LEAD AND ZINC.

NOTES ON THE MINERAL DEPOSITS OF THE BEARPAW MOUNTAINS, MONTANA.

By LEON J. PEPPERBERG.

INTRODUCTION.

While engaged in an investigation of the Milk River coal field, Montana, during the field season of 1909, the writer had opportunity to visit a number of mineral prospects located in the Bearpaw Mountains. The following notes are the result of this rather hasty reconnaissance, which was made with the view of determining the probability of discovering valuable mineral deposits within the area. The most important work published by previous investigators on the geology of the region is that of W. H. Weed and L. V. Pirsson.[a] In this series of papers, which are based on a visit to the mountain group by Weed in October, 1895, the authors describe the prominent features of the region and give detailed descriptions of the occurrence and petrographic character of the specimens collected. Their studies show the Bearpaw Mountains to be rich in rocks of unusual types and of great interest and importance to the petrographer as well as the student of volcanic geology. Brief mention of the igneous rocks of the region is also made by Waldemar Lindgren,[b] who examined some specimens, mostly altered, collected by C. A. White in 1882 from the southern foothills of the mountains, in the vicinity of Eagle Creek. Some of the sedimentary rocks of this general region have been described by T. W. Stanton and J. B. Hatcher.[c] Their report, which deals with the geology and paleontology of the Judith River formation, contains a review and bibliography of publications relating

[a] The Bearpaw Mountains, Montana: Am. Jour. Sci., 4th ser., vol. 1, 1896, pp. 283-301, pp. 351-362; vol. 2, 1896, pp. 136-148, pp. 188-199.

[b] Am. Jour. Sci., 3d ser., vol. 14, 1893, p. 287.

[c] Geology and paleontology of the Judith River beds, with a chapter on fossil plants by F. H. Knowlton: Bull. U. S. Geol. Survey No. 257, 1905.

to this formation in Montana and Canada. The stratigraphy and occurrence of coal in the Milk River basin has been described somewhat in detail by the writer[a] in a preliminary report and the glacial geology of the region has been briefly discussed by F. H. H. Calhoun.[b]

The Bearpaw Mountains (fig. 10) are included in the Great Plains region of the Northwest and form one of a number of isolated mountain groups which rise abruptly from surrounding flat treeless plains. They lie in the southern half of Chouteau County, Mont., between Milk and Missouri rivers, about 20 miles south of the main line of the

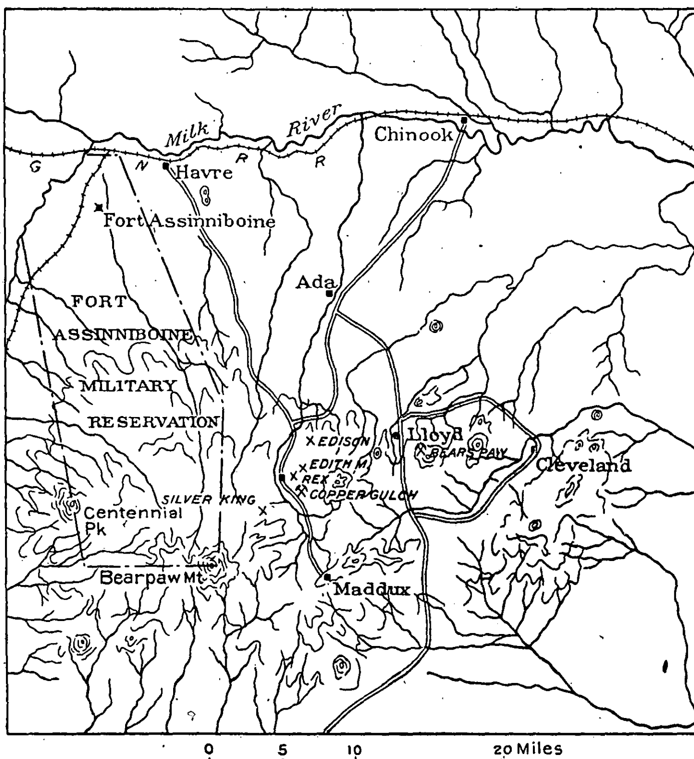

FIGURE 10.—Sketch map of the Bearpaw Mountains, Montana, showing location of the principal mines and prospects.

Great Northern Railway. The western and more mountainous part is included within the borders of the Fort Assinniboine Military Reservation. The Bearpaws do not constitute a true mountain range, but consist in the eastern part of a group of low rounded buttes more or less separated from one another, and in the western part of a series of dissected ridges gradually rising higher toward the west to their culmination in Baldy or Bearpaw Mountain and Centennial Peak. The mountain tract is about 45 miles in greatest length east and west

[a] The Milk River coal field, Montana: Bull. U. S. Geol. Survey No. 381-A, 1909, pp. 78-103.

[b] The Montana lobe of the Keewatin ice sheet: Prof. Paper U. S. Geol. Survey No. 50, 1906

and about 20 miles from north to south. Besides the main group and separated from it are numerous igneous buttes which rise above the plains, forming prominent landmarks. The region presents a type of mature topography. The highest point, Bearpaw Mountain, is about 7,040 feet above sea level. The surrounding plains have an elevation of approximately 3,000 feet above the sea, so that the area has a relief of about 4,040 feet. Except for some narrow flats along the main streams, almost the whole area is in slopes and all depressions are occupied by streams. The topography is clearly erosional and the drainage has advanced so far as to cause the development of slopes in every part of the district. This intense erosion has cut down the igneous necks and cores of the old volcanoes, leaving the narrow bands of metamorphosed sedimentary rocks surrounding them as high ridges and exposing the internal structure of the mountains.

The principal mineral prospects are located near Clear Creek and Lloyd, post-offices which are connected by stage with the railroad. One line of stage makes three round trips a week from Chinook to Ada, from which the mails are carried twice a week by separate lines to Clear Creek, Lloyd, and other inland post-offices located in the mountains. The trip to the mountains is made in one day from Chinook or Havre.

The writer is indebted to Messrs. Weed and Pirsson, whose valuable geologic data have been freely incorporated in this report; to the prospectors and ranchers of the district, who have been uniformly courteous in facilitating his investigations; and to Mr. C. E. Siebenthal, whose friendly interest and suggestions have been of great value and assistance.

HISTORY OF DEVELOPMENT.

The placer deposits of the Bearpaw Mountains are of very little importance, although some coarse gold has been recovered by panning and crude sluice methods from the small gravel bars occurring along drainage ways throughout the group. Since the early seventies prospectors have searched the mountains for lode deposits, and although several pieces of promising looking float which were reported as having been picked up within the district were brought to Havre and Chinook, no vein of value was discovered until about 1888. In that year work was begun on an argentiferous galena vein about 3 miles southeast of Lloyd post-office, by a number of Chinook business men. Development was continued on this vein for about four years after the discovery and, according to L. V. Bogy, of Chinook, who is interested in the property, about 7 tons of sorted ore was shipped to Great Falls for treatment. In 1892 the claim was patented and since that time no work has been done on this property. In 1906 Stephen Randall discovered a vein of supposed copper ore about three-fourths of a mile southeast of Clear Creek post-office. Immediately after this discovery the Copper Gulch Mining Company, of Chinook, was formed to develop a group of claims staked out by Randall and his associates. The shaft sunk on the site of the original discovery showed the vein to carry values in lead, silver, gold, and copper, and as a result of this showing much prospecting was done during 1906 and 1907 along the tributaries of Clear Creek, especially around the head of White Pine Canyon. The district is not a producer at the present time. The locations of the prospects are shown in figure 10.

GEOLOGY.

Weed and Pirsson have shown that the Bearpaws are not a mountain range of folded sediments but consist of the dissected remains of a group of volcanoes of Tertiary age. Intense erosion has laid bare the internal structure of the group, leaving the tilted, altered sediments as ridges and buttes which are cut by dikes and sills, while the upper parts of the volcanic necks and stocks have for the most part been carried away, being more easily attacked than the metamorphosed sediments. These stocks and cores now make up the slopes along the ridges that are formed partly of altered sediments.

The igneous rocks are of various kinds and include representatives of both extrusive and intrusive types. The effusive rocks are widespread and make up the larger portion of the igneous rock of the district. They form the highest peaks, small chains of hills, and outlying isolated buttes, and represent remnants of the large area originally covered by the extrusive material. These rocks consist for the most part of leucite basaltic tuffs, breccias, and lava flows of dark color. The colors vary from greenish-black tints through the purples, reds, and browns. In texture the rocks range from hard, tough, compact varieties showing no porphyritic crystals to highly porphyritic forms which become porous and grade into scoria.

Intrusive rocks of many interesting and unusual types occur within the group as dikes, sills, small laccoliths, stocks, and volcanic necks. Among these rocks as determined by Weed and Pirsson are mica andesite or mica trachyte, quartz syenite porphyry, augite syenite, leucitite, nephelite basalt, potassium tinguaite porphyry, quartz tinguaite porphyry, pseudoleucite-sodalite tinguaite (a bright-green porphyritic rock), and numerous others, including shonkinite, a dark augite-olivine-biotite-orthoclase rock. The intrusive rocks vary in color from cream and gray through red, brown, and bright greens, mottled by crystals of varicolored minerals that contrast with the predominating shade of the groundmass.

No signs of local glaciation were observed within the mountains, although they are shut in on all sides except the south by the terminal moraines of the Keewatin ice sheet.

The sedimentary rocks outcropping within the mountains are largely of Cretaceous age, but some Tertiary rocks were observed west and north of Centennial Peak. The Cretaceous rocks are represented within the mountainous tract by the dark Colorado shale and local outcrops of Eagle sandstone. The strata outcropping in the plains surrounding the mountains are given in the following table:

Stratigraphy of the Bearpaw Mountain region.

System.	Group or formation.		Thickness.	Description.
			Feet.	
Quaternary.				Alluvial deposits; glacial drift.
Tertiary.	Fort Union formation.		60+	Massive gray to buff sandstone with thin beds of gray shale, containing many fossil plants and workable subbituminous coal beds.
Cretaceous.	Montana group.	Bearpaw shale.	80-100	Leaden-gray shale, with thin beds of sandstone and large concretions, usually fossiliferous.
		Judith River formation.	480	Alternating beds of light-colored sandstone and shale; workable subbituminous coal beds within the upper 150 feet.
		Claggett formation.	350±	Dark-gray shales with thin beds of buff sandstone near top and bottom and large concretions, in places fossiliferous.
		Eagle sandstone.	250	Massive, slightly calcareous white to cream colored sandstone locally cross-bedded; at top, dark-gray shale, with intercalated beds of gray to buff sandstone.
	Colorado shale.		1,000+	Drab or lead-colored clay shale carrying round or oval concretions of gray limestone.

The sedimentary rocks, which surround the larger bodies of intrusive rocks and are cut by dikes and sills, generally show the effect of contact metamorphism. The shales have been indurated and altered to such an extent that slaty cleavage has developed; the sandstones are converted to quartzite and the limestones to impure marbles. The baking has changed them to hard, compact, flinty rocks of various shades of lavender, red-brown, lead-gray, green, and white streaked with gray laminæ, and in many places cubical jointing has developed.

Although these metamorphosed sediments break into small irregular fragments, they resist erosion better than the igneous rocks which they surround and form some of the principal ridges and divides of the region. The igneous rocks usually make up the slopes adjacent to the altered sediments.

The thickness of the rocks which show the effect of metamorphism varies with the size and character of the intrusion. The more highly altered sediments are in contact with eruptive rocks of basic types.

ORE DEPOSITS.

OUTLINE OF OCCURRENCE.

The earliest prospecting in the Bearpaw Mountains was induced by the small pieces of gold-bearing quartz float and colors which were obtained by panning small bars along coulées within the group. Numerous veinlets and stringers of quartz and calcite and a few of barite have been prospected, and although some of these carried small values in gold, as yet no important gold discovery has been reported.

The principal mineral prospects are located on the peripheries of old volcanic necks and stocks within the zone of altered sediments. These metamorphosed shales, with the intruded dikes and sheets, form some of the principal ridges and divides of the district. The mineralization occurs along shear zones, breccia zones, joints, and small fractures that are in part due to the intrusion of the igneous masses. The ore minerals consist almost entirely of sulphides, which were probably precipitated from hot ascending waters. The veins are usually associated with dikes or sills which cut the sediments and both intrusive and extrusive igneous rocks.

The most valuable ore deposits so far discovered contain argentiferous galena carrying some gold, the associated vein minerals being quartz, calcite, zinc blende, pyrite, chalcopyrite, barite, pyrrhotite, and arsenopyrite. The mineralized veins range from mere seams to veins more than 20 feet in thickness, but the average width of all veins examined was less than 1 foot. Some of the veins can be traced for several hundred feet along the surface, but in other localities there has been a considerable amount of faulting along planes at various angles to one another and this obscures the continuity of the veins.

The walls of a few of the veins are fairly well defined for short distances, but many of them show no distinct boundary between the vein material and the country rock. In those of the latter class brecciated country rock is in places included within the vein matter or the mineralization has been diffused along minute fractures extending into it. Although the mineralized veins and veinlets run in various directions, those which carry the greater values have a northeast-southwest trend.

DESCRIPTION OF THE PRINCIPAL DEPOSITS.

There has been considerable prospecting in the Bearpaw Mountains during the last twenty years, but comparatively few important discoveries have been made. No mine in the district can be classed as a producer, although several tons of galena have been shipped from the Bear's Paw mine. The most important ore bodies are described below.

BEAR'S PAW MINE.

The Bear's Paw mine (sometimes called the O'Hanlon mine) is in the NE. ¼ sec. 19, T. 29 N., R. 19 E., about 3 miles southeast of Lloyd post-office. It is located on the summit of a high butte (elevation 5,000 feet by aneroid barometer) which forms a part of the divide between Snake and Peoples creeks and is about 2 miles east of the old Lloyd-Nelson mail road.

The Bear's Paw was discovered in 1888 by a miner who had been prospecting in the mountains for a number of years. Several business men of Chinook obtained an interest in the property by furnishing funds for its development. They worked the property from time to time for about four years and were granted a patent in 1892. Very little work has been done on the property since that date, and in August, 1909, at the time it was visited by the writer, the shaft house which once formed a prominent landmark and could be seen for miles from the surrounding plains had been blown down and the shaft was in such poor condition that it could not be entered.

Mr. L. V. Bogy informed the writer that the original plan was to sink a shaft following the ore, which was supposed to be an almost perpendicular vein with regular walls. Within the first 70 feet the vein changed direction several times, so that it was necessary to abandon the plan of following the ore and the remaining 100 feet was sunk vertically after partly straightening the upper part of the shaft.

Several small drifts were made at intervals in the shaft to tap the vein. Mr. Bogy also reports that the vein is from 4 to 5 feet wide and contains several rich pay streaks from 2 to 6 inches wide. About 7 tons of this rich ore was sorted by hand, hauled to Chinook by wagon, and shipped to the smelter at Great Falls, where a mill-run test was made which showed the ore to carry about 50 ounces of silver to the ton, 50 to 60 per cent of lead, and a little gold.

The igneous rocks associated with the ore body are described by Weed and Pirsson[a] as follows:

> The ore body occurs near the margin of an intrusive mass of trachyte, which, as is commonly the case in these mountains, has been deeply cut by the drainage, while the contact zone with its denser rock and rim of hardened sediments stands out in relief, forming the summit of the butte and its most important westerly spurs. The main mass of the rock is a trachyte, generally much altered, in which large crystals of white feldspar occur in a reddish-yellow groundmass. Good exposures of the intrusive mass are rare even where the slopes are deeply cut by drainage channels, for the prevalent covering of grass, everywhere a feature of the mountains, often conceals even the débris. The rock is a trachyte or syenite porphyry which is too greatly altered and decomposed to be of value for petrographic study. It consists of a brownish, earthy feldspathic groundmass filled with limonite and with hollow cavities caused by weathering and decay of a former iron-bearing mineral. This is thickly filled with feldspar phenocrysts of a thick tabular or short columnar habit about 1 cm. in greatest

[a] Am. Jour. Sci., 4th ser., vol. 1, 1896, pp. 299-301.

length. Its determination as a rock of the alkali class rests upon the character of its contact form.

The contact form of the trachyte is a dark greenish-gray rock thickly crowded with small idiomorphic feldspar phenocrysts of thick tabular form. There is a sprinkling of rather dull inconspicuous black dots which are either pyroxene or micas. * * *

The shaft of the mine has been sunk upon a mass of shonkinite, a dark basic micaceous rock which appears to form a dike cutting transversely across both the periphery of the trachyte intrusion and its marginal zone of hardened, baked sedimentary rocks. This rock is of a moderately coarse grain and is filled with stringers and thin seams of pyrite. It consists of iron ore, apatite, augite, biotite, and soda orthoclase feldspar. It is moderately coarse-granular, and the augite and biotite, which are the chief ferromagnesian minerals, are inclosed poikilitically by the alkali feldspar in broad plates. * * *

The gangue of the ore body is a brecciated and much altered trachyte or syenite porphyry. The fragments composing it are angular, of varying size, color, and character, and the rock shows considerable pyrite scattered throughout its mass. Examined under the microscope, the thin section shows untwinned feldspar phenocrysts, biotite, and iron ore in a feldspathic groundmass consisting apparently of singly or untwinned alkali feldspars. It is now so greatly altered by leaching solutions, filled with calcite, which exists everywhere in thin films, and the feldspar is so changed into sericite that it would not be safe to assert more than this about it.

Small crystals of slightly oxidized galena and pyrite were found in place on the surface of the igneous and metamorphosed sedimentary rocks which make up the butte on which the shaft is located. The butte consists of metamorphosed shales, slightly calcareous in part and containing some sandy members, intercalated with sills of igneous rock and cut by numerous dikes. The alteration of sedimentary and intrusive rocks gives the surface a ribboned appearance. The strike of the vein is N. 40° E. The dip could not be measured but is close to vertical. A part of the brecciated gangue is probably made up of altered sediments similar to those exposed in the vicinity of the mine shaft. Specimens found on the dump indicate that the richer streaks of argentiferous galena occur in pockety geodic masses in the vein, as numerous pieces of pure galena up to 3 or 4 inches in size were observed. The main vein material, however, consists of quartz and calcite, somewhat banded and impregnated with small crystals of galena, pyrite, iron ore, and scattered crystals of chalcopyrite. This material, which probably forms the greater part of the lode, could be easily crushed and concentrated. The high-grade ore now lying on the dump indicates that further prospecting is warranted.

COPPER GULCH GROUP.

The Dividend claim, on which the shaft of the Copper Gulch Mining Company of Chinook is located, is one of a group of eight claims constituting the property of this company. This claim is located on the west slope of Greenough Butte, near the head of Copper Gulch, about half a mile east of the Clear Creek and Maddux mail road and about 35 miles south and a little west of Chinook. It was discovered in 1906 by Stephen Randall, who while looking for some cattle accidentally noticed a piece of rock that he thought might carry values. Samples collected by Randall were sent to Butte and to Great Falls for assay and showed the rock to be copper bearing. After prospecting the property business men from Chinook became interested in it and formed the Copper Gulch Mining Company to develop the group of claims. Active work was commenced in 1907, when a force of men constructed a road connecting the prospect with the Clear Creek county road. The mine workings consist of a 4 by 8 foot shaft, 108 feet in depth, from the bottom of which a drift runs 27 feet to the north, tapping the vein, which dips 70° N. 40° W.

The mineralization here, as in the Bear's Paw mine, occurs in the metamorphosed rim of a stock. The general country rock consists of a fine-grained gray augite syenite. The ore is found along fracture and shear zones in a dike of syenite porphyry. This rock, which has

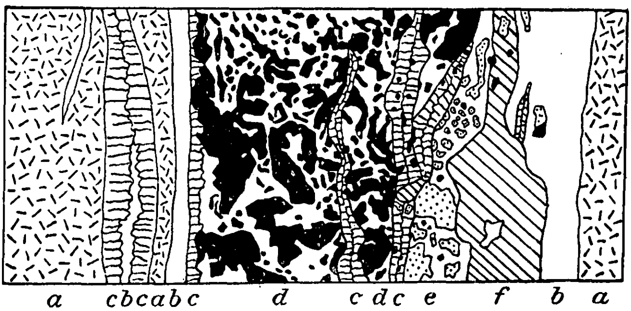

FIGURE 11.—Cross section of banded vein on property of Copper Gulch Mining Company, 35 miles south of Chinook, Mont. *a*, Country rock; *b*, calcite; *c*, quartz; *d*, galena with calcite and quartz; *e*, zinc blende with calcite and quartz; *f*, pyrite and chalcopyrite.

a greenish-gray color, is fine grained and examination of the thin section shows that it is badly altered by leaching solutions. It is made up largely of biotite, hornblende, orthoclase, plagioclase, and quartz, with secondary quartz and calcite veinlets and scattered pyrite crystals occurring along minute fractures. The ore-bearing portion is 4 to 5 feet in width and consists of several stringers of argentiferous galena from half an inch to 6 inches thick. The associated minerals are quartz, calcite, zinc blende, pyrite, and chalcopyrite. The vein shows distinct banding and in many places comb structure is well developed, as illustrated in figure 11. The ore deposited in open spaces shows evidence of subsequent crushing. In the altered, bleached, and highly calcareous country rock small grains of pyrite and galena have developed.

Although the property was thought to be copper bearing when discovered, it has proved to carry mainly silver and lead. Only small amounts of copper minerals were observed by the writer. Numerous assays of samples sent in for analysis show the ore to carry from 40 cents to $9 in gold and as high as 41 ounces of silver to the ton, up to 10 per cent of copper, and from 6 to 50 per cent of lead. The ore-bearing portions of the vein are well mineralized and could be easily crushed and concentrated.

EDISON CLAIM.

The Edison prospect is located in the SE. ¼ sec. 14, T. 29 N., R. 17 E., at the head of Spencer Gulch. At this place a 10-foot prospect pit has been sunk on a vein of barite and calcite along a brecciated zone in a highly micaceous brownish to gray dike. The mineralized zone is about 3 feet thick and consists of several small stringers connected by branching veinlets along small fractures. It has been altered by oxidizing solutions and the brecciated portion contains pieces of metamorphosed limestone and numerous cavities filled with quartz crystals. No pyrite was observed in this prospect, although oxidized iron ore is present. The chief values lie in the galena, which is found in small crystals throughout the vein matter. Assays of samples taken from the Edison claim are said by C. W. Allen, owner of the prospect, to show $6.90 in lead and silver to the ton.

REX CLAIM.

The Rex prospect is situated in the SW. ¼ sec. 27, T. 29 N., R. 17 E., and consists of a 47-foot tunnel driven on a vein of pyrrhotite, a bronze-yellow magnetic iron sulphide of metallic luster with a dark tarnish. At the breast of the tunnel 25 inches of almost solid ore was measured, and to judge by surface indications the vein is 18 to 20 feet in width. It consists almost entirely of pyrrhotite, carrying a trace of nickel. This ore is of interest, for examination of a thin section shows it to be clearly a magmatic deposit. The associated minerals are pyrite, chalcopyrite, and augite that is partly altered to hornblende and calcite. Some garnet has developed. The country rock is a dark basic micaceous dike. The vein stands almost perpendicular and strikes N. 60° E. It is said to carry values in gold and silver ranging from $2 to $10 a ton.

EDITH M. CLAIM.

The Edith M. prospect is located about 200 yards east of the Rex. It consists of a 10-foot pit sunk on a quartz-calcite vein of which a dike is the hanging wall and a metamorphosed impure limestone the foot wall. The vein is 10 to 22 inches in width. It has been altered by surface waters and although in the hand specimen the mineralization seems to be slight, an assay by Raumbauer & Co., of Butte, Mont., for C. Measles, owner of the prospect, shows it to carry the following values: Copper, 8.33 per cent; gold, $10.80 to the ton; silver, 14 ounces to the ton.

SILVER KING CLAIM.

The Silver King prospect is one of many openings made near the head of White Pine Canyon. It is situated on the spur between the main and middle forks of the canyon and consists of a 15-foot pit sunk on a small quartz vein 4 to 5 inches wide. The ore consists of argentiferous galena associated with pyrite, calcite, and quartz. The richer portions occur in small pockets, but the entire vein is mineralized. An assay made by Fisk & Co., of Helena, Mont., of a sample which F. B. Rodgers, of Maddux, owner of the prospect, informed the writer represented an average of the vein, gave the following results: Lead, 23 per cent; silver, 62.84 ounces to the ton; gold, 40 cents to the ton.

BLACK DIAMOND CLAIM.

The Black Diamond prospect is located close to the Silver King, on the spur between the main and middle forks of White Pine Canyon. It is not shown on the accompanying map. It consists of a 14-foot pit sunk on a vein of high-grade magnetite 14 to 20 inches thick. Examination of the thin section shows the ore to be a magmatic deposit. The associated minerals are apatite and augite. The country rock is a dark basic micaceous dike. This ore, like that in the Rex prospect, is of interest because it is purely an igneous product and shows that the intrusive rocks of the shonkinite type contain metals as sulphides and oxides which separate out, forming ore bodies where proper conditions are present.

CONCLUSIONS AND SUMMARY.

The mineralization in the Bearpaw Mountains is widely diffused, as comparatively few localities have been discovered where there has been sufficient concentration to form ore bodies. This is shown by the fact that though numerous openings have been made on veins and veinlets throughout the district only a small number of promising prospects have been found. The banded and comb structure of the veins points to the precipitation of the deposits by hot ascending solutions. The deposits have been altered more or less by descending waters. As previously stated, the Bearpaw Mountains are in a mature stage of erosion; consequently any mineral veins exposed in them can be considered as representing parts of ore deposits that extended upward for several hundred feet prior to the denudation of the region. In other words, the veins of the district represent the roots of former more extensive ore deposits.

The Bearpaw Mountains are not heavily timbered but furnish a sufficient quantity of pine, fir, and aspen to meet the requirements of a small number of mines. Clear, Bean, and Snake creeks carry sufficient water for mining and milling purposes, and coal is abundant in the Judith River formation, 15 miles north of the mountains.

The ores of the region could be easily concentrated and it is possible that future prospecting may develop ore bodies of some value.

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.

ADAMS, G. I. Zinc and lead deposits of northern Arkansas. In Bulletin 213, pp. 187-196. 1903. 25c.

ADAMS, G. I., and others. Zinc and lead deposits of northern Arkansas. Professional Paper 24. 118 pp. 1904.

BAIN, H. F. Lead and zinc deposits of Illinois. In Bulletin 225, pp. 202-207. 1904. 35c.

——— Lead and zinc resources of the United States. In Bulletin 260, pp. 251-273. 1905. 40c.

——— A Nevada zinc deposit. In Bulletin 285, pp. 166-169. 1906. 60c.

——— Zinc and lead deposits of northwestern Illinois. Bulletin 246. 56 pp., 1905.

——— Zinc and lead deposits of the upper Mississippi Valley. Bulletin 294. 155 pp. 1906.

——— Zinc and lead ores in 1905. In Mineral Resources U. S. for 1905, pp. 379-392. 1906.

BAIN, H. F., VAN HISE, C. R., and ADAMS, G. I. Preliminary report on the lead and zinc deposits of the Ozark region [Mo.-Ark.]. In Twenty-second Ann. Rept., pt. 2, pp. 23-228. 1902. $2.25.

BECKER, G. F. Geology of the Comstock lode and the Washoe district; with atlas. Monograph III. 422 pp. 1882. $11.

BOUTWELL, J. M. Economic geology of the Bingham mining district, Utah. Professional Paper 38, pp. 73-385. 1905.

——— Progress report on Park City mining district, Utah. In Bulletins 213, pp. 31-40 (25c.); 225, pp. 141-150 (35c.); 260, pp. 150-153 (40c.).

——— Lead. In Mineral Resources U. S. for 1906, pp. 439-457. 1907.[a] 50c.

——— Zinc. In Mineral Resources U. S. for 1906, pp. 459-489. 1907.[a] 50c.

——— The geology and ore deposits of the Park City mining district, Utah. (In preparation.)

BUTLER, B. S., and SIEBENTHAL, C. E. Silver, copper, lead, and zinc in the Central States in 1908 (mine production). In Mineral Resources U. S. for 1908, pt. 1, pp. 587-643. 1909.

[a] Earlier volumes of the Mineral Resources of the United States also contain discussions relating to the lead and zinc industries of the United States.

Calkins, F. C., and MacDonald, D. F. A geologic reconnaissance in northern Idaho and northwestern Montana. Bulletin 384. 112 pp. 1909.

Clerc, F. L. The mining and metallurgy of lead and zinc in the United States. In Mineral Resources U. S. for 1882, pp. 358–386. 1883. 50c.

Cross, W., Howe, E., and Ransome, F. L. Silverton folio (No. 120), Geol. Atlas U. S. 1905. 25c.

Cross, W., Spencer, A. C., and Ransome, F. L. Rico folio (No. 130), Geol. Atlas U. S. 1905. 25c.

Cross, W., and Hole, A. D. Engineer Mountain folio (No. 171), Geol. Atlas U. S. In press.

Curtis, J. S. Silver-lead deposits of Eureka, Nev. Monograph VII. 200 pp. 1884. $1.20.

Ellis, E. E. Zinc and lead mines near Dodgeville, Wis. In Bulletin 260, pp. 311–315. 1905. 40c.

Emmons, S. F. Geology and mining industry of Leadville, Colo., with atlas. Monograph XII. 870 pp. 1886. $8.40.

——— Economic geology of the Mercur mining district, Utah. In Sixteenth Ann. Rept., pt. 2, pp. 349–369. 1895. $1.25.

——— The mines of Custer County, Colo. In Seventeenth Ann. Rept., pt. 2, pp. 411–472. 1896. $2.35.

Emmons, S. F., and Irving, J. D. Downtown district of Leadville, Colo. Bulletin 320. 72 pp. 1907.

Emmons, W. H. Some ore deposits in Maine and at the Milan mine, New Hampshire. Bulletin 432. In press.

Grant, U. S. Zinc and lead deposits of southwestern Wisconsin. In Bulletin 260, pp. 304–310. 1905. 40c.

——— and Burchard, E. F. Lancaster-Mineral Point folio (No. 145), Geol. Atlas U. S. 1907. 25c.

Hague, Arnold. Geology of the Eureka district, Nevada. Monograph XX. 419 pp. 1892. $5.25.

Hahn, O. H. The smelting of argentiferous lead ores in the far West. In Mineral Resources U. S. for 1882, pp. 324–345. 1883. 50c.

Hoffman, H. O. Recent improvements in desilverizing lead in the United States. In Mineral Resources U. S. for 1883–84, pp. 462–473. 1885. 60c.

Iles, M. W. Lead slags. In Mineral Resources U. S. for 1883–84, pp. 440–462. 1885. 60c.

Irving, J. D. Ore deposits of the northern Black Hills. In Bulletin 260, pp. 50–77. 1905. 40c.

——— Ore deposits in the vicinity of Lake City, Colo. In Bulletin 260, pp. 78–84. 1905. 40c.

Irving, J. D., and Emmons, S. F. Economic resources of northern Black Hills. Professional Paper 26, pp. 53–212. 1904.

Keith, A. Maynardville folio (No. 75), Geol. Atlas U. S. 1901. 25c.

——— Recent zinc mining in East Tennessee. In Bulletin 225, pp. 208–213. 1904. 35c.

Lindgren, W. The mining districts of the Idaho Basin and the Boise Ridge, Idaho. In Eighteenth Ann. Rept., pt. 3, pp. 625–736. 1898. $2.15.

——— The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho. In Twentieth Ann. Rept., pt. 3, pp. 75–256. 1900. $1.50.

——— A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho. Professional Paper 27. 123 pp. 1904.

——— The Tres Hermanas mining district, New Mexico. In Bulletin 380, pp. 123–128. 1909.

LINDGREN, W., and GRATON, L. C. Mineral deposits of New Mexico. In Bulletin 285, pp. 74–86. 1906. 60c.

LINDGREN, W., GRATON, L. C., and GORDON, C. H. The ore deposits of New Mexico. Professional Paper 68. 361 pp. 1910.

MACDONALD, D. F. Economic features of northern Idaho and northwestern Montana. In Bulletin 285, pp. 41–52. 1906. 60c.

MCCASKEY, H. D. Gold, silver, copper, lead, and zinc in the Eastern States (mine production). In Mineral Resources U. S. for 1908, pt. 1, pp. 645–681. 1909.

RANSOME, F. L. Report on the economic geology of the Silverton quadrangle, Colorado. Bulletin 182. 265 pp. 1901. 50c.

——— The ore deposits of the Rico Mountains, Colorado. In Twenty-second Ann. Rept., pt. 2, pp. 229–398. 1902.

——— Ore deposits of the Cœur d'Alene district, Idaho. In Bulletin 260, pp. 274–303. 1905. 40c.

RANSOME, F. L., and CALKINS, F. C. Geology and ore deposits of the Cœur d'Alene district, Idaho. Professional Paper 62. 203 pp. 1908. 85c.

SCHRADER, F. C. Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona. In Bulletin 340, pp. 53–84.

——— The mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona. Bulletin 397. 226 pp. 1909.

SIEBENTHAL, C. E. Mineral resources of northeastern Oklahoma. In Bulletin 340, pp. 187–228. 1908.

——— Lead. In Mineral Resources U. S. for 1908, pt. 1, pp. 227–243. 1909.

——— Zinc. In Mineral Resources U. S. for 1908, pt. 1, pp. 245–273. 1909.

SMITH, G. O. Note on a mineral prospect in Maine. In Bulletin 315, pp. 118–119. 1907.

SMITH, W. S. T. Lead and zinc deposits of the Joplin district, Missouri-Kansas. In Bulletin 213, pp. 197–204. 1903. 25c.

SMITH, W. S. T., and SIEBENTHAL, C. E. Joplin district folio (No. 148), Geol. Atlas U. S. 1907. 50c.

SPENCER, A. C. The Mine Hill and Sterling Hill zinc deposits of Sussex County, N. J. In Ann. Rept. Geol. Survey New Jersey for 1898, pp. 25–52. 1909.

SPENCER, A. C., SALISBURY, R. D., and KÜMMEL, H. B. Franklin Furnace folio (No. 161), Geol. Atlas U. S. 1908. 25c.

SPURR, J. E. Geology of the Aspen mining district, Colorado; with atlas. Monograph XXXI. 260 pp. 1898. $3.60.

——— The ore deposits of Monte Cristo, Washington. In Twenty-second Ann. Rept., pt. 2, pp. 777–866. 1902.

——— Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California. Bulletin 208. 229 pp. 1903.

SPURR, J. E., and GARREY, G. H. Preliminary report on the ore deposits of the Georgetown mining district, Colorado. In Bulletin 260, pp. 99–120. 1905. 40c.

——— The Idaho Springs mining district, Colorado. In Bulletin 285, pp. 35–40. 1906. 60c.

——— Economic geology of the Georgetown quadrangle, together with the Empire district, Colorado, with general geology by S. H. Ball. Professional Paper 63. 422 pp. 1908.

TOWER, G. W., and SMITH, G. O. Geology and mining industry of the Tintic district, Utah. In Nineteenth Ann. Rept., pt. 3, pp. 601–767. 1899. $2.25.

TOWER, G. W., SMITH, G. O., and EMMONS, S. F. Tintic special folio (No. 65), Geol. Atlas U. S. 1900. 25c.

ULRICH, E. O., and SMITH, W. S. T. Lead, zinc, and fluorspar deposits of western Kentucky. (In Bulletin 213, pp. 205–213. 1903. 25c.) Professional Paper 36. 218 pp. 1905.

VARIOUS AUTHORS. Gold, silver, copper, lead and zinc in the Western States in 1908 (mine production). In Mineral Resources U. S. for 1908, pt. 1, pp. 277–586. 1909.

WEED, W. H. Fort Benton folio (No. 55), Geol. Atlas U. S. 1899. 25c.

——— Little Belt Mountains folio (No. 56), Geol. Atlas U. S. 1899. 25c.

——— Geology of the Little Belt Mountains, Montana, with notes on the mineral deposits of the Neihart, Barker, Yogo, and other districts. In Twentieth Ann. Rept., pt. 3, pp. 271–461. 1900. $1.50.

WEED, W. H., and BARRELL, J. Geology and ore deposits of the Elkhorn mining district, Jefferson County, Mont. In Twenty-second Ann. Rept., pt. 2, pp. 399–549. $2.25.

WEED, W. H., and PIRSSON, L. V. Geology of the Castle Mountains mining district. Bulletin 139. 164 pp. 1896. 15c.

WINSLOW, A. The disseminated lead ores of southeastern Missouri. Bulletin 132. 31 pp. 1896. 5c.

WOLFF, J. E. Zinc and manganese deposits of Franklin Furnace, N. J. In Bulletin 213, pp. 214–217. 1903. 25c.