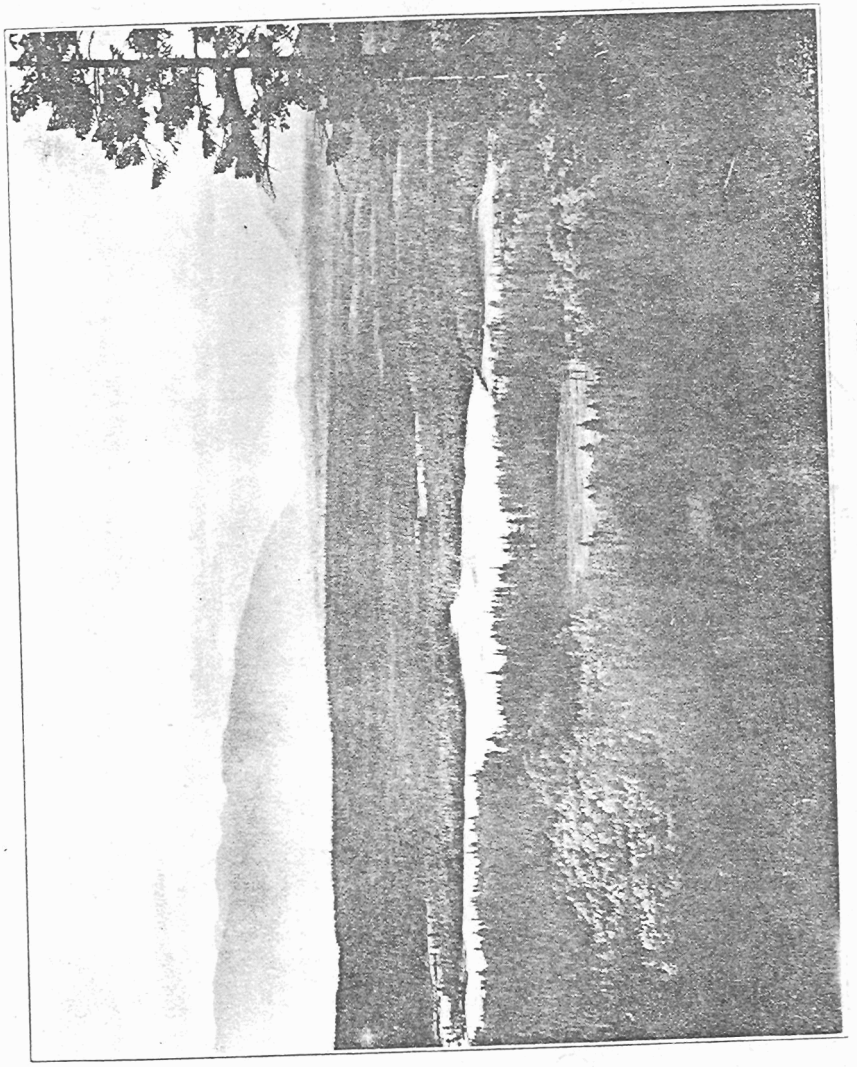

PURCELL TRENCH LOOKING NORTH.

The "Trench," dominant physiographic feature of Boundary County, was formed by faulting and subsequent glaciation. The plateau-like area is a glaciated rock terrace. Kootenai River cuts across the plateau in the middle distance and turns to the north along the western wall.

STATE OF IDAHO

C. C. MOORE, Governor

BUREAU OF MINES AND GEOLOGY

Moscow, Idaho

FRANCIS A. THOMSON, Secretary

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GEOLOGY AND ORE DEPOSITS OF BOUNDARY COUNTY, IDAHO

BY

VIRGIL R. D. KIRKHAM

AND

ERNEST W. ELLIS

UNIVERSITY OF IDAHO

MOSCOW, IDAHO

Entered as second class matter Aug. 11, 1924, at the post-office at Moscow, Idaho, under the Act of March 3, 1879.

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The writers take pleasure in acknowledging indebtedness to the Bonners Ferry Chamber of Commerce for photographs used herein and its cooperation and assistance, and to its committee on mining which facilitated the examination of the area especially during the first field season. The courtesy of Mr. R. Bartlett of the Canada Geological Survey in permitting the use of the photographs on Plate VIII. is greatly appreciated. The writers also express gratitude for the courtesies and favors received from the various mine owners and managers of Boundary County, including use of maps, reports, and photographs. The writers also wish to acknowledge their appreciation of the services of George R. Causton and A. J. Kent of Bonners Ferry for aid and interest in consummating field arrangements, as well as to thank Dr. Francis A. Thomson, dean of the School of Mines, University of Idaho, for valuable counsel in preparing the report, and for a critical reading of the manuscript. They are also grateful for the care and cooperation given by G. E. Bjork in the preparation of maps accompanying this report.

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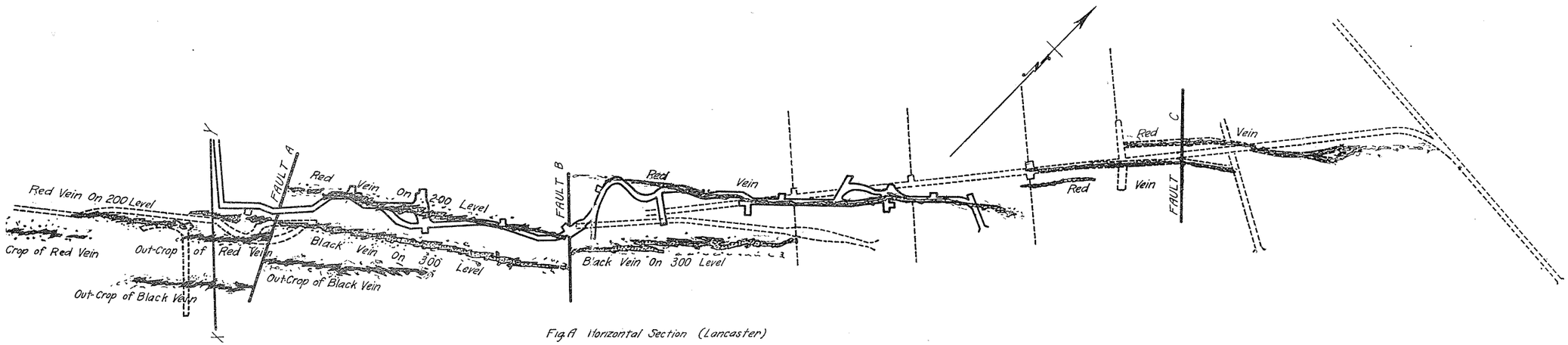


Fig. A Horizontal Section (Lancaster)

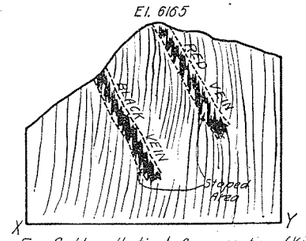


Fig. C Hypothetical Cross-section. (Kirkham)

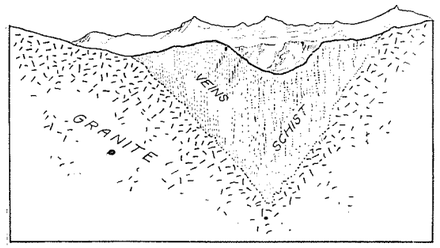


Fig. D Cross-section looking N.E. showing geologic conditions postulated (Kirkham)

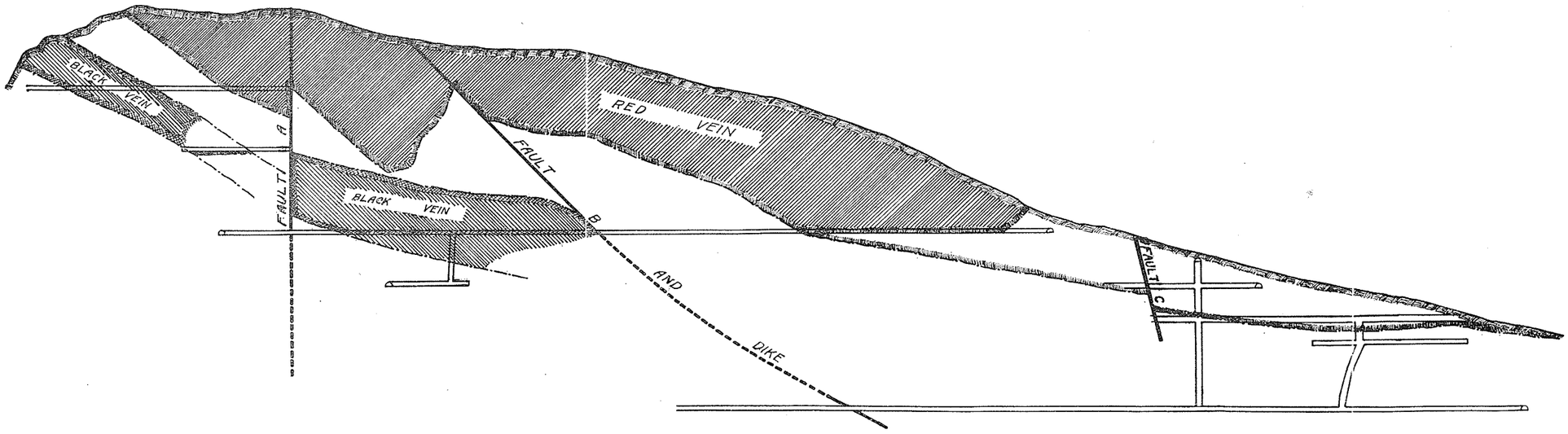


Fig. B Longitudinal Section (Lancaster)

0 50 100 200 300 Feet

LEGEND

Surface Out-Crop of Vein

Subsurface Position of Vein

RED VEIN Stoped Area

BLACK VEIN Stoped Area

Fault or Dike

Compiled by Virgil R. D. Kirkham from maps of J. Lancaster and personal observations

WORKINGS OF THE IDAHO-CONTINENTAL MINE

ILLUSTRATIONS

PREFACE

This report presents a brief analysis of the mineral possibilities and structural features of the most northerly county of the state of Idaho. Because the area adjoins the international boundary, and because the work of the Geological Survey of Canada has been more extensive and detailed to the northward than has the work of the U. S. Geological Survey to the southward of the area, the authors have drawn much more freely upon the work of Canadian writers than upon that of their American colleagues.

Although there has been a popular tendency to liken Boundary County to the Coeur d'Alenes in its mineral possibilities, the present investigation points to a resemblance rather to southern British Columbia so far as economic possibilities based upon geologic similarity are concerned. The relationship of metalliferous deposits to granitic batholiths is again emphasized and considerable evidence for a zonal arrangement of mineral deposits with respect to igneous magmas is adduced. Certain major structural features of rather wide implication are also dealt with in this report.

So far as mineral resources are concerned, it is my opinion as the result of several visits to the area, both prior to and during the investigation, coupled with a careful study of this report and numerous conferences with the writers, that the area is by no means devoid of promise and that more careful prospecting of the areas pointed out as geologically favorable is fully justified.

FRANCIS A. THOMSON,
Secretary.

GEOLOGY AND ORE DEPOSITS OF BOUNDARY COUNTY, IDAHO.

By VIRGIL R. D. KIRKHAM AND ERNEST W. ELLIS.

INTRODUCTION.

PURPOSE OF THE INVESTIGATION.

Early reconnaissances of portions of Boundary County by geologists of both the Canada and United States Geological surveys pointed to the presence there of large areas of metamorphosed sediments of great age. Speculations as to age placed them in the Algonkian (pre-Paleozoic) or Cambrian periods. They were thought to be notably faulted and folded, as well as intruded, by various younger igneous rock masses and generally to possess conditions of age and structure similar to those usually ascribed to the famed Coeur d'Alene mining district.

Because of this apparent geologic similarity, a belief that similar results were to be expected in the way of ore production had naturally arisen.

This assumption, however, ignores the fact that the part of the county west of the Purcell trench is practically unexplored, and that the mining development of the county has been, for the most part, based on early reconnaissances which had considered only certain limited areas.

This situation, coupled with the public-spirited attitude of the Bonners Ferry Chamber of Commerce and the Boundary County mine owners, made it possible for the Idaho Bureau of Mines and Geology to send into this region Messrs. Virgil R. D. Kirkham and Ernest W. Ellis. Their mission was to visit and examine operating or promising properties throughout the county, to recommend future development, where it was desirable, and to map the geology of the western part of the county, during August and part of September, 1924.

Examination of mining properties in the eastern part of the county revealed the presence of several unusual and important structural and igneous features which were not shown on earlier reconnaissance maps. Because of their importance and relationship to the mineral deposits, an additional month in 1925 was spent in mapping the

eastern part of the county and in collecting later and more detailed information concerning mining properties. A total of about nine weeks were spent in collecting the field data and several months of office and laboratory work were necessary to prepare the findings for publication.

PREVIOUS GEOLOGICAL WORK IN THE AREA.

The following brief bibliography represents, as far as is known, the chief publications on the area as well as the most important geological work done therein. References to publications throughout the succeeding pages are made by serial numbers which refer to the enumerations of publications listed.

1. CALKINS, F. C., and MACDONALD, D. F., A Geological Reconnaissance in Northern Idaho and Northwestern Montana: U. S. Geol. Survey Bull. 384, 1909.

2. CURTIS, W. M., The Priest Lake Mining District, Idaho: Engineering and Mining Jour. Vol. 82, p. 866, 1906.

3. DALY, REGINALD A., Geology of the North American Cordillera at the Forty-ninth Parallel: Canada Dept. Interior, Report of Chief Astronomer for 1910, Vols. 2 and 3, pp. 1-799, map 1913. Also issued as Memoir 38, Canada Geol. Survey, Ottawa, 1915.

4. ——————, The Differentiation of a Secondary Magma Through Gravitative Adjustment. (Moyie Sill in the Purcell Mountain Range, Idaho-Montana.) Festschrift, Harry Rosenbusch, pp. 203-233, Stuttgart, 1906.

5. KIRKHAM, VIRGIL R. D., and ELLIS, ERNEST W., Press Bulletin on Geology and Mineral Resources of Boundary County, Idaho.: Idaho Bur. of Mines and Geol. Press Bull. 12, Dec. 1924.

6. LANCASTER, JOSEPH, The Priest Lake District, Idaho: Mining World, Vol. 32, p. 100, 1910.

7. LIVINGSTON, D. C., Tungsten, Cinnabar, Manganese, Molybdenum and Tin Deposits of Idaho, Univ. of Idaho School of Mines Bull. 2, Vol. 14, pp. 11-15, 40, 1919.

8. MACDONALD, D. F., Economic Features of Northern Idaho and Northwestern Montana: U. S. Geol. Survey Bull. 285, 1906.

9. McCONNELL, R. G., and BROCK, R. W., Geologic Map of the British Columbia West Kootenay Sheet. Canada Geol. Survey, 1904.

10. Min. Res. U. S. Geol. Survey Pt. 1, p. 420, 1908.

11. ——————, p. 345, 1909.

12. SCHOFIELD, S. J., The Origin of Granite (Micropegmatite) in the Purcell Sills: Canada Geol. Survey. Museum Bull. 2, pp. 1-34. July 30, 1914.

13. ——————, The Pre-Cambrian (Beltian) Rocks of Southeastern British Columbia and their correlation. Canada Geol. Survey Museum Bull. 2, pp. 79-91, July 30, 1914.

14. ——————, Geology of Cranbrook Map-Area, British Columbia: Canada Geol. Survey Memoir 76, Ottawa, 1915.

15. SHANNON, EARL V., The Minerals of Idaho: Smithsonian Institution, U. S. National Museum Bull. 131, 1926.

16. SOPER, E. K., The Mining Districts of Northern Idaho: Mining and Sci. Press, Vol. 116, pp. 121-127, 1918.

17. VARLEY, THOMAS, WRIGHT, CLARENCE A., SOPER, EDGAR K., and LIVINGSTON, DOUGLAS C., A Preliminary Report on the Mining Districts of Idaho: U. S. Bureau of Mines Bull. 166, 1919.

The above publications probably represent all of the investigations in this district and adjacent areas, with the exception of private investigations and reports unavailable to the public. A few of the above listed publications contain reconnaissance maps of small parts of the area, and only a few discuss the geology of the area in any detail.

GEOGRAPHY.

LOCATION.

Boundary County is the northernmost county of Idaho, as is shown by the index map. (Pl. II., p. 12.) The northern part is bounded for 45 miles by Canada. On the east, Montana bounds the county for 34½ miles. Washington bounds the county for 10½ miles on the west. Bonner County, Idaho, borders the county on the south and west. The county comprises 865,520 acres.

TOPOGRAPHY.

Three types of topography are represented in the area: (1) rugged mountainous provinces, made up of tilted, faulted, metamorphosed sediments, massive basic igneous sills, and a batholithic acid igneous intrusion with its attendant stocks and cupolas, (2) plateau-like areas lower than the mountain masses, planed off by continental-glacier erosion (Pl. I., Frontispiece) and (3) stream-valley plains.

Examples of the first type are abundant throughout the county. The second type is to be found to the east of Kootenai River and the last type exists in the valleys of Kootenai, Moyie, and Upper Priest rivers, and Deep Creek.

The relief varies from an elevation of 1797 feet where the Kootenai River leaves the area at the Canadian boundary, to 7670 above sea level in the southwestern part of the county along the crest of the Selkirk Range; thus a relief of nearly 5900 feet occurs in a distance of less than five and one-half miles.

Most of the drainage is into the Kootenai River, which flows northwest along the Moyie (Lenia) fault and Purcell trench into Canada, where it joins the Columbia. The rest of the county is drained by Deep Creek and Upper Priest River, tributaries of the Clark Fork, which also join the Columbia in Canada.

Important tributaries of the Kootenai are Moyie River, Boulder, Grouse, Trail, Twenty-mile, Mission, Fall, Ruby, Caribou, Snow, Myrtle, Ball, Trout, Parker, Canyon, Smith, and Boundary creeks. Gold, Trapper, Caribou, Lion, Two Mouth, Indian, Hunt, and Soldier creeks contribute to the Upper Priest River drainage.

Numerous small lakes formed by glacial scouring lie within the area, (Pl. XII., p. 68), and until recently morainal damming was re-

INDEX MAP OF IDAHO.
The area enclosed by the heavy black line is that covered in this report.

sponsible for several permanent lakes of notable size, as well as extensive temporary lakes and swamps in Kootenai Valley, extending from Bonners Ferry to Canada.

The chief drainage lines lie in deep, wide, glaciated, fault-formed valleys. Structure generally controls the drainage system of the county.

Chief of the mountain ranges is the Selkirk Range, lying in the western part of the county. It is serrated and scenic. It is scarred both by continental and alpine glaciation and many of its peaks rise 7500 feet above sea level.

Part of Purcell Range lies in the northeastern part of the county and contains many peaks over 6500 feet in elevation. Yahk Mountain, approximately 6800 feet above sea level, is its highest point.

The northern part of the Cabinet Range occupies the southeastern part of the county and has Clifty Mountain, with an elevation of 6700 feet, as its high point. Many other peaks in this range rise above 6000 feet in elevation.

In nearly all instances the high points of these ranges are determined by the resistance of igneous rocks to erosion. All of these ranges represent structural blocks dissected by southward-moving continental ice sheets, and subsequent valley glaciation, followed by run-off consequent upon glacial melting and high precipitation.

ACCESSIBILITY.

Much of the area is difficult of access. The transportation lines are confined to the broad, low, structural valleys of Deep Creek and Kootenai and Moyie rivers. These valleys also contain most of the population, all of the towns, railways, highways, and agricultural land. The Spokane International Railway and the Great Northern main line serve the area adequately, passing through Bonners Ferry, where a branch line of the latter leaves to serve Port Hill on the Canadian border. Many excellent surfaced highways now traverse the main valleys and much additional mileage is in course of construction.

The larger mining properties are connected with shipping points by auto roads ranging from 4 to 26 miles in length, but the larger number of properties are relatively inaccessible, being approached only by unimproved wagon roads or trails, open only in the summer months.

Although the Kootenai River is navigable by small steamers and launches, little use is made of this thoroughfare.

SETTLEMENT AND OCCUPATION.

The population of the county is less than 5000. Bonners Ferry, the county seat, is the only town of any size in the area. Its population of 1350 persons depends chiefly on the agricultural, lumbering and mining industries of the tributary region. Other towns and postoffices in the area are Eastport, Meadow Creek, Port Hill, Leonia, Copeland, Naples, McArthur, Moravia, Klockman, Moyie Springs, Shiloh, and Addie.

Of the 865,520 acres within the county, 12,300 acres are in cultivation and are devoted to fruit, grain, and vegetables. The rainfall of the area averages 27 inches, making irrigation unnecessary. The 35,000 acres of meadowland and 166,000 acres of grazing land provide ample facilities for a successful dairy and live stock industry.

About 102,000 acres of the county are occupied by timberland and 59,000 acres represent the cutover area.

Much excellent timber and pulpwood give promise of a continued logging industry. Drainage projects to reclaim swamps and overflow lands by dikes are making more agricultural land available yearly. The status of the mining industry in the county is described in the rest of this bulletin.

GEOLOGY.

STRATIGRAPHY.

ALGONKIAN SYSTEM (BELT [PURCELL] SERIES.)

Aldridge-Prichard Formation.—This is the oldest known formation of the Purcell series of the Canadian Geological Survey and of the Belt series of the United States Geological Survey. The base of this formation is not revealed in the area but the upper limit is defined by a fairly distinct transition zone. Its lithology is notably different from that of the Prichard formation in the type section of the Coeur d'Alene mining district, where it consists chiefly of dark colored, gray and blue-banded argillites and slates. This difference is explained by Calkins[1] as due to changed conditions of sedimentation at the time of deposition, which altered the type section toward the north and west. Here the tendency is for the formation to become coarser and more siliceous so that wherever the formation is exposed in Boundary County, it is predominately quartzitic and sandy with a minor amount of argillaceous material.

In Boundary County the Aldridge-Prichard section is made up of pure quartzites, argillaceous quartzites, and argillites. The quartzites are generally massive, occurring in beds as thick as eight feet. The argillites are thin-bedded, and the argillaceous quartzites have a lesser thickness than the pure quartzites. Schofield[13] attributes to this formation an average stratum thickness of six inches.

The pure quartzites are light gray in color and the argillaceous quartzites and argillites are gray to black. The general weathered appearance of the formation is a reddish, rusty brown. Except for the subordinate thin-bedding, few evidences of shallow-water deposition were observed.

Basic igneous sills of great thickness and frequency are found in this formation in the eastern part of the county. They will be described under the section on igneous geology.

The entire area of eastern dipping sediments between the Purcell trench on the west and the Moyie (Lenia) fault on the east, and extending the full longitudinal length of the county is believed to be the Aldridge-Prichard formation, with the exception of a small wedge at the Canadian boundary, one mile northwest of Robinson Lake, which is assigned to the Ravalli group. A triangular patch of about 12

square miles in the extreme northeastern part of the county is also designated as of this formation. The long strip of westward dipping sediments between the Purcell trench and the igneous area to the west are assigned to the Aldridge-Prichard formation. All other areas are correlated with higher formations.

The Aldridge-Prichard formation, as interpreted by the writers, shows in this county a thickness of more than 10,000 feet, exclusive of the intruded basic sills.

Creston-Ravalli Formation.—This formation lies conformably on the Aldridge-Prichard formation. The Creston of the Purcell series conforms with the Ravalli group of the Idaho and Montana Belt series. The Ravalli is sometimes split into three formations known as the Burke, Revett, and St. Regis—from bottom to top. The lithologic changes from the Coeur d'Alene district to here are not so marked as is the change in the Aldridge-Prichard formation. However the thickness is slightly increased and the argillaceous members are fewer. In this county, it is made up chiefly, in the lower section, of thin members of siliceous shales, gray, rusty-weathering argillaceous quartzites and pure, gray quartzites, which appear to correspond fairly closely to the Burke member of the Ravalli group. The middle section is chiefly pure white massive quartzite and sericitic quartzite which correlates closely to the Revett of the Ravalli group. The top section is chiefly sandstone and the shale members are of brown, purple and green color. These have been correlated to the St. Regis of the Coeur d'Alene section.

Two basic igneous sills are found intercalated with the probable Burke section and one is found in the St. Regis member, being stratigraphically the highest sill in the area. Few evidences of shallow water deposition were observed in this group.

This formation is represented at three places in the county. The best exposure constitutes the southwestward dipping rocks which lie in a belt whose eastern boundary extends from about two miles east of Eastport southeasterly to the northeast part of T. 64 N., R. 3 E. These rocks extend to the Moyie (Lenia) fault on the west from about three miles south of Meadow Creek northward to the Canadian line. The thickness exposed here, exclusive of the sills, is approximately 5000 feet. This formation is again exposed west of the Selkirk granite area, in the northwestern part of the county, as far west as

the stream valley of Upper Priest River, which appears to flow along a major unconformity. Only the Burke and Revett members could be recognized here. The dips in this area are somewhat divergent, possibly on account of unconformities, faults, or disturbances in the shallow-lying batholith, whose undoubted nearness to the surface throughout this entire section is attested by the numerous and closely occurring cupolas. The Burke is thought to be exposed in a small wedge between two faults one mile northwest of Robinson Lake.

Kitchener-Newland-Wallace Formation.—The Kitchener of the Purcell series of Canada can be fairly well correlated with the Newland of the Belt series which is correlated by Calkins[1] with the Wallace formation of the Coeur d'Alenes. This formation appears to undergo less lithologic change in passing from the Coeur d'Alene district to Boundary County than any member of the Belt series.

The description of the Newland in its type locality and the Wallace in the Coeur d'Alene district fits very well the rocks of the Kitchener-Newland as exposed in Boundary County. A slight thickening to the north apparently occurs. The members are fine-grained and thin-bedded, and are notably calcareous. They are chiefly light gray argillaceous and calcareous quartzites, calcareous banded argillites of blue and white color. There are also a few thin members of sericitic slate and quartzite, and of green impure limestone and dolomite. All of these grade from one to the other. Evidence of shallow-water deposition is abundant; ripple marks and sun cracks aid greatly in recognition of this formation.

This formation is thought to occur at only one locality in the county. It outcrops as southwestward dipping strata in a strip about two miles wide just east of the Moyie (Lenia) fault, south of the basic sill and northeast of the Kootenai River and Leonia. It appears to rest conformably on the Creston-Ravalli formation which lies to the northeast. The Kitchener-Newland-Wallace formation as exposed here reveals a thickness of about 4500 feet, although it appears likely that the upper member has been cut by the Moyie (Lenia) fault.

Purcell Lava.—This formation, common in British Columbia Beltian sections, has no counterpart in the Coeur d'Alene section, having been either omitted or eroded. Stratigraphically the Purcell lava should overlie the Striped Peak formation of the Coeur d'Alene Belt series. The formation is called the Irene conglomerate and

Irene volcanic formation by Daly[3], who assigned to them an age considerably older than the Aldridge-Prichard.

Although the formation bears the name of an igneous rock type, it will be described under stratigraphy because it contains large thicknesses of coarse sandstone and conglomerate and a few dolomite members.

It was deposited unconformably after a great erosion interval on the underlying Creston-Ravalli formation.

The lower 5000 feet appears to be a local basal conglomerate not typical of the Purcell lava in other sections and may perhaps be correlated with the Siyeh. However, the upper part of the conglomerate is interbedded with the lowermost lava flows, and thus shows its basal relation and justification in being considered either as a part of the Purcell lava formation or as the Siyeh formation which has identical relations with the lava farther to the east. The sand and pebbles are chiefly made up of sericitic quartzite and white quartzite very similar to the Revett of the underlying and nearby Creston-Ravalli group. This was very probably the land mass that furnished the material for this huge mass of coarse depositional material. Other pebbles are dolomite and slate.

The upper 6000 feet is made up of altered basaltic and andesitic lava flows, greenstone schists, interbedded tuffs, conglomerates, breccias, and a 40-foot bed of dolomite. The formation occurs only in the northwestern part of the county west of Upper Priest River.

The lava flows are thought to be the extrusive phase of the basic intrusive sheets common in the Aldridge-Prichard and overlying formations previously described in this section, which are known as the Purcell sills, Moyie sills or St. Marys sills in Canada. These lavas will be more fully described under the section on igneous geology. The top of this series, which the writers believe is the youngest Belt formation in the county, is approximately 30,500 feet higher stratigraphically, exclusive of sills, than the lowest section of the Aldridge-Prichard formation observed in the area.

QUATERNARY SYSTEM (PLEISTOCENE SERIES.)

Lake Bed Sediments.—The outline of every dotted and stippled area on the map is also the outline of temporary or semi-permanent lakes which resulted from the glacial invasion of the Pleistocene. These lake deposits were silts, sands, and gravels eroded from the nearby terrane. The usual phases of shallow water and delta deposition are exhibited in some of these areas. (Pl. VII., p. 50.)

Kootenay Lake, which now lacks nearly 14 miles of reaching the northern boundary of the county, extended during Pleistocene time from north to south throughout the county and undoubtedly connected with the basin in which is the present Lake Pend Oreille. Although the lake has varied in depth and altitude at various times, owing to the resistance of its dam and the fluctuation of its water supply, it has deposited stratified sediments to a depth of more than 200 feet in parts of the area. The highest level of this old lake was considerably above the 2200-foot contour, as shown by the terraces. In its last stages, Kootenay* Lake was dammed at Moravia, and Deep Creek developed a drainage leading from it. The lake preserved this extent until recent times. Conversion of its southern extremity into a swamp probably has occurred only within the last few hundred years.

The lake basin, reaching from Eastport into Round Prairie and down below Snyder, was dammed on the south by a resistant basic sill which has since been severed by the stream. This lake was at a higher contour level than old Kootenay Lake, but was smaller and shorter-lived. The deposits in this basin are thin, and only erosional remnants remain. The lake near Meadow Creek had a similar history and was dammed by the basic sill which now is responsible for Moyie Falls. The old lake on Boulder Creek, formed by a melting alpine glacier, is thought to have been dammed by a basic sill. The old lakes on Grass and Cow creeks were dammed by morainal obstructions and were undoubtedly short-lived.

The old lake sediments in some places provide fertile soil and in others gravel for construction purposes and road surfacing. At some places the sediments are being washed for gold.

QUATERNARY SYSTEM (RECENT.)

Hill Wash and Alluvium.—This material, made up of a mixture of eroded materials from the mountains of the region, occupies the larger valleys and basins and masks rock exposures except in gorge-like channels where it is cut through. It comprises the chief farming area of the region. In the area dotted or stippled on the map

*The word Kootenay or Kootenai is of course an Indian tribal name. Unfortunately a variant spelling has been adopted by the two countries through which the river flows.

many areas of underlying bed-rock too small to map are exposed. In some instances they are only a few feet across. Although unmapped, they serve to justify the drawing of sub-surficial contact lines for the older bedrock formations.

CORRELATION OF PRE-CAMBRIAN (BELTIAN) ROCKS IN SOUTHEASTERN BRITISH COLUMBIA AND NORTHERN IDAHO.

The rocks of the area in British Columbia adjacent to those in Boundary County have been assigned to many different geological ages, by various geologists, and have borne many different designations.

The sediments along the Canadian boundary west of Purcell trench in British Columbia were called the Upper and Lower Selkirk series and assigned to the Cambro-Silurian and Cambrian by McConnell[9] and Brock on the West Kootenay Sheet in 1904. According to them, the younger Cambro-Silurian rocks lie to the east of the Cambrian group and the youngest rocks lie nearest the main batholithic mass of the Selkirk Range.

Daly[3], as late as 1915, published a map which shows the same area to be occupied by a group called, by him, the Priest River Terrane of pre-Beltian age, containing seven members, and also the Irene volcanic formation and Irene conglomerate, which he places at the base of the Beltian section. According to his column the oldest rocks lie to the east adjacent to the Selkirk batholithic mass. In 1917, Drysdale* placed the Irene formations at the base of the Belt series.

The writers place the rocks next to the batholithic intrusion in the Creston-Ravalli group and provisionally assign them to the Burke and Revett formations. The Irene volcanic formation and Irene conglomerate are tentatively assigned to the Purcell lava and Siyeh formation of Upper Beltian age.

Calkins[1], in 1909, believed the narrow strip of highly metamorphosed sediments lying west of Purcell trench and east of the Selkirk batholithic mass to be older than Beltian, and possibly Archean in age. The writers assign this area to the Aldridge-Prichard formation and account for the schists and gneisses as injection gneiss and metamorphic products induced by the proximity of this pendant-like strip to the closely underlying magma and adjacent granite to the east and west.

*Drysdale, Charles Wales. Ymir Mining Camp, British Columbia, Canada Geol. Survey Memoir 94, Ottawa, 1917.

The relationships of the schists, gneissic zones, and granite are obvious. A transition occurs to east and west horizontally, as well as vertically.

The gneissic shell is sometimes only a few hundred feet thick. At other places it reaches a thickness of about 2000 feet.

Traces of basic sills, highly metamorphosed and disturbed, are also found in this strip. They are altered mainly to dark heavy micaceous schists, which could be distinguished from the enclosing schists with such difficulty that sills could not be mapped in this area.

That part of the county lying east of Purcell trench is shown by Calkins[1] (1909) to contain Prichard (Beltian) near the trench, Ravalli group (Beltian) east and west of the Moyie fault at the Canadian boundary, and Prichard in the northeast corner of the county. He shows Prichard east of Bonners Ferry and southwest of his Lenia fault, and a patch of Newland (Beltian) to the east and northeast of his Lenia fault. Less than a tenth of the sedimentary mass in the county was assigned an age by Calkins in 1909, but those areas designated were all Beltian rocks.

In 1915 Daly[3] in his map of the same area shows these formations as Creston formation (Purcell) of Beltian and Lower Cambrian age, Kitchener (Purcell) of Lower and Middle Cambrian age, and Moyie (Purcell) of Middle Cambrian age.

In this same year Schofield[14] published a map of the Cranbrook area, British Columbia, showing Daly's beds as Aldridge (Purcell) of Beltian age and a narrow strip of Creston (Purcell) of Beltian age lying east of the Moyie fault at the Canadian boundary.

The writers assign all of the area between Purcell trench and Moyie (Lenia) fault to the Aldridge-Prichard except a small triangular portion a mile and a half long and a mile wide at the Canadian boundary and bounded by faults, lying about one mile northwest of Robinson Lake, which is assigned to the Creston-Ravalli group, and is probably Burke formation. This correlation agrees largely with those of Calkins[1] and of Schofield[14], although the latter shows no Creston west of the Moyie fault and Calkins shows Ravalli west of the fault and adjacent to it, at which place the writers find Prichard.

The writers accept the Prichard, Newland, and Ravalli in the rest of the eastern part of the county as designated by Calkins[1] and also the Aldridge and Creston designations of Schofield [14] as shown at the Canadian boundary.

The following six correlation tables are designed to convey to the reader the progress made in attempts to assign to the proper stratigraphic horizon and geologic age the formations within this area and the adjacent area in British Columbia. The first four are excerpts from published correlations. The writers have taken the liberty of including only those districts from each correlation which are thought to be pertinent to solving the stratigraphy of this area. The first table is made up from Walcott's* correlation. The second table is made up from Calkins' correlation.[1] The third is excerpted from Daly[3] and the fourth from Schofield[13, 14]. The fifth table is an endeavor on the part of the writers to assign stratigraphic and age values to the metamorphic sediments west of Kootenai River and Purcell trench and to show what names and ages were assigned to the same formations by McConnell[9] and Brock, and by Daly[3]. Table six undertakes to do the same for the metamorphosed rocks east of the river and to show the names and ages assigned to the same formations by Calkins[1], and Daly[3], and Schofield[13, 14].

*Walcott, C. D., Bull. Geol. Soc. Am. Vol. 17, 1906. 1, 3, 13, 14. See bibliography.

CORRELATION TABLE NO. 1 (FROM C. D. WALCOTT.)

Belt Mountains, Montana, (Walcott)	Mission Range, Montana, (Walcott)	Coeur d'Alene District, Idaho (Calkins)	Boundary, East of Kootenai River, (Daly)
	CAMBRIAN UNCONFORMITY		
	CAMP CREEK SERIES arenaceous-gray, 1,762 ft.		
	Calcareous and arenaceous, 1,500 ft.		
CAMBRIAN UNCONFORMITY			
MARSH, 800 ft.	Arenaceous mostly reddish color, 4,491 ft.		
HELENA, calcareous, 2,400 ft			
EMPIRE, 600+ft.		No superjacent strata.	
SPOKANE, 1,500+ft.			
GREYSON, 3,000+ft. arenaceous	Arenaceous red and grey colors. 198 ft. of Limestone near 700 ft. from Summit, 3,887 ft.	STRIPED PEAK, 2,000 ft.	
NEWLAND, calcareous, 2,200+ft.	BLACKFOOT, calcareous and siliceous, 4,805 ft.	WALLACE, calcareous and siliceous, 5,000+ft.	
CHAMBERLAIN, siliceous, 1,500 ft.			
NEIHART, sandstone, 700 ft.	RAVALLI, siliceous and arenaceous, purple and greenish and grey colors, 8,225 ft.	BURKE, siliceous arenaceous, ST. REGIS, purple greenish and grey beds. 8,000 ft.	YAHK, 500 ft.
			MOYIE, argillite, 3,200 ft.
UNCONFORMITY. ARCHEAN. Total 12,000 ft.	Base, concealed. Total, 24,760 ft.	PRICHARD, banded dark blue grey, blue, black and grey siliceous series, 10,000 ft.	KITCHENER, qtzt., 7,400 ft.
			CRESTON, quartzite, 9,500+ft.
		Base concealed. Total, 25,000 ft.	Base concealed. Total, 20,600 ft.

CORRELATION TABLE NO. 2 (FROM F. C. CALKINS.)

Belt Mountains, (Walcott) a	Mission Range, (Walcott) b	Coeur d'Alene District (Calkins) c	Cabinet Range West & Central Parts (Calkins)	49th Parallel Between Crossings of Kootenay River. (Daly) d
CAMBRIAN UNCONFORMITY MARSH, sh, 800 ft.	CAMBRIAN UNCONFORMITY CAMP CREEK, ss, 1,762 ft.	Eroded	ss, sh, ls, 10,000+ft.	Eroded
HELENA, ls, sh, 2,400 ft.	sh, ss, ls, 1,560 ft.		STRIPED PEAK sh, ss, 2,000+ft.	
EMPIRE, sh. 600 ft.	ss, 4,491 ft.			YAHK, quartzite, 500
SPOKANE, sh. 1,500 ft.	sh, ss, ls, 3,887 ft.	STRIPED PEAK, sh, ss, 1,000+ft.		
GREYSON, sh. 3,000 ft.				
NEWLAND, ls, sh, 2,200 ft.	BLACKFOOT, ls, sh, 4,805 ft.	WALLACE, ls, ss, 4,000 ft.	NEWLAND, ls, sh, 5,000+ft.	MOYIE, argillite 3,400 ft.
CHAMBERLAIN sh, ss, 1,500 ft.	RAVALLI, ss, qtzt, 2,550	ST. REGIS, sh, ss, 1,000 ft.	RAVALLI, qtzt, sh, ss, 8,000+ft.	KITCHENER, qtzt, 7,400 ft.
	ss, 1,060 ft.	REVETT, qtzt, 1,200 ft.		
	ss, 4,060 ft.	BURKE, sh, ss, qtzt, 2,000 ft.		
		PRICHARD, argillite, ss, 8,000+ft.	PRICHARD, argillite, 2,000 ft.	CRESTON, qtzt, ss, argillite, 9,500+ft.
NEIHART, qtzt, sh, 700 ft.			ss, sh, 10,000 ft.	
ARCHAEAN				

a WALCOTT, C. D., Pre-Cambrian fossiliferous formation; Bull. Geol. Soc. Am. Vol. 10, 1899.
b ——————, **Algonkian formations of Northwestern Montana; Bull. Geol. Soc. Am.** Vol 17, 1906.
c RANSOME, F. L., and CALKINS, F. C., Geology and ore deposits of the Coeur d'Alene district, Idaho; Prof. paper 62, U. S. Geol. Survey, 1908.
d DALY, R. A., Summary Rept. Geol. Survey Canada, for 1904, 1905.

CORRELATION TABLE NO. 3, (FROM R. A. DALY.)

Belt Mountains, (Walcott[1])	Mission Range, (Walcott[2])	Coeur d'Alene District, (Calkins[3])	Cabinet Range (Calkins[3])	Selkirk Range, Summit Series, (Daly)	Purcell Range, Purcell series, (Daly)	SYSTEM
Conformity with upper PAL.	?	Erosion surface	?		Erosion surface	
						UPPER CAMBRIAN
GALLATIN, FLATHEAD,	FLATHEAD, CAMP CREEK, 11,700 ft.	STRIPED PEAK, 1,000+ft.	STRIPED PEAK, 2,000+ft.	LONE STAR 2,000+ft.	MOYIE, 3,400+ft.	Chiefly MIDDLE CAMBRIAN
MARSH, 800 ft. HELENA, 2,400 ft. EMPIRE, 600 ft.	BLACKFOOT, 4,805 ft.	WALLACE, 4,000 ft. ST. REGIS, 1,000 ft.	BLACKFOOT, (NEWLAND) 5,000+ft.	BEEHIVE, 7,000 ft.	UPPER KITCHENER, 6,000+ft.	MIDDLE CAMBRIAN
SPOKANE, 1,500 ft. GREYSON, 2,000+ft.	RAVALLI, upper part, 4,550 ft.	REVETT, 1,200 ft. BURKE, 2,000 ft. PRICHARD, upper part, 1,500+ft.	RAVALLI, upper part, 5000+ft. RAVALLI, lower part, 3,000+ft.	RIPPLE, 1,650 ft. DEWDNEY, 2,000 ft. WOLF, upper, 1,000+ft.	LOWER KITCHENER, 1,400 ft. UPPER CRESTON, 3,000+ft.	LOWER CAMBRIAN
Lower GREYSON, 1,000+ft. NEWLAND, 2,200 ft. CHAMBERLAIN, 1,500 ft. NEIHART, 700 ft.	LOWER RAVALLI, 4,000+ft. Base concealed	LOWER PRICHARD, 6,500+ft. Base concealed.	PRICHARD, 10,000+ft. Base concealed.	LOWER WOLF, 1,900+ft. MONK, 5,500 ft. IRENE, volcanic, 6,000+ft. IRENE, cg., 5,000+ft.	LOWER CRESTON, 6,500+ft. Base concealed	
Total 11,000+ft.	Total 25,055 ft.	Total 17,200+ ft.	Total 27,000+ft.	Total 32,050+ft.	Total 20,300+ft.	
UNCONFORMITY,				UNCONFORMITY Priest River		
CHERRY CREEK BEDS				PRIEST RIVER TERRAINE		
UNCONFORMITY.						
"ARCHAEAN"						

1. WALCOTT, C. D., Bull. Geol. Soc. Am. Vol. 10, 1899.
2. ——————, Bull. Geol. Soc. Am. Vol. 17, 1906.
3. CALKINS, F. C., Bull. 384, U. S. Geol. Survey, 1909.

CORRELATION TABLE NO. 4. (FROM S. J. SCHOFIELD.)

COEUR D'ALENE District, (Calkins[1])	CABINET RANGE Montana, (Calkins[2])	PURCELL RANGE, (Daly[3]) Modified by Schofield	SYSTEM
			CAMBRIAN
Erosion Surface, STRIPED PEAK, 1,000 ft.	Erosion Surface, Shales and sandstone, 10,000 ft. STRIPED PEAK, 2,000 ft.	Erosion Surface. GATEWAY, 1,000 ft. PURCELL lava SIYEH, 4,000 ft.	PRE-CAMBRIAN (Beltian.)
WALLACE, 4,000 ft.	BLACKFOOT, 5,000 ft.	KITCHENER, 4,500 ft.	
ST. REGIS, 1,000 ft. REVETT, 1,200 ft. BURKE, 2,000 ft.	RAVALLI, 8,000 ft.	CRESTON, 5,000 ft.	
PRICHARD, 8,000 ft.	PRICHARD, 10,000 ft.	ALDRIDGE, 8,000+ft.	

1. CALKINS, F. C., Prof. Paper 62, U. S. Geol. Survey, 1908.
2. ———, Bull. 384, U. S. Geol. Survey, 1909.
3. DALY, R. A., Memoir 38, Canada Geol. Survey, 1913.

CORRELATION TABLE NO. 5.

TENTATIVE CORRELATION OF BOUNDARY COUNTY STRATIGRAPHY WEST OF PURCELL TRENCH WITH McCONNELL[9] AND BROCK, AND WITH DALY[3].

McConnell and Brock	Daly	Kirkham	System
LOWER SELKIRK SERIES, (Cambrian.)	IRENE VOLCANIC FORMATION. IRENE, conglomerate, (Basal Belt.)	PURCELL Lava? SIYEH?	PRE-CAMBRIAN (Beltian.)
	UNCONFORMITY	UNCONFORMITY.	
UPPER SELKIRK, (Cambro-Silurian.)	PRIEST RIVER TERRANE, (Pre-Beltian.)	CRESTON-RAVALLI GROUP	
	KITCHENER Middle Cambrian	ALDRIDGE-PRICHARD	

3 and 9 See Bibliography

CORRELATION TABLE NO. 6

TENTATIVE CORRELATION OF BOUNDARY COUNTY STRATIGRAPHY EAST OF PURCELL TRENCH WITH CALKINS[1], DALY[3], and SCHOFIELD[13], [14].

Daly	Calkins	Schofield	Kirkham	System
	NEWLAND WALLACE BLACKFOOT	KITCHENER	KITCHENER-NEWLAND-WALLACE	
KITCHENER, (Middle and Lower Cambrian.) CRESTON, (Lower Cambrian and Beltian.)	RAVALLI, (St. Regis) (Revett) (Burke)	CRESTON	CRESTON-RAVALLI	PRE-CAMBRIAN (Beltian.)
MOYIE, (Middle Cambrian.) KITCHENER, (Middle and Lower Cambrian.) CRESTON, (Lower Cambrian and Beltian.)	PRICHARD	ALDRIDGE	ALDRIDGE-PRICHARD	

1, 3, 13, 14, See Bibliography.

STRUCTURE.

GENERAL STRUCTURAL FEATURES OF THE AREA.

The structural factor which has most affected the county is faulting. Several large faults, including one overthrust fault of great extent and enormous throw, traverse the county, but only two folds of major importance were noted. The axis of a flat-topped anticlinal fold, with the Aldridge-Prichard formation exposed at its crest, strikes northwest to southeast through the extreme northeastern part of the county. The other fold is an undulation of the tilted beds in the Aldridge-Prichard formation and included sills. Its attitude is illustrated in structure section A. A. Plate III (in pocket.) All areas of sedimentary and metamorphic rocks, excepting Quaternary lake beds and surface deposits, are generally steeply tilted as illustrated by dip signs on the maps and by the structure sections.

Several faults are believed to exist in the area immediately bounding the main mass of the batholithic intrusion in the Selkirk Range, but metamorphism is so marked as to prevent recognition of members of the formations in the limited time available. Without detailed knowledge of the various members of these formations many apparently small displacements could not be proven. It is believed that many small faults of short length and little vertical or horizontal displacement exist in this area bordering the batholith. Only painstaking detailed study, which was impossible in this rapid reconnaissance, would reveal enough data for mapping them.

Two faults, whose location and extent are questionable, have been indicated in the extreme northwestern part of the county. All other mapped faults have been definitely identified and a good idea of the stratigraphic relationships was obtained in each case. The most important faults have been given names and are shown on the map.

Consideration of the major structural features of Idaho in light of the diastrophic wedge-theory of R. T. Chamberlain* and his associates, makes it appear possible that a compressional origin for the whole Rocky Mountain system may be assumed. Much close folding and overthrusting is present throughout the system, and further detail study, which is now being prosecuted, tentatively points to the development of two-sided wedge zones from compressional stresses. It is

*Chamberlain, Rollin T., The Wedge Theory of Diastrophism: Jour. of Geol. pp. 755-792, Vol. 33, 1925.
Flint, Richard Foster, A Brief View of Rocky Mountain Structure; Jour. of Geol. pp. 410-431, Vol. 32, 1924.

not impossible that the block between the Moyie (Lenia) overthrust and the Kootenai fault may prove with detailed study to be one of these wedges.

The down-throw of the north-south faults is on the east side of the larger ones and on the west side of most of the minor ones. Although nearly all the faults appear to be normal in character, the planes seem to be nearly vertical, and may, in some instances, actually be overthrust. The strikes of the faults appear to follow no certain system, although some of the major north-south faults follow formation strikes for part of their length.

Faults have everywhere expressed themselves in the topography. Their site is usually marked for part of their lengths, at least, by wide valleys or streams. Along the larger faults zones of weakness and much crushing must have occurred. This resulted in valleys developed both by water and ice erosion along these zones. Continental and huge valley glaciers have recently invaded these fault-formed valleys and removed evidence of any escarpments which may have existed, and at the present time, because past continental glaciers have overridden all the mountains in the area, the down-thrown side of the block is as likely as not to be the highest in elevation.

Although the age of faulting can not be definitely placed in this area it is certainly post-Beltian and pre-Pleistocene. Observations by other geologists in nearby areas place it definitely as post-Carboniferous. All the faults are almost certainly later than the folding and from evidence cited by Schofield[14] appear to be Jurassic in age, in the area immediately north of the Moyie and Yahk Ranges. Schofield[14] believes the Nelson batholith to be Jurassic in age and thus cites his chief faulting period as Jurassic. Both in this county and in British Columbia the major faulting seem to be genetically associated with the batholith and its outlying cupolas. If the batholithic intrusion is Cretaceous in age, as much evidence seems to indicate, the faulting would be assigned to the Cretaceous. Schofield[13], in his East Kootenay area, finds only one later fault which he assigns to early Tertiary.

SPECIAL STRUCTURAL FEATURES OF THE AREA.

Cabinet Range.—This range, made up of Aldridge-Prichard sediments containing intercalated basic sills with a generally eastward tilt, has been previously considered as beginning at Bonners Ferry and

extending southeastward into Montana and Bonner County, Idaho. To the writers, the structural evidence would make necessary the inclusion of that area lying west of the Moyie (Lenia) fault and east of the Purcell trench as far north as Round Prairie fault. This newly included area has formerly been assigned to the Purcell Range. The boundaries of the range in this county as now outlined by the writers are, Round Prairie Valley, caused by faulting, on the north, the Moyie (Lenia) fault on the east, the Kootenai fault and the Purcell trench on the west, and outside of the area the Hope fault on the south.

Besides the eastward-dipping Aldridge-Prichard and included sills this range contains in this county a large batholithic intrusion about 35 miles by 7 miles in dimension as well as four small outlying cupolas of the same intrusion.

Selkirk Range.—This range, within Boundary County, is chiefly made up of a large batholithic mass which is part of the Nelson batholith. The range is structurally delineated to the east by the Kootenai fault and Purcell trench, and extends out of the county in all other directions. The Aldridge-Prichard beds on the east side represent a long, narrow roof pendant about 30 miles by 3 miles in dimension. These beds are greatly disturbed and metamorphosed but have a general dip to the west, northwest, or southwest, at varying angles, but with a general strike to the northeast. This is distinctly discordant with the northwest strike of the Aldridge-Prichard formation east of the Purcell trench and supposed Kootenai fault. The Creston-Ravalli (?) beds west of the main batholithic mass are nearly vertical or dip slightly to the batholith on the east. Their strike is also generally northeast. The Siyeh (?) and Purcell lava (?) stand almost vertically in the northwest part of the county near the boundary line and also strike northeast.

The batholithic mass in this range extends the entire longitudinal length of the county and shows a width in excess of 25 miles. Two outlying cupolas are exposed in the extreme northwestern part of the county. Two questionable faults are shown on the map.

Purcell Range.—This range is represented in this county by two subordinate ranges. The Yahk Range lies in that part of the county situated east of the Moyie (Lenia) fault and is made up of Aldridge-Prichard, Creston-Ravalli, Kitchener-Newland-Wallace, and their included basic sills. The structure of this range is anticlinal, and part of the west limb of the main anticline is shown in this part of the range. The beds are flat-lying at the crest and dip steeply southwestward near the Moyie (Lenia) fault. Other structural boundaries of the range lie outside of the county.

Another minor range of the Purcell is the Moyie Range, which lies mainly in Canada but extends into this county as far south as Round Prairie fault and its valley. This range, chiefly made up of eastward-dipping Aldridge-Prichard (in this county), is bounded on the east by the Moyie (Lenia) fault and on the west by the Kootenai fault and the Purcell trench. Its northern boundary lies in Canada. In this county it contains three (possibly four) minor north-south faults which have disturbed the Aldridge-Prichard and have protected a small wedge of Creston-Ravalli (?) at one place.

Purcell Trench.—This depression, which separates Moyie Range from the Selkirks in the northern part of the county and the Cabinet Range from the Selkirk Range for the rest of its length in the county, extends without interruption as far south, according to Calkins[1], as the south end of Lake Coeur d'Alene. This is a distance along the line of the trench of more than 100 miles from the point where it leaves the southern boundary of this county. According to Daly[3] the Purcell trench extends for more than 175 miles into Canada, which with a length of forty miles in Boundary County, gives the trench a total length of at least 315 miles. To the south of the county, the trench reaches a width of nine miles and at one place within the county it becomes less than one mile across. The average width for its entire distance is between 3 and 4 miles. (Pl. I., Frontispiece, and Pl. VIII., p. 52.) The trench is occupied by Kootenay and Coeur d'Alene lakes and part of Lake Pend Oreille as well as many smaller lakes and swamps. Kootenai, Spokane, and Pack rivers, and several creeks, use this depression for a few miles each.

The present elevations of the lake surfaces in this trench range from about 2000 feet above sea level at the southern end to below 1750 at its northern extremity. The trench bottom is probably nearly 500 feet deeper in the larger lakes. The relief afforded by this depression is most notable, flanked as it is at many points on either side by ranges towering to altitudes of nearly 8000 feet.

The flat bottom of this depression, where not now occupied by lakes and swamps, is covered with fluvial and lacustrine deposits. All tributaries are marked either by hanging valleys or deltas.

The walls of that part of the trench lying in this county are made up of the Aldridge-Prichard quartzite with included sills, or granite batholithic intrusions. The rocks of the Belt series strike in a direction which cuts across the trench in this area. The sediments also have a cross-cutting relation, both north and south of this area. The origin of the trench is disputed. Schofield[14] says concerning its origin: "The region now traversed by the Purcell trench was peneplained in the Cretaceous, uplifted in the early Tertiary and the Purcell trench was eroded by one of the rejuvenated Cretaceous rivers during Tertiary times. No uplift is recorded in Tertiary or recent times. The Tertiary valley was glaciated in Pleistocene times, giving rise to the facetted spurs and hanging valleys so prominent in the architecture of the Purcell trench." Schofield[14] thinks no fault is necessary to explain the presence of this great uninterrupted depression. Daly[3] postulates the formation of the trench by faulting and suggests that it is a graben* with faults along each valley wall, and that the trench has been glaciated in Pleistocene time. Calkins[1] says that he and Ransome found some evidence that the trench had been determined by a great fault with the down-throw on the east. They thought the beds to the west of the trench to be Archean and separated from the Prichard on the east by the fault. Daly[3] also believed the rocks to the west of the trench to be pre-Beltian and postulated a downthrow of 30,000 feet in his fault.

The writers found much evidence of a major fault, but believe the sediments on both sides of the fault are Aldridge-Prichard beds. This fault will be discussed in detail as the Kootenai fault. Lobes of the Pleistocene continental glaciers intruded this depression and left hanging valleys, and truncated the spurs in some places for an estimated distance of two miles, and it appears evident that glaciation is entirely responsible for the width and depth of the trench and its present physiographic characteristics.

Kootenai Fault.—Evidence of a major fault in this area, extending from the boundary line south as far as Bonners Ferry, was discovered by the writers. The fault line, as shown upon the map, follows the trend of the meandering Kootenai, whose meanders, of course, are very recent and were developed on the flat-bottomed valley of low gradient developed by the last glacial invasion. The fault zone probably extends farther to the south but the presence of granite on both sides of its projected strike, partly covered by lacustrine deposits, makes proof difficult.

*For the benefit of the layman: A graben is a section of the crust separated by faults from adjacent areas known as horsts which have been relatively elevated.

In the northern part of the area the Aldridge-Prichard beds on the west wall of the trench strike several degrees east of north and dip about 20° to the northwest. Evidence of these beds extends out to the river where occasional rock outcrops, of a size too small for mapping on a reconnaissance map of this scale, project out of the alluvium. To the east of the river nearly flat-lying basic sills are exposed in small knobs. These sills are part of the Aldridge-Prichard formation which makes up the trench wall on the east. The Aldridge-Prichard, and included sills, strikes several degrees west of north and dips N. 12°-15° E.

The rocks on the west wall are highly schistose, but no sills corresponding to those observed on the east side were discovered, although the sills should appear on the west if the trench were cut along the crest of a wide gentle anticline in the Aldridge-Prichard formation. The discordant strikes and dips, the absence of similar sills on the west side, and the abrupt contact of the nearly flat basic sill east of the river with the western schists, all point to fault relations with he down-throw on the east side. Major structural considerations, however, point on the other hand to the likelihood of this being an overthrust with an easterly dip.. From Copeland south to Bonners Ferry, the schists and quartzites to the westward extend into the valley for a distance similar to those farther north. On the east is found a granitic batholithic intrusive whose continuous straight-line contact with the metamorphosed Aldridge-Prichard suggests a fault. The strike of the western rocks varies from northwest to north at this point and the dip to the west and northwest steepens in places to 80°. On the eastern valley-wall the Aldridge-Prichard formation and the sills continue to strike west of north and dip from 30° to 40° to the northeast. These continued discordant dips and strikes offer further persuasive evidence of faulting. Similar evidence, but not so conclusive, extends southward to the county line. The fault, if it exists, has an estimated down-throw of probably 3,000 feet or more to the east, and probably has a close genetic relationship with the long batholithic mass east of the Kootenai River and Deep Creek.

Round Prairie Fault.—This is an east-west fault which separates Moyie Range from Cabinet Range. It has formed a depression, since glaciated, which is known as Round Prairie. The down-thrown side

appears to have been on the south and a horizontal movement of about three miles may have occurred here. There seems little doubt that the two sills exposed east of Port Hill are the same two exposed on the east valley wall south of Mission Creek. These latter sills stop abruptly in Round Prairie Valley. The block north of Round Prairie contains three faults shown on the map and possibly another one paralleling the course of Upper Mission Creek. The Aldridge-Prichard is probably duplicated here but the absence of sills to serve as horizon markers made this fault too doubtful to map. The Round Prairie fault appears to be normal and the vertical throw is probably not less than a thousand feet.

Moyie (Lenia) Fault.—Calkins[1] shows his Lenia fault, in this area, extending from the Montana boundary line along the course of the Kootenai River to a point near where the river changes its course and flows west. From there he tentatively projects it to near the mouth of Moyie River near Moyie Falls. He also shows a fault about three miles long at the Canadian boundary striking nearly north and south. On both of these faults he places the down-throw on the east side where the younger beds are exposed.

The writers had no difficulty in connecting the two faults of Calkins. Beds of discordant dips and ages are obvious for the entire distances. The fault at the Canadian boundary recognized by Calkins[1] was also described and mapped by Daly[3] and Schofield[14]. The latter geologist named it the Moyie fault and traced it for a distance of 43 miles in British Columbia to the valley of the Kootenay River east of Cranbrook. Although it dipped steeply, he found it to be an overthrust fault with the overthrust block on the west. The total length of the Lenia fault, in Idaho and Montana, as mapped by Calkins[1] is about 30 miles. An additional length of 17 miles along the Moyie River in this area is given by the writers. The fault, which follows the general course of the Moyie River throughout Boundary County and much of British Columbia, is thought by the writers to be more properly named the Moyie (Lenia) fault. This steep overthrust fault has a total traced length according to Schofield[14], Calkins[1], and the writers, of 90 miles. It describes a wide arc in British Columbia, Idaho and Montana, and approximately 26 miles of this length lies in Boundary County. At the Canadian boundary the Aldridge-Prichard rocks strike west of north and dip from 45 to 50 degrees to the fault on its western side. Creston-Ravalli rocks striking north and northeast dip 60° or more to the fault on the eastern side. The entire western side of the fault in Idaho is made up of Aldridge-Prichard beds and sills dipping from 50° to 60° to the fault. From the Montana line to a point west of Perkins Lake, the east side of the fault in Idaho is made up of Kitchener-Newland-Wallace beds dipping 50° to 60° to the fault. From this point north to the Canadian Boundary, the Creston-Ravalli lies on its eastern side and dips from 50° to 60° S. W. The vertical throw in the southern part, according to Calkins[1], is more than 15,000 feet and according to estimates of the writers may be nearly 18,000 feet. The horizontal overthrust is probably not one-third of this distance. This fault has influenced the course of the Kootenai River for several miles and controlled the course of the Moyie River for much of its length. Its entire course has been glaciated, thus eliminating any notable physiographic features due to faulting.

Upper Priest River Unconformity.—Along Upper Priest River the coarse sandy conglomerate and overlying lavas tentatively called the Siyeh and Purcell lava, respectively, which are situated west of the stream, appear to lie in angular and erosional unconformity on the rocks east of the stream. These rocks, the writers have tentatively assigned to the Creston-Ravalli group. A great erosional or depositional hiatus occurred here if these assumed age relations are correct. Between ten and twelve thousand feet of Creston-Ravalli and overlying beds are missing. Either these were not deposited or they have been eroded. Evidence points to the latter. Much material in the Siyeh (?) appears certainly to have been derived from rocks very similar to these missing members. The attitude of these beds is shown in the structure section D. D. on the map, Plate III. (in pocket.) For several miles the course of Upper Priest River has been controlled by the unconformity.

IGNEOUS GEOLOGY.

BATHOLITHS.

Part of the Nelson batholithic mass lies in the central and western part of the county. Four outlying cupolas have been uncovered in the eastern part of the area and two are exposed in the northwestern part. The magmatic intrusion which is believed to have occurred during Mesozoic (Cretaceous ?) times is now exposed chiefly as granodiorite, quartz-monzonite and granite. All of these are, of

course, assumed to be differentations from a common magma possibly dioritic in composition.

In the field the rock shows a uniform light grey and pink color and at every place observed, excepting the cupola at Bald Ridge, showed large phenocrysts of pink and cream colored orthoclase feldspars. (Pl. VII., p. 50.) Phenocrysts as long as two inches were common and Carlsbad twinning appears often. The plagioclase feldspar which generally is oligoclase, albite, or both, shows striations, and is white in color. Quartz is generally abundant throughout the areas observed. Biotite and hornblende occur in small quantities. Microcline and similar orthoclase types were observed as minor minerals in some specimens. The most notable field characteristic of this igneous rock is its porphyritic appearance caused by the immense orthoclase phenocrysts. Jointing is very common throughout most of the masses. These joints are commonly occupied by pegmatitic and aplitic dikes. (Pl. IX., p. 56.) Few basic dikes were observed. It is believed that this intrusion, which is undoubtedly part of the Nelson batholith, may serve as a correlation link with the Idaho batholith to the south, which also has a similar porphyritic feldspar phase at many localities, as well as a similar mineralogical content. An aureole of gneissic and schistose material with an average thickness of about 500 feet is commonly found as a transition phase. A few circular expanses of this material, at a distance from the main intrusion, indicate areas underlain at a short distance by cupolas. Contact metamorphism is apparently greater at the roof than at the sides, on account of the presence there of more magmatic gases and altering agents. The batholith in this county has been eroded to the fourth horizon or embatholithic stage of Emmons*. In this area molybdenum is the only metal found in commercial quantities in the main granite mass.

SILLS.

The Moyie Sills described by Daly [3, 4] and Schofield[12, 14] and mentioned by Calkins[1] are abundantly represented in this area. All of the sills observed east of the Purcell trench are represented on the geologic map. Throughout the text these sills have been referred to as basic igneous sills. An attempt will now be made to describe them in more detail.

*Emmons, W. H., The Relations of Metalliferous Lode systems to Igneous Intrusives, No. 1571-I. Trans. A. I. M. E. June, 1926.

These sills are distributed generally throughout the lower part of the Belt (Purcell) series and are particularly abundant in the Aldridge-Prichard formation, in which 14 different sills were observed. The Creston-Ravalli group of formations showed three sills. These sills are believed by the writers to extend several miles into Canada, as well as into Montana, and Bonner County, Idaho, to the south. Highly metamorphosed remnants of these sills are believed to have been discovered in the Aldridge-Prichard lying west of Purcell trench. The thickness of these great, injected, tabular, igneous masses ranges in this area from 30 to 2000 feet. One sill is exposed for 34 miles within the county and is faulted at the north, where its offset extends for 5 1-2 miles more before entering Canada. Because of their superior resistance to erosion they generally are exposed in ridges, peaks or cliffs.

The lithology of these sills is variable but their main mass is made up of altered gabbro and diabase changed in many places by uralitization to a dioritic type.

Gravitational differentiation and magmatic segregation have produced, in a few instances, zones of quartz diorite and granite. The granite zone, where present, is always in the upper part of the sill and the quartz diorite seems to be a transition zone between it and the uralitized gabbro. The texture varies from holocrystalline to fine-grained in the thick sills and is sometimes porphyritic in the thinner intrusions.

The original augite of the gabbro is nearly all changed to a greenish-black hornblende in most places. Lath-shaped labradorite feldspar is second in abundance. Augite and hypersthene are minor minerals as the rock is now constituted. Magnetite, pyrite, pyrrhotite and chalcopyrite are present as accessory minerals in the basic sills. A little quartz and apatite are the other minor minerals in the basic phases. Long pegmatitic segregation zones often occur in the larger sills, but these are only streaks parallel to the contact, which do not fill cracks, joints, or fissures. According to Schofield[12, 14] the thickness of the granite zones in the upper part of the sills does not bear any relation to the thickness of the entire sill.

The sills were intruded into the flat-lying Belt (Purcell) series and have consequently taken part in all the folding, faulting and orogenic movements which built the Cabinet and Purcell ranges.

The stratification of some of the sills, which now stand at an angle of 60 degrees, makes certain that the segregation occurred in a flat-lying position. Columnar jointing perpendicular to the cooling surfaces was observed in thick sills. Metamorphism on upper as well as lower contact is obvious. Schofield[14] finds the stratified sills similar to those of Shonkinsag, and finds in them many characteristics which resemble those of the gabbro sills of Skye.

The contact metamorphic effect is much less than one would expect because the host rock in nearly all cases consists of the quartzitic Aldridge-Prichard or Burke. In no case did the writers see a contact zone more than five feet wide. It sometimes is less than one foot in width. The sills are checker-boarded and crossed by cooling or strain fissures at varying angles. These are commonly filled with white massive quartz veins which often contain iron-bearing sulphides. These veins were never observed to extend into the invaded rock.

The sills do not intrude any rock in this area younger than the Creston-Ravalli group. Daly[3] describes them as intruded in the Siyeh formation east of this area where they are in close association with the Purcell lava. The sills and Purcell lava are considered by Schofield[12, 14] to be of Beltian age. This is the age assigned by the writers.

One of the sills in this area is thought to be 2000 feet thick, two others measure 1500 feet, and two more are 1000 feet through. The total thickness of the separate sill injections in this county is estimated to be not less than 10,000 feet. The sills as now exposed take part in all the structural movement credited to the Belt Series under the section on structure.

It appears evident that two magmas, differentiated in a single reservoir, contributed the material for both the Moyie sills and the Purcell lava. The reservoir was probably gravitationally stratified and the more acid material produced the sills in which stratification now appears and a pure basic magma furnished the sills which are now entirely basic. Both acid and basic flows are found in the Purcell lavas with the acid flows, of course, subordinate to the andesites and basalts.

DIKES.

Dikes in the Belt (Purcell) series were observed at only three places in the area. At all places they were lamprophyres, and of small extent and thickness. In the two areas where they were associated with ore-bearing veins they were post-mineral and appear to have had no

influence on the mineral deposit. At the other locality the dike appeared as an offshoot from an intruded sill.

Although many aplite and pegmatite dikes were observed in the granite areas, basic dikes appear to be few and small.

LAVA FLOWS.

The Purcell Lava (?).—In the extreme northwestern part of the county west of Snowy Top Mountain crops out a thick series of basic lava flows. These are called by Daly[3] the Irene volcanic formation, of Lower Beltian age. Only a narrow wedge of their outcrop lies within the boundaries of this county. Daly[3], who has examined them in greater detail than the writers and over a larger area, gives the section as follows:

Top,	Conformable base of Monk formation.
50 feet,	Greenstone schist, a crushed basic amygdaloid.
200 feet	Angular conglomerate or breccia with phyllite cement.
1,710 feet,	Greenstone schist with a few thin bands of phyllite toward the top.
40 feet,	Gray to white, fine-grained dolomite.
4,000+feet,	Sheared and greatly altered basaltic and andesitic lavas largely greenstone schist.

Daly[3] states that the metamorphism is so great as to mask the flow contacts and to have destroyed all the original magmatic minerals except plagioclase and a few iron minerals.

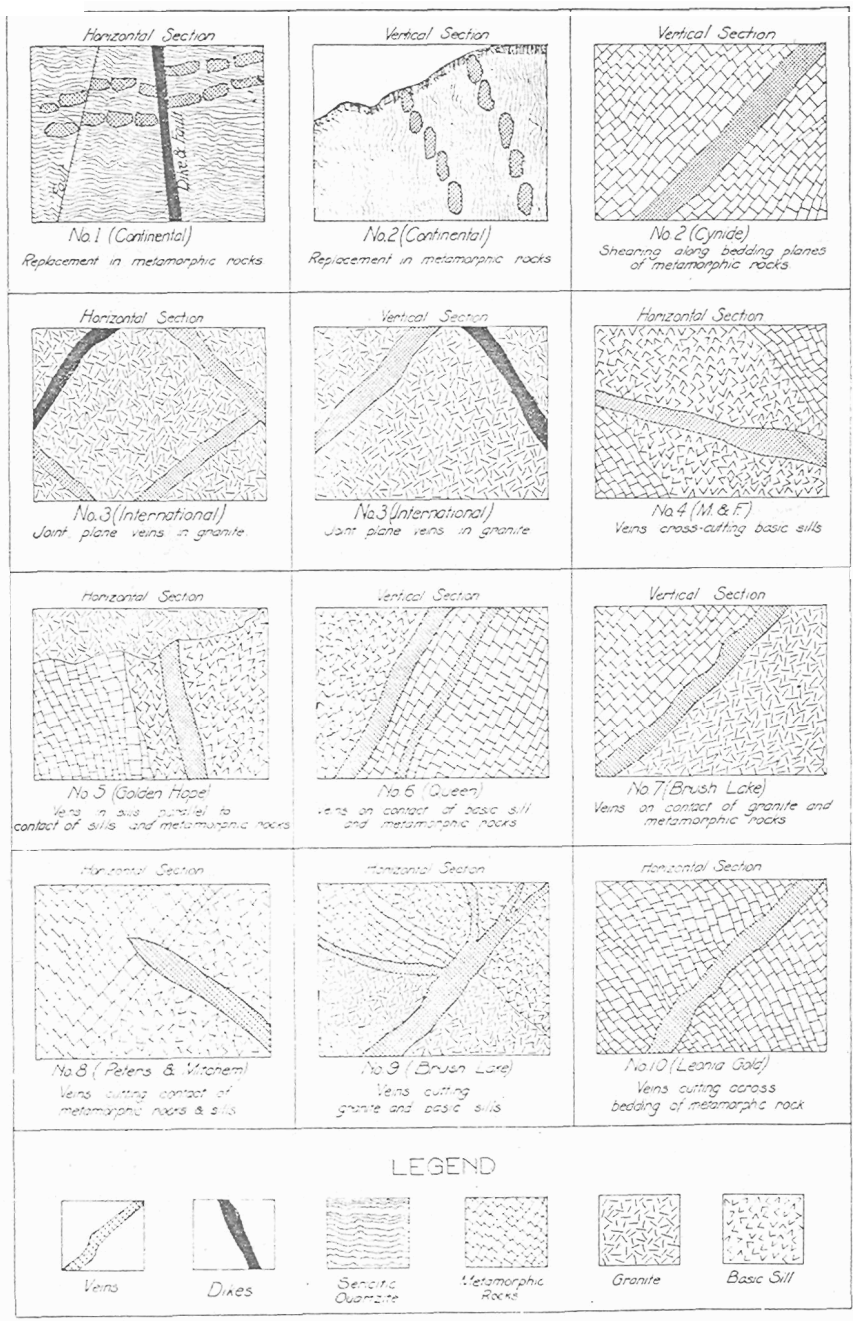
The lavas also contain several beds of tuff, and the limestone, according to Daly[3], is very similar to one in the Siyeh. Daly believes that there is no doubt from his examination of the interbedded conglomerate that the pebbles are derived from the rocks lying east of Upper Priest River. The total thickness of this lava series is nearly 6000 feet in this area.

The Purcell lava, described by Daly[3], in the McGillivray Range is 465 feet thick and chiefly amygdaloidal basalt-andesite highly metamorphosed and essentially a greenstone. It includes 40 feet of tuff and breccia. Schofield[14] finds 600 feet of lava in this range. In the Galton Range the lava is 390 feet thick, with similar characteristics and a band of coarse tuff and breccia 40 feet thick. In the Clarke Range the thickness of the Purcell lava is described as 260 feet. In the Lewis Range farthest to the east it has a total thickness of only

58 feet. It thus appears that the Purcell lava thickened to the west. The number of flows also increases to the westward. The Siyeh formation underlying it has some lithologic similarities to the Irene conglomerate of Daly[3] and also has a comformable intercalated relation with the lava such as is found in the Irene conglomerate.

Lithologically the Purcell lava and the Irene volcanic lavas are very similar. The greatest disparity is in thickness. The thickening toward the west in the four eastern ranges favors the thickness of the Purcell lavas in the Selkirk Range.

The writers believe the "Priest River Terrane" of Daly to be Aldridge-Prichard and Creston-Ravalli of the Belt-Purcell series. With Daly[3], the writers believe that the conglomerate of Daly's Irene volcanics, as well as the Irene conglomerate, contains pebbles from the "Priest River terrane" beds, which both Daly and the writers concede to be older. If Daly's Priest River terrane is Beltian then the Irene volcanic formation is the Purcell lava. The writers wish tentatively to assign this name to the formation.



TYPES OF VEINS IN BOUNDARY COUNTY, IDAHO.

VEINS.

ORIGIN AND RELATIONSHIP TO ROCKS.

Veins of ten different types have been recognized in the area, and an attempt to list them in the probable order of their economic importance is made here. But because the district has so many apparently different types, although only one or two examples have a proven value, it is difficult to be positive in this order of arrangement. On first thought, the relative importance of a vein-type might appear to depend on the number of prospects showing that particular type. On the other hand, the number of prospects of any particular type, coupled with the lack of any known commercial ore bodies, might be an argument for placing that particular type of vein lower in the scale of importance, on the ground that such veins of like type would have been attacked at many elevations and positions, thus increasing the possibilities of encountering commercial ore-bodies had any been present. One large producer, however, might quite as readily establish the importance of a single vein type. The ten types of vein recognized were:

1. Replacement ore-bodies in metamorphic rocks.
2. Shear-zone deposits along bedding planes of quartzite.
3. Joint-plane veins in granite.
4. Veins cross-cutting basic sills.
5. Veins within sills and parallel to contact of sills and metamorphic rocks.
6. Veins along contact of basic sills and quartzite.
7. Veins along contact of granite and quartzite.
8. Veins cutting contact of quartzite and sills.
9. Veins cutting granite, quartzite, and basic sills.
10. Veins cutting across bedding of quartzite.

The first three are distinct types within themselves, the latter seven have a similarity in that they are all veins whose walls show little or no movement. It might be well to state here that a detailed study was possible only in the replacement and shear-zone type of veins because for the most part the other types were undeveloped. None of the types shows any evidence of contact metamorphism, with the possible exception of the replacement deposits and veins containing the mineral scheelite, the tungsten-bearing mineral.

REPLACEMENT ORE-BODIES IN METAMORPHIC ROCKS.

The best example of the replacement type of deposit is afforded by the Idaho Continental Mine at Klockman. The country rock is sericitic quartzite of the Creston-Ravalli group. This deposit lies approximately a mile northwest of the granite batholith which forms the greater part of the Selkirk Range in Boundary County. A large granite cupola again outcrops a mile or less to the northwest and another cupola shows hardly more than half a mile to the northeast. The latter cupola, however, has a rather limited extent and is entirely surrounded by metamorphic sediments. In other words, the quartzitic area in the vicinity of the property is approximately two miles wide measured across the bedding and, as may be seen by reference to the map (Plate III. in pocket), is largely in the nature of a roof-pendant. The formation strikes northeast and extends for several hundred yards.

The ore deposit was formed by a replacement which followed the bedding of the rock. In the vicinity of the "red" vein the country rock is very light colored but farther away the rock is a much darker shade of bluish-gray. This would suggest hydro-thermal or pneumatolytic action on the country rock at the time of mineralization. The bedding dips 75° to 90° southeast, thus exposing the edges of the beds on the surface and affording an excellent opportunity to note the change in the color of the country rock as one approaches the "red" ore body. Field evidence points to contact metamorphism of sericitic shales followed by pneumatolytic action accompanying ore deposition. Such action probably would take place along the slightly broken-up zone near the center or longitudinal axis of the roof-pendant. The above discussion does not apply to the "black" ore body.

Specimens of the light-colored rock accompanying the ore, and of the more distant bluish-gray rock, were studied under the microscope.

The dark rock showed a considerable amount of magnetite, some of which appeared to be titaniferous, since a small amount of leucoxene was noted. The specimens seemed to be made up largely of sericite whose crystals showed a definite flow structure except near the magnetite. Apparently the magnetite was so hard that the crystals could not conform to the flow structure near it. The dark rock also contained a small amount of quartz and biotite mica.

The magnetite and sericite may be the result of contact metamorphism between the quartzite and the large granite intrusion. If this be the case, it is not at all unlikely that all the sedimentary rock in the vicinity of the granite is altered.

The light-colored rock from the vicinity of the ore-body contained a considerable amount of sericite which showed the same flow structure as the dark rock. The light rock also contained a small amount of quartz and no little amount of pyrite in the form of well developed crystals which were distributed throughout the mass. There seemed to be little or no magnetite or biotite. From this it would seem that hydrothermal action had accompanied ore deposition or at least followed the same course through the rock.

SHEAR-ZONE DEPOSITS ALONG BEDDING PLANES OF QUARTZITE.

The shear-zone type of deposit was found in three rather widely separated parts of the district. The width of veins varied from six inches to a maximum of five feet. The most important vein and at the same time the one most developed, namely, that at the Cynide Gold Mining property, varied in width from 1½ to 4 feet, with the actual zone of shearing probably a foot or so wider. The shearing appeared to be due to normal faulting.

This type of vein occurs along the bedding planes of the quartzite, occasionally cutting one or two thin beds diagonally but in the main holding to the strike and dip of the bedding.

The upper part of this type of vein shows very little quartz. The quartz appears to come in small bunches here and there throughout the vein. Accompanying the quartz is generally found pyrite. With depth, a small amount of galena appears with now and then some sphalerite. No siderite was noted. Gold and silver are present but their occurrence is sporadic.

JOINT-PLANE VEINS IN GRANITE.

With but one exception, to be noted later, these appeared to be pegmatite vein-dikes occurring along joint planes in the granite. Most of them are a more acidic phase than the enclosing country rock. They vary in thickness from a mere crack to three feet. One prominent series of these veins occurred in the large granite batholith comprising the Selkirk Range. They seem quite persistent. Two sets of these veins had the same strike but dipped some 60° from the horizontal in

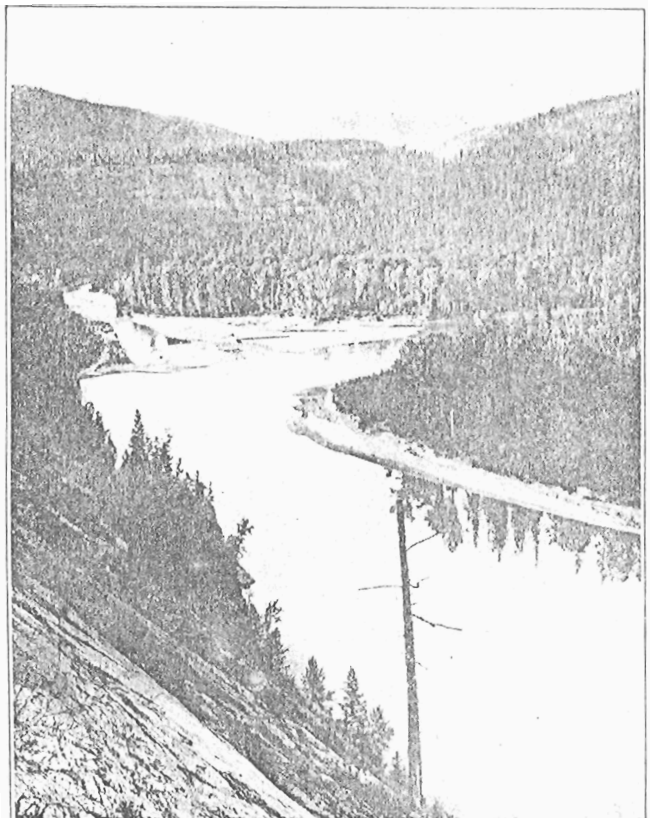
opposite directions. A third series of these veins dips at about the same angle but has entirely different strike. All of these divergent dips and strikes conform to typical joints and shrinkage cracks formed in batholithic masses. One of the fractures, which paralleled in strike a prominent molybdenite-bearing pegmatite vein, but which dipped away from the pegmatite vein, was occupied by a basic dike about two feet wide. The dike on the surface was but a few hundred feet from the vein. However, as both could be traced for a considerable distance on the surface, it is not unlikely they extended to considerable depth. In view of the divergent dips, it is not unlikely that these two fissures tapped reservoirs which were themselves a great distance apart and this may account for the difference in their filling. Another explanation might possibly be that segregation had taken place on a grand scale in one big underlying reservoir tapped by both fractures. In this way one fracture might be filled with basic dyke material while the other was being filled with the acidic material. Molybdenite and molybdite were the economic minerals in this type of vein.

FISSURE VEINS IN OR ADJACENT TO BASIC SILLS.

Under this heading will be discussed the remaining seven types of veins, namely:

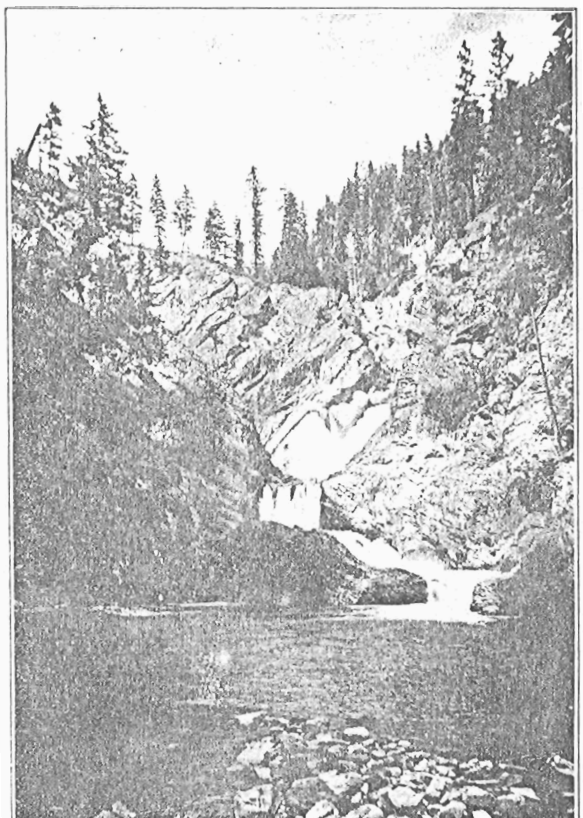
4. Veins cross-cutting basic sills.
5. Veins within sills and parallel to contact of sills and metamorphic rocks.
6. Veins along contact of basic sills and quartzites.
7. Veins along contact of granite and quartzite.
8. Veins cutting contact of quartzite and sills.
9. Veins cutting granite, quartzite, and basic sills.
10. Veins cutting across bedding of quartzites.

These are all listed under the same general heading since they have a marked similarity in that they are all of the fissure-vein type. The fissures, however, were probably formed under varying conditions. Probably the greatest forces that produced fissuring were stresses set up by shrinkage of the basic sills. If such were the case one might expect to find this type of vein striking in any direction. It would not be unreasonable, however, to expect those veins which occur in the narrow sills to run crosswise of the sill and those veins occuring in the wide sills to run not only crosswise but in any direction with



JUNCTION OF KOOTENAI AND MOYIE RIVERS.

Kootenai river in foreground and Moyie river at left center of picture. Old lake bed terrace seen in middle distance. Moyie range in background.



MOYIE FALLS.

These falls on the Moyie River are formed by a resistant basic igneous sill. The strata dipping to the right are seen underlying the massive sill in the center of the picture.

respect to the strike and dip of the sill. This theory is advanced because the wider the sill the more material there would be to contract with resultant fissuring in any direction. Furthermore, any fissuring that took place parallel to the contact of the sill with the adjacent rock might actually take place on the contact itself, since that would be a natural plane of weakness.

The veins within the sills and parallel to the contact are probably caused in thick sills by rapid cooling on contacts and slow cooling in the interior.

The actual extent of these veins is not known, for the total amount of development on any one of them is meagre. They vary in width from a few inches up to twelve or fourteen feet. The average range is from two to six feet.

With one or two exceptions, there seems to be no evidence of contact metamorphism. In the case of the exceptions, contact metamorphism has apparently taken place following the later granitic intrusion. The filling seems to be largely a hard quartz with little or no movement either in the vein or between the vein and its enclosing walls. Small quantities of gold-bearing sulphides occur throughout these veins.

Those veins which cut the contact of quartzite and basic sills seem to be greatly in the minority. They appear to be strongest in the basic sills and to finger out in the quartzite. This is what one would expect if the fissures were due to shrinkage stresses. The fissuring would progress into the metamorphics only a very short distance, if at all. Any force sufficiently great to cause fissuring of the quartzite to any extent, would probably be independent of the contraction of the adjacent igneous rock but would be likely to take place along the smaller crack which would constitute a plane of weakness.

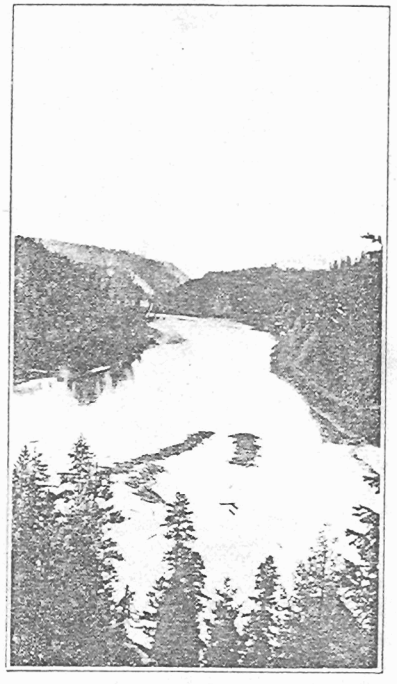
In only one or two instances were these veins explored along their strike for more than a short distance. Likewise in only one or two instances were they opened up in depth for more than a few feet. Development has been conducted only by assessment work methods —a practice resulting probably from failure to strike any commercial ore-bodies. With the considerable number of these veins throughout the entire field wherever the basic sills occur, it seems that a few commercial ore-shoots should have been discovered even with the comparatively limited amount of work that has been done on them. Certainly the horizon of attack has not been limited, for within the

entire field there is several thousand feet of difference between elevations of some of the properties.

MINERALS.

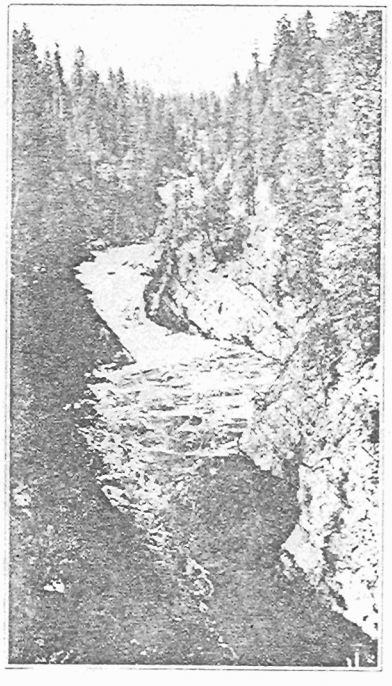
The principal economic mineral of the district is galena in close association with a silver-bearing mineral which is probably tetrahedrite. The galena varies in crystal structure from fine-grained to very coarse.

Gold is found in placer deposits and scattered along some of the streams. The size of the gold particles ranges from fine to medium coarse. Gold is also found in some of the sulphide-bearing veins. These veins show pyrite, galena, and minor quantities of chalcoyprite, sphalerite, and pyrrhotite. It is believed the gold occurs chiefly with the pyrite. Other minerals of possible commercial importance are molybdenite and molybdite, the molybdenum sulphide and oxide respectively. These two minerals are found associated with a brown, glassy quartz. Another important mineral of potential value is scheelite, the tungstate of calcium. Pyrite, pyrrhotite, arsenopyrite, sphalerite, and chalcopyrite, are found in minor quantities scattered throughout the veins in the basic sills. These minerals are sometimes found together in small bunches throughout the vein and may be accompanied by small quantities of galena. Quartz, calcite, siderite, pyrrhotite, and pyrite, are the chief gangue minerals. Garnet, actinolite, enstatite, and hypersthene are recognized in the contact metamorphic deposits. Some of the pyrrhotite found in the district is nickel-bearing.



KOOTENAI RIVER.
Gorge showing glaciated rock terraces in eastern part of area.

"SHEEP-BACK" ROCKS.
These "Roches Moutonnees" resulting from glacial erosion are common in the granite Selkirks.



MOYIE RIVER.
Turbulent stream flowing south

GORGE IN MOYIE RIVER.
Contact of underlying sill and easterly

ORE DEPOSITS.

Most of the metalliferous lode ores are genetically related to batholithic intrusions. These are great masses of igneous magma which invade the country rock of a region and extend with steeply inclined sides to an unknown depth. The magma cools to igneous rock and is later exposed at the surface in areas and patterns which vary with the degree of erosion. Batholiths are generally believed to be originally intruded as masses which are either basic or intermediate in composition but which, during the slow cooling operation, are differentiated by various processes into well-known more acidic rock types.

The lode ores are believed to be given off after the differentiation is well on its way and the larger number of lodes are associated with granodiorite, quartz monzonite, or granite phases. In recent years the association of lode ores with batholiths has received much study and very recently Emmons* has divided these ore occurrences into six groups, depending on their vertical and horizontal positions with respect to the batholithic intrusive. Each group corresponds to an erosion horizon in the batholith. In the first one the batholith is as yet unrevealed, while in the sixth stage it is cut to the core. The Coeur d'Alene district would fall in the second or acrobatholithic group, where the ore deposits occur on top of the batholith in or near cupolas or domes. In contrast with that stage, the Boundary County area would occur in the fourth or embatholithic group wherein erosion has advanced so far as to cut well into the main batholith and reveal subordinate large masses as well as many cupolas, domes, stocks, or bosses. The ore deposits in such a state are most likely to occur between the closely spaced igneous outcrops.

It is also fairly well established that the common and well-known metals have a vertical range of occurrence. This means that certain metals appear always to be deposited farther away along the vein from the parent intrusive than others. Molybdenum for example is lower than copper, which is in turn lower than zinc. The latter mineral generally underlies and overlaps lead, which is lower than or adjacent to silver, etc. Corroborative evidence for this depositional scheme, as well as the embatholithic relationship suggested by Emmons, is found in this county.

*Emmons, W. H., The Relations of Metalliferous Lode Systems to Igneous Intrusives. No. 1571-I. Trans. A. I. M. E. June, 1926.

LODE ORE DEPOSITS.

LEAD-SILVER ORES.

In 1925, lead in the form of galena was being profitably produced in only one part of the county. Silver occurs with the galena in a direct ratio of 0.35 to 0.40 of a troy ounce of silver per ton to the per cent or "unit" of lead. Pyrite and siderite are present in varying quantities. Little quartz is in evidence with the ore, and for the most part the particles of galena are coarse and easily broken along the cleavage planes. In addition, the ore contains a small amount of sphalerite. The ore occurs in the replacement type of vein and is by far the most important deposit of the district yet known. This type of deposit is best seen at the Idaho Continental Mine in the northwest corner of the county. It is not unlikely, however, that similar deposits may be opened up to the west and southwest of the Idaho Continental in similar formation.

At the Idaho Continental, the ore bodies occur in large kidneys with their axes parallel to the strike of the formation and dipping roughly parallel to the bedding. (Pl. IV., p. 41.) They also have a very flat angle of pitch to the northeast. The ore has a tendency to zigzag back and forth as it follows the various cleavage planes and cross-cracking. This "stepping-over" of the ore gives somewhat the appearance of an ore body cutting the bedding. (Pl. XIII., Figs. A and C.) The size of the kidneys of ore, coupled with the fact that the formation has a very steep dip, renders the orebody readily worked by open overhand stoping. The stopes remain open for a long period after the ore has been extracted. (Pl. XI., p. 61.)

Although several other properties throughout the county show small quantities of lead-silver ore, none has been sufficiently developed to assure commercial production.

GOLD ORES.

Gold, together with whatever silver may be alloyed with it, is found in the shear-zone type of vein in quartzite as well as in the veins of the basic sills.

The best example of the shear-zone type of vein so far developed is found at the Cynide Gold Mining Company's property on Buckhorn Mountain. The shearing has taken place along the bedding and only occasionally does it cross the bedding, and then at such a small angle at to give the impression of shearing only between the bedding. The gold is free and quite fine and seems to be associated with the iron sulphides which, of course, appear in the upper parts of the vein. There is evidence for believing that the gold will decrease with the iron sulphides at depth and give way to the sulphides of lead and zinc, with accompanying silver. There is comparatively little quartz in the vein except near the apex where it is honeycombed. There is little evidence of post-mineral movement.

Gold is also found in an 18-inch gouge seam between the bedding planes in the quartzite on Queen Mountain. This was in the Queen Group of the Moyie Gold Mining and Milling Co. The seam is 130 feet from and parallel to a vein on the quartzite-diorite contact. As the seam was exposed only by the perimeter of a cross-cut to the contact vein, sufficient evidence was not obtained to determine its importance.

Free gold was also panned from a massive quartz vein occurring in a basic sill on Boulder Creek. This vein was the property of the Boulder Gold Mining Co. The vein ranged from a few inches up to five feet in a comparatively short distance and the gold seemed to be irregularly distributed. No other minerals were observed. This vein is one of the typical veins in the basic sills approximately paralleling the quartzite contact. The contact was not found but float indicated its presence at no great distance from the vein.

All of the veins in or connected with the basic sills have apparently derived their gold from the sills themselves. The reasons for arriving at this conclusion are: First, that the sill rock was found to contain pyrite and pyrrhotite carrying gold in extremely small amounts; second, that the sills are unmistakably of Beltian age and are therefore pre-batholithic. These two facts point to a magmatic segregation of gold-bearing sulphides within the sills themselves, since the veins are not sufficiently continuous in any direction to have obtained their mineralization from an exterior and later source.

MOLYBDENUM ORES.

Molybdenum occurs in the pegmatitic veins along joint planes in granite. The pegmatite consists chiefly of smoky, glassy, quartz and mica with the metal occurring as the sulphide, molybdenite, as well as the yellow oxide, molybdite. There has been too little work done on these veins either laterally or at depth to permit judgment as to the probable extent of mineralization. The largest showing of this

metal is found at the International Molybdenum Company's property in the Phoebe Tip country. Molybdenum was also found in the granite area near Brush Lake a few miles east of Copeland. From the showing, one is justified in saying that the deposits have economic possibilities.

TUNGSTEN ORES.

Tungsten in the form of scheelite occurs at the M. & F. property formerly the Tungsten Hill, in the Queen Mountain district, in fissure veins in a large basic sill. A short distance from the property the sill contacts with granite. This granite is part of the Queen Mountain cupola. The main vein is from 5 to 6 feet wide. It strikes nearly east and dips 70° N. This vein comes under the class of veins cross-cutting basic sills. Another vein on an adjoining claim runs approximately north and dips some 60° E. It comes under the class of veins parallel to contact of basic sill and quartzite but lies wholly within the sill. This vein has been prospected only to a limited degree.

The face of the drift on the main vein showed massive quartz with scheelite, specks of galena, pyrite, pyrrhotite, and green copper stains. A sample by Professor D. C. Livingston[7] taken across a 5½ foot face showed an average assay of 1.09 per cent WO_3

Scheelite forms under conditions of high temperature and pressure and is considered a contact metamorphic product. This fact, together with the presence of several other typically contact metamorphic minerals, such as garnet, actinolite, enstatite, and hypersthene, and the proximity to the granite, suggest a contact metamorphic origin.

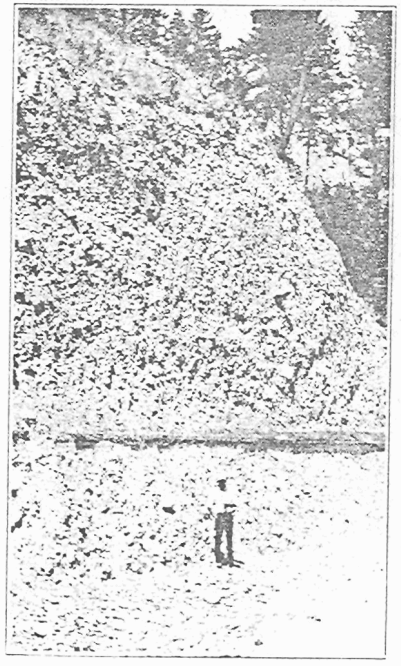
ZINC AND COPPER ORES.

Occurrences of both zinc and copper were too limited in extent to forecast their possibilities as ore. Traces of one or both were found in the majority of veins in or adjacent to the basic sills. If in in accordance with Spurr's* theory of ore deposition, these two metals underlie the lead-silver horizon, it is possible that erosion has not yet uncovered them, or that development has not proceeded to a sufficient depth to reveal them. On the other hand, even by this hypothesis, zinc and copper would not be abundant at depth, unless lead minerals were abundant nearer the present surface. Seldom is this the case, however, in the vicinity of the basic sills.

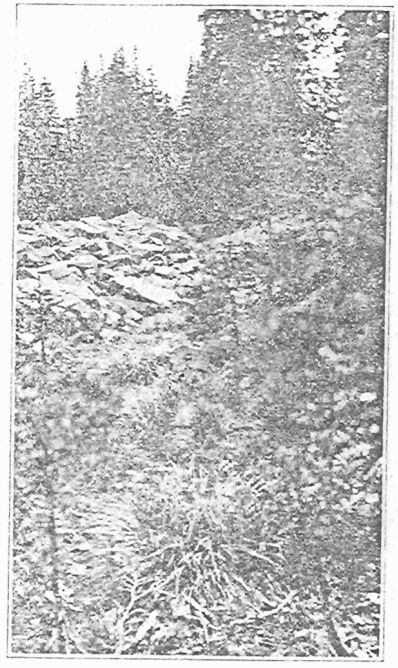
*Spurr, Josiah Edward. The Ore Magmas. McGraw-Hill, New York, 1923.

TYPICAL NELSON GRANITE.
Note the large feldspar crystals characteristic of the granite in the area.

GRANITE GLACIAL ERRATIC.
Boulder left on Belt sediments at top of Selkirk Range by a continental ice sheet.



LAKE BEDS.
Material deposited by temporary



LATERAL MORAINE.

PLACER DEPOSITS.

GOLD.

Placer gold is found on the Moyie River and on Boulder Creek. The Moyie, being rapid, has washed away most of its large banks. The gold is the so-called "oatmeal" gold and is found scattered with the black sand among the large rounded boulders lying on both sides and the bottom of the stream.

The largest probable gold-bearing gravel deposit of the county is on Boulder Creek beginning at a point a little over a mile above its outlet into the Kootenai River. Here the gravel beds are 400 feet deep in places and from 500 feet to 1000 feet wide. The yardage of gravel is enormous, running well up into the millions. No systematic sampling has been attempted, to learn the distribution of the gold throughout the gravel, but such sampling is proposed as a method of future procedure. Much of the gravel was laid down under water. It was probably brought down by ice and water during the torrential periods following the recession of the glacial period. Possibly the outlet of the stream was dammed by an ice flow following the course of the Kootenai, so that side pressure filled the mouth of Boulder Creek a distance back from its outlet, thus entrapping a lake above. A more probable theory is that a narrowing down of the gulch, due to the slower erosion of a resistant basic sill, may have caused a natural dam during the post-glacial torrential period.

Quartz veins are found in the sills and quartzite of Boulder Creek. These carry gold in varying amounts. After a general study of all of the placer gold of the area, it seems probable to the writers that the placer gold originates from the stream erosion of the gold-bearing veins of the basic sills.

MINING PROPERTIES.

THE IDAHO CONTINENTAL MINE.

(No. 8, Plate III.)

(Replacement Deposit Type No. 1.)

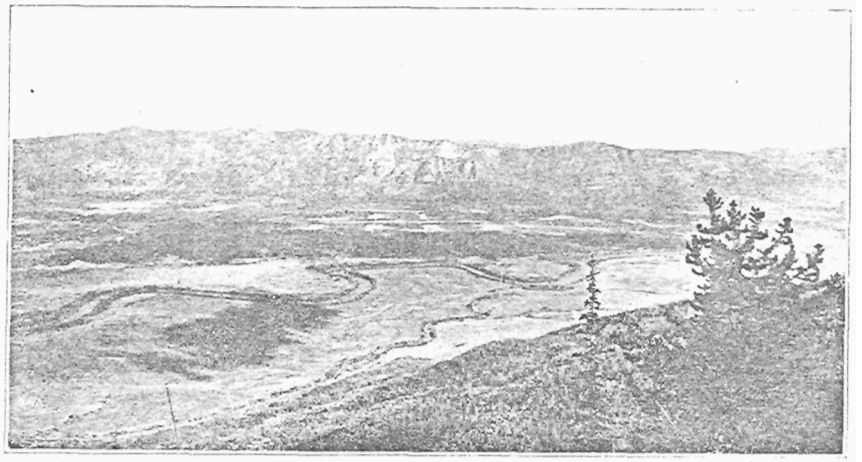
The Idaho Continental Mine in Sec. 5, T. 64 N., R. 4 W., lies 25 miles southwest of Port Hill and may be reached by a good auto road. After crossing the Kootenai River at Port Hill by ferry, the road crosses the International Boundary line twice before it reaches its destination. The ore is trammed across the river and loaded into cars for shipment on the Great Northern Railway.

The property is situated on the crest of the Selkirk Range in the northern part of Boundary County.

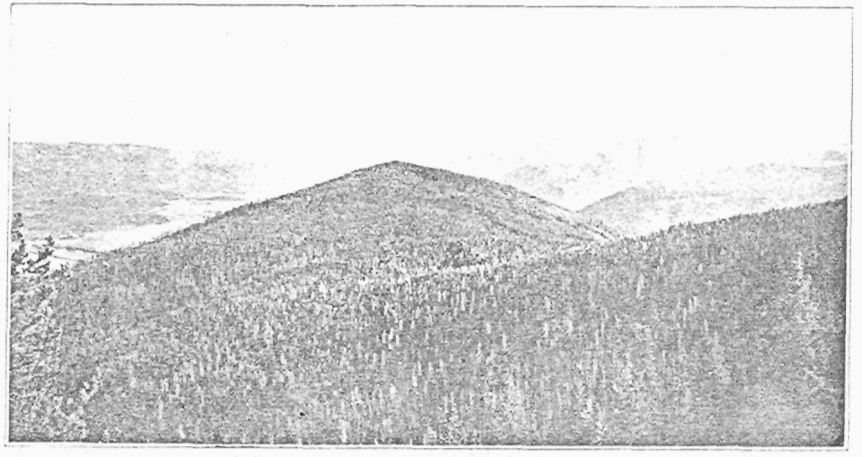
The vein, where first discovered, was a brilliant exposure of untarnished and unoxidized galena ore on the actual drainage divide of the range where relatively recent scalping by continental mountain-riding ice sheets had revealed it, with some interruptions, for a length of approximately 3000 feet. The valley, cut by Blue Joe Creek, runs almost north and consequently the outcrop which strikes in a northeasterly direction, travels down the side of the glaciated valley almost to the bottom. This makes it possible to enter the vein by adit tunnels in the valley bottom at a depth approximately 500 feet below the original discovery.

The relationship of the ore shoots to the roof-pendant and cupolas of the underlying batholith is almost an ideal one to illustrate the embatholithic stage of Emmons.* The rock in which the deposit occurs is a part of the Belt series referred to the Creston-Ravalli group and lithologically it much resembles the Burke formation of the Coeur d'Alene mining district. The Belt rocks occur here as a pseudo-roof-pendant which is flanked on the south by the main granite mass of the Selkirk batholith and on the west and northeast by cupolas of this batholith which are respectively five and two miles in diameter. The presumably wedge-shaped pendant is about two miles across at its narrower part and its long axis strikes about 40° east of north and extends for several miles. A small cupola splits it into a Y-shaped body on the northeast where the body of invaded rock narrows to a mile and one-half on either limb of the Y. (See Pl. III.

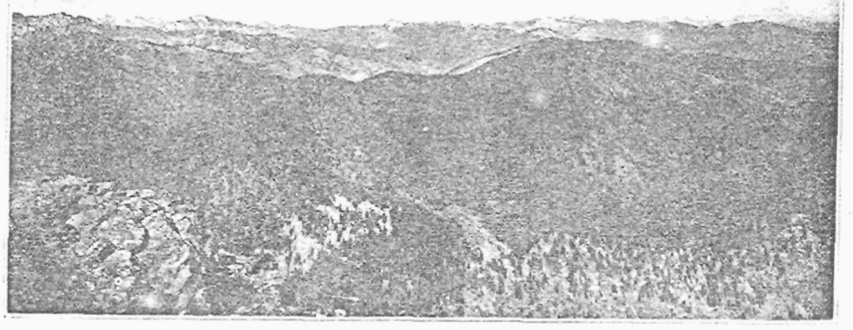
*Emmons, W. H., The Relations of Metalliferous Lode Systems to Igneous Intrusives. No. 1571-I. Trans. A. I. M. E., June, 1926.



PURCELL TRENCH.
Trench from west wall. Meandering Kootenai in middle distance.



PURCELL TRENCH AND WEST WALL.



in pocket.) The ore body which parallels the long axis of the roof pendant lies about three-fourths of a mile from the surface outcrops of the two cupolas and about one and one-quarter miles from the main batholith to the south. An idealized sketch of the relationship is presented in figure D on plate XIII, in pocket. Batholiths are characteristically steep sided and so also are their outlying cupolas. Roof-pendants between cupolas and batholiths are generally conceded to have a depth as great or perhaps two-thirds as great as their width. This gives some idea of the possible depth to which the mineralized zone may extend. The bedding planes of the grey schists and of the light colored sericitic schists and quartzites which lie adjacent to or surrounding ore are nearly vertical in places but they have been sufficiently disturbed either by folding or slipping to cause the dip to vary at other points from vertical to 75° S. E. The general strike of the beds is N. 40° E., while that of the ore body is parallel to it or nearly so. In a few places the vein strikes N. 45° E. The mineralizing solutions appear to have followed the almost vertical bedding planes. The lenses of sulphides, which make up the ore body, extend longitudinally parallel to the bedding and also parallel to the dip of the ore shoots in their vertical dimension. These lenses step over and are aligned in echelon (like shingles on a roof) both vertically and horizontally. This causes the actual strike of a line drawn through the lenses to vary about 5° from the strike of the beds and also causes a plane drawn from an upper lens to a lower one to have a flatter dip than that of the beds. The horizontal stepping is illustrated in plate XIII., figure A. The vertical stepping is shown on plate XIII., figure C.

The zone that contains these lenses dips to the northwest at an angle varying from 90° to 60° and gives a stoping area often as wide as 30 feet. The zone of lenses also appears to pitch or rake to the northeast at an unusually flat angle.

Many years after the "red" or discovery vein had been blocked out, a second or "black" vein or ore body practically identical in characteristics, attitude, and mineralization, was discovered southeast of the original vein and outcropping down the hillside at a lower level. The horizontal distance between the surface outcrops of the two veins is about 100 feet. The dip and strike are practically the same in both ore bodies. These two ore bodies thus appear in an over-lapping position but have, otherwise, almost identical characteristics.

The "black" vein has a much more meager exposure at the surface and in fact is well exposed only at its southwesterly extremity and at its highest point. This is perhaps due to greater glacial erosion at that extremity. The vein is strong and wide at a short distance underground for most of its explored length but its vertical dimension is very short as the lead ore begins suddenly at the top and ceases suddenly at the bottom of the ore body.

The flat bottom or what has been called the nearly horizontal rake of both of these ore shoots has been the object of much puzzled speculation. The apparent shallowness of these veins is hard to reconcile with a stoping width of 30 feet and an exposed length of 3000 feet along the strike. Neither vein has as yet shown a vertical stoping length on the shoot of more than 400 feet.

It appears quite obvious that much of the "red" vein has been removed by glacial scalping. This, of course, could explain the apparent shallowness of the vein, were it not for the rather abrupt cessation of the ore along a nearly horizontal line. It fails to explain, however, the shallow depth of the "black" vein which has fairly well defined upper and lower limits and which fails to outcrop at the surface for much of its length and consequently could hardly have been abbreviated by ice or other erosion.

If these veins are undisturbed and lie now in much the same positions as they were deposited, it would be unique if more ore of similar nature were not found at greater depth. In much the same nature as the lenses step-over and echelon in the ore body, so also, perhaps, may the ore bodies step over for relatively greater distances and continue at greater depths. These bodies may, perhaps, be connected by thin and relatively barren cross-fracture in rocks which were not so receptive to ore deposition and which upon exploration by the drill appear discouraging. Similar bodies might, perhaps, be expected laterally to the northwest and southeast of these two veins at similar levels and also in the strike of the formation to the southwest.

Another possible explanation of the unique dimensions of the "red" and "black" veins lies in the hypothesis that the bottom of the "red" ore body is a fault plane which also forms the top of the "black" ore body. The fault plane would have a shallower dip to the northwest than either the formation or the ore and would perhaps strike along the formation or bedding planes. It would be a normal slip fault with the down-thrown side to the northwest, thus bringing the "red" segment of the vein in its over-lapping position over the truncated "black" segment.

The flat bottom of the "black" segment would of course be explained in the same manner. This theory explains the similarity of the two veins in nearly all characteristics. Little zinc appears in the "red" vein which would be the upper portion of the vein under this hypothesis but more zinc, pyrite, and siderite occur in the "black" or supposed lower segment. If a still lower segment should lie laterally to the southwest it would perhaps contain proportionately less lead and more zinc than the "black" segment. Carrying on with the same assumption a still higher segment of the "red" vein might conceivably lie to the northwest and parallel to it.

Evidence against this theory lies first, in the fact that the "black vein lies in a dark grey schist while the "red" vein is surrounded by the light colored sericitic quartzite, second, that after the lead has disappeared in the bottom of the "red" vein some iron continues with depth, and third, that some slight structural difference is said to be apparent after long study. The latter, however, was not sufficiently marked to be noted by the writers in their brief examination.

Three minor faults cut across the ore bodies and effect slight displacements. Two of these are occupied by thin basic lamprophyre dikes. All of these faults and dikes are, of course, later than the ore bodies and had no influence in their genesis or deposition. These faults all strike in a general northwesterly direction and fault A is nearly vertical while fault B dips to the northwest at an agle varying from 40 degrees to 45 degrees. Fault C dips to the northeast at a steeper angle averaging 75 degrees. The block between faults A and C has been raised in relation to the vein east and west of it. The vertical throw appears to be at least 75 feet as evidenced by displacement in the ore. This displacement, however, may have been much greater since the segment of the "red" vein found within this block has a great keel-like irregular bottom which does not tie on to the vein in its eastern and western extermities without a considerable change in angle. (See Figure C, plate XIII, in pocket.)

A horizontal throw of about 60 feet to the northwest is evidenced on the west edge of the middle block as shown by outcrops. The eastern edge, on the contrary, is thrown southward about 40 feet in relation to the eastern block. The block east of fault C is relatively lower than the block west of this fault. The vertical displacement

appears to be about 40 feet and the horizontal displacement results in a small offset and a slight change in direction of the veins. The probable extension of the "black" vein ore body would lie northwest of the B fault below No. 4 tunnel and on one side or the other of No. 5 tunnel probably to the eastward; and is logically to be explored by cross-cuts from No. 5 tunnel. Any ore body northeast of the B fault in the "black" vein would of course be downthrown proportionate to the displacement on the west.

The ore is argentiferous galena in a series of replacement deposits which are described on page 42, 43, and 48. (Plate IV., p. 41, Vein type No. 1).

The significance of the area of light colored sericitic quartzite surrounding the "red" vein is somewhat lessened by its failure to appear in connection with the "black" vein further to the southeast. Although the evidence for the alteration is persuasive, the difference between the veins is negligible except for the slight difference in mineralization already mentioned.

The company owns twenty claims, fifteen patented and five unpatented. Underground workings thus far approximate 10,000 feet. The surface equipment consists of a 1200 cu. ft. I-R Imperial type air compressor; Leyner drill sharpener; 1600-foot aerial tramway connecting mine and mill; full mining equipment; and 250-ton concentrator.

The mill consists of a 10x20 crusher, belt conveyor, four double four-compartment Hartz jigs, three rolls 12 in. x 30 in., drag classifier, five Wilfley tables, Hardinge ball mill, four Frue vanners, flotation cells and hydroelectric power plant. The concentration of the ore is fairly simple, there being very little zinc accompanying the galena. The mill feed runs from 8% to 9% lead and is concentrated into a product varying from 65% to 70% lead. The silver accompanies the lead in the ratio of 0.35 to 0.40 of a troy ounce to the per cent lead and maintains this ratio fairly uniformly throughout the concentration.

This company has produced since 1915, 849,791 ounces of silver and 43,913,407 pounds of lead. In 1923 it produced approximately 96,000 ounces of silver and 4,500,000 pounds of lead and in 1924 it produced 100,465 ounces of silver and 4,878,931 pounds of lead. The property is operated by the Bunker Hill & Sullivan Mining and Concentrating Company of Kellogg.

APLITE VEINLETS IN GRANITE.

JOINTS IN GRANITE FILLED WITH ACIDIC VEIN-DIKES.

CYNIDE* GOLD MINING COMPANY.

(No. 15, Plate III.)
(Shear Zone, Type No. 2.)

The Cynide Gold Mining property (Sec. 27, T. 64 N., R. 3 E.) is in the old Moyie-Yahk district in the Purcell Range. More specifically, the property lies on the northwest slope of Buckhorn Mountain approximately half a mile from the Montana-Idaho line. It is reached from Bonners Ferry by a good auto road 20 miles long. The road ascends the mountain toward the end of the trip by means of switchbacks.

The formation on Buckhorn Mountain is chiefly Beltian quartzite. It has a general strike of N. 30° to 40° W. and dips 45° to 55° S. W.

The shearing is apparently due to normal faulting. The sheared zone varies from 3 to 5 feet in thickness. The vein ranges from 1½ to 4 feet. The shearing follows the bedding very closely. (See vein type No. 2, Plate IV., p. 41.) Samples are reported to have been taken varying from $2.90 to $40.00 across two and a half feet. Gold is the most important metal and is for the most part free. Little silver is alloyed with the gold. Construction and development were based on the ore running $10.00 per ton for a width of four feet. The vein carries a limited amount of quartz. The sulphides, though slight in quantity, appear to be chiefly pyrite with a small amount of galena in the lowest tunnel. The vein can be traced for a mile or more. To date, there appear to be three ore shoots; the first is about 250 feet long, the second is approximately 200 feet, and the third appears to be shorter than the other two, though, as it occurs near the face of the present tunnels it probably has not yet been fully exposed. The shoots are said to have a northwesterly rake of about 45 degrees. This was not verified by the writers, however.

The property consists of six unpatented claims. The vein is reached by six adit-tunnels which either start out as drifts or reach the vein after cross-cutting a short distance. The total length of development is approximately 6,000 feet. The relief is such as to permit depth development at minimum expense, should such development prove justified.

The surface equipment consists of a 130 cu. ft. gas-driven compressor with a 400 cu. ft. electrically-driven compressor, mining equipment, buildings sufficient to accommodate some 30 or 40 men, and

*An unfortunate mis-spelling of "cyanide," perpetuated by official illiteracy.

an aerial tramway 4200 feet long connecting mine and mill. There is a well-equipped cyanide plant, rated at 200 tons capacity and requiring 300 horse power. The equipment consists of a No. 6 Gates gyratory crusher, a set of 16x42 Traylor Rolls, four Dorr thickeners, three Dorr agitators, one Dorr clarifier, one 7-foot x 36-inch Hardinge mill, one duplex Dorr classifier, 20 leaf Dorr filter and pump equipment. In addition the company owns a 675 h. p. hydroelectric power plant on the Moyie River and some 10 miles of transmission line. High water in 1925 washed out one of the abutments of the dam, halting operations at the mine.

The company has not yet reached the stage of steady production but is carrying on a development program. Gold was produced by the early owners of the property and the present company shipped a small tonnage of gold-bearing sulphide ore to the Bunker Hill smelter at Kellogg in 1925.

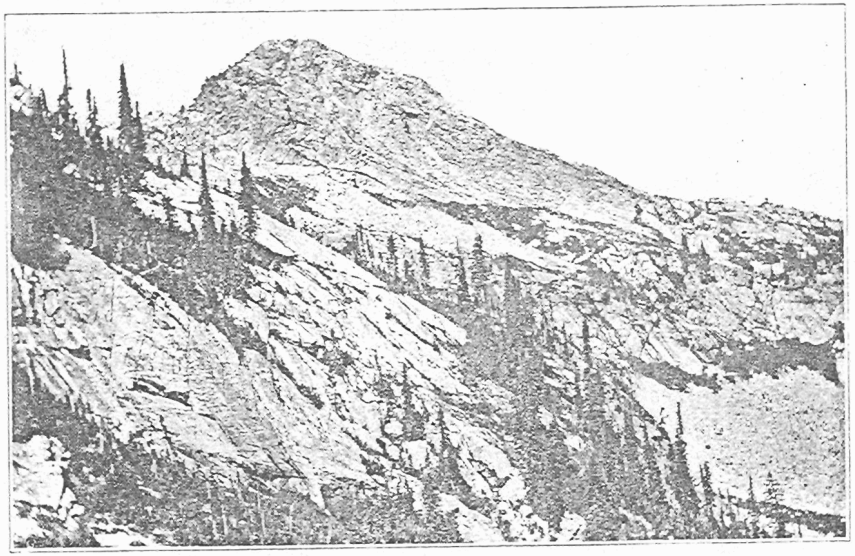
DAMON GROUP.

(No. 16, Plate III.)
(Shear Zone, Type No. 2.)

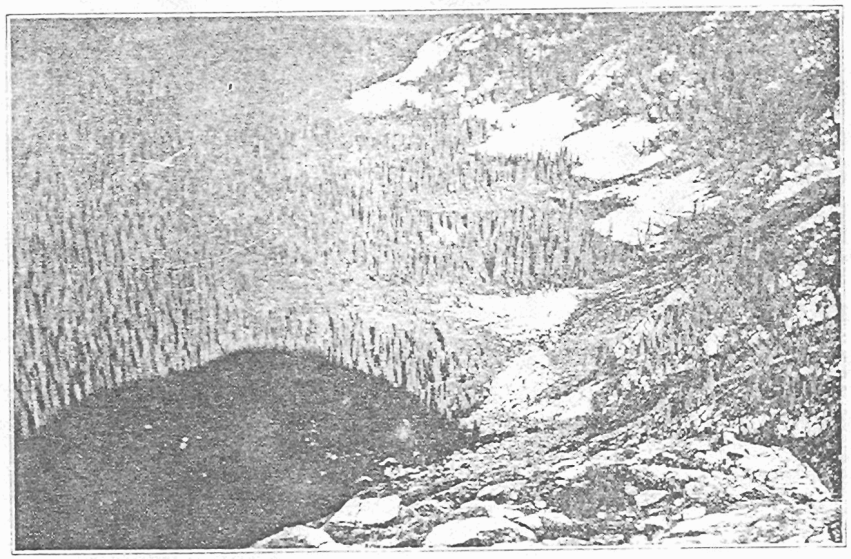
The Damon Group in Sec. 21, T. 64 N., R. 3 E., consists of seven unpatented claims a mile or more from the Cynide Gold Mining property and along the strike of the Cynide vein. The vein on the Damon group strikes N. 25° to 30° W. and dips 55° to 60° S. W. The vein appears to be an extension of the Cynide vein.

The deposit is clearly of the shear zone type, (see vein type No. 2. Plate IV., p. 41), showing more or less quartz, containing gold and a small amount of silver. The gold occurs free in part and associated in part with pyrite. The width of the vein ranges from two feet to a maximum in one place of seven feet. In places the vein consists of broken up quartzite with an inch or two of gouge. At the point where the vein measured seven feet there were several feet of quartz. The gold assays are erratic, ranging from nothing up to a reported amount of several dollars per ton.

About 500 feet of development work had been done on the property at the time of the writers' visit, at which time the property was not being worked. There was little in the way of equipment other than a building or two.



PHOEBE'S TIP.
Typical glacially serrated granite peak and cirque in Selkirks.



CIRQUE OR VALLEY-HEAD.
All valleys in the Selkirks are headed by cirques like this. Shadow of Phoebe's Tip in foreground.

INTERNATIONAL MOLYBDENUM COMPANY.

(No. 9, Plate III.)
(Joint-Plane Vein in Granite, Type No. 3.)

Probably the most important group of this type of vein is to be found in the Phoebe Tip country in the northwestern part of the county. Chief among the veins so far explored in that district is that held by the International Molybdenum Company in Sec. 27, T. 64 N., R. 4 W. The property is reached by a 25-mile pack trail from Port Hill. The trail follows Smith Creek.

The property lies in the granite of the Nelson batholith which forms the Selkirk Range in Idaho. Joint plane cracks traverse the granite in great numbers running in the four major directions of the conjugated shrinkage cracks. (See vein type No. 3, Plate IV., p. 41.) These fractures vary from an inch or so up to three feet in thickness. Their filling also varies from an extremely basic dike rock to a highly acid pegmatite. The International Molybdenum Company's property is located on one of these pegmatite "vein dikes," though one claim is also located on a basic dike.

Molybdenum occurs in the pegmatite. The ore is chiefly in the form of molybdenite (molybdenum disulphide, MoS_2) though the yellow oxide (molybdite, MoO_3) is found occasionally. The ore accompanies a brown glassy quartz.

At the time the property was visited the ore had been exposed only on the surface by means of an open cut. A short tunnel was being driven which would cut the vein a few feet in depth. The length of this tunnel would be about 75 feet. A lower tunnel, which would give considerable depth on the vein, had also been started. This tunnel was calculated to intercept the vein in 930 feet horizontally. The company holds four unpatented claims, one of which is located along the basic dike. The vein strikes N. 35° to 40° W. and dips 50° S. W. The basic dike has practically the same strike as the vein and dips 60° N. E. There has been no production to date. The equipment consists of two cabins, together with hand mining equipment.

NORTHERN STAR CLAIM.

(No. 10, Plate III.)
(Joint Plane Vein in Granite, Type No. 3.)

This claim in Sec. 23, T. 64 N., R. 4 W., is a mile or so to the north of the International Molybdenum Company. The vein strikes N. 70° W. and dips 60° S. It is 18 to 24 inches thick. Apparently this vein

is the third side of the fracturing scheme shown on the International Molybdenum property. (See vein type No. 3, Plate IV., p. 41.) Here too the molybdenum occurs as molybdenite associated with brown glassy quartz. So far development has been in the form of open cuts.

AMERICAN GIRL CLAIM.

(No. 2, Plate III.)
(Joint Plane Vein in Granite, Type No. 3.)

This claim is in Sec. 9, T. 64 N., R. 1 E., on the western side of the Queen Mountain batholith. It is in the Brush Lake district some 16 miles north of Bonners Ferry.

Here too, molybdenum occurs in a pegmatite dike in the granite. The vein had been exposed by an open cut or two. As these cuts were caved, the size, strike, and dip of the vein were not obtainable.

MORAN PROPERTY.

(No. 2, Plate III.)
(Joint Plane Vein in Granite, Type No. 3.)

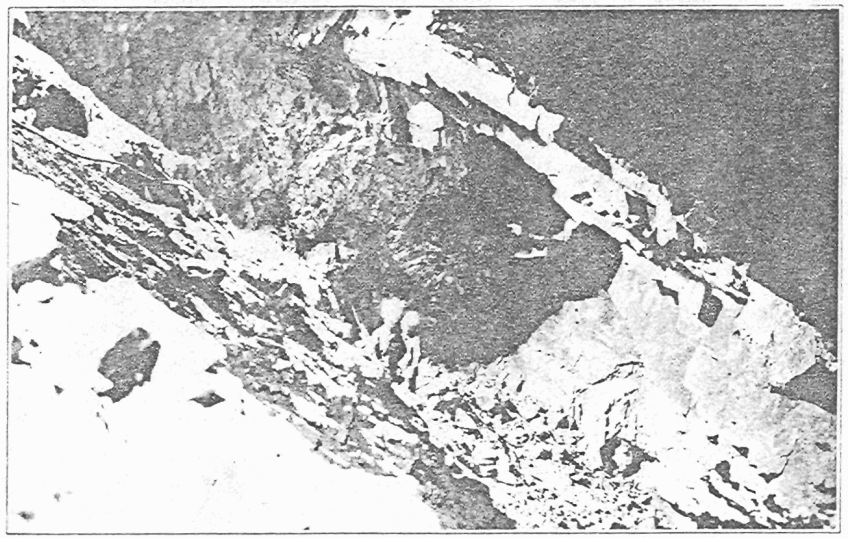
This property consists of three claims 1½ miles southwest of Queen Mountain lookout in Sec. 19, T. 64 N., R. 2 E. The veins are also in the Queen Mountain batholith (Pl. III., in pocket.) It was impossible to visit this property at the time when the writers were in the district but several specimens of ore were examined. The owners of the property reported that the main vein was approximately two feet wide and showed silver-bearing galena and gold-bearing pyrite. There is a granite-quartzite contact in the vicinity of the property. The nature of the vein filling is not known. However, it is more than likely the vein is due to joint plane fracturing.

M. & F. PROPERTY.

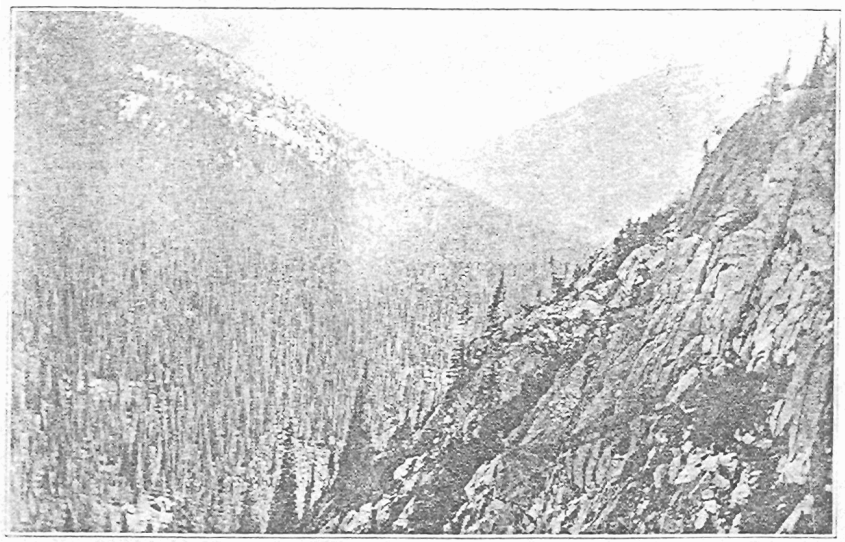
(No. 4, Plate III.)
(Vein Cross-Cutting Basic Sill, Type No. 4.)

This property is 28 miles from Bonners Ferry in the Queen Mountain district, in Sec. 13, T. 64 N., R. 1 E. It is reached, except for the last mile or two, by a good auto road, a considerable part of which is the Idaho North and South Highway.

The veins occur in coarse-grained diorite which contains considerable feldspar. (See vein type No. 4, Plate IV., p. 41.) The veins are but a short distance from the granite batholith of Queen Mountain. These veins show evidence of contact metamorphism due probably to



STOPE IN IDAHO CONTINENTAL MINE.
Inclination and width of ore-shoot can be seen.



SMITH CREEK.
Glaciated U-shaped valley with precipitous granite walls in Selkirks.

the intrusion of the granite. In this respect only do the veins of this property differ from the same type veins found elsewhere in the district.

The ore is chiefly scheelite though accompanying it in a heavy massive quartz are also specks of galena, pyrite, pyrrhotite, and copper stains. Scheelite, calcium tungstate, was in demand during the World War. At that time it could be profitably mined even in small quantities, but a lowering of the price has necessitated development looking toward mining on a larger scale.

The main vein has been opened up by one long surface cut and is again exposed by a short cross-cut which encounters it a few feet below the surface cut. A still longer tunnel has been driven which encounters the vein at considerable depth but is west of the ore shoot. The face of the lower tunnel shows "sugar" quartz and calcite. Drifting to the east should open up ore found above. The vein strikes S. 84° E. and dips 70° N. It is six feet wide where encountered in the upper tunnel. In all, 500 feet of development work has been done.

Open cuts expose another vein on the Blanche No. 1 and No. 2 claims. These cuts are probably 1500 feet northwest from the lower tunnel on the other vein just described. The Blanche vein strikes N. 4° E. and dips 60° E. The exact width of this vein was not determined, but it is probably about two or three feet wide.

The M. & F. property includes 19 claims. The equipment consists of a blacksmith shop, hand mining tools, mine car, and light rail, together with several camp buildings. Active development operations were discontinued in 1922. Since that time assessment work, including road building and general repair, has been performed. There has been little production to date. The property merits more extensive development work.

BOULDER GOLD MINING COMPANY.

(No. 10, Plate III.)

(Vein Cross-Cutting Basic Sill, Type No. 4.)

This property, which is situated in Sec. 16, T. 60 N., R. 2 E., is reached by a good Forest Service road and trail beginning at Naples. Two miles may be traveled by auto and then there are some nine miles of trail to the property.

The vein is entirely in a basic sill. Quartzite float indicates a contact with this formation somewhere between the tunnel and the top of the mountain.

The main vein strikes N. 25° W. and dips 50° N. E. It varies in width from a few inches to five feet. The owners report that the vein has been traced for 3000 feet changing its strike in that distance to N. 70° W. It is possible, of course, that the vein showing a changed strike is an entirely different vein.

The vein at the outcrop is over three feet in width and shows "lively" quartz. Samples taken at the outcrop, when crushed and panned showed fine free gold. Indeed very little crushing was required to liberate the metal. A cross-cut picks up the vein some 15 feet below the out-crop, at which point the quartz is largely absent and the vein has narrowed down to a few inches. Work had not been done to ascertain whether or not the vein continued thus at depth or whether it increased in width again. Another tunnel at a lower elevation, some distance from the first tunnel but along the strike of the vein, picks up the vein again though the gold is absent.

Beside hand mining tools the equipment consisted of a small bunk house and one other building in which were assembled a few pieces of machinery for milling on a small scale.

IDAHO MONTANA MINING COMPANY.

(No. 17, Plate III.)
(Vein Cross-Cutting Basic Sill, Type No. 4.)

The Two Tail, or Western Bell as it is now called, is in Secs. 34 and 35, T. 62 N., R. 2 E.

The vein is in a basic sill. It strikes N. 30° W. and dips gently to the S. W. at first and then increases in dip up to 45 degrees or better with depth. It ranges in width from four to eight feet. The vein filling consists of brown quartz carrying silver-bearing galena. The quartz has a "lively" appearance with many vugs.

The deposit has been explored for a short distance by an incline from the surface and by underhand stoping which also begins at the surface.

The work was performed some years ago and the buildings and workings are in disrepair. The original company held some ten unpatented claims. The present company has restaked two of the most important claims and plans development work of an exploratory character.

Aside from the M. & F. property, this vein is probably the most important showing of the Type 4 group of veins. A small amount of ore was produced by the old company.

KATE FRY CLAIM.

(No. 15, Plate III.)
(Vein Cross-Cutting Basic Sill, Type No. 4.)

This claim is on Boulder Creek approximately a mile above the mouth of the stream in Sec. 27, T. 61 N., R. 3 E.

The vein strikes S. 60° E. and dips 45° to 50° S. W. The formation strikes N. 25° W. and dips northeast. The vein occurs entirely within the basic sill, so far as explored, and consists of two to three feet of quartz. The vein carries small bunches of galena, arsenopyrite, pyrite, and copper stains.

The vein is explored by a tunnel some 350 feet long. There is no equipment on the property and there has been no production to date.

Another claim, known as the Eureka, belonging to the same group, lies across Boulder Creek and to the north of the Kate Fry Claim. It is located on the same basic sill as the Kate Fry. On the Eureka claim the vein parallels the contact and dips toward it. This vein has been explored by three short tunnels. It is characteristic of the Group 5 type of veins, differing only in dip.

KENO AND GLORY CLAIMS.

(No. 22, Plate III.)
(Veins Cross-Cutting Basic Sill, Type No. 4.)

These claims were not visited by the writers. They are in Sec. 20, T. 61 N., R. 3 E., near Leonia, Idaho. The owner reports the veins as cutting across a basic sill. A copper-bearing sulphide is apparently the chief metalliferous mineral found.

ARSENOPYRITE VEIN.

(No. 1, Plate III.)
(Vein Cross-Cutting Basic Sill, Type No. 4.)

This vein is near the county road five miles southeast of Bonners Ferry in Sec. 31, T. 62, N., R. 2 E.

The vein strikes S. 50° E. and dips 55° to the southwest. It ranges in width from several feet up to 12 and 14 feet. The vein is chiefly hard quartz carrying a considerable amount of arsenopyrite. A sample taken across the vein showed 0.5% arsenic and no gold or silver. There is no equipment on the property.

METALS MINING COMPANY.

GOLD SHAFT GROUP.

(No. 6, Plate III.)

(Vein Cross-Cutting Basic Sill, Type No. 4.)

This property is on the extreme eastern slope of Clifty Mountain in NW ¼ Sec. 1, T. 61 N., R. 2 E. It is about 10 miles southeast of Bonners Ferry and can be reached by road. The last two or three miles of the trip is made over a wagon road. The group consists of eight unpatented claims.

The vein strikes N. 75° to 80° E. and dips 65° N. It consists of three to five feet of quartz cutting across a basic sill. Galena, probably carrying silver-bearing tetrahedrite, is scattered throughout the quartz in the upper part of the vein and some copper stains are in evidence.

The vein is explored by a shaft 42 feet deep along the vein and by a 20-foot drift that begins 25 feet down the shaft.

An easterly dipping contact between the basic sill and quartzite exists some 40 to 50 feet east of the shaft collar. The writers recommended that the 20-foot drift be extended to this contact and also that a surface cut be made to ascertain whether or not the vein extended into the quartzite. The vein seemed to have little westerly extension. Another vein parallel in strike and dip exists some 800 feet to the south. This vein is about two feet wide. It likewise has been explored only in the basic sill.

The equipment consists of sinking bucket and hand-mining tools together with living accommodations for two men.

GOLDEN HOPE CLAIMS.

(No. 6, Plate III.)

(Vein Within Sill and Parallel to Contact of Sill and Metamorphic Rock, Type No. 5.)

This property consisting of four claims, is in Sections 26 and 35, T. 61 N., R. 2 E. It lies two and a half or three miles southeast of Clifty Mountain and is reached by a steep trail which passes over the ridge to the east of Clifty Mountain. Should future development warrant it, a road can be constructed up Boulder Creek from the property of the Leonia Gold Mining Company.

The vein is in a basic sill. It strikes N. 10° W. and dips 45° to 50° E. Its width ranges from two to three feet. It has been traced for about 2,400 feet and is seemingly cut off at one end by a cupola of fine-grained granodiorite which is of a later period than the sill in which the vein occurs. (See vein type No. 5, Plate IV., p. 41.)

The vein shows a "lively" white and brown quartz with numerous vugs. The minerals are galena, pyrite, chalcopyrite, and an unidentified silver mineral. A picked sample showing sulphides, assayed no gold and 3.8 ounces silver to the ton.

There has been comparatively little work done on the property as yet. With the exception of one short drift the work done is represented by open cuts along the vein. The equipment consists of a cabin and some hand-mining tools.

This vein is a good example of Type No. 5 veins but because so little work has been done it is not expedient to hazard a guess as to the possibility of finding commercial ore-bodies.

MOYIE GOLD MINING AND MILLING COMPANY, QUEEN GROUP.

(No. 5, Plate III.)

(Vein on Contact of Basic Sill and Quartzite, Type No. 6.)

This group of claims is on Queen Mountain in Sec. 8, T. 64, N., R. 2 E. It is reached by a good Forest Service trail which supplies the Queen Mountain lookout. The trail ascends the steep eastern slope of Queen Mountain beginning about three miles south of Addie. The distance to the property is about three miles. The vein strikes N. 8° W. and dips 82° E. It is four to five feet wide where cut by the cross-cut. The hanging wall is a basic sill and the footwall is quartzite. There was no evidence of movement along the vein. (See vein type No. 6, Plate IV., p. 41.)

The vein gangue consists of quartz and siderite; the metallic minerals are sphalerite, chalcopyrite, galena, and pyrite. A picked sample assayed a trace of gold and 6.7 ounces of silver to the ton. The total development on this property is about 330 feet, but most of this development is represented by the cross-cut to reach the vein, only a few feet of drifting having been done after the vein was encountered.

A small vein of the shear zone type was encountered 110 feet from the portal of the cross-cut to the contact vein. It was approximately 130 feet from the contact vein and paralleled the larger vein in strike and dip. It lay between the bedding of the quartzite and consisted chiefly of gouge 16 or 18 inches wide. A channel sample from the vein assayed $12.80 in gold and $0.90 in silver. It was exposed only by the perimeter of the cross-cut.

Several small seams occur on the other side of the basic sill from the contact vein. These seams lie several hundred feet to the east of the contact vein and evidently lead to the contact between the basic sill and the next succeeding strip of quartzite. The seams have a flat dip. They range from three to five inches in thickness and carry varying amounts of galena. In following these veins 150 feet of tunneling has been done. The proposal now is to drift toward the basic sill and quartzite contact. The equipment consists of a cabin and hand-mining tools.

TRUST MINING COMPANY.

(No. 11, Plate III.)

(Vein on Contact of Basic Sills and Quartzite, Type No. 6.)

The Trust Mining Company's property in Sec. 19, T. 65 N., R. 1 E., is half a mile off the North and South Highway and approximately four miles from Port Hill.

The vein strikes N. 7° to 15° W. and dips 35 ° to 40° E. Its thickness ranges from two to six feet. The footwall is quartzite and the hanging wall is for the most part a basic sill. (See vein type No. 6, Plate IV., p. 41.) The vein seems to be a fissure, showing little or no movement. The filling is mostly a hard white quartz containing iron sulphides. Occasionally stains of copper carbonate were noted. Varying amounts of siderite accompany the quartz as a gangue. A picked sample assayed 0.06 ounce of gold and 5.4 ounces of silver to the ton.

The vein has been opened up on three different levels. The lowest tunnel is approximately 600 feet long, picking up the vein about 480 feet from the portal. The company has located six claims all told and has done more or less surface work.

The surface equipment consists of accommodations for eight men, blacksmith shop, 35 h. p. Turmo Gas Engine, 8 in. x 6 in. Gardener compressor, mine car, rails, and mining tools.

EILEEN MINING COMPANY.

(No. 14, Plate III.)

(Vein on Contact of Basic Sill and Quartzite, Type No. 6.)

This property is in Section 35, T. 63 N., R. 2 E. It is approximately half a mile south along the Moyie River and below the power site of the Cynide Gold Mining Company. It can be reached by a car by way of the power site or else by the way of Skin Creek.

The veins occur as small quartz seams a few inches thick which are found in or adjacent to the contact between the quartzite and basic sill. (See vein type No. 6, Plate IV., p. 41.) These seams show some galena and some copper carbonate stains. The bedding strikes N. 10° to 15° E. and dips 55° S. E. A small vein follows this strike and dip. A vein in the basic sill strikes N. 55° W. and has a vertical dip. Another small seam in the quartzite strikes N. 60° W. and dips 45° S. W.

The company has located 20 claims in all. Five tunnels with a total length of 600 feet have been driven. The equipment consists of blacksmith shop, hand mining tools, and cabins.

LUCKY ABE MINING COMPANY.

(No. 21, Plate III.)

(Vein on Contact of Basic Sill and Quartzite, Type No. 6.)

The Lucky Abe in Sec. 4, T. 64 N., R. 5 W. is said to show lead, silver, and some copper. The writers did not visit this property. The vein is said by the owner to be approximately three feet wide. It strikes north and has an almost vertical dip. There are apparently two veins, one on the contact and one in the diorite paralleling the contact. The contact vein is opened by a drift 125 feet long and the parallel vein is likewise opened by a drift of 175 feet.

KENT PROPERTY (SPHALERITE CLAIM.)

(No. 2, Plate III.)

(Vein on Contact of Granite and Quartzite, Type No. 7.)

This property is in the Brush Lake district in Sec. 9, T. 36 N., R. 1 E. It is reached by a good auto road approximately two miles in length which leaves the main North and South Highway just south of Copeland.

The vein strikes approximately east and west and dips 80° N. It is two feet thick and shows sphalerite and galena. It is explored by a

shaft 110 feet deep. The shaft was for the most part inaccessible at the time visited. The vein is said to lie between the quartzite and granite, beginning some 50 feet down from the collar of the shaft.

There was no equipment on the property and, because of the condition of the shaft, could not be checked.

BRUSH LAKE MINES COMPANY (DORA TUNNEL.)

(No. 3, Plate III.)

(Vein on Contact of Granite and Quartzite, Type No. 7.)

This property is also in the Brush Lake district in Sec. 14, T. 64, N., R. 1 E. It can be reached by a good auto road which leaves the North and South Highway a short distance below Copeland.

The main vein strikes N. 60° E. and dips 60° S. E. It ranges from a few inches to two feet in thickness. The vein begins in granite and continues for some 180 feet until it reaches a basic sill at which the main body of the quartz seems to end, leaving smaller seams to enter the sill. (See vein type No. 7, Plate IV., p. 41.) The company has drifted along this vein for another 350 feet in the diorite without any apparent ore discovery. (See vein type No. 9, Plate IV., p. 41.) At a point 200 feet from the portal the drift has been turned to the left, thereby picking up a contact of granite and quartzite. The company at the time of the visit, was exploring a gouge seam along this contact which was striking N. 75° W. and dipping 50° to 55° S. W. Other development work consisted of a vertical shaft just outside the portal of this working and an adit 50 feet in length which was headed toward the bottom of the shaft. Due to water the shaft was not accessible. The work has been entirely exploratory to date.

Tunnel work has been done for 180 feet in opening up a small quartz vein in the basic sill to the northwest of the Dora vein. The quartz seems to cease near the face. This drift is known as the Mable Tunnel.

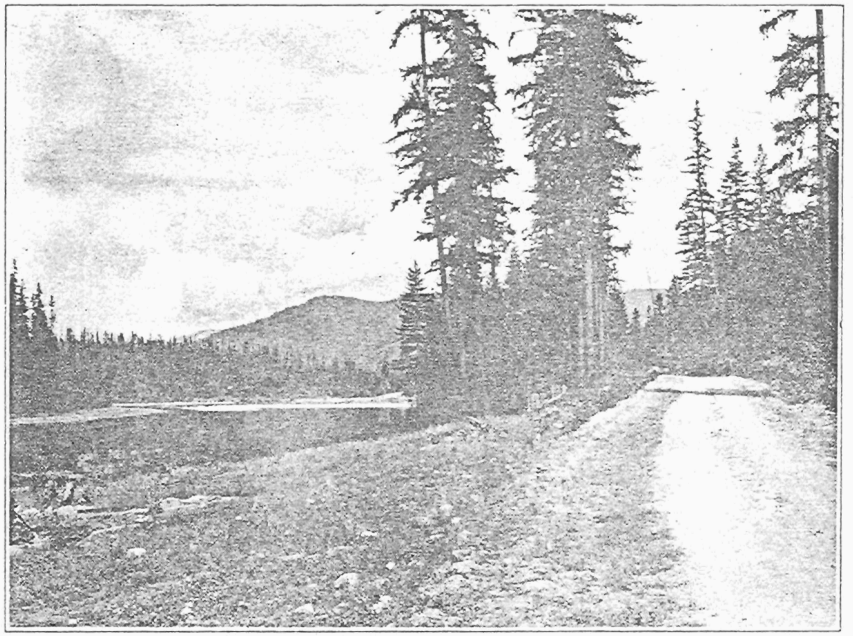
The company holds seven unpatented claims. By way of equipment there are several very substantial buildings, a blacksmith shop, mine car, rail, and hand-mining tools.

PETERS AND MITCHEM PROPERTY.

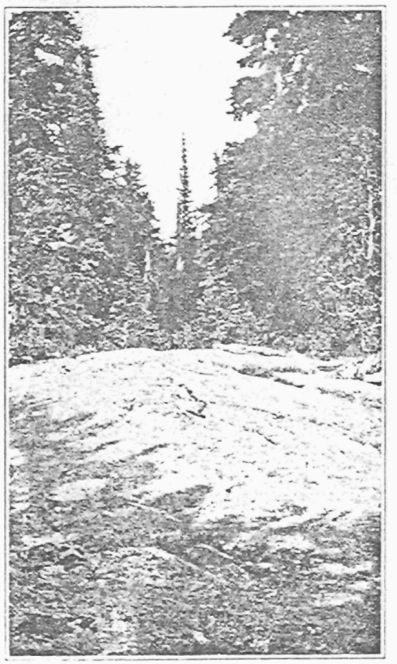
(No. 19, Plate III.)

(Vein Cutting Contact of Quartzite and Sill, Type No. 8.)

This property is on the opposite side of the Moyie River from the town of Meadow Creek. It is in Sec. 25, T. 63 N., R. 2 E.



TYPICAL GLACIAL LAKE AND SURROUNDING TERRANE IN BOUNDARY COUNTY.



ANOTHER ONE OF THE "ROCHES MOUTONNEES."

GLACIAL EROSION AND MORAINE.

The vein starts as a rather well-defined quartz vein in the basic sill and fingers out in small seams in the quartzite. (See vein type No. 8, Plate IV., p. 41.) The vein is some two feet wide where first encountered. There are three shafts, whose depths are 50, 91, and 21 feet, respectively. All are vertical. The first two start in the diorite and follow the vein into the quartzite. The quartzite here strikes N. 55° to 60° W. and dips 30° to 35° N. E. Drifts at different levels totaling altogether about 80 feet, are run into it. The longest drift, of about 45 feet, was in the 91-foot shaft, which was filled with water when visited.

The company holds 80 acres, which were procured from the Northern Pacific Railroad. Equipment consists of a small hoist, a sinking bucket, and hand-mining tools.

LEONIA GOLD MINING COMPANY.

(No. 12, Plate III.)

This company holds a considerable number of quartz and placer claims on Boulder Creek. The holdings are in sections 21, 22, 27, 28, 29, 31, 32, and 33, T. 61 N., R. 3 E.; also sections 35, and 36, T. 61 N., R. 3 E.; and sections 5, 6, 7, T. 60 N., R. 3 E.; also sections 1 and 2, T. 60 N., R. 2 E. The total placer holdings are 2965 acres. There are also many quartz claims superimposed on the placer claims.

The veins thus far explored are represented by Types No. 2, 4, 5 and 10. Neither the veins or the gravel banks have yet been sufficiently explored to ascertain the value of the deposits.

GOLDEN TRIPLET NO. 1.

(Shear-Zone Deposit, Type No. 2.)

A small shear-zone vein was encountered on the Golden Triplet No. 1 claim belonging to the Leonia Gold Mining Co. in sec. 28, T. 61 N., R. 3 E. The vein conformed to the bedding of the quartzite. (See vein type No. 2, Plate IV., p. 41.) It has a strike of due north and dips 70° W. The quartz occurs in small bunches and carries pyrite and galena.

QUARTZ TUNNEL.

(Vein Cross-Cutting Basic Sill, Type No. 4.)

This vein consists of massive quartz from three to 10 feet wide and strikes north with an almost vertical dip. The formation strikes N. 15° W. A contact of sericitic quartzite and a basic sill occurs a few

feet to the east of the uncovered portion of the vein which has been exposed by stream erosion. Apparently, however, there is no mineralization on the contact. The quartz carries a small amount of pyrite.

An 800-foot tunnel begins as a drift on the vein. The vein, however, veers some 30° to the southwest a short distance in from the portal and the tunnel continues on its course, leaving the vein.

GOLDEN TRIPLET NO. 2.)

(Vein Within Sill and Parallel in Strike to Contact of Sill and Metamorphic Rock, Type No. 5.)

This vein appears to be a stained shear-zone paralleling the contact between the basic sill and the quartzite in strike but dipping toward the contact. The vein showed some quartz but little or no gold.

CORNMEAL TUNNEL.

(Vein Cutting Across Bedding of Quartzite, Type No. 10.)

This vein showed massive quartz some 12 feet wide cutting across the quartzite with a strike of N. 10° to 15° E. (See vein type No. 10, Plate IV., p. 41), and dipping 65° to 70° S. E. Another vein just over the Cornmeal Tunnel and only a few feet to the southwest also showed massive quartz. The strike and dip were different, however, the strike being N. 15° W. and the dip 65° to 70° N. E. The relationship of these veins to each other, if any, has not been solved, and the work done on them was too limited to justify a guess as to their continuity or importance as possible ore sources.

GRAVEL DEPOSITS.

The gravel banks have already been briefly described on p. 51. In the absence of systematic sampling, the value of the deposits is unknown. An attempt was made in 1925 to evaluate the ground as a placer possibility by hydraulic methods, but thus far little has been proven.

Some of the gold recovered from the sluice boxes was assayed for its fineness. As there have been many periods of deposition in the various gravel banks, the fineness of the gold and silver varies, as the following table shows (figures are based on parts per thousand of alloy):

Sample	Gold	Silver	Base Metal

The exact source of this gold has not been determined. There are three possibilities, namely: from veins in the Boulder Creek drainage, from basic sills, or from material beyond the immediate area brought in by glacial transportation. The probabilities are, however, that the first two are the more important sources. Systematic exploration of the placer ground with the drill is proposed as an aid to determining the distribution and quantity of the gold.

Many fruitless years and upward of two and a half million dollars were spent by the former owners, the Idaho Gold and Ruby Mining Company, under the management of J. M. Schnatterly, in attempting to extract gold from unprospected and unsampled gravel banks. Part of the expenditure is represented by a six-mile ditch with a capacity of 10,000 miner's inches. A 21-ton Marion shovel was purchased and used for this ditch construction. A grandiose scheme, upon which work was actually begun, proposed to connect the camp and the railroad by a two-mile tunnel and a 500-foot raise. The present holders of the property, the Leonia Gold Mining Company also took over a camp of 45 dwellings and other buildings, a sawmill, hydraulic equipment, machinery, and an elaborate gold and platinum-saving plant of several thousands tons capacity. This plant was erected in Boulder Creek gorge. Boulder Creek canyon was lined with concrete for several hundred feet above the "mill" but high water destroyed the work soon after its completion. Such a plant, although representing a large outlay of money, was never used and was wholly unjustifiable. The new company proposes systematic investigation of the placer possibilities as well as development of the quartz veins.

A small amount of placer gold has been produced from recent hydraulicking operations.

SUMMARY.

The area examined comprises Boundary County, Idaho, and includes approximately 37 townships. It is well served by railways and highways, with Bonners Ferry as the distributing center.

The topography, outside the stream valleys, is generally rough and mountainous with elevations ranging from 1800 to 7700 feet above sea level. The area includes the Cabinet, Selkirk, Moyie, and Yahk Ranges, and is well drained and heavily forested. The most notable water bodies are Kootenai, Moyie, and Upper Priest rivers. Small lakes and streams are numerous.

Almost the entire region lies within the Pend Oreille and Kaniksu National Forests. That part of the county lying outside of these reserves is devoted largely to farming, dairying, and lumbering.

The stratigraphic column of the area includes several important and much discussed formations included in the pre-Cambrian or Beltian series. Thin Pleistocene sediments also occur. The formation names assigned to this area are Aldridge-Prichard, Creston-Ravalli, Kitchener-Newland-Wallace, Siyeh, and Purcell lava. These occupy an approximate total thickness of 30,000 feet.

Much igneous activity is represented by a batholithic intrusion with its attendant cupolas, thought to be of Cretaceous or possibly Jurassic age, also by a notable group of basic igneous sills of great thickness and extent which are especially abundant in the eastern part of the county. Their total thickness is near 10,000 feet and they are assigned a Beltian age. A few dikes of little importance were noted. Basic lava flows of late Beltian age, totalling 6000 feet in thickness, occur at one place.

Structure is dominated by faulting; several large blocks and normal faults and one major overthrust were observed. The vertical throw of some of these faults is very large. Structure has controlled drainage; the mountain ranges are chiefly tilted blocks with few folds.

The batholithic intrusion has been eroded to the fourth or embatholithic stage of Emmons and several cupolas are exposed with the formation of roof-pendants. The more significant ore deposits are connected genetically with the cupolas and roof-pendants. Considerable mineralization accompanies the basic sills. In all, ten types of veins were recognized. They include replacements, shear zones, joint-plane fillings, contact, and gash veins.

The commercial minerals of the district are silver-bearing galena, gold, gold-bearing pyrite, molybdenite, molybdite, and scheelite. The mineral which is at present being produced in the largest quantity is silver-bearing galena.

Twenty-two properties have been visited and described. Considerable development work is in progress at many of them, but not more than three of them are actually producing ore at the present time. Placer deposits have received considerable attention along with lode prospecting. Much money has been invested in some of the ventures in this county and several properties are well equipped with surface plants. The largest amount of prospecting has been undertaken on the gash veins in the sill rocks, rather than on the deposits of greater promise near the outcrops of granodiorite.

CONCLUSION.

It is now the consensus of opinion among modern students of ore deposition that the most favorable areas for the occurrence of ores of the precious and semi-precious metals are those which lie adjacent or superjacent to granitic batholiths which have stoped and elbowed their way into older and metamorphosed sediments.

In general the geologic conditions of Boundary County conform to this specification quite closely, and the area must therefore be regarded, with certain qualifications and reservations, as one justifying careful exploration.

The county contains large areas of Beltian rocks similar in age to those of the Coeur d'Alene district, and which like the Belt series in that district have also been invaded by a Cretaceous (?) granitic batholith. However, so far as revealed by the present rather meagre development, it appears either that mineralization is less in evidence, or else that such mineralization if once present has been partly removed by erosion of the topographically higher formations. In this county a great part of the batholithic roof has been eroded away by mountain-riding continental glaciers and valley-scouring alpine glaciers along with a tremendous amount of erosion attendant upon the run-off of glacial streams. The roof and upper batholithic walls are thought to have received most of the mineralizing solutions and vapors which emanate from such a batholith as is described. In the Coeur d'Alene and similar districts the roof rocks remain uneroded except in a few spots. Glaciation* has undoubtedly removed from Boundary County great masses of possibly ore-bearing rocks in some places and has dispersed deposits or concealed deposits in other places.

The Beltian rocks of this area, although much disturbed, have not experienced the crushing and tearing that the same or similar formations underwent adjacent to the Osburn fault in the Coeur d'Alene district and this may account in part for the apparent difference in the extent of mineralization. The basic sills of the county have been the scene of most of the prospecting activity. This has to date failed to reveal many important ore bodies. On the other hand the metamorphosed sediments between and adjacent to the granitic intrusives,

*Kirkham, Virgil R. D., Some adverse influences of glaciation on mining. Eng. Min. Jour. Press. Vol. 121, No. 26, June 26, 1926.

in which at the present time are the only producers, have received little, if any, prospecting.

The writers believe that the sills are more likely to contain small low-grade gold deposits, than base metal ore bodies. They further believe that the placers in the area have received most of their gold from the sills or their included quartz veins. It is also considered that the Belt series in and near the cupolas and constituting the roof-pendants are more likely to produce commercial ore deposits of lead, silver, and zinc, than any other localities in the area. Prospecting along the strike of the beds may also reveal some replacement deposits, similar to the Sullivan and other ore bodies of East Kootenay in the same geological horizon. Prospecting for molybdenum and possibly for tin ores should be confined to the larger granitic masses which are as yet largely unexplored. Tungsten ores are more likely to be found at the contact of cupolas and the intruded rock.

Although large sums of money have been spent in mining development in the county, much of this expenditure has been ill-advised. Such error undoubtedly has been due to the lack of intelligent engineering direction.

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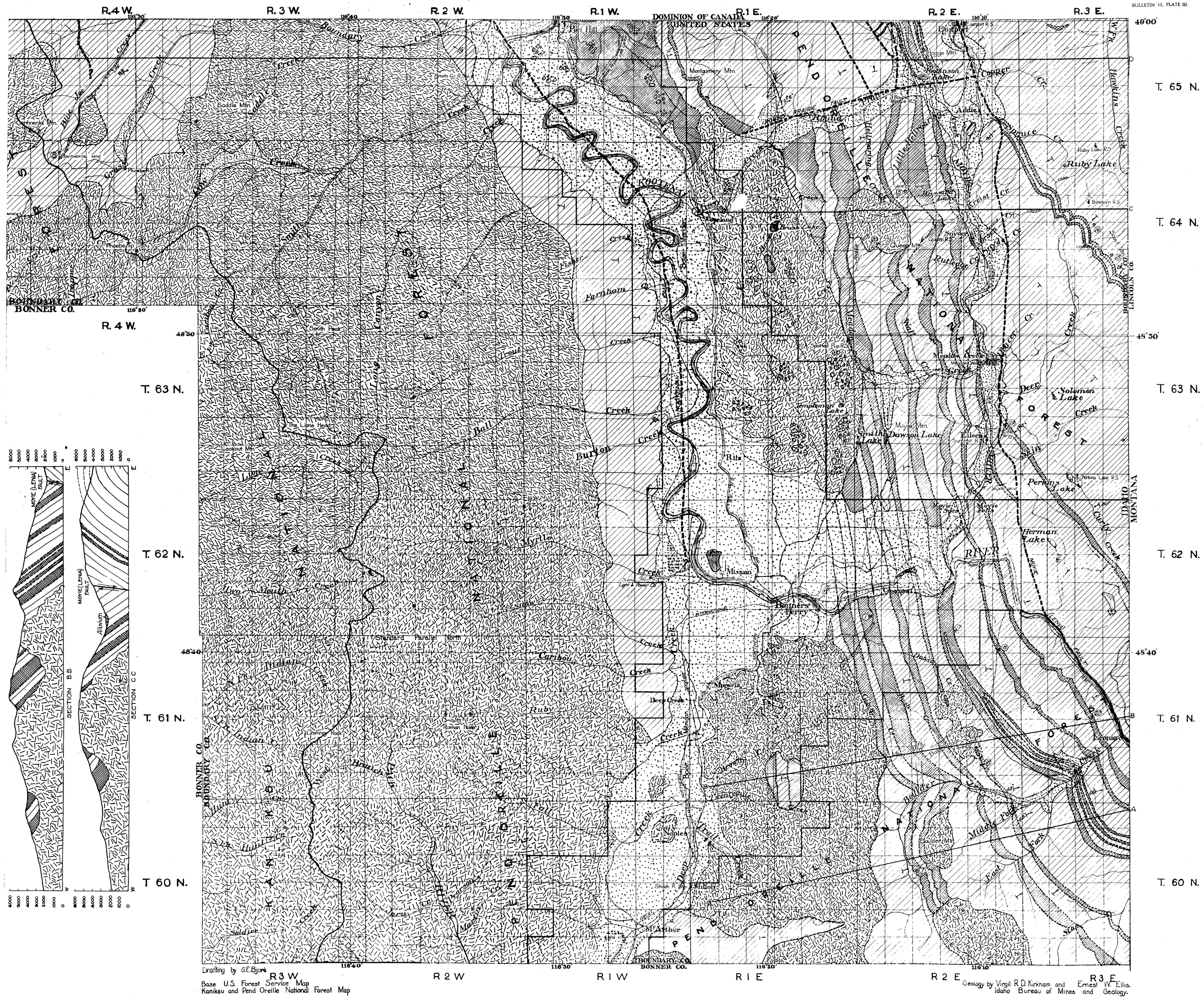

RECONNAISSANCE GEOLOGIC AND STRUCTURE MAP OF BOUNDARY COUNTY, IDAHO.