THE DUNKLEBERG MINING DISTRICT, GRANITE COUNTY, MONTANA.

By J. T. Pardee.

LOCATION.

The Dunkleberg district is in northeastern Granite County, Mont., about 50 miles northwest of Butte. (See fig. 16.) The mines and prospects are confined to an area 2 miles wide and 5 miles long, near the north end of the Flint Creek Range. From Hall, a town on the Philipsburg branch of the Northern Pacific Railway, the mining area is reached by a road that goes southeastward up a low spur known as Limestone Ridge. There is also a road, formerly used for hauling ore, that goes up Dunkleberg Creek from Jens, a station on the Northern Pacific main line.

FIELD WORK AND ACKNOWLEDGMENTS.

A brief reconnaissance of the mining area was made in June, 1916, by the writer, assisted by T. H. Rosenkranz. For courtesies extended in the field the writer's thanks are due to Messrs. Walter Neal and Albert Hollander, in charge of the Wasa mine. Acknowledgment is made also to W. T. Schaller, of the Geological Survey, for the laboratory determination of several minerals.

HISTORY AND PRODUCTION.

In the Dunkleberg district lode mining has been carried on intermittently during the last 30 years, and at one time smelting was tried on a small scale. In June, 1916, a deposit of zinc ore in the Wasa mine was being systematically explored with a diamond drill and a few other claims were being developed in a small way. The total production of the district is roughly estimated at $200,000 or more in silver and lead.

TOPOGRAPHY.

The mining area, which is in the northern foothills of the Flint Creek Range, has a rather uniform general slope toward the north, descending about 2,000 feet in 5 miles. In distant views the surface appears

rather smooth, its most prominent feature as seen looking east from the Flint Creek valley being Dunkleberg Ridge, a long spur marked by some rather conspicuous knobs, which forms the extreme north end of the Flint Creek Range. A topographic feature which occupies a considerable part of the mining area, but whose rugged character is not apparent except at close range, is the valley of Dunkleberg Creek. This drainage channel, which lies east of Dunkleberg Ridge, heads in a small, deep glacial cirque at the south and throughout its course northward across the mining area is 1,000 feet deep, narrow, and very steep-sided.

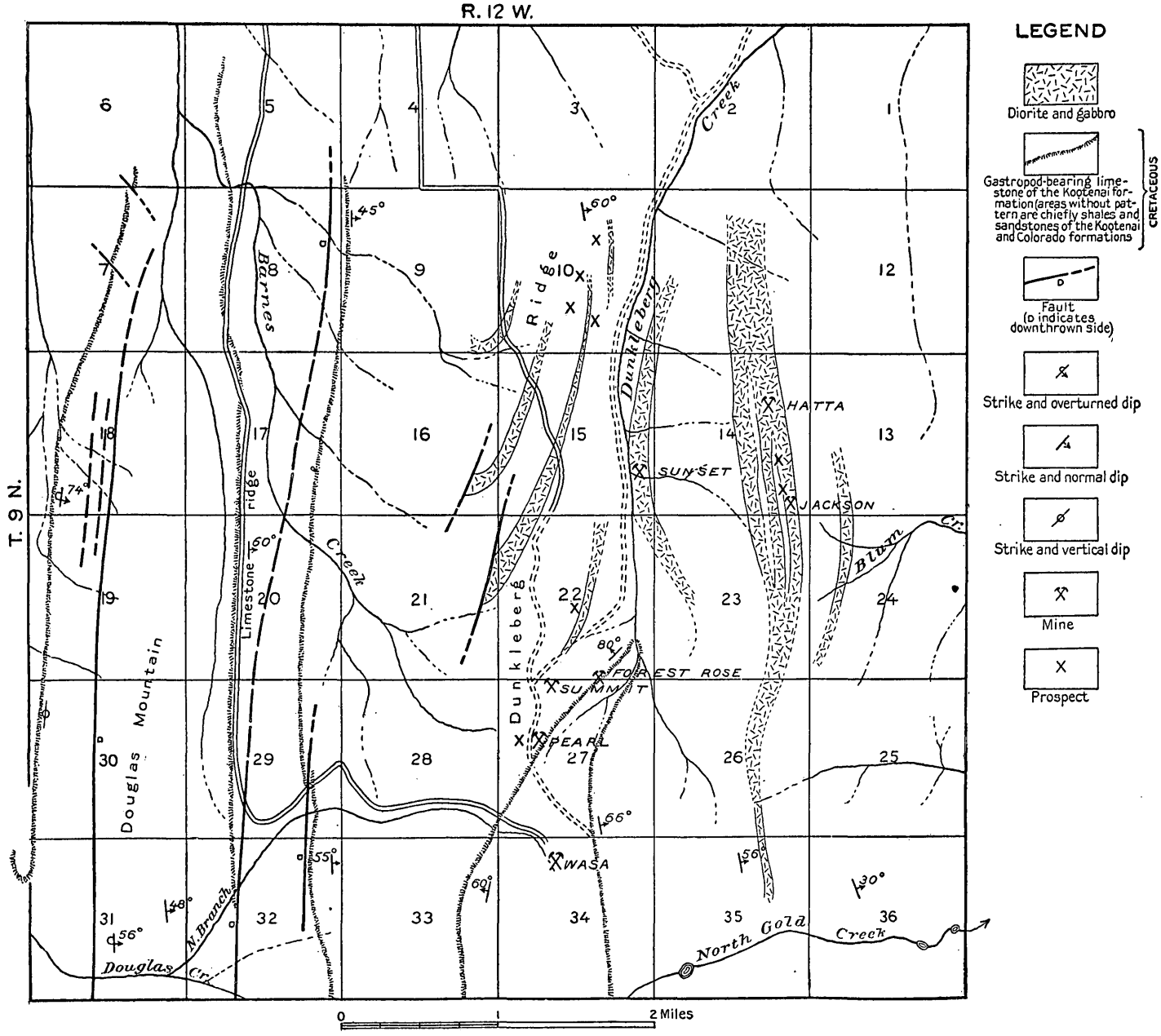
GEOLOGY.

The mining area is occupied chiefly by sandstones and shales of Cretaceous age. At the south end of the mineral belt on Dunkleberg Ridge there is a small area of Carboniferous quartzite and shale (Quadrant and Phosphoria formations) and Jurassic sandstone, shale, and limestone (Ellis formation). To the north these beds dip beneath Lower Cretaceous shale and limestone (Kootenai formation), which are exposed at the Wasa mine and which in turn are overlain by thick Upper Cretaceous shales, sandstones, and conglomerates (Colorado and Montana? formations). The most useful of these rocks as a base from which to determine the stratigraphic sequence is a limestone bed about 100 feet thick that occurs near the top of the Kootenai formation and is generally crowded with small fossil snails or gastropods. At the Forest Rose mine the fossils in this limestone are very abundant and conspicuous, but farther south, owing to contact metamorphism, they are not well preserved. The outcrop of this bed forms a loop that enters the district on the south, includes the Wasa mine, and extends northeastward, ending in a long narrow point a short distance beyond the Forest Rose. (See Pl. X.)

In the shales and sandstones above the gastropod-bearing limestone there are several sills of a heavy dark greenish-gray crystalline rock. Their aggregate volume is large, particularly east of Dunkleberg Creek, where some of the individual sills are 1,000 feet or more thick. From this locality they can be traced 25 miles eastward to a point near Avon, and apparently they were intruded throughout an area of at least 300 square miles. A specimen from one that crops out east of Hoover Creek and north of Clark Fork proved, on microscopic examination, to be gabbro.[1] Others from the sills in the basin of Gold Creek are diorite.[2]

[1] Pardee, J. T., The Garrison and Philipsburg phosphate fields, Mont.: U. S. Geol. Survey Bull. 640, p. 212, 1917.

[2] Emmons, W. H., and Calkins, F. C., Geology and ore deposits of the Philipsburg quadrangle, Mont.: U. S. Geol. Survey Prof. Paper 78, p. 87, 1913. Calkins, F. C., and Emmons, W. H., U. S. Geol. Survey Geol. Atlas, Philipsburg folio (No. 196), p. 12, 1915.



RECONNAISSANCE GEOLOGIC MAP OF THE DUNKLEBERG MINING DISTRICT, GRANITE COUNTY, MONT.

The sedimentary beds adjoining the sills have been changed to tough and flinty rocks that commonly weather to rusty shades, but the metamorphism does not extend far from the contact. The rocks in the vicinity of the Wasa mine also show a moderate degree of contact metamorphism, the Kootenai shales having lost their characteristic purple shades and the limestone being partly changed to hornstone. No igneous rocks are known within a mile of this locality, but the metamorphism plainly indicates that an intrusive granitic rock is present not far below the surface.

The sedimentary beds and the sills are folded together into a sharp-crested anticline that plunges steeply northward. At the south end the axis of this fold lies along Dunkleberg Ridge, passing through the Wasa mine, but north of that point it turns eastward into the basin of Dunkleberg Creek. Dips of 60° to 80° occur on both flanks of the anticline, and the axial plane leans slightly to the west. Large synclines appear on both sides of the anticline, the one on the east being very broad and deep. A N. 20° W. fault accompanied by a thick breccia is shown in the Wasa mine workings, and about 2 miles to the west there are several other faults that are persistent, strike about north, and have caused extensive displacements.

ORE DEPOSITS.

Lodes containing lead, zinc, silver, and other metals are fairly numerous along Dunkleberg Ridge from the head of the north prong of Douglas Creek northward for 4 or 5 miles and are found also on the slope east of Dunkleberg Creek. Except the Wasa, which is a contact-metamorphic deposit, they are simple quartz veins in fissures that follow inclined bedding planes or cut across the sedimentary rocks and the diorite sills. As a rule, the veins are narrow, but in places they widen to flat lenslike bodies 3 or 4 feet thick and of considerable length and depth. Silver-bearing galena and lead carbonate derived from it are the most valuable ore minerals, although zinc blende is commonly present and in the lower workings of the Hatta mine is so abundant that the ore could not have been profitably marketed under the conditions existing 15 or 20 years ago. Generally there is abundant pyrite and a little chalcopyrite in the lower levels and corresponding amounts of limonite and copper stain above the limit of oxidation, but little direct information concerning the amount of oxidation is available. That in places the oxidized zone extends to considerable depths is suggested by the abundance of limonite in the dumps at some of the more extensive workings, but here and there galena and other sulphides were observed very near the surface. The ore shipped is reported to have contained on the average about 40 per cent of lead and 40 ounces or more of silver

to the ton. Except in ore from the Hatta and Wasa mines, the percentage of zinc is generally low.

The Wasa lode is formed in the lower shaly limestone beds of the Kootenai formation, which were broken by the folding of the anticline described above. The limestone is recrystallized and partly replaced by quartz, feldspar, hornblende, and the sulphide minerals—pyrite, pyrrhotite, and zinc blende. Of these minerals the zinc blende came in last, as is clearly shown by its occurrence in a network of minute fractures that cut the other minerals. Small amounts of galena and chalcopyrite are also found in the lode.

So far as the development workings show, the ore body is very irregular in form but is at least several hundred feet long and at one place 40 or 50 feet wide and 140 feet deep. Certain shale beds appear to mark the upper limit of the ore, and a fault cuts it off below. Its lateral boundaries are indefinite, owing to numerous small post mineral slips and faults and to the fact that there is a gradual transition between the ore and the country rock. As determined chiefly by drill samples, large portions of this body are said to average 10 per cent or more in zinc. Where the lode is cut by Douglas Creek it is oxidized and much of its zinc is leached out.

The lodes in the Dunkelberg district are clearly later than the folding, which involved late Cretaceous rocks and their included diorite sills, and the mineralogy is characteristic of deposits formed by hot solutions ascending from intrusive granitic rocks. The distribution of the minerals and the metamorphism of the sediments indicate that the Wasa deposit is very near and the others moderately far from the source. A few miles south of the Dunkleberg district, in the basin of Gold Creek and elsewhere, Tertiary granodiorites are exposed and the Dunkleberg intrusion is probably of similar age and character. As a rule, no very large ore bodies are to be expected in the narrow veins, but some of them can doubtless be reopened profitably, especially should the metals maintain the average high prices of 1917.

Whether or not the Wasa lode will prove to be profitable can hardly be said to be demonstrated, but there is no doubt that it contains a very large body of low-grade zinc ore.

MINES AND PROSPECTS.

WASA.

The Wasa mine is on Dunkleberg Ridge near the head of the north branch of Douglas Creek, at an elevation of about 6,700 feet. From Hall (elevation 4,223 feet), a town on the Philipsburg branch of the Northern Pacific Railway, the mine is reached by a good wagon road

11 miles long that goes up Limestone Ridge, a spur west of Barnes Creek.

In addition to several hundred feet of diamond-drill holes, the principal workings consist of four adit levels that are driven eastward in a steep southwest slope and aggregate about 1,500 feet in length. Three of the adits, known as No. 1 and No. 2 tunnels and the Simmer Jack or No. 3 tunnel, are near together, and the fourth, or Kirkendall tunnel, is about 1,000 feet to the southeast and considerably higher. The country rock is chiefly thin-bedded fine-grained limestone that has been partly altered to a light-gray or buff compact hornstone. Under the microscope specimens of the most common variety of the rock show a fine mosaic of calcite and quartz in which are a few grains of secondary hornblende. A dull-greenish rock that is found close to the ore bodies shows very coarse calcite cleavages, the crystals being penetrated by irregular veinlets of secondary plagioclase, quartz, and chlorite. Grains and specks of pyrite are disseminated rather sparingly through both varieties of the rock, and near the lode pyrrhotite and zinc blende also occur. The lode is formed in a squeezed and broken zone along the axis of a northerly anticline, pyrite, pyrrhotite, and zinc blende having been introduced, replacing the rock and forming ore bodies of irregular shape and rather indefinite limits. Tunnels Nos. 1, 2, and 3, together with the drill holes, indicate the existence of a thick tabular ore body 600 feet long that trends nearly north. One drill hole near the middle of the explored area goes through 140 feet of ore; others from 20 to 80 feet. The ore is from 30 to 50 feet wide in the tunnels, but its boundaries are uncertain and irregular, partly because of many small slips and faults and partly because the mineralization gradually fades out.

In tunnels Nos. 1, 2, and 3 the ore is cut off below by a fault which strikes N. 15° W. and dips about 45° E., and whose projection also coincides with the lower limit of the ore in the drill holes. In tunnel No. 1 the fault is accompanied by 50 or 60 feet of breccia composed of country rock and oxidized lode matter. A large amount of similar breccia is shown in tunnels Nos. 2 and 3, and some other workings about 500 feet farther south along the strike of the fault have also penetrated much soft crushed material. Presumably the dislocation has been extensive and the movement normal. Owing to the absence of satisfactory exposures, the fault could not be traced along the surface in the vicinity of the mine, but it probably can be found if careful examinations are made farther north and south. Two miles west of the Wasa mine similar strike faults persist for several miles along the Douglas Mountain anticline and cause normal displacements of as much as 1,000 feet.

The ore normally is a hard, flinty rock derived from shaly limestone by replacement with silica, the process having begun along many insignificant fractures and spread outward until the whole mass was altered. Pyrrhotite, pyrite, and locally chalcopyrite accompanied the silica and were followed by zinc blende, which forms a network of veinlets that partly replace the other sulphides. In addition small quantities of galena and siderite are scattered here and there through the lode.

The lower limit of oxidation is irregular as a rule, but it is not more than 50 feet below the surface. Owing to a loose and open texture, the fault breccia is thoroughly oxidized at the tunnel levels, where it shows crusts of a pale yellowish-gray or white earthy material that contains zinc and is probably in part smithsonite.

The breccia is regarded as ore by the owners, but it appears to be of a very low grade. The main ore body is evidently rich in places, and average samples of it are said to assay from 2 to 15 per cent of zinc. An ore body 1,000 feet farther south and apparently separate from the one described is said to have been penetrated by the Kirkendall tunnel. Specimens from it show abundant pyrite and tetrahedrite cut by zinc blende.

SUNSET.

The Sunset claim is on the slope east of Dunkleberg Creek, near the stream level and about 2½ miles north of the Wasa mine. An adit level 100 feet long penetrates a diorite or gabbro sill and follows a narrow vein that strikes N. 75° E. and dips 45° N. The vein filling consists of soft, earthy, ocherous material in which bunches of quartz and partly unoxidized galena occur. There is also a little chalcopyrite. At the time of visit preparations were being made to ship this ore, which, in addition to some lead, is said to carry 30 or 40 ounces of silver to the ton.

PEARL.

On the Pearl claim, half a mile north of the Wasa mine, are the ruins of a small blast furnace in which a small amount of lead ore is said to have been smelted. An incline, now caved, has been sunk on a vein a foot or two wide that occupies a bedding plane in Colorado shale striking N. 20° E. and dipping 50° W. Ore scattered about consists of quartz and limonite showing some galena and a little copper stain.

SUMMIT.

Half a mile north of the Pearl two short adits on the Summit claim expose a vein on a bedding plane in sandstone of the Colorado formation that strikes northeast and dips steeply northwest. The

vein, ordinarily narrow, is widened in places to flat lenslike bodies as much as 4 feet thick, composed chiefly of quartz, pyrite, limonite, and galena. The production of five carloads of ore containing 40 per cent of lead and 60 ounces of silver to the ton is reported.

FOREST ROSE.

The Forest Rose mine, said to have produced about $100,000 worth of silver-lead ore, is a mile north of the Wasa and on the steep slope west of Dunkleberg Creek at an elevation of about 5,500 feet. Several workings have been made on a vein that strikes northeast and dips about 45° NW., in part following a bedding plane and in part cutting across a bed of Kootenai gastropod-bearing limestone. The size of the dumps indicates rather extensive underground workings, of which only the superficial portions were accessible for examination in 1916. Near the surface the vein is generally not much more than a foot in width and consists of quartz, limonite, and a little galena and pyrite. The dumps contain much iron-stained "honeycomb" quartz. Specimens of unoxidized ore contain abundant pyrite and galena and a very little chalcopyrite. Steps to reopen this mine were reported to be under consideration early in 1917.

HATTA.

The Hatta mine is in an area of diorite or gabbro near the top of the slope east of Dunkleberg Creek, about 2 miles northeast of the Forest Rose. A rather large production of silver-lead ore is reported, but operations were suspended several years ago because zinc blende became too abundant for the ore to be profitably mined at that time.

JACKSON.

The Jackson mine is half a mile south of the Hatta and similarly situated with respect to the topography and geology. A production several years ago of $25,000 in silver and lead is reported. Only the superficial parts of the workings, which, to judge from the dumps, are fairly extensive, were accessible for examination in 1916. The vein is a fissure in diorite or gabbro, strikes N. 20° W., dips 35° E., and is from 1 to 3 feet wide. The ore is composed of lead carbonate and limonite, which partly fill the cavities in a fine skeleton or honeycomb quartz. No unoxidized ore was seen.