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LEAD-ZINC-COPPER DEPOSITS OF THE BIRCH CREEK DISTRICT,
CLARK AND LEMHI COUNTIES, IDAHO

By

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Moscow, Idaho
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LEAD-ZINC-COPPER DEPOSITS OF THE BIRCH CREEK DISTRICT,
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Alfred L. Anderson and Warren R. Wagner

ABSTRACT

This report describes the lead-zinc-copper deposits in the Birch Creek district in Clark and Lemhi counties in the east central part of Idaho. The deposits form irregular and pipe-like replacements in complexly folded and faulted Paleozoic limestone and quartzite along the southwest margin of the Beaverhead Range. The production has been estimated at between $2,500,000 and $5,000,000, most of which represents the output during the late eighties. Operations have continued intermittently to the present time, but production since the eighties has been small. The outlook is for continued small production of base metals for some time to come.

INTRODUCTION

PURPOSE AND SCOPE

The mines in the Birch Creek district were among the most important in Idaho during the late eighties; but interest in the district rapidly dwindled after several years of feverish activity when the Viola, the largest and most productive mine, suspended operations. Since then the district received little except local attention, but it remained active in a small way and continued to make some shipments of ore annually. With the present large War demands for metal, interest in the Birch Creek and other formerly productive mining districts in the state has been revived and has been accompanied by speculation as to whether all the ore in the old mines was exhausted in the early days and whether work in some of the more recently active mines might be successfully expanded.

As a part of its contribution to the War effort, the Idaho Bureau of Mines and Geology has undertaken a study of these once more active mining districts, hoping to find out whether the decline in mining was due altogether to depletion of ore reserves and whether knowledge of geologic controls of ore deposition might not lead to the discovery of new ore bodies, thus bringing about an increase in the production of needed metals. The results of the study in the Birch Creek district show that exhaustion of ore in the largest mine was responsible for the early decline in mining but that ore still remains in the more recently active mines and that the reserves may even be increased by additional development and discoveries. The nature of the deposits is such as to discourage large-scale mining, but the outlook is favorable for continued small production for some time to come.

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Because of the immediate need for data on the mines and ore, geologic problems other than those concerned directly with the mineralization and the occurrence and distribution of ore received little attention. Detailed study was confined strictly to the mines and the geology in their close vicinity and dealt particularly with the structural features in control of ore deposition, which might prove invaluable in the search for new ore bodies and for delineating the limits of the known bodies. The investigation was centered at and about the Scott, Weimer, Worthing-Kauffman, and Viola mines.

FIELD WORK AND ACKNOWLEDGMENTS

The field studies continued from mid-June until late July 1943. As there were no adequate surface maps and no available mine maps, except at the Worthing-Kauffman, considerable time had to be spent with plane table and stadia rod in the preparation of topographic base maps and also with Brunton and tape in surveys of the underground workings. As most of the workings at the Weimer mine were inaccessible, neither surface nor subsurface mapping was attempted. Neither was a surface map made at the Worthing-Kauffman mine, but only because of the pressure of time. Thus the plane table and Brunton work was confined entirely to the Scott and Viola mines, but the others were examined and the Worthing-Kauffman workings mapped geologically using the available map as a base.

Much assistance was received in the field from operators in the district. Mr. George Brunt, President of the Birch Creek Mining Company, arranged lodging at the Scott mine and gave considerable information on the occurrence of ore at the mine and on the mine's history. Mr. Earl Arape, lessee at the Viola mine, provided lodging at the Viola mine and assisted in the surface and underground mapping. Mr. Milo Zook, who spent a day at the Viola mine, gave much information on the later work at the camp. Mr. F. G. Worthing, operator of the Worthing-Kauffman mine, gave his services as guide and pointed out features of pertinent interest. Grateful appreciation is extended those who aided so generously in the work.

PREVIOUS GEOLOGIC WORK

The mines have been mentioned in several regional geologic reports, but they have been the subject of only one detailed investigation previous to the present work. Several other publications contain descriptions of Birch Creek Valley and the bordering terrane, but they make no mention of the mines or mineralization. The publications that in any way bear on the geology of the Birch Creek district are listed in the bibliography that follows. The most pertinent data are in the reports by Shonon and Upleby.

Bell, R. N., Annual reports of the mining industry of Idaho. Particularly for 1906, 1907, and 1917. Contain brief descriptions of the mines in the Birch Creek district and some notes on the geology.

Campbell, Stewart, Annual reports of the mining industry of Idaho, 1918-1928. Contain summaries of the mining activities in the various mining districts of Idaho and lists of mining companies and officers.
Kirkham, V. R. D., A geologic reconnaissance of Clark and Jefferson
and parts of Butte, Custer, Fremont, Lemhi, and Madison
 counties, Idaho; Idaho Bureau of Mines and Geology Pamphlet
No. 13, 1927. Discusses the broader topographic and
structural features of the region and treats briefly the
building stone, coal, and road material.

Shannon, E. V., Minerals of Idaho; U. S. National Museum Bull. 131,
1926. Mentions and describes some minerals found in the
Birch Creek district.

Shannon, P. J., Geology and ore deposits of the Birch Creek district,
Idaho; Idaho Bureau of Mines and Geology Pamphlet No. 27,
1926. The most comprehensive and detailed discussion of
the geology and mineralization of the Birch Creek district
to date. Fairly detailed descriptions of the mines and
prospects. Geologic sketch map covering approximately 158
square miles.

Stearns, H. T., and Bryan, L. L., Preliminary reports on the geology and
water resources of the Mud Lake Basin, Idaho; U. S. Geol.
Survey Water Supply Paper 560-D, 1926. A brief description
of the geology and topography of the Mud Lake drainage
basin, including the Birch Creek area.

Uempley, J. B., Geology and ore deposits of Lemhi County, Idaho; U. S.
Geol. Survey Bull. 522, 1913. Reconnaissance map and
description of the geology of Lemhi County. The report
contains a short description of the Viola mine.

---------Geology and ore deposits of the Mackay region, Idaho; U. S.
Geol. Survey Prof. Paper 97, 1917. Brief descriptions of the Scott, Weimer, and Worthing and Weaver
(Worthing-Kauffman) mines.

GEOGRAPHY

LOCATION

The Birch Creek district is close to the Montana line (fig. 1), somewhat
more than half the distance from the Canadian border to the Utah State line. It
extends along the front of the Beaverhead Range on the northeast side of Birch
Creek Valley from a point not far north of Nichol to the edge of the Snake
River Plain about 30 miles to the southeast. Much of it is within a rectangle
bounded by parallels 40°00' and 40°25' north latitude and 112°50' and 113°00'
west longitude. A little less than half of the district is in Lemhi County, the
remainder is in Clark County. The district includes smaller divisions sometimes
known as the Nichol, Skull Canyon, and Buck Creek districts.

TOPOGRAPHY

The Birch Creek district is in the Northern Rocky Mountain physiographic
Fig. 1. Index map showing location of the principal mines in the Birch Creek District.
province, but the region seems more like a part of the Great Basin country than of the Northern Rocky Mountains. It has ranges of great linear extent, which are separated by broad arid basins like those of Utah and Nevada, and it does not resemble the broad dissected upland country that characterizes most of the Northern Rockies in Idaho. Birch Creek Valley, from which the district takes its name, is part of a broad arid basin, hemmed in on two sides by long narrow mountain ranges, the Beaverhead Range on one side and the Lemhi Range on the other (pl. I. A).

Birch Creek Valley makes up part of a long intermontane trench or basin that stretches northwest from the Snake River Plain to Salmon, Idaho, a distance of about 150 miles. The 40 miles of the basin occupied by Birch Creek is known as Birch Creek Valley; the remainder, occupied by the Lemhi River, is known as the Lemhi Valley. These two valleys head across a low broad divide, Birch Creek Valley sloping gently southeast toward the Snake River Plain, Lemhi Valley as gently to the northwest. Valley floors are 5 to 8 miles wide and are as wide at the valley heads as at the mouths. Where Birch Creek Valley opens upon the Snake River Plain (pl. I, B), the valley floor stands close to 5,600 feet; where it joins the Lemhi Valley, the floor is at 7,200 feet. The valley is singularly straight and the bounding ranges rise abruptly from the valley floor to altitudes above 10,000 feet.

The Beaverhead Range has an imposing front that rises like a straight-walled escarpment 2,000 to 5,000 feet above the Birch Creek and Lemhi valleys. The escarpment is cut by widely-spaced, sharply-incised canyons, which terminate abruptly at the base of the range; but otherwise, the front is unbroken, except for a small segment that projects 3 miles from the front of the range about half way down Birch Creek Valley. Back of the frontal escarpment the slope becomes gentle and the summit of the range has a topography of low, rolling hills characteristic of an old erosion surface. Where the range borders Birch Creek Valley, it has a remarkably uniform skyline unmarred by peaks, but toward its southeast and the skyline becomes lower and lower and then drops more steeply to meet the level of the Snake River Plain.

Birch Creek, which gives Birch Creek Valley its name, rises north of Nicholoria, having Willow, Smelter, and Mud creeks as its headwaters. These drain from the Beaverhead Range; but from Nicholoria southeast to the Snake River Plain there are no permanent tributaries and the canyons carved in the range carry water only after heavy or prolonged rainfall or when fed by rapidly melting snows. Birch Creek has a good flow of water until it approaches the Snake River Plain. Then the flow dwindles and the stream finally disappears into the sands and gravels as it reaches the Snake River Plain.

CLIMATE AND VEGETATION

Since the district is far inland and between one and two miles above sea level, it has a rigorous continental climate, which, because of the considerable relief, is rather diversified. No records of rainfall and temperature are available, but the character of the vegetation on the floor of Birch Creek Valley suggests an arid climate in the lower part of the district with perhaps less than 10 inches of rainfall, whereas the vegetation on the upper slopes of the Beaverhead Range indicates a more humid climate with perhaps twice the precipitation of the valley. Because of the altitude, the average temperature for the
A. BIRCH CREEK VALLEY

View diagonally across a part of Birch Creek Valley showing the Lemhi Range on the other side.

B. BIRCH CREEK VALLEY AND THE SNAKE RIVER PLAIN

View from the mouth of Birch Creek Valley looking out upon the Snake River Plain. Scott mine camp in the foreground.
year is probably about 40°. The summers are moderately warm. The daily range in temperature is considerable, and even though the days may be hot, the evenings are invariably cool. The winters are severely cold with subzero temperatures not uncommon. Except for three months of the year, much of the precipitation is in the form of snow. The snow may linger on the higher slopes throughout most of the year, but it remains on the valley floor for less than five months. Summer showers of short duration are not unusual.

Except for a line of willows along the stream, the floor of Birch Creek Valley is covered with sagebrush. The sagebrush extends well up the mountain slopes, even upon the summit itself where it has to compete with groves of evergreen trees and mountain mahogany, particularly on upper north slopes and other spots sheltered from the wind and the more direct rays of the sun.

ACCESSIBILITY

Birch Creek Valley, though remote, is within easy reach of rail transportation and supply centers (fig. 1). The southeast end of the district is about 60 miles northwest of Idaho Falls, and the north end about 90 miles northwest of Idaho Falls. The north end is only a little over half the distance between Idaho Falls and Salmon.

Idaho State Highway 28 extends the full length of Birch Creek Valley and Lemhi Valley and serves as the most direct route between Idaho Falls and Salmon. The State Highway leaves U. S. Highway 91 about 27 miles north of Idaho Falls and strikes directly across the Snake River Plain to the mouth of Birch Creek Valley. The highway has a light oil surface as far as Mad Lake and is gravelled from that point on to Salmon. Through Birch Creek Valley the highway is wide enough for three lanes of traffic. Future plans call for an oil surface.

State Highway 22 crosses Highway 28 near the mouth of Birch Creek Valley and gives access to Dubois, the county seat of Clark County, and to Arco, the county seat of Butte County.

Before Highway 28 was built, the district was served by secondary roads from Dubois, then the shipping point and supply center for the mines in the southeastern part of the district, and from Gilmore, then the shipping point and supply center for the mines in the northwestern part of the district. In 1939 the rail line that connected Gilmore with Armandet, Montana, was abandoned and the tracks removed. At present, the ores of the entire district are trucked over Highway 28 to Roberts on the Oregon Short Line (Union Pacific System) between Dubois and Idaho Falls. The chief supply center is now Idaho Falls.

Mail is received biweekly at the Reno post office about 25 miles up Birch Creek Valley and about 50 miles west of Dubois.

Graded roadways lead to each of the mines, two of which are perched high up on the front of the Beaverhead Range.
The part of the Beaverhead Range within the Birch Creek district is carved almost entirely in intricately folded and faulted Paleozoic strata. These strata have been out by a few small bodies of Tertiary porphyritic and granitic rock and in places partly concealed beneath remnant caps of Tertiary lava and "lake beds." In Birch Creek Valley the Paleozoic rocks and much of the Tertiary lava and strata are covered by Quaternary gravels.

The short time in the district did not permit much study of the Paleozoic and other rocks nor of their complicated structural relations. Much of the folding and faulting apparently took place during late Mesozoic time, but there was further crustal unrest in the Tertiary and Quaternary periods. It was during one of the late disturbances that the Beaverhead Range and Birch Creek Valley came into existence as topographic and structural entities.

**STRATIGRAPHY**

**Paleozoic Sedimentary Rocks**

Much of the Beaverhead Range appears to be carved in Carboniferous strata, but beds at least as old as Ordovician are exposed along the greatly faulted southwest slope of the range. These oldest rocks are composed of quartzite formerly regarded as Cambrian 1/, but now known to be identical with Ordovician quartzite in the neighboring Lemhi Range 2/. Other strata along the zone of deformation have been identified as Devonian, Mississippian, and Pennsylvanian. Some calcareous beds, which seemed to be stratigraphically lower than the quartzite, may be Cambrian; but no fossils were found in them, and the possibility that they may be younger beds faulted to levels below the Ordovician rocks cannot be excluded. Some dolomitic beds above the Ordovician quartzite may be Upper Ordovician.

**Ordovician System**

The Ordovician quartzite comprises the most easily recognized unit in the district, partly because there are no other rocks similar to it, and partly because its resistance to erosion makes it topographically conspicuous (pl. 2, A). The quartzite crops out at each of the mines, always within a few hundred feet or yards of the ore deposits. It also crops out elsewhere along the front of the range.

More than 600 feet of beds are visible with the base of the formation unexposed. The greatest thickness and the best exposures are in Skull Canyon just below the Weimer mine. The lower 400 feet is mainly well-bedded, maroon and pink quartzite, which upward grades into massive, white, vitreous quartzite.

1/ Shenon, P. J., Geology and ore deposits of the Birch Creek district, Idaho: Idaho Bureau Mines and Geology Pamph. No. 27, pp. 5-7, 1928.
A. OUTCROP OF ORDOVICIAN QUARTZITE

Bold outcrop of Ordovician quartzite at the head of Cedar Canyon just south of the Viola mine. Camp buildings and mine dumps on the Nichola Fraction are shown in the foreground.

B. SURFACE WORKINGS AT THE VIOLA MINE

Picture shows the large open cut on the former outcrop of the Viola ore body beneath which zinc carbonate ore has been found. Much of the wall on the right side of the cut contains zinc ore.
which is sandy in the upper 75 feet. Just the white vitreous quartzite is ex-
posed at the Scott, Worthing-Kauffman, and Viola mines. The quartzitic beds are
regarded as Middle Ordovician 1/.

Beds of dark gray dolomite lie above and are apparently conformable with
the quartzite at the Viola mine, but within a few tens of feet the beds are cut
off by a fault. Similar beds seem to be associated with the quartzite at the
Worthing-Kauffman and Weimer mines; but at the Worthing-Kauffman the relations
have been obscured by faulting, and Devonian strata lie in close proximity to
the quartzite. Detailed stratigraphic studies may reveal a considerable thick-
ness of Upper Ordovician dolomite.

Devonian System

Shenon reports an Upper Devonian fauna 2/ in several hundred feet of dark
fissile shale and thin-bedded, bluish-gray magnesian limestone near the Worthing-
Kauffman mine and infers that the same beds are present at the Weimer mine.
Beds of dark-gray limestone or dolomite with much black cherty material were
noted a short distance east and south of the Viola mine. No fossils were obser-
ved in the poorly exposed outcrops, but the lithology suggests correlation with
Middle Devonian strata in the Lost River Range to the west. Further search may
reveal a thick and perhaps complete section of Devonian strata.

Mississippian System

The Mississippian beds are widely distributed throughout the district.
They comprise a monotonous succession of bluish-gray massive and thin-bedded
limestone and a few beds of dark gray shale measuring altogether several thou-
sand feet thick. Some of the limestone is conspicuously cherty, the chert stand-
ing out as black knots and pods in the light grayish, weathered limestone. Some
beds contain cup corals, others are composed largely of crinoid stems, but there
are great thicknesses that have no fossils whatsoever. Just west of the Viola
mine the massive limestone beds have been faulted against the Ordovician
quartzite.

Pennsylvanian System

Pennsylvanian beds are also widely distributed. They apparently measure
several thousand feet thick and, where they have been faulted against the Ordo-
vician quartzite at the Scott mine, they include several hundreds of feet of
buff-colored sandstone and interbedded gray, sandy, limestone, and also a con-
siderable thickness of light and dark bluish-gray limestone with some intercal-
ated grayish shale. The grayish limestone and a little of the shale are exposed
in the mine, but much of the shale and the darker limestone appear in the gulch
and on the ridge east of the mine. About half way to the top of the ridge these

1/ Ross, C. P., Correlation and Interpretation of Paleozoic stratigraphy in
rocks pass beneath about 100 feet of highly cherty, dark gray limestone, which stands out as a conspicuous marker. On above are beds of light weathering limestone alternating with beds of dark color. Some of the upper limestone is crinoidal and many beds carry scattered cup corals. According to Shoen 1/, fossils identified by George Girty of the U. S. Geological Survey as Lower Pennsylvanian, were found in a bluish-gray sandy limestone not far below the massive cherty limestone. Similar rocks are exposed in Skull Canyon west of the Ordovician quartzite and also on the top of the ridge above the Weimer mine.

Tertiary (1) Sedimentary Rocks

Sedimentary rocks tentatively regarded as Tertiary are exposed at the Scott mine resting unconformably on an eroded surface of Ordovician quartzite and Pennsylvanian sandstone and limestone. They are partly covered by basalt. The sequence is about 230 feet thick and includes a basal limestone breccia locally as much as 100 feet thick which is covered by a series of white and pale buff clays and light gray volcanic ash. The breccia is well compacted and the clays and ash above well indurated. The latter, however, are not particularly resistant to erosion and remain only because of a protecting cap of basalt. Some wood fragments were noted in the ash and clay beds, but no attempt was made to establish the identity and age of the wood. The strata resemble some of the horizons in the Challis volcanics (Oligocene and Miocene) in the region to the west.

Much Tertiary sedimentary material also underlies upper Birch Creek and Lemhi valleys, beginning a short distance north of Nisholla and extending almost to Leadore. Most of the exposed strata appear to be made up of light-colored "lake beds" with intercalated volcanic ash.

Quaternary Sedimentary Rocks

The Quaternary sedimentary rocks include the narrow strip of gravelly alluvium along Birch Creek and the extensive fan-shaped deposits that extend outward from the mouths of the canyons in the mountains that border Birch Creek Valley. The deposits cover most of the floor of Birch Creek Valley and extend over the divide into Lemhi Valley, encircling the area of Tertiary "lake beds."

The deposits probably represent the accumulated products of erosion of the Beaverhead and Lemhi ranges since they came into existence, perhaps in late Tertiary or early Quaternary time. They are made up largely of rounded pebbles and boulders of quartzite and chert with lesser amounts of limestone and igneous rock. The proportion of limestone pebbles increases from the center toward the margins of the valley. So far as known, no wells have been drilled through the gravels, but it is likely that the deposits range up to more than a thousand feet thick.

Tertiary Intrusive Igneous Rocks

The intrusive igneous rocks include a small body of granite, several dikes

of rhyolite prophyry, and a dike each of dacite porphyry and basalt. The body of granite and the dikes of rhyolite porphyry are in the northwest part of the district near the Viola mine; the other two dikes are in the southeast end of the district at and near the Scott mine. The general relations suggest that the granite and rhyolite porphyry were intruded earlier and solidified at considerably greater depth than the intrusives in the other part of the district.

Granite

The granite is not that previously mentioned by Umpleby 1/ and Shenon 2/ on Willow Creek about 4 miles north of Nicholka, but is a new find in the immediate vicinity of the Viola mine. The body of granite may be traced over the ridge just south of the Viola mine (fig. 8) into and across deep rocky Cedar Canyon, where much of it is concealed beneath broken blocks of quartzite. Granite float for at least a thousand feet on the opposite side of Cedar Canyon suggests that the body is not less than 2,000 feet long. The shape and size of the body is distinguishable because the granite has been less resistant to weathering and erosion than the quartzite and is outlined as a shallow depression partly filled with blocks of quartzite from the higher slopes. The body passes under the crest of the ridge beneath a thin cap of quartzite but reappears just back of the old Salmon shaft. The body measures as much as 400 feet across.

Most of the granite in the outcrop and float resembles and may be easily mistaken for the surrounding quartzite. Much of it contains conspicuous lumps of quartz, especially prominent on weathered surfaces, and shows transition to rock composed largely of quartz with scattered embedded grains of feldspar. It also shows transition into a typical moderately coarse-grained, mottled, pinkish, and grayish granite composed of quartz and pinkish potash feldspar, subordinate grayish plagioclase feldspar, and minor amounts of chlorite, apparently an alteration product of original biotite. The feldspars are very much altered and it is difficult in thin section to distinguish between the two varieties. Orthoclase, highly sericitized and kaolinized, appears to be much more abundant than similarly altered plagioclase. Some of the orthoclase holds numerous remnants of quartz which are visible in the thin section orthoclase, but most of the orthoclase, as well as the plagioclase, is penetrated and partly replaced by large lobate quartz grains. Additional minerals revealed by the microscope are rather numerous grains of s phene and abundant small grains of hematite. The rock seems largely a granitized quartzite, which where completely granitized, is a typical granite.

The granite apparently was emplaced after the quartzite had been folded and faulted and therefore after Mesozoic deformation. The granite is much more alkali than the rock that composes the Idaho batholith (Cretaceous) and probably belongs to the group that was intruded in early Tertiary time. Data bearing on the early Tertiary age of this and other similar rocks will be presented in a later report.

Rhyolite Porphyry

The dikes of rhyolite porphyry are all exposed in the Dunn tunnel which has been driven in the granite. Three of them have been cut, the largest measuring 18 feet across and the smallest 6 feet.

The rhyolite porphyry is a light-colored, rather inconspicuously porphyritic rock, yet containing fairly numerous quartz and orthoclase phenocrysts 1 to 2 millimeters long in a fine-grained, microgranular groundmass composed of orthoclase and minor amounts of quartz. Most of the phenocrysts show resorptive effects. The rock appears to be bleached and contains considerable sericite, formed perhaps by the action of end-stage hydrothermal solutions.

The rhyolite porphyry is younger than the granite, but its close association with the granite suggests that it is not much younger and may be a late phase of the early Tertiary magmatic activity.

Dacite Porphyry

The dike of dacite porphyry is exposed at the Peterson prospect about a mile north of the Scott mine. The rock is conspicuously porphyritic and contains numerous white plagioclase phenocrysts about 1 millimeter long embedded in a brownish, decidedly glassy groundmass, which shows flow structure. The plagioclase is fairly calcic and has been reported by Shenon 1/ to have the composition of labradorite. A few grains of quartz and pyroxene also are present as phenocrysts.

Because of the abundant glass the magma must have been quickly chilled and probably solidified not far below the then existing surface. The exact time of its intrusion cannot be determined, but as the glassy groundmass shows no signs of devitrification, the dike probably cannot be older than Tertiary and perhaps not so old as the granite and rhyolite porphyry in the other end of the district. It may have been a feeder to flows belonging to the Challis volcanics (Oligocene) which have since been stripped away by erosion.

Basalt

The dike of basalt is exposed underground in the Scott mine in and alongside the old vertical shaft. The dike is about 3 feet wide and is composed of a dark gray, highly vesicular, fine-grained rock, which is somewhat denser and finer-grained near the walls than toward the center. Much of the basalt is almost spongy in appearance because of the numerous closely-spaced vesicles. Some of the larger vesicles are partly filled with calcite. The rock is made up of plagioclase feldspar (sodic labradorite) and lesser augite and magnetite. Secondary minerals include calcite, limonite, and iddingsite (perhaps an alteration product of original olivine).

The dike is probably a feeder to the basalt flow which remains as a remnant cap on the hill just west of the mine. Probably less than 100 feet of the dike has been removed by erosion.

Tertiary Extrusive Igneous Rocks

The extrusive rocks include flows of basalt and rhyolite, which are not found together and of which only remnants remain. These flows differ in age, the rhyolite apparently being younger than the basalt.

Basalt

The basalt caps three small buttes in the vicinity of the Scott mine and also covers a number of square miles of Birch Creek Valley northwest of Kaufman. All the basalt seems to be alike and is dark gray, fine-grained, vesicular, with pronounced jointing. The rock is inconspicuously porphyritic and contains a few small scattered labradorite phenocrysts in a matrix of smaller labradorite laths and intergranular augite and magnetite. A little olivine also is present.

The basalt has been faulted near the Scott mine and on each butte the flows dip in a different direction. At Kaufman the basalt has been faulted against the base of the Beaverhead Range, which indicates that its extrusion was prior to the faulting that blocked out Birch Creek Valley in late Tertiary or early Quaternary time. Since the flow at the Scott mine apparently rests conformably on the Tertiary (?) "lake beds" it may, as pointed out by Kirkham 1/, belong to the early Tertiary lava series (probably the Challis volcanics of Oligocene or early Miocene age).

Rhyolite

The rhyolite belongs to the series of acidic lavas that flank the Snake River Plain 2/ and is exposed at the end of the Beaverhead Range in the extreme southeast part of the district. It covers the lower slope of the range, except where it has been stripped off by erosion, and like the end of the range, is tilted toward and disappears beneath the surface of the Snake River Plain. One small remnant remains of the crest and flank of a low hill at the mouth of Birch Creek Valley just a few hundred feet east of the highway. Several miles to the northeast the rhyolite forms almost a continuous blanket on the end of the range.

The rhyolite near the mouth of Birch Creek Valley is pinkish, inconspicuously porphyritic, and shows a prominent fluidal banding. The few phenocrysts are composed of small glassy crystals of sodic plagioclase and orthoclase embedded in a pinkish, decidedly glassy groundmass.

The rhyolite belongs to the late Tertiary acid series as defined by Kirkham 3/.

STRUCTURE

The rocks of the district have been folded and faulted with the structural

relations particularly complex along and adjacent to the front of the range bordering Birch Creek Valley. Much of the faulting appears to be closely associated with the folding, but some of it is younger.

Folds

The folds comprise broad anticlinal structures on which are numerous minor folds. The structural trend is northwest, but in places faulting has caused local departures. Most of the folds are steeper on northeast than on southwest sides, indicating overturning toward the northeast. The folding appears to be more intense along the mountain front and to decrease in intensity toward the northeast, highl y complex folds giving way to those of simpler outline. Near the center of the range the dominant folding appears to be synclinal.

The folding apparently took place during late Mesozoic time and may in considerable part reflect the Laramide orogeny at the close of the Cretaceous. Just how much of the earlier Jurassic disturbance, which preceded the emplacement of the Idaho batholith in Cretaceous time, may also be involved cannot be known until more detailed study has been made of the structural and stratigraphic features over a much larger area. Kirkham interprets the low-angle overthrust at Medicine Lodge Creek, 15 miles northeast of Birch Creek, as one of the series of low-angle overthrusts produced during the Laramide disturbance. There folded Paleozoic strata have overridden Triassic beds.

Faults

The faulting seems especially localized along the zone of more intensely deformed rock of the mountain front. The faults are numerous and show much diversity in magnitude, age, trend, and direction of movement. The largest and most prominent, as well as many of the minor faults, trend northwest in the long direction of the range, but there are also some of considerable magnitude as well as smaller ones that trend in more northerly, northeasterly, and westerly directions.

Many of the faults appear to have accompanied or to have been more or less closely associated with the folding. Among these are the faults that have brought limestone of Middle and Upper Paleozoic age in contact with Ordovician quartzite. Most of these faults strike northwest, but there are some associated faults that strike in other directions and among these many that end against the quartzite-limestone fault contact. In the vicinity of the Scott mine these associated faults have produced a mosaic pattern of quartzite and limestone blocks (fig. 2). At the Northing-Kauffman mine, the fault relationships are somewhat similar, but at the Viola the fault pattern is more systematic and shows two sets of faults, one with trends slightly east of north, and the other slightly north of west (fig. 8). At each of these places are many smaller faults of similar trend and also many that follow the bedding planes of the limestone and quartzite. Most, and maybe all, of the bedding plane faults terminate abruptly against or change into steeply dipping northwest faults. None of these faults is known to out the granite, hence they must all be pre-Tertiary. Some of the faults may have been associated with the Jurassic disturbance, but

most of them probably were formed during the Laramide orogeny at the close of the Cretaceous.

Faults that cut the granites include a group in which most of the members strike N.30°E. and N.60°W. and dip 55°SW. to 80°SW. These faults have been mapped in the Dunn tunnel (fig. 10). There are others like them in the quartzite and limestone, but they are not nearly so numerous nor so conspicuous as the pre-granite north-northwest faults (fig. 7). The post-granite faults are probably a product of early Tertiary deformation and were very likely formed shortly after the granite had been emplaced.

Another group of faults has characteristics unlike those of the faults already described. In this group, the faults strike N. 35° - 40°E. and N.60° - 70°E. and dip steeply northwest or southeast. They show a prominent horizontal component of movement and may be classed as strike-slip faults. At the Scott mine they cut and produce repeated offsets of the mineralized northwest faults, displacing the segment on the northwest side, in each case to the northeast (fig. 3). These faults have the same characteristics as the mid-Tertiary faults in Boise Basin /1, Meyers Cove 2/, and other parts of south central Idaho. They are, therefore, regarded as products of the mid-Tertiary crustal disturbance.

The youngest and most impressive faults are those that have blocked out the Beaverhead Range and delineated it from Birch Creek Valley. They are so integrated as to form essentially a continuous line of faults that extends the full length of the range, and are so placed as to give rise to an almost unbroken escarpment from one end of the range to the other. In most places the fault or line of faults is concealed beneath the alluvium at the base of the range, but locally branch faults, as in the vicinity of Skull Canyon, extend into the range and are visible in aligned saddles across ridges and in stratigraphic offsets. The presence of the faults along the base of the range, which is so strongly suggested by the regularity of the range front, the alignment of faceted spurs, the abrupt termination of canyons at the base of the escarpment, and the termination of the summit erosion surface at the top of the escarpment, is verified by structural evidence. In the Lemhi Valley near Leadore "lake beds" are in fault contact with the Paleozoic rocks at the base of the range 3/, and at Skull Canyon the summit erosion surface on the faulted segment of the range stands about 2,000 feet below the same summit surface on the main part of the range 4/. Toward the south the range loses some of its regularity because the Snake River Downwarp has carried the summit and the more deeply eroded upper slopes to increasingly lower levels and finally to the floor of the Snake River Plain, where alluvial deposits and lava have buried the lower slopes and have caused the higher ridges and hills to stand out as headlands and islands. Because the escarpment has in general been so little marred by erosion, except for the scattered, sharply incised canyons, the faulting must have taken place at a comparatively recent geologic date, probably in late Tertiary and Quaternary time.

Snake River Downwarp

The youngest structural disturbance is reflected in the downwarping of the end of the Beaverhead Range. Since the warping came after the range had been blocked into its present form, much of the movement must have taken place in the early part of the Quaternary. For a full discussion of the Snake River Downwarp the reader is referred to two reports by Kirkham.

ORE DEPOSITS

HISTORY AND PRODUCTION

With the exception of the Worthing-Kaufman, all the mines were discovered and located in the eighties, the Viola mine in 1881, and the Scott and Weimer mines in 1886. The Worthing-Kaufman mine was not discovered until 1894. During the period between 1881 and 1890 the district was one of the most important producers of lead and silver in the State, largely because of the great activity and large production at the Viola mine. Beginning in 1882, ore from the Viola was hauled to Camas and then shipped by rail to smelters in Omaha and Kansas City, but later in 1886 after completion of a smelter at Nicholas, one and one-half miles from the mine, the ore was smelted locally. Mining reached its peak during 1886 and 1887, but by 1888 most of the ore at the Viola had been stumped and in 1889 the mine and smelter suspended operations. Intermittent attempts to resume operations have since been made but with little success.

The Scott mine added something to the production in the eighties, and mining has continued intermittently to the present, and production since 1907 has exceeded the earlier almost four to one. The Weimer also shipped some ore during the early days, but much of its production (all of its copper) came after the Viola mine had closed, and there has been little production since 1907. Not much work was done at the Worthing-Kaufman mine until 1906 when tunnels were driven at depth to explore bodies of ore exposed in surface workings. The deeper work failed to reveal ore and subsequent production has all come from shallow workings. The mine has been worked off and on to the present and shipments of a car or two of ore have been made almost every year. Interest in all the mines was stimulated by the present World conflict. A little work was carried on at the Viola mine in 1942, but only the Scott and Worthing-Kaufman mines were active in 1944.

Production data are incomplete, but estimates of total production range from $2,500,000 to $5,000,000, mostly from the Viola mine. The production at the Scott mine is reported close to $110,000, and the Weimer about $70,000. The Worthing-Kaufman has produced about $30,000. More details on production and sources of information are given in the descriptions of the individual mines.

CHARACTER OF THE DEPOSITS

All the deposits but one are replacements of limestone; the exception is in quartzite. These deposits show the usual irregularities of replacement deposits, but some are more or less definitely tabular or lenticular, others are pipelines, and still others can be described only as irregular masses. The bodies show a greater persistence in a horizontal than in a vertical direction. All the ore has been found close to the surface. Because the deposits are above the present water table, the ore is largely oxidized and in some places completely oxidized.

Except at the Viola mine, the deposits are not closely associated with igneous rock, but all of them show the mineralogical characteristics of deposits formed by hydrothermal solutions of magmatic derivation. The ore possesses such features as to suggest that the mineralizing solutions were not particularly hot but were rather moderate in temperature and that deposition took place under essentially mesothermal conditions.

Based on the contained metals, the deposits may be divided into three groups; one valuable for its lead and silver, another for its copper, and a third for its zinc. These have been derived from two contrasting types of primary deposits, one composed dominantly of galena, the other of chalcopyrite. Much of the lead ore that has been mined has been a sandy lead carbonate, which has generally carried less than 10 ounces of silver to the ton. Much of the copper ore has been composed of oxidized copper minerals. The zinc ore has been formed by leaching of the small amount of zinc contained in the primary lead ore and its precipitation as zinc carbonate by replacement of immediately underlying limestone.

GEOGRAPHIC AND GEOLOGIC DISTRIBUTION

The deposits are grouped at four rather widely separated points along the front of the Beaverhead Range, at each place about 1,000 feet below the crest of the range. The spacing suggests four separate centers of mineralization. One of these is at or near the Scott mine, which is close to the southeast end of the range, where the Snake River Downwarp has carried the deposits to an altitude of about 6,000 feet. The mineralization extends along the flank of the range for several miles, but ore has been found only at the Scott mine. Another center of mineralization is at the Weimer mine along Skull Canyon about 10 miles northwest of the Scott mine at an altitude of 7,500 to 8,000 feet. This is the locus of copper mineralization and all deposits are on the Weimer property. The third center of mineralization is at the Worthing-Kaufman mine, which is 3 miles north of the Weimer at an altitude between 8,000 and 8,500 feet. These deposits are quite closely spaced and the mineralization apparently does not extend for more than half a mile along the front of the range. The fourth center is at the Viola mine about one and one-half miles north of Nicholla or 10 miles northwest of the Worthing-Kaufman mine. The deposits are high up the frontal slope of the range at an altitude of 8,600 to 9,000 feet.

Part of the copper deposits at the Weimer mine are contained in Ordovician quartzite, but otherwise all the deposits in the district are in limestone, those at the Scott mine in limestone of probable Pennsylvanian age and those elsewhere in limestone of Upper Ordovician and Devonian ages. All the deposits
in the limestone lie within a few hundred feet of the quartzite. This distribution, with respect to the quartzite, suggests that the faults that brought the quartzite and limestone together extended to great depth and had considerable influence in localizing igneous intrusion and in guiding the mineralizing solutions from their deep magmatic source.

**STRUCTURAL RELATIONS**

The deposits have been localised along the zone of more intense deformation that closely parallels the front of the range and particularly along those parts where faulting has been most extensive. There has apparently been a close relationship between faulting and mineralization. Faults appear to have tapped the mineralizing solutions at their magmatic source and then to have directed them into the horizons where the ore is now found. The ore, however, is not along the larger faults, but is along those of rather minor magnitude that cut or follow the bedding of the limestone and quartzite. The ore-bearing faults are not very persistent on the dip, and the more steeply dipping faults that cut the bedding generally terminate abruptly against bedding plane faults or change their dip to conform with the bedding. These steeply dipping faults and the bedding faults are apparently closely related and contemporaneous in development. Both may be closely associated with the folding.

Fault trends differ in the several mineralized centers. At the Scott mine the direction of the main fissuring is about N.30°W. and the dip is steeply northeast and southwest. The fissure is joined by numerous bedding plane faults, which dip northeast. Less than 150 feet from the surface the fissure flattens and becomes a bedding plane fault. At the Weimer mine the fissuring extends about due east to N.60°E. and dips steeply north, but except in the quartzite, the fissuring terminates within a short distance against bedding plane fractures or passes from one bedding plane to another in offsets a few feet apart. The controlling fractures at the Worthing-Buffman mine are apparently along anticlinal flanks and synclinal troughs of minor folds of northeast trend. These fractures are seemingly confined to certain beds of limestone of limited thickness. The position of the old stopes at the Viola mine suggests rather flat controlling faults of northeast trend and southeast dip which end against more steeply dipping faults or become more steeply dipping themselves and then flatten or connect with flat faults at lower levels.

**MINERALOGY**

Most of the ore that has been mined has been oxidised and the minerals of chief importance and main interest are secondary ore minerals, mostly carbonates of lead, zinc, and copper. From remnants of primary minerals within some of the oxidised ore, however, it is possible to piece together the complete mineral assemblage and thus work out the nature of the original mineralization. The minerals are divided into two groups, primary and secondary. As a matter of systematic treatment, the minerals of primary origin are described first.

**Primary Minerals**

The complete list of primary minerals includes galena, chalcopyrite, sphalerite, tetrahedrite, and pyrite as the ore minerals, and siderite, barite,
calcite, and quartz as the gangue. The lead-silver deposits contain all these minerals except chalcopyrite. The copper deposits contain them all, but the mineral that predominates is chalcopyrite.

The galena is the most abundant of the primary minerals in the lead deposits, and has been found only in small scattered bunches in some of the copper veins. It is conspicuous on the lower levels of the Scott mine, but on the upper levels and in the other lead mines of the district, it appears only occasionally as small residual lumps or grains deeply embedded in its alteration products. Much of the galena is rather fine-grained, granular, but some shows a good cubic cleavage. It forms stringers, small lenses, lumps, and irregular masses, generally accompanied by few other minerals, except its alteration products.

The chalcopyrite has been completely oxidized in most of the copper deposits, but some of it remains in one or two of the ore bodies in quartzite. Like the galena it forms grains, stringers, lumps, and irregular masses in the rock.

The other primary ore minerals are present in very small quantities and are rarely visible except in polished sections of the ore. The sphalerite forms small widely-scattered grains and probably does not comprise more than one per cent of any of the ore. The tetrahedrite is confined to minute microscopic grains in the galena. The pyrite is present in minor amounts in both the lead and copper ore, but it has been noted only in polished sections.

The gangue minerals are not particularly noticeable in the ore, probably because of the widespread oxidation. Siderite was noted in some of the unoxidized ore at the Scott mine in one of the tunnels at the Peterson prospect, and in debris on one of the dumps close to the Viola mine. Where it has not been altered, it has a pale buff color and rather coarse crystallization; but much of the material that can be identified as siderite is partly changed to brownish, reddish, and blackish oxides of iron and manganese, which, however, preserve the rhomboedral cleavage of the original mineral. At the Scott mine, it forms seams and lenses along the mineralized faults and impregnations of the bordering wall rock. It is probably the source of the abundant iron and manganese oxides which are so characteristic of the ore at the Scott mine and may be the source of the abundant iron oxides in the other deposits of the district.

Barite is fairly plentiful at the Scott and Weiner mines and may be present in some of the other deposits. It has a coarse platy habit. Its flatness and its white, pearly cleavage faces make it stand out conspicuously in both the oxidized and unoxidized ore. It is scattered irregularly through the ore as seams up to several inches thick made up of coarsely crystalline aggregates and also as bunches and as individual crystals.

Quartz is abundant only at the Worthing-Rauffman mine, where it forms a finely assembled breccia associated with the oxidized ore. Elsewhere it appears in very small amounts, if at all.

Calcite is found in negligible quantities in the ore, but in some places is rather abundant in the bordering walls, perhaps from recrystallization of the limestone under the influence of the mineralizing solutions.
Secondary Minerals

In the lead deposits, the secondary lead minerals are cerussite, anglesite, plumbojarosite, wulfenite, and pyromorphite, and are accompanied by manganese and iron oxides and gypsum. Smithsonite also is a secondary mineral, but most of it is segregated in the limestone beneath the oxidized lead ore bodies. In the copper deposits, the secondary minerals are chalocite, covellite, copper pitch ore, cuprite, chrysocolla(?), malachite, azurite, anglesite, cerussite, and limonitic and manganese oxides.

The most abundant secondary minerals in the lead deposits are the cerussite and iron and manganese oxides. Much of the cerussite is the earthy variety, aptly designated as sand carbonate because of the ease with which it may be reduced to a coarse heavy sand or powder. Some of the lead carbonate is white or gray, but most of it is discolored by iron oxides. It tends to outline more or less closely the original body of galena. Some of the lumps and masses contain cores of galena. The anglesite is much more intimately associated with the galena than the cerussite. Most of it forms minute veinlets ramifying through the cores and grains of residual galena held within the cerussite. The iron oxides at the Scott mine include abundant yellow, brown, and black limonitic oxides and also abundant reddish and black hematite. These iron oxides, together with the black manganese oxide, pyrolusite, form the most abundant and most conspicuous minerals in the upper workings. The oxides seem to be somewhat less abundant in the other mines and comprise mainly brownish oxides.

The other lead minerals are present in very small quantities. Some plumbojarosite (rare hydrous lead-iron sulphate) was noted in the oxidized ore at the Scott and Worthing-Kaufman mines. The mineral is not easy to distinguish from the iron oxides with which it is generally mixed. Orange-colored crystals of wulfenite and greenish crusts and crystals of pyromorphite were noted in some of the ore at the Scott mine.

The smithsonite, which is abundant and forms ore on the undersides of the oxidized lead ore bodies at the Viola mine, is the yellowish to reddish-brown iron-bearing variety which has a spongy or open platy structure because of numerous compartmental cavities. Negligible quantities form pale greenish crusts or coatings on the lamellar ore.

The most abundant ore mineral in the copper deposits is the malachite, the greenish copper carbonate, which forms earthy and crystalline incrustations along fractures and beautiful needlelike crystals in small vugs. It is commonly accompanied by lesser amounts of the bluish copper carbonate, azurite, which also forms patches on the ore. Copper pitch ore and chrysocolla(?), are also relatively abundant and may make up a considerable part of some of the mineable ore. Much of this material has a brownish jasper appearance because of admixed iron oxides. Secondary chalocite appears as veinlets in some of the partly altered chalcopyrite. It generally has a narrow inner band of copper pitch ore. Umpleby records the presence of cuprite.

Paragenesis

Study of the ore in polished sections and in the hand specimens discloses

that the primary minerals were deposited in an orderly succession largely by replacement. The siderite is embedded by barite and is intricately penetrated and replaced by sulfides along fractures and cleavages. It is therefore the earliest mineral and was deposited in large part by replacing the limestone. Much of it subsequently has been replaced by the ore minerals. The barite is penetrated to some extent by the sulfides, but it has not been so easily replaced as the siderite and tends to persist as borders on the side of the galena seams. Much of the scant pyrite forms rounded and irregular remnants within the galena. The sphalerite also forms more or less rounded grains or crystals within the galena, but the grains show little or no evidence that they have been replaced. The tetrahedrite is present as small remnant inclusions in the galena. As the pyrite, sphalerite, and tetrahedrite were not in contact, relations between them are indeterminate, but it is assumed that as in the other deposits, the pyrite was deposited first, followed by sphalerite and then by tetrahedrite. The sequence from the earliest to the latest mineral is probably siderite, barite, pyrite, sphalerite, tetrahedrite, and galena. The relation of chalcopyrite and calcite in this group of minerals was not learned, but if the chalcopyrite was not deposited during a different epoch of metallization, it was probably about contemporaneous with the galena.

The succession of the secondary minerals was not examined critically. Galena shows replacement by anglesite and the anglesite, in turn, by cerussite. Where the descending surface waters with dissolved copper came in contact with galena, both covellite and anglesite were formed. Oxidation of the sphalerite gave rise to the very soluble zinc sulphate, which on coming in contact with the limestone, was precipitated as zinc carbonate, smithsonite, by replacement of the limestone. Chalcopyrite has in part been replaced by chalcocite and copper pitch ore, but most of the copper that went into solution on oxidation of the chalcopyrite was precipitated as the carbonates, malachite and azurite, on contact with the limestone or dissolved carbonates before it could reach and replace the primary chalcopyrite at lower levels. Where the copper sulphate solutions came in contact with gelatinous silice, chrysocolla, the copper silicate, was formed. Siderite, on oxidation, yielded brownish limonic oxides and black manganese oxides. Pyrite and chalcopyrite provided iron for additional amounts of limonic oxides. Conditions locally were favorable for the formation of minor quantities of plumbojarosite, wulfenite, pyromorphite, and cuprite.

SHAPE AND SIZE OF THE DEPOSITS

The ore bodies reflect more or less closely the controlling structural features, particularly the guiding fractures, but like most replacement deposits in limestone, they show considerable irregularity in shape and size. Those that are along the more steeply dipping fissures as at the Scott mine are inclined to be somewhat tabular but with considerable variation in thickness because of recurrent pinching and swelling. Ore may persist along the fissure for several hundreds of feet or may be confined here and there to irregular bunches. Thickness may range from a couple of inches to 2 or 3 feet. Along the bedding plane fractures, the deposits are rather flat tabular bodies. Some of them may extend for several hundred feet along the strike and for a considerable distance on the dip, but others may die out in a few feet. These bodies may be as much as 6 feet thick, but bodies a few inches thick are much more common. Junction of bedding and fissure veins may bring about a notable enlargement of the ore body, the fissure vein in particular showing marked expansion at or just above the
point where they come together. On the other hand, a fissure body may end on or against a lightly mineralised bedded vein. All fissure ore bodies apparently have bottomed at depths of a few tens of feet, in part because the fissures have flattened to conform with the bedding which has been accompanied by a notable decrease in the quantity of ore.

The ore at the Weiner mine formed irregular, short, lens- or pod-like bodies conforming closely to bedding planes and probably controlled by minor vertical and bedding plane fractures. These bodies split and crossed along joints or vertical slips from one bedding plane to another, and measured from 2 to 30 feet wide, from a foot to 6 or 7 feet thick, and up to 60 feet long. They had a gentle inclination down the bedding. The long dimension apparently indicated the direction of the east-west fracturing. The ore in the quartzite, however, was in steeply dipping veins along faults or shear zones and in irregular deposits beneath bands of gouge along bedding planes. The veins are reported to have ranged from 18 inches to 2 feet wide, but in one place a vein enlarged and formed a body 25 feet wide.

The ore at the Viola mine is reported to have formed large, essentially flat lying, roughly tabular bodies, one joined to another on the dip by rather steeply dipping stringers. One of these bodies is reported to have extended downward at a very low angle for a distance of 400 feet, then to have pinched to a stringer as the dip increased to 45 degrees. In about 70 feet, however, the dip flattened and another large, flat lying body continued on. These bodies were continuous for several hundred feet on the strike and measured from a foot to 30 feet thick.

Unlike the ore at the other mines, that at the Worthing-Rauffman tends to form long, pipeline bodies. These pipes are irregular and somewhat sinuous in trend apparently because of minor folding and fracturing. They are more or less elliptical in cross section with the long axis parallel to the strike of the bedding, but numerous offshoots, generally at steep angles, greatly complicate the relations. Some of the ore bodies tend to follow flanks and troughs of folds, localized apparently by fractures. The several bodies show marked changes in size within short distances and may range from a few inches to several feet thick and even up to 20 feet thick.

TENOR OF THE ORE

There are some available records on ore shipments, but data dealing with the tenor of the ore based on underground sampling are meager. Most shipments have consisted of hand-sorted ore and the smelter returns, therefore, do not reflect the actual metal content of the ore as broken down in the mine. Most of the shipments from the Scott mine have carried 45 to 70 per cent lead and 5 to 7 ounces of silver per ton. Some of the ore was notably rich as mined, but the ore uncovered in recent development work shows that careful sorting is necessary in advance of shipment. Much of the recently exposed ore along a 200-foot length of drift carried between 10 and 20 per cent lead and less than an ounce of silver per ton for an average width of about 2 feet. The values, however, were spotty, and in places there was as much as 30 per cent lead, and in other places less than 5 per cent lead. The average for the drift was probably about 12 per cent. Ore that was shipped contained 16 to 20 per cent lead. In other
parts of the mine much of the ore may have 3 to 5 per cent lead and a fraction of an ounce of silver to the ton, but some parts may contain several times that much.

Shipments from the Worthing-Hauffman mine have shown returns of about 80 per cent lead and 4 to 8 ounces of silver per ton on ore that was carefully sorted. Some of the better ore is reported to have averaged 30 to 30 per cent lead before sorting and 2 to 4 ounces of silver. Ore exposed underground now may carry 10 to 20 per cent lead.

Early shipments from the Viola mine carried 50 to 60 per cent lead and 10 to 12 ounces of silver to the ton. As mined the ore is reported to have contained 55 to 60 per cent lead and 4 to 10 ounces of silver to the ton 1/. Bodies of zinc carbonate ore in the footwall of the old lead stopes are comparatively high grade, but the ore is rich in iron. Samples along 15 feet of the wall exposed in the open cut showed 21.5 per cent zinc; a 7-foot vertical strip showed 20.5 per cent zinc.

Some of the ore shipped from the Weimer mine is reported to have averaged 40 to 45 per cent copper. Other shipments carried 35 per cent copper and 6 ounces of silver per ton.

DEPTHS OF OXIDATION

The groundwater table throughout the district lies some hundreds of feet below the surface and as a result the effects of oxidation persist to considerable depth and reach some distance below the levels so far reached in mining. It comes to within 200 feet of the surface at the Scott mine, but at the other mines, which are all perched close to the top of the frontal slope of the range or high on adjacent canyon walls, it is very much deeper and may be from 800 to 1,000 feet below the surface. The nearness of the water table to the surface at the Scott mine is reflected in the rather marked increase in unoxidized ore at lower as compared with upper levels. The deeper ore is about equally divided between primary ore and oxidised products, and the ore at shallower depth is preponderantly oxidised. In the other mines most of the ore is oxidised even in the lowest workings. Apparently considerable additional depth will have to be gained before there will be much increase in the quantity of unoxidised minerals.

GENESIS OF THE DEPOSITS

The character of the primary mineralization, particularly the association of sulfides with siderite and barite, suggests that the ore, like that of other sideritic deposits in the state, has been deposited by hydrothermal solutions that originated in magmatic sources. The presence of granite at the Viola mine tends to confirm a local relationship between mineralisation and igneous activity, and the close similarity of all the ore in the district suggests that all centers of mineralisation have magmatic affiliations though erosion has not in every case revealed associated intrusives.

The mineral-bearing solutions probably originated at considerable depth and

like the magma found the zone of more intensely deformed rock and greater structural weakness close to the front of the range especially favorable for movement toward the surface. Ore deposition, however, apparently did not take place until the temperature of the solutions had become quite moderate (mesothermal), and the solutions had passed from the more highly heated channelways into the cooler, rather reactive limestone. Then the ore was deposited as a replacement of the limestone along minor vertical and bedding plane fractures, locally along zones of shearing in quartzite, forming roughly tabular as well as irregular pipe-like and pod-shaped deposits. The solutions apparently spread laterally along especially favorable horizons, and consequently, the ore bodies appear to have a greater horizontal than vertical extent. The paragenetic relations reveal that siderite was deposited first, then barite, and that much of the siderite as well as considerable limestone was subsequently replaced by the sulfides.

Inasmuch as the idigenous activity with which the mineralization is believed to be associated has been assigned to the early Tertiary, the ore deposits also must be of the same age and must be a local expression of the metallization that was so widely manifested over the Rocky Mountain region during the early part of the Tertiary. Since the ore bodies are cut and displaced by probable mid-Tertiary faults, they cannot be as young as Miocene, the only other epoch of the Tertiary during which ore deposits are known to have formed in south central Idaho.

The change in the ore to its present oxidized form probably began when erosion had reduced the region to one of low relief, which is reflected today in the old erosion surface on the summit of the range, perhaps during the middle or later part of the Tertiary, and was continued and speeded when the range was blocked into its present form and placed in its present position in the latter part of the Tertiary and in early Quaternary time. Then the water table was dropped close to its present low level and oxidation was permitted to extend below the bottom of present known ore bodies. The siderite was changed to iron and manganese oxides, the galena to anglesite, and the anglesite to cerussite. Zinc leached from the primary ore at the Viola mine was deposited below the oxidized lead ore as the zinc sulphate solutions made contact with the underlying limestone. Chalcopyrite also was oxidized; but most of the copper was precipitated as the insoluble greenish and bluish carbonates, on coming in contact with waters containing dissolved carbonates or carbon dioxide, and by reacting with and replacing limestone. Special conditions also permitted the formation of minor amounts of other oxidized minerals.

OUTLOOK

The district has by no means been dormant since the Viola, its largest mine, suspended operations in the late eighties. Although no lead ore of consequence has since been uncovered at the Viola mine, the other mines have continued more or less active and have produced considerably more ore in late than in earlier years. The Welch mine has not been active of late, but both the Scott and Northing-Tauffman mines have had a small but fairly steady production.

Because of the erratic distribution of the ore and the irregularity of the ore bodies, it is difficult to estimate reserves, particularly since the ore bodies are quite pipe-like or tabular with but little vertical range and with no
assurance that the ore will extend more than a few feet above or below tunnel levels. Nevertheless, there are perhaps about 20,000 tons of lead-silver ore in sight, which are estimated to contain more than 4,000,000 pounds of lead and 32,000 ounces of silver; and also not less than 5,000 tons of zinc ore, which contain about 1,500,000 pounds of metallic zinc. Continued development may more than likely increase the total reserves quite considerably. The outlook, therefore, is for continued small production for some time to come, the nature of the ore bodies being such as not to encourage very large scale mining. Because of its high iron content, no steady market has as yet been found for the oxidized zinc ore.

As the ore bodies have such poorly defined outcrops, it is possible that other deposits may eventually be discovered. Any part of the district along or close to the front of the Beaverhead Range may be worthy of prospecting. More intensive search might well be carried on in the immediate vicinity of the present mines for possible additional ore bodies along known structural zones and for possible ore bodies in still unproven structurally favorable ground. Each mine apparently has controlling structural features peculiar to itself, and prospecting at each must be carried on accordingly.

Such ore as has been uncovered has been largely oxidized and no appreciable increase in the amount of primary ore need be expected in deposits found so far above the water table. The mixed oxidized and unoxidized ore apparently does not lend itself to satisfactory flotation or gravity concentration. Selective mining and careful sorting probably remain the best methods for preparing the ore for shipment to smelters. Unless the reserves of low grade ore are greatly increased, installation of milling equipment would hardly be justified, should satisfactory methods of concentration be found. Because of the lack of water at most of the mines, the ore would have to be transported considerable distances for mill concentration. The newly uncovered mine water at the bottom of the recently sunk 200-foot shaft at the Scott mine may prove adequate for all mine and milling needs, locally.

MINES AND PROSPECTS

SCOTT MINE

Location and Development

The Scott mine is in Clark County near the southeast end of the Beaverhead Range. It is just 3 miles from the Snake River Plain at a point where the Snake River Downwarp has carried the crest of the range to a relatively low level. The mine is at the edge and only slightly above the floor of Birch Creek Valley at an altitude of about 6,000 feet. The mine is partly behind some low hills at the base of the range, but from openings between the hills a commanding view may be had across the mouth of Birch Creek Valley and the Snake River Plain beyond (pl. I, B). The mine is about centrally located within sec. 31, T.9 N., R.31 E., Boise meridian, and is less than two miles from the main highway over an unimproved road of gentle grade. Until rather recently, the ore was hauled to Dubois on the Oregon Short Line, but now ore is trucked to the railroad at Roberts and supplies are brought in from Idaho Falls.
The property comprises 9 patented and several unpatented claims and three small cabins, two of which are used as living quarters. (pl. I, B). The development includes numerous outcrops and exploratory pits scattered over several claims, but most of the work has been carried on from two shafts 825 feet apart, the more recent work in the more northerly of the two shafts, which was completed in 1943 (fig. 2). The older of the two shafts is 121 feet deep and has levels at 106, 139, and 191 feet, known respectively as the 100, 150, and 200 levels. There is also a tunnel that connects with the shaft on the 100 level. This tunnel, driven into the hill slope about 31 feet below the collar of the shaft, then makes connection with the 100 level by winzes and long inlines. The new shaft has a depth of 196 feet and is connected with the old shaft by a long drift on the 180 level. The connection at the new shaft is made at a point 135 feet below the surface. Some work has been carried on from the new shaft on a level about 18 feet below the 150, which is generally known as the 166 intermediate, and also from the 200 level at the bottom of the shaft. Still another level lies about 35 feet above the 150. All this level, which is known as the 125, is inaccessible close to the old shaft, but a part of it may be entered from an inlinen and vertical raise on the 150 level less than half way between the old and new shafts. Altogether, there are more than 3,618 feet of accessible workings, all of which are shown in figure 3; but the total development is considerably more, for many of the older drifts and cross cuts have been filled with waste. About 230 feet of workings are open on the tunnel level, 138 feet of drifts and inlines from the tunnel level to the 100, 230 feet on the 100 level, 1100 feet on the 180 level, 246 feet on the 166 intermediate, and 806 feet on the 200 level with 87 feet from the old and 228 feet from the new shaft. The spacing of the levels and connecting winzes and raises and the stopes is shown in the longitudinal section, figure 4.

The camp has no springs or streams within 3 miles and all water for domestic and mining use has been hauled from Birch Creek 3 miles away, or from springs 15 miles distant. The new shaft, however, has reached the water table, and water fills the sump to within a couple of feet of the 200 level. Strong pumping has not been able to empty the sump. The water apparently enters the sump from a fracture and the flow is large and may be ample for all mining and perhaps milling needs.

History and Production

The mine was discovered and located in 1885, but apparently little work was done by the discoverer and it was relocated in 1888 by W. A. Scott. Since then, the mine has been known as the Scott mine. Scott did considerable work at the mine and made a number of shipments of ore. In 1908 he sold the mine to the Birch Creek Mining Company, the present owner. The Birch Creek Mining Company was particularly active in 1910 and 1911 and then off and on to the present day. In 1925 the mine was leased to the Idaho Lead Mines Company for a period of 15 months. The company has carried on much of the work since then, and in 1942 and 1943 sunk the new shaft at the north end of the property and drove several hundred feet of drifts on the 166 and 200 levels with funds from an R.P.C. development loan.

According to Mr. George Brunt, president of the Birch Creek Mining Company, the Scott mine has shipped 110 cars of ore valued at about $110,000. Twenty-six of the cars were shipped by earlier operators, and most of the remainder by the
Fig. 2. Topographic and geologic map of the Scott mine.
Fig. 3. Geologic map of the underground workings at the Scott mine.
Fig 4. Longitudinal section of the Scott mine showing levels and accessible stopes.
Birch Creek Mining Company. During 1910 and 1911 alone the company shipped 22 cars from the "Treasure Box" stope and to 1925 had shipped 60 cars of ore, all of which had gone to smelters at Salt Lake City, Utah. The Idaho Lead Mines Company shipped about 60 tons of concentrates and about 20 tons of crude ore. Additional shipments were made by lessees in 1935 or 1936 and by the company in 1943 and early 1944.

Geology

Stratigraphy

The rocks at the Scott mine, as shown on the topographic and geologic map (fig. 2), are made up of Ordovician quartzite, Pennsylvanian limestone, shale, and sandstone, Tertiary breccia, shale, volcanic tuff, and basalt, and Quaternary alluvium. Faults have brought the Ordovician quartzite alongside the Pennsylvanian rocks and have also broken the Pennsylvanian rocks into a maze of tilted blocks. The quartzite is several hundred feet thick with neither the top nor the base exposed. It appears to be the massive white vitreous quartzite that belongs well toward the top of the formation. Bedding is poorly defined.

The Pennsylvanian series has been so interrupted by faulting that the exact sequence is in doubt. One fault segment is made up of dark gray sandy limestone with interbedded brownish sandstone; another of brownish sandstone, which, because of weathering, has become so silicified and heavily impregnated with iron oxides that it resembles a resistant siliceous iron cap; and another of pinkish and grayish limestone with some intercalated grayish shale. Just east of the map area, the rock is a bluish gray limestone which in places has numerous bands of black chert. The rocks are scantily fossiliferous and no recognizable varieties other than cup corals were observed.

The Paleozoic rocks are overlain unconformably by the Tertiary strata. The Tertiary beds apparently fill an old steep-sided valley carved in the Paleozoic rocks. The bottom and lower sides of the valley were covered with limestone breccia, now exposed in the underground workings of the mine, and the breccia, in turn, is beneath beds of clay and white volcanic ash. These beds have been protected from erosion by a flow of basalt, which caps the hill just west of the mine.

The basalt flow, as well as the basalt dike, have been described in the earlier part of the report. The dike, which is 2 to 3 feet wide and stands nearly vertically, has been exposed in the old shaft and in the adjoining drifts on the 100, 150, and 200 levels. It cuts the ore.

Alluvium covers much of the bedrock at the mine and most of the surface for half a mile to the east.

Structure

The dominant structural feature at and near the mine is the faulting. The Paleozoic rocks have been extensively broken by faults of major and minor magnitude, those of major magnitude having produced the mosaic of tilted blocks. The largest fault is apparently the one that has brought the Ordovician quartzite in
contact with the Pennsylvanian beds; those that have produced the tilted blocks in the Pennsylvanian series are of somewhat lesser magnitude. The faults apparently have steep dips, but the direction of movement can only be inferred. Much of the faulting preceded the deposition of the Tertiary beds; subsequent faulting has been of minor magnitude but has been sufficient to cause the basalt caps on some of the surrounding hills to dip gently in opposite directions.

The strike and dip of the beds within each of the faulted blocks is shown in figure 2. The attitude of the beds apparently has had some control of mineralisation, but the only ore so far uncovered is in the block of light gray and pinkish limestone in which the beds strike about N.30°W. and dip 15° - 30°NE.

The minor faults are those of main economic interest. They include steeply dipping fissures or fractures which ordinarily strike about N.30°W. and dip either northeast or southwest at angles of 70° to 80°, or change from one direction to the other along the strike. The nearly vertical fissures are fairly persistent along the strike but are not continuous for any distance on the dip. With depth they appear to change their dip to conform with the bedding of the limestone and become typical bedding plane faults. The faults show a vertical movement and are at least in part normal faults. The bedding plane faults apparently have had no great displacement. These faults are numerous, particularly in the vicinity of the vertical faults and not uncommonly join with them. As they conform with the bedding, most of them strike about N.30°W. and dip 15° - 30°NE., but there are minor exceptions. These steeply dipping fissure faults and rather flat bedding faults are pre-mineral and are quite extensively mineralized.

Other faults include some that cut and displace the vertical and bedding faults. Most of these faults strike northeast and dip steeply northwest; a few of minor consequence may strike northwest. They have a marked horizontal component of movement, many showing horizontal grooves and striations. Displacement may range from a few inches to some tens of feet. Offsets are to the northeast on the northwest side of these faults. Because they cut the ore bodies, they are interpreted as mid-Tertiary.

The fault that guided the basalt dikes strikes in a general east-west direction. It shows some curvature with depth but otherwise is essentially vertical (fig. 4). There has been post-dike as well as pre-dike movement along the fault.

**Occurrence and Distribution of Ore**

The mineralizing solutions were directed along both the steeply dipping fissures and the more gently dipping, bedding plane faults. Ore was deposited along each, mainly by replacing the bordering wall rock. The main production, however, has come from ore bodies along the more steeply dipping fissures. These ore bodies are fairly persistent on the strike, but like the controlling fractures, they have no great vertical range and terminate or weaken as the fracturing changes dip to conform with the bedding. The fissures are not uniformly mineralized. Small shoots of fairly high-grade ore are separated by intervals of low-grade ore. The ore is erratic in its distribution and is inclined to form irregular nests and bunches and small lenses along the plane of the fissure. Since the ore extends to depths of a few tens of feet, the bodies possess length.
rather than depth and, in part, are essentially pipelike. They are somewhat irregular in width and pinch and swell. In many places they are widest just above bedding plane junctions. In most places the largest bodies are no more than 2 or 3 feet across and only some tens of feet in length. The veins along the bedding planes are more lenticular in habit and not quite so irregular. They range from a few inches to as much as 6 feet in thickness, but in general, they contain less ore and of a lower grade.

All of the veins and mineralised fractures exposed in the underground workings are shown on the mine map, figure 3. The longitudinal section (fig. 4) shows the location of stopes and hence, gives the size, shape, and distribution of the former ore bodies. The fissure-controlled veins and the bedding plane veins can be readily distinguished in figure 3 by the angle of dip, for the fissure veins dip northeast and southwest at angles of 70° to 90° and the bedding plane veins dip northeast at angles less than 30°.

The earliest work was in the tunnel on a fissure-controlled ore shoot that had a strike of about N.20°W., and a dip that was steeply northeast. The shoot was stoped as high as 20 feet above the tunnel floor, but whether stoping was carried below the floor was not learned. Winess and deeper workings are now completely inaccessible. It is reported that 10 cars of high-grade ore were shipped from the level. Numerous minor mineralised fractures and some bedding veins were also exposed in the sides of the tunnel and in crosscuts, but they apparently yielded little if any ore. The main fissure was drifted on until it ended against the limestone breccia. A vertical winze about 35 feet deep was sunk to carry the work below the breccia. Eventually it was necessary to drive the incline along the breccia contact to the 100 level, the lowest level to which the breccia extended (fig. 4).

A little stoping was apparently done from the 100 level on steeply dipping veins that strike about N.30°W., but the stopes ended against the breccia only a short distance above. Most of the workings on the 100 level are now inaccessible. Some steeply dipping mineralised fractures and small bedded veins were mapped in the drifts and crosscuts south of the main shaft (fig. 3). Former workings to the north are completely blocked.

Much of the stoping in the mine has been carried on above the 150 level, particularly in the vicinity of the old shaft, but most of the old stopes are now inaccessible. Several crosscuts 50 to 100 feet north of the shaft also are closed. The best ore in the mine is reported to have been stoped just north of the shaft on the 125 level. It was here that the famous "Treasure Box" ore body was found from which 22 cars of high-grade ore were shipped. The 125 level and the "Treasure Box" stope cannot be entered, but according to Shenon 1/ the ore shoot there was pipelike in form and measured 4 to 10 feet wide and averaged 4 feet high. The body is reported to have plunged north toward the Hadley workings at an angle of about 15°. Southward the ore body is reported to have split into two narrow veins (visible in the workings just east of the shaft on the 150 level), which pinched to narrow seams 40 feet from the stope. Numerous drifts and raiseS were run beneath the "Treasure Box" on the 150 and 200 levels, but no other ore bodies of consequence were found. The ore shoot apparently failed to reach the 150 level. A little more than 200 feet northwest of the old shaft an

inclined and vertical raise connects with the Hadley workings on the 125 level, which is about 35 feet vertically above the 150. The Hadley stope is open but in dangerous condition. It extends southeast toward the "Treasure Box," but whether the two stopes are joined together could not be determined. The former ore body appeared to dip steeply southwest. On the north the Hadley stope ends against a prominent post-mineral strike-slip fault. Fissuring continues across the fault offset about 20 feet to the southwest, but the fissuring is weak and no ore has been found.

The drift from the old shaft to the Hadley raise is along a prominent bedding vein on which a little stoping has been done. In places this vein is 5 to 6 feet wide and shows scattered stringers and small bunches of sulfides. From the Hadley raise to the end of the 150 level, the drift is along fissured limestone that is more or less persistently mineralised. The fissuring is not continuous, for the fissure vein has been offset repeatedly by northeast strike-slip faults with each offset to the northeast (fig. 3). Whether the fissuring across each of the faults is the same as that followed to the fault is not always clear. In places the fissuring is weak, in other places fairly strong. The dip is generally steeply southwest, but locally it changes to steeply northeast. As shown in the longitudinal section of the mine (fig. 4), ore was stoped in a number of places but nowhere very high above the level. Only near the new shaft have the stopes been carried below the level. The ore shoots apparently were rarely more than a foot or two wide, but mineralized branch fissures or parallel ore seams out in the bordering walls may have increased stoping widths. The ore evidently was in stringers and irregular bunches and required careful hand sorting before shifting. The small individual stringers and bunches were rich, but as stoped, the ore probably carried less than 15 per cent lead. Some bedded veins a few inches to a foot or two thick appear here and there along the drift and in crosscuts. Some of them swell abruptly into short, thick, irregular lenses or pockets, composed largely of iron oxides.

The work from the new shaft on the 166 intermediate has uncovered some ore along the main fissure and has exposed some thick bedded veins. The main fissure has been cut and offset by several northeast strike-slip faults, but the offsets range from only a few inches to about 10 feet. The mineralisation appears to be fairly persistent on the level, but the values are spotty. The ore is in seams and bunches rarely more than a few inches thick. Samples taken across the fissure show from 10 to 20 per cent lead in widths of 6 to 12 inches, and in some places, across widths of 2-1/2 to 3 feet. Some ore of good grade was uncovered close to the face of the drift (July 1943) which carried about 20 per cent lead across a width of 2 to 2-1/2 feet for a distance of about 20 feet. Stopping was started, but the shoot weakened upward. Most of the 166 intermediate has been driven on ore of mill-feed grade, with here and there bunches of high-grade ore.

Much work has been done on the 200 level from both the old and new shafts, but no ore of consequence has been found. A number of bedded veins from 6 to 18 inches thick have been uncovered in the drifts and crosscuts from the old shaft, but the fissures that contained the ore on and above the 150 level apparently did not reach the 200. Although most of the drifts and crosscuts are not placed so as to explore possible downward extensions of the fissures above, being too far to the northeast. Crosscuts now filled with waste were driven beneath the workings above, which, however, revealed neither fissures nor ore. Because mixed waste and ore were dropped down the raise that connects the 200 level with
the 150, the long drift on the 200 could not be followed to the face. At the new shaft the work on the 200 level failed to show any evidence of the ore or fissuring so prominent on the 166 intermediate just above. Although the rock is complexly fractured, perhaps in part by post-mineral faults, the fissure on the 166 intermediate level either does not reach the 200 level or it has become a part of the complex zone of fracturing shown on the level. A crosscut driven 100 feet southwest from the shaft at about right angles to the bedding has cut a weak fissure and a fairly prominent bedding vein. Samples taken along the 80-foot drift show generally less than 5 per cent lead and 1-1/2 ounces of silver per ton across widths of 6 inches to 3 feet.

Many open cuts and pits and a few short tunnels on the slopes south and southwest of the main workings have exposed a number of mineralized fractures and small veins; except for one or two bedded veins close to the portal of the mine tunnel, no ore of note has been uncovered. Most of the cuts are partly filled with slide material, and mineralization effects are inferred from fragments of ore substance on the dumps. Several cuts contain bedded veins 12 to 18 inches thick.

Mineralogy

The ore is not so thoroughly oxidized as it is in most of the deposits of the district and contains considerable quantities of the primary minerals, especially on lower levels. The chief ore minerals are cerussite and galena, but there are also small amounts of anglesite, wulfenite, plumbojarosite, and pyromorphite. Iron oxides are abundant throughout the mine. Siderite, barite, and gypsum also are present.

The galena is inconspicuous above the 100 level and has been noted only as small residual grains and lumps encaised in anglesite and cerussite. Toward the 150 level, it becomes much more abundant and forms stringers and irregular bunches only partly mixed and coated with the lead sulphate and carbonate. In some places stringers are entirely free of oxidation products, but in other places, even on the 166 intermediate level, the galena may be completely altered to cerussite, which preserves the shape of the former stringers and bunches of galena. The cerussite is the earthy "sand carbonate." Some of it is white or gray, but much of it is somewhat yellow or brown from admixed iron oxides. The appearance of some of the discolored mineral is such as to suggest the presence of plumbojarosite. Minor quantities of greenish pyromorphite and brilliant orange-red crystals of wulfenite were noted with some of the oxidized ore on the dump.

The iron oxides are distributed not only along the fissure and bedded veins but also along the post-mineral faults, where the iron and also minor quantities of lead have been carried in by circulating meteoric waters. Much iron oxide is also concentrated along the base of the limestone breccia and along both walls of the basalt dike. All fractures apparently contain more or less iron oxide and in most of them the iron is abundant either as bands enclosing the ore or as irregular bunches or masses at fracture intersections. The iron oxides are yellowish, reddish, brownish, and blackish in color, and impart a vivid painted appearance to much of the ore that has been mined. The oxides are soft and are
easily reduced to a yellow or red ochre. The two ochres occur separately within the same mass of oxidized material. Some of the black oxide is hematite, but some is pyrolusite, the manganese oxide. The blackish oxides are widespread, but the fact that much of the black oxide may be reduced to a reddish powder suggests that most of it is hematite.

The siderite is not conspicuous in the unoxidized ore below the 150 level, but considerable partly oxidized siderite is present along the 166 intermediate and the 150 levels. The unaltered siderite has a pale buff color and shows its usual excellent rhombohedral cleavage, but the partly oxidized siderite is black or shows tinges of brown and red. It is probably the source of most of the iron and manganese oxides that are so abundant throughout the mine.

Barite is widespread and is particularly conspicuous in the ore remaining along the 150 level and the 166 intermediate. It forms lenticular seams measuring up to several inches thick closely associated with galena or its earthy alteration product. The barite is coarsely crystalline and platy; its white color and pearly luster on cleavage faces make it stand out conspicuously in the ore.

The gypsum is confined to thin seams in fractures that cut across the veins. The seams are fairly numerous on the 150 level close to the new shaft. The gypsum probably has been deposited by the circulating groundwater which obtained its sulphate from the oxidation of sulfides.

Outlook

The Scott mine has had a noteworthy production and unmined ore still remains. Recent development has shown that the fissuring and mineralization extend far beyond the older workings, and that the newly exposed ore bodies are as large and contain as much high-grade ore as any that has been mined in the past, with the exception of the "Treasure Box" shoot. Some of the ore shoots have measured up to 100 feet long and 3 feet wide, and have averaged about 10 per cent lead. The ore shoot now exposed on the 166 intermediate may be longer. Parts of it carry as much as 20 per cent lead, but the average is about 12 per cent.

None of the shoots has persisted for more than a few tens of feet on the dip, apparently because the fissuring has weakened in that distance or has transferred its movement to bedding plane slips. Some ore has been found on bedding fissures, but the main production has come from the fissures that stand nearly vertical. Most of the ore bodies are somewhat pipelike rather than distinctly tabular, possessing length rather than depth.

Prospecting for possible ore shoots should be directed along the strike of the more steeply dipping fissures, all of which may be worthy of investigation. Search for possible ore-bearing fissures at lower levels should not be abandoned. Since fracturing and mineralization have been so widespread, other ore channels may be expected. It is unfortunate that so many of the crossovers in the underground workings had been filled with waste. Examination of them may have revealed geologic data of value in directing the search for ore.
Because of the limited vertical range of the ore shoots, it is difficult, if not impossible, to block out large reserves of ore as mining and development are carried along. Apparently the ore can best be recovered by careful separation from the waste in blasting and by hand sorting. As in the past, mining should be most successful if not done on too large a scale.

WEIMER MINE

Location and Development

The Weimer mine is in sec. 15, T.10N., R.30E., Boise meridian, about 5 miles from the main highway at Raftman. The workings are on both sides of Skull Canyon; those on the north side are several hundred feet above the canyon floor at an altitude of about 7,600 feet; those on the south side are at an altitude close to 7,700 feet. As much of the road from the highway to the mine has been washed out, the mine may be reached only by horseback or on foot.

The property comprises 17 patented claims. Cabins along the bottom of Skull Canyon, which were originally built to accommodate 50 men, are now beyond repair. The workings on the north side of the canyon include an open cut and more than 800 feet of tunnels, the lowest of which is not far above the canyon floor. Most of these workings are open. The development on the south side of the canyon is reported to total about 2,500 feet of workings, principally in one tunnel; but all workings, including two shafts, are now inaccessible.

History and Production

Data on the early history and production of the mine are incomplete. Ore was discovered by Peter Towlgreen in 1885 and shipments began not long after the discovery. Later the mine was acquired by J. B. Weimer, who continued operations until 1907. The mine was then sold to Judge Timlen, who leased it to Stacy and Young of Mackay, Idaho. Later it was acquired by Jesse Knight. Some work was carried on later by lessees, but apparently little has been done during the past 15 years.

The mine was most active and most productive while controlled by J. B. Weimer. It was then that most of the work was done on the two sides of the canyon. Ore shipped at that time and later was hauled to Dubois for shipment by rail to smelters.

The total production has been estimated at $70,000. The amount of ore shipped by the discoverer was not learned, but according to Shennon 2/, shipments by J. B. Weimer prior to 1907 were worth $40,000. The earlier shipments must have been valued at between $20,000 and $30,000, for Umpleby in 1917 reports that the mine, idle since 1907, had shipped $20,000 to $70,000 worth of ore 3/. The production since then was not learned, but probably has been a few thousand dollars.


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Geologic Features

The ore deposits are contained in Ordovician quartzite and in the limestone that lies not far above. Some 400 feet of the quartzite are exposed along Skull Canyon in and below the mine, the lower 400 feet of which is prominently bedded and pink and maroon in color. These beds grade upward into a massive, white, vitreous quartzite almost 200 feet thick. The limestone above is in thin, bluish-gray beds which altogether measure some hundreds of feet in thickness.

The beds have been folded, but dips are gentle and the beds are tilted northeast at low angles. A short distance to the west these gently inclined beds have been faulted and brought in contact with folded beds of Mississippian age.

The rocks locally have been fractured and fissured. In the limestone the fractures have a general easterly trend and a nearly vertical dip. Most of them are rather inconspicuous, but some are fairly prominent. None of these fractures persist with depth but they either stop abruptly against flat bedding plane slips or flatten to conform with the bedding. In the quartzite, the fissuring and shearing are pronounced. The quartzite is extensively shattered along the fissures and in places is crushed by the shearing. The fissure and shear zones strike east-northeast and dip steeply north. The fracturing apparently extends to much greater depth in the quartzite than it does in the limestone. Some bedding plane faults along which there has been sufficient movement to produce moderate amounts of gouge are also present in the quartzite.

Occurrence and Distribution of Ore

All the workings on the north side of the canyon were on or were directed toward four irregular lenticular deposits in limestone. These deposits were almost flatly dipping and had their longest dimensions in the horizontal plane, with lengths ranging up to more than 100 feet, widths from 2 to 30 feet, and thicknesses (vertically) from 18 inches to 6 or 7 feet. One body was exposed on the surface about 200 feet above the canyon floor and was mined as an open cut 130 feet long. The ore apparently did not extend below the floor nor beyond the ends of the cut. The body extended in a northwesterly direction along a zone of minor fracturess. The second ore body, which was a short distance to the northeast, extended in a more easterly direction, controlled apparently by east-west fracturing. The body measured about 50 feet long, from 2 to 30 feet wide, and 2 to 7 feet thick. It plunged east at an angle of about 10° but did not follow directly down the bedding. The third body, which was not far to the southeast, was directed by east-west fracturing for a short distance and then changed direction to conform with the bedding. The total length was 65 feet, the width 2 to 20 feet, and the thickness up to 7 feet. The fourth body, which was in part directly above the third, had a northwest trend. It was about 50 feet long, 12 feet wide, and 6 feet high. In some of the deposits, the ore extended along joints from one bedding plane to another.

In the quartzite on the south side of the canyon, the deposits form veins along well-defined fissure and shear zones and irregular masses along bedding planes. The veins strike N.60°E. and dip 80°N., cutting the bedding at steep angles 1. The ore body exposed in the main workings is reported to have

measured between 18 and 24 inches wide, but in one place it is reported to have measured 25 feet wide. The irregular deposits along the bedding are beneath a layer of gouge. They are reported as pipelike in form with an average diameter of about 2 feet.

Mineralogy

Much of the ore on the north side of the canyon was composed of malachite and ferruginous chrysocolla, but there also was some azurite and chalocite. Some malachite, azurite, and chrysocolla still remain as incrustations along openings and as stains in the wall rock. Large bunches of hematite also are present. Ore shipped from these deposits carried about 35 per cent copper and 6 ounces of silver per ton.1/

The deposits in the quartzite contain primary sulfides as well as oxidized ore minerals. The complete list of ore minerals includes malachite, azurite, chrysocolla, copper pitch ore, chalcopyrite, chalcocite, cuprite, and pyrite, together with sparingly scattered bunches of galena, anglesite, cerussite, and wulfenite. The gangue minerals are barite, limonite, and a dark brown jasperoid material. The barite is reported to have been scattered irregularly as bunches and small crystals in the ore, associated particularly with the chalcopyrite and galena. The chalcopyrite is reported to have been deposited in parallel bands along planes of shearing and as irregular veinslets around fragments of the shattered quartzite. Much of the galena is reported to have been present in sparingly scattered bunches, some of them up to 5 feet across. Bodies of lead ore large enough to work were not found.

Outlook

Some development has been carried on below the former ore bodies in the limestone, but no downward extensions of the ore bodies have been found nor new bodies of ore discovered. Since ore deposition has been controlled by fracturing and bedding in the limestone, the driving of long tunnels to intersect the ore at depth is likely to meet with disappointment. Search for controlling structural features, however, need not be abandoned. As there was no opportunity to examine the deposits in the quartzite, nothing can be said about them. Shenon has pointed out that the downward extension of the ore has not been prospected.2/

WORTHING-KAUFFMAN MINE

Location and Development

The Worthing-Kauffman mine, formerly known as the Worthing and Weaver and the Kauffman-Weaver, extends across the line from Lemhi County into Clark County. It is located about 3 miles north of the Weimer mine in sec. 34, T. 11 N., R. 35 E., Boise meridian. The mine is a thousand feet above the base of the Beaverhead Range and 800 feet above the floor of steep-walled Worthing Canyon at an altitude of about 8,300 feet. From the mine a commanding view may be had of the upper part of Birch Creek Valley and of some miles of the front of the Beaverhead Range.

The mine is about 6 miles from the highway. The road connecting the mine with the highway has been graded, but from the bottom of Worthing Canyon, the grade is steep and the road narrow. Timber for mining purposes is close at hand, but water must be hauled from Birch Creek or the Worthing Ranch.

The property is reported to contain 15 claims, about half of which are owned jointly by F. G. Worthing and Edward Kaufman, and the remainder by Mr. Worthing and P. C. Weaver 1/. The development comprises about 4,600 feet of drifts, crosscuts, and inclines in the Upper workings, the Carbonate workings, the Bell intermediate, and the lower Bell tunnel. Some 900 feet are in the now inaccessible Upper workings, 1,200 feet or more in the Carbonate workings, about 850 feet in the Bell intermediate, and 1,800 feet in the lower Bell workings. The total development also includes a 650-foot tunnel about 350 feet below the Bell tunnel level. Most of the workings, except the 650-foot tunnel, are shown in figure 5. The map is an adaptation of one prepared by the American Smelting and Refining Company in 1930. Little work has been done since then except in an inclined shaft from the surface to the Carbonate workings.

History and Production

The deposits were located in 1904 by John Weaver and Edward Kaufman, who uncovered some ore close to the surface, but no great amount of work was done until 1906 when the property was bonded and leased to a group of men headed by Robert N. Bell. These men drove the Bell tunnel and performed about 2,000 feet of development in the hope of cutting and exploring at depth the bodies of ore exposed in the surface workings. This work failed to reveal ore, and when the option expired and could not be renewed, the project was abandoned. In 1913, Kaufman sold his interest in the mine to F. G. Worthing, who has since carried on the development, mainly in the Carbonate workings. Five or six ears of ore were shipped by losses in 1915, and one or two cars annually have since been shipped by Mr. Worthing. In 1927 the mine was again bonded and leased to Mr. Bell, who rehabilitated the lower Bell tunnel and drove the Bell intermediate, which lies above the older Bell tunnel and in part below the Carbonate workings. Several years ago an inclined shaft was sunk by Milo Zook to provide a more convenient outlet for the ore uncovered in the Carbonate workings. In 1943 the Bell tunnel was being reopened so that the ore could be dropped from the Carbonate workings and removed by gravity to the loading bin at the Bell portal.

According to Shenon 2/, Mr. Worthing had estimated the total production of the mine up to 1927 at $22,000. The amount has probably been substantially increased by the shipments since that time.

Geologic Features

The rock at and in the vicinity of the mine is made up of much faulted Ordovician quartzite and dolomite and Upper Devonian thick and thin bedded, bluish-gray, magnesian limestone, which in places is somewhat sandy 3/. The quartzite is exposed on the surface and in a part of the Bell tunnel; limestone is exposed through the remainder of the mine. The beds have been moderately folded and dips

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2/ Ibid., p.17
3/ Ibid., p.7

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locally reach 30°. The beds strike northeast in some places and northwest and nearly east-west in other places. The marked changes in strike may in part reflect local disturbances induced by faulting and in part changes associated with a northwest plunging anticlinal structure. The major folds, however, have been so broken by faults that precise relationships are indeterminate, but minor folds are clearly outlined. These minor folds are important because they apparently have had some influence in localizing ore.

Faults have placed the Ordovician quartzite along side the limestone on all except the north side of the mine. Some Ordovician limestone may remain locally in contact with the quartzite, but the faulting otherwise apparently has caused omission of Lower and Middle Devonian strata and has brought the Ordovician beds in contact with Upper Devonian. The peculiar U-shape of the Bell tunnel resulted largely because of the attempt to follow the faulted quartzite-limestone contact. The larger faults trend northwest; others not so large trend west to west-northwest (fig. 5). Numerous other faults strike N.30°-40°E., and dip northwest. A few strike about due north and due east. The northeast faults apparently control the trend of most of the ore bodies. Those that trend north, east, and northwest have had but a minor influence.

Because encircling reefs of quartzite have partly protected the limestone from erosion, weathering has been deep and in places has apparently removed much limestone in solution, leaving behind layers of residual sand and clay. In some parts of the mine the original bedding of the limestone has been fairly well preserved in the weathered products, but in other parts of the mine, the limestone has been reduced to a structureless sandy clay.

Occurrence and Distribution of the Ore

All the ore that has been found has been in the limestone, particularly in the more siliceous or sandy members. The ore is contained in two separate, essentially parallel bodies which are known as the Upper ore body and the Carbonate ore body. The Upper ore body, exposed in the Upper workings, is in rather thinly-bedded, bluish-grey limestone that lies beneath more massive beds. The body apparently has been made up of irregular pipelike shoots of elliptical cross-section with the long dimension parallel to the strike of the bedding. According to Shenon 1/ the shoots tended to split and rejoin and send off numerous offsets at steep angles. Irregularities of trend are reported in part due to minor folding and in part due to fracturing. The bodies have averaged about 4 feet wide.

The ore that makes up the Carbonate body in the Carbonate workings and the Bell intermediate, appears to be in a more siliceous limestone. This body is conformable with the bedding of the folded limestone (fig. 8), and the ore is thickest on the flanks of the anticlines and the bottoms of the synclines. The body averages several feet thick where it has been mined, but bulges range up to 20 feet thick. The folds, aided by fractures, apparently have controlled the movement of the ore solutions and the replacement of the limestone. The ore bodies, pipelike in the bulges, trend about N.30°-40°E., and plunge toward the northwest. The Carbonate workings closely follow and are in large part in the ore. As a result, much of the development consists of inclines down the pitch of the ore shoots.

Neither of the ore bodies in the Upper and Carbonate workings has been cut in the Bell lower tunnel. A long raise near the end of the Bell tunnel, however, has tapped the downward extension of the ore shoot of the Upper workings. As shown in the cross sections (Fig. 5), the Carbonate ore bodies have passed above the Bell tunnel. Much of the Bell tunnel is in greatly disturbed rock, locally abounding in iron and manganese oxides, but lead is absent or at the most, does not exceed 5 per cent.

Mineralogy
Most of the ore is oxidized and consists of a sandy carbonate, but scattered remnants of sulfides and other minerals indicate that the ore was originally composed of galena and very subordinate amounts of pyrite, sphalerite, and tetrahedrite, which were contained in a gangue of milky quartz. The ore in the Upper workings is reported to have had a predominantly reddish-brown color probably because of admixed iron oxides and small quantities of plumbojarosite. It was, for the most part, a sandy carbonate, but there were numerous remnants of partly oxidized galena. The ore in the Carbonate workings has a much lighter color and is composed of a grayish sandy carbonate which is present as streaks, irregular masses, and lenses in a light-colored siliceous material composed of finely-breciated, loosely-held milky quartz. This highly siliceous, light-colored ore contains little if any residual galena. The ore is underlain by one to two feet of iron oxides.

Economic Factors
The ore in the Upper workings has been mined and all recent activity has been centered at the more promising ore shoots in the Carbonate workings and the Bell intermediate. According to a report made by a geologist for the American Smelting and Refining Company, the development in the Carbonate workings in 1930 had disclosed 13,000 tons of 15 per cent ore. The work has shown that the size of the ore shoots varies from place to place and is greatest on the flanks of the minor anticlines and in adjacent synclinal troughs. The failure of the long Bell tunnel to cut the ore bodies exposed in the upper workings indicates that prospecting can best be carried on by remaining with the ore rather than by chance intersection in deep crosscuts.

Rich galena float on the slope east of the mine suggests that other ore bodies are present and may be worthy of investigation.

VIOLA MINE

Location and Development

The Viola mine is in Lemhi County about 30 miles from the southeast end of the Beaverhead Range. It and adjoining properties are in secs. 14 and 15, T.12N., R.29E., Boise meridian. The mine is perched at the very crest of the steep frontal slope of the range at an altitude just under 9,000 feet. Back of the crest the slope is more gradual and becomes a part of the summit erosion surface. From the mine a commanding view may be had of the upper Birch Creek Valley and the Lemhi Range on the other side. A glimpse may also be had of the broad
undulating summit surface of the Beaverhead Range itself.

The mine is about 1-1/2 miles northeast and about 1,500 feet above the old smelter town of Nichollia, which nestles at the base of the range. From the town a narrow, steep, graded road with numerous short switchbacks boldly ascends the front of the range to the mine. Several miles of winding road of gentle grade join the town with the highway in Birch Creek Valley.

The Viola property comprises a single claim, the Viola, which covers the greater part of the ground formerly underlain by the ore bodies. Other claims of different ownership lie to the east and south. As most of the other properties have been explored in the hope of finding possible extensions of the Viola ore bodies or of uncovering ore bodies similar to those on the Viola, they are included in the description of the Viola mine. The old development at the Viola mine was extensive, but most of the older workings are no longer accessible. Much of the newer work, which is largely exploratory, is open. These openings were surveyed by Brunton and tape and then mapped geologically.

The location of all the old shafts, surface pits, and portals of caved tunnels, together with the newer shafts and tunnels are shown on the topographic and geologic map of the camp (fig. 6). The surveyed workings have also been transferred to this map and are shown as subsurface projections. The accessible workings on the Viola claim itself consist of a large open cut (pl. 2, B) along the crest of the ridge and a long tunnel with about 2,500 feet of workings driven from the steep west slope beneath the old ore bodies (fig. 7). Rises connect with the old stopes, but caves prevent access to the stopes and ground in the vicinity of the ore bodies. Other openings to the south on the adjoining Ida claim include the Al Shear shaft, which was sunk near the old Salmon shaft, from which much ore was hoisted in the early days. The Shear shaft is vertical for 108 feet and is then inclined at an angle of 24° to 28° for about 350 feet. Numerous drifts, some of which have exposed the old Salmon workings, extend out on either side of the incline (fig. 8). About 150 feet of workings are accessible. The depth of the Salmon shaft was not learned, but it is reported that the 175-foot level made connection with the 400-foot Westmoreland shaft on the ridge several hundred yards northeast. (Figs. 5 and 6 in pocket).

Other accessible workings include what is known as the Dunn inclined shaft, the Dunn tunnel, and the Dunn vertical shaft. The Dunn inclined shaft, started apparently in the late twenties, is in the bottom of the gulch a few hundred yards east-southeast of the Viola mine. The incline is about 391 feet long, and makes an angle of 65° for the first 250 feet and 45° for the remaining distance. From the bottom of the shaft are 1,425 feet of workings directed mainly toward the south-southeast (fig. 9). The Dunn tunnel has been driven from the bottom of precipitous Cedar Canyon toward the old Westmoreland shaft. The tunnel has a length of more than 5070 feet (fig. 10). It is connected by raise with the lowest workings reached by the Al Shear shaft. The Dunn vertical shaft, which measures 200 feet deep, is about a hundred yards southeast of the large surface out on the Viola claim. Because of a missing section of ladder, the shaft was not entered.

Important inaccessible workings include a 124-foot, two-compartment shaft on the Nichollia Fraction, a short distance south of the Dunn inclined shaft, and which has drift connections and a 130-foot incline on the bottom level; a shaft and two tunnels on the old Clipper property just east and across the gulch from

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Fig 7. Geologic map of the workings beneath the Viola ore bodies.
Fig. 8. GEOLOGIC MAP OF THE ACCESSIBLE WORKINGS REACHED FROM THE AL SHEAR SHAFT
Fig. 9: Geologic map of the workings from the Dunn inclined shaft.
Fig. 10. Geologic map of Dunn tunnel
the Viola; a 175-foot inclined shaft with drifts on the Clark and Rossi property one-half mile northeast of the Viola; and two shafts, one 90 feet, the other 60 feet deep; and 400 feet of drifts and 70 feet of inclines on the Enterprise property a short distance southeast of the Nicholla Fraction.

**History and Production**

Most of the early history of the district is centered around the activities of the Viola mine. According to Shenon ¹⁄, the ore was accidentally discovered by a horse wrangler in 1881, but the discoverer apparently did little work and after a few months disposed of the mine to a buyer from Omaha. Mining then got underway and before the end of 1882, ore was being hauled by wagon to the railroad at Omaha and then shipped by rail to smelters in Omaha and Kansas City. In 1883 the mine was sold to a British corporation, known as the Viola Mining Company. This company soon made plans for a smelter, but until the smelter was ready for operation, the ore continued to go to the Mid-West for treatment. The site selected for the smelter was in lower Smelter Gulch just above Nicholla.

The two lead furnaces that were installed were ready and put to use in the fall and early winter of 1885. Ore was conveyed from the mine to the smelter by aerial tramway. The next two years were the years of greatest activity, the smelter treating up to 130 tons of ore daily. By 1888, most of the ore at the mine had been stoped, but the discovery of ore in the Salmon lode and the purchase of ore from mines in the surrounding region helped to prolong the life of the smelter until 1889. In 1890, the entire enterprise was abandoned. Since then intermittent attempts have been made to resume operations. In 1906 the old workings were reopened and extensive search was made for continuation of the ore bodies without success. Later attempts to operate the mine also ended in failure. Some high-grade zinc ore was found in the foot wall of the old Viola ore bodies in 1925 and several carload shipments were made then and in 1926. This zinc ore again attracted attention in 1942 and 1943, and several cars were shipped, but because of a high iron content, the ore had no ready market.

Some work was also carried on at adjoining claims both while the Viola mine was active and at different times since. The inclined shaft and drifts on the Clark and Rossi property about a half mile northeast of the Viola failed to uncover any ore of mining grade. The shaft and two tunnels on the clipper property just east and across the head of Cedar Canyon opened up a body of ore that apparently was not rich enough to mine. The owner of the Clipper property, Al Shear, also did considerable work on the Ida claim which covers a part of the Salmon lode south of the Viola mine. The Ida property was leased to Milo Zook in the early twenties and the work by incline and drifts extended, but little new ore was discovered.

Most of the development in late years has been carried on by William Dunn and C. H. Stallings, mainly on the Nicholla Fraction, which was located in 1922. In 1924 a shaft house, blacksmith shop, and boarding house were built on the property, but the boarding house was destroyed by fire in 1926. During this time, the 124-foot, two-compartment shaft with its drifts and 130-foot incline were driven. Later the work was transferred to the 390-foot inclined shaft and the 1,426 feet of drifts at the bottom of the incline to the 1100-foot crosscut from the bottom of Cedar Canyon. Included in the later work program was the 200-foot vertical shaft that was sunk a short distance east of the large open out on the

Viola claim. Some drifting was carried on from the bottom of the shaft, but no ore was found. Most of the later work was done in the early thirties.

Production records are not available, but estimates of total production have ranged between $2,500,000 and $8,000,000. According to Umpleby 1/, the ore shipped to Omaha and Kansas City was probably worth about $500,000 and that smelted locally about $2,000,000. He reports that for 1886 and 1887, the two years of greatest activity, 11,900 tons of lead-silver bullion valued at $1,400,000 were produced. On the other hand, Bell 2/ states that 60,000 tons of 60 per cent ore were shipped before the smelter was completed and that the total production was about $8,000,000.

Geologic Features

The mine is in a part of the Beaverhead Range where the Paleozoic rocks have been extensively faulted and locally invaded by granite and rhyolite porphyry. These faults have placed limestone of probable Upper Ordovician, Devonian, and Mississippian ages along block- or wedge-shaped masses of Ordovician quartzite (fig. 6). One block of the Ordovician quartzite lies south of the mine, another just west. The mine and most of the workings on adjoining properties are in Upper Ordovician and Devonian limestone. A fault of considerable magnitude separates the limestone from the quartzite south of the mine, but west of the mine the limestone and quartzite appear to be conformable. Further west the quartzite has been faulted along beds of Mississippian limestone. The granite cuts the quartzite just south of the mine. The rhyolite porphyry is in the granite, and the dikes are exposed in the long Dunn crosscut in Cedar Canyon (fig. 10).

The Paleozoic rocks have been folded, but the faulting has largely obscured the local relations. The quartzitic beds west of the mine strike about N.25° - 45°E. and dip about 35°NE., and the limestone beds to the east strike about N.35°E. and dip 20° - 40°SE. South of the mine the quartzite strikes about N.75°W. and dips about 20°NE. The large faults that have blocked out the masses of quartzite strike west-northwest and north-northeast. The fault that separates the Ordovician and Devonian limestone from the quartzite south of the mine strikes N.60° - 70°W. and dips about 70°NE. The one that separates the Mississippian limestone from the quartzite west of the mine strikes N.30°E and dips 70°SW. The northeast-trending faults are apparently a little younger and cut the west-northwest faults.

The minor faults fit into a number of sets, each set with its own characteristic trend and dip. The largest number of faults and the largest number of sets were observed in the long crosscut and workings beneath the Viola ore bodies (fig. 7). One set is made up of faults that strike N.20°W. and dip 60°SW., another of faults that strike N.40°W. and dip 55° - 65°SW., and still another of faults that strike N.40°E. and dip 30° - 45°SE., exceptionally 75°SE. More faults are contained in this last set than in any other. Other sets which have fewer members than in the sets just given, include one in which the faults strike N.60°E and dip 50°-65°SW., another in which the faults strike N.15°W. and dip

2/ Bell, R. N., Mining Industry of Idaho, Ninth Annual Rept., p. 131, 1907.
60°-80° SE., exceptionally 60° NW., and still another set in which the faults strike N.20°-25° E. and dip either 70°-75° NW. or 55°-65° SE. Many faults are also contained in the granite (fig. 10). Most of those mapped in the Dunn tunnel strike N.60° W. and dip 60°-80° NE. or strike N.30°-40° W. and dip 55°-60° NW. A few others strike N.15°-20° W. and dip 35°-55° NW., or strike N.20° E. and dip 28°-35° NW. Two sets strike due east, one dipping 80° NW., the other 75° SE. The dikes exposed in the tunnel occupy a fault strike due north, N.20° W., and N.40° W. In the bottom of the incline from the Al shear shaft (fig. 8), the fault along the granite-quartzite contact strikes N.70° E. and dips 32° NW., and the fault between the quartzite and the limestone strikes west-northwest as it does on the surface. In the drifts at the bottom of the Dunn incline (fig. 9), a prominent fault in the north drift strikes N.20° E. and dips 70°-75° SE. This fault has brought black lamy shale against thick-bedded light-gray limestone. A zone of shearing just south of the incline has many fractures that trend N.20°-30° E. and dip about 35° E. Faults of considerable magnitude at the south end of the workings strike N.60°-85° W. and dip 40°-50° NW. Others strike N.40°-50° E. and dip 20°-25° NE. Altogether, there are not less than nine sets of faults at the Viola and adjacent properties.

Occurrence and Distribution of the Ore

None of the old stopes in the Viola mine is accessible and little first-hand information on the occurrence and distribution is to be had. According to Milo Zook 1/, Umpleby 2/., and Shenon 3/, much of the ore was localized within three large irregular, essentially flat-lying bodies connected by stringers of comparatively steep dip. These bodies were continuous for several hundred feet on the strike and their thickness ranged from a foot to 30 feet. The uppermost body, which came to the surface near the north end of the Viola claim and was mined in part as an open cut, was nearly horizontal for 400 feet, then as the dip steepened to 45°, the ore pinched to a narrow seam. In 70 feet the dip flattened, however, and the ore seam increased and formed another large body of considerable horizontal extent. This body also pinched as the dip increased. Further flattening gave rise to the third ore body. Mineralization is reported to have terminated in a zone of badly broken ground. The strike of the ore bodies was apparently northeast, but the pitch carried the ore toward the Salmon shaft near the south end of the Viola claim. Ore mined from the Salmon shaft apparently came from a fourth body, which, however, was not so large as the others.

The long exploratory crosscut driven beneath the Viola claim (fig. 7) is everywhere beneath the former ore bodies, but several raises, now inaccessible, made connection with the old stopes. The workings thus give little information of the occurrence of the ore, but they afford some data on general structural relations. The Zook winze from the bottom of the Al shear shaft has exposed some of the old Salmon workings (fig. 8). From the position of these old workings, it may be inferred that the former ore body had a fairly low dip (about 20°), and that the steepening of the dip probably had much to do with the pinching of the ore. The workings from the incline are of further interest in that

1/ Zook, Milo, personal conversation.
they expose the granite and also the fault that separates the quartzite from the limestone. The long Dunn tunnel (fig. 10) in which numerous faults cut the granite, show some that are bordered by hydrothermally altered rock. The workings at the bottom of the Dunn inclined shaft (fig. 9) have exposed a broad zone of fractured limestone of northeasterly trend that may be approximately parallel to the trend of the ore bodies on the Viola claim. The fractures have a rather low southeasterly dip. In places the zone contains abundant iron oxides, but ore of commercial grade apparently was not found. Neither was ore uncovered in the west-northwesterly faults at the far south end of the workings. The shaft on the Nicholia Fraction, just to the south of the Dunn incline, was sunk to the quartzite-limestone contact, but drifts along the contact and a 130-foot winze down the dip of the limestone above the quartzite contact failed to come across any ore.1

Deposits of zinc ore are confined to the undersides of the former lead ore bodies. Such ore is exposed on the north side of the large open cut on the Viola claim. The deposit is somewhat irregular but fairly continuous for several scores of feet. The thickness may range from a foot to 10 feet or more. The body has not been explored much below the floor of the cut, but the ore probably continues along the footwall of the lead ore body, perhaps for the full extent of the lead ore shoot. Zinc ore has been tapped in one of the raises that connects the exploratory crosscuts with the old workings.

Mineralogy

All the ore that has been mined has been oxidized and has been described as a sandy lead carbonate with much iron and manganese oxides. Much of this ore is said to have had a yellowish-brown color, perhaps in part because of intermixed plumbojarosite. The ore is reported to have contained 35-60 per cent lead and 4 to 14 ounces of silver per ton.

The zinc ore is composed of smithsonite, much of which has a yellowish-brown to reddish-brown color and the cellular structure characteristic of that formed by replacement of limestone above the groundwater table. Individual specimens contain up to 45 per cent zinc, but samples across and along the open cut show about 20 per cent zinc, and samples from the raises in the tunnel below up to 30 per cent zinc.

The primary ore probably was composed largely of galena with but minor amounts of sphalerite, perhaps as in other deposits in the district, having no more than about 1 per cent sphalerite. This low content of zinc sulphide would probably be sufficient to account for the concentration of zinc leached from and deposited below the primary ore. The presence of siderite on the dump of the Dunn vertical shaft just east of the Viola suggests that it may have been present in the Viola ore and the source of the abundant iron and manganese oxides associated with the oxidized ore.

Economic Factors

The many hundreds of feet of crosscuts and drifts driven since the late eighties in search for additional ore bodies tend to confirm the report that the

mine suspended operations because the ore had been mined. Since the old stopes are inaccessible, there is no way of learning how much low-grade ore, if any, may remain unmined or how much ore may have been left as pillars to support the relatively flat roof. The future activity of the camp will probably be centered on the oxidized zinc ore which forms irregular bodies in the floor of the old lead stopes. The reserves of zinc carbonate ore cannot be accurately estimated until underground development has demonstrated the continuity and size of the deposits with depth. The oxidised zinc ore is likely to favor fracture zones of special permeability beneath the old lead ore bodies and therefore cannot be expected to be so widespread as the former oxidised lead ore. The open cut exposes several thousand tons of ore containing about 20 per cent zinc.

Search for other ore bodies in and near the Viola camp will probably continue. Gently dipping fractures and fracture zones appear to offer most encouragement as possible sites for ore. Local flattening of the dip should be particularly favorable for ore shoots. Exploration, therefore, should be carried on along the dip as well as along the strike of the fractures and fracture zones, so that possible ore shoots along more gently dipping parts of these structures may be revealed.

Cedar Canyon is dry except during the spring months, and water for mine and domestic uses must be hauled from Nicholaa or from the head of Willow Creek three miles to the north. Timber also must be hauled from the head of Willow Creek.

PETESEON PROSPECT

The Peterson prospect is about a mile north of the Scott mine in sec. 30, T.9N., R.31E.

The work at the prospect consists of several tunnels and shafts which have exposed bodies of iron oxides along a mineralized zone several hundred feet wide and half a mile long. Some of the iron oxide was mined in the early days for use as a flux at the old Nicholaa smelter. Much of the iron is contained in fissure veins in intricately folded Pennsylvanian limestone.

The most southerly workings are on the crest of the ridge northeast of the Scott mine. A short tunnel connected with a 40-foot inclined shaft explores an oxidized cropping about 3 feet wide which strikes about N.15°E. and dips steeply southeast. Several small bedded veins show in the short tunnel. The shaft is timbered, and no ore is visible, but much limonite is scattered on the dump. It lacks the color that suggests the presence of lead, and is probably oxidised siderite.

The main workings on the property are across on the north side of Peterson Canyon. One tunnel about 240 feet long has been driven N.40°E. from the gulch bottom. In about 40 feet the tunnel makes a turn and for the next 200 feet continues in a more northerly direction. It lies, in part, beneath a broad gossan zone of general east-west trend, but it pulls away from the gossan and exposes dark-colored limestone which contains a few widely scattered stringers of siderite. Several bedded seams containing iron oxide are exposed near the portal. The outcrop suggests that the iron oxides form scattered lenticular bunches along
a zone 40 feet or more wide. A second tunnel a little to the east and higher on
the ridge has a northerly direction for 15 or 20 feet and then exposes a slip
striking N 50° W, on which a little stoping has been done on a body of iron oxides
that measure 18 inches thick. The tunnel has been extended along the slip
for some distance, exposing here and there bunches and seams of red and yellow
iron oxides. On the surface the goosan zone trends about N 50° W, and may be
traced along the strike for several hundred feet. The entire mineralized zone
at this locality may be about a hundred yards wide.

In the bottom of the gulch just below the tunnel is a deep cut and short
 tunnel in a 12-foot zone of oxides. The cut uncovers the intersection of several
fracture zones, the most prominent of which strikes N 50° W, and dips 60° NE.
Another strikes N 10° E, and dips 75° SE. Both are cut by a slip that trends
N 40° W, and dips 80° SE, and also by one that trends east-west and dips steeply
north. Both of the latter show horizontal movement and are probably post-mineral.

On the slope on the opposite or north side of the gulch is a cut about 50
feet long and 25 feet wide of a zone that has uncovered much red and yellow iron oxide.
The mineralized zone trends N 30° W, and the oxides are confined to a lens between
100 and 150 feet long. Nearby is a tunnel which has been driven N 20° E, in thin-
banded limestone and shale and which has exposed several 6- to 8-inch bedded
seams of oxides. To the north are several iron-stained ledges 100 feet or more
long that trend about N 30° W.

OTHER PROPERTIES

Several other properties are scattered along the range, generally close to
the mines that have been described, but little or no ore has been shipped from
them. Most of those close to the Viola mine have been mentioned and several
have been described in considerable detail. Just south of the Worthing-Tauffman
mine is a prospect belonging to F. G. Worthing, on which banded veins are exposed
in several tunnels and shafts. The veins are in the limestone close to the
quartzite contact. Scattered prospects are also known between the Heimer and
Scott mines. Among them is one known as the Worthing prospect from which no ore
has been shipped. There is also a zinc prospect, which was not visited.

Some work also has been done on a low hill or ridge on the Scott property
about a half mile northwest of the mine. Two shafts have been sunk, one about
40 feet deep in shaly limestone; the other, which is several hundred yards to the
west, about 75 feet deep in quartzite. The one in the limestone has exposed some
bedded veins a few inches thick composed of iron oxides; the one in the quartzite
has been sunk on a vein that strikes about N 20° W. This vein can be traced on
the surface for about 75 feet. Its goosan shows a little pyromorphite as well
as the reddish color common to iron oxides that contain lead.

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Fig. 5. Geologic map of the accessible workings at the Worthing-Kaufman mine.
Fig. 6. Topographic and geologic map of the Viola mine and vicinity.