LEAD AND ZINC.

ECONOMIC GEOLOGY OF THE REGION AROUND MULLAN, IDAHO, AND SALTESE, MONTANA.

By F. C. CALKINS and E. L. JONES, JR.

INTRODUCTION.

The field work of the authors in 1912 was devoted chiefly to the geologic mapping of the northern part of the quadrangle bounded by parallels 47° and 47° 30′ N. and meridians 115° 30′ and 116° W. and embracing parts of northern Idaho and northwestern Montana. This unit in the regular quadrangle system overlaps the southeastern part of the Cœur d'Alene quadrangle, whose general and economic geology was studied about eight years ago and described in a Survey publication;[1] and a welcome opportunity was thus afforded to gain information concerning recent developments in a part of the Cœur d'Alene mining district. About a month was accordingly devoted to this revisory work, which consisted mainly in the study of mines and prospects near Mullan, Idaho, but included a cursory visit to several prospects near Wallace and some review of the areal geology.

The season's work also comprised the examination of many prospects in an area surrounding Saltese, Mont., which has long been the scene of mining exploration but in which no steadily productive mine has yet been developed. Virtually nothing has been published concerning this area, although two brief papers give some account of the region to the south and southwest of it.[2] The location of the area discussed in this paper is shown in figure 20.

The present paper is intended to give a brief account of the economic information thus gathered, with so much of the geography and geology as seems pertinent to the main object. Any usefulness that it may have should be credited in large measure to the aid and facilities offered by the mining men of the region. Among those to whom special acknowledgment is due are the officers of the Morning, Snowstorm, and Gold Hunter mines. Mr. George Huston, of Mullan,

[1] Ransome, F. L., and Calkins, F. C., Geology and ore deposits of the Cœur d'Alene district, Idaho: Prof. Paper U. S. Geol. Survey No. 62, 1908.

[2] Pardee, J. T., Geology and mineralization of the upper St. Joe Basin, Idaho: Bull. U. S. Geol. Survey No. 470, 1911, pp. 39–61. Calkins, F. C., and Jones, E. L., jr., Geology of the St. Joe-Clearwater region, Idaho: Bull. U. S. Geol. Survey No. 530, 1913, pp. 75–86.

generously gave many hours to our guidance and has kept us informed by letter on developments that have occurred since we left the field.

Many prospects in the area represented by the geologic map (Pl. III) were not visited, and the reader should not infer that any prospect not described is necessarily unimportant. It is believed, however, that the properties visited illustrate the main features of the ore deposits.

GEOGRAPHY.

TOPOGRAPHY.

Mullan and Saltese lie in the heart of that broad zone of mountainous topography which forms the western part of the Rocky

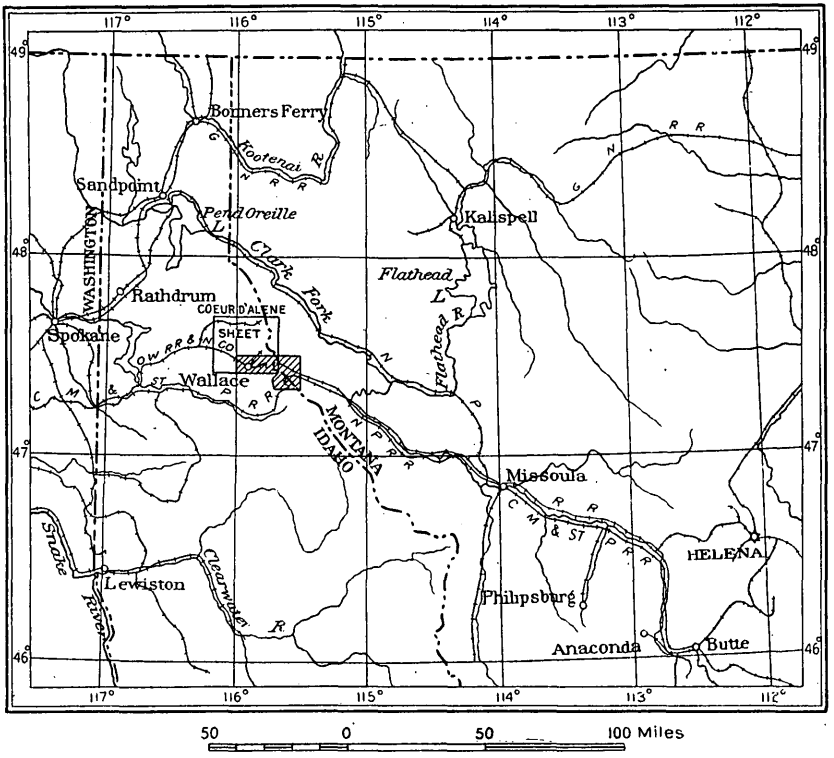


FIGURE 20.—Index map showing (by shading) location of region around Mullan, Idaho, and Saltese, Mont.

Mountain system north of the Snake River Plains. In the vicinity of these towns few of the summits exceed 6,500 feet in height, and the panorama from any commanding viewpoint suggests a surface of low relief that has been elevated and throughly dissected by streams. The valleys of this general region are relatively narrow and intricately branched. The smaller ones have no characteristic trend, but most of the larger ones have a general course near east-west or southeast-northwest, and this rule is strikingly exemplified in the area here discussed.

This area is crossed from east to west by a depression of more than local interest, which follows, with comparatively slight deviations, a straight line extending east-southeastward from Spokane, Wash., to Deer Lodge, Mont., a distance of 300 miles. Clark Fork of Columbia River flows westward in this depression from Deer Lodge to St. Regis, Mont., where it turns abruptly eastward and makes its way through a narrow gorge to another long transmontane valley. The western part of the depression is occupied by Spokane River and the Cœur d'Alene and its South Fork. The section between Clark Fork and the head of the Cœur d'Alene might appear, from inspection of a small-scale map, to be occupied by St. Regis River. In reality, however, the connecting link between the valleys of these two major streams is a trough that parallels the St. Regis Valley a short distance to the north, extending from St. Regis to the broad and deep saddle at the head of the Cœur d'Alene. This trough will be referred to in the following pages as "the old valley," for this term suggests its evident origin. Its general form is that of a mature stream valley, such as must have been excavated by a river comparable in size and age with the South Fork of the Cœur d'Alene. The work of such a stream is further attested by deposits of well-rounded gravel, containing bowlders whose source was evidently west of the present State boundary and covering remnants of the ancient valley floor. The valley has been abandoned, however, by the stream which carved it and is now drained by several tributaries of St. Regis River. The course of these tributaries is in general transverse to that of the old valley. The largest is Packer Creek, which enters the St. Regis at Saltese and whose relation to the depression is typical. The main trunk of Packer Creek is only a mile long and flows in a narrow canyon through a range of rather high hills; this trunk has three main branches, one of which flows due south from the mountains to the north, one westward about parallel to the axis of the trough but somewhat south of it, and another at first east along the axis and then southeast against the south slope. Farther west Randolph and Brimstone creeks likewise make their exit from the valley by way of transverse canyons. The erosion of these streams and their many tributaries has entrenched the floor of the old valley to a depth amounting in some places to several hundred feet, and one effect of this erosion has been to form, along the middle of the valley, a little range of rounded hills, the most conspicuous of which is Meadow Mountain, between the North and East forks of Packer Creek.

Considered in its entirety, this 300-mile depression has some of the characteristics of the physiographic type which Daly[1] calls a

[1] Daly, R. A., The nomenclature of the North American Cordillera: Geog. Jour., vol. 27, 1906, p. 596.

trench. According to Daly's definition, a trench is a "long, narrow intermontane depression, occupied by two or more streams * * * alternately draining the depression in opposite directions." The application of some such term as "Cœur d'Alene trench" to the feature under discussion might be desirable on the ground of convenience and because it would serve to emphasize the importance of this depression, but it is not formally proposed, for the term "trench" connotes a regularity of cross section that is not present here.

The geographic importance of this long depression cutting across a large part of the Rocky Mountains has long been practically recognized by its utilization as a route of travel. Most of it is now occupied by railways. These were preceded by the old Mullan Road, and this, in turn, by more or less definite Indian trails. The graded floor of St. Regis Valley, however, has generally been used in preference to the dissected floor of the old valley farther north.

The geologic history of this depression is very imperfectly known. It is clearly of considerable age, for it coincides in part with remnants of valleys that can not be later than Tertiary. Its location has been determined in large measure by faulting, this being demonstrably true of the part with which this paper especially deals.

TIMBER.

The entire region was once covered with a heavy stand of timber, much of which was of excellent quality, but only a very small proportion of this growth remains alive. Much has been cut by lumbermen and miners and a great deal more has been destroyed by repeated fires, so that no considerable areas of virgin forest are now standing except in the extreme eastern part of the area and near the Bitterroot divide, north of St. Paul Pass. Great numbers of fine trees, especially in Montana, killed by the fires of 1910 are still usable, however, and have been sold to lumber companies, who are working on a large scale to remove and utilize them. The fires have depressed the general prosperity of the part of the area lying in Montana and have perhaps been the cause of the failure to produce ore from some properties, for they not only increased the difficulty of obtaining mine timbers but destroyed buildings of considerable value.

SETTLEMENTS AND ROUTES.

The three important settlements of the region here considered are Wallace, Mullan, and Saltese. Wallace, which has a population of about 3,000, is the seat of Shoshone County and the metropolis of the Cœur d'Alene mining district. Mullan, another flourishing mining center, has a population of about 1,700. Saltese, with about 350 inhabitants, is a supply point for prospectors. Taft, a few miles farther west, is a still smaller hamlet.

The main line of the Chicago, Milwaukee & Puget Sound Railway crosses the area, closely paralleled east of Taft by the Cœur d'Alene branch of the Northern Pacific Railway, whose terminus is at Wallace. Wallace is connected with Spokane by the Oregon-Washington Railroad & Navigation Co.'s line. Roads and trails are fairly numerous. An automobile road, that has been completed recently, follows the old valley for several miles. The Bitterroot divide is followed by a good trail and is accessible by a carefully graded road between the Monitor mine and Saltese.

GEOLOGY.

PRINCIPAL FEATURES.

The dominant rocks of the area (Pl. III) belong to the Belt series, of Algonkian age, which has a great development in northern Idaho and northwestern Montana. This series consists of many thousand feet of fine-grained sedimentary rocks, including quartzites of varying purity, shales, and impure limestones, which appear to have been deposited, for the most part, in shallow water. Old as they are, these rocks have, on the whole, undergone but little metamorphism. They are very extensively and thoroughly metamorphosed in the basin of Clearwater River,[1] but about Saltese they show their usual lack of conspicuous alteration. The formations represented here comprise all those described in the early report on the Cœur d'Alene district except the lowest. They have the same general characteristics here as in the Cœur d'Alene district, but show some noteworthy variations even within the limits of the area here described.

Igneous rocks are scarce within this area. The most abundant is diabase, the largest mass of which forms a great sill in the Algonkian sedimentary rocks. There are also some small dikes, chiefly of lamprophyric character. Light-colored granular intrusive rocks, such as occur a short distance northwest of Mullan and in the Clearwater basin to the south, are absent.

The structure is moderately complex on the whole, but differs in complexity from place to place. Its most significant feature is a fault zone coinciding with the trench.

A great part of geologic time is in this area unrepresented by sedimentary deposits, of which there are none intermediate in age between the Algonkian sedimentary rocks and some presumably Tertiary gravels that form small patches on the floor of the trench and were evidently laid down by the fairly large stream that once occupied it. These gravels are not of economic importance except in the negative sense that they conceal the rocks beneath, which may be metalliferous, and they will therefore receive no more than this passing mention. The more recent stream gravels, on low terraces and

[1] Calkins, F. C., and Jones, E. L., jr., op. cit.

flood plains, and the extinct alpine glaciers, which have carved cirques on the north and east sides of the main divides and left some rather inconspicuous moraines, may similarly be dismissed. More detailed description must be accorded to the older rocks and the structure by reason of their intimate relation to the ore deposits.

ALGONKIAN SEDIMENTARY ROCKS.

BELT SERIES.

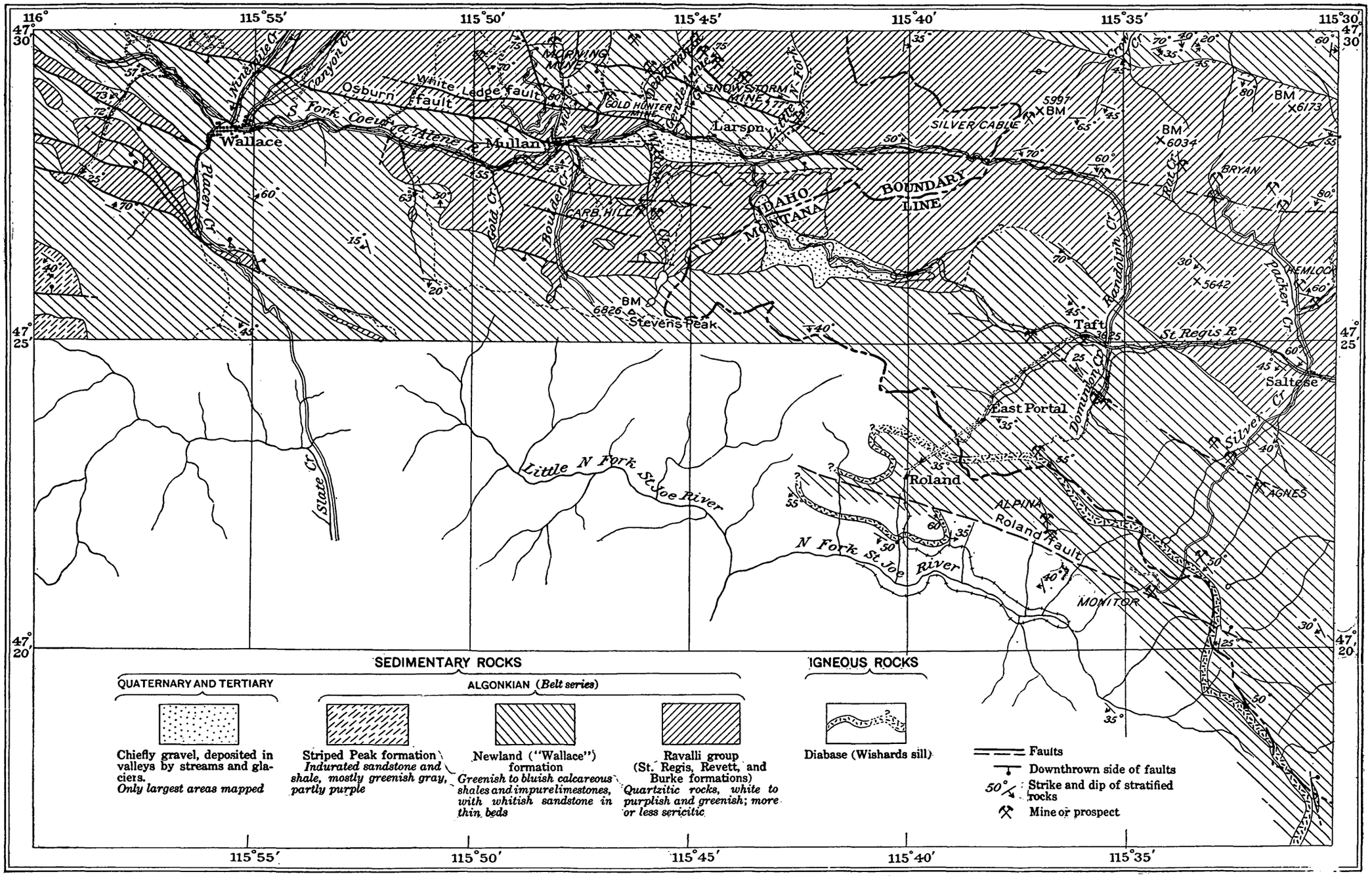
RAVALLI GROUP.

The three lowest formations of the Belt series in this area compose the Ravalli group. Named in ascending order they are the Burke formation, the Revett quartzite, and the St. Regis formation. The Ravalli group is overlain by the Newland ("Wallace") formation. In other areas it is underlain by the Prichard formation, which is not present in the areas discussed in this paper.

Burke formation.—The Burke formation, the lowest formation of the Ravalli group, consists in general of fine-grained, light-colored thin-bedded siliceous rocks. Its most abundant and characteristic rock is a light greenish-gray flaggy impure quartzite or siliceous shale, which derives its tint and a certain degree of softness from the presence of sericite, a white mica in a state of fine division. The lowest beds exposed in the area include some material with a darker bluish tint, and the upper part contains quartzite which is rather thick bedded and contains but a moderate amount of sericite; this makes it difficult to draw a sharp line between the Burke formation and the overlying Revett quartzite. The thickness of the Burke was estimated in the early study at 2,000 feet, and the present review has given no basis for a correction of this estimate. This formation occupies a large area north of the trench and northwest of Mullan.

Revett quartzite.—The Revett quartzite, the middle formation of the Ravalli group, is somewhat similar to the underlying Burke formation, but consists of thicker-bedded and more purely siliceous rocks. The lower middle part comprises some hard and brittle, almost glassy quartzite. The upper part, however, is perceptibly sericitic and greenish and therefore similar in a measure to parts of the underlying Burke formation and the overlying St. Regis formation, though thicker bedded than the Burke and lacking the distinctive coloration of the St. Regis. The formation is about 1,200 feet thick.

St. Regis formation.—The St. Regis formation, the upper formation of the Ravalli group, as developed in the Cœur d'Alene district, is composed of indurated shales and quartzitic sandstones characterized by shallow-water markings and by comparatively pronounced tints of green and purple. Neither of these hues predominates distinctly over the other, but the purple tint is the more characteristic. In



GEOLOGIC MAP OF REGION AROUND MULLAN, IDAHO, AND SALTESE, MONT.

some beds it is pale and dull and perceived with some difficulty by observers not accustomed to look for it; in others it is rich and dark, though not brilliant. These tints are typically displayed in the vicinity of Mullan, where the uppermost beds of the St. Regis are dark bluish-purple slates in sharp contrast with the green slates of the lower part of the Newland ("Wallace") formation. The dull-lavender quartzitic sandstones in the lower part of the St. Regis are less distinct from the greenish-gray rocks of the upper part of the Revett.

This distinctive coloration of the St. Regis formation is much less marked farther east. The uppermost beds of the formation are certainly paler near Borax, on the St. Regis, than they are on Mill Creek, and near Saltese the purple tint of these beds is so faint that there is real difficulty in fixing a boundary between them and the slates of the Newland formation. The coloration of the lower beds is still more indefinite; they are in general greenish and thicker bedded than the upper beds and therefore approach the upper Revett rocks in character. The railway section between Saltese and Deborgia and still farther east exposes so great a thickness of these dull-greenish impure quartzites as to give the impression that any distinction here between the St. Regis and the Revett would probably be impossible. To the north of the old valley, however, the Revett quartzite and the Burke formation are extensively exposed, each with a lithologic character that is typical and fairly distinct from that of the St. Regis. The thickness of the St. Regis near the northeast corner of the area described is about 1,000 feet. Its thickness farther south is apparently greater, but is difficult to measure owing to the indefiniteness of the lower limit.

NEWLAND ("WALLACE") FORMATION.

The Newland is the thickest formation in this area and occupies the greatest portion of its surface, being the principal country rock south of Cœur d'Alene and St. Regis rivers.

In the original reports on the Cœur d'Alene district it was mapped and described as the Wallace formation, but it has since been correlated with the Newland formation to the east, and the local name (Wallace formation) is no longer used.

The formation as a whole consists of thin-bedded rocks which are for the most part calcareous. The rocks contain carbonates of magnesium and iron as well as of calcium, but the calcium seems the most abundant. The formation comprises three members which are fairly distinct in general character, but which grade into one another and are not distinguished on the map.

The lowest member is characterized by the prevailingly green color of its rocks. The strata immediately above the St. Regis consist of

obscurely banded slates, of a rather bright apple-green color, which are very slightly calcareous, their separation from the St. Regis being determined rather by convenience than by strict logic. Higher in the formation the proportion of limy material is greater, as is indicated by the yellow color assumed by the rocks when weathered; numerous bands of whitish calcareous sandstone and a few strata of blue and white argillite make their appearance. The part of the formation in which the green color is strongly preponderant constitutes what may conveniently be called the lower member.

The middle member contains greenish beds but is characterized more especially by blue and white banded argillite and an abundance of calcareous sandstone or quartzite, together with some impure limestone. In its upper portion the limy and sandy layers diminish in quantity, and finally it passes into a blue, regularly banded noncalcareous shale. This in turn is overlain by a comparatively small thickness of green rocks very similar to those at the base of the formation.

The blue shale forming the major part of the upper member presents remarkable variations in thickness. In the basin of St. Joe River, to the south of the area here described, it is apparently not less than 5,000 feet thick, but near Striped Peak, southwest of Wallace, its thickness is insignificant. The thinning of these beds has not been continuously traced and its cause is still obscure.

The lower member of the formation also is of very uneven thickness, being apparently much thicker near Saltese than near Mullan, although the structure is not understood with sufficient thoroughness to permit reliable stratigraphic measurements. The total thickness of the Newland formation in the middle part of the Cœur d'Alene district, where the upper member is almost unrepresented, was estimated as 4,000 feet, but this is certainly less than the combined thickness of the lower and middle members near Saltese.

STRIPED PEAK FORMATION.

The Striped Peak formation occupies only a small part of the area mapped. It consists of shales and sandstones with shallow-water markings, and is remarkably similar to the St. Regis formation. The prevailing color is greenish gray, but some beds are purple.

IGNEOUS ROCKS.

Diabase.—The largest mass of diabase in the region is the Wishards sill, a sheet 400 or 500 feet in maximum thickness, which is intercalated in the middle member of the Newland formation. It persists at the same stratigraphic horizon for a remarkable distance, having been traced from the head of Placer Creek southeastward to St. Joe River, 30 miles away. The constancy of its stratigraphic

position proves that it was intruded before the Algonkian rocks were deformed, and it has been folded and faulted with them. It is of great use in deciphering structure, because it is more readily followed than any stratum of the sedimentary series, being generally conspicuous for its dark tone, bold outcrops, and the scantiness of the vegetation growing on it.

The rock has the normal appearance of diabase. Its general color is black to dark gray with a tinge of green; its texture is coarse to fine. The minerals visible to the naked eye are white feldspar, dull greenish-black augite and amphibole, and black iron ore of metallic luster. The feldspar forms crystals that give many narrow oblong sections. No olivine is visible, even under the microscope, which reveals considerable amounts of quartz, alkali feldspar, and biotite.

The shaly rocks of the Newland formation are distinctly metamorphosed by this largest diabase intrusion, but the metamorphism is limited to a distance of a few yards across the bedding.

This diabase also forms some thinner, inconspicuous sills in the Newland formation, one of which, near the boundary between the middle and lower divisions, was seen in several places south of Saltese. Diabase dikes have not been found in the area more especially considered here, although there is one on the south side of Ward Peak, penetrating rocks that underlie the Newland formation.

Other intrusives.—No other igneous rocks than the diabase form large or conspicuous masses, and none are shown on the geologic map.

In the vicinity of Mullan there are numerous dikes of rocks that were classified in the report on the Cœur d'Alene district as lamprophyres. Superficially these resemble the fine-grained portion of the diabase in being dark and of crystalline texture, but they are distinguished from diabase by the presence in them of abundant small needle-like crystals of black hornblende, and their feldspar does not show well-defined outlines. Biotite is somewhat conspicuous in most specimens.

Several of these dikes are crossed by the Hunter tunnel. One or two others crop out in the vicinity of the Gettysburg prospect, and one is cut by the workings of the Morning mine. One or two are penetrated by the workings of the Star prospect, west of the Morning. In this same prospect are two or three dikes of a greenish-gray porphyry, which are possibly offshoots from the monzonite intrusion exposed near Gem, about 2 miles to the northwest, but the rocks are too badly decomposed to supply conclusive petrographic evidence of such a relation.

A thin sill of decomposed basic igneous rock resembling diabase is intercalated in the St. Regis formation on Willow Creek and penetrated by the Carny Copper prospect.

STRUCTURE.

The most remarkable tectonic feature of the region is the fault or fault zone that has determined the location of the long depression of which the valley of the South Fork of Cœur d'Alene River and the old valley are parts. It was found in working out the areal geology of the Cœur d'Alene district that the South Fork approximately coincides with the great Osburn fault, which was traced continuously from Mullan to Wardner and which apparently persists for many miles farther west. At Mullan the fault disappears beneath the alluvial floor of the valley, which is so broad for some distance eastward as to baffle any effort to trace the fault directly, and the upper part of the valley, which is narrower, has not been fully examined for evidence of the continuation of the fault to the east. The old valley, however, is clearly located on a fault or fault zone whose identity with the Osburn fault, though it can not be absolutely proved, is strongly indicated by its direction and position and the fact that, like the Osburn fault, it effects a downthrow on the south. Between Wallace and Mullan the rocks on the south side of the Osburn fault belong chiefly to the Newland formation, while those on the north side are quartzite of the Burke formation and Revett quartzite. The areal relations along the old valley indicate a throw of the same order of magnitude; the rocks on the south belong to the St. Regis formation, and those on the north are ascribed to the Burke and Revett. This is the main evidence of the fault, but it is corroborated by abundant evidence that the old valley coincides with a zone of fracture. Breccias abound on the slope to the north, and every prospect exhibits a remarkable amount of shattering in the country rocks. The poor exposures in the deeply decayed rocks on the floor of the trench make it difficult to follow the line of the fault precisely, but the main fracture is apparently north of Meadow Mountain and the knobs aligned with it.

The course of this great fracture, which may, without serious risk of error, be called, as a whole, the Osburn fault, is a convenient line of reference in characterizing briefly the other structural features of the region, which are by no means thoroughly worked out.

The structure is simpler south of the Osburn fault than north of it. The largest structural feature of the southern area is an anticline, well shown by the map southwest of Mullan. This fold becomes indistinct to the east, but there is some plication along the general line of its axis as far as the longitude of Saltese. The area between the Bitterroot divide and St. Regis River is occupied chiefly by the southwest flank of this anticline, and here southwesterly dips are remarkably persistent. Farther south there is

rather complex folding, some of which is clearly expressed by the sinuous trace of the Wishards sill.

In the area mapped south of the Osburn fault few conspicuous faults have been found except at the extreme west, and the only important fault newly mapped in 1912 is that designated the Roland fault. This causes a large displacement of the folded Wishards sill near Roland and is probably the same fault that displaces the sill about 200 feet on the divide. Brecciation, saddles in the spurs, and sharp discordances of dip in the strata mark the line connecting the points at which the fault cuts the sill. The Roland fault might have failed of detection, however, had it not been for its clear effect on the diabase intrusion, and there are indications of other faults which may be considerable, although the evidence of them is not very tangible. A few of the more distinct lines of fracture lying in the Newland formation are shown on the map. An indication of faulting, which there was no opportunity to trace farther, is afforded by the strong jog in the St. Regis-Newland boundary northwest of Taft.

The structure north of the Osburn fault is characterized near and west of Mullan by very complex faulting, which is not fully represented on the map. The fractures range in strike from east-west to north-south. No folds can be traced here for any considerable distance. The structure along the old valley is of the same general character, but the slight variations in the prevailing quartzitic country rocks and the poor exposures make it very difficult to work out structural details. The quartzitic zone is flanked on the north by an area of the Newland formation, in which there is an eastward-pitching syncline.

ORE DEPOSITS.

GENERAL FEATURES AND GROUPING.

The ore deposits of the northern part of the zone described in this report are chiefly valuable for lead and silver, and the potential value of the prospects in the southern part depends mainly on their copper content. No sharp division can be made, however, between a silver-lead belt and a copper belt, for copper deposits, typified by that of the Snowstorm mine, northeast of Mullan, occur in the northern part of the area, and there are at least two lead prospects in the southern copper belt. The prevailing form of the deposits is that of fissure veins, mostly trending east-west to northwest-southeast; but in this respect again the copper deposits of the Snowstorm type are exceptional, for their minerals are finely disseminated in the country rock. The prevailing gangue mineral throughout the region is siderite, the Snowstorm deposits once more furnishing

the most conspicuous exception to the rule. In view of these diversities and others, it is convenient to recognize the following more or less distinct subdivisions of the region:

1. The area of silver, lead, and zinc deposits north of the river near Mullan—the Mullan area.
2. The area of silver, lead, and zinc deposits along the old valley in Montana—the Packer Creek area.
3. The area of sideritic copper veins south of Cœur d'Alene River and the old valley—the southern copper area.
4. A zone south and southeast of Mullan transitional in character between 1 and 3—the Willow Creek area.
5. The zone of disseminated copper north of the South Fork of Cœur d'Alene River—the Snowstorm copper area.

MULLAN AREA.

GENERAL FEATURES.

The deposits studied north of the river near Mullan are fissure veins whose walls are more or less indefinite owing to metasomatic replacement. Their chief valuable mineral is galena, but some of the deposits contain a large amount of sphalerite. Silver is an important source of profit and is apparently derived from argentiferous galena and tetrahedrite. The gangue is mainly siderite, but quartz is also abundant and in some properties is the predominating gangue mineral. Copper minerals other than tetrahedrite are of merely sporadic occurrence.

The most productive property in this area is the Morning mine. Second in importance is the Gold Hunter, a comparatively small but steadily productive and apparently profitable mine. The Alice mine, west of Mullan, has shipped ore but has not yet entered the class of steady producers. The remaining properties in the area are prospects of varying degrees of promise.

MORNING MINE.

DEVELOPMENT.

The Morning mine, whose mill and adit are on the South Fork of Cœur d'Alene River, about half a mile below Mullan, is the largest property of the Federal Mining & Smelting Co. and is second only to the Bunker Hill & Sullivan among the mines of the Cœur d'Alene district as a producer of lead and silver. Since 1904, when it was visited by Ransome,[1] it has been much developed and has added zinc to its products. About 1,200 tons of ore a day is now being taken from the mine.

[1] Prof. Paper U. S. Geol. Survey No. 62, 1908, p. 164.

Information supplied by the company concerning the production of the mine for the years subsequent to 1906 is given in the following table:

Production of the Morning mine, 1906 to 1912, inclusive.

	Concentrating ore.	Shipping ore.	Total.	Ratio of concentration.	Silver.	Lead.	Zinc.
	Tons.	*Tons.*	*Tons.*	*Per ct.*	*Ounces.*	*Pounds.*	*Pounds.*
10 months ending Aug. 31, 1906...	248,617	14	248,631	8.8	415,976	25,812,200	.....
12 months ending Aug. 31, 1907...	332,452	48	332,500	8.7	554,450	34,940,600	.....
12 months ending Aug. 31, 1908...	147,321	279	147,600	8.8	240,409	14,825,000	.....
12 months ending Aug. 31, 1909...	359,257	118	359,375	9.1	531,298	33,667,400	.....
12 months ending Aug. 31, 1910...	342,615	685	343,300	10.1	432,760	26,746,600	.....
12 months ending Aug. 31, 1911...	347,827	13,373	361,200	10.6	624,765	35,180,040	497,480
12 months ending Aug. 31, 1912...	374,030	27,270	401,300	11.2	726,686	44,710,880	2,375,800
4 months ending Dec. 31, 1912.....	124,446	8,354	132,800	10.8	230,451	15,041,920	1,557,440
	2,276,565	50,141	2,326,706	9.7	3,756,795	230,924,640	4,430,720

The ore that is now being mined comes almost wholly from the Morning vein, which is about 11,000 feet north of the portal of tunnel No. 6. A relatively small amount of ore is being taken from the You Like vein, about parallel to the Morning vein and 1,000 feet south of it. At least two other veins are cut by the tunnel, but neither shows much promise at the intersection and neither has been developed. The portions of these veins that are being worked are chiefly in the ridge between Mill Creek and Grouse Gulch. In 1904 both productive veins were reached by tunnel No. 5, between whose portal on Mill Creek and the mill, which had its present location, ore and supplies were hauled by a narrow-gage surface railway. The present adit, tunnel No. 6, which runs nearly north under the crest of the ridge, was completed in 1906 and transportation is now effected by powerful electric motors, which bring the ore directly to the bins. The equipment both on the surface and underground is impressively substantial.

The mill is perhaps the most interesting in the Cœur d'Alenes, but only its salient features can be touched on here. It comprises two virtually separate plants. In one the galena is concentrated by gravitational methods; in the other sphalerite, which, being of nearly the same specific gravity as siderite, is not amenable to such methods, is concentrated by flotation. The processes employed to save the galena are highly elaborated and involve repeated grinding, much of the material being finely ground in Hardinge conical pebble mills. The Macquisten flotation process [1] is the one employed to save the sphalerite. The mill losses of both lead and zinc are still considerable. They are probably carried off for the most part in the large amount of slime which results from the repeated grinding. At the time of visit experiments were being made on other flotation processes, which

[1] Described by O. B. Hofstrand, Bull. Am. Inst. Min. Eng. No. 73, 1913.

are likely to be installed in the near future and to result in a much higher saving than that hitherto obtained.

The workings above tunnel No. 5 are now inaccessible, and the level of that tunnel is the datum from which the depth of later workings is reckoned. Seven levels have been driven on the Morning vein at intervals of 200 feet below tunnel No. 5. Tunnel No. 6 is on the 800-foot level, and the lowest depth attained is 850 feet lower, where a station was being cut out at the time of the recent visit. The lowest stopes are on the 1,450-foot level, which is about 2,600 feet below the highest stopes and nearly 3,000 feet below the highest point of the outcrop. On the You Like vein there are drifts at 200-foot intervals down to the tunnel level, below which the vein has not been followed.

GEOLOGIC CONDITIONS.

The Morning and You Like veins are both nearly vertical and strike about west-northwest. The rock in which they occur is quartzite that varies considerably in hardness, purity, and thickness of bedding but which apparently all belongs to the Revett quartzite. Some of the purest and thickest-bedded quartzite is exposed in the west You Like drift on the 800-foot level (No. 6 tunnel) and on the walls of the great station on this level near the Morning lode. Even this quartzite is for the most part somewhat sericitic, however, and most of that adjacent to the lode is distinctly so. On the whole the most sericitic and flaggy rock is that in the eastern part of the mine, which probably belongs to the uppermost part of the Revett quartzite. No igneous rock was observed in the walls of the vein in the workings now accessible, although a small lamprophyric dike appears in the eastern part of the workings and another basic intrusion is cut in the outer part of the tunnel.

The bedding of the country rock near the veins is steeply inclined and remarkably variable in strike, as if the strata had been raised to a nearly vertical position by pressure in one direction and afterward crumpled by pressure acting nearly at right angles to that direction. The general strike is a little west of north and the general dip easterly, so that the rocks in the eastern part of the mine are the youngest. The ore bodies occupy narrow shear zones rather than sharply defined fissures. Considerable attention was given to the question of how much movement these shear zones represent. The presence of gouge along the slips in the lode and adjacent country rock is proof of some displacement, and the difference in the character and attitude of the rocks on either side of the veins is in many places so sharp as to suggest that the amount of this displacement may have been considerable. With respect to the Morning vein this suggestion could not be definitely confirmed, and the sharp, steeply pitching folds visible in the crosscut between the two shafts show,

indeed, how the observed relations might be explained without faulting. On the You Like vein appreciable faulting has demonstrably occurred, for near its intersection with the tunnel, where it is narrow and well exposed in the roof, the beds on either side clearly fail to match. It is not probable, however, that the movement on either vein has been comparable in magnitude with that of most of the faults shown on the geologic map of the district.

Fractures transverse to the veins are neither numerous nor important except in the extreme eastern part of the mines. Here the You Like vein in particular is thrown a few feet by several small faults whose general strike is about north-northwest to north-south. The vein is farther north on the east side of most of the faults than on the west side. These small faults are probably subsidiary to a larger one, recognized in 1904,[1] which brings the Newland formation on the surface against the Revett. It is shown on the map accompanying Professional Paper 62 as striking about northwest, but its true strike appears on review to be more nearly north and south. A thin basic dike parallels the fault a few yards to the east. The ground east of the Morning mine has been well prospected without revealing any vein comparable in size to the Morning vein except the Hunter lode, which is so far south that its correlation with the Morning vein is at least highly questionable, for it would postulate a horizontal displacement of about half a mile.

CHARACTER OF THE ORE BODIES.

The Morning vein is essentially simple in structure except for a large horse, which was noted in the previous report. In a great cave on the 200-foot level the horse is about 35 feet wide and each of the two branches of the vein is about 10 feet wide. The length of the horse is about 800 feet in the upper workings. This horse apparently persists downward nearly to the 1,000-foot level, where two branches of the vein appear to have coalesced, and here the stopes have their maximum thickness of about 40 feet. The vein is described by Ransome as being inconspicuous and practically barren where it is cut by tunnel No. 5, and it has the same unpromising character at its intersection with tunnel No. 6 but widens in both directions from that point.

The You Like vein is of simple tabular form without large inclusions. Its thickness is considerably less than that of the Morning vein, being at the maximum about 10 feet.

The ore of the two veins is alike in most characteristics. Its chief constituents are shown by analysis by the chemists of the company to be present in approximately the following proportions: Siderite, 50 per cent; quartz, 25 per cent; galena, 11.5 per cent; sphalerite, 11 to

[1] Prof. Paper U. S. Geol. Survey No. 62, 1908, p. 166.

12 per cent; calcite, 3 per cent; pyrite, less than 1 per cent. In addition, small quantities of barite, magnetite, chalcopyrite, tetrahedrite, and probably pyrrhotite are present, the barite being locally abundant and conspicuous. Magnetite and chalcopyrite are nowhere easy of recognition. The quartz probably belongs in part to the country rock. The vein structure shows that it was only partly formed by the filling of fissures and partly by replacement of the wall rocks. Its limits are not sharp, although the limit of commercial ore is fairly definite, and there are discontinuous subsidiary veins which are too small to mine. The ore presents widely varying degrees of richness. Some of it consists of solid masses of galena and sphalerite almost unmixed with gangue, and in some the minerals are disseminated in country rock.

A more or less distinct banding is characteristic of the veins as a whole, but the bands are discontinuous and irregular and afford no obvious clue to the order in which the minerals were deposited. The Morning vein is cut by longitudinal slips, some of which are very persistent. The following is a section across one of the richest parts of the Morning vein on the 1,400-foot level. The bands are named in order from north to south.

Section of Morning vein.

	Feet.
Sheared quartzite, vertical and striking about northwest, with a little ore.	
Ore (galena and sphalerite)	½–1½
Sheared country rock and ore in nearly equal parts	1
Ore with a little siderite, quartz, barite, and country rock	1
Ore (galena and sphalerite, intimately mixed, with almost no gangue)	7
Smooth slip, vertical and striking N. 60° W.	
Ore with much siderite, etc	1
Crushed country rock with a little ore	1
Ore, medium grade, rudely banded, with small transverse faults	1½
Lean ore (crushed country rock with stringers)	1½
Slip, vertical, N. 45°–55° W.	15
Crushed quartzite, nearly barren.	

STAR MINE.

The Star mine, owned by Messrs. Finch, Campbell, Moffatt, and others, is in Grouse Gulch at the foot of the spur between its principal forks. It is of interest because it shows what are believed to be the westward continuations of the Morning and You Like veins. It is developed by a tunnel about 3,500 feet long and by several very extensive drifts.

The sedimentary rock penetrated by these workings is quartzite, some of which is extremely hard and thick bedded and all of which

probably belongs to the Revett quartzite. The drifts cut several small dikes of a gray porphyry and a dark lamprophyre, both of which probably bear a genetic relationship to the monzonite that is exposed near Gem, about 2 miles to the northwest. The general dip is about 70° E., but the strike is extremely variable. Fissures, mostly of northwesterly trend, are very numerous.

The best showing is in the Morning vein east of the main tunnel, which in places contains 4 feet of fairly good concentrating ore. A widening of the vein is apparent in some places where it is joined by other fissures formed prior to the mineralization, and some vein material makes off in fissures of this character. In the easternmost accessible workings the vein seems to have divided into several small branches. A vertical fault converging westward with the vein has cut it off a short distance east of the tunnel, but its westward continuation is believed by Mr. Moffatt to be represented by a vein found at the face of the tunnel. The study on which this paper is based hardly suffices to prove or disprove this supposition. The fault, however, though very distinct, is probably not of large throw, for it has displaced a porphyry dike which it cuts only about 20 feet. A long drift in the general direction of the Morning vein west of the tunnel has not revealed any commercial ore. It follows here one and there another of a system of sinuous branching fissures, among which it is difficult to identify the representative of the Morning vein. The conditions along the drift that goes westward on the supposed You Like vein are somewhat similar, although this drift follows a straighter and more definite fissure along which some faulting has clearly taken place.

A short drift has also been run westward on a fissure intermediate between the Morning and You Like, but it reveals little, if any, ore. It perhaps corresponds with a fault that is very conspicuous on the surface.

The ore from the Morning vein contains galena in a gangue consisting chiefly of quartz with very little siderite. It is accompanied by small amounts of sphalerite and pyrite. The scarcity of siderite here is a notable contrast to its abundance in the Morning mine and seems to illustrate the general rule first deduced by Ransome,[1] that this mineral becomes less abundant in the veins as the monzonite is approached.

GOLD HUNTER MINE.

ECONOMIC FEATURES.

The lode worked in the Gold Hunter mine (commonly called simply "The Hunter") is about 1 mile northeast of Mullan, in the ridge between Mill Creek and Hunter Gulch. In 1904, when the mine was

[1] Ransome, F. L., Prof. Paper U. S. Geol. Survey No. 62, 1908, pp. 136–137.

visited by Ransome,[1] the working adit was tunnel No. 5 in Hunter Gulch, but the present adit is tunnel No. 6, whose entrance is at the mill near the South Fork of Cœur d'Alene River, on the east edge of Mullan. Through this tunnel, which is nearly a mile long, ore and supplies are transported in and out of the mine by electric motor.

No figures of production for the years subsequent to 1906 are available.

The lowest workings in 1904 were 200 feet below the level of tunnel No. 5, which is about 4,000 feet above sea level. The adit, or tunnel No. 6, is about 400 feet lower than No. 5, and drifts have been run at 75, 205, 285, and 405 feet below the adit. At the time of the recent visit a small amount of stoping had been done on the 205-foot level and almost none below it.

The amount of ore mined per day at the time of the recent visit was about 340 tons. In the mill about 40 tons a day is picked out of the sorting belt as waste and crude ore, the crude ore amounting to about 3 tons a day. The bulk of the ore is concentrated by means of Hartz jigs, Wilfley tables, and Frue vanners. The constitution of much of the ore necessitates fine grinding, which is accomplished by means of Huntington mills. The only unusual feature of the process is the saving of an iron concentrate, which is used as a flux and which contains more silver than the average ore. No zinc is saved, and the proportion of that metal is kept below 10 per cent, so that no penalty is exacted at the smelter.

GEOLOGIC FEATURES.

Rocks and structure.—Review of the surface exposures and study of the tunnel section, which was not available in 1904, afford a basis for some correction of the mapping in the vicinity of the Hunter mine. The principal error relating to this vicinity in the map accompanying Professional Paper 62 is the ascription of the country rock of the lode to the St. Regis formation; it belongs in reality to the lower part of the Newland formation, as was suspected by Ransome.[2]

The principal structural feature in the outer part of the tunnel is a synclinal fold with St. Regis rocks in the trough and Revett quartzite on the sides. This main fold is much complicated by minor plications and by fractures, on many of which there seems to have been thrust faulting with upthrow on the north side. The north side of the syncline abuts against one of the most persistent faults of the district, the White Ledge fault. Where it intersects the tunnel this has a nearly east-west strike and is nearly vertical. It marks a fairly sharp change in the country rock, that on the south being rather hard and thick-bedded quartzite and that on the north a fine-grained pale-green, somewhat calcareous slate. Otherwise the fault might

[1] Prof. Paper U. S. Geol. Survey No. 62, 1908, p. 168. [2] Idem, p. 169.

easily be overlooked, for it is extremely tight and inconspicuous, although its throw at this point can not be less than half a mile. The rock immediately north of it in the tunnel probably belongs to the lowest part of the Newland formation, for it is succeeded within a short distance by dull-purplish slate alternating with green bands, belonging to the St. Regis formation. These rocks in turn are cut off on the north by a fault whose throw is probably less than that of the White Ledge fault, yet great enough to bring bluish-banded slate of the middle part of the Newland down against the green slate of the lower Newland. This fault, which is a normal one dipping about 40° N., is probably identical with one that crosses Paymaster Gulch near its mouth and is therefore designated the Paymaster fault. The greenish slate of the lower Newland reappears, however, a short distance north of the fault and is the country rock of the Hunter lode. Another fault bringing middle Newland down on the north is shown by surface indications to cross the ridge about 400 feet north of the lode, but this has not been penetrated by the mine workings. The general dip of the beds north of the White Ledge fault is southward and very steep.

The sedimentary rocks in the tunnel are cut by several small dikes of a black fine-grained rock whose most prominent constituent is hornblende in the form of minute needle-like crystals. None of these dikes are seen in the lode, and their relation to the ore is consequently unknown.

Form of lode.—The Hunter lode is more complex in structure than most others in the Cœur d'Alenes, a character probably due to the unusual fissility of its country rock. On the No. 5 tunnel level and above, where it was studied by Ransome, the lode comprises three important veins. In the workings now accessible there are only two principal veins, whose precise relation to the three of the upper workings is not clear. The workable ore bodies are ramified and ill defined, and much ore is distributed in masses too small and discontinuous to be minable. The commercial mineralization is confined to a zone that is about 100 feet broad on the adit level, but the total breadth of the mineralized zone is about twice as great. The total length of the productive zone is about 640 feet in the active workings, and the maximum length of any individual slope is about 300 feet.

At least five ore bodies are exposed in the present workings—two in the north vein and three in the south. The general pitch of all the shoots is nearly vertical.

The largest ore body is probably the northwest one, developed by the "Ryan crosscut" stope above the adit level. In a part of this body there was about 40 feet of good ore, but the stope length of the broad part is only about 50 feet. On the east end the vein is split by a horse into two wings, both of which contain good ore; on the west

the same condition seems to exist, but here only the north wing is minable, so that in effect the vein narrows abruptly in this direction. The cause of this narrowing, locally referred to as a "break," is not very obvious. The "break" does not coincide with any clean-cut fault, separating good ores from barren country rock, but is merely a rather abrupt change from commercial ore to poor ore. Close examination shows, however, that such "breaks" coincide approximately with fissures striking about N. 30°–40° W. The broad part of the ore body was therefore probably formed by replacement of the prism of shattered rock produced by the intersection of two zones of fissuring. The outlines of the stopes suggest that there was some slight displacement of the veins on the cross fissures, but its effect is blurred by subsequent mineralization and by the lack of definition in the ore body. The vein is not seriously displaced by cross faults in any part of the mine. The northeast ore body, opened by the "north stope," shows a similar branching into "wings." The north and Ryan crosscut stope are connected on the higher levels.

The most southeasterly ore body was worked in the "iron stope," probably so called because of the large proportion of pyrite it contained. This body was not over 10 feet wide in the accessible workings and tapered out a short distance below the No. 5 tunnel level. The principal ore body of the south vein is in the south-central part of the workings. It is developed in the bench stope, which extends upward from the adit level into the old abandoned levels, and the so-called "south stope" that extends 200 feet below the adit level is evidently in a downward continuation of the same shoot. The Ryan stope, a little farther west on the south vein, extends about 100 feet up from the No. 6 tunnel level, and some work has been done on the lower levels in what appears to be the same relatively small ore body.

Although ore has been found on the lowest levels yet attained, little exploration has been done on these and the quantity of ore available below the adit tunnel is unknown.

Character of ore.—The chief valuable constituent of the Hunter ore is galena, and the gangue is chiefly siderite. Quartz and barite are other abundant gangue minerals, barite being more abundant than in any other producing mine of the region. Metallic sulphides of minor economic importance, though occurring in considerable quantity, are sphalerite and pyrite. Pyrite is rather more abundant than in most other mines of the district and seems to be particularly so in the margins and ends of ore bodies. Sphalerite is certainly less abundant than in the Morning mine and has shown no very notable increases with depth. Stibnite is widely though unevenly and sparsely distributed and is invariably inclosed in quartz. Tetrahedrite, which has been an important constituent of the ore in the mine as a whole, is said to occur in the lower levels.

Conspicuous banding roughly parallel to the walls is rather more characteristic of this lode than of others in the Cœur d'Alenes. The bands, few of which individually are more than a foot thick, are distinguished by prevalence of siderite, quartz, country rock, or barite as the matrix of the ore minerals, and also by the varying abundance of the ores. The best ore now being mined is a streak of barite and galena along the north side of the north vein. For the width of a foot or two in many places these two minerals alternate in irregular bands with little admixture.

ALICE MINE.

The Alice mine is located in Ruddy Gulch, about half a mile north of the South Fork of Cœur d'Alene River. The workings of this mine consist of a main adit on the 100-foot level; 200, 400, and 600 foot levels; a shaft; and a short surface tunnel known as the Mud Tunnel. At the time of visit the 600-foot level was inaccessible because of water in the shaft. The mine is worked from the shaft, the tunnel on the 100-foot level being boarded up and apparently long in disuse. The tunnel, however, affords an interesting geologic section. It starts south of the Osburn fault, which it crosses about 300 feet from the entrance. Up to the fault the tunnel is driven in a banded blue and black shale interbedded with quartzitic layers, belonging to the Newland ("Wallace") formation. Toward the fault the formation, which near the tunnel entrance presents a fairly regular dip, becomes crushed, folded, and faulted. North of the fault the tunnel enters into hard brecciated quartzite, which is thought to be Revett. Here again the characteristics of the formation are somewhat masked by shearing, brecciation, and silicification. All the other workings of the Alice mine are situated north of the Osburn fault. On the 400-foot level two drifts have been run to the fault, but at the time of visit the loose ground had caved and the drifts were inaccessible.

The ore occurs in three veins or, more properly, brecciated zones in the quartzite. These veins are known as the Alice, Mary J., and Mud Tunnel. The Alice and Mary J. veins are approximately parallel to the Osburn fault, but the Mud Tunnel vein makes a small angle with the Mary J. These brecciated zones are of no great persistence along either their strike or their dip. Numerous small faults and slips run through the brecciated quartzite in various directions. Some of them cut the ore off sharply, or the deposit may be limited by two intersecting slips, which are the walls of the vein. The Mary J. vein, which has been stoped on the 100 and 200 foot levels, has not been disclosed by the development work on the 400-foot level. The Mud Tunnel vein, which is exposed in the short surface tunnel and on the 100-foot level, has not been encountered in the lower workings. The Alice vein, however, persists to the lowest workings of the mine. The

workable parts of these veins are of small extent, the ore occurring in bunches or lenses. The Alice vein, for instance, which on the main level has been followed for over 1,000 feet, has been stoped in but two places, one stope being about 100 feet long and of slight vertical extent, and the other a very small stope in which the ore was extracted from the trough of two intersecting faults. The Mary J. vein has been stoped for a distance of 100 feet along the strike and through a vertical distance of 95 feet. Other stopes have been made on the several levels. A stope on the Alice vein on the 400-foot level is said to have produced ore to the value of $70,000.

The ore deposits in the brecciated zones consist of metallic sulphides and quartz veins. The principal sulphide is galena, but green stains on the walls indicate the presence of copper. The galena occurs both as replacement deposits and as narrow fissure fillings in the brecciated quartzite. It does not seem to be a constituent of the quartz veins proper, although secondary silica is prominent in the mineralized zones. In places the ore bodies are from 12 to 14 feet wide and have a lead content of 8 per cent. Cerusite is another ore mineral of these deposits, and probably equals the galena in amount. The mineral owes its presence to the porous nature of the brecciated quartzite. It was noted on the 400-foot level and is said to extend to the deepest workings. Siderite does not occur in the mineralized zones, the Alice being the only lead mine in the Cœur d'Alene district in which siderite is not an abundant gangue mineral.

Several periods of movement are apparent in the mineralized zone in the Alice mine. An idea of the disturbances accompanying and subsequent to the mineralization is best gained by a study of the Mary J. vein on the 200-foot level. The vein is about 12 feet wide in the center of the stope but narrows toward the east and west ends. The north wall of the vein is a slickensided plane trending N. 60° E. and dipping 80° S. Against this wall a narrow seam of black gouge shows ground galena, then follows a barren quartz vein about 2 feet thick, and next is the ore, consisting of brecciated quartzite in which occur seams of galena and its oxidized products, along with the secondary silica. On the south wall another slip dips to the north and strikes in such a direction as to cause a thinning of the ore body to the west, as well as to limit it in depth.

The ore is concentrated at the mine. A mill with a capacity of 125 tons a day was, at the time of visit, treating 75 tons a day. Owing largely to the absence of siderite and sphalerite in the ore, the mill treatment is simple and a saving of 75 to 85 per cent of the valuable metals is effected. The ore is crushed, screened, and first treated on jigs. The middlings from the jigs are reground and treated on Wilfley tables and Frue vanners. The concentrates consist of galena and cerusite.

VINDICATOR PROSPECT.

The lower tunnel of the Vindicator prospect has a conspicuous dump at the side of the railroad a few rods east of Deadman Gulch, and there is another tunnel about 300 feet uphill to the north. The upper tunnel has tapped the vein at a distance of 225 feet from the portal. The vein as there exposed has a maximum observed thickness of about 1 foot and is ore bearing for a length of at least 60 feet; it contains some fairly good galena ore in a gangue consisting chiefly of quartz. High returns in silver are said to have been obtained from the oxidized ore near the surface. The vein follows a zone of fissuring along which there has been considerable postmineral movement. The country rock is green slate belonging to the Newland or the St. Regis formation. The strike of the vein is east and west and the dip about 50° N., its attitude being but slightly different from that of the stratification.

The lower tunnel, although it is about 1,000 feet long and has passed well beyond the point at which it should intersect the ore body if the attitude of the vein in the upper tunnel persisted downward, has not reached a vein, nor even any fissure that appears to represent the vein as known above. The failure of the vein to appear in the lower tunnel is probably the result of faulting. A normal fault with relative upthrow on the north would evidently displace the vein in such a fashion that its north segment would be farther north on the tunnel level than if no faulting had occurred; and if the displacement were of this kind, the vein should be reached by a prolongation of the tunnel. It is possible, however, that the movement was in the contrary direction and that the north segment of the vein may be below the lower tunnel. Present knowledge hardly warrants a decided opinion as to the more probable direction of displacement, but some further exploration to the north appears to be warranted. It is of course uncertain whether the ore body if found would prove large enough to be workable.

PACKER CREEK AREA.

GENERAL FEATURES.

The Packer Creek area comprises a large number of prospects distributed along the trench determined by the Osburn fault zone. The deposits of this area are fissure veins of the same physical character as those at Mullan, and their mineralogic features resemble to a certain extent those of the Mullan area. Galena is the most generally distributed mineral, but argentiferous tetrahedrite is relatively more abundant than near Mullan, and the silver tenor is correspondingly high. Copper and gold are also present in appreciable quantity. The copper seems for the most part to be a constituent of tetrahedrite

but is partly in chalcopyrite. The usual gangue minerals of the area are siderite and quartz, but at least one baritic vein occurs; this, however, has not been explored sufficiently to demonstrate its value.

The most fully developed properties of the area are on either a very narrow zone or a single fissure extending parallel to the general direction of the trench and north of the main fault. The country rock of this lode apparently belongs for the most part to the Burke formation but probably comprises some Revett quartzite. The structure is complex and characterized by extreme crushing. The Last Chance property, which typifies these deposits, is the only one that has shipped much ore; it is reported to have made a net profit of about $200,000 but is now idle. To the east of it are the Ben Hur, Bell, Tarbox, and Meadow Mountain, showing similar ore; to the west are the Bryan and Syndicate, less clearly related to it in character and structure.

A somewhat isolated deposit, which is discussed with those of the Packer Creek basin for convenience, is that of the Silver Cable mine, which contains a high proportion of zinc.

SILVER CABLE MINE.

The Silver Cable property is near the head of Brimstone Creek, a short distance northeast of the pass at the head of the old valley. It is developed by means of three tunnels. The country rock of the ore body is gray sericitic quartzite, which apparently belongs to the Burke formation. The general strike of the bedding is about east-west and the dip steep, being in places overturned. The vein strikes a little north of east. Its ores are chiefly galena and sphalerite; a little tetrahedrite is said to be present, but pyrite is scarce. The ore resembles that of the Morning vein more than that of the principal prospects in the Packer Creek basin. An assay of representative ore is said to give 11 per cent of zinc and 24 per cent of lead.

The best showing of ore is in the highest tunnel, where there is a well-defined vein about 4 feet thick, with some small horses. The vein is partly oxidized on this upper level, and some cavities in it contain a good deal of well-crystallized lead carbonates. On the intermediate level the ore is less abundant and comparatively little work had been done prior to our visit, but exploration was being pushed there at that time and is reported to have met with some success. On the lowest level the main crosscut did not show any ore; the lode was picked up in a drift to the northeast but apparently dies out toward the east.

SYNDICATE PROSPECT.

The Syndicate prospect is on Rat Creek, 1 mile west of the Bryan mine. The workings consists of an adit 225 feet long, whose average course is N. 75° E., and several drifts extending in a northerly direc-

tion aggregating 300 feet in length. The country rock is hard white and greenish sericitic quartzite, greatly crushed and faulted. A quartz-siderite vein from 3 to 6 feet wide, which strikes N. 75° E. and dips vertically, is exposed in the adit but is cut off at the face by a northwestward-trending fault. A band of ore from 6 to 8 inches wide on the north wall of the vein contains tetrahedrite, chalcopyrite, galena, and pyrite. The ore is said to yield high returns in silver.

BRYAN MINE.

The Bryan is one of the more extensively developed properties in the basin of Packer Creek, although it has not made shipments. It is on a tributary of the West Fork of Packer Creek, at the end of a wagon road from Saltese, about 5 miles distant. It has three adits, with a vertical range of about 500 feet. About 2,500 feet of horizontal work has been done, and the lowest tunnel is connected with the one above by a raise.

The country rock penetrated by these workings consists of more or less sericitic quartzite, and probably represents both the Burke formation and the Revett quartzite. The structure is too complex and too imperfectly understood to be characterized satisfactorily and briefly. The beds dip steeply, and are considerably folded. In places they are traversed by broad zones of crumpling and mashing as well as by more sharply defined fissures, most of which have a northwesterly strike.

The principal vein strikes about N. 60° E. and has a steep dip to the south. Its chief gangue mineral is siderite, which is cut by small veins of quartz. The ore minerals are pyrite, galena, and gray copper. The maximum thickness of this sideritic vein is about 5 feet, but in places it pinches to a thin dark seam by postmineral shearing. In the highest tunnel (No. 1) this vein is cut off on the east by a fault of northwesterly strike and a dip of 45°–65° NE. The displacement caused by this fault is not known. It has not been identified with certainty on the lower levels; a fault of similar direction is followed by a drift on the No. 2 level, and this causes only a small offset of the east segment to the north. The fault has apparently not been cut on the lowest level. Difficulty in the discussion of this fault is caused by the lack of an accurate mine map.

Some of the richest ore is not obtained from the main vein but from a smaller branch, which has been followed in the raise. Some ore in the raise is said to assay 38 per cent of lead and 16.8 ounces of silver to the ton, but these figures would not be representative of the vein as a whole.

U. S. MINE.

The U. S. mine is just across the gulch from the Last Chance and on the same lode. It is of interest as having produced some ore, but it is now abandoned and its lower workings are inaccessible. The upper tunnel shows a vein about 4 feet in maximum thickness, which pinches out in places between two strong gouges. The country rock is quartzite of the Burke formation, thoroughly crumpled and shattered. The vein matter is strongly oxidized, being apparently similar to that of the Last Chance.

LAST CHANCE MINE.

The Last Chance mine is located on a tributary of Packer Creek about 3 miles north of Saltese. The workings consist of two tunnels, an intermediate level, a shaft, and several open cuts, but the only accessible entrance to the mine is through the main tunnel, which is probably 200 feet below the outcrop of the south vein. The forest fires of 1910 destroyed the entrance timbers to the other mine workings, so that caving has resulted, and although parts of the upper workings are still accessible from raises in the lower level, the caved condition of many of the workings leaves much to be inferred in regard to the rock structure. No work has apparently been done in the mine for several years. The main tunnel trends N. 70° E. for 275 feet and then branches, each branch in turn having several drifts. Two veins or probably faulted members of the same vein occur, one in each branch of the tunnel workings. A considerable quantity of ore has been stoped from each of these ore bodies above the main level. The production of the mine is said to be in excess of $200,000.

The structure is complex. The green thin-bedded quartzites of the Burke formation are extremely folded and faulted. In general the formation strikes northwesterly with steep southerly or vertical dip, but flat-lying and northward-dipping beds were also observed. The veins have undergone the same deformations as that of the quartzite beds. In a raise from the south branch of the main tunnel the vein strikes east and west and has a vertical or steep southerly dip, but on the main level it conforms to the flat-bedded structure except where it is cut off by a northwestward-trending fault. In the north branch the vein strikes N. 50° W. and has a vertical dip.

The ore of the Last Chance consists of galena, pyrite, tetrahedrite, and stibnite in a gangue of quartz and siderite. The outcrop of the deposit shows the oxidized products of these ore minerals in spongy limonite. Galena is the most abundant mineral. The antimonial compounds are sparsely distributed but where present give a high tenor in silver. The average ore is of high grade and is valuable chiefly for its lead and silver content.

BEN HUR PROSPECT.

The Ben Hur property is on a small tributary of Packer Creek about 3 miles north of Saltese and occupies the ground covering the vein between the Last Chance and Bell prospects. The workings on the Ben Hur consist of three tunnels, two of which, situated near the outcrop of the vein, have not been worked for several years and are now inaccessible. A 1,100-foot tunnel taps the vein several hundred feet below the lead of the upper workings. The developments on the vein, which strikes about N. 70° W., consist of west and east drifts. In the west drift work has been discontinued and the ground is caved in several places, but the east drift was being extended at the time of visit.

The greenish sericitic quartzites of the Burke formation are well exposed in the tunnel section. They show intense folding and faulting, to which is attributed the shalelike appearance of the quartzites. A syncline is apparently exposed in the tunnel, as north and south dips were noted on the sides of a greatly contorted zone in which are flat-lying beds.

The mineralization revealed in the lower workings consisted of the deposition of irregular bunches of quartz and siderite and the replacement of a quartzite bed, along a fault plane, by fine-grained sulphides and secondary silica. The impregnated quartzite bed is about 8 inches wide and is fairly regular in width in the east drift, but its form in the west drift could not be determined because of the timbering in that portion of the mine. Stibnite, galena, pyrite, and chalcopyrite were noted in specimens from this vein. Of these minerals stibnite is the most abundant. The minerals are strained in appearance owing to movement along the fault. No assay of this ore was made, but it is said to carry silver. Specimens from the dumps of the upper workings indicate ore entirely different from that of the vein in the lower tunnel but very similar to the ore from the Last Chance, Bryan, and other prospects on this vein. Galena and cerusite in porous limonite resulting from the oxidation of siderite were noted, but the antimonial minerals, stibnite and tetrahedrite, were not observed. This property has made no ore shipments.

BELL PROSPECT.

The Bell prospect is a short distance east of the Ben Hur. The workings are not extensive on this property and are now inaccessible owing to fire and caving. The oxidized ore on the dump contains scattered pieces of galena. The surface showing is very similar to those of other prospects situated on this vein.

TARBOX MINE.

The Tarbox mine is on the west side of the Middle Fork of Packer Creek, about 3 miles from Saltese. A 500-foot shaft has been sunk on the vein, but the mine buildings were burnt in 1910 and the mine has since been idle, its shaft being filled with water. The ore on the dump is of the same general character as that in the Last Chance and Bell properties; it consists mainly of siderite, quartz, galena, and pyrite.

MEADOW MOUNTAIN.

The Meadow Mountain property is in a small gulch tributary to Packer Creek, about half a mile north of the prominent isolated hill after which it is named, in the same zone of mineralization with the other principal prospects of Packer Creek basin. It is developed by five adits, in only two of which has any considerable work been done.

The country rock consists of grayish flaggy sericitic quartzite, which probably belongs to the Burke formation. The general strike is northwesterly. The most remarkable geologic feature is the prevalent crushing, buckling, and contortion of the strata. A crosscut on the No. 5 level extends northwestward more than 300 feet beyond the vein in soft muck, showing traces of bedding only here and there. No walls to this great breccia were found; it is not even clear in what direction the zone of crushing trends.

The workings appear to cut two veins. The more southerly contains much pyrite and is apparently of low grade. A little stoping has been done in the north vein, which shows some good galena ore. This vein appears to be much faulted and has not been followed for more than 100 feet. The present development, however, is not sufficient either to prove or to disprove the value of the property.

BARITE VEIN.

A vein consisting chiefly of barite runs about parallel to and a few rods north of the West Fork of Packer Creek and has been opened by several shallow prospect holes. The vein is apparently a little over a foot thick. Rusty cavities and masses of limonite in the barite probably represent siderite for the most part. The vein shows no ore in the weathered portion thus far explored, but the association of galena with barite near Mullan is common enough to encourage deeper prospecting.

HEMLOCK PROSPECT.

The Hemlock property is on the West Fork of Packer Creek near its mouth, about a mile and a half distant from Saltese. It is well south of the zone on which the Bryan and Last Chance mines are located. The country rock is grayish impure quartzite, which prob-

ably belongs to the St. Regis formation. The main development is a drift extending about 300 feet along a vein whose strike is almost exactly east and west. A spur to the south near the portal enters an apparently distinct vein, but this is probably the same vein repeated by faulting. The vein is affected by other minor faults.

The portion of the vein exposed in the principal drift has an average thickness of about 20 feet, and it is apparently about twice as thick as this in the outer part. It is of the common sideritic character and makes a dark-brown gossan, which is exposed in the road cutting. The siderite is cut by small veins of quartz. The underground workings show that some galena is inclosed in both siderite and quartz and that the lead sulphide forms little stringers in the quartzitic country rock, as it so commonly does in the Cœur d'Alene mines. Considerable pyrite is present. The ore as yet in sight is of low grade, but the showing warrants further development.

SOUTHERN COPPER AREA.

TYPICAL FEATURES.

Most of the ore deposits south of Cœur d'Alene and St. Regis rivers are of a very simple type. They are well-defined, nearly vertical fissure veins in which the gangue is chiefly siderite, together with some other carbonates and a little quartz, and the primary ore chiefly chalcopyrite and pyrite. The country rock of most of them belongs to the Newland formation, though some are in the St. Regis. It is noteworthy and probably significant that this copper area is roughly coextensive with the area in which the Wishards sill is prominently developed.

The only property of this area from which ore has been shipped is the Monitor mine, a few rods west of the Bitterroot divide southwest of Saltese. The mine is now idle. Many claims have been patented within a few miles of the Monitor; of those in its near vicinity the St. Lawrence, Richmond, Alpina, and Alice are the most developed. Others farther southeast along the divide were not examined. There are evidently several nearly parallel sideritic veins in this vicinity.

Several prospects have been developed near St. Regis River, but some of these have not been visited. The Agnes prospect, south of Saltese, presents an isolated occurrence of galena. The prospects visited on Placer Creek, near Wallace, may be regarded as belonging in the same copper area, although one of them—the Vienna-International—is valuable chiefly for its lead.

An interesting fact of paragenesis observed in many prospects of this area is the clear priority of siderite to quartz. This is suggested by the presence of many quartz veinlets cutting siderite. It is strikingly demonstrated by the occurrence of abundant perfect siderite

crystals, commonly 1 or 2 inches in diameter, partly embedded in quartz which has evidently filled cavities lined with druses of the carbonate. Chalcopyrite is inclosed in both quartz and siderite.

PROPERTIES NEAR SALTESE.

Monitor.—The Monitor mine has shipped about 500 tons of ore but has been idle since the summer of 1910, when the hoist and buildings were destroyed by fire. The workings are, therefore, not accessible, but the exposure in the throat of the shaft and the material on the dump give some information as to the character of the lode. The vein matter as exposed at the surface is a typical gossan—a soft, porous mass consisting mainly of limonite with some quartz and a little malachite in druses and along joints. The principal vein is nearly 15 feet thick and about vertical, though its walls are not quite parallel. It contains inclusions of the Newland country rock, which is also seamed by small subsidiary veins. The dump contains some oxidized ore that is richer in copper carbonates and some unoxidized ore showing chalcopyrite and pyrite in a gangue of siderite, calcite, quartz, and a white micaceous mineral.

Richmond.—The Richmond prospect is on a vein a short distance north of that exposed in the Monitor mine. It is developed by three shafts on the summit of the Bitterroot divide. The principal shaft is about 175 feet deep and a drift about 350 feet long has been run at the bottom of it. An adit was being driven, at the time of visit, from the west slope of the divide with the purpose of tapping the vein at a depth several hundred feet greater.

The vein is of the same general character as that of the Monitor mine and is thoroughly oxidized to the base of the present workings. The greater part consists of a paste of limonite derived from the decomposition of siderite. This is traversed by veins of quartz, mostly parallel to the walls, which enwrap pseudomorphs after siderite crystals. Joints and small cavities in the gossan are lined with malachite, but the copper content of the material seen is evidently small. The vein is from 5 to 10 feet wide, dips very steeply to the north, and strikes N. 75° E.

Copper Age.—The Copper Age property is developed by a tunnel just east of the divide and a short distance south of the Monitor mine. About 700 feet of the vein has been exposed. It is nearly vertical, strikes N. 65° W., and apparently has an average thickness of about 10 feet. The chief gangue mineral is siderite, which is not much oxidized, except in the outer part of the adit. A very little chalcopyrite and chalcocite is present.

Manhattan.—The Manhattan prospect, about 1¼ miles northwest of the Monitor mine, is developed by an adit and drifts aggregating 700 feet in length. It shows a large vein of siderite and quartz, in which no commercial ore was noted.

Alice.—The Alice prospect, on Kelly Creek, is developed by about 650 feet of drifts. The workings show two apparently distinct veins about 25 feet apart, which strike about N. 85° E. and dip 70° N. The north vein is the larger and attains a width of 6 feet in places. The veins show the usual character for this locality, the ore being pyrite and chalcopyrite, in a gangue of siderite, quartz, and calcite. It is mostly unoxidized. The tenor is rather low.

Alpina.—The Alpina property is also on Kelly Creek and taps a vein about 500 yards farther north than those of the Alice prospect. The adit is a crosscut about 300 feet long, and runs northward to a drift about 1,200 feet long. The vein strikes N. 85° E., dips 65° N., and is about 2 feet thick. The copper mineral is chalcopyrite, which is apparently more abundant than in the other prospects visited. The ore is said to assay well in gold.

Bald Mountain.—The Bald Mountain prospect is at the head of the South Fork of Dominion Creek, a short distance east of the Idaho-Montana boundary. The workings consist of an adit, 1,500 feet long, driven S. 35° W., near the end of which drifts extend to the south and east for several hundred feet. Banded shales and quartzites of the middle part of the Newland formation comprise the sedimentary rocks. The average strike is N. 34° W. and the dip 55° SW. From an excellent section in the adit the thickness of the Wishards sill was found to be 350 feet. The shales are metamorphosed to hornstones for 200 feet or more on either side of the sill. Several narrow fissures are exposed in the workings. In general they follow bedding planes, but one in the rocks, northwest of the sill, strikes east and west with apparently vertical dip, and this is occupied by a vein which carries chalcopyrite, sparsely disseminated, in a quartz-siderite gangue. The vein is several feet wide in the drift, but is apparently of no great persistence, as the extension of the strike of the vein in the adit shows only a few narrow siderite veins in a crush zone.

Switchback.—The principal opening of the Switchback prospect is just below the Monitor road and 2 miles southwest of Saltese. It consisted of a drift about 150 feet long at the time of visit. The country rock is green shale belonging to the lower part of the Newland formation. The vein averages only a few inches in thickness and consists principally of siderite with a little chalcopyrite. The ore is said to carry more than $2 a ton in gold. A tunnel 170 feet below the first one was being started at the time of visit.

Agnes.—The Agnes property is on Big Sunday Creek, about 2 miles south-southwest of Saltese. Its chief interest consists in the fact that it reveals an apparently isolated occurrence of galena in an area characterized mainly by copper deposits. The property is developed by three adits, in two of which the vein is shown; the third has not reached the vein. The total extent of the workings is about 800 feet.

The country rock is greenish slate of the lower part of the Newland formation dipping steeply southwestward. It is cut by many fissures, most of which strike about north-northwest.

The vein is composed mainly of siderite and quartz but contains a little irregularly distributed galena and chalcopyrite. Its greatest observed thickness is about 8 feet, but it varies considerably. In the middle tunnel the vein is clearly seen to be cut off, a short distance beyond the point at which it is first encountered, by a fault that strikes a little west of north and dips 80° W. In the south tunnel, which is about 20 feet lower than the middle one, the same fault is recognizable, marking a distinct change in the country rock; but the vein, though exposed in the outer part of the tunnel, was not traced as far east as the fault and appears to have pinched out.

Exploration has failed to find the vein east of the fault, but the work has not been done to good advantage. The work most likely to be successful would perhaps be the opening of a drift southward along the fault on the middle tunnel level, where the vein is largest. The wisdom of driving the north tunnel seems doubtful in view of present uncertainty regarding the position of the vein.

Taft.—The Taft prospect is on the south bank of St. Regis River a mile west of Taft. It is developed principally by means of a tunnel running S. 60° E. along a zone of fissuring. The most conspicuous fissure dips steeply to the south. The country rock belongs to the Newland formation. The fissure zone contains a little sideritic vein rock, but no sulphides were seen, although assay returns of $2 to the ton in gold and 2 per cent of copper are said to have been obtained.

Boston Colby.—The Boston Colby property is about half a mile west of Saltese, between the Northern Pacific and the Chicago, Milwaukee & Puget Sound Railway tracks. The workings consist of a tunnel driven S. 20° W. for 900 feet and drifts along a vein starting at a point 500 feet from the entrance and aggregating 450 feet in length. Near the intersection of the tunnel and drifts is a large excavation probably intended as a site for continuing development on the vein in depth.

The thick-bedded greenish quartzites with interbedded shales exposed in the tunnel probably belong to the St. Regis formation. They strike uniformly northwest and have an average dip of 50° SW. Two faults are cut by the tunnel, both of which lie in the bedding planes of the quartzite. One of these faults occurs at the end of the tunnel and is accompanied by gouge from 6 inches to 3 feet thick; the other is that containing the vein. Whether or not there has been considerable movement along these faults is difficult to determine because of the great similarity of the beds throughout the tunnel section. A strike fault has displaced a portion of the vein near the intersection of the tunnel and drifts.

The vein is from 4 to 10 feet in width in the west drift but in the east drift pinches out to a narrow gouge seam. The vein minerals consist of quartz, siderite, limonite, pyrite, and chalcopyrite. The siderite is largely altered to a porous mass of limonite, slightly copper stained, especially developed on the footwall side of the vein. The sulphides are sparsely distributed, and unless the ore contains considerable quantities of other metals than the copper it is probably too lean to be successfully milled. The deposit, however, as judged from the porous copper-stained limonite, may prove in depth to have a zone of enrichment.

PROSPECTS SOUTH OF WALLACE.

Several prospects are located along Placer Creek on or near a major fault which nearly coincides with that stream and can be traced for a long distance west. The workings here described are about 2 miles south of Wallace.

Vienna-International.—The Vienna-International, near the mouth of Flora Gulch, is the easternmost of these prospects. The workings consist of a shaft and two tunnels. At the time of visit the shaft was inaccessible and its depth was not determined. The tunnels are not over 700 feet each in length. The workings are all in banded shales and quartzites of the middle part of the Newland formation, which in general trend N. 50°–60° W. and dip 70° S. Several faults accompanied by gouge were noted in the bedding planes. The basis of the prospecting is a quartz-siderite vein from 3 to 5 feet wide, which strikes approximately east and west and has a vertical dip. The vein in the west drift of each tunnel was apparently cut off by a northwestward-trending fault. The ore on the dump, which apparently came from the shaft, shows scattered bunches of galena, pyrite, and chalcopyrite in a quartz-siderite gangue. The material seen, however, is apparently too poor to be concentrated with profit.

Castle Rock.—The workings of the Castle Rock property consist of a tunnel driven S. 35° W. for 565 feet, with a short drift to the west. The tunnel is for most of its length in thick-bedded white Revett quartzite. Near the end of the tunnel is a fault whose strike is N. 50° W. South of the fault are white banded quartzites with interbedded thin blue or black layers. The strike of this formation is N. 60° W. and the dip 60° N. North of the fault the Revett quartzite strikes N. 70° E. and dips 45° S. Two siderite veins are exposed in the tunnel. One near the entrance strikes N. 65° E., dips 75° S., and is 95 feet wide as seen in the section but probably about 40 feet wide at right angles to its strike. The vein is not homogeneous throughout but contains inclusions of quartzite. Siderite and pyrite are the most abundant minerals in the vein. Scattered bunches of chalcopyrite were noted, but the average copper tenor of

the vein is probably low. Galena is said to occur in the vein, but none was noted. A shipment of 32 tons sent to the Pend Oreille smelter is said by Mr. Graham, one of the owners, to have yielded copper 2.61 per cent, lead 3 per cent, silver 3 ounces, gold $2.75, iron 34 per cent, a total value of $15.75. The other siderite vein, exposed near the end of the tunnel, is about 16 feet wide. It strikes N. 50° W. and has a steep or vertical dip. A little gray copper was noted in the seams of this vein.

Smart Aleck.—The Smart Aleck property is situated a short distance west of the Castle Rock. The workings consist of a short tunnel which follows a quartz-siderite vein, probably the same as that exposed near the face of the Castle Rock tunnel. The vein strikes about N. 60° W. and has a steep south dip. Its maximum width is 10 feet. Gouge occurs on the north or footwall side of the vein, and the association of minerals is the same as in the Castle Rock vein. The country rock on the footwall side of the vein is hard brecciated Revett quartzite.

Horn Silver.—The Horn Silver property is located about 1,000 feet west of the Smart Aleck. The workings consist of a rather irregular tunnel driven on a quartz-siderite vein. The vein strikes approximately N. 60° W. and dips 75° S. Crosscuts to the south disclose quartzite breccia followed by dark clay gouge of considerable thickness and next by bluish-black shales or slates with interbedded quartzitic bands, the formation being apparently similar to that seen south of the fault of the Castle Rock tunnel. The vein is of variable width and is not as well defined as in the Castle Rock. The maximum width is 10 feet. Massive white Revett quartzite constitutes the country rock on the north side of the fault.

WILLOW CREEK AREA.

GENERAL FEATURES.

The area designated by the above name, for want of a better, is a relatively narrow strip paralleling the river southeast of Mullan. It is characterized primarily by a peculiar alteration of the St. Regis country rock, which has been impregnated with chlorite and thus changed in color from the usual pale tints of green and purple to a rich dark green. This alteration is associated with and may be due to a thin basic sill which has been intruded into the St. Regis. It appears to have a genetic relationship to the formation of sulphides. The only prospects of this area studied during the recent visit are the Carbonate Hill and the Carny Copper. The ores of these prospects are sulphides of copper, iron, lead, and zinc, in a gangue whose most characteristic minerals are siderite and barite. The copper mineralization which allies this area to the southern copper area appears in the Carbonate

Hill prospect to be distinct from the lead and zinc mineralization by which it is allied to the Mullan area, but the relative age of the several ores was not determined.

CARBONATE HILL PROSPECT.

The Carbonate Hill property is on Willow Creek about 2 miles southwest of Mullan and a short distance south of the railroad. It was undeveloped in 1904 but now shows considerable promise of becoming a producer of lead and zinc. About 2,500 feet of work has been done on the property, as a result of which the lode is fairly well exposed.

The country rock of the deposit belongs to the St. Regis formation but is altered in the manner described on page 200.

The ore of the Carbonate Hill prospect does not form any continuous well-defined vein but is distributed in bunches and veinlets with a diameter that rarely exceeds 6 inches. The maximum breadth of the zone of commercial mineralization appears to be less than 20 feet, although it is difficult to estimate from present developments. The ore zone shows considerable fissuring about parallel to its west-northwesterly trend but no important cross fractures.

The chief valuable mineral in the ore is rather coarsely crystalline sphalerite of a pale resinous appearance. Galena is second in abundance. Chalcopyrite constitutes a rather small proportion of the ore, occurring chiefly in a single vein about 3 inches thick and free from the sulphides of zinc and lead. The principal gangue minerals are siderite and quartz, but calcite or dolomite and barite are also present. Pyrite is present in considerable quantity. The ore would mostly require concentration and presents the problem of economically separating sphalerite from siderite, the best solution of which appears to be offered by flotation methods.

CARNY COPPER PROSPECT.

The Carny Copper property is on the slope east of Willow Creek about opposite the Carbonate Hill. The principal opening is an adit about 1,500 feet long, which was hastily examined; there are higher workings which were not visited. The country rock belongs to the St. Regis formation and has in large part been colored a dark green by chlorite. A thin sill of basic igneous rock is penetrated by the inner part of the adit.

The vein differs considerably in character from the lode of the Carbonate Hill, being wide and well defined; it strikes east and west and dips steeply northward. The gangue minerals are siderite, quartz, and barite. The primary ore minerals found in the lower tunnel are chalcopyrite, pyrite, galena, and magnetite. The chalcopyrite is partly replaced by chalcocite. The magnetite is embedded in siderite,

together with pyrite, and is notably abundant in parts of the vein. The most promising part of the vein is a baritic streak about 4 feet wide containing considerable galena, though hardly enough to constitute commercial ore. It is noteworthy that the lower tunnel shows considerably less copper ore and more lead than the upper.

SNOWSTORM COPPER BELT.

LOCATION AND PROPERTIES.

The Snowstorm copper belt runs northwestward along the south slope of the ridge north of the South Fork of Cœur d'Alene River at an average distance of about a mile and a half from that stream. Its only productive mine is the Snowstorm, the bulk of whose ore comes from a quartzite stratum about 40 feet thick, in which cupriferous sulphides and carbonates are disseminated. The copper-bearing stratum appears to extend for a considerable distance northwestward and is apparently tapped by the Snowshoe, Missoula Copper, and United Copper prospects; but its tenor is uneven and it has not yielded ore of proved commercial quantity and quality except in the Snowstorm mine. In the National tunnel of the United Copper property, however, it shows good promise. The Copper King prospect, farther west, is conveniently grouped with those mentioned because of its position and its copper content. It does not show, however, the continuation of the Snowstorm ledge and contains considerable galena, so that it may be regarded as illustrating the transition from the copper belt to the lead-bearing area. East of the Snowstorm mine the ledge is faulted down and its eastern continuation has not been found, so far as known. The so-called East Snowstorm and Pandora prospects are in higher beds south of the fault and no commercial ore was seen in them. Some prospects north of these were not visited.

SNOWSTORM MINE.

ECONOMIC FEATURES.

The Snowstorm mine is of especial interest because it is still the only producer of copper in the district, because of the uncommon character of its ore, and because it presents an important practical problem of geologic structure. It is for the last reason in particular that a reexamination has been desirable, for the great amount of development work done since 1904 has revealed structural details that were not then apparent.

The mine is situated in Daisy Gulch, which empties into the South Fork of Cœur d'Alene River, about 3 miles above Mullan. The present working adit is a tunnel 4,750 feet above sea level, near the entrance of which has been erected a large boarding house and several other buildings used in working the mine. The ore is trans-

ported by aerial tramway to Larson, at the mouth of the gulch, where there is a station on the Cœur d'Alene branch of the Northern Pacific Railway. Larson consists of buildings owned by the Snowstorm Mining & Milling Co., including the mill and the principal office. In the fall of 1912 about 100 men were employed at the mine and about 50 at the mill.

Information supplied by the company concerning the production of the mine in recent years is given in the table below. Each yearly interval begins on July 1.

Production of Snowstorm mine, 1906–1912.

Year.	Total.	Copper.	Silver.	Total value.
	Tons.	*Pounds.*	*Ounces.*	
1906–7	76,224			
1907–8	87,503			
1908–9	119,816	10,363,438	734,968	$1,292,872
1909–10	91,368	7,125,105	605,075	922,686
1910–11	34,464	2,653,036	267,263	350,064
1911–12 Crude	29,964	2,029,474	202,583	323,639
1911–12 Concentrates	130.67	44,973	2,287	7,307

The low production of 1910–11 and later is explained by the fact that most of the company's efforts in this period have been devoted to exploration and development work. The gross production of the mine to December 1, 1911, was $8,944,000.

The ore of the Snowstorm mine consists of small particles of copper minerals disseminated in quartzite. That which was being mined at the time of the former examination, in 1904, was for the most part oxidized and consisted largely of carbonate. A leaching plant that was being constructed in that year for the treatment of the ore was operated successfully for several years. It was found, however, that the sulphide ore, which preponderated in depth, could not be treated economically by a leaching process, and the leaching plant has been replaced by a concentrator whose present capacity is about 100 tons a day. Much of the ore is still shipped crude, the separation of crude ore from milling ore being effected partly in the mine by "shovel sorting" and partly by hand sorting. The proportion shipped crude varies according to the demand for siliceous ore of this kind.

The tenor of the crude ore in copper is about 3.5 per cent. Owing to its high proportion of silica—about 90 per cent—it finds no steady market, but is sold in small lots to smelters that need silica. The fact that the use of siliceous converter linings is decreasing makes the ore more difficult to dispose of than formerly.

The concentrating ore contains about 2.75 per cent of copper and is concentrated to a product that contains 20 to 25 per cent. The concentrates are all sent to the Tacoma smelter.

The ore is concentrated by ordinary wet gravitational processes. The chief difficulty arises from the minute division of the ore minerals, which necessitates very fine grinding. The saving was not much better than 50 per cent at the time of visit, but has since been increased by the installation of certain improvements.

It appears from the figures of production that the ore yields on an average about 2 ounces of silver for each 20 pounds (that is, for each "per cent") of copper, but that the silver is more liable than the copper to loss in concentration, the silver ratio in the concentrates being about half as great as in the average ore.

THE ORE.

The principal unoxidized ore of the Snowstorm mine consists of quartzite impregnated with minute particles of bornite, chalcocite, and chalcopyrite. The richest ore appears of a uniform dark-gray tone; the leaner ore is lighter and finely dappled or speckled. A relatively small proportion of the copper ore occurs in veins and bunches associated with quartz, these being especially abundant in the eastern part of the mine. Tetrahedrite is said to be a constituent and is the probable source of the silver. Although the greater part of the ore now in sight is of the disseminated sulphide variety, the oxidized ore, which was the chief product in early years, is still being mined. In this the sulphides have been converted chiefly to malachite but partly to cuprite. The carbonate ore is greenish brown, being stained by limonite. The most thoroughly decomposed ore is soft and of a bright-red color that suggests a high content of cuprite, but this material is said to be in reality very poor in copper, and the color is therefore probably due in the main to iron oxide. Malachite with some azurite forms thin films on joint faces. The walls of some drifts on the No. 3 tunnel level are gorgeously colored with these carbonates, although the ore here is lean. Some oxidation has occurred as far down as No. 4 tunnel, more than 1,600 feet below the outcrop, but the carbonate ore is not abundant below the 600-foot level.

UNDERGROUND WORKINGS.

The Snowstorm ledge is tapped by four tunnels. The No. 1 tunnel is disused; No. 2 is blocked but connected with the surface by an air shaft; No. 3 is the working adit; and the No. 4 level is the one on which most of the exploration has been done in recent years, although much ground has also been explored on the No. 3 tunnel level. Drifts have been run on the 100-foot (tunnel No. 1), 400-foot (tunnel No. 2), 600-foot, 700-foot, 800-foot, 900-foot, 1,000-foot, and 1,100-foot (tunnel No. 3) levels. Tunnel No. 4 is 535 feet below tunnel No. 3 and therefore about 1,600 feet below the outcrop.

GEOLOGIC CONDITIONS.

The workable ore of the Snowstorm mine occurs for the most part in a stratum of Revett quartzite, about 40 feet thick, which may conveniently be referred to by the term in use at the mine—"the ledge." This ore-bearing stratum is distinguished lithologically from the rock immediately above and below by its harder and grittier character. The quartzite of the ledge is thick bedded and medium grained and contains very little sericite; the portion not colored by the copper minerals is almost pure white. The rock immediately above and below the ledge is more flaggy, finer grained, softer, and more greenish, the last two characteristics being due chiefly to the presence of sericite in considerable quantity. The lower limit of the ledge is the more sharply defined. It is marked by an abrupt change in the character of the rock and in most places by a slip, which, however, appears to be no more significant than the innumerable bedding-plane slips found everywhere in this region at the contact of soft beds with hard and which in few places contains more than an inch of gouge. The country rock below this "footwall" contains a little ore in places, but on the whole the coincidence of the contact between hard and soft quartzite with that between commercial ore and the practically barren underlying rock is remarkably close. The upper limit of the ledge is less definite with respect to both lithologic character and tenor, and in working westward successive beds on the hanging wall have been abandoned as too poor to work.

The reason for the remarkably definite limitation of the ore to a comparatively thin stratum of quartzite is far from clear. A partial explanation is indeed suggested by the behavior of the mine waters, which evidently circulate with much greater freedom in the harder and purer quartzite than in the softer and more sericitic rock. It is natural to infer from this that the ore-bearing solutions flowed through the purer quartzite, which became impregnated by them because of its relatively porous texture. But this conclusion does not explain the fact that a great part of the quartzite penetrated by the mine workings, though apparently identical in character with the matrix of the copper minerals, is nevertheless quite barren.

The bedding of the Revett quartzite in the mine and consequently the ledge itself dip steeply south-southwest. A few hundred feet south of the ledge, on the surface near the workings, is a reversed fault whose general strike is east and west and which has a steep dip to the north. The relations are such that in depth the ledge is cut by the fault, and the segment south of the fault is relatively depressed.

These structural features were stated and illustrated diagrammatically by Ransome [1] in the report that was based on the exami-

[1] Geology and ore deposits of the Cœur d'Alene district, Idaho: Prof. Paper U. S. Geol. Survey No. 62, 1908, p. 150.

nation made in 1904. Chiefly on the basis of the geologic mapping, which was done by F. C. Calkins, the fault was said to be between Revett and St. Regis beds; its throw was estimated as not less than 700 feet, and its dip was shown as being such that the ore-bearing stratum would probably be cut off about 100 feet below the level of tunnel No. 3.

It now appears, from facts of which some were overlooked and others inaccessible to observation in 1904, that this description of the structure, though true in essence, is incomplete and open to some quantitative correction. The extensive workings on the No. 4 tunnel level, which had not been begun in 1904, show that the structure is more complex than was supposed and that the movements ascribed to a single fault should rather have been ascribed to a fault zone, of which the fault that was recognized was the northernmost member. The throw of this particular fault is probably less than 700 feet, for the rock on the south side of it in the mine belongs chiefly to the upper part of the Revett quartzite rather than to the St. Regis, and the ledge has been found on the No. 4 tunnel level in a position which it could not occupy if the quantitative elements of the former interpretation had been correct.

The recent reexamination made this much apparent; but it was not complete, inasmuch as the weather prevented a review of the surface exposures, and therefore an attempt to interpret the structure in detail would still be premature. Even the downward course and the throw of the northernmost fault are still somewhat problematical. The structural facts of chief practical importance, however, are fairly clear from the exposures on the No. 4 tunnel level. Two segments of the ledge appear on this level, cut apart by an east-west fault, which may be the northernmost main one; but if so, the general dip of this fault, which averages about 70° above No. 3 tunnel, must become vertical below that level. Another considerable fault, which brings St. Regis beds against Revett, is about 500 feet south of the one just mentioned in the eastern part of No. 4 tunnel level. Westward it converges slightly toward the other. Between these two faults are others that strike more nearly north and south, but the ledge is sufficiently exposed to show that a large part of it south of the main Snowstorm fault is unaffected by important fractures and could readily be opened.

The ledge, however, is not all composed of commercial ore. The portion rich enough to work at a profit—the ore shoot—has a maximum stope length of about 700 feet. It has a pitch of about 90° near the surface, but this quickly changes to a low eastward pitch. As the strike of the bedding and main fault converge toward the east, it follows that the ore shoot is cut off at less depth than the ledge, and practically no commercial ore has been found below the 900-foot

level. The portion of the ore shoot south of the main fault, if the shoot persists across that fracture, is presumably below the level of tunnel No. 4.

The element of uncertainty implied in the last sentence is one that should be frankly considered. Although the structural relations prove that the ledge is older than the faulting, it seems possible and has indeed been suggested that the concentration which produced commercial ore is later than the fault, and that the ore forming the shoot was deposited by downward-moving waters, which were dammed by the fault gouge. If this were true, the ore shoot, which has thus far proved productive, would not continue beneath the fault. Some plausibility is given to this hypothesis by the freedom with which water circulates in the crevices of the brittle quartzite of the ledge and the relative impermeability of the thicker fault gouges. The drifts on the No. 4 tunnel level in the quartzites north of the faults—that is, above them—are comparable to a vast cold shower bath. The tunnel south of the faults is relatively free from water, and some of the points at which the drifts cross wide gouges are the driest places in the mine. The gouges undoubtedly act as dams, and concentration might conceivably be due to the retarding effect of the gouge upon the mineralizing solutions. If this were true, however, evidence of the fact should be presented by the distribution of the ore. It might reasonably be expected, in such a case, that the ore shoot would extend along the intersection of the fault with the ledge. As a matter of fact, no such relation between the ore shoot and the fault is apparent. The only modification of the ore that seems to be related to the faulting is the occurrence of copper veins in the eastern part of the workings. This occurrence, however, is probably due to reconcentration of the ore in fissures contemporaneous with the major faults, and the disseminated ore of the pay shoot was evidently formed in a different way. It therefore seems reasonable to hope that a continuation of the pay shoot may be found below the No. 4 tunnel level.

SNOWSHOE PROSPECT.

The Snowshoe property is near the head of Gentle Annie Gulch, about half a mile west of the Snowstorm mine and but a short distance east of the Lucky Calumet. The workings consist of a tunnel 1,400 feet long, driven N. 60° E., near the end of which a drift runs for about 400 feet in an irregular course, averaging S. 70° E. The first 400 feet of the tunnel is driven in fine-grained green quartzites and shales, in which are a few dark-colored bands. This formation gives way to purple shales and quartzites, undoubtedly St. Regis, which continue to the Snowstorm fault, 150 feet from the drift. Beyond the fault the thick-bedded white Revett quartzite occurs. Numerous faults or slips, most of them accompanied by gouge,

were noted in the tunnel section. They are, in the main, conformable to the bedding planes, but some cross at small angles. The Snowstorm fault is accompanied by brecciation and gouge.

The ore consists of pyrite, chalcopyrite, chalcocite, etc., sparsely disseminated in the thick-bedded hard Revett quartzite exposed in the drift, the mineralization being the same as in the ores of the Snowstorm mine, but leaner. This zone has been proved for the length of the drift, and its width is from 30 to 40 feet as measured along the tunnel section, but the beds dip about 60° S., making a correction necessary.

LUCKY CALUMET.

The Lucky Calumet property is situated near the head of Gentle Annie Gulch, about a mile west of the Snowstorm mine. The workings consist of a tunnel about 1,700 feet long, driven N. 50° E., and drift about 300 feet long, driven N. 40° W., from a point 100 feet from the breast of this tunnel. The southeasterly extension of the drift, from which comes a large flow of water, is bulkheaded.

From the entrance for a distance of 600 feet the tunnel is driven through purple shales and quartzites of the St. Regis formation, then for about 200 feet through green quartzites, and finally into the typical hard, massive white Revett quartzite. The strike of the formation is uniformly northwest, but both north and south dips, due to folding and faulting, were noted in the outer half of the tunnel. About 800 feet from the tunnel entrance a brecciated zone and loose ground, requiring lagging, suggest a considerable fault, probably the westward extension of the Snowstorm fault.

Little evidence of mineralization was noted in this tunnel. Evidently the exploratory work is done in the hope of striking the supposed continuation of the Snowstorm ore body. In the drift rust specks were noted in the massive quartzite, but none of the disseminated copper sulphides characteristic of the Snowstorm deposit. Assessment work at the time of visit was much impeded by the heavy flow of water in the quartzite.

MISSOULA COPPER.

The Missoula copper property is at the head of Deadman Gulch, about 1½ miles northwest of the Snowstorm mine. The workings consist of a tunnel and drifts aggregating 4,500 feet in length, with a connecting shaft on one of the drifts. The shaft is probably several hundred feet in depth. The main tunnel trends N. 30° E. for 1,900 feet and about N. 70° E. for 700 feet. From this tunnel several drifts follow quartz veins or slip planes. The entrance of the tunnel is in the purple shales of the St. Regis formation, but these soon give way to greenish thin-bedded quartzites of the upper part

of the Revett quartzite, and the green quartzites in turn are underlain by the typical thick-bedded hard white Revett quartzite. The strike is in general northwesterly, with dip to the south, but as the distance from the tunnel entrance is increased the strike gradually swings more to the north. At the entrance of the main tunnel the strike is about N. 55° W., but at the breast the strike is N. 20° W. Numerous faults and minor slips occur in the bedding planes and a smaller number cross the strata. These disturbances were usually accompanied by the formation of quartz veins.

The ore consists of a mineralized quartz vein and disseminated sulphides, which are exposed in a drift 1,250 feet from the entrance on the tunnel level. The drift runs northwesterly and follows a quartz vein, which varies from a few inches to 2 feet in width. About 500 feet from the entrance to this drift a shaft and near by a raise are located. The shaft and raise were not examined. The vein contains scattered bunches of galena and chalcopyrite and is richest in the vicinity of the shaft, but nowhere does it give indications in itself of being a commercial deposit. A peculiar feature of mineralization attendant on the rich part of the quartz vein is the occurrence of finely disseminated sulphides in the hard quartzites on either side of the vein. This type of ore is very similar in appearance to the leaner ores of the Snowstorm mine. In the drift 75 feet northwest of the shaft these disseminated sulphides extend only a foot or two on either side of the vein, but in a drift which extends south from the shaft this type of mineralization extends for a distance of 30 feet. The dip of the quartzite here is about 30° S. About 150 feet southeast of the shaft no disseminated sulphides were noted and the quartz vein is apparently barren. At a point about 550 feet from the tunnel entrance finely disseminated copper and iron sulphides were noted in the hard quartzites, but their occurrence at this point is both sparse and of very small extent.

UNITED COPPER MINE.

The United Copper property is in Deadman Gulch, the entrance to the main adit, known as the National tunnel, being near and between the main forks. The examination of this mine consisted of a single hasty visit in which only the lowest level was examined. Mr. George Huston has obligingly supplied considerable information regarding progress since this visit and has sent good specimens of representative ore. This description, however, must still be inadequate to the prospective importance of the property.

The National tunnel is about 4,300 feet long and its direction is a little east of north. At the time of visit the only other work on this level consisted of a short drift to the east, a few hundred feet from the face of the main tunnel. Since that time considerable more work has

been done, development having been stimulated by a strike of what promises to be commercial ore.

The prevailing dip of the country rock is southwestward, and in going northward into the tunnel one encounters successively the Newland, St. Regis, and Revett formations. These are broken by numerous fissures, along some of which considerable faulting has taken place. A short distance south of the drift the tunnel is crossed by a zone of brecciation marking, in the opinion of Mr. Huston, a fault between the Revett and St. Regis formations, with downthrow on the south and strike approximating east and west.

The drift, at the time of visit, was being driven along a fissure zone in which there was some quartz containing small amounts of chalcopyrite and chalcocite. These minerals were also disseminated in the country rock, but in a manner somewhat differing from that characteristic of the Snowstorm ledge; the particles were comparatively large but rather sporadic in distribution and not abundant enough to constitute commercial ore. Shortly after this time a vein of chalcopyrite several inches thick was encountered, and somewhat later the drift penetrated the ore on whose development the future of the property is likely to depend. This ore is essentially similar to that of the Snowstorm mine and consists of a stratum of quartzite speckled with minute particles of chalcopyrite and richer sulphides. The tenor is less than that of the best Snowstorm ore and probably does not run more than 3 per cent of copper, together with 3 ounces of silver and a negligible quantity of gold. The proportion of chalcopyrite is larger than in the Snowstorm mine, where enrichment has apparently been more extensive. The United Copper ore shows clear evidence of replacement of chalcopyrite by chalcocite, as was pointed out by Mr. Huston. The ore body is about 50 feet thick and has been shown to be at least 350 feet long. As its strike is northwest and its dip south, it must converge toward the east with the fault mentioned above. As the dip of this fault is southward, however, the ore can probably be followed downward to a considerable depth.

COPPER KING MINE.

The Copper King property is on the West Fork of Deadman Gulch, northwest of the United Copper. The principal development is on the lowest level, which alone was hastily examined. The main tunnel is about 5,000 feet long and drifts and other crosscuts aggregate several thousand feet in addition.

As in the National tunnel, the prevailing dip is southwestward, although there has been some folding and faulting. The rocks in the outer part of the tunnel belong to the Newland formation, which is succeeded on the north by the St. Regis; the Revett quartzite has not been penetrated.

The principal ore body observed is a vein striking about west-northwest and dipping 40° S. Its average thickness is only about 1 foot. It contains galena, sphalerite, chalcopyrite, and pyrite in a gangue consisting chiefly of quartz and calcite. The wall rocks are slightly mineralized. The size of the lode, however, is apparently not sufficient in the workings seen to permit profitable extraction. There seems to be some difficulty in finding the vein east of the main tunnel. According to Mr. Huston considerable work was done subsequent to our visit on an ore body south of that mentioned. This consisted of a band of country rock strongly impregnated with chalcopyrite and galena. This ore would be difficult to concentrate economically. Its thickness is about 2 feet. At last accounts this ore body had been found to be cut off by a fault and had not been found on the other side of it.

THE LEAD-SILVER DEPOSITS OF THE DOME DISTRICT, IDAHO.

By JOSEPH B. UMPLEBY.

SITUATION AND HISTORY.

The Dome mining district, situated in the northeast corner of Blaine County, Idaho, consists of the southern part of the area known in the early history of the region as the Hamilton mining district. It is reached by triweekly stage from Arco, a station on the Mackay branch of the Oregon Short Line Railroad, about 50 miles distant by the road commonly traveled. This road leads down the valley of Little Lost River to the Snake River Plains and thence along the margin of the plains to Arco, situated near the mouth of the valley of Big Lost River. A route 15 miles shorter, but with a grade too steep for heavy traffic, leads across the range of mountains that separates the valleys of Big and Little Lost rivers.

Lead-silver ores were discovered in the district about 1880, and during the following decade most of the deposits now recognized were worked. At that time the ore was hauled 75 miles to a smelter at Nicholia, near the head of Birch Creek. Only high-grade ores could be handled, and from these possibly $75,000 was produced, mostly from the Great Western group of claims, which has been idle for many years.

The chief interest in the district at present centers in the Wilbert mine, formerly the Daisy Black. This property was located many years ago, but made its first production about 1906, when two hand jigs were installed and a few tons of concentrates were shipped. In the fall of 1911 H. S. Knight, A. S. Ross, and associates, of Salt Lake City, purchased the property, organized the Wilbert Mining Co. (Ltd.), and built a 100-ton concentrating mill which made its first run in May, 1912. By July 20, 1912, the date of the writer's examination, the mill had handled about 2,400 tons of ore and produced 300 tons of concentrates which carried 51 to 53 per cent of lead and about 9 ounces of silver to the ton. The saving during this run was a little less than 70 per cent, or about 10 per cent below that estimated for the mill. By the end of the year the mill had produced concentrates which yielded approximately 1,500,000 pounds of lead and 10,000 ounces of silver.

FIELD WORK AND ACKNOWLEDGMENTS.

This paper records the more important observations made during a visit of four days in July, 1912. The work was part of an extensive reconnaissance in southeastern Idaho north of Snake River, and a fuller account of the deposits of the district will appear in the general report.

The field work was greatly facilitated by the underground maps and general information courteously supplied by Mr. H. S. Knight, general manager of the Wilbert Mining Co., and to him the writer desires to express his appreciation. Thanks are also due to Mr.

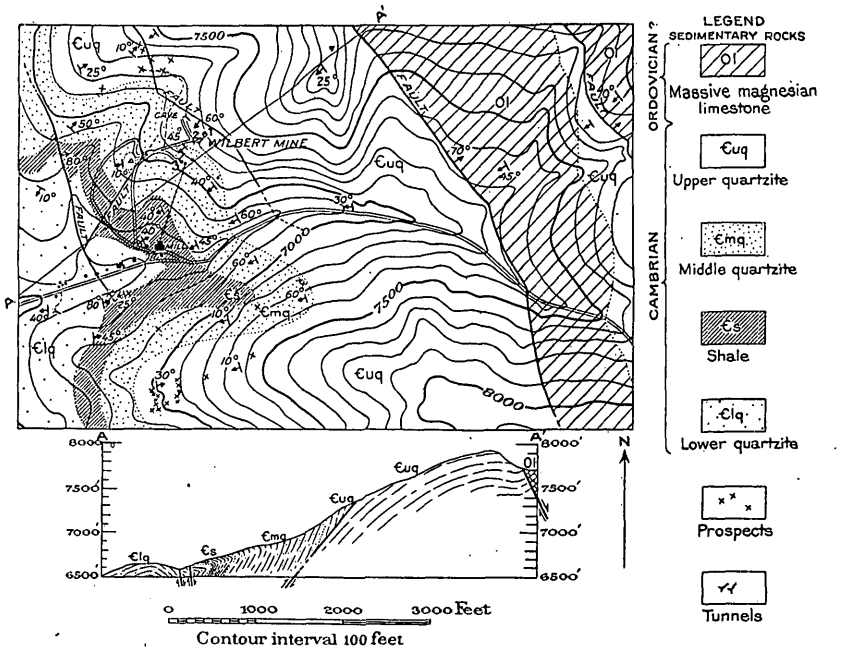


FIGURE 21.—Reconnaissance map and section of the central part of the Dome mining district, Idaho.

Charles A. Peet for supplying points of topographic control. Mr. C. H. Gray, assistant throughout the general reconnaissance, helped in the construction of the map shown as figure 21.

TOPOGRAPHY.

The district comprises a segment of the western slope of the high range which separates the valley of Little Lost River from that of Birch Creek. From the margin of the broad basin in which Little Lost River flows the slopes rise abruptly to elevations of more than 10,000 feet in the eastern portion of the district. In the northern portion Pass Creek, a tributary of Little Lost River, has cut a deep canyon far into the mountains and is the only stream readily available for local development of power. A canyon of comparable size,

but containing only an intermittent stream, extends eastward in the central portion of the district. This canyon is shown on figure 2. About a mile farther south is still another large canyon, in which is situated the Great Western group of claims.

GEOLOGY.

FORMATIONS.

The rock formations exposed in the district are made up predominantly of quartzite, but interbedded with the quartzites is a distinct shale member, and above them are massive beds of magnesian limestone. So far as known the workable ore deposits occur wholly within the quartzite areas. Three distinct quartzite formations are indicated on the map, and for convenience in reference they will be designated as upper, middle, and lower. It is probable that, had time permitted, the upper quartzite could have been subdivided into at least three parts.

The lower quartzite is the oldest formation exposed in the vicinity of the mines. It is a massive or semimassive white rock which has a wide range in texture, but in most places is pebbly, with subangular pebbles of quartz up to a quarter of an inch across, cemented by finer siliceous material. The total thickness of this formation is not known, although beds at least 200 feet thick are exposed in the north side of the canyon below the Wilbert mine.

A shale formation possibly 150 feet in thickness overlies the lower quartzite, though in some places the beds are overturned and the shale underlies the quartzite. This shale has been compressed, at least locally, until the bedding planes are in most places obscured by slaty cleavage and schistosity, which are the characteristic features of the formation. The rock is greenish gray in color and breaks readily into irregular plates which commonly have curved surfaces. Its metamorphism was accompanied by considerable recrystallization, giving rise predominantly to chlorite and sericite.

Above the shale formation is the middle quartzite, which, as measured in the canyon above the Wilbert mill, is 475 feet thick. This formation is readily recognized by its maroon color, which contrasts sharply with the prevalent light grays of the other quartzite formations. The lower part of it is made up of thick beds, some of which are intricately cross-bedded, but the upper layers are thin and regularly stratified.

Next younger is an assemblage of quartzites which are here mapped as the upper quartzite. These strata are at least 800 feet thick, although their full thickness is probably not exposed in the area studied. The lowest beds of this assemblage comprise 25 feet of milky-white fine-grained quartzite, overlain by 6 feet of dark-gray

medium-grained quartzite, then 10 feet more of the milky-white variety, which grades into a brownish-gray facies containing numerous annelid borings, the total to this horizon representing a thickness of about 170 feet. This portion would be the lower division if the upper quartzite series were subdivided. Above the brownish-gray quartzite is 80 feet of thin-bedded clear-white fine-grained quartzite, which from local evidence might also be considered a distinct unit. This is overlain by 550 feet of massive quartzite beds of light-gray color and fine-grained texture.

Above the quartzite series are massive beds of magnesian limestone, which were not examined carefully, as they occur at a considerable distance from the known deposits of ore. These limestones are unquestionably several hundred feet thick and constitute the predominant rock near the center of the range east of Wilbert.

It is believed that the quartzites are of Cambrian age and the magnesian limestones are Ordovician, a belief based on relations noted elsewhere during the general reconnaissance rather than on local evidence.

STRUCTURE.

The dominant structural features in the central part of the district are a number of normal faults which strike about N. 30° W. and an overturned fold along which thrust faulting has taken place. The thrust fault (or faults) has about the same strike as the normal faults, but it dips southwest, while they dip northeast. Both types of displacement have thrown younger beds on the northeast against older beds on the southwest. It is thought that the two types of faults represent distinct epochs of disturbance, and that the folding and thrust faulting took place first.

The overturned fold may perhaps be studied most easily in the vicinity of the Wilbert mill. Here the shale is bounded on the west by the lower quartzite and on the east by the middle quartzite, rocks quite different in appearance. On the west the dip is easterly and on the east it is westerly. Exposures in the group of prospects along the road from the mill to the mine clearly show that the shale extends beneath the middle quartzite, and numerous exposures west of the mill indicate that the lower quartzite extends beneath the shale. The overturn has thus been from the southwest toward the northeast, as shown in the section on figure 21. The fault along the northeast side of this fold was not adequately studied, but seems to have a definite relation to the ore deposits. Indeed, some of the ore bodies exposed on the lowest level of the Wilbert mine appear to be along this fault. Northwest of the mine the fault may be traced with a fair degree of certainty well beyond the limits of the area mapped, but to the southeast it is not known to cross the canyon, although as there is

generally little accompanying breccia it might readily be overlooked in this area of uniform rock.

The maximum displacement of this fault can not be more than a few hundred feet and may be less than 100 feet. The rocks in the footwall are not greatly disturbed, but those in the hanging wall are most intricately fractured, and it is in this fractured zone that the Wilbert ore bodies occur.

Four distinct normal faults of considerable extent are shown on the map. Two of these have dropped the magnesian limestone against the upper quartzite and the other two have appreciably offset the lower quartzite and shale contact. The age relation of these displacements to the folding and thrust faulting is shown clearly in the Wilbert mine, where the ore bodies, which formed along fractures related to the thrust faulting, have been offset by many normal faults of minor throw.

ORE DEPOSITS.

DISTRIBUTION AND DEVELOPMENT.

There are four local centers of prospecting and mining in the Dome district, but of these only the Wilbert group of claims has been actively exploited in recent years. About 2 miles north of the Wilbert mine is the Johnson property, where 300 feet of development work has been done on a number of small veins in magnesian limestone. The Great Western mine, 1½ miles south of the Wilbert, comprises about 2,000 feet of tunnels and is reported to have produced early in the history of the district $50,000 from silver-rich lead ores. It has not been worked for a number of years, and most of the workings are said to be inaccessible. About 3½ miles south of this mine are the South Creek properties, from which a few small shipments have been made. The Wilbert property consists of 13 claims, two of which are patented, and is developed by about 2,500 feet of tunnels, raises, and crosscuts. Only the Wilbert and Johnson deposits were examined.

CHARACTER.

The following description of the ores and their occurrence is based entirely on observations made in the immediate vicinity of the Wilbert mine. The ore here found occurs as veins, stringers, and disseminations in the fine-grained upper quartzite, most of the production coming from the disseminated lead-silver ores. The known ore bodies are very erratic in size and distribution, although they are all related to a general zone of fracturing and, except where offset by faults, are usually connected by stringers. The shoots commonly strike N. 20°–30° W. and dip either to the east or to the west at angles varying from 20° to 80°. The mine is opened on three levels,

with upper and lower intermediates between the two lower tunnels, as shown in section by figure 22. The uppermost ore body crops out a short distance above tunnel No. 1 and extends downward on a dip of about 60° SW. to a point 10 feet below level No. 2, where it is cut off by a flat-lying, westward-dipping fault. All the ore bodies found between this fault and the lower intermediate level are flat-lying and of irregular shape, but in the main dip eastward. On the lowest level, No. 3, a fairly distinct fissure, along which are two ore shoots separated by 75 feet of comparatively barren ground, has been followed for 350 feet. The south shoot is 60 feet long and varies in width from a few inches to 2 feet. The north shoot has been explored for 180 feet. This shoot contains ore of excellent

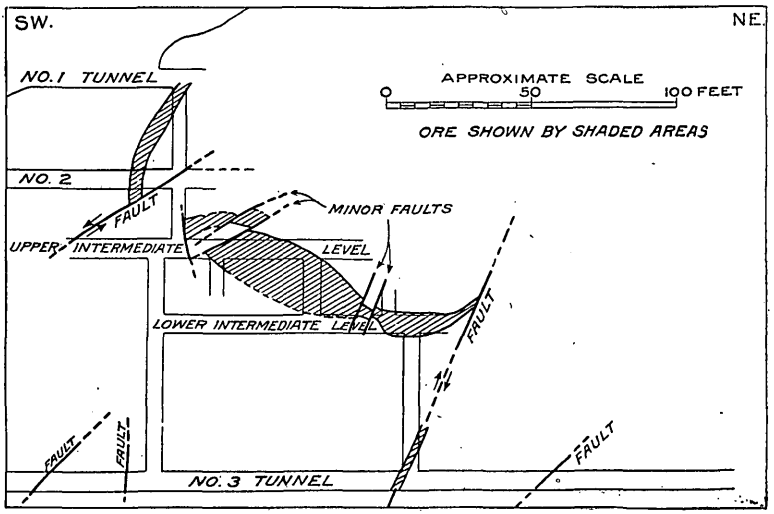


FIGURE 22.—Transverse section through the Wilbert ore bodies, Dome district, Idaho, along line of tunnel No. 3.

grade and occurs as a fairly distinct vein from a mere stringer to 3 feet in width, averaging perhaps 2 feet. Both shoots strike about N. 20° W. and dip 60° NE. The two shoots found on the third level probably extend to the lower intermediate level, 55 feet above, where two bodies of similar ore occur in normal relation to them. The south shoot presents a peculiar feature above the lower intermediate level, where it rises toward the north in the plane of the vein at an angle of about 20°. This portion of the shoot has been followed upward by an incline for 150 feet, and its average cross section so far as known is said to be about 7 feet by 6 to 20 feet. Both of these ore shoots are out of the plane of the transverse section, figure 22.

Another shoot of ore crops out near the portal of the Cave tunnel, but the development here has not been sufficient to define its attitude. The portal of the Cave tunnel is situated 300 feet N. 17° W.

of portal No. 2, at practically the same elevation. Just south of it a considerable tonnage of ore has been taken from an open cut in loose surface rock. The ore occurs as chunks from the size of a walnut to several feet across. Immediately beneath this open cut a short drift south from the Cave tunnel enters a flat-lying body of ore 3 feet thick which is inclosed in manganese-stained quartzite and averages about 25 per cent of lead. Its boundaries have not been defined.

RELATION OF THE ORE DEPOSITS TO GEOLOGIC STRUCTURE.

An adequate account of the deposits would involve the consideration of many structural problems, but the short time allotted to the work in this district made it impracticable to attempt even local detailed studies of structure. Certain broad relations, however, were worked out which should serve as primary control in the interpretation of local detailed observations. The Wilbert ore bodies occur along the zone of sharpest bending in an overturned anticline. The rocks here were greatly fractured during the development of the overturned fold, and in some places, perhaps in most places, the formations along the crest of the fold broke and a thrust fault resulted. In the small gulch north of the Wilbert mine a fault of this kind is clearly shown, and in the mine itself several small ones have been identified.

After the compressional stresses that caused the folding and the thrust faulting the area was subjected to tensional stresses, which gave rise to the normal faults indicated on the map.

The ores were deposited along fractures developed during the epoch of folding, and in many places were offset during the epoch of normal faulting. The form of the ore bodies is therefore determined by the extreme irregularity of the earlier fractures, and their position is determined both by these fractures and by subsequent faults. In many places the later faulting has found expression as small movements along the earlier fracture planes, thus causing a brecciation of the ore where no offset is seen.

THE ORES.

The ore of the Dome district is of especial interest, because in much of it the ore minerals occur as minute grains disseminated in quartzite. Ore of this variety has a "pepper and salt" appearance, but the relative amounts of the light and dark grains are very different in different places and locally within distances of a few inches. In most places the ore bodies of this type blend with the inclosing rock by imperceptible gradation through a zone from a few inches to 5 feet wide. Poorly defined bands of fairly pure galena cut in various directions through the irregular masses of disseminated ore and in places coalesce into rather distinct veins made up of thin

lenses and stringers of galena and anglesite. In the Wilbert mine the disseminated ore is characteristic of the flat bodies between tunnels No. 2 and No. 3, and the thin lenses and stringers occur extensively in the shoots developed on the lower intermediate level. Still another ore type is represented in the north shoot opened on level No. 3. Here galena forms the cement in a quartzite breccia, which occurs along a fault zone. The quartzite of the breccia is in many places not mineralized, a fact that seems strange in view of the exceptional extent to which galena has been deposited in the wall rock of the upper levels.

The mineralogy of the ore is simple, galena and its oxidation products, anglesite and cerusite, being the only abundant minerals. The galena occurs as the dense variety commonly known as steel galena, and its oxidation products are similarly fine grained. A few crystals of calamine were seen on level No. 3, suggesting the presence of sphalerite as a primary mineral, and here also a few copper stains and a little linarite (hydrous copper-lead sulphate) suggest the presence of some copper sulphide. These minerals, however, are negligible in amount.

Thin sections of the ore studied with the microscope show that the galena of the disseminated ore replaced the cement and to some extent the quartzite grains in a fine-textured quartzite. Some of the unaltered quartzite has a lime-silica cement, but in those beds in which the ore occurs the cement seems to have been entirely siliceous. Specimens of the disseminated ore effervesce slightly in acid and show in thin section a small but rather evenly distributed amount of cerusite on the outer margins of anglesite areas, many of which contain cores of galena. This carbonate, the only one noted in the sections of ore studied, is clearly of secondary origin.

In the disseminated ore anglesite, the sulphate of lead, is by far the most abundant metalliferous mineral. Sections of it usually show irregular cores of the galena from which it was formed. The alteration of galena to anglesite necessitates a volume increase of approximately 52 per cent (computed on the basis of average specific gravities), and the change from galena to cerusite an increase of only 28 per cent. In these deposits anglesite occurs so commonly as a band between a core of galena and a rim of cerusite that it is probably safe to assume that here at least it is generally an intermediate stage in the alteration of lead sulphide to lead carbonate. The volume change in the alteration of any given grain of galena is therefore first a 52 per cent increase in volume and then a 24 per cent decrease, the net result when carbonation is complete being a 28 per cent increase. The maximum possible increase of 52 per cent is probably never realized, for it is likely that cerusite begins to form before a given grain of galena is completely changed to anglesite. There is, how-

ever, a cycle of volume change in the direction stated. The writer believes that this increase in volume followed by a marked decrease during alteration accounts for the "sand carbonate" ores of many mines, so named because of the loose assemblage of the cerusite grains. In this deposit the volume changes which accompany the alteration of galena to anglesite and of this in part to cerusite appear to have had a decided influence on the coherency of the inclosing rock and to account for the loose, sandy condition of the plumbiferous quartzite, as opposed to its firmness and close texture where not metalized.

The ores found in the Wilbert mine are very different in tenor, the disseminated ore containing from 12 to 20 per cent of lead and the vein ore, made up of lenticular masses and stringers, from 20 to 30 per cent of lead. During the month of December, 1912, when the mill handled 50 tons a day, the average tenor of the ore was 23 per cent—somewhat higher than that for previous months. Recent developments, however, have encouraged the management in the hope to keep a mill feed of 20 to 23 per cent of lead. Ore of this grade usually contains about 3½ ounces of silver to the ton.

ALTERATION OF THE WALL ROCK.

A conspicuous and noteworthy feature of these deposits consists in the abundant oxides of iron and manganese which characterize the wall rock for several feet away from the ore bodies. These oxides are most abundant next to the ore and where observed grade out to unaltered quartzite within a distance of 10 to 50 feet. The altered wall rock is striking in appearance, a bright yellow groundmass of iron oxide being studded thickly with small specks of dendritic manganese. The oxides occur not only along the innumerable fracture surfaces, but throughout the rock as interstitial fillings between the quartz grains. Calcite generally accompanies the metallic oxides. Perhaps its most common situation is along the cleavage cracks, but in places it occurs also interstitially between the quartz grains. In many parts of the hand specimens where no carbonate is visible, even with the aid of a hand lens, a drop of acid causes vigorous effervescence, indicating that the calcite is present but is concealed by the oxides.

The occurrence of these oxides and calcite in the wall rock is in every particular comparable to the occurrence of the lead minerals in the disseminated ore. Both seem to have replaced a siliceous cement in the quartzite. This analogy, together with the definite decrease in their amount with increasing distance from the ore bodies and the ill-defined boundary between such rock and the bodies of disseminated ore, points rather conclusively to the development of some manganese-iron-carbonate mineral or minerals in the wall rock as an accompaniment of the primary mineralization. It is believed that

these manganese and iron oxides must be regarded as a product of metasomatic alteration closely comparable to the well-known development of calcite adjacent to fissure veins.

The primary metasomatic mineral or minerals from which the oxides of iron and manganese and possibly also the calcite have been formed were not observed in any of the specimens. By inference, however, it seems probable that the primary metasomatic mineral was manganiferous iron carbonate. Siderite, a mineral which commonly contains manganese, is abundant in the gangue of many of the lead-silver deposits of Idaho and in the Cœur d'Alene district[1] it has been shown to replace quartzite to an important extent.

GROUND-WATER LEVEL.

The level of ground water is well below the present lowest mine workings. The bottom of the canyon at the Wilbert mill is approximately 400 feet below the lowest level of the Wilbert mine and only 1,000 feet away along the strike of the steeply dipping quartzite beds. The canyon at the mill is dry throughout most of the year, the stream which rises near its head sinking about 2 miles above the camp. Thus in the vicinity of the mines the elevation of ground-water level, though not susceptible of close determination from surface observations, is at least below the level of the bottom of the canyon at Wilbert.

SUMMARY AND PRACTICAL CONCLUSIONS.

The principal points of interest in this preliminary paper and the practical conclusions which may be drawn from it are as follows:

1. The Wilbert deposits contain important bodies of plumbiferous quartzite, a type of lead ore which, so far as the writer is aware, has not been previously described.

2. The mineralizing solutions caused noteworthy metasomatic alteration of the quartzite for 10 to 50 feet or more from the ore bodies, replacing the cement of the quartzite with some mineral (or minerals) which on breaking down gave limonite and pyrolusite and possibly also calcite.

3. The loose, sandy condition of the disseminated ore is thought to be due to the volume changes which accompany the alteration of of galena to cerusite, with anglesite as an intermediate stage.

4. The Wilbert ore bodies were formed after the folding of the rocks of the district but before they were displaced by normal faults. They present many structural problems which it is believed should be considered in the light of these two epochs of disturbance—one older than the deposits and the other younger—particularly

[1] Ransome, F. L., and Calkins, F. C., The geology and ore deposits of the Cœur d'Alene district, Idaho: Prof. Paper U. S. Geol. Survey No. 62, 1908, pp. 95, 97.

because many of the later movements have taken place along the old fracture planes, which in a large part determined the sites of ore deposition.

5. Manganese oxide in this district appears to be invariably present in the wall rock adjacent to the lead-silver ores, and hence may be considered an encouraging indication, both in prospecting and in mining. This statement, however, can not be taken to mean that manganese is everywhere accompanied by lead ore, but rather that lead ore appears to be everywhere accompanied by manganese.

6. The elevation of ground-water level in the district is not known definitely; but in the area of which figure 21 is a map it is certainly below the level of the bottom of the gulch, or at least 400 feet below tunnel No. 3 of the Wilbert mine.