

## 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  $10^{\circ}$ , 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.

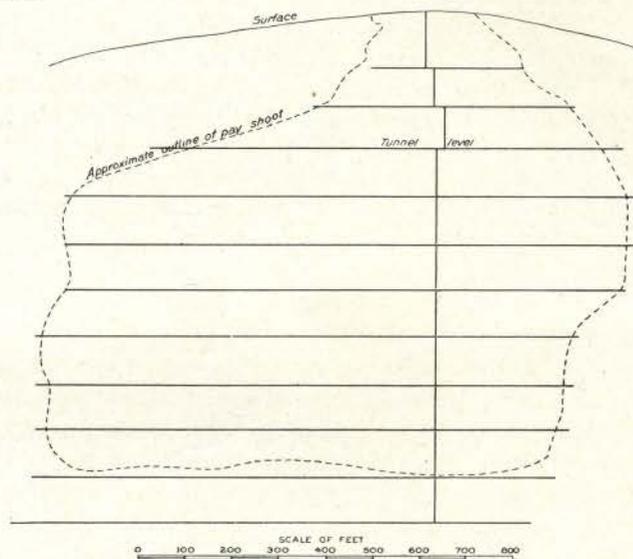


FIG. 86.—Approximate workings and extent of pay shoot in Virtue mine, in projection on the plane of the vein.

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 serpentinitoid 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  $45^{\circ}$  to  $80^{\circ}$  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 crusy 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  $20^{\circ}$  to  $30^{\circ}$  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  $70^{\circ}$  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  $4\frac{1}{2}$  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-porphry 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-porphry 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  $10^{\circ}$  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  $20^{\circ}$  to  $30^{\circ}$  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.  $10^{\circ}$  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.  $20^{\circ}$  E., the dip  $60^{\circ}$  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 boulders 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.

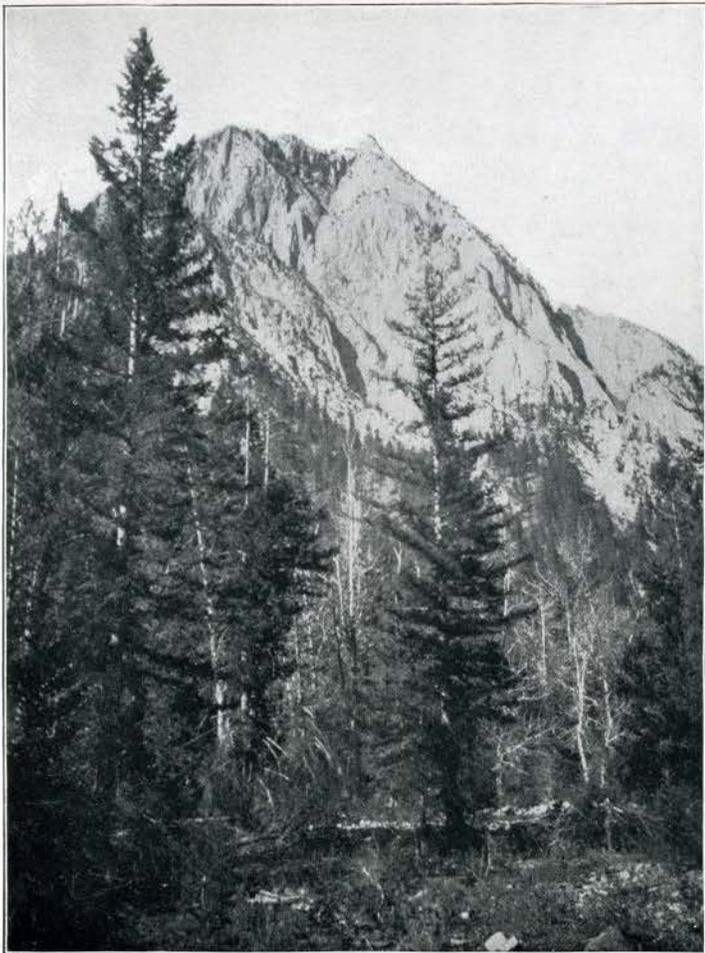
There can be no doubt that glaciers once occupied the upper part of the Eagle Creek drainage, but just how far they descended can not be decided on the present evidence. It is improbable that they extended as far as the junction of the forks of Eagle Creek, and for several miles above the topography 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  $40^{\circ}$  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-porphry without changing, but on the second level south it is squarely cut off by a basalt dike striking east-west and dipping  $50^{\circ}$  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 accurate, 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 boulders, 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  $70^{\circ}$  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.

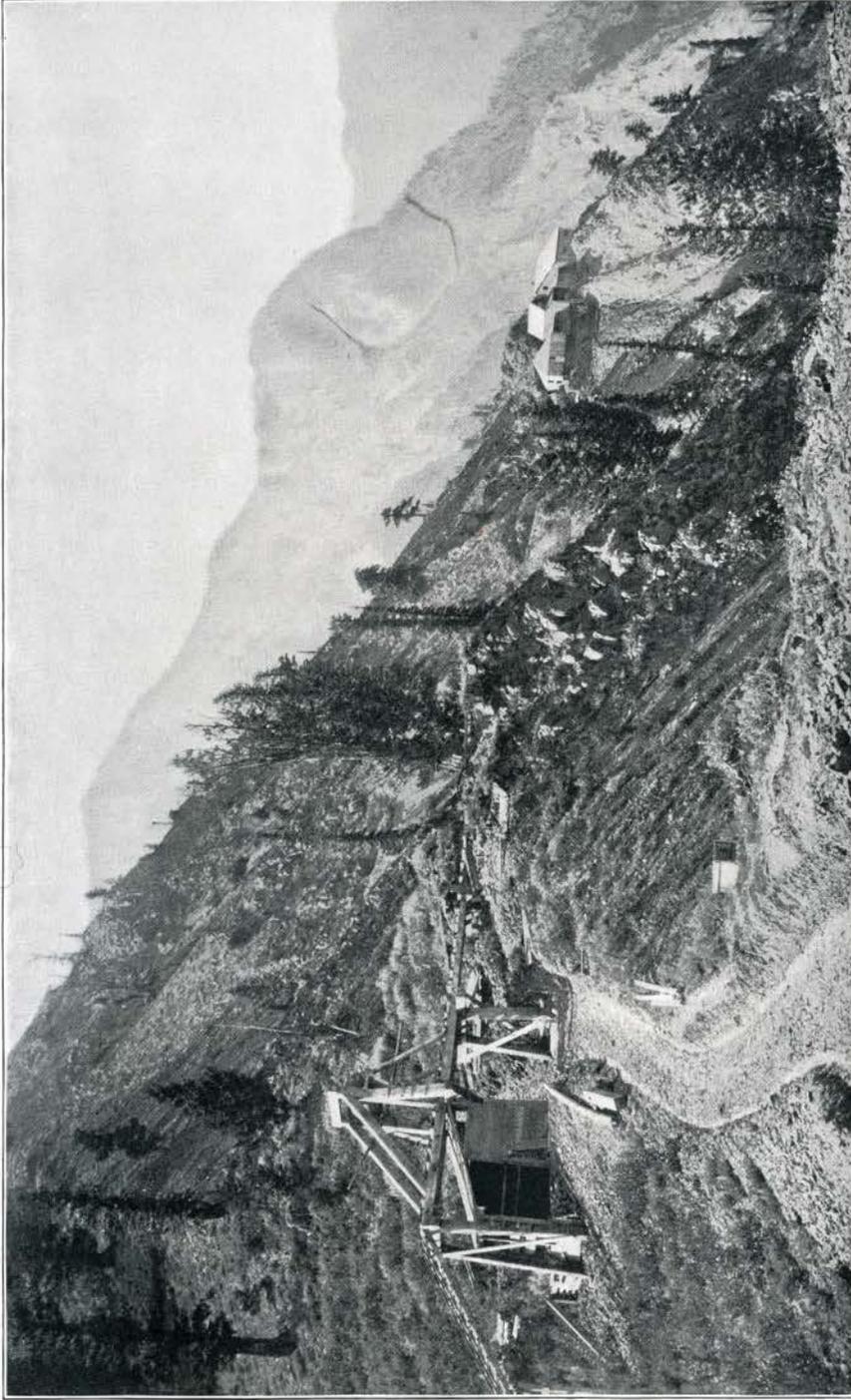
The vein strikes a few degrees east of north and dips  $40^{\circ}$  W. Its outcrops were plainly marked, though not conspicuous. The width is

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  $45^{\circ}$  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 boulders 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 Innaha, 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.<sup>1</sup>

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

<sup>1</sup> 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.<sup>1</sup>

#### 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.

<sup>1</sup>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.<sup>1</sup> 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<sup>2</sup> 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.<sup>3</sup>

*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

<sup>1</sup> Compare Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, pp. 88 and 251.

<sup>2</sup> Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 86.

<sup>3</sup> 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 ground-mass is probably an intimate mixture of chlorite and feldspar. At the end of the upper crosscut a dark-brown, much altered meta-andesite 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  $55^{\circ}$  W. and dips  $60^{\circ}$  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, chalcopryite, 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-porphry; 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.  $30^{\circ}$  to  $45^{\circ}$  E., and a northwesterly dip, which near the contact is  $20^{\circ}$  and at the gypsum mine 2,000 feet above Huntington as low as  $12^{\circ}$  to  $15^{\circ}$ . 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.  $80^{\circ}$  E. and the dip is  $60^{\circ}$  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.<sup>1</sup>

*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  $2\frac{1}{2}$  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

<sup>1</sup>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.
	<i>Fect.</i>
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 (ribbed) 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<sup>1</sup> 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

<sup>1</sup> 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 boulders 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

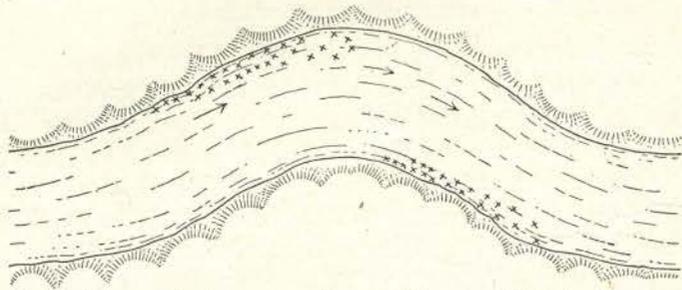


Fig. 87.—Diagram showing manner of accumulation of gold in Snake River bars.

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:<sup>1</sup>

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

<sup>1</sup> 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.<sup>1</sup> 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.

<sup>1</sup> 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  $6^{\circ}$  to  $10^{\circ}$  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  $13^{\circ}$  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,<sup>1</sup> 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

<sup>1</sup> 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  $20^{\circ}$  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.  $51^{\circ}$  W. and dipping  $65^{\circ}$  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 boulders 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  $80^{\circ}$  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 fluvial 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  $13^{\circ}$  to  $15^{\circ}$  W. Contacts with the crumbling granite on the slopes are difficult to establish. On the western side it is located about 250

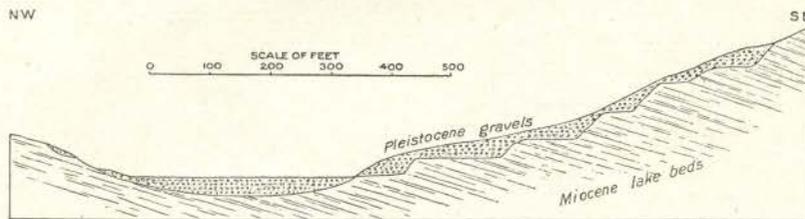


FIG. 88.—Section across Rye Valley, showing relations of gold-bearing gravels to lake beds.

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  $70^{\circ}$  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 fluvial 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  $4^{\circ}$  to  $12^{\circ}$ . 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  $12^{\circ}$  to the east, while in other cuts 2 miles farther toward Baker City similar dips of  $30^{\circ}$  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.

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