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GEOLOGY AND SILVER ORE DEPOSITS OF THE PEND OREILLE DISTRICT, IDAHO

By

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(Issued in Cooperation with U. S. Geological Survey).

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C O N T E N T S

I L L U S T R A T I O N S

FOREWORD

The following pamphlet contains the broader and more general conclusions of a detailed geological survey of the Pend Oreille mining district made by the United States Geological Survey during the years 1921, 1922, and 1924.

Dr. Edward Sampson, who was detailed to the work, severed his connections with the Survey shortly after the field studies were completed and because of other duties has not been able to complete the comprehensive report which he is preparing and which will consider in detail many features of the district, especially the individual mines and prospects, which are omitted from this pamphlet. The plans are to complete and publish the final report in the near future. It is hoped, however, that the general descriptions and conclusions presented herein will serve the immediate needs of those interested in development of the district.

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By
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N A T U R E   A N D   L O C A T I O N   O F   D I S T R I C T

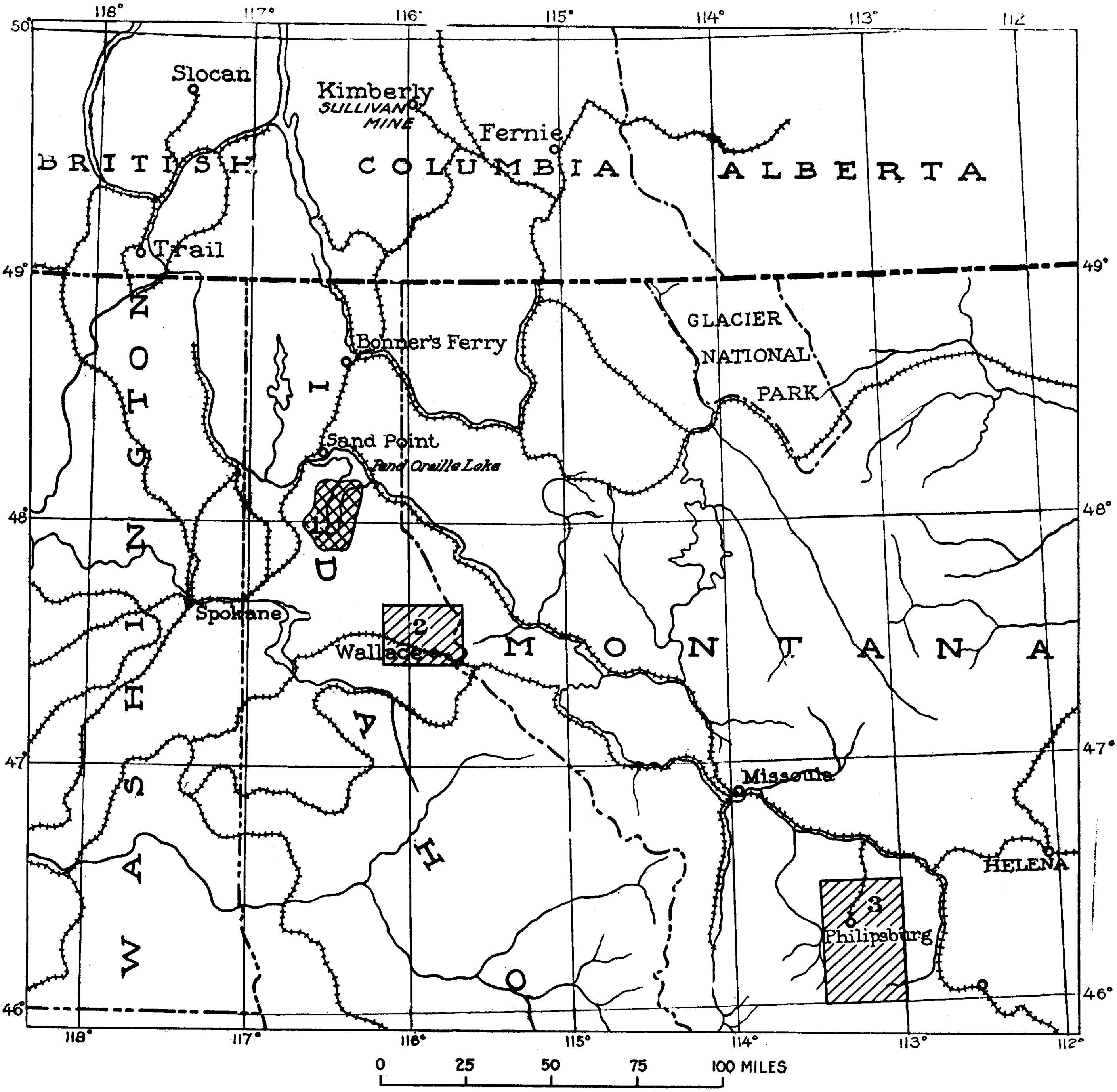
This report is an advance summary of a geological survey of the Pend Oreille district which surrounds the southern part of Pend Oreille Lake in Bonner County of Northern Idaho. (See Figure 1). Pend Oreille Lake, one of the largest lakes west of the Great Lakes, lies at an elevation of about 2,050 feet above sea level. It is surrounded by mountains, the highest reaching a height of 6,414 feet and many rising above 5,000 feet, as shown on Plate I. The mountains are covered by thick brush and second growth trees, most of the original timber having been burned in the great forest fire of 1910. A few patches of virgin timber still remain, this being mostly of cedar and found in the valleys. There is ample timber for mining purposes. In recent years fine scenery and climate have attracted numbers of vacationists.

The area mapped and discussed in this report (Plates 1 & 2) is bounded on the east and south by the height of land separating the drainage of the North Fork of the Coeur d'Alene River from that of Pend Oreille Lake. On the west the area is bounded by the Cocolalla Valley in which the Northern Pacific Railroad runs. On the north lies the eastern arm of Pend Oreille Lake. The east shore of the lake in the area here mapped is accessible only by water, there being a regular steamboat service the year round, as, due to its great depth, the lake does not freeze in winter. The Northern Pacific Railroad touches the lake, outside the area mapped, at Sandpoint, the principal town of the region, and Hope. The Spokane International Railroad has a terminus at Bayview. The principal settlements in the area covered by this report are Lakeview, Bayview, and Cedar Creek.

One of the principal group of mines of the district is in its southeastern part and is reached by road from Lakeview. Another, the Talache district, is in the northwestern part and is connected by road with Sagle on the Northern Pacific Railroad. The Falls Creek district is connected by road with the steamboat landing at Granite Creek.

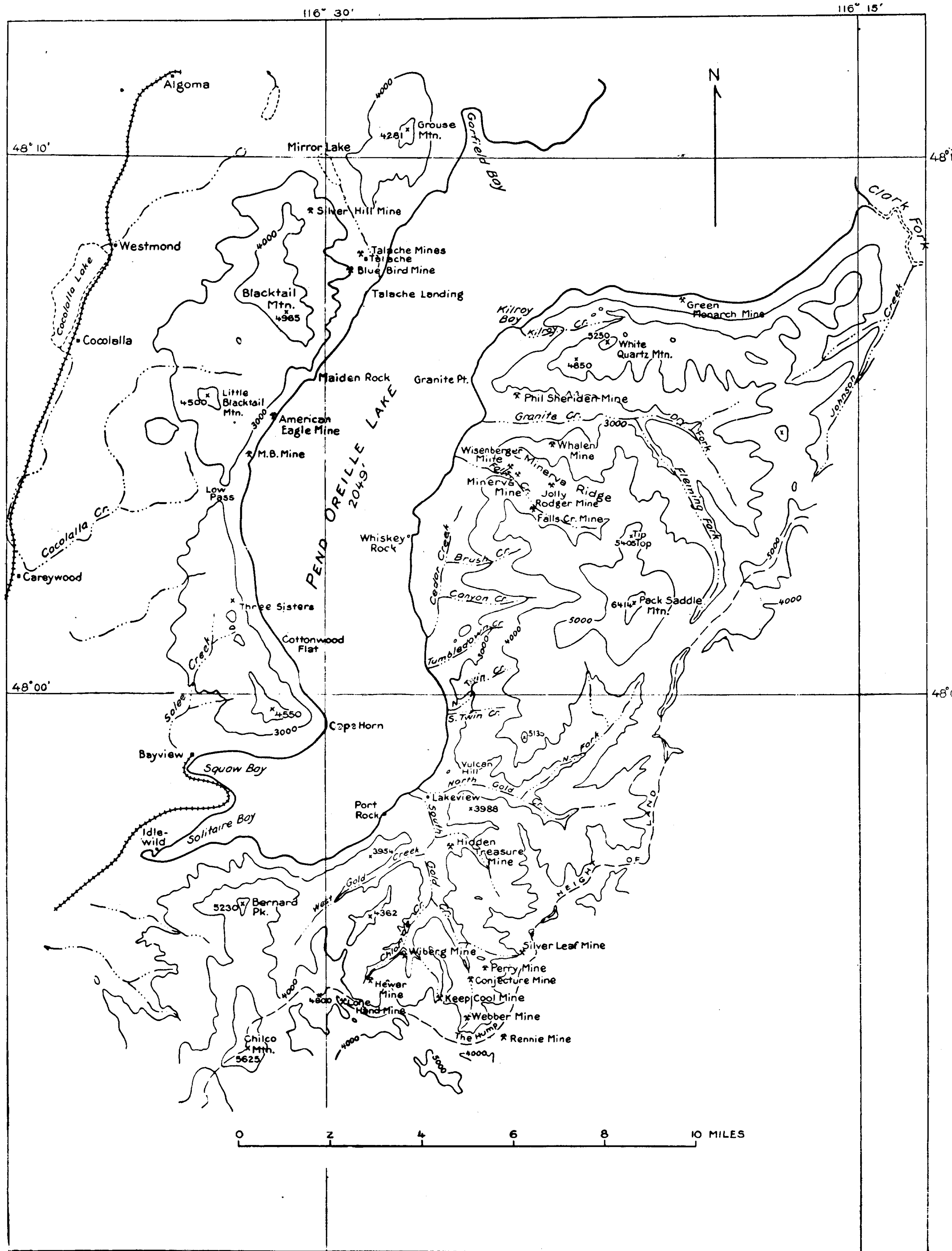
S C O P E   O F   P R E S E N T   R E P O R T

The writer was assigned to this work and spent about six months in the area in the summers of 1921, 1922, and 1924. In 1921 and 1922 the writer was assisted by J. L. Gillson. At this time most of the areal mapping was done, part of it being done independently by Mr. Gillson. Mr. Gillson has published several papers on special phases of the geology of the district. In 1924 E. L. Perry served as assistant. The writer gratefully acknowledges his indebtedness to both of these gentlemen. Circumstances have delayed completion of a detailed report which will include thorough discussions of a number of economic as well as purely scientific problems, but the present brief report summarizes the information of most interest to those engaged in mining. The outstanding economic feature is the presence of small rich deposits that can be worked with comparatively little capital; other features are the large faults and their relation to igneous activity, the relation of ores to dikes and its bearing on the source of ore forming solutions, and the presence of fossiliferous Cambrian strata which have not herstofore been identified in central and northern Idaho.



Sketch Map showing location of the Pend Oreille Mining District and its relation to other mining districts.

1. Pend Oreille District. 2. Coeur d'Alene District. 3. Philipsburg District.



Topographic Map of Pend Oreille Mining District. Z - B

HISTORY

The first discovery of ore in the Pend Oreille district was made about September 20, 1888, by Wm. A.D. Bell, Alfred Chamberlin and Peter Steinmetz. These prospectors were grub-staked by Frederic A. Weber and S.P. Donnely, all of them then living in Eagle City. The first claims, East and West Chloride, were staked on September 27, 1888, in the names of Weber and Donnely and included the large quartz cropping of what is now the Weber Mine. Fifty pounds of ore was sent to Weber at Eagle City. Mr. Weber reports that this assayed 180 ounces silver and $1.80 gold a ton. Weber then went to Pend Oreille and shortly after returned to Eagle City to close up his affairs there. At this time news of the discovery got out and there was a general exodus from Wallace, Burke, Murray, and Eagle City, the last three towns being nearly emptied. By winter 2,000 people were living in the town of Chloride but after several months of riotous living most of them left the district. The Smith ranch now marks the site of the former town, nearly every vestige of which is gone.

Immediately following the Chloride stampede a small group of keen prospectors stayed on and prospected the district with great thoroughness, so much so that it is improbable that any promising mineralized ground will be found that did not receive attention at that time. However, only high grade direct smelting ores could be treated then. In addition to the discoveries in the Lakeview area the Talache (then Blacktail) and Falls Creek-Granite Creek areas were shown to be of promise.

During the period from 1889 to 1917 a number of mines were extensively developed and many small shipments of high grade ore were made perhaps amounting to about $500,000 in all. During this time an attempt had been made to treat the ore of the Weber Mine by amalgamation, but without success as the amount of oxidized ore adapted to this process was small. Also a small smelter was built at Sandpoint, but in spite of high expectations, its operation was a failure.

The new era was opened in 1917 by developments at Talache, then called Blacktail, on the west side of the lake. Since the days of the first rush into the Pend Oreille district the Little Joe vein had been worked and two adits at the 400-foot and 700-foot levels had been driven and connected by a raise. Major Harry M. Armstead conceived the idea of extending a cross-cut tunnel which had been driven 1,140 feet to the Keystone vein until the Little Joe vein was struck at the 1,200-foot level. The vein was small, averaging less than two feet wide but Major Armstead's belief as to continuation in depth was confirmed by the results. This cross-cut haulage tunnel 4,000 feet long, was connected with the upper levels in 1919 by a 60° raise in the foot wall. Active development was then carried on and in 1921 work started on a 150-ton mill to concentrate the ore by flotation followed by tabling. Construction was rushed so as to secure the maximum advantage of the provisions of the Pittman Act and on March 1, 1922, seven months after breaking ground the mill started operation.[1] This mill proved highly efficient and fully justified the belief that the complex ore of Talache, which is typical of the district was amenable to treatment. On October 31, 1926, operations were suspended at Talache. At that time the vein had been followed to the 1,400 foot level and, according to figures published in the report of the Idaho State Inspector of Mines, about $2,000,000 of metals had been mined. Nearly 80 per cent of the value was in silver and the remainder nearly equally divided between copper, gold, and lead. At Talache zinc was not concentrated but the Little Joe vein carried less sphalerite than any of the larger veins in the district.

In the Lakeview area there were four mines which had been shown by early development to hold promise; the Weber, Conjecture, Keep Cool, and Venezuela (Hewer) groups. In 1919 the Conjecture group had been systematically explored by the Lakeview Silver Mines Company, and under the direction of Mr. T.C. Cunningham a very considerable body of ore had been shown to exist between the Graham adit level and the 200-foot level 220 feet below. In 1919 the head frame and surface plant burned. In 1923 the mine was reopened, unwatered, and further work done.

In 1924 the Venezuela group of claims was taken over by the Hewer Mining Company and became known as the Hewer mine. Underground development was actively pushed and a 100-ton all-flotation mill was built and operated for a short time.

In 1926 the company was reorganized as the Idaho Hewer Mines, Inc., and a winze was sunk to 500 feet below the extraction tunnel and according to Campbell[2] drifting at this level exposed two new ore bodies.

1. An article on "Silver mining and milling at Talache, Idaho", published in the Engineering and Mining Journal-Press, Vol. 114, pp.581-585, 1922, gives an excellent description of the mine and mill.

2. Campbell, Stewart. Twenty-eighth Ann. Rept. of the Mining Industry of Idaho for the year 1926.

GENERAL GEOLOGY

GEOLOGIC SETTING OF THE DISTRICT

The geology of the Pend Oreille district (Plate 1) resembles in many respects that of the Coeur d'Alene district 30 miles to the southeast. The principal difference between the two is the much greater abundance ot igneous rocks in the Pend Oreille district and the development of a peculiar type of mosaic faulting dependent on those igneous intrusions. The minerals of the Pend Oreille district are the same as those of the Coeur d'Alene district, although the silver-bearing minerals are relatively more abundant. The ore bodies of the Pend Oreille district, however, are mainly fillings of fissures and shear zones rather than replacement veins which characterize the Coeur d'Alene district.

The portion of the Pend Oreille district with which this report deals consists mostly of a vast thickness of quartzites and argillites of the Belt series which are of late pre-Cambrian (Algonkian) age. In addition to these there is a peculiar pebbly quartzite, some shale, and a thick limestone of Cambrian age. The occurrence of this limestone is one of the distinctive features of the district for through a large region in this part of Idaho, and in the surrounding territory limestone is scarce. The age of these Cambrian strata, the only known Paleozoic beds in Northern Idaho, is for the first time, definitely established on the basis of fossil evidence.

Several stocks of granodiorite cut the sedimentary rocks and to the west of the region mapped there lies a large batholith of granodiorite which extends northward nearly to the international boundary.

To the northeast of Pend Oreille Lake and outside the area mapped there is a rather marked change in the geology. Rocks of the gabbro or diorite families are common and, possibly for this reason, the character of most of the ore deposits is quite different, one of the most noticeable features being the greater abundance of gold as compared to silver.

Faults of unusual magnitude are common. They all dip nearly vertically, Several of the largest trend in a northerly direction and in this respect form a strong contrast to the Coeur d'Alene district where great east-west faults, the largest of which is the Osborn fault, control the structure. A similar fault, the Hope fault, lies just north of the area covered by this report. This fault runs northwest along the lower slopes of the mountains on the north side of the valley of the Clark Fork east of Pend Oreille Lake.

SEDIMENTARY ROCKS

The sedimentary rocks fall into two groups, the Belt series, of Algonkian age, and formations of Cambrian age. The two groups are readily distinguished. The Belt series comprises quartzites and argillites with sandy material predominating, although the sand is always extremely fine grained. The rocks of Cambrian age are divisible into a quartzite, a shale, and a limestone. The quartzite is much coarser grained than anything in the Belt series and pebble beds are common. The shale is rarely seen in the field and need not be described here. The limestone is rather pure and entirely unlike anything known in the Belt series in the State and in nearby regions.

Belt Series

Full descriptions of the formations are not called for here but the distribution and characteristic features of each are presented for the benefit of those interested in the development of the district. They are described in ascending order.

Prichard formation - The Prichard formation in this district attains a thickness of 7000 feet or more and is largely composed of argillaceous sandstone with some shale. In places it shows sun cracks and ripple marks, and many of its beds are laminated in various shades of bluish gray. The Prichard and overlying Burke formation are similar in many respects, but the Prichard may be distinguished by being darker colored and by its weathering to a rusty color, particularly along fractures. It is the least exposed of all the formations of the area mapped, except the thin band of Rennie shale, of Middle Cambrian age. It is best seen along the lake shore from the granodiorite contact at Kilroy for about one mile northeast to Windy Point. It forms the upper part of the south side of Grouse Mountain. The bottom of the Prichard is not exposed.

Burke formation. - The Burke formation in this district is composed of fine grained massive sandstone and of argillite with thin beds of sandstone. Cross bedding, sun cracks, and ripple marks are common. The Burke formation is most easily confused with the Prichard and with the lower part of the overlying Blacktail formation, and possibly with parts of the still younger Striped Peak formation. The fresh rock has a blue-green cast in contrast with which the Prichard is darker, the Blacktail is generally faintly pinkish, though in part only faintly so, and the Striped Peak is distinctly olive. The weathering of the Burke is one of its most characteristic features. The maturely weathered surface is a light clear gray which is in rather strong contrast with the fresh rock. In no other formation in the area is a similar contrast of colors commonly found.

The best exposures of the Burke formation are somewhat inaccessible. The formation is well exposed on the ridge extending from Blacktail Mountain to the north end of Cocolalla Lake. It is also well exposed on the ridge which is followed in going from Kilroy Bay to Kilroy Lakes.

The thickness of the Burke formation is not certainly established. It is greater than 2,000 feet but may be more than twice this amount.

Blacktail formation. - The term Blacktail formation is here defined as including all the rocks between the Burke formation below and the Wallace formation above. As thus defined it represents the undifferentiated equivalents of the Revett and St. Regis formations of the Coeur d'Alene district. The name first appeared in print in the American Mineralogist, vol. 10, p.189, 1925, in a short report by J.L. Gillson, who is joint author, with the present writer, of an unpublished report on the Pend Oreille district. Gillson also used the name in Journal of Geology, vol. 35, No.1, pp.1-32, 1927. The formation was not defined, however, in either of Gillson's reports, further than that it represents the Revett and St. Regis formations of the Coeur d'Alene district. The lower part of the formation is prevailingly quartzite and the upper consists mostly of argillite. The whole formation is distinguished from all others in the district by a pinkish or reddish purple color. The lower 5,000 feet of the formation, which consist mostly of quartzite, may have only a faint pink cast, but even in these beds thin partings of red shale are common. The lowest beds closely resemble the Burke but the faintly pink color serves to distinguish them.

The upper Blacktail beds are alternating red and green argillites with red predominating. The red argillite is present throughout the Blacktail but in the lower part of the formation it occurs only as partings. These argillite beds make up a larger and larger portion of the whole as higher parts of the formation are reached and in the upper 3300 feet argillite greatly predominates. Single outcrops may consist entirely of green argillite but most large exposures show the red beds which characterize the formation. The uppermost beds, near the transitional boundary with the Wallace formation, are green but those mapped with the Blacktail have a peculiar waxy appearance.

The Blacktail formation is best seen at the type locality, Blacktail Mountain, near Talache. The Southwest shoulder shows the lower beds and the northerly spurs show the upper argillitic portion. The lower beds are also well exposed on the slopes near the Minerva Mine on the north side of the Fall Creek valley.

Wallace formation. - The Wallce formation, which overlies the Blacktail, is the one formation in which those familiar with the rocks of the Coeur d'Alene district will find a close resemblance. Like most of the Belt formations in the Pend Oreille district, it has a greater aggregate thickness (6000 feet) than the corresponding rocks in the Coeur d'Alene district. The outstanding feature of this formation is the presence of calcium carbonate distributed through the rock in such a manner that the weathered surfaces show peculiar and easily recognized structures. The formation is the most heterogeneous of all those within the area, for it contains pure quartzite, sandy argillite pure argillite, calcareous argillite which effervesces with acid, and patches of pure lime carbonate rock. These patches of limestone are embedded in either argillite or quartzite but they are peculiar in that the commonest form is in irregularly wrinkled sheets trending across the bedding. A piece of rock broken across the beds shows a wavy line and if the specimen is weathered a depression follows the line; indeed, if the weathering has gone far, the rock is cellular. These limey patches are thought to represent deposits made by calcareous algae. They will be more thoroughly discussed in the complete report to be published by the U. S. Geological Survey, but for the present the author wishes to point out that the cellular weathering is a distinguishing feature of the formation. Scarcely a large outcrop can be found which will not show this feature and even where mapping depends upon the "float" or surface debris a few minutes search of any hillside underlain by Wallace will almost invariably show the typical cellular rock. Another characteristic is the presence in part of the formation of gray argillite which weathers rather deeply to a faun color.

The Wallace formation is widely distributed. It is the country rock at the Weber, Conjecture, Keep Cool and Blue Bird mines, and is well exposed on the south side of the valley at Talache although the Little Joe vein is in the upper part of the Blacktail formation.

Striped Peak formation: This formation which overlies the Wallace is easily recognized; it is made up prevailingly of two kinds of rock, each of which is distinctive. The most common is a sandstone or quartzite having more or less of an olive color which is accentuated by weathering. An even more marked rock which may serve in recognizing the formation is a laminated argillite. This rock contains very thin alternating dark gray and yellowish bands. There are many of these bands to an inch. In no other formation is such a rock ordinarily present. Ripple marks and sun cracks are common in the formation. The Striped Peak is the highest formation of the Belt series seen in the district and as the contact with the overlying Cambrian is thought to be unconformable the thickness exposed, which is 9,000 feet, would not represent the full thickness of the formation.

The Striped Peak formation is widely distributed to the southeast of the lake. It may be seen above the town of Lakeview on the bare southern slopes of the hill which overlooks the town from the east end of the main street. At the Hewer mine along the tramway between the mine portal and the mill typical Striped Peak rock is exposed, and the whole west side of the valley west of the Hewer mine and the Smith ranch has excellent exposures of this formation.

Difficulty of correlation: In summary it should be stated that it is not everywhere easy to distinguish the formations until some experience with them has been gained. There have been instances in surrounding regions where competent geologists have been confused by their similarity. Even a familiarity with the rocks of the nearby Coeur d'Alene district is not a thoroughly reliable basis for distinguishing them.

It is only by the careful examination of all the Belt rocks present in any district that those minor features which are truly characteristic come to be appreciated. The problem is particularly difficult in the Pend Oreille district for there is even less difference between the various formations than is usual. The outstanding feature of all the formations is their marked resemblance to each other, and the author would urge from his own experience that before an attempt is made to determine the formation present at any particular place, some of the characteristic localities mentioned above should be visited and critically compared.

Cambrian

Overlying the Belt rocks are strata entirely unlike those below them. These have been divided as a result of the present investigation into three formations; the Gold Creek quartzite, Rennie shale, and Lakeview limestone.

The lowest of these formations, the Gold Creek quartzite, is thought to be separated from the Striped Peak by a great break in the sedimentary record. The evidence from nearby districts seems to the author conclusive that such a break does exist, but in the Pend Oreille region the critical contact was not found sufficiently well exposed to furnish any useful information on the subject.

Gold Creek quartzite: The Gold Creek quartzite, named for its exposures on North and South Gold Creeks near Lakeview, is distinguished from any rock in the Belt series by its coarseness of grain. The rock is rather coarse grained throughout with many pebble beds, some of which contain pebbles as large as three inches in diameter. Its color is generally nearly pure white. Cross bedding is a very characteristic feature. The formation is probably about 400 feet thick though in the few sections where both the top and bottom of the quartzite are present there has been so much faulting that the exact thickness cannot be determined. It is probably more than 200 feet and less than 600 feet, and 400 feet is a fair approximation.

The Gold Creek quartzite is very resistant to weathering and generally forms ridges and cliffs. Conspicuous outcrops are present on the summit of the ridge above the cement rock plant at Port Rock, the summit of the commanding hill just east of Lakeview, and the 5,135 foot peak about 2½ miles northeast of Lakeview. From this peak a ridge of the quartzite runs northward for six miles across the west flank of Packsaddle Mountain.

Rennie shale: The Rennie shale is named for Rennie Ridge, one of the spurs on the south side of Packsaddle Mountain. It is a thin bed of "paper" shale, probably about 50 to 75 feet thick, separating the Gold Creek quartzite from the Lakeview limestone. It is so extremely soft and, therefore, so easily eroded and covered with debris that there are few places where its presence would be suspected. Rarely a little float is found, but only at one place was the rock found to outcrop. This outcrop is in the stream which flows along the west side of Rennie Ridge. This stream is the main tributary of North Gold Creek in the valley to the west of the south spur of Packsaddle Mountain. At this place the rock is a very thin-bedded yellowish shale. It is particularly interesting because it contains abundant fossils of Middle Cambrian age.

Lakeview limestone: The Lakeview limestone, named after the town near the southeast end of Pend Oreille Lake, where it is well exposed, is of special commercial interest in that it constitutes the only source of limestone for a large district, and is utilized in the manufacture of lime and Portland cement. It is of scientific interest because of its many fossils of which 4 genera and 28 species, mostly trilobites, are new to science, though recognized to be of Middle Cambrian age. The Cambrian fossils have been identified by Mr. Charles E. Resser of the U.S. National Museum.

The appearance of the rock constituting this formation varies greatly from place to place. This is due first to original differences in different beds and second to varying degrees of metamorphism. All gradations can be found from a pure, little altered limestone to a coarse marble like that at the Bayview quarries.

Where the formation is unaltered two main varieties of rock are found; heavy bedded extremely massive limestone, and thin bedded shaly limestone. It is the shaly limestone which has yielded the fossils. The chemical composition of the heavy-bedded variety varies between nearly pure calcite and nearly pure dolomite. It is calcite rock which is used for the manufacture of lime and cement. The heavy beds of massive limestone generally form cliffs notably along the sharply defined ridges in the wide valley west of the south spur of Packsaddle Mountain of which Ronnie Ridge, two miles long, is the most striking. The shaly beds, in addition to the above-mentioned variability of the carbonate, vary in the amount of argillaceous material. Such beds are found along the lower course of South Gold Creek where it flows over the Lakeview formation.

Moderately altered Lakeview limestone is well exposed along the lake shore on either side of the mouths of North Gold and South Gold Creeks. Metamorphism has produced two distinctive varieties; one a very hard and tough ribbon limestone in which irregular bands rich in microscopic secondary silicate mineral and corresponding to a greater argillaceous content in the original limestone weather in relief; the other peculiar rock has a gnarled structure, due also to original differences in composition.

Where the purer limestone and dolomite beds have been thoroughly altered a crystalline marble has resulted. This rock is quarried for burning into lime at Bayview, where two grades are recognized; "high-lime" or calcite and "low-lime" or dolomite. The quarry men distinguish between the two by differences in luster, as the "low-lime" rock has a pearly luster which is characteristic of dolomite and is noticeably different from the brighter luster of the calcite.

IGNEOUS ROCKS

Manner of Occurrence

Igneous rocks are present in the form of dikes, stocks, and a batholith. The stocks lie mostly on the east side of the lake where they cover from 6 to 16 square miles each. The west side of the area mapped lies on the east flank of a great batholith extending northward for 70 miles and covering an area of well over 1000 square miles. The dikes are rarely seen at the surface due to their lack of resistance to erosion but are commonly seen in mine workings, in some of which they greatly complicate the geology.

Granodiorites

The prevailing rock of the stocks and the batholith is granodiorite. At the extreme southwest side of the region mapped is an area of coarsely porphyritic quartz monzonite but elsewhere the rock locally called "granite" is granodiorite whose composition is remarkably close to the accepted typical rock. These granodiorites have been fully described by J. L. Gillson in an article entitled "Granodiorites of the Pend Oreille district of northern Idaho."[1] Their main local interest is the effect they have on the structure and their bearing on ore deposition. There are those who believe that the ores of the Coeur d'Alene district have been formed by processes wholly unrelated to the intrusion of igneous stocks, which are sparingly present in that district. The study of the Pend Oreille district, however, has shown a clear connection between igneous processes and ore deposition and lends support to the interpretation that a similar connection exists in the Coeur d'Alene district.

Gillson's paper on the granodiorites is of much interest in showing that the after-effects of igneous intrusion modify greatly the rock itself and this study, which was a by-product of work in the Pend Oreille district, serves further to bridge the gap between igneous intrusion and ore deposition.

The granodiorites form many of the landmarks of the district. Packsaddle Mountain, reaching 4,000 feet above the lake to the commanding elevation of 6,414 feet, is granodiorite. Great blocks of this rock loosened by the frost make up the chaotic pile of its summit. On the east shore of the lake many cliffs of granodiorite rise sharply out of the water. Granite Peak and most of the shore from Falls Creek to Twin Creeks is granodiorite. The lower slopes of the great cliffs of Bernard Peak and the massive shoulder of Cape Horn are also of this rock. The largest areas of the rock are the outlying portions of the batholith seen from Bayview northward to Cocolalla.

Dike Rocks

Dike rocks are encountered in nearly every mine in the district. They are all of the group known as lamprophyres, which, when unaltered, contain distinguishable crystals of dark minerals set in an extremely fine grained matrix. These rocks are seldom seen except in mines. Although they weather so deeply as readily to escape notice at the surface, the principal reason for their conspicuous presence in mine workings is their far greater abundance in association with ore than elsewhere. This association is thought to have a bearing on the origin of the ore and is further discussed in the section on the origin of the ore deposits.

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1 Gillson, J. L., Jour. Geol., Vol. 35, pp. 1-31, 1927

Dikes of lamprophyre are also common in the Coeur d'Alene district.[1] In both districts several varieties of lamprophyres are found but in each district those having phenocrysts of biotite predominate. In the Pend Oreille district the feldspar of the groundmass is prevailingly plagioclase and the rock is, therefore, strictly classified as kersantite whereas in the Coeur d'Alene district the feldspar in nearly every dike is orthoclase and the rock is minette.

PLEISTOCENE GEOLOGY

During the Pleistocene epoch southerly protrusions of the great glacial fields which covered the northern part of North America extended into the Pend Oreille district, and many of the features of the present topography are results of glacial erosion and deposition. The most striking of these is the carving of the valley now occupied by Lake Pend Oreille and its subsequent damming by morainal material. The position and size of this valley may be related to the profound faulting believed to have taken place along it, but the author believes that its present form is largely the result of glaciation. Soundings by the author indicate that the floor of the lake is nearly flat and about 1,100 feet below present water level at the deepest place found, between Granite Point and Talache. These soundings and the visible topography show that the valley has the U shape typical of those carved by glaciers.

STRUCTURE

The structure of the Pend Oreille district is determined by block faulting and by the effects of igneous intrusion (see Plate 3). Many of the faults, including those of largest displacement, were caused by the intrusion, although certain faults of great length continued to be active after the solidification of the intrusive rocks. The shattering of the rocks on such a grand scale is one of the extraordinary features of the geology of the district. It will be discussed in more detail in the final report. For convenience the two types of faults are called intrusion faults, and post-intrusion faults. The three largest post-intrusion faults of the district are given the names Packsaddle, Pend Oreille, and Cedar Creek faults. (See Plate 2).

POST-INTRUSION FAULTS

The post-intrusion faults are the longest faults of the district. Their courses lie between N. 18 W. and N. 37 E. and appear to favor these two particular directions. The only actual exposure of one of this class of faults is in the Hewer mine and their existence is largely inferred by geological mapping. In some places they have a marked topographic expression but in many places there is no topographic indication of their existence. Their age with respect to the intrusion of the granodiorite magma is determined by the complete lack of strong contact metamorphism in the sedimentary rocks brought against the granodiorite whereas at all certain intrusive contacts strong contact metamorphism is evident.

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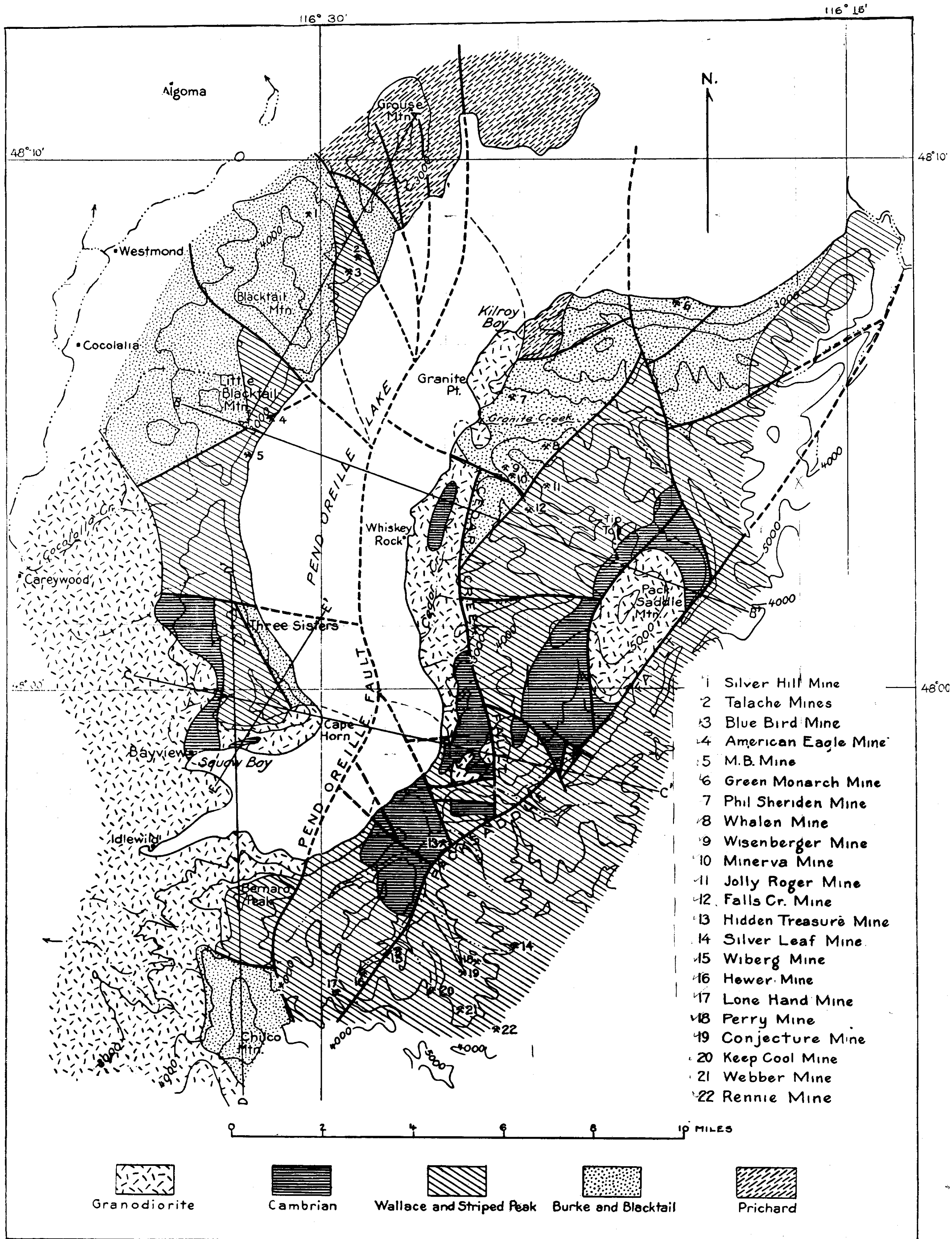
[1] Shannon, E. V., Petrography of some lamprophyre dike rocks of the Coeur d'Alene mining district, Idaho; U. S. Nat. Mus. Proc., Vol. 57, pp. 475-495, 1920.



-12 - A

Geologic Map of the Pend Oreille Mining District.

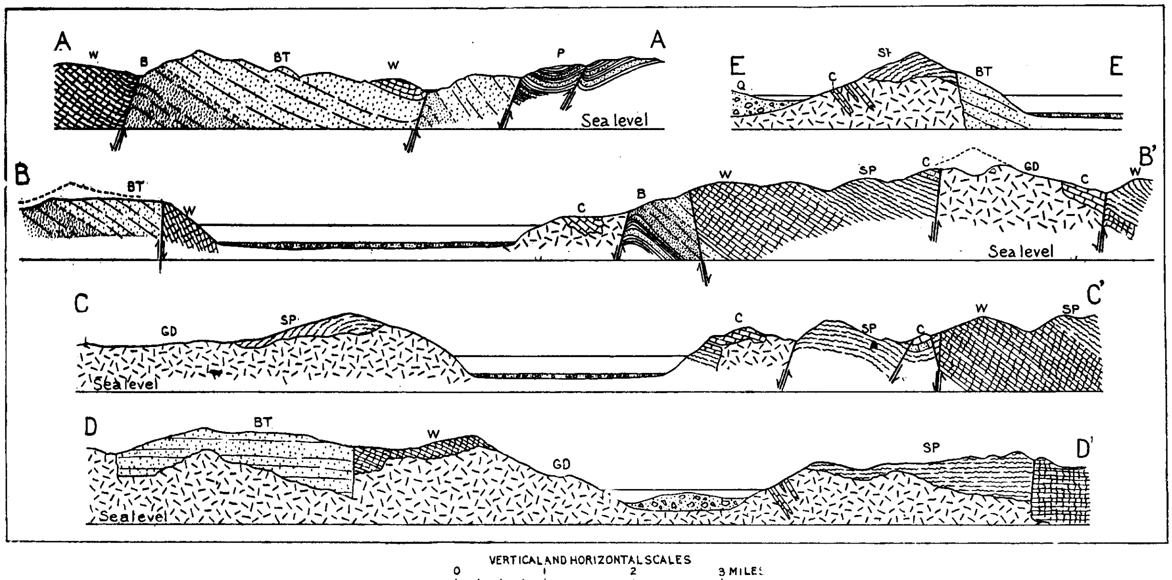


Figure 1. General Structure Sections

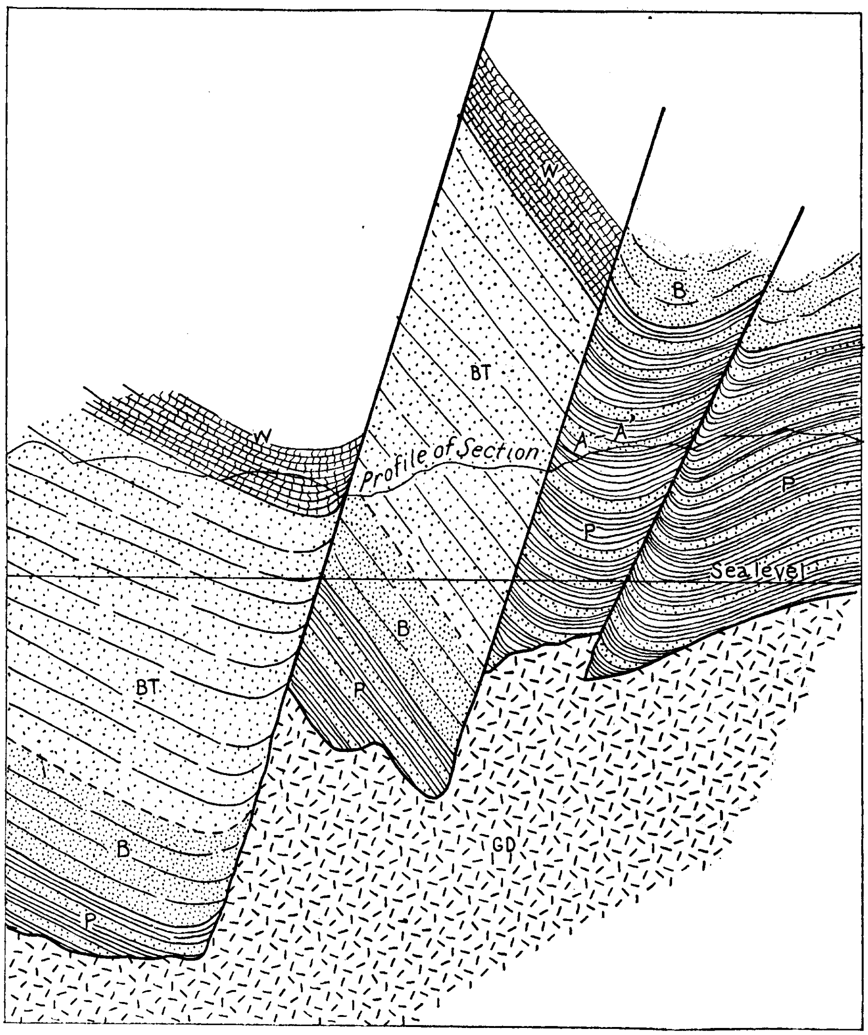


Figure 2.

Section to illustrate origin of structures along line A. A. of Plate II.

-12-B

Structure Sections of the Pend Oreille Mining District

Packsaddle Fault

The Packsaddle fault was followed for 18 miles along the eastern side of the area mapped. From the Hewer mine near the south end of the area mapped the fault is followed northeastward along Chloride Gulch across the forks of South Gold Creek, and along the upper part of North Gold Creek, and east of Packsaddle Mountain, thence northwestward down Fleming Fork of Granite Creek, and onward to Pend Oreille Lake west of the Green Monarch mine. It appears probable that the fault may split near Packsaddle Mountain, at the extreme east edge of the area mapped in detail; that one branch of it continues down the remarkably straight course of Johnson Creek to the Clark Fork valley, where Calkins has mapped[1] a fault which may be its continuation. Should this be the case the Johnson Creek branch would become the main Packsaddle fault.

The structure on opposite sides of the Packsaddle fault is very different. To the east lies a large area consisting of the Wallace and Striped Peak formations with simple structure, but to the west lies an area of complicated structure containing numerous areas of Cambrian rocks and several stocks of granodiorite. It is a fault of the first order of magnitude and it is expected that when the country to the south of Pend Oreille district is mapped that this fault will be found to continue southward for many miles.

Pend Oreille Fault

The Pend Oreille fault, is largely inferred because the geology on opposite sides of the southern arm of Pend Oreille Lake, the part shown in Plate 2, is so markedly dissimilar that the presence of a fault under the lake is almost certain. Furthermore the areal mapping shows a fault of generally southward trend extending to the east of Bernard Peak and Chilco Mountain. This has been traced from the lake shore for 3 miles to the south edge of the area mapped and is evidently the southerly continuation of the fault that is believed to be under the lake.

Cedar Creek Fault

The Cedar Creek fault branches from the Packsaddle fault east of Vulcan Hill, near Lakeview, and extends northward generally parallel to the east shore of the lake as far as Falls Creek where it is apparently cut off by an east-west fault. Its southern part separates a large area of limestone on the west from the Striped Peak formation to the east. Along this part of its course the fault is marked by a very steep sided gulch running at right angles to the general drainage. At Canyon Creek the fault divides, one branch trending northeastward and joining the west branch of the Packsaddle fault to the north of Granite Creek. From Canyon Creek to Fall Creek the main fault is bounded by the Burke formation on the east and by granodiorite on the west. The Whiskey Rock area of limestone, which is inclosed in this granodiorite, is 20,000 feet higher stratigraphically than the rocks to the east of the fault.

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1. Calkins, F.C., A geological reconnaissance in northern Idaho and western Montana: U.S. Geol. Surv. Bull. 384, Pl.1, 1909

The area cut by the Cedar Creek fault, and bounded by the Pend Oreille and Packsaddle faults, is thus anomalously characterized by containing granodiorite intruded from the depths and Cambrian sedimentary rocks down-faulted for great distances as compared to the Belt formations on the east. The down-faulting of the Cambrian rocks is thought to indicate a foundering into the granodiorite magma, part of whose upward journey was brought about by stoping.

INTRUSION FAULTS

The term intrusion fault is proposed for a fault, generally with nearly vertical dip, which is brought about by the intrusion of a magma. In the Pend Oreille district nine of the larger faults, with apparent displacements of from 4,000 to 10,000 feet, are thought to belong to this class. These faults extend in more varied directions than the post-intrusion faults. The courses of individual faults are very straight and their general pattern is of the block type. It is possible that the post-intrusion faults originated as intrusion faults but if they be of the block type the blocks are on a much grander scale.

A number of the intrusion faults are cut off by the intrusive contacts of the granodiorite. The reason for assigning the igneous magma a causative action in the formation of these faults, and not regarding the faults as being merely older and having no connection with igneous intrusion is that these faults are found only about stocks of igneous rock. This relationship applies to other districts also; for example, the Ray district, Arizona,[1] furnishes a very clear case of such structure.

Faults on Cape Horn west of Three Sisters and Low Pass indicate clearly that they were formed before the granodiorite solidified as they end abruptly at the intrusive contact. The group of faults near Talache probably belong to this period, although no contacts between them and granodiorite are exposed. To the southwest of the fault in Talache Valley is the Wallace formation, whereas the rock to the northeast, although too intensely altered by hydrothermal processes to be definitely determined, closely resembles the lowest Blacktail beds. These beds in turn are faulted against typical Prichard rock which lies at least 17,000 feet stratigraphically below the Wallace. This estimate is made on the basis of a rather doubtful extreme minimum figure of 1,600 feet as the thickness of the Burke. It is to be noted that the rocks to the northeast of the Talache fault are noticeably affected by contact metamorphism[2] showing tourmaline in thin section, whereas the rocks to the south of the fault are remarkably unaltered, although the Wallace formation there exposed is more susceptible to metamorphism than any other formation in the district. An explanation of this relation is suggested in Fig. 2. The intrusion of the magma carried up the blocks to the north and the block to the

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1 Ransome, F. L., Ray Folio, Geol. Atlas of the U. S., Folio 217, 1923.

2 The study of the thin sections which shows this was made by Mr. Gillson.

south may be considered to have foundered. The granodiorite probably lies closer to the present surface to the north. It is of interest to note that all the mines of the Talache area lie in the southern block where conditions were least intense. But also they all lie quite close to the fault line indicating that this may have exerted a controlling influence over upward course of ore-depositing solutions.

STRUCTURAL EFFECTS OF IGNEOUS INTRUSION

In few regions is the mechanism of igneous intrusion more clearly displayed than in the Pend Oreille district. The reason for this is that erosion has progressed just to the point where the upper portions of the igneous rock are laid bare and at several places remnants of the original roof are preserved. The most striking instance of this is Bernard Peak. (See Plate III section C-C). Along the shore under the peak massive granite forms the cliffs but the abundant and conspicuous light colored blocks that have fallen from above are not granite but hornfels. This hornfels has resulted from the intense baking of the Wallace formation which forms the whole summit of the mountain. Chilco Mountain has a similar structure except that the sedimentary cap consists of the lower part of the Bucktail formation. On both Bernard Peak and Chilco Mountain the beds of the sedimentary cap are nearly horizontal. Only on the west flank of Chilco Mountain and the west and north flanks of Bernard Peak is the top of the granodiorite exposed. The structural relations at Cape Horn are similar to those at Bernard Peak. (Section C-C, Plate III).

Blocks of sedimentary rock which have foundered into the granite are found at two places. The most remarkable locality is the southward face of Cape Horn two miles east of Bayview. (Section E-E, Plate III. Three slivers of Lakeview limestone are necessarily shown as one because of the small scale.). Several large blocks of Lakeview limestone are here engulfed in the granodiorite and high above at the top of the mountain is the roof of the stock consisting of the Striped Peak formation which normally lies below the limestone. The beds in the engulfed blocks dip northward, or downward towards the contact.

In the vicinity of Whiskey Rock is an area of limestone, about half a square mile in extent, which is engulfed in granodiorite. (Section B-B Plate III). One mile to the east is the Cedar Creek fault and to the east of that is Burke formation which is 20,000 feet stratigraphically lower. This block of limestone is thought to have reached this depth largely through foundering into the granodiorite magma, though a boundary fault formed after the intrusion of the granodiorite has clearly increased the total displacement.

SUMMARY OF STRUCTURE

The larger features of the structural geology have been mentioned in the chapter on the general geology. The principal conclusions concerning structure are as follows: Igneous intrusion greatly shattered the sedimentary rocks and caused a mosaic of fault blocks. Although this mosaic may be in large part caused by collapse, intrusion must have exerted much force, for only in areas of igneous intrusion is there evidence of such shattering. Consolidation of the magma followed this period of faulting. Next came the post-intrusion long faults. They accentuated the relative depression of the Cambrian limestone engulfed in granodiorite relative to the Belt sediments. Considering the district with respect to surrounding territory on the north, east, and south it is striking that the Cambrian rocks are found only where they are more or less engulfed in igneous rock. Ore deposition took plaee after faulting and the intrusion of lamprophyre dikes followed ore deposition. These last features will be discussed in the following pages.

ORE DEPOSITS

The principal ore deposits are simple fissure veins and mineralized shear zones.

Silver is the chief valuable element of the Pend Oreille district. Lead occupies a decidedly secondary place, being relatively far less important than in the Coeur d'Alene district. Zinc is in most mines present in sufficient quantity only to make trouble, but in several mines it may be recoverable in paying quantity by differential flotation. This process would yield lead and zinc concentrates, each with high silver content, and would eliminate the necessity of the extremely fine grinding necessary to free the silver minerals included in the sphalerite. Gold is present as a minor constituent and copper both in chalcopyrite and tetrahedrite adds to the value of the ore.

MINERALOGY OF THE ORES

The silver ores of the Pend Oreille district show little variation in the kinds of minerals present but considerable variation in the proportions of the minerals. This variation may have an important bearing on the selection of processes of ore dressing. In every variety of ore silver is present principally in tetrahedrite. Galena contains some silver in solid solution and the silver minerals polybasite and proustite are sparingly present. Pyrite, sphalerite, galena, and arsenopyrite are the commonest metallic minerals. Stibnite occurs locally in shoots. A mineral not positively determined, but probably boulangerite, is rather widely distributed. This mineral may contain some silver, but probably not enough to greatly affect the value of the ore. The gangue minerals are quartz and siderite.

The deposition of ore took place in three clearly separate stages. At most mines sufficient structural disturbance occurred between the stages of deposition to make the mineral assemblages of each stage clearly distinguishable. In the first stage siderite (and rhodochrosite), pyrite, and arsenopyrite are the leading minerals; in the second, quartz, sphalerite, galena, and tetrahedrite, accompanied by subordinate pyrite, chalcopyrite, stibnite, boulangerite (?), and hubnerite, and closely followed in one mine by native arsenic; in the third stage, chalcolyrite, polybasite or proustite. The first two stages are usually found in all mines and are readily recognized by the respective gangue minerals, siderite and quartz; the third is of variable importance.

The complete list of minerals follows arranged in three groups according to the order of formation of the group and within the group according to abundance of the mineral.

Stage 1, Siderite gangue	Stage 2, Quartz gangue	Stage 3, Minerals on joints
Siderite (in one mine rhodochrosite)	Quartz	Chalcopyrite
Pyrite	Sphalerite	Polybasite
Arsenopyrite	Galena	Proustite
	Tetrahedrite	
	Pyrite	
	Chalcopyrite	
	Boulangerite (?)	
	Stibnite	
	Hubnerite	

Stage 1.

Siderite and Rhodochrosite: - The carbonate gangue of the Pend Oreille district is, as is generally the case, a mixed carbonate. Its principal component is siderite except at the Conjecture mine where it is rhodochrosite. It is the prevailing mineral of the earliest stage and has the added importance of being a common host mineral for tetrahedrite which although deposited much later is found with quartz in veinlets which replace the carbonate along rhombohedral cleavage cracks. (Plate IV-a). This replacement is for the most part on a minute scale and becomes most clearly evident on examining a polished section of the ore with the microscope; however, careful inspection of any piece of carbonate ore will usually reveal the relation. In development work the presence of siderite or rhodochrosite is an almost unfailing indication of high grade ore. An analysis of the siderite from the Talache mine is given in Column 1 below and one of rhodochrosite from the Conjecture mine is given in Column 2.

Analyses of siderite and rhodochrosite, Pend Oreille district.

	1.	2.
Iron carbonate ($FeCO_3$)	78.7	12.86
Manganese " ($MnCO_3$)	18.9	60.26
Magnesium " ($MgCO_3$)	2.4	15.48
Calcium " ($CaCO_3$)	trace	11.06
	100.0	99.66

1. Siderite from Talache mine, J. G. Fairchild, analyst, U. S. Geological Survey.
2. Rhodochrosite from Conjecture mine, E. V. Shannon, analyst, U. S. National Museum.

The rhodochrosite has a distinct pink tinge in marked contrast to the brownish yellow of the siderite from most other mines. It had not been reported from Idaho before the present investigation found it at the

Conjecture mine and supplied E. V. Shannon with material for description and the analysis quoted above.[1]

Pyrite:- Pyrite is the most abundant metallic mineral in many mines. It is very noticeable that pyrite is the only metallic mineral to form by replacement in the country rock both in the walls and in fragments included in the vein.

Arsenopyrite: - Arsenopyrite is of unequal importance at the different mines. However, it is generally present when carbonate is found although its presence may be easily overlooked even when a considerable quantity occurs.

Stage 2.

Quartz: - Quartz is the chief of the second stage minerals and in the shear zones may indicate the presence of metallic minerals whose existence may not be apparent. It is the invariable accompaniment of ore. It may be said with little exaggeration that where there is no quartz there is no ore and in the mineralized shear zones it may also be said that quartz filling is an almost certain indication of silver.

Sphalerite: - The sphalerite of the Pend Oreille district is the variety commonly known as "black jack." Its color is due to a large amount of iron. It is widely distributed and presents an acute problem in ore dressing, particularly so because it commonly contains extremely minute veinlets of silver-bearing tetrahedrite. (Plate IV-b). Any attempt to discard sphalerite from the concentrates is almost certain to entail serious losses of silver.

Galena: - Galena is common. It carries considerable silver but as a source of silver it is greatly inferior to tetrahedrite. It does not contain microscopic specks of argentite as does much high grade argentiferous galena.

Tetrahedrite: - Tetrahedrite or "gray copper"[2] is the mineral which furnishes most of the silver of the ore. This mineral, like the siderite previously discussed, has a variable composition, expressed by the complex formula $5(Cu,Ag)_2\ S.2(Cu,Fe,Zn)\ S.2Sb_2S_3$.[3] Theoretically pure tetrahedrite has the formula $Cu_{12}Sb_4S_{13}$ or nearly $Cu_3Sb\ S_3$. The natural mineral, however, rarely approaches this composition but commonly contains in some proportion the elements noted in the extended formula and also some of the tennantite molecule in which arsenic is present instead of antimony.

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1 Shannon, E. V., The Minerals of Idaho; U. S. National Museum Bull. 131, p. 230, 1925.

2 The term "gray copper" though commonly used to denote tetrahedrite is also employed for tennantite.

3 Wherry, E. T., and Foshag, W. F., A new classification of the sulfosalt minerals; Jour. Wash. Acad. Sci., Vol. 11, p. 6, 1921.

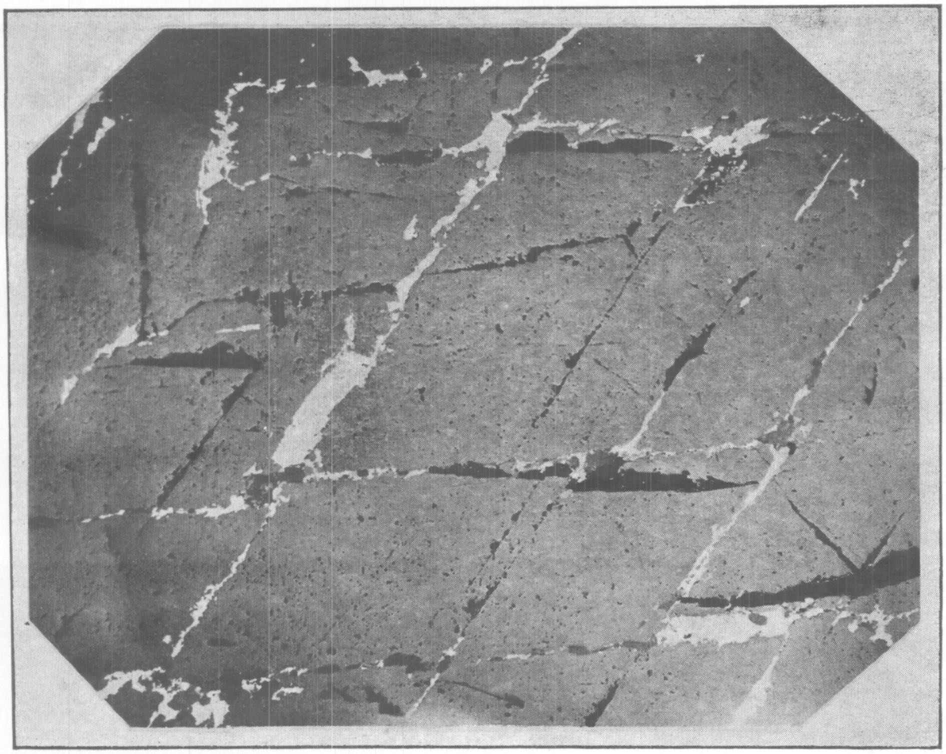

Figure 1.

Tetrahedrite (white) and quartz (dark gray) replacing siderite along cleavage lines. Black areas are pits. x 38. Sixth level, Telache mine.

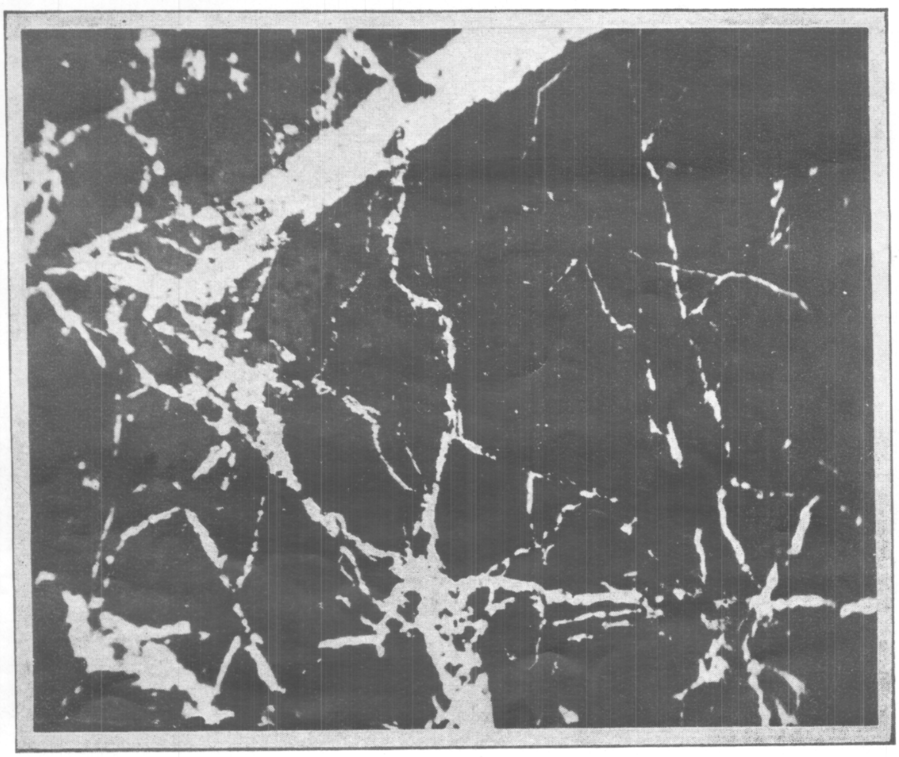

Figure 2.

Veinlets of Tetrahedrite in sphalerite. Fourth level, Weber mine x 290. At this magnification the opening in a 100-mesh screen would be 1.6 in.

-18-A

Photomicrographs of Ore Structures

The silver-rich variety, such as is found in the Pend Oreille district, is known as freibergite and has a reddish brown streak as distinguished from the black streak of pure copper tetrahedrite. This brown streak is noticeable underground where in some of the gouge ore in shear zones the presence of a high silver content might be unsuspected were it not for the brown mark made by a pick.

The following partial analysis of "tetrahedrite" from the Talache mine was made by the Idaho Bureau of Mines and Geology. The 9.8 per cent unaccounted for is reported as insoluble.

Partial analysis of tetrahedrite from
Talache Mine, Talache, Idaho.

Cu	22.9
Fe	6.1
Zn	5.2
Pb	6.7
Ag	10.7
S	22.2
Sb	13.4
As	3.0
	90.2

It is impossible to get any sample of pure tetrahedrite for analysis as intergrowths with other minerals are so intimate. Every constituent of the above analysis is subject to some error by the inclusion of other minerals, but in spite of that the analysis serves to show the approximate composition of the mineral. It should be noted that 10.7 per cent of silver is equivalent to 3,121 ounces per ton.

Tetrahedrite is in part associated with quartz thus indicating clearly their contemporaneous origin. However, most of the tetrahedrite is found replacing the earlier formed minerals, siderite, sphalerite, and galena. Sphalerite and galena belong to the same stage of mineralization as the tetrahedrite, but the deposition of tetrahedrite outlasted that of sphalerite and galena. The replacement of the early formed siderite shows a marked selective action as noted on Page 26. (See also Plate IV-a).

<u>Pyrite</u>: - Pyrite is only sparingly present with the second stage minerals.

<u>Chalcopyrite</u>: - Chalcopyrite is a mineral very widely distributed but generally present only in small amounts. It occurs as blebs in quartz veinlets, in the usual minute blebs in the sphalerite, and intimately intergrown with tetrahedrite. Chalcopyrite is most abundant in the ore from the Fall Creek area.

<u>Stibnite</u>: - Stibnite is confined to the Lakeview area where it is a common mineral. It was one of the late minerals to form during the second stage. In the Weber mine shoots very rich in stibnite were found.

<u>Boulangerite (?)</u>: - A mineral whose identity is not positively established is common, though usually in minute grains. This mineral is probably boulangerite, a sulphantimonide of lead, having the composition

$5\ PbS.2Sb_2S_3$ or $Pb_5Sb_4S_{11}$. Where recognized in the hand specimen, it looks like tetrahedrite. It is usually present mixed with galena or as minute veinlets, particularly in sphalerite. In polished sections of the ore, the mineral becomes apparent under the microscope by its anisotropism as detected by reflected polarized light. Its color in polished section is very nearly that of galena. A very small quantity (.025 g.) of the pure mineral from the ore of the Hewer mine was secured by gouging the polished surface under the microscope. Professor A.H. Phillips of Princeton University analyzed this material and reports 19.2 per cent sulphur, abundant lead and antimony, and not more than a trace of copper, iron, and silver. An arsenic determination could not be made on the material available; but in view of the general low arsenic content of the ores a sulphantimonide is much more probable than a sulpharsenide.

The mineral is about contemporaneous in origin with the tetrahedrite. Boulangerite has been reported in the ores of the Coeur d'Alene district by Shannon[1], which strengthens the belief that the same mineral is present in the Pond Oreille district. In the Coeur d'Alene district, as in the Pond Oreille district, the mineral is not rich in silver.

<u>Hubnerite.</u> - Hubnerite, the manganese tungstate, $MnWO_4$, is found sparingly. The mineral is, for the most part, embedded in quartz. Underground it strongly resembles sphalerite but when examined in a good light it is seen to have a different luster and the thin splinters have a deep clear red color.

<u>Scheelite.</u> - Scheelite calcium tungstate, $CaWo_4$, has been detected on the Rainbow claim.

<u>Native arsenic.</u> - Native arsenic was found on the dump of the No.2 level of the mine of the Argus Mining Company at Vulcan Hill. The mineral is of considerable mineralogical interest because of its rarity. It is found, as is usually the case, in the form of concentric shells. The arsenic, when examined in polished and thin sections, is seen to be intergrown with quartz and arsenopyrite in such a manner as to indicate clearly that it was formed by hypogene solutions, whereas the mineral has generally been thought to have formed from descending or supergene solutions. It is the writer's conclusion that the arsenic was deposited in a local stage of mineralization which followed the regular Stage 2 mineralization with quartz and sulphides.

Stage 3

The minerals of Stage 3 are found, for the most part, coating and filling cracks in the ore. In places they have formed in open spaces.

<u>Chalcopyrite.</u> - Chalcopyrite is the commonest mineral. It is particularly abundant as scattered crystals on the joint faces of the massive ore of the Talache mine.

<u>Polybasite.</u> - Polybasite is one of the richest of the silver minerals, having the formula $8\ Ag_2S.\ Sb_2S_3$ which corresponds to 74.4 per cent silver. It is seen more strikingly on the joint planes of the ore at the Talache mine, although it is found elsewhere is less conspicuous form.

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1 Shannon, E.V., Boulangerite, bismutoplagionite, naumanite, and a silver-bearing variety of jamesonite. U.S.Nat.Mus.Proc.,Vol.58,pp.589-94,1920.

2. Wherry, E.T., and Foshag, W.F., A new classification of the sulfosalt minerals: Jour.Wash. Acad. Sci., vol. 11, p.8, 1921.

Proustite: - Proustite, often known as light ruby silver, has the composition 3 Ag_2 S. As_2S_3. The theoretically pure mineral would contain 65.4 per cent silver. The mineral appears to be confined to the Lakeview area. It is commonly seen in the crevices of the hard ore of the Conjecture mine and is probably present in the crushed ore of Hewer mine.

DESCRIPTION OF THE MINES

The ore deposits fall into three geographic groups - the Talache, Falls Creek, and Lakeview. Although there may appear to be marked differences in the different groups of deposits, the mineralogy of all is nearly identical. Most of the more important mines and prospects are briefly described below.

Talache Area

The principal mines of the Talache area are the Talache, Bluebird, and Silver Hill.

Talache Mines, Inc: - At the Talache Mines the principal vein, the Little Joe, fills an unusually clean cut fissure. The wall rock, the upper part of the Blacktail formation, is hard and firm and the boundary between ore and wall is sharp except where stringers branch out from the main vein. The principal structural feature of the Little Joe vein is the disturbance due to minor faults which is most marked at the north end of the vein and at lower levels. This faulting was carefully worked out by the mining company and offered no serious difficulty in mining. Development showed that in the Black Jack vein there was a singular absence of well defined ore shoots, the variations in the vein being patchy and without definite system.

The occurrence of polybasite in the Little Joe vein is of much interest. This mineral was first detected as a result of increase of silver content in the tailings. It was then noted that a thin black streak appeared on the tables and this was found to assay very high in silver. This mineral was not encountered in notable quantity above the 800-foot level, it could frequently be seen as well formed crystals with chalcopyrite coating joint faces in the ore. This occurrence of polybasite at only the deepest levels of mining is a clear indication of its formation by ascending or hypogene solutions, for all effect of descending or super gene solutions had died out 700 or 800 feet above. Clearly the polybasite is not the result of supergene enrichment.

Silver Hill mine: - The Silver Hill vein is a well defined fissure vein striking due north. There has been little shearing along it, and the local geology is very simple. The vein is cut by several lamprophyre dikes.

Blue Bird mine: - The geology of the Blue Bird mine is rather complex. The country rock is Wallace formation and is much crumpled. The vein has a variable strike and the ore a marked tendency to occur in shoots.

One rich shoot was found in a rather flat pitching trough formed by a sharp roll in the vein. Early workers had passed the roll because they assumed that the vein was cut off by a small fault. Where the vein was again met by the old workings farther along the strike the ore was lean.

Falls Creek - Granite Creek Area.

The principal development in the Falls Creek - Granite Creek area is the Minerva mine. At the Falls Creek mine much exploration work has been done but little ore disclosed. The Wisenberger property has followed a strong quartz vein but no workable ore shoot has yet been encountered. In the Granite Creek valley several properties have furnished small showings but development has not been extensive.

Minerva mine: - The Minerva mine has disclosed a persistent vein on four levels. High grade ore has been stoped. This ore contains more chalcopyrite than any other silver mine in the Pend Oreille district but otherwise is not unusual.

Lakeview Area

The principal veins of the Lakeview area are of remarkable continuity. They fall into three systems, the Weber, the Conjecture-Keep Cool, and the Hewer.

Weber mine: - The Weber vein has been followed intermittently for 8,000 feet but by far the greatest showing of mineralization yet exposed is in the Weber mine. In the Weber mine the geology is unusually complex but it is sufficient here to consider briefly three principal features: a strong shear zone, the different modes of occurrence of quartz, and the presence of lamprophyre dikes. Mineralization is localized along a strong shear zone in places 80 feet wide. Much of the rock in this shear zone has been so crushed that it may readily be picked down and mine workings require heavy lagging. Irregularly distributed in the shear zone arc masses of vein quartz with which the sulfide ore is associated. The principal mass of this quartz is a great chimney traceable from the striking outcrop at the surface to the fifth level. Some of the shear zone rock has been intensely silicified so that it strongly resembles vein quartz, particularly when seen underground, but this silicified rock is barren. The dikes of lamprophyre cut the shear zone and ore in a most intricate manner. These dikes have, for the most part, been strongly altered by hydrothermal agencies so that many of them are of the consistency of gouge.

Conjecture and Keep Cool mines: - The Conjecture - Keep Cool vein system has been followed almost continuously from the Keep Cool mine for 8,000 feet through the Conjecture mine and Rainbow workings, and onward to the Perry mine. The Silver Leaf mine is directly in line with the course of the vein and is probably on the same system. If this is true, the total length of the vein is 12,000 feet.

As seen in the Conjecture and Keep Cool mines, the "vein" is strictly speaking a shear zone which, like the Weber mine, contains masses of vein quartz and associated sulphides. The Development of the Conjecture mine has shown that the vein filling is in the form of shoots raking to the west. These shoots are separated by nearly barren stretches. However, it would appear that the shoots may be reasonably persistent in depth.

Hewer mine. - The Hewer vein is one of the most striking examples of a shear-zone on record. It attains a maximum thickness of 120 feet in the Quickstep claim of the Wiberg group. Throughout the thickness of the shear zone the rock is largely of the consistency of gouge and can be picked down at nearly any spot. The shear zone has been followed from the Quickstep claim at Chloride to the Hewer mine, and the Gloria claim south of the Hewer mine is probably on the same shear zone. This makes a total length of 8,000 feet.

The ore in the shear zone is very closely associated with quartz filling. In the extremely sheared state of the lode it is difficult to distinguish crushed rock from crushed quartz filling. In a portion of the mine the quartz filling was mapped with great care and this map compared with an assay map. This showed conclusively that the ore accompanies the quartz. The quartz and consequently the ore are in the form of lenses no one of which has great continuity, but in the aggregate they form a fairly constant proportion of the vein.

The Hewer shear zone is thought to be a part of the Packsaddle fault, although the evidence in the immediate vicinity of the Hewer mine is not entirely conclusive. If this be so it is significant that although the ore is in a shear zone on which much movement has taken place, the quartz filling still is in the form of clearly defined lenses. The crushing, although sufficient to shatter the quartz, did not mix the quartz with the gouge of crushed rock. It is evident, therefore, that the ore minerals were formed after the main fault movement had taken place.

ORIGIN OF THE ORE

The relation between ore deposition and the geologic events following igneous intrusion can be worked out in the Pend Oreille District with a degree of assurance seldom possible. The sequence of events was as follows:

1. Igneous intrusion.
2. Mosaic faults connected with intrusion.
3. Post-intrusion linear faults.
4. Ore deposition.
5. Intrusion of lamprophyre dikes.
6. Hydrothermal alteration.

According to evidence in many regions the intrusion of lamprophyre dikes is a common sequel to the intrusion of granitic rocks. As the ore deposits are cut by these dikes they were then clearly forme during the period between the solidification of the upper part of the granodiorite magma and the period of intrusion of lamprophyre dikes. Furthermore, as both the ore deposits and the dikes are grouped in the same restricted areas, it is reasonable to conclude that they were derived from a common deep-seated source. The author would suggest that this source may be at such depth in the cooling magma that the composition may be decidedly more basic than that of the granodiorite exposed at the surface. The lamprophyres differ from the more common moderately basic rocks such as quartz-diorite, diorite, and some gabbro, only in their high content of alkalies and water which are important constituents of the ore-forming solutions.

Lamprophyre dikes in general are commonly altered to a considerable degree, a condition which indicates that the partial magmas represented by them were very wet and capable of producing marked changes in the principal rock-forming minerals. Hydrothermal alteration of the dikes in the Pend Oreille district, however, is far more intense than usual, for the dikes are commonly reduced to a clayey consistency. That this extreme alteration is chemical and not due merely to shearing is shown by intermediate stages in which rock textures are preserved. Chlorite is extensively developed. The association of the ore and dikes was so nearly contemporaneous that though the ore preceded the dikes, hydrothermal alteration associated with the ore-forming solutions followed dike intrusion.

A number of the above features have been noted by Shannon in his study[1] of abundant and similar dikes of the Coeur d'Alene district.

SUGGESTIONS FOR DEVELOPMENT

Quartz Fill in Shear Zones.

One of the principal problems in the heavy shear zones such as the Hower-Wiberg and the Weber is the determination of where the ore will lie in unexplored ground. The shear zone persists with amazing regularity but ore minerals in paying quantities are most erratically distributed in it. Careful mapping of the quartz fill as distinguished from crushed rock will prove of aid in ore-hunting for the quartz fill is in the form of lenses and any lead of a little quartz fill is worth following in the hope of increase of size and value. The distinction between the quartz fill and crushed rock is often difficult but is very important as the quartz may give a clue to promising ground even where careful assaying may fail.

Relation of Dikes to Ore

Since the lamprophyre dikes which are so abundant in some mines were intruded subsequent to ore deposition, they are not to be regarded as

1. Shannon, E.V. Petrography of some lamprophyre dike rocks of the Coeur d'Alene mining district, Idaho. Proc. U.S. Nat. Museum. vol. 57, pp.479-480, 1920

definite guides to ore; but since structural conditions favored the intrusion of these dikes in the more mineralized areas, an abundance of dikes implies favorable ground for prospecting. Nothing is to be gained, however, by following dike contacts unless vein minerals are present along them.

Secondary or Supergene Enrichment.

Weathering agencies have produced little effect on the ore. The upper workings of all the mines yielded rich oxidized ore generally of shipping grade, but the quantity was small. The boundary between the oxidized ore and sulfides is very sharp and there is very little enrichment of sulfides below the oxidized material. A little native silver is usually present and pearcite and a little argentite have been identified, but there is no rich zone of secondary sulfides. The accessory silver minerals, polybasite and proustite, are minerals which have come from below and not from above. They may be expected to continue to moderate depths. At Talache there was more on the 1,200-foot level than on the 700-foot level.

Lack of Influence of Country Rock

In the Coeur d'Alene region the character of the country rock is one of the controlling factors in ore deposition, though by no means as important as once thought; but in the Pend Oreille district it is a negligible factor. The ores are formed in fissures and in shear zones and not by the replacement of country rock; therefore the susceptibility of the country rock to fissuring and shearing is the only possible controlling factor and even this is of little moment since veins seem as likely to be found in the massive quartzite of the lower part of the Blacktail formation as in the easily crumpled Wallace formation.

Saving of Zinc

Tetrahedrite, the main silver mineral, may be associated with sphalerite so intimately and on such a minute scale (Plate 4b) that if there be much sphalerite the mechanical separation of the two minerals is practically impossible. If the amount of zinc in an ore is too great to permit its inclusion in a concentrate with lead a separate zinc concentrate should be made, for if zinc is thrown into the tails a large loss of silver is possible. At Talache no zinc concentrate was made and 85 per cent of the zinc went into the tails.[1] However, this vein probably contained less sphalerite in proportion to silver than any other important vein in the district and where sphalerite is an abundant constituent in the ore, as is generally the case, it will be well to consider carefully the use of differential flotation particularly as the saving of zinc may help considerably to repay the extra investment.

1. Wormser, F.E., Silver mining at Talache, Idaho. Eng. ' Min. Jour. Press Vol. 114 p. 585, 1922.