CANADA
DEPARTMENT OF MINES
HON. ARTHUR MEIGHEN, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY
WM. MCINNES, DIRECTING GEOLOGIST.

MEMOIR 117

No. 99, GEOLOGICAL SERIES

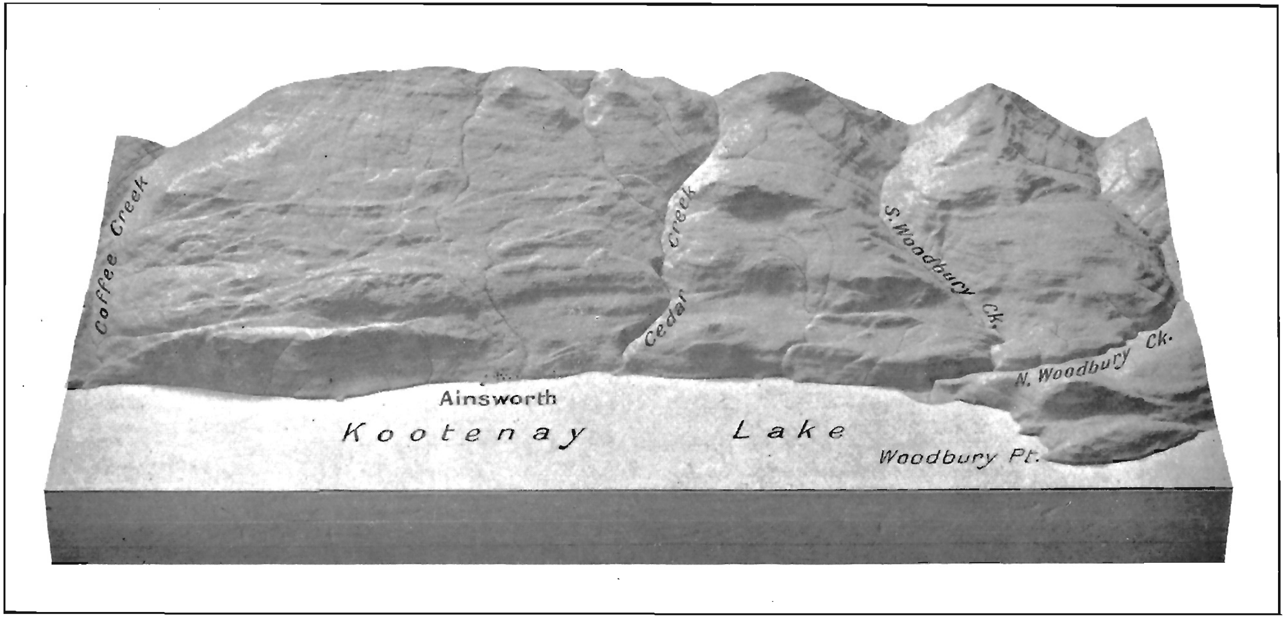
Geology and Ore Deposits of Ainsworth Mining Camp, British Columbia

BY

S. J. Schofield

OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1920

No. 1773



Photograph of a model of Ainsworth mining camp. (Model by L. Richard.) (Page 7.)

CANADA

DEPARTMENT OF MINES

HON. ARTHUR MEIGHEN, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY

WM. MCINNES, DIRECTING GEOLOGIST.

MEMOIR 117

No. 99, GEOLOGICAL SERIES

Geology and Ore Deposits of Ainsworth Mining Camp, British Columbia

BY

S. J. Schofield

OTTAWA

J. DE LABROQUERIE TACHÉ

PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

1920

No. 1773

CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

PAGE.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

Illustrations.

Geology and Ore Deposits of Ainsworth Mining Camp.

CHAPTER I.

INTRODUCTION.

GENERAL STATEMENT.

Historically, the country in the vicinity of Ainsworth is one of the most interesting in British Columbia. It is situated in the narrow longitudinal trench (Plates II and III) occupied by Kootenay lake, which in the early days before the advent of railways formed the only means of communication for the numerous prospectors who were attracted to the country by the hope of discovering mineral wealth. Since Ainsworth was on one of the main waterways its hot springs[1] attracted the attention of these pioneers, and it was early prospected with fair results. From that time until 1913 the camp was rather quiet due to the rush to the Slocan and to the Yukon. A few men who believed in the future of the Ainsworth camp remained there and with the limited resources at their disposal slowly proceeded with the development of the camp. At present their hopes have been realized, as Ainsworth is now a steady shipper with prospects that it will continue to be such for some time to come.

The principal producing mines in the district are the Bluebell on the east shore of the lake, No. 1, Florence, and the Highland; but several other minor properties ship irregularly.

The field work in connexion with this report was not confined to the actual mining camp of Ainsworth, but, in order to solve the problems which demanded attention, the region to the north and south was examined with the result that the formations in Ainsworth and around Kaslo have been correlated. A study was made of the geology of the walls of the trench from Kaslo as far south as the International Boundary, and new information has been collected which bears on the origin of the Purcell trench, as the valley containing Kootenay lake is called.

[1]The following analysis of these waters is said to have been made in 1899, by A. H. Heldich, Royal School of Mines, London, England:

"The water was colourless, not quite clear, no particular smell, but taste salty. Reaction to litmus paper distinctly alkaline.

The solid matter in solution is as follows:

Sodium carbonate	31·1	grains per Imperial gallon.
Sodium silicate	9·5	" "
Sodium chloride	7·2	" "
Lime carbonate	26·2	" "
Magnesia sulphate	3·6	" "
Oxide of iron	0·9	" "
Total solids	78·5	" "

No bromine or iodine, and the iron which probably exists as carbonate is very small. I consider the water too alkaline for general use though there may be special cases where it might be useful from a medical point of view."

FIELD WORK AND ACKNOWLEDGMENTS.

The completion of the study of the stratigraphy of the Purcell series, which make up the greater part of the Purcell range, in the eastern part of which occurs the Pre-Cambrian-Palæozoic contacts, naturally led to researches on the rocks which lie west of the Purcell series and are exposed on the eastern and western shores of Kootenay lake. In the latter part of the season of 1913 and the early part of the season of 1914 the eastern shore of Kootenay lake, together with the country lying between Kootenay lake and the western outcrops of the Purcell series, was examined in a reconnaissance, the main object of which was to determine the relationships of the Purcell series and of the so-called Selkirk series exposed on Kootenay lake. The results show that the rocks exposed on the shores of Kootenay lake are probably metamorphosed Palæozoic rocks. In August, 1914, a detailed examination of the geology and ore despoits of the Ainsworth mining camp was begun and was carried on for the remainder of that season and during the season of 1915. Two months of the summer of 1918 were spent in a re-examination of this district.

The officers of the Consolidated Mining and Smelting Company, Limited, and the owners of the several mineral properties in the district, especially Mr. W. M. Hewer of the Florence Silver Mining Company, were of great assistance in expediting the examination of the ore deposits. Mr. S. S. Fowler, manager of the New Canadian Metals Company which operates the Bluebell mine at Riondel, gave the writer the results of his investigations on that property. These cover the exploration of the ore deposit from its initiation and hence are invaluable.

Acknowledgment is made to the assistants in the field: V. Eardley-Wilmot during 1914 and O. D. Boggs during 1915.

F. S. Falconer, topographer of the Geological Survey, is to be credited with the topographic map.

LOCATION AND AREA.

The Ainsworth map-area (Figure 1) lies in the Ainsworth mining division in southern British Columbia. Coffee creek forms its southern boundary and Woodbury creek, approximately, the northern boundary. The western limit is marked by the contact of the sedimentary rocks which outcrop around Ainsworth with the Nelson granite on the west. The eastern boundary is marked by the western shore of Kootenay lake. The total area of the map sheet is about 15 square miles. The chief town of the area is Ainsworth.

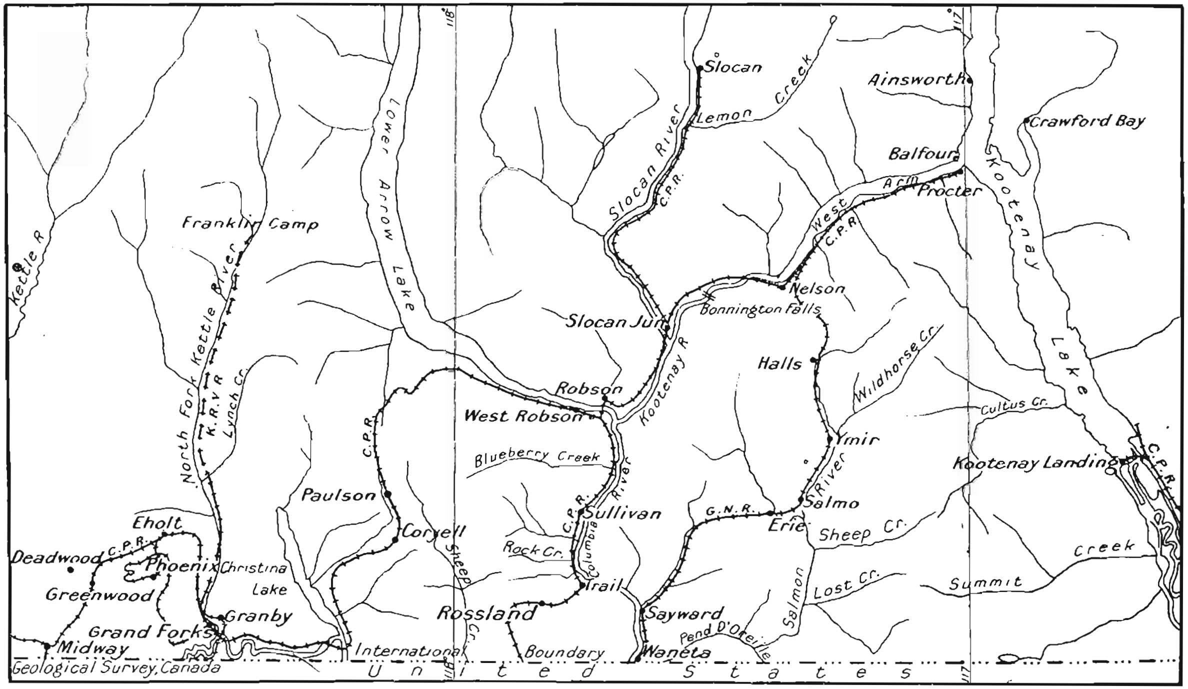


Figure 1. Index map showing the position of Ainsworth.

MEANS OF COMMUNICATION.

Access to the area is usually through Nelson, either coming from the coast or from the east by the Crowsnest route of the Canadian Pacific railway. Within the area itself a good wagon road about 5 miles long ascends by a somewhat circuitous route from Ainsworth to the No. 1, Skyline, and Silver Hoard properties. Another road joins the Highland mine with Ainsworth. A road skirts the shore of the lake as far as Cedar creek, from which point a trail continues the communication to Kaslo. A trail follows Woodbury creek from its mouth to the glacier from which Woodbury creek takes its origin and another trail ascends Coffee creek to the Kokanee glacier, the source of Coffee creek. From the Highland mine a trail leads to the Gallagher property and other trails of less importance give access to the numerous prospects of the area.

PREVIOUS WORK.

G. M. Dawson[1] was the first investigator of the rocks and ore deposits of the Ainsworth mining camp and his results were published in the Annual Report of the Geological Survey of Canada for the years 1888-1889. In this report he classifies the schists which occur along the shore of the lake in the Ainsworth district as Archæan in age and correlates them with the Shuswap series on Shuswap lakes. The sedimentary series which overlie this series are tentatively assigned to the Palæozoic from the Cambrian to the Carboniferous. The work of the writer suggests some changes in this classification. The ore deposits in the Ainsworth district are described in some detail. R. G. McConnell[2] re-examined the area and a few of the ore deposits in 1894 in his reconnaissance of the West Kootenay area.

In order to estimate the tonnage of zinc in British Columbia, a commission was appointed which examined the properties in the Ainsworth district which contained any quantity of zinc[3].

The reports of the officials of the British Columbia Bureau of Mines from 1896 to the present contain many important descriptions of the several mines and prospects.

BIBLIOGRAPHY.

Dawson, G. M.—Geol. Surv., Can., Ann. Rept., vol. IV, 1888-9, pt. B.
The Commercial, Winnipeg, July 15, 1892.
McConnell, R.G.—Geol. Surv., Can., Ann. Rept., vol. III, 1894, pt. A.
    Geol. Surv., Can., Sum. Rept., 1894, p. 33.
    Geol. Surv., Can., Sum. Rept., 1895, p. 25A.
Gwillim, J.C.—Can. Rec. Sc., vol. VI, 1895.
    Can. Rec. Sc., vol. VII, 1897, p. 293.
Brock, R. W.—Geol. Surv., Can., Sum. Rept., 1898, p. 67A.
    Geol. Surv., Can., Sum. Rept., 1899, p. 84A.
Kendall, J. D.—Min. Jour., 1900.

[1]Dawson, G. M., Geol. Surv., Can., Ann. Rept., 1888–1889, vol. IV, pt. B.
[2]McConnell, R. G., Geol. Surv., Can., Ann. Rept., 1894, p. 30A.
[1]Report of the Zinc Commission, Dept. of Mines, Mines Branch, 1906.

Ingalls, W. R.—Report of the Commission to investigate the zinc resources of British Columbia and the conditions affecting their exploration. Dept. of Mines, Mines Branch, 1906.
Thomson, F. A.—Can. Min. Jour., vol. XXXIII, 1912, p. 830.
Schofield, S. J.—Geol. Surv., Can., Sum. Rept., 1914, p. 38.
Lakes, Arthur—Min. and Eng. World, 1915, p. 411.
Schofield, S. J.—Trans. Can. Min. Inst., vol. XVIII, 1915, p. 202.
Geol. Surv., Can., Sum. Rept., 1915, p. 93.
Rickard, T. A.—Min. and Sc. Press, vol. CXIII, 1916, p. 765.
Uglow, W. L.—Economic Geology, vol. XII, 1917, p. 643.
Schofield, S. J.—Trans. Can. Min. Inst., vol. XXI, 1918, p. 422.
Trans. Roy. Soc. Canada, 1919.
Reports of the Minister of Mines for British Columbia, 1890-1918.

CHAPTER II.

GENERAL CHARACTER OF THE DISTRICT.

TOPOGRAPHY.

REGIONAL.

In the southern part of British Columbia, the Interior Plateau region separates the North American Cordillera in Canada (Figure 2) into two

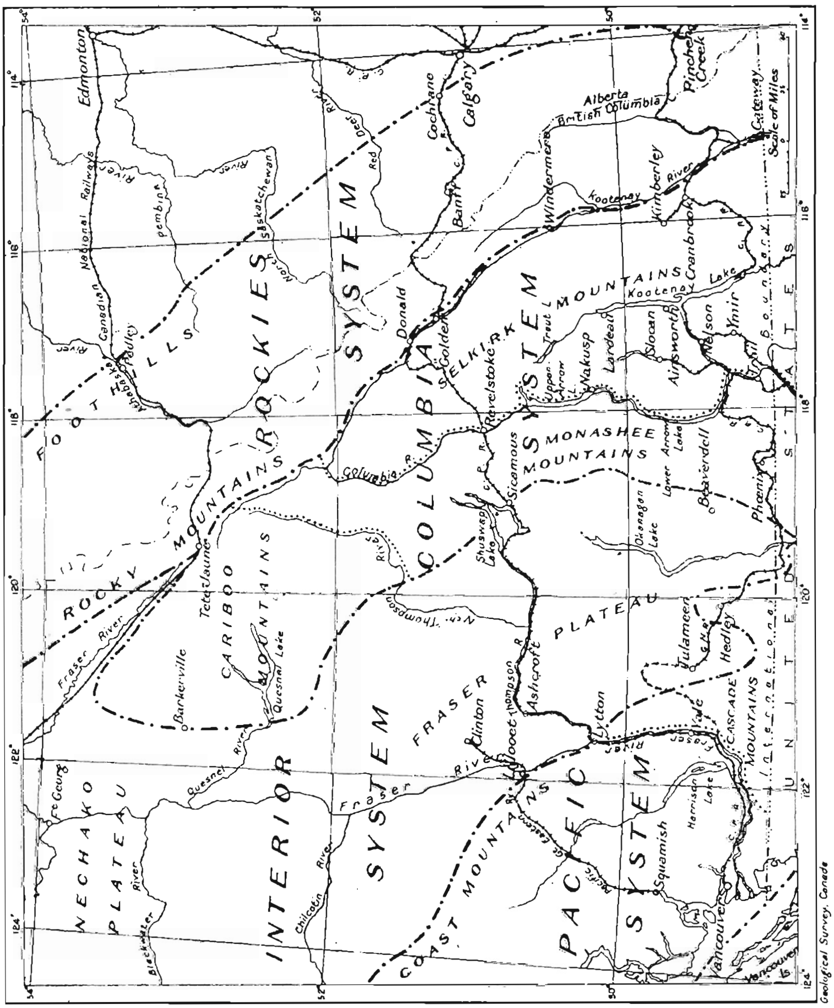


Figure 2. Diagram showing the classification of the Canadian Cordillera.

main divisions, each of which, in contrast with the Interior Plateau region, is characterized by alpine mountain topography. Each division is subdivided into mountain systems by well-defined topographic features.

The eastern division consists from west to east of the Columbia, Selkirk, and Rocky Mountain systems. The great intermontane depressions which individualize the above ranges are the Selkirk depression, occupied by the south-flowing Columbia river, which separates the Columbia range from the Selkirk range; the Purcell trench, occupied for the most part by Kootenay lake, which subdivides the Selkirk system, and the Rocky Mountain trench, occupied in its southern part by the south-flowing Kootenay river and in its northern part by the Columbia river which flows northward and crosses the main line of the Canadian Pacific railway at Golden. This trench separates the Selkirk system from the Rocky Mountain system, the most eastern mountain system of the Canadian Cordillera.

LOCAL.

The area occupied by the Ainsworth sheet (Map 1704) lies on the eastern slope of the Selkirk range which forms the western side of the Purcell trench occupied by Kootenay lake. Viewed from the vicinity of Riondel across the lake (Plates I, III), especially when the evening shadows bring out the contrast in the topography of the region around Ainsworth, it can be seen that the country rises in a series of giant steps about 1,000 feet in height, the first step coming abruptly out of the lake. These steps bear a simple relationship to the relative hardness of the underlying bedrock, as can be seen from an examination of the topographic and geologic maps. In the upper part of the slope the barren rough hills of the country underlain by granite are in marked contrast to the more rounded topography of the lower slopes which in general are underlain by sedimentary rocks of varying resistance to the agencies of erosion.

The area is drained by three main creeks which from north to south are Woodbury, Cedar, and Coffee creeks. All three enter Kootenay lake through deep canyons and are characterized by falls and rapids. The valleys in their middle courses are trough-shaped. Coffee creek and Woodbury creek rise in several branches in the Kokanee glacier which occupies the summit of this local range and from which streams radiate in all directions, the three streams mentioned above flowing to the east into Kootenay lake.

CLIMATE.

The climate in the vicinity of Kootenay lake in very healthful. The winters are short and not cold and the summers are dry, especially in the months of July and August, but at no time is the heat unpleasant. In fact, the climate of Kootenay lake is one of the most pleasant in British Columbia and this, combined with a fine contrasting scenery of mountains and lakes, makes it an ideal place of residence as well as a desirable pleasure resort for the summer months.

CHAPTER III.

GENERAL GEOLOGY.

GENERAL STATEMENT.

The stratified rocks in the vicinity of the Ainsworth mining camp form part of the Selkirk Mountain range which in its turn belongs to eastern ranges of the Cordillera carved out of the sediments once deposited in the Rocky Mountain geosyncline. Dawson[1], the pioneer in the geology of this region as well as in that of the greater part of British Columbia, classified the sedimentary rocks as belonging to the Shuswap (Archæan) and to the Niskonlith and Selkirk series, both of Cambrian age. In 1895, McConnell, in his study of West Kootenay, called the slates which overlie the Selkirk series the Slocan slates. The subdivisions of the rocks at Ainsworth are briefly described on the West Kootenay map sheet.

The writer, from the results of this study of the rocks on the east side of Kootenay lake and eastwards to the Rocky mountains, believes that the rocks at Ainsworth are all probably of Palæozoic age and were metamorphosed by the intrusion of the West Kootenay granite batholith.

The sedimentary rocks at Ainsworth are cut by the West Kootenay granite batholith, an igneous complex ranging in age from the Jurassic to possibly the Tertiary. At Ainsworth the granite in the western part of the sheet is of Jurassic age.

The lamprophyric dykes which are the last evidences of igneous activity at Ainsworth are faulted by the majority of the vein fissures wherever the two have been seen in association. A dyke in the Bluebell mine, according to Mr. Fowler, manager of this property, is an exception and cuts the ore-body.

Over the most of the area, the eroded surfaces of these rocks are covered by glacial drift.

[1]Dawson, G. M., Geol. Surv., Can., Ann. Rept., 1888-1889, vol. IV, pt. B.

Table of Formations.

Period.	Formation.	Lithology.	Thickness Feet.
Quaternary			
Recent		Calcareous tufa; sand and gravel.	
Glacial		Till.	
	Unconformity.		
Jurassic	Nelson granite	Lamprophyre dykes. Gneissic granite. Granodiorite, granite.	
	Intrusive Contact.		
Upper Carboniferous	Slocan series. Skyline formation	Argillites, limestone (fossiliferous)	4,000
	Slocan series. Silver Hoard formation	Limestones, argillites	3,200
Carboniferous or Pre-Carboniferous	Ainsworth series. Josephine formation	Hornblende schists, quartzites, and limestones	3,000
	Ainsworth series. Ainsworth formation	Limestones	600
	Ainsworth series. Princess formation	Garnetiferous mica schists and quartzites	1,250
	Ainsworth series. Early Bird formation	Siliceous limestones	2,300
	Ainsworth series. Point Woodbury formation	Garnetiferous mica schists and quartzites	1,800

—Base unexposed—

Tabular Statement of Geological Record.

Quaternary	Post-glacial	Erosion: deposition of the delta deposits, deposition of calcareous tufa from hot springs.
	Glacial	Erosion: deposition of glacial drift.
Tertiary		Erosion: uplift in early Tertiary, dissection of the Cretaceous peneplain and formation of the Purcell trench (Kootenay Lake valley) and tributary valleys by erosion.
Upper Cretaceous		Erosion: unroofing of the Nelson batholith in early Upper Cretaceous period, followed by peneplanation of the Jurassic mountains.
Lower Cretaceous		Erosion: dissection of the Jurassic mountains.
Jurassic		Vein-filling, fissure formation, dyke intrusion, intrusion of the Nelson batholith. Orogenic movements, formation of the Selkirk and Purcell mountains.
Upper Carboniferous and Pre-Carboniferous		Deposition of the Ainsworth and Slocan series of sediments.

AINSWORTH SERIES.

GENERAL STATEMENT.

The Ainsworth series, as the term is used in this report, includes the group of sedimentary and volcanic rocks which lie below the Silver Hoard formation of the Slocan series at Ainsworth. The dividing line between this series and the Slocan series which lies conformably upon it is entirely arbitrary and the contact a transitional one. The top of the series is placed at the base of the massive limestone of the Star limestone which outcrops on the Star and Sunlight mining claims. The base is not known since the rocks of Point Woodbury formation pass under the waters of Kootenay lake.

POINT WOODBURY FORMATION.

The rocks of the Point Woodbury formation outcrop on Woodbury point and occupy the whole of the point from the foot of the bluff of Woodbury knob to Kootenay lake. The rocks of this formation consist of rusty weathering, micaceous quartzites and garnetiferous mica schists intruded by dykes of gneissic granite and pegmatite, which are generally parallel to the bedding planes but in places lie at a small angle to these planes. The quartzites are thin-bedded, fine-grained, tough rocks in which biotite can be seen with the naked eye. They are smooth and stained by iron oxide on weathered surfaces. The garnetiferous mica schists are distinguished by the presence of reddish garnets which occur very abundantly in some of the beds. The biotite which makes up a large percentage of the rock gives it a glistening appearance. On the weathered surface the garnetiferous mica schist is rusty brown in colour. It frequently weathers to a dark brown, micaceous earth. The dykes of gneissic granite which cut the rocks of this formation vary in thickness from a few inches to 3 feet. The measured thickness of the formation is 1,800 feet.

EARLY BIRD FORMATION.

This formation is named after the Early Bird mineral claim, the workings of which are located in it and in the neighbourhood of which the formation is well exposed. Good exposures occur along the road and trail from Cedar creek to Woodbury creek, in the canyon of Woodbury creek, and on Woodbury knob. The typical rock is a massive, thick-bedded, blue grey limestone, in which many of the beds are separated by thin layers of mica schist. The limestone weathers to a rusty brown colour and is rough to the touch, and as it is very resistant to weathering the outcrops form steep cliffs, examples of which can be seen along the shore of the lake from Princess creek to Woodbury knob.

PRINCESS FORMATION.

Good exposures of this formation occur along the wagon road to the Florence Silver mine and along the road from Ainsworth to Cedar creek. The predominant rock is a glittering mica schist, in many cases garnetiferous, interbedded with micaceous quartzites. The mica schists weather to a brown micaceous earth and the quartzites usually have a brown iron stain on the weathered surface. Lithologically, the rocks of the Princess formation closely resemble those of the Point Woodbury formation. The beds of quartzite in many cases show minute foldings and crenulations. Under the microscope the mica schist is seen to be composed of biotite mica with a large amount of secondary hornblende and interlocking grains of quartz. The gradation from the Early Bird formation below and to the Ainsworth formation above is transitional. The thickness of the formation is 1,250 feet.

AINSWORTH FORMATION.

The limestone which makes up almost the whole formation is well exposed in the cliffs along the shore of the lake from Coffee creek to Ainsworth. The rocks can be seen in great detail in the lower tunnel of the Florence Silver mine. The limestone is massive and greyish white in colour. White layers of marble are exposed in some localities and some black, shaly members are also present. Under the microscope the limestone is seen to consist of interlocking grains of calcite with some grains of quartz. The sand grains vary in amount in different parts of the limestone and in places the weathered outcrop is made up almost entirely of sand, coloured brown with oxide of iron.

Metamorphism.

On Woodbury creek the limestone of the Ainsworth formation is altered to a hornblendite by the intrusion of the gneissic granite with which it is in contact. The hornblende occurs in large, needle-like crystals of a greenish black colour and under the microscope looks like secondary hornblende. It is very probable that the hornblende was originally augite. Small grains of quartz also occur in this rock.

Interbeds of schist occur between the limestone bands. The physical and chemical nature of this limestone seems to be favourable for the deposition of ore, although up to the present none has been found in it in commercial quantities.

Thickness.

The thickness of this formation varies somewhat in different localities, but it is on an average 600 feet thick.

JOSEPHINE FORMATION.

The base of the Josephine is marked by the upper contact of the Ainsworth limestone and the upper contact occurs at the base of the limestone (locally known as the Star limestone) which occurs on the Star and Sunlight mineral claims (Map 1787). Good exposures of the rocks of the Josephine formation outcrop on the road and trail from Ainsworth to the lower tunnel on the Sunlight claim, on the No. 1 tram-line, and on the two forks of Woodbury creek.

Distribution.

The rocks of the Josephine formation form a broad belt from north to south across the centre of the area and have been traced southwards to

Queens Bay, across the west arm of Kootenay lake to the slopes of Narrows creek, and northwards to the valley of Kaslo creek in the Slocan map-area.

Thickness.

The Josephine formation has an average thickness of 3,000 feet. It is apparently thicker in the vicinity of Coffee creek than in the vicinity of Woodbury creek.

Lithology.

The rocks of the Josephine formation are heterogeneous in character, comprising from the base upwards a succession of mica schists, alternating thin-bedded quartzites, and green hornblende schists with narrow lenses or bands of limestone, and at the top staurolite schists (Maps 1784, 1785, 1787, 1788). The above-mentioned bands are too narrow to trace and map in the field, especially as they pinch out in an irregular way and are really long lenses.

Mica Hornblende Schist. This schist can be best seen on the cliff below the Banker claim and in the lower level of the Florence Silver above the Ainsworth limestone. The schist consists mainly of biotite mica, and hornblende. The unweathered surface is a dark, blackish green with a development of biotite mica on planes of schistosity. It weathers to a soft, brownish green earth.

Hornblende Schist. This rock is a dark green, glittering schist which weathers a rusty brown colour, especially on the walls of the joint planes, and in many places breaks up into small rhomboidal blocks 3 by 3 by 2 inches. Microscopically the schist consists almost entirely of pale green secondary hornblende in interlocking needles and small grains of quartz with minor amounts of magnetite. The rock has a distinctly schistose structure. In close proximity to the veins, the green schist loses its coherency and colour from the action of mineralizing solutions and circulating waters and becomes a soft, whitish, clay-like material. This transformation is especially prominent along the main vein of the Highland mine. The hornblende schist is believed to be a basic volcanic ash which was laid down in water and subsequently altered by regional metamorphism and by the intrusion of the Nelson granite. Economically the hornblende schist is very important since the ore-bodies of the Highland mine and some of the ore-bodies of the Florence Silver mine occur near the lower contact of this rock with the associated quartzites.

Quartzites. The quartzites are of two kinds, a heavy-bedded, massive variety which occurs near the Banker ore-body and a very finely laminated variety which can be seen in the vicinity of the Spokane ore-body and on the road from the Krao to the United mineral claim. The massive type occurs in beds up to 2 feet in thickness and is a fine-grained, dense, almost pure quartzite. The laminated variety has a banded appearance due to the alternation of light grey and brownish grey laminæ. The weathering colour is a light brown derived from the limonite which forms from the alteration of small grains of pyrite occurring between the laminæ. The surface of the laminæ has a silvery sheen due to sericite. Under the microscope the quartzite is seen to be composed almost entirely of small, interlocking grains of quartz with very small amounts of calcite. All gradations exist between the pure quartzites and the hornblende schists. The quartzite is a waterlain sandstone silicified and altered by thermal metamorphism. In the northern part of the area, north of the Highland mine, the quartzite bands have been sheared so strongly that they have been changed to quartz mica schists, strongly resembling those of the Point Woodbury formation. This suggests that most of the quartz-mica schists of the Ainsworth area have been derived from quartzites by regional metamorphism. Economically the quartzites are important in that several ore-bodies occur in them, notably those of the Banker, Spokane, and Trinkett mines.

Limestone. The limestone members of the Josephine formation are well exposed in the vicinity of the Krao, Libby, Highland, Dictator, Tiger, Florence Silver, and Sunlight mineral claims (Maps 1785 and 1787). The limestones occur generally as long, narrow lenses with a maximum width of 50 feet in the neighbourhood of the Krao. An attempt was made in the field to trace and correlate the several lenses, but on account of the lenticular character of the bands and the paucity of outcrops it was found to be impracticable. The Krao limestone is banded white and grey, the white variety which is almost pure calcite, strongly resembling marble. In the neighbourhood of the Dictator claim and near the eastern boundary of the Spokane claim the limestone is dark blue to black in colour and highly argillaceous. The Libby limestone, which outcrops on the Libby mineral claim and in several levels of the Highland mine, especially the seventh level, is a dense, white crystalline limestone in which can be detected numerous needles of tremolite. Microscopic examination shows that the limestone is composed of interlocking grains of calcite with slender needles of tremolite equal in amount to the calcite. The binding effect of the needles of tremolite makes the Libby limestone tough in nature and difficult to replace by mineralizing solutions.

The limestone in which the main ore-bodies of the Florence Silver mine occur is coarsely crystalline and of a grey and white colour. The microscope shows that it is an almost pure limestone composed entirely of interlocking grains of calcite. In the neighbourhood of the ore-bodies it has been altered to a soft, granular mass and is rather difficult to determine as limestone. When traced along the strike away fron the influence of the ore-bearing solutions, the limestone gradually resumes its unaltered character.

Andalusite and Staurolite Schist. The andalusite and staurolite schist which forms the upper member of the Josephine formation is a somewhat micaceous, black, schistose argillite in which a great number of knots occur. The schist weathers to a rusty brown colour. The knots are so highly altered in most cases that their mineralogical determination is impossible except by their crystalline form which is that of staurolite. Dawson[1] mentions a sheared conglomerate occurring underneath the Star limestone. Very careful examination of the rocks of this horizon, in many localities, failed to reveal any conglomerates. The staurolite schist when

[1] Dawson, G. M., Geol. Surv., Can., Ann. Rep., vol. IV, 1889, p. 47B.

sheared shows the knots in rounded form and it may be that Dawson in his hurried visit mistook these staurolite schists for a sheared conglomerate which they resemble very strongly.

The following composite section of the Josephine formation, taken from measurements of the sections exposed in the underground workings of the Highland mine and from the exposures along the Highland tram-line gives in some detail the lithology of this formation and its succession. The thickness of the individual members varies in different places, especially the Libby limestone.

		Feet.
Silver Hoard formation	No. 1 limestone.	
	Ruth argillite.	
	Star limestone.	
Josephine formation	Staurolite schist	500
	Laminated quartzite	150
	Green hornblende schist	175
	Laminated quartzite	45
	Green hornblende schist	225
	Laminated quartzite, some mica schist	300
	Libby limestone	50
	Biotite schist	175
	Laminated quartzite	50
	Biotite schist	80
	Laminated quartzite	60
	Biotite schists, some limestones and laminated quartzites	1,200
	Total	2,990
Ainsworth formation	Limestone.	

AGE OF THE AINSWORTH SERIES.

The Ainsworth series includes the conformable sedimentary formations which are exposed from the western shore of Kootenay lake to the base of the Star limestone. Previous workers[1] classified this series at Ainsworth as Shuswap (Archæan) and Niskonlith (Lower Cambrian). In 1914[2] as a result of the study of the series of rocks lying east of Kootenay lake and west of the western limit of the Cranbrook map-area (Map 147A), the writer found that the Purcell series passed conformably under the rocks designated as Shuswap by Dawson. Hence this series exposed on the eastern and western slopes of Kootenay lake in the vicinity of Ainsworth (Map 792) must be later in age than the Purcell series and cannot be Shuswap or pre-Beltian. The abundant sills of pegmatite in the so-called Shuswap series are unmetamorphosed, whereas the series itself consists entirely of highly metamorphosed rocks. These pegmatites, becoming more numerous as the terrane is descended on the lower slopes of Kootenay lake and along the shore of the lake itself, are genetically associated with the Nelson granite of Jurassic age. In the old report the contact between the so-called Shuswap series and the later rocks was placed where the pegmatite sills cease to appear in the associated schists; but for the reasons given above it will be seen that these sills cannot be used in determining or delimiting the age or stratigraphic relationships of the so-called Shuswap

[1]Dawson, G. M., Geol. Surv., Can., Ann. Rept., vol. IV, 1888–1889, pt. B. McConnell, R. G., Geol. Surv., Can., Ann. Rept., vol. VII, 1894, p. 30A. Brock, R. W., Geol. Surv., Can., Sum. Rept., 1899, p. 84A.
[2]Schofield, S. J., Geol. Surv., Can., Sum. Rept., 1914, p. 136.

series and the later rocks and that the schists that have been called Shuswap rocks are really metamorphosed equivalents of sediments which are Beltian or post-Beltian in age.

In the Ainsworth area, the Ainsworth series consists of a conformable set of sedimentary rocks which underlie conformably the rocks of the Slocan series which are Pennsylvanian in age. Hence the Ainsworth series is Carboniferous or pre-Carboniferous and probably post-Beltian in age.

SLOCAN SERIES.

The Slocan series of bedded rocks were given that name by R. G. McConnell[1] in 1895. Previous to this, Dawson[2] has recognized the entity of the series without giving a specific name to it. He considered the series to be Palæozoic in age and probably Carboniferous. The name Slocan series is applied in this memoir to the group of rocks which was originally defined by Dawson in 1889 and called Slocan series by McConnell in 1895. For convenience, at Ainsworth the series is divided into the following formations:

Slocan series	Skyline formation	Mainly argillites, some argillaceous limestones (in places fossiliferous).
	Silver Hoard formation	Limestones, argillites.

SILVER HOARD FORMATION.

This formation is named after the Silver Hoard mineral claim on which the rocks, especially the upper limestone member, are well exposed. The southern boundary of the formation is fixed by its contact with the Nelson granite in the vicinity of the Neosha mineral claim. From there, the boundary crosses the area in a northerly direction through the Star, No. 1, Silver Hoard, and Gallagher mineral claims across the two forks of Woodbury creek, where its outcrop is marked by the appearance of white cliffs of limestone, and thence beyond the northern limit of the area.

The rocks of the Silver Hoard formation can be classified into three members as follows:

Silver Hoard formation	No. 1 limestone	thickness	950	feet.
	Ruth argillites	"	1,950	"
	Star limestone	"	300	"
	Total thickness		3,200	"

Star Limestone.

The Star limestone can be followed as a nearly continuous band from the Neosha claim northwards through the Broken Hill, Star, and Buckeye mineral claims across the two forks of Woodbury creek beyond the northern boundary of the area. The Star limestone was correlated by Argall[3] with the Krao limestone outcropping on the Krao mineral claim, but investigation did not confirm this, since in following the exposures southwards it was found that the Star limestone outcrops just west of the United claim

[1]McConnell, R. G., Geol. Surv., Can., Sum. Rept., 1895, p. 24A.
[2]Dawson, G. M., Geol. Surv., Can., Ann. Rept., vol. IV, 1889, p. 31B.
[3]Argall, Philip, "Report of the Commission to investigate the zinc resources of British Columbia." Mines Branch, 1906.

and hence is separated from the Krao limestone by several hundred feet of hornblende schists, quartzites, and andalusite schists.

The Star limestone (Map 1787) consists almost entirely of greyish white and white, coarsely crystalline limestone somewhat sandy in places. It occurs in beds from 3 inches to 1 foot in thickness. The total thickness of the limestone is estimated to be 300 feet, but as the beds are much contorted and folded this thickness is only an approximation. The limestones in many cases weather to a sand and are generally slightly stained with brown oxide of iron.

The limestone in many cases occupies depressions and in the area underlain by this member numerous "sink holes" occur giving rise to "karst topography" to some extent. These sink holes are formed by collapse of the roofs of caves caused by the solution of the limestone by underground water. These depressions are quite common just north of the Star claim and close to the crossing of the No. 1 tram-line.

The upper and lower contacts of the Star limestone cannot be definitely defined. The approach to the contact from the underlying staurolite schist to the limestone is first indicated by the occurrence of thin limestone bands in the schist. These bands increase in number and thickness until the schist bands entirely disappear and the massive Star limestone is reached. At the upper contact the limestone passes into the Ruth argillite in a similar manner.

Ruth Argillite.

The Ruth argillite outcrops on the trail which crosses the Ruth mineral claim to the No. 1 mine. It consists of two members, a lower one about 500 feet thick of staurolite schist similar to that described above, which occurs below the Star limestone, and an upper one of greyish brown argillites which occur in beds from 3 to 6 inches thick. The argillites are in places schistose with biotite developed on the schistosity surfaces and weather a rusty brown colour.

No. 1 Limestone.

The No. 1 limestone is well exposed in the vicinity of the No. 1 and Silver Hoard mines where it forms part of a belt which stretches across the area from north to south. The band becomes wider as it outcrops to the north. The limestone is greyish white to white in colour and is coarsely crystalline. It occurs in beds from 2 inches to 2 feet in thickness. Locally the limestone is contorted and broadly folded, for example in the workings of the No. 1 and Silver Hoard mines. In places thin bands of black argillite occur between the limestone beds.

SKYLINE FORMATION.

The Skyline formation rests conformably on the Silver Hoard formation. The most accessible sections are to be found on the wagon road from the No. 1 mine to the Skyline mine and on North fork of Woodbury creek.

The rocks of this formation form a broad belt across the western part of the Ainsworth area, in contact with the eastern edge of the intrusive

Nelson granite. The lithology is simple, the rock types being chiefly argillite with minor bands of limestone.

The argillites occur in beds 1 to 3 inches thick. They are greyish brown in colour and weather rusty brown.

In the neighbourhood of the granite batholith they are hard and siliceous, but show no great effects of contact metamorphism. From this it is concluded that the contact of the granite and the argillites underground is very steep, probably nearly vertical.

The limestones are of two varieties, dark blue argillaceous limestone in flaggy beds and greyish white crystalline limestone in beds from 3 inches to 6 inches thick. The dark blue limestones which occur near the western edge of the area, on the trail following the north side of north Woodbury creek about 200 yards from the third bridge crossing the creek contain fossils in an imperfect state of preservation. The fossils collected were submitted to E. M. Kindle, who reported as follows:

" The rock slabs show numerous sections of crinoid columns, a small coral and some small light-coloured bodies which may possibly represent Fusulina. The character of the metamorphosed rock is such that these show clearly only on surfaces which have been subjected to long weathering. It appears rather an unpromising collection on which to base correlations at first sight. Nevertheless some deductions may be made from it.

" Crinoids are found from the Ordovician to the present and the stems or columns can seldom be used to determine the genera and species of limited range. But a rather extended acquaintance with Rocky Mountain sections has shown me that horizons are seldom if ever met with below the Upper Carboniferous in which crinoid stems are abundant and other fossils very rare or wanting. The collection shows numerous examples of five-sided and star-shaped crinoid stems, a variety of form more frequently met with in the late Palæozoic and Mesozoic crinoids than earlier in the geological section."

"The presence of the poorly preserved coral demonstrates a Post Cambrian age for the fauna. The general appearance of this coral together with the dominance of crinoid stems in the fauna leads me to consider the fauna as probably not later than Jurassic nor earlier than Lower Carboniferous. As a provisional correlation it may be placed in the Upper Carboniferous."

AGE OF SLOCAN SERIES.

Dawson[1] first referred the rocks included under the name Slocan series in this report to the Carboniferous, as follows: "The stratified rocks of the Gold and Selkirk ranges, referred to, have not yet been closely studied from a lithological point of view, and no attempt is, therefore, made in this report to do more than broadly characterize them by their more evident features. Neither is it possible, as yet, to speak with any certainty as to the geological periods to which these rocks should be referred, as no fossils have been obtained from them. It is believed, however, that the whole of these rocks above those of the Shuswap series (No. 1) are in all probability Palæozoic in age, and analogy with what is known elsewhere in

[1]Dawson, G. M., Geol. Surv., Can., Ann. Rept., vol. IV, 1888–1889, p. 32.

British Columbia, suggests that they may eventually be referred to various systems, including the Carboniferous and extending down to the Lower Cambrian.''

Nothing further was discovered concerning the age of the Slocan series until R. W. Brock in conjunction with R. G. McConnell mapped the West Kootenay map sheet (792) in 1899. In his summary report of 1899, page 84A, Brock makes the following statement: "No definite information has so far been obtained regarding the date of this series, but it is supposed to be of about Carboniferous age. Unfortunately, the only fossil form so far obtained, does not throw much light upon the question. It is a brachiopod, probably a *Chonetes*, which was found this summer in a carbonaceous limestone boulder, in all probability, from the Slocan series. It was picked up in the drift behind Nelson."

The next advance in the determination of the age of the Slocan series is due to Brock.[1] He found poorly preserved fossil forms which resembled fragments of crinoid stems and crinoid joints in a sedimentary series of slates and limestones which he states "are certainly Palæozoic and probably about Carboniferous. No doubt they correspond to the Slocan series of the West Kootenay district."

The first discovery of fossils in the Slocan series proper was made by M. F. Bancroft while working with C. W. Drysdale [2] in the Slocan map-area (Map 1667) in 1916. Fossils were found in the lower limestone members which fixed the age of the series as Post-Cambrian and probably middle or upper Palæozoic.

The Slocan series in 1917 was placed definitely in the Carboniferous (probably Pennsylvanian) by the discovery by Bancroft of fossils in the northern continuation of the Slocan series in the southern Lardeau[3]. His conclusions are as follows: "The first three lots of fossils are from limestones which continue far to the northwest beyond the area explored in 1917. R. W. Brock, in 1903, found crinoid fragments in these rocks on the Beaton-Trout Lake wagon road and in one other locality near the head of Murray creek, a tributary of Salmon creek on the Arrow Lakes watershed.

"The fourth lot of fossils are from the "lime dyke" anticline which is also a conspicuous feature for miles through the Ainsworth, Trout Lake, and Lardeau mining divisions. C. W. Drysdale found fossils in June 1917 in the Laurie formation, which would indicate the persistence of these Palæozoic rocks north to and beyond the main line of the Canadian Pacific railway."

The discovery by the writer of fossils in the Slocan series in the Ainsworth mining camp extends the area of Carboniferous rocks as far south as Ainsworth.

[1]Brock, R. W., Geol. Surv., Can., Sum. Rept., 1903, pp. 50A and 53A.
[2]Drysdale, C. W., Geol. Surv., Can., Sum. Rept., 1916, p. 57.
[3]Bancroft, M. F., Geol. Surv., Can., Sum. Rept., 1917, p. 36B.

GRANITES.

GNEISSIC GRANITE.

Distribution.

The gneissic granite occurs as narrow dykes intruded abundantly into the Point Woodbury formation and less abundantly into the Early Bird and Josephine formations. In general these dykes are injected parallel to the bedding of the surrounding sediments, but in some cases at a small angle to the bedding plane. These dykes are well exposed on Woodbury point and in the cliff just north of the delta at the mouth of Woodbury creek. In addition to these narrow stringers there are four masses sufficiently large in area to show on the accompanying map, namely the area on north Woodbury creek, that on the Star claim, that on the Ruth claim, and the long ellipitical mass extending between the No. 1 mine almost to the Neosha mineral claim. The rock type which is very constant both in mineralogical composition and in physical appearance is well exposed at the crossing of the first bridge on North Woodbury creek and on the wagon road as it approaches the No. 1 mine. The outcrops of these masses usually stand out as low hills and cliffs.

Lithology.

Exposures of the gneissic granite in the field are whitish in colour and strongly resemble outcrops of the massive crystalline limestones, especially at a distance. In the hand specimen the gneissic granites are all light grey in colour and show distinct gneissic structure. The rock has a fine-grained, even texture and is composed of quartz, feldspar, and biotite. The microscope shows that the rock has been somewhat crushed and has a distinctly gneissic structure. The mineral constituents are quartz which is abundant, orthoclase feldspar, and biotite, with minor amounts of microcline and plagioclase feldspar.

External Relations. These granites are everywhere intrusive into the sediments, generally in planes parallel to the bedding. Their relation to the Nelson batholith is unknown as they were nowhere observed in contact with that rock. The large mass on Woodbury creek is also intruded in a similar fashion. The other masses, as shown on Map 1742, cross-cut the bedding planes of the sediments. The amount of contact metamorphism which was caused by these minor intrusives cannot be stated since the metamorphism caused by the intrusion of the main Nelson batholith masks the effect of the minor intrusives. In one locality on the north fork of Woodbury creek the Ainsworth limestone is locally altered to a hornblendite. As an intrusion of the gneissic granite is in close proximity to the hornblendite and since this metamorphism was not seen in any other locality it may have been caused by the local intrusion of gneissic granite.

Age of the Gneissic Granite.

The gneissic granite cuts the sediments of the Silver Hoard formation, a member of the Slocan series of Carboniferous age. It was not seen contact with rocks younger than the Slocan series. Hence its position in the geological time scale cannot be definitely fixed but is post-Carboniferous. From the similarity in physical and chemical composition between the gneissic granite and the Nelson granite which will be shown later to be Jurassic in age, it is concluded that they are closely related in age. The Nelson granite and the gneissic granite were intruded at the same time—during the Jurassic mountain-building period—but the gneissic granite which occurs only in relatively small bodies solidified before the mountain-building forces had ceased to act and hence took on a gneissic structure, whereas the Nelson granite which occurs as a batholith covering an area measured in hundreds of square miles remained fluid long after the mountain forces had ceased to operate. This difference in the size of the bodies naturally implies a difference in their relative length of time necessary for cooling and accounts for the contrast in the grain of the two rocks.

GRANITE.

The granite of the Nelson batholith which occurs along the border of the Ainsworth map-area is very constant in mineralogical composition and is very different from the gneissic granite described above. It is well exposed on the upper reaches of Coffee creek and on the hill above the Skyline mine where its cross-cutting character and metamorphic action can be easily seen and studied.

Lithology.

In the hand specimen the granite is light grey in colour and is characterized by the presence of large phenocrysts of pink orthoclase feldspar. Some of these phenocrysts are an inch in length elongated parallel to the "C" axis and in many cases show plainly the Carlsbad twinning. The composition of the phenocrysts has been determined by J. C. Gwillim[1]. He remarks that the small flakes of biotite are scattered through the crystals and that the analysis, as given, shows considerable lime and soda for an orthoclase.

SiO_2	59·86
Al_2 and Fe_2O_3	20·26
K_2O	12·39
Na_2O	5·76
CaO	2·90
MgO	0·78
	101·95

Gwillim states that the lime is probably present as calcium carbonate. Quartz is very abundant and with the white coloured feldspar plagioclase, occurs in the groundmass. The femic constituents consist either of biotite or hornblende, or both in varying proportions. Microcline and perthite occur as an accessory constituent in the granite. Titanite is rather

[1]Gwillim, J. C., Can. Rec. Sc., vol. VII, 1897, p. 295.

rare and shows its usual diamond-shaped cross section. The following analysis of the Nelson granite is recorded by R. W. Brock[1].

SiO_2	66·46
TiO_2	0·27
Al_2O_3	15·34
Fe_2O_3	1·68
FeO	1·83
CaO	3·43
MgO	1·11
Na_2O	4·86
K_2O	4·58
H_2O	0·29
P_2O_5	0·08
	99·93

Brock says concerning this granite, " The Nelson granite, which has been carefully studied, is a sort of granite representative of the monzonite group of rocks, intermediate between the alkali and lime-soda series of rocks, and about on the boundary between granite and diorite.

Another analysis of the Nelson granite is given by Gwillim[2]. It is evidently a more basic phase and somewhat altered.

SiO_2	60·09
Al_2O_3	17·20
Fe_2O_3	6·73
CaO	8·24
Na_2O	2·45
K_2O	6·23
MgO	0·47
	101·41

External Relations. The Nelson granite cuts the Skyline formation which is of Carboniferous age and its relation to younger formations is unknown as no newer rocks have been found in this part of the Selkirk range. The contacts of the granite with the surrounding sediments are well exposed and show that cross-cutting relations exist beyond doubt. Also many blocks of the sediments are enclosed in the granite, many of them occurring miles from any sedimentary series. They are especially abundant at the head of the south and north forks of Woodbury creeks in the neighbourhood of the Kokanee mountains, the loftiest area between the Kootenay and Slocan lakes. These masses of included sediments are highly metamorphosed, consisting of mica schists and micaceous quartzites which weather a very rusty brown and appear in strong contrast to the surrounding light grey granite. The strike of these included masses of sediments is generally north and south and hence conforms to the general strike of the sedimentary series around Ainsworth. From this general uniformity of strike it is concluded that convection currents were not very operative in the cooling Nelson batholith in this region. These blocks evidently represent remnants of the old sedimentary roof of the batholith which sank quietly in the uprising molten granite batholith.

The degree of contact metamorphism induced by the intrusive granite in the surrounding sediments is not great. Around the eastern edge of the batholith which comes within the Ainsworth map-area, contact metamor-

[1]Brock, R. W., Geol. Surv., Can., Ann. Rept., vol. XV, 1902-1903, p. 101A.
[2]Gwillim, J. C., Can. Rec. Sc., vol. VII, 1897, p. 295.

phism is very slight, the only visible effect to be seen in the nieghbourhood of the contact is a slight silicification of the argillites, which increases their hardness. As the contact is left and the exposures are examined down the slope to Kootenay lake which is really going deeper in the zone of metamorphism surrounding the batholith, metamorphism is apparently greater, the argillites are changed to andalusite schists, the limestones to marbles, and the sandstones are highly silicified and changed to dense, cherty quartzites.

Age and Correlation.

The youngest formation with which the Nelson granite was found in contact is the Skyline formation which holds fossils of Carboniferous age. In studying the relations which the granite bears to the main folding of the Selkirk range it is seen to be contemporaneous with or slightly younger than the chief orogenic movements which affected the region. The age of these movements has been shown to be Jurassic[1].

Further evidence of the Jurassic age of the granite and of the contemporary age of the orogenic movements which built the Selkirk and Purcell Mountain ranges is furnished by the character of the material making up the Cretaceous sediments of the Rocky mountains to the east.

Table Showing Character of Sediments.

Period.	Formation.	Condition of deposition.	Lithological character.
Tertiary	Paskapoo	Freshwater	Sandstones.
Upper Cretaceous	Edmonton	Brackish and freshwater	Sandstones and shales.
	Bearpaw	Marine	Shales.
	Belly River series	Brackish	Sandstones and shales.
	Colorado	Marine	Shales.
	Upper Blairmore	Subaerial	Sandstones, conglomerates (*granite* and chert pebbles).
Lower Cretaceous	Lower Blairmore	Subaerial	Shales and conglomerates (quartzite and chert pebbles).
	Kootenay	Subaerial	Sandstones and shales. Coal.
Upper Jurassic	Fernie shales	Marine	Shales.
Devonian and Carboniferous		Marine	Limestones and quartzites.
Lower Palæozoic		Marine	Limestones and shales.
	Disconformity.		
Pre-Cambrian (Beltian).	Purcell series Galton series	Continental	Mainly quartzites and argillaceous quartzites.

It will be seen from the above table that conglomerates are found first in great amount at the base of the Blairmore formation. The pebbles in conglomerates consist of quartzites and chert derived from the quartzites of the Beltian rocks which make up the great part of the Selkirk range. Evidently in Lower Blairmore times the Selkirk range was approaching the maximum of elevation and was undergoing rapid erosion. The Upper Blairmore formation also consists of conglomerates and sandstones, but in them in addition to pebbles of quartzite and chert, pebbles of granite occur

[1]Schofield, S. J., Geol. Surv., Can., Mem. 76, 1915, pp. 95–97.

for the first time and in great abundance. The presence of the granite pebbles at this horizon is interpreted to mean that the Selkirk range was unroofed during Upper Blairmore times and that the Nelson granite batholith which forms the core of the Selkirk range in southern British Columbia was exposed to rapid erosion. Hence it is established that the first intrusion of granodiorite into the Selkirk range took place before the deposition of the Upper Cretaceous. The superposition of the marine Fernie shales upon the marine Devono-Carboniferous limestones suggests that the period of stability which prevailed throughout British Columbia until the Triassic was interrupted during the upper Jurassic. The Selkirk mountains received their initial form probably at the close of the Jurassic or in early Kootenay times. If mountain-building and orogenic movements are contemporaneous, it may be concluded that the first intrusion of granodiorite in the Selkirk range commenced towards the close of the Jurassic and continued until the mountain-building reached its maximum in Kootenay time.

LAMPROPHYRIC DYKES.

In the Ainsworth area, as well as in the Selkirk Mountain system, there are many narrow dykes of dark igneous rock, which can be traced along the strike, in many cases, for distances measured in hundreds of feet. As the dykes seldom exceed a width of 8 to 10 feet in the Ainsworth area and are not important economically, only a few of them were mapped although they occur sporadically over the whole of the area. They are especially abundant in the Josephine formation. The type rock can be examined on the Florence wagon road about 100 yards north of Cedar creek where the dyke is well exposed. The same dyke is exposed on the lake shore. In general trend these dykes have two main directions, one parallel to the strike of the formations as in the case of the dyke at the mouth of the Star tunnel and of the dyke in the workings of the Highland mine and the other almost at right angles to this direction, that is, across the strike. The dykes which conform to the strike of the formation also conform to it in degree and direction of dip, whereas the cross-cutting dykes dip almost vertically.

CAMPTONITE.

Camptonite is the most common rock type in the Ainsworth area. In the hand specimen it is a dark grey, brown weathering rock which contains phenocrysts of hornblende and in places biotite. In some cases the hornblende crystals are 3 inches in length and some of them show rounded and embayed forms which contain small, round inclusions of calcite arranged in linear fashion parallel to the long axis of the crystal. The dyke of this rock exposed near the portals of the lower Star tunnel is remarkable for the size of the hornblende crystals in it as well as for the great number of inclusions it contains of the Nelson granite. The porphyritic type is rather the exception and the fine-grained variety which contains a few phenocrysts of plagioclase and biotite is very common. The chilled margins of the porphyritic variety have the characteristics of this type.

Microscopic Description. Under the microscope the hornblende is a strongly pleochroic dark brown variety embedded in a fine-grained groundmass of biotite and plagioclase, near an andesine in composition. Apatite and magnetite are quite abundant.

Age of Dyke Intrusion. The age of the intrusion of the lamprophyre dykes cannot be definitely determined. They cut the members of the Slocan series which is of Carboniferous age and carry as inclusions fragments of the Nelson granite which is of Jurassic age. Hence the dykes are not older than very late Jurassic or early Cretaceous. A study of the fissure veins, especially those of the Highland mine (Map 1784), shows that the dykes are faulted by these fissures and that they are highly altered by the action of the mineral-bearing solutions which are responsible for the ore deposits of the Ainsworth camp. The dykes are unconformably overlain by deposits of the Quaternary. From a regional study of the ore deposits of British Columbia[1], it is concluded that the ore deposits of the Ainsworth camp as well as most of the ore deposits of British Columbia are associated with the cooling stages of the Jurassic or early Cretaceous batholiths, and since the dykes are highly altered by the mineral-bearing solutions which deposited these ore-bodies, it is suggested that these dykes may be associated with the cooling stages of the Nelson granite batholith, but at a stage previous to the one in which the ore-bodies were formed, which would be very late Jurassic or early Cretaceous.

SUPERFICIAL DEPOSITS.

PLEISTOCENE.

The greater part of the Ainsworth map-area, especially that part underlain by the sedimentary series, is covered with glacial drift which is made up of compact sand clay in which are boulders and pebbles derived from the local bed rock. Glacial erratics are of common occurrence.

RECENT.

The valley floors are covered with modified glacial deposits which consist of cross-bedded sands and gravels. The gravels consist of rounded pebbles of various rocks derived from the surrounding terrane. In the stream deposits, such as those of Coffee and Woodbury creeks, the pebbles are mainly granite with minor quantities of limestone and slate.

The hot springs at Ainsworth are at present depositing an appreciable quantity of calcareous tufa.

[1]Schofield, S. J., Trans. Can. Min. Inst., vol. XXI, 1918, p. 422.

CHAPTER IV.

STRUCTURAL GEOLOGY.

REGIONAL.

The Rocky Mountain geosyncline, which includes the greater part of the Selkirk and Rocky Mountain ranges, consists of Beltian, Palæozoic, and Mesozoic sediments. The western border of this geosyncline passes through Coeur d'Alene and Shuswap lakes, along whose shores is exposed the old crystalline complex from which the above-mentioned sediments were derived in part if not wholly.

To the west of the almost horizontal Tertiary and Cretaceous strata which make up the elevated plateau of the prairie provinces, lies the folded region of the foothills, in which is found the most easterly evidences of orogenic movements in the Rocky Mountain geosyncline. The folds in the foothills trend in a northwest-southeast direction and represent the most easterly effects of the strong compressive forces which built the Rocky Mountains proper lying to the west of the foothill area. The central and eastern parts of the Rocky mountains consist of a series of overthrust fault blocks of Palæozoic and Mesozoic strata striking in a northwest-southeast direction and dipping to the southwest; in the western part of the Rocky mountains, anticlines and synclines of Pre-Cambrian and Cambrian rocks make up the dominant structure. The age of the orogenic movements which built the Rocky mountains is early Tertiary.

The wide Kootenay-Columbia valley lies between the Rocky mountains on the east and the Selkirk mountains on the west. This topographic feature, which is of first importance in the structure of the region, is called the Rocky Mountain trench. The sediments which form the greater part of the Selkirk mountains range from Beltian to Carboniferous in age and include the Purcell series, Ainsworth series, and the Slocan series. They are folded into anticlines and synclines which in this region, strike north and south—a direction different to the folds of the Rocky mountains. The mountain-building forces which affected the Selkirk mountains are of Jurassic age and earlier than the forces which built the Rocky mountains to the east. Therefore, the Rocky Mountain geosynclinal has suffered two orogenic movements, one at the close of the Jurassic, which laid the foundation of the structure of the Selkirk mountains, and the other in early Tertiary time, which elevated the eroded Selkirk mountains and imparted the Rocky Mountain structure to the sediments derived from the erosion of these Jurassic (Selkirk) mountains.

LOCAL.

The Ainsworth map-area, situated on the western slope of the Purcell trench which holds Kootenay lake, forms part of the central portion of the

Selkirk mountains. The sediments around Ainsworth, which strike north and south and dip to the west, form the eastern limb (Figure 3) of a syn-

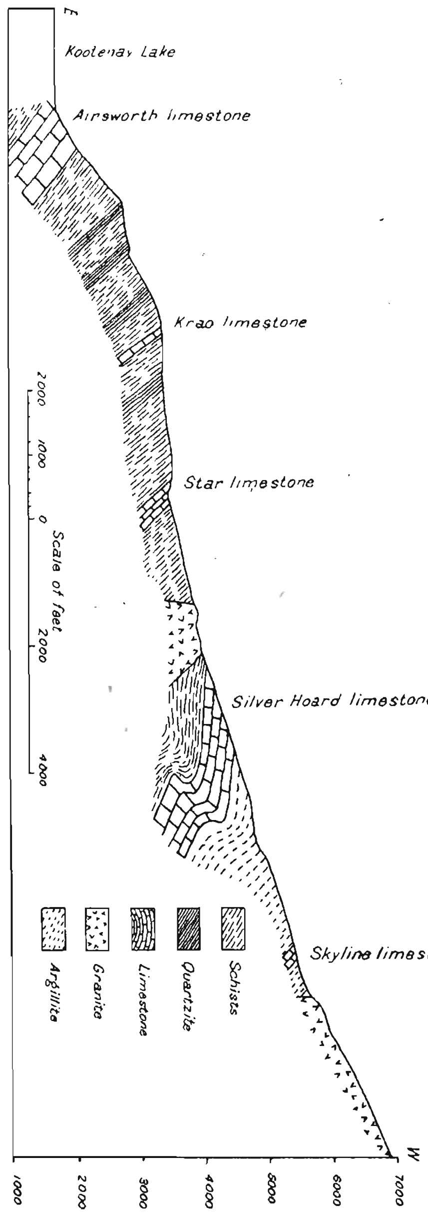


Figure 3. Structural section across Ainsworth map-area.

cline. The western limb of the syncline has been destroyed by the intrusion of the Nelson batholith, but its northern continuation is seen in the Millford syncline of the Blue ridge north of Kaslo.

CHAPTER V.

GEOLOGICAL HISTORY.

INTRODUCTION.

The formations exposed in the Ainsworth map-area are too limited in range to allow of the interpretation of the geological record with any degree of certainty, from them alone; therefore, a brief description is given of the general region of which the area around Ainsworth forms part.

The sedimentary rocks exposed around Ainsworth are Carboniferous and in part possibly pre-Carboniferous in age and are cut by granites (gneissic granite, Nelson granite) and lamprophyre dykes of Jurassic age. These Carboniferous and younger Palæozoic rocks are underlain by the Purcell series[1] which includes the greater part of the rocks of the Purcell range to the east. The contact between the Purcell series (Beltian) and the overlying Palæozoic rocks around Ainsworth has not been observed, but it is believed to lie in the vicinity of the water-shed east of Kootenay lake, since there is an apparently continuous record of sedimentation from the Beltian of East Kootenay to the Carboniferous of Ainsworth. To the west of Kootenay Lake trench the intruded mass of the Nelson granite separates the Carboniferous rocks of Ainsworth from the older Pre-Cambrian and possibly pre-Beltian rocks around Arrow lakes. These Pre-Cambrian series form part of the oldest land area in British Columbia, from which the sediments of the Ainsworth and Purcell series were derived by the processes of erosion.

PALÆOZOIC SEDIMENTATION.

The earliest geologic record in the Ainsworth map-area is one of sedimentation, and, from observations of the rocks exposed on the east side of Kootenay lake and in the area around Procter where the geological section which is concealed by the waters of Kootenay lake can be seen, it is a late phase of a long period of sedimentation.

POINT WOODBURY EPOCH.

This oldest epoch of sedimentation at Ainsworth gave rise to the quartzose mica schists and quartzites of the Point Woodbury formation, which were laid down in the sea as siliceous muds and later hardened into sandstones. These sandstones were subsequently silicified and altered to quartzites and mica schists by the mountain-building forces and the heat caused by the intrusion of the Nelson granite of Jurassic age.

EARLY BIRD EPOCH.

The sea during this epoch evidently was of such a nature that calcareous muds were deposited in it which later changed into the siliceous lime-

[1]Schofield, S. J., Geol. Surv., Can., Mem. 76, 1915.

stone of the Early Bird formation. It would seem, therefore, that there was a deepening of the water during the period, accompanied by stability of the land mass to the west which was undergoing a slow process of profound surface weathering and erosion.

PRINCESS EPOCH.

The mica schists and quartzites of the Princess formation show a return during that epoch to the conditions which prevailed during the Point Woodbury epoch and indicate the same origin for the sediments of the two formations and their metamorphosed equivalents.

AINSWORTH EPOCH.

A return to the condition prevailing during the Early Bird epoch evidently occurred during the Ainsworth epoch in which limestones were deposited. The limestones of the Ainsworth formation are not as siliceous as those of the Early Bird formation and, therefore, were probably laid down farther from the shore.

JOSEPHINE EPOCH.

The conditions prevailing during the Josephine epoch caused the deposition of lime muds (later metamorphosed to limestones) and fine sand (later metamorphosed to platy quartzites). But the most characteristic feature of the epoch was the deposition of basic volcanic ash which was laid down at intervals during the progress of sedimentation. These ash beds later were changed to green hornblende schists. In many cases the quartzites contain very thin laminæ of green hornblende schist showing that volcanic action was intermittent. Since no massive lavas were identified in the field it is concluded that the centre of eruption lay some distance from the Ainsworth area. These ash beds furnish the earliest evidence of volcanic action in the Palæozoic and the first since the deposition of the Purcell lava[1] in the Beltian. The final phase of the Josephine epoch was the deposition of mud, later metamorphosed to andalusite schists.

SILVER HOARD EPOCH.

Sedimentation with alternating deposition of lime muds and muds continued during the Silver Hoard epoch. These muds were later changed to limestones, andalusite schists, and argillites.

SKYLINE EPOCH.

The conditions prevailing in Silver Hoard epoch continued during the Skyline epoch and since the remains of marine organisms are found in the metamorphosed muds of this formation it is concluded that marine condi-

[1]Schofield, S. J., Geol. Surv., Can., Mem. 76, 1915, p. 76.

tions with land to the west prevailed during the whole period in which the Ainsworth and Slocan series were deposited, although no fossils were found in any of the formations older than the Skyline.

JURASSIC.

No record of Jurassic sedimentation is preserved in the Ainsworth area; but the period is a very important one economically and structurally, since the main orogenic movements which laid the foundations of the structure of the Selkirk and Purcell mountains took place near its close. In addition, the magma which later solidified to form the Nelson granite and which forms the bedrock of such a wide area in the Kootenay, rose in this area which had been weakened by crustal movements. These movements folded the sedimentary strata into regular anticlines and synclines which strike in a northerly direction. After this crustal movement came the intrusion of lamprophyre dykes. The cooling stages of the intrusion of the Nelson granite furnished the materials which were concentrated in favourable localities to form ore deposits.

CRETACEOUS.

The Cretaceous period in the Selkirk mountains was one of erosion in which the rugged mountains were worn down to a surface characterized by meandering streams and a slightly rolling topography. The products of this erosion went to form the Cretaceous formations of the Rocky mountains.

TERTIARY.

The Tertiary period in the Selkirk range is characterized by an uplift which was contemporaneous with the building of the Rocky mountains. This uplift imparted increased vigour to the sluggish streams and enabled them to open up the present valleys of the range.

QUATERNARY.

The Quaternary period was marked by refrigeration and glaciation, the results of which are seen in the glacial cirques, V-shaped valleys, faceted spurs, and fretted topography. Evidence of a complicated history of the Quaternary period has been recorded in an earlier memoir[1] and the reader is referred to that publication for a full description. The period of refrigeration was followed by a period characterized by a milder climate which caused the almost complete disappearance of the ice cap and the gradual approach of present day conditions.

---

[1] Schofield, S. J., Geol. Surv., Can., Mem. 76, 1915, pp. 85 and 103.

CHAPTER VI.

ECONOMIC GEOLOGY.

INTRODUCTION.

The deposits of economic importance in the Ainsworth mining camp are entirely silver-lead ores. Previous to 1914 the zinc which is invariably associated with the silver and lead in the primary deposits was worthless or detrimental to the ores; but owing to the increase in value of spelter and the erection of a smelter at Trail for the recovery of zinc, its presence now adds to the value of the deposits at Ainsworth.

As stated above the deposits at Ainsworth are entirely silver lead; the chief mineral being silver-bearing galena except in the case of No. 1 mine, the present workings of which expose only the oxidized ore zone of an original sulphide deposit. The ore deposits may be classified according to form as follows:

1. True fissure veins.
   (*a*) Cutting the bedding planes at an angle.
   Highland, Florence, Early Bird, United, Glengarry.

   (*b*) Parallel with the bedding planes.
   Maestro, Banker, Diamond, Little Phil, Spokane, Trinkett, Albion, Highlander, Tariff.

2. Replacement deposits in limestone.
   No. 1, Silver Hoard, Star, Krao, Gallagher, Crown, Florence, Buckeye, Ayesha.

Mineral Production of the Ainsworth Mining Division[1].

Year.	Tons.	Gold, lode	Silver.		Lead.		Zinc.		Totals for division.
		Ounces.	Ounces.	Value.	Pounds.	Value.	Pounds.	Value.	
				$		$		$	$
1896	....	....	374,097	250,665	3,186,592	94,961	....	....	345,626
1897	5,556	....	524,578	313,697	3,543,237	126,848	....	....	440,545
1898	17,380	....	167,147	92,515	1,978,297	67,262	....	....	159,801
1899	3,760	91	268,165	151,781	3,588,577	144,261	....	....	297,930
1900	5,313	28	352,167	205,454	3,366,962	143,433	....	....	349,465
1901	5,938	63	324,913	181,951	3,788,412	147,748	....	....	331,011
1902	4,939	5	320,719	158,916	3,083,039	112,839	....	....	272,967
1903	24,332	33	108,678	55,187	4,299,727	163,949	....	....	219,818
1904	14,569	2	90,004	48,026	3,091,648	119,956	....	....	168,023
1905	3,331	28	99,781	57,204	1,002,114	42,490	....	....	100,273
1906	19,431	19	165,915	105,273	3,173,353	161,524	....	....	267,190
1907	17,781	118	301,322	187,000	3,654,775	175,429	....	....	364,868
1908	38,282	162	314,142	157,762	4,790,216	181,070	....	....	342,181
1909	97,698	162	352,555	172,505	10,298,343	396,486	....	250,000	867,340
1910	21,850	71	233,010	118,397	2,558,353	102,334	2,083,896	95,859	318,058
1911	671	4	77,375	39,183	289,009	11,502	....	....	50,768
1912	32,741	80	301,755	174,384	4,863,894	195,723	....	....	371,760
1913	92,472	25	447,015	253,905	9,027,861	354,795	150,680	7,233	616,450
1914	66,441	100	329,586	171,714	8,069,525	282,433	280,000	12,320	468,534
1915	42,630	121	289,565	136,675	3,436,184	143,289	678,940	76,381	358,846
1916	77,841	45	321,202	200,366	7,841,869	484,000	625,971	68,106	753,402
1917	82,481	1	224,461	173,261	6,395,350	505,872	918,601	69,501	749,014
1918	44,937	18	228,669	210,243	6,206,262	407,288	640,991	44,485	662,388

[1] Report of the Minister of Mines for British Columbia.

Production of Ainsworth Mines in Tons, Reported at Trail by the Canadian Mining and Smelting Company.

July.	1903-1907 (inc.)	1908	1909	1910	1911	1912	1913	1914
Highlander	144	...	...	...	...	...	...	...
Gallagher	79	19	73	...	...	...	10	...
Krao	995	...	...	...	...	...	...	...
Maestro	201	126	65	35	113	...	157	1,232
New Jerusalem	19	31	...	...	...	...	...	...
Highland	4,334	...	198	304	22	...	1,130	2,915
No. 1	324	19	21	...	137	524	4,017	4,885
Spokane	493	13	...	...	...	...	...	...
United	182	...	...	...	...	...	...	...
Pontiac	...	...	30	...	...	...	...	...
Jessie Bluebird	...	25	...	35	...	...	...	...
Ayesha	...	...	...	...	10	...	...	...
Silver Hoard	...	...	...	...	...	202	1,287	43
Florence	...	...	...	...	...	62	16	...
Bluebell	1,663	2,229	4,907	1,262	...	3,720	7,209	4,754
Early Bird	...	...	...	...	...	...	...	57

ORE DEPOSITS.

DISTRIBUTION.

Most of the silver-lead deposits are associated with the limestone bands which occur quite commonly in the Ainsworth and Slocan series, although some of the important mines, for example the Highland, are in the schists and others like the Spokane and the Banker are in quartzites. The ores consist of galena and zinc blende in a gangue of calcite, siderite, quartz, and fluorite. The ore in the Bluebell mine, which was deposited under more extreme conditions of temperature and pressure than other deposits, is characterized by the presence of the contact metamorphic mineral diopside.

MINERALOGY.

The minerals described under this head are grouped according to Dana's system of classification.

NATIVE ELEMENTS.

Silver, Ag. Native silver was seen in the Silver Hoard, where it occurs as plates in cracks both in the country rock and in the ore itself. It has been reported to have been found in great abundance in the Krao and in several other properties. In all cases it is generally secondary, the silver in the primary state being intimately associated with the galena and invisible. The method of solution of the silver and its precipitation in the secondary form is clearly explained by Cooke in a paper on the Matachewan ores[1] in which he makes the following general statement: " Enrichment of a primary silver deposit is brought about by reactions of silver or its sulphides with the sulphides of iron and their products of oxidation....Sulphuric

[1]Cooke, H. C., Jour. of Geol., vol. XXI, 1913, pp. 1-28.

acid and ferric sulphate (derived from the oxidation of pyrite) exert a powerful solvent action both on silver sulphide and on its companion sulphides, such as galena, chalcocite, orpiment, and stibnite. Of these silver sulphide is the least affected." And further he says: "A mixture of sulphuric acid and ferric sulphate has a powerful solvent action on metallic silver.... Equilibrium in silver-bearing solutions between ferric, ferrous, and silver sulphates is such that the reduction of ferric solutions to the ferrous condition by any means will rapidly precipitate the silver in metallic form."

Native Copper, Cu. Native copper is found on the tables in the mill of the Bluebell mine and is evidently derived from the crushed and altered zone of cross fissures which intersects the main ore-bodies. This crushed zone is usually stained green from the solution of the copper-bearing sulphide and its redeposition as malachite by descending surface waters. The copper is probably secondary.

SULPHIDES.

Galena, Sulphide of Lead, PbS. Galena is by far the most important mineral in the Ainsworth camp because of the association with it of the silver values. In general, it is coarse-grained and almost invariably banded and has a gnessic appearance, owing to the simultaneous reflection of light from the cleavage planes of alternate bands. This structure is common in galena ore both in the Ainsworth camp and in the neighbouring Slocan district.

Attention was first called to the banded or gneissic galena by Carlyle[1] in the following words. "The ore has been deposited along fissures, both in the open cavities, and by impregnation of the country rock, and in the cavity-filled veins can be seen the banded structure described elsewhere, or the solid, usually big cubed galena, shows lines of foliation parallel with the walls, but it is evident that further motion has occurred along some of these vein fissures, after the ore has been deposited." Observations by the writer shows that the lines of foliation mentioned above are not usually parallel with the walls of the fissure but are parallel with the lines of foliation which cross the fissure at a small angle. Uglow[2] has confirmed and elaborated the theory put forward by Carlyle that the gneissic form of the galena is due to shearing after the galena was deposited. Uglow considers that flowage also was an important factor in the formation of the gneissic structure.

The fine-grained variety, steel galena, is found in the Highland mine, especially in the ore-body on the 5th level. The galena is always silver-bearing, carrying about 20 ounces to the ton.

Zinc Blende, Sphalerite, Sulphide of Zinc, ZnS. Zinc blende is a common mineral in the silver-lead deposits, especially in the Bluebell and Silver Hoard ore-bodies. In the Silver Hoard deposit the sphalerite is the typical resin jack. It is coarse in texture and is associated with the galena. In the Bluebell, the sphalerite is fine-grained and intimately mixed with

[1]Carlyle, W. A., Rept. of Minister of Mines, British Columbia, 1896, p. 47.
[2]Uglow, W. L., Econ. Geol.

the galena and pyrite. The composition of the zinc blende from Ainsworth is not known, but an analysis of blende from a similar deposit—the Cork-Province on the south fork of Kaslo creek—furnished by the manager Mr. Zwickey, is as follows:

Ag	3 per cent.
Pb	1 "
Zn	41 "
Fe	13½ "
Ca	1·6 "

Iron Pyrites, Disulphide of Iron, FeS_2. Pyrite is widely distributed throughout the deposits and is especially abundant in the Bluebell mine.

Pyrrhotite, Magnetic Sulphide of Iron, Fe_7S_8. Pyrrhotite occurs abundantly in the Bluebell mine, both in large masses and in rare cases as well-defined crystals.

Chalcopyrite, Copper Pyrites, $CuFeS_2$. Chalcopyrite occurs sparingly in the Bluebell mine.

Marcasite, Disulphide of Iron, FeS_2. Marcasite was actually determined only in the Highland mine where its crystal aggregates have the form typical of marcasite, coxcomb pyrites.

OXIDES.

Quartz, SiO_2. Quartz occurs in small amount in nearly all the deposits.

Limonite, $2Fe_2O_3$, $3H_2O$. Limonite is common only in the oxidized zone of the No. 1 mine as a product of the decomposition of the sulphides of iron. This oxide forms the largest part of the ore shipped from the No. 1 mine.

HALIDES.

Fluorite, Fluor Spar, Calcium Fluoride, CaF_2. Fluorite occurs most commonly in the Early Bird claim where the purple and pink varieties are abundant in the form of cubes and irregular masses associated with calcite. In the Silver Hoard it is a common gangue mineral and in the Highland it occurs in the vein in association with ankerite. It has been found occasionally in the No. 1 mine. Altogether fluorite is one of the most common gangue minerals in the deposits of the Ainsworth mining camp.

CARBONATES.

Calcite, Calcareous Spar, $CaCO_3$. Calcite is a common gangue mineral since the ore deposits in general occur as replacements in limestone. It occurs as regular masses and as rhombohedral crystals similar to those described and pictured by LeRoy[1] from Phoenix and by Drysdale[2] from Rossland.

Ankerite, Ferriferous Dolomite ($Ca\ (Mg, Fe, Mn)\ (CO_3)_3$). Ankerite was found only in the Highland mine, on the third level, where it was associated with fluorite.

Cerussite, Lead Carbonate, White Lead Ore, $PbCO_3$. Cerussite is not a common mineral in the deposits of the Ainsworth mining camp. It was

[1]LeRoy,, O. E., Geol. Surv., Can., Mem. 21.
[2]Drysdale, C. W., Geol. Surv., Can., Mem. 77.

found in crystalline form in a solution cavity in galena in the Highland mine. Although the No. 1 mine is a deposit of oxidized silver lead ore, cerussite was not identified in it with any degree of certainty.

ORES.

The ores mined at Ainsworth consist essentially of two varieties.

(1) Oxidized earthy ore containing native silver, as in the No. 1 mine. The values of the No. 1 ore for the years 1912, 1913, and 1914 as given by the Annual Report of the Consolidated Mining and Smelting Company are as follows.

	Oz. Ag per ton.	Pb. %
1912	95·7	3·22
1913	37·8	1·68
1914	32·0	1·045

(2) Primary ores consisting of galena, zinc blende, and iron pyrites, as seen in the Highland mine. The ore is a milling proposition. The values of the concentrates are as follows:

	Oz. Ag per ton.	Pb. %
1913	15·4	55·65
1914	25·6	78·17

The ratio of concentration[1] varies from 1 to 7 to 1 to 10 depending on how carefully the work is performed.

AGE OF DEPOSITS.

AGE RELATIONS OF REPLACEMENT DEPOSITS AND TRUE FISSURE VEINS.

The relationship of these two types of deposits was seen in the Ayesha claim (Map 1788) where the replacement deposit occurs at the upper contact of a limestone belt with a schist. The replacement deposit with a north and south strike was cut by two distinct fissures trending approximately east and west, and dividing the deposit into three distinct portions arranged *en échelon*, since the portion north of each fault was stepped to the west. Ore occurs in each of the fissures, especially in that portion which joined two of the replacement bodies. The fissures are identical in character with the fissures described as occurring in the Highland mine. The mineralogy of the fissure veins and the replacement deposits is identical even to the proportion of silver to lead in the galena. The above evidence supports the conclusion that the fissure veins and the replacement ore deposits are contemporaneous in their formation. This conclusion is further substantiated by the occurrence of replacement ore-bodies and ore-bodies of the true fissure type associated with the same fissure in the Florence mine.

AGE RELATIONS OF DYKES AND ORE DEPOSITS.

In the description of the Highland mine which follows, it is stated that there is a horizontal displacement of 30 to 130 feet along the fissures. The basic lamprophyre dykes which were faulted by this movement were also highly altered in the vicinity of the fissures by the ore-bearing solutions, thus proving that the ore deposits are younger than the dykes. If the

[1] Report Minister of Mines, B.C., 1914, p. 149.

dyke in the Bluebell mine cuts the ore-body, as stated by Mr. Fowler the manager, the above statement must be modified to some extent. Where the writer observed the dyke in the Bluebell mine it was very badly decomposed throughout and its relations to the ore-body could not be determined with any degree of certainty. From its position as a bounding wall to a large ore-body and from the high degree of alteration which it showed, the writer was inclined to consider the dyke as pre-ore deposition; but this opinion should not be given as much weight as that of Mr. Fowler who has carefully watched the evidence upon this point that has been brought to light during the development of the mine. In the Slocan district, which is in close proximity to the Ainsworth camp and where the conditions of ore deposition show the same features, LeRoy has found dykes which cut the ore-bodies. From the facts presented above it can at least be concluded that the dykes and ore deposits are nearly contemporaneous in age and that the dykes have no genetic connexion with the ore deposition.

AGE OF DEPOSITS.

The determination of the age of the deposits of the Ainsworth mining camp is a difficult matter since the information at hand is very meagre. It can only be stated that the deposits are younger or contemporaneous with the period of dyke intrusion and older than the glacial deposits. From a general study of the region it is believed that the dykes are closely related in age with the intrusion of the main mass of the West Kootenay granite batholith (the Nelson granite) which is of Jurassic age.

ORIGIN OF THE ORES.

The ore-bearing solutions emanating from the granite in the pneumatolitic stage of cooling (since fluorite is a common gangue mineral in the majority of the deposits), rose in fissures and at favourable localities formed ore-bodies either in the fissures (as in the vicinity of the quartzite-hornblende schist contact in the Highland mine) or in the rocks cut by the fissures (as in the Florence mine where the mineral-bearing solutions attacked and replaced the limestone bands). The ore in the No. 1, Silver Hoard, and Bluebell deposits evidently spread laterally from the fissure at the contact of the replaceable limestone with the overlying impervious argillites or schists forming replacement ore-bodies. This action took place even where portions of the contact were overturned, as shown in the No. 1 and the Silver Hoard.

FUTURE OF AINSWORTH MINING DISTRICT.

The prospects for the continuance of mining in the Ainsworth district are good. The success of the Highland in proving that the ore-bodies extend at least to 700 feet below the outcrop in the case of veins of the true fissure type and the occurrence of the replacement deposits in limestone 350 feet vertically below the outcrop in the Florence mine, augur well for deeper mining, especially as, so far as can be determined, the tenor of the ore does not appreciably decrease at depth. The failure to discover workable ore-bodies on the Tariff, Highlander, and Banker veins at the depth reached by the Highlander tunnel need not be considered discouraging; for the occurrence of the ore-bodies in this type of vein is to be looked for only on the flat portions of these veins and the ground between the tunnel and the surface has not been explored.

A study of the various mines has shown that the ore-bodies so far discovered have three well-defined modes of occurrence and in the future economic development of these deposits, this face should be kept in mind and should govern the methods of exploration of the veins. These different modes of occurrence are fully described in this report.

The great increase in the efficiency of concentrating processes arising from the introduction of flotation, which in the Ainsworth district is still in the initial stage, should increase the output of this camp and enable properties which are at present idle to resume operations.

The country between the Ainsworth map-area and Kaslo creek, in which very few mineral claims have been staked, exhibits geological features similar to those found at Ainsworth and is, therefore, considered to be worthy of attention by prospectors.

DESCRIPTION OF MINES AND PROSPECTS.

True Fissure Veins.

FISSURE VEINS CUTTING BEDDING PLANES AT AN ANGLE.

Highland Group.

The Highland group is operated and owned by the Consolidated Mining and Smelting Company of Trail, B.C. The group is situated on Cedar creek, 1½ miles from Ainsworth, with which it is connected by a wagon road. An aerial tram carries the ore from the mine to the mill on Kootenay lake at the mouth of Cedar creek.

Geology. The country rocks which outcrop on the Highland group belong to the Josephine formation which consists of mica schists, crystalline, siliceous limestones, quartzites, and green hornblende schists striking approximately north and south with a dip of 45 degrees to the west. The series is cut by mica and non-mica dykes generally parallel with the bedding of the sedimentaries. The majority of the dykes are of the non-mica variety and have widths of from 3 to 15 feet. The presence of these dykes (Map 1784) in the sedimentaries, parallel to the strike, is very important as they form good horizon-markers in the determination of the throw of the fissures. A non-mica dyke follows the main fissures of the Highland mine, in places occupying the fissure and in places lying to one side of it. The dykes as well as the green hornblende schist in the immediate neighbourhood of the fissure are highly altered to a whitish yellow mass which requires considerable care in mining. This soft material has evidently been formed by the alteration of the immediate wall rock by the action of descending surface waters which are highly charged with sulphuric acid from the decomposition of iron pyrites. This decomposition of the wall rocks makes the determination of the character of the rocks along the fissure rather a difficult matter.

Fissures. The fissures (Map 1784) which are three in number trend approximately northwest and dip to the east at an angle of 75 degrees; the most southerly one is the main vein, whereas the other two, termed angle veins, are of less importance. The fissures are well-defined and show a horizontal displacement along the vein of from 20 to 130 feet (Map 1784). The direction of displacement is the same in all three fissures. Another feature of these fissures is the fact that the amount of ore in the fissure is roughly proportionate to the amount of displacement that has taken place along the fissure. This apparent relationship may be quite fortuitous, but on the other hand it is possible that greater movement gave rise to conditions more favourable for the passage of ore-bearing solutions. In the quartzites the fissures are clean and narrow with some brecciation along the walls which are comparatively unaltered except for some silicification. The filling is usually of quartz with very little sulphides as a rule. In the hornblende schists, the walls of the fissures have been badly decomposed. In most cases, the vein which contains good ore shoots in the green hornblende schist narrows very rapidly and contains very little ore when it passes into the quartzites.

Ore. The ore consists mainly of coarse-grained galena usually with a banded structure, giving it a gneissic appearance, and a fine-grained variety which also has a gneissic structure but is less in amount than the coarse-grained variety. Zinc blende and small amounts of pyrite, marcasite, and chalcopyrite in a quartz gangue complete the mineralogy of the ore. Ankerite and fluorite occur in cracks in the ore and are the last primary minerals deposited in the veins.

Ore-Bodies. The distribution of the ore-bodies bears a striking relation to the quartzite-hornblende schist contact. From an examination of the accompanying section of the Highland mine (Figure 4) it can be seen that the ore-bodies occur as tabular masses apparently both in the quartzites and in the hornblende schists and are at the upper contact of the quartzites with the schist. In the section the ore-bodies appear to occur well within the quartzites, but when it is recalled that the displacement along the fissure is 30 to 100 feet, it will be seen that the schist and quartzite are in contact on opposite walls for the same distance. The ore-bodies follow the green hornblende schist to the displaced quartzite-hornblende schist contact, but do not occur to any extent in the region where the quartzites form both walls of the fissure. As the contact of the quartzite and the schist dips about 45 degrees to the west, the ore-bodies pitch in the same direction.

Mine Workings. Access to the ore-bodies is secured by means of five tunnels driven approximately along the strike of the vein, the three upper tunnels being approximately 100 feet apart and the two lower tunnels 200 feet apart, thus giving a depth of 700 feet below the outcrop. The

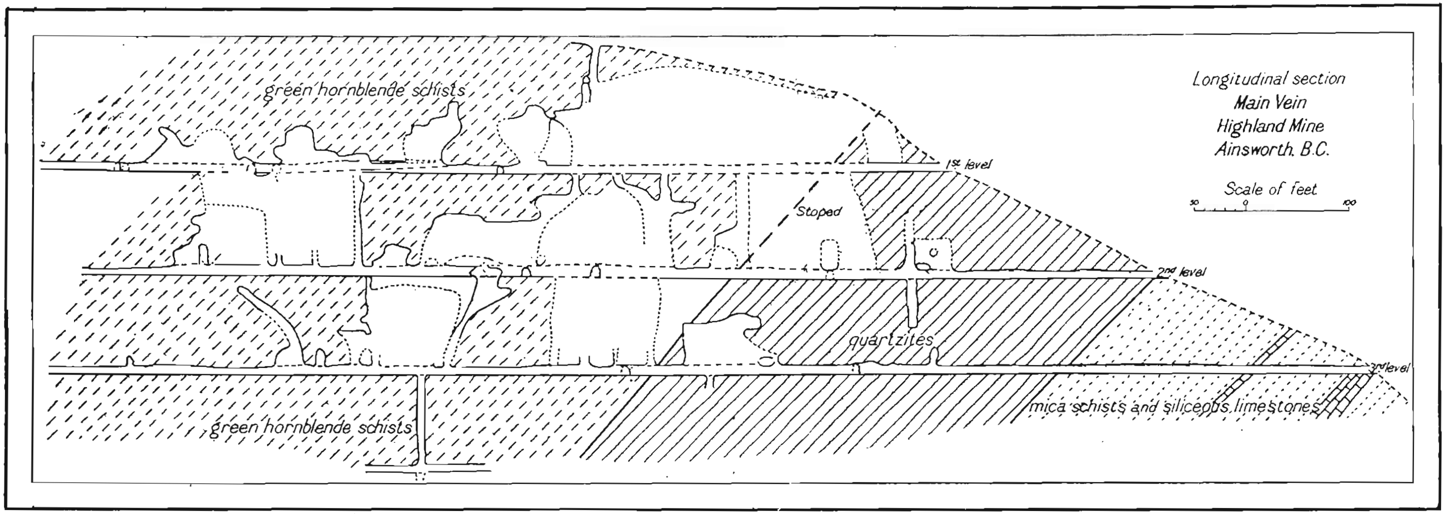


Figure 4. Longitudinal section along the main vein, Highland mine, Ainsworth, B.C.

ore is mined through the tunnels by overhead stoping and carried by an aerial tram to the mill on Kootenay lake at the mouth of Cedar creek.

Florence Silver Mining Company.

The board of directors of the Florence Silver Mining Company is F. R. Wolfle, president and manager; A. F. Kelly, vice-president; D. E. Saunders, secretary-treasurer; J. A. Lavender; and A. M. Frost. The mine is under the direct supervision of W. M. Hewer.

Situation. The Florence Silver Mining Company owns a group of claims comprising the Skylark, Florence Silver fraction, Mountain Cougar fraction, James R., Laura M., Hope, O. T. K., Twin, Fergus, and the Power fraction. As seen from the accompanying map (No. 1785) showing the location of the mineral claims, the Mountain Cougar fraction, the Florence Silver fraction, and the Skylark are situated on the shore of Kootenay lake about 2 miles north of Ainsworth and the other claims adjoin these on the west. The main entrances to the mine are on the Laura M. claim and are connected with Ainsworth by a wagon road which passes near the mouth of Cedar creek.

Geology. The Early Bird, Princess, Ainsworth, and Josephine formations outcrop on the claims striking about north and south with an average dip of 45 degrees to the west (Map 1785). A description of these formations has been given in a previous chapter. The two most important horizons economically are the limestone bands and the quartzite hornblende-schist contact, where they are crossed by the fissure. The limestone bands are members of the Josephine formation which is composed mainly of hornblende schists, banded quartzites, and some limestones. The limestones which occur in the Florence Silver mine are coarsely crystalline and greyish white to white in colour, and are composed almost entirely of interlocking grains of calcite with no associated secondary minerals such as tremolite. Hence they are very easily replaced by mineral-bearing solutions. The two bands which have been developed are about 45 feet apart and are from 6 to 8 feet thick. They strike north and south and to the west dip at an angle of 40 degrees, but the dip is modified by slight folds so that in some cases the limestones are approximately horizontal. In the immediate neighbourhood of the ore the rock is decomposed to a soft sugar-like mass of calcite and quartz and in other places it has been silicified.

The quartzites, which are overlain by mica schists and green hornblende schists, are about 25 feet thick and have the dip and strike of the surrounding rocks. The quartzites are tough and are banded light and grey in colour on fresh fracture, but change to a reddish brown colour on the weathered surface. The hornblende schists are green in colour with a glistening surface when fractured. They weather a dark rusty brown. These rocks are very similar to the quartzites and the hornblende schists exposed in the ore-bearing horizon of the Highland mine.

Fissure System. The fissure has a strike approximately east and west with a dip of 42 degrees to the south. It has been opened up at intervals on the surface from the workings of the Twin claim to those of the Laura M. The rocks for a distance of 40 feet on both sides of the replacement ore-bodies in the limestone have been so badly decomposed that it is difficult to determine the exact point where the fissure crosses the limestone bands. In the mica and hornblende schists the fissure is well defined and in the stopes on the second level it shows smooth, slickensided walls. The dip there is 42 degrees to the south.

Ore. The ore consists of a coarsely crystalline mixture of galena and zinc blende with some pyrite and chalcopyrite. The gangue is altered and decomposed limestone, calcite, and quartz. The galena in the quartzite-hornblende schist stopes is coarse-grained shipping ore with minor amounts of zinc blende, whereas that of replacement bodies is coarse-grained and fine-grained, the two varieties generally showing a gneissic or sheared structure. An analysis of the mill feed, supplied by the company, shows: Pb 7·4 oz.; Zn 7·0 oz.; Fe 11·0 oz.; Ag 2·5 oz.

Ore-bodies. The ore-bodies of the Florence mine are of two varieties: (I) replacement deposits; (II) ore-bodies of the true fissure type.

Replacement Deposits. There are two ore-bodies (Map 1786) of this type which are continuous from the surface at an elevation of 2,621 feet to the lowest level at an elevation of 2,285 feet. Exploration has not been carried below this point, but there is no doubt that the ore-bodies will continue to greater depths. These bodies, since they follow and replace the limestone, usually at its upper contact (Map 1786) with overlying schist, strike north and south with an average dip of 40 degrees to the west. In an intermediate level between the second and the lowest level the ore and the rocks are horizontal, showing that minor folds occur at irregular intervals. The length of the ore-bodies along the strike of the limestone bands has not been determined, although they have been followed for 50 feet without reaching an end in either direction. In many places the foot-wall of the galena mass is composed of a mixture of iron and copper pyrites from 1 foot to 2 feet thick, which is known locally as the iron dyke. In other cases a similar mixture of sulphides occurs in the hanging-wall side in contact with the overlying schist.

Ore-bodies of the True Fissure Type. Ore-bodies of this type occur in the fissure at the contact of the quartzite and the schist. The occurrences are very similar to those described in the account of the Highland mine. The ore-bodies are about 100 feet long and about 3 to 6 feet wide, and pitch about 40 degrees to the north along the fissure. There is no replacement of the wall rocks of the fissure and the ore breaks from the walls clean and smooth.

Workings. The mine is opened up by three tunnels, the two lower tunnels being connected by a raise from which an intermediate level is being driven.

Early Bird.

Situation. The Early Bird mineral claim is situated on the west shore of Kootenay lake about 2 miles north of Ainsworth. It is easily accessible by water. It is owned by Mr. Pringle of London, England, and in 1915 was under bond for three years by A. Baglow who at that time was shipping ore to the Trail smelter.

Geology. The vein was entirely enclosed by the Early Bird formation of which the staple rock is a very massive, grey, micaceous limestone in beds 6 to 8 feet thick. The limestone weathers a rusty brown. In many places interbeds of micaceous schist occurs with the limestone which dips on the average 35 degrees to the west and strikes north and south.

Fissures. Two fissures are exposed on the claim, which strike approximately north 75 degrees west with a dip of 80 degrees to the south. They are of the nature of gash veins which show no apparent displacement along the fissure and appear to be typical of the veins of this formation. The character of the veins of this type is well shown on the south wall of the canyon of Woodbury creek where they are numerous and well exposed. A cross-section of the Early Bird vein is shown in the accompanying cut (Map 1790).

Ore. The ore consists of massive galena and zinc blende with minor amounts of pyrite and chalcopyrite. The analysis of the ore furnished by Mr. Baglow shows the hand-sorted ore to run 45 per cent lead and 12½ zinc. The silver runs between 15 and 20 ounces to the ton. The value of the ore shipped in 1914, Mr. Baglow states, was $30 per ton.

United.

Situation. The United is situated on the Ainsworth-No. 1 wagon road about 4 miles from Ainsworth, at an elevation of 3,350 feet above sea-level or 1,590 feet above Kootenay lake.

Geology. The rocks in the immediate vicinity of the deposit consist of green hornblende schists which strike about north and south and dip 45 degrees to the west. The upper contact of the schist with the overlying andalusite schist is located at the base of a steep cliff about 150 feet west of the shaft. The lower contact of the schist with the underlying banded quartzites lies about 700 feet east of the shaft. A dyke of camptonite 4 to 5 feet wide, conforming in strike and dip with the enclosing schists, passes just east of the shaft.

Fissure. The fissure strikes north 70 degrees west and dips 70 degrees to the south. In the neighbourhood of the shaft it is well defined, but could not be traced for any distance east and west.

Ore. The ore which was seen in the open-cut just north of the shaft showed about 1½ feet of galena on the hanging-wall. From the ore on the dump it was concluded that the vein contained a large proportion of coarse zinc blende with which is associated coarse-grained galena which could be hand-sorted.

Ore-bodies. As the workings were filled with water at the time of the writer's visit, no information was obtained concerning the distribution of the ore in the vein.

If the fissure extends eastwards to the quartzites, the most favourable place for the location of the ore-bodies is in the green hornblende schists near and at the contact with the underlying banded quartzites.

Workings. The vein is opened up by means of an inclined shaft which is reported to be "170 feet deep[1] with levels extending east and west in the

[1]Report of the Commission appointed to investigate the zinc resources of British Columbia, 1906.

vein at the depth of 50 feet and for a distance of 80 feet on either side of the shaft. From the shaft and this drifting (it is claimed that the vein has not been stoped at any place) it is said that 500 tons of ore was shipped to Revelstoke by the former operators."

Glengarry.

Situation. The Glengarry is situated at an elevation of 3,315 feet above sea-level or 1,555 feet above Kootenay lake. It is connected with Ainsworth by a wagon road.

Geology. The rocks in the neighbourhood of the Glengarry belong to the Josephine formation. The shaft is sunk in banded quartzites which are underlain and overlain by green hornblende schist, the thickness of the quartzite bands being 120 feet, 200 feet, and 20 feet. The thickness of the overlying schist is only an estimate as exposures are poor.

Fissure. The fissure strikes north 70 degrees west with a dip of 68 degrees south. The fissure had not been prospected along the strike so that its extent is unknown. The shaft was filled with water when the property was visited in 1915 and 1918 so that an underground examination was impossible.

Ore. The ore on the dump consists mainly of zinc blende and some cube galena and the gangue appeared to be quartz and calcite. Part of the material of the dump was stained green with the decomposition products of chalcopyrite or cupriferous pyrite. The ore is said to run 8 to 10 ounces in silver and 44 per cent zinc[1].

Workings. The workings consist of an inclined shaft which is reported to be 65 feet deep. The shaft is filled with water and the vein can be examined at present only in a trench near the shaft, where it is exposed for a distance of 15 feet.

FISSURE VEINS PARALLEL WITH BEDDING PLANES.

All the veins of this character occur in the quartzites of the Josephine formation. Examples are the veins outcropping on the Diamond, Little Phil, Maestro, Spokane, Trinkett, Josephine, Tariff, Alpine, Highlander, and Banker. They are true veins 4 to 6 feet wide striking approximately north and south with a dip corresponding to the dip of the enclosing quartzites which varies from 25 degrees to 50 degrees to the west. They are well defined and since they occur in the quartzites which are very resistant to weathering can be easily followed on the surface for some distance—in the case of the Spokane vein a length of almost 3,000 feet is exposed.

The mineralogy is rather simple, the galena with small amounts of zinc blende and pyrite occurs in a gangue of quartz, calcite, and crushed quartzites. The galena has usually a gneissic structure and a massive character which easily lends itself to hand sorting and the zinc blende appears to be relatively smaller in amount than in the fissure veins which cross the bedding planes of the sedimentaries or replacement deposits.

[1]Report of the Commission appointed to investigate the zinc resources of British Columbia.

From observations over a limited field it is suggested that the ore-bodies occur associated with rolls or changes of dip in the surrounding quartzites, the most favourable locality being the areas of low dip which are preceded or followed by areas of high dip. This phenomenon is well shown in the Banker and Spokane veins.

Maestro, Banker (Diamond, Little Phil).

Position. These claims occur on the wagon road from Ainsworth to the No. 1 mine about 3,000 feet above sea-level at 1,240 feet above Ainsworth.

Geology. The rocks exposed on the claims consist of quartzites, green, hornblende schist, and some siliceous limestones, all belonging to the Josephine formation which strikes approximately north and south with a dip of 30 degrees to 45 degrees to the west. These rocks are cut by a lamprophyre dyke, about 6 feet wide, which is exposed in the lower tunnel on the Little Phil claim. In order to give some idea of the variations in the lithology, the following thicknesses of the rocks traversed in the above-mentioned tunnel are given, starting from the portal of the tunnel:

	Feet.
Green hornblende schist	120
Dyke (lamprophyre)	6
Green hornblende schist	54
Siliceous limestone	20
Banded quartzites	60
Green hornblende schist	20
Banded quartzites	3
Veins	6–8
Banded quartzites	60
Green hornblende schist	85
Banded quartzites (face)	2

These thicknesses are only apparent as the strata dip west at angles of from 45 to 60 degrees.

Vein. The same vein occurs on the Diamond, Little Phil, and Maestro claims and has been followed throughout the claims by underground workings. It varies in thickness from 6 to 8 feet and follows the bedding plane of the enclosing quartzites, that is 45 degrees to the west. The filling consists of altered and silicified quartzites which are cemented together by quartz and calcite. The ore-bodies usually occur at the hanging or foot-wall of the vein and consist of massive galena with small amounts of zinc blende and pyrite. In many places a layer of gouge occurs on the hanging-wall which in some cases shows slickensides.

Spokane, Trinkett, Jeanette Mineral Claims.

These three claims adjoin the Maestro on the north and are evidently a continuation of the Diamond-Maestro mineral zone. They lie above the town of Ainsworth, from which they may be reached by wagon road, and have an elevation of 2,500 feet above sea-level.

Geology. The rocks which outcrop on these claims consist of banded quartzites, green hornblende schists, and siliceous limestones of the Josephine formation which strike approximately north and south with a dip of 30 degrees to 60 degrees to the west. These rocks are cut parallel to the bedding by non-mica dykes 6 to 8 feet wide (Map 1789).

Fissures. The fissures are concordant with the enclosing platy quartzites which strike approximately north and south with dip of 25 degrees to 45 degrees to the west. They follow the two horizons in the quartzites which are rarely more than 6 feet apart, passing from one to the other at irregular intervals. The cross-cutting fissure joining the two horizons contains the same vein-filling as the main vein. This feature is well shown on the Trinkett and Jeanette mineral claims. This type of fissure, which is parallel with the bedding planes of the surrounding rocks, has not been observed in the hornblende schists.

Vein-filling. The ore consists of cube galena and fine-grained galena with small amounts of zinc blende, pyrite, and chalcopyrite in a gangue of quartz. The quartz in many places holds inclusions of small angular fragments of the quartzites and the vein-filling contains many small cavities which are lined with crystals of quartz.

Ore-bodies. So far as may be judged from the limited field of observation the ore-bodies seem to occur in areas of low dip which are preceded above and followed below by areas of high dip. The galena in the ore-bodies is usually fine-grained containing in intimate association small quantities of zinc blende and pyrite. The contents of the massive ore shipped to the smelter in car-load lots, according to Mr. McDougald, manager of the Spokane mine, was as follows:

Pb	Zn	Ag (oz.)	Weight (lb.) dry.
62·8	4·9	17·7	51,537
63·1	4·3	20·9	50,556
59·8	4·6	18·9	66,664
44·1	7·8	13·8	61,506
48·1	6·2	18·0	67,332

Albion.

Situation. The Albion mineral claim is situated just south of the Banker. The elevation of the tunnel is 2,500 feet (barometric) above sea-level or 800 feet above Ainsworth.

Geology. The rocks exposed on the Albion claim consist of mica schist, quartzites, and limestones of the lower part of the Josephine formation, cut by gneissic granite and lamprophyre dykes generally parallel to the strike of the sedimentaries, which is north and south with a dip to the west (Map 1792).

Veins. As shown in Map 1792 there are three veins which strike and dip concordantly with the enclosing sedimentaries. The veins consist mainly of quartz with small amounts of galena, zinc blende, pyrite, and chalcopyrite. In the vein which occurs in the raise from the crosscut to the north, galena was seen to the thickness of 6 inches.

Highlander.

The following description of the Highlander mine is by Argall[1].

"The Highlander vein was discovered in 1890. It outcrops on the summit of the steep escarpment on the western side of lake Kootenay,

[1]Report of the Commission appointed to investigate the zinc resources of British Columbia, Department of Mines, Mines Branch, 1906, p. 152.

about 1,100 feet above high water. A short tunnel intersects the vein 100 feet below its outcrop and development is continued by a shaft for a depth of 170 feet from the outcrop of the vein. Later, a main tunnel was started, now known as the Highlander tunnel, to open up this vein at a depth of 750 feet vertically below its apex, or 1,000 feet on the dip of the vein. The portal of this tunnel is situated about 350 feet above the lake and one mile south of the town of Ainsworth.

After penetrating the wash, the tunnel entered the mica schists of the district, and at a distance of 225 feet from the portal intersected what is known as the "Tariff" vein. (See Plate No. I). At 350 feet the schists gradually became harder, passing by insensible gradations into gneiss, through which the tunnel penetrates for a distance of 1,200 feet. In the centre of this mass of gneiss the crystallization becomes coarse, the rock in places presenting a granitic appearance, but on nearing the main lode again becomes schistose and the vein is intersected at 1,560 feet from the portal, with a westerly dip of 45 degrees giving the following general section. The footwall portion shows a banded structure of quartz and dark slaty rock, containing some seams of calcite, occupying a width of 2 feet (Plate No. II), next comes 2 feet of grey porphyritic vein filling, possibly a portion of a small dike, the hanging wall of which is polished and shows slickenside markings. Resting on this wall is a seam of quartz and slate breccia cemented by a porphyritic ground mass. The remaining portion of the vein consists of dark schists containing irregular lenses of vein quartz, the whole occupying a width of 25 feet between walls, but does not contain pay ore in any part, truly a rather disappointing showing after so much expense. On drifting to the south, however, pay ore was found in the foot wall portion of the vein.

On reference to Plate No. I it will be seen that this main vein was cut in the exact position that the prolongation of the dip from the surface workings on the Highlander vein would indicate; therefore it was assumed to be the Highlander vein; but considering the 900 feet of unexplored ground between this tunnel and the surface workings on the Highlander, it must be freely admitted that it is simply a matter of conjecture. A basic dyke four feet in thickness cuts almost vertically through the vein on the tunnel horizon, as shown in Plates I and II.

The hanging wall streak of this composite lode is continuous quartz that has been drifted on northerly for about 80 feet, showing a fairly regular seam (averaging 30 inches thick) of white and blocky quartz, but devoid of mineral.

Crossing these quartz lenses in the tunnel, at about right angles to the dip, is a sheeted zone showing four open fissures, varying from 0·5 to 4 inches in width, as seen on the line of the main tunnel; giving a basis for the impression that this portion of the vein has an easterly dip. Passing westerly along the main tunnel, the mica schists become harder, more silicified, and various breaks or open fissures occur between the hanging wall of the Highlander vein and the face of the main tunnel, a distance of 1,014 feet.

On account of poor ventilation and the amount of water that was issuing from the joints and fissures, I found it impossible to examine carefully the rock structure between the Highlander vein and the face of the tunnel. One large fissure was, however, encountered said to contain mostly loose calcite, which burst out several times in the tunnel but was timbered up closely at the time of my examination.

At the present face of the tunnel, 1,014 feet from the hanging wall of the Highlander vein, another vein was encountered with a strike north 50 degrees west, and dip 25 degrees westerly. This has been opened up on both sides of the tunnel for a total distance of 50 feet, and consists of an irregular quartz lens varying from 2 inches up to 15 inches in thickness, showing some very pale iron pyrites with a little siderite and calcite, a clay gouge of about 6 inches and a hanging wall of mica schist. This point is 2,610 feet from the portal of the tunnel and about 1,400 feet, vertical below the surface of the mountain. The vein conforms, as far as can be seen, with the strike and dip of the schists, and while the showing is very poor, there is a possibility that drifting on the strike of the vein might open up some pockets of pay ore. Work, however, had been suspended in this place for some time prior to my examination.

The last 300 feet in the main tunnel is a poor piece of work, crooked, and at extremely bad grade, but on account of the numerous slips and open fissures that have been encountered, all of which are discharging considerable water, it was doubtless an expensive and rather difficult place to operate.

Returning now to the point where the Highlander vein was intersected (1,560 feet from the portal of the tunnel) a drift extends southerly along the foot wall; while the vein was entirely barren where intersected, some blende was discovered at about 50 feet south of the tunnel and continued for 100 feet in length; then 50 feet of barren vein came in, followed by about 150 feet of vein matter, averaging about 5 feet in width and containing about 2 feet of pay streak, showing zinc blende and galena. Sample No. 51 was taken across the pay streak 320 feet south of the tunnel, and gave the following result: silver 4 ozs., lead 21·8 per cent, zinc, 7·2 per cent; width sampled 2 feet. At 400 feet south a winze had been sunk 52 feet, the vein having here a dip of 45 degrees to the west and varying from 6 to 12 feet wide. At the collar of the winze there is a very good bunch of galena which carried down nearly 2 feet wide of pay streak, following the hanging wall, for a distance of 30 feet along the winze, and from 18 inches to 24 inches of mixed zinc blende and gangue resting on the foot wall.

The vein here shows a banded structure with a large development of calcite as vein filling, together with siderite and schist; the hanging wall is very smooth and regular, next to it a 6-inch clay gouge occurs, the whole formation presenting the general appearance of a bedded deposit. A drift has been advanced about 40 feet northerly from the bottom of the winze and in places this shows quite a mass of porphyry and zinc blende fragments, encrusted with siderite and zinc blende in alternating layers. The galena in the vein rather favours a calcite gangue, makes near the hanging wall gouge, and invariably contains a sprinkling of chalcopyrite.

The general order of mineral deposition around the porphyry breccia is first a film of siderite; then zinc blende, third siderite, and fourth zinc blende as a very thin outer coating of the fragments, and beyond that the siderite ground-mass cements everything solidly.

Thirty feet south of the winze on the main level, a raise has been put up about 200 feet, which, for the first 60 feet shows a very fair vein with a pay streak, varying from 18 inches to 24 inches of blende and galena, the siderite and calcite gangue being very similar to that seen in the winze below, but the galena is less plentiful. Sample No. 52 was taken across this vein in two cuts, for a width of 18 inches, about 30 feet above the level. It assayed: silver 1·9 ozs., lead nil, zinc 13·9 per cent. The main level extends on the vein 300 feet southerly from the winze, for the last 200 feet of which the lode becomes hard and unproductive, the face of the drift showing a porphyry structure, and it looks as if at this place a grey porphyry dyke occupied part of the vein.

Two cross-cuts have been driven into the hanging wall of the vein between the main cross-cut tunnel and the face of the southern drift, without showing up any mineralization, but the foot wall portion, as opened on this level for a distance of 350 feet, shows an extremely well mineralized deposit with a pay streak that would average about 2 feet wide of a composition similar to that indicated in the samples above referred to, both of which were taken from two cuts across the vein. The best showing is in the bottom of the level but owing to the wet nature of the country and the prevalence of fissures in this rather open vein structure, mining below the level will, no doubt, be hazardous and expensive. A tunnel can be brought in 320 feet deeper, but it will necessitate driving about 2,800 feet and would not be warranted without considerable further development on the vein and the opening up of large quantities of pay ores.

The water is pumped from the winze and the ore hoisted by compressed air delivered from the Taylor Air Compressing Plant situated on Coffee creek about two miles south of the mine. There is no opening to surface except the main tunnel; the only ventilation in the mine is that supplied by the compressed air, which is insufficient, as carbonic acid is very prevalent, and in many of the workings a candle will scarcely burn.

Although there are 900 feet of backs above the tunnel level available for stoping no prospect raises have been put up, except the one described. One or more raises should be pushed through to surface, as in such a strong vein there is every probability of good shoots of pay ore being found above the tunnel level.

It is interesting to note a comparatively flat deposit, conforming to the planes of schistosity of the enclosing rock, which continues so regular and strong at a depth of nearly 1,000 feet from surface, and under such a mass of superincumbent rock.

The appearance of the Highlander vein in places would suggest that a small stratum of limestone had been in part replaced by ore, and the solution and recrystallization of the limestone had resulted in considerable settling of the hanging wall and general rock movement adjacent to the vein. There is also evidence that in various places a porphyry dyke occurs within the vein.

The Highlander property has the appearance of having had far too much money squandered on the main tunnel, in search of elusive veins at great depth, to the neglect of the large veins, which is really a first-class prospect and deserving of thorough development.

The Highlander tunnel is connected by wire tram with a concentration mill on the shore of the Kootenay lake. The tram serves to transport both the milling and hand-sorted ore, and the latter, together with the concentrates, is shipped in barges from the mill. This mill was not examined as it has not been operated for some time. The management was, at the time of my visit, figuring on shipping the crude ore in bulk to the smelter, after a preparatory hand sorting, and in this way securing the benefit in a smelter rate from the carbonate of iron and lime that the ore contains, and saving the loss incident to concentration. Though the freight and smelting charge must be necessarily higher than the combined rate on concentrates, yet, the management considers the bulk shipments more profitable. Considering the low tenor of the ore and its intimate association with the gangue, the experiment does not appear very favourably to me."

Tariff.

Situation. The Tariff mineral claim has an elevation of about 2,050 feet above sea-level or 290 feet above Kootenay lake, and is situated about one mile south of Ainsworth with which it is connected by a wagon road and trail.

Geology. The rocks met with in the Tariff mine consist of mica schists, quartzites of the Josephine formation, and gneissic granite cut by lamprophyre dykes from 4 to 6 feet wide.

Fissure System and Ore-bodies. The Highlander tunnel which intersects the Tariff vein at depth was inaccessible on account of foul air and the lower workings of the Tariff were unsafe and the following description is quoted from Ingall[1] who thoroughly explored the mine workings in 1905.

"The so-called Tariff vein, where intersected in the Highlander tunnel, is simply a clay gouge with an inclination varying from 10 degrees to 30 degrees westerly. The vein, as followed in the south drift, varies from merely a clay parting up to a couple of feet in thickness of quartz and calcite. Near the end of the drift a cross-cut was pushed into the foot wall 80 feet, and a drift was advanced 20 feet southerly on a small veinlet, showing a sprinkling of blende and galena near the face. Generally speaking one would scarcely recognize anything in this drift as an important mineral vein. It is practically an irregular series of small quartz lenses conforming to the planes of schistosity, containing in places some calcite and a little clay gouge. Practically, there is no mineralization in the vein at this depth, and as no connection has been made with the Tariff workings at surface there is nothing to show that it is the same vein, though the probabilities are strongly in favour of its being so.

The main workings on the Tariff vein consist of an incline-shaft, 175 feet vertically above the Highlander tunnel (aneroid reading). Passing down this incline everything is stoped out from the first level to surface.

On the second level the vein has a strike of north 20 degrees west and the dip from surface to this level is 25 degrees westerly. The level extends from 250 feet, and the ground has been fairly well stoped out on either side

[1]Report of the Commission to investigate the zinc resources of British Columbia, Department of Mines, Mine Branch, 1906.

of the shaft. The vein is regular in strike and dip and is stoped to a width of about 3 feet, the workings in places reaching 5 feet in width. The vein occurs in mica schist and is conformable with the planes of schistosity; the hanging wall is extremely smooth and regular.

On the third level a cross-cut east, behind the shaft, passes through the foot wall and opens up a parallel vein, 50 feet distant from the main vein, on which about 250 feet of drifting was done. I could not detect any particular values in the north drift, but the southern one showed some zinc near the face.

Passing south from the incline-shaft on this level I found the stoping had not been carried below the floor. The vein there is practically all quartz, showing a little disseminated pyrites. In the southern face of the stopes it consists of 2 feet of quartz on the foot, and close to the hanging wall a 1-inch seam of fine grained blende carrying galena in fine specks.

The face of the drift 10 feet farther south shows quartz and schist only, for a width of 2 feet, and is barren of pay mineral. In the north end of this stope, 30 feet north from the face of the drift, the vein shows for a width of 30 inches. Next the hanging wall there is 1 inch of blende, then 2 inches of quartz followed by 9 inches of fairly solid blende (containing, however, some quartz breccia), and below that 18 inches of quartz and schist with a little blende distributed through the joints and cleavage plains. This ore, however, does not continue for any considerable distance along the level, inasmuch as at a point 10 feet farther north the vein is apparently filled with quartz for a width of 3 feet and shows no appreciable mineralization.

Descending to the next level, which extends north only, or in the opposite direction to the last, considerable stoping has been done, and in one place a winze has been put down and a small stope opened below the level. Practically, however, this level forms the bottom of the northern stopes, just as the level above forms the bottom of the southern ones. This north level for the greater part of the distance consists of quartz and calcite, the former predominating. I could detect but little mineralization at any point. At this level a short drift extends southerly, showing a vein about 2½ feet wide, mostly quartz but not containing any pay minerals. A winze was started in the floor of the level and sunk 5 feet, showing a fair vein of quartz and calcite but no pay minerals. The shaft extends at least 50 feet below this level at which point water was encountered. The level previously described has been recently under water and was smeared with mud and very difficult to examine. There was no one present to represent the owner of this property, which has been abandoned for several years, and the workings were scarcely safe, but having been informed there was considerable zinc showing in the old workings, I ventured to make the examination without a guide.

Judging from the stopes, the vein so far as developed, contained one good shoot of galena together with a little blende, near the surface; which has been to all intents and purposes stoped out to the extreme boundaries of the shoot, and in depth, so far as any pay ore could be followed. Other shoots may, however, be found by development on the strike of the vein to the south.

It is evident that the ore shoot splits in depth in two prongs, and the ore becomes more siliceous; quartz predominates and little, if any galena or blende can be noticed in the lowest workings. This fact, taken in connection with the showing made on the drift from the Highlander tunnel augurs badly for a profitable exploration of this vein in depth. The easterly vein reached by a cross-cut from the incline-shaft has the best showing at that depth, and the few traces of ore found in the workings from the Highlander tunnel also occur in this easterly vein, at least the probabilities are such; for, as previously stated, neither vein has been connected between this tunnel horizon and the old workings above."

Replacement Deposits in Limestone.

NO. I MINERALIZED ZONE.

One of the most important mineralized zones in the Ainsworth camp is the upper contact of the Silver Hoard formation (No. 1 limestone member) with the overlying glossy black argillites of the Skyline formation. This zone strikes almost north and south and conforms to the dip of the surrounding sedimentary rocks, that is, in a general way, about 45 degrees to the west. It passes through the No. 1, Silver Hoard, Crown, and Gallagher claims and extends south to the Nelson granite west of the Neosha mineral claim and north beyond the limits of the Ainsworth map-area. No mineralization was seen north of the Gallagher claim, or south of the No. 1, but this extension north and south of the above limits is worthy of attention. The mineralized zone is marked at the surface by the presence of iron oxide which usually runs high in silver and since the outcrop is soft and easily eroded, it usually lies in a slight depression filled with drift.

No. 1 Mine.

Situation. The No. 1 mine is situated 6 miles from Ainsworth at an elevation of 4,200 feet above sea-level or 2,440 feet above Kootenay lake.

Geology. The No. 1 ore-bodies occur in the No. 1 limestone, the youngest member of the Silver Hoard formation of Carboniferous age. The limestone is a dense white, crystalline variety which is very like a marble in appearance. It occurs in beds from 3 inches to 8 inches thick with a general dip to the west, although minor folds and overturned folds occur occasionally (Figure 5). This limestone is overlaid conformably by black argillites of the Skyline formation. The argillites are glossy black in colour and somewhat sheared. No igneous rocks were seen in the immediate neighbourhood of the mine, but a small intrusion of gneissic granite occurs just west of the mine buildings.

Mineralogy. The ore consists of a dark brown, decomposed mass consisting mainly of iron oxide, some lead carbonates, and wire silver. In places sulphide ore is visible and shows the presence of galena and zinc blende with some pyrite and chalcopyrite. The gangue is chiefly silicified and altered limestone which sometimes shows traces of the sulphides of lead and zinc. The limestone when occurring in the ore shows the development of quartz crystals in cavities. The metallic sulphides often penetrate into the limestone of the foot-wall as minute stringers and replacement masses, but in no case were any cross veins seen which might represent the avenues through which the ore solutions passed.

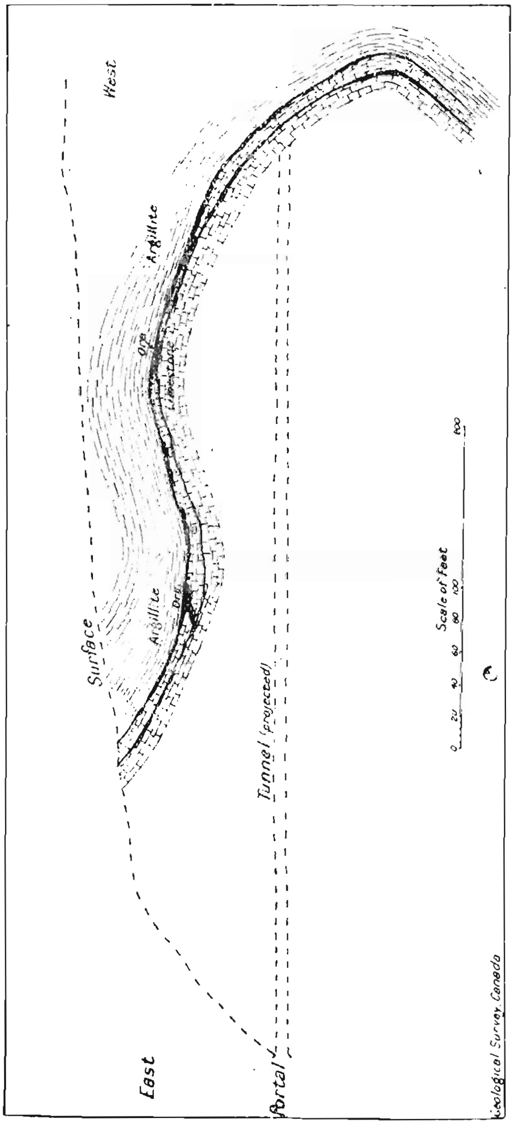


Figure 5. Diagrammatic cross-section (east-west) through No. 1 mine, Ainsworth, B.C.

Ore-bodies. From the accompanying diagrammatic cross-section (Figure 5) it can be seen that the ore-bodies occur as replacement deposits in crystalline limestone, near or at its upper contact with the overlying black argillites. The ore zones are two in number, one along the upper contact of the limestone and the other from 7 to 20 feet from this contact, in the limestone. Numerous interlacing stringers unite these ore zones, thus giving rise to a great many horsts of limestone. This arrangement of the ore-bodies taken in connexion with the structure gave the impression at first sight of a very complicated system of ore-bodies.

Structure. The structure at No. 1 mine is simple on the whole. The ore zones follow the bedding planes of the limestone which the ore replaces and hence, as shown in Figure 5, occur in the form of synclines and of an overturned fold. The point of the overturn which occurs between the first and second levels in the southern part of the mine plunges to the north, so that in the northern end of the property the overturn is found between the second and third levels. This explains the fact that as one goes from the southern end of the property to the northern end on the first level, the deposit dips to the east, then becomes vertical, and in the northern end dips to the west. The deposit on the third level is almost vertical with a slight dip to the east in the northern end of the mine, but since the whole sedimentary series at Ainsworth dips to the west, it is very probable the limestone-argillite contact will be found to have a westerly dip at no great depth. Additional support is given to this surmise by the fact that in the extreme southern end of the third level the contact has a dip of 85 degrees to the west.

An analysis of No. 1 ore furnished by the Canadian Mining and Smelting Company is as follows:

Moisture	6·5
Au	Trace
Ag	8·7–23·+
Pb	Trace
Fe	5
SiO_2	23·8
Al_2O_3	7·7
CaO	29·0
S	1·8
Zn	2·4

Silver Hoard.

Situation. The Silver Hoard mine is situated 7 miles by wagon road in a northwesterly direction from Ainsworth, at an elevation of 4,300 feet above sea-level or 2,540 feet above Kootenay lake.

Geology. The Silver Hoard ore-bodies occur on No. 1 mineralized zone. The limestone (No. 1 limestone) is a dense, whitish grey variety in beds from 6 to 8 inches thick, dipping in general about 45 degrees to the west but exhibiting minor synclines and overturned folds. The limestone is overlain conformably by the glossy black argillites of the Skyline formation. No igneous rocks were found in the vicinity of the mine.

Mineralogy. The ore consists of a mixture of coarse galena and zinc blende with minor amounts of pyrite and chalcopyrite. Native silver occurs in cracks in the ore and in the limestone in the immediate vicinity of the ore and, as wire silver, in the small cavities. The gangue consists mainly of green fluorite with minor amounts of calcite. Small pieces of silicified limestone occur in the ore-bodies. The ore and gangue in many places penetrate by means of fissures into the foot-wall as minute stringers and small replacement masses. No cross veins which might represent the avenues through which the mineralizing solutions passed, were detected in the workings.

Ore-bodies. The ore-bodies occur as replacement deposits in the No. 1 limestone at and near its contact with the overlying black argillites and like others which occur as replacement deposits in limestones are irregular in character. The ore occurs in two distinct zones in the No. 1 limestone, the upper zone occurring at the contact with the black argillites and the lower occupying a position in the limestone foot-wall from a few feet to 25 feet below the upper horizon. No oxidized ore was seen at the time of the writer's visit, but Dawson[1] states that at the time of his visit in 1889, the outcrop of the ore-bodies was almost completely decomposed, resembling the ore of the No. 1 mine. He states also that he was informed that shipments from this oxidized ore ran 105 ounces in silver. The normal unoxidized ore runs about 20 ounces in silver to the ton.

Structure. The structure of the Silver Hoard deposit is identical with that of the No. 1 (Figure 5). The ore zones dip to the west from the surface to the 100-foot level where a shallow syncline occurs which passes into an open anticline. Between the 100-foot level and the 200-foot level, the ore zones change from a westerly to an easterly dip. Below the 200-foot level no information as to the structure is available, but it is probable the ore zones follow the folding of the rocks which, on the whole, dip at an angle of 45 degrees to the west.

Crown.

Location. The Crown mineral claim occurs on the No. 1 mineralized zone halfway between the Silver Hoard and the Gallagher. The portal of the tunnel has an elevation of approximately 4,425 feet above sea-level or 2,665 feet above Ainsworth. It is reached by a trail from the Silver Hoard mine.

Geology. The mineralized zone (Map 1791) occurs at the upper contact of the No. 1 limestone with the overlying black, glossy argillites of the Skyline formation. The present workings have not explored the mineralized zone to any extent, the main tunnel having been driven past the zone into the black, glossy argillites which are generally barren in the Ainsworth area.

Ore. The ore consists of a brown, earthy, decomposed mass which in appearance resembles that of the No. 1 mine, but the values in the Crown mineralized zone are unknown. In the development of the property, this mineralized zone (Map 1791) should receive first attention.

Gallagher.

Situation. The lower tunnel of the Gallagher is 3,925 feet above sea-level or 2,165 feet above Kootenay lake and from the portal a trail leads to the Highland-Ainsworth wagon road.

Geology. The ore-bodies of the Gallagher are situated in the No. 1 limestone of the Silver Hoard formation which in this locality is folded into

[1]Dawson, G. M., Geol. Surv., Can., Ann. Rept. 1888-89, p. 52B.

a structure similar to that shown in the No. 1 mine (Figure 5). This structure can be seen in the raise from the main tunnel (1916). The workings are entirely in the No. 1 limestone.

Mineralogy. The ore being mined at the time of the writer's visit consisted of oxidized earthy ore which is reported to run high in silver. In the report of the Minister of Mines, British Columbia, for 1889, an assay is given which shows this earthy carbonate to run 280 ounces to the ton in silver, for 95 tons shipped to the smelter.

Ore-bodies. The ore-bodies which at present constitute the Gallagher mine consist of irregular replacement deposits in the No. 1 limestone. These bodies are spaced irregularly and no systematic arrangement was observed. From studies of the No. 1 mineralized belt it is evident that the main mineralization occurs in the No. 1 limestone near its contact with the overlying black argillites. The development work on the Gallagher has not explored this contact and if further development work is considered, the most likely place to find ore is at the above-mentioned contact.

Production. The production in 1915 was 13 tons; and in 1917, 31 tons.

OTHER PROPERTIES.

Star and Sunlight.

Situation. The Star and Sunlight claims are situated east of the No. 1 mine. The lower tunnel on these properties has an elevation of 3,536 feet above sea-level or 1,776 feet above Kootenay lake. A road, now difficult to follow, leaves the Ainsworth No. 1 mine wagon road above the United claim and reaches the Star shaft and cabins.

Geology. The geology of the claims is given in detail (Map 1787) in order to show the lithology of the Star limestone, the gradational contacts of the Star limestone which is characteristic of the limestone formations, and the structural features of the gneissic granite. All the rocks dip from 25 degrees to 40 degrees to the west and strike approximately north and south.

Ore-bodies. The unsafe condition of the shaft where the ore was extracted prevented an examination of the ore-bodies or the ore. It is reported[1] that the ore consisted of galena and lead carbonates with very little zinc.

Workings. The workings consist of a number of open pits, a shaft, an incline, and two tunnels. The lower tunnel has been driven (Map 1787) for a distance of about 800 feet, but no vein nor ore-body of any value was struck.

Tiger.

Situation. The Tiger claim is situated on the south slope of Cedar creek at an elevation of 3,450 feet above sea-level or 1,690 feet above Kootenay lake. It can be reached by trail either from the Highland or from the lower tunnel of the Star.

[1]Report of the Commission appointed to investigate the zinc resources of British Columbia.

Geology. The deposit occurs in the lower part of the Star limestone in the horizon represented in the lower Star tunnel (Map 1787). The rocks consist of staurolite or andalusite schist and whitish grey crystalline limestone. The rocks strike almost north and south with a dip of 50 degrees to the east. In the long cross-cut tunnel chiefly staurolite schist with small bands of limestone occur. In the upper workings an anticline was noted which showed the ore occurring in the limestone at the contact with the overlying schist. Evidently, as in the majority of the replacement deposits, this contact, as well as the limestone in the immediate vicinity of the contact, is the most promising place for the formation of ore-bodies.

Ore. The ore consists of coarse-grained galena which occurs as crystals in the open spaces in the vein, showing the cube and octahedron faces. Some zinc blende and a little pyrite which is sometimes copper-bearing complete the mineralogy of the ore. The gangue is quartz and silicified limestone.

Ore-bodies. The ore occurs as replacement bodies either in the limestone itself or at the upper contact of the limestone with overlying staurolite schist.

Ayesha.

Situation. The Ayesha mineral claim is situated on Cedar creek about 3,500 feet above sea-level or 1,740 feet above Kootenay lake and can be reached by a trail from the Highland wagon road up Cedar creek.

Geology. The rocks exposed in the Ayesha consist mainly of limestone with bands of staurolite or andalusite schist. The horizon is probably near the base of the Star limestone. These rocks strike north and south with a dip of 45 degrees to the west.

Fissure System. Two fissures (Map 1788) are exposed on the Ayesha with a general northwest trend and dipping southwest at angles of from 60 to 65 degrees. Along each fissure there is a horizontal displacement of 15 and 20 feet, the northern wall of the fissure being displaced to the west in each case. The fissures are identical in character with the fissures described in a previous paragraph, both in the strike and dip and in the character of the displacement along the fissures. The mineralogy of the fissure veins and the replacement deposits is similar even to the proportion of silver to the lead in the galena. The above evidence supports the conclusion that the fissure veins and the replacement deposits are contemporaneous in origin.

Ore. The ore consists of coarse-grained galena with small amounts of zinc blende and pyrite. The gangue is calcite and quartz.

Ore-bodies. The ore is a replacement deposit in limestone at its upper contact with the schist and hence conforms in dip and strike with the limestone. Ore occurs in each of the fissures, especially in that portion which joins the two replacement bodies.

Workings. The deposit is opened up by three shallow shafts and by open-cuts. The tunnels, one of which is on the Anna May, were not driven far enough to reach the ore-bearing horizon.

Krao.

Situation. The Krao is situated on the wagon road from Ainsworth to the No. 1 mine, at an elevation of 3,250 feet above sea-level or 1,490 feet above Kootenay lake.

Geology. The rocks outcropping on the Krao claim belong to the Josephine formation and consist of hornblende schists, coarsely crystalline limestone, the most important member, and banded quartzites all striking approximately north and south with a dip of about 45 degrees to the west.

Ore-bodies. At the time of the writer's visit (1915) the shaft was filled with water and the workings inaccessible. The following description of the Krao is taken from the Report of the Commission to investigate the zinc resources of British Columbia 1906, page 163.

"At the Krao mine the limestone exhibits a sheeted structure and there is probably a fault running parallel with the creek at this point, but no evidence of it could be detected other than the continuous sharp depression, as previously noted. In the sheeted zone at the Krao the limestone is impregnated with galena and some blende, siderite often filling the fissures while the circulating waters have dissolved irregular pipe-like cavities in the limestone, which have later become lined with mineral, chiefly galena, next to the limestone, with an outer coating of blende and siderite. The deposit has been stripped at surface for a width of about 60 feet and a length of 150 feet, and 6,858 tons averaging 22 ozs. silver, 12 per cent lead, and 8 per cent zinc had been quarried out, hand sorted, and shipped to the smelters prior to October 31, 1905. The ore apparently runs fairly well in silver, and wire silver is a common occurrence in the cavities and joint planes within the mineralized area.

Three men were at work shooting out the ledge for a width of about 30 feet, sorting it over and sacking the sorted ore for shipment. The open-cut had reached a depth of about 12 feet. The fissure near the hanging-wall appears to be the larger of the group, and contains considerable iron oxide resulting from the decomposition of the originally contained ores, in fact all the sheeting planes near the surface, and many of the vugs and pipes, are filled with this oxidized material in which rich silver ore and wire silver are very often found.

A shaft was sunk on the hanging near the main fissure to a depth, I am informed, exceeding 100 feet, but at the time of my visit the water level was reached at 35 feet at which point a cross-cut extended about 10 feet into the sheeted zone, exposing a mass of white crystalline limestone penetrated by numerous irregular tubes and vugs, lined with galena and siderite (Plate XIII, Figure 2). The galena has also penetrated the crystalline limestone for some distance from those tubes and vugs and from the fissures in its mass (Plate XIII, Figure 1). The vein was exposed at this depth for a length of about 30 feet, extending for a short distance on either side of the shaft. The northern face exhibited a very rich appearance owing to the good showing of galena, while the south side was much poorer in galena and more quartzose. The shearing has a strike of north 45 degrees west and a westerly dip of about 80 degrees. I should judge from the hardness of the limestone that it was somewhat silicified by the ore-bearing solutions which circulated within it.

This property presents, on a small scale, the same phenomena as the Blue Bell property on the east side of Kootenay lake, very little development has been carried out, and one can only class it to-day as a very promising prospect, in which development in depth may prove up good payable ore deposits."

Workings. Since the report of the Commission was published, a long tunnel has been driven through the Crow-Fledgling mineral claim to intersect the Krao limestone with its possible ore-bodies. The tunnel has an elevation of 3,060 feet (barometric) above sea-level and passes through the following rocks in the first 850 feet of its course starting from the portal. The remainder of the tunnel, which is the most important part from an economic viewpoint, was inaccessible on account of foul air.

	Feet.
Banded quartzites	350
Vein (small amounts of galena)	3 wide.
Banded quartzites	185
Crystalline limestone	45
Quartzites	60
Crystalline limestone	2
Banded quartzites	215
Remainder	inaccessible.

Buckeye.

Situation. The Buckeye mineral claim adjoins the Josephine on the north. It is connected with the Highland wagon road by a good trail. The elevation of the main tunnel is 3,540 feet above sea-level or 1,780 feet above Ainsworth.

Geology. The ore deposit proper occurs in the Star limestone which in this locality is quite siliceous, the weathered surface being characterized by the presence of sand. This limestone is underlain by a dark grey andalusite mica schist which is exposed in the lower tunnel of the Buckeye. Underneath this schist occurs the platy quartzites which were exposed in the extreme northern face of the first level of the Highland mine. The Star limestone is overlain by another belt of andalusite mica schist.

Ore-bodies. The ore-bodies occur as replacement deposits in the Star limestone and are irregular in their boundaries. The replacement bodies are associated with a fissure vein which strikes north 40 degrees west and dips 70 degrees to the south. The amount of movement along the fissure could not be ascertained.

The ore consists of pyrite, zinc blende, and galena in a gangue of silicified limestone, calcite, and quartz.

Workings. As the old shafts and tunnel were inaccessible the following description of the conditions of this deposit in 1905 may be of interest.[1]

"Development work on the Buckeye consists of two inclined shafts 100 feet apart, each about 40 feet deep, and one tunnel 200 feet long driven in under the shafts. The surface showing of zinc ore is considerable, but the work done does not seem to have been carried sufficiently far to expose the ore at depth. The two shafts are located on a northeast and southwest

[1]Report of the Commission appointed to investigate the zinc resources of British Columbia, Dept. of Mines, Mines Branch, 1906.

line, while the tend of the vein appears to be more north and south. There was too much water in both shafts to permit examination of the bottom. To the south of the first one a distinct mineralization is visible on the surface. The second shaft was started outside of the vein, with a view to intersecting it at a depth of about 70 feet, but it was never sunk to that depth.

The tunnel, which is about 75 feet below the surface showings, was driven as a cross-cut for 70 feet. At that point a body of zinkiferous ore has been intersected and followed for 45 feet. The ore-body only shows in the roof and has not been raised upon. Drifting in the tunnel was continued for an additional 150 feet through country rock, when a second shoot of zinky ore was encountered at the breast, where it can be seen. This exposure appears to correspond with the principal surface showings and seems worthy of attention. In order to learn its extensions the tunnel should be continued. The work was evidently left immediately after ore was broken into, as it was considered of no value by the owners, who at that time were looking for clean silver-lead ore, and not for a matrix of zinc and iron ore with more or less galena mixed through it. A sample of the face (top and bottom), taken on the vein for width of 18 inches assayed 23 per cent zinc, but carries less than 1 oz. silver to the top."

A lower tunnel to tap the ore-bodies at depth has been driven at an elevation of 3,540 feet, or 100 feet below the outcrop. The tunnel penetrated the andalusite schists but did not reach the Star limestone which contains the ore-bodies. In 1918 preparations were under way to continue the first level of the Highland mine to reach the Buckeye ore-bodies.

CHAPTER VII.

PHYSIOGRAPHY.

ORIGIN OF THE PURCELL TRENCH.

(Kootenay Lake Valley.)

SUMMARY.

(I). Orogenic movements first affected the Selkirk range in southern British Columbia in the late Jurassic period.

(II). The first granodiorite intrusion of the West Kootenay (Nelson) batholith took place in the late Jurassic period.

(III). The batholith was unroofed in the Upper Blairmore time.

(IV). The upland surface of the present Selkirk range was formed by erosion during the period from late Jurassic to early Tertiary. This period of erosion was brought to a close by the Laramide orogenic movements which built the Rocky mountains and raised the upland surface of the Selkirk range almost to its present height.

(V). The Purcell trench and similar master valleys of the Selkirk range were cut into this upland surface during the Tertiary and Quaternary periods and hence are antecedent river valleys.

GEOGRAPHY.

Every one who crosses the Canadian Cordillera by way of the Crowsnest pass or the southern route is struck by the beauty and even north-south continuity of the great longitudinal valleys or trenches. In east to west order the trenches are: the Rocky Mountain trench (Kootenay River valley) separating the Rocky mountains on the east from the Selkirk mountains on the west; the Purcell trench (Kootenay Lake valley); the Selkirk valley (Columbia River valley); the Okanagan Lake valley; and the Fraser River valley (Figure 2).

The Purcell trench is situated in the Selkirk mountains[1] and crosses the International Boundary line at longitude 116 degrees 30 minutes (Figure 2). It extends from the boundary in a northwesterly direction and joins the Selkirk trench at the northern end of Upper Arrow lake, a drowned portion of the valley of the south-flowing Columbia river. Daly[2] considers the valleys of the Duncan and Beaver rivers to be the northern extension of the Purcell trench, whereas the writer considers the northern portion of the trench to be the valley occupied by Lardo river, Trout lake, and Beaton creek which flows into Upper Arrow lake and thus joins Selkirk valley and Purcell trench.

[1]Nomenclature of the mountains of western Canada: Geographic Board of Canada, April 2, 1918.
[2]Daly, R. A., Geol. Surv., Can., Mem. 38, 1912, p. 26.

The following facts support the change in the delineation of the Purcell trench:

The Purcell trench is a valley formed by an antecedent river and the valley occupied by Lardo river, Trout lake, and Beaton creek is of similar origin.

The valley of Duncan river parallels the strike of the rocks and is probably a subsequent river.

Kootenay lake occupies the central portion of the trench and is drained from a point near its centre by the west-flowing Kootenay river which empties into Columbia river. The southern portion of the trench is occupied by the north-flowing Kootenay river.

TOPOGRAPHY.

In a view from one of the higher peaks of the Selkirk range, the most striking feature is the series of almost unbroken ridges, having an approximate elevation of 7,000 feet. The ridges trend in all directions without relation to the underlying structure and evidently represent the remnants of an uplifted and dissected peneplain. Numerous peaks having elevations of from 8,000 to 9,000 feet project above this old land surface and great valleys have been carved to a depth of 6,000 feet below it. The ridges form convenient highways for exploration once this upland surface is reached. In marked contrast to those of the Selkirk mountains, the ridges of the Rocky mountains to the east have remarkably constant northwest trend and have a direct relationship to the structure of that system, in that they are great northwesterly-trending fault blocks.

GEOLOGY.

The Purcell trench is carved in a series of sedimentary rocks ranging in age from Beltian to Carboniferous. This series is intruded by masses of granodiorite, offshoots of the west Kootenay batholith of Jurassic age (Plate II). The following is a condensed geological table:

Quaternary		Till, unconsolidated gravels and sands.
	Unconformity.	
Jurassic	West Kootenay (Nelson) batholith	
	Intrusive contact.	
Carboniferous	Slocan series (fossiliferous).	
Carboniferous or Pre-Carboniferous	Ainsworth series	Mainly quartzites, argillaceous quartzites, limestones and their metamorphosed equivalents.

STRUCTURE.

Viewing the geology of the whole trench as shown on Figure 6, it will be seen that the sedimentary series forms a huge and almost symmetrical bow, convex to the east. The general dip is almost everywhere towards the inside of the bow at an angle of about 45 degrees, so that in the northern part of the trench the rocks strike northwest with a dip to the southwest, bending gradually until in the middle part the strike is north-south with a dip to the west, and in the southern part southwest with a dip to the northwest. The granite masses, the eastern fringe of the west Kootenay-Nelson batholith, have had no effect on the general strike of the sedimentary series and it is seen that the Purcell trench is carved into the terrane without reference to its structure.

ORIGIN.

The origin of the Purcell trench has been described by Daly[1] in the following words: " The Rocky Mountain trench and the Purcell trench are likewise located on zones of profound faulting: in each case the constructional profiles may have been grabens as typical as that of the middle Rhine or that of the Dead sea ". The geology of the Purcell trench in the neighbourhood of the International Boundary line was worked out in greater detail by the writer in 1913 and it was found that the faults marked by Daly on the geological map as occurring on each side of the Purcell trench were not present and that the valley in this locality was not a graben[2]. The area was again examined in 1915 and these results were confirmed. In 1916 Drysdale[3] made an examination of the section in the neighbourhood of the International Boundary line and again confirmed these results. In 1915, the area in the vicinity of Procter on Kootenay lake was carefully examined for evidence of faulting. This locality was especially favourable for geological field work since the formations cross the lake almost at right angles. The formations were followed from the high mountains on the east side of the lake across Pilot point and into the mountains on the west side of the trench and a very persistent limestone band dipping northwest at an angle of 45 degrees was used as a horizon marker. A fault parallel to the trench would have offset this limestone band, but no evidence of a break was found. At the north end of the trench Bancroft has found no faults. From the above facts, it may be concluded with certainty that faulting played no part in the formation of the Purcell trench. In 1915, the writer stated his belief that the Selkirk mountains[4] were mountain-built for the first time at the close of the Jurassic. The facts on which the conclusion was based may be summarized as follows:

The present drainage bears no relation to the underlying structure.

The sediments of the Cretaceous in the neighbouring Rocky mountains to the east are, in part, made up of the products of the erosion of these Jurassic mountains.

The following table shows the succession of geological formations of the Rocky mountains in tabular form:

---

[1]Daly, R. A., Geol. Surv., Can., Mem. 38, pt. 2, 1912, p. 600.
[2]Schofield, S. J., Geol. Surv., Can., Sum. Rept., 1914, p. 41; Geol. Surv., Can., Mem. 76, 1915, p. 168.
[3]Drysdale, C. W., Geol. Surv., Can., Sum. Rept., 1916, p. 61.
[4]Schofield, S. J., Geol. Surv., Can., Mem. 76, 1915, pp. 160–169.

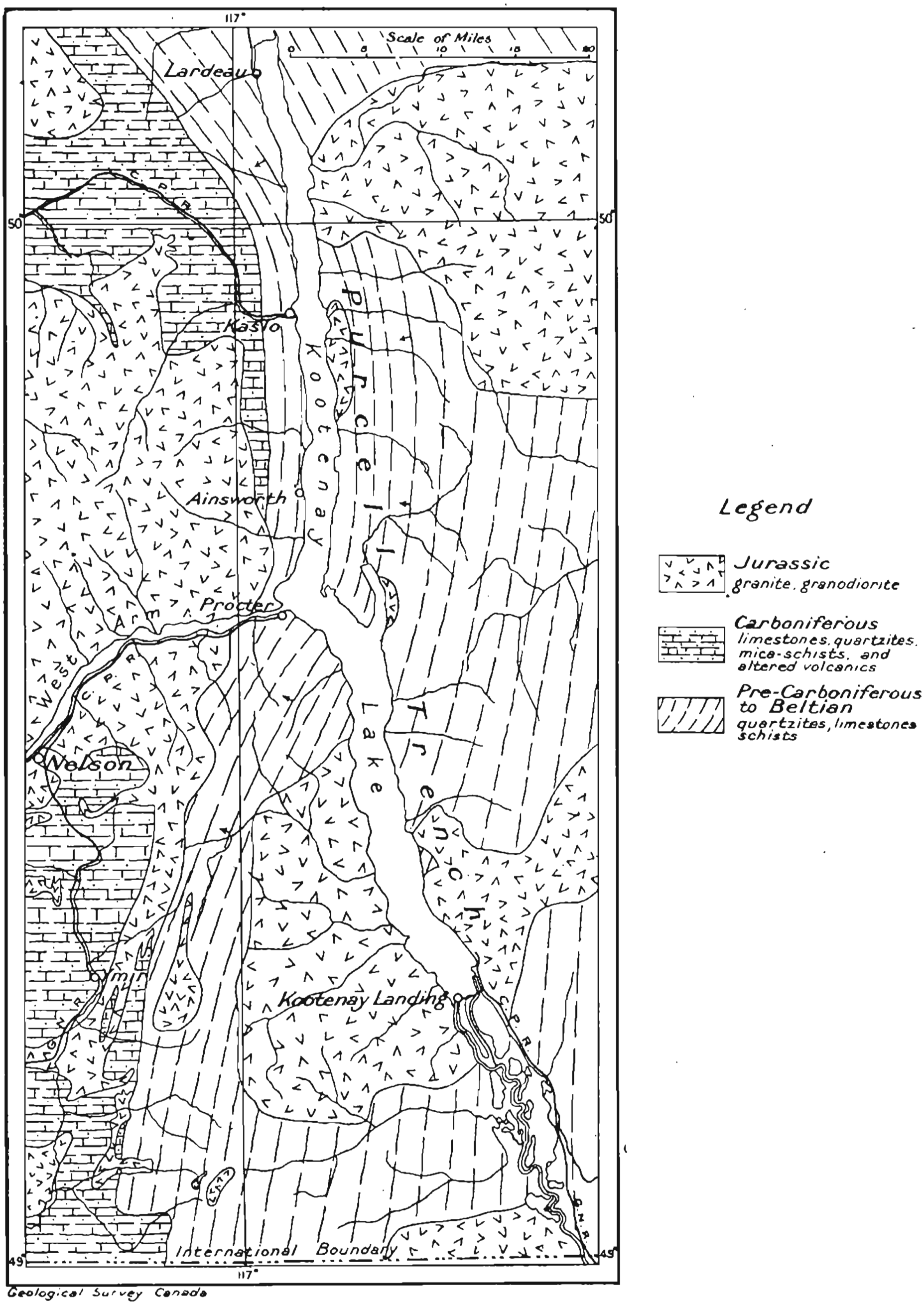


Figure 6. Diagram showing the geology of the Purcell trench.

Geological Formations of the Rocky Mountains.

Period.	Formation.	Condition of deposition.	Lithological character.
Tertiary	Paskapoo	Freshwater	Sandstones.
Upper Cretaceous	Edmonton	Brackish and freshwater	Sandstones and shales.
	Bearpaw	Marine	Shales.
	Belly River series	Brackish	Sandstones and shales.
	Colorado	Marine	Shales.
	Upper Blairmore	Subaerial	Sandstones, conglomerates (granite and chert pebbles.)
Lower Cretaceous	Lower Blairmore	Subaerial	Shales and conglomerates (quartzite and chert pebbles.)
	Kootenay	Subaerial	Sandstones and shales. Coal.
Upper Jurassic	Fernie shales	Marine	Shales.
Devonian and Carboniferous		Marine	Limestones and quartzites.
Lower Palæozoic		Marine	Limestones and shales.
	Disconformity.		
Pre-Cambrian (Beltian).	Purcell series Galton series	Continental	Mainly quartzites and argillaceous quartzites.

From an examination of the above table it will be noticed that conglomerates are first found in great amount at the base of the Lower Blairmore formation. The pebbles in these conglomerates consist of quartzites and chert derived from the quartzites of the Beltian rocks which make up the great part of the Selkirk range. Evidently in Lower Blairmore time the Selkirk range was approaching the maximum of elevation and was undergoing rapid erosion. The Upper Blairmore formation also consists of conglomerates and sandstones, but in it, in addition to pebbles of quartzite and chert, pebbles of granite occur for the first time and in great abundance. The presence of the granite pebbles at this horizon is interpreted to mean that the Nelson granite batholith which forms the core of the Selkirk range in southern British Columbia was unroofed and exposed to rapid erosion during Upper Blairmore time and furnished the pebbles for the conglomerate. Hence it is established that the first intrusion of granodiorite into the Selkirk range took place before the deposition of the Upper Cretaceous. The superposition of the marine Fernie shales upon the marine Devono-Carboniferous limestones suggests that the period of stability which prevailed throughout British Columbia until the Triassic was interrupted during the upper Jurassic period. The Selkirk mountains received their initial form probably at the close of the Jurassic or in early Kootenay time. If mountain-building and igneous intrusion are contemporaneous, it may be concluded that the first intrusion of granodiorite in the Selkirk range commenced towards the close of the Jurassic and continued until the mountain-building reached its maximum in Kootenay time.

Tabular History of Selkirk and Rocky Mountain Systems in Southern British Columbia.

Selkirk mountains.	Period.		Rocky mountains.
Uplift of peneplain	Eocene		*Orogenic movements* (Laramide Revolution).
Peneplanation	Tertiary	Paskapoo	Freshwater sedimentation.
		Edmonton	Brackish and freshwater sedimentation.
	Upper Cretaceous	Bearpaw	Marine sedimentation.
Late maturity (final) batholith unroofed		Belly River	Brackish sedimentation.
		Colorado	Marine sedimentation.
		Upper Blairmore	Subaerial sedimentation.
Early maturity	Lower Cretaceous	Lower Blairmore	Subaerial sedimentation.
Youth (initial)		Kootenay	Subaerial sedimentation.
Possible initiation of orogenic movements	Upper Jurassic		Marine sedimentation.
Stable marine condition	Devonian and Carboniferous		Marine sedimentation.
Stable marine condition	Lower Palæozoic		

In early Tertiary, the Laramide revolution took place, causing an uplift of the Selkirk mountains and the formation of the Rocky mountains. The effect of this uplift in the Selkirks was to slowly raise the old land surface formed during the Cretaceous almost to its present height, with the natural result that the streams which meandered over the old surface were rejuvenated and cut their present valleys into the old peneplain. As these streams bore no relation to the underlying structures, the valleys cut by their rejuvenated descendants, the present main valleys of the range, bear no relation to structure. Thus the main valleys of the Selkirk range have been carved during the Tertiary and Quaternary periods in a peneplain which was formed during the Cretaceous and early Tertiary periods. Such has been the origin of the Purcell trench which contains Kootenay lake.

PLATE II.

Looking south along the Purcell trench, delta of Lardo river in foreground. (Photograph by W. H. Boyd.) (Page 61)

INDEX.

A.

B.

C.

D.

E.

F.

G.

H.

I.

J.

K.

L.

M.

N.

O.

P.

Q.

R.

S.

T.

U.

W.

Z.