DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 528

GEOLOGY AND ORE DEPOSITS

OF

LEMHI COUNTY, IDAHO

BY

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1913

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OUTLINE OF REPORT.

Lemhi County, situated in the east-central part of Idaho, has until recently been difficult of access. With the extension of the railroad to Salmon in 1910, mining activity in parts of the area took on new life.

Placer gold was discovered at Leesburg in 1866, and soon thereafter lode deposits were recognized. Lead-silver deposits were worked actively in the eighties, but not until the advent of the railroad did this industry reach its maximum importance. The total production of the county is about $20,000,000, two-thirds of which has come from gold, three-fourths of the remainder from lead, about $40,000 from copper, and the rest from silver.

Lemhi County is a high mountainous area marked by broad, level-topped divides generally separating deep, narrow valleys. Near the close of the Eocene epoch the area was elevated from a lowland of moderate relief to a plateau about 8,500 feet above the sea. Remnants of this surface constitute the summit areas of the present day, lying in large part 3,000 to 4,000 feet above the adjacent valleys. Glaciers covered the highland tracts during Pleistocene time and extended down the larger valleys to elevations of 7,000 feet, rarely to 6,000 feet.

The basement rock is a gneissoid granite of Archean age which outcrops in the northwestern part of the area. Unconformably above it is a thick and widespread series of Algonkian schists, slates, and quartzites. These were mapped as a single unit, but it is thought probable that they could be subdivided to correspond with the Prichard slate, Revett quartzite, and Wallace formation of the Cœur d'Alene section. Formations of Paleozoic age are confined to the southeastern part of the county. They rest unconformably upon the Algonkian and consist of Cambrian quartzite, Ordovician, Silurian (?), and Devonian dolomitic limestones, and Mississippian limestone, in all possibly 6,000 feet of beds.

Next in order of age are large batholithic masses of granite, outliers of that great intrusive mass which crops out continuously over more than 20,000 square miles in central Idaho. Locally this intrusion corresponds with quartz diorite, and more commonly with quartz monzonite, but in most places in Lemhi County it approaches closely to the composition of normal granite. A study of the physiographic history of central and eastern Idaho and of the sedimentary record of adjacent areas leads to the belief that the granite was intruded at about the close of the Cretaceous period. During Miocene time thick lacustrine deposits accumulated in valleys which were developed after the elevation of the Eocene erosion surface.

Dikes appear in all parts of the area, but are most numerous in the vicinity of granite outcrops. Tertiary lavas, both older and younger than the lacustrine deposits, extend in a broad belt from a point near Lemhi Pass southwestward beyond Parker Mountain.

The ore deposits of Lemhi County may be grouped as gold placers and lodes, lead-silver veins and tabular replacements, copper-bearing gold veins, cobalt-nickel deposits, and tungsten-bearing veins. Two epochs of mineralization are recognized—the older late Cretaceous or early Eocene, the younger late Miocene or early Pliocene. All the deposits, except a small group of gold-silver veins, belong to the earlier epoch. Important placer deposits occur about Leesburg, on Moose Creek, and along some of the streams which flow from the Beaverhead Mountains. Lode deposits, on the other hand, are widely distributed in the county, each of the nineteen mining districts containing several.

Gold-bearing veins are inclosed in many types of rock in Lemhi County, but few of them are far distant from rocks of the granite-rhyolite family. The gold veins are of two distinct ages. The younger veins are found in the Gravel Range and Parker Mountain districts, where they are inclosed in eruptive rocks, principally rhyolites, and in the Blackbird district, where they are associated with rhyolite dikes. In general these veins are strong fissure fillings characterized by cryptocrystalline quartz, lamellar calcite, and small amounts of adularia, chalcedony, and opal. They present a banded structure parallel to the walls. Metallic minerals, nearly always of microscopic size, are distributed through the ore in dark crimpy bands of dull to submetallic luster. Pyrite is the only metallic mineral recognized, but a blue-black fine-grained mineral of metallic luster is even more abundant. Satisfactory chemical analysis of this material was not possible, but the presence of a strong trace of selenium was established. These veins were promising near the surface but have not proved profitable in depth.

The most important gold veins are of late Cretaceous or early Eocene age and are widely distributed in the northern, central, and western parts of the county. They are predominantly veins of coarse-textured, clear-white quartz, along which ore shoots occur at irregular intervals. Auriferous pyrite is the characteristic ore mineral, but with it may be small amounts of chalcopyrite, galena, sphalerite, and in a few places pyrrhotite and magnetite. Locally the metallic minerals are present almost to the exclusion of gangue material, but in general metallization is moderate. Few bonanzas have been found in these deposits, although many of the ores are of substantial grade. The ore of these veins has commonly become base within 100 feet of the surface and at the same time extraction by amalgamation has fallen from 90 per cent or more to 40 or 50 per cent. Considerable evidence (see pp. 62–63) favors the belief that these veins are genetically related to the great granitic intrusion.

Lead-silver deposits are recognized only in the southeastern part of the county. They are inclosed in Paleozoic formations and are thought to be genetically related to the quartz diorite facies of the granite intrusion. The deposits are irregular tabular bodies with extensions along bedding and joint planes. At the Leadville mine the ore is argentiferous galena remarkably free from gangue; elsewhere it is a mass of earthy lead carbonate heavily stained with iron and manganese. Probably 80 per cent of the lead ore mined in Lemhi County is the product of the oxidation and carbonation of galena, pyrite, and zinc blende. The ore is remarkable for its even tenor, averaging about 35 per cent of lead and 15 ounces of silver to the ton. The deposits are large and show every evidence of continuity. In most of the mines about 200 feet of oxidized ore remains between the deepest workings and the water level, below which primary ore may be expected. It is a matter of considerable importance to know in what respects the primary ore will differ from that now being mined. Studies of the volume changes involved in the oxidation and carbonation of galena, sphalerite, and pyrite lead to the conclusion that leaching has been important in the oxidized zone. From a consideration of the relative solubility of the oxidation products it appears that lead has remained essentially stable, that iron has probably been removed somewhat, and that zinc has been removed in considerable quantities. It follows, therefore, that below the zone of oxidation lead will decrease appreciably in amount per ton of ore, iron will increase somewhat, and zinc will probably increase considerably.

The copper deposits of the county have not proved of great commercial importance. They include fissure veins, impregnations along shear zones in schist, and contact-metamorphic deposits, with irregular mineralization along sheeted zones as the most common type. The characteristic ore is coarse quartz, studded and stained with the alteration products of chalcopyrite and carrying a little free gold. In many respects these deposits are similar to the older pyritiferous gold veins, with which they are thought to agree in age and genesis.

Cobalt-nickel deposits are confined to the Blackbird district, where they occur as lenslike bodies and as bunches and disseminations along fractured zones. In one place nickeliferous pyrrhotite occurs as small bunches scattered through a gabbro dike. The deposits are little developed, but some of them are known to contain about 2 per cent each of cobalt and nickel.

Tungsten is mined in the Blue Wing district, where it is associated with zinc, copper, lead, molybdenum, iron, and silver minerals in lenticular quartz veins. A little gold also is present. The characteristic tungsten mineral is hübnerite.

Sixty-three mineral species are recognized in the ores of Lemhi County.

The outlook for a steady growth in the mining industry of the county is bright. A large tonnage of base gold ore remains. Placers are now being worked by dredges, which are converting into an asset ground heretofore valueless for mineral. The annual production of lead-silver has increased greatly since the advent of the railroad and seems destined to become the most important in the county. Tungsten will probably become an asset, but the future of cobalt and nickel is more uncertain.

GEOLOGY AND ORE DEPOSITS OF LEMHI COUNTY. IDAHO.

By Joseph B. Umpleby.

INTRODUCTION.

SCOPE OF REPORT.

The present report embodies the results of reconnaissance studies in the nineteen mining districts of Lemhi County, Idaho. The necessity of covering approximately 3,200 square miles during a single field season obviously involves a lack of balance in the observations on particular localities. Doubtless some areas and mines were slighted and others received more attention than their relative merits warrant. During the season, however, all the mines and most of the prospects were visited; a topographic and geologic sketch map was prepared (see Pl. I); notes were taken on the general geology; and a persistent effort was made to give ample time to significant points even at the expense of other work.

In the following pages the geography and history, physiography, general geology, and economic geology of the county as a whole are discussed, and afterward descriptions are given of the several mining districts, with notes on the mines of each. Thus the general reader can confine his attention to the first part of the bulletin, but he who is interested in a particular area should turn to the descriptions of individual districts.

FIELD WORK AND ACKNOWLEDGMENTS.

Field work began June 30, 1910, and continued until October 2 of the same year. Extensive development during the following winter in the lead-silver deposits made it advisable to revisit the southeastern part of the area for two weeks during 1911. At this time Mr. George H. Girty, of the Geological Survey, spent three days in company with the writer in collecting fossils and studying the Paleozoic stratigraphy about Gilmore.

Courtesies extended by the many mining men of tne county are too numerous for separate mention but were highly appreciated and facilitated the studies materially. It would be unappreciative, however, not to thank Mr. Allen C. Merritt for the opportunity of using his map of Lemhi County; Mr. J. H. Bacon, chief engineer of the Gilmore & Pittsburgh Railroad, for access to surveys, profiles, and route map; and the engineering firm of McClung & Crandall for additional control in the Lemhi Valley. It is also desired to express special appreciation to Mr. M. M. Johnson, consulting engineer for the Pittsburg-Idaho Co. and Allie Mining Co., and to Mr. Ralph Nichols, president of the Latest Out Co., for hastening certain mine surveys in order that they might be available for this report.

EARLY WORK.

Prior to the present investigation little had been recorded concerning the topography, geology, or ore deposits of the 3,200 square miles treated in this report. The principal map of the county is that by Allen C. Merritt. The route map of the Gilmore & Pittsburgh Railroad is more accurate for the Lemhi Valley, however, and certain Forest Service maps portray more closely the area west of Salmon. For several of the mining districts claim sheets are available, and a railroad survey extends from Salmon both up and down Salmon River. In addition to these sources of control, the writer drew from the field sheets of W. H. Barringer, who mapped Salmon River below Salmon for the United States Geological Survey. Further, the Carpenter survey of the International Boundary, and numerous township plats by the General Land Office were available. Plate I (in pocket) is compiled from these several sources and from numerous aneroid readings and triangulations by the writer.

In 1895 the Geological Survey published a report by George H. Eldridge on his reconnaissance across Idaho, which included a traverse from Yellow Jacket to Salmon and thence south along Salmon River. Other than this only a few articles in technical journals and notes in the reports of the State mine inspector deal with the geology and mineral deposits of Lemhi County.

Following is a list of the more important articles and publications on this and near-by areas.

Emmons, S. F., Livingston to the Snake Plains: Compt. rend. Cong. géol. internat., 5th sess., 1893, pp. 367–374. Describes the geology along the route of travel and the geologic history of the Snake Plains.

Stone, George H., An extinct glacier of the Salmon River Range: Am. Geologist, vol. 11, 1893, pp. 406–409. Describes the glacial geology of the Leesburg basin and the mountains west of Salmon.

Eldridge, George H., A geological reconnaissance across Idaho: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1895, pp. 211–276. Describes the topography and geology along a route from Boise to Salmon and thence south to Hailey and west to Boise. The report includes notes on the ore deposits at Yellow Jacket and the placers of the Leesburg basin and Kirtley Creek.

Goode, R. U., Bitterroot Forest Reserve: Nat. Geog. Mag., vol. 9, 1898, pp. 387–400. Contains general description of the reserve and definition of mountain systems.

Lindgren, Waldemar, The gold and silver veins of Silver City, De Lamar, and other mining districts of Idaho: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, pp. 75–256. Describes the character and occurrence of the igneous and sedimentary rocks and the occurrence and nature of the ore deposits of a large area lying south and west of Lemhi County.

Bell, Robert, An outline of Idaho geology and of the principal ore deposits of Lemhi and Custer counties, Idaho: Proc. Internat. Min. Cong., 4th sess., 1901, pp. 64–80. Describes briefly the principal mines of Lemhi and Custer counties, stating the amount of development, production, and something of the geologic relations.

Russell, Israel C., Geology and water resources of the Snake River Plains of Idaho: Bull. U. S. Geol. Survey No. 199, 1902, 192 pp. Describes the topography, the basement series of rocks, recent eruptives, lacustrine deposits, and resources of the area.

Lindgren, Waldemar, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: Prof. Paper U. S. Geol. Survey No. 27, 1904, 123 pp. Describes the topography and the character, occurrence, and geologic relations of the igneous and sedimentary rocks, the structure of the area, and the character, occurrence, and development of its mineral deposits. The Gibbonsville and Mineral Hill districts, Lemhi County, are described briefly.

Carr, Henry C., Vein structure in the Monument mine: Min. and Sci. Press, vol. 98, 1909, pp. 557–558. Includes notes on the geology and character and occurrence of the ores at Meyers Cove (Singiser), Lemhi County, Idaho.

GEOGRAPHY.

SITUATION AND ACCESS.

Lemhi County, Idaho (fig. 1), situated in the east-central part of the State, lies along the eastern border of that broad area which proved impassable to the Lewis and Clark expedition. In August, 1805, Capt. William Clark crossed the main divide at Bannock Pass and proceeded down Lemhi and Salmon rivers nearly to the place where Shoup now stands. Beyond this point the narrow canyon and precipitous uplands along Salmon River made progress impossible. At this time Salmon River was named Lewis River, after the great explorer and head of the expedition, and it is to be regretted that the name was not retained, especially as another stream in the State is called Salmon River.

At present all important lines of traffic extend eastward, although feasible routes to the west have been located. The most practicable of these seems to be that followed by the recent railroad survey down the deep, narrow canyon of Salmon River to Lewiston. This route has a water grade from Bannock Pass on the east down Lemhi, Salmon, Snake, and Columbia rivers to salt water. The Gilmore & Pittsburgh Railroad, popularly supposed to be a link in a transcontinental line, was completed in 1910 between Salmon, Idaho, and Armstead, Mont., the latter being a point on the Oregon Short Line 90 miles south of Butte. From Leadore, Idaho, a branch extends 20 miles south to Gilmore. Stage routes lead from Salmon, the county seat (see Pl. II, *B*), a city of possibly 1,500 inhabitants, south to Challis and west and north to several mining camps and settlements.

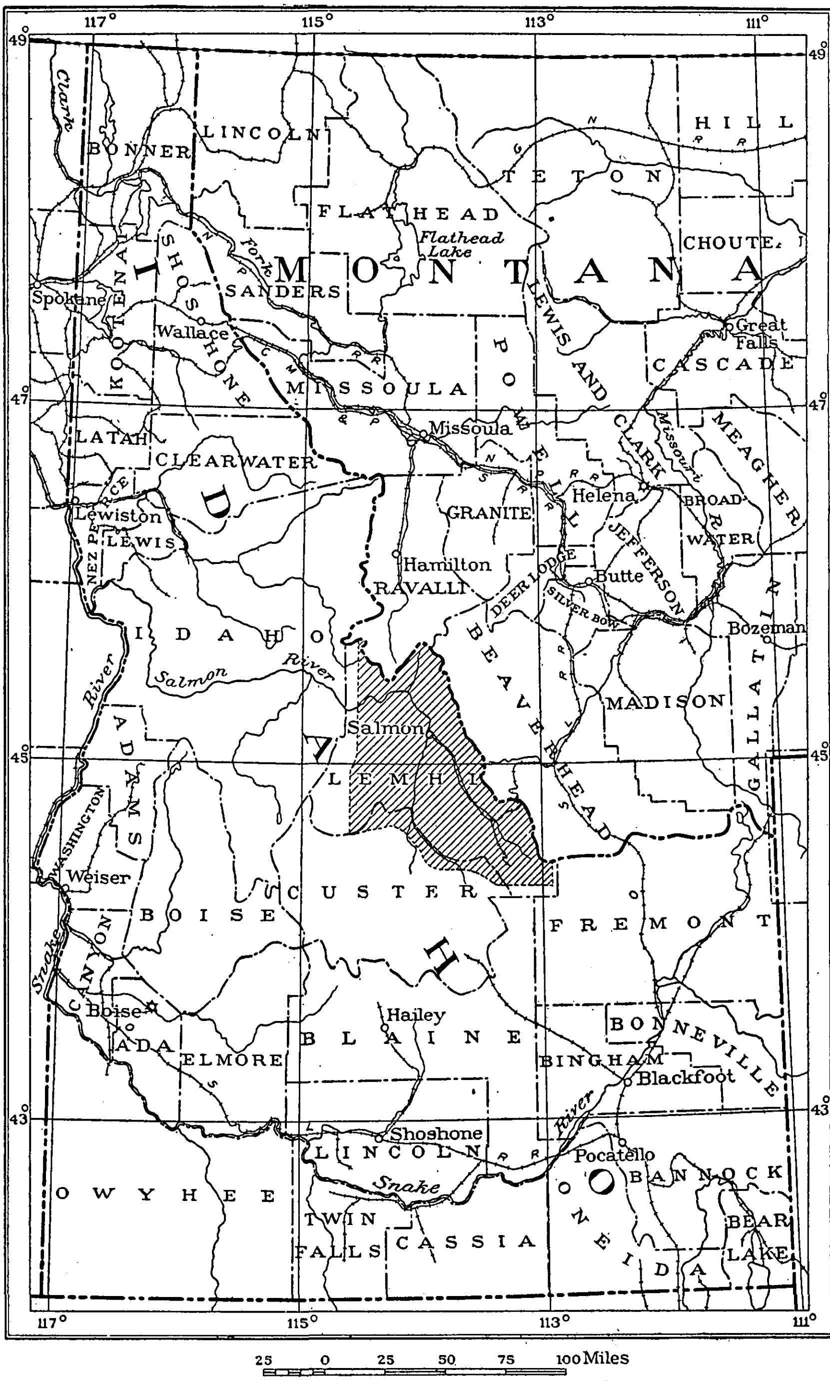
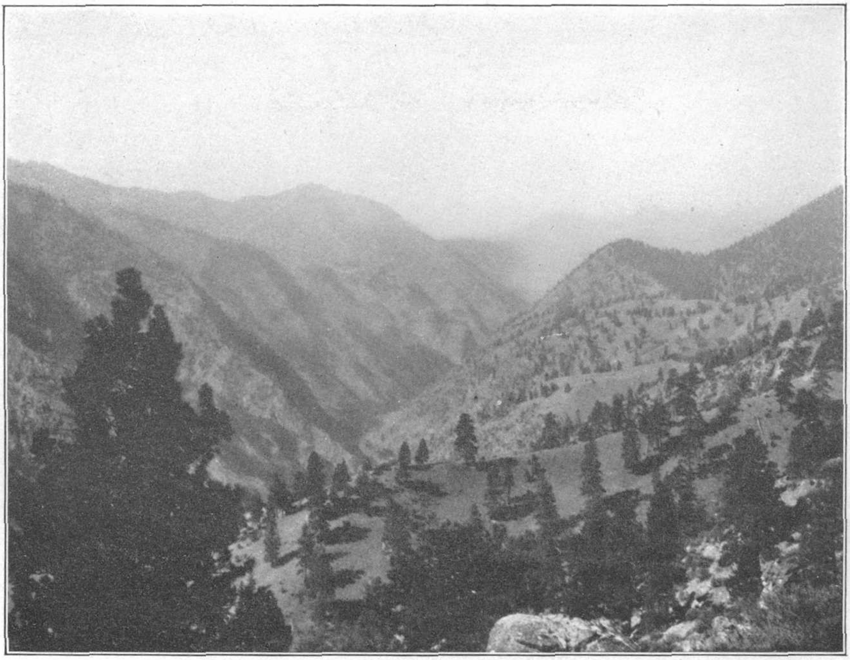
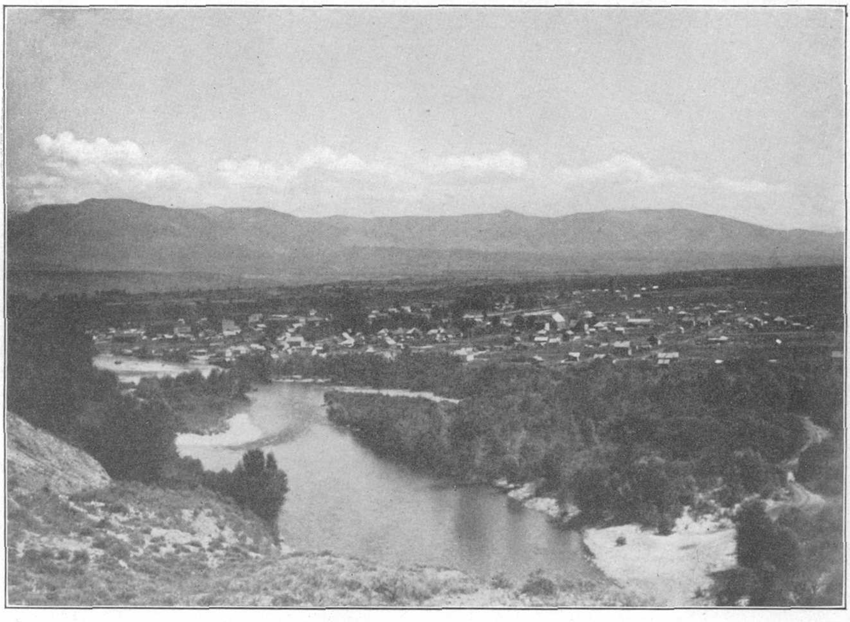


FIGURE 1.—Index map showing location of Lemhi County, Idaho.



A. SALMON CANYON BELOW SHOUP.



B. SALMON CITY.

Beaverhead Mountains in the distance.

CLIMATE, VEGETATION, AND ANIMAL LIFE.

Coordinate with Lemhi County's great range in elevation is its great range in climatic conditions. Expanses covered with snow to a depth of several feet throughout a long winter grade down to lowlands where sleighing is seldom possible. While travelers in the mountains are using skees those in the deeper valleys may be complaining of dust. Unlike many parts of the Northwest, the area is one of abundant precipitation. Almost every mountain canyon is occupied by a stream that lives throughout the year, affording power for the industrialist, fish for the sportsman, and beauty for the traveler.

Over much of the county a dense growth of medium-sized evergreen trees rises above a surface clad thickly with grasses and small shrubs. This growth extends from the lowest valleys to the highest summits, but though thus independent of elevation, it is not uniformly distributed. The great areas of Miocene lake beds are notably lacking in trees, as are also numerous talus slopes adjacent to rugged quartzite summits. The absence of forests on the talus slopes is obviously due to the constant shifting of the surface material, but its absence on the lake beds is less readily explained. Here, however, sagebrush and the grasses of semiarid regions abound, clearly indicating a dearth of moisture, thought to be due to imperfect cementation in the detrital material forming the beds.

The forest trees available for economic use are the yellow pine (*Pinus ponderosa* Lawson), the Douglas fir (*Pseudotsuga taxifolia* Britt), the lodgepole pine (*Pinus contorta* Loudon), and the Englemann spruce (*Picea englemanni* Englemann).[1] Of these the yellow pine has the widest distribution and supplies the only first-class lumber produced in the county. It is the predominant type in the northern and western parts of the area, where "it forms pure stands on south slopes, tops of ridges, and all dry situations." The average tree is about 30 inches in diameter and 120 feet high. Next in importance is Douglas fir, which yields only rough lumber, ties, poles, and fencing, although producing the best quality of fuel wood. It generally grows in open scrubby stands on north slopes and in moist places up to 8,000 feet elevation. The trees are somewhat smaller than the yellow pine. Lodgepole pine, although a small tree, commonly about a foot in diameter, is important because of its wide distribution and great range of uses. It grows on the higher areas throughout most of the county. The Englemann spruce has a wide range in altitude, but is confined to moist canyons and creek beds and is commonly in too small stands to be of commercial importance.

In few parts of the West not included in a game reserve is large game so abundant as in central Idaho, the inhabitants of the forest having

[1] McLean, F. T., Silvical report of Salmon National Forest for 1910, unpublished, but typewritten copy in files of the Bureau of Forestry.

been more or less effectively preserved by the comparative inaccessibility of the region. Within a few hours' travel from any of the mining camps west of Salmon it is possible to kill a deer. Goats and sheep are less numerous, but many are killed each season, and numbers of bear, wolves, coyotes, mountain lions, and, less commonly, lynx annually fall victims to the hunter or are ensnared by the trapper. Antelope and elk have become rare, and the State is endeavoring to revive them by absolute protection, instead of the limited protection afforded to most of the other species.

MINING.

GENERAL CONDITIONS.

Of the many conditions affecting mining, only the lack of suitable means of transportation has served as a serious handicap to development. Prior to the spring of 1910 Red Rock, Mont., and Dubois, Idaho, were the nearest railroad points, and these represented a haul of more than 70 miles from the properties situated advantageously and of more than double that distance from other mines. Even now, with the railroad terminus at Salmon, the western and northern parts of the county are benefited but little so far as marketing ore is concerned. Except the lead-silver deposits the ores are not of sufficiently high grade to warrant a long wagon haul. If transportation charges were made reasonable, however, it is almost certain that several properties in the eastern and northern parts of the county would become substantial producers.

The climate is in no sense prohibitory to successful and cheap mining, timber is abundant, and water power is practically unlimited. Deep valleys adjacent to most of the deposits make it possible to attain 1,000 to 2,000 feet of depth without recourse to deep shafts.

HISTORY.

Lemhi County, like most of the Rocky Mountain mining districts, owes the discovery of its mineral wealth to the great army of gold seekers that invaded the Sierra of California about the middle of the last century and thence penetrated to all the mountain areas of the West. Mining history attests the thoroughness of their search, for no important placers have been discovered since, and most of the lode deposits since worked were known to them. In 1862 a group of these men, following the constantly shifting centers of excitement, went to Florence, Mont., thence to Alder Gulch, and then to Elk Creek, where in the spring of 1866 a party of five outfitted and started into the then unknown area of Lemhi County. Nate Smith led the expedition, which included Lydge Mulkey, F. B. Sharkey, William Smith, and Caleb Davis. Only F. B. Sharkey, a resident of Sunfield, Idaho, survives. Their first location was on Napias Creek, in the north-central part of the county, a short distance above the mouth of Wards Creek gulch. Leesburg, for some years a prosperous camp, sprang into existence near by, and across the road from it Grantsville thrived for a time, each named by Civil War veterans. Starting in several directions from Leesburg, prospectors soon discovered the placers of Moose Creek, Gibbonsville, Bohannon Bar, and Yellow Jacket, the first lode deposit being located at Yellow Jacket in September, 1868. Most of the gold veins which have since become important were discovered during the next 15 years. Lead-silver was discovered in 1880 at Nicholia, copper in 1883 at Copper Queen mine, cobalt-nickel in 1901 at Blackbird, and tungsten in 1903 at Ima.

During the early years of mining in Lemhi County supplies were freighted from Fort Benton, Mont., and later from Corinne, Utah. Not until 1882, when the railroad reached Red Rock, Mont., was the necessary wagon haul less than 250 miles; from that year until 1910 it was about 100 miles. The extension of the railroad to Salmon has produced a substantial increase in mining in the territory along its route, the activity being especially marked by the lead-silver production of the last year, by recent activity at the Copper Queen mine, and by the installation of a large dredge on Kirtly Creek, which will increase the copper and gold output for the county. In the region west and north of Salmon the railroad has not proved to be of great benefit, for the wagon haul is still so long as to prohibit the shipment of the common grade of ores.

PRODUCTION.

The total production of Lemhi County to January, 1911, is estimated at $20,000,000. Official records are available for the period from 1881 to 1910, but the important placer operations were carried on before 1881 and little reliable information concerning them is to be had. At that time many individuals worked many properties, gold dust was used instead of money, and gambling was rife. Long-time residents of the county place the early placer production at $7,000,000 to $30,000,000, but the area of ground worked, the reported richness, and the known production since 1880, lead the writer to the opinion that $6,000,000 is probably a fair estimate for the period prior to 1881. From 1881 to 1910, inclusive, the production included $7,702,256 from gold, $1,862,081 from silver, $32,563 from copper, and $3,822,270 [1] from lead. The figures for 1911 show a marked increase in the amount of lead and silver, and a new metal, tungsten, was added to the list.

[1] About $1,500,000 of this amount is based on estimates. See pp. 84, 91.

Considered by districts, Mackinaw has been the chief source of gold, producing about $6,250,000. The Gibbonsville district is next in importance, with about $2,000,000, and then follow the Mineral Hill, the Indian Creek, and the Yellow Jacket, all of these districts being in the western and northern part of the county. In the production of lead-silver the Nicholia district led with an output of $2,500,000 up to the close of 1910, but the Texas district, with an equal production at the close of 1911, was probably ahead at the end of 1912. The Junction and Spring Mountain districts, each with an output of approximately $100,000, constitute the remaining lead-silver districts, all of which are situated in the southeast part of the county. Copper has been derived almost exclusively from the Copper Queen mine, in the McDevitt district.

The production of Lemhi County for the years 1904 to 1911, inclusive, as published annually by the United States Geological Survey in Mineral Resources of the United States, is as follows:

Mine production of gold, silver, and associated metals in Lemhi County, Idaho, in 1904–1911, inclusive.

Year.	Gold.		Silver.		Copper.		Lead.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
DEEP MINES.	*Fine ounces.*		*Fine ounces.*		*Pounds.*		*Pounds.*	
1904	9,952	$205,726	44,168	$25,286	5,000	$625	1,827,400	$79,949
1905	3,309	68,403	38,936	23,517			1,796,000	84,412
1906	3,777.51	78,088	36,324	24,337	40,000	7,720	1,144,000	65,208
1907	2,502.83	51,738	50,444	33,293	52,461	10,492	1,932,356	102,415
1908	1,785.13	36,902	22,825	12,098	10,366	1,368	700,622	29,426
1909	5,115.17	105,740	5,564	2,893	46,246	6,012	132,071	5,679
1910	2,466.26	50,982	150,119	81,064	54,887	6,971	6,526,474	287,165
1911	4,240.84	87,666	382,904	202,959	390,660	48,832	16,854,922	758,471
PLACERS.								
1904	2,236	46,222	307	176				
1905	1,440	29,768	421	255				
1906	1,346.98	27,844	129	87				
1907	1,570.93	32,474	128	84				
1908	1,730.88	35,780	167	88				
1909	1,164.29	24,068	111	58				
1910	772.98	15,979	66	36				
1911	1,621.68	33,523	135	72				
		930,903		406,265		82,020		1,412,725

PHYSIOGRAPHY.

EXISTING TOPOGRAPHY.

Lemhi County is a high mountainous area consisting of broad, level-topped divides, generally separating deep narrow valleys. The Continental Divide, which forms the north and east boundaries of the area, is the summit of a high, narrow range, which from the scanty evidence available seems to be largely, if not entirely, a product of erosion. In the vicinity of Shoup the headwaters of Bitterroot

River have crowded the crest line several miles to the south, and above Gibbonsville North Fork of Salmon River, acting in the opposite direction, has crowded it sharply north, thus forming an S, conspicuous on any map of the State boundary.

The divide is known to continue southeast without an important break to Beaver Canyon, where the Oregon Short Line Railroad crosses it. Northward the range splits, the eastern part continuing as the Continental Divide and the western part as the Bitterroot Mountains. For this section of the Continental Divide, between the Bitterroot Mountains and Beaver Canyon, the name Beaverhead Mountains is here proposed. The name is suggested by Beaverhead County, Mont., which comprises a considerable part of the divide; Beaverhead River, which drains much of its eastern slope; and Beaverhead National Forest, which is coextensive with a greater part of it.

West and south of Salmon River the mountains are carved from a high plateau made up of rocks of diverse composition. The same type of topography is seen in the Lemhi Range, although there the dissection is further advanced.

Of the several valleys that of Salmon River is the most important, though smaller than some of the others. (See Pl. II, *A*, p. 18.) Near the mouth of Pahsimeroi Valley, at the southern boundary of the county, the river enters a deep, narrow canyon which continues to a point within 8 miles of Salmon, where it opens out into a broad intermontane depression. This depression continues downstream for 20 miles and then merges into a canyon even narrower and more rugged than the first. The Lemhi Valley, in contrast to this erratic topographic feature, is broad and open, bordered by precipitous walls which gradually diverge headward and continue beyond an imperceptible divide, as the sides of Birch Creek valley. The Pahsimeroi Valley is similarly a wide depression and is occupied by an even smaller stream.

PHYSIOGRAPHIC DEVELOPMENT.

General features.—Throughout the area there is striking accordance in the elevation of interstream tracts, which, when seen from slight prominences above their level, present the semblance of a broad plain extending southeast, southwest, and north to the horizon. Eastward the Beaverhead Mountains, which in their northern part stand a little above the general level, cut off the view. From such a vantage point an observer would scarcely suspect the area to be furrowed by narrow valleys in places to depths of 5,000 feet. Significant details of contour are the spurs which extend from the main divides and terminate in square shoulders along the major valleys, features which are not to be explained by structure but point to the dissection of a once nearly level surface. Also significant are certain rock-cut terraces which parallel the plateau surface at slightly lower levels. One of these is on the west side of the Lemhi Range at Spring Mountain.

The surface rocks are gneiss, granite, and sharply folded schists, slates, quartzites, limestones, and dolomites, yet the plateau surface extends across all these rocks, truncating the resistant and nonresistant alike. This uniform truncation of upturned strata over broad areas can have resulted only from profound erosion, which during its later stages operated at elevations where differences in rock resistance no longer produced noticeable differences in surface contour. It is concluded, therefore, that the surface of this area has been reduced to one of gentle contours and since elevated. (See figs. 2 to 4.)

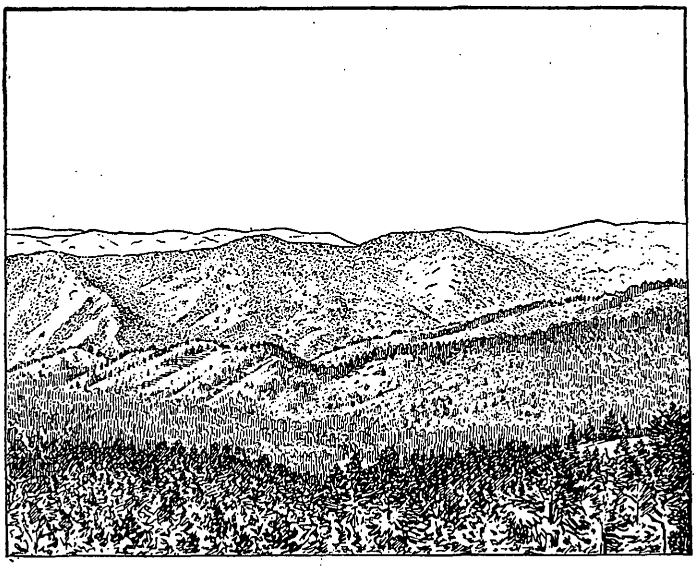


FIGURE 2.—Eocene erosion surface southwestward from a point 3 miles west of Gibbonsville. The rocks are closely folded schists and slates of Algonkian age. Drawn from photograph.

Erosion surface.—Were the flat-topped divides of the area used to determine a plane it would be found to record minor flexures, some faulting, and a broad anticline extending east and west through the Texas district. Such a plane, however, would probably prove much more nearly level than the structure of the Miocene lake beds (see p. 38) would indicate. The broad east and west anticline above referred to is post-Miocene, for it involves a gradual increase in the elevation of the lake shore that follows the Lemhi Valley and of the mountain crests from Salmon southeast to Gilmore. Near Gilmore the summits stand at about 10,500 feet, but about Salmon they are commonly at 8,500 feet, which is about the normal elevation of the summits throughout the region.

Correlation.—It is not proposed in the present paper to enter on the broad physiographic problem, but in order to date this surface of erosion it is necessary to form some idea of its extent. The same surface has been observed by Lindgren [1] in the Clearwater Mountains and in west-central Idaho; by Calkins [2] in the Cœur d'Alene, Cabinet, and Purcell ranges; and what is probably the same surface by Willis [3] in the Lewis, Livingston, and Galton ranges, Mont., by the writer [4] at Republic, Wash., and by Dawson [5] in the Interior Plateau of Canada.

Throughout this broad area the surface of recognized similarity varies in elevation from 4,500 feet to 10,500 feet, although elevations of 6,000 to 7,000 feet are the more common. In Canada and eastern

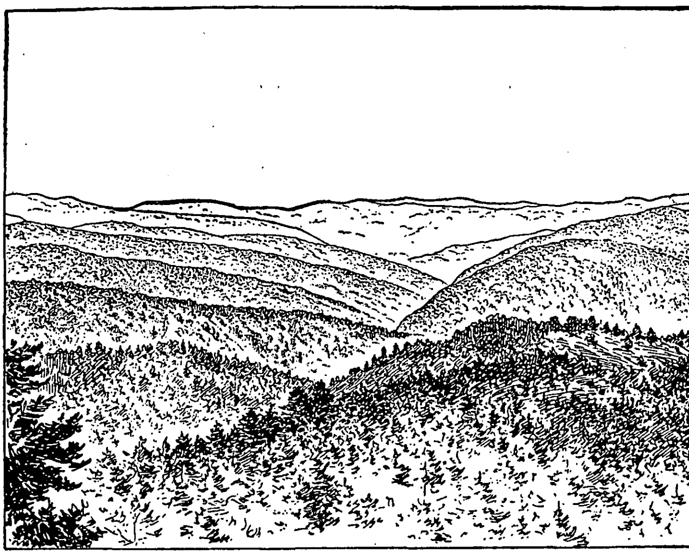


FIGURE 3.—Eocene erosion surface northeastward from Gibbonsville. Some of the valleys are 4,000 feet deep. Drawn from photograph.

Washington the surface has been recognized as Eocene and assigned to the same epoch as that in Lemhi County, which in turn is continuous with the west-central Idaho and Clearwater Mountain areas. The other localities mentioned above presumably present the same surface, a deduction resulting from considerations outlined in the next section.

[1] Lindgren, Waldemar, The gold and silver veins of Silver City, De Lamar, and other mining districts of Idaho: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 77; A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: Prof. Paper U. S. Geol. Survey No. 27, 1904, pp. 13-14.

[2] Calkins, F. C., and MacDonald, D. F., A geological reconnaissance in northern Idaho and northwestern Montana: Bull. U. S. Geol. Survey No. 384, 1909, pp. 14, 16.

[3] Willis, Bailey, Stratigraphy and structure, Lewis and Livingston ranges, Mont.: Bull. Geol. Soc. America, vol. 13, 1901, p. 349.

[4] Umpleby, J. B., Geology and ore deposits of Republic mining district: Bull. Washington Geol. Survey No. 1, 1909, p. 11.

[5] Dawson, G. M., The physiographical geology of the Rocky Mountain region in Canada: Trans. Roy. Soc. Canada, 1890, p. 13.

Age of the surface.—Sediments assigned to the Miocene on fossil evidence occupy a broad erosion valley developed after the area had assumed its present elevation. (See p. 36.) Obviously, the old erosion surface is pre-Miocene.

Vast volumes of sediments must have resulted from the reduction to a gentle topographic feature of the broad area known to have been eroded, and herein lies the possibility of further defining its age. The surface cuts Carboniferous beds, and as it is pre-Miocene only Mesozoic and early Tertiary deposits need be considered. Post-Paleozoic formations in the Northwest earlier than those of late Cretaceous time seem to bear no genetic relation to the plateau region as a whole. The Triassic sea occupied part of the same area, and Jurassic

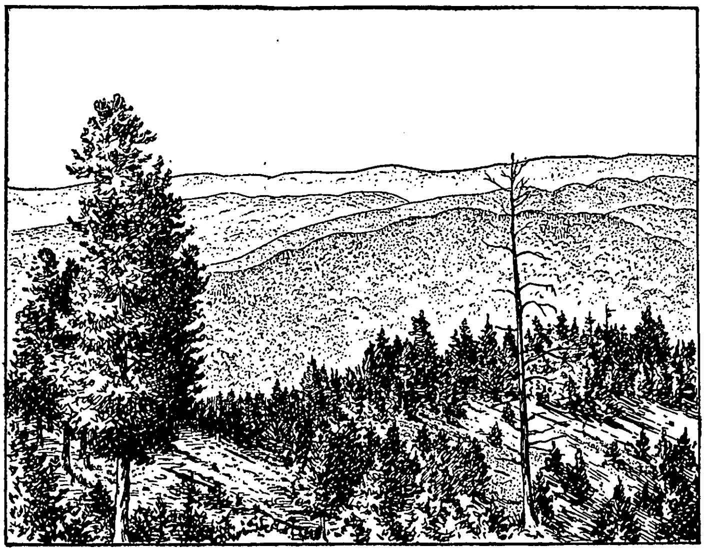


FIGURE 4.—Eocene erosion surface southward from Copper King Mountain. Cut across granite, quartzite, slates, and schists. Drawn from photograph.

deposition occurred a little farther east. The late Cretaceous is strongly developed in the adjoining areas to the east and much of the material was presumably derived from highlands to the west. The distribution of Eocene sediments, however, is far more suggestive. (See fig. 5.) They surround the plateau area in such a manner that their derivation from it, at least in large part, seems obvious. The great volume of these deposits could not have resulted from the plateau region after its last elevation, for two reasons. (1) It is very doubtful if the plateau is sufficiently dissected to afford the volume of material represented by the Eocene beds, and (2) all the great valleys which developed after the last great elevation drained westward and in all probability have done so throughout their history. This is true of the Rocky Mountain trough, the Purcell trough, and the Snake, Salmon, and Columbia River channels. It seems, therefore, only possible that the extensive Eocene deposits on the east could have been derived from the plateau region during that period of erosion which resulted in its reduction well toward base-level. Whether or not that great cycle of erosion began with the Eocene may be an open question, but that it closed with the Eocene, and therefore that the surface is of Eocene age, seems practically beyond doubt.

The Eocene sediments of the Northwest record four more or less distinct stages. This may mean either that the area supplying the material was affected by successive uplifts or that slight warpings or perhaps only piracy caused the courses of the principal streams to change from time to time. The latter view is the more probable, for beds representing successive stages in the Eocene epoch for the most part occupy different areas.

Early Eocene elevation.—A comparison of figures 5 and 6 brings out the remarkable accordance in the extent of the plateau area and in the distribution of granitic rock which may reasonably be assigned to the late Cretaceous or early Eocene age. Many of the granitic areas are shown definitely to be portions of the same batholith, but the age of others has not been determined. The magnitude of the masses which entered at about the same time, however, is almost inconceivable. It does not seem possible that such a volume of molten rock could enter the outer zone of the earth without being accompanied by a profound elevation of the surface; yet nowhere is there a record of such elevation until Eocene time. The Triassic and Jurassic seas probably crossed parts of the area now occupied by the granite, and within the configuration of the Cretaceous shore line, as commonly defined, there are no features indicating a pronounced highland centering in Idaho. Thus, prior to the Eocene, there is no evidence of special elevation in the area now common to granitic outcrops and the old erosion surface.

From these lines of evidence it is concluded that the probability is strong that the intrusion of the granite accompanied the broad elevation which was reduced to gentle topographic forms during the Eocene epoch; and therefore that the great granite mass which attains its greatest development in Idaho is of late Cretaceous or early Eocene age.

Bearing of Eocene erosion surface on economic problems.—Over much of the plateau region no geologic datum plane is recognized between the Algonkian and the Pleistocene. All the ore deposits and associated igneous activity were well removed in time from both of these periods, and hence the economic geologist is frequently at a loss to date his deposits. The Eocene erosion surface, however, constitutes a widely recognizable datum plane, separating two great periods of mineralization. As the older deposits are later than the granite, the age of the granite is important, and if the above suggestion of a genetic relation between it and the Eocene surface can be established, the numerous pre-Oligocene ore deposits found in

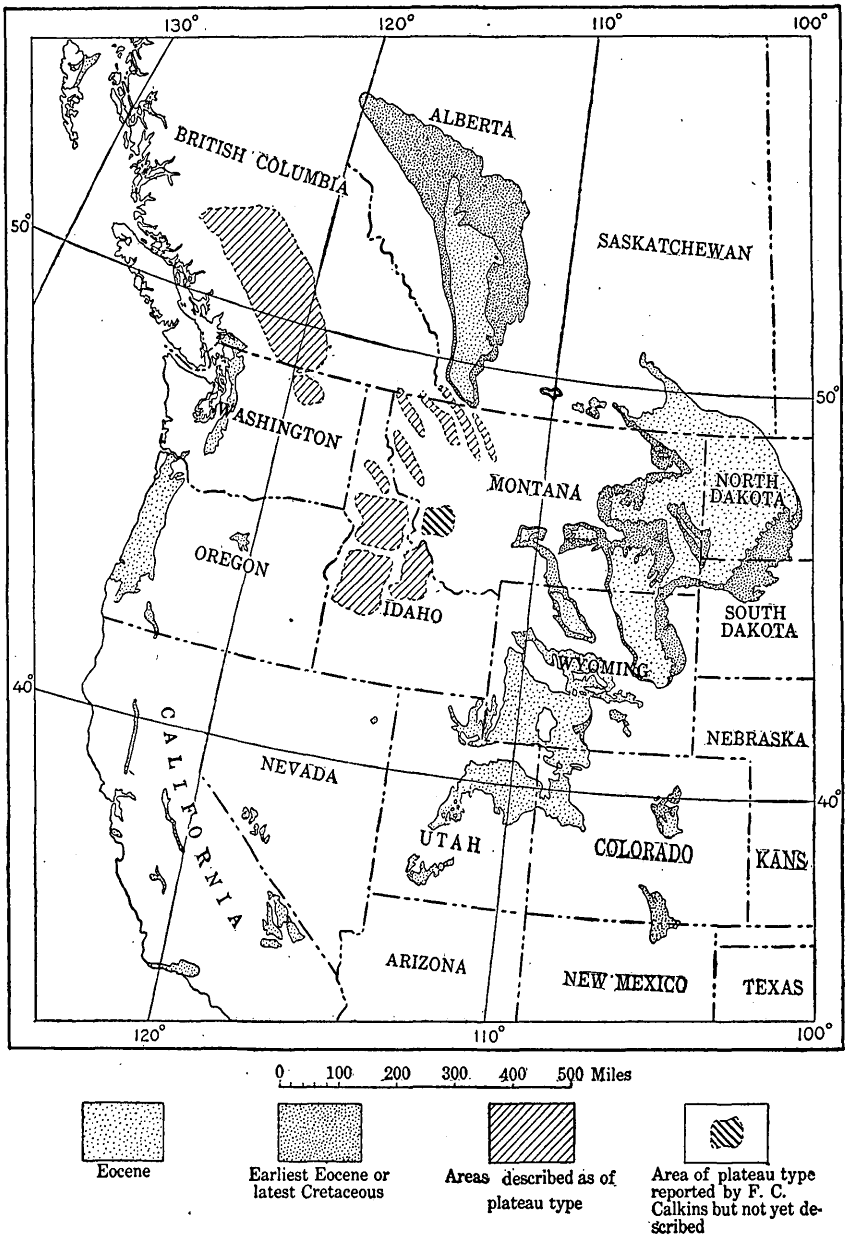


FIGURE 5.—Map showing distribution of Eocene deposits in the Northwest. Adapted from geologic map of North America.

Idaho are confined to the late Cretaceous or early Eocene. The later deposits are inclosed in or associated with eruptive rocks, which occupy valleys developed after the elevation of the Eocene surface.

If the Oligocene epoch is allowed for the development of these valleys the later deposits are post-Oligocene. They are further limited in age by Pleistocene glaciation and by the amount of erosion which preceded the glaciation but followed the development of the veins. Thus the later period of mineralization is Miocene or early Pliocene.

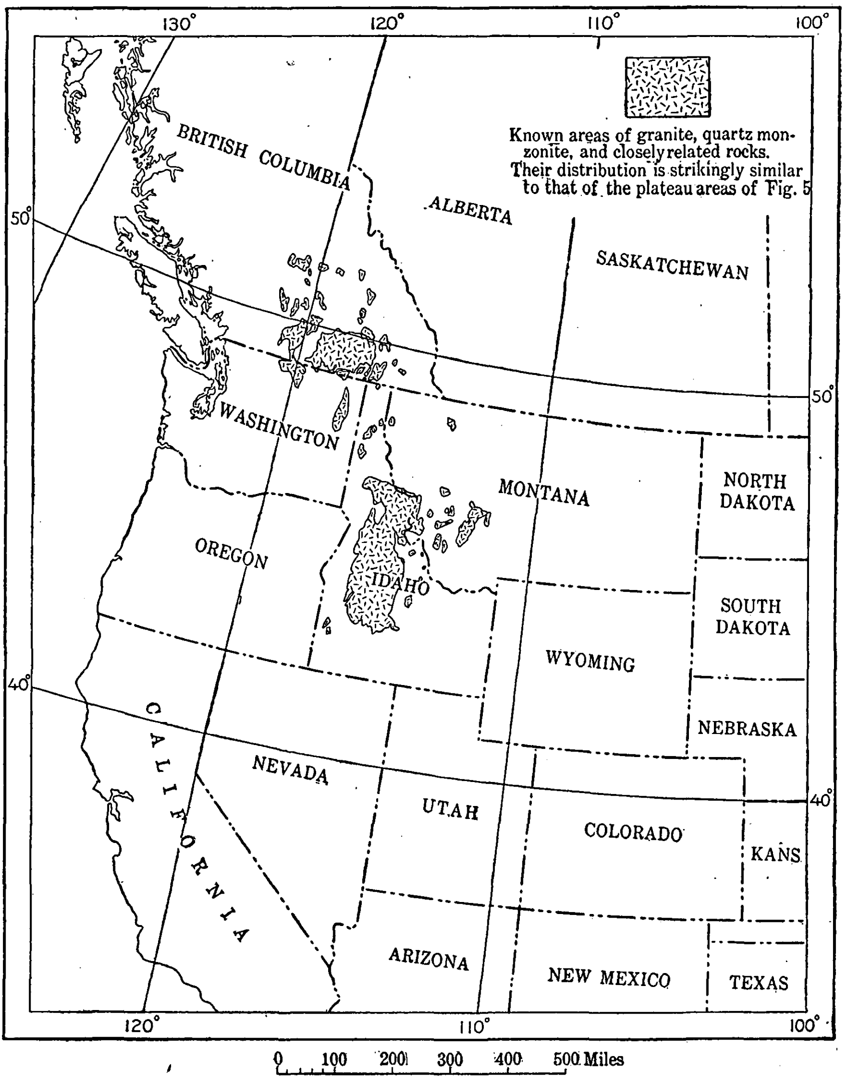


FIGURE 6.—Map showing distribution of outcrops of granitic rocks in the Northwest. These are strikingly coincident in distribution with the plateau area. Adapted from geologic map of North America.

POST-EOCENE TOPOGRAPHY.

The post-Eocene geography of the area has changed greatly from stage to stage. The marked discordance in degree of development of the valley of Salmon River from place to place, and in the Lemhi and Pahsimeroi valleys with reference to it, has been indicated (p. 23). It has also been pointed out that the Lemhi Valley increases in width toward the head of its stream and beyond, and that many of its tributaries run headward until they reach the valley flat, where they assume a normal inclination downstream. Prairie Basin is a high rolling tract, isolated by a broad area of Tertiary lavas, which may conceal a former connection with the Pahsimeroi Valley.

All the above-mentioned features are independent of structure and point clearly to profound drainage changes. The valleys now partly filled by Miocene sediments were undoubtedly formed by rivers which flowed southward and joined Snake River through the present channels of Birch Creek and possibly Little Lost River. These relations prevailed until erosion began to operate on the lake beds, when the head of the basin was tapped by Salmon River. Since then the drainage has been to the north and west. The explanation of the restricted valley occupied by Salmon River from a few miles above Salmon nearly to the entrance of the Pahsimeroi is not altogether clear but probably is to be explained by headward erosion. The broad valley of the Pahsimeroi, like that of the Lemhi, is thought to have been formed by a southward-flowing stream.

Pleistocene glaciation on all elevations above perhaps 8,000 feet, and along the larger drainage line down to 7,000 and rarely to 6,000 feet, developed deep U-shaped valleys and countless cirques in the higher mountains. (See also p. 40.)

GENERAL GEOLOGY.

AGE AND SUCCESSION OF THE ROCKS.

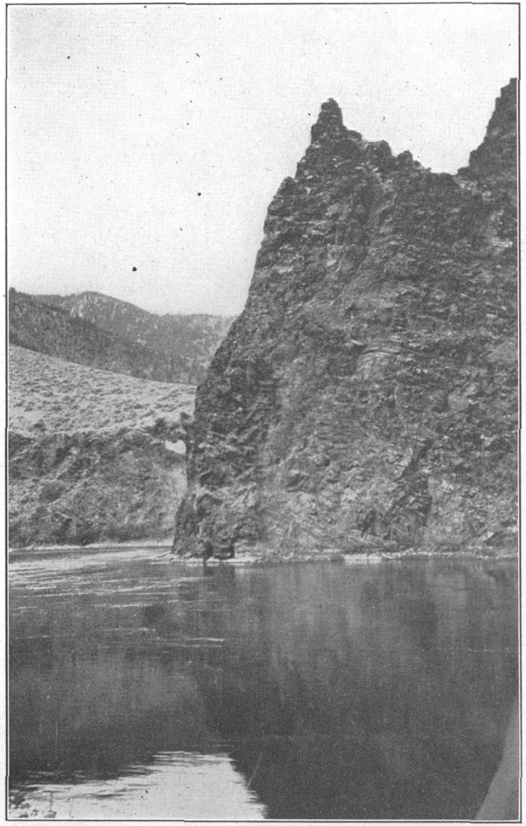
The rock formations of Lemhi County comprise a basement of Archean gneiss, a widespread unconformable series of intensely metamorphosed schists, slates, and quartzites of Algonkian age, and an unconformable series of Paleozoic formations, which are preserved only in the southeastern part of the county. The Mesozoic is not represented by stratified rocks, but intrusions of granite probably of late Cretaceous or early Eocene age occur at several places in the area, attaining their maximum development west of Leesburg.

An Eocene erosion surface is recognized on most of the summits at elevations greater than that of the next younger rocks, which are Miocene lake beds and Miocene and Pliocene lavas. Glacial débris covers much of the highland areas and extends down the larger valleys to elevations of 7,000 feet, rarely to 6,000 feet.

SEDIMENTARY ROCKS.

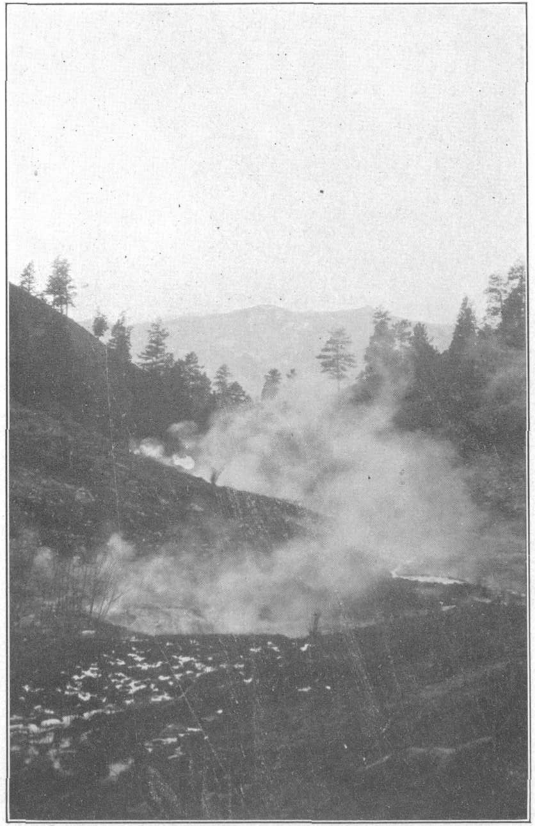
ALGONKIAN SYSTEM.

Algonkian sedimentary rocks are widespread and of great thickness in Lemhi County. Although, owing to the limitations of hasty reconnaissance work, they are here considered a unit, their lithologic varia-



A. EAGLE PEAK.

Portion of a quartzite cliff along Salmon River near entrance to canyon.
Photograph by Percy Anderson.



B. HOT SPRING 3 MILES WEST OF COPPER KING MOUNTAIN.

Photograph by Percy Anderson.

CAMBRIAN QUARTZITE CLIFF AT HEAD OF MEADOW LAKE CIRQUE, TEXAS DISTRICT.

Beds extending one-third of the way up the left slope are Ordovician.

tions are so great that detailed work will be sure to lead to several broad subdivisions. Indeed, at present it is possible to recognize several of the subdivisions of the Algonkian of Montana and Idaho assembled in tabulated form by Calkins.[1]

The rugged range that forms the Beaverhead Mountains is carved out of these rocks from Agency Creek northward, and most of the level-topped highlands west of Salmon River are formed by their truncated edges. (See Pl. III, *A*.) Within their general area they are in places widely concealed by lake beds and lava flows, and elsewhere are displaced by granite and dikes.

The Algonkian sedimentary rocks are uniformly though not intensely metamorphosed. Crumpling or intricate foliation is seldom seen, and in most places bedding structure may be recognized. Yet, in general, crystallization of the constituents has taken place, biotite and sericite being most commonly developed. Some garnet and chiastolite and more amphibole have been formed.

The rocks have had an eventful history, recorded in intricate jointing and extensive shearing. Faulting is indicated by breaks from one type of rock to another along the strike and by changes of attitude within short distances.

The base of the Algonkian as exposed near Shoup is a fine-grained micaceous schist, locally including abundant fragments of the underlying gneiss. It gives way in a short stratigraphic distance to quartzite beds which alternate with those of schist and slate for 200 or 300 feet. About Ulysses, 8 miles northeast of Shoup, the rocks are little different, but around Gibbonsville there is vastly more clayey material, the series being made up of dark thin-bedded slates and subordinate amounts of quartzite, which in many places grades into them. Bedding is fairly well preserved, although jointing is very intricate and metamorphism is well advanced. Biotite, the chief metamorphic mineral, is mostly oriented parallel to the bedding, although in places it conforms to cleavage planes which lie at 45° thereto.

In contrast to these predominant argillites to the north, gray-banded quartzites prevail in the Eureka district and along the Beaverhead Mountains east and northeast of Salmon. In the former locality the quartzite is dark gray, with faint banding resembling fine laminations, but in the latter it is uniformly light gray. In both localities the quartzites are fine grained and compact with rather thick bedding. A quartzite resembling that of the latter locality occurs about the Black Eagle mine in the Yellow Jacket district, although the best exposures of this phase of the series are along the south branch of Carmen Creek, especially in the cirque walls north of Fremont Peak.

[1] Ransome, F. L., and Calkins, F. C., The geology and ore deposits of the Cœur d'Alene district, Idaho: Prof. Paper U. S. Geol. Survey No. 62, 1908, p. 27.

Still another facies of the older rocks occurs in the mountains east of Baker and is well exposed in Pratt Creek canyon, near its mouth. Here a steep cliff, possibly 700 feet high, is formed by thinly bedded horizontal layers of quartzites, argillites, and schists, the individual members ranging in thickness from 1 to 5 feet and being conformable throughout. These beds are distinguished from those before described by their thin bedding and by the veinlets of calcite which occupy some of the joint planes. It is probably this phase which is extensively developed, though poorly exposed, in the southern part of the Yellow Jacket district. The rocks are not known in contact with the Cambrian system, but as they occur in general parallel to and not far from the outcrop of the Cambrian formations it is thought that they are near the top of the Algonkian system.

Detailed correlations can not be based on as incomplete work as the present, but purely as a working hypothesis it might be suggested that the rocks above described correspond to the Prichard slate, Revett quartzite, and Wallace formation of the Cœur d'Alene section.[1] Broadly, there is no doubt that they are to be correlated with the known Algonkian sections of Idaho and Montana.

PALEOZOIC ROCKS.

CAMBRIAN SYSTEM.

Cambrian quartzite outcrops along the crest and east slope of the Lemhi Range, from the vicinity of McDevitt Creek southward beyond the limits of the reconnaissance. The higher peaks of this part of the range, those which rise as high as 10,800 feet above sea level, are carved out of this formation. North of the Lemhi Valley the quartzite continues, crossing the Beaverhead Mountains a little south of Lemhi Pass.

The formation was studied only in the vicinity of Meadow Lake, where it is uniformly a clear-white fine-grained quartzite, more than 2,000 feet in thickness. (See Pl. IV.) A notable feature is the absence of conglomeratic and even of granular facies. Individual grains can not be distinguished with the unaided eye, and fresh surfaces have a rather opalescent appearance. When microscopically examined, the individual grains are seen to be well rounded and to average about 0.3 millimeter in diameter, the largest measured being only 0.5 millimeter. Recrystallization was unimportant in the metamorphism of the original sandstone, the firmer cementation being due to an infiltration of silica into the interstices between the grains rather than to a crystallographic addition to them. The quartzite is remarkably free from mica or other common impurities.

No fossils were obtained from this quartzite. Throughout its known extent the general dip of the formation is about 45° E., al-

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[1] Ransome, F. L., and Calkins, F. C., op. cit., pp. 25, 27.

though local variations to the north and south were noted. Below it stratigraphically are the greatly folded and extensively recrystallized Algonkian schists, so that, although an unconformity between the two was not seen, there is abundant ground for believing that one exists. Conformably above the quartzite is the Ordovician dolomitic limestone. (See Pl. IV.) Added to these local relations, the general presence of quartzite at the base of the Cambrian in many localities to the south and east, and its absence in the Ordovician, leads to the conclusion that it is of Cambrian age.

ORDOVICIAN SYSTEM.

The Ordovician is represented by a massive dolomitic limestone which rests conformably above the Cambrian quartzite, and hence outcrops in the Lemhi Range along its eastern margin. As exposed in the steep wall east of Meadow Lake, 2 miles west of Gilmore, the formation is about 500 feet thick and is made up of massive beds separated by poorly defined partings. Fossils are scattered throughout, but near the base and top they are especially abundant.

The formation here considered is assigned to the Ordovician on the basis of fossils collected from the beds. Edwin Kirk, of the United States National Museum, examined two lots of material from these beds. His report is as follows:

From the bottom of 500-foot massive blue limestone outcropping in the east side of Meadow Lake cirque:

Crepipora cf. ampla.
Stromatoporoid (indeterminable).
Streptelasma rusticum.
?Calapœcia cf. huronensis.
Heliolites sp.
Columnaria alveolata.
Halysites gracilis.
Rhynchotrema (probably copax).
Rhynchotrema anticostiensis.
Poorly preserved gastropod (indeterminable).
Endoceras sp.

From upper part of same massive blue limestone:

Columnaria alveolata (poor).
Stromatoporoid (indeterminable).
Halysites gracilis.
Diphyphyllum sp.

These two lots seem to indicate unquestionably the Richmond age of the beds containing them. They include several species that are found in beds of similar age in New Mexico, Colorado, Utah, and Wyoming.

SILURIAN (?) SYSTEM.

Beds supposed to be of Silurian age rest conformably above the Ordovician dolomitic limestone in the Lemhi Range, but differ from it in being light gray in color. They are about 200 feet thick as exposed in the west wall of the Meadow Lake cirque, the only locality where they were examined. The beds are meagerly fossiliferous near the top.

Concerning the fossil material gathered from these beds, Mr. Kirk says:

The lot is possibly referable to the Silurian, though the material is in a much poorer state of preservation than that constituting the preceding two (Richmond) lots. The single specimen from this locality consists of the external mold in dolomite of some branching coral. It may have been a Syringopora. No structure is shown.

DEVONIAN SYSTEM.

The Devonian is an important division in the southeastern part of Lemhi County, both by reason of its thickness and because of the ore deposits included in it at Gilmore. It rests conformably above the Silurian, and the Mississippian is supposed to lie conformably above it. The beds are well exposed along the divide between Liberty and Silver Moon gulches but are so disturbed (Pl. V, *A*) that accurate measurement of their thickness is impossible. They are also well exposed along the divide between Liberty Gulch and Meadow Lake Gulch and thence east along the north wall of Liberty Gulch. They were studied principally along the latter course.

The rocks consist predominantly of beds from 1 to 20 feet thick, although they include massive beds at two horizons at least—one about 400 feet from the base and the other near the top. Blue and light-gray dolomitic limestone predominate, but there are numerous beds of slate and some of quartzite. In many parts thin laminations are conspicuous. Narrow siliceous bands are numerous in the shale parts, and much of the limestone itself is siliceous. The Devonian as exposed here is at least 2,000 feet thick and, as the position of its contact with the Mississippian was not determined, it may be much thicker.

The exact areal extent of the Devonian within Lemhi County was not determined. Its outcrops are to be expected only east of a line extending from Spring Mountain north to the vicinity of Lemhi Pass.

Two lots of fossils were procured from these beds. Mr. Kirk referred them to E. M. Kindle "as evidently having Devonian affinities." The lot obtained about 200 feet above the base of the formation "contains nothing but indeterminable fragments, though apparently falling with" the other lot. The collection from a stratigraphic horizon approximately 2,000 feet from the base "contains corals hitherto referred by Kindle to the Jefferson limestone (Devonian). The only form well enough preserved for identification is a Cladopora which may be called *C. labiosa* with a question."

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

Mississippian beds crop out about the mouth of Long Canyon, in the southeastern corner of the county, and presumably thence southward beyond the limits of the reconnaissance. The point to the

A. DEVONIAN BEDS ALONG DIVIDE BETWEEN SILVER MOON GULCH AND LONG CANYON, TEXAS DISTRICT.

B. TERMINAL MORAINE AT MOUTH OF MEADOW LAKE CANYON.

Miocene lake beds in background and Beaverhead Mountains in distance.

north where they cross into Montana was not determined. Throughout their known area they dip predominantly to the east. Their contact with the Devonian beds below was not recognized, and, as the known outcrops of the two divisions are perhaps half a mile apart, it is possible to assign only minimum values for the thickness of each. The upper limit of the Mississippian is even more uncertain, for the Miocene lake beds lap over its eroded edges. Thus only a comparatively small part, possibly 300 feet of the section, is known definitely to be of Mississippian age. Here the rocks are made up of massive blue limestone, which at one horizon is rich in fossils.

A suite of fossils was collected near the base of the Lemhi Range, just north of Dry Gulch. George H. Girty has examined the material and his report is given below:

After careful examination of the collection which you and I made in the Carboniferous limestone south of Gilmore, Idaho, I am able to distinguish the following species:

Lithostrotion martini, E. and H.
Lithostrotion portlocki McCoy.
Syringopora surcularia Girty.
Clisiophyllum teres Girty.
Composita sp.
Fenestella sp.

Some of the identifications are more or less doubtful. The fauna belongs in the upper Mississippian coral horizon of Utah and Idaho.

CENOZOIC DEPOSITS.

TERTIARY SYSTEM.

MIOCENE LAKE BEDS.

Distribution and thickness.—From a point near the mouth of Fourth of July Creek, in the north-central part of the county, southeastward at least 90 miles, and presumably much farther, extends a belt of lacustrine beds averaging about 8 miles in width. Similar deposits occur in a small area in the Moose Creek basin to the west (fig. 7), and others probably lie beneath the wash which mantles the floor of the Pahsimeroi Valley in the south. The Prairie Basin may be another such area, although evidence of this is not satisfactory.

The maximum thickness of these lake beds is not known, but Salmon River in the vicinity of Salmon has cut into them to a depth of 1,800 feet. On Bohannon Bar placer workings have exposed the eroded edges of the beds for about 2 miles, and throughout they show a uniform dip of 20° to 22° E. As a hasty traversé failed to reveal duplication by faulting, it is supposed that about 4,000 feet of beds are present in this exposure.

Great as these measurements are, it is believed that the maximum thickness of the beds is attained only near the head or south end of the Lemhi Valley. The depression in which they were formed evidently drained southward (p. 23) and less post-Miocene erosion has taken place at the head of the valley. To the south, in Custer County, deposits of the same age and of similar origin are present.

Relations and constitution.—The Miocene lake beds occupy the bottoms of deep, narrow valleys, bordered by precipitous walls 2,000 to 5,000 feet high. The origin of these valleys is of particular interest. They may be regarded as possibly due (1) to erosion, (2) to down-faulting, or (3) to down-folding. Of these alternatives, the first, erosion, is believed to have been the dominant factor in their production. The second and third are untenable because certain of the valleys lie athwart the structure axes of the region. Direct observations show that the valleys are very clearly not the product of down-folding, but the down-faulting hypothesis can not be so certainly refuted in this way because of the possibility that the lake beds conceal the faults along the sides of the valleys which they occupy. The sides of Lemhi Valley beneath the lake beds, as exposed to a depth of 600 or 700 feet in places, are undoubtedly irregular surfaces of erosion, but it is conceivable that these are simply modified portions of fault scarps. If, however, the valleys are due to down-faulting they must have been

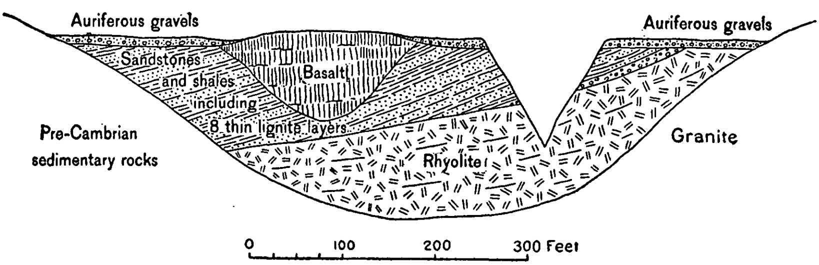

FIGURE 7.—Section at lower end of lake beds, Moose Creek valley. Scale approximate.

blocked out prior to the deposition of the lake beds and after the elevation of the Eocene surface, for the lake which occupied the Lemhi Valley is shown by its shore line to have stood at its maximum 2,800 feet beneath the plateau surface. The elevation to which the lake beds lap up on the older rocks is essentially the same on the narrow and on the wide divides between streams which cross the contact—an accordance which, as the rocks are of diverse resistance to denuding processes, should not prevail if the upper littoral deposits have been greatly eroded at these places. But there is another reason for believing that this is approximately the old shore line. In the vicinity of the divide between Lemhi River and Birch Creek, where even in the central portion of the valley the Miocene deposits are but slightly trenched, the marginal lake beds are essentially the same distance (2,800 feet) beneath the plateau level as at Salmon City, where present streams have cut into them to a depth of 1,800 feet. Thus, even if the valleys are due to faulting it does not invalidate the conclusion concerning the age of the Eocene erosion surface (p. 26). In keeping with their deposition in inclosed basins bordered by precipitous walls, the Miocene deposits vary greatly in composition and texture, consisting chiefly, in any given place, of fragments of rocks making up the adjacent highlands. As these rocks are largely slates, schists, and quartzites the beds are dominantly shales, siliceous shales, and sandstones. Along the margins and near the north end of the basin, however, heavy conglomerates are locally present, and in the upper part of the lake beds tuffaceous material is abundant. The beds are commonly thinly laminated and vary in color from light gray to buff and maroon.

Four or five lignitic layers, two of which were worked with indifferent success prior to the advent of the railroad, crop out around Salmon and Baker. The lake beds also furnish a commercial building stone from a quarry near Salmon. It is a medium to coarse grained sandstone containing numerous flakes of biotite and some fragments of feldspar. In color it varies from light gray through flesh-pink to intense maroon, which in places grades into reddish yellow.

A detailed section of these Miocene beds was not worked out, but a general idea of their stratigraphic variations may be conveyed by describing exposures between the north limit of the deposits, where their base appears, and the head of Lemhi Valley, their highest exposure.

Eleven miles north of Salmon three massive conglomerate beds aggregating about 125 feet in thickness are exposed along the road for 3 miles. They are made up of subangular waterworn material, most of it measuring less than a foot in diameter but including some bowlders 4 or 5 feet across. The cement is silica with some iron oxide. Southward, through transitions not exposed, these conglomerate beds dip beneath thinly bedded sandstones and siliceous shales of buff color. Along the river near Salmon the shales and sandstones continue, but side traverses to the west reveal eastward-dipping beds, with the quarry sandstone conspicuous about halfway up the slope. Farther west intense maroon shales give way to the black shales which inclose the lignite. In the latter locality altered rhyolite, possibly a part of the series, is widely exposed.

Between Salmon and Baker the shaly lignitic bed crops out along the river, and east of it similar beds are exposed in the placers along Bohannon Creek. From Baker southward for 50 miles there are few good exposures although abundant small outcrops prove the continuity of the lake beds. Near Gilmore, however, more than 200 feet of the section appears in some exposures. As seen in the railroad cuts in this vicinity, the beds present chalk-white slopes cut across regularly bedded layers of light bluish-gray fine volcanic ash, in places almost pumiceous enough to float. The bedding is shown by slight changes in color, the individual bands ranging from half an inch to 4 inches in thickness. In places thin layers of pebbles, consisting of limestone, slate, and quartzite, are interbedded with the tuff, and in other places pebbles and sand are intermixed with it.

These exposures suggest broad changes in the character of the deposits at different stages, from conglomerates at the base through alternating sandstone and shale members to tuffaceous beds at the top. The lignitic beds are interpreted to mean that the lake surface reached its maximum level through a series of stages, for though many of the carbonaceous bands are doubtless drift phenomena, others are thought to represent marsh conditions.

Deformation.—The Miocene lake beds are broadly though not intensely deformed. Both folding and faulting have taken place, but the latter is not general, having been noted in only two places. Near the coal mine west of Salmon a duplication of the coal bed indicates a downthrow on the west of possibly 400 feet. In the Leadville mine, near Junction, a fault with at least 300 feet displacement throws the lake beds against the ore body. Several offsets of a few feet were noted in exposures about Salmon and near Gilmore. Folding has affected the beds, but on the whole they are much more nearly horizontal than the other stratified rocks of the area.

The beds dip in various directions but generally away from north-south axes. About Salmon they incline 20° to 25° E. along both the east and west side of the basin, but toward its center they incline north or south. An east-west syncline, perhaps 100 feet deep, is exposed in the east bank of Salmon River from Salmon almost to Carmen Creek. Above the mouth of Carmen Creek the dip is 20° E. but flattens within a short distance to 10° and near the east limit of the beds is slightly west. One of the most important movements, however, is recorded by the broad east-west anticline which forms the divide between the Lemhi River and Birch Creek drainage basins. The anticline corresponds with the gradual increase in elevation of both the Eocene surface and the shore line of the lake from Salmon to Gilmore, the increase being about 2,000 feet.

Age.—The lake beds occupy broad deep valleys developed in the Eocene surface after its elevation at or near the close of the Eocene epoch. Considerable time must have been required for this excavation, for the streams not only worked headward long distances but they removed vast volumes of material, and it is probably safe to assume that this interval of erosion occupied most of the supposedly short Oligocene epoch. Thus from purely physical relations the beds would probably be assigned to the Miocene or Pliocene, preferably to the former because of the amount of erosion which has taken place in them. Fossil evidence also points to the Miocene. A small suite of material collected 2 miles south of Salmon was examined by F. H. Knowlton, whose report follows:

This collection is small, consisting of about 20 small pieces of matrix, and represents at most only three forms. These are a broad-leaved grasslike monocotyledon, which is not further determinable, and two forms of conifers, *Sequoia angustifolia* Lesquereux and Taxodium? cf. *T. olriki*? Heer.

Unfortunately neither of these conifers is a very good time marker, for both have a great vertical range. The species first mentioned has been found in the Oligocene, Miocene, and somewhat doubtfully in the Pliocene, but it is more abundant in the Miocene. The other form, if correctly identified, would appear to indicate upper Miocene age. No dicotyledons are present in this collection.

In 1895 I reported on a small lot of material submitted by George H. Eldridge from the vicinity of Salmon, and presumably from a locality near that which afforded the present material—in any event from the same beds. Owing to the confused condition of the collections, caused by moving, I have not been able to review this earlier collection, but I am inclined to think that what was then identified as *Sequoia langsdorfii* is probably the same as that called *S. angustifolia* in the present material. Furthermore, since that report was made additional information has been acquired concerning the vertical distribution of *Glyptostrobus europæus*, which, though common in the Eocene, is not confined to that series. I am therefore inclined to go a step further than at first and to regard these lake beds as Miocene in age. This is not a positive determination, for the material is not sufficiently abundant nor characteristic, but it seems that in all reasonable probability the beds may safely be called Miocene.

Correlation.—It has been shown above that both physical relations and fossils point to the Miocene as the time during which these lake beds were deposited. Correlation with other Miocene formations in the State is therefore feasible, especially with those which have similar physiographic relations. The Payette formation, widely exposed along Snake River between Salmon Falls and Weiser and on to the west in eastern Oregon, was described first as Miocene[1] and later as Eocene.[2] It is made up of detrital material from the highlands adjacent to the erosion valley in which it was deposited. Tuffaceous material is also conspicuous in parts of the formation. The thickness as recorded by Lindgren is more than 1,000 feet in the vicinity of Boise and the base is not exposed. Locally the strata are inclined as much as 50°, and the old shore line is thought to vary in elevation over broad areas as much as 2,000 feet.[3] This opinion is based on exposures near Hailey, which occur at elevations of 6,000 to 6,900 feet, or 2,000 feet higher than the shore line in the vicinity of Boise. It will be noted that the Hailey exposures correspond well in elevation with the upper limit of the lake beds in Lemhi County, and as their character is the same, the two are probably to be correlated. Russell[4] thought that the Payette formation extends eastward beneath the basalts of Snake River, saying that the known data favor "the hypothesis that beneath the surface lava sheets in

[1] Lindgren, Waldemar, The mining districts of the Idaho Basin and the Boise Ridge, Idaho; with a report on the fossil plants of the Payette formation, by F. H. Knowlton: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 633, 720 et seq.; The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, pp. 93-99. Russell, I. C., Geology and water resources of the Snake River Plains of Idaho: Bull. U. S. Geol. Survey No. 199, 1902, pp. 50-58.

[2] Lindgren, Waldemar, Silver City folio (No. 104), Geol. Atlas U. S., U. S. Geol. Survey, 1904, p. 2; Nampa folio (No. 103), idem, U. S. Geol. Survey, 1904, p. 2.

[3] Lindgren, Waldemar, Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 95.

[4] Op. cit., p. 59.

its eastern part extensive beds of clay, sand, etc., do occur." It is thought that this supposition is strongly supported by the relations of the lake beds of Lemhi County.

Deposits known as the Idaho formation, laid down in valleys cut in the Payette, appear along Snake River in Idaho. They are of Pliocene age, though similar to the Payette and in places grading into it. Deposits of this age were not recognized in Lemhi County, although it is possible that the part of the lake beds above the lignitic strata may correspond to them.

Extent of the Miocene lake.—The present studies add a large area to the known Miocene and Eocene (?) lakes of Idaho. It is altogether probable that the entire upper valley of Snake River was occupied by an immense sheet of water into which countless streams draining rugged adjacent areas carried vast volumes of detrital material and on whose surface volcanic ash was showered. Westward the lake may, as outlined by Lindgren,[1] have extended well into Oregon; and eastward it is possible that it reached beyond the Beaver Head Mountains into Montana. At least, beds of similar make-up occur west of Armstead, Mont., and extend beyond the Continental Divide into Idaho in the vicinity of Bannock Pass.

QUATERNARY SYSTEM.

PLEISTOCENE DEPOSITS.

Topographic features characteristic of glaciation are conspicuous at elevations greater than 7,500 feet, although tongues of ice extended down many of the valleys to 7,000 feet and down a few to 6,500 and even 6,000 feet (Panther Creek). Probably the largest single body of ice occupied the Mackinaw district, where an area of 200 square miles was probably entirely covered. Another large ice field, possibly connecting with this by way of Baldy Mountain, occupied the highland about Prairie Basin, where the terminal moraine crosses Panther Creek at an elevation of 6,000 feet. Within these areas rolling surfaces, lakes and marshes, valley trains, U-shaped valleys (which give way to V-shaped valleys below), striated bowlders, and the like are common.

The canyons heading against the Beaverhead Mountains and Lemhi Range north of Junction, are narrow up to altitudes of 7,000 to 7,300 feet, where they abruptly widen, the sides becoming steeper and the floors broad and hummocky. These features continue until the walls merge into a steep-sided amphitheater or cirque, within which a little lake may be expected though not always found. South of Junction, owing to the altitude of the main valley, many of the mountain valleys are glaciated through their entire length. Their terminal moraines, pushed by the ice out upon the valley flats,

[1] Lindgren, Waldemar, Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 96.

appear as crescent-like ridges. Such moraines are beautifully developed about the mouths of Meadow Creek gulch (Pl. V, *B*, p. 34) and of Long Canyon. So clear are the marks of glaciation that the Pleistocene serves as a valuable datum line in the area.

IGNEOUS ROCKS.

ARCHEAN GNEISS.

Coarse-textured granite gneiss occupies a broad area in the northwestern part of the county. It is typically developed in the canyon sides about Shoup, along the lower course of Big Creek, and on Owl Creek.

The formation is separated from the overlying schists by a profound erosional unconformity, clearly shown in a few small exposures along the road from Shoup to the Kentuck mine. In most places weathered particles of gneiss enter into the lower few feet of the schist, forming an arkose, but elsewhere coarse undecomposed feldspar crystals appear at the very contact. (See Pl. VI, *B*.) The gneiss is thought to be an intrusive rock, although the local evidence of this is little more than suggestive. In a few places within the gneiss are small masses (up to 4 feet) of fine-grained micaceous material. A conspicuous example appears in the face of a large block which lies beside the trail about one-fourth mile above Shoup. As seen in the field these areas suggest inclusions of mica schist, and such they may be, but if so they have assumed a mineralogic make-up very similar to that of the gneiss, save for a higher percentage of biotite. From the broad theories of geology, however, and as in most places where similar granitic rocks have been thought to be portions of an original earth crust they have proved to be intrusive into older sediments, the rock is believed to be intrusive. Because of its relation to the overlying Algonkian it is assigned to the Archean.

The gneiss presents a striking appearance in natural exposures. Numerous large feldspar crystals, crushed into thick lenses, interleave one with another, separated only by bands of biotite which bend about them. Quartz, all of which is crushed, is scattered through the biotite bands and among fragments of feldspar. Magnetite crystals are scattered through the finer-grained parts. The feldspar crystals on account of their length, which probably averages 1 to 2 inches and over large areas 3 to 4 inches, are most resistant to weathering and present a nodular aspect on exposed surfaces. They are especially coarse near the mouth of Beaver Creek, where one individual measured 18½ inches. Plate VI, *A*, illustrates a typical specimen.

Microscopically examined, the rock is seen to be made up of orthoclase with micropegmatite, quartz, and biotite in subordinate though conspicuous amounts. Oligoclase, muscovite, apatite, magnetite, and diopside are accessory and decreasingly important in the order named. Many of the feldspars are crushed; many of the biotites are broken and bent and others recrystallized; quartz is fractured; and apatite crystals show many cross cracks.

The schistosity planes vary markedly in attitude from place to place, some being flat but most of them dipping at a high angle southwest and a few northeast. The prevailing strike is about N. 20° W.

LATE CRETACEOUS OR EARLY EOCENE GRANITE.

Granitic rock is widely exposed in Big Creek canyon and along Salmon River from Shoup eastward to Dump Creek, but on the adjacent uplands it is concealed by the Algonkian sedimentary rocks. The occurrence west of Salmon, where it forms the divide, is an exception. The rock is also exposed about the head of Yellow Jacket Creek and at three places along the western slope of the Beaverhead Mountains; one near the head of Boyle Creek, another in the northern part of the Nicholia district and, intermediate between the two, a dioritic facies in the canyon of Little Eightmile Creek.

The granite is of light-gray color and of medium texture, with some phenocrystic development of feldspars. In the field it appears to be fairly uniform in composition, but when it is examined in thin sections it shows marked variations. The persistent constituents are orthoclase, quartz, and biotite, although the biotite is rather variable in amount. Among accessory minerals zircon, apatite, and magnetite are usually present. Microcline is locally very abundant (Queen of the Hills mine) as is also perthite, and the more acidic varieties of plagioclase feldspar are generally represented. Indeed, it is probable that more detailed studies will establish all gradations between the normal granite, the quartz diorite exposed on Little Eightmile Creek, and that found in the Texas and Spring Mountain districts, where no orthoclase was noted. The quartz diorite is a dark-gray fine-grained holocrystalline rock composed of plagioclase (about oligoclase) and a little orthoclase, quartz, biotite, and hornblende.

In the northern part of the State, in the Bitterroot Range and the Clearwater Mountains, where granitic rock prevails, its general composition is near that of quartz monzonite, although gradations to normal granite on the one hand and to diorite on the other are recorded.[1] Also in the southern part of the State, in the Wood River district, the granite and diorite blend into each other.[2]

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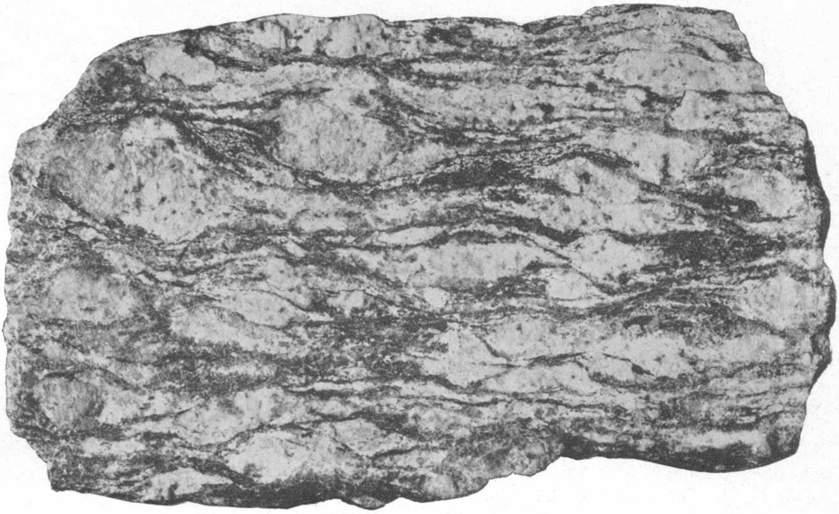
[1] Lindgren, Waldemar, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: Prof. Paper U. S. Geol. Survey No. 27, 1904, pp. 17-20.

[2] Lindgren, Waldemar, The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 195. For extent of granite area, see Pl. VIII.



A. POLISHED SURFACE OF ARCHEAN GNEISS.

The elongated feldspar crystals are surrounded by foils of biotite (black) and crushed quartz (white). One-half natural size.

B. CONTACT BETWEEN ARCHEAN GNEISS AND ALGONKIAN SCHIST ONE-HALF MILE NORTHWEST OF SHOUP.

Separated by an erosion unconformity, which, however, is not definitely shown.

The granite is clearly post-Carboniferous, and in the northern part of the State its relation to supposed Triassic sediments shows it, with the same degree of certainty, to be post-Triassic. Truncated by an Eocene erosion surface, the granite is clearly older than, say, middle Eocene. Narrower limitations are not afforded within the present area, but broad considerations lead to the opinion that the granite was intruded during late Cretaceous or early Eocene time. It has been shown (p. 25) that Eocene erosion, probably developing a continuous surface of gentle relief, operated over much of Idaho, western Montana, northeastern Washington, and northward into the Interior Plateau of Canada. One of the evidences that this surface is of Eocene age is the vast volume of Eocene sediments which border it. It is noteworthy (fig. 6, p. 28) that the granite is widely exposed within the eroded area but is absent within the area of Eocene sediments. It is scarcely conceivable that a magma of the magnitude of the one here represented, which occupies a large part of Idaho and extends into adjoining States, could intrude the formations of the region without being accompanied by an extensive raising of the general surface. Granting that the granitic intrusion caused or accompanied a profound elevation of the area which supplied the Eocene sediments, it remains to be ascertained whether or not it determined the particular elevation involved. Neither Jurassic nor Cretaceous sediments show any special development adjacent to this area, and those of Triassic age are supposed to have crossed it. These general considerations lead the writer to the belief that the broad elevation which resulted in the Eocene surface accompanied the granitic intrusions and therefore that the granite is of late Cretaceous or early Eocene age.

If this assignment of the Idaho batholith is correct, it is much younger than the great intrusive body of the Sierra Nevada of California and is probably younger than the Coast Range batholith of British Columbia and Alaska. The former is definitely known to be of late Jurassic or early Cretaceous age;[1] the latter is less definitely assigned to the early Cretaceous.[2]

DIKES.

DISTRIBUTION AND CHARACTER.

Dikes are widespread in Lemhi County and locally are very numerous. They attain their maximum numerically in the Yellow Jacket district in the west-central part of the county, where twenty-five or thirty averaging 20 to 50 feet in width parallel each other along a belt perhaps a mile wide. They are also conspicuous about Shoup

[1] Diller, J. S., Geology of the Taylorsville region, California: Bull. U. S. Geol. Survey No. 353, 1908, pp. 89-90. Also see the numerous folios of the Geologic Atlas covering parts of the Sierra Nevada.

[2] Knopf, Adolph, Geology and mineral resources of the Eagle River region, Alaska: Bull. U. S. Geol. Survey No. 502, 1912, p. 27.

and in the southern end of Lemhi Range. Along the Continental Divide and in the Eureka, Mackinaw, and Gibbonsville districts dikes are rare, but in the Blackbird and Indian Creek districts they are common.

These intrusives range in width from a few inches to 1,000 feet (Spring Mountain), those about 40 feet across being most abundant. The dikes of the area present many types of rock, but granite and rhyolite porphyries, diorites, and quartz diorites are most numerous. Lamprophyres (minettes and vogesites), aplites, and pegmatites appear locally, as do also gabbro, basalt, and dacite, syenite, trachyte porphyries and peculiar monzonites. In the following sections each kind is described briefly and its known distribution outlined. It is noteworthy that the different kinds seem to occur in all associations.

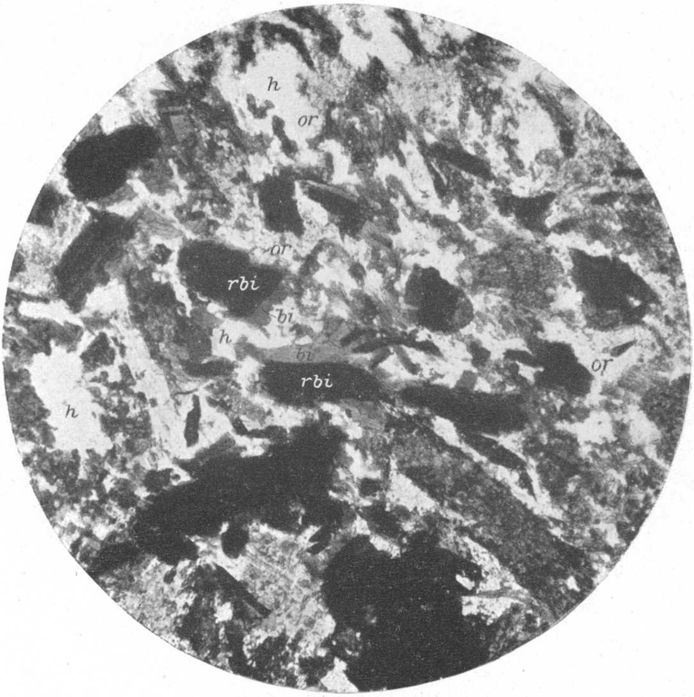
TYPES.

The granite porphyry dike rock varies in appearance from coarse porphyritic rock with phenocrysts of orthoclase as much as an inch in length and quartz of wheat-grain size thickly set in a fine-grained blue-gray groundmass to a light-gray rock of almost equigranular texture. Intermediate between the two extremes is a dark-gray variety studded with orthoclase and quartz crystals from an eighth to a quarter of an inch in length. Biotite is commonly present. Granite porphyries were noted in the Mineral Hill, Mackinaw, and Junction districts, in the northern part of the county.

Dikes of rhyolite porphyry occur in the above-named districts and also in many places in the lava-covered belt defined later. They are commonly light gray to dove-colored, but in places pale shades of green or brown predominate. Although they are similar to the granite porphyries, their crystallization is much less advanced, the groundmass being glassy to microcrystalline and constituting perhaps three-fourths of the volume.

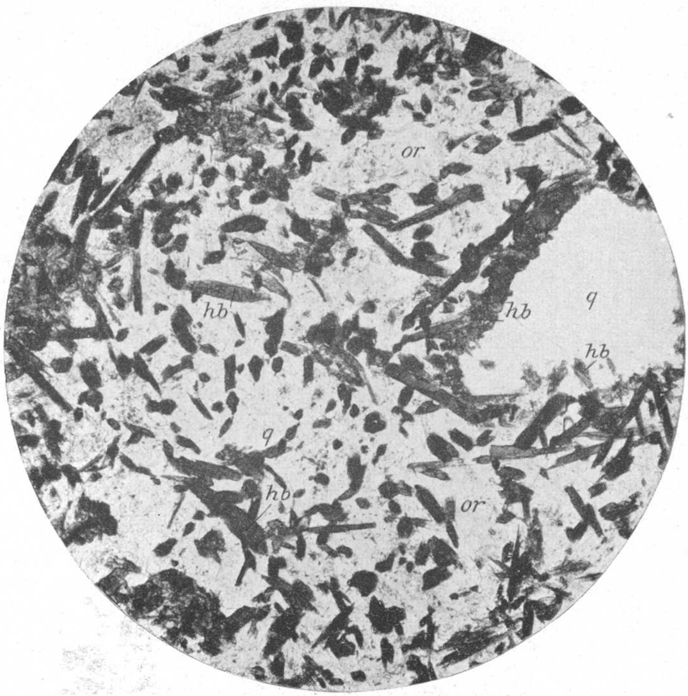
Dikes of quartz diorite porphyry have pernaps a wider geographic distribution in the area than those of any other type, although in no place are they very abundant. They are found throughout the southeast part of the county and in the Yellow Jacket, Gibbonsville, and Mineral Hill districts. On account of their brilliant medium-sized feldspar, quartz, biotite, and some hornblende crystals, set in a fine-grained variegated groundmass of the same material, these rocks are the most beautiful found in the area.

Diorite and diorite porphyry dikes occur inconspicuously in many parts of the county, but attain a marked development about the head of the Lemhi Valley. They vary considerably in texture but are commonly medium to fine grained and about equigranular. The constituent minerals are plagioclase (oligoclase-andesine), hornblende, biotite, and a little quartz.



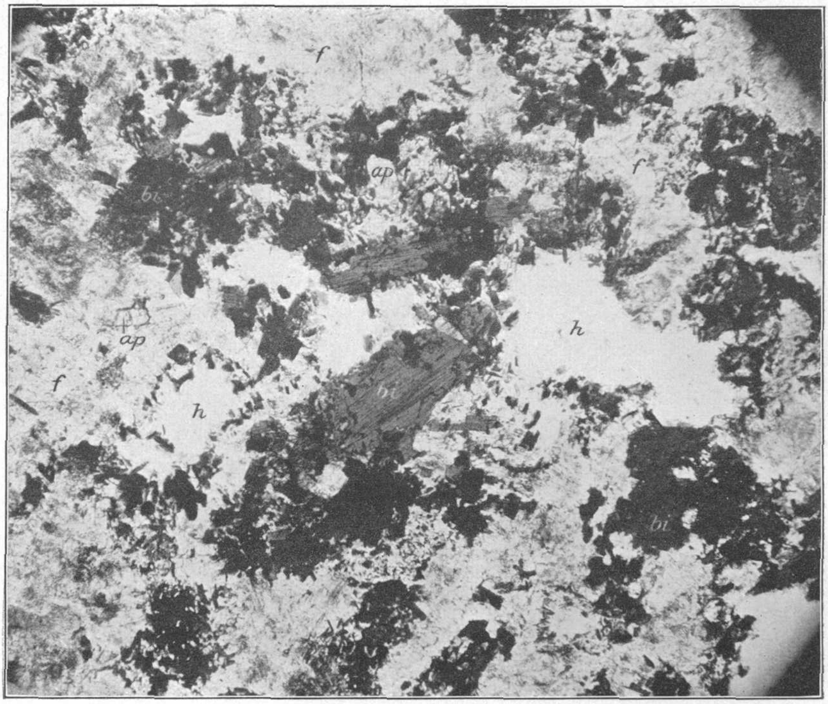
A. MINETTE FROM BROOKLYN CLAIM, BLACKBIRD DISTRICT.

or, Orthoclase; *rbi*, biotite with much rutile included; *bi*, biotite free from rutile, which seems to have been added in the *rbi* crystals; *h*, hole in section. Enlarged 35 diameters; nicols parallel.



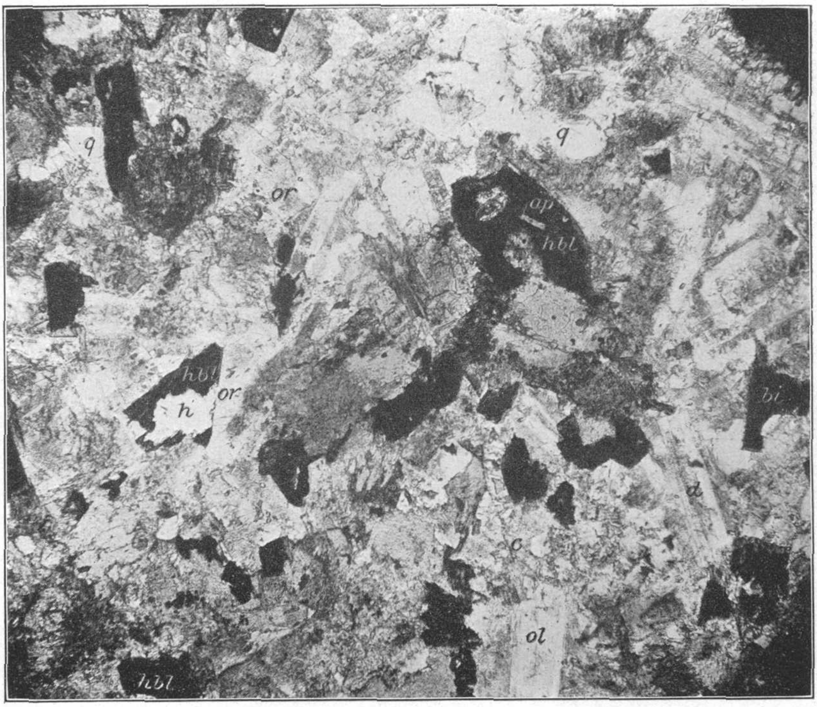
B. VOGESITE FROM GEERTSON CANYON.

q, Quartz; *hb*, hornblende; *or*, orthoclase. Note the angular area of quartz inclosing hornblende and with hornblende clustered along its contact. Enlarged 35 diameters; nicols parallel.



A. BIOTITE MONZONITE FROM ITALIAN MINE.

f, Feldspar, both orthoclase and oligoclase; *bi*, biotite; *ap*, apatite; *h*, hole in slide. Enlarged 35 diameters; nicols parallel.



B. HORNBLENDE MONZONITE FROM YELLOW JACKET HILL.

or, Orthoclase; *ol*, oligoclase showing zonal extinction with core $Ab_{60}An_{40}$; *hbl*, hornblende; *bi*, biotite; *q*, quartz; *ap*, apatite, *c*, calcite. Enlarged 35 diameters; nicols parallel.

Rocks of the lamprophyre class are represented by minette and vogesite. They are fine grained and dark gray to blue-black in color. A typical minette from the Brooklyn claim, in the Blackbird district, in the northwestern part of the county (see Pl. VII, *A*), consists of biotite (possibly 40 per cent), orthoclase, a little plagioclase, and chance crystals of hornblende. Rutile is beautifully developed as thin needles in the biotite, oriented along the directions of its percussion figures. Micropegmatite is common though not abundant as an interstitial filling. Apatite is an abundant accessory mineral, and titanite is rare. Epidote and zoisite are secondary. Structurally this rock is characterized by a phenocrystic development of biotite, which is set in a groundmass of feldspar and biotite. Thus there are two distinct generations of biotite.

Vogesite from Geertson Creek canyon consists of orthoclase and hornblende (estimated as 40 per cent), with subordinate amounts of micropegmatite, quartz, and plagioclase. Scattered through the rock are fragment-like grains of quartz as much as 3 or 4 millimeters in diameter. These are surrounded by clusters of hornblende needles which in places are embayed in the quartz near its margin. Apatite, titanite, and rutile are accessory. (See Pl. VII, *B*.) The structure of the vogesites is dominated by a phenocrystic development of lath-shaped hornblendes.

Lamprophyric dikes were noted at places along the Continental Divide north of Agency Creek and in the Blackbird and Yellow Jacket districts.

A biotite-rich rock, perhaps best classified as biotite monzonite, although closely related to the lamprophyres in composition, occurs near the Italian mine, in the Leesburg basin. It is a dark-gray fine-grained equigranular rock, which in the hand specimen seems to be made up of about equal amounts of orthoclase and ferromagnesian minerals. On microscopic examination it is seen to be inequigranular and composed of orthoclase, biotite (estimated as 20 per cent), albite, oligoclase, and quartz, the last in very subordinate amounts. Abundant apatite and less titanite and diopside are accessory. Zoisite and epidote are secondary. (See Pl. VIII, *A*.)

A similar rock, but rich in hornblende and containing more sodic feldspar, occurs near the Yellow Jacket mine and is classified as hornblende monzonite. (See Pl. VIII, *B*.) It contains about 20 per cent of hornblende and 5 per cent of biotite. Plagioclase (principally oligoclase) is slightly in excess of orthoclase. Quartz is conspicuous though not abundant. Micropegmatite is beautifully developed locally. Apatite, rutile, and titanite are the chief accessory minerals; calcite, epidote, and zoisite are secondary.

Dikes, probably to be classed as pegmatites, appear near the lower granite contact on Pine Creek, in the northwestern part of the county.

They are light gray and are made up principally of feldspar, quartz, and muscovite. The small number of pegmatite dikes about the border of the granite mass is noteworthy and seems to be a feature characteristic of the entire Idaho batholith, as from no place about its border have important pegmatites been reported.

Aplitic dikes are well developed in the Indian Creek district in the northern part of the county. They are light-gray fine-grained microcrystalline feldspathic rocks sparsely studded with quartz grains perhaps as large as a pinhead.

Gabbro was seen only in the Blackbird district. It is a blue-black holocrystalline rock consisting of pale-green hornblende, diopside, plagioclase (oligoclase-andesine), and biotite, with accessory pyrrhotite, pyrite, titanite, and apatite.

A mottled gray rock, made up of feldspar crystals as much as an inch in length set in a finely crystalline groundmass which constitutes perhaps half the mass, occurs near Yellow Jacket and is classed as monzonite porphyry. In the specimen studied phenocrysts of andesine, oligoclase, and orthoclase occur in about equal amounts. The groundmass is not determinable.

Dikes of basalt occur in a few places in the Gibbonsville and Mineral Hill districts as narrow fillings, but none of them are important.

Dikes of dacite porphyry have been produced by quartz diorite intrusions that entered very narrow fissures.

Syenite porphyry was noted at only one place, one-fourth of a mile south of Noble, in the northern part of the county, but has been reported from the Yellow Jacket district. The rock seen is light gray, coarse to medium grained porphyritic, with phenocrysts of orthoclase, scattered hornblende, and a very few quartz grains. The rock is generally badly altered, much zoisite, sericite, and epidote being developed.

AGE OF DIKES.

Representatives of all the types of dikes above described were truncated by the Eocene erosion, and as none of them bears evidence of being older than the granite and some are inclosed in it, it is probably safe to assume that they are all younger than the granite. Thus it appears that dikes of the varieties here described were intruded after the granite and before the close of the Eocene—in other words, after the Archean period of igneous activity and before the late Tertiary. These dikes are therefore considered a later phase of the late Mesozoic or early Tertiary volcanic epoch, of which the great granite batholith of Idaho is the dominant expression. Although most of the dikes of the area are thought to belong to this group, it can not be assumed that they all do, for obviously there are intrusive facies of the late Tertiary lavas. On the other hand one of the diorite dikes (possibly a sill) found at Gibbonsville is sheared and jointed in a manner to suggest that it is older than the granite.

TERTIARY LAVAS.

A great belt of Tertiary lavas extends from a point near the Beaver Head Mountains on Agency Creek southwestward past Parker Mountain. These lavas occupy summits and valleys, Salmon Canyon being cut in them most of the way from Salmon up to the mouth of Pahsimeroi River, and the highest summits on either side being capped by them. Smaller areas of volcanic rocks appear west of Gibbonsville, on Moose Creek, and in the south end of the Leesburg basin.

The lavas include rhyolites, andesites, latites, basalts, trachytes, and dacites, the last two being very subordinate in amount. Rhyolites are perhaps most widespread, being extensively developed in the Parker Mountain and Gravel Range districts, along Salmon Canyon above Salmon, north of Junction, along Napias Creek below California Bar, and near Noble. They are commonly light gray and show distinct flow lines. Orthoclase and a little biotite appear as scattered phenocrysts in a cryptocrystalline groundmass, which is made up largely of microlites of feldspar, but which becomes glassy locally.

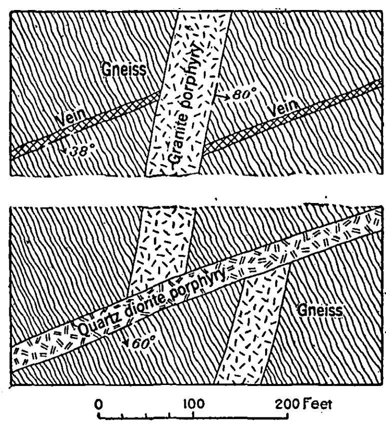


FIGURE 8.—Sketch of exposures near the Kentuck mine, Mineral Hill district, showing geologic relations.

Second in importance perhaps are andesites, which have much the same distribution as the rhyolites except that they are very subordinate in the Gravel Range and Parker Mountain districts. They present a variety of colors from dark resinous brown through many shades of pink and purple to gray. In general the microcrystalline groundmass predominates over the phenocrysts, which are plagioclase (about oligoclase-andesine), biotite, hornblende, and in some of the flows (as on Salmon River south of Salmon) augite.

Latites are also present in the series, but in what proportion is not known. A specimen of what was thought from microscopic study to be a typical andesite proves on partial chemical analysis to be a latite. It is possible that other of the andesites would prove on analysis to be latites.

The analysis follows:

Partial analysis of latite from divide on the Yellow Jacket–Forney road, Idaho.

[W. T. Schaller, analyst.]

SiO_2	62.96
CaO	4.30
K_2O	3.12
Na_2O	3.26

The rock is a porphyritic lava of purplish hue in which phenocrysts are slightly subordinate to the groundmass. The groundmass is microcryptocrystalline and is studded with phenocrysts of plagioclase (about oligoclase-andesine), and a few of hornblende and biotite. The ferromagnesian minerals are commonly surrounded by resorption zones, some of which entirely replace the crystal. From the microscopic studies there appears to be little doubt that most of the potash and much of the silica is in the groundmass.

Basalts also are widespread, perhaps reaching their maximum development just below the confluence of Pahsimeroi and Salmon rivers and in the hills about Agency. A noteworthy occurrence is near the summit of Baldy Mountain. They are fine-grained bluish-black rocks of normal composition, except that olivine is absent in some places (Agency Creek) and is very conspicuous in others (Baldy Mountain). Should this difference prove sufficiently persistent to define two ages of basalt that of Baldy Mountain will be the older.

A specimen which proves to be dacite was procured near the junction of Phelan and Napias creeks. It resembles the andesites of the same locality, but contains phenocrystic quartz and some hypersthene.

Trachyte, similar to rhyolite, but without quartz, was noted in thin beds in the Gravel Range and Parker Mountain districts.

All the lavas occupy valleys developed after the elevation of the Eocene erosion surface, and so far as seen all are thought to be preglacial. In some places, however, they underlie the Miocene lake beds (mouth of Williams Creek), in others they are interbedded (?) with those beds (3 miles west of Salmon), and in still others are poured out upon their extensively eroded surface. From these relations it appears that the lavas date from late Oligocene or early Miocene to about the close of the Pliocene. Of the different types of lava rock, basalts predominate among the youngest and probably rhyolites predominate among the oldest, although alternations seem to be present throughout. This general succession of eruptive rocks corresponds with that recorded for southwestern Idaho.[1]

EPITOME OF GEOLOGIC HISTORY.

The geologic history of the area includes granitic intrusion followed by profound metamorphism, erosion, and sedimentation in pre-Cambrian time, and sedimentation in Cambrian, Ordovician, Silurian(?), Devonian, and early Carboniferous time. After the Paleozoic the record is not legible until rocks are reached that represent late Cretaceous or early Eocene time, in which the granite mass of central Idaho, which forms one of the larger batholiths of the

[1] Lindgren, Waldemar, and Drake, N. A., Silver City folio (No. 104), Geol. Atlas U. S., U. S. Geol. Survey, 1904, p. 3.

North American Continent, formed beneath the area. The Eocene epoch was spent in reducing the uplift which is thought to have accompanied the granite intrusion. After the area had been reduced well toward the base level of erosion it was elevated to about 8,500 feet above the sea, and a new physiographic cycle was begun. The rejuvenated streams developed broad valleys, in places 5,000 feet or more deep, and in these valleys extensive lake beds were formed during Miocene time. During the Miocene also lavas were poured out and at its close thick beds of tuff were formed. Since then erosion has been dominant, the drainage being southward at first and later westward, through Salmon Canyon, lavas being again poured out after this change in the direction of the drainage. During the Pleistocene epoch glaciers capped the summits and occupied the larger valleys down to elevations of about 7,000 feet, rarely to 6,000 feet.

The area has passed through several periods of diastrophic movement. Each of the four older formations is metamorphosed, faulted, and folded more than the one next younger. Broad and pronounced elevation took place at the beginning and at the close of the Eocene and to a subordinate extent after the end of Miocene time, the post-Miocene uplift being recorded by minor faulting and folding in the lake beds and by an east-west anticline through the Texas district.

It is noteworthy that, although since the earliest Paleozoic time no important regional metamorphism has been recorded in the area, yet the schists and gneisses of pre-Cambrian age record profound dynamic disturbances.

ORE DEPOSITS.

GENERAL FEATURES.

CHARACTER OF DEPOSITS.

The principal ore deposits found in Lemhi County, Idaho, are fissure veins and replacement deposits along shear zones. In some places the metallic minerals occur in joints and crevices in the country rock (Italian mine), but elsewhere replacement has occurred along bedding and joint planes (fig. 15, p. 106). Again, ore minerals occur as disseminations in the country rock (Beliel group of claims) and possibly even as magmatic segregations in diabase (Togo claim). In general, however, the deposits are tabular and clearly to be classed as veins. Two epochs of mineralization are recognized—late Cretaceous or early Eocene and late Miocene or early Pliocene. All the deposits except a small group of gold-silver veins belong to the former epoch. The deposits may be grouped, according to the leading metal contained, as gold, lead-silver, copper, cobalt-nickel, and tungsten deposits, and they will be treated in the order named. In the past only the first four metals have been produced, but recently tungsten has been exploited, and in the future the cobalt and nickel deposits, though of low grade, will probably be worked. The total production of the county is about $20,000,000, two-thirds of which has come from gold, three-fourths of the remainder from lead, and the balance from silver ores, save for about $40,000 derived from copper.

DISTRIBUTION.

For several years after the discovery of gold placers on Napias Creek in 1866 and of lode deposits at Yellow Jacket in 1868 gold was the principal metal sought. About 1880, however, lead-silver deposits were discovered near Nicholia, in the southwest part of the county, and were exploited successfully during the next decade. This led to the locating of many lead-silver properties in adjoining areas, and although most of them were not worked for several years some of them have recently proved to be among the most valuable lode deposits known in Lemhi County. Copper has played a very subordinate part in the economic development of the area. It was first recognized in 1883, when the Copper Queen mine was located, but as this property at that time was held for gold perhaps the first copper locations may be considered as those made in 1896 in the Blackbird and Mackinaw districts. Nickel and cobalt were first recognized in 1901, and tungsten was discovered in 1903 on Patterson Creek.

Nineteen mining districts, including nearly all the upland area except that adjacent to Salmon Canyon above Salmon, are recognized in Lemhi County. Their position and approximate area are shown on Plate I (in pocket). Gold is the most widely distributed valuable metal, occurring in commercial quantities in all the districts except three located about the headwaters of Lemhi River. Silver generally accompanies the gold, but in very subordinate amounts, its chief occurrence being in the lead ores which are found only about the head of Lemhi Valley. Copper occurs in a broad belt extending across the center of the county from east to west, and in the vicinity of Spring Mountain in the southeast part of the area. Cobalt and nickel have been recognized only in the Blackbird district, 40 miles southwest of Salmon. Tungsten, so far as known, is confined to a small area adjacent to Patterson Creek, near the head of Pahsimeroi Valley.

GEOLOGIC RELATIONS.

The geologic history of the area includes the formation of great granitic masses in Archean time, probably as batholithic intrusions; extensive sedimentation in the Algonkian; deposition of dolomitic limestones, limestones, shales, and quartzites in the Paleozoic; granite intrusions in the late Cretaceous or early Tertiary, followed by the intrusion of dikes of various kinds; profound erosion in the Eocene; flows of lava and sedimentation in lakes in the Miocene and Pliocene (?); and glaciation of areas higher than 7,000 feet in the Pleistocene.

The Archean gneiss occupies the northwestern part and the Paleozoic sedimentary rocks the southeastern part of the county; between them is a broad belt of Algonkian sedimentary rocks. Granite is most widely exposed west of Salmon, but isolated patches are reported at three widely separated places along the Beaverhead Mountains. Dikes appear in all parts of the county but are most numerous in the vicinity of granite outcrops. Tertiary lavas extend in a broad belt from a point near Lemhi Pass southwestward beyond Parker Mountain, and lake beds, older than most of the lavas, occur principally along the larger valleys of the area.

Gold-bearing veins are inclosed in many types of rock in Lemhi County, ore deposits both older and younger than the lavas being clearly recognized. It is noteworthy, however, that only one deposit of gold has been found within the area of the Paleozoic formations. It is also noteworthy that the gold is principally in the vicinity of rock of the granite-rhyolite family. Lead-silver ores, on the other hand, occur only within the area of Paleozoic sedimentary rocks, and here quartz diorite is the only igneous rock recognized. Copper occurs principally within the area of Algonkian sedimentary rocks, although one deposit is known within those of Paleozoic age. It has not been found in the Tertiary lavas nor in the granite; indeed in most places it is at a considerable distance from either, although it is thought to be genetically related to the granite. Cobalt-nickel and tungsten occur within the Algonkian rocks. Diabase dikes are associated with the cobalt-nickel ores, but no igneous rocks were noted in close proximity to the tungsten-bearing veins.

GOLD DEPOSITS.

PLACERS.

DISTRIBUTION.

The older gold veins of Lemhi County have given rise to placer deposits wherever local conditions permitted their accumulation. Over a large part of the area, however, rapidly flowing streams lead from the sites of vein disintegration into larger streams which also are actively eroding their channels, thus affording no point where material transported by the torrential water may be permanently dropped. This condition accounts for the absence of placers around Shoup, Ulysses, and Gibbonsville. In a few places, however, gold veins are ideally situated for the accumulation of placers and valuable deposits have been found. Streams heading near the crest of the

Beaverhead Mountains flow swiftly through narrow canyons, gathering abundant detrital material and transporting it to the broad, gently sloping valley of Lemhi River, in crossing which the decided lessening of stream grades allows the heavier and coarser material to be substituted for the finer-textured constituents of the valley formation. Thus the auriferous gravels have accumulated along Bohannon and Kirtley creeks near the base of the range and to a less extent along other creeks leading from the same mountains. The upper valleys of Napias and Moose creeks have also been favorable localities for the accumulation of gold placers. At the latter place streams from the surrounding highlands sorted their load and dumped the heavier parts of it in crossing an old sediment-filled lake basin. In the former the gravels were similarly sorted and deposited on the floor of a broad valley.

Placers have been found also near the mouth of Beaver Creek, on Silver Creek near Rabbitfoot, below Yellow Jacket, and at several other localities, but the extent and production of all of these is comparatively negligible.

PRODUCTION AND HISTORY.

Of the four principal deposits, that of Napias Creek leads in production, having furnished perhaps $5,000,000 in gold. Gold was discovered on this creek in July, 1866, and during the few years following the deposits were worked actively. Recently only a few Chinamen have been working in the basin and the production has been very small.

Moose Creek, with an output of about $1,000,000, stands second in production. The placers there were located shortly after those on Napias Creek, but, being under one ownership, were not worked so rapidly and are still being operated. A dredge now on the creek affords an annual output of $15,000 to $20,000.

Bohannon Bar, with a production of about $400,000, ranks third. The creek bed was worked by Chinamen many years ago, but not until 1895 were preparations made for hydraulicking the adjacent benches. At present one giant is being operated on the bar with an annual recovery of about $17,000.

On Kirtley Creek hydraulic mining was pursued from about 1890 to 1894 and a considerable amount of gold was recovered, but operations were abandoned and the property sold as acreage. Recently the low bars adjacent to the creek were carefully prospected by a California dredging company, which has since purchased it and is now installing a large dredge.

ORIGIN OF PLACER GOLD.

In most of the placer deposits the gold can be directly traced to veins, lenses in schist, or stringers along fracture cracks. It has been generally true, however, that the primary deposits have not proved comparable in value to the placers formed from them. Thus in the Leesburg basin the placers have produced approximately $5,000,000 and the lode deposits probably not more than $225,000. In the Moose Creek basin the difference is almost as great, $1,000,000 being yielded by the placers and less than $75,000 by the veins which supplied them. Bohannon Bar has been a productive placer ground, but lode deposits above it have never proved valuable. The same is true to a lesser extent of Kirtley Creek.

At the head of Bohannon basin no vein deposits have been found, although numerous quartz stringers, an inch or two in width, traverse the Algonkian rocks at several places. It is probably from these insignificant deposits that the placers have been derived. About Moose Creek basin also the origin of the gold seems traceable only to unimportant stringers which traverse the schists east of the basin. Near the north end of this zone the Shoo Fly mine supplied bullion worth possibly $75,000. Most of this was derived from quartz material strewn loosely over the surface, and when search was made for a permanent vein beneath none was found. The quartz seems to have occurred as lenses in the schist, many of them of small extent. In the Leesburg basin deposits which have shown a fair degree of persistency have been discovered, but their metallization is so erratically distributed that, with the exception of the Italian property, they have not been worked at a profit. At the head of Kirtley Creek basin veins affording some bullion have been worked.

CHARACTER OF THE PLACER DEPOSITS.

In general the auriferous gravels are made up of material as large as 2 feet and averaging perhaps 6 or 8 inches. Gravel and sand fill the interstices between the larger bowlders, and the entire deposit is cemented loosely by silica. The average thickness of the gravel beds is 17 to 18 feet, but in some places it is less than 10, and in others, as in the upper benches of Bohannon Bar, as much as 31 feet. Nearly all the gold is found in the lower 2 or 3 feet of the gravels and the upper 18 inches of bedrock, although locally the lower 8 or 9 feet of the deposits are auriferous. The gold ranges in size from small flakes up to the type commonly known as "shot gold." Very rarely nuggets worth $2 or $3 have been found. A gradation from coarser grains near the head of the deposit to finer near its lower extremity is generally reported and is especially noticeable on Kirtley Creek.

AGE OF PLACERS.

Placer deposits within Lemhi County range in age from Miocene to present. The oldest beds recognized are near the mouth of Kirtley Creek canyon, where an attempt was made several years ago to wash the Miocene lake beds, which are known to contain some gold near their margin. The series here consists of shales, sandstones, and conglomerates. One of the conglomerates, which occurs about 50 feet below the top of the cliff and overlies a bed of shale, is said to contain gold in commercial quantities, and lesser amounts have been found at other horizons. The most important deposits of the area are probably of late Pliocene age, and to this class belong the gravels now being exploited on Kirtley Creek, those on Bohannon Creek, those on Moose Creek, and most of the placers in the Leesburg basin. Placer gold of post-Pleistocene age occurs below Leesburg and on Phelan Creek, where bedrock is made up of glacial till. That placers are accumulating even at the present time is illustrated at the Haidee property on Arnett Creek in the Leesburg basin, where the ground is washed each spring in order to secure gold which has been freed by the disaggregation of a highly decomposed granite during the previous winter.

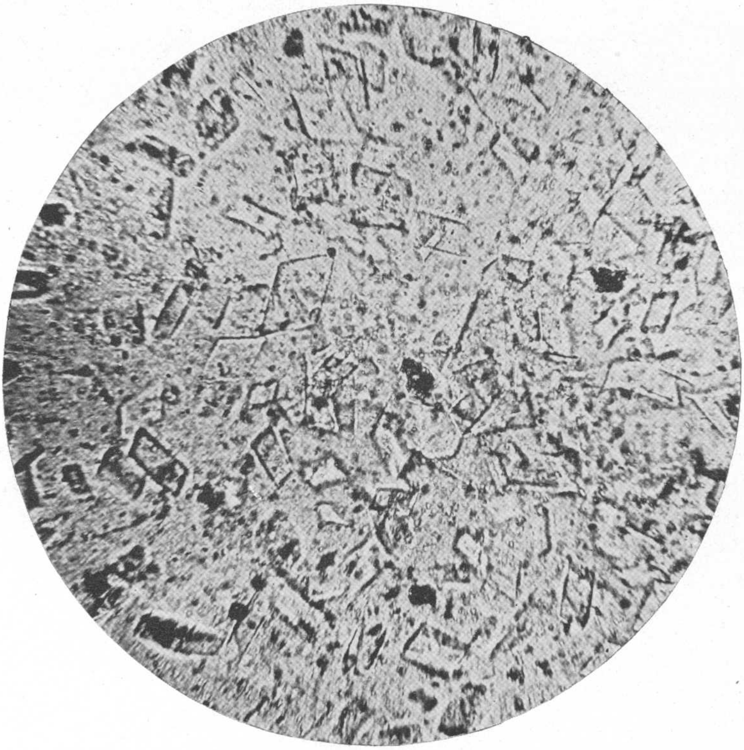
LATE TERTIARY GOLD VEINS.

DISTRIBUTION.

Gold veins of late Tertiary age are known only in the southwest part of the county, in the Parker Mountain and Gravel Range districts, and possibly at Musgrove, in the Blackbird district. The most extensive deposit yet developed is at Myers Cove (Singiser) in the Gravel Range district, where the Monument vein is opened to a depth of 200 feet, with drifts on three levels. Here considerable tonnage of ore is blocked out. At Rabbitfoot an even greater amount of work has been done, although less ore has been found. In the Parker Mountain district two properties have been opened within the past few years and possibly 2,000 feet of tunnels driven. A little ore has been shipped.

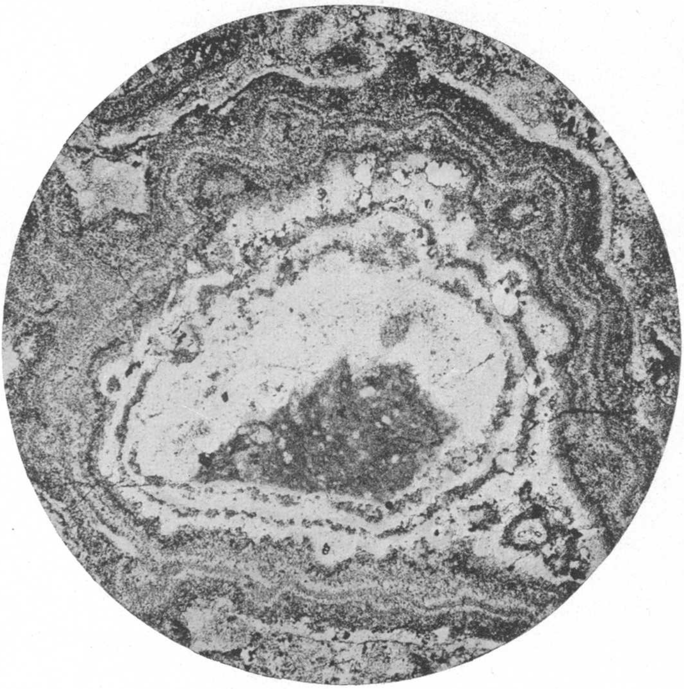
TREATMENT OF THE ORES.

The great difficulty at Myers Cove, where by far the most ore is in sight, has been to devise an efficient method of treatment. Amalgamation tests on roasted ore gave 11 to 20 per cent extraction, cyanide afforded a recovery of 20 to 30 per cent, and a combination of chlorination and cyanidation yielded 70 to 90 per cent. A mill was built in keeping with the last-named tests, but after running a month or six weeks it was abandoned, the total recovery from $11 ore being, it is said, less than $2 a ton. Other properties containing this type of ore have not been developed below the zone of oxidation, but it is probable that with greater depth refractory ores similar to those at Myers Cove will be encountered. The failure to reduce profitably the Myers Cove ore should not be given undue weight, however, for remarkable advances have been made during the last few years in the treatment of similar ores. The production from this group of veins has not been large, probably less than $100,000.



A. VEIN MATERIAL FROM LATE TERTIARY VEINS IN DOMINION MINE AT MYERS COVE.

Showing relations of adularia (rhombohedrons) to quartz. The section was photographed out of focus in order to accentuate the contacts of feldspar and quartz. Dark specks are pyrite and some metallic mineral, possibly a selenide. Enlarged 480 diameters; nicols parallel.



B. VEIN MATERIAL FROM PARKER MOUNTAIN MINE.

Crustification is due to alternating layers of the same composition but of different textures. The core is a fragment of rhyolite wall rock. Enlarged 35 diameters; nicols parallel.

GEOLOGIC RELATIONS.

The late Tertiary gold veins are associated with eruptive rocks, principally rhyolites. All the deposits except those at Musgrove are inclosed in lavas. The Musgrove deposits are in Algonkian schists and quartzites, but here rhyolites form the summits and numerous dikes of rhyolite porphyry traverse the older formations. Two series of flows, separated by a structural and erosional unconformity, were noted at Rabbitfoot (see p. 173), but both belong to the same general period of igneous activity. The older eruptives were poured out over a post-Eocene erosion surface of considerable relief and are probably of Miocene age (p. 48); the younger may be early Pliocene.

CHARACTER OF THE VEINS.

The veins in general are strong fissure fillings varying in width up to 10 or 12 feet, but commonly 2 or 3 feet wide. They dip at angles greater than 45°. The internal make-up of the Tertiary deposits is characteristic and distinct from that of the older gold veins, which are vastly more numerous in Lemhi County. The veins are beautifully crustified, consisting of wavy bands, which in their broader outlines are parallel to the walls but in detail close about many cavities not yet completely filled, or encircle angular fragments of wall rock.

ORES.

Locally intergrown with the quartz and less commonly included in quartz grains are very conspicuous amounts of adularia (Pl. IX, *A*). Calcite is common though never abundant. Sericite is very conspicuous in some specimens from the Parker Mountain mine, but as the ore at that mine is extremely altered it is possible that the sericite, at least in part, has resulted from the breaking down of adularia. The generally crustified appearance of the vein material (Pl. IX, *B*) is due largely to different degrees of coarseness in alternating layers of quartz.

The metallic minerals, everywhere of microscopic size, are distributed through the ore in dark crimpy bands of dull to submetallic luster which parallel the crustification of the gangue. In these bands the metallic minerals occur as bunches of very small particles, fillings between quartz grains, and isolated crystals. Studies were not sufficiently detailed nor development extensive enough to permit satisfactory comparison of the ores from different veins. At Myers Cove, however, pyrite is the most abundant metallic mineral; most of it is contemporaneous with the quartz, many grains of which include pyrite crystals, but it also fills minute cracks formed in the ore at some later time. Owing to the striking similarity between the Myers Cove ores and those at Republic, Wash., which are known to contain considerable amounts of selenium,[1] tests of the former were

[1] Umpleby, J. B., Geology and ore deposits of the Republic mining district: Bull. Washington Geol. Survey No. 1, 1910, p. 39.

made in the Survey laboratory and a strong trace of selenium was detected in specimens from the Monument vein. In the Parker Mountain ores a little pyrite is present, but the principal metallic mineral is a bluish-black fine-grained material of bright metallic luster; it was not identified, but its occurrence is similar to that of the pyrite described above, except that it was not noted along fractures. Very heavy iron and manganese stains record the presence of metallic minerals in the Musgrove ores.

The veins carry silver as well as gold, although the latter commonly leads in value per ton. At Musgrove silver is almost negligible, but in some mines at Parker Mountain it is more important than the gold. Within the veins the ore occurs in shoots of irregular shape and size. Thus at Musgrove several veins have been recognized, but only one of them, which runs about $20 to the ton, is considered of commercial value. At Myers Cove the principal ore body occupies a few hundred feet along one of the veins. Within this shoot individual assays reach several hundred dollars to the ton, but a broad average is said to be about $10. Promising deposits occur also at Parker Mountain, although their extent has not been shown.

AGE AND GENESIS.

As the veins are inclosed in lavas of Miocene age, they are obviously Miocene or later. On the other hand, valleys several hundred feet deep and evidently of preglacial age, because rounded by glaciers in their upper parts, cross the lodes at Parker Mountain and at Myers Cove. If the later part of the Pliocene is allowed for the development of these valleys, the deposits must have been formed in late Miocene or early Pliocene. The manner in which the veins cross the summits (Parker Mountain and Musgrove) and the valleys (Myers Cove) suggests that only a small amount of erosion had taken place after the extravasations of the lava before the veins were formed. Hence it is thought more likely that they should be assigned to the late Miocene.

The deposits are meagerly developed, and, as only a few days were available for their study, suggestions as to their origin must be by comparison with other deposits rather than by direct observation. The crustification, vug cavities, angular included fragments, fine-grained quartz, and the presence of adularia and selenium, all point to deposition near the surface, probably at depths of less than 3,000 feet. The depositing solutions were evidently rich in silica, potash, and aluminum, and carried subordinate amounts of iron, sulphur, gold, silver, and selenium. It is thought that the solutions were hot ascending waters, probably genetically related to the subterranean disturbance which found its most conspicuous expression in the rhyolitic flows.

SIMILAR DEPOSITS.

The occurrence of selenium at Myers Cove, its probable presence at Parker Mountain, and the possibility that it will be found in the primary ore at Musgrove place one of these deposits and possibly all of them among a rare type of later Tertiary veins which have been recognized in this country only during the last few years. The deposits at Tonopah, Nev., and Republic, Wash., are the only examples of this type of deposit in the United States heretofore described. Both are inclosed in Tertiary eruptive rocks and are characterized by the presence of selenium. The deposits at Tonopah carry selenium but not tellurium, and at Republic selenium is important and tellurium occurs only in traces. Gold-selenium ores have been found at two or three places in Mexico, but the most famous foreign examples of this type are the Waihi veins in New Zealand and the Radjang Lebong deposit in Sumatra.

The deposits above enumerated form a subdivision of a great class of comparatively recent veins which are widely developed in the central plateau of the West, and especially along the western slope of the Sierra Madre in Mexico. They are found in New Mexico, Arizona, southern California, Colorado, Utah, Nevada, Idaho, and at a few localities to the northwest in Oregon and Washington. Throughout, the veins are inclosed in lavas or in rocks once covered by lavas. Fine-textured quartz, a lamellar calcite in many places replaced by quartz, crustification, extensively altered wall rock, bonanzas, absence of productive placers resulting from them, and their associations with Tertiary eruptives, when taken collectively, characterize these deposits.[1]

LATE CRETACEOUS OR EARLY EOCENE GOLD VEINS.

DISTRIBUTION AND HISTORY.

The most important gold veins of Lemhi County are of late Cretaceous or early Eocene age. They are widely distributed in the northern and central parts of the county and occur in the McDevitt district on the southeast and the Yellow Jacket district on the southwest. Along the Continental Divide they occur only at elevations greater than 8,000 feet, but elsewhere their distribution is independent of elevation. Thus, in the Mineral Hill district the Grunter vein is near the river level and the Monolith is far up on the canyon side.

Deposits of this type were recognized first in 1868 at Yellow Jacket. During the next 10 years veins were located in the Mackinaw and Gibbonsville districts and later at Mineral Hill and along the Continental Divide. In point of gold production from these older deposits

[1] Lindgren, Waldemar, The geologic features of the gold production of North America: Trans. Am. Inst. Min. Eng., vol. 33, 1903, pp. 804-808.

the Gibbonsville district easily leads with an output of about $2,000,000. Then follows Mineral Hill with $750,000, Indian Creek with $600,000, Yellow Jacket with $450,000, Mackinaw with $250,000, and the several other districts of the county each with less than $100,000. Veins of this type have yielded $6,000,000 to $8,000,000 additional through the placers resulting from them. At present, however, the mines have reached base ore and the annual production is much smaller than formerly.

GEOLOGIC RELATIONS.

The late Cretaceous gold veins are inclosed in Archean gneiss, Algonkian sedimentary rocks, Devonian limestone, and Mesozoic granite. In the central part of the area they occur near the contact between the sedimentary rocks and the granite, either in the one or the other. In the Mineral Hill and Indian Creek districts they are in the older rocks, which, however, are traversed by numerous dikes, probably special expressions of the granitic intrusion. At Gibbonsville, on the other hand, the ancient sedimentary rocks are cut only by small basic dikes, the nearest known outcrop of granite being about 12 miles southwest. Along the Continental Divide the veins are inclosed by Algonkian rocks, which are cut in a few places by vogesite dikes, and in one place near the head of Boyle Creek by granite. At Yellow Jacket the unusual number of dikes which traverse the older formation and the existence of contact phenomena not to be assigned to them suggest that granite lies at no great depth, even though not exposed in the immediate vicinity of the mines. (See p. 169.)

NATURE OF THE VEINS.

The strike of the veins varies in different districts. At Gibbonsville it is east and west; at Yellow Jacket northeast-southwest, and along the Continental Divide northwest and southeast. The dip is even more variable, different veins in the same district dipping in opposite directions, as at Gibbonsville. In places, as at Shoup and Ulysses, the veins are remarkably flat, some dipping at angles less than 30° and locally even breaking into horizontal sheets ("big stope," Kittie Burton mine). In width they vary from mere stringers up to 20 feet or more, those which have been worked probably averaging between 2 and 3 feet.

Faulting has been a great handicap to the profitable exploitation of many of the deposits, especially those at Gibbonsville. Difficulties have arisen also from the great variation in width from place to place of individual veins. Many pinch within short distances or break up into numerous stringers following parallel joints or jump to one side and continue along a parallel fissure. Indeed, many of their irregularities may be well conceived by imagining mineral-bearing solutions rising through country rock traversed by numerous fractures and cross fractures and depositing where local conditions were most favorable.

ORES.

Character.—The deposits are primarily pyritiferous gold-quartz veins. In places chalcopyrite replaces pyrite, as in the copper-gold deposits of the Copper Queen and Copper King mines. Elsewhere pyrite and chalcopyrite are both present, but as a rule either one or the other greatly predominates. The better ore occurs in shoots which have a greater vertical than horizontal extent, and which pitch at angles steeper than 45°.

The vein filling is coarse-textured clear-white quartz, along which the ore shoots occur at irregular intervals. Within the shoots metallization is generally bunchy, with the bunches irregularly spaced. Pyrite is the one persistent ore mineral, and with it the others, one or all, are associated at one place or another. Chalcopyrite is nearly everywhere present, though generally in small amounts. Galena is widespread, though nowhere conspicuous, and sphalerite is equally general but less abundant. Pyrrhotite is rare in the veins and arsenopyrite even more so. Magnetite was noted in two or three of the deposits. Actinolite, chlorite, and epidote are developed in included fragments of schist on Carmen Creek. The several minerals are scattered through the quartz as isolated crystals, fine-grained masses, irregular blotches with quartz intermixed, and patches of coarse crystal aggregates. In places, as at Gibbonsville, the metallic minerals are present locally almost to the exclusion of gangue material, but in general metallization is moderate.

The oxidized ores are free milling, but many of those in which sulphides are predominant yield only 40 per cent by amalgamation. The amount of gold usually varies directly with the amount of pyrite in the ore, save where the ore is cupriferous, in which case it varies with the chalcopyrite. Thus it seems that the gold is principally associated with the pyrite and chalcopyrite, partly free and partly included in these minerals. Throughout it shows a tendency to form placers below the deposits and coarse grains in the oxidized parts of the veins. Silver commonly accompanies the gold, although seldom in amounts greater than a few ounces to the ton.

Few bonanzas have been found in these deposits, although many of the ores are of substantial grade. Probably the highest average grade of ore has come from Gibbonsville, where as much as $40 a ton has been secured from mill runs, but even there $10 to $15 is the common tenor. Elsewhere, average mill runs approximate $10 a ton, more commonly lower than higher.

Relation of ores to depth.—Throughout the county the base portions of the older gold veins have been reached while development was yet comparatively near the surface—in general within 100 feet of it. The upper oxidized portions of the veins yielded readily to amalgamation and on the strength of tests made with such material many mills were built only to be abandoned after a few months because the mine workings encountered base ores, which seldom yielded more than 40 or 50 per cent of their gold to amalgamation. In a few places cyanide was tried, but usually with doubtful success, as shown by the fact that not a single cyanide plant was operated in the county in 1910. In general, the presence of a small amount of copper has been the chief deterrent to this method of treatment, but as little or no copper was seen in several of the deposits, it should not prove a universal handicap.

Primary ore once reached, there is no reason for thinking that the deposits do not "go down," but with increase in depth the same irregularities in mineralization and vein outline which occur a short distance below the limit of oxidation must be expected. In other words, the same general characteristics which prevail at 200 feet may be expected at 1,000 feet. It appears impossible to justify a broad statement that the gold deposits of the county become either richer or poorer with depth, the lower limit of oxidation once passed. These conclusions follow from the conditions of deposition clearly recorded in the physiographic and geologic history of the region. Since these veins were formed the entire area has been planed down, a cover of 3,000 or 4,000 feet having been removed. Veins are at present exposed at altitudes differing by 4,000 to 5,000 feet, but it has not been possible to point out any persistent or significant difference, either in form, mineralogy, or tenor, between deposits occurring at the higher elevations and those found at the lower. This being true, an extra thousand feet in depth on most of the veins of the districts should not show persistent changes either for better or for worse.

Relation of ores to granite.—Another consideration, however, concerns the relation of the ores to the granite mass. It is believed (p. 62) that the ores were deposited by solutions given off from or made effective by the granite, and, even though the deposits may not vary with depth from the surface, it may be questioned whether they will not vary with distance from the granite margin. This doubt is not subject to as satisfactory a solution as the other. The only line of evidence seems to be that derivable from the comparative study of groups of deposits found at different distances from the margins of the granite areas, and in assembling the deposits for such groups the possibility of the granite being closer to some deposits than others, though concealed, is a disconcerting factor. Throughout the investigation this factor was borne in mind, and whatever geologic evidence seemed to have a bearing on it was examined. For a time it seemed that in general gold is more closely confined to the granite margins than copper, but the exceptions are so numerous that the final conclusion is that no definite variation exists.

Secondary concentration.—Within the area as a whole secondary concentration of gold, though not readily recognized, is thought to have been an important factor. At Gibbonsville, however, it is conspicuous, and the deposits deserve special mention in a general discussion. Experience there shows that few veins contained much gold for 15 to 30 or 50 feet below the surface; that for the next 100 feet or so they were comparatively rich and yielded readily to extraction by means of the arrastre; and that below 150 feet they consisted of sulphide ore lower in grade than the ore occurring between it and the surface zone. As this has been the experience of the several operators in the district, there seems little reason for doubting that secondary concentration of gold has generally taken place there.

The problem, then, is to ascertain whether the concentration of gold has been due to the leaching out of other constituents of the vein, and is thus a residual concentration, or has been due to solution and redeposition of the gold itself. The alteration of pyrite to limonite causes an increase in volume of 2 per cent, but at the same time the new form has a gravity about 25 per cent lower than the old. The change thus means a slight decrease of gold per unit volume but a pronounced increase of the number of unit volumes per ton of ore, giving thereby a decided increase in the gold contained in a single ton. Any extraction of iron from the veins operates in the same direction. It is therefore concluded that much of the enrichment of gold in this type of veins is due to volume changes and the removal of iron, but it remains to be seen why the upper 15 to 50 feet should be so much lower in grade than similarly oxidized material lying immediately below it. It has been shown both by experiment and by observation [1] that gold in the presence of manganese is very appreciably soluble in most mine waters at earth temperatures. As manganese is here present as conspicuous stains and dendrites in the oxidized ore, it is very probable that the barren zone near the surface is due to chemical leaching, the gold being reprecipitated lower down. However, a downward settling of the heavy gold particles in the loose oxidized material may be important. It is concluded from the above line of evidence that residual concentration, due to removal of other constituents, largely accounts for the enrichment of gold in the oxidized zone of the Gibbonsville veins. Near the surface leaching of gold has probably taken place, and leaching above was necessarily followed by precipitation below.

It is thought that similar conditions exist elsewhere in the older gold veins, though not recognized, probably because nowhere else is pyrite

[1] Emmons, W. H., The agency of manganese in the superficial alteration and secondary enrichment of gold deposits in the United States: Bull. Am. Inst. Min. Eng. No. 46, 1910, pp. 767-837.

so important a factor in the ore and because, consequently, nowhere else is the concentration due to its breaking down so pronounced. Indeed it is believed to be this difference in tenor, slight though it is, between the oxidized ore and the primary ore that has given rise to the local opinion that the veins decrease in value with depth—a conclusion which is apparently unfounded, if primary ore alone is considered.

AGE AND GENESIS.

The age of these veins can be placed within rather narrow limits. They are so strikingly similar in their make-up that there is little room to doubt that they date from the same period of mineralization. Some of them are inclosed in late Cretaceous granite; hence they are younger than that intrusion. On the other hand they present the mineral association and physical make-up typical of veins formed at a great depth, probably 4,000 or 5,000 feet. In many places in the Mackinaw and Eureka districts veins have been worked at elevations approximating 7,500 feet, whereas the Eocene erosion surface in their vicinity stands at about 8,500 feet. It follows that the veins were formed while the area was covered by 3,000 or 4,000 feet of material now removed—material that could only have been present prior to the erosion which culminated in the broad planation of the region and the development of the Eocene erosion surface. The veins therefore antedate the later and possibly even the middle part of the period of erosion, which probably occupied the greater part of the Eocene epoch. It is concluded, therefore, that the veins are of late Cretaceous or early Eocene age, probably the former.

The geographic distribution of the veins and the granite and their age relations lead to the conclusion that the veins are genetically related to the granite. Those in the central part of the county are conspicuously coincident in distribution with the contacts of the granite, being either in the granite or in the rocks which it intrudes, whether these are schist, as in the Indian Creek and Eureka districts, or gneiss, as at Mineral Hill. In the Mackinaw district a great outlier of schist within the granite area illustrates the same relation, the Copper King and Mayflower properties being inclosed in schist and the Italian and Haidee in granite. In the Gibbonsville district granite is not exposed, although its occurrence as great batholiths, 10 to 20 miles to the southeast, southwest, and north, suggests that it may underlie the district. At Yellow Jacket it is thought to be present though not exposed (p. 169). Along the Beaverhead Mountains lamprophyre dikes suggest the presence of granite. Thus throughout the area the veins are confined either to the margins of the granite or to areas where there are reasons for thinking that the granite lies at no great depth.

That the granite and the veins are closely related in age, the veins being a little younger, follows from the considerations stated on page 29 and outlined here. If the granite caused the elevation of the area, which by its reduction gave the Eocene surface, and if the veins are not later than the middle stages of that reduction, it follows that the granite and the veins are not far apart in geologic time. As the veins are in places inclosed in granite they are the younger. This age relation and the distribution of veins near the margins of the granite seem to point definitely to a genetic relation between them.

These relations give strong support to the theory of ore deposits that regards many veins as having been formed by solutions given off from an igneous mass, usually after its outer part has solidified. Thus the veins occur around the margins, extending into the mass itself and into the rocks which it intrudes.

SIMILAR DEPOSITS.

Deposits of this age and with similar characteristics are widespread in Idaho, Montana, and eastern Washington, and occur locally in Utah (Mercur) and Colorado (Leadville). In many places they have afforded rich placers, as at Bannock, Alder Gulch, Helena, and Confederate Gulch, in Montana.[1]

LEAD-SILVER DEPOSITS.

DISTRIBUTION.

Lead-silver deposits are confined to the southeastern part of the county, from Junction southward to the head of Birch Creek. Within this area four mining districts are recognized—Nicholia to the southeast, Spring Mountain west of it, Texas north of that, and Junction still farther north—in all covering an area about 30 miles long and 20 miles wide. The known deposits are further limited to three localities—(1) a narrow belt along the east face of the Lemhi Range, extending about 10 miles south and 2 miles north of Gilmore; (2) the Nicholia district, about 15 miles farther east, where two claims have been found to contain very productive deposits; and (3) a narrow belt, perhaps 5 miles long, northeast of Leadore. The continuation of this belt northwest of Junction has afforded reasonable encouragement to the prospector, but so far no commercial deposits on it have been opened.

GEOLOGIC RELATIONS.

The area consists of a mountainous country traversed by a broad valley filled deeply with Miocene sediments. The rocks forming the mountains are dolomites, limestones, slates, and quartzites of Paleozoic

[1] Lindgren, Waldemar, The geologic features of the gold production of North America: Trans. Am. Inst. Min. Eng., vol. 33, 1903, pp. 802–804.

age. Cutting them are broad dikes of quartz diorite and related porphyries, and in one and possibly two places small batholithic masses of the same material. In general the older formations dip east in the western part of the area and west in the eastern part.

All known lead-silver deposits in Lemhi County are inclosed in Paleozoic sedimentary rocks; most of them are in close proximity to quartz diorite dikes, though few are in actual contact.

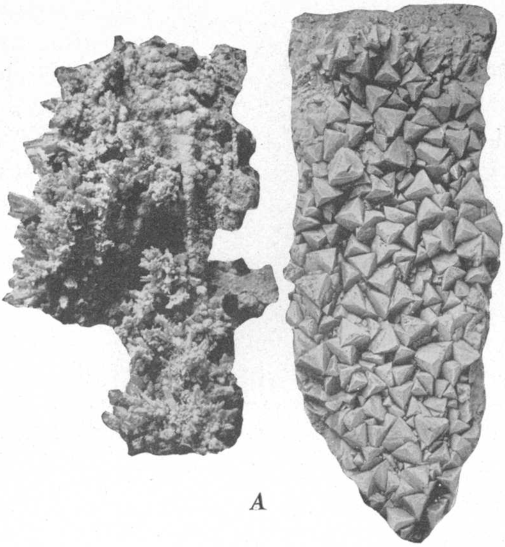
CHARACTER OF DEPOSITS.

The lead-silver deposits are tabular bodies with extensions along bedding and joint planes and numerous swells in the main mass. Figure 10 (p. 101) illustrates the veinlike character of the Pittsburgh-Idaho deposit, and figure 17 (p. 117) illustrates the same relation in the Leadville mine. The Latest Out ore body is also tabular, but many isolated bunches of ore appear in the wall rock near the vein. Figures 14 and 15 (pp. 105, 106) illustrate the outline of two bodies of ore in this deposit. In many places well-defined fissure walls continue even where the ore has ceased, the space being filled by gouge.

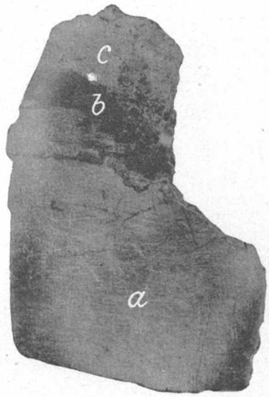
ORES.

Mineral character.—The structure of the lead-silver ores is greatly obscured by the advanced degree of oxidation which prevails throughout most of the present workings. The Leadville mine is the only developed property where primary minerals predominate. Here the ore is fine-grained argentiferous galena, remarkably free from gangue but with numerous small patches of intergrown pyrite and with a little chalcopyrite. Arsenic, antimony, and bismuth appear in analyses of the ore, but their mineral combinations are unknown.

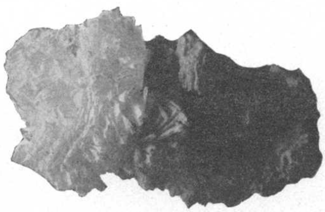
In most of the deposits oxidation is almost complete, the ore being a mass of earthy carbonate heavily stained with iron and manganese and commonly having strong suggestion of metallic luster. Probably 80 per cent of the lead-silver ore shipped from the county is composed of minerals resulting from the oxidation and carbonation of galena, pyrite, and zinc blende. Cerusite and iron oxide are by far the most conspicuous minerals in the deposits. Anglesite is common as a narrow band around galena. (See Pl. X, *B*.) Smithsonite occurs as botryoidal linings of small cavities and as stringers along joints. Calamine is rare and appears as small needle-like crystals extending from the sides of vugs otherwise lined by smithsonite. (See Pl. X, *C*.) Manganese oxides are common as stains and dendrites. Pyromorphite is rare, cerargyrite probably very common but in exceedingly small grains, malachite uncommon, and minium very exceptional. From analogy with other lead-silver deposits of



A



B



C

ORE FROM PITTSBURGH-IDAHO MINE.

A. Aragonite (on left) and calcite (on right), as developed along open fissures. Natural size. *B*. Galena (*a*) partly altered to cerusite (*c*); anglesite (*b*) is an intermediate phase. 400-foot level. Natural size. *C*. Calamine crystals on drusy base of smithsonite; East vein, between 300 and 400 foot levels. Enlarged 2 diameters.

the State, in all of which iron carbonate is a characteristic gangue mineral, it is possible though not probable that siderite occurs in the primary ore.

The general make-up, tenor, and variations in the ore from place to place are brought out clearly by average analyses derived from smelter returns. The extremes for each item, as well as the average, are given in the following tables:

Average analyses of ore from Pittsburgh-Idaho mine, Texas district.

[25 shipments, ending Sept. 10, 1910; total, 2,275 tons.]

	Gold.	Silver.	Lead.	Copper.	Silica.	Iron.	Zinc.	Sulphur.
	Ounces.	*Ounces.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Average	0.031	15.29	37.04	....	20.0	8.4	9.05	0.59
Highest	.035	16.70	41.00	....	23.0	9.6	11.00	.80
Lowest	.020	13.40	31.75	....	16.3	7.3	6.90	.06

Average analyses of ore from Latest Out mine, Texas district.

[14 shipments; total, 962 tons.]

	Gold.	Silver.	Lead.	Copper.	Insoluble.	Iron.	Zinc.	Sulphur.
	Ounces.	*Ounces.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Average	0.0285	18.09	34.25	0.34	25.31	9.23	5.48	0.86
Highest	.03	21.5	41.13	.48	27.7	10.8	6.9	1.95
Lowest	.0225	14.7	29.65	....	19.75	7.35	4.6	.6

Smelter analyses of ore from Spring Mountain district.

[On lots varying from 20 to 75 tons.]

Property.	Gold.	Silver.	Lead.	Iron.	Silica.	Lime.	Remarks.
	Ounces.	*Ounces.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Lemhi Union	....	12.2	38.7	16	10.4	4.3	
Do	....	5.08	19.8	13.71	20.6	3.84	
Iron Mask	....	9.5	19.9	10.25	49.9	3.07	
Teddy and Elizabeth.	0.02	11	19.5	10.1	21.2	9.97	Average of 7 analyses on lots of about 50 tons each. Two contained 10.8 per cent barium.
Russell	....	12.1	15.2	18.16	27.6	5.63	Contained 3 per cent of copper. 160 tons in lot.
Galena	....	2.8	20.1	25.08	13	9.6	Four or five tons in lot.
Red Warrior	....	13	53.1	....	....	....	Sample.
Do	....	5	23	....	....	....	Sample.

Smelter analyses of ore from Leadville mine, Junction district.

	Gold.	Silver.	Lead.	Copper.	Insoluble.	Zinc.	Sulphur.	Iron.	Arsenic, antimony, and bismuth, not separated.
		Ounces.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*
No. 1 shoot	Trace.	35.0	56.5	0.2	16.0	....	9.8	2.8	....
No. 2 shoot	Trace.	28.8	54.5	.2	15.0	1.0	11.0	2.0	9.7

An inspection of the first two tables shows that a very small percentage of the total metallic content is in a sulphur-bearing form; that is, is either sulphide, sulphate, or sulphantimonite. It is obvious from their general appearance that the ores are largely carbonate, but just what percentage of the lead is in this form is not readily determinable. On the assumption, however, that all the sulphur is in combination with the lead as galena, since that mineral has a higher percentage of lead than any of the others, it appears that, as a minimum, 90 per cent of the lead in the ore from the Pittsburgh-Idaho mine and 84 per cent of that from the Latest Out mine is in a form other than the sulphide, sulphate, or sulphantimonite. From the absence of other minerals in conspicuous amounts it is concluded that most of this, or 80 to 90 per cent of the lead in these ores, occurs as lead carbonate.

As in the third set of analyses sulphur is not given, calcium oxide, though unsatisfactory, is the only basis for determining the extent of oxidation. Only in the Lemhi Union and Iron Mask properties is the amount of calcium less than would be expected were the lead all in the form of carbonate. The occurrence of barium, probably entirely as barite, in some of the ores from the Teddy and Elizabeth mines is interesting in that they are the only places where barite was noted in the lead-silver deposits.

The amount of sulphur contained in the Leadville ore (fourth set of analyses) indicates that it is made up primarily of sulphide minerals.

In all the ores, copper and gold are negligible. Lead constitutes about one-third of the total vein content. There is usually about one-half ounce of silver to each unit of lead.

Oxidation and ground-water level.—Exploration of the lead-silver deposits has been well above ground-water level. In the Texas district ground-water level, based on the elevation of springs (p. 97), is thought to be from 6,800 to 7,000 feet above sea level east of the quartz diorite dikes and somewhat higher west of them. In the Spring Mountain district the level is in steps determined by low points in the quartz diorite dikes which serve as submerged dams (p. 85). In the Junction district, west of the dikes, the level of Lemhi River is probably the determining factor; east of the dikes the low points in the dikes themselves control.

Oxidation and carbonation will probably be found to be almost coextensive with the depth of ground-water level. Thus it will vary up to possibly 1,000 feet below the surface in known deposits, this maximum being probable in the Pittsburgh-Idaho mine.

Relation of ores to ground-water level.—A conspicuous feature of the oxidized zone is the loose make-up of the ore. Small vugs lined with secondary minerals are common, and a general incoherency of the mass is noticeable everywhere. In contrast to this condition the primary ore, as seen here and there in protected spots, especially at the Leadville mine, has very little pore space. The alteration of galena to cerusite involves an increase of 28 per cent in volume, of pyrite to limonite an increase of 2 per cent in volume, and of sphalerite to smithsonite an increase of 22 per cent. It appears, therefore, that the minerals occupying the oxidized zone represent far more volume per unit of metal than those from which they were derived. As they are more loosely assembled than were the primary minerals, it follows either that the space occupied by them has been enlarged or that there has been important leaching of the vein material. If the space occupied by the ore has been materially enlarged during the general period of oxidation, it would seem that the ore along its contact with the walls should be more loosely assembled than that in the central portion of the vein, a relation which does not appear to exist. In many places also the fissure walls which bound the ore continue beyond the limits of the ore shoot, but without noticeably converging. From these observations it is concluded that although solution of the walls may have accompanied oxidation it has not been sufficiently extensive to account both for the increased porosity of the ore and for the increased volume due to changes in its mineral constitution. There seems little room to doubt that there has been a pronounced leaching of the vein material, and it remains to determine the order, and as nearly as possible the ratio, in which the metals have been leached, so as to form an idea of what changes may be expected in the relative proportions of metal content when primary ore is reached.

Experiments have shown that under conditions approximating those of nature, sphalerite in the presence of pyrite is oxidized six times as readily as galena under the same conditions.[1] Pyrite is less susceptible than sphalerite when both are in the same deposit. Of the resulting products of this oxidation the lead is by far the most stable and zinc the most unstable, as shown by the relative solubility of the sulphates involved. The lead sulphate although not absolutely insoluble is relatively so; and the sulphate of iron although very soluble is three to four times less so than that of zinc. The zinc salt is so very readily taken into solution that 161 parts of it may be dissolved in 100 parts of water at 20° C.[2] These values can not be assumed as absolute in the oxidation of a vein where conditions are variable and in some respects unknown, but they represent a general order which seems susceptible of practical application.

As the alterations represented in the deposits necessitate an increase of volume per unit of metal contained and as the deposits are more

[1] Buehler, H. A., and Gottschalk, V. H., Oxidation of sulphides: Econ. Geology, vol. 5, 1910, pp. 30-31.

[2] Lindgren, Waldemar, The copper deposits of the Clifton-Morenci district, Arizona: Prof. Paper U. S. Geol. Survey No. 43, 1905, p. 181.

porous than they were formerly a considerable extraction of one or more elements must have taken place. From the relative rate of oxidation and the relative solubility of the oxidation products it appears that the lead has remained essentially stable, that the iron has probably been removed somewhat, and that the zinc has been removed in considerable quantities.

It is necessary, however, to consider the agents which may precipitate the sulphates from solution. Owing to its relative insolubility, lead sulphate need not be considered. The iron in solution will change in the presence of oxygen from the ferrous to the comparatively insoluble ferric state and be precipitated as ferric hydroxide. There is abundant evidence, however, for believing that some of it will be carried for considerable distances. In the case of zinc sulphate, lime carbonate, which acts as an efficient precipitant, forming zinc carbonate, is present in abundant supply in the walls, but it would seem that in ore bodies 6 to 20 feet wide there is ample opportunity for the migration of zinc in the central portion. Further, sphalerite oxidizes more readily than pyrite and galena, and the acid solutions formed in the oxidation of pyrite and galena higher in the deposit would descend upon the zinc sulphate. If, however, it is assumed that zinc carbonate is formed before the sulphate has moved any considerable distance, the problem resolves itself in a consideration of the relative solubility of the carbonates of lead and zinc and ferric hydroxide. Of these the simple carbonate of zinc is much more soluble than the others, and the bicarbonate is vastly more soluble. In view, therefore, of the relative solubilities either of the sulphates formed during oxidation, or the products which may result from the precipitation of these sulphates, it appears that zinc has probably been removed from the zone of oxidation.

From the above, providing the original vertical distribution in the veins was approximately the same, it follows that below the zone of oxidation lead will not change greatly in absolute amount, although it will decrease slightly in amount per ton of ore; iron will increase somewhat, and zinc will probably increase considerably. The fact that the average zinc content in the flat vein of the Pittsburgh-Idaho mine has decreased very materially in the lowest 100 feet does not refute this conclusion, for the deepest workings are yet well above ground-water level.

AGE AND GENESIS.

The deposits are obviously younger than the Carboniferous sediments which inclose some of them, and older than the Eocene erosion surface which truncates them. The general occurrence of galena in the late Cretaceous or early Tertiary gold veins of the area, and the presence of a gold vein (Allie property) closely associated with the lead-silver deposits, suggest that these are the same age as the gold veins, and hence postgranite; that is, that they are late Cretaceous or early Eocene. That they are later than the granite is further indicated by their similarity (save in the siderite gangue, which is not recognized in Lemhi County) to the deposits in the Wood River district, which are later than the granite.[1]

If the lead-silver deposits were formed during the same period of mineralization as the late Cretaceous or early Eocene gold veins, as seems altogether probable, it is reasonable to think that both were produced by the same agencies, and, as the gold veins are genetically related to the granite intrusion (p. 62), to assign the lead-silver deposits to that source. Quartz diorite dikes are so common in the vicinity of the latter deposits that a relation between the two is strongly suggested. If a relation exists, however, the two are different expressions of the same general phenomena, as the veins are older than at least some of the dikes. The dikes are pretty surely differentiations from the granite, for in the Wood River district the two are gradational,[2] hence another suggestion that the lead-silver deposits are related to the granite.

COPPER DEPOSITS

DISTRIBUTION.

Copper deposits are distributed widely in Lemhi County, although their commercial importance has not yet been demonstrated. On Spring Mountain a large deposit of low-grade copper occurs along a zone parallel to the lead-silver veins and not far removed from them. Northward, near the head of Agency Creek, is the Copper Queen mine, the only property in the county which has produced copper ore. Other properties are located across the Lemhi Valley on Diott Creek. In the mountains southwest and southeast of Salmon copper is found, and to the west of Copper King Mountain a considerable deposit exists. South of this, in the Blackbird district, 29 patented claims are held for copper.

GEOLOGIC RELATIONS.

All the copper deposits are inclosed in sedimentary formations; those on Spring Mountain are in Ordovician limestone and dolomites, but all others are in Algonkian schists, quartzites, and slates. Either quartz diorite or granite occurs in the vicinity of most of the deposits. Indeed, on Spring Mountain a broad dike of quartz diorite is said to form one wall of the deposit.

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[1] Lindgren, Waldemar, The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 217

[2] Idem, p. 195.

CHARACTER OF THE DEPOSITS.

The deposits vary in form from fissure veins (Copper Queen) to impregnations in schist (in places on Torney group) and contact-metamorphic deposits (Bruce estate) with irregular mineralization along sheeted zones as the most common type. The Copper King deposit, which represents the last named, consists of an irregular vein about 2 feet wide, accompanied by very many parallel stringers separated from each other and the main vein by mineralized wall rock. The entire mineralized zone is about 40 feet wide. In the Brown Bear shaft, Blackbird district, a similar deposit is said to be more than 100 feet wide. Each of these is opened for 400 or 500 feet and is shown to be fairly persistent, though low grade.

ORES.

The characteristic copper ore encountered in the county is coarse quartz studded and stained with the alteration products of chalcopyrite. Of these, bornite and malachite are most abundant, the former being the predominant mineral at the Copper Queen mine. Chalcocite is common in some properties (Copper King). In general, azurite, cuprite, chrysocolla, covellite, and melaconite are decreasingly abundant in the order named. Although chalcopyrite appears to be the source of most of the minerals, it is not conspicuous within the limits of present development. It occurs as cores surrounded by bornite, covellite, and rarely by malachite, and as irregular bunches, streaks, or isolated crystals, which, by reason of local conditions, have not been oxidized. Gold is associated with the copper in all of the deposits, as is also pyrite.

AGE AND GENESIS.

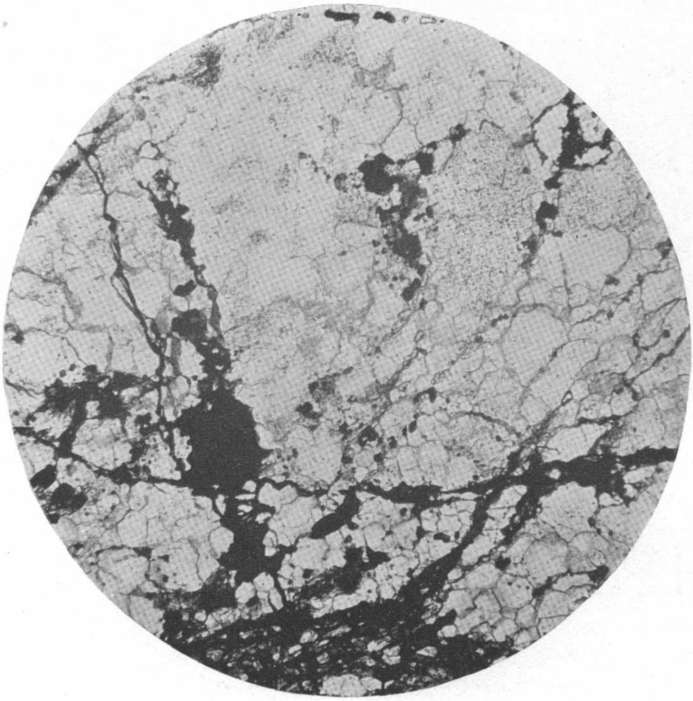
There seems to be every gradation between the pyritiferous gold veins and the auriferous copper deposits. The Carmen Creek mine is classed with the gold veins, although it might almost equally well be classed with the copper deposits. The Copper Queen mine is considered a copper property, but it might with equal justification be listed with the gold properties. It is further noteworthy that chalcopyrite is present in all the late Cretaceous gold veins and pyrite in all the copper deposits. As the gold and copper deposits possess like characteristics except for their relative content of pyrite and chalcopyrite and as the above stated relations exist between these it is concluded that the deposits are of the same age and genesis. In the copper deposits chalcopyrite simply replaces pyrite, hence the discussion as to the age and genesis of the gold-bearing veins (see p. 62) applies to copper-bearing veins and leads to the conclusion that they are late Cretaceous or early Eocene and are genetically related to the late Cretaceous granite intrusion.

A.

B.

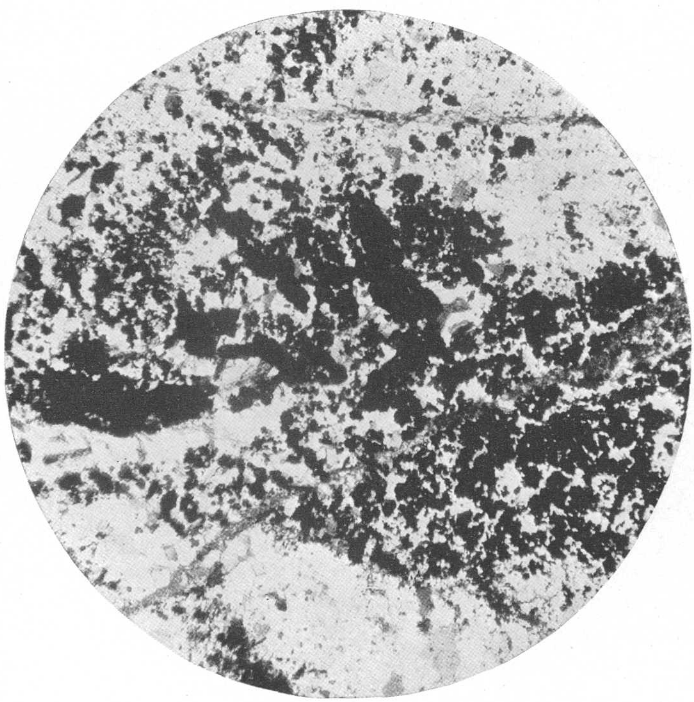
COBALT-NICKEL LODE, EAST END OF BELIEL GROUP, BLACKBIRD DISTRICT.

A, Outcrop of lode. *B*, Efflorescence of erythrite on surface of lode.



A. COBALT ORE FROM BROOKLYN CLAIM, BLACKBIRD DISTRICT.

Mineralization has taken place along fractures in a fine-grained quartzite. Enlarged 35 diameters; nicols crossed.



B. COBALTITE (?) REPLACING BIOTITE AND QUARTZ IN A BIOTITIC QUARTZITE, BLACKBIRD DISTRICT.

Very small grains bunched in poorly defined lenticular areas. Enlarged 35 diameters; nicols crossed.

COBALT-NICKEL DEPOSITS.

DISTRIBUTION.

The known cobalt-nickel deposits of the area are confined to the Blackbird district in the west-central part of the county. The most promising properties are situated near the junction of north and south forks of Blackbird Creek. Thence northward, prospects are located for 5 to 6 miles—the most northern ones being situated about the head of Little Deer Creek, a small stream which flows north into Big Creek. (See Pl. XI, *A*, *B*.)

GEOLOGIC RELATIONS.

The deposits are situated in an area of Algonkian schists and quartzites, cut by diabase and lamprophyre (minette) dikes. That a portion of the great granite batholith underlies part of the area is suggested by its occurrence in Big Creek valley, and by the extensive metamorphism of the Algonkian sedimentary rocks. Biotite is the most abundant mineral developed, although locally garnet and chiastolite crystals were noted. In general the Algonkian beds strike N. 60°–80° E. and dip 40°–60° NW. Crossing their strike is a strong joint system which strikes N. 10°–40° W. and dips 80° SW.

Gabbro dikes as much as 100 feet wide parallel the mineralized belt in north-south direction. They are blue-black holocrystalline rocks consisting of hornblende, diopside, plagioclase, and biotite, with accessory pyrrhotite, pyrite, titanite, and apatite. Minette dikes appear to follow both the strike of the formations and the cross-joints. They are fine-grained dark-gray resinous rocks consisting of biotite and orthoclase accompanied by subordinate amounts of plagioclase and hornblende.

CHARACTER OF THE DEPOSITS.

Most of the deposits are lenslike bodies, although a few assume the broadly tabular form of veins. (See Pl. XII, *A*.) Again, they form bunches or occur as disseminations along certain favored zones. In one place (Hawkeye group) irregular bunches of nickeliferous pyrrhotite up to 4 or 5 inches in diameter are sparsely scattered through a gabbro dike. This pyrrhotite may be a direct segregation from the gabbro magma, but the fractured condition of the specimens secured precludes definite determination. Elsewhere deposits are primarily of replacement origin, the fine-grained metallic minerals being distributed in bunches, lenses, and disseminations along ill-defined zones in the schist or quartzite. (See Pl. XII, *B*.) The ore minerals are everywhere accompanied by quartz, which in places is coarse and includes them as gangue but elsewhere is exceedingly fine-grained and is intergrown with them.

ORES.

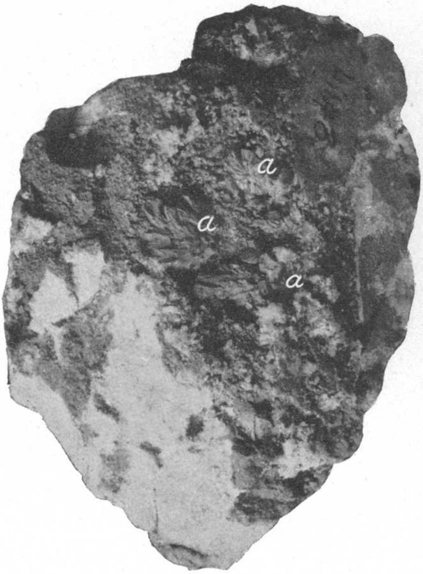
Most of the outcrops of the cobalt-nickel deposits are stained by erythrite, the pink to pearl-gray cobalt blossom, and annabergite, the pale apple-green nickel compound. In addition, malachite, limonite, and pyrolusite are present in many outcrops. The primary cobalt and nickel minerals are difficult to recognize, owing to their occurrence in grains of microscopic size which are invariably intergrown with something else. At least two cobalt minerals in the area are probably primary: The one is a reddish-gray mineral (Gray Eagle claim) which occurs in very small grains replacing biotite and quartz in a garnetiferous biotitic quartzite; the other is a steel-gray mineral, which occurs as minute grains distributed through the quartzitic rock on the west end of the Beliel group. The former is probably cobaltite and the latter is possibly smaltite. Most of the nickel of the area is thought to be in the form of nickeliferous pyrrhotite, a specimen of this mineral from the Togo claim yielding 0.8 per cent nickel. A pale copper-red mineral, rarely seen in the Togo ores, may be niccolite.

The properties are too little developed to establish the tenor of the ores. A sample representing 20 feet across the ledge, as exposed by tunnel on the west end of the Beliel group, averaged a fraction less than 2 per cent cobalt. The east end of this property afforded 2 per cent of nickel and less than 1 per cent of cobalt. As now developed this seems to be the best cobalt-nickel deposit.

AGE AND GENESIS.

Within Lemhi County it is impossible to differentiate the times of deposition of the cobalt-nickel, copper, and gold deposits. The relations indicate that they all belong to the same general period of mineralization, and as the gold veins are assigned to the late Cretaceous or early Eocene and are genetically related to the great granite mass, the other deposits also are credited to the same age and origin. The coextent of the gabbro dikes and the cobalt-nickel deposits, and the inclusion of nickeliferous pyrrhotite in the gabbro in a manner to suggest its derivation from the gabbro magma, points to a close relation between the two. This, however, is probably a minor though an important feature in the broader relation between the granite batholith and the deposits.

The cobalt-nickel deposits, therefore, are thought to be of late Cretaceous or early Eocene age and to be genetically related to the great granite intrusion. They are closely associated with gabbro dikes, which are probably differentiations from the granite magna.



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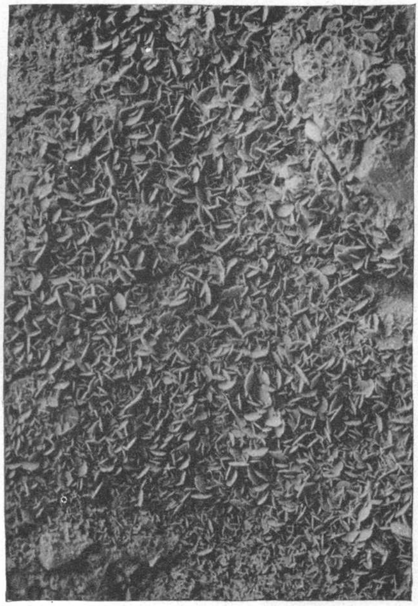

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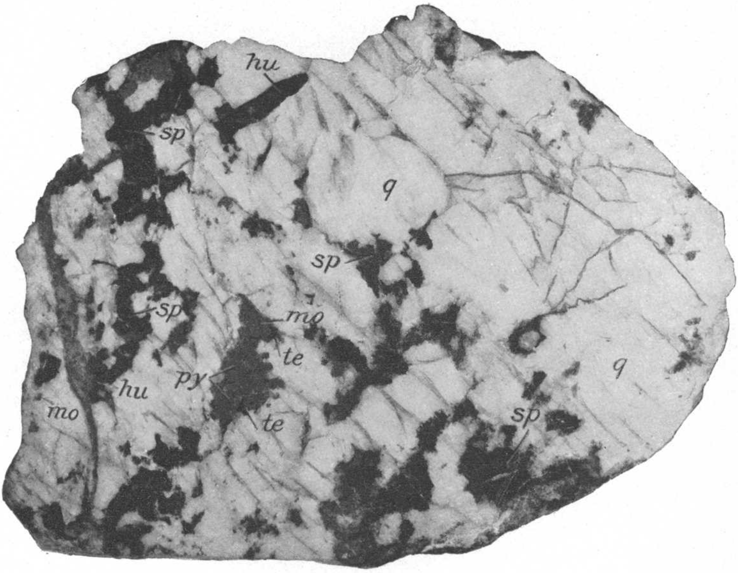


C

ORES AND MINERALS FROM BLUE WING DISTRICT.

A. Rosettes of manganese oxide (*a*) developed along fractures in the vein quartz. Natural size. *B*. Siderite occurring locally along fractures in ore. Enlarged 3 diameters. *C*. Tungsten ore from Idaho Tungsten Co.'s creek tunnel; *q*. quartz; *hu*, hübnerite; *sp*, sphalerite (resembles hübnerite but gives white instead of brown streak); *py*, pyrite; *te*, tetrahedrite; *mo*, molybdenite. Natural size.

TUNGSTEN DEPOSITS.

DISTRIBUTION.

Tungsten occurs in the Blue Wing district, situated 20 miles southwest of Leadore. This district includes a township or so along Patterson Creek, a northern tributary to Pahsimeroi River near its head. Gold locations were made in the district as early as 1881, but tungsten was not recognized until 1903. Since then it has attracted some attention, and recently active operations have been begun. A 50-ton concentrating mill is now running, and the concentrates will be hauled to Leadore as soon as the road now in course of construction is completed.

CHARACTER OF THE DEPOSITS.

The deposits are fissure veins along the axis of a pronounced anticline which strikes N. 30° to 40° W. Quartzitic slates and schists of Algonkian age inclose the deposits. No igneous rock crops out in the immediate vicinity, although quartz diorite is known to occur at several places along the Lemhi Range.

ORES.

The ore consists of coarsely crystalline quartz, which occurs in veins varying in width from stringers up to 4 feet and rarely up to 12 feet. Irregularly scattered through the quartz are small bunches of sphalerite, bladed crystals of hübnerite, small areas of tetrahedrite, and specks of molybdenite and galena. (See Pl. XIII, *C*.) Secondary to these are limonite, malachite, azurite, cerargyrite, bornite, chalcocite, and cuprite. Scheelite, probably also secondary, was noted as pale-yellow druses lining a small cavity and as specks in the loose granular filling of some crevices. Manganese oxides (Pl. XIII, *A*) are secondary, although their derivation was not recognized. Molybdenite occurs bunched along fractures and in the interstices of brecciated quartz in a manner to suggest its secondary origin. This mineral, however, because of its graphite-like character, is likely to be squeezed out of its gangue if that is crushed and to accumulate in fractures and interstices. Molybdenite is not known to be a secondary mineral and it is thought that the above explanation accounts for its occurrence in this deposit. The paragenesis of the several primary minerals is discussed elsewhere (p. 111).

GENESIS.

The tungsten veins can be traced up the canyon side almost, if not quite, to the level of the Eocene surface; hence they antedate its formation. As only two periods of mineralization have been recognized in this part of Idaho and the later is post-Eocene, these deposits are assigned to the earlier, which is of late Cretaceous or early Eocene age. They are also believed to be genetically related to the great granitic intrusion which gave rise to the older period of mineralization. Along the Lemhi Range the granitic activity is represented by numerous dikes and a few bosses of quartz diorite. The tungsten deposits are thought to be a phase of this activity.

TIN DEPOSITS.

Placer tin has been found along Panther Creek near its junction with Moyer Creek and along Silver Creek below Rabbitfoot. The latter deposit has been prospected sufficiently to show the absence of tin in commercial quantity, but the former is inadequately developed.

The metal occurs as the oxide, cassiterite, and is of the variety commonly known as stream tin. Individual pieces vary in size from small rounded grains to pebbles a half inch or more in diameter. The tin pebbles, as they occur on Panther Creek, are sparsely distributed through the lower portion of a bed of gravels which varies from 4 to 20 feet in thickness. This deposit has not been thoroughly prospected and little is known of its merits.

The source of the tin is not known, although it is safe to assume that it is concentrated from primary deposits formed during the older period of mineralization.

MINERALOGY OF LEMHI COUNTY ORES.

GENERAL FEATURES.

Sixty-three mineral species are recognized in the ores of Lemhi County. Seven of these (actinolite, chlorite, epidote, forsterite, garnet, mizzonite, and sericite) are not strictly ore minerals, but their association with the ores where they are found is so intimate that they are included in the following list. It is concluded (pp. 56, 62–63) that the deposits of the county were formed during two general periods of mineralization, the older being late Cretaceous or early Eocene, and the younger late Micoene or early Pliocene. It is noteworthy that most of the minerals of the area appear in most of the older deposits. Pyrite, chalcopyrite, galena, and sphalerite, although varying greatly in relative amount from place to place, are omnipresent, and they are all included in coarsely crystallized quartz. The younger deposits are characterized by fine-grained quartz, adularia, sericite, opal, and chalcedony.

ORE MINERALS.

Any list of minerals based on reconnaissance studies is pretty sure to be incomplete, and the considerable variety noted in Lemhi County suggests that many others are present. In the following list the known species are arranged in alphabetic order, and each is accompanied by brief notes on its occurrence.

Actinolite.—The metamorphic silicate actinolite is developed in schists included in the deposits on Carmen Creek. It is probably also present in the cobalt-nickel ores of the Blackbird district.

Adularia.—Vein feldspar (adularia) is very abundant in the ores from the Gravel Range district and is probably present in the Parker Mountain district. It occurs in minute crystals of microscopic size and generally of rhombic outline. A few crystals are included in quartz grains, but mostly they are intergrown with them.

Anglesite.—Although lead sulphate (anglesite) was seen only in the Texas and Junction districts, it is probably present elsewhere. It occurs as a transition form in the alteration of galena to cerusite but is nowhere abundant.

Annabergite.—Nickel bloom (annabergite) is conspicuous in the outcrops of nickel deposits in the Blackbird district. It occurs as crusts and stains of pale apple-green color.

Argentite.—Silver sulphide (argentite) was noted in small amounts in the Pittsburgh-Idaho mine of the Texas district.

Arsenopyrite.—Iron sulpharsenide (arsenopyrite) occurs intergrown with quartz in some of the veins at Mineral Hill and also in the older deposits at Blackbird.

Asbolite.—Earthy cobalt (asbolite) is found along a few crevices in the cobalt deposits of the Blackbird district.

Azurite.—The blue carbonate of copper, azurite, although nowhere as abundant as malachite, was noted in most of the districts of the county. It occurs in the oxidized portion of those veins which bear copper minerals.

Barite.—Barium sulphate or heavy spar (barite) is intergrown with quartz in one of the gold veins at Mineral Hill and occurs also as a gangue mineral in two deposits of lead-silver ore at Spring Mountain. It is nowhere abundant

Biotite.—Biotite is developed as beautiful rosettes in some of the cobalt-nickel ores (Togo claim especially).

Bornite.—Bornite occurs abundantly in the deposits along the Continental Divide and free gold commonly accompanies it. In the Copper Queen mine it constitutes a copper ore. It was noted in small amounts in many other parts of the county.

Braunite.—The oxide of manganese (braunite) occurs in the ores of the Kittie Burton mine, Indian Creek district, as small brownish-black granular masses and scattered minute pyramidal crystals.

Calamine.—Hydrated zinc silicate (calamine) occurs in beautiful needle crystals and sheaf-like aggregates, protruding from the walls of small cavities in the ores of the lead-silver deposits. The crystals are usually set on a base of smithsonite.

Calcite.—Lime carbonate (calcite) is widespread in the area, occurring in subordinate amounts in the gangue of most veins.

Cassiterite.—Stream tin occurs along Panther Creek near its junction with Moyer Creek and is also reported from Silver Creek. In neither place, however, have deposits of commercial extent been demonstrated.

Cerargyrite.—Horn silver (cerargyrite) occurs in very small particles in the oxidized portions of the lead-silver deposits, being one of the products in the breaking down of argentiferous galena. It was also noted as a secondary product at the Carmen Creek mine and in the Blue Wing district.

Cerusite.—Lead carbonate (cerusite) is by far the most important lead mineral mined in Lemhi County. It constitutes the principal ore in the Nicholia, Spring Mountain, and Texas districts.

Chalcedony.—Chalcedony was noted only in the ores at Parker Mountain, although it is probably present in the other late Tertiary veins.

Chalcocite.—Copper glance (chalcocite), though nowhere abundant, can generally be found a short distance below the surface in the copper-bearing deposits.

Chalcopyrite.—Chalcopyrite is one of the persistent minerals of the area, occurring in all the districts and in most of the deposits. In places it is associated with gold, but commonly is an inconspicuous companion of pyrite. It occurs in very subordinate amounts in the lead-silver deposits.

Chlorite.—Chlorite is developed in many fragments of schist inclosed in the vein filling. It appears in this relation in the Eureka and Blackbird districts.

Cobaltite.—A silver-white cobalt mineral inclined to red occurs in grains of microscopic size in the ores of the Blackbird district. It is probably cobaltite.

Copper.—Native copper occurs as films along some of the fractures of oxidized ores in the Indian Creek district. It was not noted elsewhere.

Covellite.—The copper sulphide covellite was noted in a specimen from the Blackbird district. It occurs as beautiful indigo-blue crusts surrounding cores of chalcopyrite, which in turn are surrounded by iron oxide.

Chrysocolla.—Copper silicate (chrysocolla) was noted as a secondary mineral in the Copper King vein.

Cuprite.—Red copper oxide (cuprite) is found in massive and fine-grained forms in a few parts of the Copper Queen and Copper King mines and in the Patterson Creek district.

Epidote.—The complex aluminum silicate epidote occurs at the Copper King mine and at the Carmen Creek property in small green prismatic crystals in fragments of schist inclosed in the veins.

Erythrite.—Cobalt bloom (erythrite) occurs as an earthy incrustation of pink and pearl-gray color on the outcrops of cobalt deposits in the Blackbird district. In places, as on the Beliel group, this mineral is so abundant on the faces of cliffs that it can be seen for half a mile or more.

Forsterite.—The magnesium-rich olivine forsterite was noted in a specimen of metamorphosed limestone which occurs in connection with galena along the contact with the diorite dike in Dry Gulch, Spring Mountain district. It is developed in dolomitic limestone.

Galena.—Galena is widespread in the area, occurring in all the deposits except those of late Tertiary age. Although it is the source of the minerals which constitute the ore in most of the lead-silver properties, it is worked only in the Junction district. It occurs both in coarse crystals and fine-grained aggregates, steel galena.

Garnet.—Garnet occurs at several places in the schists of the area, but its association with mineral deposits was noted in only a few localities. One of these is at Spring Mountain, where it is associated with the forsterite, and the other is in the copper deposits of the Copper King mine, where it seems to be especially developed in proximity to the vein.

Gold.—Native gold is widespread in the deposits of Lemhi County, small amounts of it occurring even in the lead-silver veins. In the Tertiary veins it is generally very fine grained, but in many of the older deposits it is sufficiently coarse to be seen readily with the unaided eye. Workable placers have resulted only from the older veins.

Hübnerite.—Manganese-rich tungstate (hübnerite) appears as long-bladed crystals and irregular patches in the quartz of the Blue Wing district. It contains 2.01 per cent ferrous oxide, which indicates that about 21.4 per cent of manganous oxide is present. It forms an ore of tungsten.

Iron oxide.—Iron oxide is widespread in the oxidized zone of all the deposits in the district.

Linnæite.—A steel-gray cobalt mineral, which weathers to a reddish tinge, occurs in grains of microscopic size in the cobalt ores of the Blackbird district. Although not definitely determined it is possible that this mineral is linnæite.

Magnetite.—Magnetic iron appears in connection with the ores on Carmen Creek and in some of the veins in the Mineral Hill, Mackinaw, and Eureka districts. It is developed extensively in the copper deposit (Bruce estate) on Spring Mountain.

Malachite.—The green copper carbonate (malachite) is present in most of the deposits of the county. It is only abundant, however, in connection with the copper lodes.

Manganese oxide.—Manganese oxide is coextensive with iron oxide. In places in the lead-silver deposits it is very conspicuous.

Marcasite.—Beautiful spherical nodules of marcasite, up to 1½ inches in diameter, were secured from the Tertiary beds a mile south of Salmon. The inclosing rock is loosely cemented clay sandstone.

Melaconite.—A little of the black copper oxide (melaconite) occurs in the oxidized ores of Copper King mine.

Minium.—Minium was noted in a very few places as a bright-red powder of greasy luster, partly filling little cavities near the surface of the deposit in the Pittsburgh-Idaho mine.

Mizzonite.—The variety of scapolite known as mizzonite appears in one of the slides from the Yellow Jacket district. It occurs in poikilitic areas, including considerable amounts of hornblende.

Molybdenite.—Molybdenum sulphide was noted as films along fractures and as minute scales and grains intergrown with the primary minerals in the tungsten deposits of the Blue Wing district.

Niccolite.—A pale copper-red mineral with dark tarnish occurs in small, indistinct crystals in the ore of the Togo claim, Blackbird district. It is possible that this mineral is niccolite.

Opal.—Opal occurs as linings of microscopic cavities in the Parker Mountain ore. Properties have been located for the exploitation of opal in the eastern part of the Gravel Range district, where the mineral occurs as linings in the vesicules of rhyolite flows. It has not been found in commercial quantities.

Pyrrhotite.—Pyrrhotite is intergrown with quartz in the Kitty Burton vein, Indian Creek district. It is also conspicuous in the Blackbird district, where much of it is nickeliferous. It occurs intergrown with quartz and possibly as a segregation in diabase.

Proustite.—Silver sulpharsenite (proustite) was seen as small red crusts on specimens from Carmen Creek. It is also said to have been found occasionally in the oxidized ores of the Texas and Spring Mountain districts.

Pyrite.—Pyrite appears in all the deposits of the county. In many of the gold veins it is auriferous.

Pyrargyrite.—Thin films and fibers of the steel-gray silver mineral pyrargyrite have been found occasionally in the Junction district.

Pyrolusite.—Pyrolusite, worthy of special mention because of its beautiful dendritic forms, is abundant in many places along fractures and bedding planes in limestone adjacent to the lead-silver deposits.

Pyromorphite.—Short, deeply striated hexagonal prisms of pyromorphite have been secured from the ores of the Texas district. It is, however, one of the rarer minerals of the deposits.

Quartz.—Quartz is widespread in the county.

Rhodochrosite.—Rhodochrosite is meagerly developed in the Kitty Burton vein, Indian Creek district. A beautiful specimen from the Blackbird district was examined; its mode of occurrence is not known.

Scheelite.—Calcium tungstate (scheelite) occurs in the Blue Wing district as thin crusts and specks of pale yellow to white, lining open spaces in the coarse quartz gangue.

Selenide of gold or silver.—A strong trace of selenium, which probably occurs as a selenide of gold or silver, perhaps both, was found in the ores from the Monument mine, Gravel Range district. Its source is probably a blue-black mineral which occurs in scattered and bunched grains of microscopic size. The similarity of these grains to others noted in the Parker Mountain ores suggests that in them also selenium may be present.

Sericite.—Fibrous white mica (sericite) is probably widespread in the area, although it was noted only in specimens from the Indian Creek, Mineral Hill, Mackinaw, and Parker Mountain districts. In the latter district it occurs both in the quartz and in the wall rock adjacent thereto. In the quartz it is probably, in part at least, derived from adularia. It invariably occurs as foils and shreds of microscropic size.

Siderite.—Iron carbonate (siderite) appears in small amounts in many of the lead-silver deposits. Specimens were also noted from the Blackbird and Blue Wing districts. (See Pl. XIII, *B*, p. 72.)

Silver.—Native silver, though apparently very rare, has been found in some of the ores of the Texas district. It is also reported from the Gold Flint property of the Mackinaw district.

Smaltite.—A cobalt arsenide, possibly smaltite, occurs in the Blackbird district, in fine grains of microscopic size, as a replacement in quartzite and schist. It is perhaps the most abundant cobalt mineral in the district.

Smithsonite.—Zinc carbonate (smithsonite) is present, though in few places abundant, in the several lead-silver deposits of the area.

Specularite.—Beautiful tabular crystals of specular iron are present in some of the veins of the Blackbird district. Specularite was also noted in the Mackinaw district and as a micaceous replacement in dolomite in the Blue Wing district.

Sphalerite.—Sphalerite is widespread in the several districts of the area, although nowhere in sufficient amount to constitute an ore of zinc. As much as 10 per cent zinc, probably mostly from secondary minerals derived from sphalerite, appears in some of the lead-silver deposits.

Sulphur.—Native sulphur, partly filling small cavities due to the removal of pyrite, was noted in one of the Clipper Bullion veins, Mineral Hill district.

Tetrahedrite.—Gray copper (tetrahedrite) carrying 1.9 per cent silver occurs as irregular patches and specks in the ores of the Blue Wing district.

OXIDATION AND GROUND-WATER LEVEL.

The depth of oxidation is one of the most vital questions in the exploitation of the gold veins of Lemhi County, for the unoxidized ores yield only a small percentage of their gold to amalgamation, and many of them contain sufficient copper to interfere seriously with cyanide treatment. Most of the properties were temporarily abandoned when primary ores were reached, but a few, especially those at Gibbonsville and Ulysses, have continued to be operated.

In most parts of the county oxidation is almost complete for 100 to 150 feet below the surface, but in the lead-silver areas it extends locally much deeper, in places possibly a thousand feet deeper. With few exceptions (notably in the Leadville mine) oxidation reaches to or below ground-water level. Where it extends below water level, however, the deposits are well above an adjacent valley which determines the low points in the water table, for it can not be assumed that because water will stand in a shaft on a hillside circulation toward the valley (in many instances active flow) does not take place. A shaft thus situated may serve as a secondary low point in the water table and may contain water, but, structural relations being normal, there will be flow from it to low points in the water table. Therefore, as descending ground water is an active oxidizing agent, deposits situated on a hillside can not be considered abnormal even if oxidation extends well below the level at which water stands in adjacent shafts. In Lemhi County, Gibbonsville (p. 13) offers the best illustrations of this relation.

AGE AND GENESIS OF THE ORES BY GROUPS.

SUPERFICIAL DEPOSITS.

The superficial deposits of Lemhi County consist entirely of gold placers. In age they are Miocene (part of those on Kirtley Creek), Pliocene (Moose Creek, Bohannon Bar, Kirtley Creek, Leesburg Basin), post-Pleistocene (Phelan Creek, part of Leesburg Basin); and very recent (Haidee mine). Of the several groups those of Pliocene age have afforded nearly all the production. The sources of all the commercial gold placers are the late Cretaceous gold quartz veins or stringers. Thus, at Leesburg the gold has come from known deposits on the west, and at Moose Creek from veinlets and lenses in the granite on the east. Above Bohannon Bar no veins have been found, but on Kirtley Creek lode deposits are worked. The late Tertiary gold veins at Rabbitfoot have yielded placers, but the production has been meager.

INCLOSED DEPOSITS.

LATE TERTIARY GOLD VEINS.

Late Tertiary veins in the county are included in Miocene rhyolites or in rocks once capped by them. On the other hand, deep valleys, glaciated in their upper parts, cross the lodes at Myers Cove and Parker Mountain. Thus the veins are late Miocene or early Pliocene.

The wall rock of the deposits shows considerable alteration, sericitization and silicification being the important processes. Within the veins adularia is remarkably abundant locally, pyrite is generally present, and selenium, probably as a selenide, is known to occur. It is concluded, therefore, that the veins were formed by hot ascending solutions which deposited along the main channels and permeated the adjacent rocks. These solutions were rich in silica, aluminum, potash, and contained iron, sulphur, and appreciable amounts of gold, silver, and selenium.

The confinement of this type of veins to the proximity of eruptive rocks strongly suggests a genetic relation between the two. The veins and rhyolites should probably be considered different expressions of the same general phenomenon.

LATE CRETACEOUS OR EARLY EOCENE DEPOSITS.

The deposits formed during the earlier period of mineralization present a great variety of types. Some are inclosed in gneiss, some in granite, some in Algonkian sedimentary rocks, and some in Paleozoic limestones, dolomites, quartzites, and shales. In internal make-up the deposits comprise pyrite gold veins, chalcopyrite gold veins, lead-silver deposits, cobalt-nickel deposits, and tungsten deposits. In form they vary from fissure veins to lenses in schist and replacements in limestone. Notwithstanding these differences in the nature of inclosing rock, in mineralogy and in form they have many points in common. All gradations exist between pyrite and chalcopyrite gold veins, although generally either chalcopyrite or pyrite greatly predominates. In all types galena is present, though only locally in commercial amounts, and gold is equally widespread. The tungsten deposits seem to be a special phase of the chalcopyrite gold veins and the cobalt-nickel deposits also are closely related to veins of this type. Throughout the deposits here grouped, coarsely crystallized quartz is characteristic.

From these gradations and similarities, and as all the deposits antedate the Eocene erosion surface and are later than the Carboniferous, it is thought that they represent one period of mineralization. They are all characterized by mineralogic associations, which mean deposition at great depth, at least 4,000 or 5,000 feet, yet they are cut by the Eocene surface, and hence can not be younger, say, than the early part of that erosion cycle. On the other hand, many of the veins are inclosed in, and hence are younger than, late Cretaceous granite. This greatly diversified group of deposits, therefore, is considered as of late Cretaceous or early Eocene age.

The gold veins (see p. 62) are believed to be definitely related to the granite, and as the other types of deposits appear to be merely variations from them, it would seem to follow that all the deposits are related to this great igneous mass. It is noteworthy that the lead-silver and cobalt-nickel deposits differ more widely from the gold-quartz veins than do any of the others. With the former quartz diorite is closely associated and with the latter diabase. These rocks, both of which occur as dikes, are probably differentiations from the granite. On the other hand, acidic porphyries and orthoclase-bearing lamprophyres commonly accompany the gold veins.

ABSENCE OF CONTACT-METAMORPHIC DEPOSITS.

The absence of important contact-metamorphic deposits in Lemhi County is noteworthy. Indeed, the Bruce estate, Spring Mountain district, is the only place where contact metamorphism enters into the genesis of the ore bodies. The explanation of the lack of this phenomenon probably involves two factors—the absence of the more acidic intrusions in contact with limestone and a lack of tendency on the part of the intrusions to cause contact metamorphism. Of these the former is thought to be the most important, as limestones are far more susceptible to such alteration than are schists and quartzites. It would be expected, however, that the broad areas of schist intruded by the granite in the western part of the county would show noteworthy contact metamorphism. But here a difficulty arises, for the schists have suffered extensive regional metamorphism, and although it is thought that contact metamorphism is superimposed upon it locally the extent of this action is not known. Certain it is that metallization in connection with such metamorphism as is known (except in the Bruce estate) is negligible; hence it is believed that the magma lacked those properties which elsewhere in the State have given rise to ore deposits along its contact.[1]

FUTURE OF MINING IN LEMHI COUNTY.

The outlook for a steady growth in the mining industry of Lemhi County is bright. It is thought that most of the free-milling gold ores have been exhausted, but in a heavily wooded and rugged mineral-bearing country there is always the probability of new discoveries.

[1] Lindgren, Waldemar, The genesis of ore deposits: Trans. Am. Inst. Min. Eng., vol. 30, 1901, pp. 721-722.

A large tonnage of base gold ore remains and this will be worked eventually, even though much of it is too low grade to ship other than as concentrates. Placers are expected to become more productive in the future than they have been during the last few years, through the introduction of dredges, which have converted ground heretofore considered valueless for mineral into an asset.

The copper deposits of the area are not developed sufficiently to justify a forecast, but increased production may be expected.

The lead-silver reserves have been largely extended during the past two years. At present most of the ore is coming from three mines, but it is probable that others will enter the list from time to time. This type of deposit has little or no surface expression, and minerals of the gossan are earthy in appearance; hence new and important discoveries may be expected.

The known cobalt-nickel deposits of the county are of uncertain value under existing market and mining conditions. Of the tin deposits little is known. The outlook for a moderate production of tungsten is encouraging.

Lignite has been worked from time to time near Salmon and Baker, but it is highly improbable that it will become of even local importance. As fuel it can not compete with coal shipped in from Wyoming, and if used for producer gas it would be unable to compete with the abundant water power available.

MINING DISTRICTS OF LEMHI COUNTY.

SCHEME OF TREATMENT.

In the following pages each of the 19 mining districts in Lemhi County is dealt with separately. The order of treatment is geographic, beginning at Nicholia in the southeast corner of the county and going north along portions of the Lemhi Range and the Beaver Head Mountains as far as Gibbonsville, thence west to Mineral Hill, and thence south to Parker Mountain, in the southwestern part of the county. This arrangement groups the lead-silver deposits among the districts first treated; the earlier gold veins follow, and the two districts containing late Tertiary gold veins come last.

NICHOLIA DISTRICT.

HISTORY AND PRODUCTION.

The Nicholia mining district, well known to the older miners of Idaho through its principal property, the Viola mine, is situated in the southeast part of Lemhi County, and includes a small area along the west face of the Beaverhead Mountains. The Viola claim, situated at an elevation of 8,700 feet, 2 miles east-northeast from Nicholia post office, was located in 1880 and is the oldest property in the southeast part of the county. Mining was begun in 1882, the ore being hauled to Camas, and thence shipped to Kansas City and Omaha for treatment. It is said that 5,000 to 7,000 tons of ore, averaging 50 to 60 per cent of lead and 10 to 12 ounces of silver to the ton, were thus transported. In the fall and early winter of 1885 two lead stacks were blown in and thereafter the ore was treated locally. Smelting operations continued without protracted intermissions until early in 1888, when depletion of the larger ore bodies began. About 1890 the entire enterprise was abandoned. The amount of lead bullion recovered by the Nicholia smelter for the two years of greatest activity is given in "Mineral resources of the United States" for 1886 and 1887 as 11,900 tons, worth about $1,000,000. The amount of silver accompanying this bullion is not recorded, but an estimate of 300,000 ounces is probably not greatly in error. With silver at 92 cents, this raises the total production for the two years of greatest activity to about $1,400,000. Figures given in the Engineering and Mining Journal (November 27, 1886) are the basis for an estimate of $500,000 total production prior to the construction of the smelter. Allowing an equal amount for the waning period of activity, it seems that an estimate of $2,500,000 for the total production of the Nicholia district is not far from correct.

Prospecting has been pursued continuously in the vicinity of the Viola mine, but so far no important discoveries have been made. In 1905 the old workings were opened and an extensive search made for the continuation of the ore bodies but without success.

GEOLOGY AND ORE DEPOSITS.

The country rock is blue and gray limestone, overlying massive fine-grained quartzite. The main tunnel crosses a north-south anticline recorded by dips of 40° W., gradually changing to flat lying, and then to dips of 60° E. No igneous rocks were seen during the hasty visit to the property, but granite is said to lie about 4 miles north.

The ore occurred as three large bodies connected by stringers. Although irregular in thickness they were remarkably continuous for several hundred feet along the strike of the vein. Along its dip the vein was nearly horizontal for 400 feet, then within a short distance it assumed a dip of 45° and held it for 70 feet; it then became nearly horizontal again, and terminated in a zone of broken ground.

The ore was lead carbonate with much iron and manganese oxide intermixed and ran from 35 to 60 per cent of lead and 4 to 14 ounces of silver per ton.

SPRING MOUNTAIN MINING DISTRICT.

SITUATION AND ACCESS.

The Spring Mountain mining district is situated in the southeastern part of Lemhi County, on the east slope of the Lemhi Range near its summit. Hahn, a settlement of perhaps 100 individuals, is the distributing center for the district. It is reached by wagon road from Gilmore, 8 miles to the north. Prior to the completion of the Gilmore & Pittsburgh Railroad, which was extended to Gilmore in 1910, the most accessible railroad point was Dubois, 75 miles to the southeast.

HISTORY AND PRODUCTION.

Many of the claims in the district were located in the early eighties, when profitable operation at the old Viola mine across the valley inspired prospectors to reach out into the surrounding country. For a few years a little ore was sent to the Nicholia smelter. In the spring of 1909 a smelter of 50 tons capacity was built at Hahn, and made a 17-day run that summer. It was refired in August, 1910, and ran for 21 days. The failure of the enterprise seems to have been due to a lack of funds sufficient to carry on exploration on bonded properties, or to buy ore from other sources. Although these futile efforts have given the district a setback, yet mineralization is widely distributed in the area, affording abundant justification for intelligent and legitimate prospecting.

The production of the district is not known, but an estimate of $50,000 can hardly be much in error.

PHYSIOGRAPHY.

The Spring Mountain district includes the summit and eastern slope of Lemhi Range from Long Canyon south for about 6 miles, Several deep, narrow gulches extend toward the summit, terminating in deep cirques whose western rims form the crest line of the range. Conspicuous among these are Dry Gulch in the northern part of the district, and Spring Mountain Canyon in the southern part, most of the mines being located about the head of the latter.

Surface waters are notably lacking in the area, the streams forming Lemhi River heading about 10 miles to the north, and Birch Creek resulting from springs about an equal distance to the southeast. Within the area melting snow furnishes considerable water, which quickly sinks beneath the surface. In places it reappears as springs on the upper sides of the unfractured quartz diorite dikes, flows across them as small streams, and disappears in the greatly jointed limestone on the lower side. It is these springs far up the mountain face which gave the district its name.

Summit areas within the district present a general accordance in elevation, and many of them are comparatively flat-topped. This is the more remarkable, as the rocks composing the range are steeply folded and present unequal resistance to erosion. These areas are imperfect remnants of the broad plateau which resulted from the elevation of the Eocene peneplain described elsewhere in this report.

GEOLOGY.

The country rock of the Spring Mountain district comprises a great series of late Paleozoic sediments which strike N. 10°–20° E. and in general dip 40° SE. They present a considerable thickness, at least 1,200 feet being exposed in uninterrupted order in the steep eastern face of the south cirque at the head of Spring Mountain Gulch. This exposure, as seen from the opposite rim, appears to be limestone throughout and is composed of beds from 8 inches to 6 feet thick, principally white and gray, but with many bluish layers variously distributed. A small portion of the section along the road from Hahn to the summit, at an elevation of 7,000 feet, follows. Here the beds strike N. 20° E. and dip 85° NW.

Part of section of Devonian beds, Spring Mountain district.

	Feet.
Fine-grained blue siliceous limestone	10
Fine-grained white crystalline limestone	20
Alternating blue and white bands grading into blue limestone	16
Light-gray fine-grained limestone with a few cherty partings	45
Bluish-gray limestone	25
White limestone (base)	20

Fossils were not found in the south part of the district, but the search for them was not exhaustive. On the lower slopes of the range, near the north boundary, a suite of material was gathered, regarding which Mr. Girty says in part: "I believe, therefore, that lot 3 is of upper Mississippian age, but owing to the difficulty of the material there is in this a chance for error." The ore deposits at Spring Mountain, however, lie west of these beds and on lithologic grounds are thought to be principally in the Devonian part of the section, as outlined in the chapter on general geology.

Three or four quartz diorite dikes, one having a width of 1,500 or 2,000 feet but the others of 50 feet or less, follow the general strike of the formations. These dikes usually present no special topographic expression, but can be followed from a distance by their grayish-brown soil, which stands out in contrast to the light-gray mantle resulting from the inclosing limestone. Contact metamorphism was noted only along the large dike, the minerals developed being calcite, coarse flecks of muscovite, biotite, magnetite, vesuvianite, abundant forsterite, and a little garnet, the last two being of microscopic size.

The dikes are obviously younger than the sediments which they cut and older than the present topography, the higher reaches of which they traverse. They are of late Cretaceous or early Eocene age (p. 46).

ORE DEPOSITS.

Prospecting sufficiently fruitful to offer reasonable encouragement to further effort has been carried on along a belt about half a mile wide which starts near the summit west of Hahn and continues northward to the end of the district, gradually dropping down the eastern slope to a point about halfway between the summit and the valley at the northern boundary. All the deposits are contained in limestone, although numerous quartz diorite dikes follow the ore zone.

The ores mined are principally lead-silver, though a low-grade copper deposit is being prospected on the Bruce estate. All the deposits, save perhaps those of copper, are replacements, in type very similar to those at Gilmore (p. 94). The copper deposits were not seen, but from the great amount of magnetite in specimens of the ore, and their stated occurrence along the contact of a large "syenite" (probably quartz diorite) dike, they are thought to have resulted from contact metamorphism.

Ground-water level is always important, both because of increased difficulties in mining and because of the changes in the tenor and mineralogy of the ore which usually accompany it. At present most of the development in the Spring Mountain district is above ground-water level, but its distance above varies greatly from place to place because of unfractured dikes which cut the intricately jointed limestone series and serve as submerged dams, causing the ground water to rise to their upper edge before escaping. In general, on the upper side of any dike the water table will be found at about the elevation of the dike in the bottom of the adjacent canyon. On the lower side the elevation will be determined by the next dike down the mountain side, and so on to the most eastern dike, beyond which the springs at the head of Birch Creek will probably be the controlling factor, allowing, however, a reasonable gradient for the water table.

The ore so far mined in the district has been principally oxidized material, although the Lemhi Union and possibly one or two other properties have furnished some sulphides. The general tenor and make-up of the ore from the district can be readily seen from the table of smelter analyses given on page 65.

As the veins are inclosed in highly folded Devonian (?) and Carboniferous strata and are truncated by an Eocene erosion surface, it follows that they are post-Devonian (?) and pre-Eocene in age. The age can not be determined from local evidence, although general considerations (p. 68) lead to the conclusion that they are late Cretaceous or early Eocene.

The deposits are clearly tabular in outline and correspond to the major fractures in the limestone. In places the ore expands along bedding planes or cross fractures and in other places bunches are isolated in the wall rock. The broader features thus indicate replacement activity, the solutions being guided in their movements by strong north-south fractures, perhaps fissures. No relation was noted between the lead-silver veins, and the quartz diorite dikes save their general parallelism. The mineralogy and reported relations of the copper deposit on the Bruce estate suggest that it is a contact phenomenon caused by the quartz diorite.

MINES AND PROSPECTS.

In the following descriptions only the properties visited will be mentioned. The list is by no means complete, but it serves to give concreteness to the general discussion.

LEMHI UNION MINE.

The Lemhi Union mine, situated at an elevation of 9,000 feet near the head of Dry Gulch, in the northern part of the district, is one of the principal properties. The vein, which is inclosed in blue limestone, strikes N. 20° E. and dips 80° NW. As is common in this general area the limestone corresponds in strike with the vein and dips 40°–50° SE. Quartz diorite dikes cross the gulch both above and below the mine. The deposits were not seen below the surface, for at the time of the investigation the shaft was almost closed by ice resulting from surface waters trickling down the walls and freezing. Analyses of two lots of ore handled by the Hahn smelter show lead-silver ore almost identical with the Gilmore ore deposits (p. 65). One of these lots, amounting to 57 tons, ran 39 per cent lead, 12 ounces silver, 16 per cent iron, 10 per cent silica, and 4.3 per cent calcium oxide.

COLORADO GROUP.

About half a mile east of the Lemhi Union mine is the Colorado group, where some ore has been found. The property is of special interest, however, because it shows better than any other visited the influence of the quartz diorite on the adjacent limestone. A tunnel crosses the margin of the dike at a small angle, giving an excellent exposure for about 35 feet along the contact. The metamorphism consists in the development of calcite, coarse flecks of muscovite, and some biotite, all readily recognized megascopically. In addition, pepper-like specks are scattered through much of the rock. When microscopically examined these prove to be forsterite, one of the olivines, and some garnet crystals. The quartz diorite dike causing the metamorphism is said to be from 1,000 to 2,000 feet wide.

Ore minerals have not been found in the tunnel just referred to, but on the hill above a vein striking north and south and dipping 45° W. furnishes argentiferous galena, manganese oxide, pyrite, and chalcopyrite as primary constituents in a siliceous gangue. Oxidation is fairly extensive.

No genetic relation was observed between the contact silicates first mentioned and the metallic minerals just enumerated.

BRUCE ESTATE.

A group of claims known as the Bruce estate extends along the mountain slope near its summit for 2 miles south from Dry Gulch. The property was not visited. Lead-silver ore is reported from several claims, but the most interesting feature is a big low-grade copper deposit found in association with large quantities of magnetite. The deposit occurs on the side of a big dike which is called "syenite" by the miners, but which is probably quartz diorite, as an abundance of the latter and none of the former was noted in the bowlders of the gulches below.

ELIZABETH AND TEDDY MINES.

These properties, which are about 1,000 feet apart, are situated on the slope of Lemhi Mountain toward Little Lost River at an elevation of 9,700 feet above sea level. Each mine has a few hundred feet of development. The ore is hauled half a mile to the rim of a cirque, 2½ miles west of Hahn, where it is trammed to the bottom, and thence hauled to the smelter. The veins have a general north-south strike and are inclosed in flat-lying limestone and subordinately in quartzite. Together, the properties furnished the Hahn smelter with 400 tons of ore averaging about 20 per cent lead, 11 ounces silver, 10 per cent iron, 21 per cent silica, and 10 per cent calcium oxide.

OTHER PROPERTIES.

The Red Warrior, Iron Mask, Galena, and Excelsior are important among the properties which were not visited. All are held for lead-silver.

TEXAS DISTRICT.

SITUATION.

The Texas mining district comprises an irregular area of about one township in the southeast part of the county near the head of Lemhi Valley. It lies immediately north of the Spring Mountain district, Long Canyon being generally taken as the dividing line. To the north and west not even approximate boundaries are recognized. The junction district lies about 18 miles to the north, and the Blue

Wing district well beyond the summit of the mountains to the west. On the east the wide valley of Lemhi River, deeply filled with Miocene lake beds, forms at present a natural boundary.

Gilmore (Pl. XIV), a mining camp of possibly 500 inhabitants, is the local post office and supply point for the district. It is reached by the Gilmore & Pittsburgh Railroad, which connects via Junction and Bannock Pass with the Oregon Short Line at Armstead, Mont.

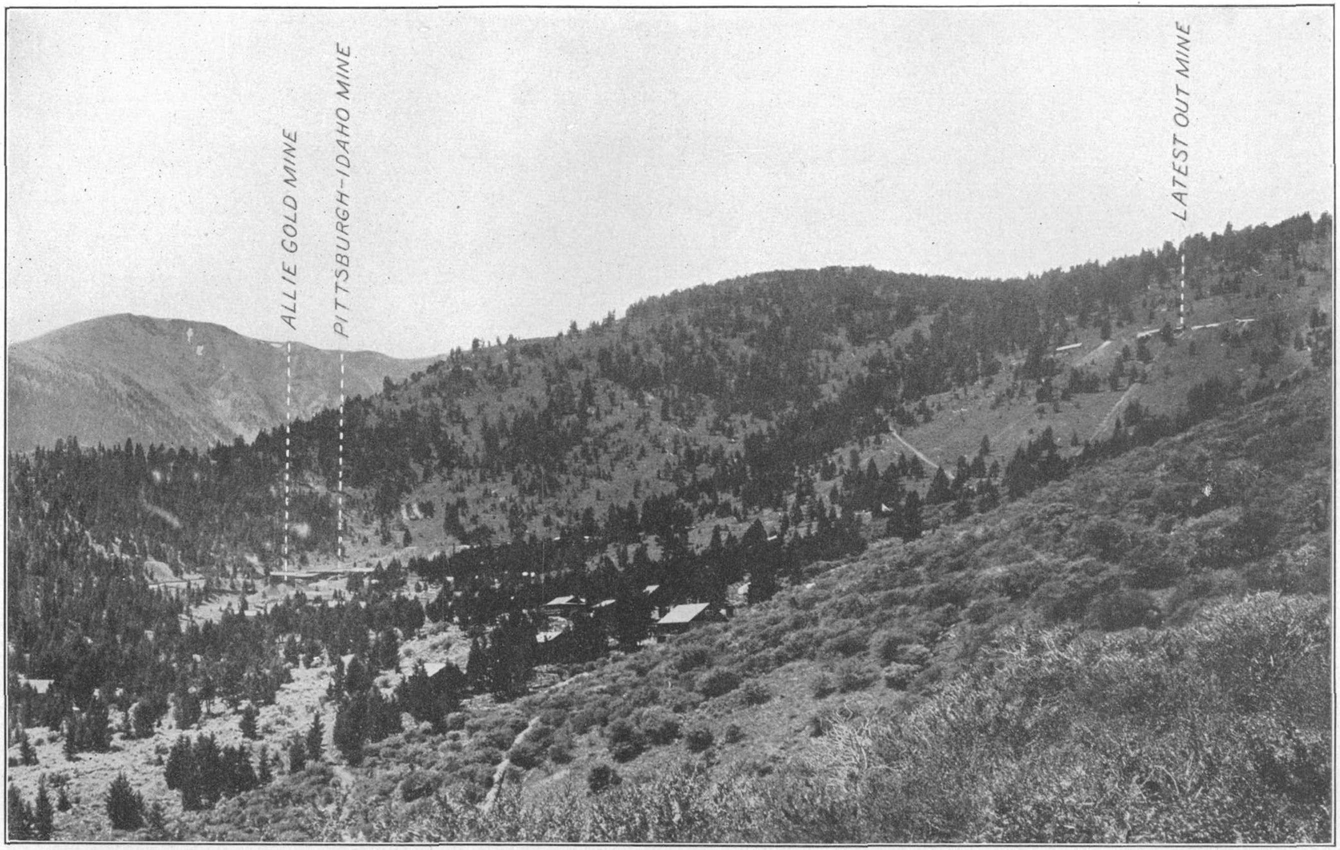
The district is primarily important for its lead-silver ores, although one gold vein (Allie) and one silver vein (Silver Moon) are recognized.

HISTORY AND PRODUCTION.

Inspired by the great bodies of lead-silver ore at the Viola mine, situated across the Lemhi Valley, prospectors located many claims in the surrounding country in the early eighties. The most promising among these claims occupied a belt about 12 miles in extent along the east face of the Lemhi Range, a little north of west from the Viola deposits. The Texas district comprises the northern portion of the mineral belt thus early discovered and largely staked out. In it prospecting continued, and mining was carried on in a desultory way for a number of years, some ore being hauled to the Nicholia (Viola) smelter; but with the abandonment of that property about 1890, whatever enthusiasm may have prompted work in the Texas district died out and for 10 or 12 years there was little progress.

In 1902 a group of claims, the chief of which now constitute the Pittsburgh-Idaho property, were purchased by F. G. Laver, of Dubois, Pa., for himself and associates. Early development revealed, at a depth of about 200 feet, ore bodies which greatly exceeded the anticipation of the owners. In a short time considerable ore was blocked out and the method of treatment became a problem of prime importance. The old Nicholia smelter, which had afforded ready market in the early days of the district, had long since been dismantled, and shipping to the large reduction works in Utah or Montana necessitated a haul of 85 miles by wagon in addition to the railway charges. The alternatives were to erect a local plant or await railway transportation. The wagon haul to Dubois, Idaho, was adopted and continued, during the open season, for four years. The roads were so destructive of wagons, however, that it became almost impossible to keep them in repair, and in the fall of 1906 a traction engine with a train of four steel wagons, each of 15 tons capacity, was put on the road. The cars were not equal to the continued strain even though the route was almost ideal for such transportation, and after a dozen trips this method of haulage was abandoned.

From the fall of 1907 until the spring of 1910 the Pittsburgh-Idaho mine was idle, awaiting the completion of the railroad which was being built from Armstead, a station on the Montana branch of the



MINING CAMP OF GILMORE, FROM NORTHEAST.

Oregon Short Line, 90 miles south of Butte. During this period the Latest Out mine became active, the ore being hauled to Dubois. In the spring of 1909 several of the smaller properties supplied small amounts of ore to a new smelter which was opened at Hahn, in the Spring Mountain district.

With the extension of the railroad to a point within 9 miles of Gilmore by June, 1910, the camp took on new life and has been increasingly active ever since. In 1910 the railroad was within 1½ miles of the producing mines of the district.

The total production of the Texas district probably falls between $2,000,000 and $2,500,000. Somewhat more than 700 tons of lead bullion and over 100,000 ounces of silver are said to have been derived from ores treated by the old Nicholia smelter between 1885 and 1888. From 1902 until 1908 about 6,270 tons of lead bullion and 325,000 ounces of silver were extracted from ores hauled 85 miles to Dubois, and thence shipped to the smelters in Utah. Between June and October, 1910, about 1,600 tons of lead and 72,000 ounces of silver were produced from Texas district ores, and for the fiscal year from September 1, 1910, to August 3, 1911, 7,750 tons of lead and 351,500 ounces of silver were produced.[1]

Prior to 1910 the district produced almost no gold, but during the spring of that year a promising gold-bearing lode was discovered on the Martha claim of the Allie group.

PHYSIOGRAPHY.

Elevations in the district range from about 7,000 feet in the eastern part to more than 10,500 feet in the mountain areas along the western border. The local topographic features are due to numerous deep canyons, which extend back well toward the crest line of an otherwise even mountain slope, which rises abruptly to a height of almost 4,000 feet above the western margin of the broad valley of Lemhi River.

These mountain valleys are invariably U-shaped and near their junction with the lowland present the irregular topography characteristic of terminal moraines; their headward terminations have striking amphitheater-like forms, in the basins of which little lakes are not uncommon.

There are no important streams in the district. Those which rise in the mountains flow for short distances only, the waters sinking before the mouths of the canyons are reached. In the lowland northeast of Gilmore numerous springs occur at elevations of about 6,800 feet; these

[1] The figures for the period prior to Sept. 1, 1910, are largely derived from the known tonnage, estimating lead at 35 per cent and silver at 16 ounces per ton of ore. The silver is not far from correct, although it is quite possible that the early shipments averaged higher than 35 per cent lead. The 8,000 tons of 60 per cent concentrates from the Pittsburgh-Idaho mill and the early production of rich silver ore from the Silver Moon property were considered individually.

give rise to Texas Creek, an important member of the group of streams which by their union constitute Lemhi River. The water supply for Gilmore is derived from a lake at the head of Meadow Lake Gulch, whence it is conveyed to the mines and settlement some 3 miles distant. Although abundant water is thus supplied for domestic purposes, a sufficient supply for concentration on a large scale can be secured only by heavy outlay. Considerable water power can be developed within 20 miles to the north.

GEOLOGY.

SEDIMENTARY ROCKS.

A great succession of sedimentary rocks, striking north and south and for the most part dipping about 45° E., occupies most of the district. Cambrian, Ordovician, Silurian (?), Devonian (?), and Mississippian formations are present. The basal series is made up of clear-white, fine-grained quartzite and is at least 2,000 feet thick. It is well exposed above Meadow Lake. Conformably above it is a series of massive blue dolomitic limestones about 500 feet thick, which is assigned to the Ordovician. Then follows 300 feet of massive white dolomitic limestone of Silurian (?) age. The strata next above comprise about 2,000 feet of thin-bedded blue and white dolomitic limestones, with here and there a siliceous band. This series is tentatively considered Devonian. Its upper contact was not seen, although it is presumably conformable with the Mississippian. The latter formation is exposed along the lower slopes of the range south of Long Canyon.

Above the Paleozoic rocks along the east side of the district, and separated from them by a marked angular unconformity, is a series of Miocene lake beds, the thickness of which is not known, although more than 200 feet appears in some exposures. If the general history of these beds, as given on pages 35–40, is correct, it is altogether probable that along the eastern edge of the Texas district they are more than 2,000 feet thick. As seen in the railroad cuts they present chalk-white slopes cut by regularly bedded layers of light bluish-gray fine volcanic ash, in places almost pumiceous enough to float on water. The bedding is shown by slight variations in color, the individual bands ranging from half an inch to 4 inches in thickness. In some places thin layers of limestone, slate, and quartzite pebbles are interbedded with the tuff, and in others pebbles and sand are intermixed with it.

The lake beds are traversed by minor faults, usually trending east and west. Dips above 25° were not noted, this maximum being recorded just north of the low divide which extends across the valley. South of the same divide the beds dip 15° S., thus presenting an east-west anticline, the axis of which lies about in line with the south branch of Long Canyon. Indeed, as seen from the valley, the limestones traversed by Long Canyon present a similar anticlinal structure. Here, however, the anticline crosses at right angles a series with an otherwise steep eastward dip, the resulting attitude being a dip to the northeast on the north side of the canyon and to the southeast on the south side.

Not much is known of faulting within the area because the different formations were but imperfectly recognized outside the type locality. West of Gilmore the structural relations are simple, but east of it the rock exposures suggest duplication of formations. Over most of the district, however, the beds dip from 40° to 50° E., thus suggesting the absence of much faulting. On the other hand, displacements were recognized in some of the underground studies. On the Martha claim a fault extending N. 10° E. presents a downthrow of possibly 225 feet on the west. A displacement, possibly the northward extension of the one just mentioned, was noted in the Little Gilmore Tunnel. It strikes N. 10° E. and records a downthrow of 55 feet on the west. In both places the fault plane dips approximately 45° W.

Crossing the north-south structure is a series of east-west vertical fissures, which, beneath the surface, commonly stand as open channels from 1 inch to 5 feet wide. In many places they are lined by beautiful aragonite crystals, and in others are loosely filled with débris from the sides. There seems to have been little displacement along them, and this, together with their obviously recent formation, suggests that they are incident to the low east-west anticline clearly recorded in the lake beds to the east. Parallel to these are older fissures, some of which are mineralized near their intersection with the north-south veins. Jointing is conspicuous throughout both the quartzite and limestone portions of the series.

IGNEOUS ROCKS.

Igneous rocks are not abundant in the Texas district, a few quartz diorite porphyry dikes being the only representatives. These are poorly exposed, so that rare outcrops and prospect openings are the only means of determining their distribution and extent. At least two dikes striking N. 10° to 15° E. are present, the east one extending through the Glen and Neversweat claims, above Gilmore. Running west of north are similar dikes, possibly spurs from the others.

In general appearance the dike material is a dark-gray dense porphyritic rock with many medium-sized dull feldspar phenocrysts. On microscopic examination both quartz and biotite are seen to be present in important amounts. The groundmass is microcrystalline and all parts have a higher index than Canada balsam. In many of the feldspars and in much of the groundmass calcite and sericite are conspicuous. The rock may best be designated quartz diorite porphyry.

The dikes were intruded in part at least after mineralization, as shown by an exposure in the upper workings of the Latest Out mine, where one of them cuts across the ore. That they are older than the present topographic features, on the other hand, is clear from an exposure at the head of Meadow Lake, where one of them is exposed in the cirque rim at an elevation of 10,500 feet. As the larger topographic features are post-Eocene, and the ore deposits are late Cretaceous or early Eocene, the dikes were intruded at about the beginning of the Tertiary.

ORE DEPOSITS.

DISTRIBUTION.

The known deposits of the Texas district occur in a comparatively narrow north-south belt bounded on the east by the Miocene lake beds of the Lemhi Valley and on the west by the quartzite that forms the crest of the range and thence dips eastward, disappearing beneath the limestones which inclose the veins.

The mineral locations are mainly along the walls of valleys which cut back into the otherwise regular mountain face, thus exposing the lodes. The mines at Gilmore are situated in such a valley. The Pittsburgh-Idaho mine appears in the south side of this depression near its head, and the Latest Out vein crosses its steep upper end. Several claims, not now operated but showing strong mineralization in places, are situated in Silver Moon and Liberty gulches south of Gilmore, and in Texas and Ulich gulches to the north. (See Pl. XV.)

RELATION TO STRUCTURE.

In general the lodes strike a few degrees east of north and dip west at angles varying widely but usually of more than 45°. Thus the course of the veins is parallel to the strike of the formations although their dip is generally opposite and steeper. This relation suggests that the fissures which the ores follow were formed when the rocks were folded into their present attitude, for it is apparent that fissures with dip toward the core of an uplift would result from the upbending of a great series of rocks with resistant quartzite at the base and inelastic limestone above.

Intersecting the veins at right angles are fissures, some of which are open and unmineralized; others, though seldom mineralized far from the north-south fissures which seem to have carried the solutions, bear a definite relation to the ore shoots. An apparent exception was noted on the Dorothy claim, where an east-west fissure, well removed from any known north-south ore-bearing vein, is locally mineralized. As some of the east-west fissures are barren and others carry ore, it is thought that the east-west breaks occurred at two distinct periods. In a few places where the open or younger channels cross soft north-south mineral veins, loose ore has worked out along the former for several feet; this, however, is the result of purely mechanical processes. An illustration of such condition is seen at the intersection of the Allie crosscut with the Martha vein.

Although the deposits are but rarely offset by faults (all small), slickensides and crushing within the ore are common, implying that movement since the ore deposition has largely followed the original lines of weakness. The faults which cut the veins follow the beds in such a way as to indicate a settling toward the Lemhi Valley of successively overlying strata. The largest offset of this kind is in the west vein on the 400-foot level of the Pittsburgh-Idaho mine, where a displacement of 10 feet is recorded.

The ore deposits, although in some places extending out along bedding planes and in others abruptly evading some rock not as susceptible to dissolution as its neighbor, are on the whole to be considered as tabular bodies and classed as veins. Figure 10 (p. 101) illustrates the veinlike character shown in the Pittsburgh-Idaho mine, and figure 15 (p. 106) illustrates replacement conditions in the Latest Out deposit. In the Jumbo mine the ore is clearly of replacement origin, narrow vertical stringers serving apparently as feeders to larger masses which extend out along the bedding (fig. 16, p. 109). The Latest Out ore body is decidedly tabular in outline, but isolated bunches of ore within the walls adjacent to the vein are common. Figure 14 (p. 105) illustrates a condition which is probably a combination of replacement and fissure filling.

ORES.

The deposits are predominantly lead-silver, only two exceptions being known. One of these is the ore shoot in the Martha vein, which carries no lead, but averages about $12 a ton in gold; the other is the Silver Moon vein, which has produced silver almost exclusively. Copper rarely exceeds a fraction of 1 per cent. Zinc is present in nearly all the deposits, but has not been found to exceed 9 per cent in broad averages.

The structure of the ore is greatly obscured by the extensive oxidation which prevails throughout the present workings. As exposed the ore is a mass of earthy carbonate heavily stained with iron and manganese and usually showing a faint metallic luster. Two types of lead-silver ore may at present be distinguished—oxidized ore consisting of lead carbonate, iron oxide, and other minerals, and primary ore made up of galena, pyrite, and zinc blende.

All the development is well within the zone of oxidation, so that such primary ore as is found occurs in spots which have escaped the influence of surface waters. In the Latest Out mine pockets of sulphide are found as bunches isolated in the limestone adjacent to the veins, and occasionally as cores within large blocks of secondary ore. In the Pittsburgh-Idaho mine, near the bottom of the east vein, where downward-percolating waters are checked by a cross seam of clay, some stopes afford galena and pyrite. In the Jumbo mine oxidation is less advanced than elsewhere, probably on account of little fissuring in connection with the deposit. The primary ore thus exposed is made up of galena, quartz, pyrite, and zinc blende, decreasingly important in the order named.

Probably more than 85 per cent of the total ore exposed in the lead-silver deposits is composed of minerals resulting from the oxidation and carbonation of the group just enumerated. Cerusite and iron oxide are by far the most conspicuous. Anglesite is frequently seen as a narrow band around a core of galena. (Pl. X, *B*, p. 64). Smithsonite is common as botryoidal linings of small cavities and as stringers along joints. Calamine occurs as needle-like crystals extending from the sides of vugs otherwise lined by smithsonite. Manganese oxide is omnipresent as stains within the ore and less frequently as dendrites on the inclosing limestone. Pyromorphite is rare, cerargyrite probably very common but in exceedingly small grains, malachite unusual, and minium very exceptional.

The general tenor and make-up of the ore are shown in the table on page 65.

In striking contrast to the composition of the lead-silver ores is that of the gold ore of the Martha vein, from which several shipments have been made. Like the lead-silver ores, the grade is remarkably uniform. The analysis below may be considered typical. In appearance the ore is a dull, earthy, more or less incoherent mass, heavily stained by iron and manganese.

Analysis of smelter ore from Martha gold vein.

Gold	ounce..	0.515
Silver	do....	.70
Silica	per cent..	11.7
Iron	do....	47.7
Lead		None.

This vein carries gold in commercial amounts but contains very little silver and no lead; in all the other veins, except the Silver Moon, the relation is the reverse. The Silver Moon is said to have produced silver almost exclusively.

GROUND-WATER LEVEL AND OXIDATION.

Nowhere in the mines of the district has ground-water level been reached. Some idea of its depth, however, may be formed from a consideration of the large springs which appear in great numbers in the adjoining valley at elevations of 6,600 to 6,700 feet. These springs, which undoubtedly drain most of Texas district, appear about 3 miles northeast of the mines at Gilmore. Just what slope the water table has between the mines and the springs is not known, but with open east-west fissures, some of which are 2 feet or more wide throughout considerable parts of their length and with intricate north-south jointings, it seems very probable that the increase in elevation of the water table from the springs to the mines is comparatively slight, probably much less than 100 feet to the mile. A study of the general geology of the district discloses another factor which probably has a bearing on ground-water level. Comparatively recent dikes of quartz diorite porphyry cut north and south through the area. They did not participate in the folding which caused the steep eastward dip and are probably antedated by very much of the jointing in the limestone. They have, however, been involved in the movement which developed the east-west open fissures. It thus appears that with submerged dams broken in only a few places, as compared with the intricate jointing elsewhere prevailing, the water level will be somewhat higher west of the dikes than east of them. It thus appears that permanent water level will probably be found in the vicinity of the Pittsburgh-Idaho mine at 6,800 to 7,000 feet. In the territory farther west, as at the Latest Out mine, it will probably be found at a somewhat higher level.

Throughout that portion of the deposit now developed oxidation is essentially complete. The mineralogic character of the primary ore in the lead-silver deposits is not fully known, but chance bunches of unaltered ore indicate that the present deposits are derived from argentiferous galena, pyrite, and sphalerite, together with minor amounts of some manganese mineral and a little chalcopyrite. Analogy with other lead-silver deposits in the State, notably those at Cœur d'Alene and Wood River, suggests that siderite also may be present in the primary ore, but none was seen. The important chemical and mineralogic changes involved in the alteration of these ores have been the conversion of argentiferous galena to cerusite and cerargyrite, of pyrite to limonite, and of sphalerite to smithsonite. Anglesite occurs in several places as a narrow band between galena and cerusite. It is everywhere very subordinate in amount, clearly indicating that the transition to cerusite follows very quickly after the breaking down of the galena, even though the sulphate is probably always an intermediate form. Minium, calamine, argentite, and manganese oxide are other secondary minerals which occur, although only the last abundantly.

As the alterations noted in the deposits necessitate an increase of volume per unit of metal contained (pp. 66–68), and as the deposits are more porous now than formerly, a considerable extraction of one or more elements must have taken place. From the relative rate of oxidation, and the relative solubility of the oxidation products, it appears that lead has remained essentially stable, iron has probably been somewhat removed, and zinc removed in considerable quantities.

From the above it is concluded that below the zone of oxidation lead will decrease slightly in amount per ton of ore. This follows from the conclusion that iron will increase somewhat and that zinc will probably increase materially. In other words, it is thought that there is a slight concentration of lead in the oxidized ore by reason of the leaching of other constituents of the deposit.

AGE AND GENESIS.

The deposits of the Texas mining district are of late Cretaceous or early Eocene age, although local evidence does not confine the limits so closely. The veins are obviously younger than the Carboniferous limestone, which is mineralized in places. They are younger than the quartz diorite dikes, for one of the latter cut the ore as shown in the upper workings of the Latest Out mine. The dikes in turn are older than the present topographic features, for they cut across the mountain tops, as near the head of Meadow Lake. As the present topographic features are post-Eocene, it follows from local evidence that the deposits are post-Carboniferous and pre-Oligocene. From broader considerations, however, it is thought that the deposits are late Cretaceous or early Eocene. (See p. 68.)

Alteration has been so complete that the ore itself retains few of those evidences of origin which are generally recorded in mineralogic structure and relations. That the deposits were formed at a depth of 2,000 feet or more is evident from their relations to the topography. The general features of the deposits indicate that both replacement and fissure filling have taken place. In the Pittsburgh-Idaho mine the east fissure continues downward after the ore has given out. In the Latest Out mine also the vein walls continue in many places after the ore has entirely ceased.

The veins are clearly older than the quartz diorite porphyry dikes which cut them. It is, however, interesting that throughout the Texas district and the Spring Mountain district to the south, these dikes are never far removed from the ore deposits, possibly indicating that the two have a common source. Broader considerations (p. 68) lead to the belief that the ores of the Texas district are genetically related to an underlying granitic or monzonitic mass corresponding to the great batholith extensively exposed in central Idaho to the west, probably in the Wood River district to the south, and at many places along the Beaverhead Mountains to the east.

MINES.

PITTSBURGH-IDAHO MINE.

Situation and development.—The Pittsburgh-Idaho mine is situated near the town of Gilmore, in the southeast part of Lemhi County, at an elevation of 7,800 feet above sea level. In 1910 the Gilmore & Pittsburgh Railroad had been completed to a point within 1½ miles of the mine, thus affording ready transportation.

The history of this group of claims is essentially the history of the Texas district. (See p. 90.)

The production of the property prior to September 1, 1911, consisted of about 12,000 tons of lead bullion and about 500,000 ounces of silver, approximately 45 per cent of which was shipped during the fiscal year 1910–11.

Development has been largely confined to two of the five claims owned by the company, the Silver Dollar and the Sixteen to One. (See fig. 9.) On the upper levels the Silver Dollar was the more productive, but with increasing depth the ore shoots pitched south into the Sixteen to One ground, and at present that claim affords nearly the entire output.

The mine is worked from a double-compartment shaft sunk from an old tunnel level 100 feet above the present adit and about 110 feet below the surface of the ground. Although now entirely abandoned, the old tunnel is still the reference point in naming the several levels. Thus the present working adit is known as the 100-foot level. Below it the shaft continues for 300 feet, and from it drifts and crosscuts aggregating about 3,000 feet have been extended on the 200, 300, and 400 foot levels. From the latter an incline winze reaches to the 500-foot or deepest level.

Geologic conditions.—Throughout the workings blue fine-grained Devonian limestone, extensively jointed and locally greatly crushed, is the prevailing country rock. Within this are lenses (and possibly here and there a bed) of fine-grained white lime, the largest observed measuring perhaps 35 feet in maximum thickness. These lenses frequently protrude into the ore fissure in a most remarkable way, and almost invariably they are covered with slickenside surfaces recorded in a layer of talcky pulverized lime. In general the limestone dips from 30° to 50°.

Quartzite, which dips toward the mine, crops out about 4,000 feet to the west. It will not be encountered in the workings, however, until they have been extended 2,000 feet or more.

Ore deposits.—The ore bodies in the Pittsburgh-Idaho mine comprise two nearly vertical veins and a flat vein which connects them and continues in depth beyond the west one. (See figs. 10–12.) All strike N. 15° E., as does also the inclosing limestone, and each has a general westerly dip, opposite to that of the limestone The east and west veins, however, are in some places vertical and in few dip less than 70°; the flat vein mostly inclines at an angle of about 45°. The flat vein joins the east vein about 30 feet below the 200-foot level but

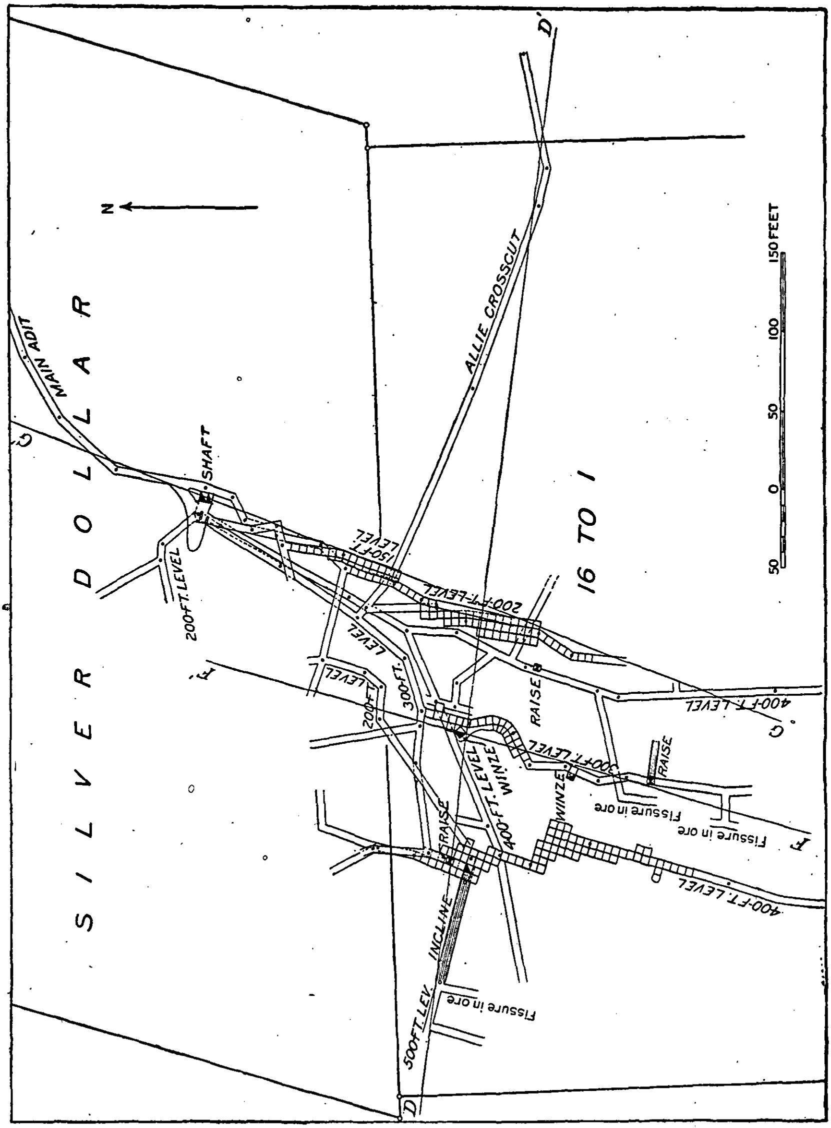


FIGURE 9.—Plan of part of underground working of the Pittsburgh-Idaho mine, Texas district. Adapted from map by C. A. Peet.

has not been found to the east. Westward it continues across the west vein and is now being worked on the 500-foot level.

In general outline the deposits are tabular and clearly to be classed as veins, yet in detail they are irregular. Many small swells extend into the walls and in places spurs follow joint planes for short distances. Usually the contact of vein material with wall rock is clean cut, but here and there isolated bunches of ore extend into the lime-

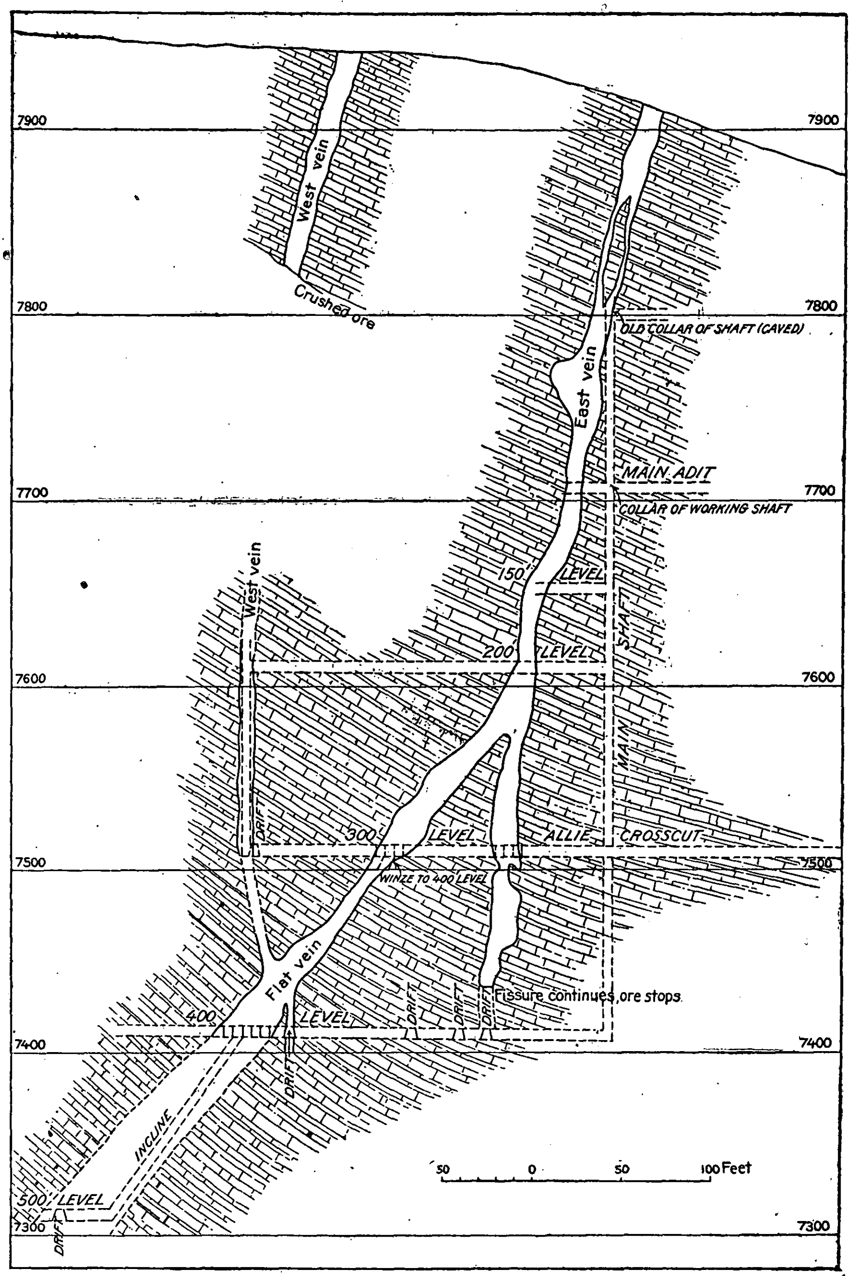


FIGURE 10.—Transverse section through Pittsburgh-Idaho mine, Texas district.

stone. In some places, notably in the bottoms of the lower stopes on the east vein, the ore stops abruptly, though the fissure continues with well-defined walls.

From these general relations it appears that the solutions depositing the ores entered along open fissures and that the principal deposition took place in cavities already existing. That the solutions were capable of replacing the limestone, however, is clearly shown by the isolated bunches of ore within the walls adjacent to the veins and also by the swells of ore into the wall rock without corresponding swells of wall rock into the ore on the opposite side.

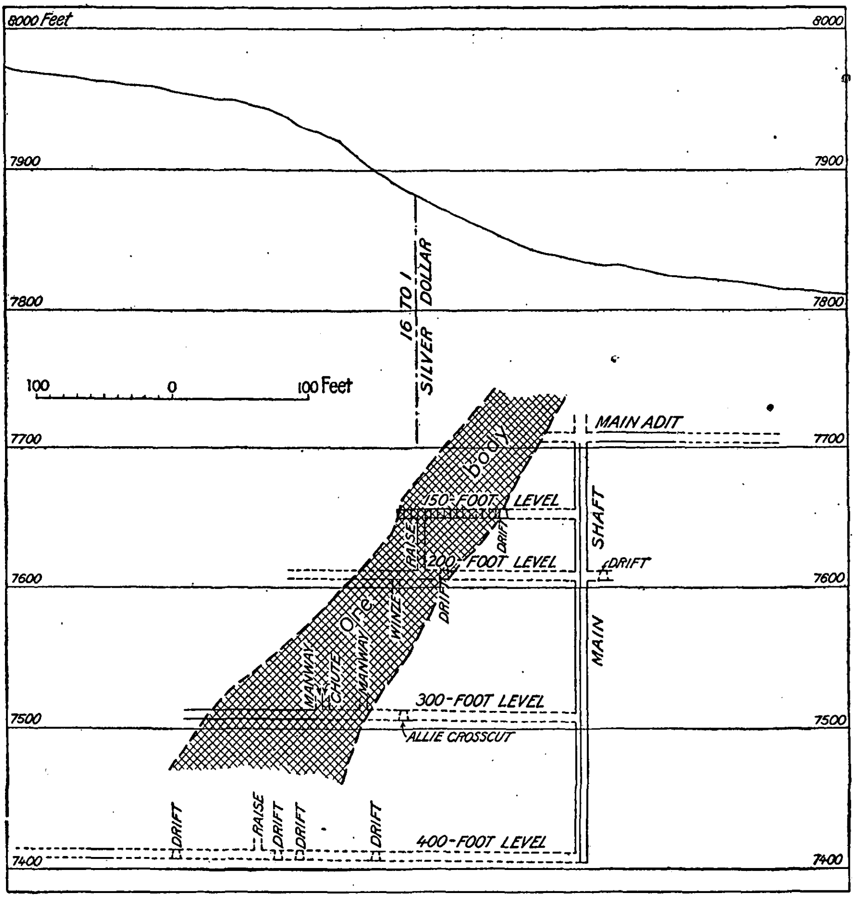


FIGURE 11.—Longitudinal section of east vein, Pittsburgh-Idaho mine, Texas district.

The ore material, all of which is at present derived from below the 200-foot level, is characterized by a high percentage of metallic elements, lead, zinc, and iron together constituting over one-half of the vein filling. The material occupying this part of the vein is very different from that which was originally deposited in it and which presumably still continues below the level of ground water. In this original material galena, pyrite, and sphalerite were abundant, but in the existing material the filling is earthy lead carbonate accompanied by abundant iron and manganese oxides. The zinc carbonate, smithsonite, is common as druses in cavities of secondary origin and as a granular intermixture with the cerusite. Calamine was noted as radiating groups of needle-like crystals protruding from cavity walls otherwise covered by botryoidal smithsonite. (See Pl. X, *C*, p. 64.)

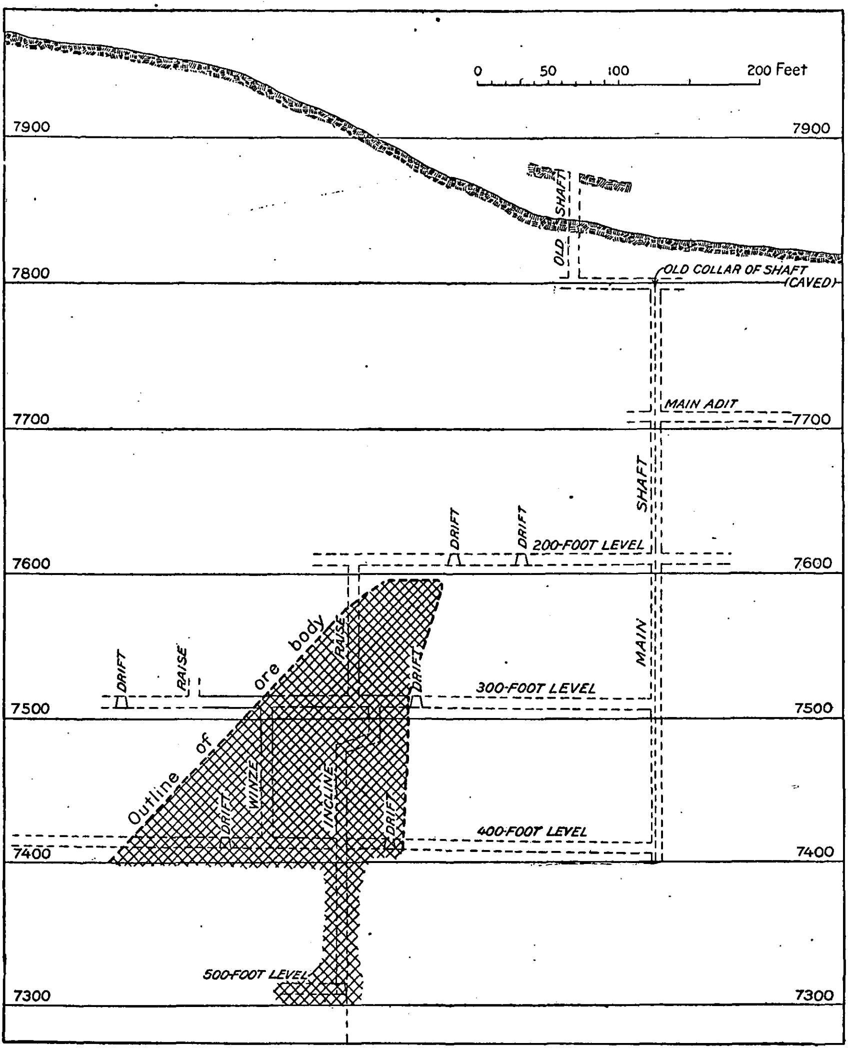


FIGURE 12.—Longitudinal section of flat vein, Pittsburgh-Idaho mine, Texas district.

The ore averages about 37 per cent of lead and 15.25 ounces of silver, and in the 500 feet of depth thus far attained little or no change has been noted in its tenor. As the ground-water level, and hence lower limit of oxidation, will probably be encountered at an elevation of about 6,900 feet above sea level, and the lowest level at present is 7,100 feet, it is probable that little change in the character of the ore will be encountered within the next 200 feet.

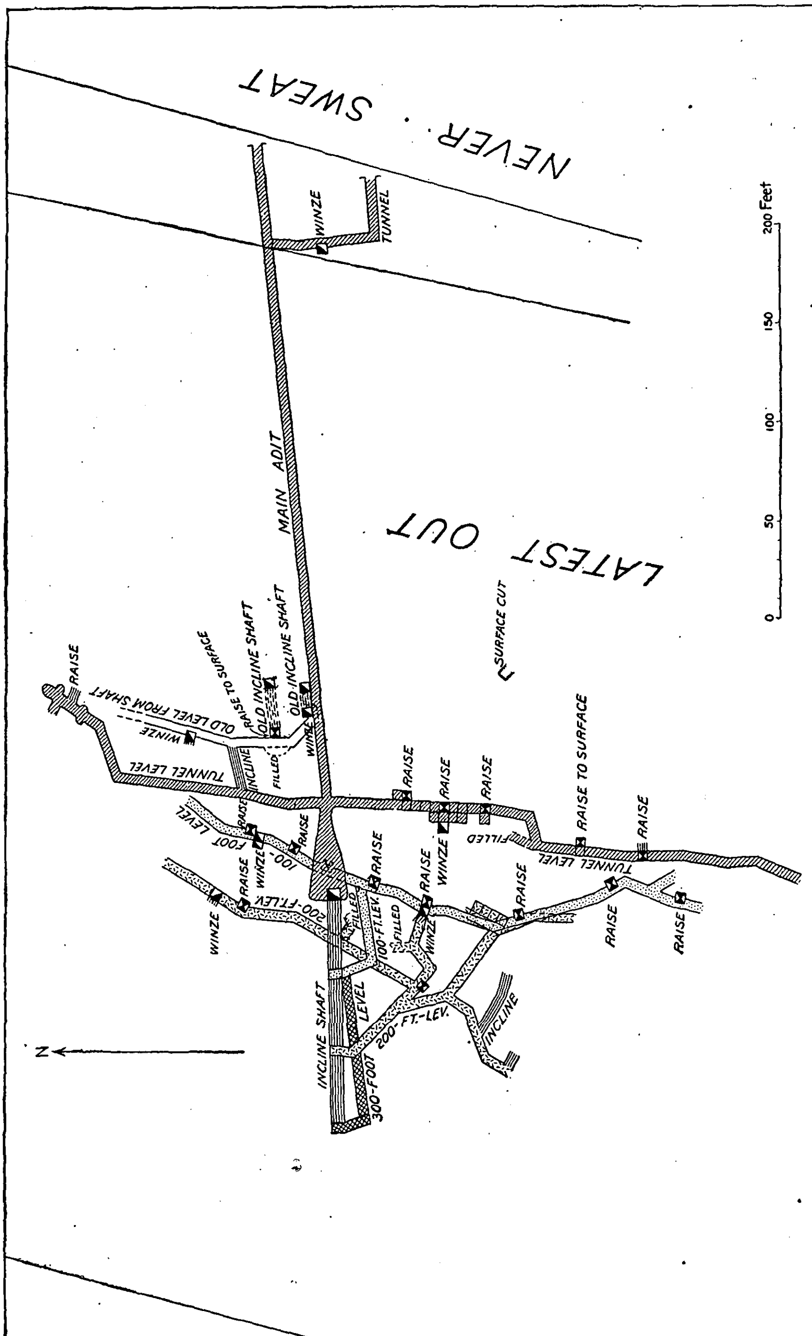


FIGURE 13.—Plan of underground workings, Latest Out mine, Texas district. Adapted from map by C. A. Peet.

LATEST OUT MINE.

Situation and development.—The Latest Out mine is situated in the central part of the Gilmore division of the Texas mining district. The property consists of one claim owned by the Latest Out Mining & Smelting Co.

Development consists of a tunnel which enters the hill at an elevation of 8,100 feet and intersects the vein 340 feet from the portal, whence an incline shaft extends 220 feet. Laterals aggregating 800 or 900 feet extend from the shaft at the 100, 200, and 300 foot levels. The ground above has been worked principally from openings farther up the mountain. These comprise 300 to 400 feet of development. (See fig. 13.)

The claim was located in 1880 and during the four or five succeeding years 1,200 to 1,500 tons of ore was hauled to the old Nicholia smelter. Not until 1908, however, when Ralph Nichols gained control, was substantial development undertaken. In 1908 and 1909 about 200 tons of ore was hauled 85 miles to Dubois and thence shipped to Salt Lake. With the advent of the railroad in 1910, transportation costs were so reduced that mining and development were undertaken on the larger scale which has since continued. Up to September, 1911, the gross production was about $350,000.

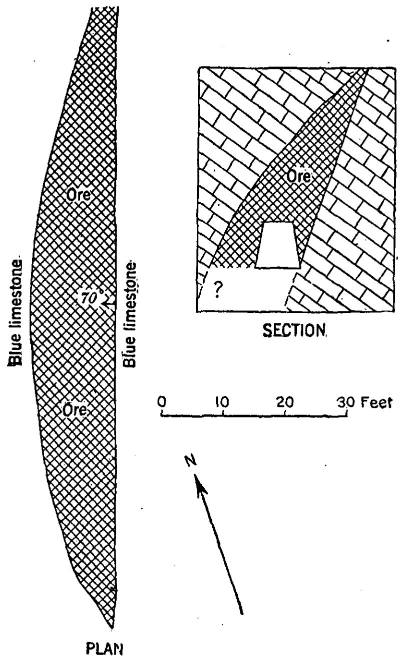


FIGURE 14.—Outline of ore body exposed in north drift, 100-foot level, Latest Out mine, Texas district. Shows the local lenslike form of the ore body both along the dip and the strike.

Geologic conditions.—The country rock is fine-grained blue Devonian limestone, underlain at a depth of 2,000 to 2,500 feet by white fine-grained quartzite. Both limestone and quartzite dip about 25° E. A dike of quartz diorite porphyry 45 feet wide extends N. 42° W. through the property, crossing the adit level 275 feet from the portal. It is also exposed in the upper workings, where it cuts across the vein. Very little if any alteration of the ore or of the limestone has been produced by the intrusion, although the weathered condition of the material precludes accurate determinations.

Two east-west open fissures, having a maximum width of about 5 feet but not averaging over 5 or 6 inches, have been encountered in the workings and are clearly postmineral. In the big stope between the 100 and 200 foot levels, however, similar cross fissures represent points of maximum width in the vein and are evidently older than the deposits. They appear to be unmineralized beyond a few feet from the main ore body, a fact which suggests that, instead of carrying mineralizing solutions themselves, their intersections with the north-south channels merely afforded favorable places for replacement.

Ore deposits.—The ores of the Latest Out mine occur as irregular lenses along a rather poorly defined fissure which strikes a little east of north and dips about 70° W. (See fig. 14.) In the few places where grooves were noted they pitch about 50° S. Thus they occur

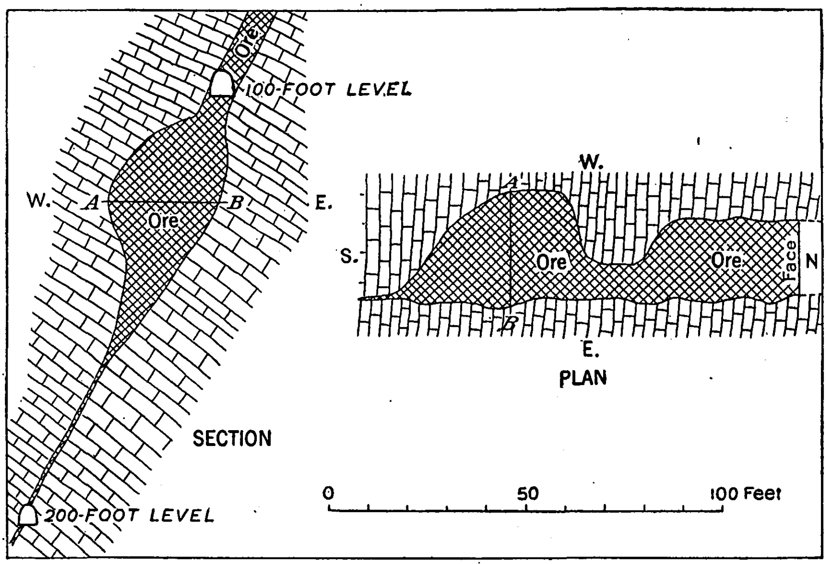


FIGURE 15.—Diagram illustrating replacement phenomena in Latest Out mine, back of incline between 100 and 200 foot levels. A-B is common to both the plan and the section.

in the south drift on the 100-foot level, where the walls are well defined but the fissure barren of ore. This relation of fissure and grooves is interpreted to mean that the ores occur along a fault, probably, however, one of minor displacement. In places the walls are in juxtaposition; in others, ground and crushed limestone fills the 3 or 4 feet intervening; and in still others, ore is the filling material. Much of the limestone adjacent to the vein contains isolated bunches of galena and rarely sphalerite, both of which from their position are clearly of replacement origin. (See fig. 15.) In most places, however, complete oxidation and carbonation have destroyed all the evidences of origin which ore usually discloses. As exposed at present the ore is an earthy iron and manganese stained material, mostly incoherent. Fresh fractures show granular cerusite intimately mixed with iron oxide.

In general, the ore runs about 18 ounces in silver to the ton, 34 per cent lead, 10 per cent iron, and 5 per cent zinc.

ALLIE MINING CO.'S PROPERTY.

Situation and development.—The Allie Mining Co. owns 18 claims surrounding the Pittsburgh-Idaho and Latest Out properties at Gilmore. The group was located in 1903 and the present company organized in 1905. About 6,000 feet of development work has been done, principally on the Gilmore, Ruth, Glen, and Martha claims.

Ore deposits.—The extensive prospecting done by the company has not disclosed commercial deposits of lead-silver. Recently, however, a promising gold vein has been discovered on the Martha and Dorothy claims, and it is estimated that about 15,000 tons of ore, averaging about $12 per ton in gold, are blocked out.

The ore, which is inclosed in flat-lying Devonian (?) limestone, occurs along a fractured zone, probably a fault plane, extending N. 10° E. and dipping about 20° W. It is developed from the Dorothy ground by a tunnel which taps it about 200 feet below the surface, and 228 feet lower it is reached by a crosscut from the 300-foot level of the Pittsburgh-Idaho mine. From the lower level a raise has been driven 175 feet on the vein and a vertical winze sunk 50 feet with crosscut to the vein. On several levels drifts extend laterally to the margins of the shoot, which as thus outlined averages 12 feet wide by 30 feet long.

The ore is an earthy iron and manganese stained mass, very soft, and in places showing casts of small pyrite crystals. Partial analysis shows 49 per cent iron oxide, 5 per cent silica, $15 in gold, a trace of silver, and no lead. The total absence of lead and the comparatively high value in gold distinguish this vein from the other known deposits of the district. It is thought, however, that it was formed during the same period of mineralization as the lead-silver deposits.

Ore has been exposed on the Ruth claim, though not in commercial quantities. It is of interest chiefly in that it occurs along a well-defined east-west fissure. The fissure is filled mainly with gouge, through which the ore is sparsely scattered as small lenses and irregular bunches.

A promising claim of the Allie group is the Roy Sauer, which joins the Latest Out on the west. It is as yet unprospected, an incline shaft 20 feet deep being the principal opening. This extends down a fissure about 4 feet wide which dips 50° W. It contains heavy iron and manganese oxides and a little lead carbonate.

OTHER MINES AND PROSPECTS.

Numerous less-developed properties south of Gilmore are grouped below under the heading "Silver Moon and Liberty gulches," and others to the north under "Texas and Ulich gulches." Not many of them were visited. Two or three are of special interest as throwing light on relations in the district.

Silver Moon and Liberty gulches.—Silver Moon and Liberty gulches are deep narrow valleys which extend back into Lemhi Range from points about 3 miles and 1 mile, respectively, south of Gilmore. In Liberty Gulch several hundred feet of development work has been done. In Silver Moon Gulch most of the deposits strike north and south with the limestone but dip west, almost at right angles to the dip of the latter. The Silver Moon vein is an exception in that it lies with the bedding of the inclosing formation. This vein differs also from the others in being predominantly a silver instead of a lead deposit. The Silver Moon ore body, as exposed in the tunnel level, is in the form of a lens about 50 feet long and 30 inches in maximum thickness, feathering out to the north and south. The vein is said to have produced about 80,000 ounces of silver during its period of activity, 20 or more years ago.

Other properties in the gulch produced a little lead-silver in the early days of the district. Chief among these are probably the Grace Phelan and Hecla groups.

Texas and Ulich gulches.—Texas Gulch, from which the Texas mining district derives its name, is situated about 2 miles north of Gilmore, and extends back into the mountains for several miles as a deep flat-bottomed canyon. Its principal properties are the Mountain Boy and Portland, neither of which was visited.

Several properties are situated in Ulich Gulch, one-fourth mile farther north, but only two—the Jumbo and the Democrat—were visited. The Jumbo deposit is opened by tunnel and incline shaft, all together constituting perhaps 800 to 1,000 feet of development. The inclosing limestone strikes N. 20° E. and in general dips east, although there are many local variations to the west. A diorite dike about 12 feet wide follows the strike of the limestone and dips 70° to 85° W. This deposit is of special interest in that it reveals, more conclusively than any of the others visited, the replacement phase of the lead-silver deposits. Stringers of galena and cerusite following joint planes here and there merge into irregular lenses of ore which extend for several feet along the bedding; in some places both ways from a given joint, in others in but one direction, either up or down the dip (fig. 16). Many of these lenses are made up of unaltered material, but some are composed entirely of secondary minerals. About 400 tons of ore running 37 per cent lead, 48 ounces in silver, and $3.50 in gold have been shipped from the property.

Near the mouth of Ulich Gulch is the Democrat mine. It was staked in 1880 and is said to be the earliest located in the district. The vein, which is wide and persistent, corresponds in strike to the inclosing limestone. Both dip east, the vein 70° and the limestone about 45°. The gangue is very siliceous, carrying galena and pyrite, together with minor amounts of derivatives from them. The ore is said to contain about 9 per cent lead and 4 ounces in silver.

BLUE WING DISTRICT.

SITUATION AND HISTORY.

The Blue Wing mining district comprises a small area along the middle and headwaters of Patterson Creek, a stream draining south to Pahsimeroi River from the crest of Lemhi Range. It is 20 miles southwest of Leadore, Idaho, which will be the outlet when a wagon road, now in course of construction, is completed over the range. Prospecting within the district has centered about Ima, a small settlement 2 miles above the mouth of Patterson Creek canyon.

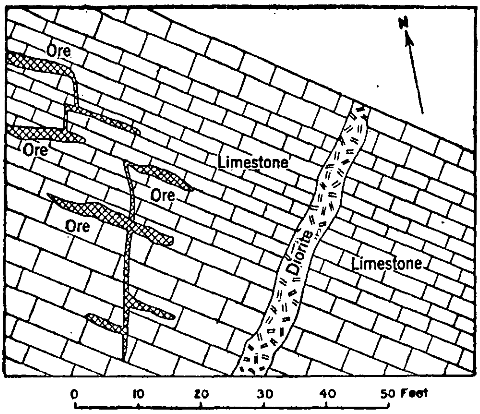


FIGURE 16.—Sketch illustrating occurrence of ore and geologic relations in Jumbo mine, Texas district. Diagrammatic in part.

Mineral locations were made near Ima as early as 1881, but active developments did not begin until 1900, when the Ima Consolidated Mining & Milling Co. started exploratory work which continued during the four succeeding years. Tungsten was first recognized in 1903, but not until the spring of 1911 did it attract serious attention. About this time the Idaho Tungsten Co. was formed and secured a seven-year lease on the 21 patented claims owned by the Ima Co. Subleases have been let to two or three companies and new locations made by individuals.

A 50-ton capacity concentrating mill has recently been installed, it being the plan to produce a 60 per cent concentrate for shipping. Developments consist of four or five tunnels and an incline shaft 75 feet deep; in all, perhaps 2,000 feet of work. The lower tunnel enters the west wall of the canyon near the creek level and the others extend in the same direction at irregular intervals above. The first above, which is known as No. 4 tunnel, is 900 feet long.

GEOLOGIC RELATIONS.

The deep, narrow canyon of Patterson Creek is cut across a prominent anticline which reaches from the canyon's mouth to the forks of the stream 2 miles above. At the lower point the beds incline 40° to 90° W., and at the upper they dip almost as steeply in the opposite direction. The rocks are quartzitic slates and schists with a little sericitic and chloritic schist, and succeed one another in monotonous succession. They are of Algonkian age, probably representing the upper members of that series.

No igneous rock outcrops in the immediate vicinity of the mines. Bowlders of quartz diorite along Patterson Creek, however, support the statement that an igneous mass appears at the surface a short distance up the west fork.

ORE DEPOSITS.

The principal mineral deposits now known cross Patterson Creek about a mile above the mouth of its canyon. From the creek level, it is said, the veins outcrop at intervals to the west rim of the canyon, 2,200 feet higher. They follow fractures which in general parallel the anticlinal axis, running N. 30° to 40° W., but locally digress 20° or more. The dip of the veins is usually 50° to 70° SW. They vary in width from stringers to 10 or 12 feet, and in one place in the lower tunnel to 20 feet. The vein filling is coarse-textured, bluish quartz, extensively crushed by postmineral movements. Its contact with the hanging wall is usually sharp, although many stringers extend out into the country rock, and in places several parallel veinlets accompany the main vein. The foot wall is locally less clearly defined, quartz being intermixed with crushed wall rock.

Scattered rather sparsely and very irregularly through the coarse white quartz are crystals and irregular areas of sphalerite, tetrahedrite, pyrite, hübnerite, galena, molybdenite, and chalcopyrite. These are clearly of primary origin, but in addition to them are a considerable number of minerals which, from their occurrence along fracture planes, in cavities, and near the outcrop, are thought to be secondary. Among them limonite, malachite, azurite, and manganese oxide are common, and cerargyrite, bornite, chalcocite, cuprite, siderite, possibly molybdenite, and scheelite are comparatively rare. Following is a list of the minerals seen in the deposit, with notes on their peculiarities and occurrence.

Azurite.—The blue copper carbonate occurs as stains in the oxidized ore.

Bornite.—The purple copper-iron sulphide occurs closely associated with chalcopyrite in partly oxidized ores.

Cerargyrite.—Silver chloride appears in the oxidized zone as one of the products in the breaking down of tetrahedrite. It occurs as green and gray crusts.

Chalcocite.—Copper glance is found in some of the oxidized ore.

Chalcopyrite.—The primary copper-mineral chalcopyrite occurs as small, irregular patches in the firm quartz.

Cuprite.—The red copper oxide is rare.

Galena.—Lead sulphide occurs as fine-grained masses and rarely as small cubes. It is not conspicuous in the ore.

Hübnerite.—Manganese tungstate is the chief ore of tungsten in the district. The variety here found contains 2 per cent of iron oxide and about 76 per cent of tungsten trioxide. It occurs embedded in the quartz either as reddish-brown masses or crystals and is likely to be confused with the peculiar type of sphalerite found here. The two may be distinguished easily, however, by scratching a smooth face, the latter giving a gray streak readily distinguished from the brown streak of hübnerite.

Limonite.—Limonite is abundant near the surface and occurs in a great variety of shades from almost red to lemon-yellow.

Malachite.—The green copper carbonate is locally conspicuous in the oxidized ore.

Manganese oxides.—Manganese oxides occur in a variety of forms from black powder to dendrites and beautiful aggregates of radiating prismatic crystals. (See Pl. XIII, *A*, p. 72.)

Molybdenite.—Molybdenum sulphide occurs as sheens on fracture planes, as thin foliated masses lining small crevices, and as scales and small grains intergrown with the primary ore minerals.

Pyrite.—Pyrite occurs as small cubes and irregular patches embedded in the quartz.

Scheelite.—Calcium tungstate is not important in the deposits. It occurs as pale-yellow grains in the powder which locally fills crevices in the ore and rarely as small druses in cavities near the surface.

Siderite.—Carbonate of iron occurs as very small platy crystals covering fracture faces. (See Pl. XIII, *B*, p. 72.) They vary from dark brown to straw color. Many of the plates stand on edge.

Sphalerite.—Zinc blende, almost black in color, is common in the ores and is likely to be confused with hübnerite. Its characteristic light-gray streak affords an easy means for field identification.

Tetrahedrite.—Gray copper is abundant locally as irregular masses of peculiar greenish color. Partial analysis by R. C. Wells, of the Survey laboratory, reveals 1.9 per cent of silver and 29.7 per cent of copper.

The most striking feature brought out by a study of ore specimens from the Blue Wing district is the absence of definite sequence in the formation of the constituent minerals. Only one period of mineralization is recorded. In some places hübnerite occurs with distinct crystal outlines indicating that it was first to form; in others, however, it is so intimately intergrown with sphalerite that their essential contemporaneity can not be doubted. The two are frequently in contact and bear the same relation to the inclosing quartz. In places sphalerite includes pyrite, molybdenite, and tetrahedrite. Elsewhere pyrite includes the last two and probably also chalcopyrite. Galena seems to be contemporaneous with sphalerite. (See Pl. XIII, *C*, p. 72.)

Most noteworthy of the above relations is the intimate association of tungsten and zinc, which are uncommon in the same deposit elsewhere, and which, so far as the writer is aware, have not been described before as resulting from the same period of mineralization, The mineral veins at Ima are of pre-Eocene age, for they were truncated by Eocene erosion. Only two periods of metallization have been recognized in this part of Idaho, one late Cretaceous or early Eocene and the other Miocene or early Pliocene. These deposits are assigned to the former.

The unusual number and variety of essentially contemporaneous minerals in the deposit indicates very complex mineral-bearing solutions. No less than twelve elements were present, and presumably several others. The structure of the ore indicates an aqueous solution which acted in open fissures and crevices. It produced little change in the wall rock. The state of combination of the several elements in the solution is not known, but of the minerals resulting from it hübnerite was locally the first to form. The several other minerals are mutually intergrown and included in coarse granular quartz. The deposits are thought to be genetically related to the quartz diorite which outcrops at several places along the Lemhi Range.

JUNCTION DISTRICT.

SITUATION AND HISTORY.

The Junction mining district comprises an ill-defined area of several townships, centering about a point a few miles northwest of the town of Junction in the southeast part of Lemhi County. It may be considered as extending northwest to the McDevitt district (which is definitely bounded by Reese Creek), northeast to the Continental Divide, and southwest to the summit of Lemhi Range. To the southeast the district merges into country from which mineral has not been reported.

The district is crossed by the Gilmore & Pittsburgh Railroad. Excellent wagon roads lead to Salmon, 50 miles northwest, and to Gilmore and Dubois, respectively 17 and 100 miles to the south and southeast.

Although mineral has been known in the Junction district for a number of years, it may be considered one of the younger districts in the county, the principal location having been made in 1904. Active development began on the Leadville mine in 1905 and most of the prospecting in the surrounding country has been done since that date.

The Leadville mine, which is the only producer in the district, made its first shipment in February, 1908. Its total production is about $75,000 in lead and silver bullion.

TOPOGRAPHY.

The Junction district comprises a segment across the broad valley of Lemhi River at a point where its course changes from north to northwest. On the northeast the valley side rises to an elevation of about 8,000 feet or 2,000 feet above the valley, and on the southwest abrupt slopes lead up to an elevation of 10,000 feet. The central valley has a gently sloping floor from 6 to 15 or more miles in width. Peterson, Little Eightmile, and Canyon creeks flow through deep narrow canyons which extend back to the crest of the Beaverhead Mountains, the last named forming Bannock Pass, one of the most accessible gateways through the divide. On the southwest side of the valley, Mill, Lee, Eightmile, and Timber creeks occupy similar canyons, which lead from the Lemhi Range.

GEOLOGY.

Along the northwest side of the Lemhi Valley at the base of the range the older rocks were examined at several points, but the opposite side of the valley was not visited. As thus encountered they presented a succession of limestones, slates, and quartzites, named in descending order of importance. In general they strike N. 30°–50° E. and dip 30°–50° SE., although locally wide departures from these values occur.

A great succession of Miocene lake beds occupies the broad Lemhi Valley. No local information was obtained concerning their maximum thickness, but if the general history of the formation has been interpreted correctly (see p. 35) they probably extend to a depth of 2,000 feet or more.

Faulting is evident along the northeast margin of the valley, where for about 5 miles prospects are distributed along a mineralized displacement plane which dips about 40° SW. and throws Miocene lake beds against the older rocks.

Both intrusive and extrusive igneous rocks occur in the area, the latter being confined to its northwest part. Near Junction a light-gray porphyritic rock about the composition of granite is found. A dike of this rock, best designated as granite porphyry, extends along the lower slopes of the range to the northeast. As float of similar material was noted in the canyons above their intersection with this dike, it is probable that other dikes occur farther up the mountain slope.

The canyon of Little Eightmile Creek near its mouth is cut in a dark-gray fine-grained holocrystalline rock composed of plagioclase (about oligoclase), quartz, biotite, and hornblende, with a few crystals of orthoclase. It is classed as quartz diorite. The mass is laccolithic or batholithic in outline, about 300 feet vertical being exposed in the canyon sides. A similar intrusive quartz diorite occurs about 3 miles from the mouth of Eightmile Creek canyon in the Lemhi Range.

Effusive rocks appearing as bowlders along the side terraces of the Lemhi Valley in the vicinity of Little Eightmile Creek are predominantly dark-gray andesite composed of plagioclase crystals sparsely studding a glassy to microcrystalline groundmass. Subordinate in amount to the andesite is a bluish-gray rhyolite composed of orthoclase, biotite, and quartz phenocrysts in a glassy groundmass.

From the local area little can be said concerning the age of these rocks.

ORE DEPOSITS.

Mining claims have been located in the mountainous areas on both sides of the Lemhi Valley, but those most important at present are confined to a narrow zone along the northeast margin. (See Pl. XVI.) The ore deposits crop out between elevations of 6,500 and 7,000 feet.

Near the town of Junction the prospects and mines are distributed along a fault plane which probably served to direct the mineralizing solutions. Later movement has taken place along this fault with the result that now unmineralized lake beds form the hanging wall of the ore bodies, being separated from them by a thin gouge seam consisting of clay and in a few places of pulverized ore. The line of prospects extends for about 5 miles northwestward from the mouth of Canyon Creek gorge. This occurrence of a vein between a footwall of Paleozoic rocks and a hanging wall of comparatively recent lake beds is unusual but not unknown in the literature. The Curlew vein near the north end of the Bitterroot Range is probably of the same age as this one and has a hanging wall of Pleistocene gravels.[1]

Other mining claims are located about the canyon occupied by Little Eightmile Creek and its tributaries. These are inclosed in slates and limestones, adjacent to a base of quartz diorite.

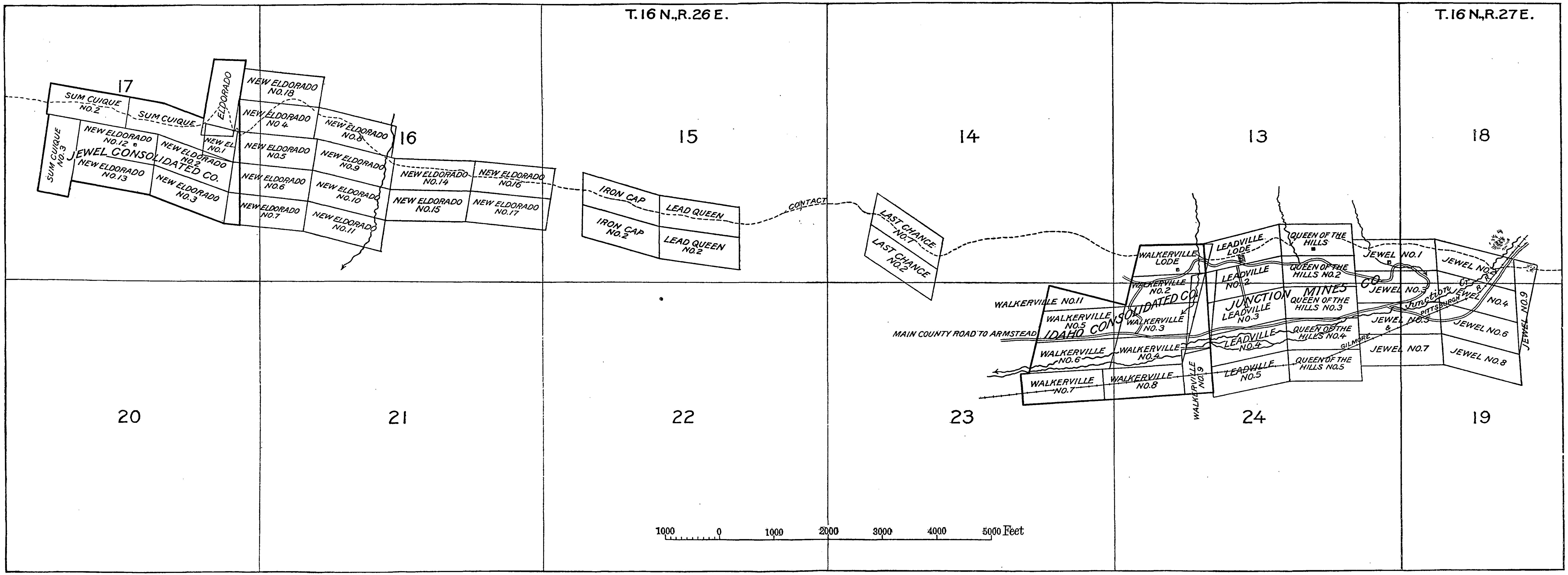
The only property with sufficient development to afford conclusions concerning the ores is on the Leadville claim of the Junction Mine Co.'s group. In this property the predominating ore is fine-grained argentiferous galena, usually remarkably free from gangue. Many small amounts of pyrite appear in the deposits and in a very few places a little chalcopyrite. The better grade of ore runs from 50 to 60 per cent lead and 28 to 35 ounces of silver per ton.

Two ore shoots occur in the deposit, the ores of which differ somewhat in composition, as shown by smelter analyses, although in the hand specimen no mineralogic difference is evident. The analyses follow:

Analyses of ores from Leadville mine, Junction district.

	Gold.	Silver.	Lead.	Copper.	Insoluble.	Zinc.	Sulphur.	Iron.	Arsenic, antimony, and bismuth, not separated.
No. 1 shoot	Tr.	35.0	56.5	0.2	16.0	....	9.8	2.8	....
No. 2 shoot	Tr.	28.8	54.5	.2	15.0	1.0	11.0	2.0	9.7

[1] Lindgren, Waldemar, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: Prof. Paper U. S. Geol. Survey No. 27, 1904, p. 86.



CLAIM SHEET, JUNCTION DISTRICT.

From the amount of sulphur contained in both shoots it is obvious that the ore is primarily in the form of sulphides. Copper is negligible, as are also zinc and gold. Iron, although present in noteworthy amounts, is much less conspicuous than in the deposits of the Texas district to the south. The relative amounts of antimony, arsenic, and bismuth are not known; neither is their mineralogic form, although it is very probable that the first two are combined with silver as sulpharsenite and sulphantimonite. Bismuth is not common in such deposits and it is not possible to infer its combinations with any degree of certainty.

Ground-water level occurs at different elevations on opposite sides of the granite porphyry dikes which parallel the range near its base. That the lower elevation prevails on the side toward the Lemhi Valley is obvious from the prevalence of springs at low points in the dikes. Canyon Creek, which derives most of its waters from springs on the upper side of a granite porphyry dike crossing the canyon near its mouth, is a case in point. West of the dikes the position of the water table is determined by the elevation of Lemhi River in the valley opposite, allowing a reasonable gradient toward the river. East of them its level is determined by the point of intersection of the adjacent canyons and the dike.

Along the fault which forms the hanging wall of the deposits near Junction a seam of very impervious clay gouge has protected the ores from descending oxygen-bearing waters, so that they in general retain their primary mineralogic constitution to an extent uncommon above ground-water level elsewhere in the lead-silver deposits. This preservation is probably conditioned by the flat attitude (35° dip) of the fault plane, although another factor may be the small amount of pyrite in the deposit, it having been shown by experiment that the presence of pyrite tremendously facilitates the oxidation of lead sulphide.[1] As the 2 per cent of iron (principally pyrite) in the deposits is sufficient to afford considerable ferric sulphate, the relative importance of this factor is not obvious.

MINES.

LEADVILLE MINE.

The Leadville mine is situated in the southeastern part of Lemhi County, 3 miles northeast from Junction and about half a mile from the Gilmore & Pittsburgh Railroad, on the margin of the valley flat traversed by that line. The property was located in June, 1904, but active development did not commence until a later year. Ore shipments, which continued regularly until the summer of 1911, began in February, 1908. In the early summer of 1911 there was a change of

[1] Buehler, H. A., and Gottschalk, V. H., Oxidation of sulphides: Econ. Geology, vol. 5, 1910, pp. 28-35.

management and the period since has been principally spent in development.

The property is developed by two tunnels and a shaft which reaches levels intermediate between them. The upper tunnel is 500 feet long, starting from a point above the shaft. The lower tunnel enters the hill near the level of the valley flat reaching the vein 876 feet from the portal and at a depth on the lode of 510 feet. The main opening at present is a single compartment shaft with drifts totaling 900 feet on the 65 and 110 foot levels.

Since 1908 the property has produced about $75,000 in lead and silver bullion.

The country rock of the Leadville group comprises both later Paleozoic sedimentary rocks and Miocene lake beds. The older rocks consist of limestones, quartzites, and quartzitic slates which strike N. 70°–80° E. and dip 35° SE., thus corresponding in attitude to the veins. Overlying these unconformably are the lake beds which occupy the broad valley of Lemhi River; they are composed of detrital material largely from the hills adjacent. As exposed at the surface and within the mine the contact between them and the older rocks is a fault plane. (See fig. 17.) That the fault occurs near the margin of the lake in which the younger beds were deposited is clearly shown by a section along the lower tunnel of the Leadville mine. In the outer part the material is well sorted and stratified, but within the last 200 feet near the fault it grades into heterogeneously arranged and poorly sorted fragments, indicative of a talus-like accumulation near the margin of the lake. Throughout, the material is firmly cemented and presents little evidence of disturbance since its original deposition.

General quiescence since their formation is recorded in the slightly fractured condition of the ore bodies, although the limestone in which they occur is extremely crushed for a few feet next the fault. As the gouge next the lake beds contains fragments of ore and the principal brecciation of the limestone seems to be older than the ore, it is thought there have been two periods of movement along the vein fissure, one prior to the ore deposition and the other comparatively recent.

A single granite porphyry dike was noted, which cuts the older series and is about parallel with it in strike but stands more nearly vertical; others doubtless occur.

The Leadville deposits contain lead-silver ore, remarkably free from other metals. They occur as replacements in limestone along the footwall of an old fault, the hanging wall of which has moved down relatively, bringing Miocene sediments into juxtaposition with the ores. The thin seam of red clayey gouge accompanying the recent movement contains fragments of galena, especially in sections

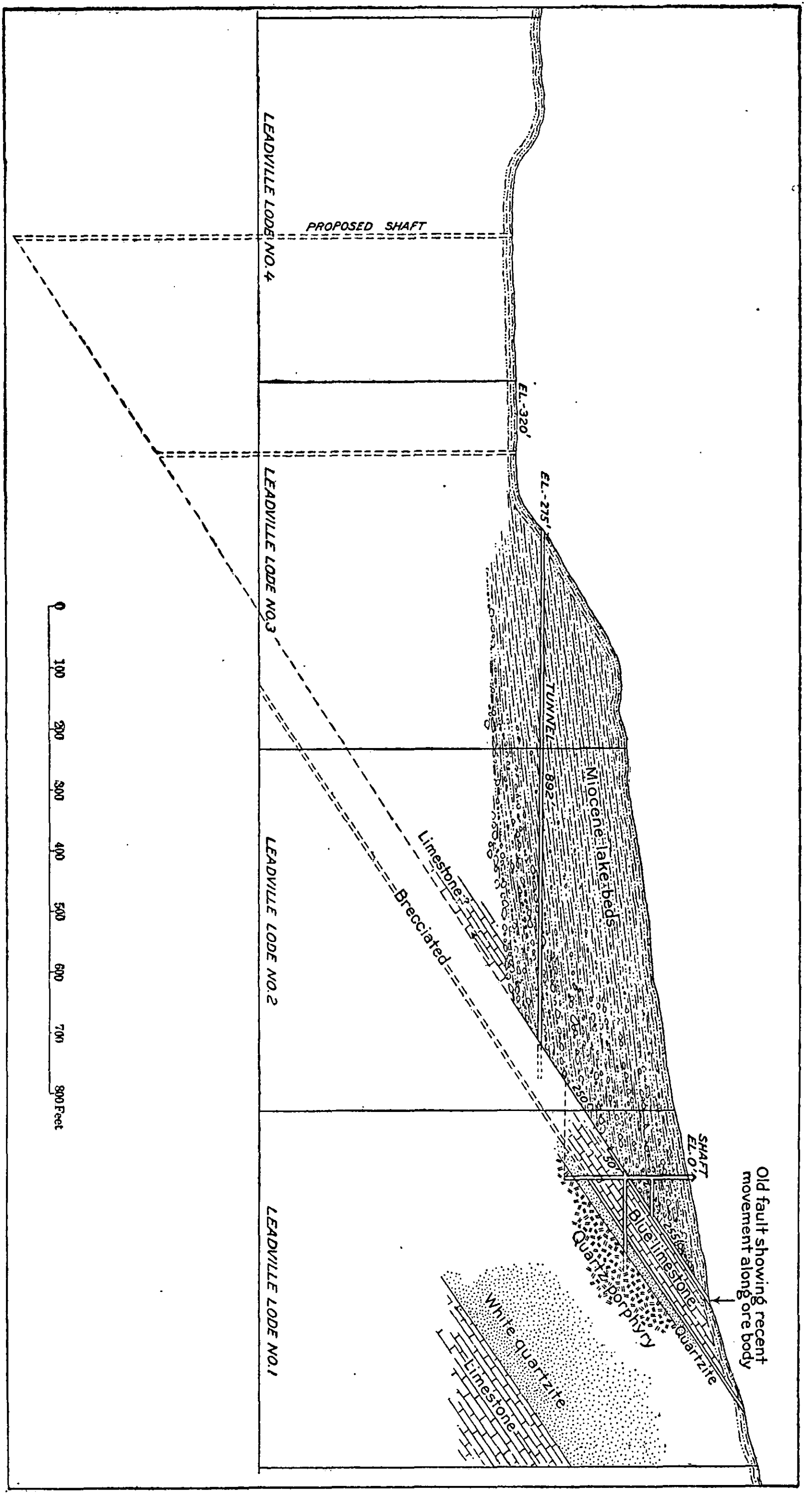


FIGURE 17.—Transverse section through Leadville mine, Junction district, showing geologic relations of the ore body. Diagrammatic in part.

opposite to and below ore bodies, and although they are in few places sufficiently numerous to constitute an ore, their presence is considered indicative of an ore body adjacent to and up the fault from the place where they are found. In general the replacement bodies are tabular in outline and closely parallel to the fault plane with which they are in many places in contact.

Two ore shoots, separated by about 40 feet of barren crushed limestone, are recognized in the mine. The shoots are respectively 180 and 110 feet long on the 110-foot level and 80 and 60 feet long on the 65-foot level, the larger body being the western or No. 1 shoot. Both reach to the upper tunnel level. In No. 1 the ore ranges from 2 inches to 2 feet in width, and in No. 2 it ranges from scattered crystals up to 4 feet of galena. No. 2 shoot differs from No. 1 in being more oxidized, containing less lead, silver, and iron, and having an appreciable amount of antimony, arsenic, and bismuth. Even here, however, oxidation is inconspicuous.

Mineralogically the ore is predominantly fine-grained galena (steel galena), with pyrite not uncommon and sphalerite and chalcopyrite very rare. The mineralogic form of the antimony, arsenic, and bismuth is not known, although they may very well be constituents either of lead or of silver minerals. Limited amounts of cerusite, anglesite, and limonite occur in the deposits. Analyses of the ore from the two stopes appear on page 65.

The better-grade ore gives a gross return of $50 to $65 a ton.

OTHER PROPERTIES.

Claims are located for 5 miles along the fault which accompanies the Leadville ores, but all of them are still in the early prospect stage. Even though ore has not been found in commercial quantities in any of these properties, their occurrence in a mineral belt and with geologic relations analogous to those prevailing at a near-by producing property should encourage a reasonable amount of exploration. Claims are also situated on Little Eightmile Creek, where, although large ore bodies have not been found, the general relations are such as to justify careful prospecting and a reasonable amount of exploration.

McDEVITT DISTRICT.

GENERAL FEATURES.

The McDevitt district, the only organized mining district in Lemhi County, lies about 20 miles southeast of Salmon. It embraces a section across the Lemhi Valley from the crest of Lemhi Range northeast to the summit of the Continental Divide, and extends from Haynes Creek 17 miles southeast to Reese Creek. The Gilmore & Pittsburgh Railroad and an excellent wagon road traverse the district along the Lemhi Valley. The old stage line from Red Rock, Mont., to Salmon enters near the head of Agency Creek, the principal tributary to Lemhi River from the northeast.

The district includes the Lemhi Indian Reservation, which was thrown open to mineral entry July 15, 1909. Immediately after its opening about 35 claims were staked, principally along McDevitt Creek. The only property that has produced, however, is just beyond the reservation boundary to the northeast, and is a mine—the Copper Queen—which was located in April, 1883, and has been operated intermittently since 1905. The total production of the district is probably a little less than $100,000.

TOPOGRAPHY.

The mountain slopes, which rise from the margins of the broad valley of Lemhi River, attain within short distances heights of 8,000 to 9,000 feet above sea level, or 2,000 to 3,000 feet above the valley. The streams tributary to Lemhi River occupy deep narrow gorges in the mountains, but on reaching the lowlands they follow comparatively shallow open depressions. Of these streams, Payette, Agency, and Yearian creeks enter from the northeast and Haynes, Baldy, McDevitt, Muddy, and Hayden creeks from the southwest.

GEOLOGY.

The sedimentary rocks of the district are of Algonkian, late Paleozoic, and Miocene age. The contact between the two older formations extends in a northeast-southwest direction and lies between Yearian and Agency creeks, although its exact position was not determined. To the southwest the contact is probably concealed by the broad belt of late Tertiary lavas which extend in that direction. The Miocene beds occupy the Lemhi Valley and extend up its sides to an elevation of about 7,000 feet.

The Algonkian rocks consist of greatly fractured massive dark siliceous slates and gray quartzites, which are readily distinguishable from the limestone, white quartzites, and thinly cleavable slates of the Paleozoic. Presumably the Algonkian and the Paleozoic are separated by a strong structural unconformity, although the exposures visited did not afford definite evidence to that effect. Each is highly tilted, the dip varying markedly from place to place, both in direction and angle. In general, however, the dips seem to be 30° to 50° W. The lake beds are made up of stratified gravels, sands, and clays, the first being most pronounced near the margins of the basin in which they lie, and the last conspicuous in the bluffs along Lemhi River. Intermixed with the clastic material, though in places occurring in fairly pure bands, is volcanic tuff. The thickness of the lake beds is not definitely known, but they are probably to be measured in hundreds, perhaps thousands, of feet, if the interpretation of conditions existing during their formation, as outlined on page 35, is correct.

Basalts and rhyolites are widely distributed throughout the district, and along Agency Creek dikes of similar composition were noted. Because of lack of time the boundaries of the lavas were determined in only a general way. From the head of Agency Creek they extend in a southwesterly direction across the Lemhi Valley and are distributed along the east face of the Lemhi Range throughout the entire length of the district. From the aspect of the topography high up on that range, it is thought that they cross the summit in places, possibly connecting beyond with the lavas along Salmon River. The two types of eruptives may be readily distinguished, for the basalts are fine-grained bluish-black rocks, in many places rusty on weathered surfaces, whereas the rhyolites present various shades of gray, commonly with conspicuous flow lines.

That the lavas are very young is suggested by their generally well-preserved vesicular structure, and confirmed by their occurrence as caps on some of the intermediate terraces developed in the Miocene lake beds by Lemhi River.

ORE DEPOSITS.

Mineral locations in the district are largely grouped about the headwaters of Agency Creek and along McDevitt Creek. Only those about the former, which include the Copper Queen mine, were visited. The Copper Queen is the only property developed beyond the early prospect stage.

COPPER QUEEN MINE.

The Copper Queen Gold Mining Co. holds a group of 12 claims on the south fork of Agency Creek, 3 miles west of the Idaho-Montana line. The property was located in April, 1883, by F. B. Sharkey and George Chamberlin, but was not operated until leased in 1905 and 1906. In the latter part of 1906 it was secured by a Duluth company, which sank a 400-foot shaft and did considerable drifting on the 120, 200, and 400 foot levels. This work and four little tunnels which enter the hill on the opposite side of the gulch at vertical intervals of about 100 feet, give a total of perhaps 2,500 feet of development.

The production consists of 480 ounces of gold secured with a 5-stamp mill and the returns from 18 cars which averaged 28.3 per cent of copper and 6 ounces of silver and $24.75 in gold to the ton. In addition to these amounts some gold was extracted during the early days of prospecting, perhaps sufficient to raise the total production to $100,000.

The property has been recently acquired by the present owners, who purpose to put in a concentrating mill and work the lower-grade ore which remains in many of the old stopes.

The veins are inclosed in quartzites and quartzitic slates, which, though varying widely in places, in general seem to strike about N. 70° E. and dip 40°–70° NW. The principal vein follows approximately the inclosing rock in strike but is said to be independent of it in dip. Above a point 152 feet below the surface (level of water at time of visit), the vein dips 40°–70° NW., but below it bends back, dipping steeply southeast. The vein is from a few inches to 9 or 10 feet wide, averaging about 3½ feet where it has been stoped. The walls are sharply defined and the hanging is very regular, although the opposite side presents many swells and hollows. Included in the quartz are many fragments of wall rock, some of them slabs several feet in length.

The gangue is a white, coarsely crystalline quartz, in places granular in appearance and in places containing a sparse intermixture of small bunches of calcite. Metallic minerals are distributed through the gangue without apparent regularity, in some places the quartz being free from metallization and in others the ore minerals predominating. Important among the ore minerals are bornite, a little chalcopyrite, chalcocite, specks of free gold, in a few spots a little cuprite, and at the surface much malachite and a little azurite. The chalcopyrite is clearly primary and in places the manner in which the bornite is included in the quartz suggests that it also may be primary, but so general is the oxidation throughout the accessible workings that this can not be certainly determined.

The better ore occurs in irregular shoots, which vary markedly in richness from place to place. In the past only the richer portions have been worked, but it is now planned to handle the considerable tonnage of intermediate grade which bounds the old stopes.

PRATT CREEK DISTRICT.

The Pratt Creek district lies 15 miles southeast of Salmon, about the headwaters of Wimpey and Pratt creeks. It includes a belt some 6 miles wide, extending from Lemhi River northeastward to the base of the mountains, and thence up their rugged slopes to the crest of the Beaverhead Mountains, the elevation in the last 5 miles increasing about 4,000 feet.

The geology is simple. Miocene lake beds occupy the lowland up to 6,500 feet, above which are Algonkian sedimentary rocks. The older rocks strike a few degrees west of north and dip from 10° to 85° W., commonly 45° to 50° W. As seen near the mouth of Pratt Creek canyon in a vertical face possibly 700 feet high, the series is made up of alternating layers of quartzites, quartzitic slates, and some schists, each in beds from 1 foot to 5 feet thick. Traversing these are a few bands of basic diorite, nowhere well exposed, but to judge from the distribution of float, locally more than 100 feet thick.

Mineral locations in the district comprise one mine and a few undeveloped prospects. As the deposits visited showed similar structure and composition, it will suffice to describe the Goldsmith mine. Mention should be made, however, of the Dark Horse property, situated 2 miles north of the Goldstone mine on the Montana side of the divide. Here about 4,000 feet of work has been done, though little ore has been developed. Some 2,400 feet of the work consists of a rock tunnel, not yet completed, through the divide from Montana to Idaho. The purpose of the tunnel, it is said, is to afford means for marketing ore at Baker, Idaho.

The Goldstone mine, now owned by the Climax Gold Mining & Milling Co., is situated on Pratt Creek 1 mile west of the Idaho-Montana line, at an elevation of about 9,200 feet above sea level. Baker, Idaho, 12 miles distant, is the supply point. The property was located in the early nineties and has changed hands several times. In 1896 and 1897 a 10-stamp mill was erected and has treated perhaps 1,000 tons of ore. Development consists of a 235-foot shaft and about 3,000 feet of tunneling.

The vein, inclosed in chloritic schist and quartzite, strikes N. 62° W. and dips 75°–85° NE. The hanging wall is sharply defined, but many stringers of vein matter extend into the footwall. The vein is a quartz filling from a few inches up to 4 feet in width and locally includes many fragments of wall rock. Scattered through the quartz are chalcopyrite, its oxidation products, and galena. Gold, for which the property is held, is said to vary directly with the percentage of copper in the ore.

ELDORADO DISTRICT.

SITUATION.

The Eldorado district lies about 9 miles east of Salmon and includes a short section of the western slope of the Continental Divide and the adjacent part of the Lemhi Valley. It is named after the Eldorado mine, a property of local prominence about 30 years ago. Interest in the area centers, however, about the placers of Bohannon Bar, which were worked in the early days by Chinamen and which have furnished by far the larger part of the $400,000 credited to the district as a whole.

TOPOGRAPHY.

The district embraces a belt of country about 6 miles wide extending northeastward from Lemhi River to the crest of the Continental Divide. From the river, at an elevation of 4,500 feet, the surface rises gently for the first 6 miles, beyond which precipitous slopes lead to the crest of the range, 9,500 feet above sea level. The principal streams are Geertson and Bohannon creeks, which flow in deep narrow canyons in their upper parts but occupy broad open valleys as they cross the lowlands to their junctions with Lemhi River.

GEOLOGY.

The older sedimentary rocks are Algonkian schists, quartzitic slates, and quartzites. In general they strike a little west of north and dip west. Overlying these strata in the southwestern half of the district are thick Miocene lake beds composed of detrital material from the near-by mountains. In general the lake beds are distinctly stratified, and in the floors of shallow valleys cut in them are long tongues of gravel washed down by Geertson and Bohannon creeks. It is in the gravel beds that the placer gold is found.

Many bowlders of a dark-gray fine-grained igneous rock appear along Geertson Creek. In thin sections of this rock small orthoclase and hornblende crystals are visible in almost equal amounts. A little micropegmatite is present, and there is a slightly phenocrystic development of quartz. The rock is classed as a quartz-bearing vogesite.

VEIN DEPOSITS.

The Eldorado and Ranger are the principal vein deposits. Both are situated on the mountain slope at elevations of about 8,800 feet. Only the Ranger mine was visited, but ore from the Eldorado mine, seen along the old tram line, is in every respect similar. The Ranger vein occurs along a shear zone whose firm walls are generally about 5 feet apart. Between them gouge and brecciated country rock include lenses, stringers, and irregular bodies of quartz. Scattered through the vein material are pyrite, chalcopyrite, and rarely a little galena, together with their oxidation products, with here and there a speck of native gold.

The properties were worked many years ago, the ores being treated in a 20-stamp mill situated a short distance down the canyon. The production was probably moderate.

PLACER DEPOSITS.

The important placer of the district is Bohannon Bar. It includes a narrow belt along Bohannon Creek, between the base of the mountains and Lemhi River. The bar was worked by Chinamen as far back as the early seventies, but not until acquired by the present owners in 1895 did its active development begin. Since then about 150 acres have been washed. Water is gathered from several canyons along the range and stored in a large reservoir, thus affording an abundant supply for operating a 6-inch giant.

The auriferous gravels occur in three benches and range in thickness up to 14 feet south of the creek and 31 feet north of it. The two lower benches have furnished most of the production, although at present the rim of the upper one is being worked. The deposit consists of round bowlders, generally less than a foot in diameter, with sand and gravels loosely filling the interstices.

The bedrock is an even floor cut across rather sharply tilted shales, sandstones, and conglomerates of Miocene age which dip 22° NE. The 5 feet of gravel lying directly above bedrock carry most of the gold, the lower 18 inches being the more productive. The gold is worth about $18.60 an ounce and occurs as coarse flakes, fine grains, and rarely as small nuggets. It is claimed that on a broad average the ground runs about 13½ cents a yard, although some pits give as high as 23 and 25 cents. The total production of the placers is said to be about $350,000, the present annual output varying from $15,000 to $20,000.

KIRTLEY CREEK DISTRICT.

GENERAL FEATURES.

The Kirtley Creek district lies a few miles east of Salmon, between the Eldorado district on the south and the Carmen Creek district on the north. It includes a strip of country 5 or 6 miles wide, extending from Lemhi River northeastward across the lowlands to the base of the mountains and thence up their rugged slope to the summit. Kirtley Creek, a tributary to Lemhi River, 3 miles above Salmon, drains the area. Placers long known along its lower course have recently attracted serious attention, and lode deposits at its head have produced some bullion.

The formations are similar to those in the Eldorado district (see p. 122), and hence will not be described again here.

LODE DEPOSITS.

The White Horse mine is situated at an elevation of 9,100 feet on the north side of the large cirque at the head of Kirtley Canyon. It was located in 1899 and worked by an arrastre for three years following, when a 5-stamp mill was built. The recovery from the early treatment is not known, but about 900 tons of ore averaging $45 a ton in gold are said to have been reduced by the mill.

The vein is very similar to the Ranger vein of the Eldorado district and may, indeed, be its northward continuation, for the two are in line and only half a mile apart. The vein strikes north and south and dips 35°–40° W., for short distances up to 85° W. Jumps from one set of fractures to another and rolls give local variations to the east. The vein is very irregular in width, in few places reaching more than 15 inches in a clean band. In places, however, as much as 3 feet of quartz appears distributed through a face of 7 or more feet wide. The quartz is coarse textured, and scattered through it in bunchy arrangement are pyrite and chalcopyrite and a little galena. In the ores now worked the oxidation products of these minerals, together with a few specks of free gold, constitute the principal minerals.

The same vein appears in the head of the cirque on the Smith claims and in the south wall of the cirque on the Confidence claim, and southward it may continue as the Ranger vein, Eldorado district.

PLACER DEPOSITS.

Placers, worked on Kirtley Creek from 1890 to 1894, were abandoned until the spring of 1910, when a California dredging company took an option on the ground and had it carefully prospected. As a result about 400 acres of placer ground, of sufficient value to warrant the installation of a dredge, has been developed; and a dredge of 9 cubic feet capacity is now in course of construction. The deposits are recent gravels along Kirtley Creek and extend for 5 miles below the mouth of the canyon. Some gold has also been found in the Miocene lake beds near their junction with the mountain slope, but the attempt to work these where they appear in the valley sides above the younger deposits was soon abandoned. The lower (younger) bed averages about 17 feet in thickness and is made up of waterworn bowlders and pebbles of quartzite, slate, and schist, in most places loosely cemented by sand and clay. The bowlders range up to 12 inches in diameter, rarely to as much as 2 feet. In the upper end of the deposit gold is confined to bedrock and the first 8 inches above it, but farther down the valley it is distributed through the lower 6 or 8 feet. Even here, however, the greater amount is next the bedrock. The gold is of the size of shot in the upper part of the basin but grades into flake gold below. Very rarely nuggets up to 75 cents in value have been found.

CARMEN CREEK DISTRICT.

GENERAL FEATURES.

The Carmen Creek mining district comprises an unorganized area around the headwaters of the creek whose name it bears. Salmon, about 15 miles southwest, is the nearest railroad and supply point. The history of the district is essentially the history of Oro Cache mine, this being the only property which has produced an important amount of bullion. The Oro Cache mine was opened about 1897. A 10-stamp mill erected shortly thereafter was operated intermittently for some years, the last run being made in 1907. In the spring of 1910 a small Ford quartz mill was installed at the Carmen Creek property, located in 1904, on the north branch of Carmen Creek, but only a small amount of bullion has been produced. The other claims in the district are in an early prospect stage.

GEOLOGY.

The Carmen Creek district is situated on the rugged western slope of the range forming the Beaverhead Mountains. Deep, narrow canyons separated by rough, serrate ridges make the upper reaches of the area almost inaccessible, but its lower part merges into the Salmon River Valley and is in many places suitable for agriculture.

The district is well within the area of Algonkian schists and quartzites, which here strike N. 20°–55° W., and generally dip west at angles higher than 45°, although showing local variations to the east. Intricate jointing and advanced metamorphism characterize the rocks. Igneous material was not seen in the district, but a few miles north at the head of Boyle Creek outcrops of granite are reported.

ORE DEPOSITS.

Two types of deposits occur in the district—gold-quartz veins in quartzite and gold-copper replacement deposits along shear zones in schist. The Oro Cache deposit represents the former and the Carmen Creek mine the latter type.

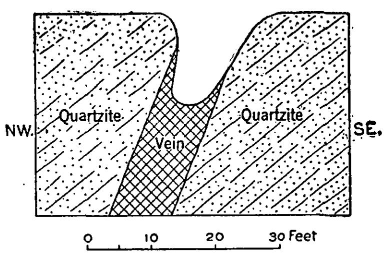


FIGURE 18.—Cross section of Oro Cache vein, Carmen Creek district, from exposure above lower tunnel, showing depression at outcrop.

ORO CACHE VEIN.

The Oro Cache vein occurs near the eastern margin of the district at an elevation of 8,200 feet. It is developed by nine tunnels distributed up the mountain side. The lowest and deepest tunnel is 700 feet long; the combined length of the others is about 2,800 feet.

The vein, which is inclosed in massive fine-grained argillaceous quartzite, strikes N. 65° E. and dips 67° NW. It is fairly constant in width, averaging about 4 feet, and has well-defined walls. (See fig. 18.) That the vein follows a fault is shown by a gouge seam about 8 inches wide which occurs along the hanging wall and includes many subangular fragments of quartzite, evidently shaped by faulting movements. In general but little primary ore has been encountered. A specimen secured from a protected pocket, however, consists of pyrite and a little chalcopyrite, galena, and sphalerite. In hand specimens the metallic minerals are irregularly scattered through pale-blue coarsely crystalline quartz, but in the vein they present a roughly banded arrangement parallel to the walls. The altered portions of the deposit are very abundantly stained by manganese. In some places lenticular openings are lined by small quartz crystals which stand perpendicular to their walls; again, similar openings are largely filled by pyrite. About 4,000 tons of ore, averaging $8 a ton, are said to be blocked out in the mine.

CARMEN CREEK ORE DEPOSIT.

The Carmen Creek ore deposit, which crosses the north branch of Carmen Creek at an elevation of 6,900 feet, strikes N. 55° W. and dips 70° SW. In general outline the deposit is tabular, suggesting a vein, but owing to its internal make-up it may best be designated a replacement deposit along a shear zone in schist. The inclosing formation, which is of sedimentary origin and intensely metamorphosed to quartzite and mica schist, seems to correspond in strike and dip with the ore body. (See fig. 19.)

The ore occurs as lenses of quartz distributed through a band of schist 8 to 15 feet wide, in amounts sufficient to constitute about one-third of the total width. Much of the schist itself is mineralized. In addition to the metallic minerals, actinolite and magnetite are rather widely developed; green epidote is less common. Much of the vein quartz includes magnetite, but actinolite and epidote seem to be confined to the schist material adjacent to the quartz filling. The metallic minerals are largely contained in the quartz, and consist of pyrite and chalcopyrite, the former generally altered to limonite and the latter to bornite and malachite, with a little chalcocite, and very little azurite. Free gold and some horn silver occur in cavities and along fracture planes in the secondary ore. Manganese stains are abundant.

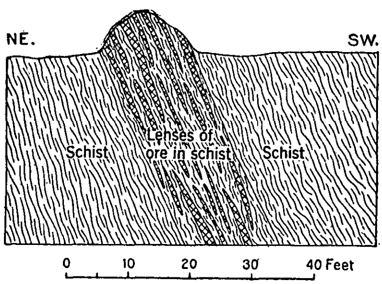


FIGURE 19.—Geologic relations and surface expression of Carmen Creek vein, Carmen Creek district.

AGE AND GENESIS.

From analogy with other deposits in the area it is believed that the veins are of late Cretaceous or early Eocene age. That they were formed at a great depth and under intense heat and pressure is shown by the development of magnetite, actinolite, and epidote in the Carmen Creek ores, minerals which when associated with each other indicate deposition under high temperature and pressure. Although igneous rock is not known closer than several miles, this deposit is strongly suggestive of its proximity, though probably not yet exposed by erosion.

GIBBONSVILLE DISTRICT.

SITUATION AND ACCESS.

The Gibbonsville district comprises the northern half of the territory drained by North Fork of Salmon River. It lies in the northward-pointing elbow of the Idaho-Montana line that is conspicuous on maps of the State. The district is readily reached by wagon road from Salmon, 30 miles south, and less easily from Pioneer, Mont., about 20 miles east. A trail crosses the mountains into the Bitterroot Valley to the northwest.

The town of Gibbonsville is a small settlement with store and post office; reached triweekly by stage from Salmon. It is the only town in the district. (See Pl. XVII.)

HISTORY AND PRODUCTION.

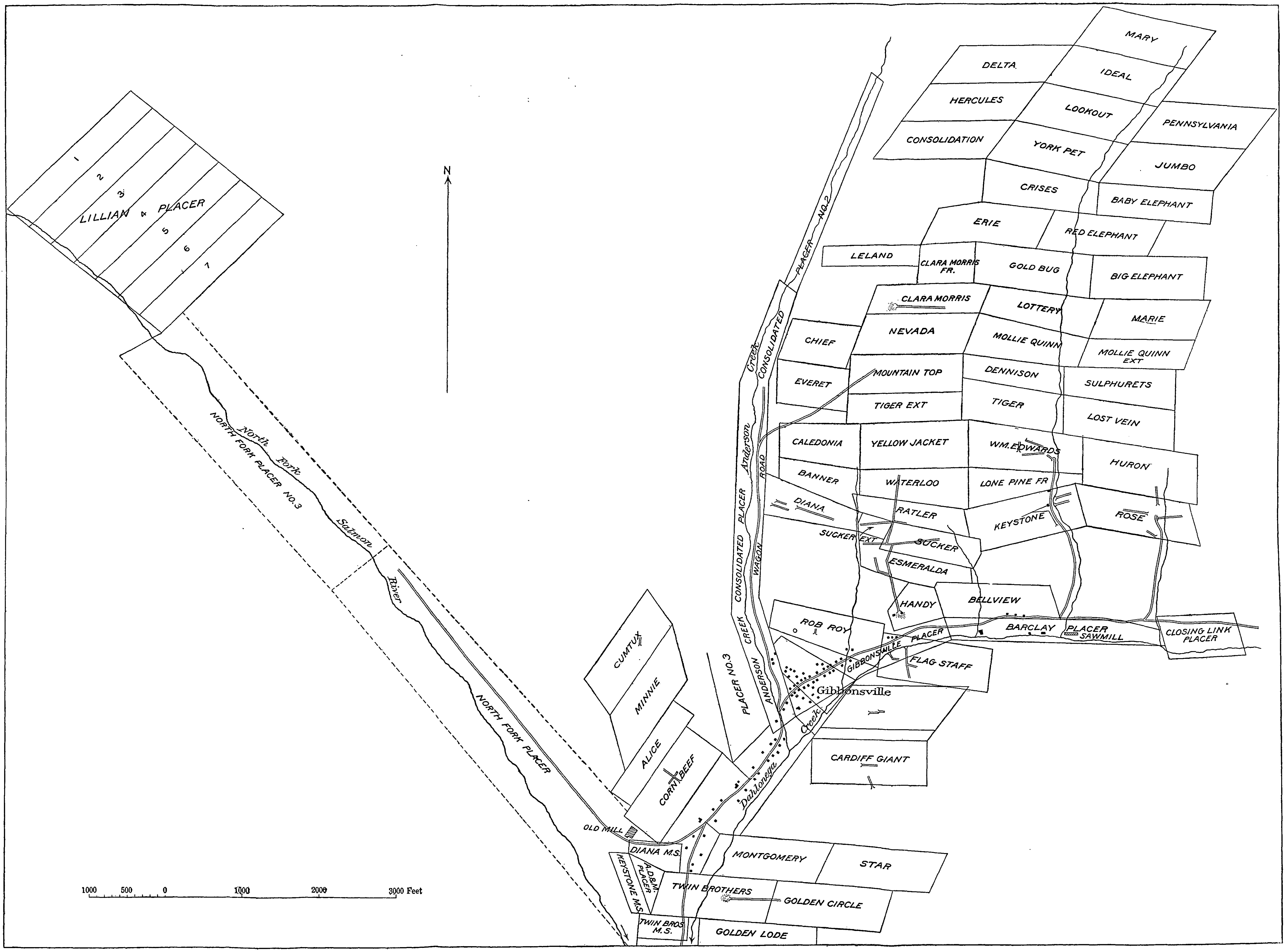
Placers were discovered on Anderson Creek in 1877, and although not very productive their presence led to the location of gold-bearing veins in September of that year. During the fall one arrastre was built, and the next year two were added. By this means of treatment $20 to $30 per ton was saved. Early in 1881 most of the producing mines were sold to an English company, which later went into liquidation and sold the properties to Adelbert Ames, of New York, who operated them for a number of years. After changing hands several times the American Development, Mining & Reduction Co. purchased the principal group and in 1895 erected a 30-stamp mill with accessory cyanide and chlorination plants. This company operated until March 20, 1898, when it also became insolvent, the receiver and others operating the property intermittently until July, 1906, when the American Development, Mining & Reduction Co. resumed control.

The district received a decided setback in the fall of 1907 from the destruction by fire of the principal reduction plant. Since then two or three small stamp mills, which during the activity of the larger plant were mostly idle, have treated the ores of the camp.

As is commonly the case where gold ore is treated locally by a number of companies operating through a period of years, the production is not accurately known. Much of the ore milled has contained from $20 to $50 in gold per ton, but of this possibly less than 70 per cent has been recovered. From the large tonnage, however, it is believed that the current estimate of $2,000,000 for the production of the district is not unreasonable.

TOPOGRAPHY.

The Gibbonsville district occupies a broad mountainous amphitheater-like basin, circled on the north, east, and west by the mountain range which forms the Idaho-Montana boundary. The basin opens to the south and is drained and deeply carved by the several streams which unite to form North Fork of Salmon River. Although slopes are rather less precipitous than in the more mountainous parts of Lemhi County, abrupt changes in elevation between 4,500 and 7,000 feet are common. The mountain slopes are clad with a dense



CLAIM SHEET, PRINCIPAL PART OF GIBBONSVILLE DISTRICT.

Adapted from map in office of American Development, Mining & Reduction Co., dated December 10, 1899.

growth of grasses and small shrubs, above which rises a forest of medium-sized evergreen trees. This growth conserves the winter's supply of moisture, so that the streams live throughout the year, affording abundant water for milling and power purposes.

GEOLOGY.

The predominant rock formation is made up of a great succession of quartzites, quartzitic slates, and micaceous slates which strike about 20° W. and most of which dip 40° to 70° E. Micaceous slates constitute perhaps three-fourths of the series; next in importance are quartzitic slates; and very subordinate in amount are quartzites. The series is thin bedded throughout, and the different kinds of rock follow each other in monotonous succession.

A belt of igneous rock, about 100 feet wide and probably to be classed as a basic diorite, extends north and south through Gibbonsville. It corresponds in strike and apparently agrees in dip with the bedding of the sedimentary rocks. Small dikes of a similar rock noted in the American Development, Mining & Reduction Co.'s mine, together with the coarse texture of the larger body, suggest that the latter is of intrusive origin, and the extensive development of schistosity in it may indicate that it has passed through the period of metamorphism which altered the Algonkian sediments. Thus it is thought that the dioritic intrusion, occurring both as a sill and as dikes, is very old, possibly pre-Cambrian. More recent igneous activity is represented by the andesite, which occupies many of the hilltops and higher slopes west of Gibbonsville.

Faulting is extensive in the area and has proved a serious handicap to the profitable exploitation of the deposit. Many faults are of the type commonly designated reverse, but enough are of the normal type to make a general rule for the miner of little value. Most of the displacements thus far encountered have offset the vein less than 50 feet. (See fig. 20.)

ORE DEPOSITS.

The ore deposits at Gibbonsville occur in narrow east-west veins. Eight or ten have yielded a total of $2,000,000 in gold, and fifteen or twenty more have afforded reasonable encouragement to the prospector. Some of the veins dip north and others south, both at high angles, usually more than 70°. Most of them are narrow fissures, averaging less than a foot in width, though some are 5 or 6 feet wide, as on the Twin Brothers property. The gangue is coarse clear-white quartz, in places heavily impregnated by pyrite, which occurs as scattered cubes, fine-grained masses, irregular blotches with quartz intermixed, and patches of coarse crystal aggregates. In general the pyrite has a crude zonal arrangement parallel to the vein walls,

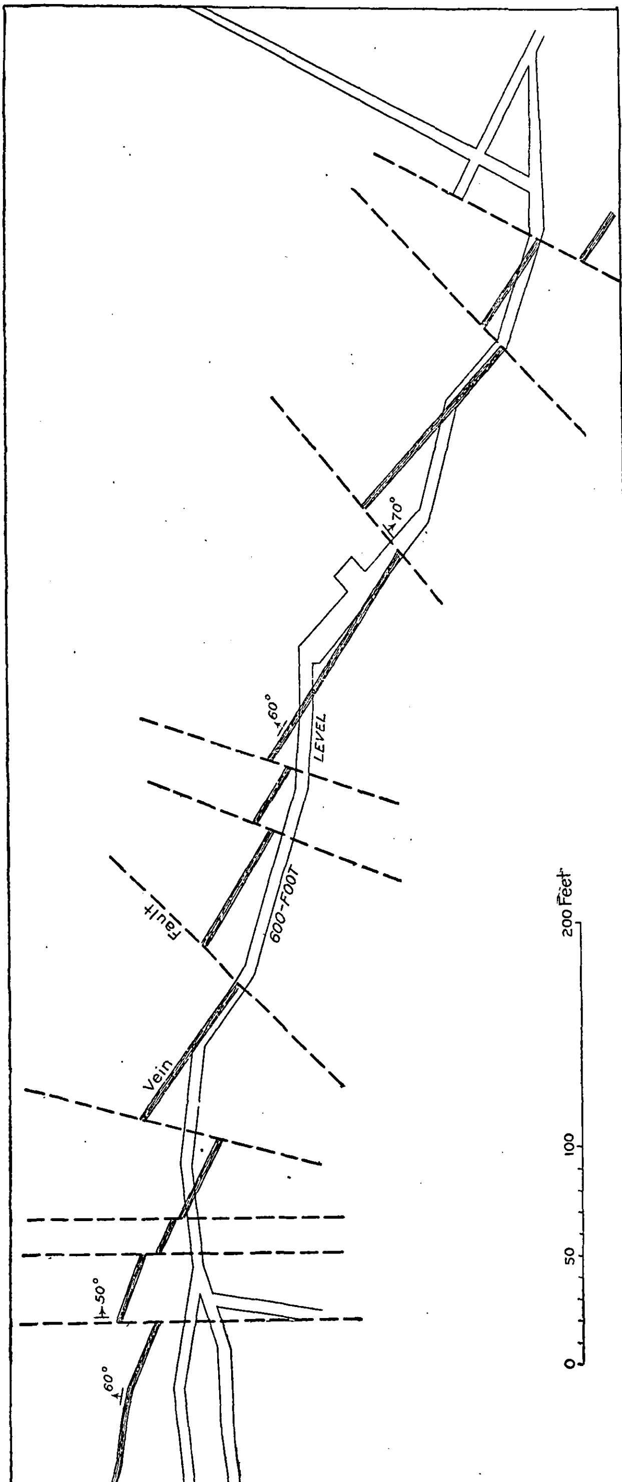


FIGURE 20.—Section of Sucker vein at 600-foot level, American Development, Mining & Reduction Co.'s mine, Gibbonsville district. Shows offsets in vein by faulting. Faults commonly agree in strike and dip with formations. Compiled from maps in the office of the company, with additions.

although it varies markedly from place to place, both in arrangement and in amount. There are all gradations, from ledge matter predominantly pyrite to that exclusively quartz. Here and there calcite appears in the gangue and in places chalcopyrite is found, in places in amounts sufficient to appreciably interfere with normal cyanide treatment. In the primary ores the gold, which in different properties averages from $10 to $40 per ton, varies directly with the pyrite, and as only 40 per cent of the gold yields to amalgamation it is probably included in the pyrite.

The limit of predominant oxidation in the district has in few places been found to exceed 150 feet and in many is less. If ground-water level be defined as the horizon at which water stands in a shaft throughout the year, it is probable that the deposits are oxidized considerably below the average ground-water level in this district. This, however, is a normal relation, for the ore deposits are situated on the sides of the mountains, high above the valleys which determine low points in the water table. Other factors being equal, oxygen-bearing underground water will circulate from the divides to the valleys. It is obvious that if such circulation is sufficiently slow a shaft reaching a point not nearly as low as the bottom of the valleys may contain water throughout the year.

The ore occurs in shoots which pitch eastward with the dip of the inclosing formation. Their distribution seems to bear a definite relation to the kind of inclosing rock; a given vein crossing the several types of rock is commonly barren in the diorite, poor in the quartzite, and productive in the black clay slate. Within the shoots there is a secondary concentration whereby a leached zone of 15 to 30 feet is found at the surface, followed by a zone of enriched ore extending usually to about 100 feet, at which depth it grades into the unaltered deposit. (See p. 80.)

MINES.

AMERICAN DEVELOPMENT, MINING & REDUCTION CO.'S MINE.

The A. D. & M. mine, as the American Development, Mining & Reduction Co.'s mine is commonly designated in the district, is situated on the south face near the base of the mountain northeast of Gibbonsville. It is estimated that from 25,000 to 30,000 feet of development work has been done on the property, most of it on the 600-foot or No. 3 tunnel level from which the Rattler, Sucker, Sucker Extension, Diana, Keystone, Lone Pine fraction, William Edwards, and Waterloo grounds are reached. From this level raises lead to the surface and a double compartment shaft reaches the 800-foot level. From the 700-foot level an incline extends to the 900-foot or deepest level. Nearly all the stoping has been done above 800 feet.

The total production of the property is estimated at a little more than $1,000,000.

The country rock is quartzite, quartzitic slate, and micaceous slate, all thinly laminated and striking N. 10°–20° W., with dips of 40°–70° E. Although regional metamorphism has caused much recrystallization in the slates, slaty cleavage is not developed and in most places the bedding structure is apparent. The quartzites are fine grained and firmly cemented. In places both the quartzite and mica slates grade into a compact black slate almost devoid of biotite. It is when inclosed in this rock that most of the veins have presented their highest degree of metallization.

In the western part of the workings a basic diorite, possibly of pre-Cambrian age, has been encountered. It conforms in strike and dip with the sedimentary rocks and is cut by the veins.

Many faults occur in the mine. They strike north and south and dip east with the bedding in most places, but in others at higher angles. Figure 20 illustrates ten such faults and shows their influence on one of the veins.

Six or seven veins have been encountered in the mine, all of them striking east and west, and all except the Eckhart dipping 50°–85° N. These veins are thin tabular bodies and present a marked variation in thickness from place to place, both along the strike and dip. The larger ones average perhaps 12 inches in width. The better ores occur in shoots, which pitch east at about the angle of the inclosing rock. As a rule the ores are higher grade where the inclosing rock is black slate, and comparatively lean where it is quartzite or diorite.

The outcrops of the veins usually have little or no topographic expression. Heavy iron and some manganese stains are everywhere present in them, and in places a short distance below the surface the vein material is an earthy mass of manganiferous hematite. The upper 10 to 50 feet is much poorer than the next 100 feet or so, and at 150 to 200 feet primary ore is reached.

The primary ore consists of pyrite, with a few crystals of chalcopyrite, in a silica gangue rarely including a little calcite. The pyrite appears as cubes, as fine-grained disseminations, and as patches. In its broader distribution the ore occurs in shoots which vary in length from 25 to 300 feet, and within the shoots pyrite has a rather even general distribution, although in detail such as is seen in the hand specimen a bunchy arrangement is pronounced.

The primary ore carries about $30 in gold, some 40 per cent of which may be recovered by amalgamation. It is possible, however, to increase the percentage of recovery to 60 or even to 85 per cent (according to the amount of copper present) by treating the concentrates with cyanide.

CLARA MORRIS GROUP.

The Clara Morris group, comprising 14 patented claims, is situated on the western slope of the mountain immediately northeast of Gibbonsville. This property is one of the older ones in the district. It has been located and relocated several times, finally being formed into a group and patented in 1900. Operation, which resulted in some 2,500 feet of development and a production of about $250,000, was carried on at intervals from 1888 to 1908. As with the other properties in camp, reduction was first by means of the arrastre and in later years by stamp mill and cyanide.

The following notes on the geology and ores are derived entirely from examination of surface exposures and from conversation with Mr. George Hughes, of Gibbonsville, for many years connected with the property, the tunnels now being inaccessible.

A broad belt of diorite extends along the western margin of the group. It is apparently parallel to the bedding of the formations, which strike N. 20° W. and dip about 60° NE. East of this belt the formation is a monotonous succession of quartzites, quartzitic slates, and mica slates. Extensive postmineral faulting is said to be shown by the multiplicity of offsets encountered in following the veins, the greatest displacement being 42 feet.

About twenty-seven veins, all extending east and west and most of them dipping south, are reported in the group. Many of these are worthless or of doubtful merit, and but two, the Clara Morris and the Nevada, have proved valuable. In these two the ore occurs in shoots up to 300 feet in length, averaging about a foot in width. The vein filling is almost exclusively pyritiferous quartz, the pyrite varying in amount markedly from place to place, and with it the gold. The ore netted about $25 a ton. Where traced into the diorite the veins have usually been barren.

TWIN BROTHERS GROUP.

The Twin Brothers group occupies the north and west slopes of the mountain immediately southeast of Gibbonsville. The property is said to be developed by some 5,000 feet of tunnels and raises which have afforded a total of 35,000 or 40,000 tons of ore from four or five veins. As in the properties already described, the deposits are pyritic quartz veins filling east-west fissures in metamorphosed slates and sandstones. The ore is somewhat lower in grade than in the properties north of Dahlonega Creek, running $11 or $12 a ton, but the ore bodies are much wider, some of them 5 or 6 feet.

The ores are treated in a 10-stamp mill by simple amalgamation, the recovery being about $9 a ton. The total production is estimated at $300,000.

OTHER PROPERTIES.

The Roland and Taylor group consists of four claims situated in Anderson Creek valley a mile north of Gibbonsville. A wide, nearly vertical quartz lode striking north and south extends through the property. It is highly altered, heavy stains of iron and manganese being generally present. Locally cores of unaltered ore show pyrite and some chalcopyrite to be the principal metallic minerals. The ledge is held for gold, $3.50 a ton being claimed.

The Bull of the Woods property is situated on Hughes Creek, about 4 miles west of Gibbonsville. The veins are included in eastward-dipping quartzites and slates, the former being more abundant than near Gibbonsville. The extent and value of the ore bodies has not been adequately determined, and save through a few small placers the deposits have produced little or no bullion. A large stamp mill has recently been erected on the property, but at the date of the visit the machinery was only partly installed.

The Chief and Eckhart claims, together with several others, have had a small production. Most of them are individual claims adjacent to larger properties through which they are worked.

INDIAN CREEK DISTRICT.

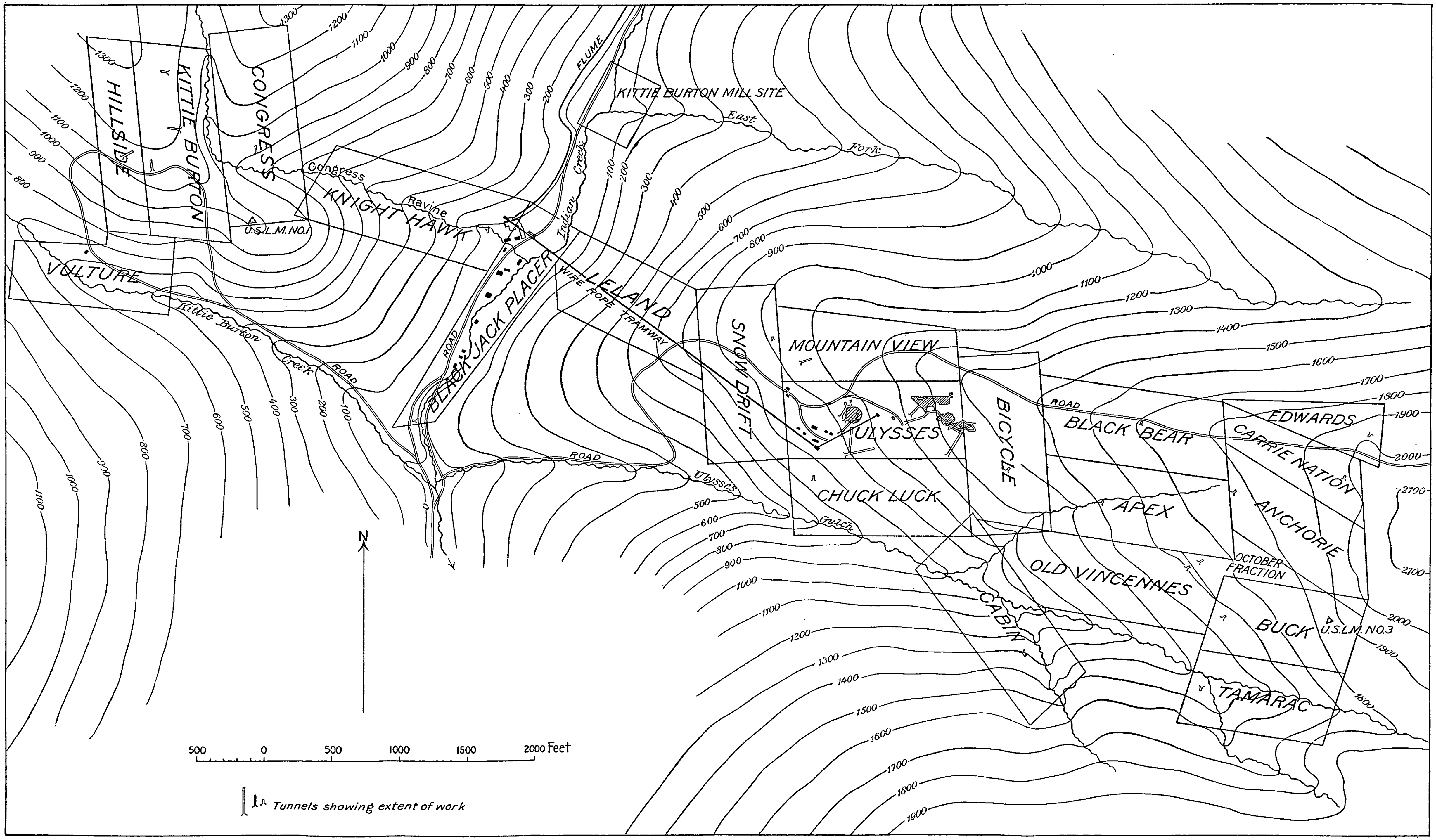
SITUATION AND HISTORY.

The Indian Creek mining district is situated along Indian Creek, which enters Salmon River about 30 miles below Salmon. Ulysses, a small settlement dependent for its existence upon the mines, is the only town in the district. It is reached triweekly by stage from Salmon. (See Pl. XXI, *B*, p. 152.)

Claims were first located in the district in 1895, but little work was done until the Kittie Burton Gold Mining Co. acquired the two leading properties, the Kittie Burton and Ulysses, in December, 1901. (See Pl. XVIII.) With the rapid development and successful operation of these mines other properties were located in the district, but none of them has been profitably operated. The Kittie Burton Co. has, however, continued operations on its properties, save for two or three short intermissions, since its organization.

TREATMENT OF ORES AND PRODUCTION.

Three or four small amalgamation mills have been operated from time to time in the district, but the only one which has turned out bullion in recent years is the mill of the Kittie Burton Gold Mining Co., which is equipped with three 5-stamp batteries, each followed by three amalgamation plates and a Wilfley table. About 80 per cent of the gold is recovered directly, part of the remainder being secured from concentrates by smelting. Two grades of concentrates are run;



MAP SHOWING CLAIMS OF THE KITTIE BURTON GOLD MINES CO., INDIAN CREEK DISTRICT.

From company maps.

the lower, averaging about $22 a ton, is stored; the higher, averaging about $70 a ton, is sacked and shipped to the smelter.

The average cost for mining and milling 68,194 tons of ore from January, 1903, to July, 1907, was as follows:

Cost per ton for mining and milling Kittie Burton gold ores.

Mining	$2.56
Milling	1.14
Transportation from mine to mill	.25
	3.95

The total production of the district is a little less than $600,000, of which the Ulysses mine has produced three-fourths and the Kittie Burton most of the remainder.

PHYSIOGRAPHY.

The Indian Creek mining district includes the central part of a small drainage basin 35 miles northwest of Salmon. Tributary to the great canyon of Salmon River, this basin corresponds to it in depth of valleys and steepness of slopes, especially in its southern part. Extremes in elevation range from 3,500 feet to more than 7,000 feet, and transitions of more than 2,000 feet within short distances are common. Indian Creek, a small stream heading against the Continental Divide, flows south through the district, affording abundant water for power and milling purposes save in winter when freezing temperatures make it impossible to keep flumes open.

GEOLOGY.

The predominant rocks of the region are the metamorphic equivalents of Algonkian shales, sandstones, and intermediate forms, perhaps 75 per cent of the total being quartzitic biotite slate. The series is rather intensely and very uniformly metamorphosed; little crumpling is noted, and where the primary structure is minutely distorted it is by gentle flexures rather than by crimpy bends.

The igneous rocks of the area are Archean gneiss older than the Algonkian sedimentary rocks, pre-Cambrian (?) diorite associated with the sediments, late Cretaceous granite and associated aplitic dikes, and granite porphyries younger than any of the others.

The several types of rock may be seen along the road between the mouth of Indian Creek and Ulysses. A broad belt of gneiss crosses the canyon about 2 miles below the mines. It is readily recognized by its large feldspars, many of them an inch or more in length, which are somewhat drawn out and appear as thick lenses around which curve sheeted bands of fine-grained biotite and quartz. The diorite appears in float along Indian Creek; it is a fine to medium grained greenish-black rock, darker and coarser than any of the dike rocks with which it might be confused. The granite, distinctive as a dark-gray medium to coarse grained equigranular rock commonly having much brilliant black biotite uniformly scattered through it, is widely exposed near the mouth of Indian Creek. Aplite dikes appear at many places on the valley sides near Ulysses; they are fine-grained rocks of light-gray or pale olive-green color, containing scattered quartz grains and, generally, cubes of pyrite as the only recognizable crystals. Rhyolite porphyry dikes are not numerous, the only one noted appearing about 1¼ miles below Ulysses on the west side of the valley at an elevation of 4,150 feet; the rock is dark gray in color and is made up of crystals of quartz, orthoclase, and hornblende, rather sparsely set in a fine-grained groundmass. In general it shows more crystals and is fresher than the other dike rocks.

Microscopic descriptions of these several rocks appear in the general section on igneous rocks.

The structural relations of the district are by no means simple. The strike and dip of the sediments change repeatedly and abruptly within short distances, although the variations fall between a strike of northeast and southwest with dip southwest and east and west with dip south.

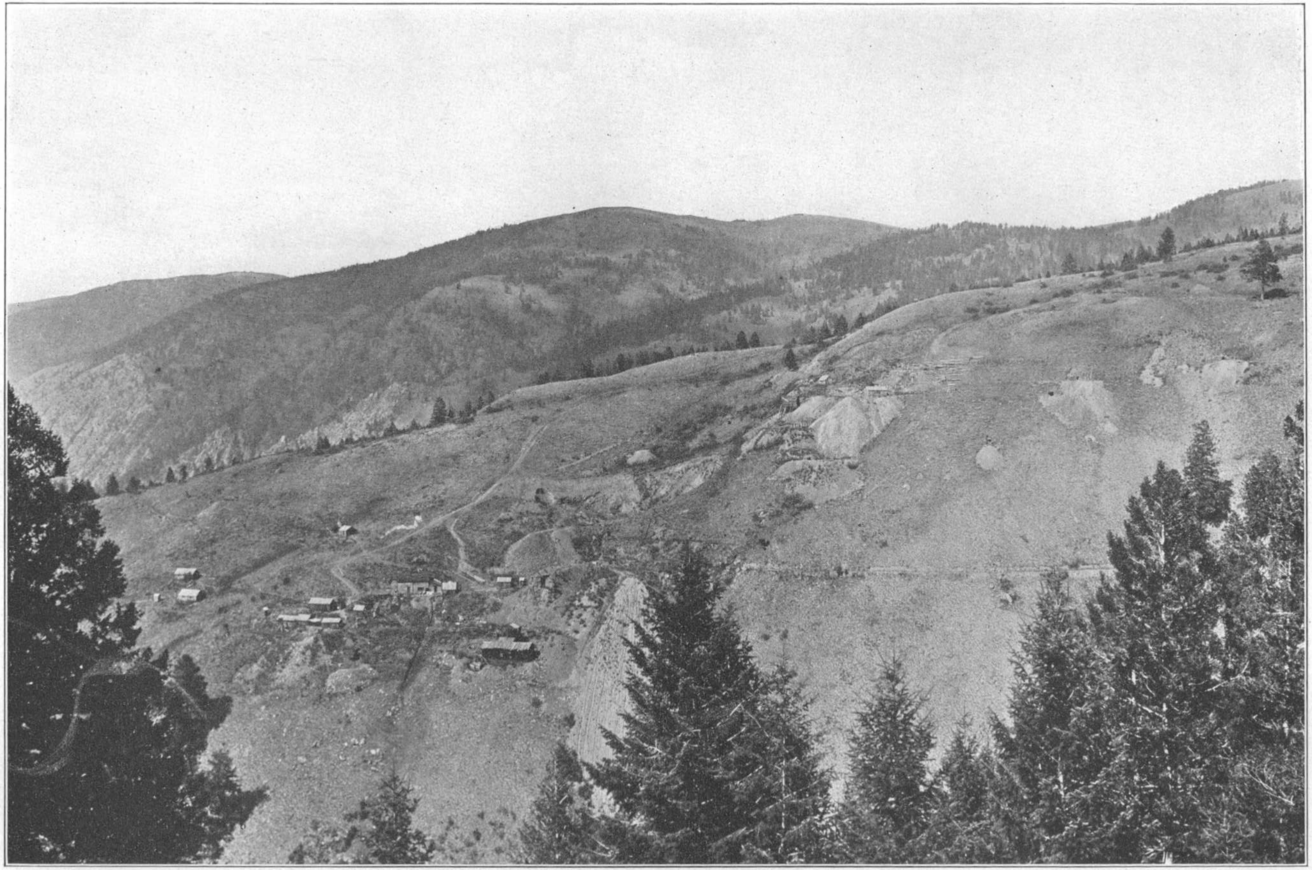
Strong joints are conspicuous throughout the area, the granite, however, being much less jointed than the old sediments and gneiss. In the granite the joints in general seem to extend N. 20° W. and at right angles thereto; in the metamorphic rocks they extend, in addition, N. 10° E. and at right angles thereto. It thus seems that the joints are assignable to two ages, pregranite and postgranite, those of earlier age being much more numerous. Slips and faults are largely along lines of jointing. Thus in the Ulysses mine some faults offsetting the ore strike N. 10°–30° W. and dip southwest, and others strike N. 60°–70° E. and dip northwest. Though faults are numerous, none with a vertical displacement of more than 100 feet has been recognized.

ORE DEPOSITS.

ULYSSES VEIN.

The Ulysses mine is situated on the steep valley side east of Ulysses, 1,400 feet above the town. It is reached by wagon road and connected with the mill at Ulysses by aerial tram. The vein, a tabular body varying in width up to 10 or 12 feet, strikes east and west and dips 10°–25° S. Its general flat dip, corresponding roughly with the slope of the hill, has made it feasible to work considerable areas near the outcrop by stripping the overlying material. (See Pl. XIX.) Nowhere has the vein been found to extend to a depth of more than 150 feet.

Slates and quartzites inclose the vein, which in most places corresponds in strike and dip. A fine-grained granite porphyry, very



ULYSSES MINE, INDIAN CREEK DISTRICT.

Showing distribution of tunnels and open cuts along the flat-lying Ulysses vein.

probably younger than the ore, overlies the vein in some places and in others underlies it. The vein filling is coarsely crystallized quartz but includes also much silicified wall rock. In places a little calcite accompanies the quartz. Pyrite, most of it in cubes but some of it in irregular patches, is conspicuous locally, and chalcopyrite and braunite appear in places. In general, however, the minerals are the common oxidation products of those just mentioned. Gold is distributed quite generally through the deposit in amounts equivalent to $1.50 or more per ton, but those parts sufficiently rich to justify handling are confined to large bodies erratically distributed in the vein. These average $7 or $8 per ton. It is noteworthy that

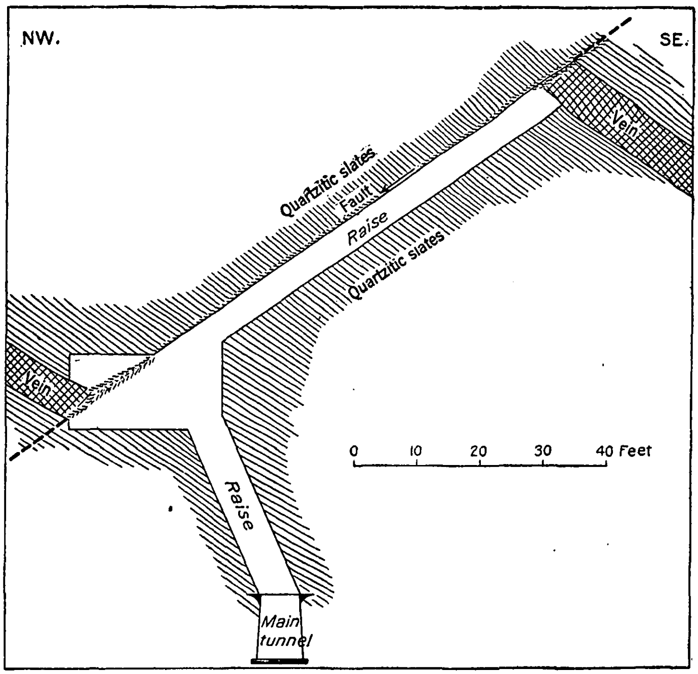


FIGURE 21.—Section at point 250 feet from portal of main tunnel, Ulysses mine, Indian Creek district Shows normal faulting of vein.

secondary enrichment has not been encountered in the oxidized ores, for iron and manganese are abundant, a combination which makes possible the solution of gold under surface conditions.

The vein is offset by several step faults (fig. 21) which successively increase its elevation northward.

KITTIE BURTON VEIN.

The Kittie Burton mine is situated on the canyon side west of Ulysses at an elevation 1,200 feet higher than the town. It is reached from Ulysses by wagon road and connected with the mill by aerial tram. The vein, inclosed in slates and quartzites, strikes N. 20°–30°

W. and dips 40° SW. in the upper 100 feet but is almost flat below that depth. In its more highly dipping section its average width is 3 to 4 feet, but in its flat part, known as the "big stope," it attains a maximum thickness of about 30 feet. From a level below the "big stope" and west of it, a winze has been sunk 40 feet on a vein which lies parallel to and west of the vein above the "big stope." Whether or not these are portions of the same vein has not yet been shown by development.

The vein filling, a coarsely crystallized bluish-white quartz inclosing much silicified wall rock, is in every way similar to that found in the Ulysses mine. In addition to abundant pyrite and some braunite and chalcopyrite, pyrrhotite is present in the ore. Of the minerals produced by oxidation, iron and manganese oxides are abundant, rhodochrosite appears as minute crystals on fracture surfaces, and malachite and azurite and rarely native copper are found in small quantities near the surface. Oxidation extends throughout that part of the deposit which has been explored, although as a whole the ore is rapidly becoming baser.

OTHER VEINS.

Veins have been found near the head of Sage Creek and at various places on the mountain slopes southeast and southwest of Ulysses, but as they are not commercially important so far as known, and as they do not differ in type from the Ulysses and Kittie Burton veins, they are not described.

MINERAL HILL DISTRICT.

SITUATION AND ACCESS.

The Mineral Hill mining district comprises a large area lying about 45 miles northwest of Salmon. On the north, east, and south it merges into the Mineral Point, Indian Creek, and Mackinaw districts, respectively. On the west no boundaries, even approximate, are recognized. Shoup, a small settlement on the north bank of Salmon River centrally located in the district, has triweekly mail communication with Salmon. A stage road down Salmon River reaches a point within 6 miles of Shoup, where it gives way to a narrow trail which winds along the canyon's side. Supplies are floated down the river on barges as far as Shoup, below which treacherous rapids make water transportation extremely hazardous.

Only the southern part of the district was visited during 1910, the northern part having been previously visited and briefly described by Lindgren.[1]

[1] Lindgren, Waldemar, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: Prof. Paper U. S. Geol. Survey No. 27, 1904, p. 90.

HISTORY AND PRODUCTION.

The district was discovered in 1882, the Grunter and Kentuck properties being located in that year. These locations were followed by the Big Lead in 1886, the Clipper Bullion in 1887, and the Monolith in 1889. During the first two years the ore was treated by arrastres and a single stamp. In 1884 the Kentuck Co. erected a 10-stamp mill, and during the succeeding few years four other mills were erected on as many properties, so that now 55 stamps are in place. Treatment of the ores in these mills has not, however, been wholly satisfactory, owing to the crude construction of most of them and to the fact that the ores rapidly became base with depth.

The total production of that part of Mineral Hill district adjacent to Shoup has probably been a little more than $750,000; about two-thirds of this amount has come from the Kentuck mine, the Grunter and Monolith affording most of the balance, although two other properties—the Clipper Bullion and Big Lead—have supplied some bullion.

TOPOGRAPHY.

Mineral Hill district is a forest-clad area of exceptional boldness of relief. Trenched across its southern part by the canyon of Salmon River, a narrow gorge 2,000 to 4,000 feet deep, which determines the depth of numerous tributary canyons, the area shows a succession of deep gashes, the sides of which rise abruptly until near the level of the uplands, where they grade back into broadly rounded topographic forms. The properties described later occupy the lower and middle slopes of the canyons of Salmon River, of Boulder Creek, a small tributary from the north, and of Pine Creek, which enters from the south.

GEOLOGY.

The uplands are in many places capped by sedimentary rocks of Algonkian age, now extensively metamorphosed to mica schists, slates, and quartzites. The base of these, separated from the underlying gneiss by an erosional contact, is a fine-grained biotite schist, locally containing much arkosic material derived from the gneiss. Above this schist is an oft-repeated succession of slates and quartzites. The series, although varying markedly in attitude from place to place, in general strikes N. 20° W. and dips 45° NE.

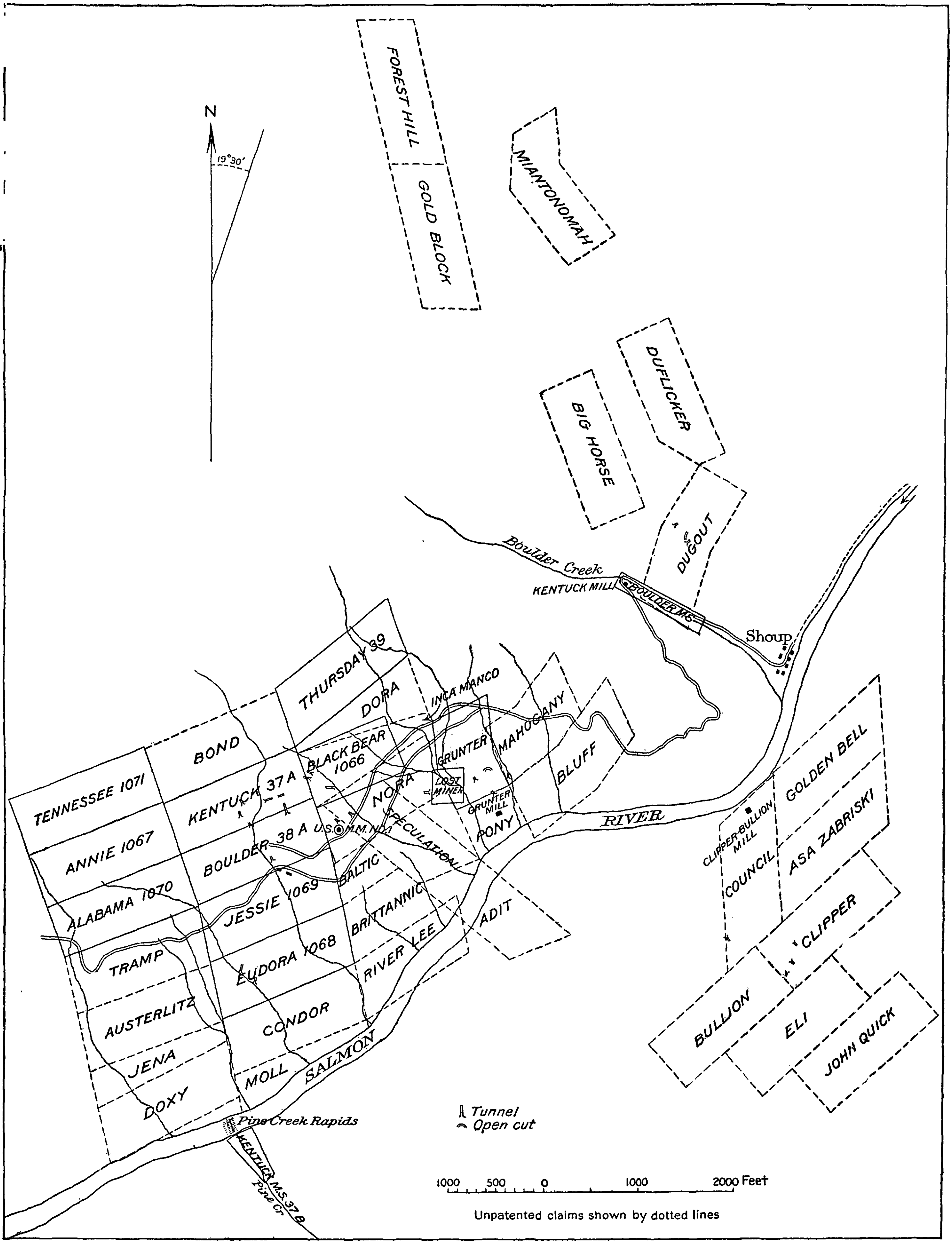
Granite gneiss, the oldest rock in the county, forms the canyon walls near Shoup and extends as a broad area north and west. Within its general field many caps of Algonkian rocks are yet preserved, but owing to lack of detailed knowledge concerning them, they are not shown on the map (Pl. I, in pocket). The gneiss is readily recognized in the field by its large feldspar crystals, many of which are crushed and drawn out into lenslike masses. Curving about these are foils of biotite and crude bands of granulated quartz, which by their arrangement give the rock a decidedly banded appearance.

Both the gneiss and the Algonkian sedimentary rocks are intruded by a great granite batholith, which is beautifully exposed in the canyon a few miles above Shoup and on the slopes to the southeast. The rock is dark gray, medium to coarse grained, and commonly equigranular. Although biotite is generally abundant, giving a mottled appearance, it is locally almost absent. This granite is distinguished from the granite gneiss by smaller feldspars, general lack of schistosity, and freshness of appearance.

Within the district dikes of coarse and fine grained granite porphyry, diorite, basalt, and quartz diorite porphyry were noted. The granite porphyry dikes are most numerous, at least six being seen, and are said to have the greatest extent. They are from 50 to 100 feet wide and extend in a general course N. 10°–20° E. The rock has a medium to coarse porphyritic texture with quartz and feldspar crystals set in a fine-grained bluish-gray groundmass. Next in importance, and younger than the granite porphyry, are the quartz diorite porphyry dikes, which in general strike N. 70° E. This rock is characterized by a dark-gray fine-grained groundmass, sparsely studded with medium-sized feldspar and fewer quartz crystals. Biotite and hornblende appear as small, brilliant, black phenocrysts. Possibly still younger, and with strike parallel to that of the quartz diorite porphyry, is a fine-grained equigranular grayish-black rock consisting of plagioclase, hornblende, and biotite. This rock is classed as diorite. Another type of dike, greatly altered but evidently a basalt, was noted in the Monolith mine. A similar rock, but fresh, accompanies the vein in the Clipper Bullion mine. The age of the basalt with reference to the quartz diorite porphyry is not known, but it is clearly younger than the veins.

ORE DEPOSITS.

The deposits of the district, all of which are mined for gold, are grouped around Shoup, in the southern part of the district (Pl. XX), and around Mineral Hill, in the northern part. Only the former were visited. Six or eight veins have been prospected. All the more important strike northeast and southwest and dip southeast. This general attitude is entirely independent of the schistosity of the gneiss and the bedding of the slates and quartzites but corresponds to the extensive joints which may be recognized in most exposures in the area. Faulting, although common, has been found to displace the ore seriously in only a few places.



CLAIM SHEET OF SOUTHERN PART OF MINERAL HILL DISTRICT.

Reduced from map in office of Kentuck Mining Co.

The veins strike N. 10°–70° E. and dip 10°–85° SE. They range from mere stringers to veins several feet wide. Although generally regular in strike and dip, they have many spurs which follow transverse joints, and in places they jump a few feet to one side and continue along a parallel course. Angular but commonly silicified inclusions of wall rock are common in the ore, especially in the deposits on Pine Creek.

The minerals of the district, exclusive of rock-forming varieties, are not numerous. All the veins are composed of coarse quartz with a little calcite and in one place (Tramway vein, Clipper Bullion group) with a little barite. The metallic minerals are irregularly distributed; in many places long stretches of quartz are essentially barren, then again a section of abundant metallization appears. The more highly mineralized parts have generally been found to have a greater vertical than horizontal extent. Pyrite, with which the gold is associated, is the most abundant metallic mineral. It occurs as isolated cubes embedded in the quartz, groups of cubes, fine-grained irregular aggregates, and here and there as films along fracture planes. Galena, much less abundant than the pyrite, occurs in most of the deposits, as does also sphalerite and arsenopyrite. Magnetite, although not noted elsewhere, is conspicuous in the Pine Creek ore deposits.

Oxidation rarely extends more than a few feet below the surface and in its extreme depth probably does not attain more than 100 feet. In general it has not reached to the level of ground water, a fact doubtless to be explained by the comparatively unfractured condition of the gangue.

The veins are cut by the granite porphyry dikes, which in turn are crossed by those of quartz diorite porphyry. On the other hand, some of the deposits are inclosed in granite. It follows that the veins are later than the granite and earlier than the granite porphyry. The granite is thought to be late Cretaceous, and the granite porphyry, being cut by the Eocene erosion surface, is earlier than late Eocene. The veins consequently are assigned to the late Cretaceous or early Eocene.

That the veins were formed at considerable depth and under great pressure is shown by the coarse quartz and by the minerals, the most significant of which is magnetite. If carefully examined the deposits on Pine Creek might be found to show direct genetic relation to the granite, for in one exposure visited a small spur from that mass was seen to contain a median zone of quartz closely resembling that which fills the fissures; a gradually increasing number of feldspar crystals grade out from this until, near the margin, the mineral composition is that of the normal granite except that muscovite instead of biotite is present.

MINES.

KENTUCK MINE.

The Kentuck, the chief mine of the Mineral Hill district, is situated 1 mile west of Shoup at an elevation of 1,200 feet above Salmon River. The property was located in 1882, and immediately thereafter pro-

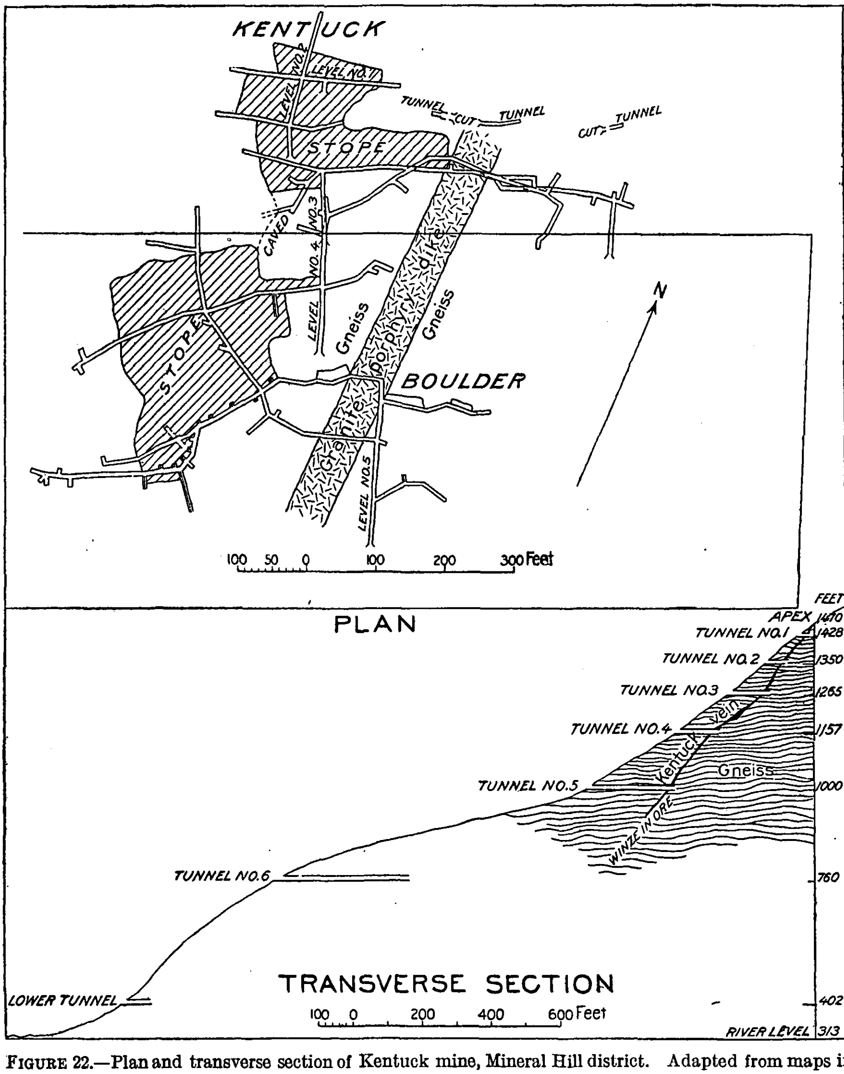


FIGURE 22.—Plan and transverse section of Kentuck mine, Mineral Hill district. Adapted from maps in the company's office, with geology added.

duction began. During the first two years the ore was worked by a mill with a single stamp and two arrastre beds. In 1884 a 10-stamp mill was erected, and from that time until 1890 the mine experienced its greatest period of production, which gradually waned during the next three years to its present inactive state. The property has yielded about 45,000 tons of ore which, on a basis of 40 per cent recovery, is said to have netted a fraction less than $10 a ton.

Development work on five levels opens a total depth on the vein of about 700 feet, although, owing to the approximate coincidence in dip of the lode and slope of the hill, a vertical depth greater than 200 feet has not been obtained. Most of the development and stoping has been done from the fifth level. (See fig. 22.)

The vein, which strikes N. 70° E. and dips 40° SE., is from 2 to 6 and in a few places 8 feet wide. It is inclosed in gneiss, which is cut by granite porphyry dikes younger than the vein and by quartz diorite porphyry still more recent. The ore is coarse-grained bluish-white quartz with pyrite, and in places has arsenopyrite, galena, and a very little sphalerite scattered irregularly through it. In the upper workings little ore was found to be oxidized for more than a few feet below the surface.

MONOLITH MINE.

The Monolith group lies a mile north of Shoup on the east side of Boulder Creek at an elevation of 4,100 feet. Development consists of several open cuts and small tunnels in addition to a principal tunnel which extends in 600 feet on the strike of the vein and from which raises and stopes connect with the surface 150 feet up the dip. The production of the property is said to be about $175,000 from ore which plated somewhat less than $10 a ton.

The country rock comprises both metamorphosed sediments and gneiss. In the workings quartzites and slates predominate, although gneiss crops out a few hundred feet below the tunnel. Both types of rock are extensively jointed. Granite porphyry, quartz diorite porphyry, and basalt occur as dikes.

The deposit, a tabular body from a few inches to 4 feet in width, strikes N. 12° E. and dips 10°–30° SE. Within the coarse quartz gangue, pyrite, nowhere abundant, appears as intergrowths and as films along joint cracks; galena occurs in small amounts, both as cubes and fine-grained bunches; sphalerite is rare, as is also arsenopyrite. Oxidation is not extensive, primary minerals commonly appearing within a few feet of the surface. Near the hanging wall, however, a narrow oxidized zone apparently serves as a water channel through the deposit which, as now exposed, is far above ground-water level.

GRUNTER MINE.

The Grunter mine is situated half a mile below Shoup and a few hundred feet north of Salmon River. The property was the first located in the district, and in the few years following its discovery, in 1882 produced some $50,000 from ores procured near the surface. The vein has never been explored in depth, most of the workings being open cuts, in places connected by short tunnels. The country rock is gneiss locally impregnated with pyrite, and rather generally silicified near the vein. The ore body is an irregular deposit, which in some places strikes N. 70°–80° E. and dips 30°–70° SE. and in others strikes N. 10° W., with dip variable but averaging perhaps 70° E. The quartz varies from 2 to 40 feet or more in width, the wider parts being generally angular in general outline. Mineralogically the deposit is rather simple, pyrite and sparse galena, sphalerite, and arsenopyrite being the only minerals noted. Oxidation has taken place only along the stronger joint cracks and within a few feet of the surface.

CLIPPER BULLION MINE.

The Clipper Bullion property consists of 10 claims south of Salmon River, half a mile from Shoup. Since its location in 1887 some 2,500 feet of development work has yielded about $75,000 in gold.

Three veins, all of which are inclosed in gneiss, have been opened on the property. They appear at successively higher elevations on

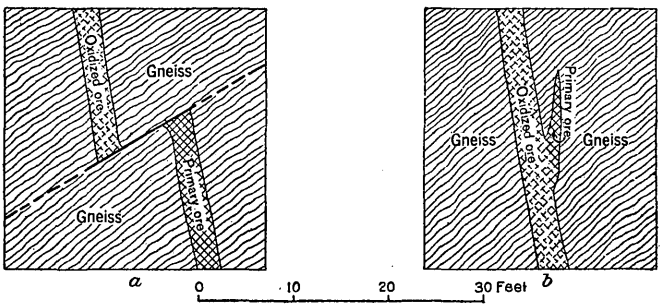


FIGURE 23.—Sketch illustrating oxidation in Tramway vein, Mineral Hill district. *a*, Influence of cross fault on oxidation of ore body; *b*, an upward spur which has not been attacked by oxidizing agents, though well within the zone of oxidation.

the mountain side and are locally known as Tramway, Hennessey, and Clipper Bullion. The Tramway vein, which averages about 3 feet in width, strikes N. 70° E. and dips 80° SE. In the upper part it is a decomposed honeycomb quartz carrying free gold. It is faulted at short intervals but is never offset more than a few feet. One normal throw of particular interest parallels the vein in strike but has opposite dip; above it the ore was completely oxidized and below it unaltered vein matter was encountered. The ore consists of pyrite and a little galena, irregularly and rather sparsely scattered in a quartz-barite gangue. Within the oxidized zone the primary minerals have altered to iron oxide and cerusite (fig. 23), and native sulphur is very generally present in the cavities formed by leaching. In treatment the sulphur forms a scum in which much of the fine gold is lost.

The Hennessey vein, which averages about 20 inches in width, strikes N. 20° E. and dips 85° SE. It is composed of clear, coarse quartz, in which are scattered pyrite crystals accompanied by free gold.

The most productive vein on the group is the Clipper Bullion, which averages about 3 feet in width, strikes N. 42° E., and dips 65°–85° SE. Only the oxidized zone, consisting of decomposed pyritic quartz, has been worked. Here, as elsewhere in the group, the ore occurs in small shoots, some of which are very rich. One shoot produced 1,000 tons of ore averaging $43 per ton.

BIG LEAD MINE.

The Big Lead mine is a gold property situated on the east side of Pine Creek, about a mile above its junction with Salmon River. Development consists of about 1,500 feet of tunnels and a few small shafts. The production of the property is not known, but probably it has been small.

The rock formations include gneiss and slates intruded by granite and granite porphyry dikes. Several veins are recognized but only the most important was visited. This vein strikes N. 65° E. and dips 80° SE. It is inclosed in granite and ranges from a few inches to 3½ feet in width. Throughout the present workings the ore is extensively oxidized and iron stained, although crystals of pyrite and considerable magnetite appear in places. The gold is free. In many places the granite next the vein is a little altered, and numerous masses of schist included in the quartz, evidently having fallen into an open fissure from higher horizons, are intensely silicified.

The ore bodies on this group are large and fairly persistent but mineralization is not intense; $6 to $8 a ton is claimed.

MACKINAW DISTRICT.

SITUATION AND ACCESS.

The Mackinaw district includes an unorganized area of about six townships situated in the north-central part of Lemhi County. Broadly defined, it is bounded on the east by the mountain crest west of Salmon, on the north by Salmon River, and on the south and west by Big Creek. On the northwest the Mineral Hill district extends a short distance into this area, and in the northeast the Eureka district is frequently considered to include the Moose Creek placers. In this report, however, these are included in the Mackinaw district.

Leesburg, a settlement of 25 inhabitants, the local supply point and post office for the district, is reached triweekly by stage from Salmon, which in a direct line is about 9 miles east-southeast but by road is much farther. Lines of travel within the area include a stage road from Leesburg, east to Salmon and south to Forney. Secondary roads extend to Moose Creek with a branch to Beaver

Creek, and branches from the Forney road up Arnett and Phelan Creeks. Trails lead from these few roads into many parts of the district.

HISTORY AND PRODUCTION.

The location of placers on Napias Creek in July, 1866, makes the Mackinaw district by several years the oldest in Lemhi County. In spite of the fact that it was necessary to freight supplies from Fort Benton, in central Montana, and later from Corinne, Utah, a prosperous camp with more than 7,000 persons early sprang up at Leesburg. The first four years after discovery marked its period of greatest activity, although placer mining has continued down to the present time.

The first quartz mine, known as the Shoo Fly, was located in 1870 on the mountain east of Moose Creek basin. The ore body was not large and was soon exhausted. In 1880 the Gold Flint was located, and in 1892 the Italian mine. Withal, quartz mining has not proved nearly as productive as placer working. Some promising veins have been found, but most of the ore bodies have proved irregular in shape and low in grade.

As is true in most districts where rich placers are worked by many individuals and where gold dust is used in commercial trade and gambling is rife, it is impossible to form even an approximately correct estimate of the total amount of gold produced. It is also true that the estimates handed down by tradition in such districts are nearly always far too high. In the Mackinaw district long-time residents place the production at figures ranging from $5,000,000 to $30,000,000, but from the area of ground worked and its reported richness it seems to the writer that the former figure must be very much more nearly correct, possibly even high. In addition to this the lode mines have afforded bullion to the amount of about $250,000, two-thirds of which came from the Italian mine and most of the remainder from the Shoo Fly.

PHYSIOGRAPHY.

The Mackinaw district is a high forest-clad area, deeply trenched in its marginal parts by canyons which extend into it from three sides. On the north the uplands join abruptly the precipitous sides of Salmon Canyon, and on the south and west meet the almost equally steep slopes of the trench occupied by Big Creek. Eastward the surface grades into the crest line, beyond which lies the broad valley in which the city of Salmon is situated.

The valleys in the central part of the area are broad and open, assuming their trenchlike character only as they approach the major streams on the margin of the district. Also characteristic of the uplands are the many features typical of glaciation. These are distinct on Napias and Moose creeks and about the head of Beaver Creek. Indeed most of the area above 8,000 feet and some of the valleys (Napias Creek) as low as 6,500 feet were glaciated in Pleistocene time.

GEOLOGY.

Algonkian sedimentary rocks, largely confined to the central part of the district, form the principal stratified rocks of the area. They are completely metamorphosed to quartzites, slates, and schists which, although varying greatly in attitude from place to place, in general dip 45° ENE. They occur as a broad outlier resting upon the granite which is extensively exposed in the canyons bordering the area.

Miocene lake beds occur in Moose Creek basin as a small area about three-fourths of a mile wide and 5 miles long. They are excellently exposed at the head of Dump Creek canyon, which is the lower continuation of the valley occupied by them. As here seen, the beds are more than 200 feet thick, consisting of about 100 feet of rhyolite flows overlain by conglomerate at the base, followed by thinly bedded alternating layers of sandstone, shale, and lignitic material for about 100 feet more. After these were tilted to a dip of 10° E. and a central trench was developed through the basin, basalt poured into the lower parts, making the surface nearly level. Then followed a thin veneer of auriferous gravels. Some time during its later history the drainage changed from its normal outlet by way of Dump Creek and escaped by way of Moose Creek. The divide remained so low, however, that during early placer mining Moose Creek was returned to its original outlet and now escapes through a deep trench, excavated by it in recent years. (See fig. 7, p. 36.) A dike of rhyolite porphyry, which crosses the valley below the deposit, probably formed the dam that caused the Miocene lake.

Granite gneiss, resulting from intense metamorphism of a coarse-textured biotite granite, is exposed in the northwest part of the district. In most exposures the gneiss is readily recognized by its large feldspar crystals, many of them 2 or 3 inches in length, which are somewhat drawn out and interspread between fine-grained bands of intimately mixed biotite and quartz. The rock is of Archean age and constitutes the basement upon which the Algonkian sedimentary rocks rest.

The next younger igneous rock is a medium-grained biotite granite which cuts both the gneiss and the schists. From the gneiss it is readily distinguished by its general lack of schistosity, its more nearly equigranular texture, and its generally fresh appearance. The rock is exposed as a broad band surrounding the large area of Algonkian sedimentary rocks which occupy the central part of the district. Along the inner side of the eastern portion its contact with the sedimentary rocks is a fault plane, but in most places it is clearly intrusive and accompanied by garnet, epidote, and chiastolite developed in the older rocks near its contact.

Dikes are not numerous in those parts of the Mackinaw district which were visited. One of rhyolite porphyry occurs near the head of Dump Creek and two or three others at the mouth of Phelan Creek. Near the Italian mine a dike of biotite monzonite 100 feet wide strikes N. 60° W. The rock is dark gray and equigranular and contains about equal amounts of oligoclase and orthoclase (Pl. VIII, *A*, p. 45), together with much biotite.

Lavas are developed along Moose Creek and along Napias Creek, near the mouth of Phelan Creek. In the former locality they consist of rhyolites which underlie the lake beds, and basalts which overlie them. In the latter area both rhyolites and basalts are seen, the former greatly predominating. The relative ages of the lavas as here exposed were not determined. In each locality their areal extent is about 4 or 5 square miles.

PLACER DEPOSITS.

Placers have been worked along Napias Creek and its tributaries, Moose Creek and Beaver Creek. They occur above 6,500 feet elevation, except on Beaver Creek, where they extend down to 3,500 feet above sea level.

LEESBURG BASIN.

Napias Creek and its tributaries drain an area commonly known as the Leesburg Basin, which comprises about 1,000 acres of ground. This ground includes the most extensive placers in the Mackinaw district and the earliest discovered in Lemhi County, being located in July, 1866. Work has been carried on almost entirely by hydraulic methods and a total of possibly $5,000,000 has been recovered. The gravels vary from 5 to 8 feet in thickness and range from pebbles to bowlders 10 inches through, with a few up to 4 or 5 feet. In most of the workings decomposed granite is the bedrock, but in places, particularly on Phelan Creek, the gravels overlie glacial till. One mile below Leesburg two beds of gravel separated by about 8 feet of glacial till have been recognized, but only the upper bed has been worked. Most of the gold occurs in the first 18 inches above bedrock, in coarse and fine grains, although some small nuggets and a few worth from $15 to $20 have been found.

Placer mining has been practically abandoned in the Leesburg Basin for many years, only a few individuals operating intermittently. An area of special interest is on the hill near the Haidee mine, where the arkosic mantle formed each winter by the disintegration of granite is washed for gold each spring and affords wages, though little more.

MOOSE CREEK.

Next in importance among the placer grounds in the district are those along Moose Creek, where 200 acres have yielded about $1,000,000. This deposit has continued productive down to the present, the annual production for several years past having been about $20,000. This property, located a short time after the Leesburg placers, was owned and worked for many years by David McNutt, of Salmon. In 1898 it passed into the hands of the Pacific Dredging Co., of Chicago, and was operated with a dredge for four and one-half years. Later it was secured by John E. Mullen, who for the past four years has operated a dredge of 2,000 yards daily capacity. In addition to the main deposit, Beartrack, Webfoot, and Dailey Creek gulches, all tributary from the east, have produced noteworthy amounts of gold.

The basement is an even floor, in places formed of decomposed granite but mostly of Miocene lake beds, themselves largely arkosic, and thus sometimes mistaken by the miners for decomposed granite. Where work has been done the overlying gravels have been found to vary in thickness from 10 to 18 feet, but near the head of the basin test pits show them to attain a thickness of 30 feet. The deposit is made up of waterworn granite and quartzite fragments, few of them more than 8 inches in diameter, averaging perhaps 4 inches, in general loosely cemented. The gold, worth about $19 per ounce, occurs as coarse and fine grains and is largely confined to the lower 12 inches of the gravels and the upper 18 inches of bedrock. Most of it is found in the joints, depressions, and loosely assembled parts of the latter. In its areal distribution the pay streak swings from one side of the basin to the other, like the meanders of a stream.

BEAVER CREEK.

Near the confluence of Beaver Creek with Big Creek placers have been worked intermittently for a number of years, producing somewhat less than $100,000. They have been recognized at three levels, the lower being the recent accumulations along the valley flats, the upper a terrace northeast of the point of intersection of the streams and 400 feet above them, and the intermediate a terrace on the same slope, 100 feet above its base. Most of the production has come from the upper terrace. Considerable drifting and shaft work has been done on the valley level, where the gravels are about 80 feet thick, but without profit. Bedrock is granite gneiss, depressions in which are said to determine the pay streaks.

SOURCE OF THE PLACER GOLD.

In many places in the district the source of the placer gold has been definitely located. The Beaver Creek placers from their distribution were evidently derived from the upper part of Beaver Creek canyon, and here the Mayflower and other veins are recognized. Those of Leesburg Basin were derived from the area to the west, for, except for Phelan Creek, which is south of the principal workings, only tributaries from the west have yielded placer gold. Up the several gulches on the west side are situated the Italian, Haidee, Gold Ridge, Gold Dust, and Gold Flint mines, all of which are held for free gold, whereas, on the east side of the basin, no veins have been worked. On the other hand, the Moose Creek placers extend only up valleys tributary from the east and south, and on all of these the source of the gold is not clear, for but one vein, that of Shoo Fly mine, has been located to the east. To the south the northward continuation of the Gold Flint lode is recognized.

AGE OF THE PLACERS.

The placers of the district occupy erosion basins formed after the elevation of the Eocene erosion surface. (See p. 53.) The earlier and more extensive probably accumulated during both Miocene and Pliocene time. A break during the Pleistocene is recorded by a bed of pulverized rock, 8 to 10 feet thick, which is clearly of glacial origin. After the glacial epoch gravel accumulation continued, as shown by bedrock of glacial till in the deposits on Phelan Creek, by some of the deposits on Camp Creek, and by deposits in some parts of the main valley near Leesburg post office. The area around the Haidee mine, where the thin mantle formed by the disintegration each winter of the already deeply weathered granite bedrock is washed for gold each spring, indicates that the accumulation of placer gold still continues in the area.

LODE DEPOSITS.

DISTRIBUTION.

The most important known lode deposits occur west of Leesburg in the granite area, north of Leesburg along a fault plane between granite and metamorphosed sediments; northeast of the Moose Creek placers in the Algonkian sedimentary rocks, and in the vicinity of Beaver Creek, in the old sedimentary rocks. In general, the lodes strike north and south and dip west.

VEINS.

The deposits occur as (1) quartz veins accompanied by stockwork in granite; (2) replacement veins along fault planes; (3) replacements along shear zones; (4) lenses in schist; and (5) veins in contact with biotite monzonite dikes. As is common, the several types grade into each other, and it would be difficult to determine which of them has been most important in yielding placers, although the third is clearly subordinate in importance to the others. The deposits of the first type have been most productive, and if plans for working the metallized granite adjacent to the veins prove a success they will be even more productive in the future.

The Italian mine and properties adjacent represent the first type. Here a fractured zone in granite extends for at least 5,000 feet in a north-south direction and dips about 45° W. In a few places quartz veins are as much as 3 feet wide, but they do not average more than 8 or 10 inches. Although the larger veins follow the north-south course and dip west, the innumerable quartz stringers, few of which are more than a fraction of an inch wide, traverse the granite in all directions, following fracture lines. In the quartz and in some crevices in the granite, almost to the exclusion of quartz, are pyrite, sphalerite, specularite, a little galena, and some manganese. In the past the quartz veins have been worked exclusively, producing about $175,000, but recently treatment of the metallized granite, said to run from $2 to $4 a ton, has been attempted. A test run of 4,000 tons which plated $2.25 a ton was mined and milled at a cost of 87 cents a ton. The few specimens secured indicate that this granite is not greatly altered, the feldspars being comparatively fresh and the metallization largely confined to fracture planes.

Replacement veins along fault planes—deposits of the second type—occur in the Gold Dust, Gold Reef, and Gold Flint mines. Here metamorphosed sediments constituting the hanging wall of the vein have been faulted against granite. Heavy gouge which accompanies the fault in most places is sparsely metallized, but next to it and continuing out into the hanging wall, locally for 20 feet or more and as a much narrower band on the footwall, wide coarse pyritiferous quartz is developed. The amount of gold in the ore varies with the amount of pyrite present, the latter being very irregular in distribution. Aside from the quartz the only minerals noted in these deposits were pyrite, and iron and manganese stains.

The third type—replacements along a shear zone—occurs on the Mayflower group on Beaver Creek, where irregular replacements of pyritiferous quartz follow a disturbed zone which extends N. 30° W. The country rock is siliceous schist. A similar occurrence is Copper King vein. In both garnet, accompanied by epidote and magnetite, appears in the inclosing rock.

Lenses in schist and probably also in granite—the fourth type—appear to have been the source of much of the placer gold found on Moose Creek. The country within the Moose Creek drainage basin and east of the placer ground was not examined during the reconnaissance, but as auriferous gravels are reported up the gulches which extend in that direction and do not appear along those leading west, most of the gold probably came from the east. The only property located on that side is the Shoo Fly vein, which is of the fourth type. Quartz stringers, however, are reported from the granite area south and east of the placers.

Ore occurs in contact with a biotite monzonite dike—the fifth type—on the Italian property. The vein, which is about 2½ feet wide and which consists of coarse-textured bluish-white quartz, lies on the footwall side of the dike. It differs from all other veins in the district in the variety and relative importance of the minerals present. Chalcopyrite is most important and sphalerite comparatively abundant; pyrite and galena are subordinate in amount and are distributed irregularly and rather sparsely through the gangue. This deposit cuts deposits of the first type—quartz veins accompanied by stockwork in granite.

Lead ores have been reported recently from a property called the Bull of the Woods near Leesburg, but their extent and character are as yet undetermined.

AGE AND GENESIS.

All the lode deposits in the district are probably of about the same age, the vein accompanying the biotite monzonite dike being assigned to a later stage of the same general period. Throughout the deposits coarsely crystallized quartz is characteristic; in some garnet, epidote, and magnetite accompany the ores; in all pyrite is present, and more or less replacement of wall rock has taken place. These general characteristics clearly indicate deposition under conditions of intense heat and pressure. The deposits occur both within the metasediments and within the granite, but in both near the contact between these types of rock. An inspection of the map (Pl. I, in pocket) brings out very strikingly this relation. In no place do they occur either in the sediments or in the granite at a greater distance than 2 miles from the contact.

These facts strongly suggest that the deposits are genetically related to the granite magma and are in accord with a view that the solutions emanated from that mass after its outer part had solidified. As the granite is of late Cretaceous or early Eocene age, and as from physiographic evidence the deposits are older than late Eocene, it is concluded that they followed closely the intrusion of the granite.

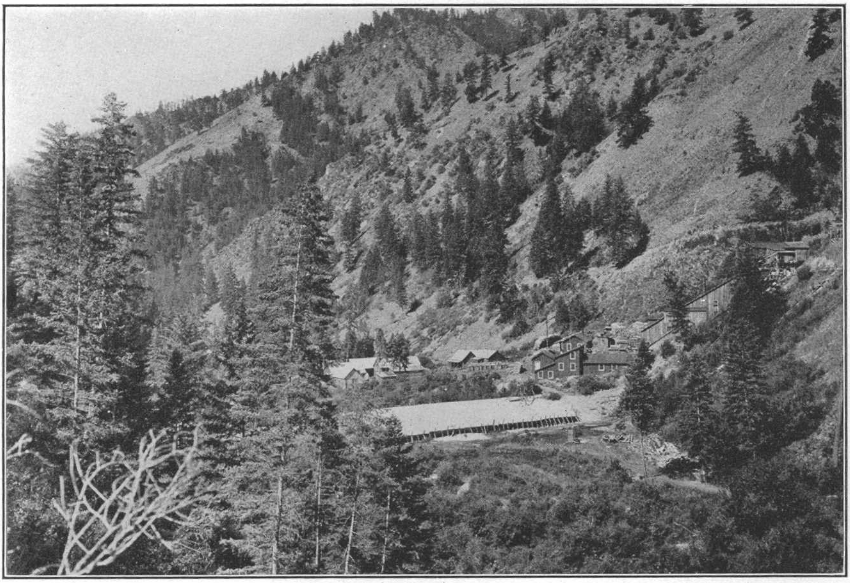
MINES.

ITALIAN MINE.

The Italian mine is situated on Arnett Creek 3½ miles from Napias Creek and at an elevation of 7,150 feet above sea level. (See Pl. XXI, *A*.) The property was located in 1892 by three Italians and operated by them until 1904 when it was purchased by the Leesburg Mining Co. Recently this company has built a 30-stamp mill and installed a 700-horsepower electric plant on Big Creek at a point 7

A. ITALIAN MINE.

Showing 30-stamp mill and location of principal workings.



B. CAMP OF ULYSSES.

Kittie Burton mill on right.

miles west from the mine. Development consists of some 3,500 feet of tunnel and a shaft 240 feet deep and of a great many open cuts and 80 acres of placer diggings. The total production of the property, exclusive of the placers, is about $175,000, most of which was extracted in a 10-stamp mill prior to 1904. A trial run of 4,000 tons in the new mill in 1910 plated $2.25 per ton at a total cost for mining and milling of 87 cents per ton.

The country rock is the normal biotite granite, in many places greatly fractured and heavily stained with iron. Cutting the granite in a N. 60° W. direction is a dike of fine-grained dark-gray equigranular rock, made up of biotite and orthoclase together with a little oligoclase and micropegmatite. The type is uncommon, but the rock should probably be classified as biotite monzonite (p. 45). The granite, when heavily fractured and iron stained, weathers very rapidly, breaking down to an arkose which is auriferous in many places.

The ore occurs in a north-south zone about 5,000 feet in length and up to 300 feet or more in width. In this zone occur innumerable quartz stringers and a few narrow quartz veins, the latter usually irregular in width and very limited in extent. The veins have afforded most of the production, but it is the intention of the present company to work the mineralized granite, said to run from $2 to $4 per ton. The principal ore minerals are pyrite, less sphalerite and pyrolusite, and a little galena. In the veins the metallic minerals are irregularly distributed through a coarse bluish-white quartz; in the granite they constitute almost the entire filling of some of the narrow joints and fractures, or are intermixed with vein quartz. The single specimen of granite studied microscopically is remarkably fresh, the feldspars being little altered, although in places the biotite is bleached. The striking feature is the great number of cracks which traverse the section in every direction. Along them iron stains are common and in places sericite has developed. In the hand specimen specularite also was noted, although none appears in the slide. Accompanying the biotite monzonite is another type of deposit—a coarse-textured quartz vein about 2½ feet wide, lying on the footwall side of the dike. It differs from the other deposits in carrying chalcopyrite but contains almost as much sphalerite and a little pyrite and galena. The dike and accompanying ore cuts the other deposit.

HAIDEE MINE.

The Haidee mine, situated 1½ miles north of the Italian mine, is similar to it in geologic relations and character of ore. Development on the property consists of a shaft 160 feet deep with 400 or 500 feet of drifting from it, and a tunnel 3,000 feet long which, because of caving, was abandoned before the vein was reached. The vein, which is inclosed in granite, strikes north and south and dips

57° W. It is a fissure filling 3 to 4 feet wide. The quartz is coarse textured, and carries irregularly spaced heavy bands of pyrite cubes, some of them 3 or 4 inches wide, in places constituting as much as one-third of the vein matter. Intermixed with the pyrite is a little sphalerite and a very little galena. Manganese oxide is abundant. The ore is said to have plated about $7 per ton in gold.

SHOO FLY MINE.

The Shoo Fly ledge, the first location in the district, was discovered through large and high-grade bowlders of vein matter strewn along the hillside below its outcrop. It was made up of irregular lenses of quartz inclosed in "schist." Although the ore was high grade in places, it never gave satisfactory returns. About $75,000 is said to have been produced, chiefly from the residual quartz bowlders.

GOLD FLINT MINE.

The Gold Flint mine is situated 1½ miles north of Leesburg. The property was located in 1880 and some ore has been blocked out but no bullion produced. The vein, which is developed by about 1,200 feet of tunnels, occurs along a fault plane which strikes N. 18° E. and dips 45° NW. It throws Algonkian sedimentary rocks against late Cretaceous granite. The deposit is of replacement origin, the best ore occurring next to the heavy gouge which accompanies the fault plane, and from there grading out into the sediments, so that in most places about 20 feet is visibly mineralized. The minerals noted were pyrite and manganese and iron oxides. Gold, accompanied by some silver, is claimed in amounts of about $5 per ton.

It is worthy of note that the Wards Gulch placers, which produced about $1,000,000, extend headward to the intersection with this deposit but not farther; also that the placer-gold found here differed from that in most other parts of the Leesburg basin in the high percentage of silver present, an amount sufficient to reduce the gold content to $14 an ounce. These facts are in perfect accord with the idea that the placers of the Leesburg basin were derived from the Gold Flint ledge and the several others south of it.

GOLD DUST MINE.

The Gold Dust mine is situated across Wards Gulch, south of the Gold Flint mine, and in its broader features is similar to that deposit. The ore either follows a fault parallel to that in the Gold Flint mine or the same one which has been offset to the east in its southern part by a cross fault along the line of Wards Gulch. The ore bodies are considerably broken and mineralization is not intense. A 10-stamp mill, which ran about 90 days, is situated on the property.

GOLD RIDGE MINE.

The Gold Ridge mine is situated on the same fault zone as the Gold Flint and the Gold Dust. It is developed by about 1,000 feet of tunnel and raises. A 10-stamp mill and a 50-ton cyanide plant which operated for parts of two years are situated near the principal portal. The ore is low grade, probably running $2 to $3 a ton.

COPPER KING MINE.

Copper King Mountain, on which the Copper King property is situated, rises a few hundred feet above the plateau area, 13 miles northwest of Leesburg. Development consists of about 500 feet of tunnel and shaft work. The country rock is quartzite, locally including garnetiferous mica schist; it strikes N. 25° W. and in general dips about 45° NE., whereas the vein strikes N. 45° E. and dips 75° NW. The latter, which averages perhaps 2 feet in width, is accompanied by many parallel stringers separated from each other and from it by mineralized wall rock. The mineralized zone thus defined is some 40 feet across. The quartz near the surface has been intricately fractured and generally leached of its metallic content. In the lowest workings, about 200 feet below the surface, the minerals noted are scattered pyrite, chalcopyrite, and magnetite, and abundant oxidation products from them.

MAYFLOWER GROUP.

The Mayflower group includes three patented claims situated at an elevation of 5,200 feet on the south wall of Beaver Creek canyon, about 3½ miles above its junction with Big Creek. Little work has been done on the deposits, which consist of replacements along a brecciated zone in siliceous schist. In some places, owing to leaching of pyrite and chalcopyrite, the quartz is extensively honeycombed but in others it is not metallized. The brecciated material accompanying the quartz is locally almost entirely made up of garnet with associated epidote and magnetite. The property is held for copper, gold, and silver.

EUREKA DISTRICT.

SITUATION.

The Eureka mining district includes a narrow strip of country extending along the western side of Salmon Valley, possibly 15 miles above and an equal distance below Salmon. Westward it extends to the crest of the mountain slope, and eastward Salmon and Lemhi rivers may be taken as the boundary. It thus includes the north end of Lemhi Range. Moose Creek, beyond the summit to the northwest, is sometimes included in the Eureka and sometimes in the Mackinaw district, but as its deposits can be more advantageously described with those of the latter area, it is discussed in connection with them. (See p. 149.)

The mining of the precious metals is confined entirely to lode deposits. Many claims have been located, but even collectively they have afforded but little bullion, $150,000 being a liberal estimate for the total production. If, however, Moose Creek is included in the district, the estimate should be increased by about $1,000,000.

TOPOGRAPHY.

In its southern part the district is trenched to a depth of 4,000 feet or more by Salmon River. Northward the western wall continues for the full width of the district; the eastern one, however, swings east, forming the end of Lemhi Range and thence continues southeast. Indenting the otherwise regular slopes of the mountains are many deep narrow gulches, rounded by glaciation in their upper parts, but narrow and V-shaped below.

GEOLOGY.

Both Algonkian quartzites and Miocene lake beds are exposed in the area, the latter along the lower mountain slopes and the former in their upper reaches. The older rocks are predominantly dark-gray quartzites which in general strike north and south and dip east, although locally the dip is to the west. Overlying these below an elevation of 5,700 feet are the Miocene beds, made up of indurated clays and sandstones, and a very few beds of conglomerate. Perhaps 1,500 feet of these beds is exposed in the area. In their lower part they are commonly light gray, but above are conspicuous beds of maroon color.

The gray granite intrusion, widely exposed in the Mackinaw district, extends into the northwest part of the Eureka district. The rock is readily distinguished by its gray color, medium to coarse granular texture, fresh appearance, and constituents—orthoclase, quartz, and biotite. It is probably of late Cretaceous or early Eocene age. From early Eocene to middle Tertiary no igneous activity is recorded, but since then there have been several periods of eruption. A rock, noteworthy because it has been recently, though not successfully, exploited for aluminum, is exposed along Jesse Creek west of Salmon. It is dull white with phenocrysts of euhedral quartz scattered through a greatly decomposed groundmass. Although the feldspars are too greatly altered for identification, it is thought that the rock is rhyolite. It is inclosed in the lake beds just below the maroon shales. The lavas of the district are best exposed in its southern part at the entrance to Salmon Canyon, where two thick flows of rhyolite are separated by massive andesite. The three, possibly aggregating 1,200 feet in thickness, are apparently conformable and dip 10° to 20° N. Yet another type of eruptive occurs in a small area near the summit of Baldy Mountain. It is a basalt, fine grained and of greenish-black color.

ORE DEPOSITS.

Both gold and copper ores are found in the district, but neither has proved very important, and only the gold has been mined. During the spring of 1910 several claims were staked in the area of the lake beds west of Salmon, and a company was formed, capitalized at $2,000,000, for the purpose of extracting aluminum from material found in this locality. The rock is a decomposed eruptive, probably rhyolite. It is hardly necessary to say that aluminum has not been extracted in commercial amounts. Coal of sufficient purity to find a local market has been worked to a limited extent on Jesse Creek (p. 83).

The properties held exclusively for gold lie high up on the mountain side northwest of Salmon in a belt about 6 miles long. They include the U. P. & Burlington, Queen of the Hills, and Tendoy mines. In each the ore occurs as veins in granite, near its contact with quartzite.

Two parallel veins have been recognized in the northern part of the belt, three in the central part, and one in the southern. Within the deposits, which are bounded by parallel walls 5 to 10 feet apart, gouge and quartz are found. The quartz is coarse and occurs as lenses, stringers following the hanging or foot wall, and fillings between blocks of gouge. In few places, however, does it constitute as much as one-third of the entire filling. Within the veins the ore occurs in shoots which in general pitch more than 45° S. Of the metallic minerals which occur within them, pyrite is most important, chalcopyrite is generally present, and galena is rare. These minerals occur in isolated crystals, irregular bunches, and in some places in parallel bands. The gold seems to vary in amount with the pyrite. The workings are all within the zone of oxidation, so that the primary minerals are seen only in protected places; in their stead limonite, bornite, malachite, azurite, and possibly cerusite are present. Manganese stains are common in the ore.

The copper deposits are inclosed in schists and quartzites. They lie south of Salmon, both east and west of the river, and where seen comprise quartz fillings and impregnations along sheared zones. In general these deposits are poorly defined, within them scattered bunches and films of chalcopyrite, in many places changed to bornite, malachite, or azurite, constitute the principal mineralization.

The type of ores found in the Eureka district and their mode of occurrence leads to their correlation with the deposits of the Mackinaw district, which are believed to be of late Cretaceous or early Eocene age (p. 152). Like the Mackinaw deposits, those of the Eureka district are thought to be genetically related to the granitic intrusion.

MINES.

QUEEN OF THE HILLS MINE.

The Queen of the Hills mine, owned by the Copper Queen Mining & Smelting Co., is situated 7 miles northwest from Salmon at an elevation of 5,800 feet on Dryer gulch. Location was made in the early eighties but active development did not commence until 1898. Since then, about 9,000 feet of work has been done, the mine being opened on five levels and to a maximum depth of 400 feet. The production is about $80,000 in gold bullion, most of which has been extracted by a 15-stamp mill situated on the property.

Three veins, all in granite, have been explored. They strike N. 27° E. and one (Queen vein) dips 80°–85° SE.; the other two (Nellie and Eva veins) dip in the opposite direction at about the same angle. The Eva, the most westerly vein, occurs as a band of quartz 8 to 14 inches wide, following one or the other wall of a 5-foot brecciated zone. The Queen (the central vein) follows a zone about 12 feet wide, possibly one-half of which is made up of quartz, either as distinct bands or filling interstices between granite fragments. The Nellie vein is similar to the Queen.

The ore occurs in shoots, five of which have been found—two in the Nellie vein, two in the Queen, and one in the Eva. They all pitch from 45° to 55° S. In them the quartz is of the coarsely crystalline variety common to all parts of the vein, but scattered through it irregularly are crystals of pyrite, chalcopyrite, and a little galena, together with their oxidation products, chief of which are limonite and malachite. Gold is thought to be associated with the pyrite, for it is said to vary in amount with that mineral. The average gold content for the Eva shoot is said to be $3.50 per ton, though in a small stope near the surface the average was $18 and in another on the fifth level it was $19.40 per ton. The better ore in the Nellie vein is said to run from $5 to $8.

U. P. & BURLINGTON MINE.

The U. P. & Burlington mine is situated at an elevation of 8,600 feet on the mountain slope west of Salmon. Development includes six tunnels, distributed up the mountain side at elevations 100 feet apart, and a shallow shaft beyond the upper one, in all about 2,000 feet of work. A 10-stamp mill, which has treated a small tonnage of ore, is situated on the property. The total production is perhaps a few thousand dollars, $800 having been derived from the last mill run of 40 tons.

The vein, which strikes N. 42° E. and dips 80°–87° NW., lies in the granite about 100 yards from its contact with the quartzites. The walls are firm and about 5 feet apart, the interim being filled with coarse gouge and vein matter. In most places the vein is about 10 inches wide, but locally it widens to 2 feet or narrows to a stringer. In some places it is split into two or more parallel bands, separated by gouge. The quartz is clear and coarsely crystalline and contains a few vugs lined with crystals of the same material. Pyrite occurs in coarse isolated cubes, bunches of cubes, and in a few fine-grained bands. It varies greatly in amount, in places constituting as much as 15 per cent of a face, and in others being entirely absent. It is claimed that 1,000 tons of ore of milling grade are blocked out.

JOHN TORMEY GROUP.

The John Tormey group of claims is situated 7 miles south of Salmon and 3 miles up Corral Creek, on the north side. Development consists of two tunnels, each about 225 feet deep, and several small prospect openings. The tunnels are about a half mile apart and on different lodes. Both are in Algonkian schist and quartzite, the ore occurring along a disturbed zone as small quartz veins, as fillings of the interstices, and as impregnations in the schist.

The deposits strike N. 35°–60° W. and dip northeast at high angles. Rather sparsely and irregularly scattered through the lode material are pyrite usually changed to limonite, and chalcopyrite usually altered to malachite, azurite, or bornite. The claims are held for copper.

TENDOY MINE.

The Tendoy mine is located 2 miles north of the Queen of the Hills mine. Two veins, developed by about 400 feet of tunnels, have been worked and a small amount of bullion recovered with a 2-stamp Nissen mill located on the property. This mine was not visited, but it is stated that the ore and its occurrence is similar to that at the Queen of the Hills.

OTHER PROPERTIES.

Several prospects are situated on the north end of Lemhi Range along its middle and upper slopes. None of these has produced and only a little development has been accomplished. Both gold and copper are reported.

BLACKBIRD DISTRICT.

SITUATION AND HISTORY.

The Blackbird mining district, situated in the west-central part of Lemhi County, merges by indefinite boundaries into the Mackinaw district on the north, the Eureka district on the east, and the Yellow Jacket district on the southwest. The area is traversed by the

Salmon-Forney stage road, from which branches extend up Blackbird and Musgrove creeks. Salmon, 35 miles to the northeast, is the supply point for the district.

The district was discovered in 1893 and most of the claims were located during the three years following. (See Pl. XXII.) All the properties were held for gold until the latter part of 1896, when copper was recognized in workable amounts. In 1899 twenty-nine claims were bonded by the Blackbird Copper-Gold Mining Co., and during the next two years about 1,400 feet of development work was done. The group was then patented and work was suspended. Cobalt and nickel were first taken into account in 1901, when John Beliel, of Leesburg, located a group of fourteen claims along the west fork of Blackbird Creek. Although mining operations have been at a standstill for the past 12 years, a small group of men have lived in the camp continuously and hold ground adjacent to the principal property. The production of the district is confined to a few mill and smelter tests.

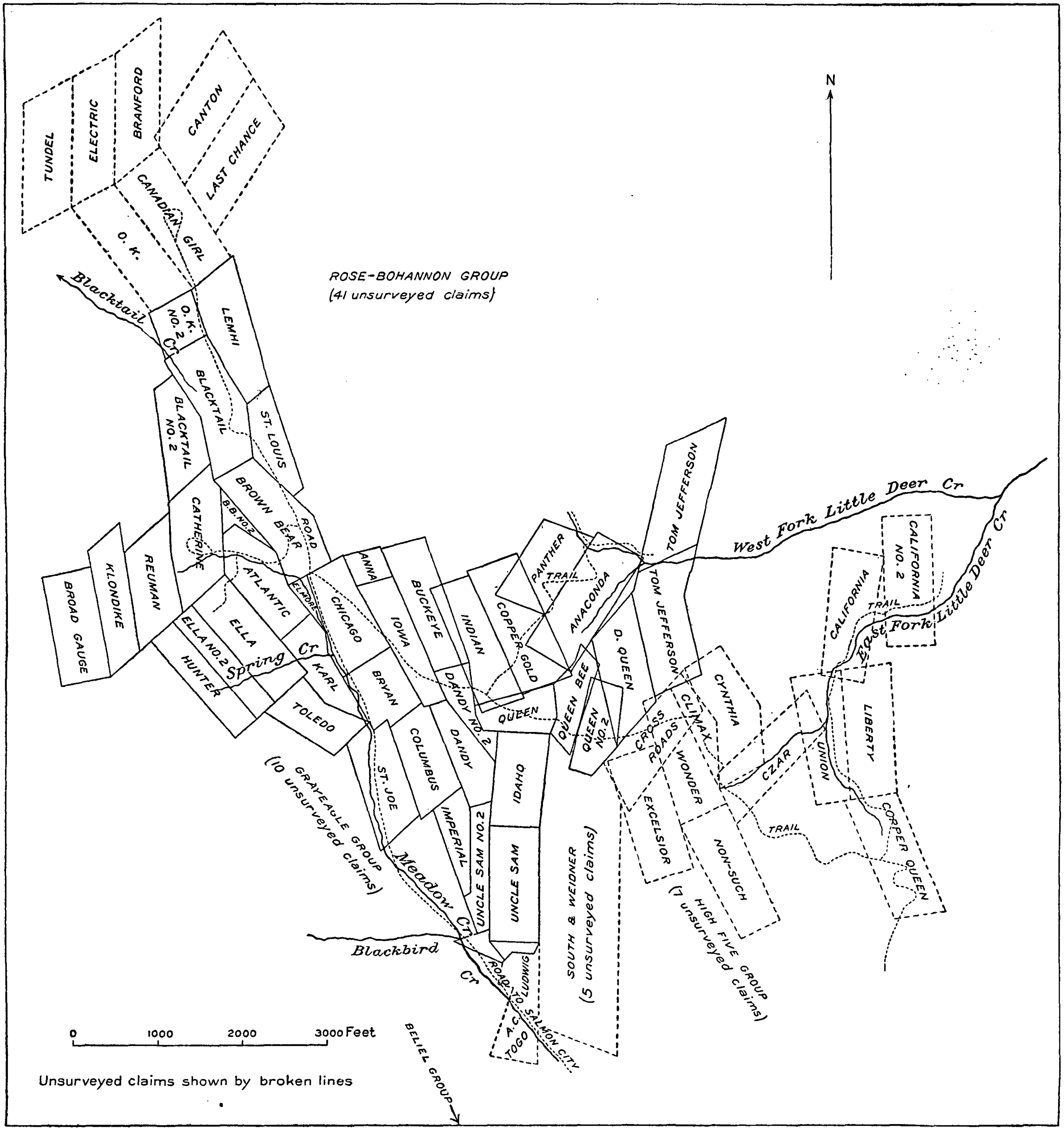
TOPOGRAPHY.

The district comprises a heavily wooded and deeply trenched tableland 7,500 to 8,000 feet above sea level. Blackbird Creek, after which the district is named, heads near the center of the area and flows east in a deep narrow valley some 7 miles long. Big Creek, the major drainage line, occupies a trench from 2,000 to 3,000 feet deep, which extends along the east and north boundaries. Other streams are Musgrove Creek, which flows east in the southern part of the district, and Little Deer Creek, which flows north in the northern part. All the streams live throughout the year and Big Creek affords opportunity for the development of considerable water power.

GEOLOGY.

The most widespread rocks of the area are mica schists and quartzites of Algonkian age. They are extensively though not intensely metamorphosed. In general recrystallization is complete, and in places garnet, epidote, and chiastolite are strikingly developed. On the other hand, crumpling is not conspicuous, and in many places, nearly always in quartzite areas, bedding structure may be easily recognized. In general the series strikes 60°–80° E. and dips 40°–60° NW. It is crossed by a strong joint system, which strikes N. 10°–40° W. and dips about 80° SW.

The igneous rocks in the Blackbird district include granite, gabbro, lamprophyre (minette), rhyolite porphyries, and rhyolites. The normal biotite granite, widely distributed to the north, is exposed in the northeast corner of the area. Near its margin there is a decided decrease in the amount of quartz and an increase in the amount of microperthite. Gabbro dikes, mostly extending in a north and south



CLAIM SHEET, BLACKBIRD DISTRICT.

direction, were noted in the central part of the area. They are blue-black holocrystalline rocks, consisting of hornblende, diopside, plagioclase, and biotite, with accessory pyrrhotite, pyrite, titanite, and apatite. The lamprophyre (minette) dikes also occur in the central part of the area. They are fine-grained dark resinous gray rocks, consisting of biotite and orthoclase accompanied by subordinate amounts of plagioclase and hornblende. They strike both north-south and east-west. Rhyolite porphyries and flows were noted in the southern part of the district. Several dikes of this material, which is a light-gray rock consisting of a finely crystalline groundmass studded with medium-sized quartz crystals, cross the deep, narrow valley of Musgrove Creek and spread out as flows along its topmost slopes.

ORE DEPOSITS.

DISTRIBUTION AND DEVELOPMENT.

The ore deposits as now known are confined to a small area about the head of Little Deer Creek, the upper basin of Blackbird Creek, and an area about a mile above the mouth of Musgrove Creek. In the two former localities copper, cobalt, nickel, and gold are present, but in the latter only gold has been found. Few districts present a more general distribution of outcrops sufficiently attractive to lend reasonable encouragement to the prospector than are to be found in the north and central part of the zone of mineralization as thus defined. Float heavily stained by manganese, iron, and copper (and much of it also by cobalt and nickel) can be found almost anywhere about the heads of Blackbird and Little Deer creeks. On Musgrove Creek the float is stained only by iron and manganese, and is confined to the outcrops of definite veins.

There are about 150 claims in the district, some 40 of which are patented. A great deal of gophering and very little systematic prospecting has been done, and as a result little definite information concerning the continuity or tenor of the deposits is obtainable. The property of the Blackbird Copper-Gold Mining Co. is an exception, but its workings were under water at the time of visit. Prospecting has shown that mineralization is widespread, so that the need of the district at present is systematic exploration of the better showings in order to determine whether or not the deposits are of commercial value. The proximity of ground water to the surface has been a serious handicap to the prospector and has led to the abandonment of most shafts at depths of less than 30 feet.

VEINS.

Two distinct types of deposits are recognized: the Moose Creek veins or fissure fillings, and the Blackbird and Little Deer Creek lodes or lenses and disseminations, which are largely due to replacement.

The Moose Creek veins are quartz fillings, some of which average as much as 4 feet in width. They have a general strike of N. 40° W. and are principally found on the steep northern side of the valley. The quartz, which is extensively fractured, is everywhere fine grained, and in places includes angular fragments of wall rock. No primary minerals were seen in the veins, but the presence locally of extensive iron and manganese stains along the fracture planes suggests that pyrite and some manganese mineral are distributed irregularly through the unaltered ore. Gold, with traces of silver, occurs in those parts where metallic oxides are most abundant. It is noteworthy that of the several veins recognized, only one has been found to contain the precious metal in sufficient amounts to constitute an ore. In this vein the principal shoot averages about $20 a ton in gold.

The Blackbird and Little Deer Creek lodes differ markedly from the above in mode of occurrence and mineral assemblage. These deposits are distributed rather uniformly throughout the areas in which they occur. Though commonly lenslike bodies, they assume in places the broadly tabular form of veins, as on the Uncle Sam claim. Again, the deposits occur as bunches or disseminations along certain favored zones. On the Hawkeye group irregular bunches of ore up to 4 or 5 inches in diameter are sparsely scattered through a gabbro dike. Their prevailing strike is N. 10°–40° W. with dip about 78° SW., although it is not uncommon to find ore extending in a general east-west direction and dipping south. The Beliel lodes, perhaps most important among the cobalt-nickel deposits, strike N. 40°–50° E., and dip 70°–80° SE. The deposits are predominantly of replacement origin, most of the metallic minerals being distributed as bunches, lenses, or disseminations along ill-defined zones in the country rock. (See Pl. XII, p. 71.) Elsewhere irregular veins, stringers, and lenses of coarsely crystalline quartz contain the ore minerals.

ORES.

Most conspicuous among the minerals of the district are the oxidation products of copper, iron, manganese, cobalt, and nickel, each of which is of striking color; malachite, the deep-green copper carbonate; limonite, the yellow hydrous iron oxide; pyrolusite, the dull-brown manganese oxide; erythrite, the pink to pearl-gray cobalt bloom; and annabergite, the pale apple-green nickel compound. Knowledge is largely lacking in regard to the cobalt and nickel ores, but is fairly definite as to the others. Iron occurs in pyrite, pyrrhotite, arsenopyrite, and less commonly in magnetite. A specimen of siderite was examined from the northern part of the area, but whether it is primary or secondary is not known. Beautiful botryoidal hematite occurs in the oxidized ore of the Big Chief claim. The source of the secondary manganese is not clear, although rhodochrosite was seen in a few places in such relations as to suggest its primary origin. At least two cobalt minerals occur in the area, and both are probably primary. One is a reddish-gray mineral, probably cobaltite. In thin section (from Gray Eagle claim) it occurs as very small grains, bunched in very poorly defined lenticular areas, and replaces biotite and quartz in a garnetiferous biotitic quartzite (Pl. XII, *B*, p. 71). The other mineral, which affords the cobalt ore on the west end of the Beliel group, occurs as minute grains, fairly evenly distributed through the mass. Where most closely spaced they give the rock a steel-gray appearance, notably lacking the reddish hue of the cobaltite (?) described above. Although the specimens did not permit definite chemical tests, the color suggests smaltite. No primary nickel mineral, unless certain small indistinct crystals in the ore of the Togo claim are niccolite, was recognized; but in almost every place where nickel bloom appears pyrrhotite is present, thus suggesting that the nickel occurs as nickeliferous pyrrhotite—a relation borne out by analysis of a specimen of pyrrhotite (from the Togo claim) which gave 0.8 per cent nickel.

AGE AND GENESIS.

All the deposits of the district are inclosed in Algonkian schists and quartzites or in basic dikes which cut them. Thus, the nature of the inclosing rock throws little light on their age. Those on Musgrove Creek, however, from their crustification, lack of evidence of replacement, fine-grained quartz, and general association with rhyolite dikes, are considered much younger than those on Blackbird and Little Deer creeks. The latter are due largely to replacement, contain much pyrrhotite, and some magnetite, have coarse-textured quartz gangue, and are exceptional in that traces of cobalt or nickel, or both, are nearly everywhere present. Both types of deposits, in that they occur far up on the sides of the valleys which probably date from the early Pliocene, are considered as of Miocene age or earlier. On the other hand, the nickel-cobalt ores are locally found included in gabbro, which is probably of later age than the granite. Thus, as the granite is late Cretaceous or early Eocene, it is fairly safe to place the two periods of mineralization between that time and the late Miocene, the veins on Musgrove Creek being much younger than the lodes of Blackbird and Little Deer Creek basins.

The gold veins on Musgrove Creek are clearly fissure fillings formed under conditions of comparatively low temperature and pressure, as shown by their fine-grained quartz, loose crustification, and the angularity of their included fragments. They probably accompanied or closely followed the igneous activity recorded in the rhyolite dikes which occur in their immediate vicinity and which are thought to be of Miocene age.

The genetic relations of the Blackbird-Little Deer Creek lodes, on the other hand, are somewhat more definite. A gabbro dike about 50 feet wide has been prospected on the Togo claim. In places within it are bunches of quartz and calcite carrying biotite, in the form of rosettes up to one-tenth inch in diameter, intimately intermixed with pyrite and pyrrhotite. From the hand specimen it is impossible to make out whether these bunches are due to replacement in the gabbro or to magmatic differentiation, but when studied in thin sections the intergrowth of pyrite and pyrrhotite with biotite and hornblende is clearly seen and leaves little room to doubt that these metallic minerals are native to the magma. Chemical analyses of pyrrhotite thus occurring record the presence of 0.8 per cent nickel. Along the contact of this dike, and as stringers and bunches in the schist near by, are nickel, copper, and cobalt ores, in all respects similar to those occurring elsewhere in the area. It is concluded, therefore, that the ores of this type are genetically related to the gabbro magma and were deposited largely as replacements in the greatly fractured metamorphic rocks which it intruded. They are thought to date from the late Cretaceous or early Eocene.

MINES.

BLACKBIRD MINES.

The Blackbird Copper-Gold Mining Co. has 29 claims in the central part of the district. Development consists of three shafts, exploratory drifts therefrom, and numerous small tunnels—in all perhaps 2,500 feet of work. Since going to patent, several years ago, the property has lain idle, so that the workings are now inaccessible.

The ore bodies, which are inclosed in Algonkian schists and quartzites, are irregular replacements along fracture zones, so distributed that in general outline they resemble veins. The ore is sought for copper and gold, a wide zone exposed in the Brown Bear workings near the west end of the group being said to average 3 per cent of copper and $1.50 in gold to the ton.

BELIEL GROUP.

The Beliel group includes 14 unpatented claims situated between the main forks of Blackbird Creek, near their junction. Little development has been done on the property, although the position of the ledge along the rugged northern wall of the valley affords fairly satisfactory exposures.

The outcrops in many places present beautiful red, pink, and pearl-gray stains and incrustations—in one place so pronounced as to be visible for a quarter of a mile or more (Pl. XI, p. 70). The ledge strikes N. 40°–50° E. and dips 70°–80° SE., thus approximating the strike and dip of the inclosing rocks. The ore consists of mineralized quartzite, rarely schist, which is more resistant to weathering than the unaltered rock and stands in bold outcrop. In it small grains of pyrrhotite and pyrite can be seen with the unaided eye; in thin section numerous specks of silver-gray color, possibly smaltite, appear irregularly scattered through the quartzite or schist which they replace. A sample from 20 feet across the ledge, as exposed by tunnel on the west end of the property, ran a fraction less than 2 per cent cobalt, and a similar face on the east end afforded 2 per cent nickel and less than 1 per cent cobalt.

MUSGROVE GROUP.

The Musgrove group consists of five claims situated on the north side of Musgrove Creek, a mile from its mouth. The veins are quartz fillings, varying from a few inches up to 4 feet in width. They strike N. 40° W., crossing the beds of the inclosing quartzites, which strike from N. 45°–60° E. Of several veins only one has been found to carry gold in commercial amounts. This vein is made up of fine-grained brecciated quartz heavily stained in places with iron and manganese. It is such material which constitutes the better grade of ore—ore averaging about $20 a ton but in spots running as high as $75. A considerable tonnage of this grade has been blocked out and plans are complete for installing a cyanide plant.

OTHER PROPERTIES.

Many groups of comparatively undeveloped claims are situated in the district. Most of them present strong surface indications, but it is thought that detailed descriptions of them would add little to the value of this paper.

YELLOW JACKET DISTRICT.

SITUATION AND HISTORY.

The Yellow Jacket mining district, comprising an area of perhaps three townships, is situated in the western part of Lemhi County, about 30 miles southwest of Salmon. It lies southwest of the Blackbird district and northwest of the Gravel Range district. A wagon road extends to Forney, 12 miles east, and thence north to Salmon and south to Challis, each about 50 miles distant. A trail leads west to Thunder Mountain. Mail reaches the camp triweekly from Salmon.

The Yellow Jacket veins, located in September, 1868, and worked by arrastres and a 5-stamp mill in the early seventies, were among the earliest, if not the earliest, lode deposits recognized in Lemhi

County. The principal mine, the Yellow Jacket, changed hands several times and was worked at intervals prior to 1897, when it was closed down and remained idle until the spring of 1910, at which time it was acquired by the Yellow Jacket Gold Mining Co., and work was resumed. A 10-stamp mill, erected in 1882, was displaced by one with 30 stamps nine years later, and the capacity of the latter was increased to 60 stamps in 1895. This mill is still standing, as is also one of 10 stamps on the Columbia property and one of 5 stamps on the Black Eagle group.

The production of the camp has come largely from the Yellow Jacket mine, which is said to have yielded about $450,000, the average saving by amalgamation being $5.50 per ton, or 92 per cent of the total content of the ore. In the early days placers were worked on Yellow Jacket Creek, but they did not produce much bullion.

The district has been briefly described by Eldridge,[1] who visited it in 1894 in connection with his reconnaissance across the State.

TOPOGRAPHY.

The Yellow Jacket district comprises a forest-clad mountainous area from 5,500 to 8,500 feet above sea level. The sides of the many deep valleys rise abruptly to the tops of rather even-crested ridges which form the divides between the major streams and extend out as bold spurs between minor ones. Yellow Jacket Creek, which flows southwest into Camas Creek, a tributary to Middle Fork of Salmon River, drains the area. It heads within the district and receives many tributaries along its course. Those of importance are Trail Creek from the east, two small streams from the northwest in the vicinity of Yellow Jacket, and Lake and Hoodoo creeks, which unite and enter the main stream about 5 miles below camp.

In the vicinity of the settlement the valley is somewhat wider than elsewhere, so that for a stretch of 1 to 2 miles a strip of comparatively level land, perhaps 1,500 feet wide, is available for building or other purposes. Yellow Jacket Creek and most of its feeders live throughout the year and afford abundant water for milling and other purposes connected with lode mining.

GEOLOGY.

Sedimentary rocks of Algonkian age prevail throughout the district. They are generally thin bedded and consist of crystalline schist, most of which is quartzitic, some micaceous, and a very little calcareous. Typical quartzite is subordinate, although one large area was noted in the vicinity of Black Eagle mine. The rocks are

[1] Eldridge, G. H., A geological reconnaissance across Idaho: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1895, pp. 49-54.

very uniformly metamorphosed, but little of the bedding structure is obliterated, and crumpling, even local crumpling, is rare. The structure is outlined effectively by Eldridge,[1] who writes as follows:

> The entire region between Panther and Camas creeks, which includes the Yellow Jacket mining district, has been in former times one of great dynamic disturbances; folds, flexures, and faults, in addition to the intrusion of eruptives, occur. The structure is, therefore, difficult to determine, and the difficulty is increased by the similarity of the schists from the base to the summit, rendering identification of horizon impossible.

In general the structure seems to be developed along lines varying from N. 30°–40° W. but with local divergences up to N. 60° E. and N. 60° W. Dips are predominantly 35°–85° W., although some of 40°–60° NE. were noted along the Forney road, 1 to 3 miles west of the summit. Independent of the attitude of the rocks is a strong system of joints which traverses all parts of the area along lines N. 50°–60° E. Almost at right angles to these are other joints, generally less conspicuous but still readily recognized in most exposures. The strong northeast joints seem to have been lines favored both by mineralizing solutions and injected igneous material.

Granite does not outcrop in those parts of the district which were visited, but the many granite bowlders which appear along Yellow Jacket Creek indicate that extensive exposures occur in the upper part of the drainage basin. Though not exposed at the surface in the immediate vicinity of the camp, it is of course possible that granite lies at no great depth, a possibility suggested by numerous dikes and by certain metamorphic phenomena scarcely assignable to their influence. A specimen of altered calcareous schist from the northeast corner of the Columbia mill contains many little veinlets of calcite, scattered quartz grains, pale-green hornblende, poikilitic scapolite (mizzonite), and a few flakes of biotite, each intergrown with or included in the other. Pyrite is sparsely distributed through the section. The above association of minerals, together with their structure, strongly suggests contact influence. None of the dikes, so far as noted, have effected such metamorphism, and none of them crop out within several hundred feet of the place where this specimen was taken.

Dikes are conspicuous in the Yellow Jacket district. Seventeen were encountered in a traverse of 4,500 feet east from the Columbia mill, and as many are said to occur west from it. With few exceptions they have entered along the strong joint planes which strike N. 50°–60° E. Scarcely less conspicuous than their number is their variety. They include, about in descending order of their numerical importance, rhyolite porphyry, granite porphyry, lamprophyre (minette), diorite, hornblende monzonite, and diabase. Eldridge [1]

[1] Eldridge, G. H., op. cit., p. 51.

also reports syenite from Columbia Hill. His quartz porphyry is probably the granite porphyry named above.

The rhyolite porphyries are generally light-gray to tan-colored rocks composed of small crystals of quartz and stalky feldspar scattered through a glassy to finely crystalline groundmass. Several of these dikes may be seen in the sides of Trail Creek gulch within 2,000 feet of its mouth. Granite porphyry within the area varies greatly in appearance. Along Trail Creek it presents two types; one a dark-gray mottled rock, with medium to coarse crystals of quartz and orthoclase set in a blue-black fine-grained groundmass, and the other a light-gray fine-grained, almost equigranular rock. Another variety was noted near the base of the hill west of Forney. It is made up of beautiful orthoclase crystals up to an inch long and also automorphic quartz of wheat-grain size, thickly set in a dense blue-gray groundmass. Lamprophyric dikes occur both in the vicinity of Yellow Jacket and Columbia mines, and along the road east of the camp. They are dark-colored fine-grained equigranular rocks composed principally of orthoclase and biotite (minette). In them a little quartz is present and micropegmatite is rather conspicuous. A dike of hornblende monzonite crosses Yellow Jacket Hill near the large glory hole of Yellow Jacket mine. One of diorite crosses Trail Creek gulch, about 300 yards from its mouth. This is a grayish-black medium granular rock characterized by coarse feldspar crystals set among well-crystallized hornblende and biotite. Greenish-black diabase, of rather felty appearance owing to its large content of lath-shaped feldspars, was noted in the float near the Yellow Jacket mine.

Andesite is the principal extrusive rock of the area, although bowlders of trachyte and of rhyolite which occur in the valley wash along Yellow Jacket Creek suggest that they, especially the latter, have a fairly wide development in the adjacent hills. The andesite occurs as a cap along the divide between Forney and Yellow Jacket. As is generally true of andesite, this rock varies greatly in color from place to place, the staple variety being a dark-gray rock which weathers to reddish brown. In the hand specimen it is characterized by a glassy groundmass, including scattered crystals of dull feldspar.

ORE DEPOSITS.

Active development in the district has been confined largely to a small area in the immediate vicinity of Yellow Jacket. North of the town are the veins of Yellow Jacket Hill, and west, those of Columbia Hill, including their northward extension, the Red Jacket veins. Westward, beyond the divide, claims are located near the headwaters of Wilson, Silver, and Hoodoo (Arrastre) creeks, but all the claims, except the Black Eagle group on the last-named creek, are comparatively undeveloped. East and south of the camp no promising deposits have been reported.

The principal veins strike N. 50°–60° E. and dip northwest; others, of much less importance, strike almost at right angles to these. In places, as in the Black Eagle mine, the ore bodies follow the bedding, but more frequently, as in the Yellow Jacket and probably also in the Columbia, they are independent of it. Indeed, their strike, as also that of the many dikes of the area, seems to be determined by a strong system of joints developed without regard to local structure.

The deposits represent both fissure fillings and metasomatic replacements. The Black Eagle property illustrates the former, for in it the vein matter terminates abruptly at its margins and the few included fragments of the wall rock present little evidence of having been attacked by the solutions. On the other hand, the Columbia Hill veins occur along breccia zones and the metallic contents "are carried not only in the interstitial quartz, but often in the fragments of the schists and slates themselves."[1] Hence, the latter are at least in part metasomatic replacements. The Yellow Jacket mine probably presents both types of deposit in the same vein. Included fragments and rough crustification suggest an open fissure, and the local mineralized condition of the hanging wall indicates metasomatic processes.

Gold is the principal metal in all the ores of the camp, but only in the Yellow Jacket mine does it occur to the practical exclusion of copper, zinc, and lead. In the other properties these base metals occur in chalcopyrite, sphalerite, and galena, the latter two being nowhere very abundant. Coarse white quartz is the common gangue mineral. In all the properties pyrite is present, and in all, save possibly the Columbia, it probably carries the gold. In the Columbia chalcopyrite is more conspicuous and the gold may be included in it. Silver is very subordinate in the deposits of the camp. Locally assays up to $150 per ton have been obtained, but it is probable that the average tenor of the workable ores is not greater than $6 to $8 a ton.

Placers have been worked for a mile or so on Yellow Jacket Creek below the camp, and, although they have yielded some gold, they have on the whole been rather disappointing.

Definite age relations within the area are largely concealed. The veins are younger than the joints which determine their position and are older than the present topographic features, the higher reaches of which they cut. The peculiar metamorphic phenomena described on page 167 and the great number of dikes lend some support to the suggestion that the gray granite, widely exposed elsewhere

[1] Eldridge, G. H., op. cit., p. 53.

in the county, may underlie the camp at no great depth. In many places in Idaho there is evidence that mineralization accompanied this granite, and to the north in the Mackinaw district similar ores are confined to the granite margin, so that it seems probable that these deposits are genetically related to a near-by though concealed batholithic mass of granite.

MINES.

YELLOW JACKET MINE.

The Yellow Jacket mine, which has produced $450,000 in gold, largely from ore averaging about $8 a ton, is situated on the mountain side three-fourths mile north of the town of Yellow Jacket. It is the oldest lode deposit in the camp—perhaps the oldest in Lemhi County, having been located in 1868. Development consists of about 4,000 feet of tunnels, crosscuts, and drifts, which reach the ore on four levels, the most extensive of which is known as No. 2. In addition to the underground development, considerable open-cut work has been done. (See fig. 24.)

The rock inclosing the veins is fine-grained quartzite, in places almost free from impurities, but more commonly micaceous and clayey. The beds strike N. 30°–60° W. and dip about 50° SW. Heavy joints extend N. 50°–60° E. Two faults, both of which strike about N. 40° W. and dip southwest, have been encountered in the mine. The western fault throws the vein 175 feet west on the east side and the eastern is said to cause a further displacement to the west of 90 feet.

The vein, which is about 15 feet wide, strikes N. 50°–60° E. and in general dips 35° NW., although locally increasing to 60° or even 80°. Its outcrop is an iron-stained honeycomb quartz, as is also the vein material found in the present workings, all of which are well above ground-water level. Primary metallic minerals are seldom seen in the ore, but the heavy iron stains and the shape of the cavities in the quartz-calcite gangue indicate that pyrite is the principal primary mineral. Rarely a stain of copper carbonate is seen. As most of the mining and much of the exploration (fig. 24) have been west of the west fault, the present owners intend to explore that part of the vein lying east of it.

BLACK EAGLE MINE.

The Black Eagle mine is situated about 5 miles northwest of Yellow Jacket at an elevation of 7,500 feet, near the head of Hoodoo Gulch. The property was located some 15 years ago, but little work was done until its acquisition by the present owners in 1905. It is opened by 350 feet of development tunnel. A 5-stamp mill, which has treated about 500 tons of ore, is situated on the property.

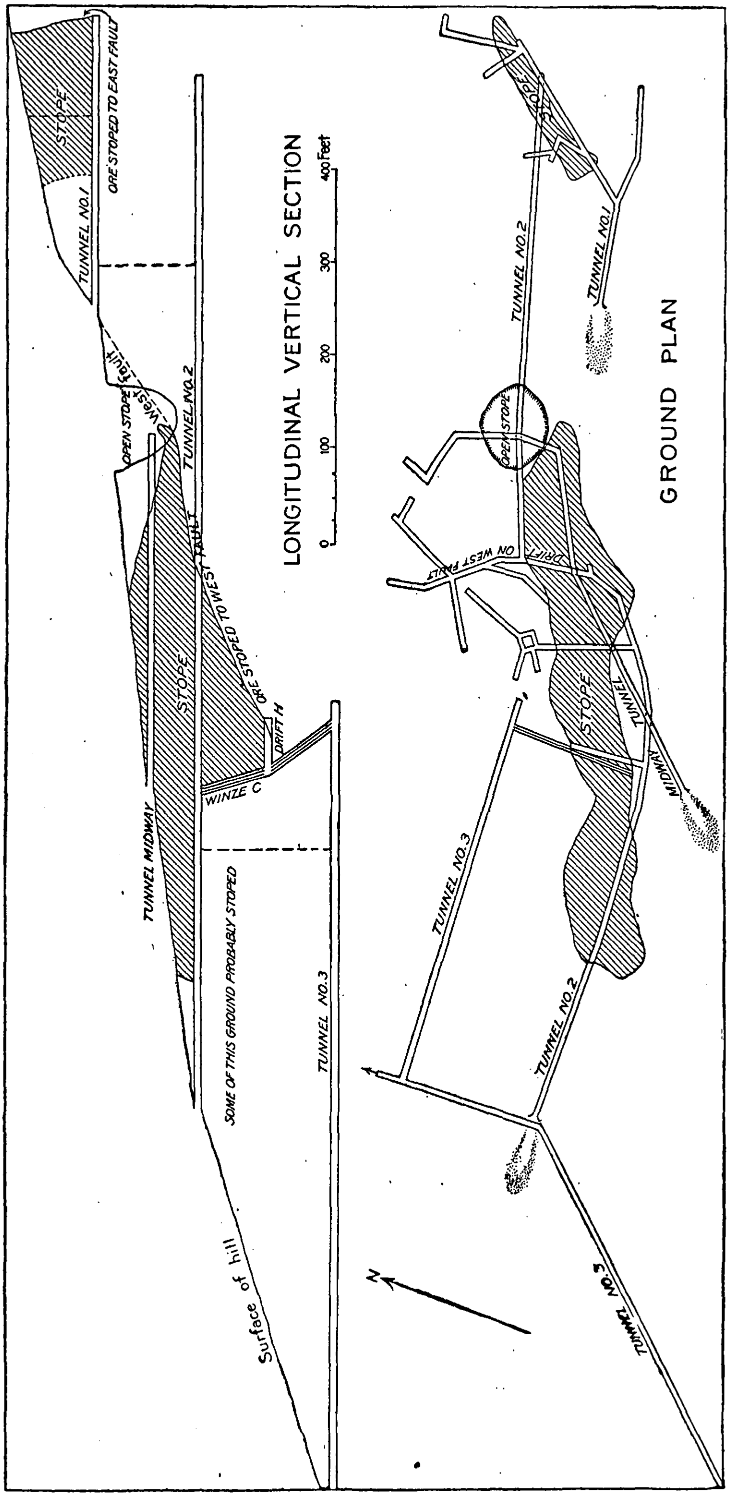


FIGURE 24.—Plan and projection of Yellow Jacket mine, Yellow Jacket district. A copy of the company's map on a reduced scale.

The country rock is a fine-grained, bluish-white quartzite which strikes N. 40°–50° E. and dips 70° NW. The ore is coarse quartz with pyrite, manganite, chalcopyrite, and a little sphalerite, scattered irregularly and generally sparsely through it. As exposed, the vein varies from a stringer up to 5 feet, averaging perhaps 6 inches. It is worked for gold.

RED JACKET MINE.

The Red Jacket mine is situated 1½ miles north of the town of Yellow Jacket, at an elevation of 7,700 feet. Two tunnels, neither of which was explored, appear on the property. As seen on the dumps the ore is coarse quartz inclosing pyrite, chalcopyrite, sphalerite, and galena, decreasingly important in the order named. Oxidation is apparently slight in the deposit.

COLUMBIA MINE.

The Columbia mine is situated a mile west of Yellow Jacket. Development consists of four tunnels, totaling about 1,800 feet. A 10-stamp mill in connection with the property is said to have treated only a little ore. The workings were inaccessible at the time of visit, but Eldridge[1] states that the deposits are chalcopyrite-bearing quartz veins and impregnations, closely associated with a minette dike, The veins strike N. 60° E. The property is held for gold and silver.

GRAVEL RANGE DISTRICT.

SITUATION AND HISTORY.

The Gravel Range mining district is an ill-defined area of perhaps three townships, situated about 35 miles in a direct line southwest of Salmon. It lies southeast of the Yellow Jacket district and northeast of the Park Mountain district. Rabbitfoot and Myers Cove, the only settlements in the area, are respectively 9 miles south and 12 miles southwest of Forney, the present terminal of the Salmon stage line. From both of the camps wagon roads lead north to Salmon and south to Challis.

An arrastre was operated at Myers Cove (formerly called Singiser) in the early seventies, and about the same time gold was found at Rabbitfoot, where a little placer work was done. Substantial developments, however, did not commence in the district until 1896, when the present owners began to operate the Myers Cove property. Considerable ore, averaging about $11 a ton, was soon blocked out and the method of treatment became vital. Amalgamation after roasting gave 11 to 20 per cent extraction; cyanide gave 20 to 30 per cent; and a combination of chlorination and cyanidation yielded 70 to 90 per cent. A mill was built in keeping with

[1] Eldridge, G. H., op. cit., pp. 52-54.

these tests, but after running a month or six weeks it was abandoned as a failure. The Rabbitfoot properties were first actively developed in 1905 when a 10-stamp mill was built and operated for about six months. Prior to this a few Chinamen had worked placers along Silver Creek below Rabbitfoot, but with doubtful success.

The total production of the district is not known, but it is probably safe to assume that it is less than $100,000.

TOPOGRAPHY.

The Gravel Range district comprises westward-sloping upland country, in most places 7,000 to 7,500 feet above sea level. In the western part it is dissected by the valleys of Silver and Arrastre creeks to a level 1,500 feet lower. About the southern border a serrate ridge of late Tertiary eruptives rises 1,000 to 1,500 feet above the general level, but to the north the surface grades into the high, gravel-covered, undulatory surface of the Prairie Basin. Silver Creek, the principal stream, heads south of Rabbitfoot, whence it flows northward and then southwestward. Its principal tributary is Arrastre Creek, which rises in a group of cirque basins near the south boundary of the district and flows northwest past the abandoned settlement of Myers Cove.

GEOLOGY.

Algonkian schists and quartzites, widely distributed elsewhere in the county, are exposed in only a few places in the district. Indeed, no outcrops were seen, although they are said to occur half a mile east and a mile south of Rabbitfoot. Their presence is indicated also by quartzite pebbles along the gulches heading in that quarter.

Bowlders of diorite and of an equigranular rock, which when examined megascopically is strongly suggestive of quartz monzonite, were noted in a few places along the gulches near Rabbitfoot. Rhyolites predominate at the surface throughout the district. They are widely exposed to the northwest and are said to extend southwestward without a break to and beyond Parker Mountain. Associated with them are a few thin beds of trachyte and considerable thickness of volcanic tuff. At Rabbitfoot the rhyolites may be grouped into earlier and later, the two separated by a structural as well as by an erosional unconformity. Near the mine the earlier rhyolite flows strike N. 10°–20° E. and dip 40°–75° NW., and the later strike a little north of west and dip 30° N. The earlier flows are individually much thicker than the later and are usually extensively jointed. The later consist, from bottom upward, of a bed of volcanic mud and soil with included carbonaceous matter, in all about 20 feet thick. This is followed by a 6-foot flow of rhyolite overlain by 100 feet or more of rhyolite tuff, which in turn is covered by a thick flow of rhyolite. The contact between the earlier and the later groups was seen in a placer bed 100 feet north of No. 1 portal and in the north drift of No. 2 tunnel. Elsewhere in the district lavas of two ages were not distinguishable.

The typical rhyolite is a light-gray rock consisting of orthoclase crystals and quartz grains set in a very fine grained groundmass. Wavy lines of flow structure are generally pronounced. Trachytes, nowhere conspicuous, resemble the rhyolites but have less-pronounced flow lines and no quartz grains. The rhyolitic tuffs are widely distributed, and locally are as much as 100 feet thick. They appear as chalky white exposures, with crude bedding, and their constituent particles are angular in outline.

The lavas occupy valleys developed after the elevation of the Eocene surface and, as they were extensively eroded before the Pleistocene, they are assigned to the Miocene.

GLACIATION.

Glaciation is beautifully recorded in numerous cirques about the head and along the south wall of Arrastre Creek canyon. The gulch itself is distinctly U-shaped down to a few hundred yards below Myers Cove mill, where the knob and kettle topography, typical of a terminal moraine, extends in a broad belt across the valley and up its sides for more than 100 feet above the present stream bed. Below this moraine, which is about 6,300 feet above sea level, the valley is distinctly V-shaped. Glaciers probably covered most of the district, moving westward down Silver Creek and merging northeastward with the comparatively large ice sheet which occupied Prairie Basin (p. 40).

ORE DEPOSITS.

Within the district mining operations have been mostly confined to small areas immediately adjacent to Myers Cove and Rabbitfoot. At one time an excitement was started by the finding of opals on Panther Creek, east of Rabbitfoot, as linings and fillings in the vesicles of dark-gray glossy rhyolite, but they did not prove to be present in commercial quantities.

All the deposits known in the district are inclosed in rhyolite. The veins at Myers Cove strike N. 35°–40° E. and dip steeply northwest, but at Rabbitfoot distinct veins have not been recognized. The general crustification of the quartz is perhaps the most conspicuous feature of the deposits. In general the wavy bands parallel the walls, but in detail they are in many places concentrically arranged, either about included fragments of wall rock or as linings in partly filled cavities. In the richer parts of the veins thin, crimpy layers of dark color and dull to submetallic luster occur parallel to the crustification. The quartz, where unaltered, is hard and flinty but instead of having the usual vitreous luster tends to a dull white. On exposure it weathers to a sugary mass with more or less clay intermixed. In the main, however, it is more resistant than the inclosing rhyolite and stands in slight relief.

The following discussion of the ores is of necessity based almost entirely on the Myers Cove ore deposits, although it probably applies closely to all deposits of the district that are inclosed in rhyolite. The ores mined are exclusively gold-silver. Assays have been secured from the Monument mine at Myers Cove which ran several hundred dollars per ton, but on a broad tonnage basis the average is said to be about $11. The vein material examined microscopically presents many interesting features. The quartz is generally fine grained and occurs in bands composed of grains of slightly different size. Adularia, commonly occurring in beautiful rhombic crystals, is intergrown with the quartz or included in it (Pl. IX, *A*, p. 54). Pyrite occurs erratically as fine-grained fillings between quartz grains and as small isolated cubes either included in the quartz or intergrown with it. Traversing the general banding of the ore are scattered quartz veinlets a fraction of a millimeter in width, which inclose rarely a cube of pyrite. Adularia was not noted in them.

Gold and silver are said to be present in the ores of the Monument vein at Myers Cove in the ratio by ounces of about 1 of gold to 18 of silver. The form in which they occur is not known, although the presence of much extremely fine-grained pyrite suggests that they may be associated with that mineral. Partial analysis of the ore by W. T. Schaller in the Survey laboratory definitely established a strong trace of selenium. It is thus possible that part of the gold and silver may be in the form of a selenide. (See also pp. 55–56.)

The veins are obviously younger than the inclosing rhyolite, which from its topographic relation is middle or late Tertiary (p. 173). They cut across the valleys and higher reaches of the present rhyolite areas and hence antedate the valleys, which, as they are glaciated, were evidently formed in preglacial time. It follows that the veins are of late Miocene or early Pliocene age.

Concerning the genesis of the ores, the hasty visit necessitates recourse to analogous conditions in well-known districts. From their similarity to deposits which have been studied in detail, these ores are thought to have been deposited by hot ascending waters and are probably to be assigned to the later stages of the igneous activity which gave rise to the extensive rhyolite flows. As shown at Rabbitfoot they are later than the second period of rhyolitic extrusion. For a list of similar deposits see page 57.

MINES.

MONUMENT MINE.

The Monument mine, the principal property at Myers Cove, consists of six patented claims situated on Arrastre Creek near its junction with Silver Creek. It is 6 miles west of Rabbitfoot and 12 miles southwest of Forney. An arrastre was operated on the creek about 40 years ago, but not until the mine was acquired by the present owners in 1896 did active development begin. A. A. Hibbs, Harrisburg, Pa., is general manager. Soon thereafter a considerable amount of ore, averaging about $11 a ton, was blocked out and the method of treatment carefully considered. As a result a combination chlorination and cyanidation process was adopted. A mill was built but, owing to very low recovery, was operated for only a month or six weeks.

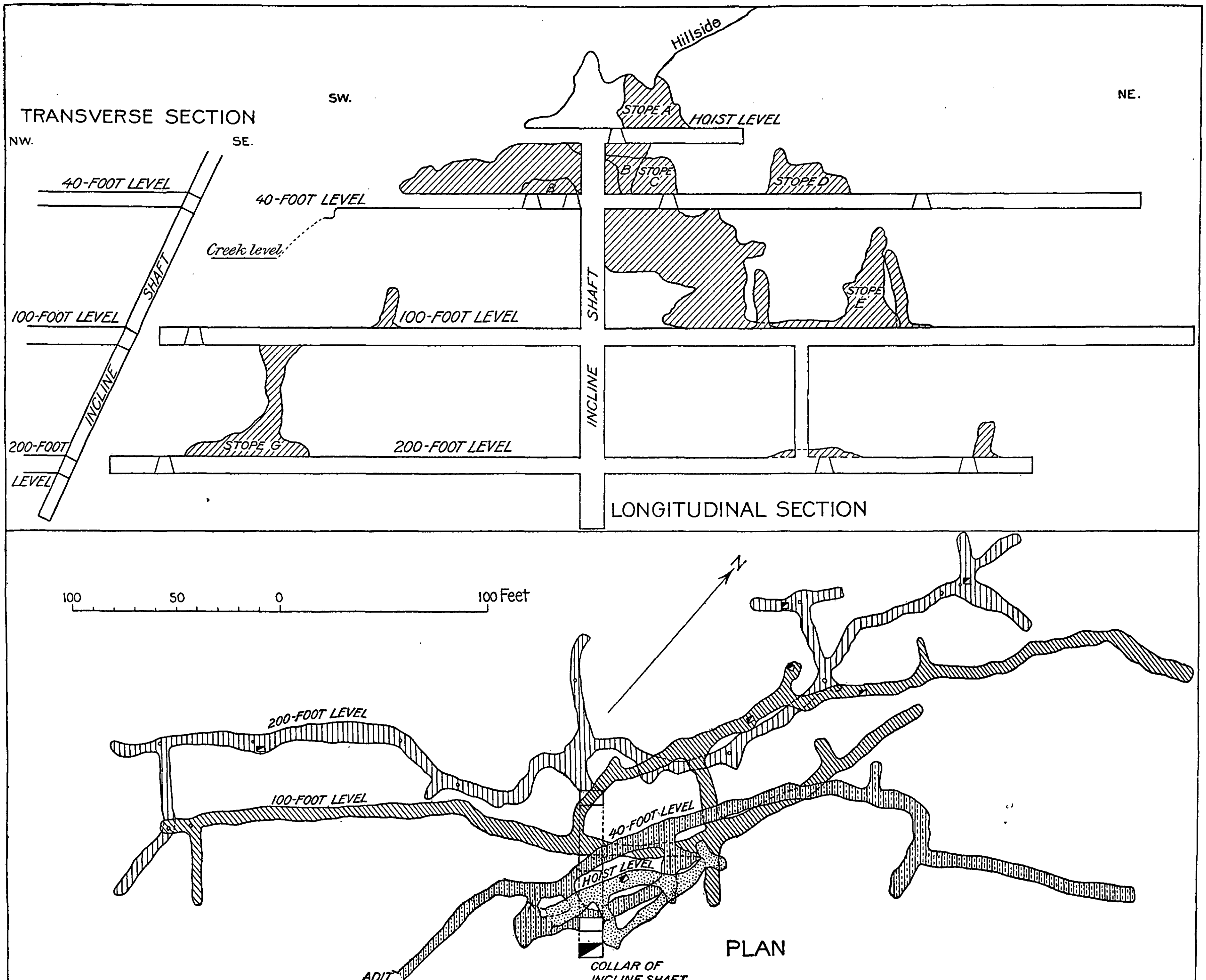
Several small tunnels and shallow shafts have been opened on the property, but the principal development consists of a double compartment incline shaft, which extends down the dip of the vein and from which drifts have been opened on the 40-foot, 100-foot, and 200-foot levels, comprising in all perhaps 3,000 feet of work. (See Pl. XXIII.)

The vein, as seen at the surface and on the tunnel level (the deeper workings being flooded at the time of visit), is a strong quartz lode striking N. 35°–40° E. and dipping 65° NW. It occurs along a brecciated but sharply defined fissured zone about 40 feet wide. The greatest mineralization has taken place along the hanging wall, where 3 to 8 feet of almost clean quartz is usually present. The contact of this with the hanging wall is fairly sharp but with the foot wall it is gradational, stringers of quartz, invariably with sharp contacts, becoming less and less numerous. From the mine map it seems that two parallel veins are present, although but one, locally paralleled by strong stringers, was noted at the surface.

Extensive crushing and weathering have commonly transformed the normal vein filling into a sugary and somewhat clayey mass. Where unaltered the quartz is crustified and in places shows a fine ribbon structure due to dark, crimpy bands of dull to submetallic luster. Cavities, few of them more than an inch in diameter, and generally lined with drusy quartz, are common. Pyrite, nowhere abundant and occurring only in very small crystals, is the single mineral seen in the hand specimen. When microscopically examined, however, the ore appears much more interesting (p. 55).

RABBITFOOT (RAME) MINE.

The Rabbitfoot mine is situated in the eastern part of the Gravel Range mining district. It is 6 miles east of Myers Cove and 9 miles south of Forney. Although located in 1872, active exploitation of



MINE MAP AND SECTIONS OF MONUMENT MINE, MYERS COVE, GRAVEL RANGE DISTRICT.

Adapted from map of Oregon-Idaho Gold Mining Co.

the property did not begin until 1905. At present development consists of about 5,000 feet of tunnel and two shafts, one 170 and the other 90 feet deep. A 10-stamp mill is situated near the portal of the main tunnel.

The ores are inclosed in rhyolite and occur in lenses and stringers, none of which have been found to extend more than a few score feet in any direction. In general appearance the quartz is similar to that at Myers Cove except that oxidation is farther advanced. In consequence recovery by amalgamation is more complete. In many places metallization has followed joint planes along which little or no quartz has been deposited, and elsewhere vesicles in the rhyolite are partly lined by pyrite crystals.

The general presence of fine gold in the soil overlying the workings has been a constant source of inspiration to further quest for a distinct vein, but so far none has been found. A short distance from the portal of No. 2 tunnel a fault is crossed which runs N. 10° E. and dips 65° NW. The crushed footwall of this fault carries about $2 per ton in gold and is more suggestive of continuity than any other deposit exposed on the property.

PARKER MOUNTAIN DISTRICT.

SITUATION AND HISTORY.

Parker Mountain district, situated in the southwestern part of the county, is comparatively new and little developed. A wagon road extends to a point within 12 miles of the principal mines, the route thence being by trail over the divide that forms the boundary line between Custer and Lemhi counties and separates waters flowing west into Middle Fork and east into Salmon River. The district was located in 1904 and is, after McDevitt, the youngest in the county. Development consists of perhaps 2,000 feet of tunnel work, nearly all of which is on the Parker Mountain and Williams groups of claims. Some ore has been shipped from each of these properties and from the former a small tonnage has been treated locally in a 6-ton roll mill. A road has recently been completed from the mine to the mill, 3 miles distant. The total production of the district has been only a few thousand dollars.

TOPOGRAPHY.

The area is high and mountainous, ranging from 7,500 to 9,000 feet above sea. Parker Mountain, in the center, and Twin Peaks, on the southeast margin, are the crowning elevations, the latter rising 500 to 1,000 feet above their surroundings and the former noteworthy because set off from surrounding highlands on three sides by the deep valleys of Warm Spring Creek and its principal north tributaries. The drainage is westward into Middle Fork of Salmon River.

GEOLOGY.

Algonkian sedimentary rocks are exposed only in the deeper gulches, most of the surface rocks being late Tertiary eruptives—rhyolites, tuffs, and a few trachytes. The rhyolites are predominantly dark gray to steel-gray in color and are made up of phenocrysts of quartz and less orthoclase sparsely set in a glassy to fine-grained groundmass. The tuffs, although widely distributed, are most conspicuously exposed just west of Twin Peaks, where they are upwards of 300 feet thick, and consist of roughly stratified beds of chalky-white color. Included in them are a few fragments of quartzite, schist, and rhyolite, but the main mass is an aggregation of pumice and angular fragments of quartz, orthoclase, and glass. Overlying them in the south peak is a band of rhyolite, possibly 500 feet thick. Trachyte, similar to the rhyolite but without quartz and generally presenting a rougher surface or fresh fracture, is known to be present as thin bands between some of the rhyolite flows. Its relative importance was not determined.

ORE DEPOSITS.

The short time available for looking over the deposits—only a few hours—necessitated a very cursory examination. That they are, however, of the same general type as those of the Gravel Range district is perfectly clear. The veins, which vary in width from stringers up to 3 or 4 feet, strike N. 20° E. and dip 55° NW. They are fissure fillings with many angular fragments of wall rock included. Lateral spurs leading out along joint and fracture planes are abundant, and in places narrow bands of quartz lie parallel to the main vein, either in the hanging or foot wall. Broadly, the vein quartz is crustified parallel to the inclosing walls, but in detail it is in many places concentrically arranged.

The quartz is fine grained. When examined in thin section, it is seen that the crustified appearance is due to alternating layers of different coarseness. Intermixed with the quartz are many small fibers and flecks of sericite, but whether these are primary or are derived from the breaking down of the adularia known to be present could not be determined from the extremely altered ore which alone was available. A very fine-grained metallic mineral of bluish-white color occurs in blotches and isolated specks. It was not identified. The ore contains gold and silver in proportions which vary markedly from place to place, although everywhere more valuable for gold. Common assay values are said to be $12 to $20 a ton.

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