at an elevation of 4,950 feet, not yet completed. The steep slopes, adjoining a gravel flat in which Olive Creek flows, consist of very decomposed siliceous argillite without clearly defined strike, and contain dikes of a likewise soft and decomposed porphyry, probably a granite-porphyry. There are two adjacent veins, one of which shows an outcrop of quartz with argillite fragments, 300 feet above the creek and 25 feet across. This is reported to average $5 in gold, one 4-foot streak showing better

values. An intermediate tunnel exposed both veins, which are here of only moderate size; the one carrying the big outcrop is here less than 1 foot wide.

Yellowstone and Van Anda claims.—Across Olive Creek from the Strasburg is the Yellowstone, opened by a 600-foot crosscut. Several other lodes are found on that side of the creek, all having a northeasterly strike.

Two miles farther up Olive Creek, also on the west side, are the Van Anda claims, which are said to cover strongly pronounced croppings similar to the Strasburg and other argillite veins. The developments are not very extensive.

Little Giant mine.—At the foot of Greenhorn Mountain, near the head of Spring Creek, is located the Little Giant mine. The elevation is 5,911 feet. The road from Alamo, which is 6 miles distant, follows up Spring Creek through thick timber. Though placers were formerly worked in this creek, no quartz vein had been found until in 1898, when this mine was uncovered. The following year it was sold for $30,000, according to report; developments were begun and a 20-stamp mill was ordered. On account of various financial vicissitudes, all work was suspended in the summer of 1900, though later on work in the lower tunnel has been resumed.

The developments consist of a 40-foot shaft on the croppings (elevation 6,240 feet) and an upper tunnel 80 feet lower down; this is a crosscut for 300 feet and the ledge has been drifted upon for 200 feet. The lower tunnel, 350 feet below the croppings, is at present 850 feet long, but had not, when visited, reached the vein.

Along Spring Creek, the prevailing rock is serpentine and diorite; but at the mill is a contact, and the whole east side of the gulch is composed of dark-gray, massive argillite. The vein strikes due northeast, while its dip is as yet unknown. The croppings do not show prominently, but are well exposed by means of trenches. Good pay is reported all along the surface for 600 feet northeast. Toward the southwest the serpentine contact is not far away and the vein does not seem to be traceable across it.

In the upper tunnel the usual character of veins in argillite is shown. It is a belt of crushed argillite, in places reaching 20 feet in width, filled with quartz seams and locally crushed and clayey. Much of the quartz is stained green by chromium mica, the metal probably being derived from the adjoining serpentine. No pyrite is visible in the decomposed quartz. The seams, as usual, show clearly defined comb structure, indicating deposition in open space, and the argillite is not much silicified.

The lower tunnel, as stated, has not yet cut the main vein, but has encountered two others, not known on the surface, which is covered by débris. The first of these was found 300 feet from the portal, strikes

northeast, is vertical, and consists of the usual quartz-cemented argillite, 3 feet wide. It is said to carry good value. The next, 800 feet from the entrance, strikes east-northeast and dips 45° SE. It is 1 to 2 feet wide and carries much pyrite and arsenopyrite.

PLACERS.

The streams above Alamo—Beaver Creek, Clear Creek, and Ruby Creek—are filled with gravel to a depth of 15 feet and a width of from 50 to several hundred feet. All of these water courses have been washed, though few placers have records of having been extraordinarily rich. Old placers on low gravel benches are also found on Spring Creek, a mile or two below the Little Giant mine. Most of this kind of placer work has been done by Chinese. Olive Creek and Quartz Gulch are the localities reported richest. For a mile or two above Alamo, Olive Creek widens considerably, but the gravels in this flat are said to have been too deep for successful work by old methods. If found rich enough they might be successfully dredged. Quartz Gulch, coming down from the vicinity of Robinsonville, is said to have been especially rich. The gold ranges in value from $14 to $17 per ounce, the poorest quality being found high up on the creek, where much ragged quartz gold appears. On the road from Olive Creek to Robinsonville, near the divide toward Lightning Creek, a patch of rhyolite covers the slates, and on this rhyolite, at an elevation of 5,500 feet, rests a small body of auriferous gravels, which have been worked to some extent. This is another instance of the high gravels which are found in the Granite Basin about elevations of from 5,300 to 5,500 feet, and which indicate a damming by basaltic flows to this depth.

The Olive Creek mining district was organized in 1863, and in 1870 80 white men and 50 Chinese were at work. About 1873 the yield began to decline. In 1882 15 white men and 20 Chinese were at work, and the placers are reported to have yielded $13,000. Since then the production from this source has steadily diminished, and at present but little placer work is being done.

GREENHORN DISTRICT.

General statement.—This district, situated in the Greenhorn Mountains, embraces an approximate area of 18 square miles, extending for 6 miles east to west and 3 miles north to south. Greenhorn Ridge forms a high backbone, with bare summits, dividing the waters of the Middle Fork from those of the North Fork of the John Day River. It culminates in Greenhorn Peak, with an elevation of 8,130 feet above the sea, situated at the head of Clear Creek. The vicinity of this peak is the highest portion of the ridge; eastward, it falls off toward Robinsonville; westward, the ridge continues with an eleva-

tion of above 7,000 feet for about 10 or 12 miles, when it gradually sinks. A prominent gap, at an elevation of 7,200 feet, exists in the eastern part of the ridge at the head of Boulder and Desolation creeks. As may be expected, the climate is rough and means of communication are scant. One principal wagon road leads up Clear Creek from Alamo, climbing a long ridge which finally reaches the summits and the gap mentioned by way of the Ben Harrison and Potosi prospects. Another road leads up to the Intrinsic group from near Robinsonville. West of Boulder Creek there are no roads and few trails. Aside from a few sharp peaks the summit of the ridge is rather flat, and is sometime half a mile or a mile broad, sharp ravines being incised on both sides.

Geologically, Greenhorn Ridge is composed of an oblong area of older rocks, surrounded on the north and south at a lower level by lava flows in which the North and Middle Forks of John Day River have cut their broad canyons. The older rocks extend eastward with lower elevations, and connect with Bald Mountain and the Elkhorn Range. Westward their extent is not known, though they are ultimately submerged below basalt; but there are considerable areas of diorites and slates in the lower drainage of the Middle Fork and on Desolation Creek. The larger part of the ridge consists of diorite, gabbro, and serpentine, with minor areas of contact-metamorphic slates. The ridge north of Clear Creek consists of hard, dark-gray to light-gray diorite and quartz-diorite. A short distance above the Potosi contact-metamorphic slate with varying strike (at the road the strike is east-west, dip vertical) begins, but is not extensive. It is cut by areas of dark-green serpentine weathering brown. At Boulder Gap the rock is a light-gray granodiorite or quartz-diorite. This continues down Boulder Creek on the east side as far as the Ornament claim, and still farther down on the west side, when serpentine and slate again begin. The same rock forms the broad and high ridge east of the gap, in which but few prospects are known. Patches of basalt cover the ridges in places, especially west of the gap.

The deposits are fissure veins carrying their value chiefly in silver, thus differing from the auriferous character ordinarily found in this region. Few of these deposits can be ranked as mines, inaccessibility and expense of treatment having retarded this section very much. A few of the claims, among them the Ornament, Tempest, Ruby, Carbonate, and Potosi, were visited; regarding some of the others reliable information has been gathered.

The silver veins of the Greenhorn Mountains have been known at least twenty years, and smaller developments are noted in the Mint reports of 1890 and 1891. Lately they have been prospected more extensively.

Rich silver ores have at intervals been shipped to the smelters in

small quantities from these prospects, the Tempest being the largest producer, with 180 tons. The expenses are very high, so that ore, to be profitably shipped, must contain at least $25 per ton. The ore must be hauled 35 miles over difficult roads to Sumpter, loaded on cars there, and reloaded on the main line at Baker City. Further, they are not very desirable smelting ores, containing no lead, but often, on the contrary, arsenic and zinc in quartzose gangue.

The ore consists of two classes: (1) Pyritic ores with pyrite, arsenopyrite, and zinc blende. These occur as seams and veinlets in large veins of altered quartz-diorite. (2) Tetrahedrite ores, consisting of irregular masses of this mineral in wider bodies of quartz. The developments are scarcely extensive enough to prove whether large masses of low-grade ore occur. If so the first class can, no doubt, be economically concentrated, but to the second this procedure is only applicable with considerable loss on account of the soft character of the tetrahedrite, which is apt to cause rich slimes.

Description of veins.—Near the eastern end of the high ridge are several important groups of claims.

The Intermountain group (also called the Snarr), about 3 miles due west of Robinsonville, was located in 1890 and is said to show three well-defined quartz veins in diorite and greenstone. The strike is northeast, the dip nearly vertical. The ore consists of quartz gangue with tetrahedrite, rich in silver, and the pay streak is reported 3 feet wide. Ore to the value of $5,000 has been shipped.

The Intrinsic group, in the same vicinity, also known as the Ordway mines, is said to contain two veins converging to one at a depth of 100 feet. The developments consist of a tunnel 800 feet long. The ore is similar to that of the Intermountain, consisting of quartz gangue with irregular grains of tetrahedrite.

A few miles farther west, on the Summit plateau, is the Morris, likewise containing rich tetrahedrite and credited in the Mint report of 1891 with a production of $15,000 in silver and $3,400 in gold. A short distance northwest of the Morris are the Mountain Consolidated, Potosi, and Savage claims, at an elevation of 7,200 feet, all fissure veins in fine-grained diorite, and developed by short tunnels. The strike of the Potosi vein is N. 20° E., the dip 40°E. The gangue is quartz, in part with comb-structure and sometimes frozen to the walls. The width is moderate and the ores consist of pyrites, arsenopyrite and zinc blende, with a little chalcopyrite and bornite. The values are chiefly in silver, but with a little more gold than is usual in the Greenhorn veins. In 1900 about 80 tons of ore were shipped to smelter, and reported to contain $53 per ton. One mile northeast of the group is the Ben Harrison, carrying similar ores.

At Boulder Gap (elevation 7,200 feet) is the Carbonate vein, strik-

ing northeasterly and developed by a short tunnel. The country rock is the quartz-diorite, close to the serpentine. The ore consists of fine-grained quartz, with some dolomite or magnesite, and containing arsenopyrite and pyrite, as well as stains of green chromium mica.

Going down Boulder Creek southward from the gap, the Ruby and the Chloride are passed on the right. Both are developed by a few hundred feet of tunnels, strike northeasterly, are contained in quartz-diorite, and present a general resemblance to the Tempest described below. Minor shipments of ore have lately been made from the three last-named claims. The ore consists of arsenopyrite, pyrite, zinc blende, and a little galena, all occurring in many small veinlets of comb-quartz in a diorite which is bleached by the development of sericite and calcite.

One mile down from the gap are the Tempest veins, at an elevation of 6,500 feet. The developments consist of several short tunnels. From this mine a considerable quantity of ore has been shipped, yielding a profit in spite of very adverse conditions; shipments are reported to aggregate 180 tons. There are 5 veins cropping in quartz-diorite, striking N. 35° E. and standing nearly vertical. The veins are from 2 to 4 feet wide and consist of altered sericitic country rock traversed by small stringers and streaks of comb-quartz, with arsenopyrite, pyrite, and zinc blende, the value being chiefly in silver, with very little gold.

Still half a mile farther down the gulch is the Ornament, developed by three tunnels, aggregating several hundred feet. The vein is located near the contact of slate and serpentine with quartz-diorite. The ore is similar to that of the Tempest. Small shipments were made as early as 1890.

ROBINSONVILLE DISTRICT.

GENERAL FEATURES.

A broad shoulder of Greenhorn Ridge projects eastward beyond Robinsonville, its flanks deeply scored by ravines leading down to Burnt River on the east and to the two forks of the John Day on the north and the south. The elevation at Robinsonville is 6,200 feet.

The rocks exposed are the same as in the Greenhorn Mountains; that is, they comprise large areas of serpentine, gabbro, diorite, and quartz-diorite. Included slate masses are not common. Near Robinsonville the serpentine occurs in extensive areas, and probably results from alteration of olivine-gabbro. All of the rocks mentioned are believed to form one series, and they can scarcely be separated on the map. They appear to be different facies of one intrusion and are more recent than the argillites into which they are intruded. Robinsonville is an old, celebrated placer camp, but at present consists only of a few dilapidated log cabins.

QUARTZ VEINS.

Since early days the presence of gold-bearing veins was known, and they have been worked intermittently. On the whole the deposits seem to be pocket veins, and many rich little quartz chimneys have been found in the flat on which the town is situated. In contrast to the other veins on the Greenhorn Mountains, these are auriferous, and present such curious features as the association of native gold, galena, and dolomite.

The Spero, at Robinsonville, is in serpentine, strikes N. 30° E., is 10 to 15 feet wide, and is composed of massive white quartz.

The Virginia, one-fourth mile north of Robinsonville, in coarse, partly crushed gabbro, has a shaft 160 feet deep. Long ago a pocket of $20,000 was found in it, but more recent prospecting has failed to produce more.

In the Morning Glory, one-third of a mile northwest of Robinsonville, the vein strikes due north and dips 80° W. The gangue is a normal comb-quartz with free gold. Some of it has been sacked for shipment. Several small pockets have been found close by.

The Junebug, one-fourth of a mile southwest of Robinsonville, in serpentine, has a northwesterly strike. The vein contains much dolomitic carbonate, and also galena, together with free gold. The developments consist of two small shafts. Fifty tons of ore, worth $25 per ton, have been milled.

The Don Juan and Phœnix are located about 1 mile south of Robinsonville, on the headwaters of Burnt River. The ore consists of coarse, granular dolomite, with a little quartz and galena. It contains abundant high-grade gold, intergrown as small grains with the carbonate. The mine has an 80-foot shaft, 1,000 feet of development, and a 10-stamp mill. A pay shoot, 30 feet long, 4 feet wide, and containing about $36 per ton, was found here, but did not hold out in depth.

The Banzett is located 2 miles west of Robinsonville, on the headwaters of the Middle Fork of John Day River, at an elevation of 6,350 feet. The vein is in a soft, decomposed, serpentinoid rock, and is developed by a shaft 100 feet deep, and a tunnel 1,000 feet long 100 feet below it. The gangue is normal vein quartz, containing a little galena and chalcopyrite, and is said to run $60 per ton in gold. Eighty-three tons of ore are said to have been shipped in 1898.

The Diadem vein is situated a short distance north of the Banzett and 100 feet higher up. The vein strikes east-west and is developed by smaller shafts and a tunnel 550 feet long. It is intended to extend the latter 200 feet, giving a vertical depth below the croppings of 425 feet. The gangue is quartz; the principal ore is mineral galena, often in considerable masses, together with a little chalcopyrite. Both are rich in free gold. The vein is claimed to be 20 feet wide, one rich

streak assaying $200 per ton. A shipment of 16 tons in 1900 is reported by the officers of the company to have netted $1,819.

In Quartz Gulch, leading down from near Robinsonville to Olive Creek, are several noteworthy prospects. The three Golden Gate claims are located 1 mile north of Robinsonville, and show a heavy vein of white quartz with little sulphurets, exposed by 500 feet of crosscut and 100 feet of drifts. Serpentine and gabbro form the country rock. The strike is due north, the dip 60° E. A total thickness of 47 feet of quartz is claimed to contain $6 to $7 per ton. A footwall streak 4 to 5 feet wide contains the best values. Another and parallel vein, dipping west, courses a short distance to the east, and is said to assay from $8 to $24 per ton.

A little lower down on Quartz Gulch are the Belcher claims, which probably do not cover the same vein as the Golden Gate. Still farther down is the Kelly group, with over 400 feet of developments. The country rock is here a tuffaceous slate cut by dikes of granite-porphyry. On one of these dikes the Imperial claim is located. Quartz Gulch is known to have been very rich in gold in early days, and the locality would seem to be a good one for prospecting. Several other claims, not visited, are located about 1 mile east of Robinsonville, on the Bonanza road. Cinnabar is reported to occur in a vein or seam near Robinsonville.

About 5 miles south of Robinsonville, at an elevation of 5,100 feet, on the road to Austin, is McNamee Gulch, reported very rich in early days. A $14,000 nugget was found here. Some prospecting for quartz has lately been done in this gulch, resulting in the location of the Pine Tree group of quartz veins. The country rock is serpentine, gabbro, and diorite.

PLACER MINES.

Robinsonville Gulch and several other small streams as far south as McNamee Gulch have been extensively worked for placer gold, and some work of this kind is done at the present time at the last-named locality. The gravels were shallow, resting in flat gulches, and were rich in high-grade gold.

UPPER BURNT RIVER VALLEY AND BONANZA DISTRICTS.

GENERAL FEATURES.

In many respects the upper drainage basin of Burnt River is very similar to that of Powder River. The lower Burnt River Valley extends from Bridgeport (elevation 3,400 feet) to a point 20 miles west of it (elevation 3,900 feet), and has a width of up to 1 mile of alluvial and bench lands, the former covered with meadows or alfalfa fields. The ridges rising south of this valley are smooth and bare,

patches of timber occurring only in some of the gulches. A few miles above Hereford, the principal settlement in the valley, the river enters a sharply cut canyon, continuous for 15 miles to the upper valley, the lowest elevation of which is 4,100 feet. This valley is an almost circular depression, 5 miles in diameter, its gravelly bench lands surrounded by gently sloping ridges rising to maximum elevations of 6,000 feet. This region, in the heart of the Blue Mountains, is covered with dense forest and is abundantly watered by a number of creeks, all converging toward the lower end of the valley. Much of the timber is excellent yellow pine.

GEOLOGY.

The older rocks are found only in the upper part of the valley, while the Neocene lavas are developed to an enormous extent in the lower drainage area. Among the older rocks argillites predominate. Such rocks make up the larger part of the long ridge separating the upper Burnt River or Clifford Valley from the Sumpter Valley. As usual, the rocks vary from fissile clay slates to dark siliceous cherts. Similar rocks are exposed on the road from McEwens to Hereford, on the north side of the ridge, below the andesite cap covering the summit. In places slightly schistose greenstones are interbedded in the sedimentary series. At the head of Gimlet and Camp creeks similar siliceous argillites form the divide. At Bonanza mine fissile black clay slates appear. At Winterville, close by the placer diggings, is found a stratum of limestone 300 feet thick, which contains unmistakable round crinoid stems. The strike of this somewhat crystalline limestone is N. 70° W. At Bonanza mine the slates strike east-west and dip 80° S. This is evidently the prevailing direction, and it is the same also in the Sumpter district. The crinoid stems of Winterville form the only cue to the age of the whole series. It may be surmised that it belongs to the Carboniferous division of the Paleozoic.

The argillites contain few intrusive bodies. In the foothills south of Sumpter Valley, near Stoddard mill, a dark granodiorite appears from the gravel flat up to an elevation of 4,900 feet. Above this follows apparently contact-metamorphosed argillite, capped by andesitic breccia. Serpentine, forming an extension of the Robinsonville areas, crops in a small area just above the town of Geiser, close to the Bonanza mine, and also a mile below it at the Winterville diggings, here associated with other, not determined, chloritic greenstones.

Neocene lavas cover an exceedingly large area south of Clifford. Rhyolites, andesites, and basalts are represented, the rhyolites being, as far as can be determined, the oldest.

Normal lithoidal rhyolite covers the whole divide between Powder and Burnt rivers from a point south of Pleasant Valley and south-

east of Baker City for 15 miles westward, to the vicinity of Hereford, where it is covered by andesitic breccia. This rhyolitic ridge attains an elevation of from 5,500 to 6,500 feet. The rock descends on the north side of the ridge to the level of the basaltic flows (elevation 4,700 feet). On the south side it reaches down to Hereford Valley and appears again in the ridges south of Burnt River. The general form of this great rhyolite mass is that of a dome sloping gradually from an elevation of 6,000 feet to 4,300 feet. From this point a sharper slope of erosion sets in to the level of the gravel benches at Hereford. Closely crowded gulches have been cut in this rhyolite dome to a depth of from 1,000 to 1,500 feet. Thinner rhyolite flows appear again in the bottom of Clifford Valley; for instance, at the junction of Pine and Camp creeks, 2 miles northwest of Clifford.

Dacite was observed closely connected with rhyolite on a small tributary of Burnt River, 4 miles north of Hereford, on the road from that place to Sumpter.

Andesite and andesitic breccia cover a very large area. Beginning on the divide north of Hereford, a thickness is exposed of 300 feet on the Powder River side and 1,000 feet on the southern slope. Near the summit, well-stratified volcanic tuffs and breccias are exposed. The latter contain angular fragments both of dark pyroxene-andesites and lighter hornblende-andesites. This area continues westward practically to the slopes of John Day Valley. The breccias appear on the floor of Clifford Valley just east of the place of that name and are here covered by bench gravels, and the same breccias extend up to the Bonanza mine. Practically the whole divide between the Middle Fork of John Day and Burnt River, forming flat-topped, forested plateaus reaching 6,000 feet in elevation, is composed of this breccia. Overflowing, the same lavas once filled the Middle Fork of John Day down to Susanville to a depth of 1,500 feet.

The breccia consist of angular fragments of normal andesites of varying appearance. Some are dark gray, others brownish or black; many fragments are vesicular. All of them are hypersthene-augite-andesites (pyroxene-andesites), and sometimes those of lighter color contain also hornblende in black needles.

Basalts are less abundant. Below Hereford, in the lower valley, normal olivine-basalts, weathering gray, cover the rhyolite. Near Austin, and above that place on the headwaters of the Middle Fork, fine-grained glassy basalts cover the andesite.

The gravel deposits found along Burnt River Valley are of several different kinds. Such deposits as may have accumulated before the volcanic period, and are, therefore, Neocene or Eocene, have mostly been eroded or covered by lavas. A few of this interesting class have been exposed by placer mining and are described under the heading "Winterville placers" (p. 703). In areal extent they are insignificant.

The damming of the lower Burnt River Valley below Bridgeport by rhyolitic flows induced the accumulation of extensive gravel deposits above. Near Hereford are two of these benches at 400 and 600 feet above the valley bottom, which is covered by alluvial deposits. They consist of coarse, well-washed gravels of rhyolite, quartz, and metamorphic rocks. The age of these bench gravels is assumed to be late Neocene (Pliocene).

Similar damming produced similar results in the upper or Clifford Valley. Wide benches are covered by coarse, well-washed gravel, resting on argillite, rhyolite, or andesite. These are excellently shown on the Sumpter road. The highest terrace slopes from an elevation of 4,550 feet down to 4,300 feet in a distance of 2 miles. A sharp escarpment separates this from a second bench 100 feet lower and 1 mile wide. Finally, a last escarpment of similar height carries one down to the alluvial flats along the river.

No indications of a former glaciation have been found in this drainage basin.

QUARTZ VEINS.

Though some gold-quartz veins are known from the head of Gimlet Creek and other places on the divide toward Granite Creek and Sumpter, the only place in which they appear strongly developed and in which they have been mined with success is the Bonanza district. The quartz veins of Robinsonville, which to some extent belong in this drainage area, have been described under separate heading.

Bonanza mine.—The Bonanza mine is situated about 10 miles west of Sumpter, on the headwaters of Burnt River, at an elevation of 5,140 feet (lowest floor of mill). 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 were 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.

A 40-stamp mill and concentrator treat the ore. During the fall of 1900 only 15 or 20 of these were dropping.

The developments consist of two tunnels, the upper 1,400 feet long and 230 feet below the croppings, the lower 1,600 feet long. The latter is the main adit, 338 feet below the croppings, and a shaft is sunk in it 600 feet from the mouth to a depth of about 200 feet.

Further sinking is being carried on at the present time. In all, there are probably 10,000 feet of development work.

The country rock is a fissile black clay slate, striking nearly due east-west and dipping 80° S. A little above the town of Geiser, at the mill, this slate is cut by a considerable belt of serpentine. The same rock appears again below Bonanza, toward the diggings of Winterville. To the north and east the serpentine and clay slate are covered by andesitic lavas. The veins appear to be exclusively contained in clay slate. The Bonanza vein, cropping on a hill 500 feet above the mill and about half a mile northeast of it, strikes N. 50° W. and dips steeply southwest. It is traceable on the surface for about 2,500 feet northwest of the main tunnel, but is then covered by an extensive lava area, referred to above.

The outcrops are neither wide nor conspicuous, and have been stoped to the surface in several places. The vein appears as 1 to 3 feet of quartz between walls of decomposed slate. In depth it widens enormously in places.

Permission to visit the mine below tunnel level was refused. The following data relating to the underground works were obtained from several persons well acquainted with the mine, and are believed to be mainly correct:

The ore consists of quartz containing free gold and sulphurets and has considerable similarity to that of the Red Boy mine. 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 the depth is increased more concentrates and less gold are obtained. The concentrates are said to vary from $20 to $60 per ton, chiefly in gold.[1] 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 up as $1,400 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 upper tunnel, 1,400 feet long, is said to have encountered two pay shoots, each 200 to 300 feet long and up to 6 feet wide. Still farther in, a third pay shoot was found, which extended only 30 feet above the tunnel level. It was 40 feet long and 5 feet wide, and averaged $15 per ton. An intermediate level, sunk 40 feet from the middle shoot, was extended for 480 feet in very poor ore.

The lower tunnel, 1,600 feet long, encountered a small shoot below the first one in the upper tunnel and was then driven for the rest of the distance on a poor streak of quartz near the hanging wall. A crosscut

[1] A sample gave 0.84 ounce gold and 0.76 ounce silver per ton.

in the foot, 500 feet from the portal, had failed to disclose anything of value; likewise a crosscut near the end. It seemed as if the mine was worked out when the owners were prevailed upon to crosscut at other places in this adit. These crosscuts, from 30 to 120 feet long, into the foot-wall side disclosed the presence of a magnificent lenticular mass of ore of a maximum width of 40 feet and 800 feet long.

Regarding the conditions below the tunnel level but little information is to be had. According to latest reports fine bodies of ore have been developed below the second shaft level, and the production, which had been declining before, rose to something like $50,000 per month.

Other mines and claims.—Near the town of Geiser are located several mines and prospects which, though not as yet producing, deserve mention. Among these is the Richmond, a vein parallel to the Bonanza and southwest of it, which is developed by a Canadian company and on which a 10-stamp mill has just been erected. The mine is developed by a shaft 300 feet deep. The Keystone Belle covers the extension of the Bonanza and is now being prospected. The White Elephant is still farther to the southwest and is being developed by a tunnel. In character all of these are similar to the Bonanza.

PLACER MINES.

Many of the creeks in the Clifford Valley have been profitably worked and some have been rich. Among them are, from west to east, Bennett Creek, Camp Creek, Gimlet Creek, and Three Cent Gulch. Placer work has been done in this valley since early days and a production is still maintained.

The gravels washed range in age from Neocene or Eocene to the most recent Pleistocene. The gold is sometimes extremely coarse, as in the Winterville placers, or very fine and floury, as in the ordinary bench gravels of Camp Creek. The fineness is remarkable, some of it reaching $19 to $20 per ounce.

Placer mining is carried on in Three Cent Gulch by Sullivan & Co., who operate one hydraulic jet with 400 miner's inches of water. Gimlet Creek has been worked extensively at the forks above the Sumpter road, and it is said that this locality has produced $100,000. In Camp Creek, at the junction of Pine Creek, 2 miles northeast of Clifford, are the Hindman placers. Here a low bench gravel is worked just above the creek bottom, at this point 200 feet wide. The 10-foot-high bank of well-washed gravel rests on rhyolite. About 70 feet above the creek the heavy bench gravels begin which skirt the eastern side of Clifford Valley. The gold is rather coarse, and has a fineness of 919. It is accompanied by much magnetite and ilmenite, the latter in beautiful crystals. There are also some garnets and zircons in the black sand,

as well as epidote. Mr. Hindman states that about half an ounce of platinum is obtained at each clean-up. This is the only occurrence of platinum thus far known from the Blue Mountains. The heavy bench gravels are, as a rule, too poor to pay for washing, but contain some flour gold with the fineness of 970.

The placers of Winterville and Parkerville are unusually interesting. The Winterville diggings are located on Bennett Creek, three-quarters of a mile south of the Bonanza mine and at an elevation of 4,900 feet. The placers have been worked intermittently for many years and have doubtless yielded a large sum in aggregate. According to Mint reports they produced $25,000 in 1889, $8,300 in 1890, $1,900 in 1891, and $1,400 in 1892. During 1900 they were in active operation and the production is supposed to have been over $20,000. The water is obtained from the Mann ditch, which, with an aggregate length of 30 miles, taps the headwaters of Clear Creek and Olive Creek and is said to have a capacity of 5,000 miner's inches.

Near the Bonanza mine Bennett Creek flows on andesitic breccia, though immediately east of the creek the high slate hills of Bonanza project from below the volcanic flows. At Winterville the creek leaves the andesite and for half a mile below flows over bed rock of slate and serpentine. In this distance the gravels along the creek bed have been worked. The gravels washed at present are found about the level of the 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 bed 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. The high bed-rock hills rising on the southwest side and the general configuration of the country indicate that it was a narrow gulch of an upper drainage system which had a general east-west direction across the present creek. The increasing height of the banks will soon interpose difficulties for continued hydraulic work. The bed rock seems to pitch downward at present and at its deepest point probably lies below the

level of the creek. Inclines sunk will probably develop a heavy flow of water. On the other hand, if the channel came down from the west, and there is little doubt of this, it would seem feasible to follow it up by a drift from the present bed-rock level.

Two miles west of Winterville are the Parkerville diggings, which are reported to have produced $150,000. They are said to be similarly situated and may represent the continuation of this channel. The continuation of this channel east of Winterville has not been found and the probability is that it would be considerably below the present level of the valley.

CHROMITE.

Heavy float of chromite was noticed at the Winterville placers; the serpentine in this vicinity must contain a pocket of this mineral.

CHAPTER V.

DETAILED DESCRIPTIONS OF MINING DISTRICTS (CONTINUED.)

SUSANVILLE DISTRICT.

GEOLOGY.

The Susanville district is situated on the Middle Fork of John Day River, 30 miles west of Sumpter in air line, though by wagon road the distance is about 55 miles. From Austin the road follows the Middle Fork down to Susanville, which has an elevation of 3,500 feet. Heavily forested ridges rise on both sides of the little gravel flat on which the town is located. About 7 miles northeast from the river the Greenhorn Ridge rises to over 7,000 feet, so that the slopes down to the river are not very steep. On the southwestern side of the river the configuration is more irregular and the ridges attain a height of only about 5,000 feet.

The geological features are as follows: The Middle Fork has cut down through the basalt flow which in Miocene times filled the valley, and the road from Austin to near Susanville is entirely in this lava rock. At Susanville the old rocks of the Greenhorn Ridge reach down to the river and across it, but only, it is believed, for a short distance. These old rocks also continue down the Middle Fork until below the mouth of Big Creek, or 6 miles below Susanville, where, according to information, the lavas again begin.

A fissile, dark-gray clay slate is the principal formation exposed above and below Susanville. At the Badger mine a strike of N. 70° E. and a southerly dip of 65° was noted; one-half mile below the mine, in Elk Creek, the strike is N. 80° E., and 1 mile below Susanville it is S. 85° E. with steep southerly dip. Thus, in general, the strike of the series is east-west and similar to that of Sumpter. Smaller dikes of aplitic rocks cut the slate between the town and the Badger mine. In Elk Creek, 2 miles above the river, at the Otter mine the slate is adjoined by serpentine, which continues up Elk Creek, mixed with much greenstone (diabase or gabbro) up to near the head of the creek, when a high ridge of granitic rock appears. This is probably the continuation of the central area of quartz-diorite mentioned in the description of the Greenhorn Mountains. Dikes of basalt are said to break through this granitic rock and on the flat summit is a small table of basaltic lava. West of the head of Elk and Deep creeks the high ridge gradually sinks.

QUARTZ VEINS.

The placers of Elk Creek have been worked since 1864 and are described below. Prospecting for quartz began as early as 1869, when Mr. Cabell's pan-amalgamation mill was built on Elk Creek 2½ miles above its mouth. Ore from a vein called the Monumental was worked there, yielding, according to Mr. Haskell, $15,000. Several other prospects were then in active operation, but for many subsequent years little or nothing was done, until recently, when renewed prospecting has given good results. While there are some narrow quartz veins with products of free gold, the bulk of the ore consists of heavy sulphurets, which contain little or no free gold. The values are chiefly in gold, though the rich shipping ore also contains much silver. The total production from the quartz veins probably does not exceed $100,000. This is to some extent due to the inaccessibility of the district, making shipping expenses extremely high. Apparently there are several claims of considerable merit.

The Badger mine is at present the most important producer. Its vein was known as early as 1869 and was worked under the name of the McQuade ledge. In 1870–1874 some free gold was extracted from the decomposed croppings. This ore yielded $26 per ton in arrastre, the gold being 691 fine. Later on a 10-stamp mill with concentrators was built on Elk Creek below the mine, but the ore was soon found unsuited to such treatment. At present the rich ore is sorted and shipped to smelter. It is clear that the values must exceed $30 per ton to make the transactions profitable. The developments consist of an incline shaft 250 feet deep, with drifts and tunnels aggregating 1,500 feet. Apparently there is an excellent chance for a deep tunnel from Elk Creek.

The Badger is located 400 feet above Elk Creek, 2½ miles northeast from Susanville, at an elevation of about 4,300 feet. The country rock is slate. The vein strikes a little north of east and dips 60° to 70° S. Though this is about the same direction as that of the slate, it is easily seen that the deposit is a fissure vein, for the slate is cut near and in the vein by a great number of parallel quartz seams (Pl. LXVII) perpendicularly to the schistosity. The first-class ore consists of a massive irregular mixture of sulphurets; pyrite, arsenopyrite, and zinc blende make the bulk, together with a little galena, chalcopyrite, and tetrahedrite.[1] The shipping ore always contains galena. On the dump are several hundred tons of second-class ore, among which is noted masses up to 2 feet in diameter of pyrite and arsenopyrite. Other parts of the second-class ore consist of veinlets of quartz in argillite, with a little pyrite, arsenopyrite, and zinc blende. The adjoining argillite, aside from a little pyrite contained in it, appears

[1] A sample of shipping ore containing tetrahedrite was found to contain 1.04 ounces gold and 909.08 ounces silver per ton.

entirely fresh. The surface ore contained some free gold down to a depth of 25 or 50 feet.

The Stockton, prospected by a 200-foot shaft, adjoins the Badger and is supposed to cover its extension.

On Elk Creek, below the Badger mine, is the Bull of the Woods group, with the Otter as one of the principal claims. The Otter vein, carrying heavily sulphureted ore, is located in serpentine near the slate contact and is developed by a 600-foot-long tunnel, above which much ore is said to have been stoped. The ore contains dolomite or magnesite, together with pyrite, arsenopyrite, and a little galena. It contains both gold and silver.

The Gem vein, 2 miles above the Badger, on Elk Creek, was worked to some extent in early days. The quartz contained free gold at the rate of $6 per ton, and the heavy sulphides assayed $35 in silver and gold, according to Mr. Haskell. The vein is noted for a considerable percentage of copper. At Elk City, 6 miles above Susanville, some prospecting for quartz has been carried on. Between Susanville and the Badger mine the slate contains several narrow quartz veins in which pockets are sometimes found. Among these is the Skyscraper, located three-fourths of a mile from town on the ridge west of Elk Creek.

Prospects have been found on Deep Creek and on Onion Creek, as well as on Camp Creek. The Princess vein is located near the head of Deep Creek at the contact of slate and granite. It is said to contain white quartz carrying free gold with rich sulphurets.

PLACER MINES.

The well-known placer mines of Susanville were discovered in 1864 and have been worked every season since then. Elk Creek has been the greatest producer, but Deep Creek, 1 mile below Susanville, as well as Onion Creek and Big Creek, still farther down the river, have also yielded considerably. All of these producing creeks join the Middle Fork from the north side and descend from Greenhorn Mountains. The Middle Fork itself has been worked below Elk Creek and is reported to have produced $50,000 in fine flour gold. The production during the first four years after the discovery amounted to at least $80,000 (Raymond's report for 1870). For subsequent years the scattered data are obtained in the Mint report as follows:

Production of placer mines of Susanville district, 1882–1892.

1882	$15,000
1883	25,000
1884	16,000
1889	8,700
1890	11,200
1891	7,000
1892	14,000

The total production is probably in the vicinity of $600,000. During 1900 all the creeks were worked, at least for a short season. Chinese miners were at work on Elk Creek, 1 mile above the town, with hydraulic apparatus and derricks. Drifting operations were in progress on Big Creek, 8 miles from the river. Of the creeks emptying into the river from the south, Bear Creek, 1 mile below Susanville, is being worked, and some gravel is being washed at the head of Camp Creek.

The placers of Susanville contain coarse gold of a fineness of 865; a nugget worth $480 was found on Elk Creek, another worth $625 on Deep Creek, while Buck Gulch, below Deep Creek, holds the record with an $800 nugget. Cinnabar in rounded masses up to 3 or 4 inches in diameter, intergrown with normal vein quartz, is of common occurrence on Elk Creek, but has not yet been found in place. No platinum occurs in the placers. Elk Creek has been worked continuously for about 2½ miles above its mouth. Eight miles above the mouth, at Elk City, some placer work has also been done. The pay seemed to be derived from the west side of the creek, the east fork being barren, and sometimes the gold may be traced up the hill to the quartz veins from which it was derived. These appear generally to have been narrow and of a pockety nature. The gravel is coarse and contains many bowlders of greenstone, which must be handled with derricks. Usually the bottom of the creek is level and 100 feet wide. It contains two or three channels or gutters, the rims of which were raised 1 to 3 feet above the bottom. These gutters practically contain all of the gold. The bottom of the creek is filled 10 to 20 feet deep with gravels. It has been stated above that some placer work has been done on the Middle Fork. This stream flows in a gravel-filled channel in places as much as several hundred yards wide, suitable for dredging, the depth to bed rock ordinarily being only 8 to 10 feet.

Prospecting operations for this purpose were carried on in 1898 between the mouth of Granite Boulder Creek, which is somewhat auriferous, and a point below Susanville. Many shafts were sunk, and it is believed that in favorable places along certain channels the gravels averaged 20 cents per cubic yard.

QUARTZBURG DISTRICT.

GENERAL FEATURES.

Between the Middle and South forks of John Day River rises a complex of older rocks, culminating in the round-topped Dixie Butte, which attains an elevation of 7,700 feet. It is probably on all sides surrounded by Miocene lava flows. From the bare summit of Dixie Butte, one of the landmarks of the country near which the old California trail runs, heavily timbered ridges extend in all directions. The thick forests on the north side of Dixie Butte are said to be favorite haunts of elk and bear.

The geological structure of this area is complicated, but in general the rocks consist of diorite, diabase, and other greenstones, together with serpentine, inclosing smaller areas of clay slates, the exact age of which is not known; they are, however, older than the accompanying intrusive rocks. The stage road to Prairie crosses the most easterly part of the area; imperfect exposures show diabase, porphyry, serpentine, and siliceous clay slates. But immediately at the summit, toward Prairie, basalts and andesites begin and continue down to John Day Valley. A beautiful view of the latter is obtained from this place. Between the scattered yellow pines of the park-like forest the bare volcanic slopes of the valley with its broad pastures and irrigated fields present an attractive picture, and across it toward the south rise the jagged, snow-flecked lava peaks of the Strawberry Range. On the easterly road, leading down to the valley from the summits by way of the sawmill and Spanish Gulch, first clay slates and then 2 miles of serpentine are crossed before the lava again begins.

Going up from Prairie to Quartzburg district, the road follows Dixie Creek, with its extensive and not yet exhausted placer deposits. Two miles upstream the valley widens and the covering basalt and andesite give place to an old sedimentary rock, a massive argillite. Two miles farther up, at the road junction, a narrow canyon begins, at the entrance to which is a little serpentine. The canyon, however, is cut in a normal, hard, medium-grained diorite, consisting of green hornblende and feldspar. One and a half miles still farther up, the valley opens, the diorite grows darker, and at the forks of the creek it is replaced by a diabase-porphyry. This is a very tough, dark-gray rock with dark-green crystals of augite in a groundmass of medium grain. Between Comer post-office and Present Need mine there is a great complication of igneous rocks, most of them dark-green diabase of varying grain, and also some diorite-porphyries or lamprophyric dike rocks. Similar rocks, mostly uralite-diabases, are seen on the east forks of the creek, where the copper prospects are located.

Just above the Present Need mine coarse diabase appears, in places containing small seams of dark-gray dense rock which consists of quartz and tourmaline; but these veinlets carry no ores. In the crosscut of the Present Need a 200-foot-wide belt of peculiar grayish-green, fine-grained, sometimes flinty rock appears, which seems to be diabase-tuff and allied rocks greatly altered by contact metamorphism. These are described more in detail on page 588.

The auriferous character of this area is shown by the fact that in practically all of the streams heading toward Dixie Butte placers have been worked. Important placers are found in Dixie Creek, but auriferous gravels have also been worked on Camp, Ruby, and Happy Camp creeks, draining toward the north, and Rich and Spanish creeks, toward the east.

The principal quartz veins have thus far been found on the west fork of Dixie Creek, though it is by no means improbable that discoveries will be made in other parts of the area. The veins are narrow and rich and contain heavy sulphurets in quartz gangue. The oxidized surface ore contains much free gold, but at slight depth the ores become much more base. The strike is generally north-northeast or northeast, while the dip, with few exceptions, is steep to the east.

On the east fork of Dixie Creek copper deposits of a very different type occur.

The quartz veins were discovered soon after the placers and have been worked intermittently at least since 1880. In 1900 the Present Need, owned by Mr. W. E. Gifford, who kindly furnished much information, was the only vein upon which active work was being done. The production of these quartz mines is not accurately known, but is not believed to have exceeded $100,000. Much gold was derived from the oxidized croppings, but few have been worked in depth.

GOLD-QUARTZ VEINS.

The first prospects are encountered a short distance below Comer post-office. The more important claims are located half a mile above this place.

The Present Need was located about ten years ago and has since been worked on a small scale, the ore being calcined in a kiln and then reduced in an arrastre. The developments consist of a crosscut tunnel 100 feet above the creek level and 200 to 300 feet of drifts. The country rock is a diabase, but the crosscut has exposed a narrow, greatly contact-metamorphosed series of diabase-tuff and allied rocks appearing in strata with a general east-west direction. The vein strikes N. 20° E. and dips 70° ESE. Like the other veins in the district, it is not traceable for a long distance. The width is 2 to 3 feet, indicated by fissures in the hard diabasic rocks. The ore occupies from 4 inches to 2 feet of this width and consists of solid quartz with heavy sulphurets in irregular intergrowth. There are pyrite, hard and yellow, softer yellowish-gray marcasite, and a little chalcopyrite, zinc blende, and galena. This ore is very rich and the pyrite often contains free gold. It assays from 6 to 25 ounces silver and 4 to 5 ounces in gold per ton, a total value of about $100. With the imperfect extraction used, only about two-thirds of this amount was saved.

The ore occurs in two shoots on the vein, both dipping 65° S. on the vein; the shoots are 70 feet long, and are separated by a barren zone of 70 feet.

A few hundred feet north of this mine is the old Keystone, now idle. The Mint reports show that it was worked in 1882, during which year the small veins of Quartzburg produced about $12,000, and that at that

time seven levels were run. In 1883 it is reported that 500 tons of ore at $40 per ton were worked at a cost of $8.50 per ton. In 1889 the mine is credited with a production of $5,800. The vein strikes northeasterly and dips southeasterly. It is 4 feet wide between walls, the pay forming a narrow streak on the hanging, on the foot, or on both. The gangue contains much calcite, but otherwise the ore is similar to that of the Present Need.

A short distance above, the Colorado, a parallel vein, is located, and still higher up are many other claims. The Yankee Boy, on the ridge between the two forks of the creek, southwest of Copperopolis, strikes northeast and dips southeast, and is developed by 1,000 feet of tunnels. The croppings showed very heavy gold specimens, but in depth the ore became more base.

COPPER VEINS.

The active development of these claims, situated in the narrow canyon of the east fork of Dixie Creek, is of recent date, though at least one, the Standard, has been known for many years.

The Copperopolis claims are located on the west side of the canyon, 2 miles above the forks of the creek, and the croppings have an elevation of 5,250 feet. The developments consist of several cuts and shorter tunnels. An 800-foot tunnel from creek level, tapping the vein 300 feet below the croppings, was begun at the time the prospects were visited, in October, 1900. The country rock consists of a medium-grained uralite-diabase in which the vein strikes about N. 60° E., the dip being uncertain. It is traceable across a small gulch for a distance of at least 1,000 feet. The deposit forms a heavy body of tourmaline, quartz, and chalcopyrite, with a little malachite and azurite near the surface, the total width being about 75 feet, including an intercalated horse. About 40 feet of the width is copper bearing. The exact percentage of copper, sampled across the width, can not be stated; it may average 3 or 4 per cent. The ore is largely a replacement of diabase by quartz, tourmaline, and chalcopyrite, but in this rock are contained richer seams with comb-quartz and chalcopyrite. The ore is said to contain gold and silver. There is undoubtedly a large body of low-grade copper ore; though the lateral as well as the vertical extent is still unknown, the showing warrants further exploration. The concentration of the ore will be a little difficult, for the specific gravity of tourmaline (3.2) is not greatly different from that of chalcopyrite (4.2).

Somewhat less than 1 mile above the forks is the Standard copper mine, located on the east side of the creek, 300 feet above it, and at an elevation of 4,900 feet. The vein crops in a dark-greenish, altered diabase-porphyry; its strike is northeast, the dip 30° SE. The developments consist of a 100-foot-deep incline; a 300-foot-long tunnel,

100 feet below the croppings, has not yet struck this flat vein, but found a stringer of ore with about the same strike and standing vertical. The ore is here from a few inches to 1 foot wide. Both the veins are probably largely due to processes of replacement. From the shaft a few tons of chalcopyrite, also containing gold and silver, have been shipped. From the tunnel 10 tons of ore were shipped in 1900, which, according to the officers of the company, contained $34 per ton in copper, gold, and silver. There is good opportunity for a crosscut to the veins 200 feet below the present tunnel.

The ore consists of chalcopyrite, with a little pyrrhotite and smaltite. The latter mineral is a light steel-gray arsenide of cobalt and is of rare occurrence in the United States. It occurs chiefly in the vertical vein intergrown with chalcopyrite. The only gangue mineral is calcite, and this occurs sparingly.

PLACER MINES.

The Dixie Creek placer mines were discovered about 1862, and were reported rich, though no data as to production are at hand. Raymond's report for 1870 contains the statement that at that time there were 100 white men and 200 Chinamen employed, and that the fine, scaly gold was 860 fine. In 1873 the creek is reported as turned over to Chinese labor. In 1882 two small hydraulic plants were in operation, producing $30,000 (Mint report). At the present time very little placer mining is done.

The placers consist of the gravels accumulated in the present creek to a depth of 10 or 15 feet. The workings extend upstream from Prairie for 5 miles, or to the entrance of the diorite canyon, where the grade becomes very steep. The width of the gravel-covered river bottom is from 300 to 800 feet, the whole of which has been worked.

Six miles east of Prairie are the old Spanish Diggings, which have yielded a moderate amount of gold. The upper end of John Day Valley contains no placers. On the east side of Dixie Butte are the old placers of Happy Camp, still worked on a small scale by Chinese. Northwest of the same mountains are the Ruby Creek placers, still worked by whites and Chinese. Small placers are also reported from the head of Camp Creek.

CANYON DISTRICT.

GENERAL FEATURES.

The celebrated placer mines of Canyon are situated in the upper drainage basin of the South Fork of John Day River. The valley here widens to a broad depression, about 18 miles from east to west, and from 4 to 8 miles from north to south. In contrast to the narrow and heavily timbered valleys of the North and Middle forks,

A. JOHN DAY VALLEY.

B. CANYON.

this is a bare expanse of gravelly pasture land with strips of alluvial soils along the river from a quarter mile to 1 mile wide. The elevation at John Day is 3,000 feet; at Prairie, 3,500. The climate is fairly mild and dry, the water supply ample; in consequence the valley was settled soon after the discovery of the placers, and has for thirty-five years supported a prosperous community of cattlemen and farmers. North of the river the hills rise gradually and culminate in a timbered ridge forming the divide between the Middle and South forks of John Day River. The eastern end of the valley is surrounded by dark forested mountains rising to about 6,500 to 7,000 feet. At the very head of the valley there is, however, an unexpectedly low pass (elevation about 4,500 feet), through which a wagon road leads over to the Malheur River Basin. South of the valley the picturesque Strawberry Range rises abruptly, with serrated peaks, culminating in Strawberry Butte, with an elevation of about 8,600 feet. Toward Canyon the sharp ridges are a little lower, but still attain 8,000 feet. The range presents a steep but not very regular slope, with numerous salients and deeply incised canyons. Hot springs are found on Reynolds Creek in the uppermost part of the valley.

GEOLOGY.

The older pre-Miocene diabases, slates, and serpentines from the north side of the valley have been described under the heading "Quartzburg district" (p. 709). The eastern end of Strawberry Range, including the butte of the same name, is built up of Tertiary lavas. But at the foot of this mountain the underlying rocks appear, and their contact gradually rises westward, until in a short distance they form the summit of the mountains, culminating in a group of peaks and ridges which a few miles south of Canyon attain 8,000 feet above the sea. South of Prairie, below Strawberry Butte, serpentine appears in great development. It reaches 900 feet above the foothills, and also continues westward across Indian Creek. At Gillespie's sawmill it contains small bunches of chromite. The range was not ascended any farther than to the claim known as the Oregon Wonder, at an elevation of 6,300 feet; but the color and configuration of the high ridges back of Canyon indicate that they are composed of a granitic rock. Prospectors state that diorites and porphyries are the prevailing rocks, and in the gulches, coming down from the peaks, are abundant cobbles of a very coarse diorite with hornblende crystals up to 2 inches in length.

Above Canyon serpentine crops below the gravels almost within the limits of the settlement. Immediately above and on the west side fissile clay slate begins, with east-west strike and steep southerly dip. This continues for a few hundred feet, with a smaller mass of serpentine intercalated with slates. The relations between the two rocks are

not clear, though the serpentine, an altered igneous rock, is probably intrusive in the slates. Above this follows another belt of serpentine about 1,000 feet wide and adjoined on the south, without well-exposed contact, by diabase and diabase-porphyry. At this point the canyon becomes deep and narrow; on the east rises the pronounced salient, Canyon Peak, which is also made up of diabasic rocks.

In general there is a marked similarity in geological structure between the Greenhorn Mountains, Dixie Butte, and the Strawberry Range. All of them are built up of diorites, diabases, and serpentines, inclosing smaller masses of sedimentary rocks, usually clay slate.

Extensive areas of basaltic and andesitic rocks surround John Day Valley. Most of them, it is believed, are of early Neocene age. The road from Austin to Prairie, after crossing the divide, descends over long ridges of pyroxene-andesite, both massive and brecciated. Lower down the gradually flattening ridges are made up of massive basalts, and these continue for 3 miles, down to the level of the valley. The same fine-grained, often vesicular basalts form the low hills bounding the alluvium on the north for several miles east of Prairie. Augite-andesite directly overlies the argillite on Dixie Creek a couple of miles above the junction with the main river, and it is, indeed, probable that the andesites are the older of the two rocks. All the way down to the town of John Day basalt bluffs follow the north side of the river, gradually increasing in height; near John Day they are about 500 feet high. In places white tuffs alternate with the basalt. The surface ascends gradually from the bluff to a moderately high divide, the slope probably indicating the surface of the lava flows. At a few places near John Day the black, glassy olivine-basalt appears on the south side of the river, but the exposures are usually small and covered by gravels.

Along Canyon Creek above John Day the basalt is overlain by a considerable thickness of light-colored rhyolitic tuff, extensively used as a building stone at Canyon.[1] Above this tuff again rest more recent gravels.

The uppermost part of the valley was not visited, but it is believed to be entirely covered by basalt and andesite, these extensive areas forming a continuation of the area surrounding Austin and extending over the headwaters of Burnt River. Without much doubt this area of lavas continues and forms the summit of the Strawberry Range to a point a short distance west of Strawberry Butte. The form and color of the jagged ridges indicate clearly enough their volcanic origin. Strawberry Butte is formed by a great number of superimposed dark lava flows, and was no doubt once the locus of a most intense eruptive

[1] This rhyolite is evidently the same that Dr. J. C. Merriam describes under the heading Rattlesnake formation, which he considers of Pliocene age (Univ. Cal., Bull. Dept. Geology, Vol. II, No. 9.)

activity. The rock forming its slope is a basalt cut by a rhyolite dike of immense size.

The broad extent of the valley from Prairie across to the foot of Strawberry Butte is a gently sloping surface covered with coarse basaltic gravel. Broad gulches cut in this slope reveal thick strata of these coarse gravels interstratified with some sandy material. At some point near the river coaly material has been found, no doubt embedded in these strata. West of Prairie the basalt north of the river is for some distance covered by these gravels.

Along the road down to John Day, volcanic bluffs, as stated, follow the north side of the river. The south side of the alluvium is bordered by lower bluffs, from 100 to 300 feet high, less abrupt and with smoother outlines. They consist of coarse gravel with occasional softer strata, and in several places are seen to rest on basalt (fig. 85). All these gravels form a part of the old, late Neocene flood plain which shortly after the close of the eruptions covered the John Day Valley to a height several hundred feet above the present river level. The position of this flood plain indicates that the river then took a course from 2 to 3 miles south of its present channel. The exposures at Canyon (see below under "Placer mines"), indicate that the bottom of these old river deposits lies considerably below the present bed of the river.

The most recent deposits are the alluvial sands and gravels along the present river course. These are over 1 mile wide at the junction of John Day River and Strawberry Creek. Two miles below Prairie are narrows, where a little canyon has been cut through a bed of basalt. Below this the alluvial deposits are from 1,000 to 2,000 feet wide.

GOLD-QUARTZ VEINS.

Canyon Peak, the bold salient from the main range which rises back of Canyon, consists of coarse gabbro or gabbro-diabase containing irregular masses of a dark-green, finer-grained diabase or diabase-porphyry. This hill is celebrated for its rich pocket veins, and most of the placer gold in the vicinity is probably derived from its veinlets. The production from these veins is very difficult to estimate. At any rate it has not been very considerable, and few of the prospects rise to the rank of a mine. On the summit of Canyon Peak, 1½ miles above the Great Northern, is the Idaho vein. There is said to be a strong vein of quartz, in the vicinity of which many small pockets have been found. Some distance below is the Mountain View. Here, also, is a well-defined strong vein, 3 feet wide, crossed by a network of stringers carrying products of coarse gold.

The Great Northern mine is located 2 miles southeast of Canyon, on a steep slope 1,540 feet above the town, at an elevation of 4,700 feet. A very fine view of John Day Valley is obtained from this point. This

deposit was discovered in 1898 by Ike Guker. Placers have been worked in the gulch a couple of hundred feet below it. In 1898 $30,000 was extracted from one of the seams in a surface cut, and prospecting operations have since that time been carried on by a company having its headquarters in Salt Lake City. The developments aggregate 2,000 feet of drifts and crosscuts.

The country rock consists of gabbro and irregular bodies of diabase-porphyry. The latter, being often soft and traversed by calcite seams, is locally called lime, though it is without doubt an igneous rock.

A surface pit, about 50 feet by 50 and perhaps 20 feet deep, shows decomposed rock cut by seams usually dipping 30° to 40° east or west. The bonanza mentioned above was extracted from one of these seams. From a tunnel level 50 feet below extensive drifting has been done in an attempt to follow these seams. A vein of quartz 1 to 2 feet thick has been uncovered, striking north to south, and dipping 25° W. This is practically barren and is accompanied by an impregnation of pyrite and seams of calcite. Some of the seams in the tunnel above the vein carried wire gold, with a tendency to crystallization, inclosed in calcite.

About 300 feet east of this point another strong quartz vein, 2 feet thick, has been found. This strikes east-west, and dips 35° S. It carries massive white vein quartz, in places stained green by chromium.

At Prairie Diggings, 3 miles east of Canyon, placers containing rough quartz gold have long been worked. In the same vicinity is reported a large vein of base character and, to judge from specimens, inclosed in slate. In Raymond's report for 1870 it is stated that the body of quartz mixed with country rock is 400 feet wide, strikes northeast to southwest, and dips 60° SE. In 1872 a mill had been erected and $10,000 extracted, but soon after this the enterprise was abandoned, the quartz being, it is stated, of too low grade.

Aside from the occurrences described, the Strawberry Range apparently contains few mineral deposits. Near the head of Canyon Creek, 7 or 8 miles southeast of Canyon, claims have been located. The Chambers group is said to show a strong quartz vein 5 to 30 feet wide, containing a little chalcopyrite and limonite. The strike is said to be N. 60° E. In the Will Cleaver group, in the same vicinity, similar ore is found, claimed to average $8 in gold and 4 per cent in copper.

Almost due south of Prairie, high up on the side of Strawberry Butte, a great number of claims have been located, the principal one known as the Oregon Wonder. A trail leads up to this place from Gillespie's sawmill (elevation 4,200 feet) near the mouth of Indian Creek Canyon. The trail for the first few hundred feet leads over serpentine. Above this rock lie heavy flows of basalt, which at the claims (elevation 6,300 feet) is cut by a big rhyolite dike at least 300 feet wide, the outcrops

of which form a bold and precipitous cliff. This dike continues for a long distance eastward and a continuous chain of claims is located on it. The rock is a yellowish-gray to brownish lithoidal rhyolite, showing very pronounced flow structure. It consists of sanidine crystals embedded in a microfelsitic groundmass. Little spots and seams of limonite abound in it, and it also carries traces of silver, and occasionally traces of gold.

PLACER MINES.

The placers of Canyon are justly celebrated as the most important and productive deposits of the kind in Oregon. They were discovered in 1862, and in less than a year many thousand miners were at work on the gravel bars of the creek and in the gulches of the surrounding hills. During the first few years the production was very great, but exact figures will probably never be known. Estimates are made varying from $3,000,000 to $5,000,000 a year. In 1865 the product was estimated at $22,000 a week (Raymond's report, 1870), or about $1,000,000 a year. In 1870 it had already fallen to $300,000 a year. In the following year the production was still further reduced, but remained for a long time about $100,000. The Mint reports for 1883 and 1884 estimate $87,000 and $80,000; for 1890 $72,000, and for 1891 $100,000. While the figures are incomplete and untrustworthy, it is scarcely probable that the total production much exceeds $15,000,000. In 1882 there were 16 hydraulic plants (many of them small) in operation, and two-thirds of the products were derived from Chinese companies.

At the present time both white and Chinese miners are operating, mostly on a small scale. Mines near Marysville and the Humboldt hydraulic mine were worked. The amount annually extracted from the placers during the last few years probably varies between $30,000 and $50,000.

The water supply is abundant, being secured from Canyon Creek and gulches east of it. The principal ditches are reported as follows:

Ditches in Canyon Creek district.

Name.	Miles.	Capacity (in miner's inches).
Miners	20	700
Hillis	11	800
Thompson	4	600
Humboldt	8	1,200
Lone Star	4	500
Forlorn Hope	4	500

The section exposed along Canyon Creek above John Day shows well the position of the older gravels and is illustrated in fig. 85. Resting on basalt and rhyolite tuff are heavy, coarse gravels, which are well exposed on the west side of the creek at Canyon, where they are 150 feet deep and overlain by finer gravel, in part sandy or clayey. At the Humboldt hydraulic mine 80 feet of the latter is exposed. On the south side of the creek, on the road leading up to Marysville and the Great Northern mine, much of these overlying sandy and clayey sediments are exposed, and they reach up to the foot of the mountains at an elevation of 3,900 feet, 750 feet above the town. In the gulches descending from the gold-seamed Canyon Peak, which have cut into these soft deposits, rich placers are found. Some of these gravels are worked now near Marysville.

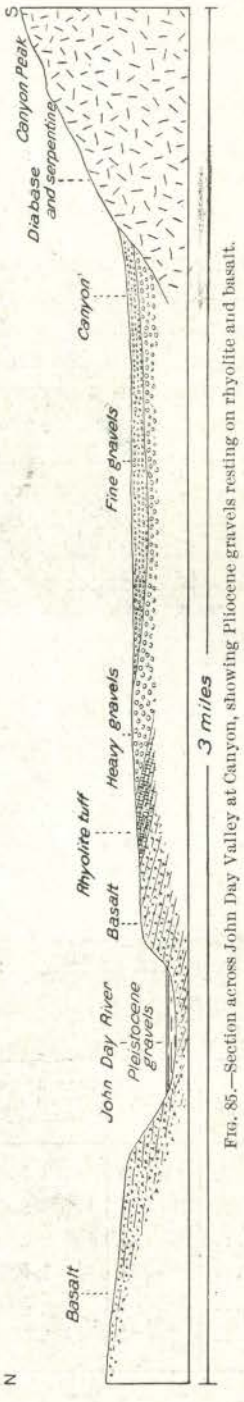
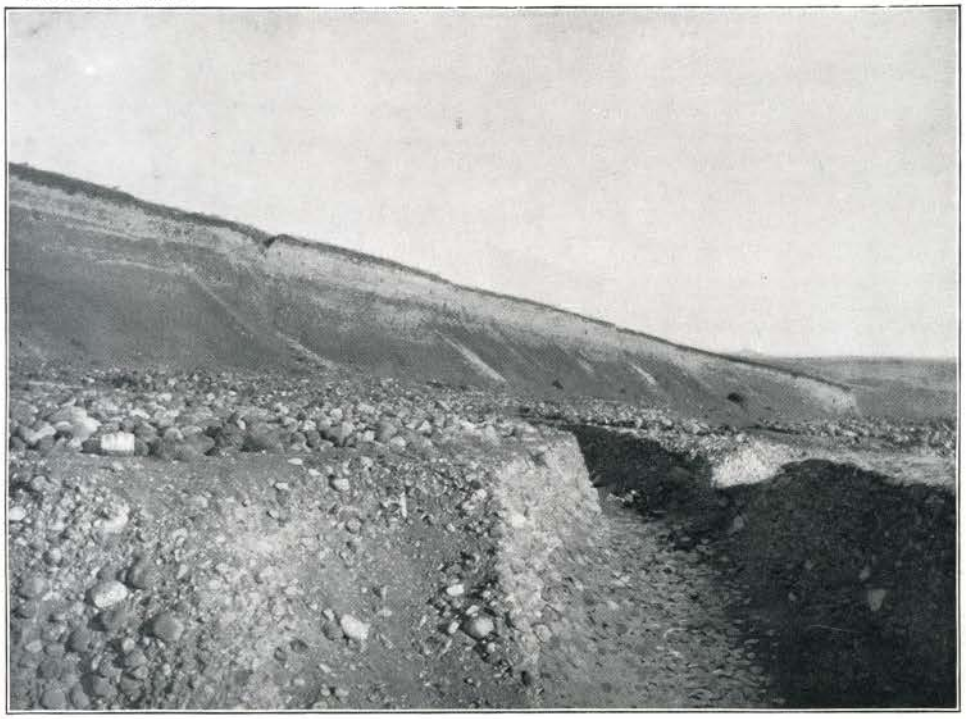


FIG. 85.—Section across John Day Valley at Canyon, showing Pliocene gravels resting on rhyolite and basalt.

In the creek bed near Canyon a shaft is reported to have been sunk in 1873 to a depth of 300 feet without reaching bed rock.

It is clear that there is a great complication of deposits at Canyon, gravels of very different periods being present, and considerable time would be required to establish the exact relations. On the whole, it seems that shortly after the eruption of the basaltic and rhyolitic lavas flowing down from the north the stream was crowded over close to the mountains and heavy gravels accumulated in it. This must have taken place in the Pliocene epoch. The bottom of this channel has never been exposed. It is probable that the Pliocene gravels cover earlier accumulations of auriferous gravels, but that these can ever, if found, be profitably worked is extremely unlikely. The coarse gravels are very poor in gold—in fact, practically barren.

As the deposit deepened the width of the river bed increased, and several hundred feet of finer sediments were deposited on top of the coarse gravels. At the same time the detritus from the high mountains on the south began to push the river northward again, and during this gradual process the high bluffs on the north side of the river were formed.



A. HUMBOLDT PLACER MINE.

B. NELSON PLACER MINE.

The finer gravels are workable only at certain places. The most important locality is the Humboldt mine, 150 feet above Canyon and on the western side of Canyon Creek. Hydraulic operations have been carried on here for many years. A strip of ground half a mile long and several hundred feet wide has been washed, leaving a bank 80 feet in height (Pl. LXXIV, *A*). The bed rock is formed by coarse, cemented gravel; the pay is said to be concentrated in the first 4 feet overlying the bed rock. The exposed bed rock is nearly level, but is said to slope gently westward. This gravel mine has been worked for over thirty years, the output being reported as from $10,000 to $20,000 per season. These gravels, no doubt, represent the bed of Canyon Creek at a time when the main stream had already been pushed northward to nearly its present position. The rich gravels of Marysville, situated on the hill 1½ miles east of Canyon, and the gravels of the present gulches above Marysville are comparatively recent deposits; they are derived from the rich pocket vein of Canyon Peak, and some of the deposits have been worked almost up to the veins. Most of the gold has, however, been caught on the clays and gravels of the older river sediments, below the outcrops of the older rocks.

With the final establishment of the present drainage, Canyon Creek has been deepened to its present level. Its bed is from 200 to 600 feet wide, covered with gravels to a depth of 15 to 18 feet. These have, of course, been worked over, some parts more than once, but a certain amount of gold is still found concentrated on the bed rock. The workings extend for 5 miles up from John Day River. In 1900 prospecting shafts were sunk in these gravels with a view to dredging operations, and the results are said to have been satisfactory. The placer gold from Canyon is often 900 fine, and sometimes, as at the mouth of Canyon Gulch, 990, or $19.82 per ounce. The gold from the quartz veins averages 830 fine.

Above John Day there is apparently not much gold in the main river, but below this place for several miles the bars have been, and are still, worked by derricks and wheelbarrows. The depth to bed rock is usually only about 18 feet. Extensive prospecting for dredging ground was recently undertaken 4 miles below John Day by the Pomeroy Company, of Portland. The results have been so satisfactory that a dredger will soon be erected here. The gravels are reported to average over 30 cents per cubic yard, most of the gold, of course, being found on the bed rock. Bed rock of serpentine and slate shows at intervals, according to Mr. J. H. Pomeroy, in the river below John Day, and the gold is often so coarse that it must be of local origin instead of having been washed down from Canyon Creek.

At Spanish Gulch, about 70 miles west of Canyon, on Crooked River, auriferous gravels were deposited on serpentine, and have been worked for many years. A production of $1,400 is given for

1882 in the Mint reports. In 1898 $16,000 was taken out in a couple of months, the gold being very coarse. This locality, which was not visited, is, as far as known, the most westerly point of the gold belt of eastern Oregon.

Another district not visited is that of Fox, Hamilton, and Long creeks, about 20 miles due west of Susanville. Small but persistent amounts of from $1,000 to $7,000 of placer gold are yearly reported from this vicinity.

CHAPTER VI.

DETAILED DESCRIPTIONS OF MINING DISTRICTS (CONTINUED).

VIRTUE DISTRICT.

GENERAL FEATURES.

The Virtue mining district, one of the oldest in eastern Oregon, is situated about 7 miles east of Baker City, and extends for about 12 miles in a northwesterly direction, the width varying between 3 and 6 miles. It covers a region of low arid hills rising in the great bend of Powder River, and may be considered as the northwesterly continuation of the Lookout complex. The elevations range from 3,400 to 5,000 feet. The hills rise rather abruptly from Baker Valley and slope gently eastward toward the lower Powder River Valley. Most of the drainage is toward the latter. A rather remarkable feature within the hills is Virtue Flat, a desolate, sage-covered depression extending 8 miles east and west by 2 miles north and south. The water supply is very scant, the only flowing stream being Ruckles Creek, practically outside of the district.

GEOLOGY.

The predominating rock of the northern part of the district is a lighter or darker greenish-gray dioritic rock of granular texture, which nearly always bears evidence of strong crushing, but rarely of schistosity. Frequently the rock is a veritable breccia, the different fragments being cemented by seams of feldspar or zoisite. The feldspars are largely converted into a flinty white mass resembling saussurite, and the hornblende seems uralitic. The microscope shows, in fact, that the rock is rather a saussuritic uralite-gabbro than a true diorite. This rock decomposes to a very light-colored dusty soil. At Virtue mine the dark-green rock seems more like a tuff belonging to the surface eruptions of a basic magma, and, though the exposures are poor, it is believed to be interbedded with the argillites which appear a short distance south of Virtue mine.

The argillites occupy the whole southern part of the district. Their exposures are very poor, and a reliable strike and dip can scarcely be obtained. The rocks range from siliceous to calcareous, but are always

dark in color. Limestone occurs 3 miles west-northwest of Pleasant Valley, and also about halfway between that place and Baker City. No fossils could be found, and the deposits are small lenses instead of definite strata. Still the appearance seems to indicate a general east-west strike of the formation, and the belief seems justified that they are continued westward by the argillites of the southern end of the Elkhorn Range.

A thin basalt flow covers the hills north of the Cliff mine and slopes gently eastward. The long slope toward the lower Powder River Valley is largely covered by shallow tuffs and gravels, apparently deposited in the waters of a Neocene lake. Many basaltic flows, also dipping northeast at angles of 10°, form the complex southeast of Baker City, rising to 5,077 feet. At their base is a thinner series of rhyolite and light-colored rhyolitic tuffs.

On the western side of the district, at the foot of Flagstaff Hill, extends the alluvium of Baker Valley. On the eastern side the Virtue Flat is covered by deep loams, sands, and semiangular gravel. On the hills surrounding it, up to 200 feet above the flat, lies fine, well-washed gravel. The very divide near Flagstaff is covered by deep, light-colored loam. In the gravels near the Virtue mine a molar of a mammoth has been found.

QUARTZ VEINS.

Quartz veins striking in many directions are found in the district, but the most prominent veins have a northwesterly course, a very unusual strike for this region. Individual veins are not traceable for long distances. The dips are usually southwesterly. Most of the deposits are normal, simple quartz veins, with very small amounts of sulphurets, and free, coarse gold of a high degree of purity. Pockety shoots of coarse gold are of frequent occurrence. The total production is probably $2,500,000.

Virtue mine.—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 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 $259,000 and the minimum in 1898 with $13,100. The total production is thus $2,189,000.

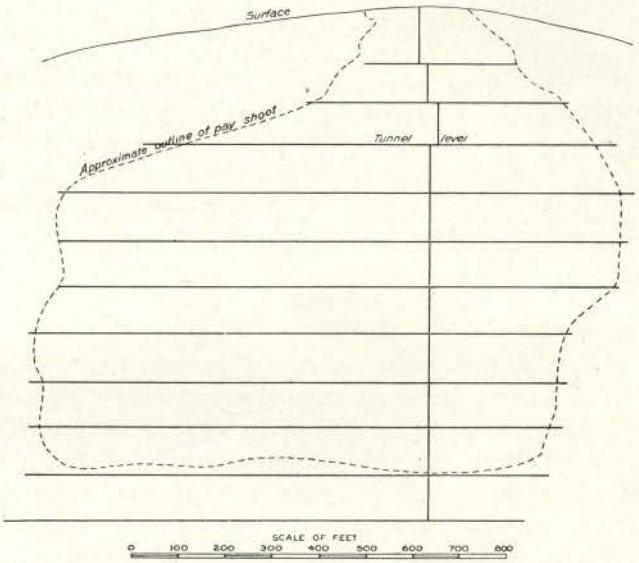


FIG. 86.—Approximate workings and extent of pay shoot in Virtue mine, in projection on the plane of the vein.

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 or 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.

The approximate extent of the pay shoot is shown in the accompanying figure, the data having been kindly furnished by Mr. R. R. Grayson. 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.

As may be expected, there are a great number of claims and prospects near the Virtue mine, but none of these have as yet proved important producers. The southeasterly extension of the Virtue has been worked by means of a shaft in the Virginia. Adjoining on the southwest is the Collateral, a vein said to be similar in character to the Virtue, and accessible by crosscuts from the lower levels of the Virtue workings.

Flagstaff mine.—This is situated 6 miles northeast of Baker City, on a small knob in the low range of hills separating the upper and lower Powder River valleys. The elevation is 3,900 feet. During the last few years the mine has been developed with a 730-foot incline and drifts aggregating 5,500 feet. A 10-stamp mill was erected in 1898 and run for a few months, yielding a production of $32,000. The mine has been idle since that time.

The country rock is a diorite or gabbro, showing evidence of much irregular crushing. The vein strikes east-northeast, and dips 55°; it is very persistent, 5 to 8 feet wide, with 18-inch-wide pay streak.

The ore is a white, massive quartz, with some calcite and occasionally scheelite, but containing scarcely any sulphurets, except a little stibnite and tetrahedrite. The average value per ton is said to be $16. The fineness of the bullion is 820. Plate amalgamation does not extract the full value, and tailings should be further treated, perhaps with the cyanide process. Three levels are turned 100 feet apart, except the first, which is 160 feet below the surface, and a considerable amount of ore is said to be blocked out. The fourth level is not opened. In a crosscut from the third level a new vein was struck, said to show 2 feet of quartz of excellent value. Water was not found in the shaft until 575 feet below the surface, or 450 feet vertical depth, that is, about 100 feet above the level of Powder River at Baker City.

Other mines and claims.—Half a mile north of the Flagstaff is the Cliff mine, the vein of which crops just below the basaltic cap in crushed and partly schistose diorite. It is developed by a vertical shaft 300 feet deep. The vein has a northerly strike and consists of 1 to 3 feet of soft quartz in decomposed dioritic rock. Scheelite in considerable masses was identified from this mine by Mr. C. L. King, of Baker City. A little calcite also occurs in the quartz.

In the foothills north of Virtue Flat, 3 miles east of Flagstaff, the Columbia-Friday vein crops through several locations. On the Friday and the Columbia the vein has been opened by small incline shafts. The vein is similar to the Flagstaff, strikes northwesterly, and dips 40° SW. The quartz of the Columbia shows very fine comb structure.

Many prospects are found on the ridge 500 feet high 1 mile south of the Flagstaff, the principal developments being on the Rachel claim. The country rock is a crushed and partly schistose diorite. In general appearance the vein is like that of the Flagstaff; the strike is northwesterly. In some of the prospects stibnite has been found.

The White Swan mine is situated 3 miles east-southeast of the Virtue at similar elevation and in the same desolate foothills. Here, also, rich gulch diggings led up to the vein. The mine was worked most successfully about ten years ago, and has been idle since 1897. The production is estimated at not less than $200,000. The Mint reports give $72,000 and $72,642 as the output during 1891 and 1892. The developments consist of a nearly vertical shaft 300 feet deep, with drifts on the various levels. The mill equipment consists of 10 stamps. In contrast to that at the Virtue a black, soft argillite, with a few sharply defined dioritic dikes here forms the country rock. The vein strikes northwesterly and is nearly vertical. The quartz is white and massive, like that of the Virtue, and contains a very small amount of sulphides. A little calcite is present. Several other veins, not developed, are found in the immediate vicinity.

The argillite hills south of the Virtue and southwest of the White Swan contain many small veins, in some of which good chimneys of

ore with coarse gold have been found. Among them are the Mabel, St. John, and the Carrol B. In the last named a rich streak has recently been developed. The Mabel produced $7,000 from a similar pocket.

Brazos mine.—Two miles north of Pleasant Valley and the same distance south of the White Swan is a vein covered by the Pleasant Valley and Brazos claims. On the latter the elevation is 4,100 feet, the drainage being southward toward Burnt River. The development of the Brazos is of recent date, and a 10-stamp mill was erected on it late in 1900. The developments consist of a tunnel with 1,000 feet of drifts, no ore having been stoped at the time of the visit, in August, 1900.

A black argillite, most of it soft and crushed, and without clearly defined bedding planes, forms the country rock. The vein strikes northwesterly and dips 20° to 30° SW. The croppings, which are not conspicuous, rise to 125 feet above tunnel level. The hanging wall is clearly defined by a clay seam, while the foot wall is also well marked. The width averages 3 or 4 feet, the vein matter consisting of soft, black argillite full of little nodules of quartz, rarely forming continuous veins. The appearance suggests that movements on the vein have separated the quartz into isolated lenses. All of these quartz seams and nodules carry gold, some of it being coarse. The pay shoot is claimed to extend for 400 feet along the vein. The ore is probably low grade, but the cost of extraction and treatment, on the other hand, should be very low.

In its northwesterly continuation the Brazos vein changes character, and the claim is exposed on the Pleasant Valley by a 175-foot incline as a normal quartz vein filled with 3 to 4 feet of massive quartz said to assay from $2 to $7 per ton.

One mile east of Pleasant Valley two normal quartz veins crop on the Keystone claim with a northeasterly strike and flat southeasterly dip. The developments consist of a small shaft and several tunnels and cuts.

PLACER MINES.

The only placer mines in the district were found in the gravel-filled gulches leading up to the Virtue and White Swan mines. These are now exhausted and only occasionally worked on a small scale.

VICINITY OF NORTH POWDER.

GENERAL FEATURES.

North Powder is a little town situated at the northern end of Baker Valley, at an elevation of 3,250 feet, near the point where Powder River abruptly turns from a northerly to a southeasterly direction. The North Fork, heading among the granite peaks of the northern

Elkhorn Range, joins the main stream in this vicinity, and a short distance below this junction the latter enters an abrupt though not very deep canyon, through which it flows for about 16 miles before entering the lower Powder River Valley, the average elevation of which is 2,700 feet. This narrow and steep canyon bears every evidence of recent excavation. At the bend it is cut in older rocks, while farther south it is incised in the covering lavas. A low, lava-covered divide with maximum elevation of 3,440 feet here separates the Powder River from the Grande Ronde Valley. The narrow point in the bend is occupied by bare, arid hills, rising 600 feet above the canyon. Eastward and westward from the bend the hills are covered with basalt flows. The floor of the valley gradually rises west of North Powder and almost imperceptibly passes into the heavily forested hills between Wolf Creek and the North Fork. South of that river the contrast between the valley level and the foothills of the Elkhorn Range become much more marked. In the middle of the valley, south of North Powder, rise two isolated groups of hills, the southerly points, 500 feet high, being known as the Coyote Hills.

GEOLOGY.

The older rocks of this region are similar to the Triassic lavas from the foothills of the Eagle Creek Range, and probably belong to the same age. There is a marked absence of sedimentary formations, and most of the rocks might be classified under the general term greenstones. Along the principal mineral zone in the bend of the river, a locality known as the Farley Hills, dull, dark-green, fine-grained rocks prevail, containing much epidote and chlorite. In places they are cherty and partly silicified. A somewhat fresher, dark-gray rock from the Guthrie shaft proved to be an old basalt or metabasalt greatly altered and uralitized. At the bend of the river the canyon is cut in a medium-grained, somewhat crushed dioritic rock, which contains much orthoclase and is probably a monzonite.

The Coyote Hills consist principally of normal, dark diorite with numerous dikes. Some of these are lamprophyric, practically dark-green and very fine-grained diorite; others are pegmatitic, consisting of orthoclase, microcline, with a little quartz and augite. The foothills north of the North Fork are made up of dark-green, medium-grained uralite-gabbro and diabase. South of the river similar rocks prevail, but the débris indicates that argillite and slate are also present. Near the mouth of Muddy Creek Canyon the light-gray granodiorite of the Elkhorn Range reaches the foothills.

Tertiary volcanic rocks chiefly appear on the divide north of Wolf Creek and the sharp bend of Powder River. The prevailing rock is a black, glassy basalt, very similar to that occurring northwest of Medical Springs, and probably belonging to the same system of flows. At

a place in the foothills near North Powder a gray rhyolite tuff also appears and is locally used as a building stone.

The basalt flows which begin north of Flagstaff mine in the hills between the upper and lower river extend westward into the district as far as Magpie Peak. The Pleistocene deposits are abundantly represented by the flood plain of Baker Valley, extending from Baker City on the south to the beginning of the canyon near North Powder on the north. The main river has not cut into the accumulated gravel of its alluvial deposits, but along the North Fork evidences of a somewhat more active erosion are seen. Westward from North Powder slightly undulating plains extend for several miles and then grade into gravel slopes, through which the river has cut a trench 20 to 40 feet deep, filled with the most recent deposits.

MINERAL DEPOSITS.

No mines of any importance have yet been developed in this vicinity, but there are many prospects and indications of mineralization. Fissure veins are seen in a few places only. The predominating type seems to be a pyritic impregnation in the old greenstones.

A belt of prospects extends for several miles along the base of the hills southeast of North Powder, the locality being generally known as the Farley Hills. Seven miles east of Haines is the Jenkins group of prospects, which were not visited. Two miles northwest of the latter place is another group of claims, the most important of which is known as French Joe. The greenstone is here covered by a few feet of iron capping, chiefly limonite, which is said to contain some gold. Associated with it is much partly silicified and iron-stained rock. A prospect hole close by shows magnetite and epidote, and another, not far distant, some copper-stained and silicified greenstone. No vein quartz is visible. About 3 miles farther northwest, in the same low foothills, are the claims owned by Forsey and Coppinole. Here much iron-cap and honeycombed quartzose material is exposed in a shaft 40 feet deep. This ore is reported to contain over $6 in gold. Samples from this and the previously described claims showed only small quantities of gold and silver, but it is stated, on apparently reliable authority, that some very rich ore has been found. A mile farther northwesterly is a group of claims covering croppings, 200 feet wide, of rusty and cellular iron cap. The Buckeye and Pittsburg claims extend to the west and east from this place, while another line of claims, the Keystone, Gallagher, Climax, and Delta, is laid out from north to south across the same croppings. A 50-foot shaft with drifts represents the development on the Keystone, and shafts of about the same depth have been sunk on the Delta, Gallagher, Buckeye, and Pittsburg. The Buckeye, also known as the Guthrie, is said to show a considerable body of auriferous material. East of these claims are

others which are reported to carry oxidized copper ores. It seems most probable that all these deposits were originally impregnations of pyrite and chalcopyrite along certain lines and, in the main, similar to those found in the foothills of the Eagle Creek Range. Extensive decomposition and oxidation, due to the low ground-water level, has converted these impregnations into masses of iron capping. The copper and the silver have been extracted and the small amount of gold concentrated. At least this seems the most plausible explanation.

Five miles west of North Powder, in the low foothills half a mile north of the North Fork, are several prospects showing narrow quartz veins with reported good values in gold. They are contained in greenstone and have a northerly strike and an easterly dip.

Six miles west of North Powder, in the same locality and in the same country rock, are several copper prospects, the principal one named Copper King. The deposit is developed by an inclined shaft 150 feet deep. The ore shows some chalcopyrite, as well as malachite and chrysocolla. At the southern foot of the most prominent peak in the Coyote Hills a well-defined quartz vein is exposed by a small shaft and several hundred feet of tunnels. The yellowish, honeycombed quartz carries some stibnite, and gold values of about $7 per ton were obtained from it. The vein strikes north and south, and dips 70° W.; width of vein matter is 2 to 3 feet; width of quartz, 2 to 6 inches. The vein crops in diorite. Close by is a prospect showing dark diorite, copper stained on the joints.

PLACER MINES.

Among the few placers known from this vicinity are those of Bulger Flat, situated between the Elkhorn Range and the sharp conical hill rising at its foot 7 miles west-southwest of North Powder. The production is small, but has been pretty constantly maintained for many years. Placers have also been worked near the head of Wolf Creek, 10 miles northwest of North Powder. The North Powder and its tributary, Antone Creek, do not seem to contain any placers, nor are any other kinds of deposits reported from their watershed.

COPPER BUTTE DISTRICT.

GENERAL FEATURES.

This mining district, which has attracted much attention recently on account of its copper deposits, is situated about 18 miles northwest of Baker City, in the first foothills of Eagle Creek Range, rising from the alluvium of lower Powder River Valley. The low arid hills ascend very gradually toward the higher basaltic plateau, which is covered with forest, and the elevations in the copper-bearing district

vary from 2,700 to 4,000 feet. The drainage is toward Powder River, by a series of creeks and gulches which do not cut far back into the mountains. The water supply is not abundant.

GEOLOGY.

The foothills below the basalt cap are occupied by a series of old eruptive rocks associated with minor masses of clay slates and limestones. The outcrops are generally poor and the whole surface is deeply decomposed, often rendering an exact determination of the rocks difficult. The old eruptives may be designated greenstones—that is, greatly altered basalts and diabasic basalts (metabasalts)—together with tuffs, which also have undergone much alteration. Some of the rocks were very vesicular, the cavities now being filled by calcite and zeolites. These old amygdaloid basalts were formerly often called melaphyres. The alteration consists in the abundant formation of chlorite, hornblende, and epidote. Alternating with these rocks are minor masses of black clay slate and lenses of limestone. One of the largest of these limestone lenses crops 1 mile northwest of Table Mountain and is called the Big Lime dike. It is at least 600 feet long and 100 feet wide. Smaller masses are found 1 and 2 miles north of Medical Springs; others at the mine of the North American Copper Company and near Gilkeson's ranch. Many of them appear entirely embedded in greenstone. The limestone is not greatly altered, but it was not possible to obtain any recognizable fossils, though there are many indeterminable remains of organic life. The stratification of this series is not well defined, but it is believed that it has a moderate dip and a northwesterly strike. From the great similarity to the rocks of Eagle Creek, adjoining this district on the east, in which fossils have been found, the age of this series is believed to be Triassic. The greenstones and tuffs should be considered as surface eruptions which took place along the shore of a shallow sea.

This area of old lavas is almost entirely inclosed by subaerial lava flows of a much later—Neocene—age. From Baker City to Medical Springs the gentle slopes down to the lower Powder River Valley are covered with shallow basalt flows in which the river canyon above the valley is cut. These flows extend continuously across the river, forming the high complex of hills north of Medical Springs, and, in fact, the whole region of the higher forested foothills. The flow structure of this lava is very well defined. Seen from a distance it forms a sloping table-land sharply rising above the bare foothills occupied by the older lavas; behind this table-land rise the high peaks of the Eagle Creek Range. The flows range in thickness from 200 or 300 to nearly 1,000 feet; their lower edge is marked by a prominent line of rocky bluffs. Two miles east of Gilkeson's ranch a point of this bluff, evidently underlain by clays and similar material, has slid down toward

Balm Creek, and forms an exceedingly confused topography, characteristic of landslides. The basalts are, as a rule, fine grained or glassy and vesicular.

MINERAL DEPOSITS.

The minerals of value occurring in this district are all found in the older Triassic lavas and slates. The Neocene basalts contain no deposits. The principal interest is claimed by the copper deposits, which have received much attention during the last two years; large areas are covered by claims of more or less value. The copper ores contain some gold and silver, but gold-quartz veins and placers are not found until the drainage areas of Goose Gulch and Eagle Creek are reached. These are described under another heading.

The copper deposits have been known for a long time. In Raymond's report for 1873 is a statement that "W. B. Crane & Co. sold their copper mine [at Copper Butte] to Messrs. Carson, Williams & Co., of Detroit, Mich." A furnace was erected and one smelting made of 4½ tons of copper. Since that time the copper deposits have attracted but little attention until the recent high price for that metal encouraged further prospecting. That copper is extremely widely distributed in these rocks admits of no doubt. Slight green stains and minute grains of chalcopyrite or chalcocite are very commonly found. As far as can be judged from the small developments, the majority of these copper deposits are not normal fissure veins, but replacements by chalcocite or bornite along certain ill-defined lines. Epidote and hornblende accompany the sulphides. A secondary development of native copper or oxidized copper minerals is often found near the surface.

Below the basaltic bluff half a mile east of the Medical Springs, at an elevation of 3,850 feet, is a copper prospect developed by a 70-foot shaft. The surface exposures are partly covered and unsatisfactory, but the dump shows some chalcopyrite in gangue of garnet, epidote, specularite, and calcite. Normal diorite and crystalline limestone are also present, but the diorite is probably a dike, for it does not show prominently on the surface. Though there does not seem to be much copper in sight, the deposit is interesting on account of its identity in mineral composition with the occurrences from the Seven Devils, Idaho. It is, in all probability, a contact deposit due to the metamorphic action of the diorite on the limestone in which it is intrusive. No other deposits of a similar type have thus far been found in eastern Oregon.

The claims of the North American Copper Company are located 1 mile southeast of Table Mountain, at an elevation of 3,300 feet and a short distance below the basalt bluffs. The country rock is here an amygdaloid metabasalt, with small veinlets of natrolite or similar

zeolites. Prehnite was not observed. Much of the rock contains chalcocite, in fine distribution, associated with epidote. Near the surface the rock also contained finely divided native copper throughout its mass, and especially in the little white zeolitic seams. For more detailed description see page 630. Of well-defined fissures or veins there is no indication. A shaft 120 feet deep has been sunk in this copper-bearing rock and crosscuts extend for 80 feet. It is claimed that a large mass of this rock contains enough copper to be profitably mined, milled, and smelted. The assertion is based on the well-known record of the Atlantic mine in the Lake Superior district, in which ore containing 0.648 per cent copper, or 13 pounds per ton, has been treated at a profit, the total cost being $1.19 per ton. This certainly sounds promising, but it must be borne in mind that, even if a large body of copper-bearing rock exists here, it would not be possible to mine it as cheaply in eastern Oregon as in the Lake Superior region, that transportation would be higher, and that, owing to the presence of chalcocite, conditions for concentration and smelting are much more unfavorable. The Lake Superior estimates must be revised to hold good for eastern Oregon. Large quantities of 3 or 4 per cent ore might be handled profitably in the present case. The total expense could scarcely be reduced below $5 or $6 per ton.

Copper Butte is one of the earliest-known copper-bearing localities. It is situated on Clover Creek, near Gilkeson's ranch, at an elevation of 3,600 feet, and at the foot of the basalt bluff which overlooks the lower foothills. The road from Erwins, on the Powder River, at first ascends over low hills covered by tuffs and fine gravels, then crosses a belt of granite-porphyry about 1 mile wide, which probably is connected with the Sparta granite area, and then enters the greenstones and clay slates.

On the hill south of Gilkeson's ranch is a copper claim known as Little Baby. Two small shafts, in soft, black, clay slate, disclose what apparently is a vein striking northeast and dipping flat northwest. The vein is 1 to 2 feet wide and carries a very decomposed oxidized copper ore, chiefly malachite and chrysocolla, together with minute foils of a brilliantly yellow mineral which is a vanadate of copper containing sodium. It is closely allied to calciovolborthite and probably represents a new species. Half a mile north of the ranch is Copper Butte, with Copper Queen as the principal claim. Below the basalt bluff a considerable amount of oxidized ore, malachite, chrysocolla, and cuprite, was found, irregularly permeating the amygdaloid greenstone and greenstone tuff which form the country rock. Some of this was rich, and the remains of a small furnace and widely scattered slag rich in copper bear evidence to former attempts to work the property. About 100 tons of 12 per cent copper ore are said to have been shipped, and about the same amount of 7 per cent ore could prob-

ably be sorted out. The surface cuts are extensive and irregular and there are besides several short tunnels and shafts. Below the rich surface ore but little of value has thus far been found. Narrow seams are coated with malachite. Two of these seams are more regular than the others, strike northwesterly, and dip steeply; these contain, besides malachite, a little sulphide ore as bornite. No gangue is noticeable.

A few hundred feet northeast of these croppings a tunnel 400 feet long has been driven into the hill to cut a supposed ledge carrying some copper stain, but nothing has thus far been found.

A number of prospects have recently been located on Baker Creek 2 miles east of Gilkeson's ranch and a short distance below the basalt bluff. The country rock is the same altered greenstone. Many and extensive croppings of rusty and cellular iron capping are seen, and, in one place, copper stains. Although this iron cap is suggestive of pyritic deposits, the various cuts and tunnels seem to have developed very little of value. A few hundred feet below these croppings a body of impregnated rock, perhaps 10 to 20 feet wide, crosses the creek, and short tunnels have been driven on both sides. The rock is here fairly fresh and contains scattered pyrite and chalcopyrite, the latter made conspicuous by sulphate of copper incrusting the walls of the tunnel. A quarter of a mile farther down the creek a different and peculiar formation is found, consisting of strong outcrops of whitish silicified rock with much iron stain. No pyrite is visible. This rock forms a bluff 150 feet high, 200 feet wide, and extending for 300 feet on each side of the creek. This whole mass is said to be auriferous and to contain from a trace to $5 per ton in gold. It is probably an altered and silicified greenstone.

Many of the copper prospects are found on Goose Creek, some of them containing chalcopyrite. At the Snowstorm gold-quartz mine and also in the Goose Creek drainage are several copper claims. The surface shows much copper-stained float, and several 10-foot pits have disclosed the presence of vertical streaks impregnated with bornite in the dark-green chloritic diabase, often amygdaloid, which forms the country rock. In one pit three of these impregnated streaks were noted in a width of 10 feet. Spreading from the small masses of bornite are malachite and chrysocolla. There is no distinct fissure vein, nor is the bornite connected with any visible gangue. An average sample across 6 feet gave 2.44 per cent copper and, further, 2.3 ounces silver and 0.1 ounce gold per ton.

SPARTA AND EAGLE CREEK MINING DISTRICTS.

GENERAL FEATURES.

Eagle Creek is one of the principal tributaries of Powder River, and its several branches head far back among the alpine peaks of the imposing mountain range named after it. From their sources in the

bare, rocky amphitheaters, formerly filled with glaciers, the streams flow through forested canyons opening here and there to beautiful, park-like valleys with luxuriant pastures. At the junction of the forks the canyon is about 1,000 feet deep, and even in the driest season carries an abundance of water. With gradually diminishing depth the canyon continues through the timbered ridges of the Eagle Range foothills and through the bleak lava flows skirting its base, until finally its stream emerges into the broad, alluvial Eagle Valley, where it joins Powder River.

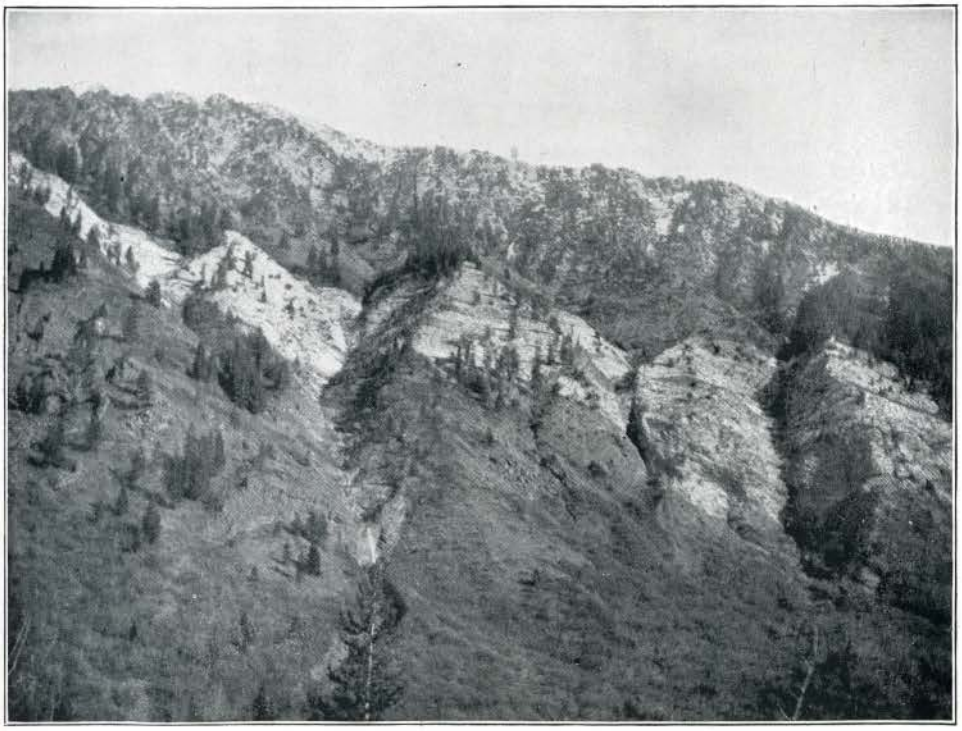
GEOLOGY.

Three main geological features may be distinguished. First, the granite area of Sparta; second, the great area of Triassic sediments forming much of the foothills and most of the high mountain region; and third, the basaltic plateau of Neocene lavas, the flows of which surround the Eagle Creek Range and fill the basin of the lower Powder River Valley.

The Sparta granite occupies about 300 square miles at the end of the long ridge between Goose Creek and Powder River on one hand and Eagle Creek on the other. On the south and east it is covered by basalt; on the west it appears to change into the granite-porphyry exposed north of Keating. On the north it is replaced by the sedimentary series a short distance north of Sparta. The rock is a grayish, medium-grained, apparently normal granite, decomposed on the surface to a yellowish-gray, sandy soil, so that outcrops are rarely, if ever, seen, and fresh specimens can be obtained only in the mines 50 feet below the surface. The analysis shows it to be a soda-granite containing much albite. The relations of the granite to the Triassic sediments were not observed.

The Triassic series is well exposed on Eagle Creek. Rocks of the same age have been described from the Copper Butte district, but while there the prevailing rocks were old surface lavas (greenstones), here the sedimentary part of the series is developed much better.

Limestone and black slate in small croppings were noted a short distance north of the Dolly Varden mine on the road from Sparta to Lily White. Similar rocks were noted 2 miles west of Sanger, at the Sanger mine, and at Lily White. On the road from the latter place to Cornucopia gray, soft, calcareous shale and limestone, with northerly strike, crop near the crossing of Eagle Creek, and the bluff at the bridge shows nearly horizontal gray limestone and calcareous shale, but little altered, in strata from 1 to 10 feet thick. The road continues up Paddy Creek, and limestone with uncertain dip is seen in places up to 800 feet above Eagle Creek, where it is covered by red and green shale and volcanic breccia of the same colors, containing fragments of old lavas and quartz-diorites. The dip is here probably 10° N., and



A.

B.

TRIASSIC LIMESTONE ON EAST FORK OF EAGLE CREEK.

these rocks continue for a mile or two until the basaltic area is entered a short distance beyond Little Eagle Creek. On the high slopes above, toward Paddys Paradise, strong croppings of limestone are seen.

Between the junction of the forks and Miles Camp, 2 miles below, the series is well exposed in mostly horizontal beds, sometimes faulted, and in places containing strata of interbedded volcanic rocks. Half a mile below the junction is a high bluff, on the east side, which at its base shows horizontal strata of calcareous shale and limestone. Two hundred feet above the creek the strata dip 20° to 30° E., and contain abundant *Halobia* shells and fragments of ammonites. Above the junction, on the east fork, bluish-gray limestone appears in heavy beds and continues in bluffs on both sides of the creek for half a mile. Three miles above the junction heavy limestone bluffs appear on the west side and the rock contains pentagonal crinoid stems and spines of echinoids. Interbedded with this limestone is a volcanic breccia of red and green colors, containing fragments of various lavas as well as of a quartz-diorite. From here on the limestone gradually becomes more crystalline. The trend of the strata is N. 10° E. and the dip probably east, though it is difficult to determine exactly. The highest point reached was about 7 miles from the junction, where, at an elevation of 4,500 feet, an important creek comes in from the west. Above this place the canyon, which has been open with sloping benches in the bottom, becomes narrower, and the mountains rise several thousand feet on both sides. On the west side an enormous white sugar loaf of highly crystalline limestone, containing prisms of tremolite (Pl. LXXVI), reaches an elevation of about 6,000 feet. On the east the slopes are a little more gentle, but the mountains are much higher and consist of heavy masses of dark-green amphibolitic schist showing, high up on the declivities, huge, interbedded, lenticular masses of gray limestone. The strike of the schistosity and also of the bedding is N. 20° E., the dip 60° E. (Pl. LXXV). This schist is the volcanic breccia mentioned above, which has been compressed and made schistose by regional metamorphism. The transition from a series of altered limestone, shale, and volcanic breccias to schists and crystalline limestone is exceedingly beautiful and instructive. The change is rapid and yet gradual. High up at the head of the creek sharp limestone pinnacles rise to elevations of 8,000 feet; granitic rocks are probably entirely absent, though bowlders of this rock were noted in a gulch joining Eagle Creek 5 miles above the junction. A passable wagon road leads up the East Fork from Lily White as far as 7 miles above the junction. From here a very bad trail leads across the mountains into the Imnaha drainage basin.

The girdle of basalt flows of the Columbia River lava which surround the Eagle Range is locally interrupted at the point where Eagle Creek breaks through the foothills. A few hundred feet of basalt

overlies the Triassic shales at Sanger, and covers the top of the divide at Lily White. Another area is seen on the slopes between the two forks of Eagle Creek, and isolated basalt knobs are found as far down as Sparta Butte, a conical hill covered with a small patch of this rock. East of Eagle Creek and Sparta the basaltic flows occupy large areas, and the aggregate thickness increases to over 1,000 feet. Here, as elsewhere in the realm of the Columbia River lava, the series is made up of a great number of thin superimposed flows, some vesicular and glassy, others diabasic and massive. Tuffs are absent. The source of the basalt is probably to be found in dikes in the higher parts of the Eagle Range, as is so beautifully shown at Cornucopia, but local eruptions may well have taken place elsewhere. In the Gem mine at Sparta, for instance, a basaltic dike cuts the vein. The time of the eruptions may unhesitatingly be determined as Neocene.

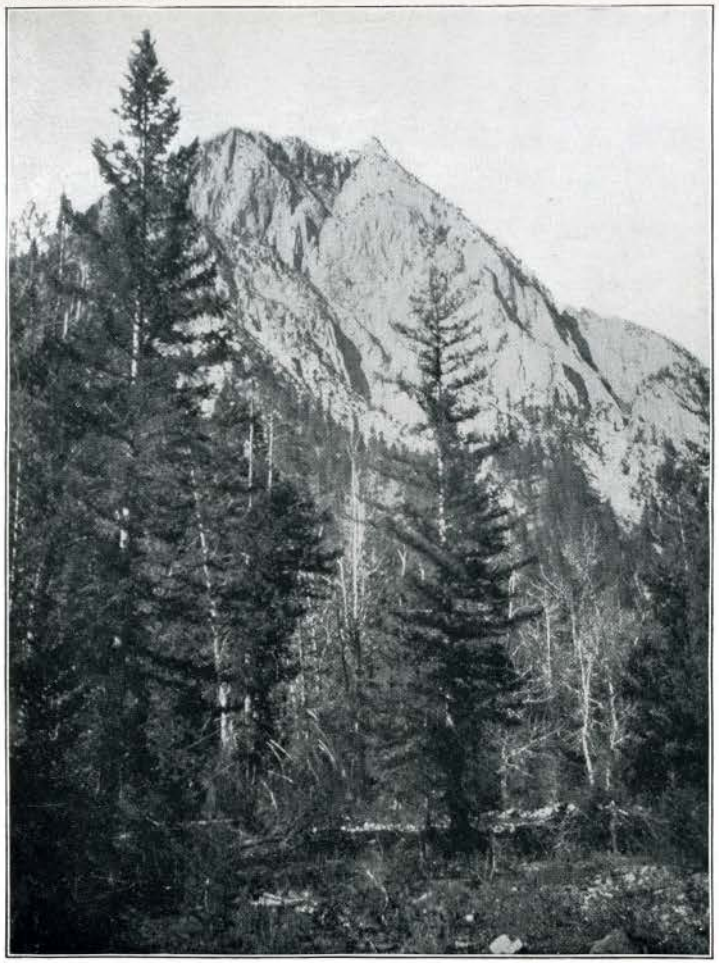
There can be no doubt that glaciers once occupied the upper part of the Eagle Creek drainage, but just how far they descended can not be decided on the present evidence. It is improbable that they extended as far as the junction of the forks of Eagle Creek, and for several miles above the topography suggests rather the gravel flats common below the terminal moraines than the actual presence of the ice stream.

QUARTZ VEINS OF SPARTA.

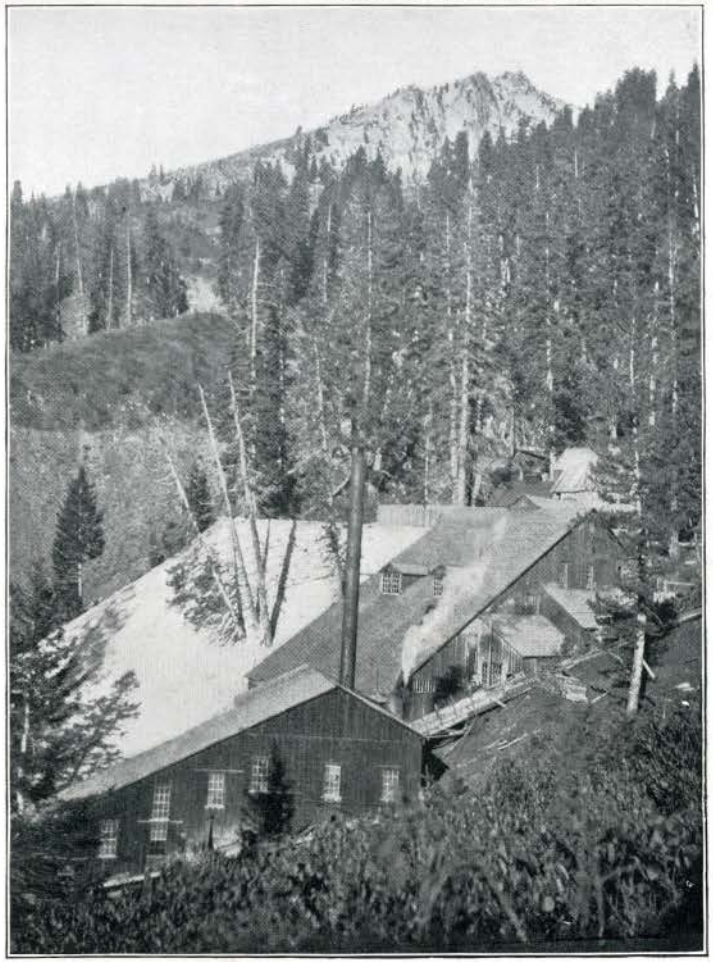
The gulch placers of Sparta in most cases led up to well-defined quartz veins. Many of these were known in early days and gold was extracted by hand mortars, arrastres, and small mills. These operations were not continued, however, and the production from the veins gradually fell off; from $60,000 for Union County in 1880, the output was reduced to $7,300 in 1885, $15,000 in 1886, and $15,000 in 1887; but in 1889 there was a most remarkable change, the output in that year rising to $576,000. Most of this, of course, came from the Sanger mine and the Cornucopia, but a large proportion was contributed by the quartz mines of Sparta. For the four years (1889–1892) from which complete returns are available, the following productions are compiled:

Little Pittsburg	$111,000
Windsor	72,000
Union Tunnel Company	91,000
Gold Ridge Company	124,000
Free Thinker	65,000
Arkansas Belle	83,000
Magpie	19,500
New Gem	59,000
Del Monte	27,500
Buffalo	25,000

As the workings deepened the country rock became harder and the general conditions more unfavorable, so that of late years the produc-



A. LIMESTONE CLIFFS ON EAST FORK OF EAGLE CREEK.



B. UNION-COMPANION MILL, LOOKING WEST.

tion has again been declining, and in 1900 only one mine, the Gem, was worked on a larger scale. Though the veins are narrow they are rich, and it is more than probable that thorough prospecting will develop many good mines in the vicinity. The prevalent strike of the veins is north-south or northeast-southwest; the dip is to the east or southeast. The country rock is throughout a granite, in which the biotite is usually converted to chlorite. The ore is free-milling quartz, with some sulphurets.

The Gem mine, located 2 miles west of Sparta, was worked in early days, a 10-stamp mill being erected in 1873. Two years afterwards the mill was removed to Connor Creek, and the mine was idle for a long time. The vein strikes north-south and its dip is 40° E. The old workings followed the vein to a depth of 100 feet or more on the dip. The new developments consist of a vertical shaft 179 feet deep, with drifts extending 150 to 200 feet from two levels. The vein shows sharply defined foot and hanging walls from 1 to 4 feet apart, between which lie crushed granite and streaks of quartz in some places 2 feet in width. The ore is normal coarse vein quartz, with free gold and a little pyrite and black zinc blende. Near the shaft the vein cuts a dike of granite-porphyry without changing, but on the second level south it is squarely cut off by a basalt dike striking east-west and dipping 50° S., along which some faulting has also taken place. The vein will in all probability be found to continue, as before, beyond the dike.

PLACER MINES OF SPARTA.

A long, heavily timbered ridge follows the western side of Eagle Creek for a long distance toward Powder River. The Sparta mining district occupies the southern end of this ridge, where the rounded hills, here scantily forested, gently slope toward the arid foothills of Powder River. The elevation of Sparta is 4,200 feet. The normal granite which forms the country rock is deeply decomposed and the gulches are filled with gravel. It was found at an early date that these gulches, draining in all directions from the central hill, were auriferous, but on account of lack of water little could be done until, in 1873, the Sparta ditch was completed, with a capacity of 3,000 miner's inches and a length of 22 miles. This canal takes its water from the west fork of Eagle Creek and carries it down on the long ridge to Sparta. Great activity followed its completion, but in a few years the output rapidly diminished. According to the Mint reports the placers produced $35,000 in 1882, $30,000 in 1889, $4,500 in 1890, $3,100 in 1891, $85,000 in 1892. These figures may not be acurate, but they give a general idea of the importance of the district. At present a small production is maintained and much ground is still said to be available on the south slope toward Powder River.

QUARTZ MINES OF SANGER AND EAGLE CREEK.

At the head of Goose Creek, and at an elevation of about 4,600 feet, is situated the Sanger mine, which holds the record as the greatest producer in Union County. The mill is located on Goose Creek, and the mine itself a couple of hundred feet higher, near the divide between that creek and the West Fork of Eagle Creek. The vicinity constituted the old placer camp of Hog'em, and from the gulches leading up to the mine the sum of $500,000 is reported to have been extracted. The principal vein, called the Summit lode, was discovered in 1870 and actively worked during the following years. In 1874 the production was $60,000, from ore containing $16 per ton. Just how much was produced up to 1887 can not be ascertained, but it is not probable that the amount was very great. In 1887 a 10-stamp mill was built, and in 1889 the production began to increase rapidly. During the four years 1889–1892 the Mint reports give a total of $813,000 for this mine. Work was discontinued in 1897 and the mine was idle until December, 1900, when preparations were made to reopen it. What the total production has been is difficult to estimate. It is commonly given as $1,500,000, and this figure is very likely approximately correct.

The developments consist of several tunnels and an incline shaft 400 feet deep. Unfortunately there was no opportunity to examine the deposit, so that the information available is scanty.

The country rock is a black clay slate, containing pyrite near the veins. The latter are well-defined quartz veins, with clay selvage, and dipping at gentle angles. To judge from available specimens, the ore is a normal coarsely crystalline vein quartz, with a little gray calcite. It contains about 3 per cent sulphurets, consisting of pyrite, chalcopyrite, brown zinc blende, and a little galena, together with free gold. On the whole, it has considerable similarity to the ores of many California gold-quartz veins. The principal vein is said to contain three pay shoots. The upper stopes were worked for a horizontal distance of 600 feet, 50 to 100 feet below the surface. The average width of the vein was here 15 inches and the ore yielded $20 to $25 per ton. Below the zone of surface oxidation the vein was from 2 to 4 feet wide and the ore yielded $12 per ton. If these figures are reliable it may mean that the oxidized vein has been leached and compressed to smaller volume; while the absolute amount of gold remained the same the tenor appeared to be increased by this process.

Several other mines and prospects have been discovered in this district. Among them are the Basin claims, a few miles northwest of Sanger, which have been small producers. Three miles southeast of Sanger is the Snowstorm, cropping in greenstone, striking northeasterly and dipping 30° NW., developed by a 160-foot incline. Some rusty quartz was extracted and milled in the arrastre at Lily White.

The Lily White is situated 4 miles southeast of Sanger, on the divide

between Eagle and Goose creeks, has the same strike and dip, and crops in argillite country rock. The production is small.

Four miles south-southeast of Lily White, on the same divide, is the Dolly Varden. This is a big outcrop of rusty quartz and silicified shale, developed by irregular surface cuts and pits. No regular vein could be recognized. The Mint reports credit this locality with a production of $115,000, probably contained in rich pockets.

Several claims are located on the east fork of Eagle Creek. About 10 miles up from the forks Miller and Lane have been running an arrastre for several years. Two miles up from the forks is Cady's mill, with 10 stamps. This was partly supplied from a gold-quartz vein in Triassic sedimentary rocks above the mill, but most of the ore came from the Sheep Rock mine, located 1 mile farther up the creek and 1,000 feet above it on the west side. A considerable amount of gold was formerly extracted here. The Mint report for 1892 credits $29,400 to this mine. The country rock is a Triassic volcanic breccia, the ore normal vein quartz with chalcopyrite and presumably free gold.

Bornite in quartz, said to come from the contact of limestone and igneous rocks has been found in this vicinity. Another arrastre is located on Paddy Creek at the White claim, 3 miles southeast of the Lily White.

PLACER MINES OF SANGER AND EAGLE CREEK.

The old placers of Sanger have already been mentioned. Shallow placers also occur on the road 2 miles west of Sanger mill and are occasionally worked.

The placers of Eagle Creek have been worked at least since 1869, and each summer more or less mining is still carried on. The total amount extracted from these placers is probably considerable, but estimates are very difficult to obtain. In 1869 the district was known as the Cooster and 250 men were working in it. All along Eagle Creek are benches of heavy gravel, 50 to 100 feet above the stream; they are not large, however, and contain heavy bowlders, making the work expensive. In 1900 hydraulic work on a bench of this kind was proceeding on a small scale near Martin's camp, half a mile above the forks of the creek. A year or two ago it was proposed to handle this gravel on a large scale, but the attempt was abandoned.

Near the forks drift mining has been carried on underneath the gravel benches. Similar and more successful drift mines are located at Miles's camp, 1½ miles below the forks. Finally at Martin's, still farther down, where the Cornucopia road crosses Eagle Creek, small placers have been worked for a long time.

Placer mines are also found on upper Paddy Creek and at Paddys Paradise, which are credited with a production of $43,000 between 1889 and 1892. The present annual output of the placer mines of the Eagle Creek district is probably only a few thousand dollars.

CORNUCOPIA MINING DISTRICT.

GENERAL FEATURES.

The town of Cornucopia, which in recent years has become the home of a promising mining industry, is situated in the Eagle Creek Range not far from the head of Pine Creek, and at an elevation of 4,700 feet. In air line it is 36 miles northeast of Baker City, but by the devious ways of the mountain roads the actual distance is more nearly 55 miles. Pine Creek drains about 3,500 square miles of the basaltic plateau at the eastern foot of the Eagle Range. Cornucopia is located on the west fork of the stream, 7 miles above the little agricultural town of Carson, at the upper end of the fertile Pine Valley. From Carson the road ascends a narrow canyon through the basalt plateau. At Cornucopia the creek forks. The underlying older rocks rise from below the covering lavas and form ridges and peaks attaining elevations of from 7,000 to 9,000 feet above the sea. It is an impressive region of deep canyons and precipitous slopes, and the geological features are not less striking than the topographic forms (see Pls. LXXVII and LXXVIII).

GEOLOGY.

The older rocks exposed at Cornucopia are granodiorite and micaceous schist. The granodiorite, which occupies a large part of Granite Mountain to the west of Cornucopia, is a light-gray, granitic, fairly coarse granular rock, consisting of andesine feldspar, orthoclase feldspar, biotite, and quartz. In places the prevalence of plagioclase and hornblende makes the rock assume the aspect of a diorite. A few small dikes of pegmatite or aplite are contained in the granodiorite. This rock is well exposed at the Union-Companion mine, in the high peak rising above it (Pl. LXXVI, *B*), and also in the upper part of Bonanza Basin (Pl. LXXVII, *B*).

The predominant rock is a dark-gray to greenish micaceous amphibolitic schist, weathering reddish or brownish, and contrasting strongly with the gray granodiorite. The schist borders the granodiorite with exceedingly irregular contact, and is well exposed at the Red Jacket, Emmet, and Last Chance mines. Dikes of granodiorite are found in the schist, which is thus clearly the older rock. Brownish schist occupies the whole of Simmons Mountain between the forks of the creek, and also most of the very rough country at the head of the west fork, culminating in Cornucopia Mountain, the highest point in the range. The general strike of schistosity appears to be north-south, the dip 70° E. At the Red Jacket mine the schist is a fine-grained biotite-feldspar-quartz rock with rough cleavage. It is very similar to certain contact-metamorphic rocks or "hornfels." But little attention could be devoted to the schist area. It would not be surprising, however, if

A. EAST FORK OF EAGLE CREEK, LOOKING UPSTREAM.

B. BONANZA BASIN, NEAR CORNUCOPIA.

these rocks should prove to be Triassic sediments and lavas altered by regional metamorphism, like those of upper Eagle Creek.

The Columbia River lava is a very prominent feature of Cornucopia geology, and the exposures are particularly interesting, giving an excellent clue to the manner of eruption of these enormous basalt flows. The road from Eagle Creek enters the area on the divide between that stream and Pine Creek. Emerging from the dense forests, one obtains a magnificent view from the basalt bluff, 1,000 feet high, overlooking Pine Valley. Long ridges of monotonous brown lava beds surround this fertile oasis, and, a little more heavily forested as the elevation increases, they cover the whole eastern slope of the Eagle Mountains up to elevations of 6,000 or 7,000 feet. Another fine view is obtained from a point near the Last Chance mine at Cornucopia. The heavy lavas extend right up to the Union-Companion mine, and rise, leaning against Granite Mountain, to an elevation of 6,200 feet. The town of Cornucopia practically stands at the contact of granodiorite and lava, at an elevation of 4,700 feet. On looking up the east fork of Pine Creek the lava beds are seen forming its east wall up to the very divide. Their highest flows slope gently eastward and lean against the older rocks, at an elevation of 7,500 feet.

The character of this remarkable lava formation is the same here as elsewhere: A series of dark-brown superimposed flows, each from 20 to 150 feet thick, and distinguishable by slightly different weathering, due to slightly different texture. Tuffs are absent. The rocks are fine-grained to glassy olivine-basalts, some of them extremely vesicular, and there can be no doubt that they were poured out as subaerial flows, gradually piling up to their present depth. Rocks in the bottom of Pine Creek Canyon, a mile below Cornucopia, are likely to be as vesicular and glassy as those found 800 feet higher up in the series. The course of the contacts shows that the basalt was poured out over an extremely rugged mountain side scored by deep ravines. These ravines were filled by the lava, and, in many cases, the same gulches have been again excavated by post-basaltic erosion.

The question of the mode and locus of eruption of the Columbia River lava has long been a matter of much interest. A partial solution of the problem is found at Cornucopia. It was to be expected that the source of these flows, which encircle the base of Eagle Range as a somber mantle, should be found in the mountains, in spite of the absence of the ordinary topographic forms of volcanic centers of eruption. And it is found, indeed, that the old rocks near Cornucopia, the granodiorites and the schists, are cut in every direction by numberless dikes, through which the lavas once poured out—a liquid, basic magma pressed out in quiet flows accompanied neither by explosive action nor by ashes, breccias, or tuffs. Numerous dikes cut Simmons Mountain, but they are less clearly visible on account of the dark-gray color of the schists,

and similar dikes cut the high granite hill above the Union-Companion mine.

A fine 10-foot dike cuts the granodiorite on the scale platform 200 feet above the Union-Companion mill. Others, 50 feet wide, are seen on the Red Jacket claim. But nowhere are they developed on such a magnificent scale as in the rocky glacial cirque of Bonanza Basin (Pl. LXXVII, B).

Two long straight basalt dikes, from 10 to 30 feet wide, cut across the basin with a strike of N. 30° E. and an easterly dip of 70° to 80°; this is perhaps the prevalent direction, but there are other dikes running east-west or even curved and irregular. One of the latter kind descends the slope in a curve and is squarely cut off by the upper of the two straight dikes, which also possesses a very marked jointing, perpendicular to its walls. Other more coarse-grained basalts weather in rounded outcrops. The rocks are greenish gray to dark gray, of fine to medium grain, and not vesicular; they are normal basalts, with or without olivine. Most of them contain but a small amount of glass, and some have a well-marked diabasic granular structure.

The basalt dikes are younger than the gold-quartz veins and frequently cut and fault the latter.

The Pleistocene deposits of Cornucopia consist chiefly of moraines and glacial débris. Above Carson a gravelly and bowldery deposit, 200 to 300 feet wide, covers the bottom of the canyon. A well-marked terminal moraine is met with 3 miles above Carson at an elevation of 4,250 feet. Above this, glacial material is abundant.

GOLD-QUARTZ VEINS.

General statement.—The mines of Cornucopia were discovered comparatively late; very little was reported from this district until between 1880 and 1885, soon after which production began. In 1889 the district was credited with $74,000 and since then an output has been steadily maintained. The camp has passed through various vicissitudes and much money has been unwisely spent. Even at the present time the industry is not established upon as firm a basis as it ought to have, for without doubt it is a district of great promise and should yield good returns from capital judiciously invested.

The producing veins are all situated from 2 to 3 miles east to north of the town and at elevations ranging from a few hundred to 3,000 feet above it. Prospects have also been found on Red Mountain, at the head of the west fork of Pine Creek, several miles above Cornucopia, but these are not, as yet, much developed. At least five principal veins may be distinguished; one of these is on Simmons Mountain, the other west of the creek. The strike is in general north-south, but with directions slightly converging northward. The dip on Simmons Mountain is eastward, while the other veins dip west

at moderate angles. The veins are simple, sharply cut fissure veins with a filling of quartz and sulphurets; the ore is, to a great extent, free milling.

Union-Companion mine.—One of the principal veins of the district is that passing through the Union-Companion and Red Jacket claims. These properties, together with the Last Chance vein, described later, and many other outside claims, are owned and operated by J. E. Searles. During 1900 the Union-Companion was the only mine worked on a large scale in this vicinity. Before the present owner acquired it, in 1894, it was operated by the Oregon Gold Mining Company, of Louisville, Ky.; much money—$500,000 it is reported—was spent on it, and a 20-stamp mill was erected with pan amalgamation, according to the Boss continuous system. Being entirely unsuited to the character of the ore, this process was soon abandoned and plate amalgamation, concentration, and chlorination substituted. Shortly after the present management acquired control, chlorination was given up, proving more expensive than shipping to smelting works. The principal expense of mining in the district is the heavy freight charges over 50 miles of bad road. At present the ore is crushed by a 20-stamp mill with 12 vanners, for which an electric power plant has lately been installed. The mill and principal working tunnel are located near the head of Fall Creek, 1 mile northwest of Cornucopia, at an elevation of 5,700 feet.

The total production can not be ascertained, but it is scarcely probable that it has reached $100,000 in any one year since the beginning of operations, about 1888. In 1889 production from this vein reached $79,400; in 1890, $11,300; in 1891, $20,800; in 1892, $21,700. The total production for the three claims may, with some probability, be estimated at $600,000. The Red Jacket, actively worked for several years after 1889, is now idle.

The total developments at the group probably amount to 10,000 feet of shafts and tunnels. The present workings are accessible through a crosscut 1,000 feet long, 300 feet below the Union croppings. Near the point where the vein is struck an incline shaft is sunk 200 feet long on the dip of the vein and the deposit opened by drifts on two levels.

The crosscut traverses 600 feet of basalt before meeting the granodiorite. The contact seems very sharp, and is accompanied by a breccia, so that it seems possible that we have here a flow directly associated with a neck or dike. The vein is contained in granodiorite. On the south side below the crosscut the vein is unbroken, but on the north side on the first and second levels it is badly cut and somewhat faulted by basalt dikes up to 50 feet wide. Similar dikes cut across the vein at the Red Jacket tunnels, where the schist area begins.

The vein strikes a few degrees east of north and dips 40° W. Its outcrops were plainly marked, though not conspicuous. The width is

from 2 to 5 feet, though occasional pinches occur. On the whole, the vein is remarkably persistent. Hanging and foot wall are sharply marked, inclosing a massive vein of white normal quartz from 2 to 4 feet wide. A ribbon structure by shearing is usually developed in the lower part of the vein, or at least for a few inches from the foot wall. Pl. LXV, *A*, from a photograph taken in the stopes above the second level south, well illustrates the character of the vein. It is extremely similar to some of the simpler quartz veins of Nevada City and other parts of California. Free gold is rarely seen, but from 10 to 60 per cent of the assay value is recovered on the plates, the bullion having a fineness of 870. The sulphurets, amounting to from 2 to 7 per cent, are irregularly scattered through the quartz and consist chiefly of pyrite, with smaller quantities of galena, zinc blende, chalcopyrite, and arsenopyrite. Ordinarily the richness of the ore is in proportion to the quantity of sulphurets contained. There is very little silver in the ore. The concentrates run from $150 to $200 per ton, the latter containing 9 ounces of gold and 50 ounces of silver per ton. Tellurides are said to occur in the ore, but none were recognized in the specimens collected. The average value is $15 per ton, of which 85 per cent is recovered. While fresh granodiorite often adjoins the vein, it is usual to find 1 or 2 feet of highly altered rock on the foot wall. This light-gray, soft material contains little pyrite and has ordinarily no value, but consists of quartz, sericite, and much calcite, indicating an entirely normal sericitization and carbonatization, similar to that of the California gold veins. The principal pay shoot dips south and is now worked to the south of the shaft.

As in all of the Cornucopia veins, the surface oxidation plays a very small part, probably owing to the recent glaciation, which has removed the upper and softer parts of the vein. Normal unaltered quartz is found a short distance below the surface.

Robert Emmet mine.—Northward from the Red Jacket shoot the vein pinches in the hard schist of the backbone of the ridge, but opens again in the Emmet claim, which has been worked successfully on a moderate scale since 1899. A tramway connects it with a mill built in Elk Creek. The elevation is 6,350 feet. The developments consist of a shaft 165 feet deep on the incline, drained by a tunnel, and of drifts on two levels. The vein is similar to the Union-Companion, though only 1 to 2 feet thick. It contains a shoot of good ore; some of the partly oxidized ore near the surface, 100 feet south of the shaft, contains up to $100 per ton (Pl. LXXVIII).

A short distance below the Emmet is the Bryan claim, on which a few years ago a pocket containing $7,000 of very rich telluride ore was found. Subsequent operations have not developed anything of value. The telluride is a silvery, ductile sylvanite, covered by a film of dull-brownish gold and inclosed in normal vein quartz.

ROBERT EMMET MINE.

Last Chance mine.—This is located on a parallel vein 1,000 feet higher than the Union-Companion mill, at an elevation of 6,700 feet, and is connected with the mill by a winding and dangerous road, down which the ore is hauled by teams. The output is as yet not great, but the mine promises well if properly developed by tunnels. The present developments consist of a tunnel 400 feet long, an incline 200 feet long on the dip of the vein, together with 200 feet of drifts on the 100-foot level. There is an excellent opportunity to develop this vein by deep tunnels.

The vein fills an extremely well-defined fissure dipping 45° W., and consists of 5 to 6 feet of massive, coarse-grained vein quartz. The terminals of the quartz crystals often project in cavities. As far as exposed, the same width of solid quartz is maintained. Through the quartz the sulphurets are scattered irregularly; they consist principally of pyrite, with a little chalcopyrite and zinc blende. The ore is said to average $23 over the whole width. Near the vein the micaceous schist which forms the country rock is bleached and sericitized.

Other veins.—A third vein system cuts across Bonanza Basin and is accessible by trails from the Last Chance mine. None of the many claims has been extensively developed. At the Queen of the West short tunnels expose a sharply defined quartz vein, 1 to 2 feet wide and containing pyrite and chalcopyrite. On the Wild Irishman, near the summit of the mountain, the same or a parallel vein is exposed, with a large body of medium-grade ore. Two miles north of Cornucopia, on the long ridge between the East and West forks, are the several claims of the Simmons vein. This is reported to be an extremely sharply defined quartz vein striking north-northwest, but dipping east, in contrast to the veins on the other side of Pine Creek. The developments consist of several tunnels and shafts, the latter 100 to 200 feet deep. Good pay shoots with rich pockets are said to exist, but for some reason active work has not been taken up.

PLACER MINES.

While there are no placer deposits at Cornucopia, gold-bearing gravels form the bottom of the canyon just above Carson and below the terminal moraine, and shafts have been sunk in this gravel 1 mile above Carson. The amount of heavy bowlders in the gravel would render placer work difficult and expensive.

PINE CREEK AND LOWER POWDER RIVER.

COLUMBIA RIVER LAVA.

East of Cornucopia and Sparta extends a very large area of Columbia River lava. It connects westward by a narrow strip along Powder River with the great flows north of Medical Springs. It also crosses

Snake River and extends, south of the Seven Devils, for 40 miles eastward into Idaho. Northward it is apparently continuous for over 100 miles, extending up to and beyond Lewiston. The area forms a table-land of varying elevation. Near Carson it rises to 4,200 feet; at Sparta it is only 3,500; along the lower Pine Creek it probably averages 3,500 or 4,000 feet; but farther north, on the divide between Pine Creek and the Imnaha, it rises to elevations of from 6,000 to 7,000 feet, and extends from Snake River Canyon to the foot of the Eagle Creek Range. This is the prominent plateau seen across the river from the Seven Devils and figured in a preceding report.[1]

Throughout the larger part of the area the formation consists of a great number of superimposed flows well exposed along many sharply incised canyons. On Pine Creek, a few miles up from Snake River, about thirty flows were counted in a bluff 1,800 feet high. Owing to slight differences in texture, weathering brings out the structure in an excellent manner. Most of the rocks are normal olivine-basalts with dark-brown glass, but some flows show a fine-grained, diabasic, granular structure without glass.

LAKE BEDS AND COAL.

Along the foothills of Eagle Valley, at elevations of 2,300 to 2,500 feet, appear light-colored sands, tuffs, and clays, sometimes also coaly material; these apparently indicate deposition in a lake basin, but were not further investigated. All along Powder River, upstream from Eagle Valley, the basalts are interstratified with tuffs and sediments. At the mouth of Goose Creek, on the south side of the river, opposite Love's ranch, prospecting operations have been carried on for coal. The developments are 200 feet above the river in rolling foothills and consist chiefly of a gently sloping incline, 100 feet long, at present full of water. Dioritic bed rock is not far below the surface. In another cut the coal seam was exposed, showing 2 feet of a poor quality of shaly, crumbling lignite, underlain by tuffaceous clay and covered by a thin seam of clay, above which rested a basalt flow. The clay and coal are thus clearly intercalated into the volcanic series. Prospecting by boring above these inclines has been undertaken, but apparently without success; and, indeed, the chances of developing a paying coal bed seem very slight.

PLEISTOCENE.

In this large area of volcanic beds the Pleistocene period is represented by few deposits. Narrow bars occur along Snake River and Pine Creek, but rarely rise more than 50 feet above the stream. In many cases these small areas are covered with excellent soil from decomposing lavas, and the mild climate is favorable to horticulture

[1] Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, Pls. XIV and XV.

wherever water is obtainable. The only alluvial areas of importance in this vast extent of pastures and forests are those of Pine and Eagle valleys, both of them dotted with beautiful fields and orchards. Pine Valley, in the middle course of Pine Creek, is 10 miles long and up to 3 miles wide, with elevations ranging from 2,500 to 3,400 feet.

Eagle Valley, at the confluence of Eagle Creek and Powder River, is eroded in the soft lake beds and tuffs deposited in this vicinity. The elevation is a little lower than Pine Valley, reaching only 2,200 feet. Between Eagle Creek and Powder River a flat-topped ridge rises to an elevation of about 3,300 feet; from here to Sparta extends a continuous gentle slope. This whole ridge consists chiefly of coarse gravels of both older rocks and Neocene basalts. It is clearly the deposit of a post-Neocene stream corresponding to the present Powder River, and was made at a time when the main drainage level stood about a thousand feet higher than at present. The elevation of 3,300 feet clearly marks an old base-level. These gravels should probably be considered as of late Neocene age.

COPPER DEPOSITS OF SNAKE RIVER.

GENERAL FEATURES.

Under this heading will be described a number of recently developed copper prospects in the canyon of Snake River, southwest of the Seven Devils and extending from the mouth of Pine Creek 12 miles northward at least, to Eckles Bar. Snake River here flows in a rather open canyon from 2,000 to 5,000 feet deep. The slopes are not as precipitous as farther north, and they are covered by abundant bunch grass. Forest growth does not appear below an elevation of 4,000 feet. No important tributaries join the river for a long distance north of Pine Creek. The swift and yet smooth river which has excavated this wonderful trench since the Neocene period pursues its course in a rocky channel a few hundred feet wide and in places very deep. A few small gravel bars and alluvial cones from tributary canyons form the scant amount of agricultural land available. The color of the water, here as above, is a peculiar light green, no doubt due to the suspended fine sediments of the lake beds of the upper valley. The climate along the river is comparatively warm, and very little snow falls during the winter.

This isolated country is reached by wagon road from Baker City via Pine, a total distance of about 80 miles, or by wagon road from Salubria, Idaho, via Cuprum, in the Seven Devils, and the so-called Kleinschmidt grade, which in many serpentine curves descends the canyon slope to Ballards Ferry.

Much has been said regarding the possibilities of navigation on Snake River. The many rapids encountered make the distance

between the mouth of Burnt River, near Huntington, and Ballards Ferry practically unavailable for navigation, and to improve the channel would be extremely costly. About 1892 the stern-wheeler *Norma* was built by the owners of the Peacock mine, who also constructed the Kleinschmidt grade. The steamer, which was 150 feet long, made two trips between the points mentioned, but came to grief on the second trip. After repairs, the steamer was taken down through the canyon to Lewiston, a most dangerous but successful undertaking. About 1896 a small appropriation was made by Congress to improve the channel of the river. Some rocks were blasted out and the money was expended, but the work done was of little value compared with the number and extent of the rapids. In 1898 the steamer *Mabel* was built by the Northwestern Copper Company, which was then attempting to open the Peacock mine. The steamer was 100 feet long. The engines are said to have been too weak for the size of the boat. At any rate, the *Mabel* made sixteen trips during periods of high water between Ballards and Huntington. Going down the river was not difficult, but returning, the steamer had to be towed at from eight to twelve places. Finally the steamer was wrecked, and now lies stranded near the mouth of Powder River. Navigation between Huntington and Ballards is possible only during three months of the year.

Regarding the river below Ballards, navigation is there even more impracticable. No steamer has ever come up from Lewiston, and this feat is, indeed, believed to be impossible. The worst rapids are at the mouth of Deep Creek, below the Seven Devils.[1]

GEOLOGY.

For a long distance above the mouth of Pine Creek the canyon is cut entirely in the flows of Columbia River basalt, but a short distance below the point mentioned the older rocks emerge from below this cover of igneous flows. On the west side the latter continue for many miles northward, forming the upper wall of the canyon slope, well marked by its brown color and lines of volcanic flows. At the Iron Dike mine the contact runs 1,000 feet above the river, at Ballards about 2,000, and at Spring Creek about 1,800 feet above the stream. The thickness of the volcanic flow is from 2,000 to 2,500 feet. On the east side the contact follows more or less closely the course of Indian Creek, and near Cuprum bends eastward. A great mass of older rock is thus exposed on the Idaho side, culminating at White Monument Peak, which rises 6,400 feet above the bottom of the canyon. The ridge between Indian Creek and the river north of Cuprum is called Horse Mountain.

[1] For a report on the Snake River between Huntington and Ballards Ferry see Ann. Rept. Chief of Engineers, U. S. A., 1891, Part V, p. 3285.

In the older series the predominant rocks are greenstones of various kinds, ranging from metabasalt to metarhyolites, and frequently containing roughly bedded masses of tuffs and breccias. These igneous rocks are old lavas erupted during the Triassic period. Though greatly altered, they have rarely been much compressed or acquired schistose structure. Embedded in those volcanic flows are smaller streaks of sedimentary rocks.[1] These consist of black clay slates and bluish-gray limestones, neither extremely altered. On the Kleinschmidt grade, 2 miles west of Huntley's ranch, at an elevation of 3,800 feet, limestone and shale crop with northerly strike; more limestone is found northwest of this place, in Lime Peak Gulch; finally, a heavy mass of limestone crosses the river between Spring Gulch and Eckles Bar. On the slopes a mile west of Ballards a band of clay slates crops with northeasterly strike. In the latter Mr. E. Antz, of Ballards Ferry, found flat impressions of shells which Dr. T. W. Stanton informs me are large *Halobia* or *Daonella*. In the limestone mass 4 miles below Ballards fossils have also been found. A piece of this limestone given to me by Mr. Antz showed a *Lima*, with fragmentary imprints of a *Halobia* or similar form. These finds place the series, without much doubt, in the Triassic. During a reconnaissance in 1897 a number of round crinoid stems were found in the limestone on the grade 2 miles west of Huntley's ranch, mentioned above, and the belief was expressed[2] that the series was Carboniferous; it was thus indicated on the accompanying map, the doubtful character of the determination being emphasized by a question mark in the legend. From the present data the rocks are Triassic, and this is also confirmed by the great similarity to the Triassic series of Eagle Creek (see p. 581).

COPPER DEPOSITS.

A great number of copper deposits have lately been discovered in this district, and active prospecting is proceeding. Ordinarily they have the character of impregnations along certain lines in the old greenstones. While these deposits may represent lines of fracture, they have only exceptionally the features of clearly defined fissure veins. The ores are chalcopyrite, bornite, and chalcocite, the gangue epidote and quartz. The deposits are not at all similar to the contact type characteristic of the mines of the Seven Devils and described in a previous report.[3]

Iron Dike.—This is a copper deposit discovered in 1897, on which developments have recently been undertaken by the Northwest Copper Company. It is situated on the west side of Snake River and about 2,000 feet distant from it. The croppings are 675 feet

[1] Compare Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, pp. 88 and 251.
[2] Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 86.
[3] Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 251.

above the river and 375 feet above the lower tunnel which now is being driven, expecting to crosscut the deposit 800 feet from the mouth. The uppermost tunnel is 70 feet lower than the croppings, and there is an intermediate crosscut 120 feet below the same.

The prevailing country rock is a chloritic, indefinite greenstone, without schistose structure. The microscope shows it to be an extremely fine-grained igneous rock with streaks and spots of chlorite, as well as abundant but very minute fibers of sericite; the groundmass is probably an intimate mixture of chlorite and feldspar. At the end of the upper crosscut a dark-brown, much altered metaandesite occurs. The croppings are large masses of black and brown stained rocks, one knoll rising 75 feet above the general slope and measuring 100 feet across. It is said that the croppings can be traced for some distance in a west-northwesterly direction. At any rate, few walls or fissures can be seen; one near the mouth of the highest tunnel strikes north 55° W. and dips 60° S. The maximum width of the croppings is probably 200 or 250 feet. On the rusty surface of the croppings scarcely any copper stain indicates the heavy body of chalcopyrite immediately underlying it. Holes a foot or two deep show somewhat decomposed pyrite, but very little chalcopyrite, the latter appearing only a little farther below the surface. The upper tunnel, for the first 100 feet, is in heavy ore of mixed chalcopyrite and pyrite; then follows 80 feet of poorer ore. A sharp contact here separates the chloritic greenstone from the dark-brown metaandesite. Crosscuts extending 25 feet each way in the best part of the ore show a width of 4 feet of solid sulphides which may average 15 to 20 per cent in copper. The largest part of the tunnel is, of course, in poorer ore, consisting of disseminated pyrite and chalcopyrite in chloritic greenstone. There are also abundant quartz seams, veinlets, and nodules which contain chalcopyrite, and often a regular silicification of the rock may be noted. Zinc blende or galena rarely occurs, and a little antimony is contained in the best ore. The ore contains about $2 in gold and 6 to 30 ounces silver per ton. These amounts are apparently independent of the percentage of copper. The intermediate tunnel, 150 feet long with a crosscut 125 feet toward the west, also shows a heavy body of sulphides.

If the lowest crosscut, now being driven, exposes similar bodies of ore the deposit will be of considerable value. At present, owing to lack of development, it is not easy to form a positive idea of the character and prospects of the property, but there can scarcely be any doubt that it is a zone of crushing in which copper-bearing solutions have deposited their contents, largely by processes of replacement.

Near the Iron Dike, on both sides of the river, are many other prospects showing similar ores.

River Queen.—This deposit is situated on the Idaho side, half a

mile above Ballards. The croppings are 250 feet above the river. The developments consist of a crosscut 200 feet long, 100 below the croppings, and 100 feet of drifts on the vein. The rock is a greenish metarhyolite, with large corroded quartz crystals. In places it is distinctly silicified, but contains also in other places some sericite and calcite, as well as much chlorite. Near the end of the crosscut are two ore streaks, striking northeasterly. The first, a fairly well-defined seam with steep dip, shows a few inches of copper ore, chalcopyrite, or oxidized ore associated with silicified country rock; the second is in places several feet wide, but is not connected with any clearly defined fissure, often branching and rapidly changing in width. The ore is here cuprite and malachite, the former rich in silver.

Other prospects.—There are many other prospects near Ballards. In most of the gulches copper-stained float may be found, and deposits have been located on both sides of the river. One of these is situated in the gulch just south of the first bend of the Kleinschmidt grade, 500 feet above the river. In addition to oxidized copper ore, this prospect contains a little galena and zinc blende. Other deposits are found in McKinley Gulch above the grade.

A number of deposits are reported from the Oregon side of the river 5 miles below Ballards, at the mouth of Spring Creek. A string of claims is here laid out, following the contact of a large limestone mass from the river up to the covering flows of Columbia River basalt. These were not visited.

Copper King group.—This group of claims is situated 2 miles below Ballards, on the Oregon side, at a place known as McDougals Camp. The prevailing rock is the usual greenstone or old and altered Triassic lava. Here, however, it is very amygdaloidal, the cavities being filled with white or reddish calcite. The microscope shows it to be a meta-andesite containing much chlorite.

The Copper King prospect presents a fairly well-defined vein in tuffaceous amygdaloid rock, striking N. 70° W., dipping 45° N., and traceable for a few hundred feet. The ores are bornite, with some chrysocolla, accompanied by much epidote and a little quartz. The quartz seems to be shattered and silicified rock rather than a simple filling.

The Harvest Queen is another prospect 1,500 feet above the river. This a small but well-defined vein up to 1 foot thick, striking N. 20° E., and dipping 50° E. It is said to be traceable into the adjoining claim, Cap. Miller. The clearly defined filling consists of normal vein quartz, much epidote, and heavy masses of chalcocite.

A thousand feet above the river, between the two prospects already mentioned, is the Golden West, with several extensions, most prominent of which is the Leonard. These claims have a northwesterly direction, following the ore streak, which is not a well-defined vein,

but probably a crushed zone in which the amygdaloid is impregnated with copper glance, always accompanied by microscopic epidote. As usual, there is much calcite in veinlets and nodules. This zone is well marked for half a mile or more, and its width is from 10 to 30 feet. Hardly any copper stain is visible on the surface, but appears, together with chalcocite, a very few feet below the surface in many pits and short tunnels along the line of the deposit. The richest showing is said to be on the Leonard, where much solid chalcocite appears. Throughout the rest of the zone it occurs only as small grains scattered through the rock. The average grade of the ore here exposed is very difficult to determine without deeper exploration, which is now in progress. The surface appearance fully warrants further prospecting.

UPPER SNAKE RIVER CANYON FROM HUNTINGTON TO MINERAL.

GENERAL FEATURES.

A few miles above the mouth of Burnt River, Snake River enters the canyon, through which it flows practically until its junction with the Columbia. For a few miles north of Burnt River the canyon is rather narrow and about 2,000 feet deep. Above this point it broadens and the divides recede; the slopes are more gentle, while the depth is fully maintained. Along the bottom are several large bars and gravel benches supporting prosperous fruit and hay ranches. The grass-covered slopes are bare of forest until elevations of 4,000 feet are attained.

GEOLOGY.

Until well down toward the mouth of Powder River the canyon is eroded almost entirely in older rocks. A little above Burnt River the basalt flows descend nearly to the level of the river, and a short distance above the mouth of Connor Creek a ridge on the Idaho side is covered from the summit down to the river level by characteristic sloping flows of the Columbia River lava, showing that while the canyon has been reexcavated, the old drainage system was fully as deep as that at present followed by the stream. Another basalt area crosses Burnt River Canyon 8 miles above Huntington; the appearance is very much as if an earlier canyon, draining southwesterly, crossed the present and had been filled to the brim with lava. The Neocene formations west of Huntington are described in a subsequent paragraph on Rye Valley, Mormon Basin, and Malheur.

The older rocks form two well-defined divisions. The lower division consists of greenstones, predominatingly old rhyolites, rhyolite tuffs, and quartz-diorite-porphyry; it occupies the vicinity of Huntington and the narrow canyon extending for 8 miles north of that place. It is probable that this whole series consists of old surface flows. These rocks are covered by an extensive series of clay slates and limestones

of uncertain age. Near the contact, on Burnt River and on Snake River, are red and green tuffaceous slates embedded in the greenstones before the main sedimentary series begins. Similar rocks crop near the head of Durbin Creek, giving the whole series a strike of N. 30° to 45° E., and a northwesterly dip, which near the contact is 20° and at the gypsum mine 2,000 feet above Huntington as low as 12° to 15°. The same contact crosses the river and is exposed in the creek leading up to Mineral from Snake River. The strike of the clay slates is here N. 80° E. and the dip is 60° N.

Besides the predominating black clay slates the sedimentary series contain heavy masses of bluish-gray limestone. The largest mass, several hundred feet across, is exposed 4 miles above Huntington, continues up to the top of the mountain between the two rivers, but is not seen in Snake River Canyon. Other heavy limestone masses crop above the Connor Creek mine. At the Gypsum mine crinoid stems and doubtful remains of corals were found. The age of the series is in great doubt; most likely the sediments and old lavas are of Triassic age.

LIME AND GYPSUM.

The largest limestone masses in Oregon, conveniently situated near railroad, are found 4 miles above Huntington, and kilns have been in operation for a long time. It has been known for thirty years that important gypsum deposits occurred near Huntington, but it is very recently that they have been utilized. The deposit is situated 4 miles from Burnt River and 8 miles from Huntington, near the summit of the ridge overlooking Snake River. The elevation at the lower tunnel is 3,950 feet. A tunnel 170 feet long connecting with an upraise 100 feet long exposes a bed of good quality of gypsum, 20 feet thick, resting with gentle westerly dip on slate and limestone and covered by red and green tuffaceous slate. About 80 feet higher up is another stratum of gypsum, 30 to 40 feet thick, and covered by gypsiferous limestone and green volcanic tuff. The conditions for exploitation are excellent. The gypsum is in part pure white and crystalline; in part, however, it contains thin strata and films of greenish chloritic mineral. The Oregon Plaster Company quarried 1,800 tons of rock at this place in 1896 and erected works near the limekiln on Burnt River which the same year were destroyed by fire. A plant for the dressing and milling of the material has been recently rebuilt. In 1899 and 1900 several hundred tons of plaster of paris were produced. Discoveries of gypsum are also reported from the Idaho side and in similar geological position.

MINERAL DEPOSITS NEAR HUNTINGTON.

A few miles above the mouth of Burnt River, on the Oregon side of Snake River, a number of claims are located, among them the Bay

Horse, which stands credited with a small silver production in 1891. Other prospects with some galena and zinc blende are reported from the summit of the ridge separating the rivers. The localities were not visited, but are evidently contained in the basal series of old igneous flows similar to the deposits of Mineral.

SILVER MINES OF MINERAL, IDAHO.

The road to Mineral follows the west side of Snake River for 20 miles below Huntington, where the river is crossed and Dennett Creek ascended for a distance of 4 miles. The lower part of the creek has a southwesterly direction and forks about 3 miles above the river. The town of Mineral is situated on the South Branch, which heads a few miles due east among the gulches leading down from Iron Mountain, the elevation of which is over 5,000 feet. The town and the smelters are situated in the narrow gulch at an elevation of 3,000 feet. As along Snake River, the hillsides are bare, but good forests crown the summit of Iron Mountain.

Fissile clay slates with one intercalated stratum of limestone crop in the gulch below the junction, the strike being N. 80° E. and the dip 60° N. Below the slates follows, apparently conformably, a heavy series of old greenstones and tuffs, together with some minor diorite areas and occasional dikes of basalt.

The mines of Mineral were discovered about twenty-five years ago, but for many years remained undeveloped prospects. About 1888 a wagon road was built into the district, and in 1889 Messrs. Biddle and Lang erected the first smelter. This ran successfully, applying the pyritic process, until 1893, when, owing to the low price of silver, the works were closed down. Another smelter had been built in 1890 just below the forks of the creek, and this also was closed in 1893. Smelting charges were $16 per ton of wet ore, and coke at the smelter was worth $28 per ton. The camp remained dormant until November, 1900, when a new 60-ton smelter was being erected by Mr. A. J. Crook. The total production of the camp is roughly estimated to be 600,000 ounces of silver.

Most of the ore deposits occur in the igneous rocks below the clay slates, in the immediate vicinity of the town. The most prevalent type contains chalcopyrite, pyrite, galena, zinc blende, and tetrahedrite in a calcite gangue. No great depth has been attained, and in some cases surface oxidation prevents accurate diagnosis; but in general the deposits seem to be vein or irregular bodies connected with fissures. To a large extent the ores are certainly formed by replacement of the rock.

The Silver Bell is situated on the hillside, a short distance above the town, at an elevation of 3,600 feet. It is developed by three tunnels and in all by 2,000 feet of drifts and crosscuts. The upper tunnel

cuts the vein 100 feet from the portal. The strike of the vein seems to be northwesterly, the dip southwesterly, but the ore body is not very regular or well defined. A short distance beyond the crosscut it widens to a big body, 40 feet square, of oxidized ore, full of copper sulphate and gypsum. A similar big chamber is struck on the middle level. The lowest tunnel is in sulphide ore, less rich than that of the upper workings.

The Silver Bell has been worked, together with the Black Hawk and the Maria, and the group is credited with the largest part of the total output of the camp. Besides copper, the ore contains much silver and a little gold.

The Maria is located on the hillside south of the town, and is developed by several tunnels for a vertical distance of 200 feet. The vein is fairly well defined, from 2 to 4 feet wide, and dips northeasterly. The dip decreases in depth to 20°. A dike of basalt similar to that found in the Jessie cuts the vein. The oxidized ore is confined to within 50 feet of the surface. In depth the sulphide consists of pyrite, chalcopyrite, tetrahedrite, galena, and zinc blende, all fine grained and intimately intergrown with calcite gangue. The percentage of copper is small—from 1 to 2 per cent. The average silver content is said to be 25 to 30 ounces per ton. The zinc blende and galena, which are not very abundant, are most intimately intergrown in concentric masses. A specimen of richer ore assayed contained 0.28 ounce of gold and 55.92 ounces of silver per ton. The production of the Maria is reported as 150,000 ounces silver.

The Black Hawk, situated between the Silver Bell and the Maria, is similar to the latter. It is credited with 200,000 ounces of silver.

There are many other prospects of note in the camp. The Eagan group, northwest of the town, on the steep slope toward the North Fork of Dennett Creek, is credited with 100,000 ounces of silver, found in rich tetrahedrite ore, also containing arsenic. The Boone and the Enterprise, on the ridge north of the town, have also produced some rich ore.

The Jessie, situated half a mile northwest of the town, at an elevation of 3,400 feet, represents a totally different type of deposit, and is developed by a tunnel 100 feet from the croppings. It is contained in a dioritic rock, but in the hanging wall is a dike of normal basalt with diabasic-granular structure. The strike of the well-defined vein is northeasterly, the dip 45° NW. The vein shows 2 to 3 feet of pyrite and chalcopyrite in gangue of quartz and tourmaline; in addition, the microscope shows the presence of specularite, vesuvianite, and a little dolomite and calcite. This ore is said to contain, besides much copper, 0.1 ounce of gold and 3 ounces of silver per ton.

IRON MOUNTAIN.

A large deposit of somewhat titaniferous magnetic iron ore is reported to occur at the head of Dennett Creek, on Iron Mountain. The ore also contains a little malachite from decomposed copper sulphides. The country rock is a diorite. Limestone also occurs in the vicinity, hence it is very possible that the occurrence represents a contact deposit.

PLACER MINES ALONG SNAKE RIVER.

A little placer work has been prosecuted at various places along Snake River, especially between Mineral and the mouth of Powder River. These localities were not visited. Placers have also been worked on Fox Creek and especially on Connor Creek, naturally deriving their gold from the Connor Creek vein. The whole creek has been worked over twice, and every season some washing is done. The grade of the creek is very steep and the gold coarse. The total production is said to be about $100,000.

CONNOR CREEK MINE.[1]

Location.—This mine, well known in the annals of eastern Oregon, is situated on Connor Creek, a small tributary to Snake River. Heading near Lookout Mountain, this small water course, a gulch rather than a creek, follows a southeasterly course for about 6 miles and joins the main river at a point 14 miles north-northeast of Huntington. The grade is steep and its canyon deep and narrow, branching in two forks near the mine, which is located 2½ miles up from the river. The hills near the river are smooth and covered with grass. Above the mine cliffs of limestone appear and scattered bunches of pine. The elevation at the river is nearly 2,000 feet, while at the mine the corrected aneroid reading is 2,950.

History.—The vein was discovered in 1871 by Wood and Edelmann. In 1872 a 5-stamp mill was running on rock carrying $23 per ton in gold. The mine continued to be worked on a smaller scale till 1876, when a 15-stamp mill was erected. Since that time it has been worked almost continuously, though the production has been irregular and at times very small. The present owners, the Connor Creek Mine and Mill Company, bought the mine in 1884 for $60,000. At the present time there is on the property a 35-stamp mill, with plate amalgamation and concentrators, built some fifteen years ago.

Production.—Statements of production for this mine vary greatly. It is estimated by some that the mine has yielded a total of $9,000,000, but this appears to be an exaggeration. Captain Myrick states that

[1] Much of the information regarding this mine was obtained from Mr. J. H. Pomeroy and Captain Myrick, the present superintendent. I visited the mine in November, 1900, but owing to a combination of circumstances could not enter the workings.

only $100,000 was produced previous to 1876, and he believes that the production since then has amounted to only $1,000,000. At any rate, it is not probable that the total has exceeded $2,000,000.

The only Mint reports containing detailed statistics give the following data: In 1882, production for three months amounted to $26,000. Twenty stamps were dropping and 250,000 tons were in sight. The production up to 1889 was $400,000; in 1889 it was $119,000; in 1890, $24,000; in 1891, $13,000. In 1892 nothing was produced. During the last few years the mine has yielded little or nothing, though development work proceeded on a small scale. Recent developments give hope of resumed production. The period of greatest activity falls between 1880 and 1890.

The mine is exceptionally favorably situated for cheap mining and milling, having abundant water supply and timber available and the workings being well above tunnel levels. As early as 1882 it was expected that the expenses for mining and milling would be reduced to $2.50 per ton, and at the present time they ought not to exceed $2 per ton.

Development.—The vein which crops high up on the mountain is developed by the following tunnels:

Name.	Length.
	Feet.
Upper	486
Middle	577
Lower	610
Bulger	1,200
Dry Creek	1,400
Connor Creek	3,700
Total	7,973

The upper tunnel is about 1,000 feet above the Connor Creek level. The latter is a crosscut about 3,000 feet long, with the drifts on the vein aggregating 700 feet. The Dry Creek follows the vein for 1,400 feet and strikes it by means of a short crosscut. This level is the one on which the mill was built, the Connor Creek being about 150 feet lower.

Country rock.—The vein is inclosed in black clay slate with a general north-northeast strike and dip of about 60° WNW. Above the outcrops are heavy bodies of blue limestone, which, however, are not cut by the vein or by any of the drifts or crosscuts.

The vein.—The strike of the vein is N. 40° W., the dip from 70° to 75° SW., thus decidedly crossing the slates in dip and strike. The

outcrops are only distinctly visible in one place, though in many places the vein has been stoped almost up to the grass roots. The vein has been followed and stoped on all levels in a westerly direction up to a break locally termed the "final cut-off." This forms a body striking N. 31° E. and dipping from 45° to 60° SE. It consists apparently of a shear zone of puckered, somewhat chloritic clay slate about 130 feet wide and crossing the normal slates in strike and dip. On none of the upper five levels has the vein been traced west of this "final cut-off;" in fact, it is understood that no very extended search has been made for it. The principal ore bodies were found above the Dry Creek tunnel; between this and the lowest level the vein was very much crushed and split. Recently extensive explorations have been made beyond the "final cut-off" on Connor Creek tunnel level. The vein has finally been found here and is similar to that in the old workings, carrying excellent values in coarse gold. This is very encouraging, as it is now believed that a pay shoot may extend all the way up to the surface on the west side of the final cut-off. More explorations are necessary, however, to prove this. In the light of the latest results the cut-off appears as a fault, later than the vein and cutting across it. Beyond the cut-off normal slates are again found.

There are also several minor faults cutting the vein. These have in general a northeast strike and southeast dip, the horizontal throw amounting to 30 to 50 feet to the left, going northwest on the vein. The faulted part soon curves back into the normal line of the vein.

The vein is followed along its whole course by a dike from 6 to 8 inches wide, always on the hanging wall and cutting the slates sharply. In appearance it is a greenish, greatly altered rock containing abundant cubes of pyrite. The slates adjoining the vein are in places well filled with cubes of the same material. The ore consists of normal white, coarse vein quartz up to 8 feet wide and never pinching out entirely. The usual width of the quartz filling is from 3 or 4 feet down to 18 inches. The gold is largely native and often in very coarse masses. The value is from $19 to $20 per ounce. This is unusually high, but similar to that from the Virtue mine. A small amount of pyrite and sometimes argentite accompanies the quartz. When the pyrite occurs in heavy masses its value is low. The quartz is partly massive, partly ribboned by subsequent shearing. On Connor Creek level the recently discovered vein is 18 inches thick, massive on hanging wall, and ribboned on foot.

Pay shoots.—The vein carries the best values when of somewhat considerable thickness, say 3 to 4 feet. It has been stoped from the level of Dry Creek tunnel up to the croppings. The main pay shoot is irregular in outline and attained its greatest development of 1,400 feet in length on the Dry Creek tunnel. It consisted of milling ore worth $3 to $10 in gold per ton. Within this shoot, however, smaller

and much richer ore bodies were found carrying coarse gold. One of these pitched 60° NW. on the vein, and its extent was 60 feet by 10 feet, the vein being of average width. The rich ore may be irregularly distributed through the thickness of the vein, or there may be 1 foot of exceptionally fine ore on the hanging or on the foot. The above-mentioned rich shoot contained $120,000, the coarse gold being associated with some argentite.

Secondary alteration.—The vein being located on a steep sidehill, where the watershed is irregular and fluctuating, it may be expected that secondary changes have taken place. But the evidence is not sufficient to indicate the extent of these changes. Possibly the very rich shoots in which argentite occurs may be due to this cause, and very probably some concentration may have occurred in the sheared (ribboned) parts of the vein, which, however, are not exceptionally rich. The specimens show, however, that the larger part of the ore is of primary origin and not due to later enrichment. Except near the surface the quartz is white, and the pyrite occurring in it, unaltered.

SNAKE RIVER PLACERS.

Occurrence.—No detailed examination has been made of the Snake River placers; indeed, if a solution of the several problems involved were desired, such an investigation would require much field work, extended from the source of the river to its junction with the Columbia. For many years mining on a large scale has been attempted, but not until recently has any measure of success been achieved. The gold is extremely fine, flaky, or floury, and occurs in thin and not very persistent pay streaks. This fine gold is contained in the sandy bars all the way down from its headwaters, and its origin has been the source of much speculation. It is thought by some to be derived from the lava beds of central and eastern Idaho; this does not appear very probable. Other prospectors have traced its origin to vast bodies of old conglomerates in northwestern Wyoming; this view seems more plausible. A short article by W. H. Washburn[1] explains the occurrence of the gold better than any statement that has come to my notice. It is in substance as follows:

> The gravel bars of Snake River, in Idaho, Oregon, and Washington, have attracted attention for forty years. Extending for hundreds of miles along this river, from its headwaters to its junction with the Columbia, these bars contain gold to the value of from a fraction of a cent to several dollars per cubic yard. The latter values are found in a very few spots and of limited extent, and when discovered are soon worked out by itinerant prospectors. Twenty years ago these best spots were a favorite resort of miners and prospectors in search of a grubstake, but they have nearly all been long since exhausted, so that the man with a pan and rocker has slim picking these days.
>
> The source of the gold can not, of course, be accurately determined. The generally accepted theory is that it is the finer particles from the placer deposits of tributary

[1] Mining and Scientific Press, December 29, 1900.

streams, its extreme fineness and usually flattened shape permitting it to be transported hundreds of miles along with the sand and gravel. In fact, it travels much faster than the larger sizes of the latter. Some claim that the vast lava beds of southern Idaho (which are said to contain a small amount of gold) have contributed the greater portion of the values. In support of this theory it may be said that, so far as the writer has observed, fine gold is to be found in the streams draining any extensive lava formation in a mining country. Probably it has been derived from both sources.

Our investigations having been made from a point about 20 miles below Huntington, Oreg., to 50 miles above Ontario, these remarks will be mostly confined to what is to be found between these points.

The gravel ranges in size from fine sand to bowlders seldom larger than a man's head. The current has a velocity of from 3 to 5 miles per hour. The gold is very unevenly distributed throughout these bars, being generally found in strata of medium-sized gravel, from a few inches to a few feet thick, usually overlain by from 2 to 10 feet of barren sand or gravel. Below these strata the gravel may also be worthless. Depth does not seem to cause any increase in values; where the bed rock has been reached at a few points on the rim it holds but little gold.

As a typical instance of values, on one claim I found about 18 inches of gravel at water level, from which I rocked from 75 cents to $2.50 per yard. It was overlain

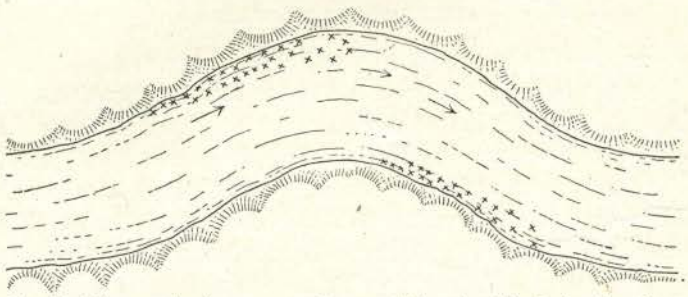


FIG. 87.—Diagram showing manner of accumulation of gold in Snake River bars.

by about 8 feet of sand practically barren, the gravel below being afterwards proven to carry but little value. Another claim shows strata of from 2 to 4 feet thick and about 150 feet wide by about 300 feet long, carrying about 50 cents per yard, also overlain by about 6 feet of barren sand, the underlay being barren for at least 6 feet to water level. These figures are given to give a fair idea of the pay streaks in general. There are open bars in places with no overlay, and where the pay streak is of sufficient depth they are generally preferred by those engaged in dredging. There are many pay streaks found some distance from the river, but usually under the conditions as to overlay above described. In some places there are strata of cemented gravel from 1 to 3 feet thick, but generally it is absent.

It may be useful to note the conditions under which these pay streaks are laid down, as indicated by the open bars along the river. We find the gold is deposited along the short or inner side of the curves in the course of the river. Any stratum of good gravel in the opposite bank has evidently been laid down at some previous time under the same conditions.

The accompanying sketch (fig. 87) will show the occurrence of gold more clearly. The colors are coarser at the head of the deposit, gradually becoming finer and fewer, and spreading out below, until the gravel is too poor to pay. As long as the river retains its course the pay streak will continue to form as the bar is extended from year to year, thus forming the larger deposits. One old resident worked a certain

spot over for eleven consecutive years, a fresh deposit of gold being made by the annual June rise of the river. The average size of the gravel, as well as other signs, seems to indicate that the gold is only deposited where the current has a certain medium velocity. The valley is from 3 to 10 miles wide and quite flat generally, the course of the river having from time to time swerved from side to side across its whole width. At a few points where the bends in the river are made more permanent by rocky banks, the pay streaks seem to be deeper and of greater extent than elsewhere. * * *

The gold above the mouth of the Boise River is very fine, averaging about 1,200 colors to 1 cent, and is worth from $17 to $19 per ounce. Below the mouth of the Boise the gold is not quite so fine, averaging about 900 colors to 1 cent. The value is lower, being from $14 to $16 per ounce. It is always associated with black sand (principally magnetite) and a heavy reddish-gray sand made up of minute rubies [garnets, W. L.] and other various-colored crystals. When carefully separated the black sand contains only a trace of gold. Below Huntington, as far as I prospected, the most of the gold is evidently of local origin, being quite coarse, and nuggets of considerable size are found, although the pure gold from above is still in evidence in favorable spots.

Methods of mining.—The finely distributed gold of Snake River has long been a favorite subject for experiment by people who have "new processes" for catching flour gold. Most of these schemes are based on amalgamation, either on copper plates or by forcing the sand through mercury. Practically all of these have failed. The pan and rocker is occasionally used, but fails, of course, when the gold is very fine and the gravel poor. The ordinary sluice is not a success. The process used with most success is the burlap system. The sluices are made about 20 feet long and much wider than the ordinary box. The bottom is covered by burlap and the screened material allowed to pour over it in a thin, even stream. At intervals the burlaps are taken out and washed. The gold does not always amalgamate easily, but amalgamated copper plates can be used in conjunction with the burlaps as follows:[1]

A short sluice carrying a considerable stream of water is first prepared; attached to this there is an inclined table about 16 feet in width and from 10 to 20 feet in length. Where the table is 20 feet in length it is usually divided in its incline; that is, the first 10 feet adjoining the sluice box is sharper in its incline than the last 10 feet, which is almost level. There are flanges or a rim on each side of this table, 4 to 6 inches high, and through its center it is divided by a partition board, leaving each half 8 feet wide. On the first 8 feet of each length there is placed a quicksilvered copper plate, and over this is laid a sheet of burlap, usually of manila bagging, firmly stretched and secured, so as to give an even surface to meet the current that is to pass over it. To the sluice there are screens attached for catching the coarse gravel and sand, and the gravel being shoveled into the sluice, the fine sand, magnetic iron, and fine gold particles soon reach the burlap sheet that is spread over the table. The current carries forward the sand and all lighter matter, and the short, hair-like surface of the burlap retains the gold and black sand. Some of the gold particles penetrate the bagging and are caught on the quicksilvered plates. After exposure to the current for about twelve hours or less, the water is turned entirely into one side, the burlap sheet on the other side removed and carefully

[1] Mining and Scientific Press, Dec. 29, 1900.

washed in a large vat filled with water, where it is entirely freed of the particles of gold and black sand which adhered to it on the table. It is then replaced on the table, the current turned on again and the burlap on the other side treated in the same way. When the washings of these burlap sheets have accumulated to a considerable quantity in the vat, mercury is poured upon them and, by means of an agitator, the mercury is forced over and over and through the mass of auriferous black sand until it has taken up every particle of gold. The black sand or magnetic iron is then washed out and the amalgam renewed, the free quicksilver separated by forcing through felt or buckskin, and the remainder separated from the gold by fire.

During the last years dredging has been attempted and considerable success has been attained after much experimenting.[1] A suction dredge is in use near Minedoka, pumping the sand and gravel from the river bottom. Ladder and bucket dredges have been lately built on other parts of the river. The pay gravels contain from 5 to 15 cents per cubic yard, the gold being in flat and cup-shaped scales, 1,000 to one cent. In order to make a profit on sand containing 10 cents per cubic yard, at least 1,000 cubic yards must be handled daily. The gravel is screened to one-eighth-inch size, and the gold caught in broad and shallow burlap sluices, with an area of 1,300 square feet.

The cost of dredging by means of suction pumps with a capacity of 2,500 cubic yards per day is stated to be $100 per day, or 4 cents per cubic yard. The ladder dredge is reported to work somewhat cheaper, or at the cost of 3 cents per cubic yard.

LOWER BURNT RIVER VALLEY.

GENERAL FEATURES.

After traversing a deep canyon for 12 miles Burnt River emerges into an open valley near Durkee, turning at the same time to a southeasterly direction, which it maintains until near its junction with the Snake. A few miles below Durkee a canyon again begins and continues down to Huntington with a depth of from 2,000 to 2,500 feet. Above Weatherby a number of smaller tributaries join the river, all heading up toward Lookout Mountain (elevation 6,900 feet), the highest point in the divide between Burnt and Powder rivers and a well-known landmark visible from all directions. The elevation of the river at Durkee is about 2,650 feet, descending to 2,117 at Huntington. The grass-covered slopes rise steeply from the narrow flats along the river, and are forested only along the highest portions of the Lookout Ridge. During the rainy season Burnt River carries a considerable amount of water, but so much is taken out in ditches for mining and agricultural purposes that it is almost dry at times during August and September near Huntington. Dixie Creek, heading some 12 miles westward on Pedro Mountain, is the only tributary of note entering Burnt River from the western side.

[1] F. Powell, Gold dredging on Snake River: Eng. and Min. Jour., Oct. 6, 1900.

GEOLOGY.

Burnt River Canyon, in the region here described, is cut in older rocks—slates, limestones, and diorites. The great sedimentary series is, as far as can be seen, conformable with the Huntington and Snake River series. It consists almost exclusively of fissile clay slates and strata or lenses of gray limestone. It is only toward Unity and Pleasant Valley that greenstones and greenstone tuffs begin to appear, probably as intercalated flows. The strike is very constantly N. 70° to 80° E., and the dip usually at very steep angles toward the north. The most prominent stratum of limestone crosses Cave Creek south of Burnt River Canyon, and continues with well-marked croppings several hundred feet wide to the foothills of Durkee Valley. The age of this series is not known, no fossils of any kind having been found in the limestone masses or in the slates. Occasionally greenstone-schists are interbedded with the clay slates.

Large masses of granitic rocks are intruded into this sedimentary series on a line from Lookout Mountain to Malheur, a line also followed by the gold deposits. The most easterly of these masses occupies Lookout Mountain and the summit of the ridge. A smaller area of granodiorite begins on Gold Hill, a few miles southeast of Durkee, and probably continues down as far as Sisley Creek. The third and largest area contains quartz-diorite and diorite along the margins, but granodiorite and possibly also granite in the center. This is the area of Pedro Mountain, extending for about 10 miles southwest and northeast, with a maximum breadth of 6 miles. The intrusive character of these rocks is proved by dikes of similar material in the slates and by contact metamorphism of the latter. As far as observed, these granitic rocks show no schistosity.

The Neocene formations are developed extensively only in Durkee Valley and in the foothills 5 or 6 miles north and northeast of the railroad station. Durkee Valley is one of the many peculiar depressions found in the mountain rims surrounding the great Neocene lake basin of Idaho. It is surrounded on all sides by slopes of slates and similar old rocks. The only outlet is a narrow canyon which Burnt River seems to have cut at a comparatively late date, and which is so inconspicuous that from most points of view the valley looks like a closed basin. The entrance of Burnt River from its upper canyon is equally inconspicuous. This valley is filled with a series of fine-grained sediments, well bedded and interstratified with rhyolitic and basaltic tuffs. Near the Gold Hill mine basalt flows are intercalated in the beds and a few miles north of Durkee a butte of igneous rock protrudes through the sediments. The beds rest against the slates on both sides of Burnt River at its entrance in the valley. The elevation of the top beds is 3,100 feet, and they are capped by horizontal

strata of calcareous tufa deposited by the abundant springs which here issue from the limestone lenses of the older series. On the northeast side these Neocene beds reach a much higher elevation, probably 3,500 or 4,000 feet. The general structure is that of a shallow syncline, the beds dipping 6° to 10° toward the center of the area. Near the railroad crossing at Unity, cuts expose contorted siliceous beds of the older series separated by an east-west fault from the Neocene tuffaceous sediments, which here dip 13° E. and are cut by several small fissures showing repeated normal faulting of 1 or 2 feet. Neocene conglomerates are also exposed at several points northwest of Durkee. The total thickness of the Neocene sediments and tuff is at least 600 feet.

Small areas of rhyolite are found on the slopes high above the valley. The long ridge a few miles northwest of Lookout Mountain is covered by a series of basalt flows, bedded after the manner of the Columbia River lava.

FIRE OPALS.

A few miles below Durkee a small creek joins the river from the slopes of Lookout Mountain and cuts through the bedded series of tuff. A few hundred feet from the Gold Hill mill opals have been found in this yellowish-gray rhyolite tuff, and a quarry opened to exploit the occurrence. The opals are abundant, filling cavities in the rock, but most of those which were examined had a bluish color and did not possess much fire. A pit 50 feet square and 30 feet deep has been excavated, but the operations are suspended at present. In connection with the opal occurs a peculiar mineral in the form of white fibers, resembling wool. This has recently been examined by Dr. A. S. Eakle,[1] who finds that it is a new zeolite closely related to stilbite.

GOLD-QUARTZ VEINS.

Auriferous veins and placers accompany the series of intrusive granitic rocks from Lookout Mountain to Malheur. In contrast to the strongly developed vein systems of the Sumpter region, these veins are not very persistent. They can not be traced for long distance, nor are directions of strike and dip constant. On the whole, this belt is more noted for its placers than for veins, from which fact it might be inferred that the gold is scattered in many small fissures rather than concentrated in prominent vein systems.

Several prospects are located north of Lookout Mountain, but have not as yet attained prominence. On Chicken Creek, near Weatherby, are several veins which have been worked in a small way for many years. Among these are the Weatherby Bonanza, Gold Thread, and the Essex, none of which were visited.

The Gold Hill mine is located 4 miles southeast of Durkee, at the

[1] Zeitschr. f. Kryst. und Min., Vol. Vol. XXX, pt. 2, 1898.

foot of Gold Hill, a prominent rounded mountain which overlooks Burnt River Canyon. The elevation at the mine is 3,075 feet, while on the summit of the hill 4,050 feet is attained. On the east side of Gold Hill granodiorite with some dikes of finer-grained diorite is the prevailing rock, while the western slope is occupied by slates with a bed of crystalline limestone 100 feet wide. The contact runs in an irregular line over the summit. Croppings of quartz are seen in many places in the granodiorite between the lowest tunnel and the top of the hill. Rich quartz has been taken from many of these. It is clear that the hill is traversed by a network of small veins. The main tunnel is driven for 1,700 feet south-southwest with the intention of reaching the contact. There is, however, little reason for believing that a large vein exists on this contact. In the different tunnels 6 or 8 veins have thus far been found, most of them having an east-west direction and southerly dip. The first vein found is the Spring Gulch, a sharply defined quartz vein 2 feet wide, dipping 20° SE. It contains good, free milling ore, a considerable part of which has been stoped. The quartz contains 2 per cent of sulphurets which are of high value. Adjoining the quartz is altered granodiorite containing much sericite, pyrite, and calcite, though no calcite is contained in the vein. West of the Spring Gulch another vein is opened, showing 4 feet of crushed granodiorite with quartz seams, accompanied by a gradually fading sericitic zone. A few hundred feet from the portal the main tunnel cuts a horizontal quartz vein from 2 to 4 inches wide with the accompanying narrow sericitic zone, which continues for a long distance. Several other veins with east-west strike are cut by the tunnel. One of these, 1,700 feet from the portal, shows 2 to 4 feet of quartz, accompanied by a zone of strong sericitic-carbonatic alteration. Development work is still in progress, though some ore from the Spring Gulch vein has already been extracted and treated in the 10-stamp mill built below the tunnel. The mine is owned by the Burnt River Gold Mining Company and managed by Mr. F. Powning.

The Gold Ridge mine is situated 4 miles south of Durkee, at an elevation of 4,230 feet. It is an old discovery, doubtless found soon after the placers in the creek below it. A 10-stamp mill was built in 1881 and operated until 1886. The mine was then idle until 1896, when work was resumed for a short time. Another period of quiescence followed, until in 1900 an attempt was made to open the vein in depth by means of a vertical shaft 250 feet deep. The veins had not been reached by the crosscut from the bottom of the shaft when the mine was visited. Total developments consist, besides the shaft, of 2,000 feet of tunnels. The total production is given by Mr. H. R. Nichols as $210,000, practically all extracted from 1881 to 1886.

The country rock at the mine is a normal diorite of medium grain, which southward changes into a coarser and more granitic rock. Three

principal veins, not far apart, cut this diorite, two of them striking N. 51° W. and dipping 65° SW. A third strikes more nearly east-west and dips south. A few hundred feet to the west, near the shaft house, is a flat blanket vein, upon which, as yet, but little work has been done. The veins, which have inconspicuous croppings, cross the summit of the ridge 200 feet above the shaft. The lowest tunnel is 75 feet below the collar of the shaft. Thus far only the oxidized ore above the tunnel has been worked, and if values continue there would seem to be fair assurance of a new lease of life for the mine. The veins are sharply defined, with normal quartz filling 2 to 3 feet wide. In several places branching veins are met with. The ore above tunnel level had a value of $12 to $15, the largest part of which was free milling, the gold having a value of $18 per ounce. The concentrates were rich, containing 8 ounces of gold and only 1.5 ounces of silver.

The pay shoots on the two easterly veins are said to be 780 feet long, while that on the third is considerably shorter.

PLACER DEPOSITS.

A number of gulches in the vicinity of Durkee and Weatherby have been worked in early days, and some are not yet exhausted.

A few miles northeast of Durkee is Parker Basin, with some placer mines; 5 miles southward, below the Gold Ridge mine, are the Raven placers, in Shirttail Creek, which are said to afford promising ground if water could be brought to them. Most celebrated, however, are the diggings of Sisley Creek and Chicken Creek. The former is a tributary of Burnt River entering near Weatherby and heading a short distance south of Lookout Mountain. Rich placers, now mostly worked out, were found at its mouth, and more or less work has been done for a distance of 7 miles, up to Chicken Creek, a tributary joining Sisley Creek from the east. The Chicken Creek placers have been mined for many years, producing from $8,000 to $24,000 annually, and are not yet exhausted. The creek is said to carry pay up to the divide, and even across the latter on the Snake River slope some pay is found.

The gravel bed of Burnt River is more or less auriferous all along from Bridgeport down to the mouth, and the low bars have been worked with some success, both in the upper canyon and below Durkee. The gravels in the river bed itself are also auriferous, but in the upper canyon heavy bowlders interfere with successful work. Between Durkee and the mouth of the lower canyon good dredging ground is said to exist, though the gravels are probably not of high grade. At Weatherby, where the canyon widens to a bottom 700 feet wide, just below the mouth of Sisley Creek, placer work is done by the Pomeroy Dredging Company, of Portland. The area available is about 160 acres. The maximum depth of the gravel is up to 35 feet. Prospecting shafts indicated a yield of from 17 to 25 cents per cubic

yard, of fairly coarse gold, most of it contained next to the bed rock. The dredge is of the ladder-and-bucket chain type, 100 feet long and 33 feet wide. The ladder is 76 feet long and carries 35 buckets, each holding 5 cubic feet. Actual capacity is about 1,500 cubic yards per twenty-four hours. After passing through a 15- by 4-foot trommel, which eliminates cobbles over 4 inches in diameter, the gravel passes through a suspended sluice 140 feet long, 3 feet wide, and 2 feet deep, containing wooden riffles shod with sheet iron, and having a grade of 9 inches per 12 feet. The operating necessitates 6 tons of coal a day, at $6 per ton; 10 men are employed, and the total expenses are about $70 per day, or a cost of 5 to 7 cents per cubic yard. The cost of the whole plant, including prospecting operations, was $68,000.

At the mouth of Dixie Creek the gravels of the river bed have also been prospected with a view to dredging, but they are said to be less rich here than above, and the gold is finer in size.

All along Burnt River, from Huntington up to Gold Hill, small bars are found 50 feet above the present bed; all of these have been worked and are practically exhausted. Corresponding to this former stage of the river are gravel terraces, 50 feet high, near Durkee, extending up to the mouth of the upper canyon.

Near Weatherby small gravel bars are also found as high as 200 feet above the river.

RYE VALLEY MINING DISTRICT.

GENERAL FEATURES.

The well-known placers of Rye Valley are situated 6 miles west-southwest of Weatherby, at an elevation of 3,230 feet. The district is drained by Dixie Creek, a tributary of Burnt River. The stream descends from Pedro Mountain in a narrow canyon to a point about 3,000 feet above the town, where it widens into a broad valley. A mile below, at the mouth of the south fork, the bottom lands are half a mile wide, but 2 miles farther down another canyon begins, which continues to Burnt River, with smooth slopes and an average depth of 1,500 feet. A little west of the high slate hills in which the canyon is cut begins a lower plateau (elevation about 4,000 feet), falling off with abrupt edge toward the south fork of Dixie Creek. On the west, above the table-land, rise the higher mountains of the south fork, which connect with Pedro Mountain. The slopes are bare, only supporting a scattered forest growth high up on Pedro Mountain.

GEOLOGY.

The slopes on all sides of Rye Valley consist of a granitic rock, which in part is a granodiorite. It shows in white outcrops on Pedro Mountain, but is elsewhere deeply disintegrated to a sandy soil. Slates and limestones crop in the south fork along the southern contact of the gra-

nitic area. As usual, the strike is east-west, the dip 80° N. Similar rocks are also met in the lower canyon of Dixie Creek. To judge from the large amounts of siliceous argillite, greenstone, and greenstone-schists in the creek, these rocks appear abundantly at the head of the stream.

The valley is another of those basins so remarkably common along the margins of the great Neocene lakes of Idaho. The whole trough is filled with Neocene lake beds, above which rests a basalt flow which forms the above-mentioned plateau, breaking off with a sharp bluff toward the valley. There is little doubt that the lake beds continue below the basalt table, and they may well connect with the lake beds exposed southward on the slopes of Willow Creek. Carved in these lake beds is a series of fluviatile terraces of later date. These are the auriferous deposits. Fig. 88 shows the general relations of the deposits. The lake beds are well stratified, and consist of white and gray clays and sandy clays; they contain no tuffs. The whole series dips 13° to 15° W. Contacts with the crumbling granite on the slopes are difficult to establish. On the western side it is located about 250

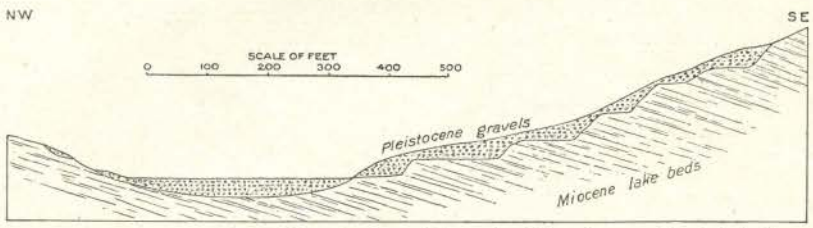


FIG. 88.—Section across Rye Valley, showing relations of gold-bearing gravels to lake beds.

feet above the creek bed, while on the eastern side it probably reaches fully 300 feet above the same datum plane. The beds thus form a monocline, possibly separated by a fault from the granitic rock on the west side. If not repeated, the series has a thickness of 500 or 600 feet. Leaves and shells are sometimes found in the lake beds. Rarely, gravels are interbedded in the series, and in such case contain a little fine gold.

The gravel benches are chiefly developed on the west side of the creek; on the opposite side are only a few insignificant bars. The gravel rests unconformably upon the planed-off surfaces of the lake beds, and forms nearly continuous benches from half a mile above the town to the mouth of the South Fork of Dixie Creek. The width of this gravel bar is from 500 to 900 feet; its maximum elevation above the creek, 250 feet.

The stripping of the gravel has proved the existence of six or eight benches, carved horizontally in the inclined lake beds. The first bench is only a few feet above the level of the tailings; then follows a rise of 30 or 40 feet to the largest bench, which often is several hundred

feet wide. Several other benches follow above this. The hydraulic banks are from 30 to 50 feet high. The gravel is coarse and well rolled. A few feet above the lake beds which form the bed rock a stratum of tough clay 4 feet thick is often found, which locally is called "web-foot." In this material the Cartwright Brothers, who own the consolidated placer mines, have found teeth of mammoth and mastodon, which Dr. F. A. Lucas identified as *Mastodon americanus* and *Elephas columbi*, stating that both species are characteristic of the Upper Pliocene.

The creek bed is filled to a depth of about 90 feet with tailings, which vary in width from a few hundred feet to half a mile.

PLACER MINES.

The Rye Valley placers were discovered shortly after 1862, and have been successfully worked up to the present time, with an annual yield of from $5,000 to $50,000, so that the total production is probably above $1,000,000. In 1873 the yield was $50,000; in 1882, $26,880; in 1889 $34,000. During the last few years a steady production has been maintained. Most of the claims have been consolidated and are now owned by Cartwright Brothers. Water is available for only a few months in the year; it is taken from all the gulches of Pedro Mountain, and the quantity varies from 1,500 miner's inches in flood time down to 100 inches in July. The grade of the creek is 3 per cent.

The creek has been mined for 3 miles up from the town, but by far the largest production is derived from the high gravel bars already described. The gold is of a fineness varying from 750 or 800 on the lower bars to 650 on the upper benches. It is fine, the maximum size being that of a pinhead. The largest amount is on the bed rock, though some fine gold is distributed throughout. The yield varies from 11 to 30 cents per cubic yard. Some bench gravel still remains, though the supply is by no means inexhaustible.

It has been proposed to work the gravels in the stream bed by bed-rock flume or by dredges. Both projects offer some difficulties, as the depth is 90 feet. Borings in the creek bed are said to show an average content of 30 cents per cubic yard.

QUARTZ MINES.

A number of quartz veins containing silver have been found on Pedro Mountain and attracted great attention between 1870 and 1880. The Monumental, Green Discovery, Washington, and Rising Sun veins were known in 1872; all of these were very rich in wire silver, chloride, and silver glance, besides containing a little gold. In 1875 a 5-stamp mill was erected on the Lafayette, a gold-silver vein, and a similar pan-amalgamation plant on the Green Discovery. In 1880 the New England and Oregon Mining Company erected a large pan-amalgama-

tion mill, spending $50,000 on the property, evidently with unfavorable results. All these veins are situated high up on Pedro Mountain. Green Discovery is said to strike northwest and dip 70° SW.

In the canyon of the south fork, leading up to Mormon Basin, are many quartz prospects containing both silver and gold; tetrahedrite is frequently found in them. Seven miles from Rye Valley a 3-stamp mill had been erected, but was idle in 1900. It was built to treat the oxidized sugary quartz of the Golden Gate, a small, flat vein occurring in granite half a mile north of the road. The contact between granite and metamorphic schist with crystalline limestone is crossed a short distance from the wagon road.

MORMON BASIN, MALHEUR AND CLARKS CREEK DISTRICTS.

GENERAL FEATURES.

Willow Creek is one of the larger tributaries of Snake River, and joins it a short distance above Huntington. West of Rye Valley Willow Creek approaches Burnt River, both flowing in an easterly direction. A bare, comparatively gentle ridge separates the two rivers, its divide rising from 1,000 to 2,000 feet above the streams. On the slopes of this ridge, from 6 to 12 miles west of Rye Valley, are situated a number of famous placer mining camps—Clarks Creek and Bridgeport on the Burnt River side; Mormon Basin, Amelia, Malheur, and Eldorado on the Willow Creek side. But a short visit was made to these localities, and the observations lack much in detail.

GEOLOGY.

The broad ridge separating Willow Creek and Burnt River consists chiefly of pre-Neocene rocks. The granitic area of Pedro Mountain ends just east of Mormon Basin, but a smaller separate area projects to Amelia between Mormon Basin and Malheur. The rest of the ridge is made up of clay slates, siliceous slates, and some greenstone schists. The general strike is west-southwest, the dip steep northwest, sometimes changing to south-southeast. The series is clearly the continuation of that exposed near Weatherby and Connor Creek.

The Neocene volcanic rocks are not very abundant. In Clarks Creek, near Griffin's ranch, rhyolite begins and connects with the great rhyolite area north of Bridgeport. Associated with it are bedded tuffs, which continue, skirting the foothills, toward Bridgeport. Small basalt flows crown the hills north of Mormon Basin, and near Willow Creek thin basalt flows overlie lake beds. A dike 75 feet wide of normal basalt, with diabasic granular structure, cuts the granodiorite of Pedro Mountain on the road from Rye Valley to Mormon Basin, 7 miles from the former camp.

South of Bridgeport a series of gravel benches, at elevations of from

3,650 to 3,700 feet, begins, and skirts the hills eastward as far as the south side of Clarks Creek. The gravels, which are from 10 to 20 feet thick and highly auriferous, rest on soft tuffaceous lake beds, which again lean against slates and schists. The whole indicates a period of quiescent water during the time of the eruption, followed by an epoch of fluviatile activity at a time when Burnt River stood 250 feet higher than at present.

Similar conditions prevail on the Willow Creek side. The base of the slate hills has an elevation of about 3,900 feet, and the shallow gulches cut in the slate above the base are filled with 10 to 30 feet of auriferous detritus. A gentle slope covered with subangular wash descends to an elevation of 3,400 feet. In the sharply cut little canyons one-half mile from Willow Creek 50 to 100 feet of white clayey and sandy beds, having the appearance of lake beds, underlie the wash. Near the bottom of Willow Creek fissile clay slate appears below the lake beds. Thin flows of basalt cover the lake beds along Willow Creek. These facts indicate that a body of comparatively still water occupied the Willow Creek Valley at least to an elevation of about 3,400 feet. From a point near the junction of Mormon Gulch and Willow Creek the road continues 20 miles due east to Huntington. Over the whole distance the ridges slope gently southward, and are cut by shallow, broad gulches. Fine-grained deposits, loam and sand, such as elsewhere in Idaho and Oregon are characteristic of lake beds, cover these ridges, and the thin basalt flows occasionally appearing are probably interstratified with the sediments. The high slate hills are in view a short distance northward. Along the road the highest point reached is 4,100 feet above the sea. All this would seem to indicate that, besides the level mentioned at an elevation of 3,400 feet, there might be present an older and higher level of deposition having an elevation of over 4,000 feet, both indicating Neocene lake levels, the former corresponding to the Pliocene Idaho lake, the latter to the Miocene Payette lake.

PLACER MINES.

All of the districts included in this description have yielded heavily in placer gold, but the production has diminished greatly and gradually. Except Clarks Creek and Bridgeport, the camps are situated in Malheur County, and constitute its only producing area. The total production is impossible to obtain with even approximate accuracy, as the records are very defective. The earlier returns from Malheur County are probably under those of Baker County. The available reports give the production of Malheur as $60,000 in 1889, $40,000 in 1890, $29,000 in 1893, $13,000 in 1894, and $11,600 in 1899.

Mormon Basin.—The road from Rye Valley ascends the South Fork of Dixie Creek, reaching its divide of schists and greenstones at an ele-

vation of 5,000 feet. From the broad, bare ridge a fine view across Mormon Basin is obtained. Like so many other camps around the confines of the Neocene lake of Idaho, it is a broad, shallow basin 9 miles in circumference. The only outlet is through a narrow canyon at the southern end of the depression. The sloping floor of the nearly circular valley is covered by heaps of tailings from placer mines.

The shallow auriferous gravels rest on fine-grained deposits which look like lake beds. The gold is coarse and has a fineness of about 800. In 1866 a nugget worth $640 was found. Placer mining has been carried on in Mormon Basin since 1863. The water supply is scant, and hence the placers have lasted a long time and are not as yet exhausted. Regarding the yield in early days, but little reliable information is available. In 1882 two American and one Chinese company were operating, with a total yield of $40,000. In 1883 a yield of $35,200 was reported. Since that time the production has greatly diminished.

A number of quartz veins have been known for many years in Mormon Basin. As early as 1863 some very fine specimens of crystallized gold in quartz were found, and in 1873 quartz was worked on a small scale. At the present time Mr. Porter Colt has erected a small Crawford mill, and a little ore is occasionally extracted and milled. The veins seem to be small and of a pockety character.

Clarks Creek.—Going north from Mormon Basin, the Clarks Creek divide, covered with a small basalt flow, has an elevation of 5,560 feet. Immediately below the divide indications of old placer mines appear in Clarks Creek, and gold-bearing gravels continue nearly to its mouth. The most important deposits form benches overlying tuffs and lake beds from Griffin's ranch down. The gravels are from 10 to 20 feet thick, and in many places are overlain by 1 or 2 feet of a white deposit very similar to the kaolin of Pine and Salmon creeks, in the Elkhorn Range (pp. 646, 649). They have been extensively worked and proved very rich, but are now largely exhausted. A yield of $10,000 is reported for 1889, $8,000 for 1890, and $13,700 for 1892.

Malheur and Eldorado.—From Bridgeport south to Malheur, fine gravels are met with in the shallow gulches soon after crossing the divide. Three hundred feet below the summit are the ruins of Eldorado Camp, once a flourishing town. All the way from here to Malheur the gulches have been filled with 6 to 30 feet of gravels of fine texture, which now are almost entirely exhausted. The principal water course is called Shasta Creek, and another gulch just west of it is Rich Gulch. These were the largest producers.

The mining of these gulch gravels has been made possible only by the completion of the Eldorado ditch, 134 miles long and having a capacity of 2,400 miner's inches. Projected in early days, it was completed in 1874 at an expense of $250,000. It takes the water from upper Burnt River and carries it through Shasta Gap across to the

Willow Creek side of the ridge. Shortly after its completion the district attained its greatest production. In 1875 the production is reported as $150,000, and this very likely was the maximum.

At the present time the gulch gravels are practically exhausted, but a hydraulic elevator has been erected on Shasta Creek, near Willow Creek, and it is believed that some of the deeper gravels can be worked at a profit.

QUARTZ MINES.

A number of quartz veins have been found near Malheur, but as yet none of them have attained prominence. The veins strike northeast and contain white quartz with coarse gold. The Red, White and Blue vein is located close by Malheur and is developed by a shaft 150 feet deep. The vein, which is from 1 to 2 feet wide, dips 45° SE., and is contained in clay slates with dioritic dikes. The Golden Eagle is situated near Willow Creek and has been developed by a short crosscut tunnel.

SUTTON CREEK BASIN AND THE BURNT RIVER DIVIDE SOUTH OF BAKER CITY.

GENERAL FEATURES.

A mile south of Baker City, Powder River and Sutton Creek emerge from the deep and short canyons cutting through the volcanic ridge which here bridges the gap between the Virtue Hills and the southern part of the Elkhorn Range. South of these short canyons extends a wide basin, bordered on the south by the Burnt River divide, on the west by the Elkhorn Range, and on the east by the lower hills south of the Virtue mine. The western part of the basin is drained by Powder River, flowing through a deep canyon near its great bend, but opening again into an alluvial valley in the center of the basin. The eastern part is drained by Sutton Creek, with its numerous and spreading branches. A pass with an elevation of 4,000 feet is the lowest gap on the south from this basin into the Burnt River drainage, and this is the direction followed by the railroad, which ascends Sutton Creek to its head, and then, in a sharper slope, descends Alder Creek to Burnt River. The central and eastern part of the basin is formed by rolling hills destitute of forest growth, but the Burnt River divide on the south, as well as the Elkhorn Mountains on the west, is covered by heavier forests.

GEOLOGY.

The geological features of this basin are exceptionally interesting, especially in their physiographic aspect. A key is here found to the direction of the rivers and the stand of the lake levels during Neocene times.

The older rocks belong to the series of argillites with a general east-west strike, which is so prevalent in this part of the Blue Mountains

and which has been described in greater detail under the headings of the "Virtue mining district" and the "Elkhorn Range." The hills at the head of the different forks of Sutton Creek consist of black argillites, as a rule with well-defined indications of stratification. Greenstones are often interbedded in the series, and though more greatly altered were probably originally fragmentary volcanic rocks. Isolated masses of limestone occur in the series, as, for instance, in the foothills 1 mile northeast of Norton station. Another area of similar rocks occurs on the Burnt River divide, toward the head of Denny Creek and Stices Gulch on the north side, and Cow Creek and Pine Creek on the south side. Again argillites appear, as already described, in the foothills of the Elkhorn Range southwest of Baker City.

The prevailing rocks of this region are not the older series, but the Neocene volcanic flows. The broad ridge which forms the boundary of the southern side of the basin and the divide toward Burnt River is almost entirely built up of heavy masses of rhyolite. This area has already been mentioned under the heading "Burnt River district." Along the northern slopes of this rhyolite dome rest later eruptions, chiefly normal basalts, in which the canyon at the bend of Powder River has been eroded. The same flows skirt the southern end of the Elkhorn Range and continue northward, forming the whole of the complex of hills which bridge the distance between the Elkhorn Range and the hills of the Virtue mining district. Standing at a commanding point in the basin, one may clearly see that the basalt flows must once have filled the whole western portion of the basin up to a level of about 4,700 feet. These rocks form a series of flows, black or brown in color and with a general and well-defined dip toward the east or northeast of from 4° to 12°. Though varying much in aspect, some flows being extremely vesicular and others conspicuously massive, the rocks all appear to be normal basalts. At the base of the flows in Sutton Creek and Griffin Creek, as well as in the foothills due east of Baker City, rhyolite tuffs are found. These form an excellent building stone, being soft and yet durable, and are extensively used for that purpose in Baker City.

In the eastern part of the basin the volcanic rocks are not extensively developed, but instead the argillites are covered by thin well-washed gravels and soft, light-colored, and well-stratified sediments. More recent subangular wash, carried down by the present gulches, rests near the mountains, on top of these sediments. About 9 miles south of Baker City, in the south-central part of the basin, heavier masses, of medium-sized, well-washed gravel, form the long ridges descending from the Burnt River divide. At the low pass where the railroad crosses into the Burnt River drainage the fine-grained sediments, which appear like lake beds, are strongly developed and occupy the very summit. The most satisfactory exposures are seen in cuts along

the railroads, where 20 to 30 feet of these beds are exposed. The dip is here 12° to the east, while in other cuts 2 miles farther toward Baker City similar dips of 30° were observed. The rocks are fine-grained sands or clays, in part distinctly tuffaceous. The field relations show that the beds were deposited very shortly after the volcanic eruptions, and, further, that they have suffered a notable deformation since their deposition. Standing at the prominent point near the gap, an old level of deposition is clearly perceived, the sediments of which skirt the hills on both sides up to an elevation of about 4,300 feet, or 200 feet above the lowest point.

To the Pleistocene period doubtless belongs that epoch of erosion during which the present canyons and valleys of Sutton Creek and Powder River have been cut. To the most recent Pleistocene belong the sediments accumulated along both of these streams, and especially prominent among these is the alluvial valley extending along Powder River for a distance of 3 miles south of the last canyon which Powder River has to traverse before reaching Baker City.

Though the geological facts are not complicated, yet it is by no means easy to interpret the geological history which they involve. The topography, before the volcanic flows, was materially different from that of the present time. Its detailed character can not be ascertained without further investigation, but the fact that the rhyolitic and basaltic flows, for a long distance, descend to the level of Powder River and Burnt River indicates distinctly that a deep depression once existed south of the Powder River bend. After the rhyolite eruptions had built up the high divide between the two rivers extensive outflows of basalt took place, which again radically changed the condition of affairs. Flooding the basin to a height of 4,700 feet along the foot of the Burnt River divide and the Elkhorn Range, these flows also extended northward, and there can be no reason to doubt that they once continued in an unbroken ridge south of Baker City from the Elkhorn Range to the Virtue Hills and that the elevation of this barrier reached 4,200 feet. This, however, is higher than the Burnt River gap crossed by the railroad, and it seems that a necessary consequence of this should have been the establishment of a new course for Powder River through this gap and down into Burnt River Valley. That this did not occur can be explained only on the supposition that the great Neocene lake of Snake River Valley once extended up to and above the level of this gap—that is, to about 4,200 feet. This, indeed, is the highest elevation reached by this sheet of water, as proved by many observations in Idaho. If the lake did extend to this level, a very slight further elevation would be sufficient to establish a northerly outlet for Powder River across the basalt flows south of Baker City. A fairly rapid recession of the level of the lake would very soon have carried it below the Burnt River gap, thus preventing the establish-

ment of a permanent outlet in that direction. This interpretation, though not free from objections, is the only plausible one which can at present be advanced to account for the observed facts.

PLACER DEPOSITS AND QUARTZ VEINS.

Both placers and quartz veins occur in the eastern and western margins of the basin, and have already been described under the headings "Virtue district" and "Elkhorn Range." The only other placers where auriferous gravels have been found are in several creeks on the Burnt River divide about 12 to 18 miles southwest of Baker City. Areas of argillite and other older rocks occur on the Burnt River divide in this vicinity outcropping below the lavas, and placers have been worked in several creeks on a small scale during a long period. Among these creeks may be mentioned Denny Creek and Stices Gulch, on the north side of the ridge, and Cow Creek and Pine Creek, on the south side, toward Burnt River. Placer work is still occasionally prosecuted here. On Pine Creek especially placers were in operation during 1900.

Though quartz veins are said to occur on all of the creeks mentioned, no paying deposits of this kind have thus far been developed.