LEAD AND ZINC.

NOTES ON LEAD AND COPPER DEPOSITS IN THE BEAR RIVER RANGE, IDAHO AND UTAH.

By R. W. RICHARDS.

INTRODUCTION.

The purpose of this paper is to give a short summary of incidental notes on the mineral deposits, mainly lead and copper, in the Bear River Range of Idaho and Utah, concerning which there is apparently little on record. The notes were taken by members of the United States Geological Survey in connection with a reconnaissance examination of the portion of the range lying partly in and bordering on the phosphate reserve as originally constituted by the withdrawals made by the Secretary of the Interior in December, 1908, and December, 1909. The Bear River Range extends in a north-south direction from latitude 40° 15′ to 42° 45′ and separates Cache Valley on the west from Bear Lake Valley on the east. Its length is approximately 120 miles and its average width 10 to 15 miles. The location of the range and the localities described are indicated in figure 29.

GENERAL DESCRIPTION OF MINERALIZED AREA.

The mineral deposits of this area have been known and prospected for 15 or 20 years and the prospect pits are so numerous that only a small part of them were visited. They are scattered over the east side of the range from the vicinity of Woodruff, Utah, north to Soda Springs, Idaho. The lead ores consist of galena with small amounts of cerusite and wulfenite in a gangue of iron-stained calcite and dolomite and are found at Swan Creek, Utah, and near St. Charles and Paris, Idaho. They appear to be tabular replacement deposits in limestone, more or less parallel to the bedding and cut and limited by fissures.

The copper ores consist mainly of the carbonates, azurite and malachite, in quartz veins and locally of the sulpharsenite and sulphantimonite, tennantite and tetrahedrite, in a brecciated quartz and

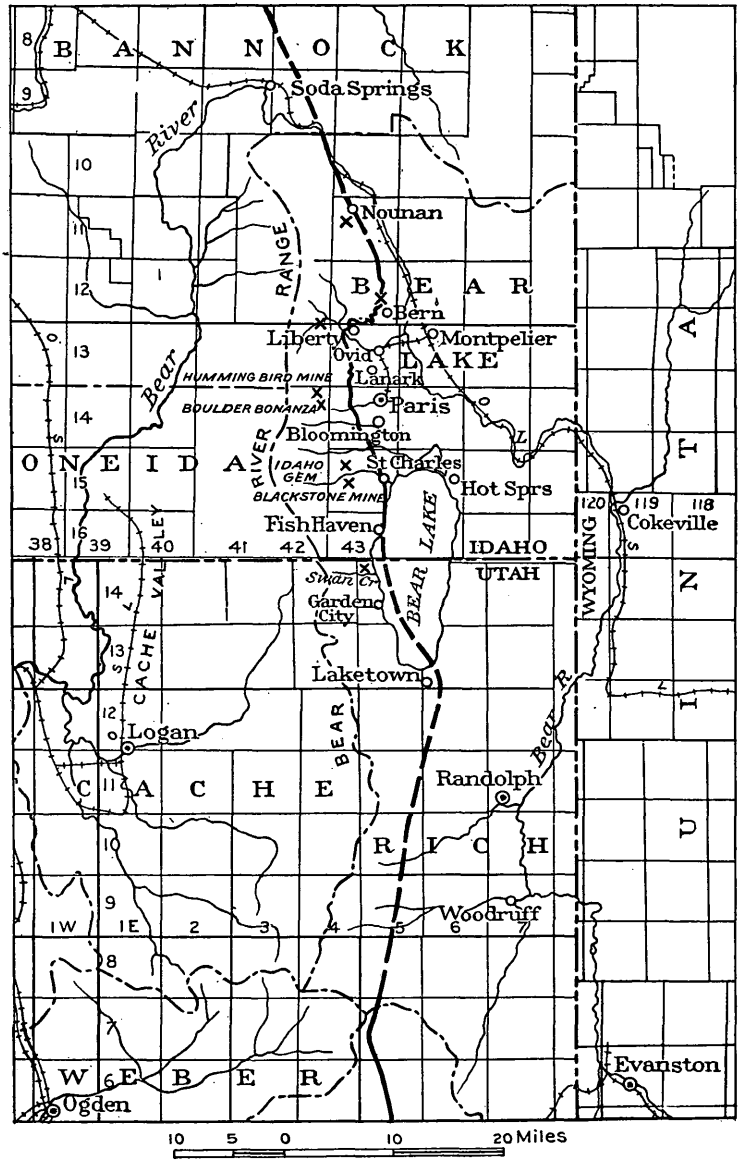

FIGURE 29.—Map showing relation of mining prospects to Bear River Range and overthrust. The margin of the overthrust block is indicated by the heavy broken line.

jasper gangue. Both modes of occurrence are found in quartzites of probable Cambrian age. Igneous rocks are not associated with either the lead or the copper ores.

Shipments of ore have been made from two localities, the Boulder Bonanza-Humming Bird group and the Blackstone mine, west of Paris and St. Charles, Idaho, respectively. The shipments from the former group are reported to have been somewhat less than 100 tons, partly lead and partly copper ore, while that of the latter comprise about 800 tons of high-grade concentrates.

GEOLOGY.

STRUCTURE.

The geologic structure of the range as a whole has not been worked out, but the data collected by the geologists of the Hayden Survey[1] lead to the inference that it is synclinal, the youngest rocks occupying the center of the trough. The eastern flank is known to consist of a great overthrust block of folded and broken Middle Cambrian to Mississippian limestones and quartzites. This block rests on rocks in part of Triassic age, and the magnitude of the thrust is indicated by the fact that it is traceable for a distance of about 100 miles, from the vicinity of Woodruff, Utah, to a point north of Soda Springs, Idaho (see fig. 29), and is practically coextensive with the range itself. The direction of movement is from west to east and the maximum apparent displacement about 10 miles. The dip of the fault plane is low, not over 10° on an average, although locally it may exceed that amount. In general the fault is not expressed in the topography, but west of Lanark, Idaho, a retreating scarp bears evidence of the efficiency of erosion. The strata included on the eastern margin of the thrust block form an anticline paralleled on the west by a syncline in the vicinity of St. Charles and Paris, Idaho, and the mineral deposits which have been visited in that neighborhood are located on the intervening monocline. The dips in this fold are uniformly toward the west and range from 20° to 30°.

STRATIGRAPHY.

The main mass of the Bear River Range is made up of Paleozoic sediments ranging from Middle Cambrian to Mississippian in age. Rocks of probable Triassic age underlie the overthrust block on the east and minor amounts of Tertiary lake beds are found in patches on the summits and in a terrace-like fringe about the lower hills. No igneous rocks are known in the range proper, but its northern end is embayed by basaltic flows of post-Pliocene and possibly late Quaternary time. The mineral deposits are found particularly at the base of the Middle Cambrian Ute limestone, the position of which is shown in the generalized section which follows.

[1] Peale, A. C., Eleventh Ann. Rept. U. S. Geol. and Geog. Survey Terr., for 1877, 1879, pp. 587–589.

Generalized section of rocks in Bear River Range.

	Feet.
Quaternary: Alluvium, travertine, basalt flows	?
Tertiary (Pliocene?): Marls, marly limestones, and calcareous conglomerate	?
Tertiary (Eocene): Sandstones, conglomerates, and limestones	?
Unconformity.	
Jurassic: Twin Creek limestone (shaly limestone)	3,500
Jurassic or Triassic: Nugget sandstone (dark red to white sandstone and quartzite)	1,900
Triassic or Carboniferous:	
Ankareh shale (a red-bed horizon)	1,500
Thaynes limestone	2,000
Woodside shale	1,000
Carboniferous:	
Pennsylvanian:	
Park City formation (chert, phosphatic shales, and limestone)	600
Weber quartzite	1,000
Morgan formation	500
Mississippian	1,200
Limestone, upper Mississippian age	?
Madison limestone	?
Devonian: Jefferson limestone	?
Silurian: Limestone	?
Ordovician: Quartzite and limestone	?
Upper Cambrian: [1] St. Charles limestone (bluish-gray to gray arenaceous limestones, with some cherty and concretionary layers, passing at the base into thin-bedded gray to brown sandstones)	1,197
Middle Cambrian:	
Nounan limestone (light-gray to dark lead-colored arenaceous limestones)	814
Bloomington formation (bluish-gray, more or less thin-bedded limestones and argillaceous shales; small rounded nodules of calcite are scattered irregularly through many of the layers of limestone)	1,162
Blacksmith limestone (gray arenaceous limestones in massive layers)	23
Ute limestone:	
Blue to bluish-gray thin-bedded fine-grained limestones and shales, with some oolitic, concretionary, and interformational conglomerate layers	731
Spence shale member (argillaceous shales)	30
Langston limestone (massive-bedded bluish-gray limestone, with many round concretions)	30
Brigham quartzite (massive quartzitic sandstones)	1,000

LOCAL DESCRIPTIONS OF MINERAL DEPOSITS.

The principal mineral deposits visited are described in geographic order from south to north.

[1] The details regarding the Cambrian formation are taken from Walcott, C. D., Nomenclature of some Cambrian Cordilleran formations: Smithsonian Inst. Misc. Coll., vol. 53, 1908, pp. 1-12; Cambrian section of the Cordilleran areas: Idem, pp. 167-230.

SWAN CREEK, UTAH.[1]

The prospect on Swan Creek, described as the Victoria No. 1, is a short distance south of the Utah-Idaho line. It is said to be the center of a group of eight claims. The wall rock is massive limestone. The ore consists of malachite, azurite, accompanying barite, and calcite in a much brecciated zone approximately parallel to the stratification of the beds. Recrystallization or marbleizing of the limestone is shown at the same horizon 100 yards or more to the south.

The amount of ore at this place has not yet been proved to be sufficient to make a commercially valuable property. It is reported that prospecting has been carried on for some 16 or 17 years in the vicinity, and it can not be said that any deposits yet shown are promising. The locality is of interest, however, as showing the continuation of the mineralized zone in association with these sedimentary rocks.

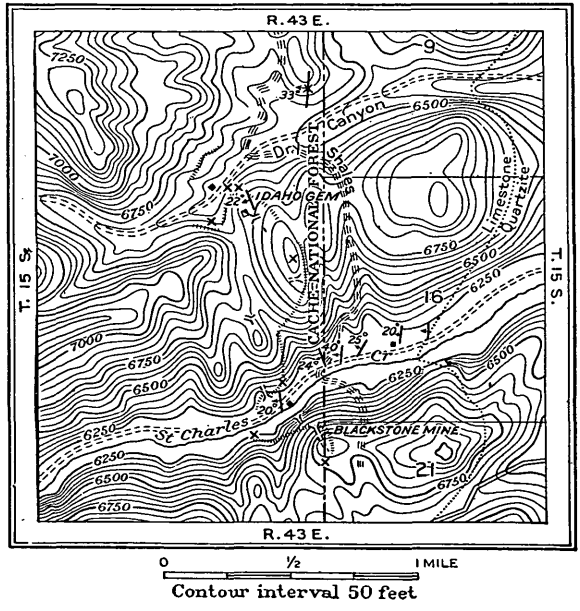

FIGURE 30.—Topographic map of vicinity of Blackstone mine, west of St. Charles, Idaho, showing rock outcrops.

ST. CHARLES, IDAHO.

BLACKSTONE MINE.

The Blackstone mine is located on St. Charles Creek, sometimes called Big Creek, about 3½ miles west of the town of St. Charles, and nearly on the eastern boundary of the Cache National Forest. (See fig. 30.) It is owned by the Blackstone Mining & Power Co. (Ltd.), a corporation controlled by Edgar B. Cloud, of Twin Falls, Idaho. When it was visited by the writer in October, 1910, preparations were being made for undertaking further work on the several claims. The discovery of the deposits in this vicinity is attributed to R. S. Spence, of Evanston, Wyo. The only shipments from the property are reported by W. H. Cloud to have been made in 1896 and to have consisted of 3 carloads of hand-picked or "slab" galena running 80

[1] Notes of Hoyt S. Gale, 1909.

per cent of lead and of 16 carloads of concentrates averaging 78 per cent of lead. The property at that time was controlled by W. M. Dodge and operated by W. M. Raht under lease. The concentrating mill erected by Mr. Raht burned and no shipments have been made since that time.

The ore as seen at the Blackstone mine consists of crystalline aggregates of galena, much broken and surrounded by a thin alteration zone of dark-colored cerusite, the whole held in a gangue composed of iron-stained limestone with a small amount of siderite. The galena after exposure has a bluish tinge on cleavage surfaces, which is due to the presence of an extremely thin film of lead carbonate. The only other minerals from the mine seen were a few flecks of pyrite in a matrix of gray crystalline dolomite and a dark substance which on examination seems to represent remnants of the dolomite prior to its recrystallization. In some of the openings on the north side of the creek the ore is of similar character, except that galena does not appear to be so abundant and its alteration to the dark structureless cerusite is more complete and the carbonate of iron is present more prominently in the matrix. In one of the prospects wax-yellow tabular crystals of wulfenite, lead molybdite, are associated with the galena. Sphalerite in rich brown rounded crystals was also noted, but only in small quantities. The ore of the Blackstone mine is said by the present owners to be nonargentiferous and zinc-free; the prospects to the north carrying traces of zinc are reported to contain gold and silver values which tend to offset the lower percentage of lead. However, R. N. Bell,[1] State inspector of mines, states that the ore runs about 27 per cent of lead and 50 cents in gold and 4 ounces in silver to the ton. He also notes that the shipment of 3 carloads mentioned above was probably the highest grade of lead ore ever shipped from the State.

Little opportunity was found to study the nature of the ore bodies in this region except in the Blackstone mine, and the examination made here was by no means as thorough as could be desired. The rocks in the mineralized area strike N. 20° W. and are cut by a set of nearly vertical fissures which strike N. 60° W. and appear to dip northeastward—that is, the fissures dip into and strike about midway between the strike and the dip of the bedding of the limestone. In a portion of the mine a fissure with a trend slightly east of north limits the ore body on the west. The mineralized area appears to be tabular, and its longest dimension is parallel to the strike of the sediments. The top of the ore body is determined by a limestone apparently less soluble than that replaced by the ore and slightly dolomitic. The ore is richest toward the top. The maximum thickness of one of the richer mineralized portions, as estimated in the

[1] Ninth annual report of the mining industry of Idaho, p. 1907.

stopes, is 8 feet measured at right angles to the roof. The mineralized portions decrease in richness downward and sidewise toward the fissures and are in these directions inclosed in iron-stained dolomite and limestone having a banded structure that is probably due to

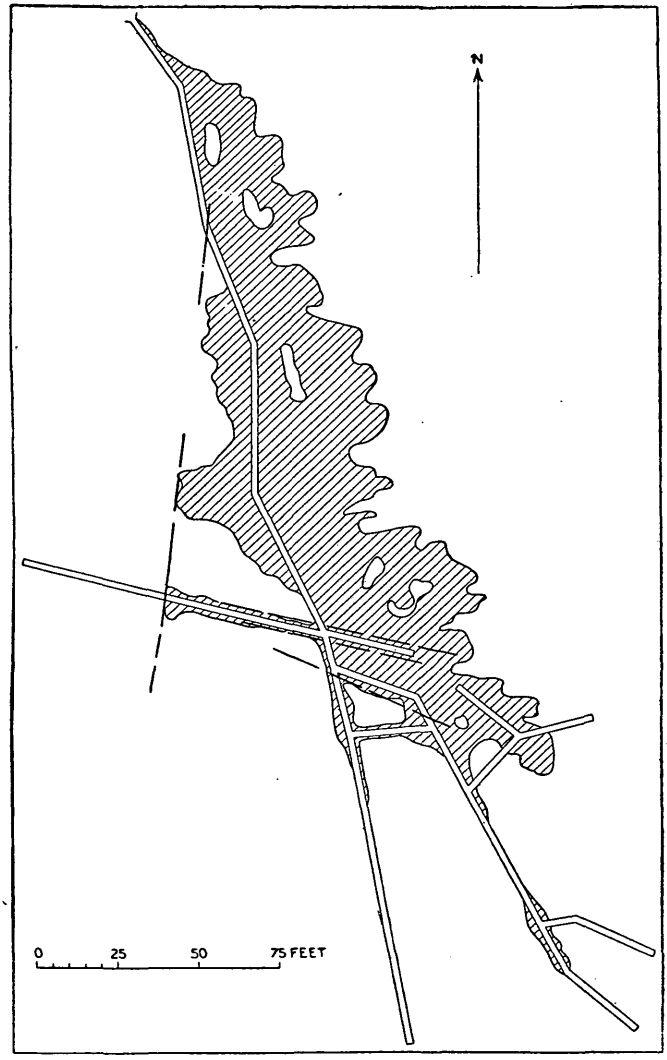

FIGURE 31.—Plan of Blackstone mine. After survey by W. H. Cloud. Shading shows area of stoping. Heavy broken lines show fissure systems.

recrystallization. The bands appear to be in general parallel to the bedding of the limestones and are from half an inch to an inch thick. The ground composed of this material is said to be tight and very hard to break. The heading of the main tunnel is at present in this banded ground, but it is expected to encounter, about 50 feet farther

in, an ore body which makes an excellent showing of ore on the surface of the hill above.

The developments of the Blackstone mine comprise some 800 feet of tunnels and drifts. The area of the stopes was not calculated, and no attempt was made to estimate the quantity of ore in sight. The general character of the development is indicated in figure 31.

OTHER DEVELOPMENTS NEAR THE BLACKSTONE MINE.

On the north side of St. Charles Creek, a few hundred yards west of the Blackstone mine, a tunnel has been driven in a northerly direction for about 200 feet, and at 75 feet from the entry a 125-foot drift branches off in a westerly direction but gradually swings to the north. The ground opened by these workings is apparently barren. Nearly north of the main tunnel of the Blackstone there are a number of shallow inclines in which recent assessment work has been done and from one of which the wulfenite specimens mentioned elsewhere were obtained.

IDAHO GEM.

The group of claims clustered about the Idaho Gem, on the side of Dry Canyon (fig. 30), were idle at the time of the writer's visit, but evidence of recent work was abundant. A shaft equipped with a horsepower hoist had recently been opened and an attempt made to cut some leads of ore that are disclosed in pits and are thought to pitch toward the shaft. Little evidence of values was found on the dump.

BLOOMINGTON, IDAHO.[1]

In secs. 18 and 19, T. 14 S., R. 43 E., on the divide between Bloomington Canyon and Paris Canyon, a number of pits, some of which are 30 or 40 feet deep, show thin, nearly vertical mineralized zones or bodies 3 inches to a foot in thickness, with an east-west trend. The nature of the values was not evident on inspection and no report on them was obtained. Limonite and quartz appear to be the only minerals present in visible amounts, suggesting that the openings are on gossan rather than ore.

PARIS, IDAHO.[2]

HUMMING BIRD MINE.

The Humming Bird mine, in Paris Canyon, is the center of a group of claims situated near the northeast corner of T. 13 S., R. 42 E., Boise meridian. Several hundred feet of tunnels, inclines, and shafts have been driven on this property, and a considerable amount of ore-bearing rock has been thrown out on the dump. Ore has been

[1] Notes of G. R. Mansfield, 1910.

[2] Notes of Hoyt S. Gale, 1909.

shipped from several properties in the vicinity, but none of these properties have been regularly worked on a commercial basis.

The ores occur in association with the sedimentary series, chiefly Cambrian limestone and thin-bedded shales. Prospecting has traced similar mineralization for many miles along the north-south outcrop of these formations as exposed on the east side of the Bear River Range.

There appear to be at least two zones of mineralization in upper Paris Canyon, an eastern lead-bearing "belt" and the western copper veins, to which the Hummingbird belongs. The developments on the Hummingbird afford some evidence as to the character of these ore bodies. The vein trends N. 60° W. and dips 40° W., as developed in the lower entry. It lies approximately parallel to the bedding in an area of intense compression folds and overthrust faults. The ore body is presumed to occupy a bedding thrust, and it is not known whether the section is there in normal or in overturned position. The vein is continuous throughout the extent of the present workings and is several feet thick.

The ore consists of brecciated quartz and jasper vein material, in which are secondary quartz and malachite deposited contemporaneously. It contains tetrahedrite-tennantite (gray copper ore) reacting in the close-tube test for both antimony and arsenic. There are also secondary veins of azurite and some patches of radially fibrous malachite.

The possibility of the use of this ore as gem or ornamental stone has been suggested.[1] Some of this material was cut and polished, and a thin section was examined by Sterrett, who gives the following description:

> The constituent minerals are quartz, with a very fine red dust pigment and malachite. Under the microscope the quartz is seen to be granular, with close-fitting grains, and is dusted full with minute red specks, probably hematite. The malachite is in bright-green grains and masses with a radial fibrous and occasional spherulitic crystallization. The quartz incloses numerous small grains of buhrs of malachite bristling with needles. In the hand specimen the rock is bright jaspery red, with dark-green splotches throughout. The quartz is close grained and tough and takes a good polish. The malachite is softer, though sufficiently hard to be polished along with the quartz. The contrast between the two colors is pleasing and for use in small ornaments, as inkstands, paper weights, etc., the rock would serve well. It is also probable that it would be accepted as a gem for scarfpins, brooches, etc.

A prospect pit southeast of the Hummingbird mine showed a considerable amount of very pure galena. This occurred in rounded masses, many of them several pounds in weight, embedded in the residual soil adjacent to one of the limestone outcrops. The limestone itself contains large masses of pure-white calcite. This deposit has been but recently discovered and little work has been done upon it.

[1] Sterrett, D. B., Gems and precious stones: Mineral Resources U. S. for 1909, pt. 2, 1911, pp. 739–808.

BOULDER-BONANZA GROUP.

Several prospects were visited in the Boulder-Bonanza group, which is situated a mile or more north and east of the Hummingbird mine. One of these prospects showed lead ore, not, however, in place, the prospect shaft showing a mixture of soil and loose bowlders to a depth of 15 feet or more. This vein is said to lie in a "belt" east of the Hummingbird or copper-bearing "belt." Some of the ore taken from the Boulder-Bonanza claim shows vein material composed of brecciated white quartz and jasper, somewhat iron stained, containing galena in disseminated grains. It was reported that previous to 1909 a total of 13 tons of ore had been shipped from this claim and that this had yielded a good percentage of lead. There was little evidence to be seen in the existing prospect from which to judge as to the size and continuity of the ore deposits.

LIBERTY, IDAHO.

A group of prospects situated 3½ miles west of Liberty, Idaho, was only partly examined. These prospects possess the same general character as the groups already described, which are localized in limestones. The banded recrystallized structure similar to that in the Blackstone mine is prevalent. The stratigraphic position of this particular group of prospects is definitely located at the base of the Ute limestone of Walcott's [1] Liberty section, which was measured at this place.

BERN, IDAHO.

Northwest of Bern, in sec. 26, T. 12 S., R. 43 E., E. A. Jonely has a prospect from which he reports values in gold, silver, and lead ranging from 70 cents to $20 a ton. This prospect is located near the margin of the thrust block and west of the axis of a small anticline in dense bluish-black limestone. The prospect, well named the Tiptop, is situated on the highest point in sec. 26. It consists of a 125-foot shaft, a 60-foot drift or crosscut to the west at the 100-foot level, and at the 125-foot level a 110-foot crosscut to the northeast, which was only started at the time the prospect was visited. The shaft is in bluish-gray limestone, except for a few feet near the top, where it passes through a clayey wash. The western 20 feet of the crosscut on the 100-foot level is in a red and blue clay or talcose selvage which is reported to contain values. The crosscut on the 125-foot level is said to have cut several mineralized fissures, and at its heading, nearly under the crest of the fold, iron oxide containing free gold was found. The prospect is equipped with a horse-power hoist and shaft house.

[1] Walcott, C. D., loc. cit.

Openings in the Tertiary lake beds, probably Pliocene, were seen in the NW. ¼ NE. ¼ sec. 35, consisting of a now partly filled tunnel, a shaft, and several shallow holes. No evidence of mineralization could be observed and no reports were heard concerning the nature of the values. A considerable expenditure had, however, evidently been made within the last 5 or 10 years.

In the SE. ¼ NW. ¼ sec. 26 a tunnel extended for about 80 feet into a white marly limestone which was somewhat sheared and slickensided in some places. The only mineralization evident consisted of a thin bluish dendritic deposit, probably pyrolusite (manganese oxide). The tunnel gained only a few feet of cover and the roof at the face had caved, making a natural upraise to the surface. Mr. E. A. Jonely, of Montpelier, reported that assays showing gold values had been obtained from samples at this place. The greater number of assays indicated about 75 cents in gold to the ton.

Similar prospects were seen in the eastern part of sec. 22. The only difference noted is that the country rock consisted of a calcareous conglomerate. No values were evident at this place.

NOUNAN, IDAHO.

A group of copper prospects about half a mile southwest of Nounan post office show copper carbonates, malachite and azurite, and the silicate, chrysocolla. The country rock is a gray dolomite which weathers brown and the soil derived from it has an iron-red color. The bedding of the rock is indistinct, but the strike seems to be about 15° east of north and the dip about 65° E. The ore appears to be in fissures filled with quartz; some of these strike N. 65° W. and have an easterly dip of about 55°, but the attitude of others is indeterminate. The principal opening consists of a shaft, the depth of which is estimated at 100 feet. This was inaccessible when visited. The dump shows a small amount of commercial ore.

Somewhat more extensive prospecting of similar deposits is reported on Coon Creek about 1½ miles southwest of the Nounan prospects, but these were not visited.

LEAD AND ZINC DEPOSITS IN THE METALINE MINING DISTRICT, NORTHEASTERN WASHINGTON.[1]

By HOWLAND BANCROFT.

GENERAL DESCRIPTION.

LOCATION AND EXTENT OF THE DISTRICT.

The Metaline mining district has the following boundary, as recorded in the office of the county clerk of Stevens County:

Beginning at the northeast corner of township 40 and the southeast corner of range 45; thence south along the east line of range 45 to the south line of township 38; thence west along the south line of township 38 to the west line of range 42; thence north along the west line of range 42 to the south line of township 40; thence east along the south line of range 40 to the east line of range 42; thence north on the east line of range 42 to the international boundary line; thence east on the international boundary line to place of beginning.

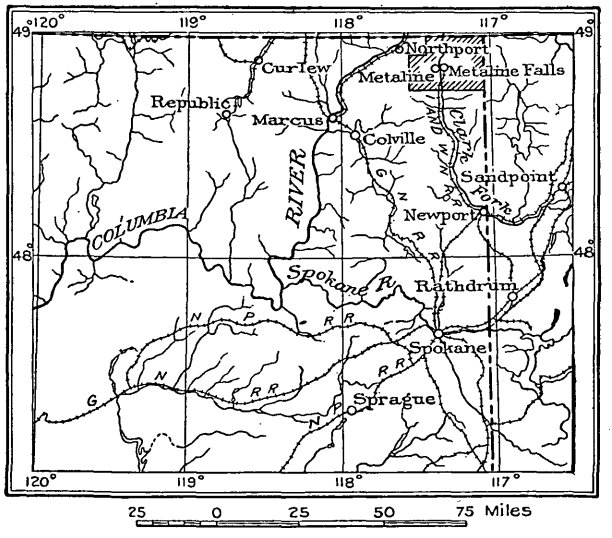

FIGURE 32.—Index map of a part of Washington, showing the location of the Metaline mining district.

The district, which covers about 400 square miles of unsurveyed land, occupies a corner in the extreme northeastern part of the State of Washington, the State of Idaho lying to the east and British Columbia to the north. (See fig. 32.) The western part of the district is cut by the valley of Clark Fork[2] of Columbia River and the most accessible and probably the best-developed properties lie within a mile or two of this stream. The elevations in the district range from about 2,000 feet at the river to 6,000 feet or more on top of the highest peaks.

[1] This paper is a preliminary report on the writer's investigation in this field and is subject to revision.

[2] This stream is known locally as Pend Oreille River.

The town of Metaline is on the west bank of Clark Fork, some 2 miles south and 4 miles west of the center of the district, and is 79 miles in an air line due north of Spokane. Just across the river, on the east bank, the new town of Metaline Falls has recently been built near a partly completed cement plant. In each place accommodations can be obtained and general-merchandise stores are numerous. The population of both towns in July, 1910, probably did not exceed 500.

MEANS OF ACCESS.

Until 1910 the Metaline mining district was one of the most isolated in northeastern Washington, being more remote from railroad transportation than any other part of Stevens County. Previous to 1910 craft on Clark Fork were used for transporting materials and supplies between Newport, which is 9 miles north of the southeast corner of Stevens County, and the Metaline district. Stages, launches, and tugboats were necessary features of the last 7 miles of the journey northward from Ione to Metaline as late as October, 1910, the total distance between Newport and Metaline being about 60 miles by the route traveled. A stage road from Colville was also used to reach the district, but this route involved about 50 miles of travel over rather poor roads.

With the completion of the Idaho & Washington Northern Railroad to Metaline Falls in October, 1910, a much cheaper and more efficient means of transportation was afforded throughout the district, the properties located on the east side of the river being especially benefited. The railroad has not yet published freight rates on ore to be shipped from the district.

CONDITION OF MINING INDUSTRY IN THE DISTRICT.

Lack of transportation and low-grade base ores have no doubt had much to do with the small progress made in developing the several properties in the Metaline district. Although there are many prospects in the area only a few have 300 feet or more of underground development, and no one of these is reported to have shipped over a few tons of ore. In general the district has been explored by means of surface cuts and trenches. If these have uncovered ore bodies persistent enough to warrant deeper exploration it has in places been attempted. The results thus far have not been gratifying, but the developments are still too meager to warrant final conclusions concerning the extent of the ore bodies.

Wagon roads are scarce in the district, practically all of the claims being reached by trails, and at the time of the writer's visit to the camp it was almost impossible to obtain saddle horses or any other means of conveyance. With the completion of the cement plant and

the extension of the railroad many improvements may be expected in the district. At the time of the investigation this was the least-developed camp in Stevens County. One small concentrating mill had been erected to work the ores of the Spokane Lead Co., and this mill is reported to have been a failure.

TOPOGRAPHY.

The most prominent topographic feature in the Metaline district is the valley of Clark Fork. This stream, which flows northward in a course that lies 6 miles west of the center of the district, is far-famed for its waterfalls, swift eddies, and box canyons, all of which preclude extensive water transportation on the river north of Metaline Falls. The cliffs along the river become prominent near the southern boundary of the Metaline district and grow more conspicuous throughout the northward course of the stream, which, though a mile wide in part of its course farther south, is in this region confined in one place between walls reported to be only 18 feet apart. The rocks that form the banks of the river rise rather abruptly to benches ranging in height from 150 to 350 feet, and above these benches rise steep timber-covered mountains, the highest of which attain altitudes of 6,000 to 7,000 feet above sea level, or 4,000 to 5,000 feet above the river. The mountains on the west side of the river form a continuation of the Calispell Range; the mountains on the east side are not known by any generally accepted name.

Smaller mountain streams, tributary to Clark Fork, are numerous in this district, the more prominent being Sullivan and Slate creeks on the east side, flowing approximately west; and Flume, Evarts, and Perry creeks on the west side, flowing east or southeast. These streams are exceedingly valuable for generating power and for many other purposes, their valleys having in places high gradients.

GEOLOGY.

The geologic section exposed by the erosion of Clark Fork and its affluents, so far as it was seen in a visit to the prospects from Metaline some 8 or 10 miles northward, consists of a thick series of more or less dynamometamorphosed sedimentary rocks composed essentially of shale and dolomite. The rocks are believed to be of Paleozoic age, although no fossils were found to substantiate this conclusion. Igneous rocks were not observed in the localities visited. The beds throughout a large part of the section examined have a more or less general north-south strike and a fairly constant westward dip at a steep angle. In many places the strike is several degrees east of north and the dip is to the northwest or southeast. Local changes in the direction of strike and dip were observed and there is some intricate folding on a small scale.

Observations of the rock formations in the district were practically confined to a narrow strip of country near Clark Fork, but investigations in the contiguous Northport district and elsewhere in northeastern Washington indicate that these metamorphosed sedimentary rocks are simply a continuation of the series so universally present in the eastern part of Stevens County. Accurate measurements of these sedimentary beds were not made, but it is certain that they are several thousand feet thick. The rocks observed are mainly lime shales or slaty argillites, with intercalated dolomite which is in places completely silicified. These rocks occur in alternating beds of shale and dolomite, which appear to be conformably interbedded, the thickness of the intercalated shale or dolomite strata varying from a few inches up to several hundred feet. In general thin beds of dolomite occur between beds of shale, though the reverse arrangement is seen in some places, and the shale probably occupies the greater part of the Metaline district. On the west side of the river dolomite is prominent, and in several places it extends across the valley and forms high cliffs and mountains on the east side. Much of the dolomite resembles limestone and some of it was regarded as limestone in the field. However, analyses of three specimens collected from widely separated localities showed the presence of 17 per cent or more of MgO, and therefore all these rocks are termed dolomites, although there are probably in the area pure limestone strata which the writer did not recognize as such. Some cliffs in the vicinity of the Clark property are composed of nearly pure calcium carbonate. Here huge blue and white calcite crystals, some of them 3 inches long, form strata several feet in width and over 100 feet in height. The calcite is crystallized in perfect form and shows no notable change due to subsequent movement. The formation appears to be the result of a complete recrystallization of limestone under rather exceptional conditions.

As the rocks strike generally north and south the river has in many places cut its channel nearly parallel to the direction of the strike, and the steep cliffs and box canyons suggest faulting or slipping along the cleavage planes of the shales. Faulting and brecciation of the country rock are common and are important factors to be considered in connection with the ore deposits, having controlled to a large degree the extent and location of the mineralized areas.

The dolomite is in general of fine, even texture and varies in color from the predominating bluish-gray tone to white and in places to a dense black.

The dark variety contains 21.5 per cent of MgO and 27.9 per cent of CaO, as shown by the analysis of a sample taken from the vicinity of the Lead King prospect. The lighter-colored dolomites contain approximately 17 per cent of MgO and 30 per cent of CaO. The shales

are in general dark blue or black in color and are finely cleavable, the planes of lamination being distinct and close together. In places greenish shales were noted, which may be chloritic. The Inland Portland Cement Co.,° of Allentown, Pa., has kindly furnished the following analyses made by it of the shales in the vicinity of Metaline Falls:

Analyses of shales from Sullivan Creek, Metaline Falls.

	1	2	3	4	5
Silica	25.72	15.62	37.40	20.32	32.22
Alumina and iron oxide	15.72	9.82	25.14	12.20	20.52
Lime carbonate	53.02	68.66	29.71	62.11	39.11
Magnesia carbonate	3.66	4.81	2.93	3.66	3.87
Ignition loss	25.64	32.82	16.20	29.66	20.34

Analyses of shales from Sand Creek, 5 miles south of Metaline Falls.

	1	2	3	4	5
Silica	71.00	81.16	78.00	65.72	66.50
Alumina and iron oxide	13.20	11.06	11.24	17.84	13.32
Lime carbonate	5.95	1.41	2.19	4.37	8.12
Magnesia carbonate	6.61	2.70	3.41	3.80	8.71
Ignition loss	6.40	2.04	3.80	7.44	8.42

ORE DEPOSITS.

DISTRIBUTION AND CHARACTER.

Because of the small amount of development work done on prospects in the Metaline district and the general unsettled conditions which exist there, the character and distribution of the ore deposits are rather difficult to ascertain. Examinations were made of the Schellenburg, Riverside, and Meade properties, on the east side of Clark Fork, and of the Cliff, Lead King, Clark, and Oriole prospects, on the west side. The deposits on these properties are reported to be typical of the lead and zinc deposits in the Metaline district. They are all within a short distance of Clark Fork, extending from Metaline 10 miles northward.

In general the deposits are irregular, disseminated replacements of lead and zinc ores in dolomite. Scattered bunches and pockets of galena also occur. One large fissure vein was seen. There is no visible connection between the pockets of galena and any mineralizing agent, but the zinc ores in this district almost invariably accompany a rock that is either silicified dolomite or limestone, it being impossible to determine its original character. Especially worthy of note is the relation of the mineralized areas to the brecciated and faulted zones, marked disturbances in the sedimentary rocks having been noted in all the deposits examined. Where brecciation was the most severe

mineralization appears to be correspondingly high. That these zones of movement indicate the former existence of channels in irregular fractures through which mineralizing solutions have passed is clearly shown by the intimate association of the ores of the district with such fracture zones and cemented breccias.

The principal minerals occurring in these disseminated deposits are cube galena and light-colored sphalerite, the latter in places possibly containing some cadmium. The resemblance of much of the sphalerite to that of the Joplin district, Missouri, is noteworthy. "Steel" galena and the ordinary dark-colored sphalerite, "black-jack," are also present in some of the ores. Pyrite and marcasite are found in many of the deposits, the quantity present varying greatly from place to place. As a rule the pyrite appears to occupy fissures rather than to be generally disseminated through the sedimentary rocks. Some chalcopyrite occurs in a few of the deposits. The oxidation products of the sulphides above mentioned are common, smithsonite and anglesite having been seen in the ores from many of the workings. Calamine was not definitely recognized, but it has been reported from the district and there is no reason to doubt that it is present. Cerusite also forms a part of the ore. Malachite, azurite, and limonite are less conspicuous minerals in the disseminated deposits.

In the property whose vein occupies a large fissure the mineralization by pyrite is much more profuse, and the iron sulphides, which elsewhere but sparingly replace the country rock, here occur in a vein from 2 to 8 feet in width. The amount of galena and sphalerite is scanty, and secondary oxidized products fill some of the small fissures and fractures in the country rock adjoining the vein.

ORIGIN OF THE ORES.

About 7 miles west of Clark Fork, near the border between the Metaline and Northport mining districts, a great area of granite was seen, similar in many respects to that in the Old Dominion mine, 7 miles east of Colville, and in fact resembling the granite found in places throughout northeastern Washington. Specimens of molybdenite which have been sent to the United States Geological Survey from a prospect located 4 miles east of Clark Fork, in sec. 18, T. 37 N., R. 43 E., show every indication of a pegmatitic origin, which also implies the presence of a granitic magma in this part of the area. The silicified zones of dolomite or limestone are evidently the results of siliceous solutions. These solutions may have accompanied the granitic intrusions seen throughout a large part of northeastern Washington, tongues of which probably extend into the Metaline district.

The light-colored sphalerite is almost invariably found in silicified zones in this district. As the lead and zinc ores are commonly associated in this locality, it seems only reasonable to suppose that the siliceous solutions brought also the lead ores. The apparent uniformity of the deposits and the geologic section throughout the portion of the area examined and the probability that a similar geologic series extends over a greater part of the district seem to justify the conclusion that deposits elsewhere in the Metaline region are of the same general nature as those examined.

FUTURE OF THE METALINE DISTRICT.

At the time of the investigation (August, 1910) the Metaline district was more sparsely settled than any other locality investigated in northeastern Washington. In December, 1910, direct railroad transportation was available for some of the properties on the east side of Clark Fork. There are no wagon roads in practically the whole of the district, and the trails to the several properties do not afford an economical means for shipping out the ore.

All the deposits examined were of extremely low grade, none of them showing over a small percentage of lead or zinc, so that shipping without concentration would probably be unprofitable even with railroad transportation at the properties. One mill has been built, which proved a failure. Whether others can be constructed so that the ore minerals can be economically saved is an open question. Many tons of ore would have to be mined to produce 1 ton of concentrates containing roughly, say, 50 per cent of lead and zinc. It is the writer's impression that in most of the prospects examined the ratio of crude ore to such a concentrate would be about 30 or 40 to 1, which means a high initial expense of installation and much wear and tear on the milling machinery. The mineralization is scattered and irregular, and at present the boundaries of the mineralized areas are unknown.

In prospecting other areas in the Metaline district it would be well to look for zones of intense brecciation and faulting in the country rock, accompanied by local silicification. The lead and zinc ores seem to have been introduced by solutions accompanying the intrusion of the granite batholith, and it is highly probable that mineralization has taken place along fissures and fracture zones that have been more or less closely followed by the solutions accompanying the acidic magma. Some operators in the district believe that contacts between light and dark dolomite, or between dolomite and shale, are favorable places to look for ore bodies. This may be true of contacts contiguous to zones of intense movement, but elsewhere such contacts are likely to be barren.

Comprehensive smelter and mill tests have not, to the writer's knowledge, been made on ores from this district, and it is essential, before erecting plants to treat the ores, to make a thorough investigation of the chemical and physical properties of the constituent minerals of the ore bodies. Until recently it was not generally known that zinc minerals occurred in this district. From observation the zinc minerals seem to be as widely disseminated in the ore deposits as the lead ores, although heretofore the district has been considered as principally a lead camp. It is possible that as greater depth is reached in future developments a complete change in the mineral character of the ores may be revealed, so that mills erected with the present meager knowledge of the ore occurrences throughout the district would prove unsuitable.

DETAILED DESCRIPTION OF PROSPECTS.

WEST SIDE OF CLARK FORK.

ORIOLE.

The Oriole property is located about 1 mile due west of Metaline and some 700 feet above it, the camp being at an elevation of 2,750 feet. The workings start near the base of steep dolomite cliffs which flank mountains that attain altitudes of several thousand feet, forming some of the highest peaks in the vicinity. These mountains are about a mile back from the river and form the eastern front of the Calispell Range. The camp is located on a small flat near the head of a minor gulch. The equipment consists essentially of a small compressor plant and a boiler.

The rocks encountered in the workings are fine to medium grained grayish-blue dolomites, which are locally more or less silicified. They strike approximately north and south and dip about 45° W. or NW. The main level has been started at a point several hundred feet south of the camp and approximately 100 feet higher. It consists of an adit tunnel some 250 feet long, driven in a westerly direction in the east slope of the ridge above referred to. A slip or fault in the country rock was encountered at this distance from the portal and a drift reported to be 250 feet long has been driven on this slip, which trends N. 70° W. and dips 70° NE.

The mineralization in the prospect has been confined to the fault plane, the width of which varies from practically nothing up to 12 inches, or in places perhaps a little more. The gangue is principally gouge, with here and there some irregular stringers of quartz, which in places nearly fill the space between the walls. Some calcite was noted in parts of the vein. The ore minerals appear to be chiefly sphalerite and galena, but some pyrite is scattered in a very irregular

pockety manner throughout the quartz, the vein as a whole being exceptionally lean. A few fairly massive pockets of ore were seen, one of which measured as much as 12 inches across. A little "steel" galena was seen in a few of the ore specimens. A winze, said to be 65 feet deep, is located near the center of the drift. This winze is now nearly filled with waste rock. Near the top of it are two small quartz veins, separated from each other by 12 inches of country rock, the total width of the veins, including the horse, being about 30 inches at this place. This lens of ore exposed in the top of the winze is of uncertain relation to the main fault seen in the drift above referred to. The country rock contains many small fractures that traverse it in all directions.

The upper workings, located at an elevation of 2,950 feet, a little north of the lower level, consist of a 30-foot adit tunnel and a 20-foot drift on a slip in the country rock which strikes N. 70° E. and dips 45° NW. Here a vein having an average width of 6 inches but attaining a maximum of 24 inches in the bottom of an 8-foot winze shows some mineralization by galena, sphalerite, chalcopyrite, pyrite, and the oxidation products limonite, azurite, and malachite in a gangue of quartz and gouge.

The ore is reported to carry appreciable values in silver and a little gold, in addition to the lead and zinc.

In general the ore body is lenticular and not at all persistent. This property has more underground development than any of the others visited in the Metaline district by the writer.

CLARK PROPERTY.

About 2½ miles north of Metaline, on Flume Creek near its confluence with Clark Fork, is a group of claims known locally as the Clark property, controlled by the Metaline Lead Co. A wagon road extends northward from Metaline to Flume Creek half a mile west of the prospects, and good trails have been built from this place to the workings along the north side of the creek. Exploration, principally by means of stripping, trenching, and open cuts, is being carried on along the cliffs which lie directly northwest of the junction of Flume Creek and Clark Fork. These cliffs rise rather steeply from an elevation of 1,970 feet at the river channel to 2,800 feet or more on top of the first prominent bench or ridge and are cut by gorges from 100 to 500 feet deep, through the most precipitous of which courses Flume Creek. Because of its relatively steep fall in the distance traversed, Flume Creek affords an excellent opportunity for generating power.

The claims constituting the Clark property number about 20. The principal surface development is on the Josephine claim, which includes within its boundaries part of one of the high cliffs above

referred to. On this claim there are 18 or more surface cuts, a short tunnel, and a shallow shaft. About 400 feet lower, just above the stream bed of Flume Creek on the Hidden Falls claim, are two adit tunnels, one on each side of the creek, driven in opposite directions some 270 and 340 feet. These have been started with a view to prospecting the cliffs and possible ore bodies at this depth. So far, however, mineralized rock is not reported to have been encountered. Still farther down, near the level of Clark Fork, are an open cut and an adit tunnel some 300 feet long on the Chickahominy claim. This tunnel has been driven on a fault plane in the dolomite series near which occur scattered pockets of the ordinary lead and zinc ores found in the district. On each of the other claims in the group a small amount of work has been done, consisting mainly in sinking the discovery shafts, the title of the whole group being held by work concentrated on one or two claims.

The rocks exposed by the workings are the light-colored dolomites, dark shales, and calcite (?) strata referred to in the general description of the geology of the district. The strike and dip of these strata are difficult to ascertain. The general direction of the strike is northeast and that of the dip northwest.

The ore minerals are chiefly sphalerite and galena; the oxidation products smithsonite, cerusite, and anglesite are prominent in certain parts of the outcropping strata. No regular veins of ore-bearing material were found and the extent of replacement in the country rock is undetermined. The ores occur as pockets in dolomite and disseminated through brecciated and silicified country rock, and it is impossible to give authentic data on their probable extent. In places the mineralized zone appears to be at least 10 to 20 feet wide and to extend 50 to 100 feet along the strike of the strata.

The mineral-bearing rock contains little silver and is of low grade, so that concentration would be necessary; during this operation a partial separation of the lead and zinc minerals would be effected. It is an expensive ore to handle and for profitable mining considerable machinery would have to be installed; this means a large initial outlay of money.

LEAD KING.

The Lead King property, also controlled by the Metaline Lead Co., is located on the west side of Clark Fork some 6 miles north of Metaline, at an elevation of approximately 2,600 feet. The wagon road built by the company has been partly completed for a distance of about 4 miles and is connected by trail with the prospect. A small bunk house is located near the south end of the claim.

The country in the immediate vicinity of this property, unlike that near most of the other prospects of the district, is rather flat, the main

workings being located on top of a small ridge which rises a few feet above the first high bench west of Clark Fork.

The principal developments consist of shallow shafts, surface cuts and trenches, and two short tunnels, the longer one having been driven about 200 feet. The rocks in the vicinity are dolomites, similar in many respects to those found in other parts of the Metaline district. They appear to strike northeast and to dip northwest at a steep angle. One peculiarity of the geologic section exposed in this vicinity is the presence of a very fine grained black dolomite, containing 21.5 per cent of MgO and 27.9 per cent of CaO. This rock appears to be nearly barren of mineral values. The mineralization by galena and zinc blende seems here to be very sparse and the minerals are irregularly disseminated through the dolomite. In places calcite accompanies the ores. As exposed by the surface workings in this property, the lead ores seem to predominate.

All of the work done here is of so superficial a nature that few data were obtained as to the extent of the mineralized area.

CLIFF.

The Cliff is the most northerly deposit examined by the writer in the Metaline district, and is located some 7 miles north of Metaline, on the west side of the first high bench west of Clark Fork. The workings are situated at an elevation of 2,730 feet and are approximately three-eighths of a mile southeast of Carmichael's ranch. The developments consist of a 30-foot trench in dolomitic limestone, this formation apparently dipping northwest at a rather steep angle. One shipment is reported to have been made from this property, but the returns were not accessible to the writer. There are no surface improvements, and the property is in the early prospecting stage.

The mineralization seems to be confined to a zone of brecciated limestone, the extent of which is indeterminable. As exposed on the surface the apparent width of this partly silicified zone is not over 8 or 10 feet and the mineralization is scattered and of uncertain extent. Galena and perhaps a little sphalerite form the ores. In general there seems to be less replacement of the country rock than in the Josephine claim of the Clark group and more segregation in vugs along the siliceous zone.

EAST SIDE OF CLARK FORK.

SCHELLENBURG PROSPECTS.

The properties known as the Schellenburg prospects are located about 2½ miles north of Metaline Falls, on the east side of Clark Fork, at an elevation of 2,550 feet. They are reached by trail or wagon road from Metaline Falls and up to the present time have not

made any shipments of note. The developments consist of surface trenches from 1 to 5 feet deep and from 6 to 100 feet long. From their proximity to the new railroad which is built to Metaline Falls, these properties are perhaps more accessible than any others described in this paper.

The rocks in which the mineralization occurs are dolomitic limestones, which strike northeast and dip 70° to 80° NW. They are typical of the series found in this district and show in the most highly mineralized belt considerable brecciation.

The workings on this group expose a number of fault planes which have general northeast-southwest and northwest-southeast directions. Much of the mineralization throughout the area is found along the fault planes and appears to have accompanied or followed the more intense movements. The present developments are superficial and little can be said about the future of these deposits.

RIVERSIDE.

The workings of the Riverside property, about 6 miles north of Metaline Falls, are situated on the face of a cliff which rises almost vertically above Clark Fork. The camp is located on top of the first bench, some 300 feet above the river. The developments consist of several short tunnels or drifts on or near the vein, which show in an uncertain manner the lateral extent of the replacement of the sedimentary series. Outside of the mineralized zone fresh medium to fine grained blue and gray dolomitic limestones form the country rock. A few hundred feet to the east blackish shales appear in the series and extend eastward for some distance. These rocks strike N. 55° E. and dip 70° to 80° NW.

The deposit constitutes a true fissure vein in dolomitic limestone, the vein being exposed for a vertical distance of about 250 feet. The country rock is partly replaced on either side over a distance of several feet, and parallel fissures extend from the main vein for 15 to 20 feet. These lateral stringers are much smaller than the main vein, which is in general from 2 to 8 feet wide. The trend of the vein is N. 55° E. and the dip 70° to 80° NW.

The vein filling is principally pyrite with a little galena, the mineral aggregate showing concentric or kidney structure representing alternate replacement of the limestone by pyrite and galena. A radial structure is also developed in the pyrite. The iron minerals have been partly decomposed, so that a very heavy gossan caps the vein and extends downward for a distance of 100 feet or so. Gypsum crystals occur in abundance along the small cracks and fissures and are no doubt derived from the alteration of the dolomitic limestone by the action of sulphuric acid liberated in the oxidation of pyrite. Some "steel" galena was noted in a small tunnel halfway down the

cliff, but farther down this mineral seems to be absent. Chalcopyrite was seen in the lower levels. Because of the highly oxidized condition of the iron ores in this deposit, the strata on both sides of the fissure are very much stained and form a noticeable red and yellow zone which can be seen for a great distance.

Although the fissure seems to be well defined and to have a persistent bearing, the vein filling is of such a nature that the lead ores may not occur in sufficient quantities to warrant mining. It is possible, however, that developments along the vein proper may uncover larger quantities of the lead ores, which form only a small part of the vein filling so far exposed.

MEADE PROPERTY.

The Meade prospects are situated at an elevation of 2,300 feet on a small hill just north of Slate Creek, some 7 or 8 miles north of Metaline Falls. The developments consist of two short tunnels driven on opposite sides of the hill, each one being approximately 110 feet long. The country rock is dolomite or limestone similar to that noted in the vicinity of other prospects in the district. The mineralization seems to consist principally in the introduction of pyrite with here and there a bunch of galena, the latter apparently occurring along the bedding planes of the dolomite. The pyrite has a radial structure. The main pockets of ore have been found along a slip in the country rock, which strikes N. 20° E. and dips 50° SE. A small amount of chalcopyrite is present in the ore. Calcite and quartz form the gangue, which is locally brecciated.

Because of the slight amount of development on the slip in which these pockets of galena occur, it is impossible to state the extent of the ore body. It seems highly probable, however, that this deposit is small and that future developments will show only a continuation of the irregularly spaced aggregates of ore minerals.

SURVEY PUBLICATIONS ON LEAD AND ZINC.

The following list includes the more important publications on lead and zinc published by the United States Geological Survey. These publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

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