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SOME ORE DEPOSITS IN NORTHWESTERN CUSTER COUNTY, IDAHO

BY

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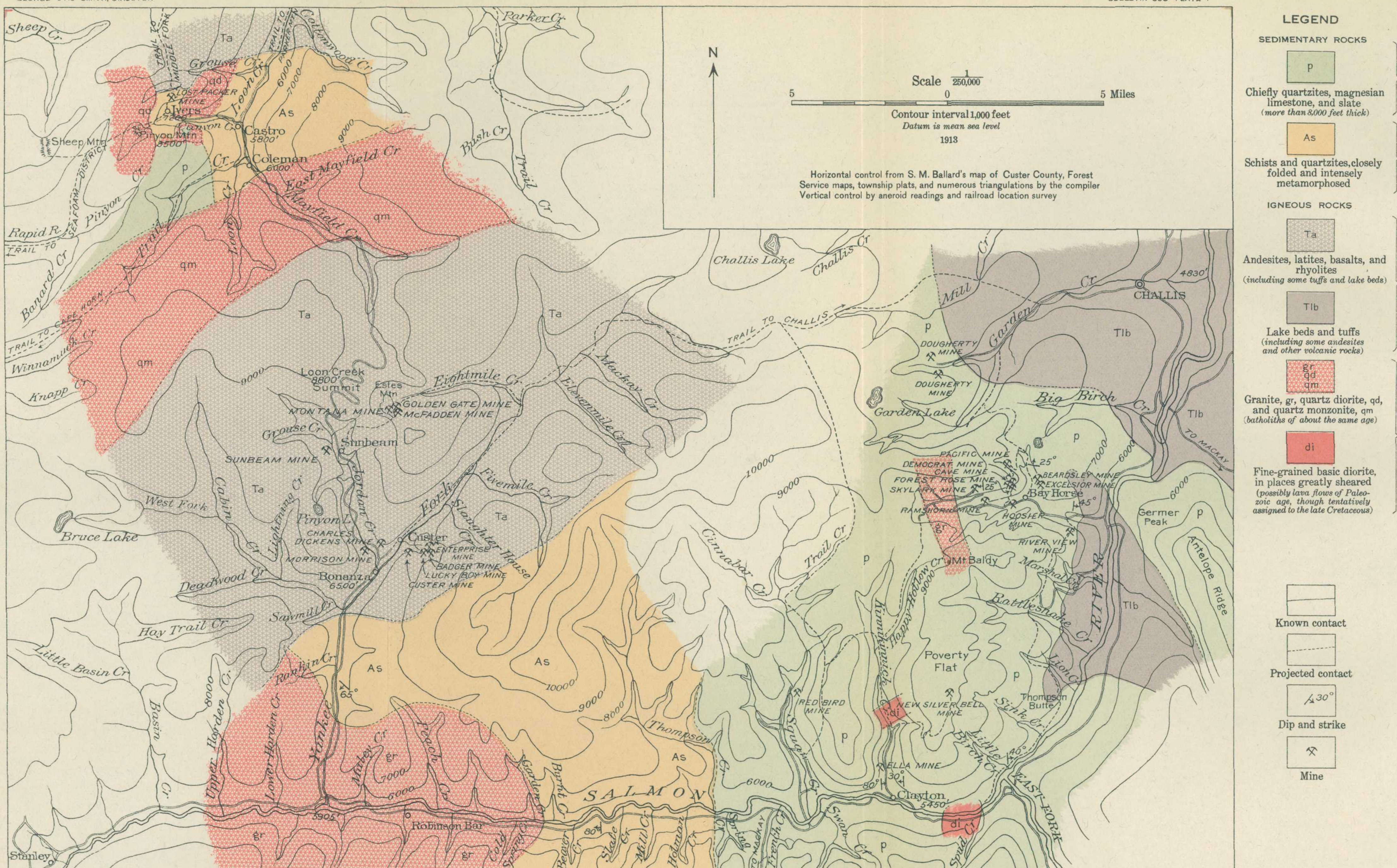

TOPOGRAPHIC AND GEOLOGIC SKETCH MAP OF A PORTION OF NORTHWESTERN CUSTER COUNTY, IDAHO

By Joseph B. Umpleby

SOME ORE DEPOSITS IN NORTHWESTERN CUSTER COUNTY, IDAHO.

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INTRODUCTION.

SCOPE OF THE REPORT.

This report sets forth the results of a short reconnaissance in the Loon Creek, Yankee Fork, and Bay Horse mining districts, situated in the northwestern part of Custer County, Idaho. The area includes several promising ore deposits and a few mines where a considerable tonnage is blocked out, awaiting more advantageous transportation facilities.

The area is first treated as a unit in order to bring out the broader relations, and then the three districts are taken up separately. Although this arrangement involves some repetition, it is thought to be justified in order that the report may be equally valuable to the student of the general subject and to the person interested in a particular district.

FIELD WORK AND ACKNOWLEDGMENTS.

Early in the fall of 1910 three days were spent in examining the Bay Horse district, it being the plan at that time to incorporate notes on the deposits there found in a report on Lemhi County. Later it was decided to make a reconnaissance of two other districts adjacent to Bay Horse and incorporate the results of the work in the three areas in a separate bulletin. Pursuant to this plan field work was begun August 27, 1911, and continued until September 20 of that year. The time was divided about equally between the Loon Creek, Yankee Fork, and Bay Horse districts. A topographic and geologic sketch map was prepared showing most of the area (2,500 square miles) included in these districts. (See Pl. I.) On this map only the broader geologic divisions are recognized and except along the main line of traffic from Challis to Ivers and over small areas adjacent to the more important metalliferous deposits, the positions assigned to their contacts are based largely on information derived from mining men and prospectors.

The base map is compiled from S. M. Ballard's map of Custer County, data furnished by the local office of the Forest Service, and

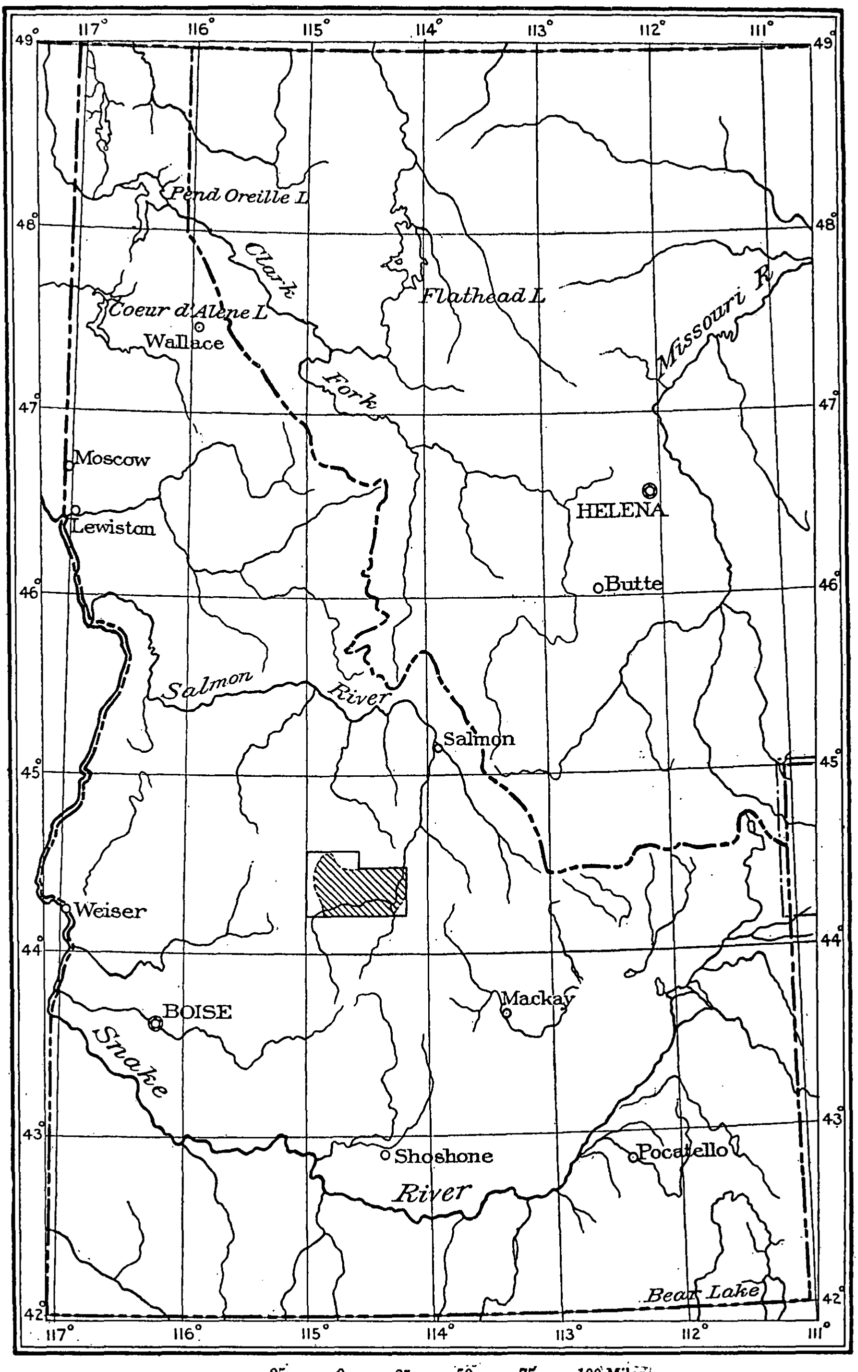


FIGURE 1.—Index map of Idaho showing location of area investigated.

numerous compass triangulations by the writer. Vertical control along Salmon River is taken from a location survey by the Gilmore & Pittsburgh Railroad; elsewhere it is taken form aneroid readings.

Field work was greatly facilitated by generous courtesies and assistance given by mining men in the area, especially by the officials of the Lost Packer Mining Co.

EARLIER WORK AND LITERATURE.

The earlier work in the area is described principally in short articles. George H. Eldridge, during his reconnaissance from Boise to Salmon, passed through a part of the Loon Creek district and on his return touched the northeast corner of the Bay Horse district. His report, however, contains little specific information concerning the area here considered. The Bay Horse district is the subject of a few notes by R. N. Bell, in which he describes the geologic features of the region and the occurrence of silver ores. In another paper the same writer incorporates notes on the mines of the Yankee Fork and Bay Horse districts. The Lost Packer mine is described briefly by E. P. Jennings. The annual reports of the State Mine Inspector, many of which contain notes on the geology of the deposits, form another source of information regarding the ore deposits of the area. The more important reports and articles on this and nearby areas are listed below in chronologic order:

EMMONS, S. F., Livingston to the Snake Plains: Cong. géol. internat., Compt. Rend. 5th session, 1893, pp. 367–374.

Describes geology along route of travel and 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 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, Pls. XV-XVII.

Describes topography and geology along a route from Boise to Salmon and thence south to Hailey and west to Boise. Includes notes on the ore deposits at Yellow Jacket and the placers of Leesburg Basin and Kirtley Creek.

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

BELL, R. N., The deepest mine in Idaho, the Ramshorn at Bay Horse: Mines and Minerals, vol. 21, 1900, pp. 174–176.

Describes geologic features of the region and occurrence of the silver ores.

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, Pls. VII-XXXV.

Describes character and occurrence of the igneous and sedimentary rocks and 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 amount of development, production, and something of their geologic relations.

RUSSELL, I. C., Geology and water resources of the Snake River Plains of Idaho: Bull. U. S. Geol. Survey No. 199, 1902, 192 pp. 25 pls.

Describes topography, basement series of rocks, recent eruptives, lacustrine deposits, and resources of the area.

LINDGREN, WALDEMAR, A geologic reconnaissance across the Bitterroot Range and Clearwater mountains in Montana and Idaho: Prof. Paper U. S. Geol. Survey No. 27, 1904, 123 pp., 15 pls.

Describes topography and character, occurrence, and geologic relations of the igneous and sedimentary rocks, the structure of the area, and character, occurrence and development of its mineral deposits. Gibbonsville and Mineral Hill districts, Lemhi County, are described briefly.

JENNINGS, E. P., The Lost Packer copper-gold lode (Idaho): Jour. Canadian Min. Inst., vol. 9, 1906, pp. 54–57. Min. and Sci. Press, vol. 92, June 30, 1906, pp. 435–436.

Describes geologic relations and constitution of the Lost Packer vein.

CARR, HENRY C., Vein structure in the Monument mine: Min. and Sci. Press, vol. 98, Apr. 17, 1909, pp. 557–558.

Includes notes on the geology and character and occurrence of the ores at Meyers Cove (Singiser), Lemhi County, Idaho.

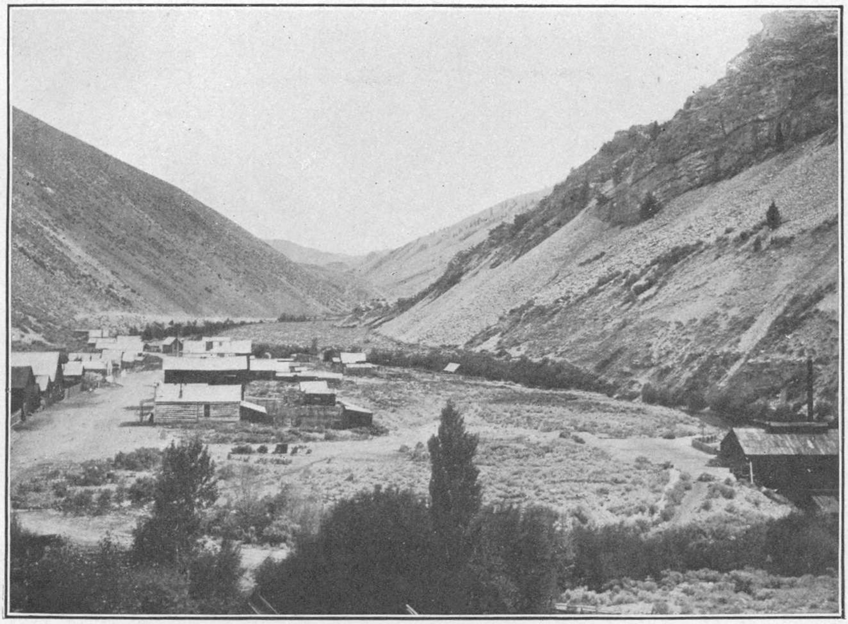
UMPLEBY, J. B., Geology and ore deposits of Lemhi County, Idaho: Bull. U. S. Geol. Survey No. 528, 1913, pp. 182, pls. 23.

Describes physiography, general geology, and ore deposits of the county. In the final chapter the nineteen mining districts are treated separately.

GEOGRAPHY.

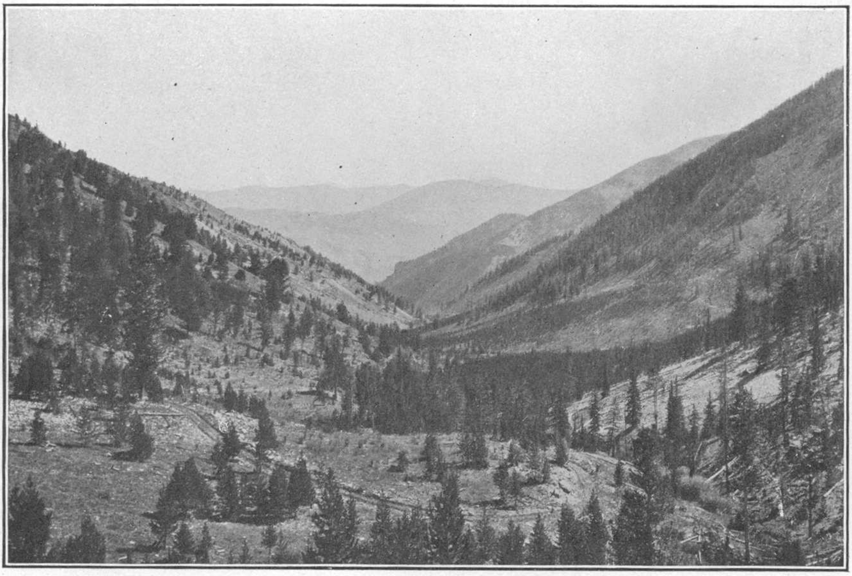
Situation and access.—Northwestern Custer County, in east-central Idaho, is most easily reached from Mackay, a terminus of a branch of the Oregon Short Line Railroad. Stages run daily except Sunday to Challis, 60 miles distant, and thence on to Bonanza and Custer, 60 and 62 miles farther, respectively. These stage lines are official mail routes, but from Custer the mail is carried by private conveyance 28 miles westward to Ivers, thrice weekly when the smelter is running and twice monthly at other times. Challis may also be reached by stage three times a week from Salmon, 60 miles north, a terminus of the Gilmore & Pittsburgh Railroad.

Settlements.—The region covered by this reconnaissance contains seven settlements, the chief of which is Challis, the county seat of Custer County, in the northeast corner of the area. Challis is an attractive little village of about 1,000 inhabitants and has a bank, two hotels, churches, a good school, and several stores. Adjacent to it are several valleys well adapted for agriculture, which have been settled largely within the last few years. Streams from the mountains afford abundant water for irrigation, and crops of the north temperate latitude flourish. At present the costs of transportation for



A. SALMON CANYON WITH CLAYTON IN THE FOREGROUND.

Looking north.



B. BAY HORSE CANYON AS SEEN FROM A POINT NEAR ITS HEAD

Bay Horse is beyond the second bend.

agricultural produce are prohibitive, so that agriculture in the region is only incidental to stock raising.

The other settlements are of about equal importance, and each depends on the mining industry for its existence. The old camp of Bay Horse, 14 miles south of Challis, once the site of an important smelting and mining industry, is now inhabited by only a few persons, representatives of the larger companies, lessees, and prospectors.

Clayton, 20 miles south of Challis, on the north bank of Salmon River (Pl. II), is also the dwindling remainder of a once flourishing smelting and mining center. Being situated on the main stage route, however, and possessing a post office and large company store, it is still a center for prospectors and cattlemen.

Bonanza, half a mile below the junction of Jordan Creek and Yankee Fork, Custer, 1½ miles northeast of the same point, and Sunbeam, 4 miles northwest of it, were each small settlements that are now abandoned except by a few prospectors and by persons held there by property interests.

Ivers was the only active camp in 1911. It is 28 miles northwest of Sunbeam and about 90 miles, by a circuitous route, west of Challis. Fifteen or twenty persons live at the camp throughout the year, but during the summer months the settlement has a population of 100 to 200.

Lines of travel.—A good road follows Salmon River through the area and beyond and from it important branch roads extend up the valleys of Yankee Fork and East Fork, and numerous laterals follow tributary streams for a few miles. The East Fork branch leads to Mackay, and the Yankee Fork branch leads to Bonanza, whence it forks, one road leading to Custer and the other northwestward over Loon Creek summit, at an elevation of 8,800 feet, to Ivers.

The roads are good and as far as Sunbeam are open throughout the year; but thence westward traffic is impossible during the winter.

The great highland portions of the area are reached only by trails, which are few and little traveled. Perhaps the trail most used is that leading from Challis westward over the summit, 30 miles to Custer.

Climate and life.—The range of climatic conditions is wide. From the highlands, which are deeply covered with snow throughout the winter, the climatic transition is gradual to the lowlands, where sleighing is seldom possible. The open season for the region comprises May to October, inclusive. Frequent showers characterize May, and flurries of snow are common in October; but the intervening period is delightfully warm by day and cool at night.

The forests abound in wild game; hundreds of deer, and scores of bear, wolves, mountain sheep, goats, bobcats, and lynx are killed every year. Antelope and beaver are protected by State laws.

Licenses are required of all huntsmen, and the charges are so fixed as to favor greatly the residents of the State. Heads and hides may be shipped from the State only by special permit.

History of the area.—The history of northwestern Custer County since its discovery by whites closely involves its mining development. Its early inhabitants were totally dependent upon the mining industry, but other sources of revenue, such as agriculture and grazing, were gradually developed until perhaps most of the present population is independent of the mining industry.

For about 30 years after the discovery of placer gold on Loon Creek, in 1868, mining was active and the population was much greater than at present. Custer, Bonanza, Clayton, and Bay Horse were flourishing settlements. More recently Sunbeam prospered, but at present Ivers alone is an active camp.

With the certain revival of mining in the future, agriculture will become much more important, by reason of increased local market and the probability of better transportation facilities.

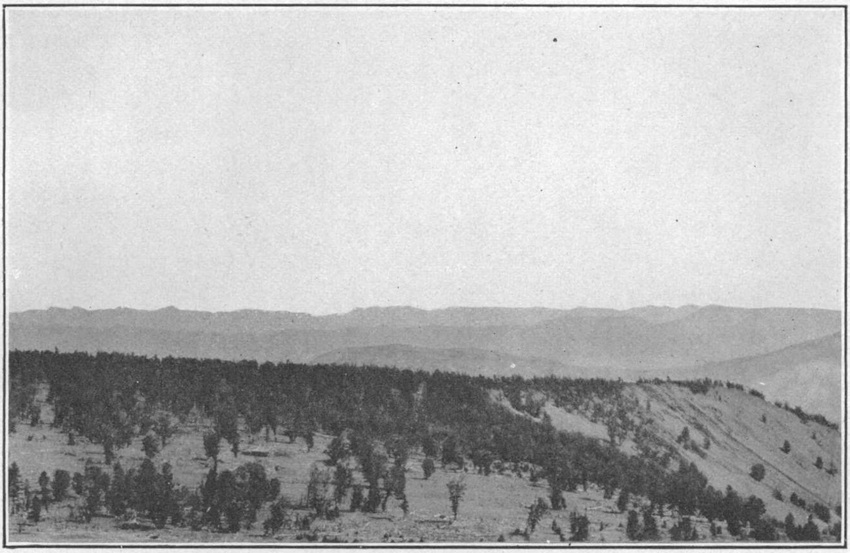
PHYSIOGRAPHY.

GENERAL RELIEF.

Northwestern Custer County comprises a high mountainous area in which the summits stand about 9,600 feet and the beds of the major streams 5,000 to 6,000 feet above sea level. The mouth of Challis Creek, by railroad location elevations, is 4,830 feet and the mouth of Yankee Fork is 5,905 feet in elevation. The highest point visited in the area, as determined by aneroid, is Estes Mountain, which attains an altitude of 9,800 feet. The highlands form a network of connecting ridges, small areas, and flat-topped spurs. In extent they exceed the lowlands, though steep slopes connecting the two represent most of the surface.

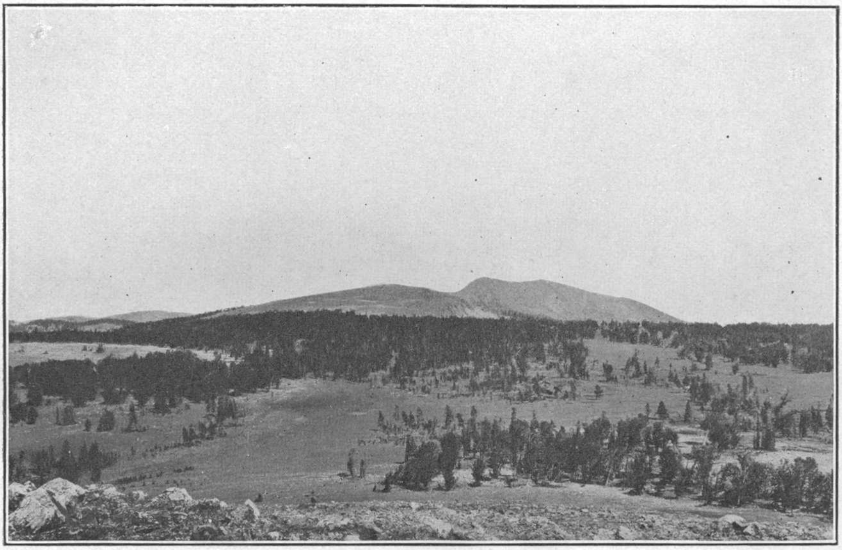
DRAINAGE.

Salmon River, the main artery of this part of Idaho, heads southwest of the area mapped, flows eastward along its southern border, and then abruptly turns to the north and continues along its eastern margin and beyond, finally by an abrupt turn flowing westward across the central part of the State. All the streams of the area are tributaries of Salmon River; most of them join the Salmon at headwaters, but those in the Loon Creek district reach it at a point in the central part of the State, well toward its mouth. Loon Creek Summit and its continuation to the southwest and northeast forms the local divide between northward and southward flowing drainage. Loon Creek and its tributaries have intricately dissected the country north of the divide, and numerous streams, most important among them Yankee Fork, have deeply carved the area south of it.



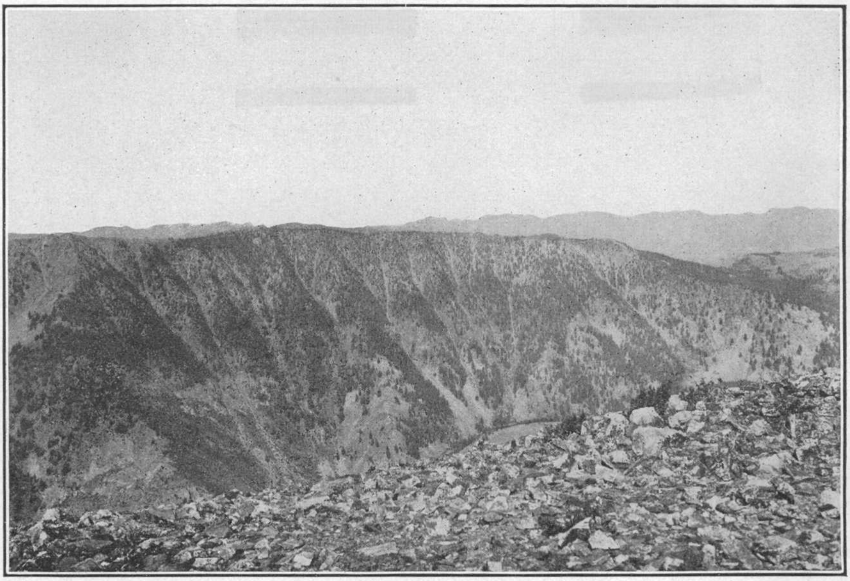
A. SPUR ON THE NORTH SIDE OF POVERTY FLAT.

Showing the highly inclined beds across which the flat has been developed. The flat is 9,600 feet above sea level.

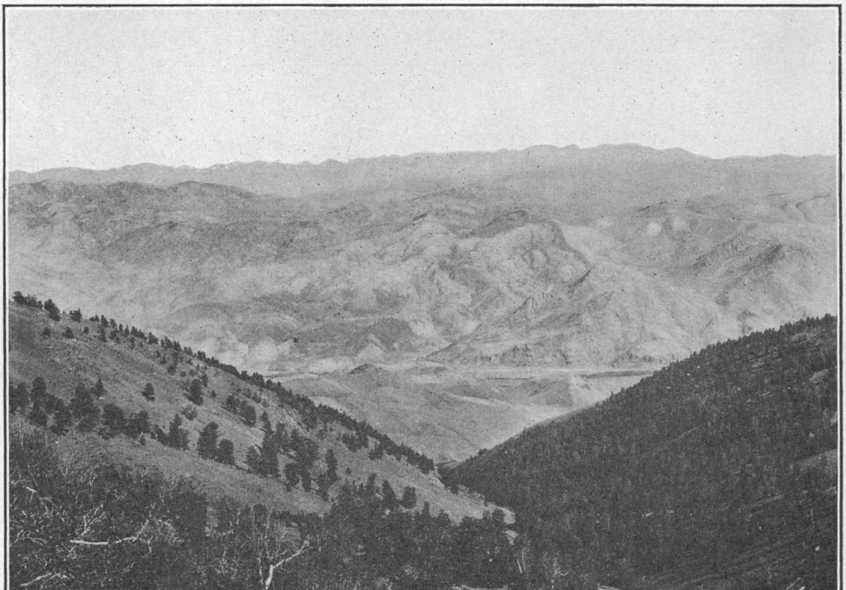


B. CENTRAL PORTION OF POVERTY FLAT.

The low hills in the background are quartzite; in the foreground is steeply dipping slate.



A. SOUTH WALL OF KINNIKINNICK CANYON AS SEEN FROM POVERTY FLAT.



B. MIOCENE LAKE BEDS NORTHEAST OF POVERTY FLAT.

Note scarcity of vegetation in areas of lake beds.

SUMMIT AREAS.

The uplands are characterized by small flat-topped areas, from which extend square-shouldered spurs, and by level-crested ridges. The striking character of these features has given rise to such local names as "Poverty Flat," applied to a tract 9,600 feet above sea level and about 25 square miles in extent, and "Railroad Ridge," which is more than 100 miles long and so even crested as to resemble, when viewed from a distance, a railroad grade. This ridge lies southeast of the area studied but may be clearly seen from Poverty Flat near Clayton. Equally striking in the evenness of their crests are Antelope Ridge, the Lost River Range, and Lemhi Range—all blending to form the northeastern horizon as seen also from Poverty Flat. To the northwest there are no distinct ranges but instead a veritable labyrinth of small summit areas and short ridges, remarkable for their general accordance in elevation. Poverty Flat itself is a comparatively level tract (Pl. III) bordered by canyons as much as 5,000 feet deep. It is reached with difficulty by trail from Clayton, 4 miles distant, but once on top a wagon could be driven over most of it. A few low quartzite hills rise from its general level and attain a height perhaps 100 feet greater. Along portions of the western and southern borders, notably on a spur west of the New Silver Bell mine, an almost horizontal bench, in places 50 to 100 feet wide but generally rather indistinct, follows along the side slope about 100 feet below the level of the flat. The level part of the flat is deeply mantled with soil, but the quartzite buttes are covered with angular blocks of the underlying material.

This striking summit surface extends across the rocks of the area irrespective of their attitude or composition. The intensely metamorphosed and crumpled schists of the Algonkian, the generally folded slates, quartzites, and dolomitic limestones of the Paleozoic, and the comparatively undisturbed granitic intrusions of the late Cretaceous or early Tertiary have all united to form the present high-level topography. (See Pl. IV.)

The summits of the area, if combined, would determine an undulating plain, differing little in elevation from place to place though here truncating resistant beds and there cutting across shales and schists. The surface could have resulted only from erosion. The area was reduced nearly to base level for the region, where inequalities in rock resistance no longer found pronounced expression in the topography; then it was elevated and dissected by the streams which now drain it.

VALLEYS.

The valleys of the area are of two types—those now occupied by lavas, tuffs, and lacustrine deposits, and those followed by the present streams.

The present valleys of the area are for the most part deep and narrow, but a few have broad floors of gravels in which the streams are now intrenched to a depth of 10 to 50 feet. Valleys of this sort are locally typified by those of Loon Creek and Yankee Fork, but even along Salmon River remnants of deep gravel deposits occur in many places, Robinson Bar being a striking illustration.

The valley of Salmon River is narrow and canyon-like throughout most of its extent, but about Challis it widens, affording broad slopes admirably adapted for agriculture. Antelope Creek, a comparatively insignificant stream, occupies a valley vastly wider than that of Salmon River west of Big Birch Creek. These features are not to be accounted for by difference in rock formations or by structure. They may be interpreted only in the light of a complex drainage history—a history which can be worked out only by physiographic studies broader than those yet undertaken.

Largest among the older valleys is the one crossed by the Ivers Road between points 7 miles south and 5 miles north of Loon Creek Summit. The bedrock of this old valley is exposed at Sunbeam at an elevation of 7,000 feet, but elsewhere it was not seen. If the Sunbeam exposure, which is almost halfway between its margins, is assumed to indicate the general elevation of its bed, the old valley is about 3,000 feet deep and is now filled in most places by lavas and tuffs throughout its width of 12 miles.

About Challis the Miocene lake beds occupy a similar depression, but no exposures of its floor are known. Similarly situated topographically are the deposits east of Bay Horse.

RELATION TO ADJACENT TYPES.

The area herein described is a part of that great plateau-like expanse known as the Salmon River Mountains, which is characterized throughout by even summits and deep, narrow canyons carved from rock formations of diverse type and complex structure. Lemhi County, to the north, is continuous with this area and similar physiographically. There the history has been worked out in some detail and broad correlations have been made.[1] The discussion need not be repeated in this bulletin, though the general conclusions are incorporated below.

The old erosion surface represented by the summit levels of this area is known to have extended over much of Idaho and probably into adjoining parts of Montana, Washington, and British Columbia. It has been assigned to the Eocene, both because of the relation of Miocene lake deposits to it, and because of its relation to the Eocene deposits of the Northwest.

[1] Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho; Bull. U. S. Geol. Survey No. 528, 1913, pp. 23-30; An old erosion surface in Idaho; its age and value as a datum plane: Jour. Geology, vol. 20, No. 2, 1912, pp. 139-147.

PHYSIOGRAPHIC HISTORY.

The record of the physiographic history of the region is legible for only that comparatively small portion of geologic time since the late Mesozoic. Near the close of the Cretaceous period extensive regional elevation, thought to have been accompanied by folding and great batholithic intrusions, rejuvenated the streams and inaugurated a period of rapid erosion which, by the close of Eocene time, had resulted in a far-reaching surface of gentle topographic forms. The amount of this early Eocene elevation is not definitely determinable, but it was doubtless a few thousands of feet, possibly comparable to that at the close of the same epoch.

Elevation at the close of the Eocene or early in the Oligocene once more rejuvenated the streams of the area. This uplift extended over essentially the same vast area as the former one. In northwestern Custer County the elevation may be taken as about 8,000 feet, or somewhat less than the difference between the present high-level surface and base level for the region. During the Oligocene epoch the major streams developed broad, deep valleys, which in the Miocene and possibly also in part of the Pliocene were the sites of lava flows and lacustrine deposition.

The Pliocene again was a period of dominant erosion. Valleys as much as 4,000 or 4,500 feet deep were locally developed in the Miocene rocks and later shaped by glacial ice.

Ice fields covered the highlands during the Pleistocene, and glaciers extended down the valleys to elevations between 6,500 and 7,500 feet. Below these elevations glacial waters deposited deep and extensive gravel beds, into which many of the present streams are cutting.

Erosion is now active within the region, and perhaps one-third of the task of reducing it once more to an area of gentle topographic forms has been accomplished, this in spite of the far-reaching interruptions of the Miocene epoch.

GENERAL GEOLOGY.

OUTLINE.

The oldest rocks exposed in northwestern Custer County are schists, slates, and quartzites of Algonkian age. Unconformably on these rocks in the eastern and locally in the northwestern part of the area lies a great series, at least 9,000 feet thick, of Paleozoic quartzites, slates, and dolomitic limestones. These were not further subdivided, although there is some reason for thinking that they range in age from Cambrian to Devonian, inclusive. These rocks, and also the older rocks, are cut by large intrusive masses of granite, quartz diorite, and diorite, which are probably outliers of the great batholith that invaded central Idaho during the late Cretaceous or early Eocene epoch.

Dikes of granite, granite porphyry, and diorite porphyry, closely related in age to the granitic rocks, are locally abundant in the western part of the area. In the central portion and along the eastern margin occur vast accumulations of Miocene lava and tuff, which occupy old erosion valleys. Morainic material covers much of the highland area and extends down the larger valley to elevations of 6,500 or 7,000 feet. Locally it coalesces with outwash gravels deposited along the major streams. (For distribution, see map, Pl. I.)

ALGONKIAN ROCKS.

Distribution.—Algonkian rocks are widely distributed in the northwestern and south central parts of the area included in the reconnaissance. Perhaps the best exposures of these rocks are along Salmon River, between Thompson and Cold Spring creeks, where for a distance of about 6 miles outcrops are almost continuous. For about 4 miles along Yankee Fork, south from Sawmill Creek, and about the junction of Canyon Creek with Loon Creek, there are also numerous exposures.

Characteristics.—The Algonkian rocks comprise an intensely metamorphosed series of sedimentary deposits, in which schistosity is well developed, in many places to the concealment of bedding structure. Where the attitude of the beds is determinable, however, steep dips, usually away from north-south axes, prevail.

The stratigraphic sequence of the series could not be carefully worked out in the short time available. Along Yankee Fork perhaps 2,000 feet of beds dipping steeply southwestward are exposed between the lavas on the north and the granite on the south. The lower part is dark-gray medium-grained quartzite, and the upper part is composed of thin-bedded blue-black micaceous slates. About Ivers the series comprises sericitic and chloritic schists with interbedded siliceous bands. The three facies of the series—schists, slates, and quartzites—outcrop in the Salmon River section. In the western portion of this exposure bluish-gray fine-grained quartzites are cut off by granite. Below the quartzites are dull black, slightly crumpled slates, which dip 80° W. and outcrop along the road for about 4,000 feet. East of these slates micaceous schists continue to the area about the mouth of Thompson Creek, beyond which Paleozoic formations come in. The relation of the schists to the slates was not observed, although it is believed that they occur lower in the stratigraphic column.

Correlation.—Close correlation of these old metamorphic rocks is not possible from the incidental attention given them during these studies. From their lithologic character and degree of metamorphism, however, there is no doubt that they are part of the same general series which is widely exposed to the north in Lemhi County. The rocks there found fall into divisions which accord roughly with the Cœur d'Alene Algonkian section,[1] and it is believed that careful study would reveal approximately the same sequence here.

PALEOZOIC ROCKS.

Distribution.—Beds of Paleozoic age are widely exposed in the eastern half of the area mapped and also occur in a small area south of Ivers in the northwestern portion. The best exposures are along Salmon River, from Thompson Creek to East Fork, and in the walls of Bay Horse Canyon.

Structure.—The eastern area only was studied even in moderate detail. Here three large anticlines and two synclines characterize the structure. The west anticline, later referred to as the Clayton anticline, forms a broad arch between Clayton and Squaw Creek. On the eastern limb the dips are about 80°, and on the western about 45°. Beds which reach the river level at points 2 miles apart are approximately 2,000 feet above it along the axis of the anticline. A similar structural feature about 4 miles wide but with maximum dips to the west and east of 30° and 40° respectively spreads between Clayton and East Fork. It is across this anticline that the erosion surface of Poverty Flat extends. The third and most important anticline, because of its relation to the ore deposits, extends in a north-south direction through the Bay Horse district, and is designated the Bay Horse anticline. On its east limb the beds dip about 40° and on its west about 80°. Northward within 2 miles the arch flattens, and at the same distance beyond the beds are almost horizontal.

Lithology.—The Paleozoic section is perhaps best exposed in the north wall of Bay Horse Canyon. At Bay Horse the beds are almost horizontal, and in a single cliff at the mouth of Beardsley Creek about 1,000 feet of the section is exposed as follows: At the base lies 300 feet of thinly laminated dark bluish-gray slate, minutely crumpled but without slaty cleavage. Above this is 500 feet of rather massive beds of dolomitic limestone of diverse purity, in some places a dolomite, in other places limestone, and in still others either argillaceous or siliceous. This grades into a thin-bedded slate, about 200 feet of which is here exposed. Westward from Bay Horse the beds are nearly horizontal for about a mile and in the southeast face of Democrat Hill the section may be continued. Here the slate, which is 200 feet thick in the other exposure, is 600 feet thick, and is overlain by dolomitic limestone 1,300 to 1,500 feet thick. About 2 miles above Bay Horse the beds assume a steep westerly dip and this

[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.

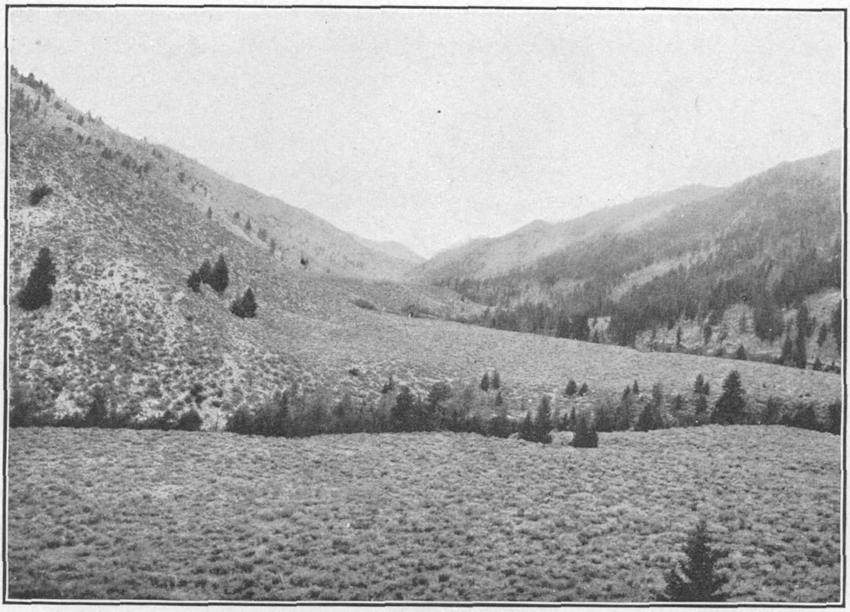
limestone in a short distance descends to the creek level. Beyond is a monotonous succession of thin-bedded slates in which slaty cleavage is in many places more conspicuous than the bedding planes. These slates continue for 1½ miles and are cut off by granite. Their average dip is possibly 35°, which if duplication by faulting be negligible, as is thought to be the case, indicates a thickness of more than 4,000 feet. Thus the Paleozoic section as exposed in Bay Horse Canyon is thought to be about 7,000 feet thick.

In the walls of Salmon Canyon, above Clayton, are massive flat-lying quartzites, which extend from the water line upward possibly 2,000 feet and underlie 200 or 300 feet of massive blue dolomitic limestone. These beds do not appear in the Bay Horse section. Thus the total thickness of the Paleozoic section as exposed in this area is more than 9,000 feet, including neither top nor bottom, and with an unspanned break between the two sections studied.

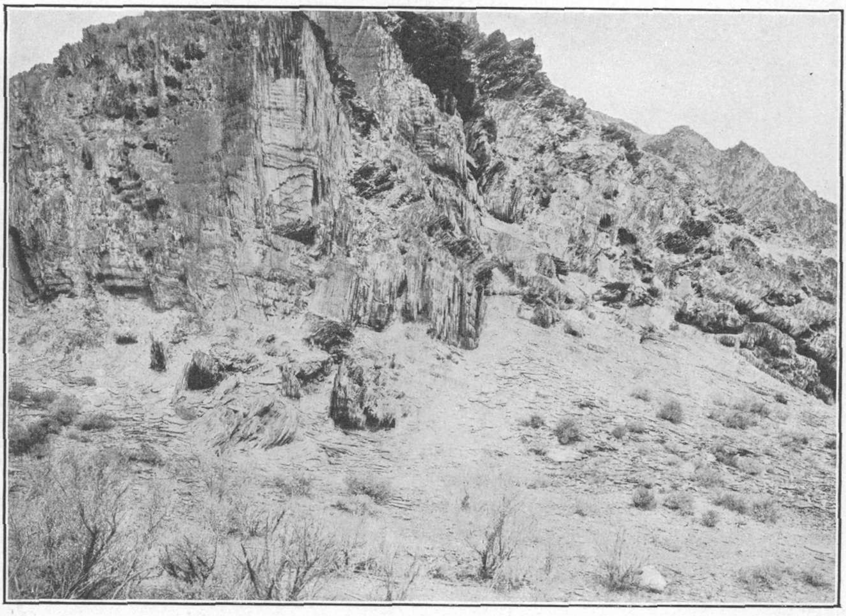
It is possible that the 4,000 feet of slates which outcrop above Bay Horse may prove to be Algonkian, separated from the Paleozoic rocks east of them by a fault, but this is thought improbable, the only suggestion of the relation being their greater metamorphism, a metamorphism more likely resulting from the granite intrusion than from the diastrophism which preceded the Paleozoic era. A fault does cross the canyon a short distance above Bay Horse, but the meager evidence secured favors a downthrow on the west. (See Pl. V, *B*.)

Correlation.—Lithologically the rocks here found agree closely with the Paleozoic formations of the Gilmore section, Lemhi County.[1] There the section comprises between 5,000 and 6,000 feet of beds, including 2,000 feet or more of fine-grained Cambrian quartzite, 500 feet of massive Ordovician dolomitic limestone, 300 feet of massive Silurian (?) dolomitic limestone, 2,000 feet of thin-bedded Devonian dolomitic limestone, and at least 300 feet of massive blue limestone of Mississippian age. Comparing the two sections, it seems probable that the quartzite exposed above Clayton agrees with the Cambrian quartzite at Gilmore. The 200 to 300 feet of massive blue dolomitic limestone above it may thus be tentatively correlated with the Ordovician at Gilmore, with which it corresponds lithologically. That portion of the section at Bay Horse does not agree closely with any part of the Gilmore section. In the Bay Horse section there is no group of limestone beds free from dolomite, which affords some basis for thinking that the Mississippian, which constitutes the top of the Gilmore section, is absent. Thus it seems most probable that the Bay Horse section falls between the Ordovician and Mississippian—that is, that the beds probably represent the Silurian and Devonian.

[1] Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: Bull. U. S. Geol. Survey No. 528, 1913, pp. 32-35.



A. PLEISTOCENE GRAVEL TERRACES ALONG SALMON RIVER BELOW ROBINSON BAR.



B. SLATY CLEAVAGE IN PALEOZOIC (?) SHALES AT ROADSIDE 2 MILES BELOW BAY HORSE CANYON.

If this is true, however, these systems are vastly thicker than at Gilmore. In later work it might be well to entertain as a field hypothesis the possibility that the slates west of Bay Horse are Pennsylvanian and that the Mississippian is there faulted down by the displacement believed to extend northwest across the canyon above Bay Horse.

Fossils were not found, but as only incidental search for them was made, it is not unlikely that the problem may be ultimately solved on fossil evidence. For the present the beds are simply assigned to the Paleozoic, the closer correlations being merely suggestions.

LATE CRETACEOUS OR EARLY EOCENE PLUTONIC ROCKS.

DISTRIBUTION.

Plutonic rocks appear at the surface in the northwestern and south-central parts of the area mapped, also at three localities in the eastern part. In the Loon Creek district a great batholith of quartz diorite extends into the district from the west and again outcrops as quartz monzonite in a belt about 6 miles wide along its eastern border. The largest area of plutonic rock is perhaps that near the junction of Yankee Fork and Salmon River. The main stream in this locality flows between rugged walls of granite for 14 miles below this junction. Northward the area continues for 2½ miles, but to the south and west its extent was not determined. In the Bay Horse district there are three small areas of plutonic rocks. The largest is granite, which comprises a north-south belt about a mile wide that crosses the upper end of Bay Horse Canyon. The other two are diorite, and each is about three-fourths of a mile wide; one crosses Kinnikinnick Canyon 4 miles above Clayton, and the other traverses Salmon Canyon 3 miles below Clayton.

VARIETIES.

The several areas of granitoid rocks differ markedly in composition and in the following paragraphs will be described separately. The rocks were studied hastily in the field and the specimens secured may not be altogether typical. Granite, quartz monzonite, quartz diorite, and diorite are represented.

Granite.—Granite occurs about the mouth of Yankee Fork and near the head of Bay Horse Canyon. Specimens from the former locality are light gray to pink in color, medium grained, and about equigranular, but locally, as near Robinson Bar, there is a marked phenocrystic development of orthoclase, individual crystals attaining an inch or more in length. Megascopically the rock is characterized by its light color and the small amount of biotite compared with the other granitoid rocks of the area. Microscopically examined, it is seen to contain the following minerals, named in order of decreasing amount: Orthoclase, quartz, microcline, biotite, albite, oligoclase, micropegmatite, muscovite, apatite, magnetite, and rutile. Some of the feldspars show zonal growth from albite, possibly also oligoclase, at the center to orthoclase on the margins. The granite from Bay Horse Canyon is coarse textured and contains much more biotite. It is dark gray in color. Although orthoclase is by far the most abundant feldspar in this rock, albite and oligoclase are both present in amounts about equal to the quartz and biotite. Hornblende, micropegmatite, magnetite, and apatite, may be considered accessory.

Quartz monzonite.—A rock intermediate in composition between the granite and quartz diorite comprises a large area west of Loon Creek Summit. It is commonly medium gray in color, though locally, as near the mouth of East Mayfield Creek, it is dark gray. The darker shades are due to excessive amounts of biotite. In places gneissoid structure is well developed, but this appears only along local zones of shearing. In the thin sections studied orthoclase and plagioclase (oligoclase and less albite) are about equally abundant. Quartz is almost constant in amount and biotite may be either much less or much more abundant than the quartz. Apatite, titanite, and magnetite are the more important accessory minerals.

Quartz diorite.—Quartz diorite is widely exposed south and west of Ivers. It is a dark bluish-gray equigranular rock, rich in biotite. It contains abundant plagioclase (oligoclase and andesine), much quartz, about an equal amount of biotite, and a little orthoclase. Hornblende, apatite, and titanite are accessory constituents.

Diorite.—The diorite in Kinnikinnick Canyon was only seen as float along the east wall, where it is continuous for about three-fourths of a mile. The rock is fine grained, equigranular, and of dark greenish-gray color. The feldspars have approximately the composition of andesine and occur as interlocking lath-shaped crystals. Hornblende is abundant and olivine and augite are almost equal to it in amount.

The other area of diorite occurs east of Clayton. Here the rock is extensively sheared and so highly altered that microscopic study adds little to the field diagnosis. Its texture is equigranular and it consists of andesine and ferromagnesian minerals, the latter completely changed to chlorite and calcite. Its gneissoid structure suggests that it is older than the other intrusive masses, but as older igneous rocks were not found in the area it is grouped with the late Cretaceous or early Eocene plutonic rocks.

AGE AND CORRELATION.

The plutonic rocks of northwest Custer County extend up to the level of the Eocene erosion surface and hence must have invaded the area before the close of the Eocene. On the other hand the youngest rocks which they cut are the Paleozoic sediments, so that their local geologic relations show only that they are later Paleozoic, Mesozoic, or very early Cenozoic. Broader considerations, however, permit their age to be rather definitely fixed.

Batholithic intrusions are widespread in Idaho. In the central part of the State is a granitic mass more than 20,000 square miles in extent. Numerous smaller areas have been considered outliers from it. Some of these granites are of the same composition, others are more basic, and in one locality granite and diorite have been found to grade into each other.[1] For these reasons, and because nowhere in the State have batholithic intrusions of widely different age been recognized, it is believed that these several types of rock date from the same general period of intrusion and are of the same age as the great Idaho batholith. This batholith has been assigned on what are believed to be sound deductions to the late Cretaceous or very early Eocene,[2] and it is therefore concluded that the batholithic intrusions of Custer County are also of that age.

EARLY EOCENE DIKES.

DISTRIBUTION.

Dikes are abundant only in the northwestern part of the area, in the immediate vicinity of Ivers, where 10, averaging perhaps 30 feet in width, have been encountered in the workings of the Lost Packer mine. Most of these dikes are approximately parallel and dip northwest at about 40°. In the Yankee Fork district dikes of this age were not recognized, and in the Bay Horse district but one was noted. This is a narrow intrusion which appears in the lowest tunnel of the Ramshorn mine.

VARIETIES.

The dikes fall into three general groups—granite, granite porphyry, and diorite porphyry. Included in the last is the peculiar rock which occurs in the Ramshorn mine and which is designated an augite melaphyre. The several groups will be briefly described.

Granite.—Granite dikes, in places 30 feet wide but generally about 10 feet across, parallel the ore body on the hanging-wall or footwall side in parts of the Lost Packer mine. The rock has been greatly crushed, but the constituent minerals are readily determinable. It is light gray, inequigranular—due to a phenocrystic development of the feldspars—and consists of microcline, orthoclase, quartz, and

[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. 195.

[2] Umpleby, J. B., An old erosion surface in Idaho; its age and value as a datum plane: Jour. Geology, vol. 20, No. 2, 1912, pp. 139-147.

muscovite, decreasingly abundant in the order named. Ferromagnesian constituents are rare.

Granite porphyry.—Granite porphyry, younger than the granite dikes (fig. 4, p. 95), occur in the Lost Packer mine as flat-lying bodies 20 to 40 feet wide. It is a medium-gray rock with phenocrysts and groundmass about equal. The degree of alteration of the specimens studied leaves some doubt as to whether the rock might not better be called a quartz monzonite. Most of the feldspars seem to have an index lower than Canada balsam, but a few are certainly higher. Quartz exceeds biotite and hornblende is rare.

Diorite porphyry.—Several flat-lying dikes of diorite porphyry about 20 feet wide occur in the Lost Packer mine. They are intermediate in age between the granite and granite porphyry. The rock is dark gray, rather mottled by the lighter-gray feldspar crystals. The feldspars are predominantly andesine, though in some of the thin sections labradorite appears and in others oligoclase. Biotite is abundant, though in few specimens conspicuous. Quartz and apatite are the principal accessory minerals. Locally, as in No. 3 tunnel, marginal phases of the rock contain a large amount of augite.

The small dike that is cut about 200 feet from the face of the lowest Ramshorn tunnel differs from the others in that augite, its only recognized mineral, studs a groundmass itself containing much augite. A few other phenocrysts, now completely altered—largely to calcite—were probably feldspars.

AGE OF THE DIKES.

All the dikes above described are cut by the Eocene erosion surface. On the other hand the granite dikes are probably almost contemporaneous with the granitic batholiths; if there is any difference in age, they are a little younger. The other dikes are still younger than these. As the granitic rocks are assigned to the late Cretaceous or early Eocene the dikes are thus believed to have entered during the early part of the Eocene epoch. It further follows that they entered in fairly rapid succession, the sequence being granite, diorite porphyry, granite porphyry.

MIOCENE VOLCANIC ROCKS.

DISTRIBUTION AND CHARACTER.

Lavas and tuffs extend as a broad belt northeast through the central part of the area covered by this reconnaissance. They fill completely an Oligocene erosion valley which, where traversed by the road to Ivers, is 12 miles wide and about 3,000 feet deep. Lavas and tuffs also form broad areas in the northeastern and eastern parts of the Bay Horse district. Here also they occupy erosion valleys, but in no place were they seen to reach the level of the Eocene surface.

The general sequence of volcanic rocks seems to be andesites and latites, followed by andesitic and rhyolitic tuffs, and these in turn followed by basalts. In the western part of the Yankee Fork district the series is chiefly tuff, but east of Custer lava flows appear in the canyon sides through a vertical range of several hundred feet. The extrusive rock above the Lost Packer mine is quartz latite, and that near the lower end of the Loon Creek placers is andesite. About Challis and east of Bay Horse both lavas and tuffs are abundant, and in them the major sequence is from lavas, presumably andesites, to tuffs. East of Bay Horse, however, basalt dikes cut the tuffaceous material and locally spread out as flows on its upper surface.

The dearth of rhyolites in this area is in striking contrast to the great amount of this rock which appears about Parker Mountain, in Lemhi County.[1] The two areas are said to be continuous, yet the prevailing type of rock is very different. In each locality 2,000 feet or more of the series is exposed. About Salmon, still farther north, however, andesites are abundant,[1] and this area also is believed to be continuous with that at Parker Mountain. The several rocks will be described briefly.

ANDESITES AND LATITES.

Latite was not recognized from microscopic examination, but one specimen, thought from the thin section to be a dacite, proved on partial analysis to contain 3.26 per cent of potassium oxide, and another, which appeared to be a normal andesite, was found to contain 3.86 per cent of potassium oxide. (See p. 26.) In these specimens, the only ones analyzed, the potash is evidently in the groundmass, which leads to the belief that many of the rocks herein described as andesites will prove, on chemical analysis, to be latites. Thus the two groups are described jointly.

The rocks range in color from dark gray through various shades of purple to bluish black, perhaps a brownish-gray variety being most abundant. Phenocrysts and groundmass comprise about equal areas. The minerals of the groundmass are determinable in but few specimens. Among the phenocrysts feldspar predominates, though some ferromagnesian mineral is generally conspicuous. The feldspars are commonly oligoclase and andesine, but a few crystals of labradorite are present. In a specimen taken near Jensen's bridge, in the Bay Horse district, hypersthene, biotite, and augite occur with andesine. A rock from the mouth of Jordan Creek contains much pyroxene and a little olivine. In another specimen, obtained near the

[1] Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: Bull. U. S. Geol. Survey No. 528, 1913, p. 47.

Badger mine, augite is abundant. A dark-gray rock at the head of Bay Horse Canyon contains conspicuous amounts of biotite and hornblende. Partial analyses of two of the rocks included in this group appear below:

Partial analyses of volcanic rocks from northwestern Custer County, Idaho.

[R. C. Wells, analyst.]

	1	2	3
SiO_2	60.58	64.20	80.47
CaO	4.31	3.99	.14
Na_2O	3.86	3.40	.16
K_2O	3.86	3.26	3.80

1. Latite, taken from roadside 1 mile below Sunbeam. Phenocrysts><microcrystalline groundmass. Feldspar $Ab_{75}An_{25}$. A little augite as small anhedral crystals. Biotite and magnetite accessory. Calcite and iron oxide secondary.
2. Quartz latite, taken above Lost Packer mine. Phenocrysts<cryptocrystalline groundmass. Feldspar about $Ab_{70}An_{30}$. Scattered grains of quartz and less biotite. Chlorite, calcite, and iron oxide secondary.
3. Rhyolitic tuff, taken on west slope, 200 feet below Loon Creek Summit, at roadside. Very fine grained, fragmental, mostly glass. A few feldspar grains, all with higher index of refraction than Canada balsam.

TUFFS.

The tuffs of the area are fine-grained rocks of dull-white to reddish color and generally form steep chalky white slopes. They are well exposed on the west face of Estes Mountain, where for several hundred feet below its summit vegetation is meager. In the Yankee Fork district the tuffs are commonly massive, but about Challis they are thin bedded and interstratified with seams of clay that are again referred to in connection with the lacustrine deposits.

The tuffs are commonly fine grained and composed of angular fragments of glass, quartz, and feldspar, together with a few needles of hornblende and scales of biotite. The feldspar grains are commonly striated and have an index of refraction higher than Canada balsam, but the only specimen submitted for partial analysis contains 3.80 per cent of potash and less than 1 per cent each of soda and lime. It is clearly a rhyolitic tuff. That some of the tuff, however, is andesitic or at least latitic is shown by the abundance of the striated feldspar fragments. The tuffs near Challis have been described petrographically by A. A. Julien.[1]

AGE OF THE LAVAS AND TUFFS.

The lavas and tuffs of northwest Custer County are assigned to the Miocene for the following reasons: They occupy valleys developed after the elevation of the Eocene erosion surface. If the Oligocene be allowed for the development of these valleys the lavas and tuffs are post-Oligocene. On the other hand, glacial ice occupied the

[1] Volcanic tuffs of Challis, Idaho: Trans. New York Acad. Sci., vol. 1, 1882, pp. 49–53.

upper parts of the valleys carved in the volcanic rocks. Some of these preglacial valleys, as Yankee Fork and Jordan Creek, are 3,000 feet or more deep. It therefore seems probable that much of Pliocene time was consumed in their development.

MIOCENE LACUSTRINE DEPOSITS.

Distribution.—Lacustrine deposits occur in the northeastern and eastern portions of the area studied. The northern area comprises an irregular belt about 10 miles across, with tongues reaching up the several valleys tributary to the basin in which Challis is situated. To the south, west, and north the lake beds give way to lava flows, but to the southeast they connect across a low divide at the head of Antelope Valley, with similar deposits in the valley of Big Lost River. The area east of Bay Horse is of peculiar shape, but seems to have an outward continuation south of Antelope Ridge.

Character.—Perhaps the best exposures of these beds are along the east bank of Salmon River below Challis. Here the bluffs are about 200 feet high, and as seen from across the river are made up of light gray sandstones, probably tuffaceous, and dove-colored shales. Conglomeratic members are sparsely and irregularly distributed through the section. The beds vary in thickness from less than an inch to several feet. In bluffs north of Challis tuffaceous material, generally very fine grained and of green, gray, and white color, predominates. It is nicely bedded, in places thinly laminated.

The hurried observations afforded little idea of the thickness of the deposits, although it must unquestionably be hundreds of feet.

Age.—Fossils were not found in this area, but the topographic relation of these beds is similar to those at Salmon, which were assigned to the Miocene on floral evidence.[1]

PLEISTOCENE DEPOSITS.

Morainic material.—The highland parts of the area in most places are covered by loose unsorted rock material, locally overlying distinctly striated rock surfaces. The innumerable valleys and canyons which head at elevations greater than 7,500 or 8,000 feet are terminated by cirques, widely different in size and many of them occupied by small lakes. Below these the canyons are U-shaped, strewn unequally with detrital material, and in many places followed by low hummocky ridges roughly parallel to the base of the walls. Deposits of this sort extend down the larger valleys to elevations of about 7,000 feet, rarely to 6,500 feet, as in Bay Horse Canyon.

These several features clearly indicate glacial action. The ice probably covered all the areas above 8,000 feet and attained the lower levels only in the form of alpine glaciers.

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[1] Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: Bull. U. S. Geol. Survey No. 528, 1913, pp. 38–39.

Outwash material.—The valleys of Yankee Fork from Custer to Salmon River and of Loon Creek, at least from Cottonwood Creek headward for 10 or 12 miles, are filled to a maximum known depth of 90 feet (see p. 80) with roughly sorted rounded to subangular material derived from the adjacent highlands. These deposits indicate a change from conditions of erosion, as shown by the existence of the valleys which they occupy, to conditions of deposition; there was a transition from degradation to aggradation. Such a change may take place conceivably in many ways, but the essential factor must be either a decrease in stream velocity or an excess of available material. The presence of the deposits in great valleys developed within areas of Miocene lavas shows that the deposits are Pliocene or later.

Erosion preceded the formation of the deposits and erosion is now removing them, hence it is reasonable to look to the Pleistocene, a period of special climatic conditions, for an explanation of their presence. At this time glacial ice operating on the highlands and within the upper parts of the valleys was loosening and grinding up vast quantities of material, some of which has not yet been removed. During the general period of ice advance much of this was covered by the ice and protected, although even then vast amounts of material were doubtless available for transportation. Not, however, until the general period of ice recession commenced did the supply of available material reach its maximum, and at this time, also, the run-off from the glacier areas was greatest, and the streams fully loaded in their upper, swifter portions, must have deposited their load farther downstream, where the gradient was less. It is therefore believed that the great gravel deposits of Loon Creek and Yankee Fork valleys are of late Pleistocene age.

RÉSUMÉ OF GEOLOGIC HISTORY.

The earlier geologic history of northwestern Custer County, Idaho, comprises a record of long-continued sedimentation, followed by strong regional metamorphism and erosion in the pre-Cambrian. In the Paleozoic, again, sedimentation was the dominant feature, and some time after its close great dynamic movements developed folds whose limbs now commonly dip about 45° away from general north-south axes. In so far as the record is legible, erosion was the dominant feature during the Mesozoic, but near its close great batholithic intrusions entered beneath the area. Their invasion is believed to have been expressed at the surface by a pronounced elevation, which during the Eocene was planed well toward the base-level of erosion.

The Eocene surface of gentle topographic forms was soon elevated 7,000 or 8,000 feet, and deep valleys developed by the close of the Oligocene. During the Miocene, volcanic activity was rife; vast quantities of lavas and tuffs filled the larger valleys, some of them more than 3,000 feet deep. Incident to the lava eruptions many of the streams were impounded, and lakes corresponding in shape to former valleys ramified among the mountains. In these lakes muds, sands, and volcanic ash accumulated to great depths during Miocene time. During the Pliocene epoch erosion once more became dominant, but accompanying it were the dying stages of the volcanic activity which characterized the Miocene. The Pleistocene was an epoch when destruction of the highlands exceeded erosion along the main arteries. Glacial ice covered the summits and occupied the heads of canyons. More material was supplied than could be carried onward by the larger streams, which along their lower courses deposited vast beds of gravels, ready for removal when conditions of erosion once more became normal.

The deposition of metallic ores followed both the late Cretaceous or early Eocene and the Miocene igneous activity. The former resulted in gold-copper, silver-copper, and lead-silver deposits; the latter in gold-silver veins.

ORE DEPOSITS.

GENERAL FEATURES.

Character of the deposits.—The ore deposits of northwest Custer County comprise gold placers and lodes carrying gold-silver, gold-copper, silver-copper, and lead-silver ores. The first, second, and third types of lodes are typically fissure fillings, but the fourth might equally well be considered of replacement origin, the solutions, however, directed largely by fissures. Thus they are all characteristically of tabular outline.

In most of the deposits the ore is of excellent grade, little of that which has been mined affording a return of less than $30 to the ton and some of it $500 or $600. Perhaps most of the production of the area has come from ores worth $50 to $100 to the ton.

The gold-silver deposits are characterized by a highly siliceous gangue; the others by a siderite gangue. The former also present much more intense metasomatic alteration of the wall rock than the others.

Periods of mineralization.—Two distinct periods of mineralization are recognized. These periods were separated by a long interval in which the area was reduced to gentle topographic forms, elevated several thousand feet, further dissected, and many of the valleys filled or partly filled with volcanic material. The deposits of the two periods are distinct in character and their age relations so clearly determinable that in the following sections age is taken as the basis of major classification, and the deposits are grouped as pre-Oligocene and post-Oligocene. Great difference in age with profound erosion intervening shows that the older deposits must have been formed at vastly greater depth than the younger, a fact thought to account for conspicuous differences in the structure of the ores and probably also in the mineralogy of the two groups of deposits.

Distribution.—Ore deposits are widely distributed in the northwestern part of Custer County. In the Loon Creek district they are largely grouped around Ivers, near which town gold placers, gold-copper veins, and lead-silver veins are recognized. In the Yankee Fork district the old mining towns of Custer, Bonanza, and Sunbeam are each centrally situated with respect to gold-silver veins. Near Bonanza gold placers occur. In the Bay Horse district the deposits are more widely distributed, but here Bay Horse, Clayton, Squaw Creek, and Slate Creek may be taken as centrally situated with reference either to silver-copper or lead-silver deposits.

Little is known of the country intermediate between these widely separated localities. In the early days much of it was run over by the prospector, but there is little evidence in the way of prospect pits to show that it was seriously examined. Many outlying deposits may yet be discovered.

Geologic relations.—The oldest rocks known to be exposed in the area are Algonkian schists, slates, and quartzites, widely distributed in the south-central and northwestern portions. These rocks are overlain unconformably by a great series, more than 9,000 feet thick, of quartzites, dolomitic limestones, and slates, of Paleozoic age. These are most widely exposed in the Bay Horse district, but are also present south of Ivers in the Loon Creek district. The next younger rocks are the batholithic intrusions which are assigned to the late Cretaceous or early Eocene. These appear at the surface as an area of quartz diorite near Ivers; an area of quartz monzonite between Ivers and Sunbeam; a broad expanse of granite about the mouth of Yankee Fork and a smaller mass near the head of Bay Horse Canyon; and two small areas of diorite, both near Clayton. The boundaries of the several intrusions are not indicated completely on the map, but in general terms these types may be considered to form the surface rock over about 10 per cent of the area.

Closely related to the batholithic intrusions are the granite, granite porphyry, and diorite porphyry dikes, which are numerous only in the vicinity of Ivers.

The youngest rocks in the area, exclusive of glacial débris, are tuffs, lavas, and lacustrine deposits of Miocene and possibly in part Pliocene age. The largest area of these extends northeast-southwest through Yankee Fork district. Here an old valley, some 10 miles wide and 3,000 feet deep, is filled with latites, andesites, and tuffs, the latter locally nicely stratified. In the east-central and northeastern parts of the area are other widespread deposits of this age, but in these localities clastic material is of equal abundance with the tuffs and lavas.

Deposits of ore occur in all the groups of rocks above mentioned. The late Tertiary eruptives inclose the gold-silver veins of the Yankee Fork district. Granite is the inclosing rock of part of the lead-silver deposits south of Ivers. Formations of Paleozoic age inclose the lead-silver and silver-copper deposits near Clayton and Bay Horse. Algonkian schists constitute the country rock for the gold-copper deposits and may also inclose the lead-silver veins of the Livingston group.

PRE-OLIGOCENE ORE DEPOSITS.

CLASSIFICATION.

The pre-Oligocene metalliferous deposits of northwestern Custer County may most advantageously be classified, according to the principal metals which they contain, as silver-copper, lead-silver, and gold-copper deposits. The three types have much in common and mineralogic gradations between them occur locally, but as groups they are exceptionally well characterized by their leading metals. The features which they have in common are (1) a siderite gangue; (2) similar paragenesis, the general order being iron carbonate followed by quartz, the metallic sulphides, and sulphantimonites; (3) subordinate metasomatic alteration of the wall rock when compared with the post-Oligocene deposits; and (4) a close accordance with one another in age.

The kind of inclosing rock may also be taken as the basis for classification, but this only separates, and that incompletely, the lead-silver deposits from the others. Such a classification comprises (1) deposits inclosed in calcareous and dolomitic rocks, and (2) those inclosed in slates and schists. The first includes the lead-silver deposits, the second those carrying silver-copper and gold-copper ores. The classification according to metals contained is followed in the later discussion.

SILVER-COPPER DEPOSITS.

DISTRIBUTION AND HISTORY.

Deposits of silver-copper ore have been found only in the Bay Horse district, where the two most important mines—the Ramshorn and Skylark—produce ores of this kind. In addition to these mines the lodes of the New Silver Bell mine, one of the Hoosier veins, and some small deposits near the head of Garden Creek are of this type.

The Ramshorn vein, located in August, 1877, was the first deposit of this type recognized in Custer County. A short time thereafter the Skylark and Silver Bell were staked and for 20 years following these and the Ramshorn were active producers. Although during recent years but little ore of this type has been mined, there is more of it blocked out in the area than of any other type. In all about $6,250,000 has been derived from this ore; approximately $625,000 from copper, the balance from silver.

GEOLOGIC RELATIONS.

All the silver-copper deposits are inclosed in slates, probably of Paleozoic age, whose cleavage, forming high angles with the bedding planes, is commonly well developed and locally is more conspicuous than the bedding structure.

Granite outcrops a few hundred feet west of the Skylark and Ramshorn veins, but no igneous rock was noted in the immediate vicinity of the Silver Bell deposits.

FORM AND STRUCTURE OF THE DEPOSITS.

The silver-copper ores occur in tabular deposits which range in width from a few inches to 4 feet, averaging perhaps 20 inches. They are bounded by well-defined walls and the few offshoots follow bedding or joint planes. Their general strike is north-south and the dip either to the east or to the west. The dip of the veins is largely determined by lines of parting which antedate the period of fissuring. The Ramshorn vein follows the slaty cleavage of the inclosing rocks; the Skylark occurs along a bedding plane; but the New Silver Bell is independent of either cleavage or bedding planes, the fissuring here cutting across the flat-lying beds at a low angle in the upper part and a considerable angle in the lower part. (See Pl. VI.)

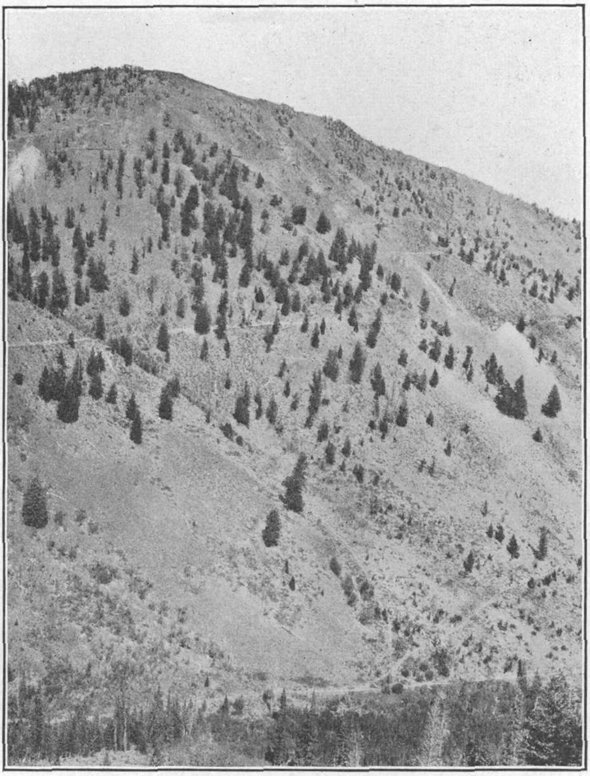
THE ORES.

PAY SHOOTS.

Within the veins the ore occurs in shoots of irregular shape which range in length from 15 or 20 to 200 or 300 feet, and in width from a few inches to 4 feet, averaging perhaps 20 inches. The vertical extent of the shoots generally exceeds the horizontal and in many places, as in the Skylark mine, the shoots are distributed one above the other along roughly parallel lines. The portion of the fissures intermediate between the shoots is locally filled with gangue or gouge, equal in width to the ore, but in most such places the walls are close together and only a narrow selvage marks the fissure.

MINERALS.

Relative abundance.—The ore is characterized by tetrahedrite in a siderite gangue. Associated with these minerals, but in very subordinate amounts, are quartz, chalcopyrite, galena, arsenopyrite, pyrite, and sphalerite. Within the deposits as now worked secondary minerals are negligible, although in the upper levels cerargyrite was present in large amounts. It is said that there, too, lead was much more abundant than in the present ore.

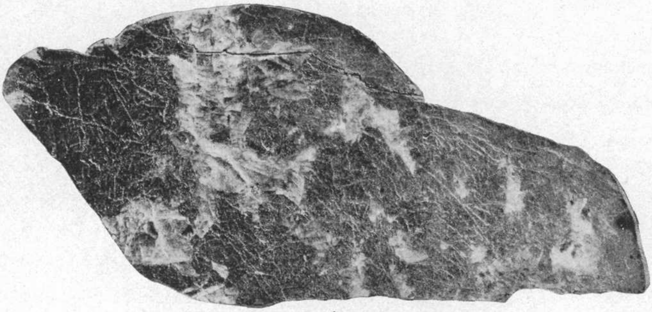


A. RAMSHORN AND SKYLARK MINES, BAY HORSE DISTRICT.

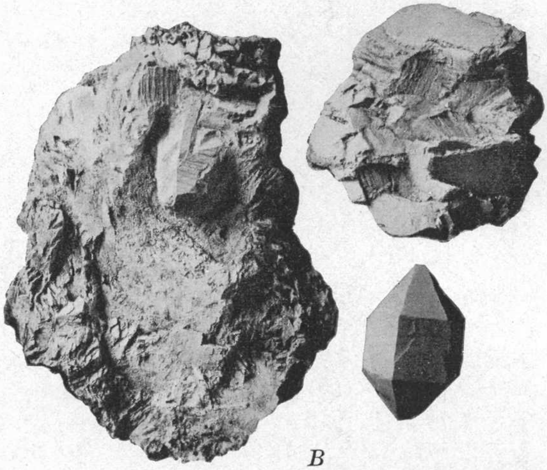
The strike of the Ramshorn vein is shown by the series of dumps on the right. The Skylark dumps are shown at the left, in the upper part of the view.

B. DETAIL OF STRUCTURE NEAR THE RAMSHORN AND SKYLARK MINES.

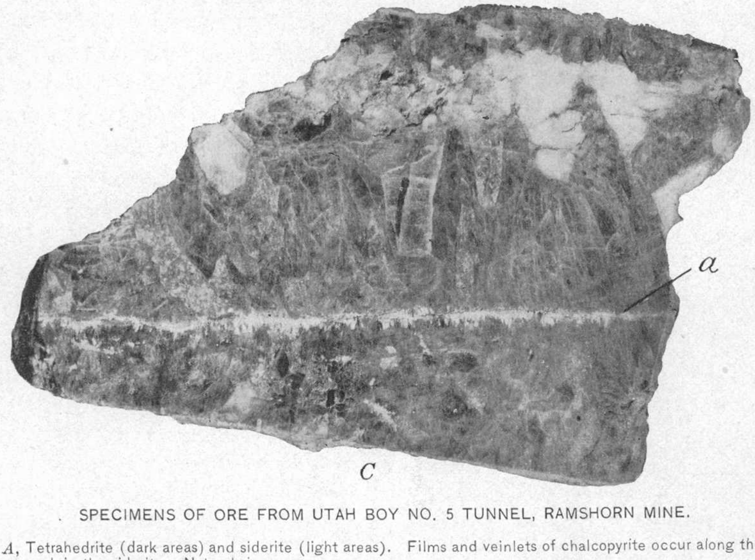
Showing slaty cleavage followed by the Ramshorn vein and bedding planes followed by the Skylark vein.



A



B



C

SPECIMENS OF ORE FROM UTAH BOY NO. 5 TUNNEL, RAMSHORN MINE.

A, Tetrahedrite (dark areas) and siderite (light areas). Films and veinlets of chalcopyrite occur along the crack in the siderite. Natural size.
B, Euhedral crystals of quartz in nicely crystallized siderite. Natural size.
C, Along the fracture (*a*) is a veinlet of arsenopyrite with columnar crystals replacing the inclosing siderite. Near the top is quartz intergrown with the siderite. Natural size.

In addition to the minerals which are confined to the fissures, the vein solutions have developed certain others in the inclosing rock. Among the minerals here formed sericite alone is abundant, but as it characterizes the slates well removed from the fissures, the extent to which it is due to the ore-bearing solutions is difficult to determine. Perhaps the best basis for comparison is the state of preservation of minerals other than sericite which were developed by the earlier metamorphism. Of these an andalusite-like mineral [1] is excellently preserved in the slates well removed from the fissures, but near them this mineral is completely altered to sericite and calcite. Thus in thin sections taken near the vein sericite of two generations is thought to be present; the earlier resulted from regional metamorphism, the later represents metasomatic alteration by vein solutions. Accompanying the sericite are numerous small opaque specks which in reflected light are dull gray. They were not identified.

Paragenesis of the vein minerals.—The sequence of formation of the more abundant vein minerals is rather definite, but among the accessory minerals the order is recurrent. Siderite is clearly the earliest mineral formed. It was closely followed by tetrahedrite, which occurs along fractures in the siderite and occupies embayments in it, but in a few places the two are so intergrown as to suggest contemporaneous deposition. Arsenopyrite bears the same relation to siderite as does tetrahedrite, but their relation to each other is not known. Quartz occurs both as massive intergrowths with the siderite and tetrahedrite and as doubly terminated prisms either occupying small cavities in the tetrahedrite or embedded in the siderite. Chalcopyrite occurs principally as narrow films along fractures and as tetrahedrons lining cavities in the tetrahedrite, but locally seems to be intergrown with that mineral. In many places a narrow band of chalcopyrite separates the tetrahedrite from the siderite. Galena is found as isolated grains in the tetrahedrite but most commonly occurs as bunches partly filling cavities an inch or more across. Pyrite is extremely rare, but a few crystals were noted embedded in the siderite. In such places it was formed later than the tetrahedrite, but before the chalcopyrite, the latter mineral in some specimens coating it. Upon some of the free faces of the galena are small crystals of sphalerite so thickly spaced as to form a drusy surface. They appear to be entirely superficial, for in no place were they seen to extend into the galena. Also among the last minerals to form are small lamellar crystals of siderite, which protrude from the sides of small cavities along the margins of siderite areas. (See Pl. VII.)

Thus the general sequence of deposition was from carbonate to sulphantimonite to sulphides, the order of formation of the sulphides

[1] The index of refraction is 1.62±, whereas andalusite (mean) is 1.638. A few sections also give an inclined extinction up to 11°.

being iron-copper, lead, and zinc. It is noteworthy that pyrite is rare in the deposits, but arsenopyrite is very generally present, though nowhere abundant.

Composition of the tetrahedrite.—Tetrahedrite, commonly known as gray copper ore, is a sulphantimonite of copper in which the copper is commonly replaced in part by iron, zinc, lead, mercury, silver, manganese, nickel, and the antimony by arsenic and bismuth. It is widely distributed in metalliferous deposits but is usually an accessory constituent. Perhaps the largest deposits in the United States heretofore described are those of the Sheba and De Soto mines in Humboldt County, Nev. Here, however, the principal ore mineral was jamesonite.[1] Tetrahedrite is also found at many localities in Colorado, Mexico, Bolivia, and Chile, and in numerous deposits in Europe.[2] So far as the writer has been able to ascertain, however, no locality has been described which has produced an amount even comparable to the $6,250,000 derived from the three deposits of this mineral in the Bay Horse district. Of this amount $3,000,000 came from the Ramshorn mine, in which a large tonnage yet remains.

The tetrahedrite here found is dark gray with splendent luster on fresh fracture and metallic luster after moderate exposure. It is massive in its occurrence; in no specimen was a crystal face seen. Numerous fairly smooth planes appear on the specimens, but the arrangement of these is such as to indicate fracturing instead of cleavage. Locally such faces are doubtless due to juxtaposition with siderite.

A complete analysis of the tetrahedrite from Utah Boy No. 5 level, Ramshorn mine, was made in the Survey laboratory by R. C. Wells. The material was carefully selected to preclude chalcopyrite, the only mineral likely to be intermixed with it. The analysis follows:

Analysis of tetrahedrite from Ramshorn mine, Custer County, Idaho.

[R. C. Wells, analyst.]

Gangue	0.08
Sulphur	25.74
Silver	4.86
Bismuth	.34
Arsenic	1.46
Antimony	25.22
Copper	33.39
Iron	4.64
Zinc	3.53
Manganese	.01
Nickel	tr.
	99.27

[1] Ransome, F. L., Notes on some mining districts in Humboldt County, Nev.: Bull. U. S. Geol. Survey No. 414, 1909, p. 43.

[2] For a list of localities and numerous analyses, see Hintze, Carl, Handbuch der Mineralogie, vol. 1, 1902, pp. 1082–1120.

If the analysis is calculated in molecular quantities the following proportions result: Sb(Bi,As), 1; Cu (all other metals), 3.03; S, 3.48. The theoretical proportions for tetrahedrite are 1.3.3, but a study of available analyses [1] shows that sulphur is commonly in excess. In this tetrahedrite, however, the excess is greater than in any of the analyses which have been examined. Chalcopyrite is the only mineral which, from metallographic studies, can reasonably be assumed to be present as an impurity, but to calculate the excess sulphur as that mineral uses up all the iron in addition to an equal number of copper molecules, and thus reduces, beyond reason, the molecular value of the copper component. From these calculations it is concluded that the analysis was of essentially pure tetrahedrite and that the excess of sulphur, if significant, may be in solid solution or possibly combined as a higher sulphide of one or more of the metals.

Vertical distribution of minerals.—Throughout the workings now safely accessible there is no appreciable difference in the mineralogic association with depth from the surface. The lowest level of the Ramshorn mine is 1,650 feet vertically below the apex of the vein. From the lowest tunnel up to the Utah Boy No. 3, a vertical distance of about 900 feet, the tunnels were explored; above are abandoned stopes. In this lower half of the mine the relative amount of the several minerals, so far as observed, is constant. Of the mineralogic make-up of the ore from the old workings there is no available record. A brief note on the Ramshorn deposit when only two tunnels had been driven [2] states that the better grade of ore ran 500 ounces in silver per ton and 16 per cent of lead, no mention being made of copper. This probably means an abundance of cerargyrite and sand carbonate near the outcrop, but whether that part of the vein once contained copper as well as lead can not be determined from such a statement, for the copper, if formerly present, would readily have been leached during the formation of cerargyrite and sand carbonate. A zone of secondary chalcocite below the oxidized ore would support the opinion of the writer that tetrahedrite once extended up to and beyond the level of the present surface. No information was procured concerning the mineralogy of the zone between the oxidized ore and the primary ore now exposed. It is said, however, that most of the production has come from ores similar to those now developed.

AGE AND GENESIS.

The three principal silver-copper deposits are truncated by the Eocene erosion surface and hence were formed at least before the close of the Eocene. On the other hand, they have much in common with

[1] Kretschmer, A., Analyse und chemische Zusammensetzung der Fahlerze: Zeitschr. Kryst. Min., vol. 48, No. 5, 1910, pp. 484–513.

[2] News note, Min. and Sci. Press, Oct. 2, 1880, p. 220.

the lead-silver deposits and are thought to have been deposited during the same period of mineralization. As in the Loon Creek district some of the lead-silver veins are inclosed in granite, it is probably safe to assume that the silver-copper deposits are postgranitic even though the youngest rock inclosing them is of Paleozoic age. The granite is pretty surely of late Cretaceous or early Eocene age, hence these deposits are believed to date from the late Cretaceous or early Eocene. This assignment is compatible with the age of deposits in Idaho of similar type though somewhat different mineralogically, which have been described elsewhere.

The depth at which the deposits were formed can not be definitely determined, but it is certain that a vast amount of erosion has taken place since their deposition. In the development of the Eocene erosion surface several thousand feet of beds must have been removed; a conclusion which follows from a study of the anticlinal structures truncated. Another line of suggestion is based on the belief (p. 24) that the granitic intrusions accompanied the profound elevation of the surface which inaugurated the rapid erosion of the Eocene epoch. The cover was entirely removed from the batholiths over broad areas and the igneous rock itself deeply planated. Still another line of attack is based on the accumulation of great fluviatile deposits in adjacent areas during the Eocene. The region must at that time have been sufficiently elevated for the efficiency of the streams in transporting sediments to be far greater within the area than beyond it. From these several lines of evidence it is believed that 5,000 feet may be taken as a safe minimum estimate of the amount of Eocene erosion. Thus the highest deposits are thought to have been formed at a depth of at least 5,000 feet, probably much deeper, and the lowest ones at a depth 3,000 feet greater. These figures correspond closely to those thought by Ransome [1] to be applicable at Cœur d'Alene.

The temperature at which the deposits formed can not be known even approximately, although the normal temperature gradient for increasing depth below the earth's surface places a minimum of about 100° C. for a depth of 8,000 feet. The proximity of the cooling granitic mass which now outcrops within 600 feet of the deposits must have raised this temperature greatly. Therefore, in any consideration of genesis high temperature and, because of the depth, high pressure must be assumed.

There is abundant reason for believing that the deposits were formed from solution. The two other possibilities, namely, volatilization and a melt, are ruled out by the mineral compounds of the deposits. The carbonate gangue is incompatible with the conception of a melt,

[1] Ransome, F. L., and Calkins, P. C., The geology and ore deposits of the Cœur d'Alene district, Idaho: Prof. Paper U. S. Geol. Survey No. 62, 1908, pp. 139-140.

and the difficulty of volatilization of the metals in the right proportions, even when combined, eliminates the other hypothesis.

The most striking feature of the deposits is the great quantity of tetrahedrite, a mineral remarkable for the complexity of its composition. It is thought that this must have a marked significance with respect to the genesis of the deposits. R. C. Wells, who made the analysis (p. 34) of this mineral, has supplied the following comment on the conditions of formation of tetrahedrite from aqueous solutions.

The conception that tetrahedrite forms from simple aqueous solutions is unsatisfactory for several reasons. In the first place, the sulphides are among the most insoluble compounds known in chemistry and tetrahedrite commonly contains lead and silver, whose suplhides are among the most insoluble of sulphides.[1] Secondly, it would be remarkable if such a process did not result in greater differentiation into single sulphides; for if the solutions were acid the precipitation of zinc and iron would be retarded, whereas if they were alkaline the deposition of antimony and arsenic would be prevented. In neutral solutions fractionation should still occur.[2] These are the behaviors under ordinary conditions, and it seems reasonable to suppose that they would persist to some extent even under high pressure, although by a mass effect of much hydrogen sulphide under pressure all the sulphides could probably be produced under any condition of acidity or alkalinity.

As a sulphide dissolving into pure water would be hydrolyzed into metallic hydroxide and hydrogen sulphide, it is obvious that a large excess of hydrogen sulphide would be required to prevent this hydrolysis and maintain a suitable concentration of sulphide in the solution to reprecipitate the sulphide at another point. Similarly, with the concentrations of metallic ions. It is conceivable that a particular concentration of copper and antimony, and of all the other bases as well as the sulphide, might be in equilibrium with tetrahedrite and by cooling deposit it from solution. For this to occur I should hazard the guess that the metals in solution would be in the following order, beginning with that of the highest concentration: Iron, zinc, arsenic, antimony, copper, silver. This guess is made upon the principle that the concentrations should be in inverse order to the solubilities. However, our knowledge of these matters, particularly about the conditions of the precipitation of compound sulphides, is so scant that further speculation might not even be suggestive.

The solvent usually assumed for carrying these sulphides is sodium or potassium sulphide. Becker[3] showed that mercuric sulphide, pyrite, cupric sulphide, and zinc sulphide are soluble in differing degrees in sodium sulphide solution. He concluded, however, that "the sulphides of lead and silver seem to be entirely insoluble in sodic sulphide, sodic sulphydrate, or in solutions of sodic carbonate partially saturated with sulphydric acid." He obtained no evidence of solution with these sulphides even when heated above 100° with reagents in closed tubes. As silver is an important constituent of the Bay Horse tetrahedrite, this would indicate that it was not carried in sodium sulphide solutions unless antimony, copper, or some soluble salts affect the solubility of the silver. I have been unable to find any marked solubility of silver sulphide in sodium sulphantimonite. Ditte[4] has shown that silver sulphide in contact with potassium sulphide solution forms a very slightly soluble compound of red color, possibly of the composition $4Ag_2S.K_2S.2H_2O$. This compound is decomposed by excess of water. A double salt with sodium sulphide was obtained by Ditte

[1] Weigel, O., Zeitschr. physikal. Chemie, vol. 58, 1907, p. 293.

[2] Wells, R. C., Econ. Geology, vol. 3, 1910, p. 6.

[3] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: Mon. U. S. Geol. Survey, vol. 13, 1888, p. 430.

[4] Ditte, A., Chem. Rev., vol. 120, 1895, p. 91.

only at a high temperature from a saturated solution of sodium sulphide which at 110° contains about 800 grams of Na_2S. Its formula is given as $3Ag_2S.Na_2S.2H_2O$. It is decomposed by excess of water.

Hence silver sulphide is soluble in concentrated potassium or sodium sulphide solutions but practically insoluble in dilute solutions of the alkalies.

In view of these facts it appears that the transfer of tetrahedrite could not be accomplished by dilute solutions of alkaline sulphides much more advantageously than by solutions of any other salts, although if the solutions were concentrated it might be carried.

Two factors which seem to have a bearing on the nature of the mineral-bearing solutions are, first, the development of sericite, a potash-rich mineral, in the walls, and second, the presence of an excess of sulphur in the tetrahedrite. This would seem to justify an opinion that potassium sulphide was a constituent of the mineralizing solutions, and from Wells's discussion of the chemistry involved that it was very possibly the solvent of the tetrahedrite.

The source of the solutions is even more difficult of determination than their nature. If potassium sulphide was the solvent it could have been efficient only at high temperatures, as indicated by Ditte's experiments [1]—temperatures probably greater than are normal at a depth of 8,000 feet. It has already been shown from geologic and physiographic evidence that the granite intrusions and the veins are closely related in age, and as special conditions of deposition are necessary to account for the deposits it seems altogether reasonable to assume a genetic relation between the two. Elsewhere in Idaho, notably in the Wood River district [2] and in Lemhi County,[3] a genetic relation to an igneous mass of the same age is indicated by geographic distribution. Thus it is concluded that the silver-copper deposits are genetically related to an outlier of the great granitic batholith of Idaho. The nature of this relation, however, is not susceptible of demonstration. The magma may be thought (1) to have supplied the solutions or (2) to have stimulated the circulation of meteoric waters. The first view is favored by most economic geologists, but to distinguish between the alternatives is a problem on which individual deposits of this type throw but meager light.

LEAD-SILVER DEPOSITS.

DISTRIBUTION AND HISTORY.

Lead-silver deposits have been recognized in the Bay Horse and Loon Creek districts. In the Loon Creek district only two prospects have been opened on this type of ore and neither is extensive, but about Bay Horse and Clayton there are several mines noteworthy

[1] Op. cit.

[2] 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. 217.

[3] Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: Bull. U. S. Geol. Survey No. 528, 1913, p. 51.

for their lead-silver production, important among which are the Red Bird, Excelsior, Beardsley, River View, Pacific, and Cinnabar properties.

The total production from deposits of this type within the area is about $4,000,000, three-fifths of which has been derived from lead and the balance from silver. Since the general slump in local mining, which took place about 1900, the annual production has averaged perhaps $15,000, derived largely from small shipments made by leasers operating on inadequately developed claims.

GEOLOGIC RELATIONS.

The deposits near Bay Horse are inclosed, without exception, in dolomitic limestone and dolomite, but the Red Bird deposit is in part inclosed in dolomitic limestone and in part in calcareous shales. One of the deposits near Ivers is within granite and the other within Algonkian schist, but both are in close proximity to areas of dolomitic limestone. Schist also is said to be the country rock at the Livingston property, near the head of Slate Creek. It is most striking, however, that the lead-silver deposits which have been important producers are all situated within or near areas of dolomitic limestone or dolomite.

Igneous rocks do not occur in their immediate vicinity, although both diorite and granite outcrop within a few miles of the principal mines.

CHARACTER OF THE DEPOSITS.

The lead-silver deposits are commonly tabular in general outline, but in their formation replacement processes have played an important though not a dominant part. Preexisting lines of parting have determined the general shape of the deposits. Thus they follow either fissures, as the Red Bird vein, or bedding planes, as the Pacific deposit, extensions from each being determined by fissures, joints, or bedding planes. In detail, however, some of the deposits are most irregular. In the Beardsley mine, for instance, bunches of ore isolated in the walls, save for narrow stringers connecting them with the main deposit, are common. These bunches of ore range from pieces the size of baseballs to masses 10 or 25 feet across. Also in old stopes, where the walls have been carefully stripped of ore, the surface is in many places exceedingly ragged and characterized by angular protuberances from a few inches to 3 or 4 feet in length, corresponding to which were embayments of ore into the country rock. In contrast to the deposits where such irregularities are common, the Red Bird vein is bounded by rather even walls.

Although all development has been well above the ground-water level of the region, yet in but few of the deposits is oxidation complete or even well advanced. The Red Bird ore is largely oxidized, but elsewhere the primary minerals predominate, most important among them being argentiferous galena and siderite. This is true of all the deposits at Bay Horse, with the possible exception of the Beardsley and Excelsior, in which oxidation, though well advanced, is by no means complete.

THE ORES.

Ore shoots.—Pay shoots, in the strict sense of that term, are not common in the lead-silver deposits. The relative amount of ore and gangue is almost constant from place to place, so that when one gives out the other also is absent. Certain of the ore bodies have proved especially remunerative because of their persistence, and these have commonly been called shoots, important among them being the Potato Patch shoot of the Red Bird mine, and the main Beardsley-Excelsior ore body. The latter ranged from 100 to 200 feet in length and 1 to 20 feet in width; the former was 60 to 80 feet long and 20 to 30 feet wide.

Minerals of the ore.—Mineralogically, the lead-silver ores are simple, the essential primary minerals being argentiferous galena in a quartz-siderite gangue. Associated with the galena is a little tetrahedrite, sphalerite, pyrite, and chalcopyrite. Near the surface in all the deposits, and in the Red Bird mine throughout its known vertical extent of perhaps 900 feet, the ore consists of the oxidation products of these minerals.

The secondary ore is predominantly composed of sand carbonate heavily stained with the oxides of iron and manganese. The sulphate of lead, anglesite, is an intermediate product in the transformation of galena to cerusite, but, though very common, is abundant only locally in the Red Bird mine. Its usual occurrence is as a narrow and poorly defined band between the sulphide and carbonate, easily recognized by its dark color and adamantine luster, thus contrasting with the metallic luster of galena on the one side and with the lighter color of cerusite on the other. Smithsonite occurs as botryoidal surfaces of drusy appearance, lining cavities in the secondary ore. In many places columnar crystals of calamine protrude from such surfaces. Fluorite occurs locally in the Red Bird mine as small bluish-white cubes set on drusy surfaces of smithsonite. Manganese oxide is conspicuous in much of the secondary ore, but its primary equivalent was not recognized. Copper carbonates, though not abundant, are rather uniformly distributed. Iron oxide, derived largely from siderite and subordinately from pyrite and chalcopyrite, is everywhere present in the sand carbonate ores. Of the several elements found in the oxidized ores the mineralogic form of silver alone is doubtful. Minute grains of cerargyrite have been identified, but it can not be said that all the silver is in this form. Minium, the red oxide of lead, was recognized in specimens from the Beardsley ore bins.

A general and probably fairly accurate idea of the composition of these ores may be had from the following smelter returns. The shipments represent roughly hand-sorted material, which, from the range in sulphur, evidently includes both primary and secondary minerals.

Average analyses of 13 shipments of ore from the McGregor group, Bay Horse, Custer County, Idaho.

	Au.	Ag.	Pb.	Cu.	Fe.	Zn.	S.	SiO_2.	Total shipped.
	Ounces.	*Ounces.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Tons.*
Average	0.041	69.90	57.34	1.76	1.29	2.59	4.92	21.17	553
Highest figure	.016	92.5	63.30	3.06	3.16	3.4	7.4	29.5	....
Lowest figure	.075	44.7	47.85	1.80	.58	1.86	.91	15	....

Tenor of the ore.—The lead-silver ores are of excellent grade, perhaps 40 to 60 per cent of lead and 60 to 80 ounces of silver to the ton being the tenor of those most commonly mined in this area. So generally and uniformly is the galena argentiferous that where it is present somewhat more than 1 ounce of silver for every per cent of lead may be assumed with fair safety.

The many problems connected with the alteration of this type of ore—the relative amounts of lead, silver, and zinc near the outcrop compared with the relative amounts below, and the value of the oxidized ore relative to the primary ore—can be elucidated but little as a result of these studies. When the district becomes active, however, it will be an excellent field for special studies on these problems.

AGE AND GENESIS.

The discussion of the age of the silver-copper veins (pp. 35–38) applies equally well to the lead-silver deposits. They are thought to have formed during the late Cretaceous or the early Eocene.

The genesis of the lead-silver deposits also is thought to be similar to that of the silver-copper veins. The two types have many important features in common. In each the formation of siderite characterized the earliest stage of mineralization. This was followed by quartz and the metallic sulphides and sulphantimonites. Both types are rich in silver; both contain lead and copper, although the vastly different amounts of these metals afford the basis for a fairly definite distinction. The Hoosier mine contains two parallel flat-lying veins 60 feet apart, which have the same geologic relations; both are followed by a thick vein of barren quartz, and indeed there is every geologic reason for thinking that they are absolutely contemporaneous in origin, yet one furnishes a distinct lead-silver ore and the other a distinct silver-copper ore.

Two eccentric occurrences which may have considerable genetic significance are related to this type of deposits, and although no attempt is made to interpret them the facts are recorded in this connection. The peculiar veins of massive clear-white quartz, one 10 to 12 feet thick and the other 40 feet thick, which overlie both of the Hoosier veins, form one of these features. They are slightly later than the vein, and, as is suggested (p. 70), it is believed that they followed closely the opening of the spaces which they occupy, or perhaps caused them. The other special feature is the sharp transition of the Red Bird lead-silver ore body into an underlying mass of vuggy pyrite 50 or more feet across, at a point between the seventh and eighth levels of the mine, the only place where it has been crosscut. (See p. 75.)

GOLD-COPPER DEPOSITS.

Deposits characterized by gold-copper ores are recognized only in the Loon Creek district, in the northwestern part of the area studied. Here but one mine, the Lost Packer, has been an important producer of this type of ore, although two or three similar veins are situated in its immediate vicinity.

GEOLOGIC RELATIONS.

The deposits are situated in a mountainous area in which elevations range from 5,000 to more than 9,500 feet. The topographic features are carved from rocks of Algonkian, Paleozoic, late Cretaceous, and early Tertiary ages. The Algonkian comprises mica schists and quartzites which outcrop over an irregular area of about 2 square miles, in the northern part of which the deposits are situated. West of the Algonkian area a vast extent of quartz diorite appears at the surface, and southwest of it outcrop the Paleozoic beds, which consist of quartzites, slates, and dolomitic limestones. A great number of granite, granite porphyry, and diorite porphyry dikes traverse the Algonkian rocks, and extrusions of quartz latite cap the Algonkian in its northern part.

In age the veins are intermediate between the granite and the numerous granite porphyry and diorite porphyry dikes.

CHARACTER OF THE DEPOSITS.

The gold-copper deposits occupy fissures which strike a few degrees east of north and dip about 75° NW. The Lost Packer fissure has been traced from Canyon Creek, at Ivers, north about 3,000 feet to the quartz latite above the mine. South of Canyon Creek it has not been definitely recognized, but several small outcrops may represent its continuation. This fissure has been explored for about 2,000 feet along its strike and 1,000 feet on its dip. It is bounded by well-defined walls which commonly stand 3 to 5 feet apart, the interim being filled with gouge, sheeted wall rock, or ore. The walls present numerous slickensides, but distinct grooves having even an approximately uniform direction do not appear. The gouge also evidences much shearing and gliding between contiguous parts. Important displacement along this fissure, however, is not recorded. Most of the movement clearly antedates the ore and probably determined the channels along which the ore-bearing solutions traveled. In general, the vein material is confined to the fissure, though in a few places bunches of chalcopyrite have been found as far as 20 feet from the main ore bodies. Within the fissure, in most places the ore occurs as a definite band, ranging in width from a few inches to 3 or 4 feet and averaging perhaps 20 or 24 inches. It follows either the footwall or the hanging wall, perhaps being more commonly next to the former.

ORE SHOOTS.

The deposits are further characterized by ore shoots, which lie in the plane of the vein at irregular intervals along its strike. In the Lost Packer mine three are recognized. Intermediate between the shoots the walls are much closer together than elsewhere, although the position of the fissure is always indicated by a band of gouge from 1 inch to 3 or 4 feet thick. The shoots are unequally spaced, but all pitch to the south, thus presenting a decided parallelism (fig. 4, p. 95). The position of these shoots is thought to have been determined by relative movement of the walls sufficient to bring reversed curves opposite each other. This opinion is based on two observations: First, although in any cross section in a shoot both ore and gouge are commonly present, it seems to be true that where the walls are farthest apart the ore is widest, and also that the walls are farther apart within the shoots than at points intermediate between them. Second, the general parallelism of the shoots suggests this origin.

THE ORES.

General character.—The gold-copper ore is essentially auriferous chalcopyrite in a siderite-quartz gangue, the relative importance of the three minerals varying markedly from place to place in the same shoot and especially in the different shoots. The amount of gold associated with the chalcopyrite is exceptionally large, assays of this mineral commonly showing 2 to 3 ounces of gold to the ton. Intergrown with the siderite of the gangue is a little calcite. Pyrite is exceedingly rare, but locally occurs as small grains and cubes within the chalcopyrite. Similar in its occurrence is pyrrhotite, but it is even less abundant. A little barite has been reported by Jennings,[1] but careful search during the present studies failed to reveal this mineral.

[1] Jennings, E. P., The Lost Packer copper-gold lode [Idaho]: Jour. Canadian Min. Inst., vol. 9, 1906, p. 55.

Oxidation products are not quantitatively important in the deposits and disappear entirely within 50 or 75 feet from the surface. Most important among them are oxides of iron and carbonates of copper. Films of bornite and a few of native copper occur locally a few feet beneath the surface.

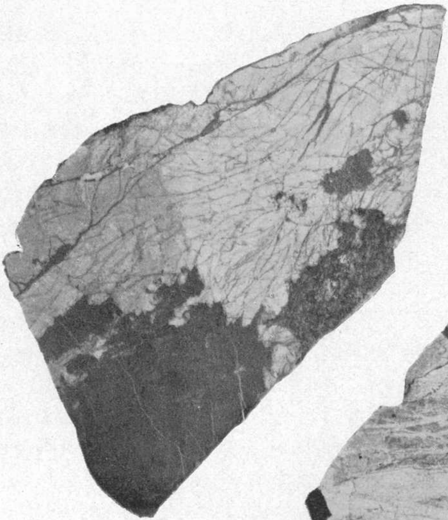
Mineralogy of the different shoots.—The three shoots of the Lost Packer mine, the only developed deposit of this type, contain ores rather distinct from each other in mineralogic composition. The shoots are locally designated the north, south, and middle. Ore from the north shoot consists of coarse-textured milky to bluish white quartz with much chalcopyrite and a little pyrrhotite irregularly scattered through it. On most levels siderite is rare, but on No. 4 it is equally abundant with chalcopyrite and presents the same irregular distribution. The middle shoot, the most productive in the mine, contains ore which consists essentially of chalcopyrite and distributed as bunches, small patches, irregular grains, and interstitial fillings in a gangue of coarse white quartz. Here chalcopyrite constitutes about one-third of the total material mined. Siderite is present but is never an important constituent. The south shoot contrasts with the other two in that siderite is its most abundant mineral. Chalcopyrite is associated with the siderite in such proportions that the ore runs 26 per cent iron and 4½ per cent copper. (See Pl. VIII, *A*.)

Gold is included about equally in the quartz and the chalcopyrite, each containing 2 to 3 ounces to the ton, but less is present in the siderite, assays of this mineral commonly showing about half an ounce to the ton.

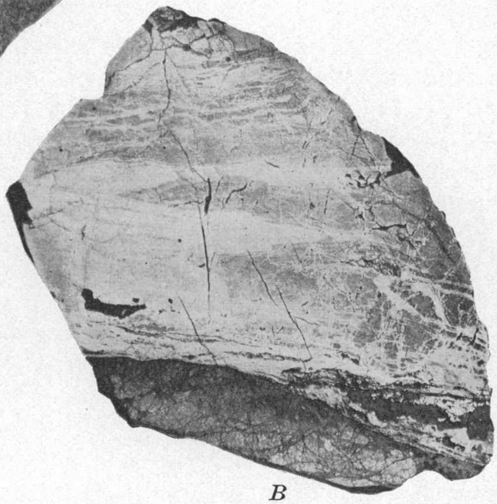
Tenor of the ore.—The ore which has supplied the total production of about half a million dollars, has averaged between $80 and $90 to the ton, but for every ton of this grade which has been encountered in the deposit there is estimated to be 2½ tons which will average $25.

AGE AND GENESIS.

The gold-copper veins outcrop through a vertical range of about 1,600 feet, the highest exposure being but little below the level of the Eocene erosion surface. Within this distance there is no mineralogic change which seems in any way related to depth of deposition. In the deposit, however, are appreciable quantities of pyrrhotite, a mineral believed to indicate deposition at considerable depth—a depth probably exceeding 3,000 or 4,000 feet. It is believed, therefore, that the veins were formed well before the close of the Eocene. On the other hand, the Lost Packer vein cuts across granite dikes which are evidently a phase of the quartz diorite intrusion. Thus the veins are post-quartz diorite. It has been shown (p. 23) that this igneous mass was very probably intruded at about the close of the Cretaceous.



A



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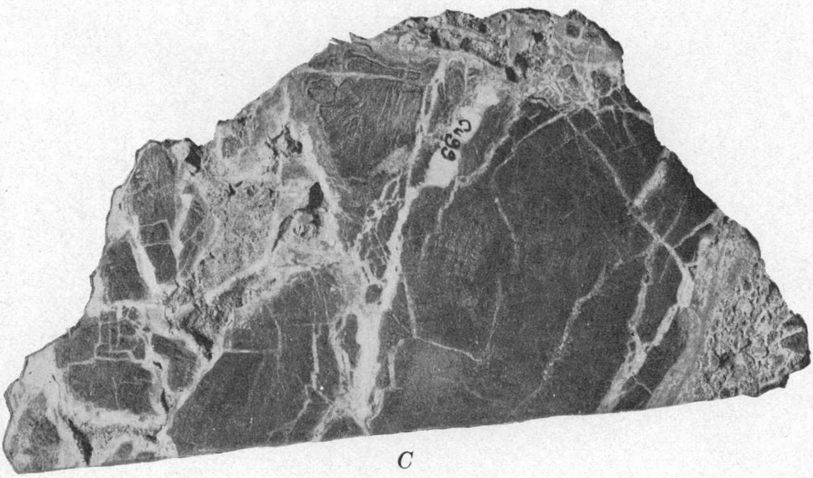

C

SPECIMENS OF ORE.

A, Chalcopyrite (dark) which has replaced siderite. Note the veinlets of chalcopyrite along the fractures in the siderite. Dark mottled area on right middle margin is a fragment of schist. Lost Packer mine. No. 7 level. Natural size.
B, Sheared galena (main mass). The large area at the bottom is siderite. The structure in the galena was brought out by etching for 24 hours in warm dilute acetic acid. From dump of Beardsley mine. Natural size.
C, Fractured galena cemented by quartz. From Forest Rose mine. Natural size.

These veins are therefore believed to have formed during the early part of the great period of erosion which resulted in an Eocene surface of gentle topographic forms (p. 28). Further evidence that they were formed during the early part of this period is afforded by their relation to the granite and granite porphyry dikes. These dike rocks are probably very closely related in age, yet the veins are older than the one and younger than the other.

The genesis of the deposits is not apparent from local evidence, although their close accordance in age with the quartz diorite batholith strongly suggests a genetic relation between the two. Considered broadly, the most significant fact relative to the genesis of ore deposits in general is the almost universal presence of igneous rocks near them. The metallic constituents of some types, such as contact-metamorphic replacement deposits and segregated ores, have been unquestionably derived from the inclosing or near-by igneous rock. Gradations exist between these types and veins, and hence in studies of small areas it is not inappropriate to revert to broad correlations for evidence on genesis.

Granitic rock, one phase of which is represented by the quartz diorite near Ivers, outcrops continuously over more than 20,000 square miles in central Idaho. Surrounding this area are numerous batholiths, reasonably supposed to be outliers. Igneous intrusions, therefore, which must have created very exceptional physical and chemical conditions at about the time the ores were deposited, are present. In places in adjoining regions comparable deposits are definitely distributed along the margins of such intrusions. Thus the deposits at Wood River occur along the borders of a central granitic mass,[1] and those in the Mackinaw district, Lemhi County, are similarly situated.[2]

From the above considerations it is concluded that the quartz diorite intrusion is the direct cause of the formation of the gold-copper veins, and it is believed that it supplied most of their constituents.

POST-OLIGOCENE ORE DEPOSITS.

GOLD-SILVER VEINS.

Veins characterized by gold-silver ores have been found only in the Yankee Fork district, but here they are rather widely distributed. Custer, Bonanza, and Sunbeam have each in the past been centers of important mining operations. The total production of the gold-silver veins is estimated at $12,000,000, about 40 per cent of which has been in gold and the remainder in silver.

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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, pp. 190–230.

[2] Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: Bull. U. S. Geol. Survey No. 528, 1913, p. 152.

GEOLOGIC RELATIONS.

The rock formations in the vicinity of the gold-silver veins include Algonkian schists and quartzites, and Miocene tuffs, latites, andesites, basalts, and rhyolites. The Miocene rocks occupy a great erosion valley about 10 miles wide and 3,000 feet deep, which was developed after the elevation of the Eocene erosion surface. The gold-silver veins are wholly inclosed in these rocks.

METASOMATIC ALTERATION OF THE WALL ROCKS.

Intense metasomatic alteration of the wall rocks adjacent to the fissures is a conspicuous feature of the gold-silver veins. Silicification or sericitization, or both, characterize the rocks for 50 or 100 feet, and in many places for 1,000 feet or more from the deposits. The silicification is most intense next to the veins and gradually gives way to sericitization at a distance of 50 or 100 feet. Well removed from the veins, say beyond 200 feet, chlorite is locally an abundant metasomatic mineral. So intense is this alteration that in many of the thin sections it is impossible to determine whether the original rock was a tuff, andesite, or rhyolite. Where better preserved the rhyolites show phenocrysts of quartz and partly altered orthoclase in a highly sericitized or silicified groundmass. In the andesites and latites the phenocrysts and groundmass seem to have altered with about equal facility. Small cubes and patches of pyrite are abundant in most of the wall rock near the veins. For more detailed descriptions see page 83.

CHARACTER OF THE VEINS.

The ore bodies commonly occur as veins about 4 feet wide, but in the Golden Sunbeam mine the principal body was a great irregular mass of mineralized tuff, which on No. 2 level was 130 feet long by 75 feet wide and extended upward 85 feet and downward 115 feet. The Montana shoot also was of exceptional shape, being 20 to 25 feet in length by 5 to 17 feet in width and 530 feet in depth. In general, the contact of the vein material with the inclosing rock is sharp and the numerous included fragments of wall rock are angular. A pronounced banding is conspicuous in the veins; the bands broadly parallel the walls, but in detail concentric arrangement is common.

The vein filling is predominantly fine-grained quartz, and associated with it are small amounts of chalcedony and opal. Calcite is conspicuous in some of the deposits, as in the Lucky Boy, where it constitutes perhaps 20 per cent of the vein. The calcite occurs both as equidimensional rhombohedral crystals and as lamellar crystals, the latter commonly replaced by quartz. Indeed, much of the quartz has this lamellar form, showing it to be pseudomorphous after calcite. Adularia is locally either intergrown with or embedded in the quartz.

The metallic minerals are irregularly distributed through the quartz and, to a less extent, through the calcite. Dark-gray bands of submetallic luster parallel the crustification of the vein material in many places. Within these bands individual minerals are too small for identification even with a microscope. Along the strike of the veins the ore minerals are largely confined to definite sections, thus forming the ore shoots, which alone have been mined at a profit.

ORE SHOOTS.

The ore shoots of these deposits comprise (1) segments of otherwise comparatively barren quartz-calcite veins, (2) disseminations of stock-like form not related to fissure fillings, and (3) chimneys of ore apparently independent of fissure veins. The most important deposits are of the first type, which represents all the mines except the Golden Sunbeam and the Montana. The Golden Sunbeam was a great stock-like body of mineralized tuff, and the Montana was a chimney of ore about 10 by 20 feet in cross section.

THE ORES.

Mineralogy.—The unaltered ore is a fine-grained quartz, locally accompanied by large amounts of calcite and a little chalcedony, opal, and adularia. Of the metallic sulphides pyrite alone is abundant and uniformly present. Tetrahedrite is not uncommon, and chalcopyrite, galena, and rarely enargite occur in some of the deposits. Widespread and important, as they have been found to characterize the richer ores, are blue-black submetallic bands and blotches, in which pyrite and gray copper and rarely chalcopyrite may be recognized with the aid of the microscope, but the predominant material shows as blue-black specks too small to be identified. Partial analyses of two specimens of this material were made by R. C. Wells. A specimen from the Montana mine showed gold, selenium, lead, a little bismuth, and a trace of copper. Tellurium was not present. A specimen from the Lucky Boy dump contained gold, selenium, lead, some copper, and a trace of bismuth. Here also tellurium was not detected. The definite amount of selenium in both of these ores, the only ones analyzed for it, suggests the presence of some selenide.

An analysis of Lucky Boy ore taken at a depth of about 400 feet from the surface was furnished by Mr. Nicholas Treweek, manager of the Lucky Boy Gold Mining Co., and is as follows:

Partial analysis of ore from Lucky Boy mine, Custer County, Idaho.

[Analysis by Union Assay Office. Gold and silver in ounces per ton; other items in percentages.]

Gold	1.34
Silver	25.90
Lead	.00
Copper	.00
Insoluble	67.30
Zinc	.00
Sulphur	.50
Iron	1.40
Lime	15.40

By calculating the calcium oxide as calcite, and adding to this the amounts of other constituents shown in the analysis, it is readily seen that about 3 per cent of material is not accounted for. Some of this material is doubtless moisture, but it probably also represents the several constituents identified by Mr. Wells (cited above).

The oxidized ore is firm quartz, heavily stained with iron, manganese, and locally with copper. Calcite is rare in the outcrops, but numerous lamellar and rhombohedral forms of quartz indicate its former presence. Kaolin of creamy white color, unless stained by iron oxide, occurs in cavities and along crevices in the oxidized ore. It is probably in part due to the weathering of adularia, and in part is infiltrated from the sericite and feldspar of the wall rocks. Cerargyrite and wire silver are both present, but only locally do they occur in noteworthy quantities. Much of the gold even in the primary ore is free, though so minutely divided as to be invisible even microscopically. Coarse gold occurs near the surface in some of the deposits, notably the Morrison vein. Some of the gold may be associated with the selenium as a selenide, though the relation, if it exists, has not proved susceptible of demonstration with the material at hand.

Tenor of the ores.—Gold and silver are present in quantities which vary from place to place. Thus the Montana shoot furnished predominantly gold ores, whereas the General Custer contained only 1 ounce of gold to 80 or 90 ounces of silver. In general, the ores mined have been high grade, common assays ranging from $50 to $100 per ton, some of them much more.

It has been generally found in the area that the tenor of the ores decreases markedly with depth. The Montana shoot was worked at big profit for the first 500 feet, but a tunnel driven to tap it at greater depth failed to reveal ore in commercial quantities. The General Custer ore body was not worked below the level of Yankee Fork.

The Golden Sunbeam was disappointing on the lower levels. The Charles Dickens was abandoned at a depth of 250 feet, as was also the Morrison. The Lucky Boy, the deepest mine in the district, was worked to the 900-foot level, but most of the production came from much nearer the surface.

An analysis of the problem, however, indicates that for the veins as a whole this impoverishment may be more apparent than real. In the first place, the ores below a depth of 50 to 100 feet are primary; second, they were formed before erosion had carved most of the present topographic features; and, third, they occur at various elevations between 6,500 and 9,500 feet. Otherwise stated, primary ore plays out at a moderate depth below an accidental surface of erosion which is far from parallel to the surface prevailing at the time of ore deposition. Thus it can not be assumed that depth below the original surface determined the lower limit of the deposits as now known. From this line of evidence it would seem that though the shoots now known have given out at moderate depth, others like them in shape may be present well below the now existing accidental surface. Opposed to such a conclusion, however, is the fact that with a few exceptions veins of this type and age have not been worked at a profit below 1,000 feet, and the greater part of their aggregate production has come from a depth less than 500 feet.

AGE AND GENESIS.

The gold-silver veins are inclosed in lavas of Miocene age. After their formation great valleys were carved and as these valleys are partly filled with outwash from the ice they evidently existed at the beginning of the Pleistocene. Some of them, as that of Yankee Fork, are more than 3,000 feet deep, and because they occur near the headwaters of the stream which drains the area it does not seem unreasonable to assign most of the Pliocene epoch to their development. As the veins existed before the valleys were formed, and as they are inclosed in Miocene rocks, the ore deposits are believed to be of late Miocene or early Pliocene age.

In a study of the genesis of these deposits three principal features stand out—(1) the intense and far-reaching alterations of the wall rock, (2) the angular form of wall-rock fragments inclosed in the veins, and (3) the general crustified arrangement of the vein material. The composition of the veins themselves is important but seems to have less bearing on the problem of genesis. Intense alteration of the wall rock appears in every specimen studied—near the veins silicification, farther removed sericitization, and locally also chloritization. Solutions thus capable of working out into the walls were probably highly heated and impelled by considerable pressure.

They did not, however, possess corroding properties to any marked degree, for included fragments of wall rock are notably angular. Further, the solutions operated in open channels, as shown by the general crustification of the vein material and the numerous cavities lined with druses of quartz crystals.

It has been shown above that the veins are closely related in age to the lavas and tuffs which inclose them. They also present the type of wall-rock alteration which in many districts where detailed studies have been made has been attributed to hot ascending solutions genetically related to some igneous activity. It is believed, therefore, that the gold-silver veins of Yankee Fork district are genetically related to the same igneous activity which earlier found expression in the great beds of tuffs and lavas.

GOLD PLACERS.

Distribution and history.—Gold placers are recognized in the Loon Creek and Yankee Fork districts. The first discovery was made near the mouth of Canyon Creek, a tributary of Loon Creek, in 1869 and during the decade following the placers were actively worked, producing upward of $1,000,000. During the period of placer activity on Loon Creek gold was discovered in the gravels along Jordan Creek in the Yankee Fork district. Here the production was not large, probably not more than $50,000.

Character of the deposits.—Placer locations along Yankee Fork cover the valley flat from Salmon River to Jordan Creek, and thence extend up the latter stream for about 2 miles. Extensive exploration by drilling has been accomplished, but with what success is not generally known. The early production came from the area near the mouth of Jordan Creek, where the gold occurred as fine flakes and a few large nuggets that were found near bedrock. Here the gravel bed was thin, but south of this place it is known to be as much as 90 feet thick.

On Loon Creek 470 acres are held as placer ground by the Loon Creek Hydraulic Placer Co. The area is 4½ miles long and about 1,000 feet in average width. A strip 75 feet wide and about 1 mile long, situated along the upper part of the main channel, afforded the early production. Here the gravel bed is 2 to 6 feet thick, but back of it are terraces 10 to 30 feet high, which the present owners have prospected during two seasons and are now planning to hydraulic. The average return from the numerous prospect pits in these terraces was about 25 cents a cubic yard.

The Loon Creek placers comprise loosely cemented auriferous gravels which rest upon a rather even floor of schist. The pebbles average perhaps 3 inches in diameter, though locally bowlders as much as 3 feet and a few 6 feet across are encountered. Sand is the cementing material. The gold occurs in the lower 2 or 3 feet of the deposits and in joints and shallow depressions in bedrock. Coarse gold prevails, nuggets weighing an ounce or more being not uncommon, and perhaps 50 per cent of the product averaging 25 cents a color or more. Its market value is $18 per ounce.

Source of the placer gold.—The gold of the Yankee Fork placers is obviously derived from the late Tertiary veins, above which it does not extend. Most of the production came from that portion of Jordan Creek immediately below its intersection with the Morrison-Charles Dickens vein—a relation which points to that vein as the source of most of the gold heretofore mined.

The Loon Creek Placer gold is thought to have come from the late Cretaceous or early Eocene veins which cross Canyon Creek, for the following reasons: First, placers have not been found above the mouth of Canyon Creek, and, second, the amount of gold diminishes abruptly with increasing distance below its junction with Loon Creek.

It is noteworthy that, although the older veins themselves have not been nearly as productive as the younger ones, the placers derived from them have been vastly more productive—a relation in keeping with the widely made observation that the late Tertiary veins do not yield extensive placers even though they are not uncommonly bonanza deposits.

Age of the placers.—The placers are believed to have formed late in the Pleistocene epoch. The great gravel beds, which in part are auriferous, occupy post-Miocene erosion valleys. Their accumulation in such valleys indicates a change from conditions of erosion to those of deposition. This may most reasonably be thought to have occurred during the general period of ice recession. At this time there was an abundant supply of running water and a proportionately greater supply of rock rubble loosened and in part ground up by the glaciers. As the ice front retreated up the precipitous tributary canyons, vast amounts of material would continually be made available for transportation, and the streams, if fully loaded in their upper, swifter parts, would necessarily deposit below, where the grade was lower.

It is therefore believed that the auriferous gravels were deposited late in Pleistocene time—a belief which is supported by the small amount of erosion which they have undergone.

MINERALS OF THE DEPOSITS.

At least 32 mineral species occur in the deposits of the three districts herein described. These include 7 gangue minerals and 8 primary and 17 secondary metallic minerals. Of the several species chalcopyrite, galena, tetrahedrite, and quartz (auriferous) are individually important as ores. The minerals are listed in alphabetical order below, together with brief notes on their occurrence.

Adularia.—Vein feldspar is common though not abundant in the late Tertiary veins of the Yankee Fork district. It is usually of microscopic size and occurs either intergrown with the quartz or included in it.

Anglesite.—Lead sulphate occurs in all the lead-silver deposits of the area. It represents an intermediate stage in the alteration of lead sulphide to lead carbonate.

Argentite.—Silver glance is rather abundant in many of the silver-rich oxidized ores of the late Tertiary veins.

Arsenopyrite.—The iron sulpharsenide is a primary mineral of minor importance in the silver-copper deposits of the Bay Horse district.

Azurite.—This carbonate of copper appears in many of the vein outcrops of the area but is nowhere sufficiently abundant to constitute an ore.

Barite.—Barite has been reported from the Lost Packer vein, but none was seen during the present investigation.

Calamine.—Zinc silicate occurs as bundles of clear white columnar crystals protruding from the walls of small cavities in the oxidized lead-silver ores.

Calcite.—Calcite is a common gangue mineral in the late Tertiary veins, in one of them, the Lucky Boy, constituting about 20 per cent of the ore.

Cerargyrite.—Silver chloride, though little of it is susceptible of identification, is probably the most abundant silver mineral in the oxidized lead-silver ores.

Cerusite.—Sand carbonate is the most important ore of lead that has been mined in the area. It occurs as granular masses, as a rule heavily stained with oxides of iron and manganese.

Chalcocite.—Copper glance is found locally as films along cracks in the upper level of the Lost Packer mine. It is probable that it was also present in the upper levels of the silver-copper deposits.

Chalcopyrite.—Chalcopyrite is the principal ore mineral at the Lost Packer mine, where it carries 2½ to 3 ounces of gold per ton. It occurs in small amounts in most of the other deposits of the area.

Dolomite.—Dolomite occurs rarely as a gangue mineral in the lead-silver deposits.

Enargite.—Enargite was found in a few specimens of ore from Dickens Hill, Yankee Fork district.

Fluorite.—Small cubes of fluorite occur in cavities in the oxidized ore of the Red Bird mine, Bay Horse district.

Galena.—Argentiferous galena constitutes the chief primary ore mineral in the lead-silver deposits. It also occurs sparingly in the silver-copper deposits.

Gold.—Native gold is found in placers in the Yankee Fork and Loon Creek districts. It also occurs in the oxidized gold-copper ores, and in both the primary and secondary gold-silver ores.

Hematite.—Ferric oxide is widespread in the deposits of the area as an oxidation product.

Limonite.—Ferric hydroxide is similar in distribution to hematite.

Malachite.—Green copper carbonate is common as a stain in the outcrops of the gold-copper and silver-copper deposits.

Minium.—Lead oxide was seen in one specimen of ore from the Beardsley ore bins.

Pyrite.—Pyrite is a persistent mineral in the area, occurring in all the deposits. In the wall rock of the late Tertiary veins abundant small cubes of it accompany the metasomatic alteration.

Pyrolusite.—Dendritic manganese oxide is not uncommon along fractures in the lead-silver deposits.

Pyrrhotite.—This sulphide of iron was seen only in the ores of the Lost Packer mine, where it occurs sparsely as small crystals inclosed either in chalcopyrite or in quartz.

Quartz.—Quartz is a common gangue mineral in all the deposits, but is the predominant constituent only in the late Tertiary veins.

Siderite.—Iron carbonate is the characteristic gangue mineral in the pre-Oligocene deposits.

Silver.—Native silver occurs sparingly as twisted wirelike filaments in cavities in the late Tertiary oxidized ore.

Smithsonite.—Zinc carbonate occurs as botryoidal forms with drusy crystal surfaces lining cavities in the oxidized lead-silver ores.

Sphalerite.—Sphalerite is common in the primary lead-silver ore and occurs sparingly in the silver-copper ores. A few crystals also appear in the late Tertiary veins.

Tetrahedrite.—Tetrahedrite is the characteristic ore mineral in the silver-copper veins.

Wad.—An earthy mixture of metallic oxides in which manganese oxide is the dominant constituent is abundant in the upper portions of the lead-silver deposits. It may best be classed as wad.

OXIDATION AND GROUND-WATER LEVEL.

The extent to which oxidation has affected the ore deposits of northwestern Custer County varies markedly in different parts of the area and in different deposits in the same district. In general, the gold-silver deposits are comparatively little oxidized below a depth of 40 or 50 feet. In the gold-copper veins oxidation is even less extensive, but in the lead-silver and silver-copper deposits probably most of the ore which has been mined has been largely oxidized.

The difference in extent of oxidation is due to a number of factors, most important among them the amount of postmineral fracturing. The gold-copper veins are not only comparatively unfractured but are crossed by flat-lying, unjointed dikes, which protect the underlying portions of the ore body. Lack of fracturing also is the dominant factor in preserving the primary minerals of the late Tertiary veins. The deposits of Bay Horse district, on the other hand, are rather extensively fractured, but even here the extent of oxidation is erratic. In the Red Bird mine sand carbonate is conspicuous in the ore of the lowest workings, about 900 feet below the surface, although galena also is abundant. In the Pacific mine, however, with less than 200 feet of cover, galena predominates. The River View ore, as seen on the dump, is largely galena, though the mine is situated well up on a cliff of intricately jointed limestone. The silver-copper deposits, with the exception of the New Silver Bell, present primary ore throughout those portions of the workings now safely accessible.

If permanent ground-water level for the region be assumed to accord approximately with the bottoms of the numerous canyons, nearly all the mining development has been well above ground-water level. As in this area, where the beds are in general steeply inclined and joints and slaty cleavage are abundant, there seems no reason to doubt the above assumption, it is concluded that in the general erosion of the region oxidation has not kept pace with the general lowering of the water table.

FUTURE OF MINING IN NORTHWESTERN CUSTER COUNTY.

Northwestern Custer County is certain to produce important amounts of silver, lead, copper, and gold in the future, if only from deposits now developed. The deposits of the Bay Horse district are by no means exhausted, and in some a considerable tonnage is actually blocked out. Many others are inadequately developed and much of the intermediate territory is comparatively unprospected. In the Yankee Fork district little ore is in sight, and any important future production from the shoots now recognized is problematic, but in a heavily timbered area where such bonanza deposits have been found there is ever the probability of new discoveries. The Loon Creek district contains gold placers which will probably be worked in the near future. In addition to these are gold-copper veins, one of which has been explored to a depth of 1,000 feet and throughout the ore has varied in value from $25 to $90 to the ton with no evidence of impoverishment with depth. The area of dolomitic limestone near the head of Deer Creek is also thought to be a promising field in which to prospect for lead-silver deposits.

It is highly probable that in a rough country like northwestern Custer County new deposits will be found when mining again becomes active. Whether such activity will precede the advent of a railroad is doubtful, for the larger properties are held by companies which for many years have shown no inclination to rob the known deposits. The advent of a railroad, however, would doubtless inaugurate a mining activity of considerable importance.

The area is one far more worthy the attention of the prospector than many which are being more adequately explored. Few silver-lead deposits show prominently at the surface not only because they are slightly less resistant than the inclosing rocks but because the oxidation products, cerargyrite and sand carbonate, are earthy in appearance and commonly break up into small fragments. The absence of a quartz gangue implies the absence of the iron-stained quartz float, which has led the prospector to most deposits of ore. The silver-copper and gold-copper deposits, in that copper stains accompany their outcrops, are more readily recognized, and it is probable that fewer of them have been overlooked. The gold-silver veins outcrop fairly distinctly at the surface and their iron-stained float lessens the probabilities of new discoveries. New discoveries of any of the types of deposits, however, are to be expected, for most of the area is well timbered and many of the upper slopes are covered by a mantle of drift.

MINING DISTRICTS.

BAY HORSE DISTRICT.

SITUATION AND EXTENT.

The Bay Horse district, situated in the west-central part of Custer County, Idaho, comprises the area about that great bend in Salmon River where it changes from an easterly to a northerly course. Challis, the county seat of Custer County, is near its northern border, and the old mining town of Clayton is centrally situated within it. About midway between Challis and Clayton is Bay Horse, once a flourishing settlement of several hundred inhabitants, which now has dwindled to 7 or 8 persons, as most of the properties are held by three companies.

Excellent roads connect the principal settlements, and a daily (except Sunday) stage runs both up Salmon River to Yankee Fork district and down the Salmon to Challis. Mackay, reached from Clayton by way of East Fork and from Bay Horse and Challis by a more northerly route, is about 60 miles southeast and is the principal supply point.

The district is unorganized and of very indefinite extent. From the Livingston group in the southern part to the Dougherty claims in the northern is a distance of about 30 miles. Its average width is perhaps 15 miles.

HISTORY.

The first location in the Bay Horse district was made in March, 1877, when the River View deposit was staked. In August of the same year the Ramshorn, Beardsley, and Excelsior were located. Active development began in 1880, and from then until 1898 the district supported an important mining industry. Two smelters, each of 60 tons daily capacity, are situated in the district, one at Bay Horse the other at Clayton. Both commenced operations in 1880 and operated four to five months each year until 1897, when the Bay Horse plant was permanently closed and later dismantled. Operation of the other plant continued until 1902, when it also was closed. In 1896 a mill was built at Bay Horse for concentrating the low-grade lead-silver ores encountered in the deeper workings of the Beardsley mine but was operated only a short time.

Since the smelters and mill were closed some of the mines have continued to produce a small amount each year, the ore at first being hauled 165 miles to Blackfoot, and after the fall of 1901 60 miles to Mackay. This annual output, larger at first, has averaged about two cars of ore, derived largely from development work.

During the period of activity three principal companies operated in the district—the Ramshorn Mining Co., the Clayton Mining & Smelting Co., and the Beardsley Mining Co. The Beardsley mines, however, early passed into the possession of the Ramshorn Co. Recently a large group, known as the James McGregor group, has been formed and now includes most of the smaller properties. The properties of the Clayton Co. are situated on Squaw Creek, near Clayton, and in Bay Horse Canyon (Skylark and Hood mines); the holdings of the other companies are near Bay Horse.

PRODUCTION.

Only a rough estimate of the total production of the district is possible. Much ore has been shipped in small lots and the early production is not definitely known. The total of the estimates given by local residents and the State mine inspector for the several properties indicates a production for the district of approximately $10,000,000. This has been derived from three metals about as follows: $6,900,000 from silver, $2,700,000 from lead, and $650,000 from copper. The silver was associated with the lead as argentiferous galena and its oxidation products, and with the copper as tetrahedrite and minerals derived from it. Of the productive mines the Ramshorn, Skylark, and Silver Bell, producing silver-copper ores, and the Red Bird, Beardsley-Excelsior, and River View, producing lead-silver ores, have been by far the most important.

MINING CONDITIONS.

The Bay Horse district is a well-timbered, well-watered area of bold topographic forms. It is a region of widely diverse climatic conditions due to its great ranges in elevation, but the principal roads are open to traffic throughout the year, and communication with outside supply points is easily carried on, even during the winter months. Salmon River and its tributaries present water-power sites suitable for the development of far more power than will ever be needed by local industries. The bold topographic forms encourage mining by tunnels in many places to depths of 2,000 feet or more.

Exclusive of transportation facilities, conditions affecting mining are far better than in most western camps. Under existing conditions a freight and treatment charge of $20 to $25 must be met by every ton of ore which is hauled the 60 miles to Mackay and thence shipped to the smelters at Salt Lake; the local treatment rate, including the consequent haulage of coke and bullion, was but little less. Much of the ore in the district could meet this charge and allow a good margin of profit, but to rob the deposits of their better ores has not been the policy of the companies which own the larger mines. As the district is traversed by the valley of Salmon River, a natural railroad route, and separated from Mackay by an exceptionally low divide, it would seem that the companies are justified in awaiting and expecting better transportation facilities.

At the time of the writer's visit the district was inactive, but in the spring of 1912 the properties of the Clayton Mining & Smelting Co. were purchased by the Idaho Smelting & Mining Co., and early in the fall the smelter at Clayton was blown in.

TOPOGRAPHY.

The Bay Horse district is a portion of an old plateau now deeply dissected by the streams which drain it. The largest of these is Salmon River, which flows in a deep, narrow canyon whose walls rise abruptly from its water line at an elevation of 5,000 to 5,500 feet by precipitous slopes to 9,000 or 9,800 feet above the sea and there open out into summit tracts remarkable for their accordance in elevation. The best-preserved remnant of the old plateau surface which these summits record is Poverty Flat, an area of about 25 square miles near Clayton. It stands 9,600 feet above sea and clearly bespeaks a former erosion surface which once stood near the base level of erosion for the region. This old erosion surface was developed during the Eocene epoch (see p. 17) and constitutes the most valuable local datum plane for that part of geologic time between the Paleozoic and the late Tertiary.

Salmon River is a rapidly flowing stream which heads about 50 miles west of the district. Within the district East Fork constitutes its principal tributary, although Slate, French, and Spudd creeks from the southeast, and Thompson, Squaw, Kinnikinnick, and Bay Horse creeks from the northwest add greatly to its volume.

GEOLOGY.

The most widespread rocks in the Bay Horse district are dolomites, dolomitic limestones, slates, and quartzites of Paleozoic age. In the southwestern part Algonkian metamorphic rocks are present, and in the eastern and northeastern parts are Miocene lacustrine deposits. Andesites and tuffs are intimately associated with the lake beds, and locally intruded into the older rocks are masses of late Cretaceous or early Eocene granite and diorite.

The Algonkian rocks, composed of slates, schists, and quartzites, outcrop along Salmon River from a point near the mouth of Thompson Creek westward for about 6 miles. The Livingston deposits are possibly inclosed in rocks of this age, but all the others are within Paleozoic beds. The Paleozoic section is perhaps best exposed in the north wall of Bay Horse Canyon and in the sides of Salmon Canyon near Clayton. It comprises about 9,000 feet of beds, consisting of massive quartzite overlain by dolomite, dolomitic limestones, and shales, and these followed by a great thickness of shales and slates. The section is discussed in some detail in another part of the report (p. 19) and need not be further described here.

Igneous rocks of late Cretaceous or early Eocene age comprise three areas; two of diorite and one of granite. One diorite mass outcrops for three-fourths of a mile in Kinnikinnick Canyon 2½ miles north of Clayton; the other is of comparable size and is cut across by Salmon River 2 miles east of Clayton. The granite crosses the upper end of Bay Horse Canyon as a belt about a mile wide. Contact metamorphism due to the diorite was not noted, but adjacent to the granite the slates present an abundant development of andalusite (?) and muscovite, together with a few crystals of zoisite, actinolite, garnet, and tourmaline.

The lake beds and associated eruptive rocks and tuffs have no direct bearing on the ore deposits and will not be discussed here. A description of them appears on pages 26-27.

Structurally the dominant features of the district are north-south anticlines, one of which, traversed by Bay Horse Canyon, is about 3 miles across and on its limbs the beds dip 30° to 60°. From Bay Horse it plunges northward, and within 2 miles the flat-lying beds constituting its crest descend to the bottom of Beardsley Gulch on a dip of about 25°. The structure of this anticline south of Bay Horse is not known. Between East Fork and Squaw Creek are two anticlines separated by a syncline which is followed by Kinnikinnick Canyon. Common dips on the limbs of these are 40° and 50°.

Faults are not conspicuous in the district, although the hurried nature of the examination makes it possible that important dislocations were overlooked. Probably the largest fault noted passes northwest-southeast a short distance above Bay Horse. It has a throw sufficient to bring the overlying (?) shales against the limestone which outcrops near the bottom of the canyon above Bay Horse—a throw which is probably hundreds of feet. In the Ramshorn mine two north-south faults with downthrow of 20 to 30 feet on the east were noted, and in the Skylark mine an east-west fault displaces the vein about 50 feet to the east on the north side.

ORE DEPOSITS.

CLASSIFICATION.

The ore deposits of the Bay Horse district fall into two fairly well defined groups, according to the principal metals contained. Thus they may be classified as lead-silver and silver-copper deposits, the two differing somewhat in form and geologic occurrence. The lead-silver deposits, though broadly tabular, are very irregular in detailed outline, in most places clearly showing the action of replacement processes or at least the filling of solution cavities. The silver-copper ores, on the other hand, occupy fissures of comparatively definite outline, which probably stood open at the time of mineralization. Closely related to this difference in the two groups is the unexplained fact that the lead-silver deposits are by far more commonly inclosed in dolomitic limestones and dolomites and the silver-copper deposits in slates and shales.

The silver-copper deposits have been more extensively explored than the others and have afforded about two-thirds of the total production of the district. Among the more important mines the Ramshorn, Skylark, and Silver Bell have produced this kind of ore, and the Red Bird, Beardsley, Excelsior, and River View have produced the other.

Both types of deposits afford high-grade ores, 60 to 80 ounces of silver being commonly associated with 40 to 50 per cent of lead, and 80 to 100 ounces of silver with 8 to 10 per cent of copper.

LEAD-SILVER DEPOSITS.

Distribution.—Lead-silver ores have been mined at widely scattered localities in the Bay Horse district. Between the Livingston group on the south and the Daugherty claims on the north, a distance of 30 miles, similar ores have been found on Squaw Creek, near Clayton, and in the east half of the area adjacent to Bay Horse.

The deposits occur at widely different elevations, the Ella mine, 5,500 feet above sea, being the lowest, and the mines on Democrat Hill, at an elevation of about 8,500 feet, the highest. Thus they range vertically about 3,000 feet.

Geologic and structural relations.—The lead-silver deposits are principally inclosed in dolomitic limestones and dolomites. The more important exceptions are the Livingston ore bodies, said to be inclosed in slate, and part of the Red Bird deposit, which is also in slate.

The general strike of the deposits is north-south, but the dip is variable, some being blanket veins, as the Pacific, and others dipping steeply, as the Red Bird. In the flat-lying veins, bedding planes determine the general altitude of the ore bodies, though locally joints have had a controlling influence. The steeply dipping deposits in general follow fissures, which in many places have been greatly widened by solution and metasomatic replacement of the wall rock.

Many of the deposits are definitely related to anticlines. Thus the Red Bird and South Butte properties are on the west limb and the Ella group is distributed along the east limb of what may be termed the Clayton anticline. The River View mine is on the east limb of the Bay Horse anticline, and the Pacific, Democrat, Cave, Forest Rose, and other properties are situated near the point where the anticline plunges north at an angle of about 30°. The Excelsior and Beardsley properties are near the axis of this structural feature, but not far removed from its north end.

Character of the deposits.—In shape the lead-silver deposits are broadly tabular, but in detailed outline they are exceedingly irregular. Bunches of ore varying in size from that of a baseball to a mass 10 to 15 feet across occur in places out in the walls several feet from the main ore body, with which they are usually connected by narrow stringers. Elsewhere ore extends out along joint planes or expands from the main mass. In general the flat-lying deposits are more irregular in outline than those that dip steeply, but in both types bodies of regular outline may merge into those of most erratic shape.

The Beardsley-Excelsior vein, which produced about $2,500,000, and the Red Bird veins, which produced more than $1,000,000, were the largest and most regular deposits recognized in the district. The principal ore body in the former varied from 100 to 200 feet in length and from 1 to 20 feet in width; that in the latter was 60 to 80 feet long and 20 to 30 feet wide. The Beardsley-Excelsior shoot was worked to a depth of 500 feet, where it expanded into a mass of low-grade ores; the Red Bird shoot was worked for somewhat more than 400 feet below the surface, although below this and to the side other shoots were found, at least five now being recognized.

Mineralogically the lead-silver deposits are rather simple. The primary ores consist predominantly of argentiferous galena, with which quartz and siderite are associated as gangue minerals. Tetrahedrite, sphalerite, pyrite, and chalcopyrite occur in unimportant amounts. As mined, however, the ores are mostly earthy sand carbonate stained with iron and manganese. Anglesite, the lead sulphate, occurs as a transition stage in the alteration of galena to cerusite but is local in its occurrence and abundant only in parts of the Red Bird mine. Minium, the oxide of lead, was noted in one specimen from the Beardsley ore bins. The alteration products of the sphalerite are smithsonite and calamine, the former occurring as druses and the latter as sheaf-like bundles of crystals extending from the walls of cavities otherwise lined with smithsonite. Fluorite occurs in places in the oxidized ore of the Red Bird mine as small bluish-white cubes set on druses of smithsonite. In many of the deposits a large amount of manganese oxide colors the secondary ore, but the primary mineral from which it is the alteration product was not recognized. The iron oxide, abundant in the altered ores, results principally from siderite and subordinately from chalcopyrite and pyrite.

Analyses of ores from most of the mines were not available, but the compilation which appears on page 41 is probably fairly typical of the composition of roughly hand-sorted material.

SILVER-COPPER DEPOSITS.

Distribution.—Silver-copper veins, though less widely distributed in the district than the lead-silver deposits, have played an even more important part in its economic history. Three properties have produced considerable amounts of this type of ore—the Silver Bell mine, on Poverty Flat, and the Ramshorn and Skylark mines, at Bay Horse. The first is about 8 miles south of the other two. Some 6 miles north of Bay Horse a little gray copper also occurs in the ores of the Dougherty property at the head of Garden Creek. Thus this type of deposit is recognized at intervals along a north-south belt about 15 miles in length.

Geologic and structural relations.—All of the silver-copper deposits are inclosed in slates, presumably of Paleozoic age. The slates generally present a marked slaty cleavage at a high angle to the bedding, a structure locally so pronounced that the bedding planes are not discernible. The two principal deposits bear a definite relation to these structures; the Skylark vein follows the bedding and the Ramshorn the lines of slaty cleavage. The Silver Bell, however, occupies a fissure independent of either type of parting. All the deposits are fissure fillings, the fissures having opened along preexisting planes of parting in the two larger deposits and in the other one along a zone independent of any such planes.

About 600 feet west of the Skylark mine and possibly 1,000 feet from the Ramshorn is a granite mass about a mile across. The slates adjacent to this mass present an appreciable metamorphism, characterized by the development of andalusite (?) and muscovite and to a minor extent of zoisite, actinolite, garnet, and rarely tourmaline. No igneous rock was seen in the immediate vicinity of the New Silver Bell mine.

Character of the deposits.—The silver-copper deposits are tabular in outline and conform closely to the walls of the fissures which they occupy. Bunches of ore isolated in the walls, such as are common in the lead-silver deposits of the district, are rare in the silver-copper deposits. Where offshoots from the main body occur they follow distinct lines of parting, as joints or bedding planes, and then are mere stringers, some of them little more than films of ore.

The ore occurs in shoots of irregular shape, which range in length from a few feet to 200 or 300 feet and in width from a few inches to 4 feet, the most common dimensions being possibly 100 feet by 20 inches. Their vertical extent is commonly two or three times greater than their horizontal extent. Within the veins shoots are distributed without apparent regularity, although they commonly show a tendency to occur one above the other and in the same deposits to pitch in the same direction. Along their margins the shoots wedge out or merge into comparatively barren gangue and gouge.

The ore.—The silver-copper ore as mined consists of two quantitatively important minerals and several others which, though persistent, are accessory. Siderite constitutes possibly three-fourths of the vein material and tetrahedrite one-third of the remainder. Among the accessory minerals quartz is by far the most abundant, but chalcopyrite is more evenly distributed. Galena, arsenopyrite, pyrite, and rarely sphalerite occur in small amounts. Secondary minerals are negligible in the deposits as now worked.

The siderite is coarsely crystallized and most commonly occurs in rhombic forms, as in Plate VII, *B* (p. 33), but locally in elongated forms (Pl. VII, *C*) and as lamellar crystals lining small cavities. Tetrahedrite occurs in bunches, which cut across the siderite crystals or follow their cleavage planes. A complete analysis of the tetrahedrite appears on page 34. The quartz is intergrown with the siderite in most places, but locally occurs as beautiful doubly terminated hexagonal crystals, either embedded in the siderite or perched against the sides of small cavities in the tetrahedrite. Chalcopyrite occurs as netlike films along numerous minute fractures in the ore and as linings of small cavities in the tetrahedrite. Galena occurs as small grains and crystals intergrown with the tetrahedrite or clustered in cavities in it. Less abundant than the chalcopyrite, though probably formed before most of it, is arsenopyrite, which occurs as grains and columnar crystals, generally related to fractures in the siderite (Pl. VII, *C*). The only sphalerite seen in the deposits occurs as minute crystals set upon free faces of galena in cavities in the Ramshorn ore.

The tenor of the ore varies according to the amount of tetrahedrite it contains. Specimens of this mineral from the large ore shoot in the Ramshorn mine contained 33.39 per cent copper and 4.86 per cent silver (or 1,417 fine ounces to the ton). The average tenor of the ore in this shoot is said to be 3 per cent copper and about 125 ounces in silver to the ton. By roughly hand sorting, however, this grade may be greatly raised. The Skylark ore, on broad averages, is said to have contained 8 per cent copper and 80 to 100 ounces silver to the ton, although some of it ran 12 per cent copper and 600 to 700 ounces in silver.

Little information is available concerning the nature and tenor of the ore from the old Silver Bell workings, but it occurred so near to the surface that oxidation was probably well advanced, the tetrahedrite being altered to carbonates of copper and chloride of silver. It is said that chalcocite was rare.

AGE AND GENESIS.

The two types of deposits recognized in the Bay Horse district are closely related in age and as phases mineralogically intermediate between the two occur, they are thought to have had practically the same origin. They have a wide vertical range, the difference in elevation between the Ella mine, at Clayton, and the Silver Bell mine, on Poverty Flat, being about 3,000 feet. No single ore body has been traced throughout this extent, but the Ramshorn vein has been explored to more than half that depth and ore found on all the levels.

The higher deposits, such as those on Democrat Hill, the Ramshorn and Skylark veins, and the Silver Bell, are truncated by the Eocene erosion surface and hence are older than late Eocene. On the other hand, they are inclosed in Paleozoic sedimentary rocks, which probably range from Cambrian to Devonian, perhaps younger. Closer than this the age of the deposits can not be determined from local evidence, but from the broad considerations outlined on pages 35–36 it is concluded that they were formed shortly after the intrusion of the granitic rocks, which are considered to be late Cretaceous or early Eocene.

Their genesis is more difficult of determination. The conclusion that they were formed at great depth follows from the similarity in the mineralogy of the ore found at different elevations in the mines, for if conditions of deposition were the same throughout the range of 2,000 to 3,000 feet, the upper part must have been sufficiently below the then existing surface to exclude the influence of oxidizing surface agencies. Aside from this, however, there are physiographic reasons (see p. 36) for believing that a vast amount of erosion took place after the deposits formed and before the elevation of the Eocene erosion surface; probably more than 5,000 feet of beds were removed.

The deposits are thought to be genetically related to the intrusive masses of granitic rocks—a relation discussed in the general section, pages 35–38, 41–42.

MINES AND PRINCIPAL PROSPECTS.

RAMSHORN MINE.

Situation and development.—The Ramshorn mine comprises seven patented claims situated on the north side of Bay Horse Canyon about 2 miles above Bay Horse. Development consists of 15 tunnels which enter along the strike of the vein at unequal intervals through a vertical range of about 1,650 feet. From highest to lowest the tunnels are designated Ramshorn Nos. 1 to 7, Utah Boy Nos. 1 to 5, and Post Boy Nos. 3 to 1. Above the Utah Boy No. 3 most of the tunnels are inaccessible, but those below are open. Raises connect the several levels and above the Utah Boy No. 2 are large stopes from which the early production was derived. In all there is perhaps 6 or 7 miles of development on the property.

History and production.—The Ramshorn mine was located in August, 1877. Development began soon thereafter and was pursued actively most of the time until the fall of 1897. Since then a watchman has been kept at the mine and a small amount of tunnel work accomplished each year. During the period of activity the ore was conveyed by aerial tram from the upper tunnels to the bottom of the canyon and thence by wagon to the smelter at Bay Horse. The total production of the property is said to have been about $3,000,000.

Geologic relations.—The Ramshorn mine is situated well within the area of slates that forms the western limb of the anticline which centers near Bay Horse. The slates are all fine grained and characterized by an abundant development of sericite. In some of the slates which outcrop on the lower slopes of the canyon side at the mine small elongated crystals, possibly andalusite but now completely altered to calcite, stud rather evenly the otherwise fine-grained mass. In color the slates vary from dull to light gray, though locally they present a greenish cast. Slaty cleavage is well developed and in places completely obliterates the bedding structure, across which it cuts at an angle of about 50°. The ore bodies follow fissures which parallel the slaty cleavage, though locally stringers extend out along the bedding planes.

The veins.—The vein fissures strike N. 15°–30° W., and dip 57°–85° SW., the average strike being about N. 15° W. and the most common dip about 80° SW. Above the lower three levels two parallel veins 30 to 50 feet apart are recognized, but below them only one has been encountered. In each a zone of crushed wall rock, 3 to 6 feet wide, follows the fissure and is generally present even where mineralization is lacking. In these parallel fissures the ore bodies occur in shoots, which alternate from one fissure to the other. Thus in many places where the ore body pinches out in one fissure a crosscut to the other one has revealed another shoot.

The veins are bordered by well-defined walls, though locally stringers extend into the country rock. In general, the fissures parallel the cleavage of the inclosing slate, but in a few places ore follows the bedding planes, which dip westward at a much lower angle. This is thought to explain the difference in dip between the ore body in the Post Boy tunnels and that in the Utah Boy tunnels. Nos. 3, 4, and 5.

Faults are not numerous in the mine, only two being seen during the hasty examination, both of which occur in the Utah Boy section of the vein, to which they are parallel in strike but opposite in dip. In each of these faults the hanging wall has moved down about 25 feet relative to the footwall.

The ore.—The ore is essentially gray copper in a siderite gangue. Associated with the tetrahedrite are unimportant amounts of pyrite, galena, chalcopyrite, arsenopyrite, and sphalerite. Quartz occurs as isolated euhedral crystals, which stud sparsely the siderite gangue, and as irregular patches intergrown with the metallic minerals. A complete analysis of the tetrahedrite, which contains 4.86 per cent silver (equivalent to 1,417 fine ounces per ton) and 33.39 per cent copper, appears on page 34. This mineral is present on all levels of the mine, but the largest body found lies between the Utah Boy tunnels Nos. 3 and 4. Here occurs a shoot of ore, which on No. 4 level is between 350 and 400 feet long and continues upward to No. 3 level, 140 feet higher, although there the north end draws southward, shortening it many feet. The ore averages about 2 feet in width and is made up principally of tetrahedrite and siderite in such proportions that the average ore contains 3 per cent copper and 100 ounces of silver per ton. The tetrahedrite occurs in bunches both along cleavage planes of the massive siderite and as tabular bodies cutting across them. In general the tetrahedrite attains its maximum development on the footwall side of the vein.

The paragenesis of the ore minerals is discussed on page 33.

SKYLARK MINE.

Situation and development.—The Skylark mine is situated immediately west of the Ramshorn on the same side of Bay Horse Canyon. The property comprises 9 or 10 claims, two of which are patented. Development consists of 16 principal tunnels, which enter at unequal intervals along 2,000 feet of the outcrop of the vein and represent in all perhaps 25,000 feet of work. The tunnels are divided into east and west groups with the old boarding house as datum. Thus they are known as Nos. 1 to 7 east and Nos. 1 to 10 west. All the ore is said to have been removed above No. 7 west.

History and production.—The property was located in 1877 and in 1880 was purchased by the Omaha Smelting & Mining Co., which recently sold it to the Idaho Smelting & Mining Co. In 1883 the Ramshorn Mining Co. had the property bonded for $35,000, but owing to the poor showing of ore they allowed the option to lapse. A short time thereafter the ore bodies which afforded the principal production were encountered and for several years the mine was an important producer of silver and copper. A great deal of the ore was smelted at Bay Horse, but far more was sent by pack trains over the summit, 12 miles to Clayton. After the Clayton smelter was closed in 1902 considerable ore was shipped by leasers to Salt Lake and Denver at a cost of about $30 per ton for freight and treatment. The charge for treatment by the local smelters was $18 and $20 per ton, the lower charge applying when the amount of lead exceeded a stated percentage.

The total production of the property is said to be $2,700,000, derived from ore which averaged about 8 per cent copper and 80 ounces of silver per ton.

Geologic relations.—The vein is inclosed in greenish-gray thin-bedded sericitic slates, which strike N. 8° W. and have a general dip of 22° SW., although locally as steep as 60°. These extremes of dip were recorded in tunnel No. 9 west, where for 250 feet from the portal the beds dip about 60° and then abruptly dip 22°. The plane of transition is an east-west fault, which displaces the north-lying beds 50 or 60 feet east. Westward from the mine the thin-bedded slates grade into micaceous quartzites, which occur in beds 5 to 10 feet in thickness. These quartzites continue as the predominant type of rock to a point possibly 500 feet west of tunnel No. 9 west, where granite comes to the surface as a mass about a mile across. At the border of the granite an andalusite-like mineral (p. 33) is abundantly developed in the sedimentary rocks, as well as muscovite and biotite. This metamorphic effect contrasts rather sharply with that which accompanies the ore bodies, where calcite and sericite are the important alteration products.

The vein.—The vein follows the bedding of the inclosing formation. In most places there is an appreciable brecciation along the particular bedding plane which the ore follows, but this is in few places more than 3 feet wide and is bordered by firm walls. Within this general crushed layer the ore occurs in irregular lenslike shoots, which are usually elongated parallel to the dip, but few of which have proved continuous for more than 200 or 300 feet, most of them having given out within 100 feet. The old workings were not safely accessible at the time of visit, but an inspection of an old mine map showed more than 40 such lenses of ore to have been worked. The tenor of the ground between the old stopes is not known to the writer, although it should be borne in mind that at the time this portion of the vein was worked the cost of mining and treatment was about $25 to the ton of ore. Thus it is thought to be highly probable that a considerable tonnage of medium-grade ore remains in the abandoned workings. Another possible source of ore may be vertical veins which follow the slaty cleavage, as in the Ramshorn mine. Apparently all of the development has been along the bedding planes, yet there seems to be no particular reason why the ore-bearing solutions should have followed one set of major partings to the total exclusion of the other.

The ore.—The Skylark ore, like that of the Ramshorn mine, is essentially gray copper in a siderite gangue. Accompanying the tetrahedrite in very subordinate amounts are chalcopyrite, arsenopyrite, galena, and less pyrite and sphalerite. In the oxidized ore cerargyrite and the carbonates of copper were common, and argentite, leafy native silver, wire silver, pyrargyrite, and native copper were occasionally found. The average width of the ore bodies is said to have been about 20 inches, the ore in general running 8 per cent copper and 80 ounces in silver to the ton. Some of it, however, ran several hundred ounces in silver and up to 20 per cent copper.

RIVER VIEW MINE.

The River View mine is situated 1½ miles southeast of Bay Horse, well up on the cliff which faces Salmon River. This claim was staked in March, 1877, and was the earliest location in the district. Development consists of several tunnels and a 100-foot shaft, in all perhaps 5,000 or 6,000 feet of work. The total production of the mine is said to be $500,000, derived principally from silver-lead ores.

The deposit is situated within the area of dolomitic limestone on the east limb of the Bay Horse anticline. The limestones occur in massive beds, which vary in color from sky-blue to bluish gray. Joints traverse them in various directions; the most conspicuous, perhaps, strike N. 60° W. and dip 80° NE. Eastward the dolomitic limestones are covered within a short distance by lacustrine deposits and lavas of Tertiary age.

The ore occurs in irregular lenses and bunches, and as parallel stringers alternating with quartz and limestone, and represents about one-fourth of a zone 5 feet wide. The larger lenses conform to the bedding planes, and most of the stringers and bunches are related to joints. Those parts of the workings which were visited have been stoped, but good ore is said to occur in drifts from the bottom of a shaft, now inaccessible. Near its collar, however, is a pile of ore, containing perhaps 400 tons. This ore is for the most part argentiferous galena accompanied by a little sphalerite and is associated with a porous manganese-stained quartz. Much of it is oxidized, the secondary minerals being cerusite, a little argentite and native silver, malachite and azurite, and small amounts of smithsonite.

EXCELSIOR MINE.

The Excelsior mine comprises one claim situated at an elevation of 6,600 feet, on the east side of Beardsley Gulch, about 1,500 feet northeast of Bay Horse. Development consists of a principal tunnel and a winze which attains a depth of 500 feet. The production of the property is not known, although the total output of the ore body which is common to this and the Beardsley mine is stated as 1,500,000 ounces of silver and 15,000 tons of lead.[1]

The mine is situated near the axis of the Bay Horse anticline and is well within the area of dolomitic limestone. The surface workings (the only part accessible) are inclosed in this type of rock, but it is probable that the lower levels extend into the calcareous and dolomitic slates which outcrop at the base of the cliff a short distance south.

The chief ore body was a large lenticular mass which varied from 100 to 200 feet in length and from 1 to 20 feet in width. The ore was sand carbonate heavily stained with iron and manganese, and ran from 40 to 60 per cent of lead and 50 to 60 ounces of silver to the ton. At a depth of about 500 feet the rich ore is said to have given way to disseminated material of much lower grade.

BEARDSLEY MINE.

The Beardsley group comprises four patented claims in Beardsley Gulch, the principal workings being situated about midway of the group and half a mile above Bay Horse. The mine has not been worked for 20 years and at the time of visit was extensively caved. The development consists of several tunnels and a winze on the ore; the latter attained a depth of 500 feet.

The inclosing rock is gray dolomitic limestone, which is intricately jointed in various directions and fissured along north-south courses. The fissuring parallels the crest of the anticline near the longitudinal axis of which the deposit occurs.

The principal ore body followed a north-south fissure and varied in width from 1 to 20 feet or more. The shoot, which was from 100 to 200 feet long, extended south into the Excelsior ground, and is said

[1] Bell, Robert, An outline of Idaho geology and of the principal ore deposits of Lemhi and Custer counties, Idaho: Proc. Internat. Min. Cong., 1901, p. 73.

to have yielded about 1,500,000 ounces in silver and 15,000 tons of lead from a sand carbonate ore. Of the several tunnels only the northernmost one was accessible at the time of visit. In this tunnel 300 or 400 feet of work has been done on a ledge which strikes north-south and dips 30° E. The deposit, which consists of innumerable veinlets of ore along fractures and bunches in the solid limestone, is extremely irregular. The bunches range from lumps the size of baseballs to masses 14 or 15 feet across, yet all distributed along a zone perhaps 40 feet wide which dips 30° E. The minerals are iron-stained sand carbonate and cerargyrite, the latter in minute grains identifiable with difficulty. Stains of copper carbonate and druses of smithsonite are common; sheaf-like aggregates of calamine crystals are less numerous. It is said that the purer grades of ore ran 40 to 60 per cent lead, 2 to 3 per cent copper, and 50 to 60 ounces in silver to the ton.

PACIFIC MINE.

The Pacific claim is now one of the McGregor group, but as it has commonly been considered a separate mine it will be described separately here. It is situated at an elevation of 7,800 feet on the northeast slope of Democrat Hill, about 1¼ miles northeast of Bay Horse. The property has produced $65,000 from the two short tunnels, which total perhaps 1,000 feet in length and comprise its only development.

The deposit, which follows the flat-lying beds of the massive dolomite that forms the summit area of Democrat Hill, varies in width from narrow stringers to 5 or 6 feet. The ore is locally clean sand carbonate, though in most places quartz is the predominant mineral. Commonly the ore extends as irregular bunches into the adjacent wall rock or leads off along joints and narrow fissures. The ore minerals are sand carbonate, cerargyrite, smithsonite, and a little argentiferous galena, so proportioned in a quartz gangue that average shipments of hand-picked material run 50 to 60 per cent of lead, 60 to 80 ounces of silver, 2 to 3 per cent of zinc, 4 to 6 per cent of sulphur, and 20 to 25 per cent of silica. Two partial analyses of the inclosing dolomite, which were supplied by Mr. James McGregor, of Salt Lake City, owner of the property, are as follows:

Partial analyses of country rock at Pacific mine, Custer County, Idaho.

	1	2
Silica	7.00	5.1
Lime	35.00	30.60
Magnesia	14.63	20.18

HOOSIER GROUP.

The Hoosier group, recently consolidated with the McGregor group, consists of four claims situated on the lower slopes of Bay Horse Canyon, a few hundred feet above the Beardsley mill. (See fig. 2.) The development consists of several short tunnels on either side of the creek, in all perhaps 2,500 feet of work.

The principal deposits are two parallel veins about 60 feet apart. They strike north-south, dip 22° W., and are inclosed in the shales and slates which at this place extend well up the valley sides. The upper or west vein ranges from 1 inch to 4 feet in width, averaging about 2 feet. Pyrite associated with coarsely-crystallized quartz is the most common metallic mineral, though tetrahedrite, which occurs only locally, is the mineral sought. Hand-picked shipments from this ledge contained 20 to 25 per cent copper and 200 to 400 ounces in silver to the ton. To such ore a production of about $50,000 is credited. The lower vein differs from the upper in that little tetrahedrite is present, the dominant ore mineral being argentiferous galena. This vein averages about 15 inches in width, but the valuable constituents occur only in small irregular patches in its general plane. It has produced about $20,000 in silver and lead.

A remarkable feature of both veins is a mass of clear-white, coarsely crystallized barren quartz which overlies them. The quartz above the upper vein is 10 to 12 feet thick; that above the lower, 40 feet thick. This quartz is almost if not altogether devoid of metallic inclusions. Locally a thin clayey seam separates it from the veins, but elsewhere the quartz cuts the ore. The country rock is a slate so fissile that the footwall of an open, flat-lying fissure in it would have been covered before long with fragments from the roof. No such rubble is present on the upper surface of the ore, which suggests that the incoming quartz material followed quickly the opening of the cavity or perhaps caused it.

SILVER BRICK CLAIM.

The Silver Brick claim, also one of the McGregor group, joins the Pacific on the west. The development consists of two tunnels 100 feet apart vertically, the lower 700 feet and the upper 150 feet in length. The ore occurs irregularly along a fissure which strikes N. 10° W. and dips 40° NE. A small production has resulted from stopes between the two levels.

The inclosing rock is a dolomite similar to that at the Pacific mine.

CAVE MINE.

The Cave mine, owned by Christopher Peterson, a local resident, comprises a single unpatented claim situated about a mile northwest of Bay Horse, at an elevation of 8,100 feet on the south slope of Democrat Hill. Development consists of a shaft and an 840-foot tunnel in

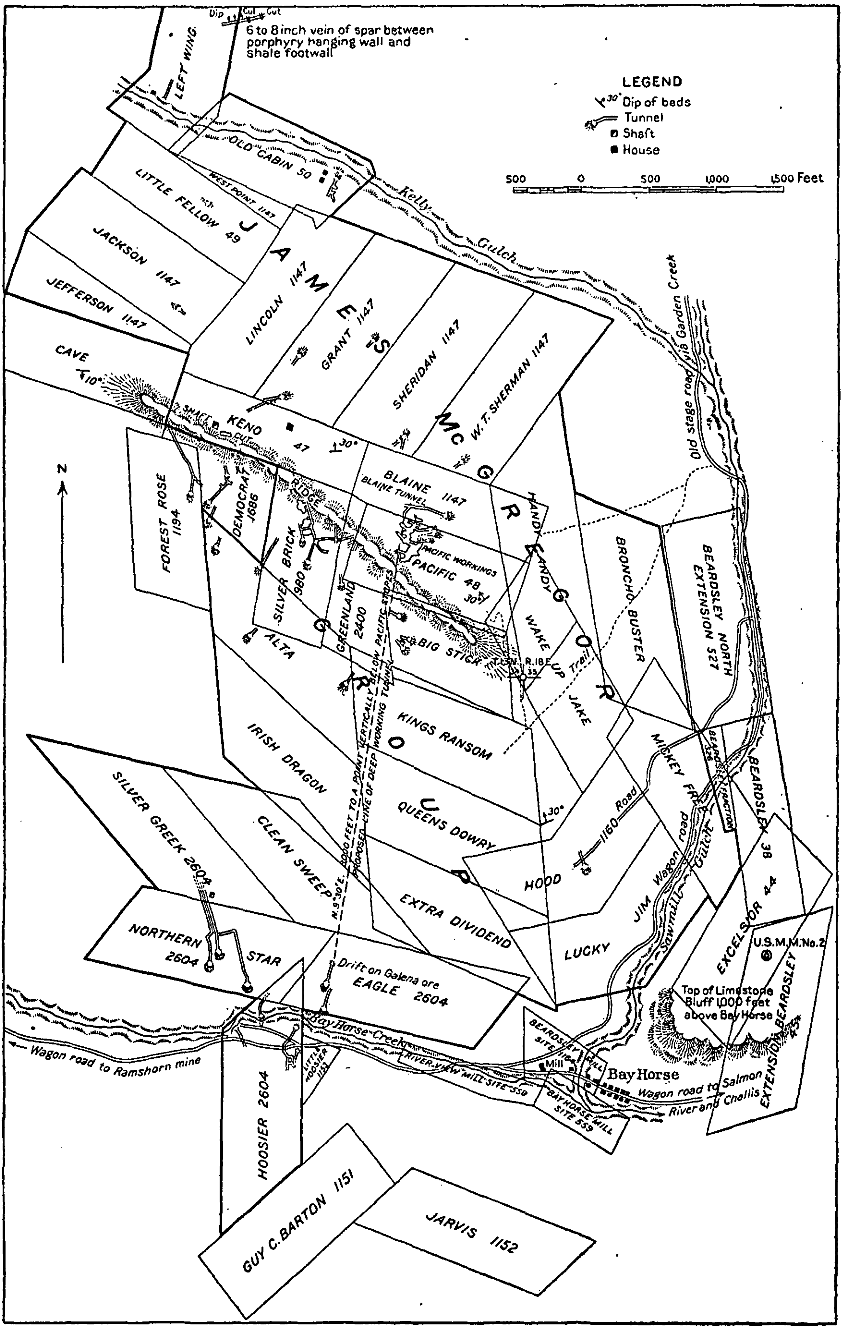


FIGURE 2.—Claim sheet of James McGregor group, Bay Horse district.

addition to various drifts and crosscuts, in all perhaps 1,500 feet of work. Two veins which strike N. 20° W. and dip 70° NE. are recognized, but only one has proved productive. This vein is a band of ore about 18 inches in average width, which is accompanied by a variable amount of gouge, the usual distance between the fairly well defined walls being about 4 feet. The ore contains lead and silver and is similar to that found in the Beardsley and Pacific mines. In the outer part of the tunnel thin-bedded slates dipping 10° S. pass in a short distance through more massive varieties into the underlying dolomite which incloses the veins.

FOREST ROSE MINE.

The Forest Rose group, consisting of three patented claims, lies immediately south of the Cave property on Democrat Hill. It is situated on the same ledge which is worked in the Cave mine, but the shoots here found have been less productive. Development consists of a tunnel 600 feet long and two raises on the ore. The ore occurs in shoots, which range in width from a few inches to 5 or 6 feet. These appear to strike north-south and to dip approximately 60° E., although development is not sufficient to determine their attitude definitely. The ore is partially oxidized argentiferous galena. At present the property is being worked by lessees.

NEW SILVER BELL MINE.

The New Silver Bell mine (formerly known as the Silver Bell) is situated on the east margin of Poverty Flat at an elevation of 9,500 feet. The mine is reached by trail from Clayton, 4 miles on a direct line south-southeast. The deposits were discovered in 1879 and were worked for the 18 years following, having produced in all about $600,000 from silver-copper ores. The property comprises five unpatented claims and is developed to a maximum depth of 100 feet by some 10,000 feet of tunnels.

Poverty Flat is a remnant, several miles in extent, of an Eocene erosion surface developed at this locality across steeply tilted slates and quartzites of Paleozoic age. The quartzites are fine-grained and massive; the slates thin bedded and fissile, in many places with marked slaty cleavage. The ore deposits are found within the slates.

The vein strikes N. 60° W. and dips 30° NE. It follows the inclosing formation in strike but is independent of it in dip, cutting across both the primary and secondary structures. The vein is said to have steepened with increasing depth. Within a general zone of fissuring, perhaps 100 feet wide, ore occurred as narrow lenses of irregular shape and unequal extent. The ore consisted of gray copper in a siderite gangue and is similar to that of the Ramshorn and Skylark mines, although the shoots here were much less continuous. In many places along the vein ore was mined within 5 or 10 feet of the surface, where the copper occurred principally as malachite and azurite and the silver as cerargyrite and argentite. The claims have recently been relocated and are now being prospected at greater depth.

ELLA GROUP.

The Ella group comprises four claims situated on the south slope of Kinnikinnick Canyon near its junction with that of Salmon River. Development consists of several tunnels, the longest of which starts near Clayton and continues 1,600 feet on a course N. 15° W. This tunnel follows the general strike of the Paleozoic formations which constitute the country rock. The ore occurs along bedding planes between a general hanging wall of dolomitic limestone and a footwall of fine-grained quartzite. Very little ore appears in this tunnel, but a considerable amount of argentiferous galena in a quartz-siderite gangue lies on the dump. Pyrite and tetrahedrite are intermixed with the galena but in subordinate amounts.

The group produced a considerable tonnage during the early days of mining in the district, but most of it was derived from openings which are farther up the canyon and are now inaccessible. The ore was desired because of its high content of siderite, which served as a flux in smelting other ores of the district.

RED BIRD MINE.

Situation and history.—The Red Bird mine is situated on the east side of Squaw Creek, 5 miles above its confluence with Salmon River and by wagon road 9 miles northwest of Clayton. The deposit, situated near the north end of a group of 10 claims (fig. 3), was located in 1878, and the active work, which continued until 1902, was begun in 1880. During this period from 1,000 to 1,500 tons of ore which ran 30 to 40 per cent of lead and 40 to 60 ounces of silver to the ton were delivered to the Clayton smelter annually.[1]

The mine is opened on eight levels by five tunnels, the upper four of which enter the canyon side at intervals of about 100 feet. All the tunnels are connected by raises and between Nos. 4 and 8 are three blind levels, the total development aggregating 10,000 to 15,000 feet. Most of the production came from the upper four levels, which represent a depth on the ore shoots of 600 to 700 feet. Below this depth little ore had been mined at the time of the writer's examination, but since then this portion of the deposit has been extensively worked.

Geologic relations.—The Red Bird mine is well within the area of Paleozoic rocks. The sharp anticline cut across by Salmon River

[1] The mine was reopened in 1912 by the Idaho Smelting & Mining Co. and has been actively worked since, supplying most of the ore for the Clayton smelter.

between Squaw Creek and Clayton continues northward, and these deposits occur on its western limb. The rocks inclosing the ores are predominantly dolomitic slates; but locally dolomitic limestone and clayey quartzite occur. The lower tunnel crosscuts the beds for 1,600 feet and affords a fair idea of the formations and their attitudes. Thin-bedded calcareous slates, dipping 70° W., prevail for the first 80 feet of this tunnel, but from this point they grade rapidly into more massive varieties and the dip flattens to the horizontal. About 600 feet from the portal the beds are steeply inclined eastward and the thin-bedded slates seen near the portal again appear, but within a short distance give way to massive dolomitic limestone, which continues to a point 1,400 feet from the entrance. From this point on to the face at 1,600 feet the beds are nearly horizontal and argillaceous quartzite predominates.

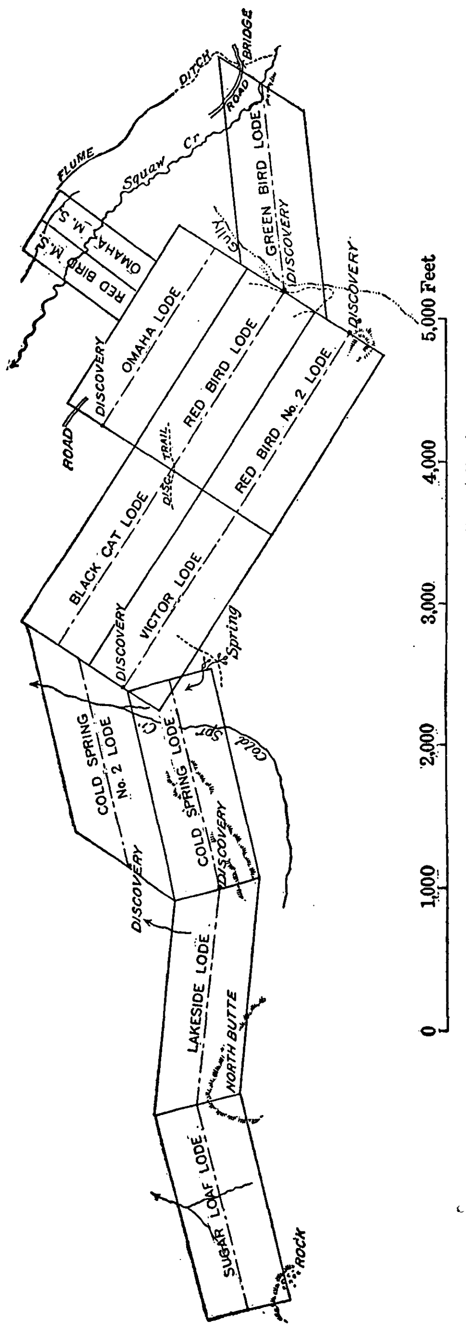


FIGURE 3.—Claim sheet of Red Bird group, Bay Horse district.

The ore bodies.—At least five ore bodies have been encountered in the mine, but two have proved of paramount importance. One of these bodies, known as the Potato Patch shoot, was 60 to 80 feet long by 20 to 30 feet wide and was worked to a depth of more than 400 feet. Its strike was N. 65° W., and its dip 45° SW. The ore throughout was an earthy mass of sand carbonate which ran 30 to 40 per cent of lead and 40 to 60 ounces in silver to the ton. Although of broadly regular outline, the old stopes show the ore body to have been irregular in detail. Here and there it extended out along joint cracks; elsewhere great swells protruded into the inclosing rock.

Parallel to this shoot and about 150 feet east of it is another, which on No. 2 level corresponds to it in strike and dip but on the lower levels changes to a strike of N. 20° W. and dips 40° NE. A considerable tonnage of ore is blocked out on this shoot between No. 2 and No. 8 levels. Within it the ore occurs in bunches of irregular shape and extent which, however, usually have a roughly tabular form parallel to the general plane of the fissure. In places the bunches give way to a veinlike mass 50 to 75 feet in length and as much as 12 feet in width, as near No. 2 level. The ore is similar in general character to that in the west shoot and is fairly continuous to a point within 65 feet of No. 8 level, where it gives way to a mass of pyrite 55 feet wide at the only point where it has been crosscut. This pyrite carries traces of gold and an unimportant amount of copper. It is exceptionally vuggy throughout the mass. The vugs are lined by pyritohedrons of pyrite and here and there a little manganese oxide. Among the minerals which occur in the productive part of this shoot, sand carbonate heavily stained with iron and manganese is most common. Minute grains of cerargyrite occur with it and vugs in the ore are commonly lined with crusts of smithsonite. Set upon these smithsonite druses are needlelike crystals of calamine and bluish-white cubes of fluorite. In protected spots only do the primary minerals, argentiferous galena, pyrite, and sphalerite, occur. Anglesite occurs in places as the principal ore mineral in this shoot. It contains 2 to 3 ounces of silver to the unit of lead, whereas in the carbonate ore there is only 1 ounce of silver for each 1 per cent of lead, the latter ratio being about the same as in the argentiferous galena, in which 0.5 to 1 ounce of silver accompanies each unit of lead.

Since the writer's examination a large ore shoot has been found on No. 7 level and penetrated for 60 feet, although its dimensions have not been determined.

SATURDAY GROUP.

The Saturday group consists of two patented claims situated on the west side of the canyon near the mouth of Squaw Creek. The development consists of a shallow shaft and one or two tunnels, all of which date from the early days of mining in the district. The property is said to have produced a few thousand tons of argentiferous galena ore but has not been worked for 20 years or more.

CINNABAR GROUP.

The Cinnabar group comprises two patented claims situated 5 miles up Bruno Creek, a northwest tributary of Squaw Creek, which it joins at a point 2 miles below the Red Bird mine. The property was not visited but is said to have produced about $100,000 from lead-silver ore. At a later date it was sold as a gold mine to certain eastern speculators, but as such it proved a total disappointment.

SOUTH BUTTE GROUP

C. L. Tratht owns a small group of claims immediately east of the Red Bird mine, which produced about 1,000 tons of argentiferous galena ore in the early days and have been worked intermittently by leasers during the past few years. They were not visited.

DOUGHERTY GROUP.

The Dougherty group, consisting of seven claims, is situated on Garden Creek, 9 miles west-southwest from Challis, at an elevation of 7,700 feet. The development consists of six tunnels on the north side of the gulch and two on the south side—in all, perhaps, 2,000 feet of work. The deposits are irregular lenses inclosed in dolomitic limestone and thin-bedded slates. Two types of ore ore recognized—argentiferous galena and tetrahedrite accompanied by pyrite and chalcopyrite. In general the strike is N. 50° W. and the dip 30° SW., but in no place has a sufficiently continuous deposit been exposed to determine any persistent attitude.

LIVINGSTON MINE.

The Livingston group, consisting of five or six patented claims, is situated near the head of Slate Creek, about 9 miles from Salmon River and 20 miles southeast of Clayton. This property was not visited during the reconnaissance, but its promise is such that it deserves special mention.

The development consists of about 600 feet of tunnels and several open cuts on a ledge said to be remarkable for its continuity. The production amounts to $40,000 or $50,000, which has resulted from ores removed during development. The property has been sampled several times and would probably have been worked before this were it not for its comparative inaccessibility. It is said that a large tonnage of silver-lead ore is partially blocked out.

YANKEE FORK DISTRICT.

SITUATION.

The Yankee Fork district comprises an unorganized area of possibly 150 square miles situated in the northwestern part of Custer County. It lies south-southeast of the Loon Creek district, northeast of Stanley

Basin, and west of the Bay Horse district—about 20 miles from each. There are three settlements in the area—Bonanza, Custer, and Sunbeam—all grouped within a radius of 5 miles from the junction of Jordan Creek with Yankee Fork. The settlements have regular stage communication with Challis, 60 miles distant by a route which follows Yankee Fork and Salmon River. Mackay, the nearest railroad point, is 85 miles southeast by a route which leaves the Challis stage road near the confluence of East Fork with Salmon River. Roads also connect north-northwest with Loon Creek district and southwest with Stanley Basin. A trail which is used a great deal leads over the mountains to Challis, 30 miles northeast.

HISTORY.

Prospectors spreading from the placer excitement on Loon Creek discovered placer gold on Jordan Creek near its confluence with Yankee Fork in the middle seventies of the last century. Soon thereafter the lodes on Dickens Hill and those about Custer were located and quickly drew attention from the placers. The General Custer vein was especially attractive to those seeking lode deposits, for it lay against the canyon side as a great slab several thousand square feet in extent and promised strength and persistence together with exceptional amounts of the precious metals. In many respects, however, it was misleading. Developments have failed to add more than 20 per cent to its productive area as exposed by erosion and none of the other veins have even approached it in total production.

The district experienced its greatest activity prior to 1900, though the General Custer mill operated most of the time until 1905. After that mining operations were unimportant until 1907, when the Golden Sunbeam was opened on a large scale, a mill built, and a hydroelectric plant installed on Salmon River. In 1911, however, this enterprise also was temporarily abandoned, leaving the entire district inactive.

PRODUCTION.

The total production of the Yankee Fork district is estimated at $12,000,000, two-thirds of which is credited to the General Custer vein. Of the remainder about one-third was derived from the Lucky Boy and the rest principally from the Charles Dickens, Golden Sunbeam, Montana, Morrison, and McFadden properties.

The relative importance of gold and silver in making up the total production can only be roughly approximated. During the twenty-odd years that the camp was active the price of silver varied greatly, as did also the amount of bullion produced each year. The latter factor is not known, hence the only means of estimating the separate amounts of gold and silver produced is a survey of their relative importance in the ores of individual mines. The General Custer, Lucky Boy, and Charles Dickens veins contained about 85 ounces of silver to 1 of gold. These properties produced three-fourths of the total amount derived from the district. The Montana and Golden Sunbeam contained much more gold than silver, but their combined production was less than a million dollars. In the other veins in the camp silver exceeded gold in amount. Thus considered, it is estimated that about 40 per cent of the total production of Yankee Fork district has been from gold and the remainder from silver.

TOPOGRAPHY.

The Yankee Fork district is a high, mountainous area which varies in elevation from 6,000 to 9,500 feet. Yankee Fork, a stream which flows south-southwest through the district, occupies the principal valley. Tributary to it from the west are Cabin, Jordan, and Eightmile creeks, and from the east a number of small streams of minor importance.

The dominant feature of the higher areas is the general accordance of summit levels, a feature conspicuous from any point of vantage. This is somewhat remarkable, for most of the rocks in the district are Miocene tuffs, and the plateau surface of this part of Idaho is of Eocene age. The key to the explanation, however, is afforded by the water-laid tuff, which appears at elevations of 9,000 feet on Estes Mountain and is well exposed at 8,800 feet along the road over Loon Creek Summit. This tuff clearly bespeaks a Miocene water surface, which stood at about the level of the Eocene erosion surface, at least locally, and probably over a considerable area. The present valleys of the district are in large part cut in these volcanic rocks and hence are obviously post-Miocene in age.

Among the minor features of topographic interest is the valley of Yankee Fork below the mouth of Jordan Creek. Above this point it is comparatively narrow, but below it broad terraces follow the stream to its junction with Salmon River. These terraces in many places extend back 500 or 1,000 feet from the present channel. Locally the gravels composing them are more than 90 feet deep, though usually their thickness is less than 25 feet.

GEOLOGY.

ALGONKIAN ROCKS.

Distribution.—Rocks of Algonkian age [1] are exposed locally in the district. They outcrop along the sides of Yankee Fork valley for a distance of about 3½ miles, beginning at a point 2 miles below Bonanza and continuing southward. They are said to continue a short distance to the west, but to the northeast they open out into a broad

[1] For age determination see pp. 18–19.

area along the eastern border of the district. A small isolated area of the same system of rocks is exposed in the bottom of Jordan Creek valley near Sunbeam.

Composition.—Within this district the Algonkian system is represented by dark-gray massive quartzites, mica schists, massive black slates, and thin-bedded gray slates. Their sequence was not determined. Metamorphism is well advanced throughout, slaty cleavage and schistosity in most places concealing the original bedding structure. Sufficient primary structure remains, however, to indicate unmistakably their sedimentary derivation.

LATE CRETACEOUS OR EARLY EOCENE GRANITE.

The late Cretaceous or early Eocene granite, which is widely exposed in Idaho, is found only in the south part of this district, where it forms the walls of Salmon Canyon near the mouth of Yankee Fork. Northward from this point granite outcrops for about 2½ miles, but to the east, west, and south its extent is much greater. A description of the rock constituting this area appears on pages 21–22.

TERTIARY VOLCANIC ROCKS.

Distribution.—Tertiary volcanic rocks are widely exposed in the Yankee Fork district, extending through it as a broad belt in a northeast-southwest direction. Their maximum thickness is not definitely known, although near Sunbeam they are exposed in uninterrupted succession through a vertical range of 3,000 feet, the lowest member resting on Algonkian beds. They occupy a post-Eocene erosion valley, and as the Sunbeam exposure is near the center of this old valley, it may be safely assumed that the exposure there presents approximately the maximum thickness.

Composition.—In general the volcanic rocks of this area are andesites and latites below and andesitic and rhyolitic tuffs, with interbedded andesite or latite flows, above. In the western part of the district the series is chiefly tuff, but east of Custer lavas, principally andesites, predominate. Northeast from the Enterprise mine numerous low hills, which attain perhaps 8,000 feet elevation, present excellent sections of parts of the lava series. These were not visited, but as seen from a distance of a mile or so eight or ten distinct flows of lava, each 10 to 25 or 30 feet in thickness, were recognized. About the Enterprise mine and over the summit to the Lucky Boy andesites are predominant, but toward Custer, at an elevation of 1,500 feet lower than the summit, tuffs are present in thick beds. Below these beds andesites are again exposed in the valley sides near Custer. Northwest of Sunbeam, along the road to Loon Creek, the Tertiary rocks are predominantly of different type, tuffs being very abundant and, together with a few lava flows, outcropping through a vertical range of possibly 2,000 feet. In places the tuffs are massive, but elsewhere they are thin-bedded, even finely laminated, and were clearly deposited in standing water. An exposure of this variety forms Loon Creek Summit, but here siliceous shales are interbedded with the tuffs. The west face of Estes Mountain, as seen from Loon Creek Summit, presents the chalky white slopes typical of the areas of tuff.

Petrographic descriptions of these volcanic rocks appear on pages 25–26.

QUATERNARY DEPOSITS.

Evidences of glaciation appear on all those parts of the Yankee Fork district which exceed 7,500 feet in elevation and in places morainal débris and U-shaped valleys extend to elevations 500 or 1,000 feet lower. Jordan Creek valley is glaciated as far as Sunbeam. Glaciers radiated from Estes Mountain and left topography especially typical of their action on the north slope and down the valley of Eightmile Creek. About the Lucky Boy and Enterprise mines also glacial deposits are widespread.

The thick gravel deposits along Yankee Fork are thought to date from the period of general ice retreat which closed the Pleistocene. These gravels indicate the overloading of a stream which earlier in its history actively eroded its channel, and it seems that only during the period of ice recession were conditions favorable for this excess of material. At this time there was an abundant supply of running water, and a proportionately greater supply of rock rubble was loosened and in part ground up by the glaciers. As the ice front retreated this material was continually available for transportation, and the streams, if fully loaded in their upper swifter parts, must necessarily deposit nearer to their mouths, where the grade was lower. This was the condition along the valley of Yankee Fork.

ORE DEPOSITS.

GENERAL CHARACTER.

The ore deposits of the Yankee Fork district are exclusively gold-silver veins inclosed in volcanic rocks of middle Tertiary age. In some of the deposits gold is present almost to the exclusion of silver and in others silver is greatly in excess. Copper and lead are much more abundant in these veins than is common in the late Tertiary deposits, though in none of them are these metals in sufficient quantities to constitute an ore.

The veins were worked for a number of years at a large profit, but in general have not proved remunerative below a depth of a few hundred feet. The General Custer vein is a feature of especial interest, and within the knowledge of the writer is unique in that erosion had exposed most of its ore body.

THE VEINS.

Distribution.—The veins of the district may be considered as two parallel systems about 4 miles apart. In each system four or five veins are recognized, most of which strike in a general northeast-southwest direction and dip westerly. The eastern system attains its maximum development on Custer Mountain, where it comprises the Badger, Lucky Boy, Enterprise, Summit, and General Custer veins. Southward it is represented on Dickens Hill by the Charles Dickens, Letha, and Julietta veins, and southwestward across Jordan Creek, by the Morrison, Fairplay, and Passover veins. The western system is best developed on Estes Mountain, where the Montana and McFadden veins are the most important representatives. Southwestward the deposits at Sunbeam should be considered in the same general group, although here much of the ore occurs as disseminations of irregular shape instead of in veins.

Characteristics.—The veins range from stringers to 18 feet or more in width, averaging perhaps 4 feet. In general their contact with the inclosing rock is sharp and the numerous included fragments are angular. Crustification is conspicuous throughout; the bands broadly parallel the walls, but in detail concentric arrangement is common. The predominant gangue mineral is cryptocrystalline quartz associated with which are small quantities of chalcedony, opal, and adularia. Calcite is important in some of the deposits, as in the Lucky Boy, where it comprises perhaps 20 per cent of the vein. The calcite occurs both as equidimensional rhombohedrons and as lamellar crystals, some of which have been replaced by quartz that retains perfectly the crystal form of the calcite.

Metallic minerals are irregularly distributed through the quartz and to a less extent through the calcite. In many places they are arranged as broken layers parallel to the banding of the gangue. Along the strike of the fissures the metallic minerals are largely confined to definite sections of the veins, thus forming the ore shoots, which have proved to be the only parts worth mining.

Ore shoots.—The ore bodies of the Yankee Fork district comprise (1) segments of otherwise comparatively barren quartz-calcite veins, (2) disseminations of stocklike form not related to fissure fillings, and (3) chimneys of ore apparently independent of fissure veins. The most important deposits belong to the first type, which is illustrated by all the deposits except the Golden Sunbeam and the Montana, the former being a great stocklike body and the latter a chimney of ore.

THE ORE.

The unaltered ore of the district is a fine-grained quartz, locally accompanied by considerable quantities of calcite and a little chalcedony, opal, and adularia. Scattered irregularly through the gangue, yet conforming roughly to the crustification which characterizes it, are metallic sulphides, of which pyrite is most abundant and is present in all the deposits. In some of the veins, as the McFadden and Julietta, chalcopyrite and galena are also present, and in some of those about Custer enargite, probably also primary, was recognized. Tetrahedrite is not uncommon in the ores, although nowhere an abundant constituent. Most important, however, as they have been found to inclose the gold and silver, are blue-black submetallic bands and blotches which are present in all the better grades of ore. In these bands and blotches pyrite and gray copper and in a few specimens chalcopyrite are recognizable, but the predominant mineral occurs as minute blue-black specks too small to be identified. Partial chemical analyses of these bands show a definite trace of selenium, suggesting the presence of some selenide.

The oxidized ore is very different in appearance, being a firm quartz heavily stained with iron and manganese oxides and locally with malachite. Calcite appears in the immediate outcrop in but few places, but its former presence is indicated by lamellar and rhombohedral forms of quartz pseudomorphic after it. Kaolin of creamy white color, unless stained by iron, is common along crevices in the oxidized ore and is probably partly derived from the adularia of the gangue and partly infiltrated from the sericite and feldspar of the wall rock. The silver of the oxidized ore occurs as cerargyrite, argentite, and wire silver, and locally is found in conspicuous quantities. Gold is free but is generally so minutely divided that it is not visible to the unaided eye, although coarse gold has been reported from some of the deposits, notably the Morrison vein.

The ores of the district have been mined exclusively for gold and silver. In the western system of veins gold is commonly equal to or in excess of the silver, but in the eastern system silver greatly predominates. Extremes are possibly recorded in the General Custer vein, where there was 1 ounce of gold to 80 or 90 ounces of silver, and in the Montana shoot, where only traces of silver accompanied the gold.

ALTERATION OF WALL ROCK.

Metasomatic alteration of the wall rock is a conspicuous feature of the Yankee Fork gold-silver veins. It is impossible to take a specimen within 50 feet of the vein, and in many places within 1,000 feet or more, that is not intensely silicified or sericitized. The silicification is most intense next to the deposits and gradually dies out with increasing distance from them until at 100 feet or so secondary silica is scarce, if present at all. Well beyond this distance, however, sericitization is a conspicuous feature of the wall rock. This relation is well illustrated in the Golden Sunbeam mine. A specimen taken from the lower tunnel of this property at a distance of possibly 400 feet from the main ore body is a chalky-white rhyolitic tuff, sparsely specked with iron stains. When microscopically examined it is seen to be made up of fragments of altered quartz and orthoclase scattered sparsely through a mass of highly sericitized material. A specimen taken from the similar rock next the ore body contains much secondary quartz, commonly as bunches of small anhedral crystals, accompanied by pyrite and a little sericite. The same relation exists in two specimens from the General Custer mine, one taken next the vein and the other 1,000 feet or so distant. The more remote specimen, however, is also chloritized. Similar pairs of specimens from the Lucky Boy and Charles Dickens properties show the same relation, seeming to indicate that in the deposits of the district as a whole the wall rock has been silicified near the veins and sericitized farther away.

AGE AND GENESIS.

The age of the Yankee Fork deposits is rather definitely limited by the age of the inclosing rocks on the one hand and the amount of preglacial erosion which has affected them on the other. Thus they are assigned to the late Miocene. (See pp. 49–50.)

Their genesis is less definite, but, as discussed on pages 49–50, several lines of evidence lead to the belief that they are genetically related to the igneous activity which earlier found expression in the great accumulation of tuffs and lavas that incloses them.

MINES AND PRINCIPAL PROSPECTS.

GENERAL CUSTER MINE.

Situation and history.—The General Custer mine is situated on the east wall of Yankee Fork Canyon near the town of Custer. The property comprises several claims located along the vein from a point near the valley flat at an elevation of 6,600 feet up the rugged mountain slope to an altitude of 8,500 feet. The vein was discovered in the late seventies and was worked actively most of the time from then until 1905, when it was closed.

The total production of the mine is said to be about $8,000,000, most of which was extracted by a mill situated at Custer and connected with the workings by aerial tram. Prior to the construction of the mill, however, a considerable amount of ore was hand picked and shipped to Salt Lake, the returns averaging about $600 per ton. The local mill is equipped with 30 stamps, several Wilfley tables, a roaster, and cyanide tanks.

Geologic relations.—The wall rock of the General Custer vein is a bluish-gray lava, probably andesite, which is now intensely altered. The phenocrysts of feldspar are completely changed to quartz, sericite, and calcite, and those of ferromagnesian minerals to quartz, sericite, and chlorite. A little sericite also appears in the groundmass, which is studded with small grains of quartz and a few cubes of pyrite, both apparently secondary. This rock inclosed the upper 500 feet of the vein, now exposed, but below that portion a formation of different composition is said to have been encountered. The latter is probably one of the tuffaceous beds common in the district. A specimen secured at 7,300 feet from the next gulch north of the one occupied by the General Custer vein, and which is probably from the same bed of tuff, is a greenish-gray rock composed of fragments of unstriated feldspar in part altered to calcite and sericite. The ferromagnesian constituents are altered to chlorite and commonly arranged in beautiful spherulitic patches. This rock is probably a trachytic tuff. Beneath it andesite crops out again, as shown in the valley walls near Custer.

The vein.—The General Custer vein is a fissure filling which strikes N. 60° W. and dips 35° NE. It varies in width from a few inches up to 12 feet and in a few places to 18 feet, averaging perhaps 6 feet. The topographic relations of the vein are unique in that erosion has completely stripped the hanging wall from perhaps 80 per cent of its known extent, so that the ore lay as a great slab against the side of a narrow gulch tributary to the main canyon at Custer. Now that the vein has been worked off, the footwall resembles a dip slope pitching toward the bottom of the gulch and clearly records the structural disturbances which affected the vein after its formation. The wall is remarkably smooth and regular but is offset by several faults both along the strike and along the dip. The former throw the west side 5 feet to 20 feet to the south and the latter present drops of equal extent on the lower side.

Drifts to the east from the margin of the exposed portion showed that the vein split into two parts, neither of which was sufficiently metalized to constitute an ore; westward the vein has been removed by the erosion of Yankee Fork. Down the pitch of the ore shoot, which corresponded closely with the grade of the gulch, the ore changed on entering the tuffaceous beds, widening to 30 feet and becoming too low grade for profitable extraction.

East of the General Custer vein, on the same property, is a vein which crops out on the Summit claim at an elevation of 8,500 feet. It strikes N. 45° W. and dips 80° SE., thus according in general course with the other vein. The opinion held by some who are acquainted with the deposits that the lower vein is a portion of the upper which has "broken over," is not supported by geologic evidence; both are clearly in place.

The ore.—That portion of the vein which constitutes an ore is characterized by dark-colored blotches and bands which grade into the general gangue. The metallic minerals which give the dark color to these portions are in most places too minute for identification, but locally gray copper, pyrite, and in a few specimens chalcopyrite can be identified in them.[1] The ore in that part of the shoot which has been developed is highly oxidized, and in many places is minutely fractured. Of the oxidation products which have formed, iron oxide alone is conspicuous, but manganese oxide and malachite occur locally.

The ore removed was of excellent grade, several of the earlier mill runs averaging from $150 to $300 to the ton in silver and gold. During the later stages of mining, however, the tenor fell to $30 and lower. The gold was largely free, and the silver occurred as wire silver, argentite, and cerargyrite. The proportion of the metals was 1 ounce of gold to 80 or 90 ounces of silver.

LUCKY BOY MINE.

The Lucky Boy property, said to have produced about $1,750,000, comprises several claims, two of which are patented. It is situated east-southeast of the General Custer group, at an elevation of 8,400 feet above sea level. The deposit was discovered about 1878, but not until the General Custer ore body began to show signs of exhaustion in the late nineties was it extensively opened. It was worked actively from then until 1904, the ore being carried by aerial tram to the General Custer mill. Development consists of two incline shafts, one of which attains a vertical depth of 900 feet, with drifts at 100-foot intervals.

The rock inclosing the Lucky Boy vein is a bluish-gray lava, probably andesite, which has been so completely altered in proximity to the vein that its identification is uncertain. Within this rock sericite is extensively developed, both in the groundmass and after the feldspar phenocrysts. Chlorite is present in small scattered patches and quartz is abundant as small grains and veinlets. Small cubes of pyrite stud the altered rock in many places, numbers of them being inclosed in the quartz veinlets.

The Lucky Boy deposit is a quartz-calcite vein which averages about 5 feet in width, though in places it narrows to a stringer and elsewhere widens to 15 or 18 feet. It strikes N. 85° E. and dips 64° NW. At the time of the investigation most of the workings were inaccessible, but from material on the dump it appears that the deposit contains 15 or 20 per cent calcite, much more than is present in any other known vein in the district. The calcite occurs both as lamellar crystals and as irregular areas; in many places it has been partially replaced by quartz. The predominant gangue mineral is cryptocrystalline quartz, which is generally arranged in bands parallel to the vein walls. Included in the gangue are numerous angular

[1] For other minerals, which a more thorough study would probably reveal in this ore, see the general discussion, p. 47.

fragments of wall rock which are intensely silicified and studded thickly with minute cubes of pyrite. Chalcedony and opal both appear locally in this deposit, but adularia was not recognized.

The precious metals accompany the darker bands of quartz. These bands owe their color to very minute metallic particles, which, though rather abundant, it was not possible to identify. Associated with them are small cubes of pyrite and a little gray copper. The ore is said to have contained gold and silver in about the same proportions as that of the General Custer, but was of lower grade.

BADGER MINE.

The Badger claim adjoins the Lucky Boy property on the east. The mine was worked intermittently for several seasons, the ore being treated at the General Custer mill, but for the past 12 years the property has been idle. The vein parallels the Lucky Boy, with which it corresponds in general characteristics.

BLACK MINE.

This property joins the Badger on the south, but has not produced as much ore. A 20-stamp mill situated on the property was operated intermittently for two or three years.

ENTERPRISE GROUP.

The Enterprise group comprises six unpatented claims situated a few hundred yards northeast of the Lucky Boy mine. Development consists of a tunnel 850 feet long and a few open cuts. Three ledges have been recognized on this property, two of which are possibly offshoots from the southern or largest ledge, which is known as the "back vein." This vein strikes N. 75° E. and dips 65° NW. It consists of a brecciated zone 25 or 30 feet wide which has been impregnated and cemented by vein quartz, in amount constituting perhaps one-half of the whole. Metallization is most intense near the hanging wall, where a cross section of 10 feet gave returns of $10 to the ton in gold, together with traces of silver. The gold is probably contained in the ill-defined blue-black bands which traverse the quartz. In these bands pyrite is the only recognizable mineral, and it is not abundant. Laterally or vertically the lode has not been explored more than a few feet from the tunnel.

CHARLES DICKENS MINE.

The Charles Dickens mine is situated at an elevation of 7,200 feet on the south slope of Dickens Hill, a bold topographic feature bounded on the east by Yankee Fork and on the south by Jordan Creek. The property produced about $600,000 in gold and silver bullion during the period from 1888 or 1889 to 1902. Development consists principally of a tunnel and a winze from it, the total depth attained being about 250 feet.

The vein, which strikes N. 70° E. and dips 70° to 75° NW., is a fissure filling ranging in width from 2 to 6 feet. It is inclosed in tuff in its upper portion and probably in andesite in the lower workings. The gangue is the fine-grained quartz common in the deposits of the district. Associated with it, however, there seems to be less calcite and more of the base metals than is common elsewhere. Small cubes of galena, irregular specks and bunches of chalcopyrite, and small areas of gray copper are common in the better grades of the primary ore. Gold is not visible. In the oxidized ore the valuable minerals are free gold, wire silver, cerargyrite, and argentite.

MORRISON GROUP.

The Morrison property is situated across Jordan Creek west-southwest from the Charles Dickens. The property produced about $100,000 during the early days of the camp. It was not visited during the reconnaissance but is thought to be a continuation of the Charles Dickens, with which it corresponds in strike and dip.

FAIRPLAY, PASSOVER, LETHA, AND JULIETTA CLAIMS.

South of the Morrison mine are the Fairplay and Passover claims, each of which has produced $20,000 to $25,000. North of these, across Jordan Creek, are the Julietta and Letha claims; the former has produced a few thousand dollars and the latter $60,000.

GOLDEN SUNBEAM MINE.

Situation and history.—The Golden Sunbeam group, comprising nine claims and three fractional claims, is situated on the south side of Jordan Creek, 4 miles above its confluence with Yankee Fork. The property was worked for several years prior to 1906, but not until then was extensive development begun. About this time a large irregular body of ore was encountered, which encouraged the operators to construct a 450-ton mill and install a hydroelectric plant on Salmon River, 10 miles distant. The mill is arranged for six Monadnock mills, four of which are installed. Two of the mills were operated for a time with indifferent success, and in June, 1911, the plant was closed. It is said that on broad averages the deposit was of too low grade to be worked at a profit. The property is said, however, to have produced about $400,000 from gold and silver.

Development consists of three tunnels and two intermediate levels in the main mine, the Bismarck tunnel a short distance south of it, and the Matilda to the north, in all perhaps 8,000 feet of tunnel work. The maximum depth on the deposit is 440 feet.

Character of the deposit.—The Golden Sunbeam ore bodies comprise mineralized zones and chimneys of ore in bedded tuffs. Locally, as in the Bismarck tunnel, the ore follows fairly well defined brecciated zones and thus resembles the veins found elsewhere in the district, but in general there is little evidence of fissure filling. The most important ore body, locally known as the "big stope," was an irregular mass which on No. 2 level was 130 feet long by 75 feet wide. From this level it extended upward 85 feet and downward 115 feet. Most of the production came from this stope, the ore running $2 to $4 to the ton. The shoot had a general strike N. 30° E. and stood nearly vertical.

The ore, as seen on the margin of the "big stope," is a soft grayish-yellow rhyolitic tuff studded sparsely with small specks of iron oxide, doubtless due to the alteration of pyrite crystals. In a few places copper stains also are present. The tuff is intensely silicified near this stope, minute bunches and scattered grains of secondary quartz being abundant. A specimen taken about 200 feet from the same stope is not silicified but is extensively sericitized.

Both in the "big stope" and elsewhere on the property vertical fractures are followed by narrow stringers of ore, in places high in grade. These stringers, however, are so small that as a rule it has not paid to mine them. The gold is pale yellow, owing to the high percentage of silver, in some specimens more than one-half, which is associated with it. Near the surface native silver is said to have been found, and with it a purer grade of gold, which suggests a separation of the two metals during oxidation.

MONTANA MINE.

The Montana mine is situated on the south slope of Estes Mountain, a few hundred feet below its summit. The property was worked many years ago and was reopened in 1905 to 1907. It has produced $337,000, most of which was recovered from a shoot 20 to 25 feet in length by 5 to 17 feet in width, which extended to a depth of 530 feet. In the upper 250 feet the shoot dipped 80° W., flattening below to 45°. The inclosing rock is a fine-grained tuff rather intensely silicified near the ore shoot. The ore differed from that found elsewhere in the district in the small quantity of silver associated with the gold, less than 1 ounce to the ton being common.

McFADDEN GROUP.

The McFadden group of two patented claims lies on the northeast slope of Estes Mountain at an elevation of 8,600 feet. The property was located in 1878 and has been worked at intervals since, producing in all about $200,000. Development consists of about 2,000 feet of tunnels and a shaft 500 feet deep. A 10-stamp mill is situated on Eightmile Creek, 3 miles below the mine.

The vein, which strikes N. 20° E. and dips 37° NW., lies between a hanging wall of light-gray fine-grained tuff and a footwall of greenish-gray porphyritic rock, possibly andesite. Both are intensely silicified, and in the footwall rock zoisite and chlorite are also abundantly developed. The vein averages about 3 feet in width and is composed principally of coarse quartz roughly crustified parallel to the walls or concentrically banded about included fragments of wall rock. Both intergrown with the quartz and included in it are a few crystals of adularia. The metallic minerals are distributed erratically through the quartz and consist chiefly of chalcopyrite, pyrite, tetrahedrite, and galena, decreasingly abundant in the order named. The gold and silver are associated with these minerals in the ratio to each other of about 1 to 100. The ore occurs in two shoots which are poorly defined but range in length up to possibly 100 feet. In the upper workings oxidation is well advanced, but about 200 feet below primary minerals predominate. The oxidized ore is stained with iron and copper and contains seams and small isolated specks of kaolin, the last probably derived from the alteration of adularia.

GOLDEN GATE GROUP.

The Golden Gate group joins the McFadden on the north. The two mines are on the same vein and as the geology is similar in both it will not be necessary to repeat the description. One ore shoot is recognized in the 1,000-foot tunnel which comprises the development on this property. From it some ore has been taken, but the production is much less than from the McFadden mine.

OTHER PROPERTIES ON ESTES MOUNTAIN.

Several other veins are recognized on Estes Mountain, but they are little developed and have produced only small amounts of bullion.

YANKEE FORK PLACERS.

Placers, said to have produced $50,000 in gold, were discovered in the middle seventies on Jordan Creek, near its junction with Yankee Fork. About the same time gold was found in the high bars below Bonanza, but these have never proved profitable. During the past few years the valley flat along Yankee Fork from Salmon River to Jordan Creek and thence along that stream for about 2 miles has been located, and extensive exploration carried on by drilling, but with what success is not known to the writer.

The gravels form broad terraces, said to be 90 feet deep in places although averaging possibly less than 30 feet. Little is popularly known of the distribution of gold in the gravels except on Jordan Creek, where the placers have been largely worked out. Here the gold was next to bedrock, and although commonly fine some large nuggets were obtained, one weighing 32 ounces being said to have been found near the outcrop of the Morrison vein. Several others from the same vicinity weighed 8 or 10 ounces, and many exceeded 1 ounce in weight.

LOON CREEK DISTRICT.

SITUATION.

The Loon Creek mining district comprises an unorganized area of perhaps 75 square miles situated in the northwestern part of Custer County. It lies immediately west of Sheep Mountain district and about 15 miles northwest of Yankee Fork district. Mackay, 110 miles southeast of Ivers, the principal local settlement, is the most accessible supply point. To reach Ivers from Mackay, however, it is necessary to cross two high summits in addition to a 3-mile climb from the mouth of Canyon Creek to the settlement. The roads are better than in most mountainous regions, but owing to snow on the summits are impassable for teams during the winter months.

MINING CONDITIONS.

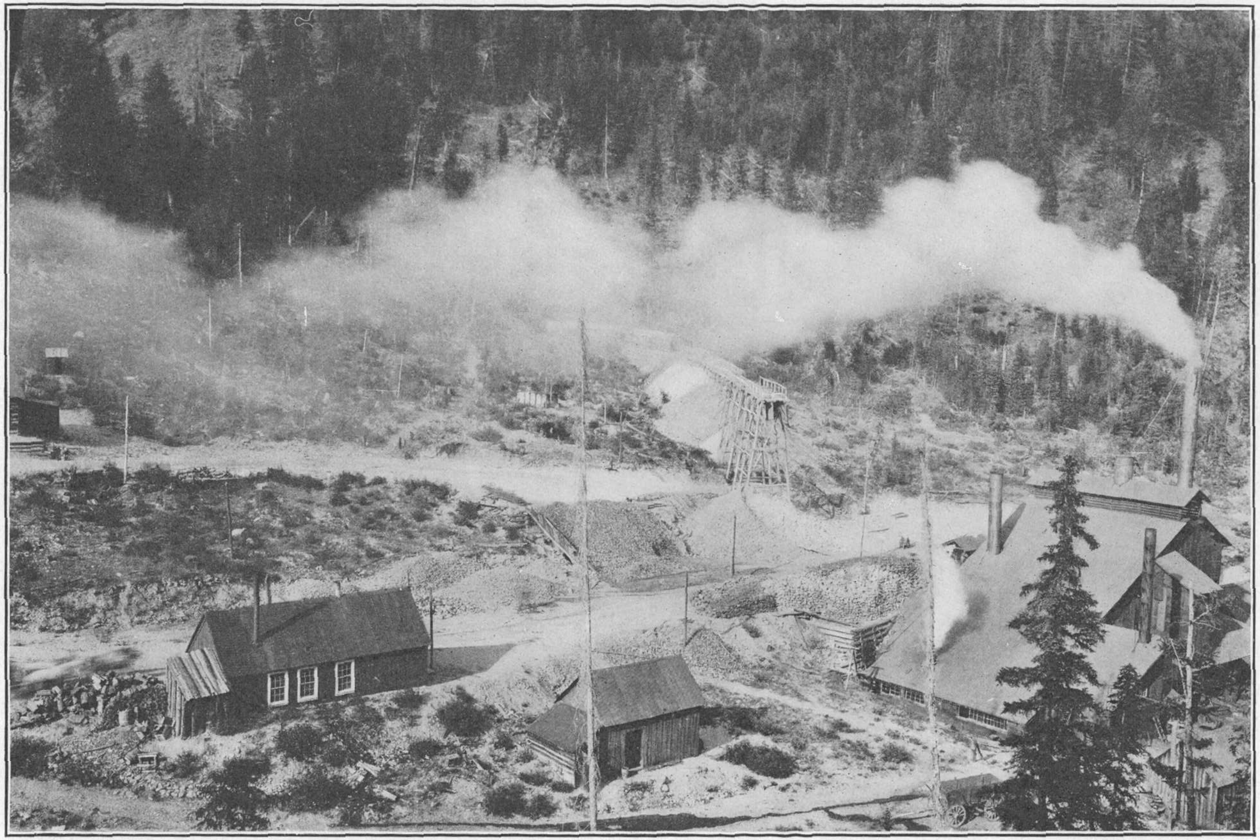
The Loon Creek district is a well-timbered and well-watered region of bold topographic forms. Owing to the range in elevation from 5,000 to 9,500 feet, the district experiences a great variety of climatic conditions. Snow covers the higher areas to a depth of several feet throughout the winter months, but in the lowlands the weather is seldom severe.

The area is well adapted to mining operations. The abrupt transitions from lowlands to highlands make it feasible to explore most of the known deposits to a depth of 1,000 to 2,000 feet by means of tunnels. Local smelting is facilitated by an abundance of suitable fluxes within the area. Indeed the only handicap to successful and economical mining is the expense of freighting supplies, especially coke, from the Oregon Short Line terminus at Mackay, 110 miles distant. The cost of this haulage is 2½ cents a pound for the round trip. When loaded both ways this is spilt into 1½ cents in and 1 cent out. The cost of coke, therefore, is the prime problem in local smelting, its average price laid down at Ivers being $46 per ton.

The various expenses charged against a ton of ore delivered as matte free on board at Mackay aggregate $20 to $22. It is this high cost which retards mining activity in the Loon Creek and adjoining districts; the need of the region is railroad transportation. Only ore running $70 to $90 a ton has been smelted, but for every ton of this grade which has been developed there are estimated to be 2½ tons which will average $25.

HISTORY AND PRODUCTION.

Placers which produced a large amount of gold were worked actively on Loon Creek during the decade closing with 1879. Most of the production, however, dates from the first half of this period, the excitement gradually dying out until only 30 or 40 Chinese



LOST PACKER SMELTER AND ORE PILES AS SEEN FROM THE SOUTH.

remained, who were massacred in the winter of 1879 by a band of men supposed at that time to be Indians but now commonly believed to have been whites. Since that time comparatively little mining has been done on the creek, although all the promising ground is now held as placer claims.

The principal lode mine in the district at present is the Lost Packer, located by Clarence E. Eddie in July, 1902. Soon thereafter it was purchased by Ivers & Finlan, of Salt Lake, who instituted development in the spring of 1904. A 100-ton smelter (Pl. IX) was completed in 1905, and although it has been necessary to haul coke 110 miles consistent development has been carried on with the returns from three short smelter runs—one in 1907, one in 1908, and another in 1911.

Numerous other properties have been located in the district, but they are little developed and most of them have changed hands several times, successive holders becoming discouraged because of the difficulties of transportation.

The total production of Loon Creek district is variously estimated from $1,000,000 to $2,500,000, $500,000 of which is credited to the Lost Packer lode and the remainder to the gold placers during the decade of their activity which closed with 1879. In recent years the placers have produced a small amount, the recovery each year being sufficient to pay assessment costs. The lode production includes both gold and copper, about $150,000 having been derived from the latter. A good grade of lead-silver ore occurs in the district, but little or none has been marketed.

GEOLOGY.

Physiography.—The Loon Creek district is a high mountainous region ranging in elevation from 5,000 to more than 9,500 feet. Loon Creek, a rapid stream, averaging perhaps 30 feet in width, flows north through the area. Its more important tributaries are Mayfield and Cottonwood creeks from the east and Trail Canyon and Grouse creeks from the west. The area is a part of the broad region known as the Salmon River Mountains and preserves on its highest parts the Eocene erosion surface from which those mountains were carved. This feature constitutes the most valuable geologic datum plane in the area. The topography and geology of a part of the district are shown on Plate X.

Sedimentary rocks.—The oldest rocks in the area are mica schists and quartzites of Algonkian age. They outcrop over an irregular area of about 2 square miles in the central part of the district. In most directions they are cut off by quartz diorite which invaded the region in late Cretaceous or early Eocene time, but northward they disappear beneath a capping of quartz latite. These ancient sediments are intensely metamorphosed, a strong schistosity, which strikes west of north and dips southwest, obliterating the bedding structure in most exposures.

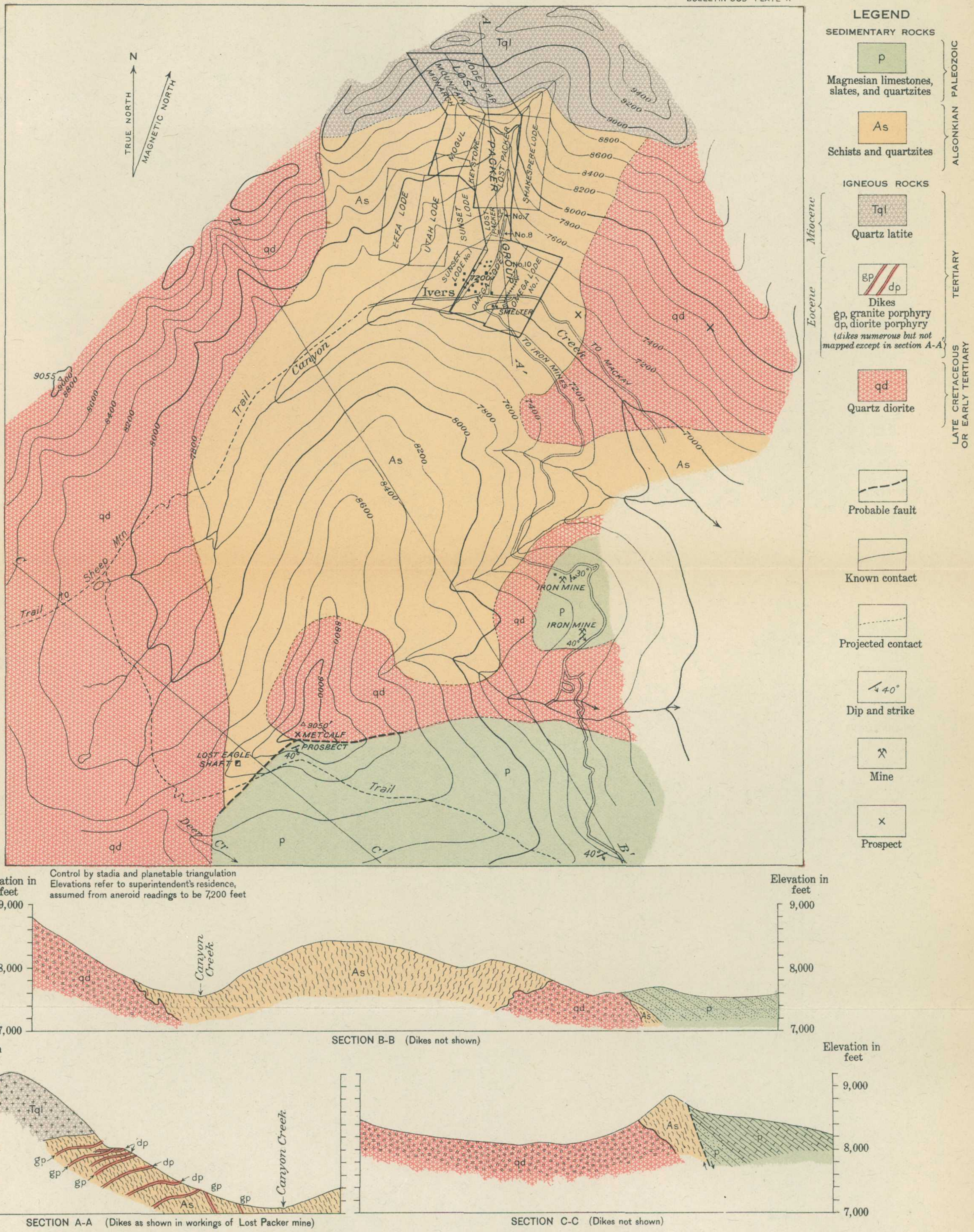
Beds of Paleozoic age overlie the Algonkian deposits and are separated from them by a marked structural unconformity. These beds are confined to the south-central portion of the district. They are steeply inclined to the east, south, or southeast, the direction varying from place to place. Within them schistosity occurs only along special zones of shearing; thus they are readily distinguishable from the underlying Algonkian, from which they differ also in composition.

The Paleozoic beds consist of fine-grained quartzites and massive blue dolomitic limestones, neither of which yielded fossils on a cursory examination. Nevertheless the lithologic similarity of the beds to those at Gilmore, Lemhi County, suggests that the quartzite is of Cambrian age and that the massive blue dolomitic limestone is Ordovician. This assignment is apparently refuted by the juxtaposition of the Algonkian schist with the dolomitic limestone near Lost Eagle mine, but it is thought that this contact records faulting, although, owing to a thick mantle of soil, the relation was not determined with certainty. The thicknesses of the quartzite and dolomite were not determined. Higher horizons of the Paleozoic probably outcrop in the extreme south-central part of the district, but this area was not visited.

Igneous rocks.—Igneous rocks of diversified types and widely different ages are present in the district. The oldest and most important of these rocks is a great batholith of quartz diorite which extends into the area from the west and again crops out along its eastern border. It is a dark-gray rock, composed of oligoclase, quartz, conspicuous amounts of biotite, and subordinate hornblende. Orthoclase, titanite, and apatite are accessory. This batholith is thought to be a phase of the great granitic magma which invaded central Idaho in late Cretaceous or early Eocene time and which now crops out over a continuous area more than 20,000 square miles in extent.

Soon after the quartz diorite invasion came the intrusion of numerous medium-grained granite dikes, peculiar because of their small content of ferromagnesian minerals. These dikes are from 2 or 3 to more than 30 feet in width; yet the texture in all is about the same. In general they follow the schistosity of the Algonkian rocks, but locally they cut across it.

Subsequent to the intrusion of the granite dikes there entered dikes and sills of granite porphyry and diorite porphyry. These dikes are excellently exposed in the Lost Packer mine, where they traverse the ore body in several places (fig. 4, p. 95). On No. 3 level they intersect, but in this place the fine grain and extremely altered



TOPOGRAPHIC AND GEOLOGIC MAP AND SECTIONS OF A PORTION OF THE LOON CREEK DISTRICT, IDAHO

By Joseph B. Umpleby

Scale $\frac{1}{24,000}$

0 ½ 1 Mile

Contour interval 200 feet.
Datum is mean sea level
1913

condition of the specimens collected from the older dike make it impossible to classify it definitely. The younger dike also is altered, but numerous quartz phenocrysts indicate that it is a granite porphyry. Near the portal of No. 6 tunnel the diorite porphyry presents a marginal facies similar in appearance to the older dike in No. 3 tunnel, and this is thought to further indicate that the granite porphyry is the younger intrusion. In the larger dikes a phenocrystic development of quartz characterizes the granite porphyry, but this is lacking in the narrower dikes. The age of these intrusions is not definitely known, although they are thought to antedate the Eocene erosion surface.

Quartz latite flows, still younger than the granite and diorite porphyries, cap the summit above the Lost Packer mine. They rest on an uneven erosion surface of post-Eocene age, but further than this the period of their extravasation is not fixed. They are gray in color and made up of phenocrysts of oligoclase, quartz, and biotite set in a fine-grained groundmass, which constitutes over one-half of the rock and which from partial chemical analysis is known to contain considerable potash. (See p. 26.)

Glacial deposits.—During the Pleistocene epoch glacial ice covered those parts of the area above 8,000 or 8,500 feet and sent tongues down the larger valleys to points about 7,000 feet above the sea, locally perhaps to 6,500 or even 6,000 feet. Evidence of such glaciation is presented by all the larger valleys. At their heads are invariably steep-sided cirques, many of them occupied by small lakes. Below these cirques the canyons are broad and U-shaped for a distance, with morainic material along their sides and bottom, but finally they become narrow and V-shaped. This transition in most places marks the lower limit of glaciation.

ORE DEPOSITS.

GENERAL CHARACTER.

The Loon Creek district comprises an area noteworthy at present because of its gold deposits, including lodes in which chalcopyrite, quartz, and siderite carry the gold, and placers along the streams in favorable places below them. In addition to the gold-bearing lodes, lead-silver deposits are found in the district. These lead-silver deposits have been inadequately prospected, but the ore is of excellent grade, being in many places clean galena that carries from 60 to 100 ounces of silver to the ton.

Iron and lime fluxes are abundant along the contact between the Paleozoic dolomitic limestone and the quartz diorite south of Ivers. They are especially valuable as they contain about 60 cents in gold and 1 ounce in silver to the ton—almost sufficient to pay for handling them.

GOLD PLACER DEPOSITS.

The Loon Creek Hydraulic Placer Co. owns six claims, in all 470 acres, which extend from a point near the mouth of Canyon Creek to the Loon Creek Narrows, 4½ miles north. Their average width is approximately 1,000 feet. A strip about 75 feet wide and 1 mile long, comprising the upper part of the central channel, was worked during the sixties and is variously estimated to have produced from $500,000 to $2,000,000, an occasional pan having yielded as much as $300. These gravels were 2 to 6 feet thick, but back of them are gravel terraces which were not explored during the early days. The present owners prospected these terraces during two seasons and obtained an average yield of 25 cents a cubic yard. A flume capable of delivering 80 second-feet of water to any part of the ground is partly completed, and will probably be in operation in a short time. Heretofore water has been derived from two small streams—Grouse Creek and White Creek—but the present plans include the diversion of Loon Creek at a point well above the placer grounds.

The auriferous gravels rest on a floor of schist, which as now exposed presents a comparatively even surface. The inclosing gravels are usually less than 6 inches in diameter, although in places at various distances from the base of the deposits bowlders as much as 3 feet and a few up to 6 feet in diameter are encountered. As the gravels are loosely cemented they fall apart readily when undermined by the hydraulic giant. The beds are in few places more than 15 or 20 feet thick, although locally they attain a depth of 30 to 40 feet. The gold is near bedrock and in joints and shallow depressions in it. As a rule the gold is coarse, nuggets weighing more than an ounce being not uncommon, and perhaps 50 per cent of the product averages 25 cents or more to the color. The market value is $18 an ounce.

GOLD-COPPER DEPOSITS.

THE LOST PACKER VEIN.

Situation and development.—The Lost Packer vein, the principal lode deposit in the Loon Creek district, crops out here and there along a course extending north from the town of Ivers. It follows roughly a steep, narrow gulch, which within 4,000 feet attains an elevation 2,000 feet greater than that at Ivers. The development comprises eight tunnels which enter along the strike of the vein, the lowest, or No. 10, attaining a depth of 1,000 feet below the quartz latite flow that caps the vein at an elevation of 8,700 feet. The levels are numbered from No. 1, driven 100 feet below the apex of the vein, to No. 10, the lowest, and all except Nos. 5 and 9 connect directly with the surface. (See fig. 4.)

General character of the vein.—The fissure followed by the Lost Packer vein strikes N. 5° E. and dips 75° NW. It has been traced from

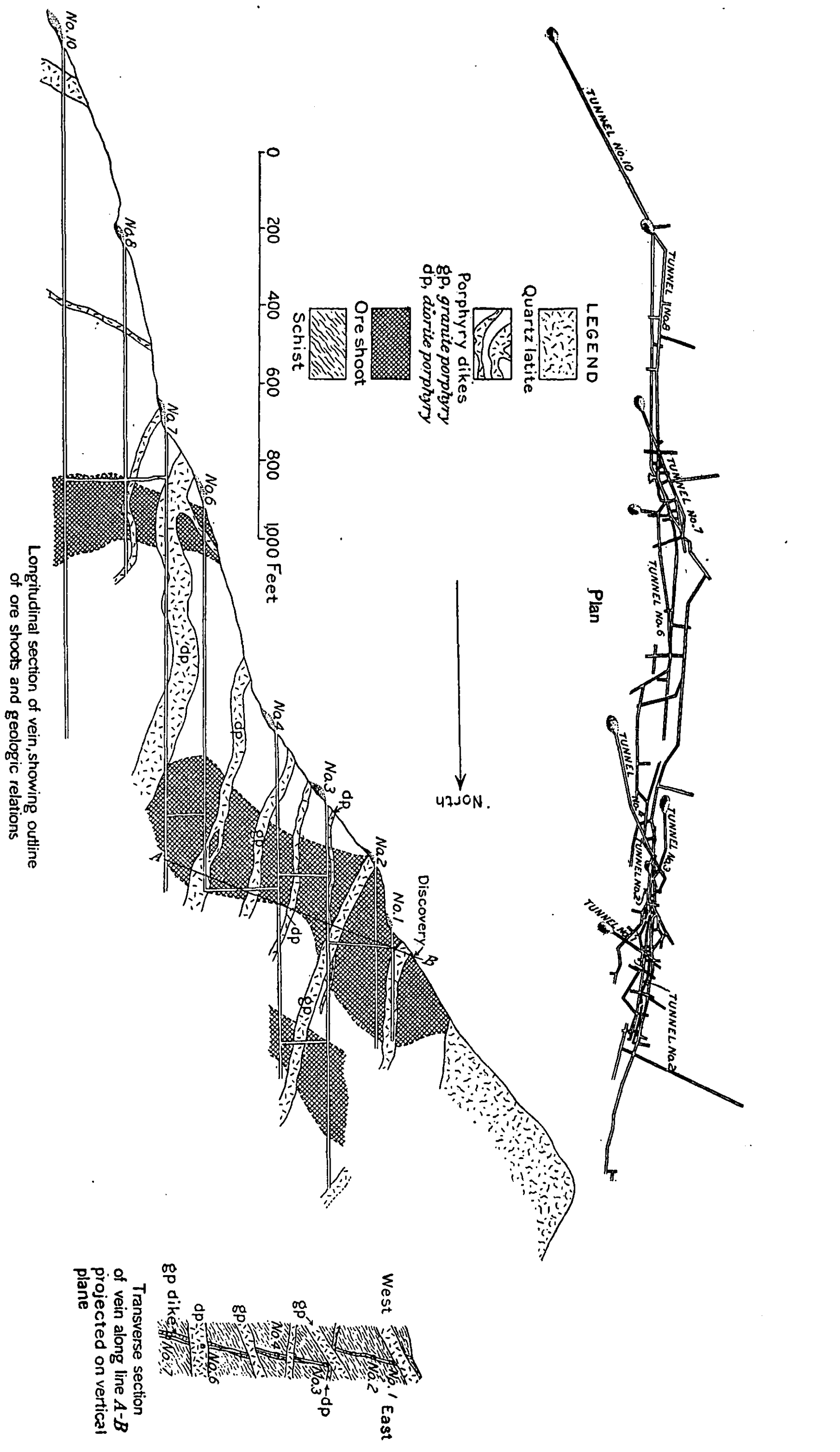


FIGURE 4.—Plan and sections of Lost Packer mine, Loon Creek district, showing the geology.

Canyon Creek, at Ivers, north about 3,000 feet to the dacite cap above the mine. South of Canyon Creek it has not been definitely recognized, although a few small-prospects have been opened on its general course. Northward, where the fissure has been explored by tunnels throughout about 2,000 feet of its extent, it presents well-defined walls, which commonly stand 3 to 5 feet apart, with gouge, sheeted wall rock, and ore between them. The walls present numerous slickensides, but distinct grooves having even an approximately uniform direction were not noted. Within the gouge also there is abundant evidence of shearing and gliding of contiguous parts, all bespeaking important movements along the vein fissure. Most of the movement, however, antedates the ore and determined the channels along which the ore-bearing solutions entered. Evidence of extensive displacement along this plane is apparently lacking; the dislocation probably did not exceed a few score of feet at most.

The fissure traverses the schists and granite dikes but is itself crossed by the granite porphyry and diorite porphyry. In general it cuts the structure planes of the schists, which commonly strike a little west of north at a low angle.

The vein material follows the fissure closely, although in a few places as far as 20 feet from it small lenses of chalcopyrite occur in the schist. Within the fissure the ore is distinct from the gouge and sheeted schist and usually comprises a single band, either next the hanging wall or footwall, more often next to the latter. The ore varies in width from a narrow stringer to 4 or 5 feet, averaging perhaps 20 inches. Along the strike of the fissure mineralization is so localized that three distinct shoots of ore are recognized. Where not vertical each shoot pitches south at a high angle. The shoots are connected on most levels by narrow bands of ore.

Even though ore and gouge are commonly present in the same cross section, it seems that where the walls are farthest apart the ore is widest. This relation suggests that the shoots are determined by a relative movement of the fissure walls sufficient to bring reverse curves opposite each other; a suggestion further supported by the parallel arrangement of the shoots.

The ore.—The ore consists of auriferous chalcopyrite in a siderite-quartz gangue, the relative importance of the three minerals varying markedly from place to place in the same shoot and especially in the different shoots. Thus in the south shoot siderite predominates and in the two others quartz is most important. The relative amount of chalcopyrite is greatest in the middle shoot, where it represents about one-third of the total vein material. The Lost Packer ores are exceptional in the amount of gold associated with the chalcopyrite; assays of this mineral usually show 2½ to 3 ounces of gold to the ton. Equally important with the chalcopyrite as a carrier of gold is the quartz, especially that of the middle shoot, but the siderite as a rule does not contain more than half an ounce of gold to the ton. In both the chalcopyrite and the quartz silver runs about 2½ ounces to the ounce of gold. The total production of the property, about one-half million dollars, has been derived from ore averaging between $80 and $90 to the ton. However, for every ton of this grade which has been encountered in the mine there is estimated to be 2½ tons which average $25.

Mineralogically the ore is comparatively simple; chalcopyrite, siderite, and quartz only are common. A little calcite is present. Pyrite is exceedingly rare, occurring as small grains and cubes, usually included in the chalcopyrite. Pyrrhotite has a similar distribution but is even less abundant. Jennings[1] reports barite as a primary constituent, but careful search during the present studies failed to reveal this mineral. The oxidation products are principally iron oxides and the carbonates of copper. Immediately beneath the surface films of bornite and native copper are locally present, but here also the chief alteration products are malachite, a little azurite, and much limonite and hematite.

Ore shoots.—The three ore shoots recognized in the Lost Packer vein present important differences in constitution and form and hence will be discussed separately. Each stands vertical or pitches south at a high angle.

The north shoot is reached only by No. 4 and No. 3 tunnels. On the former level it is 120 and on the latter 250 feet in length, the average width on each being about 2 feet. The ore consists of coarse-textured milky to bluish-white quartz with chalcopyrite and a little pyrite irregularly scattered through it, the chalcopyrite frequently inclosing small cubes and grains of the pyrite. On No. 3 level siderite is rare, but on the next level below it is equally abundant with chalcopyrite and has a similarly irregular distribution. This ore body is comparatively lean, roughly sorted material running about $20 to the ton—one-half ounce of gold, 2 ounces of silver, and 3½ per cent of copper.

The middle shoot is by far the most important in the mine. It lies 200 feet south of the north shoot and is developed from the seventh level to the quartz latite cap 700 feet above. The southern limit of the ore is a fairly regular line, but the north boundary is not parallel to it. Thus the shoot is about 500 feet long on No. 2 level, narrowing both above and below, its average length being about 300 feet. Locally the shoot appears at the surface as a honeycombed quartz heavily stained by iron together with a little manganese oxide and copper carbonate, but in most places it has little or no surface expression.

[1] Jennings, E. P., The Lost Packer copper-gold lode [Idaho]: Jour. Canadian Min. Inst., vol. 9, 1906, p. 56.

The ore ranges in width from a few inches to 4 or 5 feet, averaging about 20 inches, and wedges out on the ends of the shoot. This wedging out of the shoot seems to bear a definite relation to the tenor of the ore, for it has been commonly found that as the ore body narrows its assay value diminishes. Thus the ends of stopes temporarily abandoned are generally in ore running about $25 to the ton, whereas the portion removed averaged between $70 and $90 to the ton. On No. 4 level the shoot is shorter than elsewhere in the mine and here also it contains a minimum amount of gold to the ton. Ore from levels both above and below contained 2 to 3 ounces to the ton, but here less than 1 ounce was present.

The ore consists essentially of chalcopyrite distributed as bunches, small patches, irregular grains, and interstitial fillings in a gangue of coarse white quartz. The chalcopyrite constitutes about one-third of the total material mined. Siderite is present in small quantities, but is nowhere an important constituent. The chalcopyrite and quartz each carries about 3 ounces in gold to the ton, but less than half an ounce is present in the siderite.

The south shoot of ore differs markedly from the other two in its high content of siderite. It lies 500 feet south of the middle shoot, and is developed from No. 10 level to its outcrop near the portal of No. 6 tunnel. This ore body ranges in length from 75 to 150 feet and is about 20 inches wide. It consists of siderite and chalcopyrite intergrown with coarsely crystallized quartz in such proportions that the ore runs 26 per cent of iron and 4½ per cent of copper. Gold and silver averaging half an ounce and 3 ounces respectively are present. This ore body is a valuable asset to the mine because it combines a fair amount of the precious metals and copper with an excess of iron, an element which must be added in the smelting of ores from the other shoots.

Considerable ore was blocked out in the mine at the time of visit, and this was materially increased during the last year. Returns from the last smelter run were used to extend No. 7 tunnel beneath the north shoot and No. 10 tunnel beneath the middle shoot (fig. 4, p. 95).

UNDEVELOPED VEINS.

A description of the Lost Packer vein constitutes essentially a description of the known gold-copper deposits of the district. Other veins are recognized, but they are little developed and have produced only returns from test samples. Among these, the Effa ledge, which outcrops a few hundred feet west of the Lost Packer vein, is promising. The Sunset and South Packer groups also present some encouragement to the operators, although the small amount of development on them has not revealed commercial deposits.

SILVER-LEAD DEPOSITS.

Silver-lead deposits have been found near the dolomite area south of Ivers. The Lost Eagle claim and the Metcalf group are the principal properties, but neither is sufficiently developed to afford a satisfactory idea of the nature or extent of this ore body. Their occurrence, however, is thought to be of special significance, and therefore they will be described briefly. The Lost Eagle claim is situated on the divide between Canyon and Deer Creek cirques, at an elevation of 8,800 feet above sea. It is inclosed in Algonkian schist, though removed but a few hundred feet from an area of Paleozoic dolomitic limestones. Development consists of a shaft 50 feet deep and a short drift from it. The vein, which strikes N. 5° W. and dips 85° SW., is about 6 feet wide and bordered by well-defined walls. Between them is crushed wall rock with bands and interstitial areas of argentiferous galena, pyrite, and a little chalcopyrite in a quartz-siderite gangue. (See Pl. VIII, *A*, p. 44.)

The Metcalf property, situated about 1,000 feet northeast of the Lost Eagle shaft, contains an irregular vein partly developed for about 100 feet along its outcrop. The deposit is a fissure filling inclosed in granite near its contact with Paleozoic dolomitic limestone. The ore consists of argentiferous galena, which fills the fissure almost exclusively and ranges in width from a narrow stringer in most places to 3½ feet in other places. The galena contains about 1 ounce of silver to the unit of lead.

In each of the deposits just described the amount of ore actually found is not of so much significance as its geologic occurrence. Both deposits as now known are inclosed in rocks which are not nearly as favorable to the deposition of lead ore as is limestone, even when impure; hence, in the opinion of the writer, the area of dolomitic limestone adjacent to these deposits should be encouraging territory for the prospector. In the few places where time permitted an examination of the limestone area it was found to be rather intensely mineralized, as illustrated by the three iron mines which supply flux to the Ivers smelter, each of which is in a deposit of pyrite, now oxidized, which has replaced the dolomitic limestone.

AGE AND GENESIS.

The Loon Creek deposits crop out at elevations ranging from 7,200 to more than 9,000 feet; the greatest elevation is essentially that of the present Eocene erosion surface. As the mineralogy of the deposits clearly indicates deposition at great depth, a depth probably exceeding 3,000 or 4,000 feet for the Lost Packer vein, where pyrrhotite occurs, it is evident that the veins were formed before the close of the Eocene epoch. On the other hand, the

Metcalf deposit is inclosed in granite and the Lost Packer cuts across granite dikes; thus the deposits are postgranitic. If the granite caused or accompanied the elevation which resulted in the Eocene erosion surface, as brought out in another paper,[1] it follows that the age of these ore deposits is limited to the late Cretaceous or early Eocene.

The genesis of the deposits is not susceptible of as satisfactory analysis. From broad considerations discussed on page 45, it is concluded that these deposits are genetically related to the quartz diorite intrusion. Just what part that intrusion played, however, is not clear. It is certain that two distinct types of ores were deposited, namely, gold-copper ores and silver-lead ores. Both occupy fissures, but the former are in schist and the latter not far removed from thick beds of dolomitic limestone, thus suggesting the possibility that the beds traversed by the solutions exercised some control on the nature of the deposits. But to accept this view it seems necessary to suppose that the metals either were derived in large part from the stratified rocks or that the different rocks precipitated different metals from the same magmatic solutions. The latter view seems more tenable, as if the intrusion served only to stimulate meteoric circulation, ore deposits should occur in connection with the later intrusions also. It is thought, therefore, that the Loon Creek ore deposits owe their origin to solutions given off from the quartz diorite magma during the later stages of its consolidation.

A study of the sequence in which the minerals were formed brings out some interesting facts in the deposition of the ores. In both the gold-copper and the silver-lead deposits siderite was the earliest mineral to form, followed by chalcopyrite and quartz in the former, and galena and quartz in the latter. Chalcopyrite, galena, and quartz replace the siderite, as shown by their protuberances and the thin films of them which follow fractures and cleavage planes in the siderite. This seems to indicate that in their early stages the solutions were highly charged with carbon dioxide, and that later the copper and lead-bearing compounds, possibly chlorides of these metals plus hydrogen sulphide, became of paramount importance in the solutions.

[1] Umpleby, J. B., An old erosion surface in eastern Idaho; its age and value in time determinations: Jour. Geology, vol. 20, 1912, pp. 139-147.

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