GENERAL AND ECONOMIC GEOLOGY OF THE WEST KOOTENAY BATHOLITH WITH SPECIAL REFERENCE TO THE CRANBROOK AREA

by

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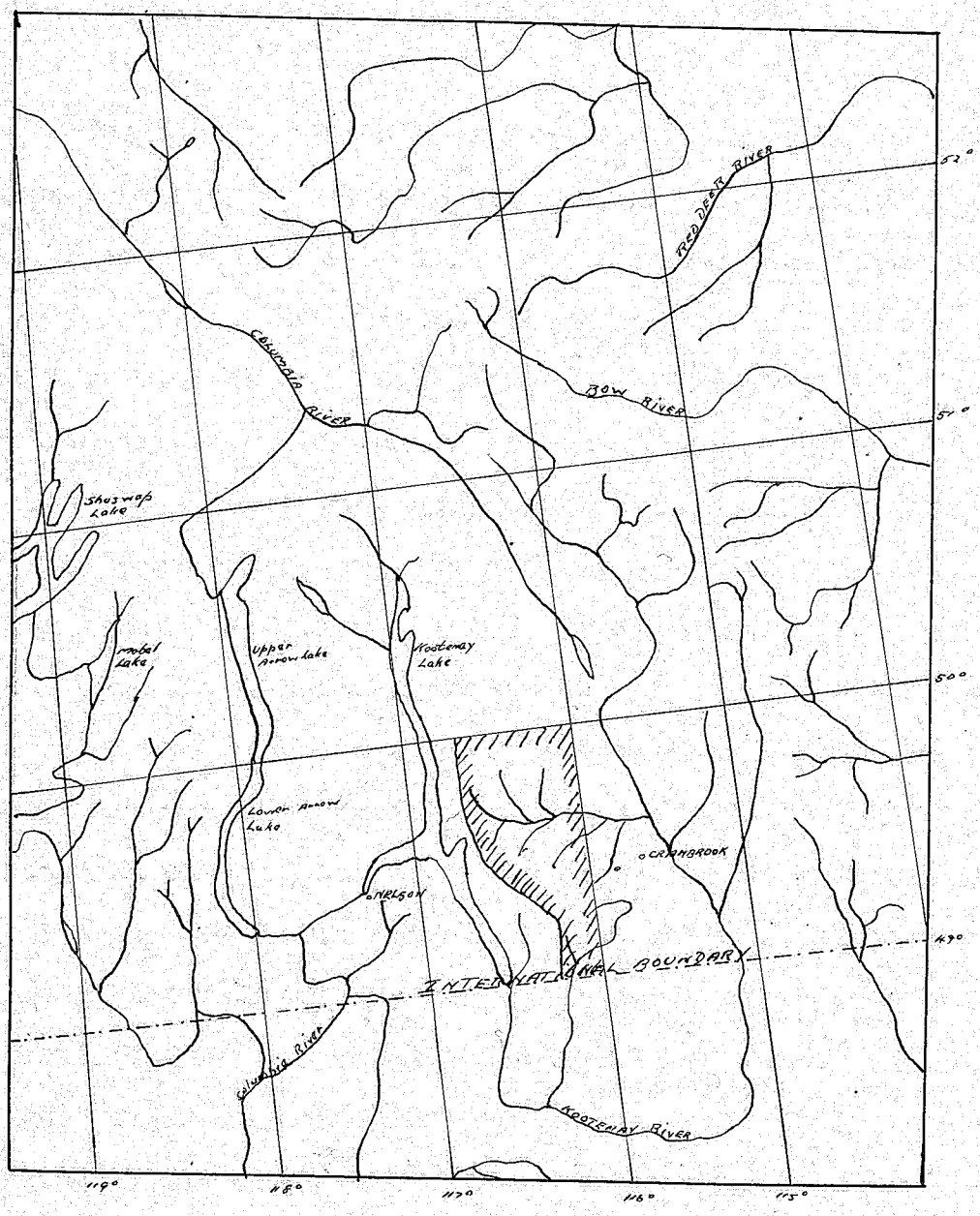
CHAPTER I

This paper presents the general and economic geology of the Cranbrook area in which the West Kootenay batholithic rocks intrude the overlying sediments. It also embraces work by the writer on the mineralogical determination and genesis of the ores collected in the field in the summer of 1936, together with the identification of the Cambrian fauna found there.

The writer wishes to record his indebtedness to Dr. M.Y. Williams, Head of the Department of Geology, Dr. S.J. Schofield, Professor of Structural Geology, and Dr. H.V. Warren, Assistant Professor of Mineralogy, under whose guidance this work was made possible. To Dr. H.M.A. Rice, Chief of the Survey party, the writer is very grateful for the help in the writing of this paper.

The area to be discussed is drained mainly by the St. Mary River. The northern limit of the area is 50° north latitude, its western limit longitude 116°45', and eastern limit longitude 116°. The southern limit is variable. The chief town and distributing point for the region is Cranbrook.

The Crowsnest division of the Canadian Pacific Railway passes to the south and east of the area. Cranbrook is the divisional point for the C.P.R., and from there a branch


RED DEER RIVER
COLUMBIA RIVER
BOW RIVER
SHUSWAP LAKE
ROSTAL LAKE
UPPER ARROW LAKE
KOOTENAY LAKE
LOWER ARROW LAKE
NELSON
CRANBROOK
INTERNATIONAL BOUNDARY
COLUMBIA RIVER
KOOTENAY RIVER
52°
51°
50°
49°
119°
118°
117°
116°
115°

INDEX MAP

line runs to Kimberley, the centre of the Kimberley mining area. From Yahk, a town situated in the southern part of the area, another line divides along the Moyie River, crossing the International Boundary at Kingsgate, on its way to Spokane and Portland.

The drainage area of the St. Mary River is accessible by a wagon road from Marysville, as far as the ranch of Wm. Meachem. From here a new trail was constructed in the summer of 1936. This trail follows the west fork of the St. Mary River to Rose Pass. From this point it follows Crawford Creek to where it joins a wagon road eleven miles from Crawford Bay. The trails on the south-~~east~~ and north forks of the St. Mary River are in poor condition, and are either overgrown or covered by windfalls. From the foot of St. Mary Lake a good trail runs up Whitefish Creek to Sanca on Kootenay Lake. One branch trail from the Whitefish trail goes over the St. Mary River-Goat River summit and follows the Goat River to Kitchener on the Canadian Pacific Railway. However, due to a forest fire in 1936, the Goat River trail is now inaccessible for travel. A good trail runs up Hell-Roaring Creek to some old placer workings, and also to the old Boy Scout Mine. On Perry Creek a good road reaches Morchester Creek, from where the Consolidated Mining and Smelting Company have built a trail leading to their magnesite deposits at the head of Hell-Roaring Creek.

From Lumberton a logging road runs up to Cooper Lake. This road has numerous branching logging roads which make

travel in this section comparatively easy. A trail from the mouth of Irishman creek leads up this creek to the Limestone Falls. From Yahk a logging railway runs to Canuck Creek. A logging road follows Canuck Creek to the International Boundary. There are many numerous branching roads along Canuck Creek.

All these trails, although well defined, are usually covered by windfall which renders travel exceedingly slow. This area is practically impassable for a pack train without trails.

CHAPTER II

In the southern part of British Columbia the Interior Plateau region separates the North American cordillera in Canada into two main divisions, each of which, in contrast to the Interior Plateau region, is characterized by alpine mountain topography. Each division is subdivided into mountain systems which are separated from each other by well defined topographic features. The eastern division includes - from west to east - the Columbia, Selkirk, Purcell and Rocky Mountain systems.

The Purcell system, to be discussed in this paper, according to Daly is an elliptical-shaped group of mountains, 250 miles long and 60 miles wide, lying between the Selkirk system on the west and the Rocky Mountain system on the east. Although the greater part of this range is contained in British Columbia, a section extends into the United States. The Purcell system is separated from the Selkirk system on the west by the Purcell trench in which occur Duncan River, Kootenay Lake, and the north-flowing part of the Kootenay River. The Purcell Range is separated from the Rocky Mountains on the east by the Rocky Mountain trench, in which occur the north-flowing portion of the Columbia River and a south-flowing

section of Kootenay River. The latter river, after flowing southwards into the United States, swings through a semi-circle, and with a northward course crosses the International Boundary line again, emptying itself into Kootenay Lake. This semi-circular valley forms the southern boundary of the Purcell Mountain system.

Local

The area embraced by this report includes the central part of the Purcell Range in southeastern British Columbia. The mountains here are very rugged, and rise on the average to over 8,500 feet in elevation.

Intercirque divides or arretes are saw-like in character, and are almost vertical. The peaks have serrated summits, and are subject to rapid erosion by the action of ice and snow. Valley-head cirques or basins are numerous throughout the district, and are somewhat modified by the talus slopes which at times encroach upon the small tarns so characteristic of these glacial amphitheatres. One small glacier exists on a cliff above Hall Lake, while another large ice field exists near Jung Mountain. To the east and south-east of this mountainous region lies the subdued mountain belt characterized by rounded hills rising to a height of 7,000 to 7,500 feet above sea-level.

This section of the Cranbrook area is drained mainly by the St. Mary River which rises in the heart of the

Purcell Range, and the south-flowing Kootenay River near Fort Steele. The headwaters of Findlay Creek and Skookamchuck Creek drain this area. In the southern portion of the area the Moyie River traverses a large section of the area.

Practically all of the tributaries of the St. Mary River owe their beginnings to beautiful cirque lakes. These streams which flow through wide,rocky floors contain many small falls, the result of the hanging valleys left by the continental glaciation, near their confluence with the main stream. These streams enter the St. Mary River at grade, and their lowest reaches are characterized by gravel cut banks about fifty feet in height.

The main tributaries of the St. Mary River are Hell-Roaring Creek, Whitefish Creek, Perry Creek, North, East, South and West Fork Creek, Pyramid Creek, Alki Creek and Matthew Creek.

The main stream of the St. Mary River pursues a meandering course eastward in a wide, flat valley floor, the walls of which rise abruptly to a height of 4,000 to 5,000 feet. The spurs have facetted fronts which give the valley a trough-like shape. As St. Mary Lake is approached the valley floor becomes marshy, and contains many oxbow lakes. The river forms a delta at the point it enters St. Mary Lake - a body of water two miles in length and one mile in width, on either side of which the hard Aldridge quartzites and intercalated Purcell sills rise abruptly, while the valley

itself is narrowed. Terraces gradually make their appearance in the stratified gravels and sands of the trough through which the river continues its winding course.

CHAPTER III

During early Pre-Cambrian times there was laid down a great thickness of extremely homogeneous sediments in the western part of the Rocky Mountain geosyncline. These sediments consist of fine-grained quartzites, argillaceous quartzites, argillites and limestones, which show at various horizons shallow water characteristics such as ripple marks and mudcracks. These strata are called the Lower Purcell series, and include the Fort Steele, Aldridge, Creston, Kitchener, Siyeh and Gateway formations. After this series had been deposited there occurred a period when the old land-mass to the west was eroded to a surface of very low relief. Deposition took place only in the western part of the basin of sedimentation. These formations are called the Upper Purcell series, and include the Dutch Creek and the Mount Nelson formations.

In the late Pre-Cambrian times a broad uplift occurred which resulted in the deposition of the Windemere series. At the base this series is marked by a coarse conglomerate, while higher pebble conglomerates and inter-bedded limestone are to be found.

After the Windemere series was laid down the whole

surface was submerged, and at this time the Cambrian sediments were deposited. These sediments preserve records of early life as fossil remains.

The large stocks and small cross-cutting bodies of granite and porphyritic granite, which intrude the Purcell series, are believed to bear a ~~granite~~ genetic relationship to the great West Kootenay granite batholith.

The age subdivision and correlation of the great thickness of sedimentary strata exposed in the Purcell Range have been the subject of much study. The subdivision into formations is based on physical and lithological as well as palaeontological grounds. The table of formations given below is based on the work of previous surveys and also on the new classification used by the Geological Survey of Canada.

POST GLACIAL	Stratified clays and sands	
GLACIAL	Wycliffe drift	
MIOCENE	St. Eugene silts and gravels	
JURASSIC	Dyke intrusions West Fork granite North Fork granite East Fork granite Skye granite	Kootenay Granite
MISSISSIPPIAN	Not represented	
DEVONIAN	"	
SILURIAN	"	
ORDOVICIAN	"	
LOWER CAMBRIAN	Eager formation Cranbrook formation	

UNCONFORMITY

	Windermere	Hamill series Horsethief formation Toby conglomerate
		Unconformity
PRE-CAMBRIAN	Upper Purcell	Mount Nelson formation
	Dutch Creek Formation	(Roosville formation (Phillips " (Gateway "
	Lower Purcell	Gateway formation Purcell lava Purcell sills Siyeh formation Kitchener " Creston " Aldridge " Fort Steele "

TABULAR STATEMENT OF GEOLOGICAL RECORD

QUATERNARY	Post Glacial	- Erosion, deposition of clays and sands in depressions in drift.
	Glacial	- Erosion, deposition of Wycliffe drift
TERTIARY(Miocene)		- Erosion, deposition of St. Eugene silts, sands, Tertiary gravels and fossil leaves. Uplift in early Tertiary and dissection of Cretaceous peneplain
CRETACEOUS		- Erosion, formation of Cretaceous peneplain
POST TRIASSIC (Jurassic?)		- Orogenic movements, formation of Purcell Range followed or accompanied by intrusion of Kootenay granite and some peridotite.
CARBONIFEROUS		- Erosion
DEVONIAN		"
SILURIAN		"

ORDOVICIAN -Erosion
MIDDLE CAMBRIAN "

LOWER CAMBRIAN - Eager Formation, marine deposition of green, black, brown and reddish argillites (fossiliferous).
Cranbrook Formation - continental deposition of fine-grained, white, pink and sometimes green quartz conglomerate and siliceous massive sandstone.

UPLIFT AND EROSION

PRE-CAMBRIAN -/Windermere Series

1) Hamill series
2) Horsethief formation - deposition of grey, green and purple slate, coarse quartzite, pebble conglomerate and magnesium limestone
3) Toby conglomerate - deposition of conglomerate beds and some lenticular beds of slate and quartzite.

UPLIFT AND EROSION

Lower Purcell Series - 1) Gateway -(continental deposition) sandstones, sandy argillites, some concretionary, siliceous dolomites.
2) Purcell Sills and Lava - intrusion of gabbro, accompanied by outpouring of basalt over land surface.
3) Siyeh Formation -(mainly continental, and some possible marine deposition) red, purple and green mud - cracked argillites, sandstones and some limestones.
4) Kitchener Formation -(continental and possible marine deposition) calcareous argillites, argillaceous quartzites, ripple marked, mud-cracked, some limestones.
5) Creston Formation - shallow water deposition, quartzites, argillaceous quartzites, mud-cracked and ripple marked.
6) Fort Steele - wide banded, argillaceous quartzites

The Pre-Cambrian Rocks of East Kootenay - General Statement

The Purcell series of East Kootenay was described by Daly in the Annual Report of 1904.[1]

The following is Daly's stratigraphic section:

		Feet
MIDDLE CAMBRIAN	- Moyie	3,400
	Purcell lava	465
	Kitchener, upper part	6,000±
LOWER CAMBRIAN	Kitchener, lower part	1,400±
	Creston, upper part	3,000-
BELTIAN	Creston, lower part	6,500±

Base unexposed

Later work by Schofield[2] on the East Kootenay proved that Daly's work was erroneous, and Schofield's stratigraphic section is as follows:

Erosion Surface

		Feet
PRE-CAMBRIAN	- Gateway	2,000+
	Purcell lava	300
	Siyeh	4,000
	Kitchener	4,500
	Creston	5,000+
	Aldridge	8,000-

Base unexposed.

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1. Daly, R.A., C.G.S. Annual Report, 1904, p.91A
   Daly, R.A., C.G.S. Memoir 38, 1913, p.119

2. Schofield, S.J., C.G.S. Memoir 76, 1915, p. 25.

Walker's report on the Windermere area[1] and the Kootenay Lake[2] area subdivides the Pre-Cambrian rocks as follows:

UNCONFORMITY

PRE-CAMBRIAN	Windermere Series	Feet
	Lardeau Series	15,000
	Badshot Formation	250
	Hamill Series	2,500
	Horsethief Formation	5,000+
	Toby Conglomerate	50+
	UNCONFORMITY	
m	Upper Purcell Series	
	Mt. Nelson Formation	3,000+
	Dutch Creek "	2,550+

Subsequent work by Rice[3] in the East Kootenay subdivides the Purcell series as follows:

PRE-CAMBRIAN	Gateway Formation
	Purcell Lava
	Siyeh
	Kitchener Formation
	Creston Formation
	Aldridge Formation
	Fort Steele Formation

The Fort Steele formation is exposed on the west flank of the Rocky Mountains near Wildhorse Creek and underlie the Aldridge formation conformably.

Work in the East Kootenay during the field season of 1936 was able to correlate the Pre-Cambrian complex of that district. The Creston formation was measured by the writer with

1. Walker, J.F. G.S.C., Memoir 148, 1926, p.6
2. Walker, J.F. G.S.C., Summ. Rept., 1928, Part A, p. 121 A
3. Rice, H.M.A. G.S.C., Mem., 1935.

telemeter and rod near Yahk, and its thickness was determined to be 5,700 feet. The following is the writers stratigraphic section:-

Erosion Surface

PRE-CAMBRIAN

Windermere Series

Lardeau Series
Badshot Formation
Hamill Series
Horsethief Formation
Toby Conglomerate

UNCONFORMITY

Upper Purcell Series

Mt. Nelson Formation
Dutch Creek "

Lower Purcell Series

Gateway Formation
Purcell lava
Siyeh Formation
Kitchener "
Creston "
Aldridge "
Fort Steele "

Fort Steele Formation

The Fort Steele formation is the oldest known member of the Purcell series. This formation, named by Rice in 1935, embraces a succession of dark grey, argillaceous quartzites which are noted for their wide banding. These rocks underlie the Aldridge beds conformably, and are found in the western flank of the Rocky Mountains.

Aldridge Formation

Distribution

The Fort Steele formation passes by gradual transition into the overlying Aldridge quartzites. As the base of the Aldridge is approached the rocks take on the rusty, weathered appearance which characterizes this formation. This formation consists of a very homogeneous succession of dark grey argillaceous quartzites, noted for their rusty weathering, and occupies a large region within the discussed area. A northern belt embraces part of the area drained by the St. Mary River. The northern border of this belt is drawn at the point where the formation is cut off by the East fork granite. The western border of this belt passes conformably beneath the Creston formation. The strata here form, in general, an anticlinorium plunging to the north. The southern border is formed by a fault which brings the Aldridge and the overlying formation from the Creston to the Eager in contact. From Marysville this fault strikes on the one hand south-west, and on the other east. The eastern portion of this belt passes under the Pleistocene deposits of the Kootenay River valley.

The next area of the Aldridge formation to the south is separated from the northern area by a block of Creston argillaceous quartzites. The western border of this belt was explored to the head of Moyie River. Its eastern limit is formed by the Moyie fault which brings Aldridge into contact

with the overlying Creston and Kitchener formations.

The most southerly area of the Aldridge formation is an elliptical shaped mass of anticlinal structure whose greater portion lies south-east of the Canadian Pacific Railway and west of the main Yahk River. Its western limit is formed by passing conformably under the overlying Creston argillaceous quartzites. The eastern border was not explored.

Thickness

The Aldridge formation from measured sections is 8,000+ feet.

Lithology

The Aldridge formation is made up of a series of argillaceous quartzites, purer quartzites and argillites. The argillaceous quartzites form the greater portion of the whole series and occur in beds with an average thickness of one foot. In the hand-specimen they are fine-grained rocks, dark grey on fresh fracture and weather to a brown colour due to their content of iron oxide. In a few cases purer white quartzites were noted in this formation. Near the top of Bootleg Ridge the rocks are well bedded, brown, purple, green and white argillaceous quartzites. The Aldridge formation, exposed to the north of Cone Mountain, contains an interformational conglomerate bed whose pebbles vary in size from a fraction of an inch to one inch in diameter, consisting of sandy pebbles and black, sheared pebbles probably of igneous

origin. Most of the pebbles are sheared as they are near a fault zone.

Metamorphism

The metamorphism of the rock types of the Aldridge formation has been for the most part very slight. It is notable that at the contact of some sills the quartzites become bleached and charged with sericite, while at others a green chloritic schist is formed. On Bootleg and Pitt Creek ridges a belt of quartz-mica schist, garnetiferous mica schist and sillimanite schist is exposed. These schists represent the metamorphosed argillaceous quartzites of the Aldridge formation since they pass gradually on all sides into the normal argillaceous quartzites. In the hand-specimen it is a glistening rock containing a great quantity of mica (muscovite and biotite) and quartz. The garnets are idiomorphic, pink in colour, and from a fraction of an inch to one-half an inch in size. On Bootleg Ridge an intrusive dike of graphic granite pegmatite was found giving evidence as to the source of the metamorphism. At two localities in the area two regions of ottrelite schist were located. Numerous stocks and apophyses of granite intrude this formation, and thermal metamorphism plays a large role in the metamorphism produced. A perfect example of zoning in a metamorphic region is afforded on the Crolle property.

Shearing plays an important role in the incompetent beds of this formation, and usually forms schistose rocks. Near the contact of the East Fork granite, the Aldridge formation is metamorphosed to a quartz-mica schist. Some of these quartzites are changed to a knotted or spotty schist, the knots consisting of the accumulation of carbonaceous material.

The Aldridge formation is characterized by the occurrence of economic deposits of silver-lead ores. The ore deposits from field evidence seem to be genetically related to the granite intrusion. They are also related to well defined shear zones which provided access for the mineralizing solutions. These solutions traversing these zones replaced the purer, thick-bedded quartzites and to a less extent the argillaceous thin-bedded members.

Structure

The present attitude of the strata of the Aldridge formation shows that it has suffered some orogenic movements. In general, it is warped into a series of anticlines and synclines striking in a northerly direction. The Moyie Valley in the neighborhood of Yahk has been eroded along the axis of an anticline which plunges to the north. The folds are usually gentle, but occasionally as in the mountains minor overturned anticlines, mashing and faulting modify the major folds. The faults can be traced for great distances in this

formation. Schistosity is developed in the incompetent beds as small drag folds.

Creston Formation

Distribution

As the top of the Aldridge formation is approached the rocks, while still rusty-weathered, take on a peculiar greenish colour. This zone is from 10-100 feet thick. Above this is a series of rocks which are green in colour and mud-cracked. The base of the Creston formation is placed at the point where these beds are encountered.

There are four main belts of Creston quartzites in this area. The northern border of Creston rocks is formed by the cutting off of the formation by the East and North Fork granites.

The western belt has as its northern border the North Fork granite. The western border is formed by this formation passing conformably beneath the overlying Kitchener formation. Its eastern border is formed by the East Fork granite and by being conformably underlain by the Aldridge quartzites. This boundary is modified by the intrusion of the Hall granite. Its southern boundary has only been explored as far as the head of Whitefish Creek.

The north-eastern belt of the Creston rocks lies north of Matthew Creek, and is cut off to the north-west by

the East Fork granite. Its western and southern borders are formed by the conformable underlying Aldridge formation. The north-eastern border passes conformably below the overlying Kitchener formation.

The north-eastern and western belts of the Creston formation are parts of the great anticlinorium plunging to the north. This anticlinorium is cut off by the granites to the north.

The middle belt of the Creston formation, where the Aldridge is faulted against it, appears at the head of Pitt Creek. This belt of Creston rocks strikes south-west to the head of Hell-Roaring Creek. The eastern border is formed by the formation passing conformably into the underlying Aldridge formation. The southern border has only been explored to the headwaters of the Moyie River.

The southern belt pursues from Moyie Lake a course varying with the Moyie fault. The western and north-western borders are bounded partly by the Moyie fault which brings the Aldridge formation into contact with the Creston rocks. At the head of Irishman's Creek the Creston was found to pass conformably beneath the overlying Kitchener formation. The eastern border is formed by passing conformably into the underlying Aldridge quartzites.

Thickness

The section of the Creston formation south-west of Yahk was measured by the writer, and its thickness was found

to be 5,700 feet. As this belt is free from folding, the writer's measurement may be considered correct.

Lithology

The Creston formation embraces a succession of argillaceous quartzites which have the following characteristics. The base is formed of mud-cracked, green argillites and argillaceous quartzites. Further up in the section the rocks become green-white and purple mottled. This purple mottling is now regarded as typical of the Creston quartzite formation, and is due to finely divided, specular hematite contained in the rocks. The greenish varieties range in colour from dark to light green. Near the top ~~of the top~~ of the formation the Creston quartzites become interbedded with the calcareous rocks of the Kitchener formation. The quartzites of the formation under discussion are in beds sometimes measuring up to one foot in thickness, while the interbedded argillaceous material varies from one inch to three inches in thickness. Characteristics of this formation are ripple markings, mud cracks and cross-bedding.

Metamorphism

The members of the Creston formation are not metamorphosed to any considerable degree. Around the Skye granitic intrusion the rocks are quartz-mica schists. There are also some spotted schists due to accumulation of carbonaceous

material. As the Creston formation is typically quartzitic, that is a metamorphosed sandstone, further metamorphism has no appreciable effect. Regional metamorphism has induced shearing at right-angles to the bedding planes of the argillites which separate the thick-bedded purer quartzites.

Structure

Since the Creston quartzites lie conformably upon the Aldridge formation, it would follow that these two series must have a similar structure. That is, the Creston has been folded into anticlines and synclines. The Creston quartzites are characterized at various horizons by shallow water features: mud cracks and ripple marks are notable characteristics of this region.

Kitchener Formation

Distribution

The Kitchener formation embraces four belts of calcareous argillites and quartzites.

The northern belt, conformably overlies the Creston quartzites near the head of Skookumchuck Creek, has not been explored far past its contact with the underlying Creston formation.

The western belt is cut off to the north by the North Fork granite. Its north-east border is formed by a

synclinal roll through which the North Fork of the St. Mary River flows. This belt crosses the West Fork River near the head of Moon Creek. The southern boundary has been explored as far south as the head of Redding Creek. The western border of this formation passes conformably under the Dutch Creek formation. The South Fork of the St. Mary River cuts through an anticline of Kitchener quartzites leaving it exposed on both sides of this creek.

The Hell-Roaring belt of Kitchener rocks has as its northern boundary the Hell-Roaring fault. The eastern border is formed by the underlying Creston formation, and the western border by the overlying Siyeh formation. Small synclinal pads of Kitchener rocks occur in the Creston formation. On Perry Creek near the Sawmill fault there occurs a belt of calcareous quartzite.

The southern belt of Kitchener formation at the head of Irishman's Creek is wedge-shaped, and is cut off to the north by the Moyie fault. The southern border passes conformably into the underlying Creston quartzites.

Thickness

The best section of the Kitchener formation for measurement is to be found along the Canadian Pacific Railway on Upper Moyie Lake in the vicinity of Jerome. Here exposures are satisfactory, and show little evidence of folding. Hence the measured thickness of 4,500 feet can be taken as correct.[1]

1. Schofield, S.J. G.S.C., Memoir 76, 1915.

Lithology

In comparison with the underlying Creston and Aldridge formations, the most notable feature of the Kitchener formation is its content of lime. It lies conformably on the Creston quartzites, and the contact is transitional. The formation consists of calcareous and argillaceous quartzites, quartzites and limestones, having general weathering colours of buff with some grey tones. On the weathered surface parallel to the bedding planes are numerous linear depressions about one-eighth to one-quarter inch wide and one-half inch deep, while on the planes perpendicular to the bedding these depressions are irregular and sometimes vermicular. Evidently these depressions are the result of the leaching out of the purer calcareous phases. The peculiar weathering effect is characteristic of these argillaceous limestones and is termed "molar tooth" structure. Argillaceous quartzites consisting of banded white and black rocks are commonly found interbedded with the calcareous members.

Metamorphism

The impure members of the Kitchener formation form schistose rocks when subjected to metamorphism. These rocks are usually quartz-mica schists. On the North Fork of the St. Mary River one zone of thermal metamorphism was found to contain an andalusite schist. Much pyrite was found in this zone; the intrusion was located in the near vicintiy of the metamorphic rock.

Structure

The Kitchener formation rests conformably on the Creston formation. The contact is transitional, and the division between the two formations is drawn at that point where the limey beds predominate. The Kitchener is overlain conformably by the Siyeh formation, this contact also being transitional.

Siyeh Formation

Distribution

There is one main belt of Siyeh rocks in this portion of the Cranbrook area.

This belt starts half-way up the main fork of Hell-Roaring Creek, and follows the creek bottom for 2½ miles, then swings to the west of the head of that creek. The northern border is formed by the Hell-Roaring fault which brings the underlying Aldridge formation into contact with the Siyeh formation. On the western border the Siyeh rocks pass unconformably below the Cranbrook formation. The eastern border is formed by the transition to the underlying Kitchener formation, while the southern border has not been explored south of the head of Hell-Roaring Creek.

The western belt is of too small a thickness to be mapped. It has the same relations to the other formations as stated above.

Lithology

The Siyeh formation exposed in this area is composed of thin-bedded purple, olive green, white and black banded argillites and argillaceous quartzites.

Thickness

As the Siyeh formation is not very thick in this area, a section was not measured. According to Schofield[1] and Daly[2] the thickness is 4,000 feet.

Structural Relation

In this area the Siyeh formation is underlain conformably by the Kitchener formation and therefore has the same structural features.

The Purcell lava is absent in this area, but Schofield[1] places the top of the Siyeh formation at the bottom of the last flow of lava.

Gateway Formation

In this area there is one belt of Gateway rocks. Walker[3] proposes that the Dutch Creek and Mount Nelson formations be called the Upper Purcell series. The base of this series is defined as being the horizon of the uppermost

1. Schofield, S.J. G.S.C. Memoir 76, 1915.
2. Daly, R.A. G.S.C. " 38, 1912.
3. Walker, J.F. G.S.C. " 148, 1926, p.7

Purcell lava at the boundary between the Gateway (lowest horizon of the Dutch Creek formation) and the underlying Siyeh formation.

As the only Gateway rocks found in this area occur in the Dutch Creek formation it will be permissible to include them in it as defined by Walker.

Dutch Creek Formation

The name of this formation which is the northern extension of the Roosville, Phillips and Gateway is derived from Dutch Creek.[1]

Work in 1936 proved that identically the same formation occurs in the Kootenay district in the St. Mary River drainage area. This formation occurs in one belt on the western side of the area. The North fork granite forms the northern boundary which follows the North fork south for five miles from where it crosses the West fork at ~~Eagle~~ Cogle Pass. The southern border has not been explored below ~~Eagle~~ Cogle Pass. To the east the formation is underlain conformably by the Kitchener formation. The western border is formed by the conformably overlying Mount Nelson formation and is modified by the Stub granitic stock which intrudes this formation.

Lithology

This formation is made up of a succession varying

1. Walker, J.F. G.S.C. Memoir 148, 1926, p. 7

from argillite and quartzite to magnesium limestone. The argillite comprising the greater part of the formation is grey green and purple on fresh fracture, fine-grained and laminated. There are some sandy beds but this is not a common characteristic. Pyrite cubes are numerous in the argillites. The quartzites are thin-bedded and fine-grained with a faint greenish colour. The limestones are slaty magnesium and thin-bedded, in colour, grey, weathering cream to buff. Some chert beds were found to be associated with the limestone.

Thickness

The maximum observed thickness of this formation in the Windermere map-area is about 3,500 feet.[1]

Metamorphism

This formation has been intruded by and is probably underlain by igneous rocks. It has been subject to a great amount of thermal metamorphism. The rocks form garnetiferous mica schists and quartz mica schists. Some gneisses are formed and the limestone in one locality formed wollastonite, probably due to metasomatism.

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1. Walker, J.F. G.S.C. Memoir 148, 1926, p. 8

Structure

As this formation conformably overlies the Kitchener formation, it will have the same structural relations. However, these are modified somewhat by the intrusive stocks of granite material.

Mount Nelson Formation

Distribution

In the Cranbrook area one belt of Mount Nelson rocks were found. The northern border of this belt is formed by the Stub granitic stock. The formation was not explored beyond this stock, but it is probable that it runs north into the Windermere map-area. The southern border was explored as far south as Cogle Pass. The eastern border is formed by the conformable underlying Dutch Creek formation. The unconformable Toby conglomerate forms the western border of this belt.

Lithology

The Mount Nelson formation is a succession of crystalline magnesium limestones and slates, and has at its base and also near the upper erosional surface massive white quartzites. The magnesium limestones are grey blue, white, purple and brick red on fresh fracture and weather to a grey cream, buff and purple. The argillites are grey to

black, green and purplish and weather to the same colours. The beds average one foot in thickness.

Thickness

The observed thickness is 3,400'.

Structure

As this formation is conformably underlain by the Dutch Creek formation, the structural features are identical.

Origin of the Purcell Series

In the foregoing description of the Purcell series the writer stated that the series consist of a great thickness of argillaceous quartzites, quartzites, argillites and limestones. In general the rocks are well bedded, the individual beds varying from 1 inch to 8 feet in thickness. The rocks consist of interlocking grains of quartz, striated feldspar and argillaceous material. At various horizons in the series occur ripple marks and mud cracks which are especially abundant in the Creston and Siyeh formations. Casts of salt crystals are numerous only in the Gateway formation (Lower Dutch Creek). Evidence of contemporaneous erosion is seen in the Aldridge formation.

The extreme fineness of grain and the almost perfect separation of the siliceous and aluminous material advances the opinion that these sediments were derived from an older terraine probably composed of acid gneisses and schists in a region of topographic late maturity.[1]

The Aldridge argillaceous quartzites are dark grey on fresh fracture and weather to a rusty brown colour, hence, the iron contained in these quartzites is in the ferrous condition. It is also probable that some carbonaceous material is present. This would show that the climate at the time of the deposition of the Aldridge sediments was humid. The presence of striated feldspar in the quartzites supports the idea that mechanical disintegration of the source of supply was more rapid than decomposition or weathering. The evidence of contemporaneous erosion, as well as the conglomerates found in the Aldridge formation on Cone Mountain suggests that the water in which the sediments were deposited was shallow and that subsidence and deposition proceeded approximately at the same rate.

The quartzitic Creston formation is characterized by a green and purple colour. The base of the Creston is notable for its abundance of mud-cracks. This fact suggests that at the close of the Aldridge sedimentation the basin of deposition was very shallow. Ripple markings are found in this formation. The top of the Creston formation is characterized by interbeds of limestone indicating a deepening of the sea.

[1] Schofield, S.J. G.S.C. Memoir 76, 1915

The more calcareous portion of the Kitchener formation seemingly accumulated in comparatively deep water, since no shallow water features were noted in it.

The next succeeding formation, the Siyeh metargillite, is characterized by the presence of alternating greyish-green and purple to chocolate brown argillites, which are especially distinguished by the presence of abundant mud cracks. Hence the water in which these sediments were deposited was shallow and even shallower probably than the Aldridge or Creston sea.

Continental deposition under arid conditions prevailed throughout the Gateway times, as is shown by the presence of the casts of salt crystals and the abundance of ripple marks.

Sources of the Sediments

The Aldridge formation in the eastern part of the Purcell range contains no conglomerates, but in the central and western parts as in the vicinity of the Goat River and Cone Mountain these conglomerates are abundant. The Creston formation is coarser in the western part of the range, from which is drawn the conclusion that the land from which these sediments were derived was situated to the west of the Purcell Range and probably as close as West Kootenay, for the Pre-Cambrian complex of gneisses and schists outcrops

at various points in that region. Daly[1] in his study across the whole Rocky Mountain geosyncline remarks on the decrease in the coarseness of the sediments from west to east.

Purcell Sea

The water in the Purcell continental basin in which the Purcell sediments were deposited was shallow for the most part. Walcott[2] believes from the abrupt appearance of the Cambrian fauna in the sediments of the Rocky Mountain geosyncline that the Purcell sea was not connected with the ocean and that the water in the sea was either fresh or brackish.

Walker's[3] opinion is that the great thickness of limestone in the neighborhood of the International Boundary scarcely bears out such a hypothesis as Walcotts, but ~~rather~~ rather indicates true marine conditions. The apparent lack of life in the Purcell strata can now be explained by the extent of the hiatus existing between the Cambrian and the Purcell series, for the gap is much greater than had previously been believed even by those who claimed unconformable relations. Evidence of the extent of the break is afforded by the Pre-Cambrian Windermere series which is definitely post-Purcell

1. Daly, R.A. G.S.C. Summ. Rept. 1904
2. Walcott, Smithsonian Collection, Vol. 57, 1910, p. 1
3. Walker, J.F. G.S.C. Memoir 148, 1926, p. 12

in age, and the relations as propounded on a later page are such that it is evident the Purcell sediments were subjected to at least two cycles of erosion before the laying down of the Lower Cambrian marine sediments.

Structure of the Purcell Land Mass

The Purcell sediments were subjected to folding in Pre-Windermere time, this being indicated by the angular unconformity between the two series. The unconformity is marked, though the discordance seldom reaches 45 degrees. There is little difference between the degree of metamorphism exhibited by the two series, and this fact coupled with the moderate angular discordance would point that the Pre-Windermere folding was of an open broad character. There must, however, have been considerable uplift to give a relief that would account for the formation of the great basal conglomerate of the Windermere series.

Windermere Series

The strata of the Windermere series were observed by Schofield and Shepard, but their relations to the underlying and overlying formations were not determined. Walker[1] first proposed this name for the series of strata lying

1. Walker, J.F. Geol. Surv. Can. Mem. 148, 1926, p. 13

unconformably above the Mount Nelson formation in the Windemere map-area. Walker[1] correlated this series with the Windermere series in the Kootenay Lake district.

Work in 1936 by the Geological Survey was able to correlate the Purcell series of the Cranbrook map-area with the Windermere of the Kootenay Lake district.

Toby Conglomerate

Distribution

The Toby Conglomerate forms a narrow belt that lies to the west of Rose Creek. The northern border of this belt is formed by the Stub granitic stock which cuts the Toby conglomerate off from its northern extension. The eastern border is formed by unconformably overlying the Upper Purcell sediments while the western border of this belt passes conformably under the Horsethief formation. The southern border was explored only as far south as Rose Pass.

Lithology

The Toby Conglomerate is the basal member of the Windermere series and was named after Toby Creek in the Windermere area. Its nature is extremely variable. In places the matrix is largely slate through which are scattered fragments of slate and shale and occasional boulders of limestone and quartzite. Along or across the

1. Walker, J.F. Sum. Rept. G.S.C., 1928 Part A p. 124A

strike the matrix may change repidly to one of limestone holding chiefly limestone boulders, or it may grade into a highly siliceous type in which the boulders are chiefly quartzite. In other places quartzite and limestone boulders are equally abundant and lie in a slaty matrix. The percentage of boulders to matrix is extremely variable, ranging from scattered fragments forming only 5 to 10 percent of the rock to a compact boulder mass.

Within the formation are a few lenticular beds of slate and quartzite.

The materials comprising the cnnglomerate have not travelled far, and in all cases the boulders can be identified with the underlying rocks of the Purcell series. A large number of the boulders are rounded while many others are subangular and angular indicating rapid erosion and transportation with but little opportunity for wear. The boulders and fragments vary in size from 4 to 5 feet down to pebbles and shingle. The average size is about 4 to 10 inches.

Thickness

The Toby Conglomerate in the Windermere area varies from ~~50~~ 50 to 2000 feet thick.

Horsethief Formation

Distribution

This formation conformably overlies the Toby Conglomerate. The northern border of this series is formed by its contact with the Stub granitic stock; the western border passes conformably beneath the overlying Hamill series. The southern border was explored only as far south as Rose Pass.

Lithology

This formation is made up in large part of grey, green and purple slate with several lenticular beds of coarse quartzite and pebble conglomerate and numerous thin interbeds of blue-grey crystalline and mostly non-magnesium limestone, which occur at different horizons but form a relatively small part of the whole formation.

The coarse quartzite and pebble beds vary in thickness from 20 up to 100 feet or more. Most of the pebbles are quartz and quartzite, but a few are limestone which are well sorted and closely packed. The pebbles which are apparently derived in large part from the Purcell series, differ in size in the various beds and grade downward from an average minimum diameter of 1½ inches to grains such as make up the coarse quartzites. There are some argillaceous schists with beds of fine conglomerate, some grey quartzite, and grey limestone. A few beds of limy boulder conglomerate occur in the lower part of the series

thus indicating that the conditions giving rise to the massive Toby Conglomerate were still active to a slight extent.

Thickness

Walker[1] states that in the northern part of the Kootenay Lake district the series reaches a thickness of 5000 feet and in the southern part 7,000 feet.

Structure

The Horsethief formation conformably overlies the Toby Conglomerate. In the eastern part of the Windermere map-area it is overlain unconformably by the Upper Cambrian Ottertail limestone and in this area it is overlain conformably by the Hamill series of Windermere age.

Hamill Series

The Hamill series conformably overlies the Horsethief formation, and is part of the same sedimentary succession. This series was not explored far past its contact with the underlying Horsethief formation and therefore its base will be described.

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1. Walker, J.F. Summ. Rept. G.S.C. 1928, Part A, p 125 A

Lithology

The base of the Hamill series is composed of massive white and greenish quartzite which forms many of the highest, most rugged peaks along the west side of the Purcell Range.

The area surveyed field season of 1936 did not cover the upper beds of the Windermere series mentioned by Walker,[1] so that they are not included in this report.

Origin of the Windermere Series

Toby Conglomerate

The size and shape of the boulders, the unassorted character of the formation as a whole, and the evident derivation of the boulders from the immediately underlying Purcell series indicate that the materials were not transported any great distance.

Horsethief Formation

The conglomerate at the base of the Horsethief formation similar to that of the Toby conglomerate seems to indicate that the conditions were identical with the above, but slightly diminished. The formation was probably formed in a subsiding basin or valley bordering on an area

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1. Walker, J.F. Sum. Rept. G.S.C. 1928, Part A, p. 126A

of high relief along the margin of which the Toby conglomerate was deposited. No shallow water features were noted in this formation, but there was some cross-bedding in the quartzitic beds.

Palaeozoic Formations of the Discussed Area

The Palaeozoic formations occurring in this area are of Lower Cambrian age. The Cambrian near the Fort Steele-Eugene mission road were identified as Lower Cambrian by Schofield.[1]

In the area under discussion, the Cambrian strata will be referred to as the Cranbrook and Eager formations.

Cranbrook Formation

Distribution

The Cranbrook formation embraces one belt in the Cranbrook area. The northern border of this belt is formed by the Hell-Roaring fault. This border is just west of where the fault crosses Hell-Roaring Creek, bringing the underlying Aldridge formation into contact with the Cranbrook formation. The Cranbrook rocks unconformably overlie the Siyeh formation to the east. The western border is formed by passing conformably under the overlying fossiliferous

1. Schofield, S.J. Mus. Bull. No. 35, 1915, p.12

Eager formation to the west. The southern border was not explored south of the Hell-Roaring -Goat River divide.

Lithology

This formation consists essentially of a quartz pebble conglomerate at the base and grades upwards into a massive quartzite. The colour is green, red or white and the rock has a very decided vitreous appearance. Some magnesite was found in this formation.

Thickness

This formation is about 600 feet thick.

Structure

The Cranbrook formation unconformably overlies the Siyeh formation. Orogenic movements and this is evidenced by the change of the Siyeh argillites to the Cranbrook pebble conglomerate. The land mass must have stood high in relation to the basin of deposition in early Cambrian times.

Eager Formation

Distribution

This formation overlies the Cranbrook formation conformably. It forms one belt in the area under discussion

The northern border of this belt is formed by the south-west trending Hell-Roaring fault, which fault brings the Aldridge formation into contact with the Eager formation. The eastern border is formed by passing conformably into the Cranbrook formation. The southern border was only explored to the Hell-Roaring - Goat River divide. The western border was traced to the headwaters of the east fork of the Goat River.

Lithology

Near the top of the Cranbrook formation the massive quartzite becomes more sandy and contains thin interbeds of argillite. These argillites finally make up the larger portion of the Eager formation. Chocolate brown and black, weathering to a reddish brown colour, they are characterized by their peculiar silky lustre and content of fossils.

Age and Correlation

The age and correlation of the Eager formation based on the fossil content of the rocks were identified by the writer. The fossils are as follows:

Holmia ? (Zittel)
Wanneria wallcottanus (Wanner)
Olenellus gilberti Walcott
Salterella Billings

The fauna belong to the Lower Cambrian, possibly the upper portion, and are of the same age as the Eager formation.

Superficial Deposits

The valley bottoms in this area are usually covered with glacial drift. Near Marysville the St. Mary River has cut through about 300 feet of glacial drift which are sometimes stratified. One good exposure of till may be seen on the St. Msry road near Bear Creek. Recent stream alluvium is represented as gravel bars and sands throughout the area.

CHAPTER IV

IGNEOUS GEOLOGY

The Purcell and Windermere series have been intruded by two distinct periods of igneous activity. These will be discussed under the headings of:

1) Pre-Windermere Intrusion
2) Post Orogenic Intrusion

Pre-Windermere Intrusions

To this group of intrusions is given the name Purcell sills.[1] This series of rocks intruded the sediments when they were horizontal, later being tilted into their present condition. They are in greatest abundance in the Aldridge formation and occur occasionally in the Creston, Kitchener, Mount Nelson and Dutch Creek formations. The Purcell sills have a wide distribution in East Kootenay and Idaho since the Aldridge formation and its equivalents occupy extensive areas. In this area the sills can be well ~~received~~ viewed in the valley walls which enclose St. Mary Lake. The Moyie sills outcrop on the western slope of the first longitudinal valley west of Kingsgate on the International

1. Schofield, S.J. G.S.C. Memoir 76, 1915, p. 56

Boundary. These sills occur in all the formations named above; they vary in thickness from 2 to 2,000 feet and being more resistant to weathering agencies than the stratified rocks which enclose them usually form steep cliffs which are conspicuous features in the topography of the country.

Lithology

The rocks which constitute the Purcell sills vary in composition from a hypersthene gabbro to a very acid granite or granophyre with intermediate members between these extreme types. The texture of the sill rock varies from fine-grained to porphyritic. The granophyre is always associated with the gabbro and occurs at or near the upper contact of the sills. The thickness of the granophyre which grades downwards into a hornblende gabbro bears no relationship to the thickness of the sill. For a detailed description of the different types of sill rock, the writer would refer the reader to the report of Dr. S.J. Schofield.[1]

Internal Relations

The folding and faulting to which the sills have been subject are evidenced by the attitude and the distribution of the sills now exposed in the Purcell Range. As they were intruded when the strata were flat, they have suffered all the movements which have taken place in that

1. Schofield, S.J. G.S.C. Memoir 76, 1915, p. 57

range, so that they now form anticlines and synclines with all angles of dip from zero to 90 degrees. The sills often end abruptly against strata which are older or younger than those holding the sills, and in some cases, the vertical displacement may be several thousand feet.

The most striking phenomenon in the internal structure of the sills is a stratification of the material according to density. The writer studied Dr. Schofields Sill C on the International Boundary. This sill had an upper zone of granitic composition which graded into the normal quartzitic rocks. The lower zone passed into a rock of slightly basic character and finally into a zone of gabbroic rock. The lower border of the sill did not exhibit a granitic zone.

The second type of sill was studied on St. Mary Lake and all gradations from micropegmatite and gabbro were observed.

External Relations

The metamorphism produced at the contacts of the sill and country rock is very slight. The country rock is usually baked thoroughly, vitrified and charged with needles of hornblende. Shreds of white mica are commonly found in these zones, which vary from 1 inch to 1 foot in width, and pass into normal quartzitic rocks.

Age of the Purcell Sills

The youngest rocks which the gabbroic sills intrude are the Upper Purcell formations. These sills were intruded when the strata were horizontal for they have been faulted and folded in the same manner and to the same degree as the quartzites which enclose them. The granitic border is always at the upper contact while the differentiate ore is always near the lower border. This fact would indicate that at the time of intrusion the strata must have been horizontal. The sills were not found above the unconformity at the base of the Windermere series. This fact seems to indicate that the age of the Purcell sills is Pre-Windermere. At the close of the period of Purcell deposition a broad upwarping occurred. That the strata were not greatly disturbed is shown by the overlying Windermere series. The Purcell sills would have greater access for intrusion as a result of the upwarping; and as shown above, the sediments were approximately horizontal. Igneous intrusion and uplift have been proven usually contemporaneous and hence the Purcell sills are probably Pre-Windermere in age.

Post Orogenic Intrusion

The northern border of this area is underlain by a large number of huge granitic stocks. These were explored as far north as latitude 50 degrees. North One stock occurs on

the east fork of the St. Mary River and is called the East Fork granite. The other two northern belts are designated North fork granite and Stub granitic.

The formations in the vicinity of these intrusions are cut by numerous dykes and veins which are found in shear and fault zones. These zones must have afforded easy access for the magmatic solutions. These granites are porphyritic in texture and contain large pink feldspar crystals of orthoclase embedded in a groundmass of quartz, mica and feldspar. The apophyses usually are finer grained and contain abundant quartz, mica, and feldspar. The veins are composed of quartz together with certain minerals such as pyrite, galena, chalcopyrite, sphalerite etc.

A similar porphyritic granite was exposed at the headwaters of Meachem Creek, and was identically the same as the northern granites. Such a similarity seems to indicate that the whole area is underlain by a great mass of igneous rocks. This fact is further evidenced by the outcroppings of granitic rocks throughout the whole area.

A micaceous variety of granite is well exposed on the valley walls of Hall Lake, while in the vicinity of the Boy Scout Mine a pegmatitic granite is exposed. This granite consisted of large flakes of muscovite, feldspar crystals and black tourmaline crystals, one crystal attaining a length of six inches. In the ridge to the east of Bootleg Mountain a graphic granite pegmatite is exposed. The graphic inter-

growth is between the quartz and feldspar.

The dyke rocks cut both the granite and sedimentary rocks and usually have a maximum width of 15 feet and the pegmatites a width of 200 feet.

Lithology

Megascopically the granites are all light grey in colour, and vary in texture from pegmatitic to fine-grained. The porphyritic varities are characterized by the presence of pink orthoclase feldspar crystals. The pegmatites contain large flakes of muscovite, crystals of feldspar, quartz and sometimes tourmaline. The finer grained varieties are composed of biotite, quartz and feldspar.

Structural Relations

The granitic intrusions cut all the formations in this area. Contact metamorphism varies from place to place. Metamorphism results in the formation of quartz mica schists, garnetiferous mica schists, sillimanite and andalusite schists. The Purcell sills are in the vicinity of the granites metamorphosed to chlorite schists.

In the ridge to the east of Bootleg Mountain, a fine example of an aureole of metamorphism is exposed near a pegmatite body.

The metamorphism was greater around the pegmatitic stocks than it was near the other varieties of granite.

That the magma intruded the overlying rocks by stoping was exhibited on Meachen Creek. Here large, irregular inclusions of sediments were found in the granite body.

Age and Correlation

As the youngest sedimentary formation with which the granites are found in contact is Windermere (Pre-Cambrian), the age of this intrusive can only definitely be placed as Beltian or younger. The relations of the granite to the folding and faulting movements which affected the region indicate that the intrusion is younger than the orogeny. From work in the Blue Mountains of Oregon, Lindgren[1] places the date of the granite as certainly post Triassic and pre-Neocene and likely post-Jurassic. Working to the west of this area, Walker dates these intrusives as Post-Triassic.[2]

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1. Lindgren, W. 22nd Annual Rept. U.S.G.S. Pt. 2, 1901, pp. 551-766

2. Walker, J.F. Summ. Rept. 1928, Pt. A, p. 1274.

CHAPTER V

STRUCTURAL GEOLOGY

The structure of the Purcell Range in this area may be described as a huge, northward pitching arch composed of numerous synclinoria and anticlinoria. These folds are modified by faults, fissures and joints which are very abundant and of different ages.

Folds

The first period of folding in this area was at the close of the Purcell period, which was characterized by uplift and broad open folding, later accompanied probably by intrusion of the Purcell gabbro. The folding which now characterizes this area is definitely older than the intrusion of granite. Schofield[1] dates the building of the Purcell Range as late Jurassic and Drysdale[2] gives the granite mass along the Selkirks a Jurassic age. The folds have a general north and south trend, and are the result of compressive

1. Schofield, S.J. G.S.C. Memoir 76, 1915, p. 95
2. Drysdale, C.W. G.S.C. Memoir 56, pp. 61-62

forces acting in an east and west direction.

The Yahk Range has as its controlling structure the northward plunging Yahk anticline. The axial portion of this anticline is made up of Aldridge argillaceous quartzites. The eastern limb was only traced as far as west longitude 116°. The western limb is formed by the conformably overlying Kitchener formation which is cut off to the west by the Moyie fault.

To the east of Yahk this anticline is modified by the formation of the Yahk syncline.

North of the Moyie fault and into the drainage of the St. Mary River the general structure is that of a huge arch which plunges to the north. The St. Mary River, flowing in an easterly direction, cuts across the axis of this anticline. The structure of this arch is complex, as it is greatly modified by minor overturned anticlines smashed and faulted. The northward extension of the arch is cut off by the large intrusion of granitic rocks. The general trend of the axes of folding is northwest and southeast, with the anticlinal axis of the arch passing to the west of Pyramid Mountain in a southeasterly direction. To the west a synclinal axis runs through the North fork of the St. Mary River. This syncline is followed by an anticlinal axis to the west. The western limb of this anticline dips steeply to the west and was explored as far west as the St. Mary River - Crawford Creek divide. The eastern limb of the

arch is formed by Creston and Kitchener rocks which dip to the east and pass out of the discussed area.

Faults

The third great movement which affected the Purcell Range was faulting, which was a northeast-southwest system, including the Hell-Roaring, Sawmill, Perry Creek and Moyie faults and several small faults of lesser importance, and a northwest-southeast system, the chief one being the Alki fault. All of these major faults are thrust faults, due to compressive forces originating from the west. The reason for this statement is as follows:

1. All of the faults dip to the west.
2. The older strata always lie to the west of the fault and the younger strata always to the east.
3. The succession of rocks shows that the formations are younger to the west; therefore, only thrust faulting could bring the older rocks which are exposed in the west into contact with the younger rocks to the east.
4. Development of stretch thrusts in easily visible sections clearly demonstrates that the western or hanging wall of the faults have moved up in relation to the eastern or footwall side.

5. In all these faults the stratigraphically older formations are always found on the hanging wall or west side of the fault plane.

These faults may be subdivided as follows:

1) Thrusts or Compression Faults
   a) Branching Faults
      i) High Angle Oblique Faults
         Hell-Roaring Fault
      ii) Low Angle Strike Faults
         Perry Creek Fault
         Sawmill Fault
   b) Independent Faults
      i) High Angle Stretch Faults
         Alki Fault
      ii) High Angle Oblique Faults
         Moyie fault
   c) Minor faults
      Dewar Shear Zone

2) Normal Faults
   a) Low Angle Faults
      Hall Fault
   b) High Angle Fault
      Creston Fault

1) a) i) The Hell-Roaring fault was located just at the point where Pitt Creek crosses west longitude 116°. Here the Creston and Aldridge formation are in contact. The fault strikes southwest to where it crosses Angus Creek, and then pursues a more westerly course. In the valley of Hell-Roaring Creek, Kitchener, Siyeh, Cranbrook and Eager formations are in contact with the Aldridge formation to the west. This fault was traced only as far as the headwaters of the Goat River, but the belief is that it swings south at that point. The fault cuts obliquely across the strike of the beds and has a westerly dip of over 50 degrees. The displacement along this fault has been very great, as it brings into contact the Lower Cambrian Eager formation and the Aldridge formation.

1) a) ii) The Sawmill fault was first exploited at the headwaters of Sawmill Creek. Here the Creston formation itself was faulted. The fault strikes in a southwesterly direction and passes beyond the limits of exploration to the west of the head of Hell-Roaring Creek. From the head of Sawmill Creek the fault pursues a northeasterly course and it is believed, joins the Hell-Roaring and Perry Creek faults. This fault dips to the west at an angle of 40 degrees and parallels the strike of the strata. The displacement on this fault is not as great as that on the Hell-Roaring fault.

The Perry Creek fault is a branching fault of the Hell-Roaring fault. This fault strikes southwesterly and parallels Perry Creek up to the point where the creek forks. From this point the fault swings due south and passes beyond the limits of exploration. It brings the Creston to the west into contact with the Kitchener to the east. Its southern contact is in the Creston formation itself. This fault parallels the strike of the beds and dips to the west at an angle of about 45 degrees.

1) b) i) The Alki fault was first explored at the headwaters of Alki Creek. The sections are well exposed and the fault is clearly defined. Its attitude is strike south-east with a dip of 50 degrees west. On either side of this fault the Aldridge formation is found. To the south this fault curves until it passes into the Dewar shear zone and disappears under the valley of the St. Mary River just west of St. Mary Lake. The northwesterly extension of the fault is not definitely known. To the north of this fault a similar fault was located on Cone Mountain. This fault strikes south-east and dips 50° west and is identically of the same type as the Alki fault. No formations other than the Aldridge was found in the vicinity of this fault.

1) b) ii) The Moyie fault enters this area at the headwaters of Irishman's Creek where the Aldridge and Kitchener formations are in contact. It then strikes southwest to the head of Englishman's Creek, at which point the Aldridge and Creston formations are in contact. The fault swings in an arc to the east of Goatfel and pursues a southerly course, crossing the International Boundary line in the valley of the Moyie River at Kingsgate. The Moyie fault dips on the average 60° to the west and does not exactly parallel the strike of the strata.

1) c) The Dewar shear zone is located on Alki Creek near the Mystery Mine. Here two open cuts have revealed a very heavily mineralized shear zone. This zone is 8 feet wide. The strike of the shearing is south and the dip is 85 degrees west.

2)a) There was only a small number of normal faults found in this area. The Hall fault which is located at the head of Hall Creek is one example. The strike of the fault is southeast and the dip 30 degrees west.

2)b) The Creston fault is a minor one, occurring in the Creston strata to the southeast of the head of Hall Creek, with its strike southeast and dip 70 degrees west.

Age of Faulting

As the granitic intrusions in this area are known to be genetically associated with the faulting, the faulting must be Jurassic. Also, the faults are later than the folding which is considered to be of Jurassic age. This seems to place the faulting as middle or late Jurassic.

CHAPTER VI

GEOLOGICAL HISTORY

The geological history outlined below will refer only to the area under discussion.

Pre-Cambrian (Beltian)

Aldridge Epoch

During Beltian times the first record is that of sedimentation, the deposition of the Aldridge argillaceous quartzites. No shallow water features were noted except the interformational conglomerates found on Cone Mountain. These sediments were laid down in a shallow sea with the shoreline to the west.

Creston Epoch

The Creston sediments were deposited in a shallower sea, as they exhibit numerous shallow water features such as ripple marks and mud cracks. The sediments are more siliceous than the Aldridge quartzites.

Kitchener Epoch

The sediments of the Kitchener formation, consisting of calcareous quartzites and limestones suggest a deepening of the Beltian sea, or a lowering of the land either by erosion or subsidence.

Siyeh Epoch

Towards the close of the Kitchener time, mudflat conditions must have prevailed over a very wide area. This is evidenced by the great prevalence of mud cracks and ripple markings in the Siyeh formation. The relative thinness of the strata separating the mud-cracked surfaces indicate probably seasonal variations from arid to pluvial conditions.

Dutch Creek Epoch

This period of sedimentation was characterized by the laying down of the Gateway, Phillips and Roosville formations. As these formations are only present in the western half of the Purcell Range, the eroded land mass to the west must have stood very low, thus sedimentation did not cover the whole basin, but only the western part. These formations exhibit shallow water features.

Mount Nelson Epoch

This epoch of sedimentation is characterized by the same features as the Dutch Creek, namely shallow water ones.

Pre-Windermere Epoch

At the close of the Purcell period of Mount Nelson deposition a broad uplift occurred. This was accompanied by folding as is evidenced by the angular unconformity between the Purcell and Windermere series. There is little difference between the degree of metamorphism exhibited by the two series, and this fact, coupled with the moderate angular discordance, indicates that the pre-Windermere folding was one of a broad open character. There must, however, have been considerable uplift to give a relief that would account for the formation of the great basal conglomerate of the Windermere series.

That igneous intrusion and uplift or mountain building are usually contemporaneous seems to indicate that this uplift and the Purcell sills were genetically related. This broad folding would provide the means of access (zones of weakness) for intrusions of the igneous rocks. As the sills have been found as high up as the Mount Nelson formation seems to indicate that the intrusion was Post-Purcell. There are not any sills in the Windermere series; this fact places the intrusion as Pre-Windermere. Since this period of orogenic movement produced folds that were broad, a form such as a sill could very easily be formed in the sediments.

Pre-Cambrian (Windermere)

Toby Conglomerate Epoch

The period of uplift and intrusion was followed by rapid erosion of the land surface. The size and shape of the conglomerate boulders, the unassorted character of the formation as a whole, and the evident derivation of the boulders from the immediately underlying Purcell series indicate that the material was not transported any great distance.

Horsethief Epoch

The Horsethief formation has as its base a thin-bedded limestone and further up a pebble conglomerate. No shallow water features such as sun-cracks or ripple marks were observed. This formation was deposited in standing water in a subsiding basin or valley bordering the area of high relief along the margin of which the Toby conglomerate was deposited.

Hamill Epoch

This formation was not explored beyond its conformable contact with the underlying Horsethief formation.

Cambrian

Cranbrook Epoch

An unconformity exists between the Cranbrook formation and the Siyeh formation of Pre-Cambrian age. The pebble conglomerate contains pebbles of the underlying Pre-Cambrian rocks and exhibits shallow water features.

Eager Epoch

No shallow water features were seen in this formation. The fossils indicate marine conditions were present at the time of deposition.

Devonian-Carboniferous Epoch

The Devonian sea spread over the eastern part of the Prucell Range, and are missing in this section. The deposits of the Devonian-Carboniferous epoch are mainly limestones with minor amounts of argillaceous and quartzose limestones.

Jurassic

No record of sedimentation is present in the Purcell Range during this period.

Late Jurassic or Early Cretaceous

The next event recorded in East Kootenay is the folding and faulting which affected the broadly folded Purcell sediments and the nearly horizontal later deposits. The first movement was one of compression which caused the region of the Purcell Range to be raised above the sea and to form an area of erosion. At this time the dominant structure of northerly striking anticlines and synclines of the range was created. This period of compression was accompanied and followed by thrust and normal faulting. The strike of these fault lines is dominantly northeast-southwest and one northwest-southeast. The folding and faulting were accompanied by an intrusion of granite magma which apparently slowly replaced the overlying sediments by overhead stoping. These granitic masses occur in large stocks. The small bodies of granites occur in the neighborhood of the main faults and probably have some genetic relationship to them.

Following the intrusion of the granite, with no great interval of time came the intrusion of numerous dykes of aplite and pegmatite. During the cooling stages of the granitic magma occurred the deposition of the metallic ores of this district.

Cretaceous Erosion

After the Jurassic uplift which formed the Purcell Range, no record of younger sedimentation other than the Miocene has been found. During the Cretaceous period, erosion was very active in wearing down the Purcell Range and in depositing most of the eroded material in the Cretaceous geosyncline, which covered the area now occupied by the Rocky Mountain system and the Great Plains. Erosion had proceeded so far at the close of the Cretaceous and early Tertiary periods that the Purcell Range was reduced to a land of low relief or to a peneplain, which might be called the Purcell peneplain.

Tertiary

Pre-Miocene Epoch

In early Tertiary times the Cretaceous geosyncline to the east of the Purcell Range was mountain-built with the formation of the Rocky Mountain system. At the same time the Purcell Range, characterized by a rolling, monotonous landscape, was uplifted without any deformation, thus rejuvenating the streams which proceeded to entrench themselves into the Cretaceous peneplain. The valleys now seen in the Purcell Range, are due to Tertiary river erosion.

Miocene Epoch

Deposition of the gold-bearing Miocene gravels occurred during this period. There are a few beds of lignite associated with these gravels.

Quaternary

The Quaternary history was characterized by the advance of the continental ice sheet and also by the erosion produced by local alpine ice caps. The beautiful cirque lakes so characteristic of this mountainous region were produced by the plucking effect of the ice caps. The main movement of the continental ice sheet was governed by the directions of the main valleys, the two main valleys being the Rocky Mountain and Purcell trenches. From a study of roches-moutonnèes and glacial markings the continental ice sheet moved in a southerly direction. This was further indicated by large glacial erratics which were moved in a southerly direction from their origin.

During the disappearance of this ice-sheet, the clays which lie in the depressions in the Wycliffe drift were deposited. Later the streams cut down their channels into the deposits of clays, sands and gravels, giving us the present topography of the valley floors.

CHAPTER VII

ECONOMIC GEOLOGY

The Kootenay area contains varied deposits of economic value. The great lead-zinc-silver producing mine, the Sullivan, and the now-exhausted St. Eugene Mine are to be discussed. A portion of this area was never geologically surveyed or prospected before 1936: in this chapter the economic geology of all the resources of the Kootenay area will be reported upon. Many of the specimens collected in this area and its mines were microscopically examined and these are reported on later.

History of Mining in the Fort Steele Mining Division

The bars of the Columbia River above Colville, in what is now the State of Washington, had been mined to some extent before the East Kootenay and Big Bend discoveries of British Columbia attracted thousands of men. Some gold colours had been found on the bank of the Columbia at Colville in 1855, and the prospecting expedition of Angus McDonald found moderately renumerative diggings at the mouth

of the Pend d'Oreille, near the boundary line. Miners gradually worked their way up the Kootenay River from Idaho, and in 1863-64 a short distance north of the International Boundary line rich diggings were discovered which gave rise to the Kootenay gold mining excitement.

Wild Horse Creek became the centre of the East Kootenay mining district in 1863 when gold was discovered there. The Creek, which received its name from the number of wild horses in its district, had by May 1864 become an important camp, with four hundred miners distributed along its banks. Prospects of one dollar to the pan were obtained, while ordinary claims paid twenty to thirty dollars per day: nuggets running from two and one-half dollars to seventy-eight dollars were found.

In 1865 the Dewdney trail to the Kootenay River was built, thus giving the miners an outlet to Victoria, without travelling south of the Boundary.

From 1864-69 hydraulic mining was carried on; a number of new gold-bearing creeks having been discovered, the most important of which was Perry Creek, a branch of the St. Mary River. Here the ground generally yielded an ounce a day per man, while on one occasion three men took out two hundred and twenty-five dollars in five days. In 1869, good prospects were found on Moyie River. Despite this success, however, the Gold Commissioner, A.W. Vowell, in 1872 stated that the principal mines, with the exception of

those on Wild Horse and Perry Creeks, were exhausted.

In 1876 most of the white men had left and the output dwindled to twenty-five thousand dollars. The next year, chiefly through the work of Chinese miners, the yield from Wild Horse, Perry and Palmer creeks increased to thrity seven thousand dollars. The following figures will show the output of the district:

1878-1885	$ 188,380
1855-1885	500,000
Value of gold per ounce	18.25
1884	60,826

From 1888 to 1895 hydraulicking and lode mining were carried on with the yield of gold varying from twelve thousand to thrity thousand dollars per year. Many new lode mines were discovered between 1893 and the early 1900's, notably among these discoveries were the Sullivan and St. Eugene mines.

During 1936, placer mining operations were continued on Wild Horse, Palmer and Perry creeks. The Sullivan Mine operated the full year. Prospecting in the Cranbrook area was not carried on to any extent.

Classification of the Economic Deposits

1. Lode Deposits

a. Purcell Gabbro Mineralization

1) Hydrothermal veins

2) Differentiates

b. Late Jurassic Mineralization

1) Fissure veins

a) silver lead type

b) gold-quartz type

c) hematite type

d) galena-gold type

e) arsenopyrite-gold type

2) Replacement deposits

a) silver-lead type

b) gold-pyrite type

2. Placer Gold

3. Lignite

4. Building Stones

5. Magnesite Deposits

1 a Purcell Gabbro Mineralization

The mineralization is wide spread throughout the area, but has not, up to date, produced any mines. This is partially due to the great importance of the silver-lead deposits, and also due to the fact that ~~that~~ not sufficient work has been done on the deposits to prove their size. Nevertheless from their extent and character, careful working of these deposits may produce satisfactory returns.

Distribution

Since these deposits are associated with the Purcel sills, their distribution is governed by that of the Purcell sills, which occur almost exclusively in the Aldridge formation. The sills in the younger formation are thin and do not contain workable ore deposits. The deposits of this nature which have received most attention occur on the several branches of the St. Mary River, where sufficient work has been done to expose their geological relationship.

Geology

These deposits occur only in the Prucell sills. These sills are tabular intrusive bodies injected along the bedding planes of the quartzites and vary in thickness from 2 to 2,000 feet. They consist mainly of hornblende gabbro with large irregular masses of differentiates of a peculiar hornblende ~~gabbro~~ granite.

Character of the Deposits

The deposits are of two varieties:

(1) Hydrothermal veins perpendicular to the plane of the sills.

(2) Irregular bodies which have been formed by differentiating out from the cooling body.

The veins of the variety (1) vary from 2 to 4 feet in width and always occur in shear zones in the sills.

A notable feature of these veins is that they end abruptly at the contact of the sill and quartzite. In not any case was one of the veins noted entering the quartzite. The hornblende gabbro which forms the wallrock, shows the effect of shearing at the time of the formation of the shear zone by the occurrence of an alignment of the feldspar constituents of the gabbro parallel to the vein. The filling of the shear zones consists most frequently of quartz impregnated with chalcopyrite, pyrite and pyrrhotite. Erythrite, a hydrated arsenate of cobalt, was noted as a red stain on the weathered surface of the outcrops. Native copper is reported as sometimes being found in the quartz. Coarsely crystalline calcite formed part of the veins in several cases and usually is the latest filling.

Mineralogy

Native Elements

Copper Cu: Native copper occurs in a vein on the Evans property on Whitefish Creek. It occurred as small plates in quartz.

Sulphides

Pyrrhotite Fe_7S_8: This mineral occurs in large amounts in these deposits. It occurs as small masses of irregular outline associated with pyrite and chalcopyrite in both

the differentiates and the true veins.

Chalcopyrite $CuFeS_2$: Copper pyrites - chalcopyrite occurs in small irregular masses in the copper deposits associated with pyrite and pyrrhotite.

Pyrite FeS_2: Iron pyrites, pyrite, occurs sparingly in both the differentiates and in the true veins.

Pentlandite FeNiS: Nickeliferous pyrrhotite - pentlandite occurs in these deposits of the differentiate type and is usually found bordering the pyrrhotite. Its colour is creamy white.

Oxides

Quartz SiO_2: Oxide of silicon - quartz is the most abundant gangue mineral in the copper-bearing veins. It occurs massive and contains the sulphides as impregnations. In the differentiates quartz occurs as an opalescent variety.

Magnetite Fe_2O_3 : Magnetic iron ore - magnetite occurs in the deposits of the differentiate type and veins the first-formed minerals. It is usually in the form of threads and small irregular masses containing inclusions of the earlier minerals. The colour is grayish white.

Carbonates

Calcite $CaCO_3$: Calcium carbonate is a prominent gangue mineral of the copper deposits of the vein type. It is generally white and coarsely crystalline.

Malachite $CuCO_3Cu(OH)_2$: Malachite occurs as green incrustations on the outcrop of the copper-bearing veins as a result of the decomposition of chalcopyrite and cupiferous pyrite.

Azurite $2CuCO_3Cu(OH)_2$: Azurite occurs as a blue incrustation on the weathered outcrops of the copper-bearing deposits.

Silicates

Hornblende: Hornblende is the most common mineral in the differentiates, occuring as black, lustrous crystals associated with micro-pegmatite and sulphides of copper and iron.

Arsenates

Erythrite $Co_3As_2O_8.8H_2O$: Hydrated arsenate of colbat - known as cobalt bloom. Erythrite occurs as a crimson-red incrustation on the oxidized outcrop of the copper-bearing veins. Although no cobalt sulphides were identified in the copper deposits, it is very probable that they exist in small

quantities associated with the other sulphides.

The differentiates (2) occur usually in the interior of the sills and are of varied shape and size. No single body has been outlined, but they are believed to be at least 200 to 300 feet in diameter. The boundaries of these bodies with the surrounding rocks are always gradational. The differentiates consist generally of a peculiar hornblende diorite containing some quartz. The hornblende is usually fibrous and makes up to 50 per cent of the ore. The ore minerals, chalcopyrite, pyrite, pyrrhotite and pentlandite, occur sporadically throughout the differentiates.

Persistency

The differentiates from their very nature cannot extend beyond the limits of the sills. In the case of the veins, they were not found at any location to extend beyond the limits of the sill. The following facts tend to verify the above statement:

(i) The veins occur within the sills themselves.

(ii) All gradations exist between the differentiates and the true veins and show that the deposits originated from the sills.

(iii) In Kelly basin a very good example of the top of a vein can be seen. Here the vein comes up through the sill to the contact with the quartzites where it abruptly pinches out.

(iv) No veins have been located in the quartzites.

Paragenesis

The age relations of all minerals in the differentiates are clearly exhibited in the polished sections. (Fig. 1 & 2)

The general order of formation may be summarized as follows:

(i) Hornblende
(ii) Pyrrhotite
(iii) Chalcopyrite
(iv) Pentlandite
(v) Magnetite

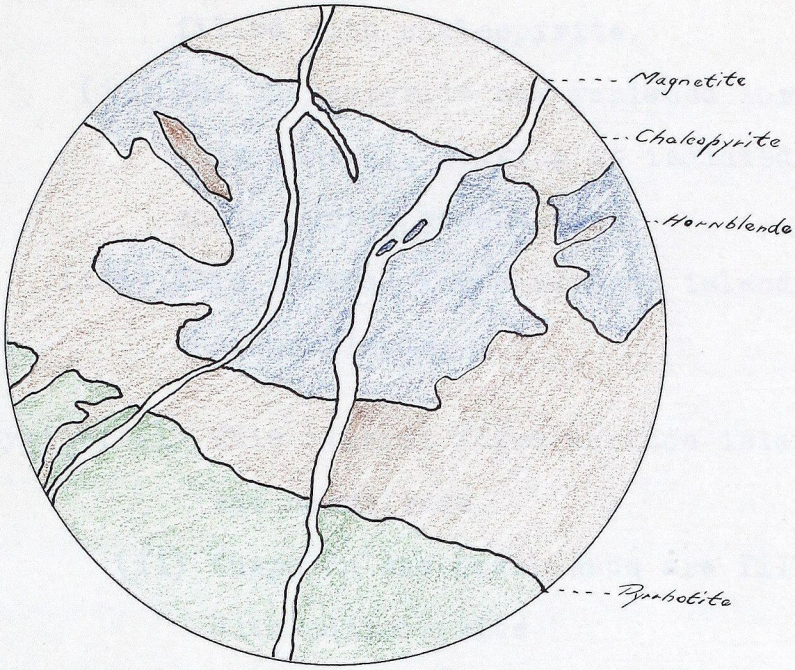
The above list is the primary mineralization seen in the first specimen. The zone of oxidation is of no great extent and is represented by stains and encrustations of supergene green malachite and blue azurite on the surface of the outcrops.

The criteria established for the age relations given above is as follows:

Hornblende: (i) The hornblende exhibits unhindered crystallization.

(ii) The hornblende is veined and embayed by all later minerals.

(iii) The hornblende exhibits irregular and definitely corroded borders.



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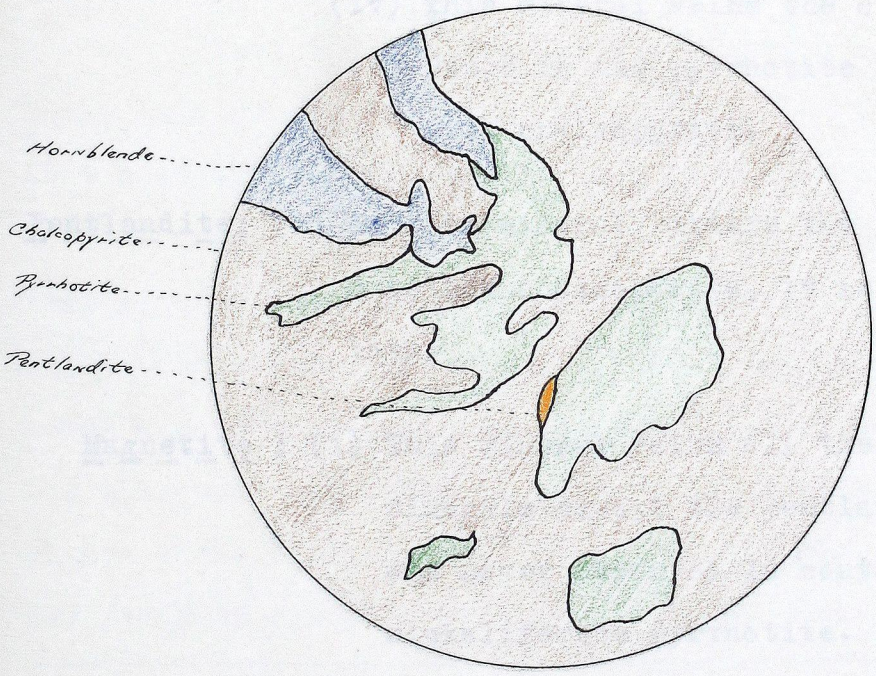

Differentiate Type

Pyrrhotite: (i) This mineral has embayments which are filled with chalcopyrite.

(ii) The chalcopyrite has replaced portions of this mineral, leaving it isolated in a chalcopyrite ground mass.

(iii) This mineral forms advance islands in the hornblende.

Chalcopyrite: (i) This mineral forms advance islands in the hornblende.

(ii) Cusps in the hornblende are filled with chalcopyrite

(iii) Advance islands are found in the pyrrhotite

(iv) This mineral veins the chalcopyrite.

(v) Cusps in the pyrrhotite are filled with chalcopyrite.

Pentlandite: (i) As this mineral borders the pyrrhotite and cuts the chalcopyrite, it is later than both.

Magnetite : (i) This mineral veins all the earlier minerals except the pentlandite. It was never observed in contact with the nickeliferous pyrrhotite.

(ii) Replacement remnants of the earlier sulphides are found in the magnetite.

Genesis of the Deposits

The origin of these deposits may be safely associated with the cooling stages of the Purcell sills, since all gradations exist from the normal gabbro through the differentiates to the true veins and all gradations carry sulphides of copper and iron. Also, the occurrence of the copper deposits always in association with the sills, and the fact that the veins pinch out when passing from the sills to the quartzite support this statement.

A notable feature is that the concentration of differentiate ore minerals does not occur in the top half of the sills, but is confined to the lower portion. Also, these bodies are of an irregular shape and grade out into a gabbroic rock.

That the ore sulphides are concentrated in the lower half of the sill, and in irregular bodies indicates that some type of differentiation has taken place.

Vogt[1] has clearly demonstrated that at furnace temperatures the mutual solubilities of copper iron sulphides and silicates are small. Analyses show that the metal always contains a small proportion of silicate, while the silicate slag contains a little sulphide. These sulphides and silicates, when heated to a higher temperature, are found to dissolve more of the other until eventually a

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1. Vogt, J.H. Die Sulfid-Silikatschmelzlosugen Kristiania

temperature is reached above which the two are miscible in all proportions. The reverse is true when the melt is cooled. This limited miscibility of solutions is characteristic of sulphide silicate magmas observed in nature. The above facts refer to intermediate or acid slags. Further work by Wanjukoff[1] indicates that sulphides of copper, nickel iron, zinc and cadmium are soluble in basic slags to a notable degree. Vogt suggests that the presence of mineralizers other than sulphur would increase the solubilities.

Many observers have stated that the chalcopyrite and pyrite which often occur in basic rocks are of primary magmatic origin.[2]

However, none have treated the subject better and more convincingly than E. Howe[3] who described the gabbro-norite and pyroxenite of the Cortlandt series. His conclusions are as follows:

The extremely fresh rocks contain small amounts of pyrrhotite, pentlandite and chalcopyrite. There is no post-magmatic alteration. The sulphides are as essentially magmatic as the silicates. Although most of the sulphides separated from solutions at an early stage in the cooling of the magma, small quantities continued to separate or to redissolve, until the magma had nearly crystallized. The form

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1. Metallurgy, 1912, pp. 1-48
2. Lindgren, 17th Annual Rept. U.S.G.S. Pt. 2, pp. 67-70
3. Economic Geology 10 1915, pp. 330-347

and the interstitial relations of the sulphides seem to show that, although they may have separated early from the silicates, they remained liquid until the silicates had crystallized. The sulphide-bearing rocks are regarded as products of differentiation from magmas which are poorer in these substances. This type of origin exactly answers that of the Purcell sills, except that other factors relating to a sill have to be considered.

As the temperature of the Purcell magma decreased the sulphides would no longer be fully miscible with the silicate melt. It is conceivable that in such a way dissolved sulphides may separate out in globules which would grow and eventually, if the magma continues fluid, would settle to a molten sulphide layer. The molten sulphides, as in slags, mix in all proportions to form a uniform fluid phase. They are extremely liquid with low viscosity and crystallize later than the rock minerals. The basic Purcell magma had a very low viscosity as is evidenced by the absence of deformative features and the great extent of sediments they traversed. However, as the Purcell sills are only relatively thin bodies of molten rock, the loss of heat due to the heating of the country rock would be very great. This loss of heat would tend to promote crystallization of the femic minerals before the fluid phase of the sulphide melt had time to collect in the bottom of the sill. This action would tend to prevent the globules of sulphide melt

from coming into contact with each other. There would be a concentration of the sulphide minerals in the lower portion of the sills, but it would not be carried to completion. Grading from one large sulphide mass through a mixture of silicate sulphide material to another sulphide mass would occur. As the rock minerals crystallized out, the pressure of this mass on the still liquid sulphides, contained between the crystals of the femics, would tend to expell the sulphides. The sulphides would be then concentrated in a region of less pressure and less temperature, so that in this manner they may conceivably form large bodies. The crystallization of the sulphides now proceeds in the order discussed under paragenesis.

On cooling, the Purcell magma underwent a period evidenced by the formation of contraction fissures normal to the plane of the sills. The more volatile components still containing some metals in solution, together with the second injection of acid material from the parent magma, filled these fissures and deposited their minerals there.[1]

Detailed Description of Copper Properties

Evans Property

The Evans group of claims owned by C. and W. Evans of Marysville is situated on the western slope of Evans Mountain. The mountain is composed of easterly dipping

1. Schofield, S.J. G.S.C. Museum Bulletin, No. 2 p. 1

Aldridge quartzites intruded by diorite sills. The lower one is faulted and its lower half forms the lower deposit while the upper portion forms the upper deposit. The summit of Evans Mountain is formed by a gabbro sill.

The claims on which there are showings of ore are the Gigantic and S.J. Schofield in Kelly basin; the Elizabeth and Kokore in Pollen basin; the Curfew and Pacific down near the main camp on Fiddler Creek. They have in all fifteen claims held by annual assessment.

Fiddler Creek is a small creeklet;entering Whitefish, Pollen and Kelly basins are the heads of small creeks which have the same main stream. Besides the camp of two cabins near the head of Fiddler Creek, there is another in Pollen basin, and a base camp down near the confluence of Fiddler and Whitefish creeks. The elevations are as follows: Base camp, 4750 feet; Fiddler Creek camp, 6200 feet; Pollen Basin camp, 7,000 feet; Kelly basin 7,500 feet.

In Kelly basin there is a high bluff which is not possible to climb, but in the slide-rock at the foot there is a considerable percentage of rock showing slight mineralization with chalcopyrite and larger amounts of pyrrhotite. Along the face of this bluff several large patches of copper stain and iron oxide can be seen. It is evident that whatever ore there is in this bluff is irregular and of the differentiate type. A piece of the best looking ore picked from this slide is said to have yielded on assay: gold, trace; silver, 2 ounces; copper, 1.4%.

On the Gigantic claim in Kelly basin, what is known as No. 3 vein is developed by an open cut which is 25 feet long, with a 12-foot face. The vein is about 5 feet wide and strikes east and west, with a dip of 75 degrees to the north. The centre of the vein shows from 12 to 18 inches of good copper ore, and the rest of the vein, largely quartz with some calcite, carries a little copper stain. The mineralized portion ofthis vein has yielded values as high as 16 per cent copper with some gold and silver values.

On the S.J. Schofield claim in Kelly basin, there are two veins, No. 1 and No. 2. No. 1 vein has a 10 foot cut on it with a 5-foot face. The vein is 3 feet wide and consists largely of quartz carrying a little chalcopyrite, while the No. 2 vein is relatively barren.

The Kokonee claim, at the head of Pollen basin, contains a large quartz vein varying from 10 to 15 feet in width. The strike of the vein is east and west,and has a dip to the south of 75 degrees. It is developed by an open cut 40 feet long with a 10-foot face. The mineralization here consists of chalcopyrite, pyrite and pyrrhotite in a quartz-calcite gangue. This ore carries about 2 per cent copper and traces of gold and silver.

On the Elizabeth claim, also in Pollen basin, there is a vein from 4 to 8 feet in width. It is developed by several open cuts and a shaft 15 feet deep from the end of one cut. The mineralization here occurs in bands from 1 to 3 feet wide. Galena was noted in some of the specimens of

this vein, the mineralization of which is very irregular in character.

More work has been done at the Fiddler Creek camp than at any of the other properties. The main workings are a tunnel 300 feet long which prospects a quartz-calcite vein of the usual type. It contains very little chalcopyrite or other sulphides. In the summer of 1936 the bottom of the tunnel was partially filled with water. The vein is of a very low grade type with the result that no further work willbe pursued.

The lower claims contain a tunnel 200 feet long driven into a low grade ore body of the differentiate type contained in a gabbro sill about 400 feet thick and forming the lowest of the three sills. The ore consists of pyrrhotite, cupiferous pyrite and pentlandite.

On the mountain on the north side of Whitefish Creek is the Alliance group of four claims owned by the Evans Bros. The diorite sill at this point is a continuation across the valley of the one exposed in Kelly basin. The ore body here is one of the differentiate type. The mineralized zone runs east and west, and crossing it there is at least one quartz vein, possibly others; these veins, however, carry practically no sulphides. In the neighborhood of the vein the gabbroic rock is slightly more mineralized, the ore consisting of chalcopyrite, pyrrhotite in a quartz-calcite gangue.

Mystery Mine

This property, owned by J. Dewar of Fort Steele, is situated on the western side of Alki Creek, about 4 miles from where the creek joins the St. Mary River. The elevation of the creek at the camp is 4,000 feet. The country rocks consist of Aldridge quartzites intruded by hornblende gabbro-sills, all dipping at an angle of 20 degrees to the west.

The entire workings are confined to one gabbro sill whose base is not exposed near the camp. The top of this sill is 500 feet above the creek bottom. Three tunnels are driven at intervals of 50 feet in elevation from the creek bottom and numerous open cuts expose three veins and a small body of differentiate ore across the entire width of the sill.

A notable fact is that the vein exposed near the top of the sill pinches out as the quartzite-gabbro contact is reached. The veins average from one foot to three feet in thickness and are very irregular. Concentration of the ore minerals along the vein-gabbro contact was observed. Mineralization of the vein type is confined to the vein or contacts, but does not enter the gabbroic rock. The veins strike in a north-westerly direction and the dip is nearly vertical.

The differentiate body has only been exposed by an open cut.

The ore of the vein type consists of pyrrhotite, chalcopyrite, in a quartz-calcite gangue. The differentiate ore consists of pyrrhotite, chalcopyrite and hornblende

irregularly distributed. The copper content of the ore is said to be 3 per cent copper.

The Tracy Property

This property is located at an elevation of 4,300 feet on the ridge to the north of the ranch of W. Meachem. It is owned by Mr. Tracy of Cranbrook and Mr. Meachem of Marysville.

The workings consist of two open cuts exposing two quartz-calcite veins in sheared gabbro. The gabbro sill is about 50 feet thick and is intruded into the Aldridge argillaceous quartzite formation. The sediments here strike north 15 degrees east and dip steeply to the west. The veins vary in thickness from 1½ feet to 3 feet, and the mineralization consists of yellow chalcopyrite in a quartz-calcite gangue.

1b Late Jurassic Mineralization

After the Purcell period of mineralization in Pre-Cambrian times, the next record of mineralizing activity is that of the late Jurassic period. This period is characterized by intrusions of granitic stocks, dikes, and allied apophyses of the West Kootenay batholith. These bodies of igneous rock are later than the folding and faulting to which the region was subjected. The mineral deposits are genetically related to this great mass of intrusives. The genesis of the deposits will be discussed later under that heading.

Relation of Mineral Deposits to Fault and Shear Zones

The quartzites of the Aldridge and Creston formations, especially the Aldridge, in the part of British Columbia and in the adjoining parts of the State of Idaho are exceptionally favourable for ore-deposits and contain several of the largest deposits in the world. Their favourable character is due to two causes; namely,

(i) Their ability to sustain large uniform fractures for great distances.

(ii) The susceptibility of certain of the beds to replacement by mineralizing solutions.

To the former habit may be attributed the immense veins of the Coeur d'Alene district of Idaho, such for example, as the Bunker Hill and Sullivan and, more notably still, the Morning vein which has been followed continuously for about one mile down the dip. To the susceptibility of certain of the beds and the resistance of adjacent beds to replacement by mineralizing solutions may be attributed the great ore-body of the Sullivan Mine.

Under the heading of Structural Geology, the faults therein discussed were demonstrated to continue for several miles in length. The faults were the zones of weakness through which the igneous rocks gained access to the overlying sediments, and in them many small dykes, especially pegmatite dykes, are found. Vein-forming solutions entered these zones and there deposited their mineral content, either

as veins or as replacements in the country rock. The ability of these rocks to sustain large, uniform fractures warrants thorough prospecting in the vicinity of fault zones. The fact that all of the good prospects and mines lie on well-defined lines of faulting is a significant one. Also, all faults in this district contain some type of mineralization.

1b (1) Fissure Veins

True fissure veins are common in this area and embrace a number of different types of deposits.

Silver-Lead Type

Distribution

Since these deposits are associated with the Jurassic intrusions, their distribution will be widespread, as all favourable mineralizing conditions exist in this area. Such a statement is authentic, since these deposits are by far the most important economic deposits in the region. The ores generally consist of an intimate mixture of the sulphides pyrite, pyrrhotite, galena and some sphalerite. The gangue is usually quartz and calcite; the deposits of this type are widespread and include the Socity Girl, Aurora, Boy Scout, Wellington and Great ~~Dome~~ Dane mines.

Mineralogy

Sulphides

The sulphides of iron, lead and zinc comprise almost the entire ore content of the silver-lead deposits.

Galena PbS: Sulphide of lead is the most important mineral, as it contains not only the lead values, but also the silver. It occurs as two varieties - the fine-grained type seen at the Boy Scout Mine and the coarse, cubic variety of the Great ~~Done~~ Dane Mine.

Zinc-blende - Sphalerite ZnS: Sulphide of zinc is always present in varying quantities in all the silver-lead deposits. It occurs intimately associated with the galena and iron sulphides. The percentage of zinc-blende varies widely in the several deposits. To such a degree is this ~~ture~~ true that the Aurora might be classified as a zinc mine.

Marmatite - Ferriferous Sphalerite $FeZnS_2$: This mineral, found at the Boy Scout Mine, was observed to be intimately associated with fine-grained galena.

Iron pyrites FeS_2: Disulphide of iron. Pyrite is widely distributed throughout all the deposits.

Pyrrhotite - Magnetic sulphide of iron: Pyrrhotite occurs abundantly in the Boy Scout and Great Dane Mine.

Chalcopyrite $CuFeS_2$: Copper pyrites - chalcopyrite occurs abundantly at the Great Dane Mine.

Oxides

Quartz SiO_2: Quartz occurs as the main gangue mineral in these deposits.

Limonite $2Fe_2O_3 \cdot 3H_2O$: Limonite commonly occurs as a product of the decomposition of the sulphides of iron. It usually occurs as a brown stain on the outcrop surface.

Phosphates

Pyromorphite $(PbCl)Pb_4(PO_4)_3$: Lead phosphate. Pyromorphite was found in the oxidized zone of two of the deposits.

Paragenesis

The age relations of the minerals in lead-silver fissure vein type were found by examining polished sections of these minerals.

The general sequence may be summarized as follows:

(i) Quartz

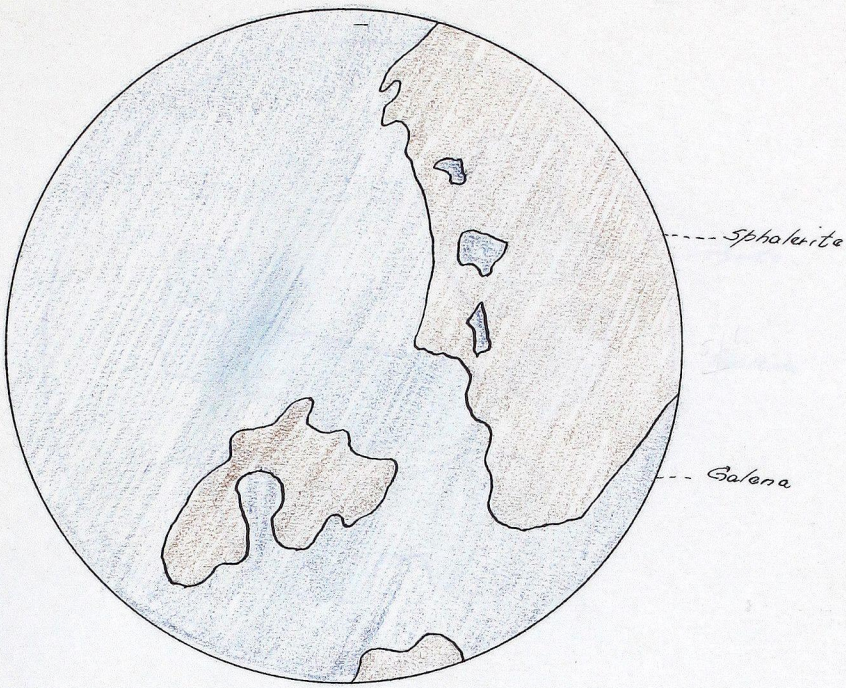
(ii) Pyrite

(iii) Pyrrhotite

(iv) Zinc-blende

(v) Galena

(vi) Pyromorphite, limonite



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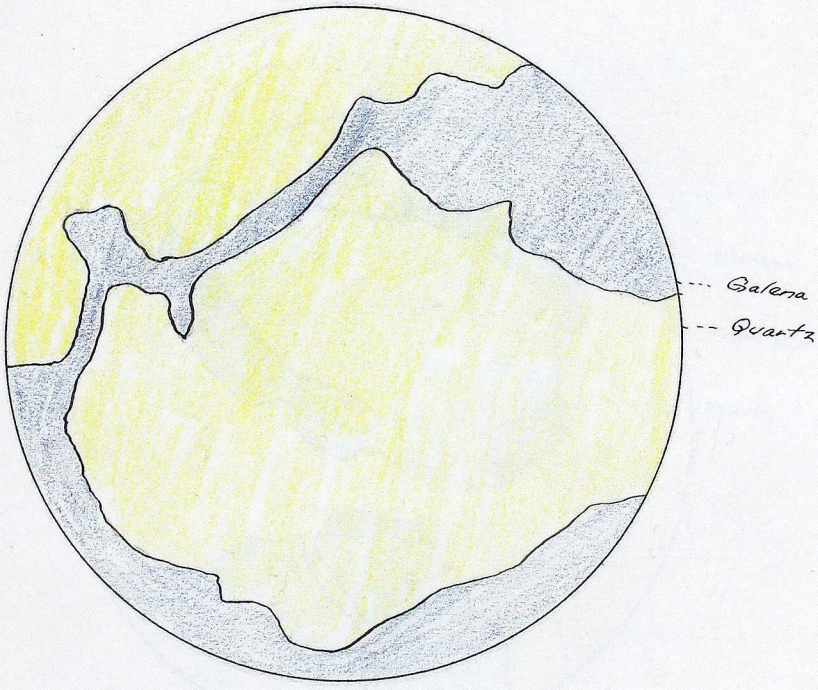
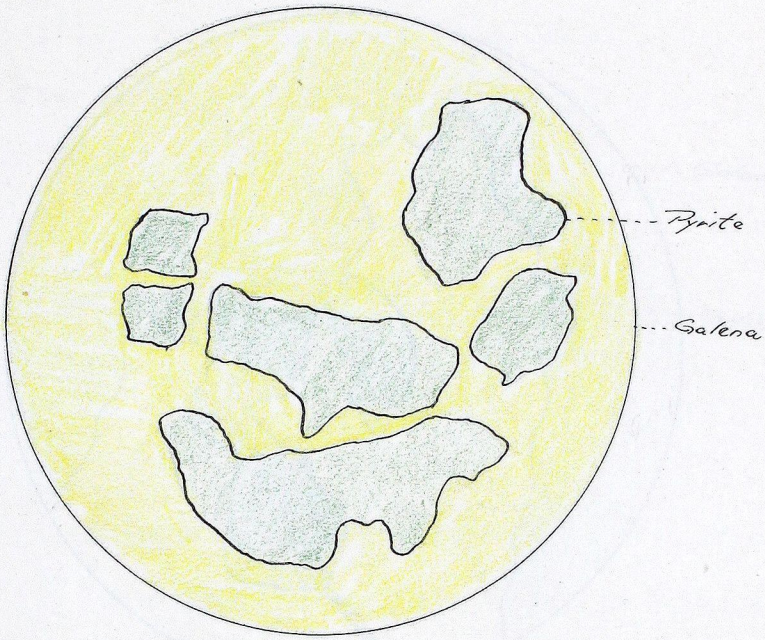


Silver-Lead Type



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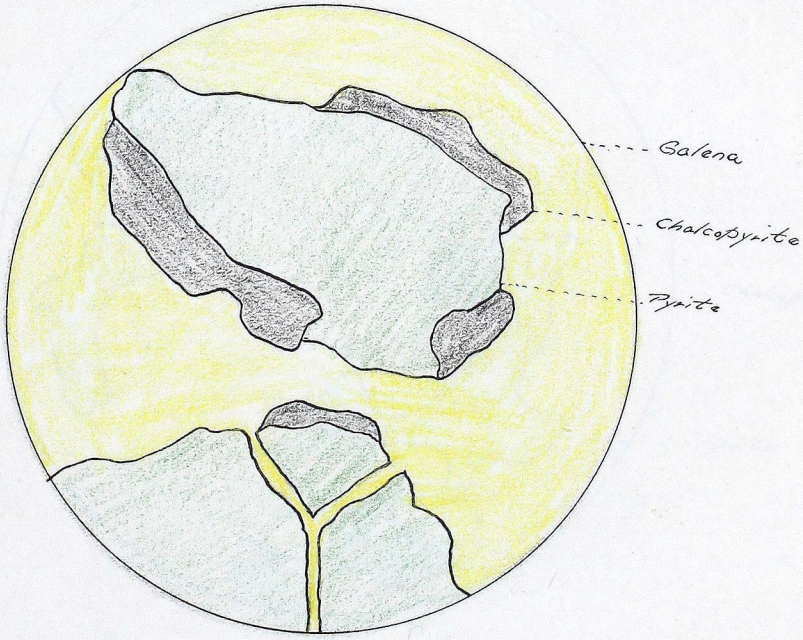
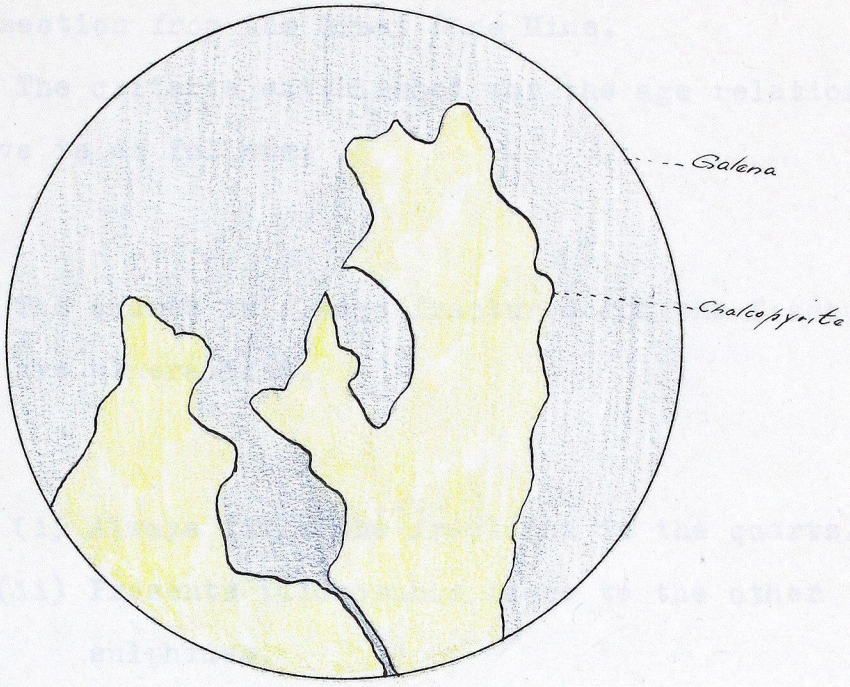


Silver-Lead Type



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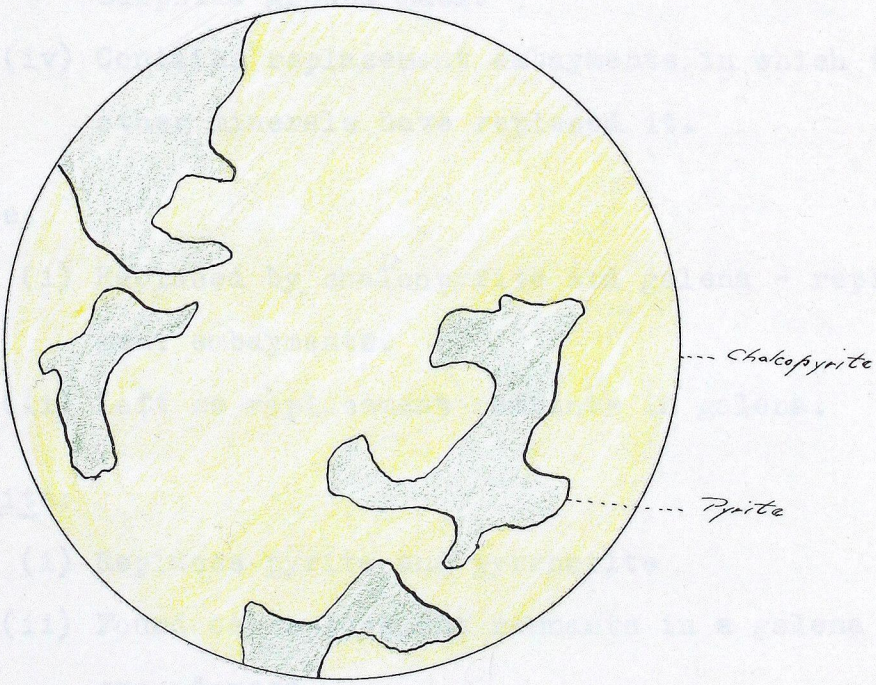


Silver-Lead Type

The mineral sequence was best observed in the polished section from the Great Dane Mine.

The criteria established for the age relations given above is as follows:

Quartz:

The quartz is always fractured and the fractures are mineralized.

Pyrite:

(i) Always fills the fractures in the quartz.

(ii) Presents idiomorphic faces to the other sulphides.

(iii) Left as replacement remnants in the later sulphide ground-mass.

(iv) Contains replacement embayments in which the other minerals have replaced it.

Pyrrhotite:

(i) Replaced by chalcopyrite and galena - replacement embayments.

(ii) Left as replacement remnants in galena.

Chalcopyrite:

(i) Replaces pyrite and pyrrhotite

(ii) Found as replacement remnants in a galena ground-mass.

Sphalerite and Galena:

No criteria was established to prove one earlier than the other. From a study of contacts they appear to be contemporaneous.

Limonite and Pyromorphite:

Subsequent hydration and phosphatization produced the minerals limonite and pyromorphite in the oxidized zone.

Description of Mines and Prospects

Boy Scout Mine

This group, consisting of four crown-granted claims, is situated on Hell-Roaring Creek at a distance of approximately 4½ miles by trail from the wagon road at St. Mary Lake. It is owned by A.H. Mayland of Calgary, Mrs. John Bennet and N.A. Wallinger of Cranbrook. The workings are situated on a steep, wooded hillside on the eastern side of the valley. The formation in which the deposit occurs is the oldest subdivision of the Purcell series, and is called the Aldridge formation. The property lies in the shear zone formed near the Hell-Roaring fault; the shearing stikres south-easterly and dips from 50 degrees to 60 degrees to the south-west.

The principal working developing the shear-zone

consists of three tunnels at approximate elevation (aneroid) of 5,410, 5,300 and 5,100 feet above sea-level. The upper or No. 1 tunnel, about 160 feet long, is driven along the general direction of the lead from where the original discovery was made. At the portal a wide exposure of rusty-weathering, argillaceous quartzite contains narrow bands of silicified rock and quartz mineralized with lead and iron sulphides. The greater part of the tunnel lies on the hanging-wall side of the lead where no definite mineralization is in evidence; but towards the inner end a turn is made towards the footwall side so that a 3-foot width of ore is exposed. This showing is of a more definite character than the mineralization at the portal and gives promise of more continuity, the sulphides being uniformly distributed throughout a quartz gangue. In the inner showing the mineralization apparantly conforms with the bedding of the country rock, which strikes about south 50 degrees east, and dips at 58 degrees to the south-west.

The No. 2 tunnel, which is slightly more than 300 feet in length, is also driven in a general south-easterly direction, but lies for the most part in the softer argillaceous rocks on the footwall side of the lead. From this tunnel three short corsscuts have been made to the south-west, or hanging-wall side. The first two cross-cuts cut widths from 4 to 5 feet of quartz interbanded with country rock with which some disseminated sulphides and streaks of oxidized material are associated. The third

cross~~ut~~cut, about 75 feet back from the face of the main tunnel, exposes a width of 6 feet of strong mineralization in which galena is uniformly distributed. The lower or No.3 tunnel has been driven for a length of over 700 feet. At about 400 feet in from the portal a wide zone of scattered galena and pyrite mineralization, associated with quartzose phases of the country rock, was encountered. Some cross-cutting at this point shows the mineralized zone is from 20 to 25 feet wide. At about 700 feet in from the portal crosscuts have been driven on both sides of the main tunnel to further explore the extent and character of the mineralization.

The ore consists of finely crystalline galena, sphalerite, marmatite, chalcopyrite, pyrrhotite and pyrite in a quartz gangue.

Wellington Mine

This property, owned by J. Angus of Marysville, is situated on the East Fork of Hell-Roaring Creek, about 7 miles by trail from the road near St. Mary Lake.

The vein, very sharply defined, follows the strong Hell-Roaring fault zone. It conforms closely with the schistosity of the enclosing quartzites ra~~hter~~ther than with their stratification, the strike of which approximates North 30 degrees east with the dip varying from 65 to 80 degrees east. About 200 feet down the hill from the outcrop

of the vein, the sediments are intruded by a granite porphyry dyke which contains large idiomorphic crystals of orthoclase in a groundmass of plagioclase, quartz and hornblende. The workings cover a length of 1,000 feet of outcrop ranging from 5,950 to 6,160 feet in elevation. They consist of eight open cuts, one shaft and one drift. The ore consists of galena, pyrite and chalcopyrite in a quartz gangue.

Great Dane Mine

This property is optioned by the Consolidated Mining and Smelting Company. It is located 4 miles up the west fork of the St. Mary River, from where the east, north and west forks unite. The entrance to the portal of the tunnel is approximately 5,000 feet above sea-level. The workings consist of 2 open cuts and a tunnel 180 feet long. The vein occurs in the argillaceous quartzites of the Creston formation which here strike north 20 degrees east and dip 70 degrees to the west. The vein strikes due north, and dips to the west at an angle of 75 degrees. The tunnel runs from the portal along the strike of the vein for about 85 feet and then swings 100 feet due west. The vein varies in width from 3 feet at the portal to 1½ feet at a distance of 85 feet. The crosscut to the west did not disclose any new veins. The ore consists of gneissic galena, pyrrhotite, sphalerite, pyrite, chalcopyrite, cobaltite(?) in a quartz

gangue. Many fine specimens of erythrite stains were found on the ceiling of the tunnel.

Society Girl

This group comprises seven Crown-granted claims situated about 2 miles east of Moyie, at an elevation of 5,000 feet and adjoins the eastern boundary of the St. Eugene Mine. Work was carried out on the property between the years 1908 and 1914. Small irregular shipments of ore were made, but there was no steady production.

The formation in which the deposits occur is the oldest subdivision of the Purcell series and is called the Aldridge formation, which here strikes north and south with a dip of 25 degrees to the east.

The deposit is a vein that strikes north 60 degrees west and dips 60 degrees to the south. The vein is narrow where it traverses the thin-bedded argillaceous quartzites and widens in the heavier bedded quartzites; and the ore is essentially galena carrying about one-half ounce of silver to the per cent of lead, occurring in a quartz gangue, and with it is associated some zinc blende.

In the upper workings the ore is oxidized, and consists of cerussite and pyromorphite, both massive and in beautiful crystals. The cerussite is commonly embedded in dense masses of limonite.

The workings consist of open cuts, prospect

shafts and several tunnels.

Aurora

The Aurora group is on the west side of Lower Moyie Lake opposite the town of Moyie, from which ~~twon~~ town it is reached by motor-road. The group was originally operated by the Aurora Mining and Milling Company of Moyie. About 1,500 feet of workings, mostly in the form of tunnels, constituted the development work. In 1925 the property was taken over by the Aurora Mines Syndicate and work was recommenced. The ore is hand-picked, shipped by motor-truck to Moyie, and finally by train to Trail.

The deposit is a fissure vein striking easterly across the quartzite series. The vein varies up to 6 feet in thickness, and the ore is massive sulphides, chiefly zinc blende with minor amounts of galena. In places the sulphides are deposited around fragments of brecciated country rock, and in some places there is evidence of replacement, the sulphides extending into the wall-rock.

Mineralization has clearly taken place along fracture or shear zones. The deposit is chiefly in the nature of a fissure vein, but a certain amount of replacemnet has taken place. The source of the mineralizing solutions was probably an underlying mass of granite. The probability that such an intrusive mass underlies the region is suggested by the outcrops of a number of granite stocks

along a north and south line in the district.

The upper workings are reached from No. 1 shaft, and the lower from No. 2 tunnel. The latter enters on the 200 foot level. It shows a main fissure zone and a parallel one which is called the Sullivan vein. In the stopes above this level there is a definite ore zone about 2 feet wide showing sharp contaxts with the country rock.

The 100-foot level reached from the shaft, shows an almost vertical vein about 1 foot wide. The ore zone rakes to the west, the lower showings appearing on the surface. This low, westerly rake is parallel to the bedding of the quartzites and suggests that certain beds have been more influential than others in precipitating ore. The more argillaceous beds seem to be better ore-making horizons than the massive blue quartzites.

The ore contains 18.4 per cent of zinc, 8.7 per cent of lead, and 2.5 ounces of silver to the ton.

The Tracey Property

This property is located on the ridge to the north of the ranch of W. Meachem at an elevation of 4,300 feet. It is owned by Mr. Tracey of Cranbrook and Mr. Meachem of Marysville, and is reached by pack-trail from the Meachem ranch, a distance of one-half a mile.

The workings consist of mumerous open cuts and two tunnels in the Aldridge quartzites. These two tunnels

expose two small quartz veins. The country rocks here strike north 15 degrees east and dip steeply to the west. The veins strike north 30 degrees west and dip at an angle of 30 degrees to the southwest. The ore consists of very coarsely crystallized galena with small amounts of chalcopyrite in a quartz-calcite gangue.

Gold Quartz Type

Distribution

The gold-quartz veins occur widely distributed throughout this area. The majority of claims were staked by prospectors on the north side of Perry Creek when in search for placer gold.

Geology

The deposits occur in the Aldridge, Creston and Dutch Creek argillaceous quartzites. These quartzites are well-bedded in beds 2 inches to 2 feet in thickness, and are separated by thin beds of argillaceous material. The deposits usually occur in well defined shear zones as true fissure veins. Their width averages about 8 feet, but some are as wide as 20 feet. They can be traced for long distances along the strike.

Mineralogy

The mineralogy of the gold-quartz veins is very simple and consists of free gold, pyrite and quartz. However, small amounts of chalcopyrite have been found in these deposits.

Native Elements

Gold Au: Gold occurs native in the weathered outcrops, but in depth it is associated with the pyrite.

Sulphides

Pyrite FeS_2 : Sulphide of iron, occurs disseminated in the quartz gangue, usually as idiomorphic crystals or as large masses.

Chalcopyrite $CuFeS_2$: Sulphide of copper occurs sparingly in some of the deposits.

Oxides

Quartz SiO_2: Quartz is the only gangue mineral noted in the deposits.

Paragenesis

The age relations of the minerals in the veins of the gold-quartz type were found by examination of polished sections.

The general sequence may be summarized as follows:

(i) Quartz

(ii) Pyrite and gold (?)

(iii) Chalcopyrite

The pyrite fills fractures in the quartz, while the chalcopyrite replaces the pyrite where the two are found together.

No visible gold was noted in any of the specimens.

Genesis

On the west fork of the St. Mary River, near the confluence of this fork and Rose Creek, a body of granite outcrops in the river bottom. This body of granite can be followed for a mile until it ends finally in a quartz vein on Cogle Creek. Gradations from true granite through pegmatite to quartz vein carrying pyrite were observed. This vein occurs on a property which is being worked, and around the vein the country rock ~~fro~~ for a distance of 20 feet has been replaced by pyrite. This occurrence, combined with the fact that this area is presumably underlain by igneous rocks, indicates that these gold-quartz type of deposits are associated with the late Jurassic intrusions.

Detailed Descriptions of Properties

Roman Valley Group

This group is situated approximately one mile up Roman Creek from that creek's confluence with Perry Creek. The property is reached by pack trail from this junction point. The property is owned by Mr. J. Hutchcroft and associates, of Cranbrook. The deposits occur as fissure veins in the green Creston argillaceous quartzites which strike north 20 degrees east and dip at 60 degrees to the southeast.

The workings consist of surface stripping and about twelve open cuts, which disclose three veins varying in width from 6 feet to 10 feet. The veins strike northeast, and dip about 50 degrees to the east. The last open cut, some 300 feet down the dip of the vein, proves that the veins do extend to this depth.

The ore consists of ~~pathces~~ patches of pyrite disseminated in the quartz gangue. Some pyromorphite crystals in the characteristic barrel-shape were noted, but the galena from which they were probably derived was not visible. The ore assays from $1.50 to $17.00 a ton in gold.

Quartz Mountain

This group of claims is situated at the headwaters of Sawmill Creek, a short tributary of Perry Creek. An interesting discovery of quartz mineralized with gold-bearing iron and copper sulphides was made by Elmer Rice and associates of Kimberley. There are two massive quartz outcrops on the property. The Consolidated Mining and Smelting Company of Kimberley took an option on the property and since that time development work has been carried out. The westerly showing lies up the hill from the camp at 6,400 feet elevation, and averages 50 to 70 feet in width. Its continuity has been established for a length of several hundred feet by two series of trenches and numerous outcrops. About 600 feet to the east, downhill from the massive showing and separated from it by a dyke of diorite, is the second and most important of the showings. Here the owners have dug a 150-foot trench. The gold values for 105-foot length assayed .25 ounces of gold per ton. Further work is planned for 1937 by the Consolidated Mining and Smelting Company.

Homestake Mine

This property is situated on the west side of Perry Creek, near its head, between Manchester and Liverpool creeks, and is owned by the Cranbrook Gold Mining Company.

A series of parallel quartz veins, very persistent in length, and in some cases very wide, strike parallel with

the enclosing argillaceous quartzites and schists of the Creston formation. In the vicinity of the Homestake Mine the strike of these rocks is north-easterly. The deposits are true fissure veins.

The workings consisting of open cuts, shafts and tunnels. The ore is composed of free gold and pyrite in a quartz gangue. A few men were engaged in the summer of 1936 doing assessment work.

Midway Mine

This prospect adjoins the highway near Aldridge, a siding south of Moyie Lake, and is owned by the B.C. Cariboo Gold Fields Limited. The deposit consists of a quartz vein heavily mineralized with pyrite and small amounts of lead, zinc and copper sulphides, and occurs in the Aldridge formation. The veins strike north-westerly into the mountain and dip 45 degrees and 55 degrees to the north-east. In width, the ore shoot varies from 5 to 8 feet, and near the face of the tunnel is over 8 feet wide. The vein has been followed for about 300 feet by the tunnel and has been traced on the surface for over 800 feet. There is a fault just beyond; the wide ore section referred to. The vein varies in width from a seam to 3 feet, but is always in the same shear zone. As the sheared rock required much timbering in the vein zone, the tunnel was driven in the hanging-wall country rock parallel to the vein. At 290 feet in from the

portal the vein was 18 inches wide, with similar intensity of mineralization as in the ore-shoot south-east of the fault, where the sulphides consititued probably 30 per cent of the total volume. The gangue consists entirely of quartz with minute amounts of siderite. In places the quartz has been intensely brecciated and recemented. The sulphide content is mainly pyrite, with only minute amounts of zinc-blende, galena, tetrahedrite and chalcopyrite. Arsenopyrite has been identified as well as small but definite amounts of tin. The principal value is in gold, but silver is invariably present, and in places in important amounts.

The continuity of the mineralization exposed throughout the limits of the work done, the uniform character of the ore, and gold and silver values so far obtained warrant a large amount of development work to explore for the possible occurrence of large ore bodies. The ideal transportation facilities, and exceptionally favourable geological conditions combine to make this prospect of unusual interest.

Cogle Creek Property

This property lies 2 miles up Cogle Creek from where it joins the west fork of the St. Mary River. Here Cogle Creek cuts a canyon 30 feet deep and 15 feet wide in the Dutch Creek formation, exposing a heavily mineralized quartz vein. The strata here strike north 20 degrees east,

and dip at 30 degrees to the south-east. The vein can be traced by continuous outcrops directly to a granitic mass exposed in the west fork valley bottom. The workings consist of a single open cut exposing the mineralized vein. Around the vein and replacing the country rock for a width of 30 feet is much pyrite. The pyrite carries low gold values not warranting further work on this property. The low gold values are probably due to the fact that the temperature conditions were too high for the deposition of gold.

Southern Cross

This property is located 5 miles up Boulder Creek from Lumberton No. 2 camp. The buildings at the prospect are situated on the creek bottom, while the workings are 300 feet above on a side-hill. The vein occupies a shear zone in the Creston formation. The shearing strikes north 10 degrees east and dips 75 degrees to the north-west. The workings consist of a tunnel 85 feet long which follows a vein varying in width from 1½ feet at the portal to 6 inches at the face of the tunnel. The wall-rock is also replaced by pyrite. The ore, consisting of pyrite, is sais to assay $5 a ton in gold; the gangue is mainly quartz.

Hematite Type

Distribution

These deposits occur mainly in the Creston formation. The purple mottling effect, so characteristic of this formation, is due to the presence of finely divided specular hematite. Thus mineralizing solutions traversing the Creston formation may have dissolved and precipitated the hematite in a more concentrated form as deposits. This distribution would be expected to be greater in the Creston formation, but could conceivably be present in other formations through which the solutions traversed.

Geology

These deposits occur mainly in the argillaceous quartzites of the Creston formation. The quartzites are usually sheared and the deposits occur as true fissure veins in well-defined lines of faulting. A characteristic feature of the Moyie fault is that at the places where it crosses the Creston formation this type of deposit occurs.

Mineralogy

Oxides

Hematite Fe_2O_3: Iron oxide - Hematite occurs as the main mineral constituent of these deposits. In the Creston

formation it occurs as the finally divided specular variety. In the vicinity of faulting the hematite occurs as large micaceous plates ½ inch long by ½ inch wide. In true veins this mineral is found in dark red masses veining a quartz gangue.

Quartz SiO_2 - Oxide of silicon: Vein quartz occurs only in the true fissure veins. Here it is usually brecciated and the interstices are filled with later pyrite and hematite.

Sulphides

Pyrite FeS_2 - Iron pyrites: Pyrite occurs in five and six-sided forms modified by the later replacing hematite solutions.

Paragenesis

The mineral sequence may be summarized as follows:

(i) Quartz and pyrite

(ii) Brecciation

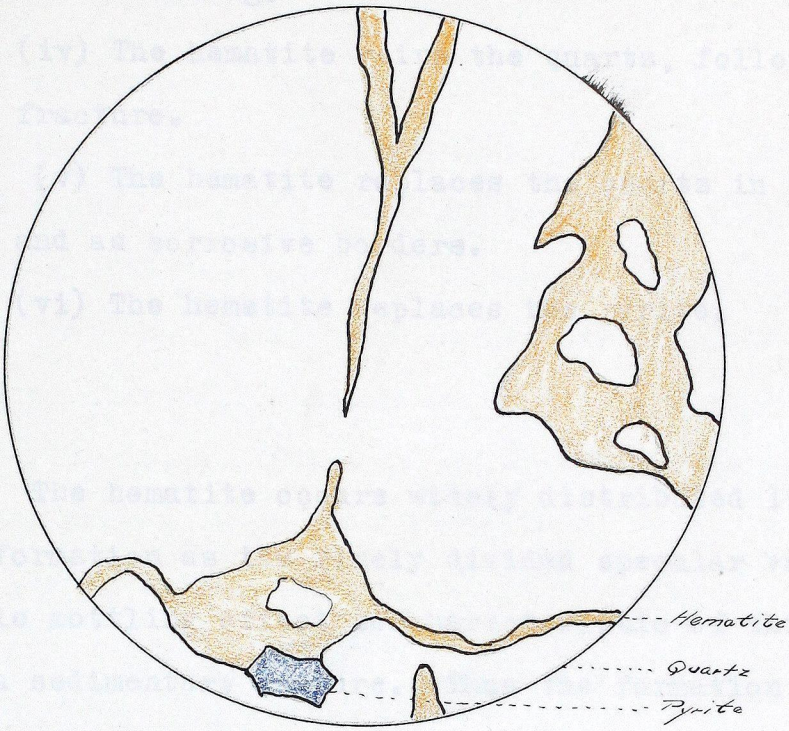
(iii) Hematite

The criteria for the age relations are as follows:

(i) The quartz and pyrite exhibit smooth contacts, no cusps, no corrosive effects and no replaced embayments.

(ii) The quartz vein containing the pyrite was brecciated.

(iii) The brecciated material forms bosses in the



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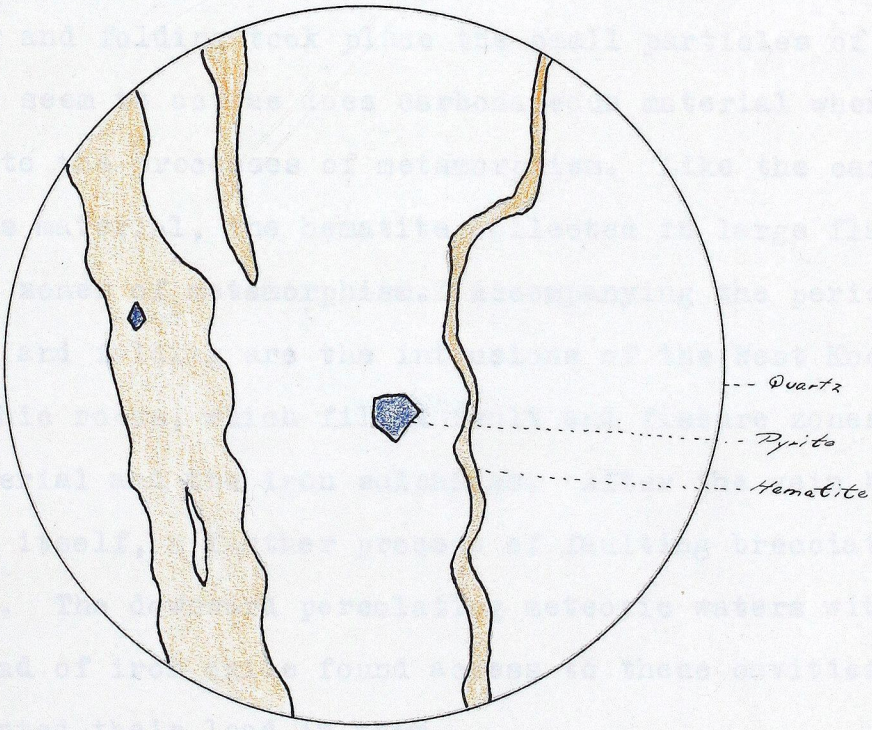


Hematite Type

later hematite filling.

(iv) The hematite veins the quartz, following the zones of fracture.

(v) The hematite replaces the quartz in the form of cusps and as corrosive borders.

(vi) The hematite replaces the pyrite.

Genesis

The hematite occurs widely distributed in the Creston formation as the finely divided specular variety. The purple mottling effect so characteristic of this formation is a sedimentary feature. Thus the formation of the hematite and sedimentation were contemporaneous. The deposition of the hematite was syngenetic. As the period of faulting and folding took place the small particles of hematite seem to act as does carbonaceous material when subject to the processes of metamorphism. Like the carbonaceous material, the hematite collected in large flakes or knots in zones of metamorphism. Accompanying the period of faulting and folding are the intrusions of the West Kootenay batholithic rocks, which filled fault and fissure zones with vein material and the iron sulphides. After the vein had cemented itself, a further process of faulting brecciated the vein. The downward percolating meteoric waters with their load of iron oxide found access to these cavities and precipitated their load in them.

Detailed Description of Properties

Although no work has been done in the vicinity of the Moyie fault, it is of scientific interest. This fault is well defined, and in places brings the Aldridge formation into contact with the Kitchener formation and also the Creston formation. Where this fault traverses the Creston argillaceous quartzites, large amounts of specular hematite plates are developed. There is sufficient quantity of this material to warrant some work being done, as it is reported that the hematite carries some values in gold.

Weaver Creek Property

This property is located in the vicinity of Weaver Creek, 1½ miles up from this creek's confluence with the Moyie River. Here the creek cuts a canyon through the contact of the Aldridge quartzites and a Purcell sill. There is a large shear zone developed in the quartzites, which is filled by an 8-inch vein of hematite and quartz with amounts of ~~marcasite~~ pyrite. The brecciation of the vein is clearly exhibited in the hand specimens. The workings consist of two tunnels in the shear zone on opposite sides of the creek. This ore is said to carry up to $10 a ton in gold. The ore consists of hematite and marcasite, and the gangue of brecciated quartz.

Perry Creek Property

This property, located on the ridge at the head of Perry Creek, is owned by Mr. B. Frasseni of Cranbrook. The workings occur at the top of a steep talus slide, where a tunnel penetrates a vein about 6 feet wide. The vein is contained in the argillaceous quartzites of the Creston formation which here strikes north 10° east and dips 40° to the north-west. Due to the inconvenience of this talus slope, the property was abandoned. The vein outcrops at the top of the ridge, about 300 feet above the workings. The ore consists of large masses of hematite in a quartz gangue. The owner said that some of the assays ran $30 a ton in gold.

Galena Gold Type

Distribution

There was only one deposit of this type of any economic value in this district. This type is confined to the Aldridge argillaceous quartzites and related to a well-defined fault zone.

Geology

The Aldridge formation, with which this type of deposit is associated, is a hard, argillaceous quartzite formation. It is able to carry a fracture for long distances, producing a means of access for the mineralizing

solutions.

Mineralogy

Native Elements

Gold Au: Gold does not occur native, but is evidently associated with the galena.

Silver Ag: Silver does not occur native, but is associated with the galena.

Sulphides

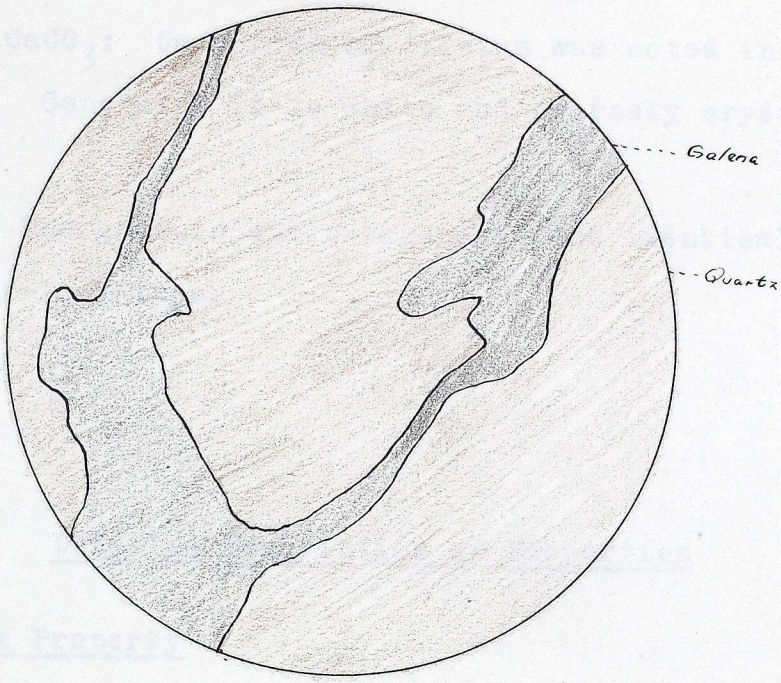
Galena PbS: Sulphide of lead is the most important mineral, as it contains the gold values. It is usually in the coarse, cubic variety, and in places is of a gneissic variety.

Chalcopyrite $CuFeS_2$: Copper pyrites - chalcopyrite occurs sparingly in this type of deposit.

Pyrite FeS_2 : Iron pyrites - pyrite was absent in the section.

Oxides

Quartz SiO_2 : Oxide of silicon, quartz is the most abundant gangue mineral in these deposits. It occurs massive and has been fractured, the fractures being filled with the sulphides.



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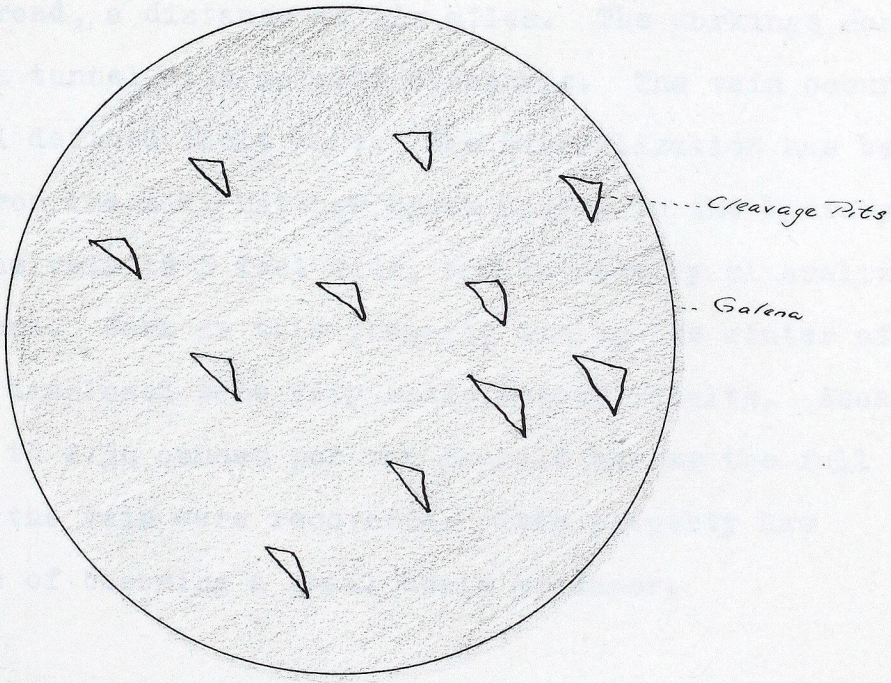


Galena-Gold Type

Carbonates

Calcite $CaCO_3$: Carbonate of calcium was noted in these deposits. Generally it is white and coarsely crystallized.

The genesis and paragenesis are identical with the silver-lead type.

Detailed Description of Properties

Alki Creek Property

This property is located at the headwaters of Alki Creek, and is reached by pack-trail from the Marysville-Meachem road, a distance of six miles. The workings consist of a tunnel with several crosscuts. The vein occurs in a well defined fault zone. The mineralization has been traced from the Alki-Matthew Creek divide to the Mystery Mine. The vein is 5 feet wide, and is heavily mineralized with galena. Work on this property during the winter of 1936 has disclosed some very satisfactory results. Assays from .77 to 2.56 ounces per ton in gold across the full width of the vein were recovered. This property has prospects of becoming a small scale producer.

Arsenopyrite Gold Type

Distribution

There is only one example of this type of deposit in the district, and it occurs on the eastern ridge of Bootleg Mountain.

Geology

The deposit occurs in the argillaceous quartzites of the Aldridge formation. These quartzites are well exposed on the ridge. About 500 feet to the east of the deposit an outcrop of graphic granite pegmatite outcrops. The sediments around this dyke are metamorphosed in distinct zones. Near the dyke sillimanite schists are developed, while away from the intrusion these grade into garnetiferous mica schists and further to quartz mica schists containing biotite which are of the low temperature type. A diorite sill at the property is metamorphosed to a chlorite schist.

Character of Deposits

The deposits occur as veins. The width varies, but is about 3 feet.

Mineralogy

The mineralogy of these veins is very simple and

consists of gold, arsenopyrite, pyrite and galena in a quartz gangue.

Native Elements

Gold Au: Gold is evidently associated with the arsenopyrite or galena.

Sulphides

Arsenopyrite FeAsS: Mispickel- Arsenopyrite occurs widely distributed in these deposits. It was the earliest formed mineral, as it is brecciated and the fractures produced are filled with all the later minerals.

Pyrite FeS_2: Iron pyrites - sulphide of iron occurs sparingly throughout these deposits and was not found in contact with the arsenopyrite.

Galena PbS: Sulphide of lead occurs as an intricate vein system following the fractures in the arsenopyrite.

Oxides

Quartz SiO_2: Oxide of silicon - quartz is the only gangue mineral noted in the deposits. It evidently came in later than the arsenopyrite, as it veins this mineral but was contemporaneous with the galena.

Paragenesis

The general sequence of mineralization may be summarized as follows:

(i) Arsenopyrite

(ii) Pyrite (?)

(iii) Brecciation

(iv) Quartz and galena.

The criteria for the age relations are as follows:

(i) The arsenopyrite is brecciated and the interstices later filled with vein quartz and galena.

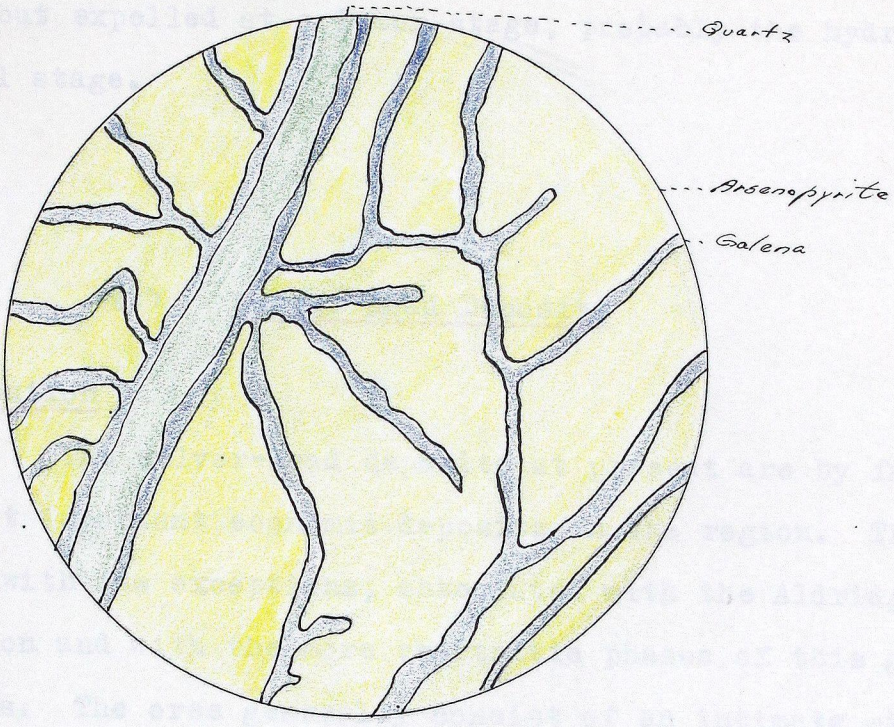
(ii) In the pyrite replacement type of deposit the arsenopyrite was found earlier than the pyrite.

(iii) The pyrite was also involved in the fracturing movements

(iv) The quartz and galena vein the arsenopyrite and exhibit smooth contacts one to the other.

Genesis

The close proximity of the deposit to the graphic granite pegmatite dyke and also the presence of the mineral arsenopyrite suggest that the pre-brecciation minerals are genetically related to the dyke intrusion. A notable feature in this district is that the mines near these pegmatite intrusions contain the high temperature mineral arsenopyrite. Elsewhere in the district, this mineral is missing in the deposits. The later galena and quartz indicate that they were probably formed from the same



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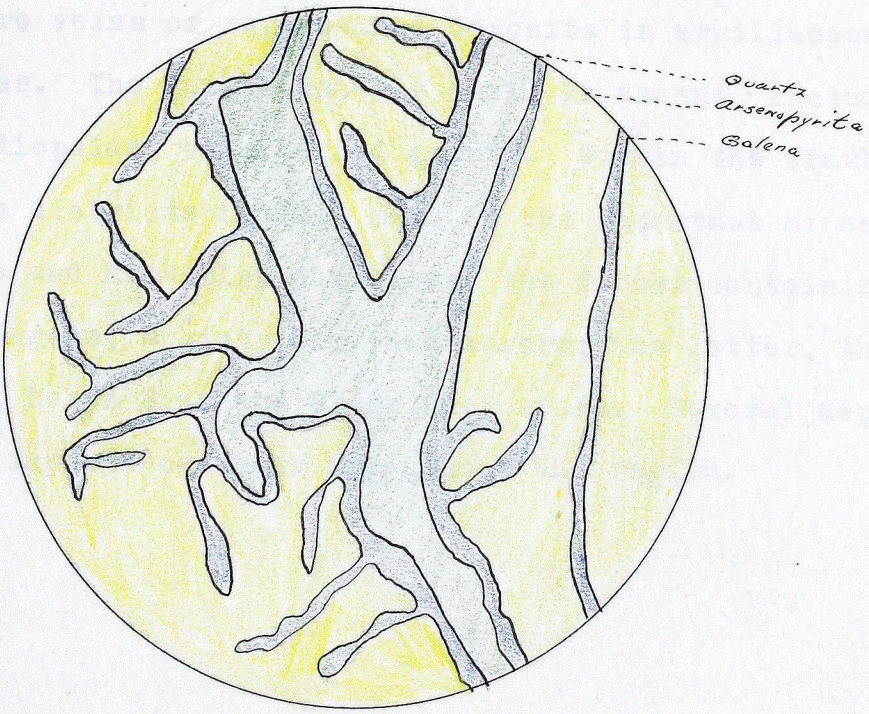


Arsenopyrite Type

magma but expelled at a later stage, probably the hydrothermal stage.

2(a) Silver-Lead Deposits

Distribution

The silver-lead deposits at present are by far the most important economic deposits in the region. They occur, with few exceptions, associated with the Aldridge formation and with the more quartzitic phases of this group of rocks. The ores generally consist of an intimate mixture of the sulphides pyrite, pyrrhotite and galena, either as fissure veins or replacement deposits in argillaceous quartzites. The gangue, usually small in amount, includes garnet, diopside, calcite and quartz. Within the Cranbrook area, two districts include most of the important mines, the Moyie and Kimberley districts, the former containing the St. Eugene, Society Girl and Aurora; the latter, the Sullivan, North Star and Stemwinder mines. Several deposits of minor importance occur throughout the region.

Mineralogy

Native Elements

Silver: Native silver occurs in the oxidized zone in the North Star Mine as arborescent and reticulated aggregates in cavities in limonite.

Sulphides

Galena PbS: Sulphide of lead is the most important mineral, as it contains not only the lead values but the silver values as well. In general, it is the fine-grained, steely variety in the Sullivan ore body; but it often occurs as the coarse, cubic variety which constituted the ore-bodies of the North Star and St. Eugene.

Sphalerite ZnS: Sulphide of zinc - sphalerite is always present in greater or less quantities in all the silver-lead deposits in the Sullivan. It is intimately associated with the fine-grained galena and iron sulphides. In the St. Eugene and the Aurora the larger part of the sphalerite is coarse in texture and of a dark brown colour.

Pyrrhotite - Magnetic sulphide of iron: Pyrrhotite occurs abundantly in the Sullivan and Stemwinder intimately mixed with pyrite and zinc-blende. It occurs rarely in the St. Eugene and as far as known, is absent from the Aurora.

Iron Pyrites FeS_2 - Disulphide of iron: Pyrite is widely distributed throughout all the deposits, but is especially prominent in the Sullivan and Stemwinder.

Arsenopyrite FeAsS - Mispickel: Arsenopyrite is a rare mineral in the silver-lead deposits and was only noted in the Sullivan Mine where it was in the form of crystals embedded in a mixture of pyrite, pyrrhotite and zinc-blende.

Chalcopyrite CuFeS2 - Copper Pyrites: Chalcopyrite occurs sparingly in the Sullivan and the St. Eugene, associated with the sulphides of iron.

Sulpho-Salts

Jamesonite $2PbSSb_2S_3$ - Sulpho-ahtimonite of lead: Jamesonite has been found only in the Sullivan Mine in small stringers of calcite, which were deposited later than the main ore-body. Its form is always fibrous. It has a steel grey colour and a metallic lustre.

Oxides

Quartz SiO_2: Quartz occurs in small amounts in the silver-lead deposits as irregular grains of glassy appearance.

Magnetite $FeOFe_2O_3$ - Magnetic Iron Ore: Magnetite occurs only in the St. Eugene Mine, where it is associated with garnet and actinolite.

Limonite $2Fe_2O_3 \cdot 3H_2O$: Limonite is a common mineral in the oxidized zone of the deposits. In the Society Girl it occurs as a dark, brown, compact mineral associated with cerussite and pyromorphite.

Carbonates

Calcite $CaCO_3$ - Calcareous Spar: Calcite occurs sparingly as a gangue mineral in all the silver-lead deposits, but more abundantly in the St. Eugene. In the Sullivan, it is found in stringers cutting the ore-bodies, and was evidently formed at a period later than that of the amin ore deposition.

Cerussite $PbCO_3$ - Lead carbonate or white lead ore: Cerussite is white and colourless, and occurs in the oxidized zone of the North Star and Society Girl mines, mainly in the form of crystals and crystal aggregates, but often compact and massive, coating the surfaces along fissures. At the Society Girl, the cerussite is often embedded in dense masses of limonite.

Silicates

Diopside $CaMg(SiO_3)_2$, $Ca(MgFe)(SiO_3)_2$: Diopside occurs in the Sullivan ore-body and towards the centre of the mass. It forms transparent, light green crystals of imperfect outline and good cleavage.

Actinolite $(MgFe)SiO_3$ - non-aluminous variety of amphibole: Actinolite is a gangue mineral in the Sullivan and St. Eugene ore bodies. It occurs as radiating aggregates associated with the other gangue minerals.

Garnet: Manganese-bearing garnet occurs in the Sullivan-St. Eugene ore bodies. In the Sullivan, the garnet is found as idiomorphic crystals embedded in fine-grained galena.

Biotite - magnesium-iron mica: Biotite occurs generally in the exterior sulphide zone of the ore bodies and in the neighbouring country rocks in small, irregular plates.

Phosphates

Pyromorphite $(PbCl)Pb_4(PO_4)_3$ - lead phosphate: Pyromorphite occurs only in the oxidized zone of the Society Girl Mine where it occurs in massive forms in barrel-shaped aggregates, and in crystals with a high degree of crystal development.

Paragenesis

The general order of mineral sequence may be summarized as follows:

(i) Magnetite

(ii) Actinolite

(iii) Garnet, diopside, pyrite and arsenopyrite

(iv) Pyrite, pyrrhotite, zinc-blende, and galena

(v) Calcite

(vi) Cerussite, pyromorphite, native silver and limonite
(vii) Jamesonite

The gangue minerals such as garnet and diopside are usually regarded as deposited first, since the fractures in them are filled with a mixture of pyrite, pyrrhotite, zinc-blende and galena. Some of the sulphides are probably contemporaneous with the gangue minerals, for idiomorphic crystals of pyrite and arsenopyrite were observed embedded in the fine-grained sulphides. The sulpho-salt, jamesonite, is associated with the small calcite veins which are later than the main ore-bodies, and is probably a secondary mineral.

Genesis

The presence of the diagnostic minerals, garnet, diopside, actinolite and muscovite, which are entirely restricted to the ore deposit and absent from the surrounding quartzites, suggests that the deposition of the ore took place in the deeper vein zone under conditions of temperature and pressure comparable to those of contact metamorphic deposits. Three miles to the southwest of Kimberley, on the western ridge of Mathew Creek, a dyke of graphic granite pegmatite was found cutting the sedimentary formations. This dyke was composed of large flakes of muscovite and graphic intergrowths of quartz and feldspar (orthoclase). Surrounding this dyke were pronounced aureoles of metamorphism. Garnet, mica and sillimanite schists were developed in these aureoles.

About 500 feet from this dyke, in a biotite schist, is a deposit of quartz and arsenopyrite. These minerals are identical with those found in the replacement deposits, and present a very good example of zonal arrangement from high to low temperature types. It is therefore concluded that the intrusive basement of granite upon which the Purcell Series of East Kootenay rests was the source of the silver-lead ores developed there.

Description of Mines

The Kimberley Area

This area is situated near Kimberley, the terminus of the Canadian Pacific branch line from Cranbrook to Kimberley, and includes the Sullivan, Stemwinder and North Star mines.

Geology

The Kimberley area is underlain by the argillaceous quartzites and argillites of the Aldridge formation. These rocks are intruded by several Purcell sills composed of gabbro, which are well exposed on Mark Creek, above Kimberley. The Aldridge quartzites of the Kimberley area form the eastern limb of the large anticline the axis of which is located in the vicinity of Matthew Creek. In general, the strike of the rocks near Kimberley is nearly north and south, with the

most prevalent dip to the east, but minor folds modify this simple structure.

Character of the Deposits

These deposits are replacement deposits in argillaceous quartzites. The ore bodies in general conform to the dip and strike of the quartzites. The hanging-walls and foot-walls are not usually well defined; but the ore gradually passes into the normal country rocks, so that the distinction between rocks and ore is commercial rather than structural. Exceptions to this occur where the walls consist of the thin-bedded, slaty quartzites which are evidently difficult to replace. The deposits are arranged in distinct zones. The centre of each body is occupied by a fine-grained mixture of galena and zinc-blende in which occur masses of purer galena as lenses. This inner portion gradually passes exteriorly into a fine-grained, intimate mixture of pyrite, pyrrhotite and zinc-blende. The sulphides gradually diminish in amount and finally give way to a fine-grained chert and then to normal argillaceous quartzites.

Sullivan Mine

Location

The Sullivan Mine is situated at Kimberley which is 19 miles by rail from Cranbrook on the Crow's Nest line of the Canadian Pacific Railway. It is easily reached from

Cranbrook by train or motor-bus.

History

This deposit was staked in the summer of 1892. From 1896 to 1899 some surface stripping was done and several small shafts were sunk. In 1900 systematic development was begun, and the first shipments of ore made to the Hall Mines smelter at Nelson and to the Canadian Smelting Works at Trail.

In 1903 construction was commenced of a smelter and power plant at Marysville, 5 miles below Kimberley, on Mark Creek. Many metallurgical difficulties were encountered, and in 1907 the mine and smelter were closed down. In 1909, the bond holders and the creditors of the company reorganized the company under the name of the Fort Steele Mining and Smelting Company, the control being vested in the Federal Mining and Smelting Company. In December, 1909, the Consolidated Mining and Smelting Company of Canada, Limited, took a lease and bond on the Federal Mining and Smelting Company's holdings in the Fort Steele Mining and Smelting Company. Underground development and diamond drilling were carried out with the result that towards the close of 1910 the option on the stock of the Federal Mining and Smelting Company and on that of some of the other share-holders was exercised and the control passed into the hands of the Consolidated Mining and Smelting Company of Canada. Other claims were acquired by the company in 1911 and the metallurgical problem was

attacked in earnest. Continuous shipments of ore to Trail have been made since 1910.

Production

The production of the Sullivan Mine from 1894 to September 30, 1913, was 188,648 tone of ore, containing 1,694,402 ounces of silver and 86,821,629 pounds of lead. The production for the year 1935 was 1,861,245 tons of ore, containing 226,837 tons of lead concentrates and 209,078 tons of zinc concentrate. This was an increase of 112,844 tons over the production of 1934.

Character of the Ore Bodies

The Sullivan occurs in the Aldridge formation of argillaceous quartzites of late Precambrian age. In the vicinity of the mine the beds strike approximately north and south, and dip east at angles of 10 to 60 degrees. The Aldridge formation is intruded by several large sills of gabbro, but none of these occur in the immediate vicinity of the mine. To the north and west of the deposit the strata are intruded by granite of late Jurassic age. A fault zone lies in the immediate vicinity of the mine and it swings from there over towards the north side of Bootleg Mountain.

The deposit consists of massive sulphides occupying a definite zone in the sedimentary series. Though there are irregularities in the foot-wall and hanging-wall, in general the deposit is conformable to the beds, forming a lens

striking north and south and dipping at an angle of 23 degrees to the east. The lens has a maximum thickness of 272 feet, and a length of over 6,000 feet, with a rake to the north.

The ore lens consists of pyrite, pyrrhotite, sphalerite and argentiferous galena. Small amounts of other minerals such as garnet, cassiterite and tourmaline also occur. Of the iron sulphides, pyrite is dominant in the upper working, whereas in the lower working pyrrhotite predominates. The sphalerite is of the iron-bearing variety known as marmatite. The ore is commonly a fine-grained mixture of the four common sulphides. In places it shows a banded structure, and the bands may be either straight or contorted. The deposit was formed by replacement of the Aldridge formation. The banding of the ore probably corresponds to original bedding planes of the replaced strata. Deposition clearly took place under conditions of high temperature approaching that of contact metamorphism. The source of the solutions is believed to be the underlying mass of granite exposed 3 miles to the southwest of the deposit.

The lens is mined from two adits, an upper known as the 4,600-foot level and a lower called the 3,900-foot level, these figures approximately representing their respective elevations above sea-level. There are two connections between the upper and lower workings. In both levels there are two ore-shoots, known repsectively as the north ore-body and the south ore-body.

In the upper workings, stoping in the south ore-body was carried on over a length of 2,000 feet. The ore is lead and zinc in a gangue of pyrite. In the north ore-body stoping on the same level was carried on over a length of 1,200 feet. This zone contains more zinc than lead. Between these two zones is a barren zone of massive pyrite 700 feet long. Work is also being carried out on the 4,500-foot and 4,400-foot levels, but the ore from these is sent down to the 3,900-foot level to be hauled to the surface.

The lower, or 3,900-foot tunnel, has a length of over 13,000 feet. At a distance of 7,100 feet from the portal, the ore lens is reached. The south ore-body on this level consists of sphalerite in a gangue of pyrrhotite. The amount of galena is small. Stoping is carried on over a length of 900 feet. Between the south and north ore bodies there is a zone of pyrrhotite with only low values of zinc and lead, and about 1,100 feet long. In the north ore-body stoping is being carried on over a length of 1,200 feet. Though the ratios of lead and zinc vary considerably, lead is here uniformly in greater amounts than zinc. The greatest thickness of the ore lens is 272 feet.

The 3,900-foot tunnel bears north 2 degrees east for the first 9,000 feet from the portal. At this point it swings to the west until its direction is north 40 degrees west. In the south and north ore-bodies it follows the foot-wall, but north of the north body the lens is so irregular that the drift, being straight, is sometimes in the

footwall and sometimes in the hanging-wall. The average width of the lens in this continuation of the north ore-body is 30 feet and it has been followed for over 4,000 feet beyond the north ore-body. It carries here an excellent grade of ore with high values of both lead and zinc.

The sulphides found in the Sullivan Mine are galena, sphalerite (marmatite), pyrrhotite, pyrite, arsenopyrite(rare) and the gangue is composed of garnet, diopside, chert and normal argillaceous quartzites.

In 1936 the Sullivan Mine continued to be the most important factor in the economic life of the East Kootenay district. The concentrator treated an average of 5,959 tons of ore per day.

An interesting feature in this year's operations is the filling of the "K" stope with boulder-clay from the surface. This is an initial and, to some extent, an experimental step in the programme designed to make possible recovery of the large tonnage of ore in mine pillars.

The ore is treated by flotation, and the lead and zinc concentrates are shipped to Trail for treatment.

At the present rate of mining the reserves in sight are estimated to last 35 years. Little is known of the depth to which the ore lens extends below the 3,900-foot level, but its thickness and its great length suggest the probability that there is as much ore below this level as there is above.

North Star Mine

Location

The North Star Mine is on the east slope of the North Star hill at an elevation of 5,260 feet above sea-level or about 1,500 feet above Kimberley, which lies at the foot of the North Star hill on Mark Creek.

History

The property was located in 1912 by Boureois and Langill who bonded the claims to Woods Brothers of Quebec; the latter transferred four-fifths of their interest to D.P. Mann of Montreal in 1893. Later the North Star Mining Company was organized. In 1895, 62 tons of ore, valued at $68.70 a ton, was shipped to the United States. In 1900, the railway from Cranbrook to Kimberley was completed and an aerial tram built to join the mine with the railway. During the same year, 16,000 tons of ore, averaging 50 to 55 per cent lead and 20 to 25 ounces of silver, was shipped. In 1904 the mine was reported to have been worked out, but the cleaning up of the deposit lasted until 1908, in which year 3,000 tons were shipped.

In 1918, a lease was taken on the property by O.C. Thompson and associates, and between that year and 1920 over 16,000 tons of lead carbonate was shipped from the dumps and shallow surface diggings.

In 1924 the property was acquired under option by the Porcupine Goldfields Development and Finance Company, Limited, of London, England, and a certain amount of diamond-drill exploration was carried out.

Geology

The country rocks are argillaceous quartzites of the Aldridge formation of Precambrian age, forming part of the eastern limb of the Kimberley anticline. In the vicinity of the mine small anticlines and synclines modify this general structure. The general strike of the quartzites is north and the dip is to the east at various angles. In the immediate vicinity of the ore-bodies the quartzites are bleached to a greyish white colour.

Deposit

The ore was primarily a very clean, solid, argentiferous galena, rather fine-grained and with only a small amount of sphalerite. The assay value from smelter return was: silver, 23.50 to 43.3 ounces to the ton; lead, 53 to 68 per cent.

The upper part of the ore-shoot was composed of a reddish brown, blakc, and yellow mixture of oxides and carbonates of iron and lead, with specimens of wire silver, crystals of cerussite and sulphides of iron. Most of this secondary material carried a higher silver value than the

crude galena. The values from smelter returns of this carbonate ore are: s lver 52 to 60 ounces per ton; lead 49 to 57 per cent.

There are two main ore-bodies lying in synclinal basins formed of argillaceous quartzites separated by an anticline. The larger ones of these ore-bodies are parallel, both striking a little east of north. The western had a length of 400 feet, a width of 70 feet, and a depth of 50; the eastern had a length of 180 feet and a depth of 40 feet.

The original ore-body was a replacement deposit, similar to the Sullivan, occupying a definiite zone in the Aldridge quartzites. During subsequent erosion most of the ore zone was removed, leaving only the lower portions in the two synclines. The exposure to surface agencies altered the original ore, forming carbonates and removing the zinc.

The main bulk of the tonnage was mined by glory-hole methods, and taken out by an adit-tunnel in the foot-wall at a depth of 60 feet below the surface, and thousands of feet of tunnelling and numerous small shafts were sunk to rpospect and prove the content of the ore-bodies.

Regarding future possibilities, Langley states: "Conditions would seem to warrant further exploratory work by diamond-drilling at some distance down the mountain side. Besides a large tonnage of low-grade carbonate ore being available, there is also a considerable tonnage of good milling grade of sulphide ore similar in character to some

of that at the Stemwinder. A sample taken of this ore ran: silver, 9 ounces to the ton; lead, 12.1 per cent; zinc, 1719 per cent.

On the northerly end of the property a good deal of exploratory work has been done on strong showings of iron sulphides, but it is understood the values were too low to constitute ore."

Stemwinder Mine

The Stemwinder is situated near Kimberley, on Mark Creek about half a mile to the west of the portal of the Sullivan Mine. It is readily reached either by train or by bus from Cranbrook on the Crow's Nest line of the Canadian Pacific Railway.

The property was originally owned by the Mackenzie and Mann interests. In 1923 it was bonded by D.C. Thompson who in 1924 interested the Porcupine Goldfields Development and Finance Company. Work was carried out in 1925 and 1926, but early in 1927 work was discontinued and the option dropped.

The country rock consists of argillaceous quartzites of the Aldridge formation, intruded by several sills of hornblende gabbro, one of which outcrops a short distance to the east of the workings.

The ore-body is a lens of massive sulphides entirely enclosed by the quartzites. The lens consists largely of pyrrhotite, strikes nearly north, and dips at an angle of about 75 degrees to the west. It is difficult to see its relations to the country rock, for the contacts are not well exposed in the workings. The thickness of the sulphide zone is about 200 feet.

The ore zone lies along the foot-wall side of the sulphide lens. It consists of a fine-grained mixture of galena and sphalerite passing into a fine-grained mixture of pyrrhotite, pyrite and zinc-blende. The ore zone has a width of about 20 feet. It is separated from the normal quartzite by a cherty layer.

The workings consist of a shaft sunk to a depth of 250 feet and drifts run from it on the 80, 125, 200 and 250-foot levels. This work and a certain amount of diamond-drill exploration have disclosed the extent of the ore zone. The latter has apparently a length of 260 feet and a width from 15 to 30 feet. The average values are reported to be 20 per cent zinc, 1 percent lead, and 1 ounce in silver to the ton.

The Moyie Area

Geology

The Moyie area is underlain by the Aldridge and Creston formations of the Purcell series. These formations are folded into a northerly-dipping anticline, the axis of which roughly coincides with the depression occupied by the Moyie lakes and rivers. The Aldridge formation occupies the axial portion of the anticline, and consists of dark grey, argillaceous quartzites in beds up to 1 foot in thickness, and dark grey, siliceous argillites generally not exceeding 2 inches in thickness. The weathering colour of these rocks is a dark rusty brown. On the eastern side of the lake, in the vicinity of Moyie, the rocks strike east and west with a dip of 30 degrees to the north and are close to the axis of the anticline, while proceeding eastward up the hill towards the Society Girl the formation gradually changes its strike to a northwest-southeast strike with a dip of 25 degrees to the northeast. The axial portion of the anticline is occupied by the Creston argillaceous quartzites which are well exposed on each side of the Upper Moyie Lake.

Fissure System

All the ore deposits in the Moyie area are connected with two main parallel fissures striking a little north of west and dipping on an average 70 degrees to the south. They cross the axis of the anticline composed of the Aldridge

formation. These two fissures occur on both the east and west side of the lake and it is probable that they occur in the rock formation under the lake. The walls bounding the fissures show very little evidence of relative displacement, the greatest movement observed being 18 inches; however, in such a homogeneous series of quartzites the detection of such a movement might be impossible.

St. Eugene Mine

Location

The St. Eugene Mine is owned by the Consolidated Mining and Smelting Company of Canada, and the property is situated on the east side of Moyie Lake near Moyie, B.C.

History

This property was first discovered by an Indian who lived at the St. Eugene Mission.

On the advent of the Canadian Pacific Railway, John Finch of Spokane, Washington, purchased the holdings for $12,000 and this money was used in building the beautiful church now to be seen at the St. Eugene Mission.

The development of the St. Eugene Mine now progressed rapidly under the management of Mr. Croxin. Later, the Moyie and the Lake Shore group of claims, which lie

between the St. Eugene and Moyie Lake, were purchased and the St. Eugene Consolidated Mining Company formed. In 1905, the properties of this company were taken over by the Consolidated Mining and Smelting Company. Steady production continued till 1914, and since that time only irregular shipments of ore were made.

Production

The total production of the St. Eugene Mine, since its discovery, has been about 1,017,106 tons of ore containing 5,365,232 ounces of silver and 229,305,721 pounds of lead, having a given value of $70,626,608.

Character of Ore-bodies

The ore bodies are replacement deposits in the heavy bedded purer quartzites, and are restricted to the fractured area between the two main fissures. Where the fissures cross the more argillaceous quartzites, the veins are narrow and usually filled with quartz containing small quantities of sulphides.

The ore consists mainly of coarse-grained galena with subordinate amounts of zinc-blende, pyrite, pyrrhotite, magnetite, and a little chalcopyrite. It is also reported that the sulphides pyrite, pyrrhotite and zinc-blende were slightly more abundant near the periphery of the ore-bodies and that zinc-blende showed no increase with depth. The

gangue, which is small in amount, consists of pink garnet, actinolite, quartz and some calcite. The garnet, actinolite and quartz are more abundant in the transition zone of the ore and country rock, and at times the fissured quartzites near the vein are heavily charged with these minerals. In some cases the quartzites show evidence of silicification, although no true chert, as found in the Sullivan deposit, was identified in the St. Eugene. In the ground above the level of Moyie Lake, the veins are mined by a series of adits driven along the main veins. The ore from the higher levels is transported by an aerial tramway to the ore bins. Below the level of the lake a 3-compartment shaft has been sunk to a depth of 800 feet.

Gold Pyrite Type

Distribution

These deposits occur in all the formations from the Aldridge to the Dutch Creek. They are not worked at the present time except in one case, that being on Alki Creek.

Geology

These deposits occur disseminated in the more schistose rocks. They are found usually in definite shear and fault zones and near intrusive vein dykes. The schistose rocks are chlorite and quartz mica schists.

Character of Deposits

These deposits occur as replacements in the schistose quartzites. Their size varies, and in the vicinity of shear and fault zones is restricted to the width of the zone.

Mineralogy

Native Elements

Gold Au: Gold occurs free in the Dewar Shear zone, and is also associated with the pyrite.

Sulphides

Pyrite FeS_2: Sulphide of iron occurs widely distributed throughout these deposits.

Gangue

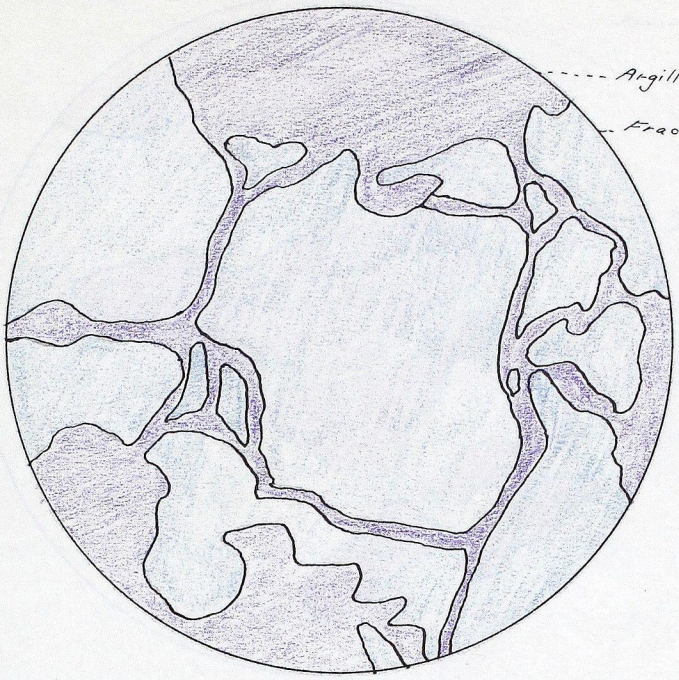
The gangue usually occurs as chloritic and quartz mica schist. Considerable quantities of calcite were noted at the Dewar shear zone.

Detailed Description of Properties

Cogle Creek Property

This property is located 3 miles up Cogle Creek from its confluence with the west fork of the St. Mary River. The elevation of the property is about 4,500 feet. The trail of the west fork-Crawford Creek branches at Cogle Creek, one branch going over Cogle Pass and the other over Rose Pass. This trail over Cogle Pass follows Cogle creek past this property.

Here the creek flows through a box canyon 30 feet deep and 15 feet wide, exposing a mineralized vein and replacement of the sediments by pyrite. The vein is worked by an open cut. The mineralization in the country rock was traced thirty feet from the vein. Under the microscope a specimen showed that the pyrite was formed by replacing the sediments. After replacing the sediments, the rock was deformed by some shearing stress. This produced fractures in the brittle pyrite. These fractures provided access for the easy flowage of the argillaceous material which occupied and replaced the pyrite in these fractures. The sediment itself took the form of gneiss. The gold is not visible , but this deposit is said to assay $4 a ton in gold.



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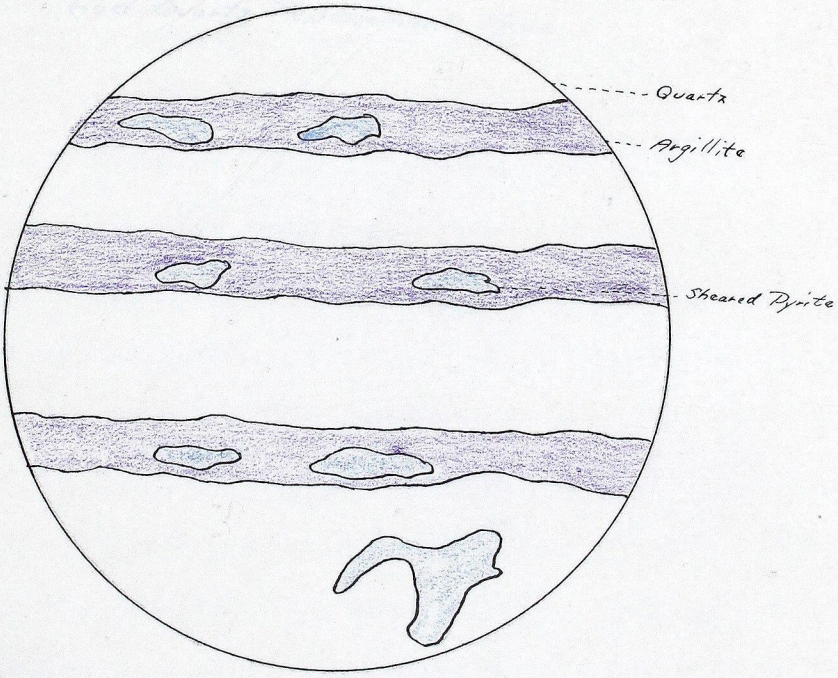
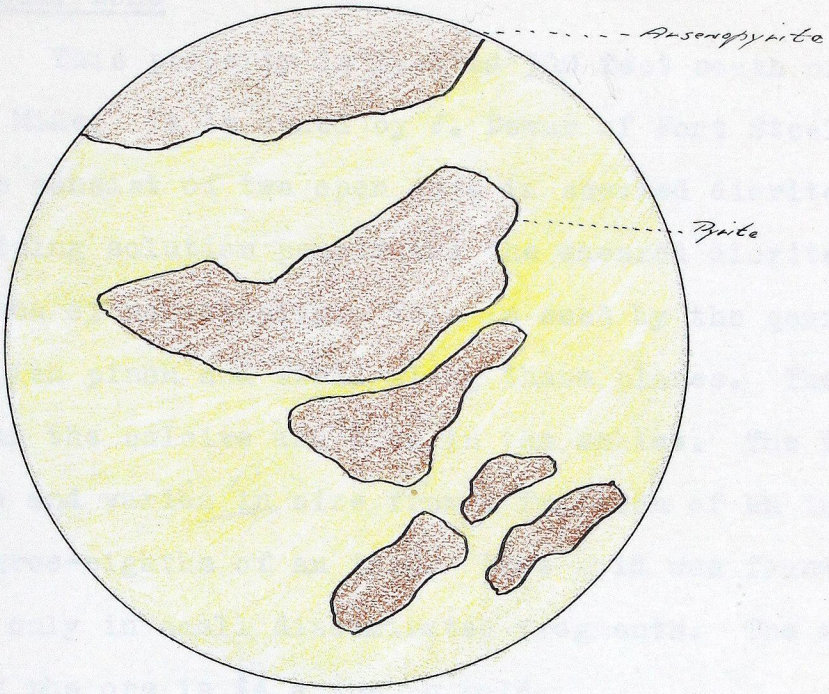


Gold-Quartz Replacement Type



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Gold-Quartz Replacement Type

Dewar Shear Zone

This property is located 300 feet south of the Mystery Mine. It is owned by J. Dewar of Fort Steele. The workings consist of two open cuts in sheared diorite. The mineralizing solution penetrated the sheared diorite along the planes of schistosity. This is seen by the quartz-calcite veins which pinch and swell along these planes. The pyrite occurs in the calcite and also in the schist. The form is the cube and varies in size from a fraction of an inch to about three-eighths of an inch. Free gold was found in this deposit only in small disseminated fragments. The average value of the ore is $4 a ton in gold.

Genesis

These deposits are related to the granitic intrusions as explained for the Cogle vein under the Gold-Quartz type. However, the solutions in which they were contained must have been thin as compared with the pasty vein type. If the pasty type had been present, a quartz vein would have been formed, as this type of solution would have been able to force its way along the planes of the schist. That the solutions were thin is seen from the fact that no vein is formed, and the solutions probably lost themselves in the schist. Subsequent shearing and metamorphism would obliterate all traces of this quartz if it did form in such small veins.

2. Placer Deposits

Placer deposits have been an important source of gold in East Kootenay district, but during the last few years the only activity has been on Werner, Moyie, Palmer Bar and Perry creeks.

In 1874 the output of the district was $50,000, and in 1912 was $2,000. In 1936, the value of the placer output was less than that in 1912.

Detailed Description of Properties

Perry Creek Hydraulic Mining Company Property

In 1903 this company started operations on a large scale to hydraulic a high bank over which Perry Creek falls to a depth of 400 feet. A tunnel was driven in the bank from 1,200 to 2,000 feet to tap the old creek bottom. However, this was disappointing as it was found that bedrock did not cnntain the gold, but that it was concentrated on a false clay bedrock in the glacial drift. This necessitated the hydraulicing of the whole bank in order to work the several pay streaks. This work was carried on until 1914 when only $1,000 was credited to this operation. Since that year individual miners have worked the ground, averaging fair wages.

The East Kootenay Placer Mining Company

This company operated a property about 4½ miles above the falls, and used a steam shovel for lifting the gravel into the sluice boxes. The stream here has a grade of .3 per cent, and at a depth from 3 to 10 feet there occurs a "false bedrock" consisting of sandy clay, on and above which gold in considerable quantities has been found. Numerous shafts were sunk to bedrock, and are reported to have yielded fair to good renumeration in gold values. The dipper of the shovel was found to be too short, due to flattening of the bedrock, and operations had to cease. Individual placer miners were working this property in 1936.

Hell-Roaring Creek

On a southeasterly flowing tributary, 8 miles up Hell-Roaring Creek from its confluence with the St. Mary River, is a placer working. The gravel consists of the ordinary stream type interspersed with large glacial boulders. The sluice derives its water from a point further up the creek.

Possibilities of the St. Mary Tertiary Gravels

In three localities between Wycliffe and Kootenay River, St. Mary River has exposed unconsolidated sediments which have been determined on fossil evidence to be Tertiary (Miocene) in age. At two of these localities gravels are missing. The third is located on the north end of a sharp

angle in the river 2 miles in a straight line below Wycliffe. At the base of this exposure, at river level, lies a small patch of rusty gravels.

The gravles are composed of well-rounded pebbles up to 6 inches in diameter, many of which are sufficiently decomposed to be crushed between the fingers. Interbedded with these gravels are sandy beds in which are fragments of wood almost completely changed to lignite.

It is believed, for the following reasons, that there is some possibility of commercial quantities of gold at some point in these gravels:

(i) The immediate source of the bulk of the gold in the placers elsewhere in the district must have been pre-existing Tertiary placers.

(ii) These gravels are definitely of Tertiary age.

(iii) Small quantities of fine gold may be panned from the gravels at the place where they are exposed.

However, it is not certain that all Tertiary streams deposited placers and nothing is known of the shape or location of the old channel. It, however, seems to warrant prospecting.

Moyie River

Consolidated Mining and Smelting Company

This section has been the scene of renewed vigour in placer mining in 1936. The Consolidated Mining and Smelting Company of Canada operated a steam-shovel near the mouth of Palmer Bar Creek. Seven men were employed in this operation. The gravel is scooped up from the creek bed and emptied into a sluice box and the gold is caught by riffles and also by means of mercury pits. This work proved a success this year, and further work is planned for the coming season.

Individual Operations

At Camp Number 3 of the Lumberton Lumber Company a placer project was in operation. Here the miner had the Mohie River dammed up and his sluice box of the "Long Tom" type was placed on the creek bottom. The river at this point cut through glacial till and the gold is concentrated on false bedrock. Considerable difficulty was encountered in trying to remove the large glacial boulders which are sometimes 3 feet in diameter. The gold here was of the coarse variety, and wages not lower than $4 a day were achieved.

Weaver Creek

This property is located 3 miles up Weaver Creek from its confluence with the Moyie River. The property is owned by S.A. Nogals of Cranbrook. A large "boomer" dam is constructed across the creek, and the bedrock is washed into sluice boxes. At this property $400 worth of nuggets the size of small gravels have been recovered. They consist of yellow gold mixed with small amounts of vein quartz.

3. Lignite

Lignitized wood occurs in the Tertiary gravels of Miocene age near Wycliffe. The pieces of lignite are scattered and do not consititute a workable deposit.

4. Building Stones

Building stones have not received much attention in this district. However, this is not due to a scarcity of them, but to the high cost of transporting the rocks in this almost inaccessible area. The beautiful green and purple mottled Creston quartzite in foot beds would be an excellent building stone. There are numerous granites which could be tested. The only rocks which have received any attention are the differentiates of the Purcell sills.

Hutchcroft Granite Quarry

This quarry is owned by a small syndicate of Cranbrook men headed by J.F. Hutchcroft, who opened up a quarry which adjoins the Canadian Pacific Railway 3½ miles southwest of Cranbrook. The rocks here are part of a considerable area of Purcell sills which vary from a hypersthene gabbro to a very acid granite or granophyre with intermediate members between these two extreme types. Of the various grades of granitic rock present in the deposit, the greenish black variety which takes a fine polish is reported to be the most in demand. The granite shipped is reported to have been highly satisfactory for monumental work and for building purposes. This property is only in the experimental stage.

5. Magnesite Deposits

Magnesite deposits were first discovered in this area in 1934 by Rice of the Geological Survey. These deposits occur on the western ridge of Perry Creek near Old Town. The claims are now all held by the Consolidated Mining and Smelting Company of Canada. These claims have not had much work done on them.

At the Hell-Roaring-Moyie River divide occurs another deposit of magnesite. Consolidated Mining and Smelting Company of Canada have constructed a trail from the Perry Creek wagon road over the Perry Creek-Hell-Roaring

Creek divide.to the property. Several tons of the magnesite have been extracted, but as this deposit is considerably smaller than the Perry Creek one, it has been abandoned. This deposit occurs in a monoclinal syncline interbedded with the Cranbrook massive quartzites. The mineral is very coarsely crystalline, brown in colour, hardness of about 4, and a specific gravity slightly heavier than a dolomite rock.

Origin

The origin of these magnesite deposits is not known. However, they are of a sedimentary origin, and probably were deposited as colloidal magnesite. Upon the metamorphism to which this region was subjected the magnesite became coarsely crystalline. Since the deposit is covered by impervious argillites, it does not seem possible that the deposit would be due to the action of magnesium-bearing waters on calcite.

CHAPTER VIII

THE FUTURE OF THE DISTRICT

The future of mining in this area depends principally on development in the lode deposits. Of these, the lead-zinc deposits are the most important, and it is possible that some of the now developing prospects will become producing mines in the future. Careful prospecting in the Purcell sills may disclose large, low grade copper deposits.

Facts regarding this area may be summarized as follows:

(i) This area is underlain by a basement of granitic or related rocks.

(ii) The ability of the formations to sustain large, uniform fractures for great distances.

(iii) The susceptibility of certain of the formations, especially the Aldridge formation, to replacement by mineralizing solutions.

(iv) That every well defined fault and shear zone in this area contains some type of mineralization.

(v) That all the deposits of the well known mines and prospects (except the Purcell mineralization) are on or

related to well defined shear zones. They occur as fissure veins or replacement deposits.

(vi) That the Jurassic intrusives are younger than the folding and faulting to which the district was subject.

(vii) The northern contact of the granitic mass has yielded some very interesting lead-zinc-silver deposits.

From these facts the following conclusions are drawn as regards prospecting in this district.

(i) All fault and well defined shear zones should be carefully geologically mapped.

(ii) Prospecting should be confined to work along these well defined fault zones, or in their near vicinity.

(iii) Mining at some depth may disclose an easily replaceable bed where replacement of the sediments may produce a workable deposit. (E.G. Sullivan and St. Eugene mines.)

(iv) Because of the ability to sustain fractures for long distances and the susceptibility of this formation to replacement the Aldridge formation should be given careful consideration.

(v) The contacts of the granitic stocks should be carefully prospected as mineralization was noted near them.

(vi) Poor travelling facilities are a hindrance to work in this area. Travel is either confined to creek bottoms or extremely high and precipitous ridges.

Purcell Mineralization

Facts

(i) From the nature of the differentiate ore-bodies, it is evident that they are limited to the sills.

(ii) The present development has not shown any of these deposits to carry sufficient copper to constitute even low-grade ore.

(iii) The veins are confined to the sills.

(iv) Their depth is limited to the thickness of the sill.

(v) The length of the vein is limited by the lateral extent of the sill.

Conclusions

(i) The deposits are very limited.

(ii) They are mainly of geologic or scientific interest.

(iii) Further work may disclose large low grade bodies, but up to the present this has not been the case.

Placer Mining

The future of the placer mining industry in this area does not look very bright. The only way it can be profitably worked is by individuals for no well defined pay stakes seem to occur in the deposits, thus eliminating large-scale workings. The Tertiary gravels may present some interesting features when further work is done on them.

Building Stones

Until this area is opened up, the building stone industry cannot possibly progress because of high transportation costs.

Coal

The small amount of lignitized wood in the Tertiary gravels is of no economic value.

Lumbering

This industry is concentrated in the area around the ~~twon~~ town of Yahk and has opened up quite an area. However, in the central and northern portion there is no logging carried on at all because of poor transportation facilities.

Agriculture

On account of the early frosts in this area, agriculture is not a profitable enterprise.

Summing up the assets of this area, only one conclusion can be drawn and that is that mining and only mining will open up this now idle district.

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LEGEND

MESOZOIC

- JURASSIC
  - Granite

PALEOZOIC

- LOWER CAMBRIAN
  - Eager Formation
  - Cranbrook Formation

PRE-CAMBRIAN

- UPPER PRE-CAMBRIAN (Windermere Series)
  - Hamill Series
  - Horsethief Formation
  - Toby Conglomerate
- MIDDLE PRE-CAMBRIAN (Upper Purcell Series)
  - Mount Nelson Formation
  - Dutch Creek Formation
- LOWER PRE-CAMBRIAN (Lower Purcell Series)
  - Siyeh Formation
  - Kitchener Formation
  - Creston Formation
  - Aldridge Formation

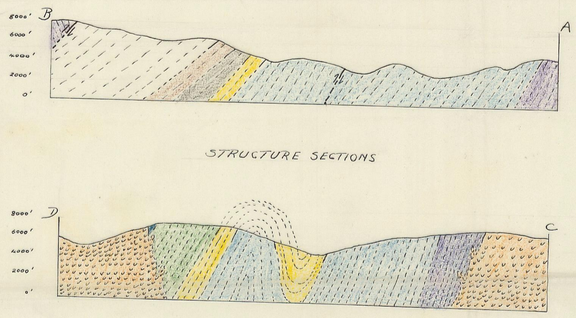
Geological Boundary (Position observed)

Geological Boundary (Position inferred)

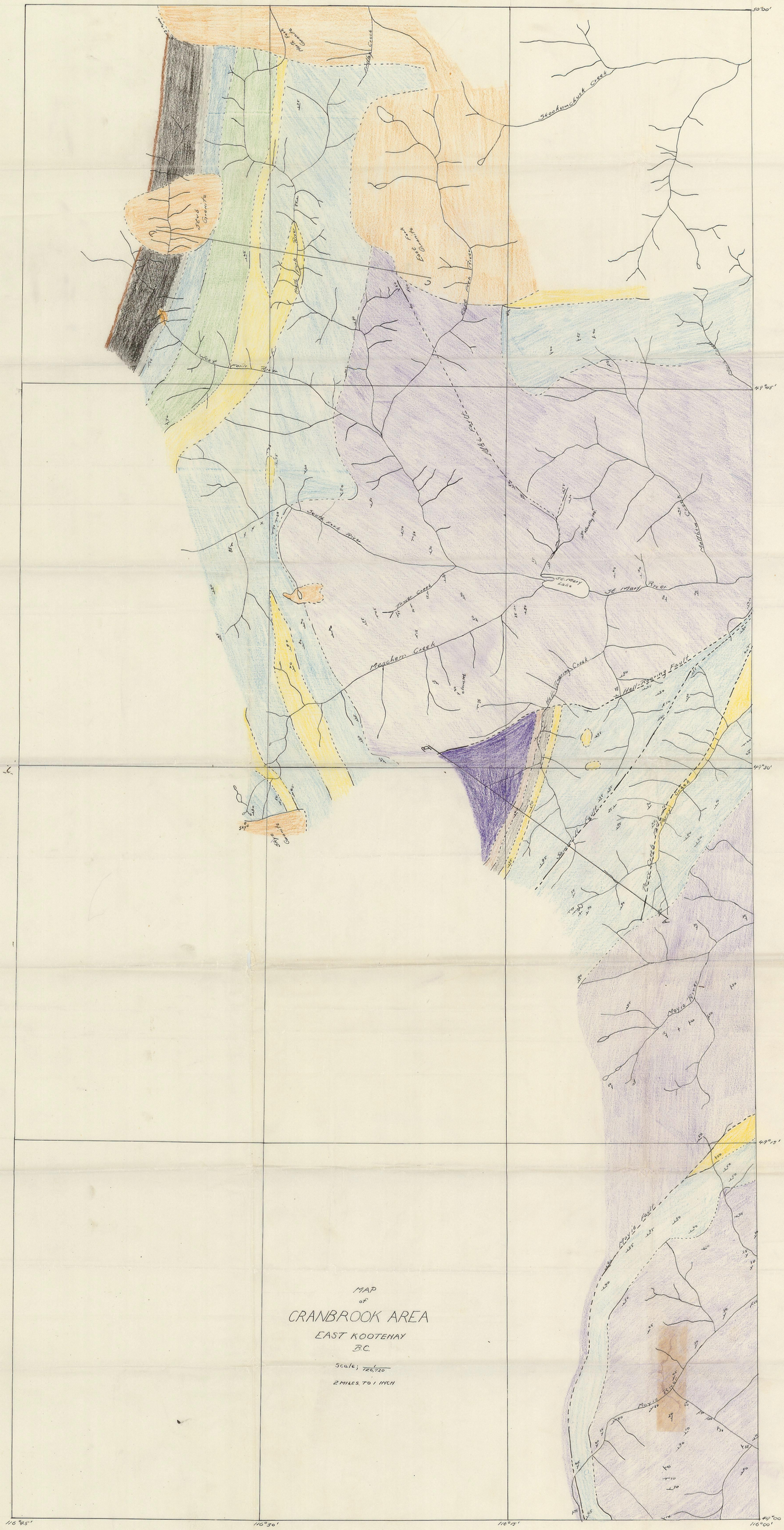
Fault (Position observed)

Fault (Position inferred)

Attitude



STRUCTURE SECTIONS



MAP
of
CRANBROOK AREA
EAST KOOTENAY
B.C.

Scale; 1/126,720

2 MILES TO 1 INCH