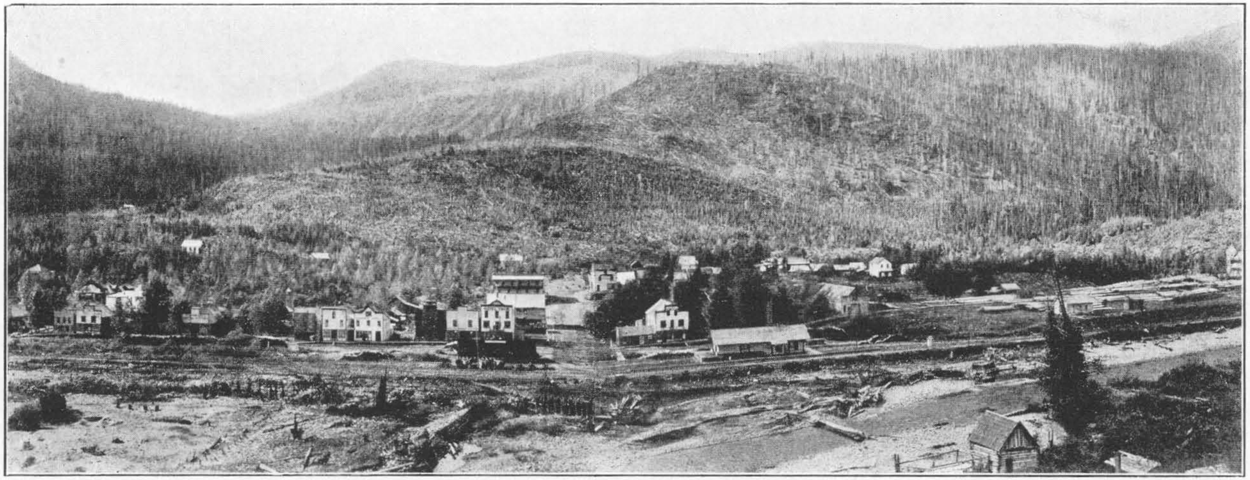
MEMOIR 94

YMIR MINING CAMP, BRITISH COLUMBIA

BY

CHARLES WALES DRYSDALE

PLATE I.



Town of Ymir, 1914. (Page 2.)

CANADA

DEPARTMENT OF MINES

HON. P. E. BLONDIN, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY

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Ymir Mining Camp, British Columbia

BY

Charles Wales Drysdale

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CONTENTS

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

ILLUSTRATIONS.

Ymir Mining Camp, British Columbia.

CHAPTER I.

INTRODUCTION.

GENERAL STATEMENT.

Ymir[1] gold camp forms a part of Nelson mining division of West Kootenay district, British Columbia. Of the eight divisions in West Kootenay district Nelson ranks third as a metal producer. West Kootenay district for the past two decades has been closely contesting with the Boundary district for the position of chief producer of metals in the province.[2] The total production of the two districts since 1894 exceeds \$200,000,000 of which more than \$127,000,000 is credited to West Kootenay. From 1905 to 1913 the Boundary district led in production and in 1906 exceeded by over \$500,000 the maximum production of West Kootenay district for any one year. Since 1913 the production of the Boundary district has fallen off and at present West Kootenay district leads the province in metal output.

Although Ymir is one of the oldest lode mining camps in British Columbia and the Ymir mine was at one time the largest gold mine in Canada, very little geological work has been done there since the investigations of McConnell in 1897.[3] The present report gives the results of later field work carried on during August and September, 1914.

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[1] In old Norse mythology the name Ymir was that of the progenitor of the giants who arose through the interworking of heat and cold in the primeval abyss. Ymir was slain by Odin and his brothers Vili and Vê and out of his body they created the world. Ymir's flesh became the land, his bones the mountains, his blood lakes and streams, his hair the forests, his skull the heavens, and his brains the clouds.

[2] For statistics of production see Reports of the British Columbia Bureau of Mines.

[3] Geol. Surv., Can., Sum. Rept., 1897, pp. 31–32 A.

FIELD WORK AND ACKNOWLEDGMENTS.

The area mapped is about 145 square miles in extent and includes the mineralized zones lying south of Hall, east of the crest of the Nelson (Quartzite) range, and north of Salmo. The west boundary of the area is 5 miles west of the Nelson and Fort Sheppard railway and includes the Fern and Porto Rico mines. In the field work W. J. Gray rendered able assistance. Indebtedness is gratefully acknowledged to the owners and superintendents of the various properties for their interest and aid in the progress of the work.

SITUATION.

The town of Ymir (Plate I)—the centre for the gold camp of the same name—is situated on the Nelson and Fort Sheppard railway, 27 miles south of Nelson and 7 miles north of Salmo. It is about 20 miles north of the International Boundary and 172 miles from Spokane, Washington, via the Great Northern railway. The accompanying index map (Figure 1, page 8) shows the position of the Ymir map-area with respect to neighbouring mining camps in West Kootenay and Boundary districts.

HISTORY.

In 1885 two brothers named Hall, who two years later discovered the Silver King mine at Nelson, made locations near the headwaters of Wild Horse creek. This creek was worked to some extent for placer gold in the early days. The Nelson and Fort Sheppard railway, constructed in 1893, made the district more easily accessible and in the summer of 1895 the Rockland, Ymir, and Mugwump claims were located. It was not until the summer and autumn of 1896, however, that prospectors who had been attracted by the mining boom at Rossland, began to pay attention to other districts. It was then that mining really commenced at Ymir and among the many claims that were staked in 1896 were the Free Silver, Elise, Dundee, Summit, Sterling, Blackcock, Good Hope, Tamarac, Foghorn, Wilcox, and Porto Rico. In 1897 the Fern mill was installed and the Ymir and Porto Rico properties were being energetically opened up. Development was also being done on the Dundee, Wilcox, Porcupine, New Brunswick, Union Jack, Jubilee, Roanoke, Tamarac, and other properties. In 1898 the camp began to attract widespread attention, the population of Ymir town increased to 1,000 people, and the pay roll exceeded $20,000 a month. The Ymir, Fern, and Dundee mines were being rapidly developed and several concentrating plants were installed throughout the district. In 1899 mine development was impeded by labour troubles and in 1900 and 1901 by a general mining depression due to labour troubles at Rossland[1] and other causes.

Mining conditions improved in 1902 and the Ymir, Yellowstone,[2] Wilcox, Arlington,[2] Fern, Tamarac, and Spotted Horse properties produced ore; the total production aggregating, approximately, 80,000 tons. Most of the ore mined was treated in local stamp mills. The average monthly production of the Ymir 80-stamp mill was at that time 6,000 tons, and that of the Fern 10-stamp mill was 750 tons. In 1903 the Ymir mine ran into lower grade ore and mining and milling operations were not so profitable. The Hunter V mine commenced operations in 1903 and in 1904 shipped ore in the crude state to the Hall smelter at Nelson. The Ymir, Wilcox, Fern, and Porto Rico mines continued to treat ore at their own stamp mills. About this time developments in the neighbouring Sheep Creek gold camp overshadowed mining operations at Ymir. The Ymir camp may be said to have had a comparatively steady growth though many of the properties in operation ten years ago have been worked only intermittently since then and others have been abandoned.

PREVIOUS WORK AND BIBLIOGRAPHY.

The first geological work in the Ymir camp was done in 1897 by R. G. McConnell, now Deputy Minister of Mines, in connexion with the preparation of the West Kootenay map-sheet. In 1902 and 1903 R. A. Daly, geologist to the Boundary

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[1] "Geology and ore deposits of Rossland", Geol. Surv., Can., Mem. 77, p. 11 and fig. 2, p. 13.

[2] These properties are outside the limits of the Ymir map-area.

Commission, examined a 5-mile belt along the International Boundary and in his report describes the southern extensions of many of the formations found outcropping within the limits of Ymir map-area. During the field seasons of 1910 and 1911 O. E. LeRoy, of the Geological Survey staff, mapped and reported on both the Nelson and Sheep Creek map-areas, the former adjoining the Ymir map-area to the northwest and the latter to the southeast. The following bibliography contains the main articles and references bearing on the Ymir mining camp, arranged chronologically.

1894.

McConnell, R. G., Geol. Surv., Can., Sum. Rept. 1894, p. 35A. Describes visit to Fern mine, Hall creek.

1896.

McConnell, R. G., Geol. Surv., Can., Sum. Rept. 1896, pp. 18-30A. Reconnaissance work in region.

Carlyle, W. A., Bull. No. 3, Bureau of Mines, B.C., p. 75. Describes Fern group of claims and Nelson mining division.

1897.

McConnell, R. G., Geol. Surv., Can., Sum. Rept., pp. 31-32A. Describes Ymir, Dundee, and Porto Rico mines.

Minister of Mines, British Columbia, Annual Report 1897, p. 531.

1899.

Minister of Mines, British Columbia, Annual Report 1899, pp. 691-692.

1900.

Minister of Mines, British Columbia, Annual Report 1900, pp. 838-843.

Fowler, S. S., "The Ymir mine and its mill practice," Jour. Can. Min. Inst., 1900, pp. 3-10.

1901.

Mining Record, British Columbia, vol. VIII, pp. 65-135, 203, 239, 273, 340, 384.

1902.

Daly, R. A., Geol. Surv., Can., Sum. Rept., pp. 144-147A. Geological work at International Boundary.

Minister of Mines, British Columbia, Annual Report 1902, pp. 158-161.

Mining Record, British Columbia, vol. IX, Ymir district in 1901, pp. 67-68, 107, 138, 188, 281, 317.

1903.

Daly, R. A., Geol. Surv., Can., Sum. Rept., pp. 91-100A.

Minister of Mines, British Columbia, Annual Report 1903, pp. 142-149.

Mining Record, British Columbia, vol. X, Ymir district, pp. 459-461, 640, 835.

Holden, Edwin C. "The cyanide plant and practice at the Ymir mine, West Kootenay, B.C." Am. Inst. Min. Eng., vol. XXXIV, 1903, pp. 599-608.

1904.

Mining Record, British Columbia, vol. XI, "The Ymir district in 1903," pp. 21-23.

Minister of Mines, British Columbia, Annual Report 1904 pp. 122-128.

Geol. Surv., Can., West Kootenay map sheet No. 792.

1905.

Mining Record, British Columbia, vol. XII, 1905, "The Ymir, district in 1904," pp. 20, 61, 475.

Minister of Mines, British Columbia, Annual Report 1905, pp. 164, 167.

1906.

Minister of Mines, British Columbia, Annual Report 1906, p. 148.

1907.

Minister of Mines, British Columbia, Annual Report 1907, pp. 102-103.

1908.

Brock, R. W., Geol. Surv., Can., Sum. Rept., pp. 18-21.

Minister of Mines, British Columbia, Annual Report 1908, p. 107.

1909.

Le Roy, O. E., "Sheep Creek mining camp, West Kootenay," Geol. Surv., Can., Map No. 1068, with explanatory notes.

1910.

Minister of Mines, British Columbia, Annual Report 1910, pp. 106-107.

1911.

LeRoy, O. E., "Geology of Nelson map-area," Geol. Surv., Can., Sum. Rept., 1911, pp. 139-157.

Minister of Mines, British Columbia, Annual Report 1911, p. 159.

1912.

Minister of Mines, British Columbia, Annual Report 1912, p. 154.

LeRoy, O. E., "Nelson and vicinity," Geol. Surv., Can., Map No. 62A.

Daly, R. A., "Geology of the North American Cordillera at the 49th Parallel," Geol. Surv., Can., Mem. 38, 1912, pp. 141-203, 257-316.

1913.

Minister of Mines, British Columbia, Annual Report 1913, pp. 131-132.

1914.

Drysdale, C. W., Geol. Surv., Can., Sum. Rept. 1914, pp. 37-38.

1915.

Minister of Mines, British Columbia, Annual Report 1915, pp. 148-156.

CHAPTER II.

GENERAL CHARACTER OF DISTRICT.

TOPOGRAPHY.

Regional. West Kootenay district lies mainly within the Selkirk Mountain system of the North American Cordillera (Figure 1). The narrow portion of the district, however, west of the Columbia river and Selkirk valley, falls within the Columbia Mountain system. The Selkirk system is bounded on the east by the Purcell intermontane trench occupied by Duncan river, Kootenay lake, and the north flowing portion of Kootenay river.[1]

The Selkirk system has been further subdivided by Daly into the Slocan, Valhalla, Nelson (Quartzite), Bonnington, and Pend-d'Oreille Mountain ranges. The boundaries between the different ranges are indicated in the accompanying index map (Figure 1). It will be noted that the boundary between the Bonnington and Nelson (or Quartzite) ranges passes through the centre of Ymir map-area and is delineated by the Salmon river.

The southern portion of the Selkirk Mountain system including the Nelson (Quartzite) and Bonnington ranges, does not show the rugged alpine topography of the Slocan, Lardeau, and more northerly ranges of the system. The mountains of the southern Selkirks are more subdued and rounded than those of the north with fewer rugged peaks and serrated ridges and without the youthful glacial forms due to higher uplift and more recent sculpture by mountain glaciers (Plate XV). In this portion of the Selkirks there are practically no glaciers and the ranges form a transition belt of mountains connecting the high and rugged Canadian Selkirks with the low, subdued mountain ranges of the same system which border the Columbia lava plain in Washington state.

[1] Daly, R. A., "The nomenclature of the North American Cordillera between the 47th and 53rd parallels of latitude," Geog. Jour., vol. 27, 1906, pp. 586–606.

Local. As may be seen on the index map (Figure 1) Ymir map-area includes both the west central portion of the Nelson (Quartzite) range and the east central portion of the

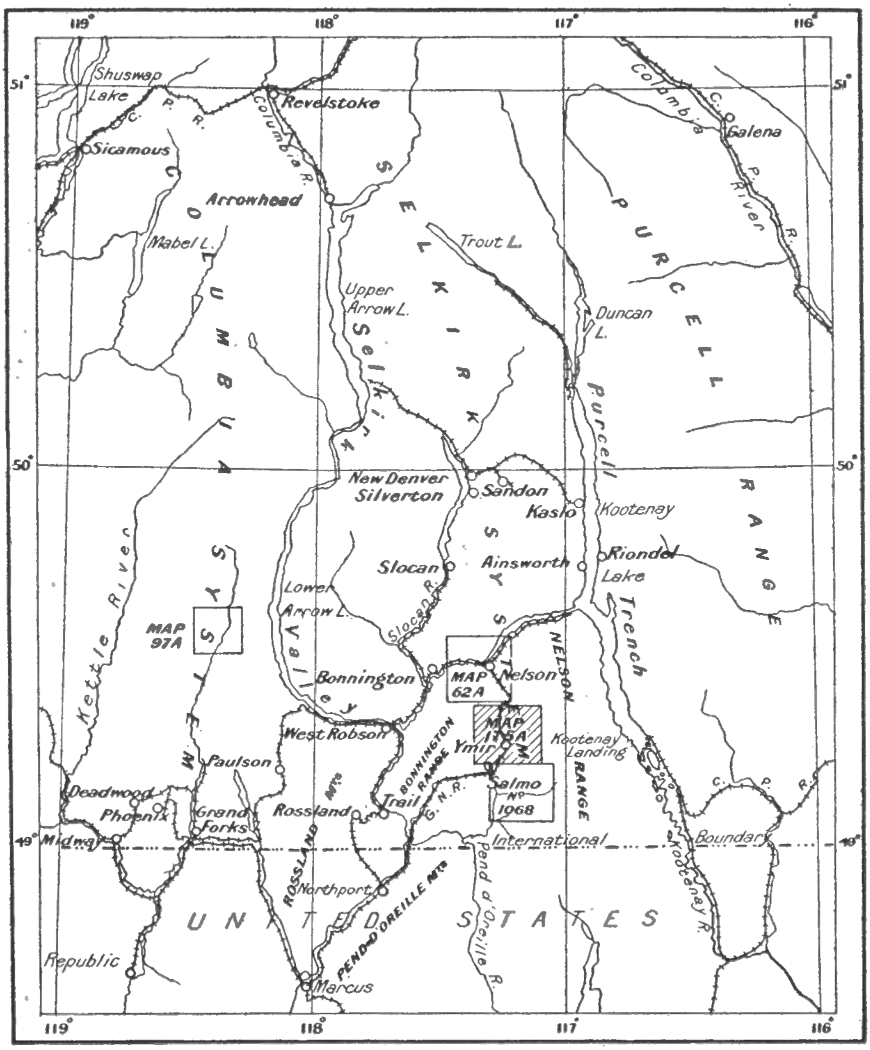

Figure 1. Index map showing position of Ymir map-area.

Bonnington range. The two mountain ranges are separated by the deep, flaring valley of Salmon river which flows in a meandering course southward through the centre of the area. This river drains virtually the whole district and empties into Pend-d'Oreille river near the International Boundary.

The highland areas of Ymir district range in elevation from 5,000 to 6,000 feet above sea-level and have slopes grading gently toward the main valleys. The valleys, with their steep, heavily-timbered sides, trench the upland areas to depths varying from a few hundred to 2,000 feet. Surmounting the gentler highland topography, particularly toward the eastern and western borders of the map-area, occur high mountain peaks and serrated ridges. The highest mountain in the district is Mount Baldy[1] which lies along the axis of the Nelson (Quartzite) range and attains a height of 7,660 feet above sea-level. The transition from highland to lowland topography, although generally very gradual, is pronounced in certain localities and marked by prominent topographic shoulders or unconformities.[2]

Glacial forms, including cirques (Plate XV), arêtes, trough-shaped valleys (Plate XIV A), truncated spurs (Plate II), hanging valleys, roches mountonées (Plate XIV B), and valley terraces are prominent topographic features in the landscape.

The influence of bedrock structures upon the topography may be observed in many places. Strike ridges and depressions are of common occurrence and areas underlain by certain sedimentary and igneous rocks, display characteristic forms by which they may be recognized and traced for great distances.

PHYSIOGRAPHIC CONSIDERATIONS.

The physiography of the Selkirk mountains is complicated and much additional field work is required before safe inferences can be drawn and a connected account given of the probable origin and physiographic history of the Ymir landscape. The physiography of the Selkirks appears to have many points in common with that of the bordering Purcell and Columbia

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[1] Also known as Marble mountain from the white quartzite of which it is composed, which resembles marble at a distance.

[2] Indicative of a more than one erosion cycle physiographic development.

systems.[1] A detailed study of this physiographic province and its relation to bordering provinces should make clear many obscure points in the life history of this section of the Cordillera; but theoretical problems of this kind do not fall within the scope of this memoir which is devoted primarily to a study of the ore deposits.

CLIMATE.

The Ymir district has a most agreeable and healthful climate. The cold in winter is not extreme, although there are short periods when the thermometer drops considerably below zero (Fahr.), and the summers as a rule are temperate and dry, with cool nights and moderately warm days, the thermometer occasionally rising 80 or 90 degrees in the shade. Farm lands in the district do not require to be irrigated as the annual precipitation amounts to nearly 30 inches, a large part of which falls as snow in the winter months.[2] The snowfall at Ymir varies from 2 to 4 feet per annum, the heaviest fall being in January.

Mr. R. F. Stupart, director of the Dominion Meteorological Service, has kindly furnished the following summary of meteorological observations at Nelson, 15 miles north of Ymir, as well as a summary of records made at Fruitvale on Beaver creek, about 22 miles southwest of Ymir. The first table gives the monthly, seasonal, and annual means and extremes of temperature and precipitation from September 1898 to June 1901 and from January 1904 to December 1913.

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[1] For descriptions and tentative conclusions regarding the physiography of the Purcell and Columbia systems see:

Schofield, S. J., "Geology of Cranbrook map-area", Geol. Surv., Can., Mem. 76, 1915, pp. 160–169.

Drysdale, C. W., "Geology and ore deposits of Rossland", Geol. Surv., Can., Mem. 77, 1915, pp. 175–188.

[2] Ten inches of snow equals approximately one inch of rain.

Meteorological Observations Taken at Nelson, B.C.

Month	Temperature							Precipitation in inches.						
								Rain				Snow		Total
	Mean	Mean maximum.	Mean minimum.	Highest monthly mean.	Lowest monthly mean.	Extreme highest.	Extreme lowest.	Average monthly fall.	Greatest amount in one month.	Total amount in driest year.	Total amount in wettest year.	Average monthly fall.	Greatest amout in one month.	
December	30·5	34·6	26·4	36·4	24·0	49	3	0·78	4·59	0·40	0·60	17·6	31·0	2·54
January	24·8	29·8	19·8	34·8	16·1	49	–17	0·80	2·74	0·84	0·63	25·5	46·0	3·35
February	28·5	35·3	21·7	33·3	23·2	54	– 7	0·55	1·53	0·10	0·78	17·6	69·3	2·31
Winter	27·9	33·2	22·6			54	–17	2·13		1·34	2·01	60·7		8·20
March	36·7	45·2	28·1	41·7	32·4	65	4	0·89	1·88	1·29	1·88	7·5	45·0	1·64
April	46·4	57·8	35·1	50·5	43·3	79	9	1·18	2·22	1·23	1·16	1·1	4·0	1·29
May	53·7	66·0	41·4	57·3	50·8	86	29	2·17	4·00	0·55	4·00	S	0·5	2·17
Spring	45·6	56·3	34·9			86	4	4·14		3·07	7·04	8·6		5·10
June	60·6	73·6	47·6	64·6	58·6	100	34	2·79	4·55	2·67	4·55			2·79
July	65·9	80·3	51·4	71·2	62·0	94	40	2·00	5·60	1·29	1·92			2·00
August	62·8	75·9	49·8	65·5	59·3	94	34	1·94	7·51	0·90	0·63			1·94
Summer	63·1	76·6	49·6			100	34	6·73		4·86	7·10			6·73
September	56·1	68·2	43·9	58·7	52·9	86	29	1·79	3·33	0·48	2·27			1·79
October	45·0	54·7	35·3	48·7	41·7	75	20	2·27	4·11	1·53	3·59	0·3	3·7	2·30
November	36·5	42·3	30·8	41·1	30·6	56	7	2·57	5·95	2·78	1·55	9·4	27·5	3·51
Autumn	45·9	55·1	36·7			86	7	6·63		4·79	7·41	9·7		7·60
Year	45·6	55·3	35·9			100	–17	19·73		14·06	23·56	79·0		27·63

Meteorological Observations Taken at Fruitvale, B. C.

Year.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
						Mean Temperature						
1910.........	....	19·3	39·9	48·3	55·2	57·3	64·3	58·0	53·6	45·4	34·3	29·3
1911.........	16·2	22·4	35·4	43·7	49·5	59·0	62·9	58·5	....	....	....	....
						Rainfall						
1910.........	....	0·14	1·62	1·09	1·69	2·17	0·69	0·69	1·19	2·92	3·76	0·18
1911.........	0·00	0·00	0·65	0·32	3·65	2·03	0·80	1·02	....	....	....	....
						Snowfall						
1910.........	....	15·6	3·2	0·0	....	....	....	....	....	....	4·2	33·2
1911.........	20·1	9·3	4·5	4·9	....	....	....	....	....	....	....	....

FLORA AND FAUNA.

The Ymir area was once heavily forest-covered, but the reserves have been considerably depleted by fire and to furnish wood for the mines. The burnt areas or brûlés are covered with scrubby second growth excepting where they have been recently re-burned and are now grown over with fireweed (Plate IX). There are, however, some good areas of green timber still left. The Nankin Pole and Post Company are probably the largest lumber operators in the district and have under lease about 5,300 acres of timber lands on Clearwater, Hall, Barrett, and Porcupine creeks. Timber limits on Stewart creek are also being worked by another company. The forest is principally coniferous and made up mainly of the following trees: cedar[1] (*Thuya plicata*), hemlock (*Tsuga heterophylla*), white fir or balsam[2] (*Abies lasiocarpa*), wh~~ite pine (*Pinus monticola*~~), spruce

[1] Chiefly in the valley bottoms.
[2] Chiefly on high mountain slopes and benches.

Ym 94

(*Picea Englemanni*), tamarack (*Larix americana*), scrub or jack-pine (*Pinus Murrayana*), Douglas fir (*Pseudotsuga mucronata*), and red pine[1] (*Pinus ponderosa*). Other trees of common occurrence are the poplar or aspen (*Populus tremuloides*), the cottonwood (*Populus balsamifera* var. *candicans*), the birch (*Betula occidentalis*), and a small maple (*Acer Douglasii*). Ground hemlock or yew (*Taxus brevifolia*), mountain laurel or "buck brush," rhododendron (*Rhododendra albiflorum*), willows, and alders grow in damp ravines and in the shade of the larger trees and render travel on many of the ridges and valley sides slow and tedious. W. C. Sandercock, a member of the field party, collected about 150 species of plants within the limits of the map-area, during August and September. These were submitted to J. M. Macoun of the biological division of the Geological Survey who reports on the collection as follows:

POLYPODIACEÆ.

[2]235 *Polypodium occidentale* (Hook.) Maxon.
139 *Phegopteris alpestris* (Hoppe) Mett.
10 „ *Dryopteris* (L.) Fée.
214 „ „ „
156 *Adiantum pedatum* L. var. *aleuticum* Rupr.
113 *Cheilanthes Feei* Moore.
307 *Cryptogramma densa* (Brack.) Diels.
82 „ *acrostichoides* R. Br.
301 „ „ (Kootenay river).
305 *Asplenium Trichomanes* L. (North of river across Taghum bridge.)
234 *Athyrium cyclosorum* Rupr.
81 *Polystichum Lonchitis* (L.) Roth.
190 „ *Braunii* (Spenner) Fée var.
147 *Aspidium Filix-mas* (L.) Sw.
11 „ *spinulosum* (O. F. Muller) Sw. var. *dilatatum* (Hoffm.) Hook.
233 „ *spinulosum* (O. F. Muller) Sw. var. *dilatatum* (Hoffm.) Hook.
221 *Cystopteris fragilis* (L.) Bernh.
13 *Woodsia oregana* DC. Eaton.

OPHIOGLOSSACEÆ.

200 *Botrychium silaifolium* Presl.

LYCOPODIACEÆ.

322 *Lycopodium annotinum* L.
58 „ *clavatum* L.

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[1] Of rare occurrence in the Ymir district.

[2] The numbers used in this list are Mr. Sandercock's field numbers and are retained here as his field notes are also so numbered.

TAXACEÆ.

14 *Taxus brevifolia* Nutt.

PINACEÆ.

326 *Pinus ponderosa* (Dougl.) Lawson (Cottonwood creek).
327 „ *Murrayana* Balf.
203 „ *monticola* Dougl.
232 „ „ „
209 *Picea Engelmanni* Parry.
30 „ „ „
19 *Thuja plicata* Donn.

GRAMINEÆ.

212 *Festuca Hallii* (Vasey) Piper.

CYPERACEÆ.

180 *Carex festiva* Dew.

JUNCACEÆ.

181 *Juncus Mertensianus* Bong.
179 „ *ensifolius* Wiks. var. *major* Hook.
222 *Luzula glabrata* Desv.

LILIACEÆ.

77 *Xerophyllum tenax* (Pursh.) Nutt.
155 *Zygadenus venenosus* Wats.
120 *Veratrum viride* Ait.
304 *Allium cernuum* Roth.
148 *Erythronium grandiflorum* Pursh.
64 *Clintonia unifolia* (Schult.) Kunth.
9 *Smilacina stellata* (L.) Desf.

ORCHIDACEÆ.

51 *Epipactis decipiens* (Hook.) Ames.
69 *Corallorhiza maculata* Raf.

SALICACEÆ.

227 *Salix Barclayi* Anders.

BETULACEÆ.

61 *Corylus californica* (A.DC.) Rose.
20 *Alnus tenuifolia* Nutt.

ARISTOLOCHIACEÆ.

105 *Asarum caudatum* Lindl.

m. 94

POLYGONACEÆ.

136 *Oxyria digyna* (L.) Hill.
65 *Rumex Acetosella* L. (Introduced).
306 *Polygonum Douglasii* Greene.
124 *Eriogonum heracloides* Nutt.
145 „ *subalpinum* Greene.

CHENOPODIACEÆ.

193 *Chenopodium Botrys* L. (Introduced).
303 „ *capitatum* (L.) Asch.

CARYOPHYLLACEÆ.

132 *Arenaria capillaris* Poir. var. *nardifolia* Regel.
186 *Silene Menziesii* Hook.
144 „ *Douglasii* Hook. var. *multicaulis* (Nutt.) Rob.

PORTULACACEÆ.

23 *Claytonia parvifolia* Moç.
133 „ *asarifolia* Bong.

RANUNCULACEÆ.
71 *Ranunculus Bongardi* Greene.
226 „ *Eschscholtzii* Schlect.
63 *Thalictrum occidentale* Gray.
115 *Pulsatilla occidentalis* (Wats.) Freyn.
114 *Clematis columbiana* (Nutt.) Torr.
6 *Actaea arguta* Nutt.
119 *Aquilegia flavescens* Wats.
16 *Aconitum columbianum* Nutt.

BERBERIDACEÆ.

93 *Berberis repens* Lindl.

CRUCIFERÆ.

231 *Arabis Lyallii* Wats.
161 *Radicula obtusa* (Nutt.) Greene.

CRASSULACEÆ.
121 *Sedum stenopetalum* Pursh.
220 „ *roseum* (L.) Scop.

SAXIFRAGACEÆ.

228 *Leptarrhena amplexifolia* (Sternb.) Ser.
134 *Saxifraga bronchialis* L.
140 „ *Mertensiana* Bong.
230 „ *Bongardi* Presl.
7 *Tiarella unifoliata* Hook.
97 *Tellima grandiflora* (Pursh.) Dougl.
96 *Heuchera columbiana* Rydb.

17 *Parnassia fimbriata* Koenig.
210 *Mitella pentandra* Hook.
196 *Philadelphus Lewisii* Pursh.

ROSACEÆ.

224 *Spiræa lucida* Dougl.
201 *Aruncus sylvester* Kosteletzsky.
213 *Sibbaldia procumbens* L.
160 *Fragaria bracteata* Heller.
219 *Potentilla Nuttallii* Lehm.
229 „ ?
26 „ *monspeliensis* L.
135 „ *fruticosa* L.
31 *Geum macrophyllum* Willd.
79 *Rubus leucodermis* Dougl.
90 „ *pedatus* Smith.

LEGUMINOSÆ.

302 *Hosackia americana* (Nutt.) Piper.

GERANIACEÆ.

216 *Geranium Bicknellii* Britt.
217 „ *viscosissimum* F. and M.

CELASTRACEÆ.

94 *Pachystima myrsinites* Raf.

ACERACEÆ.

72 *Acer Douglasii* Hook.

RHAMNACEÆ.

76 *Ceanothus velutinus* Dougl.

MALVACEÆ.

54 *Sphæralcea rivularis* Torr.

HYPERICACEÆ.

163 *Hypericum Scouleri* Hook.

VIOLACEÆ.

107 *Viola sempervirens* Greene.
5 „ *glabella* Nutt.
108 „ *pallens* (Banks) Brainerd.

ONAGRACEÆ.

60 *Epilobium latifolium* L.
154 „ *luteum* Pursh.
150 „ *fastigiatum* (Nutt.) Piper.

UMBELLIFERÆ.

101 ~~*Ligusticum Grayii* C. and~~ R.
15 ~~*Angelica Lyallii* S.~~ Wats.

CORNACEÆ.

18 ~~*Cornus stolonifera*~~ Michx.
106 ~~„ *canadensis* L.~~

ERICACEÆ.

325 *Pyrola secunda* L.
152 ~~„ „~~
57 ~~„ *bracteata*~~ Hook.
323 ” ” ”
27 ~~„ *asarifolia*~~ Michx.
8 ” ” ”
324 ~~„ *chlorantha*~~ Sw.
55 ~~*Chimaphila umbellata*~~ (L.) Nutt.
100 *Gaultheria ovatifolia* Gray.
142 *Phyllodoce glanduliflorus* (Hook.) Cov.
141 ~~„ *empetriformis*~~ Don.
126 *Rhododendron albiflorum* Hook.

APOCYNACEÆ.

25 ~~*Apocynum androsæmifolium*~~ L.

POLEMONIACEÆ.

137 ~~*Polemonium humile*~~ R. and G.

HYDROPHYLLACEÆ.

86 ~~*Phacelia leptosepala*~~ Rydb.

BORRAGINACEÆ.

102 ~~*Mertensia ciliata* Don.~~

SCROPHULARIACEÆ.

123 *Pentstemon fruticosus* (Pursh) Greene.
164 ~~*Veronica americana*~~ Schwein.
112 ~~„ *serpyllifolia*~~ L.
22 ~~*Mimulus Lewisii* Pursh.~~
158 ~~„ *nasutus*~~ Greene.
78 ~~*Castilleja lanceifolia*~~ Rydb.
122 ~~*Pedicularis*~~ *racemosa* Hook.
143 ~~„~~ *groenlandica* Retz.

CAPRIFOLIACEÆ.

53 ~~*Linnæa borealis* L.~~ var. *americana* (Forbes) Rehdner.
99 ~~*Lonicera involucrata*~~ Banks.
49 ~~*Symphoricarpus racemosa*~~ Michx.

VALERIANACEÆ.
129 *Valeriana sitchensis* Bong.

CAMPANULACEÆ.
75 *Campanula rotundifolia* L.

COMPOSITÆ.
118 *Aster Engelmannii* Gray.
116 „ *conspicuus* Lindl.
218 „ *foliaceus* Lindl. var. *frondeus* Gray.
215 *Erigeron acris* L. var.
117 „ *salsuginosus* Gray.
168 „ *philadelphicus* L.
73 *Solidago lepida* DC. var. *elongata* (Nutt.) Fernald.
211 *Artemisia discolor* Dougl.
103 *Arnica* ?
128 „ *latifolia* Bong.
149 *Senecio canus* Hook.
321 „ *triangularis* Hook.
74 *Adenocaulon bicolor* Hook.
45 *Anaphalis margaritacea* Benth.
127 *Hieracium Scouleri* Hook.
110 „ *gracile* Hook.

Supplementary List of Flowering Plants Collected by W. C. Sandercock in the Ymir District, August, 1916.

239 *Lycopodium complanatum* L.
240 *Streptopus amplexifolius* (L.) DC. (Boulder creek).
2 *Trillium ovatum* Pursh.
241 *Listera cordata* R.Br. (Boulder Creek flats).
237 *Habenaria orbiculata* Torr. (Boulder Creek flats).
248 *Sanguisorba occidentalis* Nutt.
249 *Rosa gymnocarpa* Nutt.
146 *Lupinus Burkei* Wats.
54 *Sphaeralcea rivularis* Torr.
243 *Zizia cordata* (Walt.) DC. (At mouth of Boulder creek.)
244 *Osmorrhiza divaricata* Nutt. (Up Boulder creek.)
236 *Moneses uniflora* L. (Near Boulder creek, Ymir.)
238 *Monotropa uniflora* L.
247 *Mimulus Langsdorfii* Donn. (In Ymir.)
250 *Prunella vulgaris* L. var. *lanceolata* (Barton) Fernald.
242 *Solidago lepida* DC. var. *elongata* (Nutt.) Fernald.
184 *Agoseris grandiflora* (Nutt.) Greene. (Probably introduced from coast.)
Cypripedium montanum Dougl. (Dewdney trail.)
Dryas Drummondii Hook. “ “
Comatium nudicaule (Pursh) C. and R. “ “

The fauna of the Ymir district includes both mule and white-tailed deer, black, brown, and grizzly bears, coyote, ruffed and blue grouse, foolhen (Franklin's grouse), and ptarmigan, chipmunks, red squirrels, weasels, porcupine, beaver, pika or little chief hare[1], wood rats, gophers. Humming birds and Steller's jay are also included in the fauna noted. The streams are well stocked with brook trout.

[1] Locally known as rock rabbit.

CHAPTER III.

GENERAL GEOLOGY.

INTRODUCTION.

The West Kootenay geological map[1] on which the geology of the Ymir district was first outlined by McConnell in 1896[2] furnished a good base for the more detailed economic work of the field season of 1914, and more recent work by R. A. Daly from 1902 to 1904 and by O. E. LeRoy in 1910 and 1911 in neighbouring regions has thrown additional light on certain phases of the geology. The enlarged scale of mapping (1 mile to 1 inch) necessitated changing some of the geological boundaries on the earlier map and made possible the separation of certain prominent formational members that had been grouped under the name Rossland Volcanic group. For instance, a thick series of sedimentary formations—the Hall series—was found on the eastern flank of the Bonnington Mountain range and has been mapped as a separate unit of the Rossland group.

In the following table of formations the geological ages assigned to the different formations are tentative only, as fossil evidence is wanting.

TABLE OF FORMATIONS.

ERA.	PERIOD.	FORMATION NAME.	FORM AND LITHOLOGICAL CHARACTER.
QUATERNARY	Recent.	Stream deposits.	Gravel, sand, silt, clay, soil, and subsoil.
	Pleistocene.	Stream deposits. Glacial deposits.	Gravel, sand, silt, and clay. Boulder clay or till.
TERTIARY.	Miocene (?)	Younger dykes.	Dykes and tongues of syenite porphyry, granite porphyry, and lamprophyre.

[1] Geol. Surv., Can., Map No. 792, 1904 (scale 4 miles to 1 inch.)
[2] Geol. Surv., Can., Sum. Rept., 1896, pp. 18–30 A.

TABLE OF FORMATIONS.—Continued.

ERA.	PERIOD.	FORMATION NAME.		FORM AND LITHOLOGICAL CHARACTER.
TERTIARY.	Oligocene (?)	Salmon River monzonite.		Stock of coarsely granular monzonite containing a small core of granular pulaskite (Coryell).
MESOZOIC.	Jurassic.	Monzonite		Chonolith of monzonite.
		Nelson granite.		Batholith, cupola stocks and tongues of granitic intrusive rock varying from granite to diorite and varying in texture from porphyritic granite to granite porphyry.
		Rossland group.	Granite porphyry.	Injection tongues which have been much altered and are in part schistose
	Triassic (?)		Augite porphyrite, and andesite.	Sills, flows, and pyroclastic deposits of dominantly augite porphyrite which are in part schistose.
			Hall series.	Continental deposits of conglomerate, sandstone (reddish), and shale (carbonaceous).
PALÆOZOIC.	Post-Cambrian	Niskonlith series.	Pend-d'Oreille group.	Metamorphic sedimentary group of argillite, quartzite, quartz schist, andalusite schist, and siliceous marble.
	Lower Cambrian or Pre-Cambrian.	Selkirk series.	Summit series (in part).	Metamorphic group of banded quartzite, metargillite, quartz-mica schist, and massive white quartzite.

DESCRIPTION OF FORMATIONS.

PALÆOZOIC.

LOWER CAMBRIAN OR PRE-CAMBRIAN.

Summit Series (in part).

The oldest formations found in the area covered by the Ymir map consist of banded quartzites, quartz-mica schists, metargillites, and massive white quartzite outcropping in a conformable series along the eastern quarter of the area and forming the high and rugged Nelson or Quartzite range. The regularity of bedding in the quartzite is well shown by belts of spruce which stand out boldly on the higher hillsides, owing to the habit of this tree of following the schist bands. This series is the upper portion of the Summit series of Daly's Boundary report.[1]

Distribution. The western border of the Summit series extends from the source of Wild Horse creek, on the divide between the latter creek and Midge creek, southwestward down the upper stretch of Wild Horse valley to the bend below the Wilcox mine. Thence the contact follows the same southwestward trend crossing over to South Fork valley and the basin of Bear creek to the forks of Porcupine creek and thence over the divide between the latter and Hidden creeks at a low point about a mile east of the Hunter V mine. The series extends to the eastern border of the map-area and several miles beyond it before it is cut off by the Nelson granite.

Lithology. The members of the Summit series are chiefly light grey to greenish-grey quartzites interbanded with siliceous metargillites and quartz-mica schists. The rocks are much altered near the granite intrusions and display rusty weathered outcrops. The highest member outcropping in the area is a heavily bedded mass of snow-white to light yellow quartzite which forms the summit of Mount Baldy. The white quartzite on weathering breaks up into large heavy plates which give a

[1] Geol. Surv., Can., Mem. 38, pp. 141–159.

sonorous metallic ring when struck with a hammer. Ripple-marks and scalloped and pitted forms of unknown origin are found on some bedding planes. No feldspar was detected in thin sections under the micoscope, although shreds of sericite occur, cementing subangular and rounded grains of glassy quartz. The quartz grains are strained and fractured in places.

Structure. The portion of the Summit series present in the northern part of the area appears to be the uptilted western limb of a syncline which forms the Quartzite range. In the vicinity of Wild Horse creek it is sharply cut off by a large mass of Nelson granite. This granite farther south swings westward and intrudes the Pend-d'Oreille group and on this account a wider belt of the Summit series is found to the south. There it is in contact with and interfolded with the younger sedimentary group (Pend-d'Oreille). The axis of the syncline is a couple of miles east of Baldy mountain and may be traced to beyond the International Boundary. The western limb consists of alternating bands of Beehive schist and Ripple quartzite which are repeated on the eastern limb. The east boundary of the syncline is marked by a thrust fault which brings up the basal arkosic and conglomeratic members of the series to the surface (Dewdney or Monk, Wolf and Irene conglomerate formations). Roof pendants in the form of long wedge-like ribs of much altered Summit series occur within the eastern granite masses.

Origin. Owing to numerous granitic injections the Summit series is so poorly developed and fragmental that it has not been possible to collect sufficient diagnostic data to enable a conclusion to be drawn as to the origin of the sediments or the topographic and climatic conditions under which they were formed. Recent work in the same formations elsewhere by Daly and Schofield have led them to infer that the sediments were laid down in a shallow continental basin disconnected with the ocean and containing fresh or brackish water. The climatic conditions alternated between humid and arid and the water in the basin was shallow enough at times for the formation of ripple-marks and mud cracks. In other places eolian deposits of dune sand quartzite and loessic quartzite were laid down.[1]

[1] Daly, R. A., Geol. Surv., Can., Mem. 68, pp. 100-107.

Age and Correlation. McConnell referred this quartzite series to the Cambrian and correlated it with Dawson's Lower Selkirk series[1] of the northern Selkirks. The upper portion of the Summit series has been tentatively referred by Daly to the Cambrian. As the Ymir quartzite members lithologically resemble most closely Daly's Ripple and Beehive formations they may be assigned a Lower and Middle Cambrian age. Much more field work in the Nelson range is needed to confirm the stratigraphic sequence of formations and to correlate Daly's Summit series with Schofield's Purcell series in East Kootenay district. Schofield favours a Pre-Cambrian age for the whole Purcell series, while Daly refers only the lower portion of the series to the Pre-Cambrian or Beltian.

For purpose of comparison the following abridged correlation tables taken from Daly's and Schofield's related work in adjoining areas is here presented.

Correlation According to Daly.[2]

SYSTEM.	SUMMIT SERIES SELKIRK MOUNTAIN SYSTEM.	PURCELL SERIES PURCELL MOUNTAIN SYSTEM.	CŒUR D'ALENE SERIES. IDAHO.	GALTON SERIES ROCKY MOUNTAIN SYSTEM.
CHIEFLY MIDDLE CAMBRIAN.	Lone Star 2000 + ft.	Moyie 3400 + ft.	Striped Peak 1000 + ft.	Roosville 600 + ft. Phillips 550 ft. Gateway 1850 ft.
MIDDLE CAMBRIAN.	Beehive 7000 ft.	Kitchener 6000 ± ft.	Wallace 4000 ft. St. Regis 1000 ft.	Gateway 125 ft. Siyeh 4000 ft.
LOWER CAMBRIAN.	Ripple 1650 ft. Dewdney 2000 ft. Wolf 1000 ± ft.	Kitchener 1400 ± ft. Creston 3000 ± ft.	Revett 1200 ft. Burke 2000 ft. Prichard 1500 ± ft.	Wigwam 1200 ft. MacDonald 2350 ft. Hefty 775 ft.

[1] Recent field work by the writer has forced him to the conclusion that the chronological sequence of the rocks named upper and lower Selkirk and Niskonlith series on the West Kootenay map sheet is the opposite of that given.

[2] Geol. Surv., Can., Mem. 38, 1913, p. 178.

Correlation According to Daly.—Continued.

SYSTEM.	SUMMIT SERIES SELKIRK MOUNTAIN SYSTEM.	PURCELL SERIES PURCELL MOUNTAIN SYSTEM.	CŒUR D'ALENE SERIES. IDAHO.	GALTON SERIES ROCKY MOUNTAIN SYSTEM.
BELTIAN.	Wolf 1900 ± ft. Monk 5500 ft. Irene volcanics 6000 ± ft. Irene conglomerate 5000 + ft.	Creston 6500 ± ft. Base concealed	Prichard 6500 + ft. Base concealed	Altyn 650 ft. Base concealed
	Unconformity.			
Pre-Beltian	Priest River terrane.			

Correlation According to Schofield.[1]

CAMBRIAN.				Lowest Middle Cambrian.
				Unconformity.
				Roosville 1000 ft.
		Erosion surface.		Phillips 500 ft.
		Gateway 1000 ft.		Gateway 2025 ft.
PRE-CAMBRIAN (BELTIAN).		Purcell lava.	Erosion surface.	Purcell lava.
		Siyeh 4000 ft.	Striped Peak 1000 ft.	Siyeh 4,000 ft.
		Kitchener 4500 ft.	Wallace 4000 ft.	Wigwam 1200 ft. MacDonald 2350 ft. Hefty 775 ft.
		Creston 5000 ft.	St. Regis 1000 ft. Revett 1200 ft. Burke 2000 ft.	Altyn 650 ft.
		Aldridge 8000 ± ft.	Prichard 8000 ft.	

[1] Geol. Surv., Can., Mem. 76, 1915, p. 52; also Mus. Bull. No. 2, Geological series, Nos. 16 and 17.

From the above tables it may be noted that Schofield correlates the Creston quartzite of the Purcell series, which lithologically most resembles the Ripple quartzite of the Summit series, with the St. Regis, Revett, and Burke formations of the Coeur d'Alene series. If this correlation is correct the Dewdney and Wolf formations of the Summit series may be correlated with Schofield's Aldridge formation, and the basal Irene and Monk formations of the Summit series be considered to represent the base of the Belt terrane in Canada.

Further stratigraphic work is necessary in the Quartzite range between Ymir map-area and Daly's section, to properly clear up this problem of Pre-Cambrian and Cambrian correlation.[1]

POST-CAMBRIAN.

Pend-d'Oreille Group.

The metamorphic group of dark coloured argillite, quartz-mica schist, andalusite schist, and siliceous marble named by Daly the Pend-d'Oreille group and referred to the Carboniferous (?) or Ordovician (?) period is of later age than the Summit series. Prior to Daly's work, the same group of formations had been referred to the Lower Cambrian[2] and correlated with Dawson's Niskonlith series.

Although diligent search was made for fossils in the Ymir field, none were found and the age of the group is still in doubt.

Distribution. The Pend-d'Oreille group occurs through the central portion of Ymir map-area, extending from Clearwater creek southward through the valley of the North Fork of Wild Horse creek to the Dundee mine and the town of Ymir where it is cut off by the main granite mass. The group appears again east of the granite and extends in a narrow belt to the Hunter V mine and thence to Hidden and Sheep creeks where it has a greater width.

Lithology. The Pend-d'Oreille group in Ymir district consists chiefly of metamorphosed sedimentary rocks including

[1]See addenda, p. 149.

[2]During the 1916 field season the writer found Post-Cambrian (Ordovician at base) fossils in the northern extension of this belt in the Slocan district (memoir in preparation).

dark argillaceous and arenaceous members which are altered near the granite to andalusite and mica schists. Phyllites, metargillites, impure quartzites, altered tuffs, and siliceous marble are present in certain localities. The marble is fine grained and completely recrystallized. Greenstone occurs sparingly in the group throughout the area.

Structure. The strike of the rocks, as a rule, conforms to the north-south trend of the border of the granite masses; the dips are steep and chiefly to the west although easterly dips are present in certain localities. The formations are generally sheared, mashed, crumpled, and to a minor extent faulted, so that their primary structures are very difficult to interpret. The Pend-d'Oreille schists, where surrounded by granite, are severely foliated, crumpled, and crenulated (Plate III). The present structure is ***homoclinal***[1] in which the Pend-d'Oreille group occupies an intermediate position between the older Summit series and the younger Rossland group.

Origin. It is inferred that the rocks of the Pend-d'Oreille group were laid down in a shallow continental sea, probably an arm of the Pacific ocean which periodically transgressed the low, lying Cordillera of Palæozoic time. In this sea, mud, sand, and lime rocks were deposited, the limestones representing the offshore deposits and the carbonaceous argillites and sandstones the inshore deposits. Marine sedimentation was interrupted at intervals by volcanic activity which resulted in the accumulation of volcanic dust in a few localities and elsewhere in the outpouring of lavas.

Age and Correlation. No fossils were found within the area so that no definite age determinations could be made. The group has been called the Niskonlith series on West Kootenay map and correlated lithologically with Dawson's series of that name occurring along the main line of the Canadian Pacific railway. The Niskonlith series was tentatively referred by Dawson to the Lower Cambrian.

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[1] A new term introduced by R. A. Daly for a block of bedded rocks all dipping in the same direction. A "homocline" may be a monocline, an isocline, a tilted fault-block, or one limb of an anticline or syncline. The field data, however, are insufficient to show which of these categories is represented. Geol. Surv., Can., Mem. 68, 1915, p. 53.

As a result of recent geological work along the International Boundary line, this group of formations has been provisionally referred by R. A. Daly to the Carboniferous. This correlation is based on the lithological similarity between the crystalline limestone member and a similar formation bearing fossils of Carboniferous age found by McConnell[1] and Daly[2] in Rossland district. Daly also notes the similarity between Lindgren's[3] Wood River series of supposedly Carboniferous age and the Pend-d'Oreille group. He also calls attention to the lithological similarity between the Slocan series and the Pend-d'Oreille group. The rocks of the Slocan series were first referred by McConnell and Brock[4] to the upper or middle Palæozoic but Schofield[5] obtained evidence during the field season of 1914 leading him to refer the whole sedimentary series to the Beltian or Pre-Cambrian.

From the above statement it is evident that much uncertainty exists as to the age of the Pend-d'Oreille group and that additional stratigraphic work is required before it can be determined.[6]

MESOZOIC.

TRIASSIC (?)

Hall Series.

During the field work of 1914 a series of sedimentary formations was found within the volcanics of the so-called Rossland group. The series is well exposed in the valley of Hall creek and has been mapped as a separate unit under the name Hall series.

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[1] McConnell, R. G., Explanatory notes to Trail sheet, Geol. Sur., Can., 1897.

[2] Daly, R. A., "Geology of North American Cordillera at 49th Parallel," Mem. 38, pt. I, p. 275.

[3] Lindgren, W., 20th Ann. Report, U.S. Geol. Surv., part III, pp. 86–90, 1900.

[4] Explanatory notes to West Kootenay map sheet; Geol. Surv., Can.

[5] Schofield, S. J., Geol. Surv., Can., Sum. Rept, 1914, p. 38.

[6] Since writing this and during the 1916 field season fossils were found in the Slocan and Niskonlith series, which at least proves the Post-Cambrian age of the rocks: (Geol. Surv., Can., Sum. Rept. 1916, in preparation).

Distribution. The Hall series extends in a general north-south direction from the east side of Toad mountain and Noman creek in Nelson area southward to the May Blossom property, where it becomes narrower and is cut off by a monzonite chonolith.

The widest exposure of the series is in the vicinity of Barrett creek, and, as indicated on the map pinches both northward and southward. The maximum thickness of the series is about 7,000 feet.

Lithology. The Hall series is composed of coarse to fine conglomerates (chiefly arkosic), sandstones, and argillites, all considerably mashed and altered (Plate IV). The conglomerate is heterogeneous in character containing pebbles of the older rocks which range in size from a fraction of an inch to one foot and more in diameter. The pebbles include quartzites, greenstones, argillites, quartz grains, and feldspathic material. The sandstones are usually red in colour and are made up in large part of quartz and feldspar.

Structure. The Hall sedimentary series appears to be infolded with volcanic rocks of contemporaneous age, chiefly augite porphyrites and related pyroclastic types. Since deposition, the series has been uptilted by mountain-building forces and now dips steeply to the west or has a vertical attitude.

Origin, Age, and Correlation. The lithological character of the sediments of the Hall series leads to the inference that they were in large part laid down subaërially, probably on a delta extending out into an epicontinental sea. During an interval free from volcanic outburst, coarse gravels and sands were washed down from a land surface of moderate relief and became interbedded with mud and silt. The red colour of the sandstone, and the dark colour of the mudstone or argillite indicate probably semi-arid conditions of deposition with seasonal rainfall.[1]

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[1] Barrell, J., Jour. of Geol., 1908, pp. 292, 293.

Professor Barrell states: "Turning to the climatic significance of red, it would therefore appear both from theoretical considerations and geological observations that the chief condition for the formation of red shales and sandstones is merely the alternation of seasons of warmth and dryness with seasons of flood, by means of which hydration, but especially oxidation of the ferruginous material in the flood-plain deposits is accomplished. This supplements the decomposition at the source and that which takes place in the long transportation and great wear to which the larger rivers subject the detritus rolled along their

The Hall series has been provisionally referred to the Triassic and correlated with Dawson's Nicola series in Kamloops district. This reference to the Triassic has been made for the following reasons: (1) the distinctly fresher and less altered condition of the sediments as compared with those of the Pend-d'Oreille group, and (2) their lithological resemblance to the Nicola series, which contains fossils of Triassic age grading up nto lower Jurassic.[1]

Augite Porphyrite Sills, Flows, and Pyroclastics.

A complex group of basic volcanics, generally included as part of the "Rossland Volcanic group" or "Porphyrite group", encloses the Hall sedimentary series. In Ymir district this group consists of augite porphyrites, augite-feldspar porphyrites, agglomerates, breccias, and their metamorphosed equivalents, greenstone schists of different varieties.

Distribution. The porphyrites and their related pyroclastic types have a very wide distribution throughout the region. They underlie virtually half of Ymir map-area. The eastern boundary of the group cuts through the centre of Elise mountain, extending from Clearwater creek southward to the town of Ymir and thence over Pulaskite hill to Salmon river at the southern boundary of the map-area. Westward the Porphyrite group extends beyond the map-area, almost to the Kootenay river, but is cut out for several miles along the axis of the Bonnington range by the Nelson granite batholith.

Lithology. The Rossland volcanics are basic porphyrites chiefly augite porphyrite and an augite-feldspar porphyrite. Both augite andesite flows and fragmental types are present and include amygdaloidal basalts, agglomerates,[2] tuffs, and breccias

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beds. The annual wetting, drying, and oxidation not only decompose the original iron minerals but completely remove all traces of carbon. If this conclusion be correct, red shales or sandstones, as distinct from red mud and sand, may originate under intermittently rainy, subarid, or arid climates without any close relation to temperature and typically as fluvial and pluvial deposits upon the land, though to a limited extent as fluviatile sediments coming to rest upon the bottom of the shallow sea. The origin of such sediment is most favoured by climates which are hot and alternately wet and dry as opposed to climates which are either constantly cool or constantly wet or constantly dry."

[1] Geol. Surv., Can., Sum. Rept., 1912, pp. 134–135.

[2] Veinlets of epidote cutting the agglomerates are of common occurrence, as well as gas pores.

with their schistose equivalents. The greenstones are in many places epidotized and torsion cracks are common in them. Films of specularite were noted on some fractured surfaces. Fresh types are somewhat rare and in most cases the rocks are chloritized and calcified to such an extent that microscopic examination of them is unsatisfactory. Ten micro-slides made from various rock phases of the group were examined and the main types of rock represented were found to be augite porphyrite (a coarse and a fine-grained variety), augite andesite, and basalt with their schistose equivalents.

The augite porphyrite is a dark greyish to greenish black rock, studded with numerous dark crystals of augite in a dense groundmass. In many places the coarse variety passes into a variety without visible phenocrysts. In cases where the dense fine-grained variety is highly silicified it is difficult to distinguish it from certain Palæozoic metamorphics. In other places the augite porphyrite assumes a brecciated or agglomeratic structure; that is, the mass appears to be made up of rounded, oval, and angular fragments, up to several inches in diameter, of a porphyrite slightly different in colour or texture from the material in which they lie. Torsion cracks are present in the fragments in places. Near the western border of the map-area a sill of coarse-grained, augite-feldspar porphyrite outcrops, in which the plagioclase phenocrysts are very much altered. A similar granular type is exposed on the eastern slope of Elise mountain above the Ymir mine, and at a distance resembles outcrops of granite. On the western slope of Elise mountain the augite porphyrite is agglomeratic, vesicular, and amygdaloidal, the gas pores being filled in most cases with calcite (Plate V). Under the microscope the typical augite porphyrite appears to be composed of phenocrysts of augite, hornblende, and plagioclase feldspar lying in a fine groundmass chiefly of plagioclase and hornblende. The hornblende has a green colour, low pleochroism, and in the case of some of the larger individuals the core is colourless augite, indicating that much of the hornblende is of secondary origin. The plagioclase is chiefly labradorite.

Structure and Origin. The general lithological and structural relations of the augite porphyrite masses to the bedded rocks, in which there is a parallelism of strike and dip, indicate that the bodies of augite porphyrite probably represent both sills and contemporaneous surface flows and fragmentals. On the north border of the map-area, west of Salmon river, a series of augite porphyrite sills 50 feet thick and upwards outcrops. They pinch and swell and preserve their porphyritic texture to the actual contact with the sheared eruptives. The porphyrite includes rounded fragments of red quartzite at the contact which is a reddish weathered pitted zone 3 feet wide and impregnated for several inches by augite porphyrite (replacement).

The rocks of the Porphyrite group as already indicated have been involved in crushing and shearing movements to such an extent that in certain belts they are metamorphosed to quartz-biotite, chlorite, and other schists that may be included for convenience under the term greenstone schists.

The most sheared and altered femic lavas and pyroclastics[1] are confined largely to a northeast-southwest belt over one mile wide, lying between massive sills of augite porphyrite to the east and the Hall sedimentary series to the west. This belt extends with few interruptions from the mouth of Clearwater creek southwestward to the southern border of the map-area.

The manner in which similar porphyrite sills are found at the borders of the volcanic group, within the area of the map, with a belt of altered volcanics (characterized by torsion cracks) intervening between the bordering sills and the central area of Hall sedimenatry series, suggests the possibility of close folding with repetition of formations. If this is true the Hall series occupies the axis of a compressed syncline and represents the youngest formation of the group. The lava flows and pyroclastics antedate the deposition of the sediments; and the sills represent the deeper seated injection of the same magma contemporaneous with or slightly following the surface eruptions.

Further detailed study of the regional structure of the entire area of Rossland Volcanic group is necessary before safe conclusions can be drawn regarding the structure and nature of the possible folding in this complex group of volcanics.

Age and Correlation. The augite porphyrites and related volcanics of the Rossland Volcanic group are provisionally

[1] Locally referred to as the Summit Ridge volcanics.

placed in the Triassic and correlated with Dawson's Nicola group.[1] Daly in his report on the geology along the International Boundary line states "the more massive phases of the Rossland Volcanic group resemble the Nicola Triassic lavas on South Thompson river."[2]

JURASSIC.

Granite Porphyry Tongues.

Younger in age than the porphyrites of the Rossland Volcanic group but older than the Nelson granite are a set of persistent granite-porphyry tongues which are readily separable from the other members of the Rossland group by their boldness of outcrop. The tongues appear to be genetically related to certain of the ore deposits in the region and on that account it was deemed advisable to delimit their extent and as far as possible indicate their position on the map.

Distribution. The main occurrences of the granite porphyry tongues follow the western slope of Elise mountain and a belt not so well defined occurs west of the Hall series in the vicinity of the Fern mine. The tongues are found most typically developed at the Silver King mine on Toad mountain.

Lithology. The granite porphyry when fresh is a green or greenish-grey rock generally spotted with prominent crystals of orthoclase, up to one inch in length, embedded in a fine-grained groundmass made up chiefly of quartz and feldspar. Apatite and zircon are present as accessory constitutents. Much of the quartz is secondary and in some thin sections of the rock appears in the form of rosettes. The orthoclase shows incipient sericitization along the cleavage planes. The edges of the crystals are sericitized first, thus forming secondary border rims. In most cases the granite-porphyry is much altered and schistose. It appears to have been subjected to regional movements that did not affect the Nelson granite. The sericitized orthoclase crystals exposed at the surface, weather from a light to a dark

[1] "Geology and ore deposits of Rossland," Geol. Surv., Can., Mem. 77, 1915, p. 208.
[2] Geol. Surv., Can., Mem. 38, p. 372.

green colour and at a distance the rock might be mistaken for augite porphyrite. Other ferruginous varieties on exposure weather red and through disintegration the crystals of orthoclase are set free. The alteration in some cases has been accompanied by the introduction of iron and magnesium to form hornblende, and in other cases the rocks are calcified. The quartz phenocrysts, where present, are corroded. One specimen of granite porphyry contained microscopic inclusions of schist. The granite porphyry at the Tamarac mine wasfoundto contain inclusions of greenstone schist up to 14 inches in length, with longest diameters standing vertical. In this case the greenstone had become schistose before the intrusion of the porphyry.

Structure and Origin. The granite porphyry intrusions have the form of apophyses or tongues of irregular shape with a dominant north-south trend. They generally follow the strike of the greenstone schists into which they are intruded and in many cases the tongues appear to have been metamorphosed along with the femic schists to form light, greenish grey sericite schists. The light-coloured schists stand out in strong contrast to the dark greenish schists derived from the femic porphyrite members of the Rossland group.

Age and Correlation. The granite porphyry is intrusive into the porphyrite and volcanic members of the Rossland group, and is intruded by the younger Nelson granite. The intrusions probably represent the earliest manifestations of the Jurassic revolution in the region. The tongues, although more alkalic in character than the so-called diorite porphyrite (granodiorite porphyry) of Rossland, may represent igneous intrusions of the same age.

Nelson Batholith, Stocks, and Tongues.

All the preceding formations are intruded by large masses of granitoid rocks, which form a part of what is termed the Nelson batholith, and, as may be seen from the map, cover an extensive area in the Ymir district. The term "Nelson granite," though in common usage, is only applicable to very small portions of the batholith. The rocks vary in composition considerably from place to place, the most common type being a granodiorite, a rock transitional between a granite and a diorite.[1]

Distribution. Stocks and tongues from the Nelson batholith outcrop over a large part of the eastern half of the area, occurring as a series of long, parallel intrusions, pinching to a few feet and swelling to a maximum width of 4 miles. The remnants of rocks belonging to the Pend-d'Oreille group and Summit series, into which the granitic mass has been intruded and which formed the roof to the batholith, now outcrop as a series of long, parallel bands varying from a few inches to thousands of feet in width. Such down hanging wedges of schist are generally spoken of as roof pendants. The roof pendants which follow the general trend of the schist formations, are injected to such an extent by granitic material from the underlying batholith that it is difficult in places to delimit the various masses by precise boundaries (Plate VI). The contacts are in reality transition injection zones and can be defined only arbitrarily by considering the relative proportions of granite to schist.

An isolated mass of Nelson granodiorite outcrops near the northwestern corner of the map-area on Dominion mountain and another smaller area between it and the Salmon river.

Lithology. In mineralogical composition the rocks of the Nelson batholith and allied intrusions range from a true granite to a quartz diorite and more femic types. Texturally the granitic rocks vary from a fine-grained granodiorite through several gradations to the coarse porphyritic granite outcropping in the vicinity of the Foghorn and Wilcox mines.

The porphyritic granite is a light grey to pinkish grey rock characterized by a very coarse grain and in places by well pronounced augen and gneissic structures. The granite is traversed by well-defined joint planes, the master set being closely spaced and corresponding in strike and dip with the older intruded formations (Plate VII B and C). Large phenocrysts of alkalic feldspar (orthoclase and microcline) and, less commonly, of acid plagioclase are embedded in a groundmass of quartz,

[1] According to W. Lindgren granodiorite contains 8 to 20 per cent alkali feldspars and the amount of plagioclase is at least double that of the alkali feldspar. Am. Jour. Sc., 4th ser. vol. 9, 1900, p. 269.

orthoclase, microcline, biotite, and sericite with accessory magnetite, apatite, and titanite. The porphyritic granite resembles in many respects Daly's Rykert granite at the International Boundary.

The most common rock of the Nelson batholith is a grey granodiorite of medium texture, with orthoclase and plagioclase (chiefly andesine) feldspar, biotite or hornblende, and quartz as essential constituents; microcline, titanite, magnetite, apatite, and zircon as accessory constituents; and chlorite, epidote, kaolin, and limonite as alteration products.

The granitic rocks of the stock and tongue members of the Nelson batholith are predominantly fine-grained or porphyritic. They have, however, the same mineralogical composition as the parent granitic batholith and are sometimes referred to as *aschistic*[1] (undifferentiated) dykes.

Genetically connected with the Nelson batholith are many *diaschistic* (differentiated) dykes which, in contrast to the aschistic dykes, represent extreme divergences from the main parent batholith. They differ from one another in composition, ranging from aplites, the acidic extreme, to lamprophyres, the femic extreme. The aplites are light grey or pinkish in colour and are most numerous in the more femic phases of the batholith at or near its contact with the schists. They are of very fine, even grain, in which are seen occasional black specks of biotite. They break with a slightly crumbly fracture and have the sugar-like, granular texture of typical aplites. Lamprophyre dykes, or femic extremes of differentiation from the parent batholith, occur throughout the whole area. The lamprophyres are probably of two ages: the older set related to the Nelson batholith and the younger more alkalic set to the Coryell batholith[2] of Tertiary age. They are dark green to black in colour, weathering and disintegrating readily on exposure to a greenish grey to brown sand. The lamprophyres, as a rule, are persistent dykes with steep dips and are found chiefly in the cover rocks of the batholith. The main types are minette,

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[1] Brögger, W. C.: Die Eruptivgesteine des Kristianiagebietes, vol. I, Die Gesteine der Grorudit-Tinguait-Serie, 1894, pp. 125-153.

[2] "Geology and ore deposits of Rossland," Geol. Surv., Can., Mem. 77, pp. 32, 237-240.

kersantite, vogesite, and spessartite. The lamprophyre dykes bear important structural relations to some of the ore-bodies as, for instance, in the Porto Rico and Fern mines.

Structure. The rocks composing the batholith have commonly yielded to the differential pressures of mountain-building periods by mashing and flowage producing gneissic structures. The foliation in the gneiss generally corresponds in strike and dip to that of the intruded schists; and both were later subjected to the Laramide orogenic revolution at the close of the Mesozoic era.

Secondary structure within the batholith is present in the form of joint planes in two or three directions. Vertical planes in two directions nearly at right angles and a horizontal set are the most prominent joint planes. A north and south trending set with steep easterly dips passing into sheeted zones is common toward the eastern border of the map-area. Diagonal jointing is prominent in the central portions of the mass. In many cases shearing has taken place along joint planes.

Origin. The nature of the origin of the Nelson batholith is a matter for speculation. Probably a combination of the hypotheses of active intrusion and magmatic stoping would best fit the facts as observed in the field. The manner in which the granitic intrusives conform in most instances to the structure of the overlying formations favours the former, while the presence in a few cases of crosscutting bodies of granite and the presence of angular inclusions near the contacts and freedom from them in the interior point toward the latter, or stoping hypothesis.

Age and Correlation. The date of the intrusion of the Nelson batholith and related stocks and tongues has been generally assigned to the late Jurassic or post Jurassic by McConnell, Brock, and Daly. In the Ymir district there is no evidence of its precise age, other than that it is later than the main orogenic movements, which occurred, probably, in Jurassic times, and older than the Tertiary intrusions of alkalic granitic rocks.

Monzonite Chonolith.

Distribution. Between Quartz and Boulder creeks southwest of the town of Ymir there outcrops over an area of less than one square mile an irregularly-shaped intrusive mass (chonolith) bounded in some places by flatly dipping contacts and elsewhere by steeply dipping contacts. The Free Silver and May Blossom properties are situated in and at the border of this minor intrusion.

Lithology. The monzonite is a granular to semi-porphyritic rock. It is a greenish grey to black colour with dark pyroxenes scattered through the light-coloured feldspathic constituents, the contrast between the two giving the rock a mottled appearance. In mineralogical composition the monzonite is of a somewhat syenitic type with femic constituents in large amount. It may be classed as between an augite-biotite syenite and a normal monzonite. The essential constituents are augite, biotite, orthoclase, and acid plagioclase; the accessory are iron ore, apatite, hornblende, and quartz; and the alteration products are chlorite, epidote, kaolin, and limonite.

Structure and Origin. The monzonite appears fresher than the Nelson granodiorite and does not show the effects of regional dynamic metamorphism as much as does the granodiorite. The exposed contacts between the monzonite and the Rossland Volcanic group are sharp, with little variation in the monzonite but considerable metamorphism in the intruded compact rock. This crosscutting, monzonite mass is very irregular in form and may be classed as a *chonolith.*[1] Apophyses or tongues of monzonite porphyry apparently connected in depth with the chonolith were noted farther north in the vicinity of Barrett and Hall creeks.

The contact relations of the monzonite with the older formations indicate its intrusive nature, and the size and shape of the mass and its homogeneity in texture and mineral composition indicate in all probability that it solidified under a thick cover of overlying formations. There is no evidence in the Ymir district to indicate that the monzonite magma or

[1] Daly, R. A., "Classification of igneous intrusive bodies," Jour. Geol., 1905, vol. XIII, p. 485. Daly defines a chonolith as "an igneous body (a) injected into dislocated rock of any kind, stratified or not; (b) of shape and relations irregular in the sense that they are not those of a true dyke, vein, sheet, laccolith, bysmalith, or neck; and (c) composed of magma either passively squeezed into a subterranean orogenic chamber, or actively forcing apart the country-rocks. Word derived from Χωνος, a mould used in the casting of metal, and λιθος a stone."

molten rock reached the surface to form latite flows.

Age and Correlation. The monzonite is younger than the Hall series, the augite porphyrite and the granite porphyry, and is older than the main period of mineralization and the Salmon River monzonite and pulaskite. It is considered that the monzonite chonolith is intimately connected in origin with the Nelson batholith and closely followed its intrusion, in late Jurassic or post-Jurassic time. The Ymir monzonite may be correlated with similar intrusives at Rossland and elsewhere throughout West Kootenay district.

CENOZOIC.

TERTIARY.

Oligocene(?).

Salmon River Monzonite Stock.

Distribution. About one mile south of Ymir on the Nelson and Fort Sheppard railway a small stock of coarsely granular monzonite forms prominent spheroidally weathered outcrops. The rock disintegrates rapidly into huge bouldery masses through exfoliation and concentric weathering on joint blocks.

Lithology. The Salmon River monzonite is a dark greenish grey, coarsely granular rock with stout prisms of augite and biotite in a feldspathic matrix, the contrast between the two giving it a mottled appearance that is characteristic. The larger crystals of feldspar schillerize in sky-blue colours which are particularly brilliant on wet surfaces.

Under the microscope the augite appears as the pale green, almost colourless diopside and the crystals commonly measure between one-eighth and one-quarter of an inch or more in length. The orthoclase is a soda variety and the plagioclase which is present in relatively small crystals is labradorite. Apatite and magnetite are present as accessory constituents and kaolin and chlorite as alteration products. A specimen of Salmon River monzonite collected by R. A. Daly from a similar stock farther down the valley was analysed by M. F. Connor of the Mines Branch and found to have the following composition:

Analyses of Salmon River Monzonite.

	I	II	III
SiO_2	50.66	52·38	62·59
TiO_2	1·32	1·10	0·54
Al_2O_3	16·91	15·29	17·23
Fe_2O_3	1·71	2·99	1·51
FeO	6·17	5·53	2·02
MnO	0·16	0·10	tr.
MgO	5·50	5·84	1·30
CaO	8·26	7·30	1·99
SrO	0·08	0·15	.....
BaO	0·23	0·25	.....
Na_2O	2·89	3·68	5·50
K_2O	4·45	3·84	6·74
H_2O at 110° C	0·14	0·21	0·30
H_2O above 110° C	1·06	0·63	.....
P_2O_5	0·91	0·75	0·11
	100·45	100·04	99·83

I. Salmon River monzonite, M. F. Connor, analyst.
II. Basic contact phase (monzonite) Coryell batholith, M. F. Connor, analyst.
III. Coryell pulaskite, north of Record mountain, Professor Dittrich, analyst.

Structure and Origin. The Salmon River monzonite is traversed by two or three sets of joint planes rather widely spaced, a flatly-dipping set being most prominent, as illustrated in Plate X. The manner in which the intrusion assumes a rounded to oval outline, in places crosscutting the rocks of the Pend-d'Oreille group, apparently independent of structure, is highly suggestive of the possibility of the pipe-like mass representing the eroded core of an old volcanic conduit. The occurrence of pulaskite in the central portion of the stock further favours this possibility.

Age and Correlation. The Salmon River monzonite stocks have been referred by Daly[1] to the post-Eocene (Miocene?) and may be correlated with the border phases[2] and cupola stocks and tongues of the Coryell batholith at Rossland.[3]

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[1] Daly, R. A. Geol. Surv., Can., Mem. 38, pt. II, p. 317.

[2] Compare analysis of basic border phase of Coryell pulaskite with Salmon River monzonite.

[3] "Geology and ore deposits of Rossland, B.C." Geol. Surv., Can., Mem. 77, 1915, pp. 29–30,233–236.

At Rossland the writer provisionally referred the porphyritic monzonite intrusions to the time of crustal movements in the Oliogocene and considered them genetically related to the alkalic syenite intrusions (pulaskite).

Pulaskite.

The core of the Salmon River monzonite stock one mile south of the town of Ymir, is composed of a typical granular pulaskite[1] almost identical with that of the Coryell batholith farther west. The transition from the one to the other is sharp and may be seen, well defined, near the railway track.

The pulaskite is a fresh, coarsely granular rock of a mauve grey colour; it is finely speckled with light to dark green augite and has a typical syenitic habit. It is composed essentially of long rectangular feldspars (intergrowths of orthoclase and albite) with augite (diopside) and biotite. Apatite and titanite are accessory constituents. The large feldspars which have a trachytoid structure display when wet, a brilliant blue schillerization colour.

The pulaskite is very closely related to the Salmon River monzonite and in all probability represents a slightly later intrusion. Very likely the molten pulaskite reached the surface to form trachyte flows, but erosion has left no remnants of such lavas within the Ymir map-area.

Miocene (?).

Syenite Porphyry, Granite Porphyry, and Younger Lamprophyre Dykes.

Throughout the district there are many salic and femic dykes which are found cutting all the previous formations, with the possible exception of the Salmon River monzonite and pulaskite. They are probably genetically connected with a Tertiary batholithic invasion (Coryell) and are predominantly alkalic in composition. All such dykes in this district are later than the main period of mineralization and are of little economic importance.

[1] Pulaskite is a type of alkalic syenite between a normal syenite and a nepheline syenite with biotite as chief ferromagnesian constituent. Nordmarkite is a quartz-bearing pulaskite.

QUATERNARY.

Boulder Clay or Till.

Till is found blanketing many portions of the upland and valley surfaces, becoming more abundant southward. It is made up of compact sandy clay with stones and boulders scattered abundantly and irregularly through it. Locally it coalesces with the outwash gravels lying along the major streams. Glacial erratic boulders are also of common occurrence.

Fluvioglacial Alluvium and Stream Deposits.

The modified glacial materials predominate in the valley floors and were in large part laid down by heavily burdened streams as outwash valley-trains contemporaneous with and subsequent to the retreat of the valley glaciers. Such deposits are well stratified and consist of cross-bedded sands, silts, and gravels. The gravels consist of well-rounded pebbles, cobbles, and boulders with lenses of coarse sand. The boulders are mainly of granite although all the more resistant rocks outcropping in the district are represented.

The older granite porphyry intrusives, Salmon River monzonite, and pulaskite readily disintegrate into a coarse feldspathic subsoil. The valley slopes and cliff bottoms are more or less skirted by wash and talus accumulations.

GEOLOGICAL HISTORY.

The Ymir district lies along the boundary line between the two great geosynclinal zones or prisms into which the North American Cordillera may be naturally divided. These are the eastern or Rocky Mountain geosynclinal and the western or Pacific geosynclinal. It has been pointed out by Daly that prior to the Mesozoic the two geosynclinals, as regards their relative periods of deposition and erosion, bore reciprocal relations to each other. A relatively small eastern portion of the Ymir map-area composed of the Summit series belongs to the Rocky Mountain geosynclinal, whereas the remainder of the area is part of the Pacific geosynclinal.

The earliest record in the Ymir district is one of early Cambrian or Pre-Cambrian sedimentation when sands, silts, and clays were deposited in a relatively shallow sea, later to be metamorphosed into the quartzites, metargillites, and schists of the Summit series. The climate at the time was probably arid with seasonal rainfall. Sedimentation was followed by uplift and crustal movements. The Palæozoic era was a time of everchanging epicontinental seas with intervening land barriers of a general low topographic relief. It was during one of the many such transgressions of the Palæozoic sea that the sand, mud, and lime rocks of the Pend-d'Oreille group were laid down. This long period of relative quiet was terminated by a series of great disturbances when the region was uplifted above the sea and the rocks deformed and in large part rendered schistose. The Palæozoic era closed with the beginning of continental conditions of erosion and sedimentation which have continued down to the present time.

The Mesozoic and later history is characterized by a higher relief of the region with a stronger tendency towards emergencies rather than submergencies as was so typical of Palæozoic history. The Triassic opened with vigorous erosion of the newly uplifted land surface. The main event at this time, however, in the Ymir district, was extensive volcanic activity in which coarse fragmental material and lava flows were erupted with contemporaneous intrusions of porphyrite sills. A short interval of quiet prevailed, however, long enough for several thousand feet of conglomerate, reddish sandstone, and carbonaceous shale to accumulate and these now form the Hall series.

In the Jurassic a most important geological event, from the economic standpoint, known as the Jurassic mountain-making revolution, took place throughout the Cordilleran region. It gave birth to many of the western mountain ranges and was accompanied by much igneous activity and related mineralization. Granite porphyry tongues were injected upward into the cover rocks, under great pressure from an invading granitic mass known as the Nelson batholith. Granodiorite and related rocks were intruded in great amount and produced wide contact aureoles of various kinds of schist—andalusite and biotite schists being perhaps the most common types.

A slightly younger intrusion of small areal extent, but one closely related to the Nelson granodiorite, took the form of an irregular monzonite mass (chonolith) which forms the country rock of the Free Silver and May Blossom veins.

Following batholithic and chonolithic intrusion and consolidation there was a period of extensive fissuring and mineralization and during that time the main ore deposits of the region were formed. Then came a long period of erosion, lasting throughout Cretaceous time; the mountains were slowly worn down, the cover rocks of the Nelson batholith largely removed, and the veins laid bare.

Toward the close of the Cretaceous crustal unrest commenced, which culminated in the Laramide revolution. The present ranges were outlined at that time. The climate in the mountains was probably cool and humid as evinced by the thoroughly leached, light-coloured sediments of the early Tertiary in adjoining districts and the presence of scratched and facetted boulders and pebbles from an early Tertiary tillite found in the Columbia range.[1]

Following the erosion and continental sedimentation of the Eocene, deformative movements took place, probably in Oligocene and Miocene times and were accompanied by the intrusion of the Salmon River monzonite, pulaskite, and related alkalic dyke intrusions. Then a long period of crustal stability ensued and the late Miocene-Pliocene erosion cycle commenced, which was largely responsible for the removal of great thicknesses of Tertiary sedimentary and volcanic records. The present gentler though still mountainous upland topography with broad flaring valleys may be referred to this Tertiary erosion cycle. It is inferred that the Tertiary era in this region closed with the land reduced to a surface of relatively low relief, but not so near the level of the sea as it was at the close of the Mesozoic.

The Quaternary era began with a great regional upwarping of the late Tertiary erosion surface which permitted the invigorated drainage to entrench itself deeply into the older upland surfaces and produce the present steep-walled valleys, since smoothed and modified by glacial ice.

[1] "Geology of Franklin mining camp," Geol. Surv., Can., Mem. 56, p. 65.

During the Pleistocene refrigeration of climate, the Cordilleran ice-sheet advanced and retreated leaving much drift. At least two distinct periods of valley glaciation and alluviation succeeded the disappearance of the ice-cap. With the retreat of valley ice the eroding activity of the streams increased and the dissection of the alluvial gravels, sands, and silts began. A series of terrace steps mark successive stages in this down-cutting process. At present stream deposits are being laid down at certain aggrading sections in the valley bottoms while the accumulation of subsoil, soil, and "wash" continues under the action of frost, ice, snow, rain, and humus.

SUMMARY OF GEOLOGICAL HISTORY.

The geological and physiographic history of the Ymir district may be presented for the sake of conciseness in the following tabular scheme:

Palæozoic.

(1) Cambrian or Pre-Cambrian sedimentation in a shallow epicontinental sea with accumulation of sand, silt, and clay (Summit series). Seasonal variation in climate from arid to pluvial conditions.

(2) Emergence of district above sea and continued erosion.

(3) Transgression of a Post-Cambrian sea over a downwarped peneplain. Marine sedimentation with deeper water conditions (Pend-d'Oreille group). Probably warm tropical climate.

(4) Uplift and local deformation of coastal plain deposits at close of the Palæozoic, followed by cycle of erosion.

Mesozoic.

(5) Great volcanic activity with ejection of pyroclastics and lavas; injection of porphyrite sills; short interval of quiet with deposition of continental sediments (Hall series). Probably semi-arid climate. Moderate relief.

(6) Orogenic uplift—"Jurassic revolution." Batholithic invasion with related intrusions (Nelson granite and monzonite); main period of fissuring and mineralization.

(7) Long continued cycle of erosion producing the Cretaceous peneplain.

(8) Laramide revolution. Epeirogenic upwarp of Cretaceous peneplain with maximum uplift along the axes of present mountain ranges. Probably humid, cool climate and mountain glaciers.

Tertiary.

(9) Eocene continental erosion and sedimentation with development of topography from state of youth through adolescence to maturity in places.

(10) Oligocene or early Miocene diastrophism and intrusion of Salmon River monzonite closely followed by pulaskite and later alkalic intrusions.

(11) Late Miocene and Pliocene cycle of erosion; production of mature topography in Ymir district, late maturity in broad intermontane depressions and local peneplanation in the Interior Plateau province; climate becoming cooler; drainage well organized.

(12) Differential upwarping of erosion surface in late Pliocene and early Pleistocene. Uplift slow enough for antecedent streams, some of whose courses were probably inherited from a Cretaceous peneplain, to maintain their general courses. Incision of Pliocene drainage beneath upland surfaces (youthful valleys).

Quaternary.

(13) Pleistocene erosion and glaciation. Arctic climate with milder interglacial periods; Cordilleran ice-cap and valley glaciers softened the contours of the old upland surfaces, steepened and bevelled the slopes of the youthful valleys, and left on its retreat much morainic and outwash material.

(14) Post-Glacial erosion cycle with formation of terraces, gorges, and ravines. Recent stream deposits, subsoil, and soil.

CHAPTER IV.

ECONOMIC GEOLOGY.

INTRODUCTION.

The province of British Columbia affords a varied field for the study of different types of ore deposits. Although many of these have characteristics in common, no two deposits are alike and geological principles that apply well to one will not necessarily apply to another. On this account many mistakes have been made; for geological generalizations carefully established as applicable to certain mining camps have been disastrously employed in others, resulting in the retardation of development on certain deposits and the waste of money on other less deserving occurrences of ore.

Owing to recent advances in the study of ore deposits and their origin it is now possible to apply geology to mining with a much higher degree of accuracy and safety than heretofore and it will be possible in the future to carry on prospecting and mine development in a much more scientific and economic manner than at present. It is important, therefore, that all the known mineral deposits of the province be systematically examined and classified and the basis for their classification made clear. By so doing investigators will know the criteria by which the various types of deposit may be recognized and referred to their proper place in the scheme. In this case the natural and ideal basis for classification would appear to be the genetic one; for upon the origin of an ore deposit depends the localization of ore shoots, their persistence laterally and in depth, and other fundamental problems most vital to the life of a mine.

The Ymir district, although at present a comparatively small producer, presents a number of diverse types of ore deposit, and the need of some such classification was felt in describing and correlating in the succeeding chapter the fifty or more properties scattered throughout the area of the map. In this chapter, therefore, after dealing in a general way with the mode of occurrence, structure, and character of the various Ymir ores and gangues, a section is devoted to their origin and age and their correlation with other better known ore deposits in the province. Accompanying this section is a table of classification of British Columbia ore-shoots, based on the physical conditions of their deposition and origin. The table, of necessity, is tentative and subject to change and revision as mine development and geological field work progress.

ORE OCCURRENCE.

The ore deposits of the Ymir district occur chiefly in quartz veins, the economic importance of which depends on their gold, silver, and lead content. The most important veins so far developed are indicated on the geological map (in pocket). They occur both in the granitic rocks of the Nelson batholith and in the metamorphic rocks of the Pend-d'Oreille and Rossland groups. No deposits have been found in the Summit series, although the gold-quartz veins of the neighbouring Sheep Creek camp occur in the southern extension of that series.

TYPES OF ORE DEPOSIT.

For convenience and clearness of treatment the Ymir deposits are described in the order of their present importance under the following heads:

(1) Ore-shoots in fissure veins cutting the country rock formations diagonally or at right angles.
(2) Ore-shoots or pockets in fissure or shear zone veins striking with the country rock formations.
(3) Replacement ore-shoots in limestone.

For an amplification of the following brief general description of the ore deposits the reader is referred to the detailed accounts of the various properties in the succeeding chapter.

Fissure Vein Ore-Shoots Cutting Formations.

To this class belong the most productive and persistent ore-shoots so far developed in Ymir district including, amongst others, the ore-shoots of the Ymir, Yankee Girl, Dundee, Wilcox, and Fern mines. The shoots occur in veins which represent quartz-filled fault fissures having a general northeast by east strike with steep northwesterly dips. The shoots vary in size, shape, and pitch, depending as a rule on local structures. In

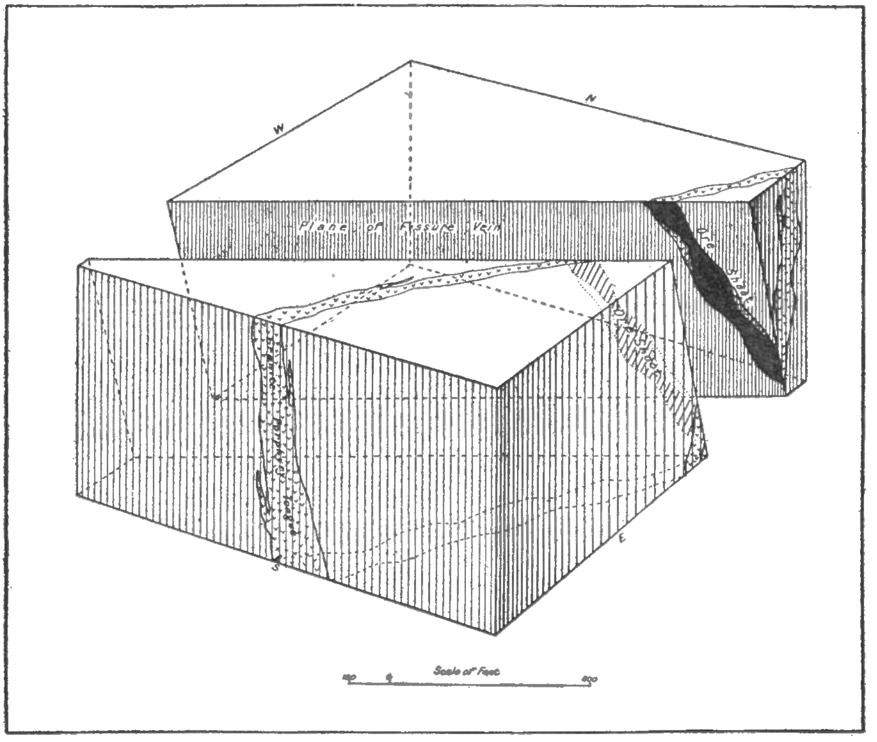

Figure 2. Block diagram to show localization of ore-shoot in quartz filled fissure vein at intersection of vein with granite porphyry tongue approaching main granite mass. Typical of shoots in the Dundee, Yankee Girl, and other properties south of Wild Horse creek.

certain cases the wall rocks of the vein are impregnated with ore and may be mined. Most of the ore-shoots owe their localization to changes in the country rock formations traversed by the fissure vein or to the intersection of dykes or faults with the veins. This is particularly applicable to fissure veins which intersect the country rock formations at acute angles (Figure 2). Veins of this character occur commonly in the contact injection zones between the rocks of the Pend-d'Oreille group and the Nelson granitic batholith. The faulting along the vein fissures has been such as to tend to offset or "heave" the northern or hanging-walls eastward with respect to the southern or foot-walls. Where the fissure planes were curved and undulating, the faulting along the planes resulted in the formation of pinches and swells in the vein, both along the strike and along the dip of the fissure. The swells in some cases afforded favourable places for ore-shoots. In character and direction the faulting in the Ymir district corresponds to that which took place along the principal vein fissures of the neighbouring Sheep Creek gold camp as well as to the regional faulting in the heavily-bedded quartzites of the Summit series at the International Boundary. In the case of the Sheep Creek gold veins, the ore-shoots pitch in the direction of the dip of the quarzite beds (Summit series) and were influenced by the nature of the faulted walls, whereas in the Ymir veins under discussion, the ore-shoots pitch in the direction of the granitic tongues or toward the batholithic source of the solutions. Well-defined fissure veins in some cases cut for hundreds of feet through the Pend-d'Oreille schists, and contain only barren quartz, except where the favourable granitic intersection is encountered.

Certain vein fissures, amongst others the Ymir, Wilcox, and Tamarac, have a general east-west trend and appear to differ in some respects from the northeast by east striking fissures just referred to. So far as known the ore-shoots of the Ymir vein were independent of granite intersections. As the critical workings of the mine were inaccessible in 1914 it was impossible to determine whether or not any local change in wall rock or intersection was responsible for the localization of the main shoot. The Ymir quartz vein is very strong and well defined on the lowest (No. 10) level but the ore-shoot played out at No. 7 level. The position of ground-water levels during previous geological periods may have been the main factor determining the depth of the ore-shoot. The physical character of the rock also and its amenability to replacement may have been influential factors as well as the nature of the faulting along the curving fissure which produced the lenticular swell in the vein now stoped out (Figure 8, page 103.) Secondary fracturing in the veins has lowered in some cases the zone of oxidation as evinced by the presence of carbonate zones containing limonite, cerussite, calcite, pyromorphite, and other minerals characteristic of that zone.

In the case of the Tamarac, east-west, curving fissure vein which dips flatly to the north, the ore-shoots are localized at relatively sharp bends in the fissure which apparently were in a state of tension and thus afforded ready access to ore-bearing solutions (Figure 3). The lateral extensions of the shoots are limited by drag structures in the vein, due to torsional stresses set up in the crust. The massive granite-porphyry bordering on both sides the ore-bearing, granite-porphyry schist acted as units, the western mass being thrust northward with respect to the eastern. The thrust subjected the intervening schist formation to a torsional strain which resulted in a crevasse-like fissure of elongated S-shape. The direction of the forces involved and the localization of the ore-shoots as exposed by underground and surface work are indicated in Figure 3.

In other cases in Ymir district ore-shoots or pockets are localized at the intersections of mineralized fault planes with the fissure veins, particularly where the angles of intersection are acute.

In the case of fissure veins traversing the Nelson granite, as for instance in the northeast corner of the map-area, it is significant that a number of the veins correspond in strike and dip with the master joint planes. The hanging-wall is invariably well defined and marked by both selvage and quartz, whereas the foot-wall is as a rule ill-defined, and contains quartz angulars (Figure 4). The quartz veins, furthermore, have a tendency to be curved with their concave side toward the centre and widest portion of the batholith. This may be explained as due either to shrinkage effect toward the border of the batholith or to subsidence of the central portion of the batholith during consolidation. The latter would result in tensional stresses being set up toward the border of the batholith with the formation of fissure arcs having concave surfaces toward the area of subsidence.

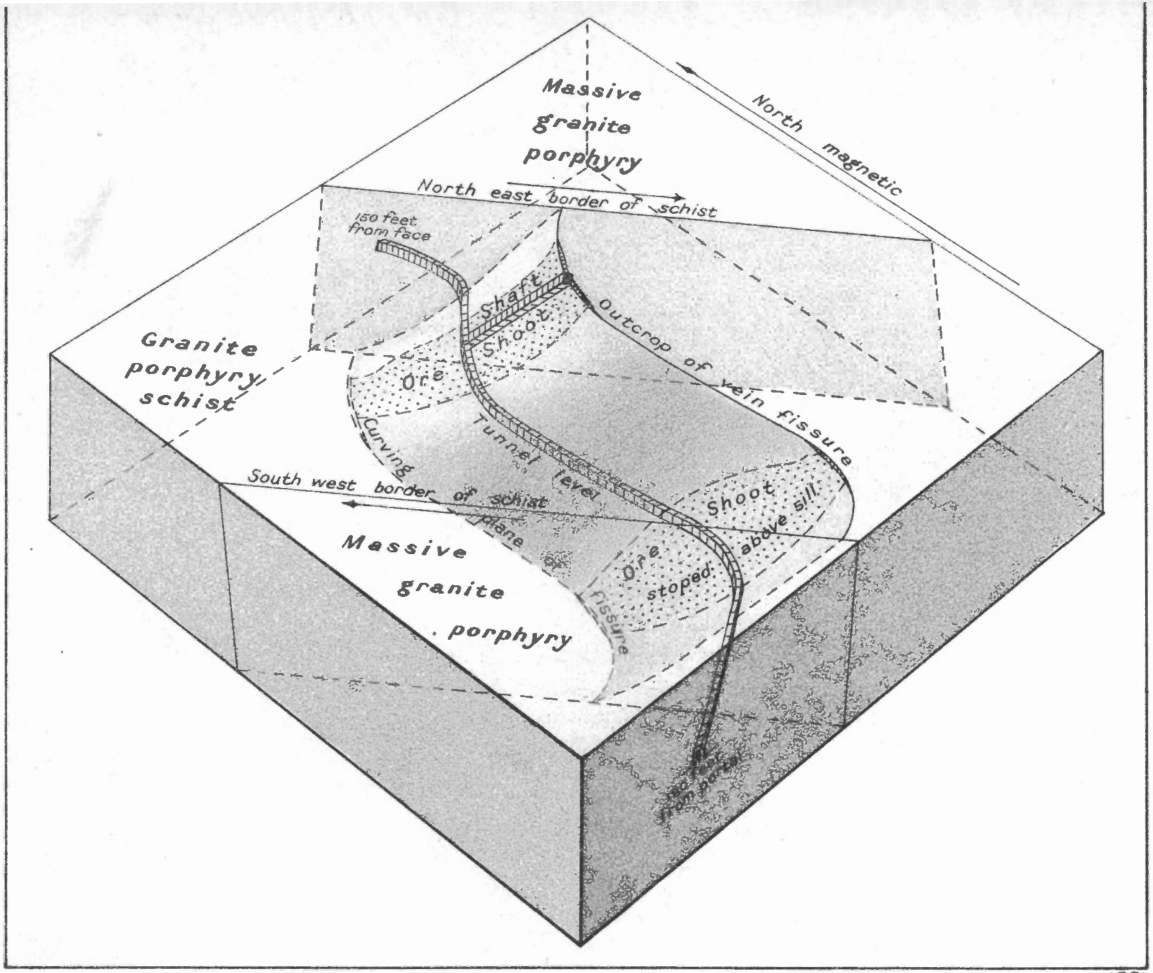

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Fig. 3. Block diagram of the **Tamarac** fissure vein showing structural relations of the ore shoots. The vein dips at an angle of 35 degrees and is curved as indicated.

Scale of feet

100 50 0 100

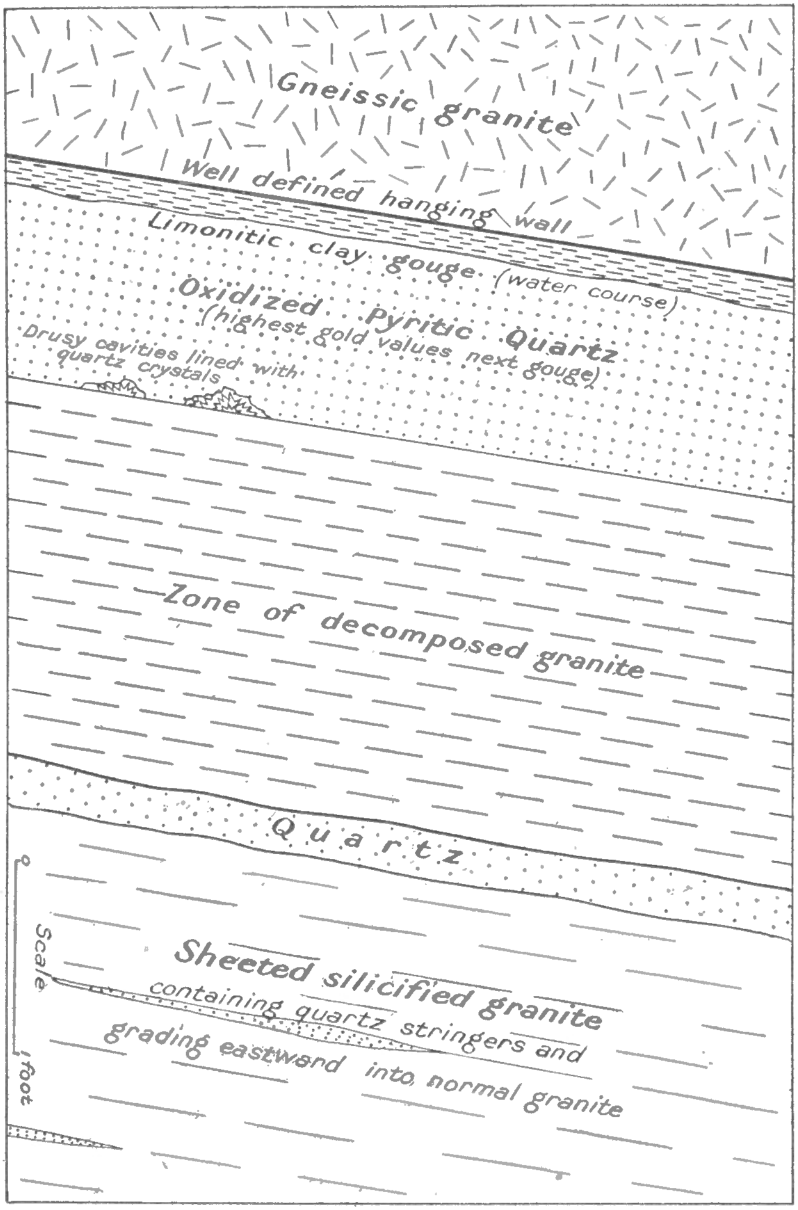

Figure 4. Complex fissurre vein at Foghorn mine.

Fissure Vein Ore-Shoots and Pockets, Striking with Formations.

As is shown on the geological map the regional trend of the formations is in a general north-south to north-northeast-south-southwest direction. It is natural, then, when Ymir district was subjected to the severe strains and stresses set up consequent upon crustal readjustments following batholithic intrusion and consolidation, that breaking points were reached and various systems of fissuring formed. The formational contacts and schist formations of the roof pendants in many cases afforded lines of least resistance to shearing and fracturing and a great many of the veins described in the succeeding chapter were formed in this way. The Pend-d'Oreille schist of the roof pendants, and the oldest granite porphyry (Rossland group) tongues form the main country rocks of such veins. The granite porphyry tongues are in large part schistose and difficult to distinguish from the darker-coloured greenstone or porphyrite schists of the Rossland group.

The ore in the veins of this system of shearing and fissuring is apt to occur in lenses or pockets and so generally lacks continuity, although it may carry high values. The pockets are dependent in most cases upon dyke or fault intersections, and the best ore is recovered from the veins where the wall rocks are granitic rather than sedimentary. In such cases the granitic dykes invariably strike with the schist formation, but dip at steep angles toward the main batholithic mass. As a result deep development on many veins of this type has proved disappointing.

Owing to continental and mountain glaciation and the absence of protective lava cappings, the zone of oxidation in this district is very shallow compared with that in regions farther south beyond the border of continental glaciation. It is, however, more in evidence here and still more so at Sheep Creek gold camp than farther north where glaciation was more intense. The ore in veins of the type under discussion is in many cases enriched by surface weathering and oxidation.

Replacement Ore-Shoots in Limestone.

The only case of a replacement ore deposit in limestone, within the limits of the map-area, is that of the Hunter V-Double Standard property, situated on the divide between Hidden and Porcupine creeks. The ore is very low grade galena, zinc blende, and pyrite and carries values in silver and lead with a little gold scattered through a carbonate gangue. It occurs as irregularly tabular masses having "commercial" boundaries and dipping flatly into the hill (Plate VII). The country rock is the crystalline limestone of the Pend-d'Oreille group which, unfortunately, in the neighbourhood of the ore, runs too high in silica to be much desired by the smelters as a mineralized flux. Surface enrichment on the Double Standard claim has resulted in the formation of small arborescent aggregates of native silver along fracture planes in the ore.

CHARACTER OF ORES AND GANGUES.

Ores.

The ores of the Ymir district may be classified as follows on a basis of mineral content:

(1) Ores consisting essentially of auriferous galena (both steel and cube) and iron pyrites (coarse and fine) with some zinc blende, in a gangue of quartz of varying colour and texture. No copper minerals are present in this class. Rarely cerussite and pyromorphite are present in the oxidized ores. These ores occur in the form of shoots in fault fissures which cut the Pend-d'Oreille group and Nelson granitic rocks. They are by far the most important ores yet known in the district and carry values in gold, silver, and lead. This occurrence of high gold values in galena and zinc blende is unusual and quite characteristic of Ymir ores.

(2) Quartz ores carrying free gold, also a little pyrrhotite, chalcopyrite, pyrite, and rarely tetrahedrite with associated carbonates and oxides. These ores are found associated with intrusive dykes in the Rossland Volcanic group.

(3) Galena ores with some pyrite and zinc blende, carrying values chiefly in lead and silver, in a quartz gangue. The country rock is mainly monzonite.

(4) Ores of auriferous pyrites in a quartz gangue. These ores are found generally in shoots and pockets in fissures or shear zones, in part replacement ores, striking with the enclosing schist and injected granitic formations.

(5) Low grade sulphide ore of galena, zinc blende, and pyrite, containing chiefly silver values, disseminated along with silica through a lime gangue. The ore where it is oxidized contains minute leaves of native silver as a surface enrichment product. The country rock of this mineralized flux material is the Pend-d'Oreille limestone and marble.

Gangues.

The chief gangue mineral in practically every case is quartz. Several varieties of quartz are present, most abundant being:

(1) A massive, clear, white variety so finely crystalline that no distinct crystals are visible to the naked eye.
(2) A fine-grained dense, bluish variety in some places smoky with a vitreous lustre.

The massive, white variety is the most common, although the bluish variety was noted very frequently in stringers in the roof pendants of the Pend-d'Oreille schist. The bluish colour may be due to the presence of finely disseminated sulphides or included microscopic rutile needles. In the fault fissure veins free gold is most commonly found in the dark, smoky, blue quartz in close association with the fine sulphides, the quartz in many cases occurring as glassy blebs throughout the mass of sulphides. The coarser, more brightly coloured sulphides scattered through the white quartz carry lower values in gold and silver. In the northeastern corner of the map-area large crystals of clear quartz occur in vugs in veins cutting the Nelson granite, and display comb structure. Kaolin, chlorite, and calcite occur less commonly as gangue minerals depending on the nature of the wall rock.

MINERALOGY.

In the following description of the minerals occurring in Ymir district only those found in close relationship to the veins will be included. The mineralogy of the Ymir veins is comparatively simple as a characteristic to be expected in veins formed as they were by ascending circulation at intermediate depths, with shallow zones of oxidation, and virtually lacking secondary enrichment and contact metamorphic zones. The list of minerals, arranged according to chemical composition, is as follows:

Native elements....................	Gold, silver.
Sulphides..........................	Pyrite, galena, zinc blende, chalcopyrite, pyrrhotite, tetrahedrite, arsenopyrite, molybdenite.
Oxides.............................	Quartz, limonite, wad.

Phosphate	Pyromorphite.
Carbonates	Calcite, cerussite, malachite, azurite.
Silicates	Tremolite, epidote, biotite, chlorite, serpentine.

Native Elements.

Gold (*Au*). Native gold is found in small flakes and finely disseminated specks in many of the Ymir quartz veins. It is most commonly found in the rusty honeycombed quartz of the oxidized zone. A part of the gold in the sulphides is in the free state but it has not been determined in what form the combined gold occurs. Tellurides of gold have been reported to occur in the ores from several of the properties and possibly some of the minutely disseminated gold may be in this form.

Silver (*Ag*). Native silver occurs very sparingly as arborescent aggregates or flakes along fracture planes in the oxidized ore of the Hunter V-Double Standard property. It is associated with limonite and tarnishes to a greyish black. The galena, zinc blende, and pyrite generally contain silver, a portion of which probably occurs in a relationship similar to that of the gold.

Sulphides.

Pyrite (*FeS_2: Iron 46·6, Sulphur 53·4 per cent*). The sulphide of iron is the most common of the metallic minerals occurring in the district and is found both in the veins and wall rocks. In the quartz veins it occurs in disseminated form either massive or in cubes and cubo-octahedral crystals and may have originated at different periods of mineralization. Much of the pyrite is gold-bearing, particularly that associated with galena and zinc blende. The coarsely crystalline and massive varieties occurring alone, in most cases, carry low values in gold and silver.

Galena (*$Pb\,S$: Lead 86·6, Sulphur 13·4 per cent*). Lead sulphide is probably the most sought after sulphide in the district. Occurring as it does in the fault fissure veins which cut the rocks of the Pend-d'Oreille group as well as the Nelson granite, it contains most of the gold and silver values. Both the fine-grained, steely, and the coarse, cubic varieties of galena are present.

Sphalerite, Zinc Blende (*Zn S: Zinc 67, Sulphur 33 per cent*). Zinc blende occurs in close association with the galena and pyrite and in many cases carries high gold and silver values.

Chalcopyrite (*$CuFeS_2$: Sulphur 35, Copper 34·5, Iron 30·5 per cent*). Copper pyrite or "yellow copper" occurs sparingly as impregnations and veinlets in association with pyrrhotite and pyrite. It is chiefly confined to quartz veins cutting the Rossland group.

Pyrrhotite (*Fe_8S_9: Sulphur about 39, Iron about 61 per cent*). Pyrrhotite or magnetic iron pyrite occurs very sparingly in association with chalcopyrite and pyrite, chiefly in the veins of the Rossland group.

Tetrahedrite or Grey Copper ($Cu\ (Ag)_8\ Sb(As)_2\ S_7$). Grey copper was seen in small aggregates at the Gold Cup property on Elise mountain, where it is associated with chalcopyrite and malachite in a quartz vein cutting the Rossland group. The occurrence of tetrahedrite scattered sparsely through the quartz on this property probably gave rise to the report that telluride ore occurred in the vein.

Arsenopyrite (*FeAsS: Iron 34·3, Sulphur 19·7, Arsenic 40 per cent*). Arsenical iron pyrites occurs sparingly in the district, but was observed in only a few of the ores collected.

Molybdenite (*MoS_2: Molybdenum 60, Sulphur 40 per cent*). Molybdenite is reported to occur in the Stewart Creek belt and at the Free Silver property, but was not seen. The mineral occurs at the border of a very quartzose variety of Nelson granite on Lost creek 10 miles south of the border of the area[1] and elsewhere in the Sheep Creek district.

Oxides.

Quartz (*SiO_2: Silicon 46·7, Oxygen 53·3 per cent*). Quartz forms the principal gangue of the veins and, as described in a

[1] Drysdale, C. W., "Notes on the geology of the Molly molybdenite mine," Jour. Can. Min. Inst., vol. XVIII, 1915, pp. 247–255.

previous paragraph on gangue minerals, occurs in various colours and textures.

Limonite ($2Fe_2O_3$ $3H_2O$: *Iron 59·8, Oxygen 25·7, Water 14·5 per cent*). Hydrous oxide of iron is commonly found in the oxidized zone of the veins as a product of the decomposition of the sulphides of iron and the rusty colour of many of the rocks is due to the alteration of disseminated sulphides to limonite.

Wad (*variable* H_2 Mn_2O_5). In many cases the wall rocks and selvages of the quartz veins in the oxidized zone, as exposed in the surface and underground workings, are covered with a thin coating of a dark-coloured, probably impure oxide of manganese. The black oxide is particularly noticeable in and near the quartz veins cutting the Nelson granite, and displays fern-like coatings on fractured surfaces.

Phosphate.

Pyromorphite($(PbCl)$ Pb_4 $(PO_4)_3$: *Lead Phosphate*). A bright yellow, encrusted, oxidation product was collected in the honeycombed surface ore at the Old Timer property up the North Fork of Wild Horse creek. This was determined by R. A. A. Johnston, mineralogist of the Geological Survey, to be pyromorphite. This mineral is very rarely found in Canada, the only other known occurrence being from the oxidized zone of the Society Girl vein in East Kootenay district, B.C.[1]

Carbonates.

Calcite ($CaCO_3$: *Lime 56·0, Carbon Dioxide 44·0 per cent*). Calcite, or calcareous spar, occurs as the main gangue mineral of the replacement ore-shoots in the Pend-d'Oreille limestone. It is either massive granular or coarsely crystalline in form, and near the ore it is usually siliceous. It is also found filling secondary slip planes, particularly in the shear zones striking with the Pend-d'Oreille schists, and was evidently formed at a period later than that of the main ore deposition.

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[1] Schofield, S. J., "Geology of Cranbrook map-area", Geol. Surv., Can., Mem. 76, pp. 110–111.

Bowles, O., Am. Jour. Sc., 4th ser., vol. 28, 1909, p. 40.

Cerussite (*Pb CO_3: Carbon Dioxide 16·5, Lead Oxide 83·5 per cent*). Cerussite is reported as occurring in the upper portion of the Ymir ore-shoot where secondary fracturing has locally lowered the zone of oxidation.[1]

Malachite (*$CuCO_3$ Cu $(OH)_2$: Cupric Oxide 71·9, Carbon Dioxide 19·9, Water 8·2 per cent*). Green copper carbonate is the common alteration product of the ores containing chalcopyrite. It forms coatings on fracture planes and colours the gouge at the surface.

Azurite (*2 $CuCO_3$ Cu $(OH)_2$: Cupric Oxide 69·2, Carbon Dioxide 25·6, Water 5·2 per cent*). Blue carbonate of copper is less common than the green carbonate and was noted at only one property.

Silicates.

Tremolite (*$CaMg_3$ $(SiO_3)_4$: Silica 57·7, Magnesia 28·9, Lime 13·4 per cent*). Tremolite was noted in long fibrous aggregates forming with calcite the gangue of a specimen of ore from the Hunter V-Double Standard property.

Epidote (*HCa_2 $(AlFe)_3$ Si_3O_{13}*). Epidote is a common secondary product of rock alteration and is found in nearly all the rocks of the district. Much of it was formed in the rocks prior to the main mineralization.

Chlorite (*Silicate of Aluminum with Ferrous Iron and Magnesium and Chemically Combined Water*). Chlorite is frequently found in and near the veins as an alteration product of the ferromagnesian minerals in the wall rocks and in gouge material.

Serpentine (*$H_4Mg_3Si_2$ O_9*). Serpentine occurs like chlorite as an alteration product in fissures and along fault surfaces.

Kaolin or Kaolinite (*H_4 $Al_2Si_2O_9$, or $2H_2O$, $Al_2O_3 \cdot 2SiO_2$: Silica 46·5, Alumina 39·5, Water 14·0 per cent*). Kaolin occurs in the weathered gouge material accompanying fissure veins and faults which cut the granitic and gneissic rocks and porphyries. Many of these gouge zones are wet and form water courses and the kaolin results from the decomposition of the aluminous minerals occurring in them, especially the feldspars of the granitic rocks.

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[1] Fowler, S. S., "The Ymir mine and its mill practice," Jour. Can. Min. Inst., 1900, pp. 3–10.

ORIGIN OF ORE DEPOSITS.

From a consideration of the occurrence and mineralogical association of the ores and gangues, it is inferred that the metallic sulphides were deposited from hot, ascending solutions. Minerals diagnostic of contact metamorphic zones, or deep vein and upper vein zones are absent, so that the zone of deposition must have been at intermediate depths.[1] That the deposits were formed from aqueous solutions is indicated by the manner in which they exist as fissure fillings, the veins being in many cases well banded, and in some places exhibiting comb and druse structures.

At different periods in their history the rocks have been fissured and sheared and suffered considerable displacement and alteration. Many of the later faults followed old planes of fracture; for the accumulated crustal stresses found in them planes of weakness. The most important fissures from the economic standpoint bear genetic relationships to the Jurassic mountain-making revolution and intrusion of the Nelson batholith. The orogenic movements at that time uptilted the sedimentary formations to almost their present attitude. Compressive stresses probably dominated immediately prior to the granitic intrusion as a result of the upward pressure of the igneous mass. Many shear zones and fault fissures developed in the formations of the batholithic cover with a local tendency to offset and shear the formations to the northeast. The granitic batholith reached its present position by active intrusion and *lit par lit* injection under great hydrostatic head. The molten rock, with preceding gases and liquids, was forced into the already much sheared and fissured roof rocks and caused the recrystallization of the Pend-d'Oreille limestone to marble, the formation of andalusite schists from the clay rocks rich in aluminum and low in calcium, and the infiltration of much quartz, feldspar, and mica to form various schists. The schists are in many places much contorted and foliated, particularly the limy varieties in the roof pendants.

[1] Lindgren, Waldemar, "Mineral Deposits," pp. 513–515.

Lindgren suggests temperatures of from 175 to 300 degrees Centigrade and pressures of from 140 to 400 atmospheres for ore-bodies formed at intermediate depths. He further states that such deposits are formed from 4,000 to 12,000 feet from the surface.

It must be borne in mind that long continued denudation through Cretaceous and Tertiary time has removed great thicknesses of formations which formerly covered the batholith and has exposed the granitic rocks and pendants. Immediately following the batholithic intrusion of the late Jurassic, the direction of the crustal stresses probably changed to one more nearly vertical than horizontal and such as would result from differential elevations or subsidences over the region.

The fissuring systems, which resulted from the relief of the tensile stresses and from local contractional and shrinkage forces set up in the roof rocks and underlying batholith itself, afforded channels of circulation for the mineralizing solutions. The solutions—the after effects of batholithic intrusion—ascended from great depths and deposited their burden of gold, silver, lead, zinc, and iron in the fissures in the form of metallic sulphides in a quartz gangue. The earliest solutions, under high temperature and pressure conditions, were very siliceous and deposited quartz and pyrite in the fissures and even replaced the wall rocks in places, and sent into them branching angulars of barren white quartz. They were closely followed by the ore-bearing solutions which deposited auriferous galena, zinc blende, and pyrite in quartz gangue at certain favourable localities in the vein.

The localization of the ore-shoots in the veins has been alluded to in a previous section; and it may be stated here that although, in this type of vein deposit formed at intermediate depths, the country rock formations do not play the important rôle in the localization of values that they do in the replacement type of deposit formed in the deep vein zone, nevertheless, the physical and chemical character of the country rock has influenced considerably the nature and extent of the enclosed ore deposits.

The zone of oxidation in Ymir district, although not so extensive and deep as in the neighbouring Sheep Creek gold camp to the south, is much more pronounced than it is in the Slocan and other mining camps farther north. This change in the oxidation zone may be due to the gradual diminishing of the eroding effect of the Cordilleran continental ice-sheet towards its southern border which was not far south of the International Boundary. The oxidized zones, where present, are found on the upland slopes above the youthful valleys. The valleys have been cut since the late Pliocene uplift and have been occupied by at least two valley glaciers since the retreat of the Cordilleran ice-sheet. Consequently, the vein out crops on the upland have been exposed to weathering for a longer period of time and have developed a deeper zone of oxidation than the veins in the more recently glaciated valleys.

AGE AND CORRELATION OF ORE DEPOSITS.

The ore deposits of Ymir district are referred to the Mesozoic era and probably closely followed the intrusion of the Nelson batholith. The Nelson batholith and related satellitic intrusions have been assigned to the late Jurassic or post-Jurassic by McConnell, Brock, and Daly. The deposits are of the same age as those of Nelson, Sheep Creek, Bayonne, Slocan, Ainsworth, and other mining camps in West Kootenay district whose ores, too, appear to be genetically connected with the same granitic batholith and cupola stocks.

The chronological sequence of the geological events influential in the formation of the ore deposits as now exposed is tabulated as follows:

(1) Late Jurassic orogenic revolution; uptilting and faulting of formations belonging to the Pend-d'Oreille and Rossland groups.

(2) Faulting and shearing followed by *lit par lit* injection of Nelson granitic tongues and stocks into the steeply dipping cover rocks of the batholith; infiltration and crystallization of quartz, feldspar, and mica in Pend-d'Oreille schists; and formation of contact metamorphic aureoles of andalusite schist, marble, and chert.

(3) Period of fissuring followed the intrusion of the Nelson granite; first mineralization by siliceous sulphide waters, and formation of barren white quartz veins and angulars and replacement of certain wall rocks.

(4) Main deposition of ores in the form of ore-shoots and pockets in fissure veins at intermediate depths.

(5) Cretaceous period of erosion and removal of much of the batholithic cover.

(6) Laramide uplift; faulting and offsetting of the veins.

(7) Tertiary erosion; surface weathering and oxidation in veins.

(8) Cordilleran ice-sheet glaciation during the Pleistocene and subsequent valley and mountain glaciation which removed much of the Tertiary vadose zone of the veins.

(9) Post-Glacial weathering and oxidation with formation of limonite, cerussite, pyromorphite, malachite, kaolin, and chlorite in shallow oxidation zone; surface enrichment of gold and silver.

For correlation purposes the accompanying table of classification for British Columbia ore-shoots is offered. The basis of classification is the genetic one and in the tabulation the guiding principle has been the temperature and pressure conditions of deposition as established by Lindgren[1] and other economic geologists.

PRESENT STATUS AND FUTURE OF DISTRICT.

At present there is very little mining being done in Ymir district. The properties being worked, for other than annual assessment purposes, are the Yankee Girl, Gold King, Wilcox, and Foghorn mines. Within the area of the map there are five completed gravity-stamp mills most of which are now in a state of disrepair. Water-power and timber for mining purposes are plentiful and the Nelson and Fort Sheppard railway affords good transportation facilities. The Trail smelter is about 30 miles distant and the Northport smelter, Washington, about 40 miles. Much of the ore was shipped to the Hall smelter at Nelson 18 miles to the north before it was destroyed by fire several years ago, although a limited quantity was sent to the Granby smelter at Grand Forks, B.C. The main producers in the district have been the Ymir, Fern, Porto Rico, Yankee Girl, Dundee, Wilcox, and Hunter V mines, their total production amounting to about 500,000 tons. The details regarding production and values, mining methods, etc., for each individual property, are given in the succeeding chapter.

Without doubt many undiscovered veins and ore-shoots are still hidden under the thick cover of wash and drift in certain promising belts. Much of this territory, however, is held by crown grant and there is little encouragement to the prospector. Veins parallel to those of the main producers of the past should be sought after and many of the abandoned barren veins should be tested further for the occurrence of ore-shoots at geologically favourable localities.

The successful exploitation of the ores in the district would be aided by an amalgamation of interests which would result in

[1] Lindgren, Waldemar, "Mineral Deposits," p. 188.

systematic prospecting and the development of the ore reserves. The following policy advocated by O. E. LeRoy[1] for the Nelson district is equally applicable to Ymir district. "The owners should be willing to permit their properties being developed under a practical working bond without any cash consideration. If the property is not sold the development work proves its value to a certain extent, and if the property is worthless the sooner that fact is discovered the better for the owner. There are so many cases throughout the country generally where the owner is spending his money in desultory development which is oftentimes valueless. The majority of mineral deposits are not easily exploited, but call for the employment of strict technical and business methods beyond the resources of the small holder. If reputable people could be secured to interest themselves every facility should be given to encourage them. Such a policy if generally adopted would undoubtedly yield results beneficial both to the individual and the community."

[1] "Geology of Nelson map-area," Geol. Surv., Can., Sum. Rept., 1911, p. 146.

CHAPTER V.

DESCRIPTION OF MINES AND PROSPECTS.

INTRODUCTION.

More than three hundred mineral claims are located within Ymir map-area and about one-half of them are surveyed and crown-granted. Some of the claims originally crown-granted have since been forfeited to the crown and sold for taxes. With a few notable exceptions the crown-granted claims are allowed to remain idle and are barred to the prospector, although some of them are at times leased or bonded. Annual assessment work is done on many of the ungranted claims in the area. There are five gravity-stamp mills in the district and one about to be constructed.

For purposes of description and in order to avoid repetition the properties and claims in the district are grouped in ten mineralized belts, each named after the creek which gives access to it. The belts are described in order of location from Wild Horse creek southward (east of Salmon river) in extensions of the same ore-bearing formations; then from the south border of the area (west of Salmon river) northward to Clearwater creek. The properties or claims are arranged alphabetically under each belt heading and their precise position in the district is shown on the accompanying mineral-claim map compiled by the late Geo. E. Revell[1] (Figure 5).

Killed in action in France with the Canadian Engineers.

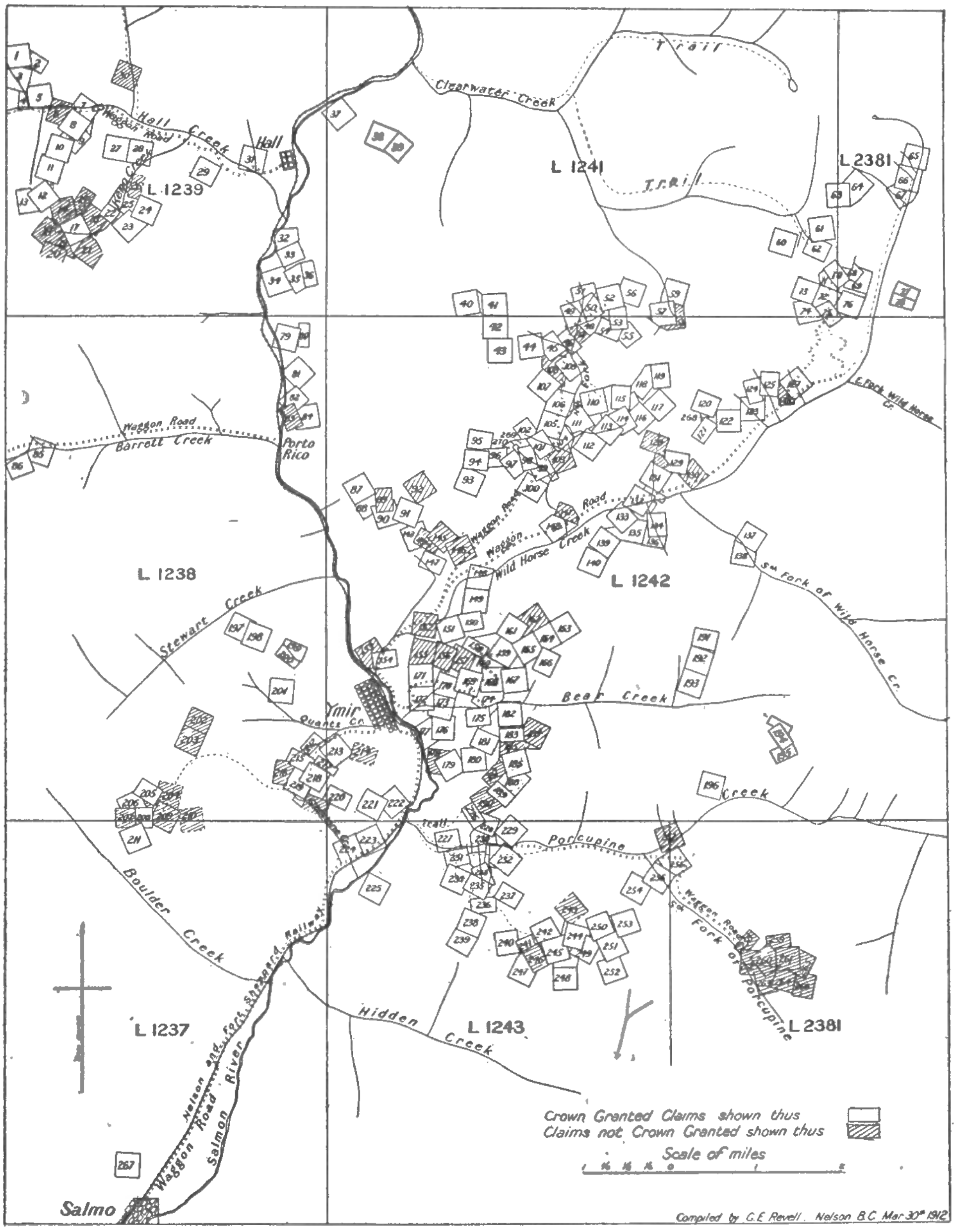


Figure 5. Mineral claims in the vicinity of Ymir (see Addenda, page 149).

LIST OF PROPERTIES.

The following is a list of the main crown-granted claims:[1]

No. (see Fig. 5)	Name of claim	Locator	Date of locating
98	Rockland..........	Jerome Pitre.............	July 9, 1895
101	Ymir..............	Joseph Pitre..............	July 17
97	Mugwump.........	Oliver Blair..............	Aug. 5
—	Goodenough........	Alex. Gayette............	June 16, 1896
—	Free Silver.........	J. M. McLaren...........	„ 22
46	Elise...............	Oliver Blair..............	„ 30
99	Golden Horn.......	Jerome Pitre.............	July 7
52	Summit[2]	C. W. Anderson et al......	„ 8
131	Sterling............	Wm. Caldwell............	„ 9
129	Blackcock..........	A. Julien.................	Aug. 1
122	Wilcox...........		
268	Fourth-of-July....	Phil. White and S. Bywater	....
120	Bywater..........		
132	Roanoke[3]..........	R. R. Burruss............	Aug. 3
228	Gold Queen........	Swan Nelson.............	„ 30
230	Mulligan...........	Geo. Eicherman..........	Sept. 3
70	Good Hope........	J. J. Dewar et al..........	„ 5
186	Blue Quartz........	E. Peters................	„ 12
91	Tamarac...........	J. W. Handen............	„ 12
188	Rover.............	E. Peters................	„ 14
75	Foghorn...........	A. Parks and P. Keo......	„ 16
248	Empress...........	F. Britton...............	„ 25
—	Porto Rico.........	Maxwell and Day.........	....
—	Joplin.............	H. R. Bellamy............	Oct. 8
	Robertson Frac.....	R. B. Wood..............	Dec. 8
	Nora Frac.........	B. A. Robertson..........	„ 16
209	May Blossom......	W. Birmingham..........	May 1, 1897
10	Fern..............	Capt. Duncan............	June
57	Dumas............	E. Croteau and G. Pellent.	July 20
—	Union Jack.........	Michael Nealy...........	„ 23
110	Carthage[4]..........	H. Kearns...............	Aug. 25
116	Golden Calf........	E. Peters................	Sept. 30
117	Canadian Pacific ..	T. S. McPherson..........	Oct. 3
270	Lawrence Frac......	London and B.C. Gold Field Ltd...............	„ 30
269	Pountney..........	S. S. Fowler..............	„ 30
59	Alexandre..........	E. Croteau and G. Pellent.	March 18, 1898
234	Nevada............	J. B. Stover..............	July 1
158	Atlin..............	J. W. Masterton..........	Oct. 27

[1] Mr. J. Cartmel, gold commissioner at Nelson, has kindly furnished the dates and names of locations of most of the claims mentioned.

No. (see Fig. 5)	Name of claim	Locator	Date of locating
161	Canadian Girl......	O. A. Lovell..............	Oct. 30, 1899
159	Yankee Girl........	J. H. Graham............	„ 30
	Dundee............	J. Lang Stocks...........	May 7, 1900
245	Hunter V..........	A. A. Vernon.............	„ 21
160	Yukon Frac........	A. C. O'Neill.............	Oct. 1, 1901
	Commodore........	Philip White.............	June 17, 1902
	Old Timer.........	E. M. Peters, R. R. Shrum, Chas. Desrosiers........	July 26, 1903
	Gold Cup..........	Ernest Ballinger..........	Oct. 25, 1910
	Lost Cabin[5]........	Ernest Ballinger..........	July 6, 1911
	Jennie Bell.........	J. Kileel and J. R. Bremner....................	„ 17

[2] Forfeited to Crown Nov. 5, 1907.
[3] „ „ „ „ „ 1905.
[4] „ „ „ „ „ 1905.
[5] Lapsed.

WILD HORSE CREEK AND SOUTH FORK BELT.

Blackcock.

The Blackcock claim adjoins the Sterling, lying to the northeast between the Sterling and the Wilcox. The property was located August 1, 1896, by A. Julien who did development work on it during 1898 and 1899 and made a shipment of about 35 to 40 tons of ore running about $25 per ton in gold and silver. The property is owned by McMillan Brothers.

The Blackcock vein belongs to the general north-south (magnetic) trending system of veins and occurs in the same roof pendant of Pend-d'Oreille schist as the Sterling and Roanoke veins. The roof pendant is about 300 feet wide, contains much injected granitic material, and is transversely cut by a series of lamprophyre dykes. To the west it is bounded by porphyritic granite and to the east by the normal granodiorite of the Nelson batholith. The mineralization appears to follow fracture planes striking and dipping steeply with the schists. That there has been considerable movement along the fissures is indicated by the occurrence of much gouge material and slickensides. A nearly horizontal set of striations, tending to plunge southward, is present in certain of the veins, indicating a differential horizontal movement or heave. The mineralized zone appears to be confined to the eastern half of the roof pendant and the values are found in the pyrites in a quartz gangue associated with some zinc blende and galena. Calcite occurs in the gouge material in some places as dog-tooth spar.

The Blackcock property has been practically idle for more than fifteen years.

Canadian Pacific.

The Canadian Pacific group consists of twenty-four claims and fractions, seven of which are crown-granted, and embraces a tract of territory lying on the mountain divide between the Wilcox and Ymir mines. The crown-granted claims were located during the autumns of 1896 and 1897 by E. Peters, H. R. Bellamy, and T. S. McPherson. They are the Canadian Pacific, Golden Calf, Annie Maud, Ramsey, Joplin, Oronogo, and S. J. M.

Open-cuts, and prospect tunnels and pits have disclosed several parallel veins. The Canadian Pacific veins, like the Blackcock, Sterling, and others, belong to the north-south (magnetic) system striking and dipping with the schist formation. The gold values are in the pyrites and are highest where the gangue is blue quartz.

Commodore.

Location and Development. The Commodore group of six claims is situated on the south side of Wild Horse creek nearly opposite the mouth of the North Fork and at an elevation of about 2,750 feet above sea-level. The Commodore claim was located June 17, 1902, by Philip White and has not been crown-granted. The group of claims including the Commodore is now owned by D. E. Grobe and others who have done at least

300 feet of tunnelling besides open-cut work on the property. One tunnel was caved-in at the time of examination and could not be examined.

Geology. The vein is in a contact zone between Nelson granite and Pend-d'Oreille schist. It strikes with the schist, but where opened up has a westerly dip of 50 degrees. The upper tunnel encounters two parallel veinlets of quartz and in one place the quartz swells to form the whole "back" or roof of the tunnel. The face of the tunnel is in massive granite. The lower tunnel is 130 feet long and follows the north-south (magnetic) trending vein which, when followed southward for 60 feet, swings westward and assumes a strike of north 40 degrees east (magnetic) with a dip of 50 degrees to the northwest. A heavy sulphide showing is present near the face, but the values in gold and silver are low. Ruby silver has been reported to occur in ore from this property.

Foghorn.

Location and Development. The Foghorn property is situated on the steep western side of Wild Horse valley at an elevation of approximately 5,800 feet above sea-level and 2 miles below the source of Wild Horse creek. The Foghorn crown-granted claim was located September 16, 1896, by A. Parks and P. Keo. It was acquired a few years later by the Golden Monarch Mining and Milling Company of Spokane under the management of Mr. Conrad Wolfe who carried on energetic and almost continuous development work during the years 1901, 1902, and 1903. The mine has not been operated since March 26, 1904[1]. There is nearly 2,000 feet of tunnelling on the property all done by hand drilling, as well as four prospect shafts and numerous open-cuts on the veins.

Geology. The work has been done on three quartz veins known as Nos. 1, 2, and 3 veins, Nos. 2 and 3 are almost parallel, and No. 1, on which the first work was done, forms an acute angle with the other two. All three veins have been well exposed on the surface by means of open-cuts and prospect shafts. No.

[1] During the summer of 1916 the property was being prospected by means of the diamond drill.

1 vein is the most northerly and the highest and No. 2 the most southerly and lowest with No. 3 vein traversing the intervening ground. No. 1 vein, as exposed in an open-cut, strikes north 8 degrees east (magnetic) and dips at an angle of 52 degrees to the west. The foot-wall of the quartz vein is an aplitic variety of granite grading into gneiss; the hanging-wall is normal granite and contains small angulars of quartz. The quartz is honeycombed and iron stained in places. A little farther north there is a prospect shaft about 15 feet deep on the same vein. At that point the vein contains quartz and strikes north 10 degrees 30 minutes east (magnetic) and dips 44 degrees to the west. An angular of quartz is present in the foot-wall. About 40 feet below the prospect shaft a crosscut tunnel 166 feet long taps the vein after passing through a fine-grained siliceous granite which is in many places foliated. The vein, where it is intersected by the crosscut tunnel, strikes north 10 degrees east (magnetic) and dips at 45 degrees to the west. A drift on the vein for 24 feet southward shows that it swings slightly to the east, the dip of the foot-wall flattens locally to 35 degrees and the hanging-wall dip steepens to 55 degrees. A drift northward on the vein for 22 feet shows that it swings 1 degree to the west in strike, and steepens in dip to 54 degrees. In the face of the north drift 1 foot of quartz is present in the vein with 2 to 3 inches of selvage or gouge on the hanging-wall. Wad is common in and near the vein. The hanging-wall is well defined and marked by gouge and slickensides. Ore from a heap near the portal of the tunnel consisted of iron pyrites in a blue quartz gangue.

No. 1 vein has been further developed along its northern extension in a nearby gully by a shaft sunk inside the portal of a short tunnel. The vein at the shaft strikes north 10 degrees east (magnetic) and dips at an angle of 50 degrees to the west. The hanging-wall is gneissic granite; against the wall is 2 inches of oxidized, iron-stained selvage; next to this is 1 foot of glassy comb quartz with vugs separated by a parting plane from 1 foot of decomposed granite. This is followed by 3 to 4 inches of clear finely crystalline white quartz on the foot-wall. The foot-wall of the vein is the same siliceous variety of granite; it contains quartz stringers, and passes gradually into the normal Nelson granite at a distance from the vein.

No. 2 vein is exposed in an open-cut about 250 feet lower in elevation than the tunnel on No. 1 vein. No. 2 vein strikes north 40 degrees east (magnetic) and dips 45 to 50 degrees in a northwesterly direction. A crosscut tunnel 20 feet long is driven 40 feet below the level of the open-cut and from the crosscut there is a drift on the vein for 66 feet. The vein in the face shows one inch of quartz containing pyrite and limonite with several inches of oxidized and kaolinized granitic vein rock. The country rock is salic, foliated granite containing large phenocrysts of orthoclase.

No. 3 vein, from which the highest values were obtained, is opened up by three surface cuts, a shaft with drifts, and an adit tunnel. The open-cuts expose a vein 1½ to 3 feet wide, of comminuted, decomposed granite containing bunches of quartz (honeycombed in places). The hanging-wall is well defined and undulating and both walls are of granite. Large quartz crystals are present in vugs in the oxidized vein. An incline shaft sunk on the vein is down about 20 feet and there appear to be drifts in both directions from it which were filled with water at the time the mine was visited. The elevation of the shaft collar and portal of the tunnel is about 100 feet higher than that of the tunnel on No. 2 vein, and about 135 feet lower than the uppermost open-cut on No. 3 vein. The workings are close to the upper terminal of the aerial tram.

The vein is encountered 39 feet in from the portal and there it strikes north 33 degrees east (magnetic) and dips northwesterly at an angle of 53 degrees. This strike persists for 99 feet; then the dip steepens to 65 degrees and the vein swings northwesterly and strikes north 61 degrees east (magnetic) for 54 feet to the face. A mica-lamprophyre dyke occurs in the face of the tunnel striking north 50 degrees west (magnetic) and dipping northeast at an angle of 70 degrees. The vein is a fissure zone containing much gouge and breccia and has served as a water course. Quartz bunches occur in the gouge material and of the two walls the hanging-wall is by far the best defined.

In 1900 the Golden Monarch Company commenced a crosscut tunnel several hundred feet lower than the apex of No. 1 vein, intending to tap the veins in depth, particularly No. 3 vein from which the highest values were obtained. The tunnel runs north 65 degrees west (magnetic) and is all in granite. At a distance of 525 feet in from the portal a shear zone, striking north 36 degrees east (magnetic) and with a steep dip to the northwest, was encountered and drifted on for 51 feet in a southwesterly direction and for 8 feet in a northeasterly direction. This may be the lower extension of No. 2 vein. Thirty-nine feet farther along the tunnel another parallel shear zone dipping 70 degrees to the northwest, has been raised on for 10 feet. A 20-foot drift has been driven to the northeast on a small shear in the granite, 123 feet farther in. Forty-five feet farther a vein which, in all probability, is No. 3 vein in depth is met. Here the fractured zone is drifted on for 80 feet to the south where the same lamprophyre dyke which terminates No. 3 vein at the upper tunnel is encountered. The vein southwest of the dyke was searched for in all directions by running short workings, but without success. No work was done northeast of the crosscut, although the upper tunnel and shaft proved that the best values in No. 3 vein are at that level, over 200 feet northeast of the lamprophyre dyke. What is probably the lower extension of No. 1 vein is opened up in a 210-foot drift (110 feet northwest and 100 feet southeast from the crosscut) about 1,100 feet in from the portal of the tunnel. At this level the vein has little quartz and is a shear zone pinching at the northwest end to a gouge seam. At the southeast end of the drift two well-defined slip planes resembling a hanging-wall and a foot-wall dip at angles of 70 degrees to the west.

Good Hope.

Location and Development. The Good Hope claim is north of the Foghorn property and is at an elevation of about 6,200 feet above sea-level. The claim was located September 5, 1896, by J. G. Dewar, O. J. Hadley, J. H. Galbraith, and J. A. Dewar, and is crown-granted. Development consists of 97 feet of crosscutting, 207 feet of drifting, nearly 100 feet of sinking, and several open-cuts. The property has been idle for at least fifteen years.

Geology. Two parallel veins were noted on the Good Hope property one about 160 feet higher in elevation than the other. The country rock is Nelson granite. The highest and main vein is opened up by means of two open-cuts 100 feet apart, a crosscut tunnel, drift, and winze. The vein on the surface strikes north 21 degrees east (magnetic) and dips to the northwest at an angle of 48 degrees. The crosscut tunnel is about 40 feet lower in elevation than the open-cuts and at 97 feet encounters the vein. At this point a winze is sunk on the vein for nearly 100 feet. The vein at this level strikes north 22 degrees east (magnetic) and dips at 50 degrees to the northwest. The vein is drifted on for 207 feet, a sharp bend occurring about halfway down. Southwestward the dip of the vein decreases from 50 degrees to 45 degrees. The quartz vein is much broken in the face of the drift and there is much gouge material. At the bend in the vein there is a prominent gouge of white kaolin. There is evidence of much movement along the vein which is a water course in places. The hanging-wall is well defined and is slightly undulating. The granite contains orthoclase and microcline showing incipient kaolinizationand has considerable secondary quartz. Near the portal of the tunnel the granite is foliated and includes drawn out fragments or schlieren of a fine-grained hornblende granite characterictic of some granitic borders.

The lower quartz vein is exposed in an open-cut about halfway between the main vein and the Good Hope cabin. It strikes north 16 degrees east (magnetic) and dips to the northwest at an angle of 46 degrees. A short distance below the cabin a roof pendant of the Summit Series schist outcrops as a series of cliffs.

Roanoke.

Location and Development. The Roanoke claim is situated in the bottom of Wild Horse valley about one mile above its junction with that of the North Fork. Wild Horse creek flows diagonally through the middle of the claim. It was located August 3, 1896, by R. R. Burruss, was crown-granted, but later forfeited to the crown, November 6, 1905.

Geology. The Roanoke is on the southwesterly extension of the same mineralized belt as the Sterling and Blackcock properties which adjoin it on the northeast. The tunnel is on the south side of the creek close to the water's edge and is caved in. Vein rock on the dump contains pyrite and a little galena. The country rock is the Pend-d'Oreille schist (banded quartzite) occurring as a roof pendant about 300 feet wide in the Nelson granite batholith and striking north 7 to 12 degrees east (magnetic) and lying vertical. The mineralization at this locality appears to follow the southeastern border of the roof pendant. The schist on the north side of the creek is injected by much granitic material, large orthoclase phenocrysts forming prominent "augen structures" (Plate VI B). The strike of the schist at this locality is north 15 degrees east (magnetic) with a reverse dip of 75 degrees to the southeast. Most of the claim is covered by a heavy overburden of alluvium so that prospecting is rendered difficult. Ground sluicing might be worked to advantage in certain sections.

Sterling.

Location and Development. The Sterling property is situated between the Roanoke and the Blackcock claims, the Wilcox wagon road passing through the southeastern corner of the claim. The workings are at an elevation of approximately 3,220 feet above sea-level. The claim was located July 9, 1896, by Wm. Caldwell and is crown-granted. The property has been worked at intervals up to 1912. In the autumn of 1908 the Sterling group was bonded to Philip White, of Vancouver, who let a contract for 100 feet of tunnelling and erected cabins. During 1912 it was reported that the tunnel had encountered about 4 feet of good grade ore of free milling character. The development consists of about 450 feet of tunnelling and several open-cuts and pits.

Geology. The Sterling vein belongs to the same class as the Blackcock and Roanoke veins, striking and dipping with the schist formation. The values are in the sulphides, pyrites, zinc blende, and galena in a gangue of quartz and a little calcite (dog-tooth spar). The country rock is Pend-d'Oreille contorted schist occurring as a roof pendant downhanging into the Nelson granite batholith. The mineralization is toward the southeastern border of the roof pendant. Both schist and granite are intruded by a parallel set of vertical lamprophyre (chiefly minette) dykes striking north 77 degrees west (magnetic). The schist is injected by much granitic material and quartz stringers.

The main workings follow and are on both sides of a steep ravine which cuts diagonally across both roof pendant and vein, the latter being exposed by several open-cuts. The main tunnel crosscuts the schist for 51 feet, then follows a very strong gouge zone striking north 10 to 15 degrees east with dip varying from 60 degrees eastward to vertical, or steeply to the west. This fracture zone is drifted on for about 250 feet and from the drift two crosscuts run, one 12 feet and the other 42 feet, into the hanging-wall (northeast side) and one 15-foot crosscut into the foot-wall. The latter discloses an altered, kaolinized dyke in the face striking with the schists and having a little quartz and graphitic schist next to it. The tunnel leaves the gouge zone farther along, crossing through the foot-wall and granite to intersect the same altered kaolinized dyke. The working follows this vertical dyke for 30 feet, then a 12-foot crosscut to the southeast, or hanging-wall side, taps the same gouge zone first drifted on. Here the gouge is 3 feet wide and made up of soft graphitic, decomposed schist containing pyrites, calcite, and clay. Striations on slickensided surfaces plunge gently to the southwest indicating a strong horizontal component in the faulting. Stringgers of quartz are present in the foot-wall country, some of which are of the bluish variety and mineralized.

An upper adit tunnel on the east side of the ravine is 35 feet long and exposes oxidized vein material for a width of 5 feet.

Wilcox.

Location. The Wilcox mine is situated on the northwest side of Wild Horse valley about 2 miles above the mouth of the North Fork, and at an elevation of approximately 4,300 feet above sea-level. The mill is 800 feet lower in elevation than the mine and about 7 miles east of the town of Ymir. The property comprises five mineral claims, a millsite, and a timber tract, covering in all an area of 187·5 acres. The Warwick, Bywater, Willcock, and Fourth-of-July claims are crown-granted, whereas the J.C.B. Fraction and the Wilcox millsite are held by location (Figure 6). The property is owned by the Ymir-Wilcox Development Company.

Transportation. A wagon road extends from the Wilcox mill to the town of Ymir, on the Nelson and Fort Sheppard railway (Great Northern Railway system). Nelson is 23 miles north by rail from Ymir and Spokane, Washington, is 172 miles south. The wagon road, with the exception of two steep hills, has a gentle gradient from Ymir to the mill. It is in good repair save for a mile and a half stretch of "corduroy" near Ymir which was put in prior to the big forest fire of 1902 and is now much in need of repair.

Topography. The topography in the vicinity of the mine is rugged and youthful, the mine itself being situated high up in the steep-walled glaciated valley of Wild Horse creek and below the more subdued topography of the upland. Wild Horse creek has its source in a low pass which forms the divide between the Salmon River drainage and that of Midge creek and Kootenay lake. The valley sides display much evidence, with their truncated spurs, hanging tributary valleys, and striæ, of intense mountain glaciation.

Water Supply, Timber, and Climate. The mine is plentifully supplied with water for ordinary purposes all the year round from Rapid, Avalanche, and Wild Horse creeks, although for power purposes the supply diminishes considerably for six months in the winter. Wood for fuel and mine timbers is found in abundance within easy hauling distance.

The winters, which have a duration of about four months, are not excessively cold. The snowfall is heavy, necessitating the construction of snow sheds over the mine buildings of the upper workings to protect them from snowslides.

History. The Willcock, Fourth-of-July, and Bywater claims were located in July and August 1896 by Phil. White and S. Bywater. They commenced operations on the western portion of the Fourth-of-July vein and located shoot No. 2 from which

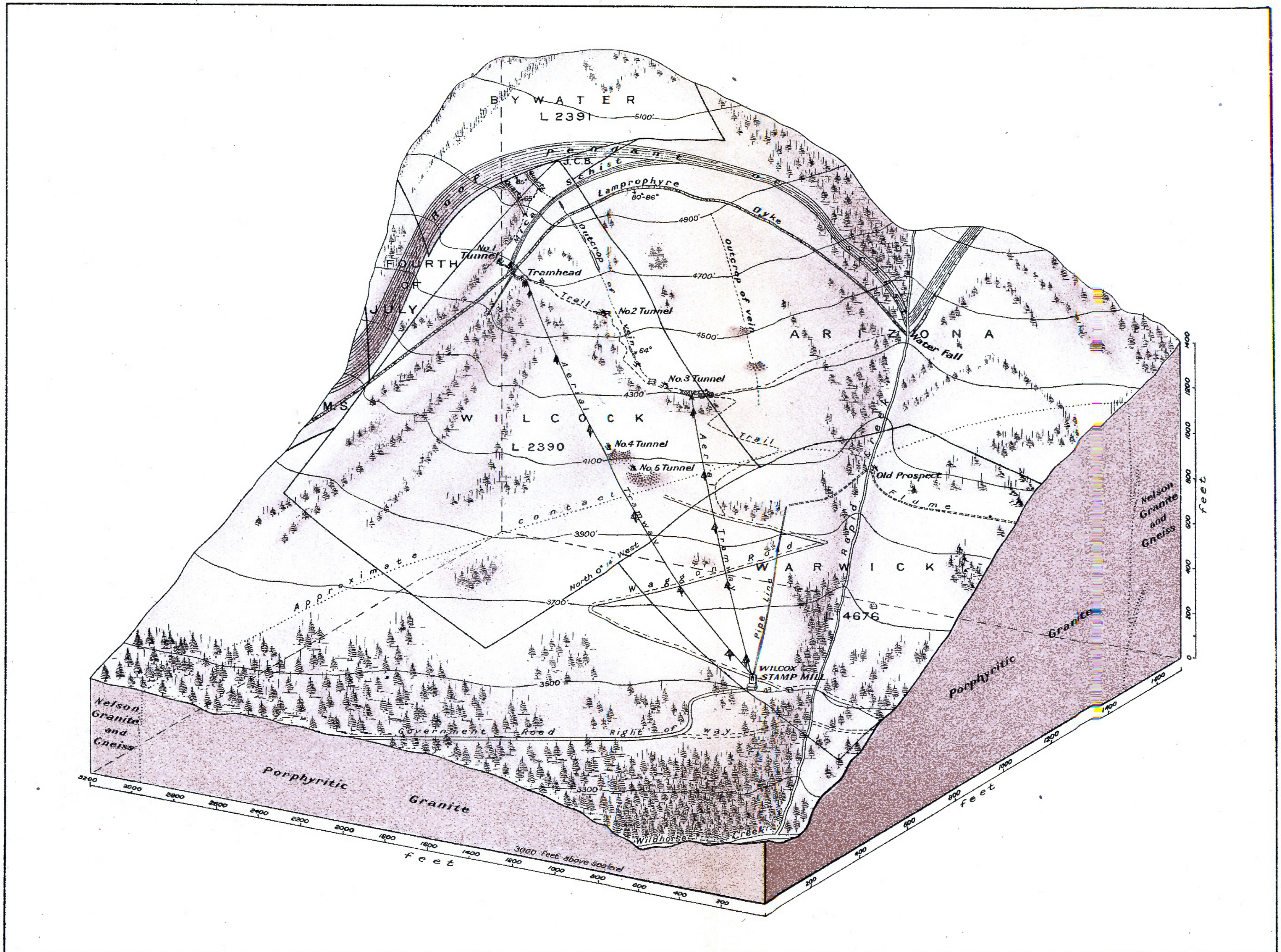


Fig. 6. Stereogram of **Wilcox Mine** and adjoining properties showing geological relations of main veins and claim boundaries. Contour interval 200 feet

they mined the richest lenses and paystreaks. The ore was "rawhided" down the steep valley side and shipped to the Northport smelter. Despite poor and expensive transportation facilities, the profits of this company, which was known as the Broken Hill Mining and Development Company with a capitalization of $1,000,000, were high at that time. In 1897 ten men were employed at the mine. In 1898-99 a four-stamp, amalgamation mill was installed which saved less than 70 per cent of the ore values. No method was used of saving the concentrates nor of impounding the tailings. In 1901, the average smelter tests gave values of $53 per ton. During 1902, the company erected a Joshua Hendry mill with a capacity of 20 tons per day and connected the mill with the mine by means of a tramway 2,200 feet in length. The mill was started on an experimental run December 15, and for 40 days the feed averaged 18 tons per day and returned $8 per ton. A 20-ton shipment of high grade ore was made in February of the same year from the Fourth-of-July vein and gave smelter returns of $70 per ton. The mine at that time employed fifteen men. In 1903, the first run of the company's stamp mill on a commercial scale was made. The mill commenced operations on May 1 and for the six months following made a very successful run, the total values from the mill and from shipments of crude ore being $22,000. For the entire year the output of the mine was 2,200 tons milled and 100 tons of high grade ore which was shipped to the smelter in the crude state. The work accomplished during the year consisted of 300 feet of drifting and stoping on the first and second levels of the Fourth-of-July vein, and 200 feet of development tunnel. The tunnel on the Wilcox vein was in 400 feet in 1903 and it was estimated that a 200-foot crosscut would tap the Fourth-of-July vein at a depth of 400 feet below the present workings.

In November 1903 the control of the Broken Hill Company passed into the hands of American capitalists and the operations for the next few years were not profitable. Most of the work was done on the "Little Willcock vein" parallel to the Fourth-of-July vein and was not very successful. A tramway was built from the mill to No. 1 workings, the ore from which was treated profitably. The ore was nearly all stoped out to the surface by the overhead system, then underhand stoping was commenced; but the high cost of hand work, hoisting by windlass, and the handling of water prevented any profit being made even though the average value of the ore across the stoping width was over $18 per ton.

The property went into liquidation and Stephen Bywater, one of the largest individual stockholders, was appointed liquidator. Late in the year Mr. Bywater resumed work at the property and from the mine earnings paid off 50 per cent of the preferred claims. Immediately following this, attention was directed to the eastern portion of the Fourth-of-July vein where a limited amount of ore was mined at a profit. The underhand stope was further extended at a loss.

In September 1904 the stamp mill was started up again and by the end of the year crushed about 800 tons of ore, while 22 tons of concentrates were shipped to Trail. From that date on, until 1911, the property was worked intermittently. In 1911, Mason and Odell took over the property and Arthur Lakes, jun., was sent in to do further development work with a view to determining the probable extent and value of the mineral deposits and to improve mining facilities. The stamp mill was run only to clear away the accumulation of ore mined in development and it was the intention of the owners to continue development at the mine until the ore reserves would be sufficient to keep the mill in continuous operation for an indefinite period.

The mine closed down in August 1914 shortly after the outbreak of the war, although development work is still being carried on by a small staff of men.

Production. The following table of net production of the Wilcox mine has been kindly furnished by Arthur Lakes, jun. He states that the figures are derived for the period prior to June 21, 1905; from the records of taxation of mineral production under the assessment act; and that the production from June 21, 1905, to September 1, 1911, is from the sworn statements by A. H. Tuttle of net production made for taxation under the Mineral act. The amounts are given in dollars and cents and no separation made between gold and silver returns. Some of the earlier records were not available and are not estimated herein:

Produced prior to the mill installation	$10,000.00
Bullion from mill up to Oct. 1, 1910	53,861.60
Concentrates from mill to 1910	500.93
Produced by S. Bywater (estimated)	13,000.00
Bullion from mill, Oct. 1910 to Sept. 1911	7,450.02
Concentrates from mill, Oct. 1910, to Sept. 1911	1,513.89
Total production to Sept. 1, 1911 (8,450 tons)	$86,326.44

This is divided as follows:

No. 1 shoot.	
No. 3 tunnel and stopes	$10,000.00
No. 2 shoot.	
No. 1 tunnel and stopes	67,362.53
No. 2 tunnel and stopes	8,963.91
	$86,326.44

Mine Development. The steep valley side on which the Wilcox mine is located affords ideal conditions for opening the veins to considerable depths by means of tunnels. There is a total of 5,852 feet of development work on the property, of which 4,958 feet is tunnel. Of this amount 1,953 feet is drift on the ore in the vein; 1,225 feet is crosscut and drift of value in the exploration and exploitation of the ore deposits; and 1,780 feet was drift and crosscut of practically no value either in exploration or in proving the ore deposit. There is a total of 894 feet of shaft and upraise; of this, 744 feet has been excavated in the Fourth-of-July vein which has been opened up to a maximum depth of 462 feet, and the remaining 150 feet is in the Little Wilcox vein.

Geological Structure. The main country rock of the Wilcox veins is a greenish grey, fine to coarse-grained granitic rock belonging to the Nelson granite batholith. The granite varies in texture and composition from place to place. The porphyritic granite of the Foghorn mine with its dominant north and south joint planes outcrops to the east of the property and strikes north and south in a manner similar to the long downhanging inclusions or roof pendants of Pend-d'Oreille and Summit Series schists. The different varieties of granite, gneiss, and schist, as well as the long roof pendants of older altered sedimentaries all occur as northeasterly and southwesterly trending zones varying in width from several feet to several hundred feet. The roof pendant material lies in most cases nearly vertical. The Wilcox appears to be near the centre of the intrusive mass, the schists west of the Wilcox having a tendency to dip westward with the Pend-d'Oreille schists, whereas those east of the Wilcox tend to dip eastward with the Summit Series rocks. The intrusive and intruded rocks are traversed by several lamprophyre and aplitic dykes, chiefly the former, which belong to the minette class in which biotite and orthoclase are the dominant minerals. The largest dyke encountered is a lamprophyre (Figure 6) 40 feet wide which strikes north 30 to 40 degrees east and dips about 80 to 86 degrees east; as far as known it forms the western limit of the ore in No. 1 shoot.

A fault occurs along the lamprophyre dyke which has thrust the ground west of the dyke over 30 feet southward with respect to that east of the dyke. The Fourth-of-July vein with its average strike of south 80 degrees west and dip to the north of 65 degrees, is also offset along a narrow roof pendant of mica schist about halfway between the lamprophyre dyke and the shaft. Another shifting of the vein to the extent, in this case, of about 10 feet, occurs along a mica schist band near the portal of No. 3 tunnel.

The broad roof pendant shown on the map was found to terminate the vein abruptly in the faces of Nos. 1 and 2 tunnels. The ore abuts against the altered sedimentary schist of the roof pendant where it is disseminated to form T-shaped and L-shaped shoots. This roof pendant has not been cut through in any of the workings nor has the ground west of it been prospected. In No. 2 tunnel the pendant has been crosscut to a distance of more than 100 feet.

There are three main veins on the property, all of the fissure type with mineralized walls, viz., the Fourth-of-July, Willcock, and Little Willcock. They are warped fissures which vary a great deal in strike and dip from place to place. The Fourth-of-July vein has an average strike of south 80 degrees west, and dips to the north at an angle of 65 degrees. The

Willcock vein, which outcrops about 30 feet to the north of the Fourth-of-July vein, has an average strike of south 80 degrees west and dips to the north at an angle of 70 degrees. It has a width of about 1½ feet. The vein fissure cuts diagonally across the planes of foliation in the gneissic granite.

The ore occurs in the form of tabular bodies or shoots lying within the vein and with their greatest diameters pitching steeply to the east. Commonly the shoots are lenticular in shape, over 6 feet in width at the swell but pinching elsewhere to a few inches. The shoots vary in stope length from 20 to 50 feet and in pitch length from 30 to 70 feet. They terminate in some places against dykes and roof pendants. Bands or pay streaks of high grade ore occur most commonly along the hanging-wall but are also found in places along the foot-wall or in streaks within the shoot itself. From No. 1 tunnel level downward the best values tend to follow the foot-wall, whereas above that level the ore on the hanging-wall yields the highest values.

The gangue of the ore is principally silicified country rock and quartz. The ore varies in appearance and composition in different parts of the mine, and a representative body of it would consist of the altered country rock with reticulating veins, irregular masses or disseminations of iron pyrite, galena, iron oxide, quartz, and occasionally zinc blende; the sulphides form 10 to 20 per cent of the mass (Figure 7). The ore from No. 1 shoot carries less sulphides and quartz and on that account has a greater tendency to slime in milling. The ore from No. 2 shoot has a greater proportion of silica and also of sulphides. A gouge of decomposed feldspar in many places accompanies the ore. The ore is very deceptive in appearance and constant assaying is necessary to separate ore from waste.

The values occur principally in gold of which 70 per cent is in the free state. Silver occurs in minor quantity, even the galena giving small returns. The iron pyrites is auriferous and the presence of galena here as elsewhere throughout Ymir district, is invariably a sign of good gold values. Zinc blende is of rare occurrence but where found is generally accompanied by good gold values. Free gold is frequently found in the ore, particularly where the gangue consists of much shattered and

Assays, Wilcox Mine.

East drift.					West drift.				
Sample number.	Width inches.	Gold oz.	Silver oz.	Value dollars.	Sample number.	Width inches.	Gold oz.	Silver oz.	Value dollars.
135	36	0·86	1·8	19·10	135	48	0·70	1·4	14·70
1002	48	0·28	3·5	17·35	1001	30	0·42	0·8	8·80
1004	42	0·54	1·6	11·65	1003	28	1·10	0·9	22·45
1006	40	0·32	0·5	6·65	1005	54	0·92	1·9	19·35
1008	48	0·24	1·0	5·30	1007	60	0·52	1·2	11·00
1010	42	0·16	0·55	3·40	1009	48	0·98	1·2	20·20
1012	54	0·62	1·2	13·00	1011	60	2·74	3·5	57·50
1014	52	0·22	1·2	5·00	1013	60	2·50	2·4	51·20
1016	37	1·04	2·2	21·90	1015	50	2·56	2·1	52·20
1018	37	1·04	2·2	21·90	1017	50	3·08	2·2	62·70
1020	48	0·48	1·6	10·40	1019	30	0·64	0·65	13·15
1022	24	0·26	2·5	6·45	1021	30	0·30	0·3	6·00
1024	30	0·54	1·9	11·75	1023	30	0·24	0·85	5·20
1026	30	0·54	1·90	11·65	1025	24	0·52	0·90	10·25
1028	30	0·54	2·10	11·80	1027	24	0·52	1·10	10·95
1030	30	0·34	0·40	7·00	1029	24	0·52	0·90	10·35

	1032	30	0·22	0·45	4·60	1031	30	0·32	0·60	6·65	
	1034	30	0·38	1·00	8·10	1033	30	0·28	0·30	5·75	
	1036	24	0·38	0·80	8·00	1035	24	0·42	0·60	8·70	
	1038	36	1·70	2·10	35·00	1037	18	0·42	0·60	8·70	
	1040	42	0·42	0·80	8·80	1039	18	0·26	0·40	5·40	
	1042	42	0·62	1·00	12·90	1041	12	0·34	0·40	7·00	
	1044	48	1·16	1·80	24·10	1043	8	0·32	0·55	6·65	
High grade	1044	13	6·80	16·70	143·30	1045	14	0.46	0·55	9·45	
						1047	24	1·16	1·9	24·30	
						1049	24	1·16	1·9	24·30	
						1051	30	1·68	2·4	34·99	
						1053	30	1·68	2·4	34·99	
						1055	26	1·02	2·3	21·73	
						1057	28	1·64	1·7	33·79	
						1059	46	1·52	2·3	31·73	
						1059a	10	3·62	3·9	74·66	Gouge and carbonates.
						1059b	20	2·30	3·4	47·97	Quartz and lead.
						G–10	18	2·18	3·4	45·57	General sample 1047 to 1059 "Pay streak."

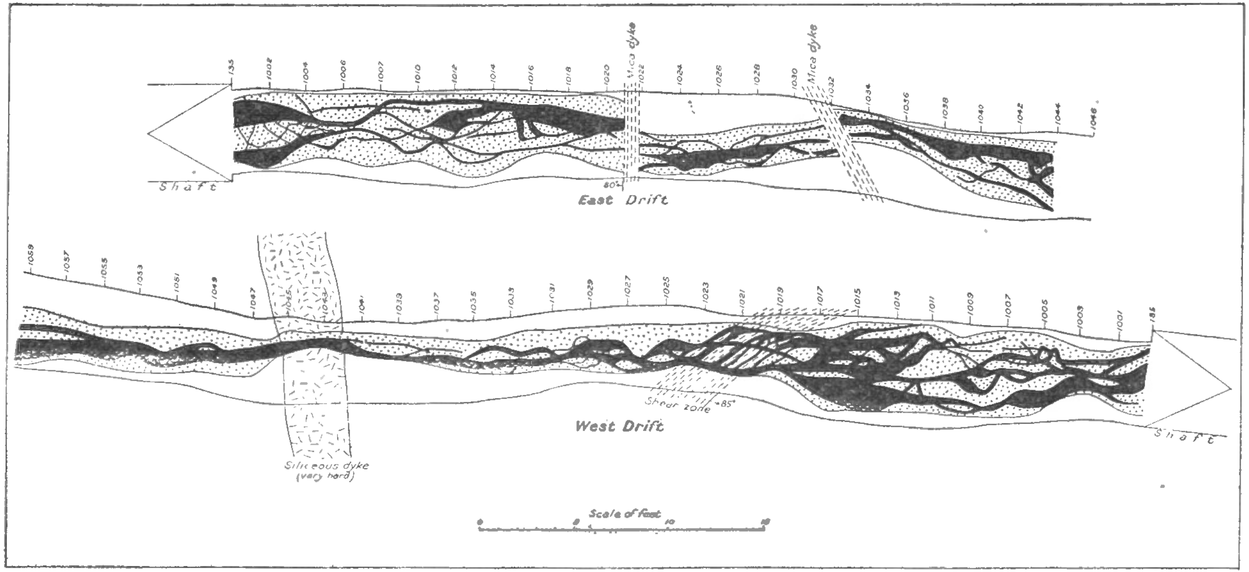


Figure 7. Vein structure at Wilcox mine. Assay map of No. 141 drift, Fourth-of-July vein, by Arthur Lakes, Jun.

friable blue quartz; it is also found where iron oxide is associated with honeycombed quartz. The vein displays considerable oxidation in a zone 145 feet below No. 2 tunnel level; elsewhere the sulphides dominate over the oxides even at the surface.

Geology of Mine Workings. There are three main tunnels and several open-cuts on the Fourth-of-July vein, the work having proved the continuity and position of the vein. No. 1 tunnel is a crosscut, for the first 40 feet penetrating mica schist and granite, then the tunnel swings and follows the vein for a distance of 415 feet. The ore-shoot at this locality has been stoped for 200 feet horizontally and for 95 feet upward to the surface. On this tunnel level the boundary of the ore-shoot is delimited by a kersantite lamprophyre dyke. The best values, however, were found at the west end of the shoot away from the lamprophyre. The ore from this stope is said to have averaged $16 per ton, whereas the ore at the east end of the stope next the lamprophyre ran from $8 to $10 per ton.

To the east of the above main stope are several smaller stopes. Shaft No. 1 was sunk near the west end of an underhand stope 47 feet deep by 225 feet long, which lies immediately contiguous to No. 1 tunnel and below the main stope.

The face of No. 1 tunnel is in the roof pendant of altered sedimentary rocks which dip to the southeast at an angle of 82 degrees. The working follows the eastern border of the pendant for 35 feet.

No. 2 tunnel follows a tortuous course for 471 feet through barren ground cutting several lamprophyre dykes (kersantites and vogesites) the dykes dipping to the southeast at angles varying from 75 to 80 degrees. The downward extension of No. 2 ore-shoot, in which there is a stope 100 feet long by 20 feet high, contains a streak of ore varying from 6 inches to 35 inches in width. Beyond the ore-shoot the vein was drifted on for more than 300 feet until the roof pendant was reached when, the ore was found to terminate against the schist formation in a T-shaped mass. At this point the ore was raised upon and some high grade ore taken out along the exact contact. The driving of the tunnel was continued 100 feet farther into the schist but not far enough to penetrate the granite beyond.

Shaft No. 2 (12 by 6 feet) extends from No. 2 tunnel level down 219 feet to No. 3 tunnel level. Above No. 2 tunnel and over the shaft, upraise No. 1 extends for 120 feet to make connexion with the bottom of the underhand stope from No. 1 tunnel. At a distance of 59 feet up No. 1 upraise, a drift was run 56 feet westward on the Fourth-of-July vein, thence 64 feet southwestward along a branch vein with small pockets of fair ore. In No. 2 shaft at a depth of 145 feet below No. 2 tunnel level, a sub-level, known as No. 141, was driven. The sub-level follows the vein for 60 feet to the west and 46 feet to the east.

No. 3 tunnel is an adit driven on the vein for about 375 feet. A stope commences about 50 feet in from the portal and extends about 100 feet connecting up with the No. 3 + 50 shoot above. The tunnel then cuts through barren country for 546 feet to make connexion with No. 2 shaft. From the shaft it follows the vein westward for a distance of 48 feet. Several lamprophyre dykes and mica schist bands were crosscut by the tunnel. The main roof pendant intersected on the other levels has not yet been reached on No. 3 tunnel level. East of No. 2 shaft there are three short crosscuts driven to intersect the vein to the north, the farthest being 130 feet east of the shaft.

Nos. 4 and 5 tunnels were driven on a fault fissure with considerable gouge known as the Little Willcock vein. At the portal of No. 4 tunnel a pocket of ore was encountered, which, however, has not been proved to be in place. No. 4 tunnel is about 540 feet and No. 5 tunnel 350 feet long; the country rock in both tunnels is granite porphyry and gneiss. A shaft farther west (shaft K) has opened up the Little Willcock vein to a depth of 16 feet, the vein being at this point 4 feet in width.

Mining. In the past the ore was mined by both underhand and overhead systems of stoping, but now that the workings are connected by raises and winzes it will be possible to use the overhead system with any modification of the filled stope method found advisable. Ore from above No. 2 tunnel can be dropped down No. 1 upraise, and No. 2 winze to No. 3 tunnel, thence by tramway to the mill. Heretofore, most of the ore was mined by hand, but now all the workings are piped for air supplied by a compressor installed at the mill.

Milling. A two-bucket aerial tramway (back balance) about 2,350 feet long, extends from the portal of No. 3 tunnel, which is the main working of the mine, to the mill. The difference in elevation between the mine and mill is about 800 feet. Another two-bucket aerial tramway at present not in use, connects No. 1 working with the mill. The tram buckets have a capacity of 1,000 pounds each and run on a $1\frac{1}{8}$-inch standing rope, with a $\frac{5}{8}$-inch haulage rope. The ore is dumped from the tram buckets into a bin of 30 tons capacity, from which it is fed to an 8 by 14-inch rock crusher. The crushed ore is then fed, by means of two automatic Challenge feeders, to the battery of 10 stamps, amalgamating plates and four Frue vanners. Two flumes, totalling about 2,600 feet in length, convey the water from Avalanche and Rapid creeks to a 4-foot Pelton water wheel by way of a penstock and pipe-line 1,400 feet long, the latter grading from 14 to 8 inches in diameter. In this manner a head of 600 feet is obtained, which is sufficient to drive the power plant. The power plant consists of a 480-volt generator (50 kilowatt, alternating current, 1,200 revolutions per minute, 30 phase, 60 cycle) belted to the water wheel in the mill. This supplies power to a 25-horsepower motor driven compressor (size 10 by 10, 134 cubic feet capacity per minute at 150 revolutions per minute) which is sufficient for the two $2\frac{1}{4}$ Ingersoll-Rand piston drills or one $2\frac{3}{4}$ drill at the mine. The mill extracts about 80 per cent of the values, but this could be increased by cyanidization.

Origin. The ore from the Wilcox mine, like that of most Ymir properties, is believed to have been derived from the same parent source as the Nelson granodiorite which in this case encloses the ore. The fissure veins containing the ore traverse the upper portions of the granodiorite mass lying between the long down hanging rock ribs or roof pendants of Palæozoic schist formations. The deep seated, mineralized, fracture planes represent the old channels through which the ascending alkaline solutions containing the metals circulated. The fracturing and readjustment of crustal stresses probably took place shortly after the intrusion and consolidation of the granodiorite mass. The solutions were thus permitted to ascend from deeper-seated, metallic hearths through such fractures in the already consolidated upper portion of the granodiorite mass (batholith) and to reach at least to the downhanging portion of the batholithic roof. The ores were deposited at certain localities in the channels where physico-chemical conditions were favourable. A little later in the geological history of the region, the veins were cut by persistent lamprophyre dykes, the femic differentiate from the original parent, magma reservoir.

The ore zone, so far developed, appears to be confined to the vicinity of the roof pendants and to the intervening granodiorite areas; as yet the dimensions of the ore zone are undefined.

Future Work. The granodiorite territory in the vicinity of the broader roof pendants should be carefully prospected for vein systems cutting transversely to the structure. The ground west of the roof pendant which was found to terminate the Wilcox ore to the west deserves further prospecting for the possible presence of parallel fissure veins similar to those already developed east of the pendant.

The future productivity of the property rests more upon the systematic opening up of several different veins in a system and the containing ore-shoots than upon the extensive development of any particular vein. The strength and persistence of any one vein fissure is not sufficiently pronounced, nor are the ore-shoots regular and numerous enough to justify extensive development work on one vein alone. Ore-shoots should be sought for in less developed, parallel veins in the same or other fissure systems on the property.

With the data at hand concerning the direction and nature of the vein system and roof pendants so far developed in the mine, and with the opportunity of using compressed air, now that a compressor has been installed on the property, diamond drilling would be the cheapest and best way to prove or disprove the presence of parallel veins in the hanging and foot-wall sections. No. 2 tunnel might then be extended to crosscut the roof pendant so that the granodiorite west of the altered sedimentaries could be explored in a manner similar to that on their east side.

Lateral development of the ore zone, as outlined above, would be more likely to yield satisfactory results in this case than deep development. In the search for ore-shoots in the veins attention should be given to the position of the roof pendants rather than to that of the lamprophyre dykes. The western end of the Little Willcock vein approaching the main roof pendant deserves further testing for the possible presence of one or more ore-shoots.

Ymir Belle.

Location and Development. The Ymir Belle group of four claims, held by location, is situated between the Foghorn and Wilcox mines at an elevation of about 4,500 feet above sea-level. Development consists of about 145 feet of sinking on the vein, besides small open-cuts and pits. The owners are H. L. Jackson, A. McDougall, M. Tait, and J. G. Dewar.

Geology. The workings have disclosed portions of three veins, two of which have the same east and west (magnetic) strike with northerly dips of from 60 to 70 degrees. The two east-west veins are in alignment and may be portions of the same vein; but the third vein, nearer the wagon road, strikes almost at right angles to the others and dips to the east. The east and west trending vein has an average width of 2 to 3 feet with a maximum of 5 feet. It is composed of oxidized vein rock with disseminated iron pyrite, galena, and zinc blende in small amounts in a gangue of decomposed granite and iron-stained quartz. An average sample across the vein at the west end, near a shaft full of water, is reported to run $9 per ton in gold; an 18-inch pay-streak farther east in a 45-foot shaft on what may be the extension of the same vein, is said to have assayed $41 per ton in gold. The northerly trending vein farther south is reported to run $30 per ton across a width of 18 inches. The country rock is Nelson granite, porphyritic granite with roof pendant of mica schist, and quartzite, all cut, in turn, by lamprophyre dykes.

Apex and Adjoining Claims.

The Apex and Silver Reef claims are situated to the north of the Good Hope and Foghorn properties on the sharp divide between Wild Horse and Clearwater creeks. The Apex cabins are in the lowest saddle on the divide at an elevation of about 6,330 feet above sea-level.

The Apex main vein, as well as a parallel vein 90 feet southwest of it, outcrops prominently on the rocky divide. The latter, an oxidized vein, strikes north 40 degrees east (magnetic) and dips steeply to the northwest. The main vein is opened up by means of a 92-foot adit tunnel driven from the Clearwater Creek side. The working discloses a curved fissure vein concave to the northwest. The vein contains a 1½-inch width of quartz with considerable gouge material on the foot-wall which is by far the best-defined wall. The hanging-wall is silicified, pyritized granite. The vein forms a bold outcrop above the tunnel on the Clearwater side and varies in strike from north 53 degrees east (magnetic) on the ridge to north 73 degrees east westward at the portal of the tunnel. The dip varies from 65 degrees northwest on the ridge to 75 degrees northwest at the portal of the tunnel. The country rock is Nelson granite with narrow roof pendants of Summit series schist.

Farther north on the ridge on what may be the B and C and Longsley claims the granite becomes gneissic and passes transitionally into a roof pendant of schist striking north 17 degrees west (magnetic) and dipping to the east at an angle of 70 degrees. The schist is much contorted in places and injected with pegmatitic material from the granite. The adjoining granite on the ridge is sheared and altered. A peculiar, curved, quartz vein, concave to the northwest, is opened up by means of two open-cuts on the ridge. The vein is 2 feet wide and varies in strike from north 37 degrees east (magnetic) at the southwest end to north 10 degrees west (magnetic) at the north end. The dip varies from 60 degrees northwest at the southwest end of the vein to 53 degrees west at the centre of the vein and 55 degrees west at the north end of the vein. Another quartz vein 30 inches wide is reported as occurring on the Wild Horse slope on the

Longsley claim. It is said to have a general east and west strike with a dip of 70 degrees to the north and to be traceable for 1,000 feet.

Black Diamond.

Near a creek crossing about halfway between the Sterling cabin on the Wilcox wagon road and the bridge over the North Fork, an adit tunnel known as the Black Diamond tunnel has been driven at an elevation of about 3,175 feet above sea-level. It has a bearing of north 5 degrees west (magnetic) and is 174 feet long.

The tunnel is driven on two closely spaced fractures or joint planes in the Nelson granite. The fractures appear as strong walls dipping from 50 to 55 degrees to the west enclosing hanging-wall and foot-wall quartz veins and a few feet of intervening, altered granite containing much secondary quartz and kaolin. The hanging-wall, pyritic quartz vein averages 2 inches in width, but is intersected about halfway in the tunnel by a 3-inch foot-wall vein, the two uniting for a short distance to form a whole "back" of massive, white quartz with disseminated sulphides. The foot-wall fracture tends to dip at a lower angle than the hanging-wall fracture. The granite is quite dark in colour and in places porphyritic. It contains drawn out inclusions of a fine-grained, femic variety resembling a lamprophyre.

Georgina.

The Georgina claim is located on the south side of Wild Horse creek directly south of the Roanoke from which claim the trail commences. The claim has been staked several times, in 1909 as the Hardy Boy by J. R. Bremner and in 1913 as the Augusta by Geo. Walker. The present owners are Thos. Wilkinson and Jos. Kileel. The workings are at an elevation of approximately 4,200 feet above the sea and consist of two short tunnels and four open-cuts.

The country rock is granite which is very siliceous close to the vein. The main tunnel is a crosscut bearing south 23° 30′ east for 50 feet, all in granite; then the vein is drifted on for 20 feet to the east. The west drift is filled with muck. The vein in the east drift contains in places, heavy sulphides in quartzose gangue, strikes north 66 degrees east, and is vertical. The face is siliceous granite with quartz stringers; and near a shallow winze the vein rock is pyritized for one foot from the north wall. Directly above the crosscut tunnel and about 25 feet higher in elevation, is a 17-foot adit tunnel driven on oxidized vein material 3½ feet wide. The vein strikes east and west and has vertical walls of granite. The south side of the vein is much oxidized and honeycombed and contains some bluish quartz. At the second open-cut on the trail, west and below the main tunnel, a quartz vein is exposed having as hanging-wall a mica lamprophyre dyke 2 feet wide, striking north 67 degrees east and dipping 75 degrees in a southerly direction. The upper side of the dyke is a water course. Two other open-cuts have been made farther down the trail, the first one in a creek bottom about 150 feet distant. A short distance down the trail towards the Roanoke property, a prominent enstatite peridotite dyke 4 feet in width forms a bold outcrop. The dyke displays massive, columnar jointing; it has a pitted, weathered surface greenish grey to pink in colour and studded with olive-green, orthorhombic pyroxenes. The dyke strikes north 65 degrees west (magnetic) and dips northeasterly from 55 to 60 degrees. The dyke contains angular inclusions of a siliceous granite.

Rosalia.

The Rosalia and Centennial claims are situated on the east side of Wild Horse creek opposite the Foghorn property and at an elevation of about 4,500 feet above sea-level. There are two short tunnels on the Rosalia claim, one about 50 feet higher than the other. The upper tunnel follows for 20 feet a one-foot quartz vein striking north 5 degrees east (magnetic) with vertical dip. The lower crosscut tunnel is 80 feet long and cuts through a band of quartz-mica schist and quartzite (Summit Series roof pendant) which trends north and south and lies vertical or dips steeply to the east. The bearing of the tunnel is north 82 degrees east and the traversed schist contains much pyrite in the form of cubes.

Alexandre and Dumas.

Location and Development. The Alexandre and Dumas claims are situated at an elevation of about 5,750 feet above sea-level on the mountainous slope east of the pass between the head-waters of the North Fork of Wild Horse creek and the South Fork of Clearwater creek. They are both crown-granted claims; the Dumas was located July 20, 1897, and the Alexandre March 18, 1898, by E. Croteau and G. Pellent. In 1898 Croteau and Pellent drove an adit tunnel 150 feet in length on a quartz vein reported to be 3 to 4 feet wide and to contain zinc blende, galena, and pyrite. Four average assays are said to have given 20·5 ounces in silver, 21 per cent lead, and $40 in gold.

Geology. The tunnel is about 250 feet above the main trail. It has a bearing of south 27 degrees east (magnetic) and was inaccessible in 1914. The country rock is Pend-d'Oreille schist chiefly argillaceous, with andalusite schist about 1,000 feet west of the western border of the Nelson granite batholith, although injection tongues from the batholith penetrate the rocks in the vicinity of the property.

Carthage.

Location and Development. The Carthage claim lies between the Canadian Pacific group and the Ymir Mine group and is situated on the steep eastern slope of the North Fork of Wild Horse valley. The claim was located August 25, 1897, by H. Kearns, and was forfeited to the crown November 6, 1905. In 1902 the Chicago National Development Company bonded the claim; it was supposed to have the continuation of the Ymir vein. Two tunnels were run 250 and 150 feet in length; the former was reported to have disclosed 2 feet of good ore very similar to that of the Ymir mine.

Geology. The country rock is Pend-d'Oreille schist, much of it andalusite schist due to the contact metamorphism caused by the nearby Nelson batholith. Spotted porphyry dykes are also found intrusive into the schists. The veins, many of which are parallel and strike with the schists, contain slightly mineralized blue quartz. They penetrate the crumpled schist and end in sharp tongue-like terminations. A milky-white variety of quartz with films of kaolin also forms bold outcrops.

Elise.

The Elise crown-granted claim is situated on the pass between Clearwater creek and the North Fork of Wild Horse creek and adjoins to the south the Summit group, the wagon road to the latter property passing through the middle of the claim. The claim was located June 30, 1896, by Oliver Blair. A crosscut tunnel was commenced in 1898 to intersect the vein. Since then practically no work has been done on the property. The chief country rock is Pend-d'Oreille schist.

Gold Cup.

Location and Development. The Gold Cup claim is situated about 4 miles north of the town of Ymir on the western slope of Elise mountain. The workings are at an elevation of approximately 5,200 feet above sea-level and are accessible by means of a switchback trail from Porto Rico siding. The property was under development during 1903 by Mr. Conrad Wolfe and Dawault Brothers, who took a lease on the Gold Cup and erected an experimental mill of two stamps. At that time the vein was opened up to a depth of 100 feet and was reported to have an average width of 4½ feet and to assay $15 in gold with small values in copper and silver. A shaft extends down 85 feet on a vein which widened in that distance from 4 feet to 5 feet. A tunnel which was run to get below this shaft encountered, it was reported, 5 feet of ore containing rich bunches assaying as high as $220 per ton. The property is at present owned by Ryan and A. Burgess of Ymir.

Geology. The underground workings were inaccessible in 1914. Ore from the lowest dump sacked and ready for shipment contained chalcopyrite, tetrahedrite, and malachite in a quartz gangue stained with iron oxide. An assay of a sample weighing 1 pound 2 ounces made by the Mines Branch gave 0·60 ounce to the ton in gold and 4·24 ounces in silver. The quartz vein outcrops farther up the trail near the shaft and strikes north 72 degrees east (magnetic) and dips 68 degrees to the south. The vein consists of 1½ feet of rusty quartz with parallel veins all cutting the schists almost at right angles. The foot-wall of the vein contains a zone of much oxidized schist and some limonite and is bounded by a narrow quartz stringer. The lower workings are in granite porphyry schist and the upper in augite porphyrite schist; the contact between the two formations passes close to the prospect shaft. The schist trends north 18 degrees west (magnetic) and is vertical. The belt underlain by granite porphyry forms a relatively broad undulating bench on the mountain slope. Above the workings the greenstone schist passes into massive augite porphyrite which stands out in bold relief as a series of rocky bluffs.

Goodenough and Surprise.

Location and Development. The Goodenough crown-granted claim adjoins the Ymir group to the southwest and is at an elevation of approximately 4,200 feet above sea-level. It is connected by a wagon road with the main road at the Ymir mine. The claim was located June 16, 1898, by Alex. Gayette. A shipment of 20 tons of ore is said to have assayed $22 per ton. In 1897 the Ymir Gold Mining Company took an option on the property and sank a shaft 60 to 70 feet deep. The Goodenough and Surprise claims are owned by O. A. Lovell and O. Poulin.

Geology. The country rock is Pend-d'Oreille schist and at least two veins have been opened up by means of open-cuts and pits. One vein, as exposed in three cuts, strikes north 15 to 26 degrees east and dips to the northwest at an angle of 85 degrees; the other vein exposed by two trenches and a pit, strikes north 28 degrees east and dips 64 degrees to the northwest. The ore consists of pyrite, zinc blende, and galena in a quartz gangue and a sample weighing 3¼ ounces was found on assay by the Mines Branch to contain a trace of gold, and silver at the rate of 17·64 ounces to the ton of 2,000 pounds.

Jennie Bell and Ymir Mint.

Location and Development. The Jennie Bell and Ymir Mint claims are situated in a glacial basin on the east side of Elise mountain at the source of the North Fork of Wild Horse creek. The group includes five or six claims held by location. The upper workings are at an elevation of about 5,800 feet above sea-level. A rawhide trail connects the property with the North Fork wagon road. The Jennie Bell claim was located July 17, 1911, by Joseph Kileel and J. R. Bremner. They ran a short tunnel and prospect winze on the Jennie Bell vein in 1911 and developed some ore, carrying, it is said, $100 to the ton in gold, silver, and lead. In 1912 a tunnel was commenced to tap the vein at a point 50 feet lower in elevation than the upper working. J. J. Hennessey, representing Martin Woldson of Spokane, Washington, took a bond on the property and had three men working in 1913. Work in the lower tunnel was commenced May 20, 1914, and by August 20 had proceeded 80 feet. There were 80 sacks of ore ready for shipment, said to average $50 per ton. The gold values are higher than those of silver and lead.

Geology. The vein in the upper tunnel strikes north 25 degrees west (magnetic) and dips to the southwest at an angle of 65 degrees. The adit tunnel on this vein is 25 feet long and has a prospect winze at the face (full of water in 1914). The vein varies from 1 foot to 2 feet in width and on the foot-wall side, near the portal of the tunnel, the quartz vein appears to cut the schist whereas elsewhere it follows the planes of schistosity. In the face of the tunnel two veins of quartz are present with an intervening schist band. The ore shoot is reported to have a pitch of 30 degrees northwestward or into the hill. The dip of the vein at the face is 40 degrees to the southwest whereas the schist dips at an angle of 65 degrees in the same direction. The foot-wall of the vein is a dark, greyish green schist, fine grained and pyritic; the hanging-wall is a more massive pyritic greenstone schist. Quartz ore with a very little pyrite (weighing 3½ ounces from a sack of ore) was assayed by the Mines Branch and found to contain 0·28 ounce in gold and 142·8 ounces in silver per ton.

The lower tunnel commences as a crosscut in a greenstone schist and continues as such for 146 feet. The bearing of the crosscut is south 73 degrees west (magnetic) for 66 feet, then south 78 degrees west for 55 feet, and north 50 degrees west for the remaining 25 feet. The Jennie Bell vein was encountered about 86 feet in from the portal and drifted on to the northwest for only a few feet. At 146 feet from the portal a water course and schist ore zone were encountered and drifted on for 45 feet. The strike of this shear zone, thought to be the northern extension of the Ymir Mint vein which is exposed on the opposite side of the Jennie Bell basin, is north 8 degrees west (magnetic) and the dip vertical. The working then swings to a bearing of north 50 degrees east, crosscuts more massive greenstone for 36 feet, meets the Jennie Bell vein and follows the latter for 108 feet. The vein, where first encountered, is 6 inches in width and lies between schist walls. The strike of the vein on this level corresponds with that of the schist viz., from north 30 degrees west to north 20 degrees west; the dip varies from 40 to 55 degrees southwesterly. A quartz vein 2 inches wide is exposed in the face between walls of fine-grained, greenstone schist belonging to the Rossland Volcanic group.

Old Timer.

Location and Development. The Old Timer claim is situated north of and adjoining the Alexandre and Dumas claims on the mountain east of the pass between the North Fork of Wild Horse and Clearwater creeks. The elevation of the workings is roughly 6,000 feet above sea-level and the property is accessible by means of both the Dumas trail and a new and more direct trail cut during the summer of 1914. The claim was located July 26, 1909, by R. R. Shrum, E. M. Peters, and Chas. Desrosiers, who do annual assessment work on the claim.

Geology. The Old Timer vein is 4½ feet wide, 75 feet in from the portal of the tunnel. It varies in strike from north 13 degrees east to north 44 degrees east (magnetic) and dips steeply to the northwest. The ore is galena, blende, and pyrite in a quartz gangue, and is reported to run from $11 up to $114 per ton. There is considerable oxidization near the surface and the yellow chloro-phosphate of lead, pyromorphite $(Pb\ Cl)\ Pb_4(PO_4)_3$, was found in this zone of oxidation. The occurrence of pyromorphite in Canada is rare, the only other known occurrence being at the Society Girl mine in East Kootenay, B.C.[1]

The country rock is very much altered Pend-d'Oreille schist (andalusite schist in part); it trends in a general north and south direction and is injected by granitic dykes from the adjoining Nelson batholith. The contact between the batholith and the schist cuts through the Old Timer claim near the prospect shaft and dips steeply to the west.

Summit.

Location and Development. The Summit claim lies in the pass between Clearwater and North Fork of Wild Horse creeks at an elevation of about 5,000 feet above sea-level. It is connected by wagon road (at present in need of repair) with the main road to Ymir. The claim was located July 8, 1896, by Chas. W. Anderson, John Lindblad, and John Bergman who did some development work on it. It was forfeited to the crown, November 5, 1907.

Geology. The country rock of the Summit vein is Pend-d'Oreille argillite; it strikes north 30 degrees west (magnetic) and dips steeply to the southwest. A crosscut tunnel bearing south 65 degrees east (magnetic) is 162 feet long and intersects a quartz vein about 2 feet in width and having a prominent hanging-wall. The vein which has been drifted on for 162 feet strikes north 44 degrees east (magnetic) and dips steeply to the northwest.

Tamarac.

Location and Development. The Tamarac property is situated at the southwestern end of Elise mountain at an elevation of approximately 4,600 feet above sea-level. It is connected by aerial tramway with the Nelson and Fort Sheppard railway at a

[1] Schofield, S. J., "Geology of Cranbrook map-area", Geol. Surv., Can., Mem. 76, 1915, p. 110.

point halfway between Porto Rico siding and the town of Ymir. The Tamarac crown-granted claim was located September 12, 1896, by J. W. Handen. The property was first developed by the Kenneth Mining Company who employed ten men in 1897. The company installed a steam hoist in 1898 and shipped seven tons of ore during 1899. In 1901 a Riblet aerial tramway was built at a reported cost of $17,000 to connect the mine with the railway, a distance of 3,000 feet.

During 1902, the company went into liquidation and a company called the Tamarac Mines, Limited, was formed; the bonds were issued to the Kenneth shareholders with a liability of ten cents, of which four cents were called up. The new company shipped about 150 tons of ore to the reduction works at Silica, chiefly for experimental purposes. The ore was reported to average $11 per ton and to be susceptible to profitable treatment by the cyanide process. The property was idle for some years until 1905 when lessors rawhided a few tons out to the Ymir road and shipped to a Boundary smelter. The character of the ore shipped did not conform to the samples submitted to the smelter and altered rates for treatment rendered it unprofitable to continue operations. Since 1905 the property has been idle.

Geology. The Tamarac vein as developed by an incline shaft, prospect pits, and crosscut tunnel occupies a curving fissure with general east and west trend and dipping to the north at an angle varying from 30 to 50 degrees. The quartz vein varies in width from one to several feet. The geological relations of the vein and ore-shoot are best shown in the accompanying block diagram (Figure 3)[1] from which it may be seen that the ore-shoots are confined to the bends in the vein. The ore consists of heavy sulphides, chiefly pyrite, in a white massive quartz gangue. The country rock is the spotted granite porphyry (Jurassic) and the ore zone is confined to the schistose portion of it. Where the porphyry becomes more massive the vein is dragged out in the direction of shear and terminates.

[1] Page 50.

Ymir.

Location. The Ymir mine is situated on the North Fork of Wild Horse creek, 5 miles from the town of Ymir and at an elevation of approximately 4,500 feet above sea-level. A wagon road connects the mine and mill with the town of Ymir.

Topography. As illustrated in the accompanying block diagram the Ymir mine lies on a steep mountain slope conveniently situated, however, with respect to the mill and cyanide plant which are in the valley bottom (Plate XI). The property is near the junction of North Fork valley with that of the main Wild Horse creek. This portion of the valley is characterized by many prominent alluvial benches or terrace-steps and cuspate forms. Such forms have resulted from the slow excavation by the creeks of the fluvioglacial valley-fill material since the retreat of the valley ice.

History and Development. The Ymir group of claims includes the following crown-granted claims in order of location: Rockland by Jerome Pitre July 9, 1895; Ymir by Joseph Pitre July 17, 1895; Mugwump by Oliver Blair, August 5, 1895; Golden Horn by Jerome Pitre July 7, 1896; Robertson Fraction by R. B. Wood, December 8, 1896; Nora Fraction by B. A. Robertson, December 16, 1896; Lawrence Fraction by London and British Columbia Gold Fields, Limited, October 30, 1897; and Pountney by S. S. Fowler, October 30, 1897.

In November 1896 the London and British Columbia Gold Fields Company Limited, under the direction of S. S. Fowler, M.E., took over the Ymir and adjoining claims and put in a wagon road to connect the mine with the railway at Ymir. The Ymir Gold Mines Limited was incorporated in August 1898 with a capital of £200,000. The head office of the company was in London and the provincial head office in Nelson. The Ymir property was transferred to this subsidiary company although it remained under the management of the parent company until January 1, 1903, when Mr. R. M. Atwater took over the separate management of the Ymir Gold Mines Limited.

A compressor plant was installed in 1898 and the building of an 80-stamp mill commenced. During the year ending September

1899, 7,400 tons of rich carbonate and galena ore were crushed and 46 tons shipped. In 1900 the 80-stamp mill was completed and the output for that year amounted to 42,660 tons of ore, giving a yield per ton of $7.20 in gold and 1·06 ounces in silver. By 1901 the Company was producing gold bricks valued at $40,-000 per month. The cyanide plant was installed and was expected to effect a saving of about $1 per ton. Active development was in progress, including the driving of a tunnel to tap the vein at a depth of 1,000 feet. The recoveries in bullion and concentrate at that time represented a value of about $9 a ton, while the cost, including actual mine development but exclusive of expenditure on account of the long tunnel operations, was from $3.50 to $4 a ton.

Ymir Gold Mines Limited underwent reconstruction November 21, 1902; pound shares in the new company were issued with 17 shillings credited to them for surrendered shares in the old company, the arrangement being equivalent to an assessment of 3 shillings per share on the stock. The provincial office was removed from Nelson to Ymir. In 1902 the output was about 50,000 tons of ore, yielding, per ton, $6.69 in gold and $1.27 in silver and lead. The total net profit during 1902 was reported to have been about $75,000 only, as against four times that amount in 1901. Between June 30, 1903, and December 31, 1903, the Ymir shipped only 219 tons of ore. The ore milled during the year amounted to 54,850 tons, a slight increase over that treated during the year 1902; but the values were smaller than those of the previous years. According to the Provincial Bureau of Mines report the values resulting from the milling and cyaniding were 11,160 ounces of gold, 50,060 ounces of silver, and 515 tons of lead, which, with the concentrates, brought the total product up to something over $300,000—a falling off of $45,000 from the previous year's record. Excess of water in the lower workings, a diminution in the grade of the ore, together with the general decrease in the price of silver and lead, all materially affected the net profit of the mine.

On January 1, 1904, R. M. Atwater, manager, was succeeded by G. H. Barnhardt, who had formerly been superintendent of the property under the London and British Gold

Fields Company. Mr. Barnhardt resigned in the autumn of 1904 and was succeeded in turn by S. J. Speak and later by E. M. Hand. The output in 1904 was not so great as that of 1903, being between 30,000 and 35,000 tons. Extensive prospecting on the hill above the outcropping of the Ymir vein was done during the summer of 1904 in search of a parallel vein which was supposed to have been the source of some rich gold-quartz "float" found on the property.

The output of the Ymir mine for the year 1905 was considerably less than for 1904; the earnings amounted to $32,878 over and above the cost of tramming, milling, freight, and treatment of the concentrates. The company's mill was in operation off and on during the latter half of the year 1906, but the mill feed was of low grade. In the early part of 1907 Ymir Gold Mines Limited was reconstructed and the sum of $200,000 provided for additional development of the mine. About forty men were employed during nine months of the year and prospecting for the vein, which is indicated by rich float as existing above the old Ymir vein, was continued as well as additional development in the deep levels of the mine. Small bodies of ore were found and about 1,000 tons, averaging $5 per ton, was put through the mill. Since 1908, when 39 tons were shipped to the smelter, the mine has been idle and as a result the workings are in bad condition, many of them inaccessible. A few years ago the mine buildings were destroyed by fire.

The extent of mine development including sinking, crosscutting, and drifting may be noted on the accompanying plan and longitudinal projection of the workings (Figure 8).

Geology. The Ymir ore deposits occur as lenticular-shaped shoots in a quartz-filled fissure vein striking south 65 degrees west (magnetic) and dipping from 60 to 70 degrees to the northwest. The vein cuts diagonally across the strike of the enclosing Pend-d'Oreille schist and argillite which trend north 35 degrees east (magnetic) and dip from 70 degrees northwest to vertical. Lamprophyre dykes with branches occur throughout the workings. On No. 2 tunnel level, Mr. S. S. Fowler reports an interesting occurrence of a 4-foot lamprophyre dyke which he found

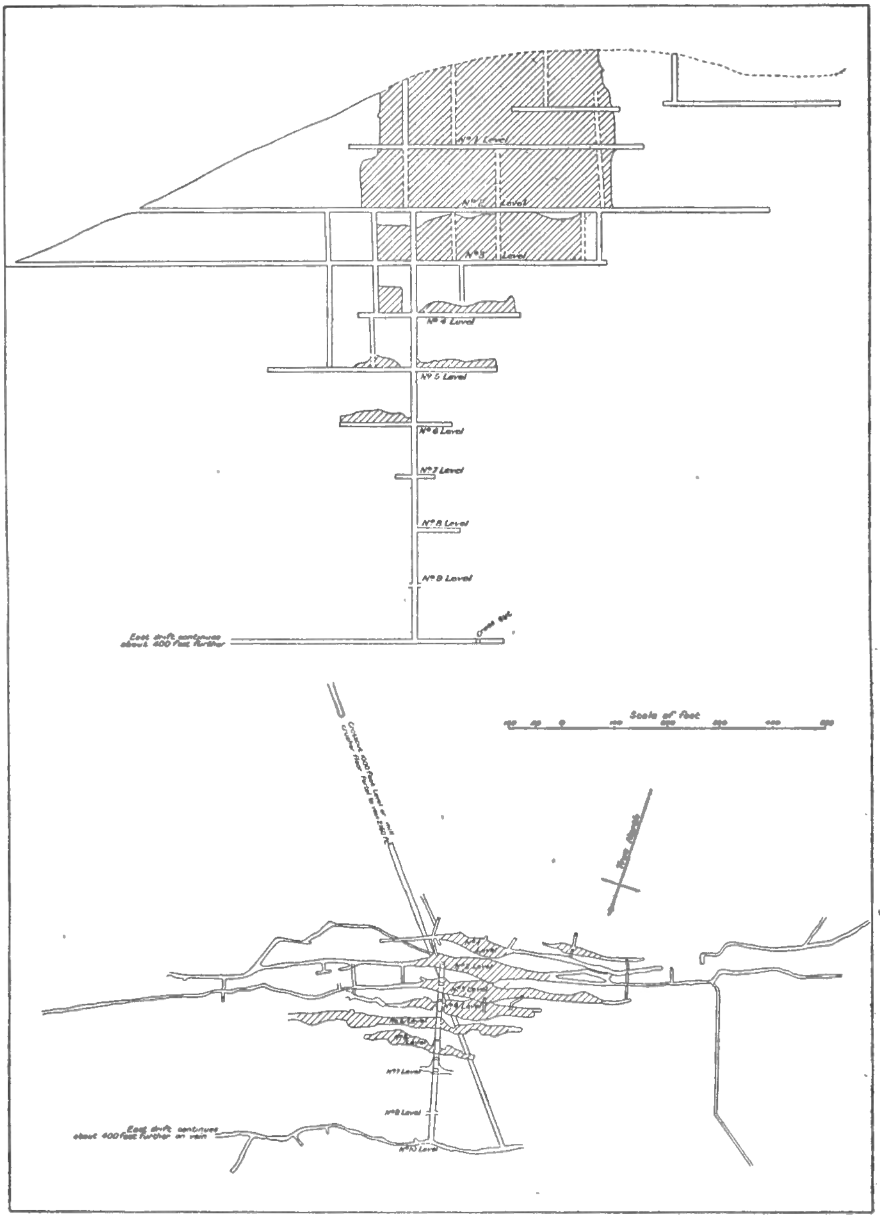


Figure 8. Plan and longitudinal section of Ymir mine.

cutting squarely up to the foot-wall "where it turns a right angle to the left along the wall, and so continues, gradually curving to the right for 20 feet where it crossed the drift squarely. Going through the dyke we found slate, and, cross-cutting on the outer side of the dyke, we found it suddenly turning again and butting against a fault fissure, nearly filled with 2 feet of calcite. Just how or where the dyke proceeds into the hanging-wall we do not yet know, nor is it specially important."[1]

The width of the vein varies from a few feet to 40 feet and as a rule the walls are free, well defined, and marked by gouge. Replacement of the wall rock by silica, particularly the hanging-wall, has taken place in many instances and both walls contain angulars of white quartz generally barren of values. Although the vein below the No. 7 level is strong and in many places 5 feet wide, the ore is pockety and low grade. Inclusions or horses of Pend-d'Oreille argillite occur in the vein in many places, generally as sharply angular fragments.

Faulting in the plane of the vein has taken place on more than one occasion as evidenced by various pronounced fracture and gouge zones, offsetting of dykes, slickensides, and the lenticular shape of ore-shoots. Drag structures were noted in the surface workings, indicating that at least the last movements resulted in the heaving of the hanging-wall (north wall) eastward with respect to the foot-wall. This corresponds to the direction of faulting along the principal vein fissures of the neighbouring Sheep Creek gold district, as well as to the regional faulting in the quartzites of the Summit series at the International Boundary. The geological relations of the Ymir vein fissure to the Rossland Volcanic group and Nelson batholith are indicated in Plate XII.

The ore consists of galena, iron pyrite, and zinc blende, and contains gold, silver, and lead values; the gangue is quartz and altered wall rock. The quartz is in many places of a dark smoky blue colour and, where present, is associated with high gold values. No copper mineral was ever found in the ore. Where the ore-body is fractured and oxidation has taken place,

[1] Jour. Can. Min. Inst., 1900, p. 8.

carbonate ores occur containing cerussite and an enrichment of free gold values.

The main ore-shoot in the mine, known as the "Bonanza shoot," has a horizontal or stope length of 480 feet and a depth of 500 feet. The stope in the shoot is bounded by approximately parallel boundaries and varies in width from 10 to 40 feet (Plate XIII). In plan, it presents a lenticular shape and appears to pitch steeply to the east in the direction of the creek bottom (Figure 8).

Mining. The mine has been developed and worked by three adit tunnels, No. 3 tunnel cutting the ore-shoot at a depth of about 400 feet. Most of the ore was taken out of this adit and conveyed by a Hallidie tramway, 2,400 feet long with a 650-foot drop, to the mill ore bins. The buckets were filled by an automatic loader. The plant had a capacity of 250 tons in 10 hours. From No. 3 level a winze connects No. 4 and No. 5 levels. At a vertical depth of 1,000 feet No. 10 crosscut level intersects the vein which on this level is extensively drifted on; connexion is made with the upper workings by a raise to the winze from No. 3 level. The portal of this crosscut tunnel is in line with the upper receiving bins at the mill and some of the ore was trammed directly from this level to the bins. The stopes were filled by material blasted from an open-cut on the surface and sent down by chutes to where required.

The compressed air for the drills was supplied by an Ingersol-Sargeant duplex 10-drill compressor situated at the mill. There was also a 5-drill Rand compressor at the mine.

Milling. The manner in which the Ymir ore is treated in the 80-stamp mill and cyanide plant is indicated in Figure 9. The mill was run by water-power aided by steam; the two powers were connected to the same line shaft (Plate VIII). Three 75-horsepower boilers and one of 60-horsepower were used to supplement the water-power when required. The cyanide plant is situated half a mile below the stamp mill, the difference in altitude being 30 feet. About 70 per cent of the ore treated in the mill found its way to the cyanide plant as vanner tailings. The latter carried about 20 per cent of the gross values of the ore, and of this there was an extraction of fully 80 per cent by

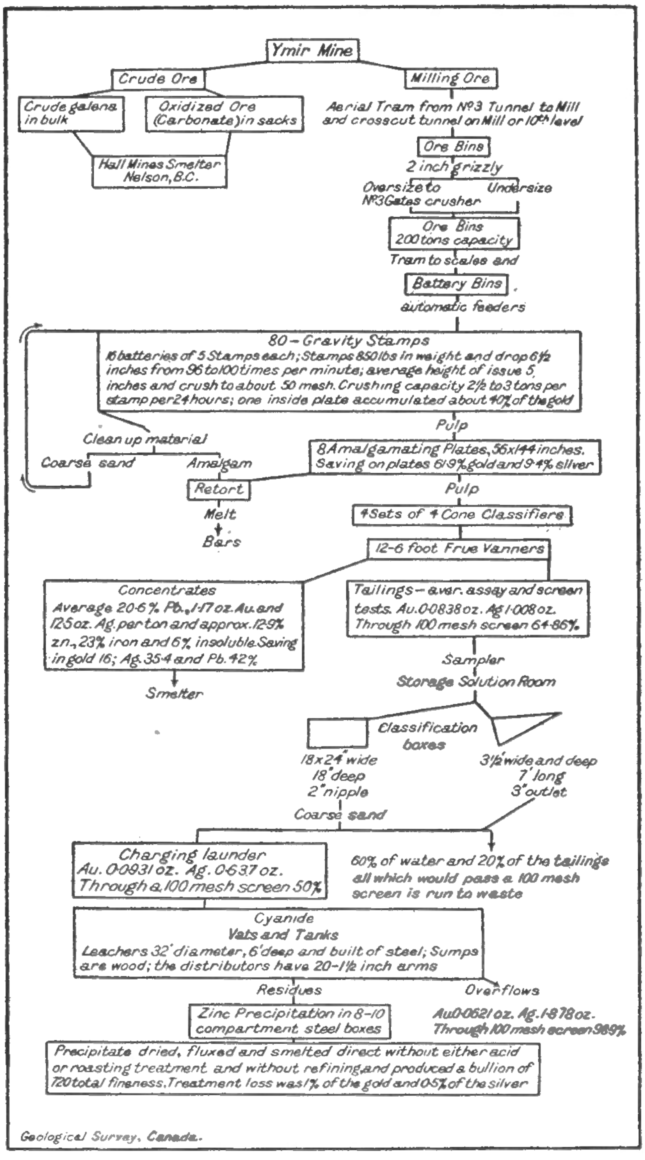


Figure 9. Flow sheet for Ymir Mine ore, Ymir mill and cyanide plant.

cyaniding. During the latter part of 1902 the company's statistics showed an aggregate extraction of 95 per cent of the gross value of the ore. The mill has treated about 350,000 tons of ore. About 20,000 tons of concentrate and nearly 600 tons of crude ore have been shipped to smelting works. Ymir Gold Mines Limited paid dividends to a total of £60,000.

X Ray.

The X Ray claim is situated on the eastern slope of the North Fork valley, opposite the Ymir group of claims, and to the south of the Carthage claim. With the exception of one short tunnel the workings are all caved in. Considerable prospecting was done on that side of the valley in search of the extension of the Ymir vein.

The country rock belongs to the much silificied and sheared members of the Pend-d'Oreille group and is cut by occasional fine-grained, granitic dykes and quartz veins. One vein, as exposed in a 93-foot crosscut tunnel bearing south 48 degrees east, strikes north 7 degrees east (magnetic) and dips at an angle of 63 degrees to the west, corresponding in these respects with the formation. The hanging-wall is an impure quartzite and the foot-wall a carbonaceous schist. The vein consists of fractured quartzite traversed by reticulating quartz veinlets and containing slickensided fracture planes with graphite films. A little pyrite and chalcopyrite are present. The vein was drifted on for about 54 feet.

BEAR CREEK BELT.

Atlin-Nome.

Location. The Atlin and Nome claims are situated to the northeast of the Dundee mine and higher up the hill. A branch road connects the Atlin with the Dundee. The Atlin claim was located on October 27, 1899, by J. W. Masterton. Both the Atlin and Nome claims were held by location for some time by P. Daly, A. Parr *et al.* The Atlin claim is now owned by the Hobson Silver-Lead Company, Limited, of Fort Worth, Texas.

Development. Development consists of an incline shaft sunk on the ore to a depth of about 60 feet and a crosscut 50 feet in length to the north. About 238 feet down the hillside a crosscut tunnel was run which intersected the vein at 215 feet. This was continued 100 feet farther but without encountering any parallel veins. The vein was drifted on to the south toward the shaft and an incline raise to connect with the upper workings was run for about 170 feet.

Geology. The vein is fairly regular and has a strike of north 15 degrees east (magnetic) and dips to northwest at an angle of 70 degrees. It cuts diagonally across a roof pendant of Pend-d'Oreille schist 200 feet in width which is much altered, decomposed, and injected by granitic material from the bordering Nelson granite and gneiss which underlies and surrounds the roof pendant. The ore is pyrite in a quartz gangue and in some places there are pockets of solid sulphide. The values in the sorted ore as shipped in the early nineties are said to have run from $20 to $25 per ton.

Canadian Girl.

Location. The Canadian Girl, crown-granted claim adjoins to the north the Yankee Girl and was located the same day as the latter, October 30, 1899. The locator was O. A. Lovell. The claim is owned by the Hobson Silver-Lead Company, Limited, with head office at Fort Worth, Texas.

Geology. The underground workings were not examined. The surface geology is similar to that of the Yankee Girl and Dundee mines which lie in the southern extension of the same belt of formations. The country rock is Pend-d'Oreille schist injected by a series of fine-grained, granitic dykes from the Nelson batholith to the east. The vein belongs either to the general north and south class striking with the formations or to the east and west class (parallel to the Yankee Girl and Dundee veins) diagonally cutting the formations. The latter class of veins are by far the most promising and should be prospected at their acute angled intersections with the granitic tongues (Figure 2).

Dundee.

Location. The Dundee mine is situated on the north slope of Bear Creek valley adjoining to the southwest the Yankee Girl mine. It is connected by a good wagon road with the Nelson and Fort Sheppard railway at Ymir about 2 miles distant. The group consists of five crown-granted mineral claims as follows: Old Bill, Parker, Lightheart, White Pine, and Annie Fraction. The first three were located in 1896 by Hugh Morrison and Tom Flynn, the remainder at a later date. The name of the group was taken from the original owner Mr. Dundee and the mountain on which the claims are located is also known as Dundee mountain.

Development and Production. The Dundee mine is one of the oldest properties in the district and was operated from 1897 to 1904 and at intervals since then. In 1897 several carloads of ore were shipped from the Dundee mine. During December 1898 the company shipped two carload lots to the Hall Smelter at Nelson; the first carload ran 18·4 ounces in silver, 2·858 ounces in gold, and 19·9 per cent lead, or a total of $77.15 per ton; the second carload ran 7·65 ounces in silver, 1·095 ounces in gold, and 4·3 per cent lead or a total of $28.40. In 1898 a concentrator was installed. Assays from concentrates are reported to have run as follows: from coarse jig $24.90 and $30.10; from No. 2 screen $50.30 and $50.82; from concentrates off the Wilfley tables $34.20 and $36.95; the average values were $40. The ore from which the concentrates were obtained averaged $7.27 per ton. From 185·6 tons of milling ore, running 0.36 ounce in gold, 0·4 ounce in silver, or of a gross value of $7.50 per ton, 50·6 tons of concentrates were obtained running 0·96 ounce in gold and 4·9 ounces in silver. The extraction of values was 77.6 per cent. During 1899, 700 tons of ore were crushed. The total amount of ore shipped from the mine is reported to be about 300 tons averaging from $15 to $20 per ton.

The shaft house and concentrator were destroyed by fire April 13, 1899, and the mine closed down for a few years. The workings were pumped out in 1903 and work was carried on under the superintendence of A. H. Gracey on behalf of coast interests.

The property was acquired in 1910 by a syndicate in New Westminster and they formed a company, of which E. B. Morgan is president while the directors are John Henry of Vancouver, G. E. Corbould, C. E. Major, and A. E. Rand of New Westminster. This company drove a crosscut tunnel at a level of 904 feet below the collar of the shaft, or 644 feet below the lowest point to which the property had been developed from the shaft. This tunnel was run a distance of 2,954 feet, crosscutting the vein at a distance of about 1,850 feet; thence it was continued on the vein as a drift for about 1,000 feet, of which the last 100 feet is in an ore-shoot. During the summer of 1914, Mr. B. H. Washburn took a lease on the property and was about to make a small shipment. The extent of development is shown in Figure 10.

Geology. The Dundee vein is a strong fault fissure with well-defined walls traceable for several thousand feet. A gouge, a few inches to over one foot thick, marks the hanging-wall. The fissure, which is filled by quartz and altered, mineralized, wall rock, strikes northeast and southwest with a northwestward dip of 60 to 70 degrees. It is parallel to the Yankee Girl vein. The vein varies from 5 to 20 feet in width and cuts diagonally across the trend of the Pend-d'Oreille schists. Toward the northeast, where the ore-shoot occurs, the vein encounters a fine-grained granitic tongue injected from the main mass of Nelson granite and gneiss to the east. The ore-shoot occurs in the granite at its acute-angled intersection with the fault fissure (Figure 2). The ore is galena, iron pyrite, and some zinc blende, carrying gold and silver values; the gangue is quartz. Some of the ore first opened up ran as high as $100 per ton. As a general average, however, the ore would run about $25 per ton in gold and silver. Much pyritic milling ore is present, averaging $6 or $7 per ton. Both foot and hanging-walls carry pay-streaks aggregating 30 inches in width with disseminated ore between. The ore-shoot in part represents granite replaced by silica containing sulphides. Galena, as is so characteristic of Ymir ores, is accompanied by good gold values and in places good silver values; zinc blende is accompanied by both gold and silver values, especially when associated with galena.

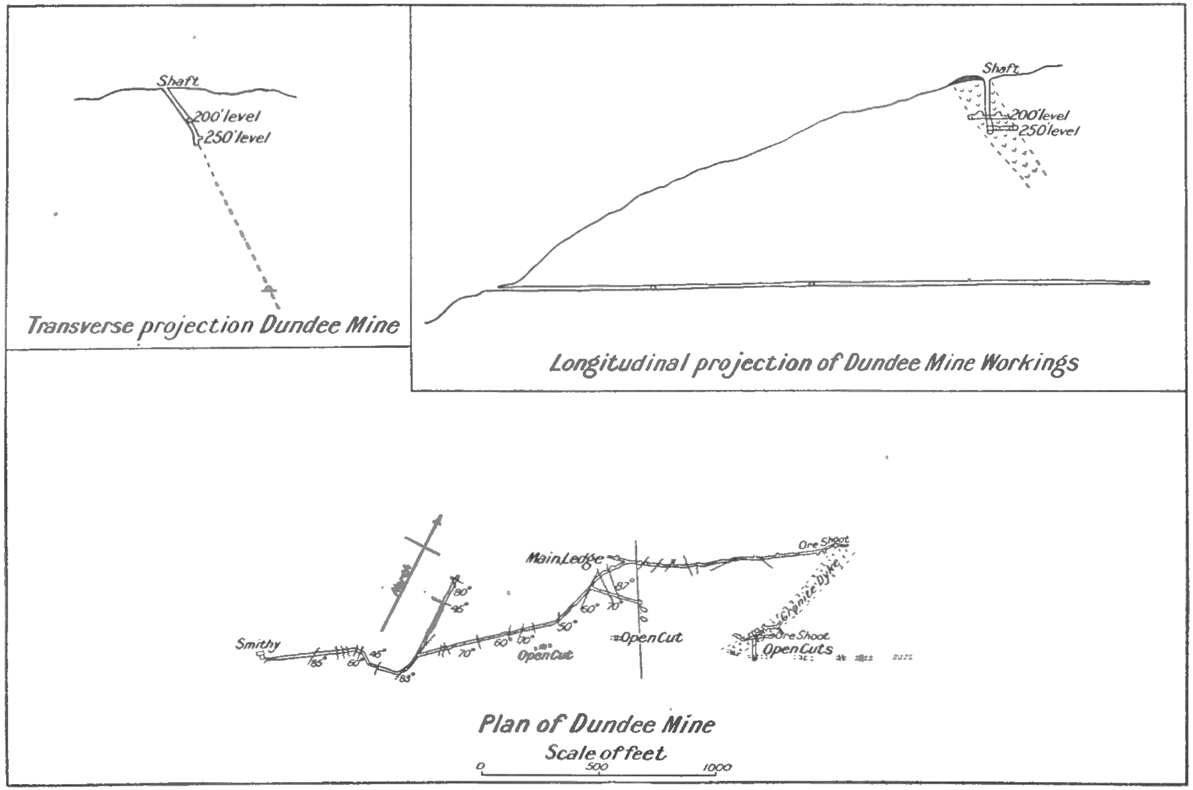


Figure 10. Plan and sections of Dundee mine.

Yankee Girl.

Location. The Yankee Girl mine is situated about 2 miles from Ymir on the north slope of Bear Creek valley above and adjoining the Dundee mine to the northeast. The group includes the following claims: Yankee Girl located October 30, 1899, by J. H. Graham, D. E. Grobe, and D. McLeod; Yukon Fraction located October 1, 1901, by A. C. O'Neill; Atlin located October 27, 1899, by J. W. Masterton; Canadian Girl located October 30, 1899, by O. A. Lovell; Lakeview, Evening Star, and Morning Star—the last two located prior to 1897 by T. Flynn.

Development. The original owners of the Yankee Girl mine drove a tunnel about 200 feet long and did considerable open-cutting. They disclosed a quartz vein 2 feet in width, following one border of a tongue of fine-grained granite which at that locality strikes north 40 degrees east (magnetic). Doyle brothers then took a lease and bond on the property and shipped about 250 tons of ore valued at $6,600. In February 1907 an American syndicate operated the property for six months, and, during that time, drove over 1,000 feet in development; they also erected a 2-bucket aerial tramway from the mine to a point on the Dundee wagon road about 1¼ miles from the Great Northern Railway station at Ymir. In August this company relinquished their bond. The owners, at a later date, shipped a few carloads of ore running from $20 to $25 per ton. Early in 1908 H. L. Rogers bonded both the Yankee Girl and the Yukon, and did considerable development work on both claims. In 1909, the Yankee Girl mine shipped 2,622 tons of ore to the Trail smelter, valued at $64,000. The same year the group was transferred to the Yankee Girl Gold Mines Limited of New York. Between January and November 1910, 4,738 tons of gold ore were shipped to the Trail smelter. At the end of November the company was reorganized, making available new capital. A 7-drill compressor for supplying power underground was installed in December. During 1911 the mine reduced shipments to the Trail smelter to 1,352 tons while the property was being transferred to the Hobson Silver-Lead Company Limited. In the autumn of 1912 the Yankee Girl mine, under new management, resumed shipments, shipping to Trail smelter 610 tons of ore, carrying about $15 in gold per ton. In 1912 No. 2 tunnel was continued to encounter the main ore-shoot and small shipments were made. In 1913 the mine shipped 3,034 tons to Trail smelter and about 850 tons to the smeltery of the British Columbia Copper Company at Greenwood, B.C. The gross value of this amounted to $92,215.14 making an average value per ton of $23.86 in gold, silver, and lead. In 1914 the company shipped 226 tons and commenced work on a new hydro-electric power plant and mill. The grading was completed and water is to be brought down by means of a 3 by 2-foot flume 6,500 feet long from Wild Horse creek to a penstock, thence by pipe-line 1,200 feet long to a water wheel under a head of 240 feet. The total amount of ore shipped from the mine is reported at about 8,500 tons, averaging about $22 per ton. No ore was shipped in 1915 but the adit tunnel commenced in 1914 was driven over 1,000 feet[1]. It is the intention of the company to put in a new 6000-foot aerial tramway, from the mine to the ore bins (240 tons capacity) at the railway, and thus do away with the slow and expensive wagon haulage.

Geology. The Yankee Girl vein resembles in many respects the Dundee vein and is parallel to it. The localization of the ore-shoot is also at an acute-angled intersection of the fissure vein with granitic tongues from the Nelson batholith (Figure 2). The vein cuts diagonally across the trend of the Pend-d'Oreille schist which in the upper workings is much altered and oxidized and contains lenses of quartz. The vein has well-defined hanging and foot-walls, as a rule from 4 to 6 feet apart. The granitic tongue rock varies in character from a fine-grained, sheared granite containing pyrite to a fresh granular granite, as exposed in a short crosscut in the hanging-wall at a point southwest of the main ore-shoot on No. 1 tunnel level. A femic phase of the granite is also present in places as in the foot-wall drift of the same working. The values on this level are confined to the fissure vein where it is traversing the fine-grained, pyritic granite and the values run out where the fault fissure leaves the granite to follow along the contact (schist hanging-wall, and granitic

[1]A cloth-like growth found clinging to the wall of an old watercourse in a raise above No. 4 tunnel was determined by Mr. Charles W. Lowe, university of Manitoba, to be a mass of iron bacteria of the genus *crenothrix*.

foot-wall). The strike of the west border of the main granite tongue, as exposed on the surface below the Overland tunnel, is north 15 degrees west (magnetic). The granite contains large rounded inclusions of a more femic phase. The Pend-d'Oreille schists in this contact zone are much altered, foliated, and contorted, and, on account of their iron content, are much oxidized (Plate III). The strike of the schist varies considerably as do also the shapes of the granitic injection tongues from the batholith with their irregularly curving offshoots. At one locality, where the schist is well exposed in contact with the granite, it strikes north 53 degrees west (magnetic). The fault striæ on the walls of the vein pitch at an angle of 65 degrees to the west or in the direction of the slope of the hill. The ore is galena, zinc blende, and pyrite, in a gangue of quartz and altered wall rock; the highest values in gold are associated with the steel galena. The dimensions and shape of the highest grade ore-shoots, so far developed, are indicated in Figure 11. The most easterly shoot, known as the Yankee Girl or Hobson shoot, is by far the most important one. On account of the manner of its localization at an acute-angled intersection of granite with schist it resembles a "chimney" with its stope length of 35 feet at the Overland tunnel level widening to 200 feet at No. 2 tunnel level. The width of the shoot varies from 2 to 3 feet. There is considerable low grade concentrating ore between the ore-shoots.

Yukon.

Location and Development. The Yukon Fraction claim lies above the Dundee and between it and the Atlin group already described. It was located October 1, 1901, by A. C. O'Neill and crown-granted in 1904. For some time it was held by a few of the owners of the Atlin group and in 1907 was bonded along with the Yankee Girl to an American syndicate who operated the property for about six months. In 1908 H. L. Rogers secured a bond on it and worked it in conjunction with the Yankee Girl mine. Development consists of a 245-foot adit tunnel, the first 150 feet being barren of values. Owing to the gentle slope of the ground a depth of only 50 feet was attained on the vein. The property is now owned by the Hobson Silver-Lead Company.

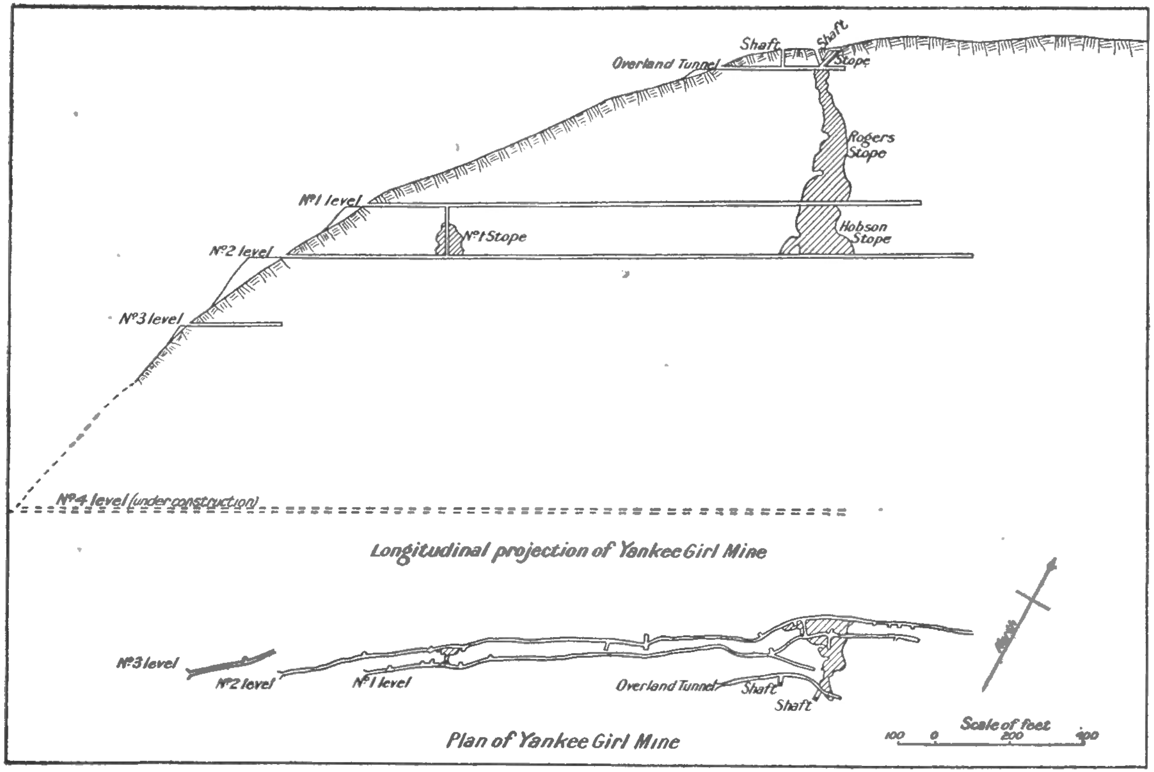


Figure 11. Plan and section of Yankee Girl mine.

Geology. The workings have disclosed a fairly well-defined vein striking in a northeast and southwest direction, dipping almost vertically, and cutting through a roof pendant of altered schist (barren) and granite. The width of the vein is 3 to 6 feet, the shipping ore being in a streak 1 to 2½ feet wide. The ore is pyrite, zinc blende, and galena in a gangue of quartz and altered country rock and carries gold and silver values. The ore shipped is reported to have run from $10 to $20 a ton.

PORCUPINE CREEK BELT.

Hunter V.

Location and Development. The Hunter V mine lies on the divide between Porcupine and Hidden creeks at an elevation of about 5,700 feet above sea-level. The property is accessible by means of a switch-back trail from the Porcupine wagon road. The Hunter V claim is crown-granted and was located May 21, 1900, by A. A. Vernon. The Double Standard claim and five others are included in the group. Prior to 1903 the property was owned and operated by William Davis. About that time it was acquired by Nelson interests known as the British Columbia Standard Mining Company with capitalization of $200,000. Mr. G. J. Campbell of Nelson is manager. During 1903 development consisted of 120 feet of sinking and 100 feet of open-cut work on the Hunter V claim and over 400 feet of work on the Double Standard claim. A double rope aerial tramway (Riblet) about 13,000 feet long, with two subsidiary tramways 1,800 and 500 feet in length, were built to connect the mine with a siding on the Nelson and Fort Sheppard railway at the mouth of Porcupine creek. The production for the year 1903 was 400 tons. During a part of 1904 an average output of 200 tons per day was sent to the smelters at Trail, Nelson, Northport, and Granby. The shipments for 1904 were as follows: February 541 tons; March 1,194 tons; April 1,573 tons; May 1,964 tons; June 1,258 tons; July 1,447 tons; August 1,703 tons; September 1,537 tons; October 1,508 tons; November 2,295 tons, and December 2,146 tons—a total of 17,166 tons. In 1905 owing to a decided depreciation in the value of the ore shipped and the limited capital of the mining company the mine went into liquidation. The Hall Mining and Smelting Company worked the property for the last six months of 1905 and treated about 6,600 tons of a little better grade ore. Since then the property has been idle.

Geology and Mining. The Hunter V ore deposit belongs to a unique type for the Ymir district, namely replacement of limestone in which the fine-grained sulphides, galena, zinc blende, and pyrite, carrying values in silver and a little gold, occur disseminated in a carbonate gangue. Native silver is reported as occurring on the Double Standard claim in small flakes and tremolite occurs in places as a gangue of the sulphide ore. The replacement shoots are very irregular but have a tendency to dip flatly into the hill and toward the granite. Near the centre of the shoot the sulphides are abundant, but gradually fade away toward the borders and into pure limestone. The mineralization appears to be independent of the adjacent granite and does not follow along the contacts. The boundaries of the ore-shoots are purely commercial, there being no structural hanging and foot-walls. The limestone, which is in large part coarsely crystalline, belongs to the Pend-d'Oreille group and has a general north and south trend. It is limited on the east and west by belts of Nelson granite. The limestone is not pure and in the vicinity of the ore carries from 10 to 25 per cent in silica. The ore shipped in December 1903 averaged as follows: 0·14 ounce in gold, 8·6 ounces in silver, 21 per cent silica, and 30 per cent lime. One lot that assayed 33 ounces in silver ran 67·4 per cent silica and 18·5 per cent lime. An average sample of the ore shipped in 1904 assayed 0·03 ounce in gold, 5·30 ounces in silver, 23 per cent silica, and 39 per cent lime. Silica was penalized at the rate of 10 cents per unit over 10 per cent. The Double Standard ore is more siliceous than that from the Hunter V claim. The lime content in the ore rendered it valuable to the smelters for fluxing purposes and thus it was possible to obtain low smelting rates from certain smelters. Furthermore, the cost of mining and mucking the ore from the Hunter V glory hole and from the dumps, exclusive of general expenses, only amounted to 90 cents per ton, while the cost of tramming it to the railway varied from $10\frac{1}{2}$ to 30 cents per ton (Plate VII A). The output of the property was practically limited by the requirements of the smelters for flux such as it produced.

Mining was carried on by what is locally known as the glory hole or milling system by which the ore was recovered at the surface from the ore zones in large open pits or by dropping the ore from the pits down through chutes into mine cars and then tramming it from the level below to the aerial tramway.

Iowna.

Location and Development. The Iowna group of claims is situated on the north side of the valley of Porcupine creek at an elevation of about 3,300 feet above sea-level and about $1\frac{1}{2}$ miles from the railway. The Iowna claim was located in 1898 by the present owner, A. Burgess. Other crown-granted claims in the group are the White Star located in 1897 and the Annie located in 1896. Adjoining the Iowna and White Star and above the Annie is the Blue-eyed Nellie claim. In 1908 H. L. Rogers took a bond on the Iowna group of claims but very little work was done on the property. Two sacks of ore were shipped which ran $9 per ton.

Geology. The country rock of the property is Pend-d'Oreille schist and Nelson fine-grained granite. The vein strikes north and south and dips steeply to the west with the schist formation. The vein fissure as exposed in the tunnel undulates and a quartz vein $1\frac{1}{2}$ feet wide follows the hanging-wall. The schist is cherty and pyritic in places containing small stringers of blue quartz. The fault striæ on the hanging-wall are vertical. A mica lamprophyre dyke striking nearly north and south (magnetic) and dipping to the east at an angle of 55 degrees is present in the hanging-wall country. The eastern border of the dyke is marked by a slip plane slightly mineralized.

The ore is pyrite in quartz and altered wall rock gangue and contains gold values. Pockets of ore occur at intersections of the main fissure vein with a 10-foot granitic dyke dipping eastward, and with an eastward dipping mineralized fissure. The best ore came from the prospect pit which is on the granite

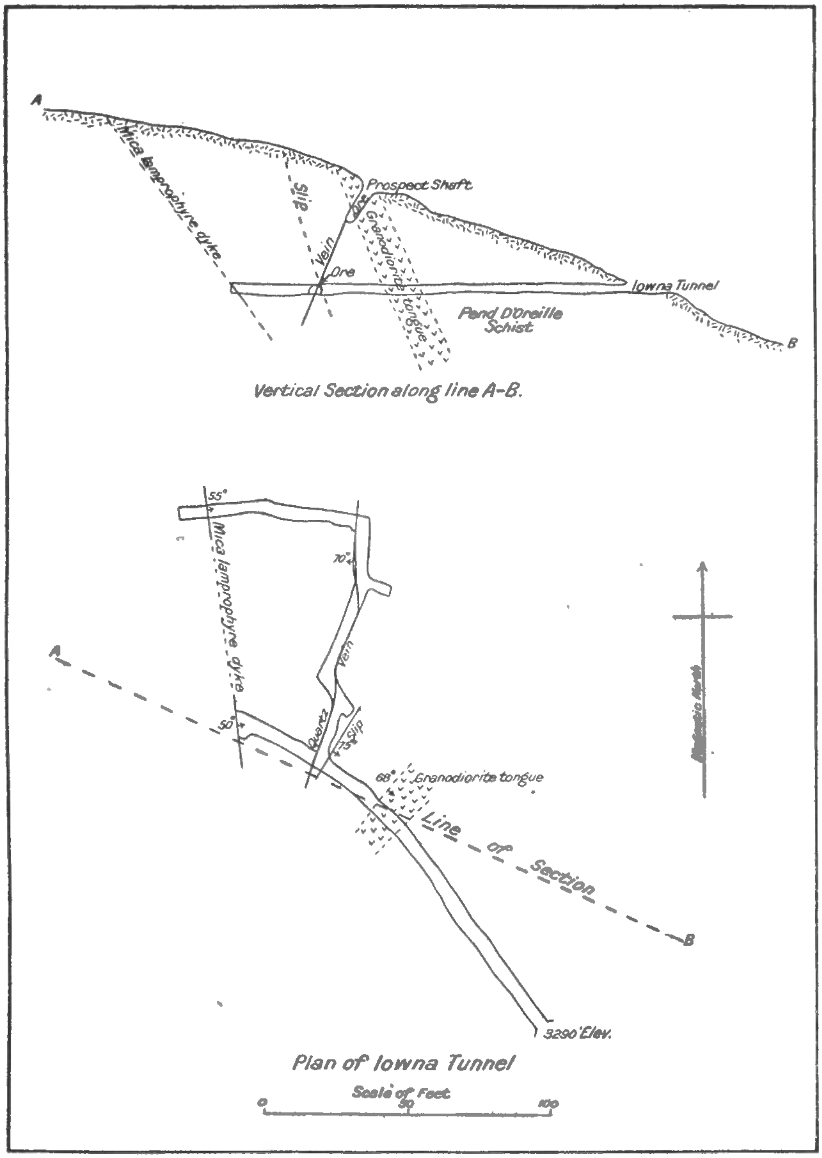


Figure 12. Plan and section of Iowna mine.

intersection and assayed from $7 and $8 to $25 per ton; the ore from the tunnel level ran from $2 to $20 per ton.

The structual relations of the vein and pockets of ore are indicated in Figure 12.

Mulligan and Gold Queen.

Location and Development. The Mulligan and Gold Queen properties are situated near the valley bottom of Porcupine creek, the wagon road passing close to the main workings. The Mulligan claim was located September 3, 1896, by Geo. Eicherman and the Gold Queen August 30, 1896, by Swan Nelson; both are crown-granted. The tunnel was inaccessible at the time of visit and the properties have been idle for many years.

Geology. The ore is galena and pyrite in quartz gangue and occurs in a general north and south trending vein in a roof pendant of Pend-d'Oreille schist. The latter is injected by granitic material and limited to the east and west by Nelson granite which at this locality is foliated and mottled in appearance. The strike and dip of the vein are with the schist formation.

Nevada.

Location and Development. The Nevada group of claims is situated on the southern slope of Porcupine Creek valley at an elevation of about 3,200 feet above sea-level and about 4 miles southeast of Ymir. The trail to the Hunter V mine passes by the Nevada cabin and workings. The Nevada crown-granted claim was located July 1898 by J. B. Stover. The property is now owned by D. E. Grobe of Ymir who in recent years has been doing annual development work.

Geology. Two short tunnels near the trail and open-cuts higher up the hill have disclosed a couple of veins. The main tunnel is about 125 feet long driven in on a vein which strikes and dips with the enclosing Pend-d'Oreille schist formation. The westward dipping vein at the portal shows zinc blende at an intersection with a 1½-foot mica dyke which dips at 50 degrees to the east. The vein contains pyrite in a gangue of white quartz. For the first 65 feet the vein strikes north 5 degrees west (magnetic) with steep westerly dip; it then swings to a strike of north 25½ degrees east for 30 feet, whereas for the last 30 feet it strikes north 64 to 42 degrees east. The walls are fairly well defined and about 2 feet apart. On the surface where the best ore was obtained the granite occurs on the hanging-wall. The ore is pyrite, galena, and zinc blende in a quartz gangue and picked samples with galena assayed $36 per ton. The banded, quartz-biotite schist at this locality in the roof pendant strikes north 64 degrees east (magnetic) and lies almost vertical. The geological relations of veins and ore pockets are similar to those on the Nevada and other deposits belonging to this roof pendant type.

Union Jack and Empress.

The Union Jack and Empress properties are situated near the headwaters of the South Fork of Porcupine creek on the eastern slope of the valley. A well-graded wagon road, now in need of repair, connects the Union Jack power plant with the railway at the mouth of Porcupine creek, a distance of about 6 miles.

The Union Jack crown-granted claim was located July 23, 1897, by Michael Nealy, and the Empress September 25, 1896, by F. Britton. In 1901 the Union Jack and Empress groups, consisting of five claims, were acquired by the Active Gold Mining Company of British Columbia with capitilization of $1,500,000, promoted by Cincinnati men. About 1,000 feet of development was done on the property in 1902. The company purchased some 5,000 acres of good timber in the Porcupine valley and had intended to erect a sawmill near the mouth of the creek, but mining results were unsatisfactory and the company went into liquidation.

Time did not permit of the examination of the workings on the claims but it is reported that four distinct veins are present, varying in width from 6 to 16 feet, containing galena, zinc blende, and pyrite in quartz gangue and assaying from a few dollars up to $29 per ton in gold. The main country rock is Nelson granite.

Big Four and Jubilee.

The Big Four group is situated on the divide south of the Hunter V mine and near the headwaters of Hidden creek. In 1901, the British Lion Syndicate of Owen Sound, Ontario, who were the owners, let a contract for a 50-foot shaft on the property. The country rock is said to be limestone.

The Jubilee claim, owned by G. Keefe and E. Donahoe, is situated on the northern spur which forms the junction between the valleys of Porcupine creek and Salmon river. The claim adjoins the Iowna group to the west. The claim was worked during 1897 and there is a shaft 100 feet deep on it. Rich ore is said to have been found on the property. The claim is in a contact zone between Pend-d'Oreille schist and Nelson granite. Selenium has been reported as being present in a mineral found on this property.

New York Central.

The New York Central group of claims, owned by E. Peters of Nelson, lies farther up the same spur from the Jubilee at an elevation of about 4,500 feet above sea-level.

The ore occurrence is similar in many respects to that of the Iowna, Mulligan, and Nevada properties—the mineralization following the strike of the Pend-d'Oreille schists. The schists occur as a roof pendant in the Nelson batholith, are much altered and contorted, and contain veins of mineralized quartz frequently blue in colour. The schist, as exposed near the New York Central cabin, strikes north 15 degrees east (magnetic) and dips to the west at an angle of 50 degrees. The main working on the property is a crosscut tunnel driven from the Salmon River slope; it has a bearing of south 78 degrees east (magnetic) and is 100 feet long. At 50 feet a slightly mineralized contact between schist on the west and granite on the east side was encountered and drifted on for 55 feet in a direction north 7 degrees east (magnetic). This pyritic, contact, shear zone contains a vein of blue cherty quartz varying from 1½ to several feet in width. The altered fine-grained granite of the foot-wall is considerably decomposed and oxidized near the surface.

Twenty feet from the face of the crosscut is a prominent slip plane in the granite striking north 8 degrees west (magnetic) and dipping to the west at an angle of 45 degrees. On this slip surface are slickensides with vertical striations.

Porcupine.

The Porcupine claim, which is the oldest claim in the belt and the one the creek is named after, was staked in 1895 by Lloyd and Thompson. The claim is situated in the valley bottom of Porcupine creek a couple of miles up from its junction with the Salmon river. The prospect tunnel run in 1897 is close to the wagon road. The property has been idle since the early nineties. The geology is similar to that of the Iowna and Nevada.

Cristabell.

Miller and Johnston own the Cristabell group of claims on the South Fork of Porcupine creek and have a branch trail to the wagon road. The property was not examined.

BOULDER CREEK BELT.

Free Silver.

Location and Development. The Free Silver crown-granted claim is situated on the divide between Boulder and Quartz creeks at an elevation of about 4,750 feet above sea-level. It adjoins the May Blossom to the west and was located June 22, 1896, by J. M. McLaren. The Free Silver group includes nine claims. In 1908 J. H. Schofield and Thos. Bennett secured an interest in the property and did some development work. The property was worked for a short time in 1912. Since then very little work has been done. Adjoining the Free Silver claim to the north is the Fairview Fraction located August 14, 1914, by C. E. Bennett.

Geology. A series of parallel fissure veins, from 2 to 8 feet in width and carrying values chiefly in lead and silver, cuts through a monzonite formation. The monzonite is in turn intruded by a series of parallel dykes of a pinkish, fine-grained syenite porphyry.

The main galena showing on the ridge is in a vein striking north 72 degrees west (magnetic) and dipping to the northeast at an angle of 80 degrees. The vein at the northwestern end of the trench is cut by one of the younger, pinkish, syenitic dykes which have a general northwest and southeast trend and appear to be vertical. The ore is reported to carry average values of 60 per cent lead, 30 ounces in silver, and $2 or $3 in gold. One vein of dry ore, it is said, ran 40 ounces in silver and 3½ per cent copper, and in another molybdenite was found. A 14¼ ounce sample of the fine, crystalline galena in quartz gangue, from a trench on the ridge, was assayed by the Mines Branch and found to contain no gold, 35 ounces in silver, and 81·12 per cent lead.

May Blossom.

Location. The May Blossom property lies on the Quartz Creek side of the divide between Boulder and Quartz creeks and about 675 feet lower in elevation than the adjoining Free Silver property. The claim was located May 1, 1897, by W. Birmingham and is held by location. The property is controlled by an American company known as the May Blossom Mining and Milling Company, who own the May Blossom group, including the May Blossom, May Day, May Flower, Big Diamond, and Electric claims.

Geology. The extent of development and the geological relations of fissure vein to country rock formations are indicated in Figure 13. Some good grade ore was opened up at the surface and also in a 40-foot prospect pit at the intersection of a fissure vein with the southern border of a monzonite chonolith—the hanging-wall being monzonite and the foot-wall an augite porphyrite member of the Rossland volcanic group. About 100 feet lower in elevation than the open-cuts on the vein a tunnel was driven about 200 feet through altered sedimentary and augite porphyrite members of the Rossland group. A streak, 4 inches wide, of quartz ore containing galena and pyrite, is exposed in the face of the working; it strikes north 38 degrees west (magnetic) and dips northeasterly at 82 degrees. The hanging-wall is augite porphyrite and the foot-wall a pyritic

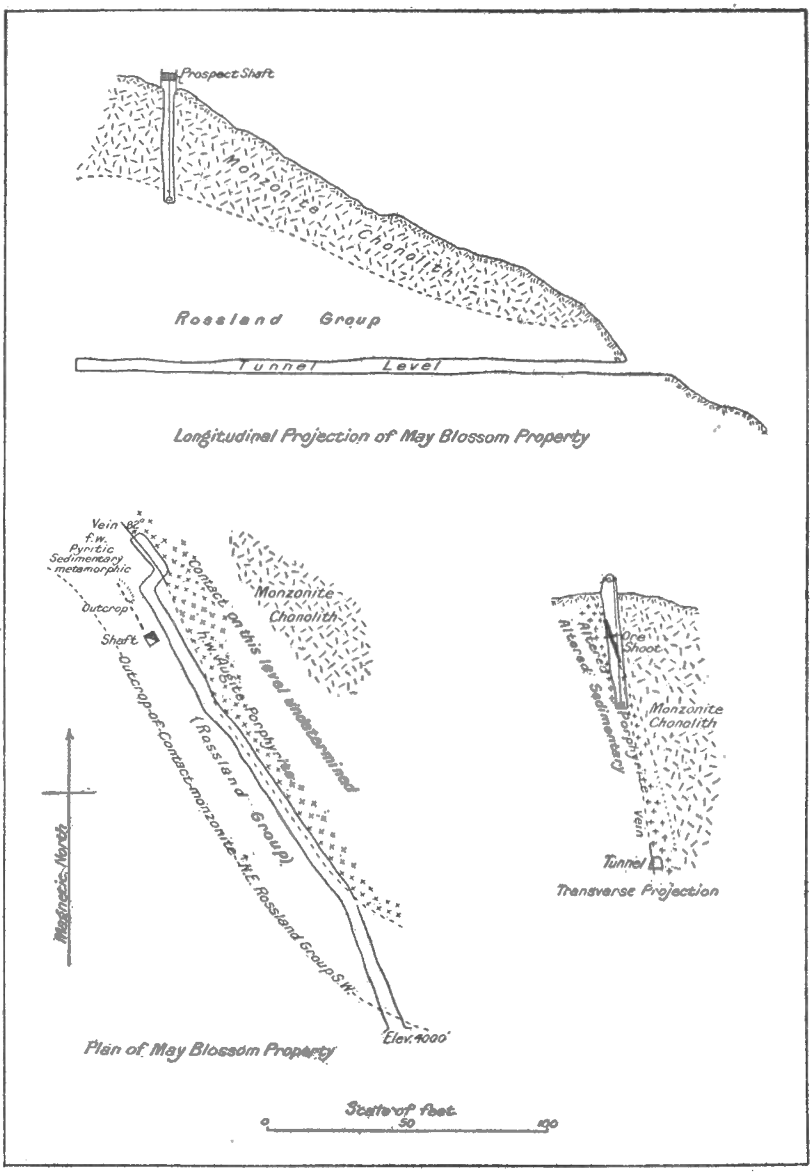


Figure 13. Plan and sections of May Blossom mine.

metamorphic rock. Striations on the slickensided walls pitch at an angle of 15 degrees to the southeast in the plane of the vein. The workings have not yet penetrated the ore-bearing monzonite formation.

Bimetallic.

The Bimetallic claim lies in the valley bottom of Salmon river near the mouth of a small creek (Gladstone creek) flowing into the river about halfway between Boulder and Porcupine creeks. In 1912 the property was purchased by a subsidiary company of the Hobson Silver-Lead Company and about 300 feet of development was done that year. Since then little work has been done on the claim.

The contact between the Rossland Volcanic and Pend-d'Oreille groups passes through the centre of the claim.

Bullion, Last Chance, and Ivanhoe.

The Bullion, Last Chance, and Ivanhoe claims lie in a low pass or saddle between the Free Silver and Pulaskite hills. This marked depression is probably a wind gap representing a former course of the Salmon river that has since been uplifted high and dry. The claims are underlaid by the femic volcanics of the Rossland group.

QUARTZ CREEK BELT.

Golden Horn.

Location. The Golden Horn claim lies at the north end of the town of Ymir just outside the town limits. The claim is held by location by B. Needham, Geo. Walker, G. Collins, *et al.* In 1897 a prospect shaft about 45 feet deep was sunk on the Golden Horn quartz vein and in recent years a crosscut tunnel and drift, over 200 feet long, was driven to intersect the vein in the shaft. This tunnel, however, gave no additional depth on the vein.

Geology. The strike of the vein, as exposed in the incline shaft, is north 15 degrees west and the dip is 52 degrees westerly.

The shaft follows the foot-wall of the vein which is a brownish schist with augite crystals (probably schistose augite porphyrite) and contains quartz veinlets. The hanging-wall is a fine-grained eruptive containing hornblende and feldspar crystals (Summit Ridge volcanics[1]) with some pyrite; in large part it is altered and sheared to a greenstone schist traversed by quartz stringers. Both formations belong to the Rossland volcanic group. The ore consists of galena, pyrite, zinc blende, and limonite in a gangue of quartz. It is found in streaks and nests at intersections of subordinate slip planes and dykes with the main vein fissure. One such streak occurs near the bottom of the shaft under and at the intersection of a flat slip striking with the vein but dipping at an angle of 17 degrees eastward and toward it. This slip unites with the main hanging-wall slip and forms an ore pocket below the intersection. A few feet below this intersection a one-foot lamprophyre dyke is faulted by one of the vein fissures for a distance of 2 feet vertically and an undetermined distance horizontally. Heavy sulphide several inches wide occupies that portion of the fault plane between the offsetted ends of the dyke. The tunnel was driven 54 feet in a direction north 31 degrees west (magnetic) and with the strike of the formation; then 72 feet in a direction north 20 degrees west; and finally 46 feet in a direction north 15 degrees west to a point where the vein was encountered. Twenty feet back (south) from this point a lamprophyre dyke cuts across the working striking north 45 degrees west (magnetic) and dipping to the northeast at an angle of 68 degrees. The vein was drifted on for 40 feet; it strikes north 10 degrees west and dips west at an angle of 48 degrees. The ore is 10 inches wide in places and made up of heavy sulphides—pyrite, zinc blende, and galena—and siderite in a siliceous gangue.

STEWART CREEK BELT.

Several claims, the Atlanta, Alabama, U.B., and Tennessee are situated on the south side of Stewart Creek valley near its junction with the Salmon River valley. No work, however, has been done in this belt since the early nineties and results

[1] See page 31.

at that time were unsatisfactory. Molybdenite is reported as occurring on a claim toward the headwaters of Stewart creek. The Hall sedimentary series crosses the creek about halfway up the valley; the main country rocks of the belt belong to the Rossland Volcanic group intruded here and there by granitic masses and younger Tertiary dykes.

BARRETT CREEK BELT.

Porto Rico.

Location. The Porto Rico mine is situated at the headwaters of Barrett creek on the divide between the creek and the East Fork of the North Fork of Salmon river. The property, which includes five full mineral claims, falls within Nelson mining division of West Kootenay district, B.C.

Transportation. A well graded wagon road, 7 miles long and running down Barrett Creek valley, connects the mine and mill with Porto Rico siding on the Nelson and Fort Sheppard railway. This railway, which belongs to the Great Northern system, follows the west bank of Salmon river as far south as Salmo, B.C. The road from Porto Rico siding to the mine is at present (1915) being put in repair by the provincial government.

Topography. The topography of the surrounding country is rough and rugged and typical of the Selkirk Mountain system to which it belongs. The mountain summits and valley slopes bear evidence, in the presence of serrated ridges, cols, horns, cirques, U-shaped valleys, truncated spurs, hanging valleys, and terraces, of intense alpine and valley glaciation.

The Porto Rico mine and mill lie within the most southwesterly of the many rock-bound, glacial basins or cirques. The cirques are the sources of glacially-smoothed valleys tributary to Barrett Creek valley. The mine workings are confined to the steep, northwestern-bounding wall of the cirque and extend up its rocky face to the low divide or col (elevation 6,400 feet above sea-level) which separates Barrett creek from North Fork of Salmon River drainage basins. The vein, which trends in a general northeast by north direction, with low dip to the west, outcrops or "apexes" in the col itself. The mill is situated several hundred feet farther down in the basin near the lip of the cirque.

Timber. The upper stretches of Barrett Creek valley with its tributaries support a heavy growth of timber suitable for mining purposes. Cedar is very plentiful in the valley bottoms and white fir or balsam on the higher mountain slopes and bench lands. Spruce, hemlock, tamarack, white pine, Douglas fir, jack-pine, poplar, cottonwood, birch, willow, alder, and yew are also common throughout the valleys. Red pine is rare. Mountain laurel or "buck brush" and rhododendron render travel on the upper slopes of the valleys difficult. The lower stretches of the valley of Barrett creek have been burned over and now support a thick growth of fireweed.

The Nankin Pole and Post Company are the largest lumber operators in Ymir district, having leased 5,300 acres of timber lands which include areas up Barrett Creek valley.

Water Supply. The water supply at the mine and mill is not sufficient for power purposes or extensive milling operations and could hardly be depended upon for service throughout the entire year. An abundant supply for mining and milling purposes, however, might be obtained from the main Barrett creek to the northeast (see map). The precipitation in the region probably averages 30 inches per annum, a large part of which falls as snow in the winter months. Ice remains in certain parts of the mine workings all the year round.

History and Production. The Porto Rico property was first discovered and located by two prospectors named Maxwell and Day, in the autumn of 1896. Assays of some of the ore samples, obtained by them from surface outcroppings, are said to have run as high as $2,600 to the ton. Within two months of their staking, the two prospectors had leased the property upon very favourable terms to the Canadian Pacific Exploration Company, Limited, an English company capitalized at £500,000 in £1 shares. Having acquired the property, Mr. W. H. Corbould, managing director for the company, at once commenced to thoroughly exploit the ground. Mr. J. J. McMullen was engaged as superintendent and under his management, operations were commenced and development work actively carried on by means of adit tunnels driven on the Porto Rico vein. Forty miners were employed. A good wagon road 7 miles long was built from the Nelson and Fort Sheppard railway and 700 feet of adit tunnelling was driven in 1897. In the same year 41 tons of ore was sent to the Trail smelter, which was reported to have yielded $76.25 per ton in gold. In 1899, a trial shipment of ore was sent to San Francisco which resulted in 90 per cent of the gold values being saved on the amalgamating plates. A ten-stamp mill and 2,500-foot, wire-rope tramway connecting it with the mine were completed in December 1898. The aerial tramway was installed by Mr. B. C. Riblet, then of Sandon, Slocan district, B. C. The following is an extract from a report of the directors for the year ending September 30, 1898: "Crushing commenced on the 8th of December and on the 20th of that month the result of the first clean-up was as follows:— Crushings 142 tons which gave a return of 295 ounces of retorted gold; also 20 tons of concentrates. The approximate value of clean-up was $5,500.00; an average sample of the tailings assayed 3 dwts. per ton." In the company's report for the year ending September 30, 1899, appeared the following: "Crushings during the year ending September 30th, there were as near as could be estimated 3,280 tons of ore crushed yielding in bullion 3,178·06 ounces, value as per bullion certificates $53,227.91, and 140.69 tons of concentrates, value $3,283.59, making a total of $56,511.50 or an average of $17.21 per ton of ore crushed. Of the above, 1,317 tons of ore yielding $20,757.36, were taken altogether from the stopes above No. 2 level and the balance, 1,963 tons yielding $35,754.14, was taken from the stopes between No. 2 and No. 3 levels so that the grade of that ore has improved with depth. On September 30th there existed ore in sight in the stopes sufficient for five months mill run."

The Canadian Pacific Exploration Company expended over $150,000 in the development of the Porto Rico property and of that amount $8,000 was used for the construction of the wagon road. In April 1899, the mine closed down owing to the difficulty of getting wood cut for fuel. Seven cords of wood were required per day at the mill and mine and the wood-cutters demanded $8 per cord for cutting and delivering it.

The Porto Rico mine was opened up again in 1903, after three years idleness, under lease to G. H. Barnhardt, formerly superintendent of the Ymir mine. During the first mill run 600 tons were crushed having a gross value of over $16,000, the returns from which yielded considerable profit to the lessee after paying a heavy royalty. In July 1904 Mr. Barnhardt signed another lease for a period of three years on a lower royalty basis. The mine was closed down the following spring. During the summer of 1914, Mr. W. B. DeWitt, formerly of the Queen mill in Sheep Creek camp, took a two year's lease on the Porto Rico mine and along with three partners did a few months work making a trial run of ore through the mill. In the spring of 1915 Mr. Smith Curtis bought out Mr. DeWitt's three partners and did some work on the property. Gold bullion to the value of $670 and concentrate worth about $250 are reported to have been recovered.

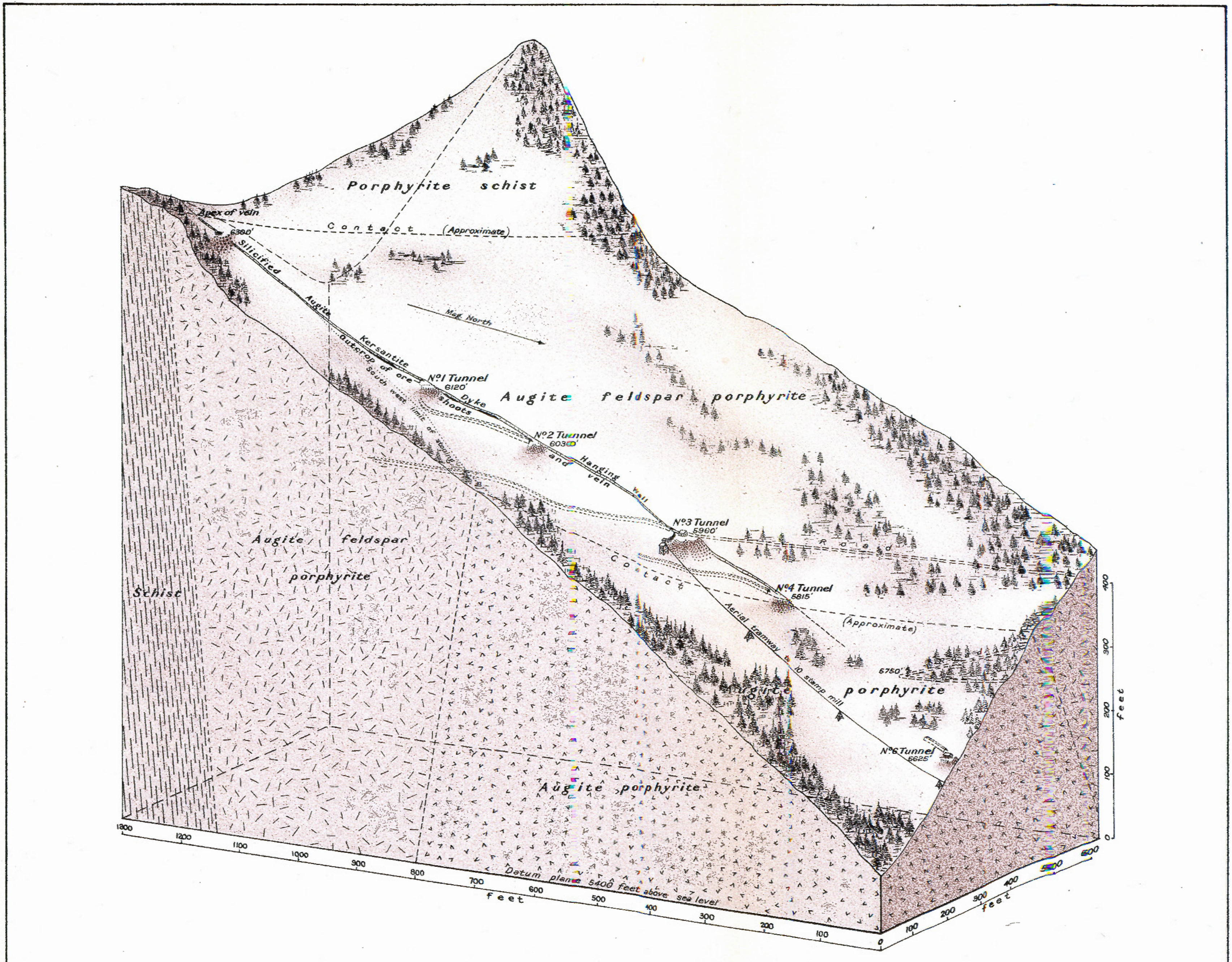
The mine is developed by means of four adit tunnels driven in on the vein, as well as by open-cuts. The tunnels are numbered from above downwards. No. 1 tunnel is 250 feet long: No. 2 tunnel 90 feet lower down is about 380 feet long; No. 3 tunnel 87 feet lower than No. 2 is about 600 feet long; and No. 4 tunnel 85 feet lower than No. 3 is about 300 feet long. Two hundred feet below No. 4 tunnel but off the vein is No. 6 tunnel only 90 feet long. In No. 3 tunnel is an upraise, 7 feet wide, extending up to No. 2 tunnel, a distance of 130 feet, the working being all in ore. Much of the stoping and development work was done by five machine drills run by air compressed at the mill.

Geological Structure. The vein, which belongs to the true fissure-vein type, has a filling of quartz scattered through with iron pyrites. The values in the ore are in gold and silver, the former chiefly in the free state. Native gold may be seen in hand specimens from the vein. The values vary from $3 up to $146 per ton. The ore that Mr. Barnhardt put through the mill in 1903 ran about $17 to $18 per ton. The width of the vein ranges from 2 to 5 feet with an average width of 3 feet. It widens, however, in a few places to 8 feet, but the values in such places are not so high. The vein is very regular and continuous, striking north 49 degrees east and dipping to the west at an angle of 45 degrees. The ore-shoots are tabular in shape and in the vein appear to have a vertical pitch. The largest shoot has a stope length of 450 feet at No. 3 tunnel level. The vein has been opened up at intervals for about half a mile along its outcrop from No. 4 tunnel up to its apex on the divide and is found invariably in contact with a narrow, fine-grained, cherty lamprophyre (altered augite kersantite) about 2 feet in width and having the same strike and dip as the vein. The dyke generally forms the hanging-wall; but in some places ore occurs on both sides of the dyke and both vein matter and dyke have been stoped out and put through the mill.

The country rock of the ore-producing portion of the vein is a somewhat granular, dark porphyrite containing prominent white feldspar phenocrysts. This augite-feldspar porphyrite (Triassic ?) occurs as an intrusive sill striking north and south and dipping steeply to the west. The east boundary of the sill passes close to the mouth of No. 4 tunnel, whereas the west boundary falls outside the map-area. Another sill, of an augite porphyrite of contemporaneous age to the augite feldspar porphyrite, is about three-quarters of a mile thick and outcrops to the east. This sill has a strike and dip similar to the ore-bearing one. No. 6 tunnel is entirely in the augite porphyrite, and, as the vein has not been traced from the augite-feldspar porphyrite eastward into this sill, any variations that may be present in vein character and ore value with change of country rock cannot as yet be determined.

Figure 14 indicates the probable structural relations of the two sills and the positions of the adit tunnels and stopes.

Geology of Mine Workings. The vein has been trenched and developed on the surface by means of open-cuts and prospect pits above the tunnel levels. No. 1 tunnel is about 300 feet from the apex of the vein on the divide and 142 feet vertically. The tunnel was driven in on the vein, which has since been stoped from below. The tunnel was inaccessible at time of visit but appeared to branch beyond a winze which was full of water and covered by rotten boards. The tunnel is reported



Geological Survey, Canada.

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Fig. 14. Stereogram of **Porto Rico** contact vein Showing the relations of the vein to kersantite dyke and porphyrite sills

to be 250 feet long. The vein near the portal of the tunnel has been stoped above the sill floor almost to the surface, a distance of 15 feet. The hanging-wall of the observed portion of the vein is the same cherty eruptive as elsewhere throughout the mine and is here 2 feet wide. A hanging-wall stringer of the vein was found in one place to follow the other border of the dyke.

No. 2 tunnel is about 380 feet long and is 90 feet vertically below the level of No. 1 tunnel. No. 2 tunnel also follows the vein for a distance of about 300 feet to a point where the working becomes deflected from the main vein and dyke and appears to follow a stringer of ore with a steeper dip to the west in the foot-wall country. A few inches of calcite and red iron oxide is present in this stringer, and iron-stained quartz impregnated with pyrites appears in another vertical stringer which intersects the first one. The country rock is augite-feldspar porphyrite throughout. The altered augite kersantite dyke forms the hanging-wall to the vein which has been extensively stoped above this level. Both dyke rock and ore have been stoped out in many places and run through the mill.

No. 3 tunnel is the main adit tunnel of the mine, being nearly 600 feet long. It is 87 feet vertically below No. 2 tunnel level. The ore in the vein may be well seen at the portal of the tunnel near the door on the east side of the sill floor. The main ore-shoot on this level is 450 feet in stope length and the dip of the stope from this level up to the surface is 45 degrees. The quartz vein contains a little calcite in some places. At 500 feet, a lamprophyre dyke was encountered striking north and south, at an angle of 35 degrees to the trend of the vein, and between well-defined walls which dip to the east at an angle of 50 degrees. The hanging-wall of the vein on this level, for long productive stretches, is the cherty, augite kersantite dyke which is intrusive into the augite-feldspar porphyrite sill. About 40 feet from the face of the tunnel, the vein was lost in a brownish, fine-grained, schist formation containing lime films. The east boundary of this schistose zone strikes north and south and dips vertically or steeply to the east. The working was deflected from the course it should have taken by the schistose band and is too far in the foot-wall country. The schist formation is in all probability a metamorphosed phase of the porphyrite caused by regional mashing. It may be expected to occur as a comparatively narrow, tabular zone trending with the formation. Beyond it, the vein should be found enclosed in the normal porphyrite. A grab sample of milling ore taken from one of the stopes was assayed by the Mines Branch and found to carry a trace of gold and silver.

No. 4 tunnel is 85 feet lower in elevation than No. 3 and is driven about 300 feet in on the foot-wall side of a curving, quartz vein which contains scattered sulphides. The vein here dips to the northwest at an angle of 56 degrees. A dense, cherty eruptive, probably the altered augite kersantite, forms the hanging-wall, whereas the foot-wall is the augite-feldspar porphyrite.

There is no No. 5 tunnel and the lowest working is No. 6 tunnel which is at an elevation nearly 200 feet below the level of No. 4 tunnel. This tunnel is only 90 feet long and was driven with the intention of crosscutting the vein and then raising some 310 feet to No. 3 level for ventilation purposes. Such a project would have involved over 900 feet of work at a considerable cost. The tunnel is driven in the western portion of the augite porphyrite sill which lies between the augite-feldspar porphyrite sill of the mine and the Summit Ridge volcanics to the east. The augite porphyrite is cut by two dykes of augite minette, one 6 feet and the other 4 feet in width, both striking north 34 degrees east and making an angle of 15 degrees with the strike of the Porto Rico vein.

Mining and Milling. The ore was mined by the overhand stoping method, and air for five machine drills was supplied by a Rand air compressor placed in the mill. The ore, consisting chiefly of a mixture of clean ore and low grade wall rock, was dumped into ore bins situated near the mouth of No. 3 tunnel. It was then conveyed from the bins to the mill by means of a wire rope tramway 2,500 feet long and with a vertical drop of 600 feet. The tramway has two one-inch cables, supported upon five towers; the buckets each have a carrying capacity of 1,000 pounds. To each bucket is attached a ⅜-inch cable which passes over a drum with a lever and brake attachment located at the mine station. By this method 50 tons of ore were trammed from mine to mill in ten hours or at the rate of 5 tons per hour. At the mill the buckets dumped automatically and dropped their contents into two ore bins with a capacity of 200 tons. From the bins the ore was fed over a grizzly; the fine ore passed into No. 2 bin whereas the coarse ore was run through a Blake crusher which reduced it to pieces about $1\frac{1}{2}$ inches in diameter. The crushed ore from No. 2 bin fell into the self feeders, then into the mortars and under the stamps. The pulp from the stamps passed through a 40-mesh screen, directly to the amalgam plates, which are 12 feet in length. From the amalgam plates the product was carried through the classifiers, of which there are three, to the Frue vanners. The mill is well equipped; it has 10 stamps each weighing 1,000 pounds and two 6-foot and one 4-foot Frue vanners. The power plant consists of two boilers, a five-drill air compressor, and a 40-horsepower high speed engine; the latter was employed in the operation of the mill. The building was illuminated by acetylene gas and the company had telephonic communication between mill and mine. The capacity of the mill was 25 tons of ore every twenty-four hours, provided the water supply did not fail. The recovery in the mill amounted to 94 per cent of assay values and the concentrates averaged between $40 and $50 per ton.

Origin. The comparatively meagre underground data in the Porto Rico mine at present available is hardly sufficient to form the basis for any safe inferences regarding the origin of the ore deposit. Until further development work is done on the property only mere suggestions can be offered with the hope that further investigation into this important economic problem may be stimulated.

Comparing the trend of the Porto Rico fissure vein with other fissure veins in Ymir camp, it is noted that the Porto Rico vein lies intermediate in direction between the general east-west strike of the veins on the Ymir, Wilcox, Foghorn, Tamarac, and Gold Cup properties, and the general north-south strike of the veins on the Fern, Lost Cabin, Jennie Bell, Canadian Pacific, Golden Horn, Iowna, and Nevada properties. The north and south trending veins appear to owe their direction to the influence of the country rock formations, either striking with the formation or following along dykes. The east and west trending veins, on the other hand, cut the formations and as a rule bear evidence of being fault fissures. These fault fissures, which resulted through accumulated regional stresses in this portion of the crust having reached their breaking point, have not been controlled in their direction by the strike of the country rock formation nor the dykes. Although the Porto Rico vein resembles in strike most closely the veins of the Dundee and Yankee Girl mines, it does not belong to the same system, for the latter veins cut the formations and are independent of dykes although the ore-shoots are not. They are most closely related to the east and west trending veins. The fissure vein of the Porto Rico mine, as shown by conformity of strike and dip between vein and lamprophyre dyke, belongs rather to the north and south system of fissure veins, and has been controlled in its development by the dyke found invariably on the hanging-wall of the ore-body. Recent fractures frequently follow ancient fracture planes. This old dyke-filled fracture may have re-opened under the accumulated stresses and thus permitted heated ascending alkaline solutions carrying gold and some silver to circulate and, under suitable conditions of temperature and pressure, to deposit their burden of precious metals along the underside of the lamprophyre dyke.

The source of the mineralizing solutions was probably the same magma reservoir that gave rise to the Nelson granodiorite batholith (late Jurassic in age) and the solutions represent the after effects (solfatarism) of igneous intrusion.

Future Work. Since the apex of the vein is well exposed on the divide and has the same structural relations there as below in the mine, with the same persistent lamprophyre dyke as hanging-wall, it would seem advisable to explore the vein more extensively and systematically both laterally and in depth. The vein to the southwest could readily be explored for ore-shoots by continuing the adit tunnels beyond the schistose zone which, in No. 3 tunnel, deflected the working to the foot-wall. No. 2 tunnel also left the main vein and dyke and is in the foot-wall country. The dyke ought to prove a good indicator of the position of the vein. Should the vein leave it, however, and the values in the vein cease, other dyke intersections with the same or parallel veins should be sought after. Before doing this underground development work in search for lateral extensions of ore, the vein and dykes should be carefully traced on the surface and, if possible, the width of the schistose zone measured. Neither the vein nor dyke have as yet been proved to extend to the northeast into the augite porphyrite sill. Although the augite porphyrite of the lower workings is not the ore-bearing country rock of the Porto Rico mine, yet it is the country rock to high grade ore from prospects below the mine near the wagon road, as well as from the Fern mine. In the case of the Fern mine, however, the ore-shoots are found in contact with a granite porphyry dyke. Dyke intersections, both lamprophyres and porphyries, with veins, particularly where at acute angles, should be carefully prospected for. As several lamprophyre dykes have already been disclosed in the mine workings and found to strike at acute angles to the main vein fissure, the chances are fair for finding not only extensions of old ore-shoots but also new shoots on the Porto Rico and adjoining properties.

HALL CREEK BELT.

Fern.

Location. The Fern mine is situated on the steep southern slope of Hall Creek valley at an altitude of about 5,000 feet above sea-level. The property is near the west border of Ymir map-area. The Fern mill is located in the valley bottom, about 1,400 feet below the mine, and opposite the junction of the tributary Noman creek. The site is about 3 miles up-valley from Hall, a railway siding on the Nelson and Fort Sheppard railway (Great Northern system).

Transportation, Timber, Water Supply. A well graded wagon road about 3 miles long connects the Fern mill with Hall which is 10 miles by rail south of Nelson. The road is in a fair state of repair and could be put in excellent condition in a short time. The north side of Hall Creek valley is well watered and wooded, supporting an abundant growth of timber suitable for mining purposes. The Nankin Pole and Post Company has leased the timber lands for 6 miles up Hall creek. The company has erected bunk houses and other buildings, as well as a supply depot at Hall which is at present their main shipping point. There is a sufficient supply of water in Hall and tributary creeks for extensive mining and milling operations. This water supply has been used in past years for placer mining.

History and Production. The Fern property was first located by Captain Duncan who staked the claims in June 1897. He shortly afterwards sold it for the reported sum of $60,000. The property was owned by the late Mr. Frank Fletcher and associates of Nelson and later by the Fern Gold Mining and Milling Company whose stock is chiefly held in Victoria and Montreal. Mr. G. J. Campbell of Nelson is the president of the company. In 1897 this company erected a 10-stamp mill and built a 3-rail gravity tramway down from the mine, all at a cost of some $50,000. During 1897 there were two clean-ups at the mill: the first one covering a period of three months yielded $28,500 at a cost of $12,000; the second, covering a period of forty-four days, during which time 1,251 tons were crushed, yielded $9.25 per ton of which $7.70 was caught on the amalgamating plates and the remaining $1.55 was obtained from the concentrates. Besides the ore milled, a small lot of sorted ore was shipped directly to the Hall smelter at Nelson. A dividend of $10,000 was declared. In December 1898 a clean-up after a 33-day mill-run amounted to $6,650. One carload of ore shipped along with concentrates was estimated at that time to be worth $3,000. The Fern Gold Mining and Milling Company declared one 5 per cent dividend in 1898 and at that time they claimed to have sufficient ore in sight to keep the ten-stamps pounding for at least several months. During 1900 about 6,000 tons of ore was mined and milled, but toward the end of the year the ore-body was lost apparently through faulting and the mine closed down for a few years. During the summer of 1902 Mr. P. J. Nichols took a lease of the mine and mill. More ore was opened up, the property was put in good working order, and the ore was treated in the mill at a considerable profit. The average monthly production from the Fern mine in 1902 was 750 tons of ore which was all put through the 10-stamp mill.

In 1903, the property was closed down for a few months. It was re-opened again in 1904 under another lease. The mill was operated for only a short time and has since been badly damaged by the collapse of the roof due to the heavy burden of snow. A few years ago, T. Brown, J. L. Warner, Dr. Wilson, and John Swanson took an option on the Fern and did a little work. A quartz vein farther down the hill, thought to be possibly an extension of the Fern vein, was opened up. In 1915 Mr. W. S. Hawley of Spokane took a lease with the option of purchase on the Fern and prospected for the lateral extension of the main vein beyond the fault plane.

Mine Development. The mine, which is situated on a steep hillside, lends itself to development by means of tunnels and open-cuts. There are four tunnels, the upper two being adit tunnels driven in on the vein. They are numbered from above downwards and are indicated in Figure 15 which shows the total amount of development work. The longitudinal section shows the manner in which the workings are connected by raises and stopes. No. 1 tunnel (elevation 5,040 feet above sea-level) is 157 feet long; No. 2 tunnel (elevation 5,000 feet) is 270 feet long; No. 3 tunnel (elevation 4,950 feet) is a crosscut for 95 feet and a drift for 350 feet; No. 4 tunnel (elevation 4,850 feet) is 620 feet long, being a crosscut for the first 160 feet and a drift for the remaining 460 feet.

Mining and Milling. The ore from the Fern mine was conveyed from the workings to the mill by means of a gravity 3-rail tramway about 3,000 feet in length and at a gradient of 52 per cent. On account of the heavy snowfall in this region, the tracks were laid on trestle work about 12 feet above the mountain side. Each tram was capable of carrying about 1½ tons of ore and it was possible to make the trip in 2½ minutes.

From the tramway the ore was dumped automatically into skip cars and taken to the mill, the loaded car hoisting the empty one. The mill is built on a small creek about 1,400 feet lower than the mine workings. It is equipped with 10 stamps, an amalgamator vat, 4 Frue vanners, and a small cyanide plant. The mill is constructed so as to permit of the addition of another 10 stamps and 4 Frue vanners, as well as either a chlorination or larger cyanide plant, without disturbing the present buildings. The foundation for the additional batteries is in place. The tramway and mill are at present in disrepair.

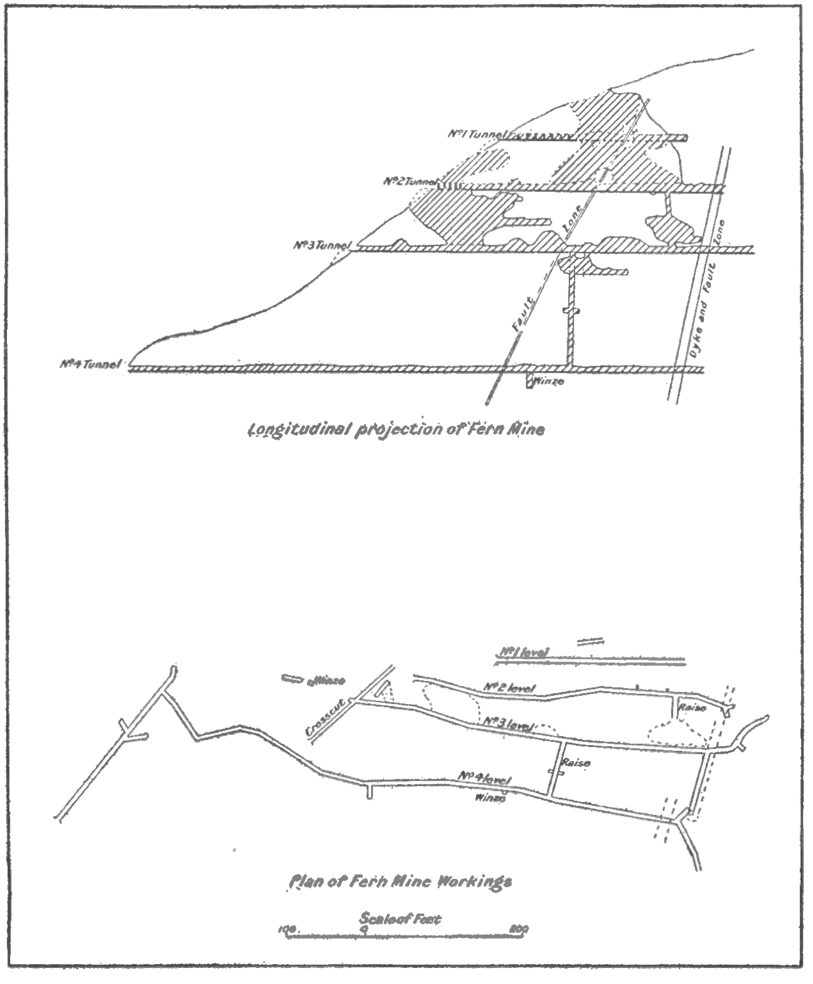

Figure 15. Plan and section of Fern mine.

Geological Structure. The vein, which is of the fissure vein type contained between fairly well-defined walls, has a somewhat sinuous course varying in strike from north 54 degrees east to 74 degrees east and it dips at an average angle of 60 degrees to the northwest. It is persistent but varies in thickness, pinching to a few inches in places and swelling elsewhere to as much as 8 feet. The high grade streaks, however, vary from a few inches to over one foot and as a rule follow the hanging-wall of the vein. The vein filling and gangue is quartz containing pyrite and free gold. The ore is reported to assay from traces up to $70 per ton in gold. Some siderite and a little chalcopyrite and bornite were noted on the dump of No. 2 tunnel. The ore in the upper levels is so thoroughly oxidized that it is readily free milling. In depth the ore becomes more refractory and some ore was found so much so that smelting had to be resorted to in order to recover its high gold content, which certainly would have been lost in amalgamation.

The ore-shoots, as shown in the longitudinal section (Figure 15) have irregular shapes and a tendency to pitch southwestward or into the hill; but this is not always the case. The common country rock is a dark, greenish, massive to schistose, augite porphyrite. The vein near the surface cuts the porphyrite schist, but 25 feet down on the vein the massive, augite porphyrite appears in the foot-wall, the vein following the contact between the two formations down to near No. 2 tunnel level, where it cuts right through the massive porphyrite and encounters the schist again at No. 3 tunnel level. Throughout the productive stretches, however, the vein follows a dyke of granite porphyry which dips and strikes with it and forms one or the other wall. This porphyry, which is generally highly altered and schistose, also forms barren horses in the vein (Figure 16) and is a good indicator of values. The fissure vein appears to cut through the dyke on No. 3 tunnel level so that although the ore-shoots may be said to be contact shoots the vein itself is truly a fissure vein. The granite porphyry dyke makes an acute-angled intersection with the vein near the end of No. 3 tunnel. A similar relationship of vein and altered granite porphyry occurs in No. 4 tunnel where the productive portion of the vein has a

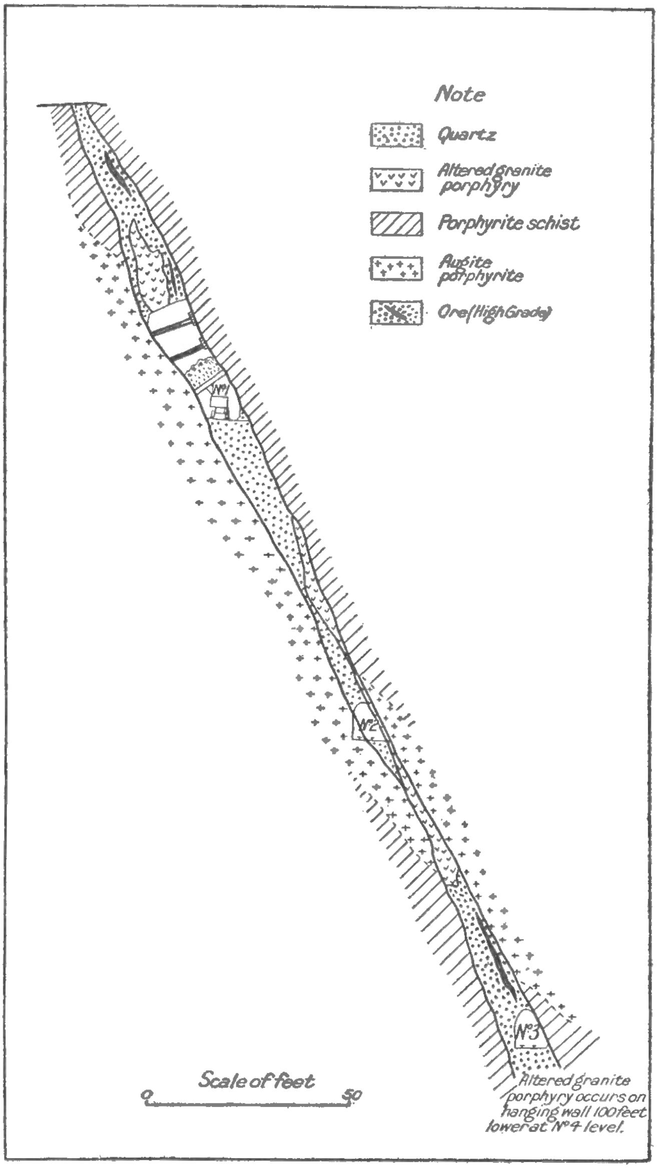

Figure 16. Transverse section of Fern vein, diagrammatic.

hanging-wall of granite porphyry. In No. 2 tunnel, however, the main ore-shoot has a foot-wall of granite porphyry.

Geology of Mine Wŏrkings. No. 1 tunnel (elevation 5,040 feet) is a straight adit tunnel driven in on the vein for a distance of 157 feet. The first 67 feet consisted of very much broken ground and the ore has been stoped up from below right to the sill floor. The ore beyond this point has been stoped out for a distance of 90 feet, the ore varying in width from 1 to 5 feet. Two pillars were left, the main one standing about halfway through the shoot where a zone of faulting was encountered. The fault zone strikes south 39 degrees east and dips to the north at an angle of 60 degrees. The ore-shoot narrowed to 1 foot, 15 feet from the face of the tunnel, and the ore below the sill floor was rich enough to be shipped direct. The tunnel has not been driven far enough to cut the 10-foot lamprophyre dyke opened up in the lower tunnel levels. This dyke, which dips 80 degrees to the north and strikes south 82 degrees east, should be encountered about 45 feet farther in. About 60 feet farther north than the portal of No. 1 tunnel at an elevation of 5,075 feet is a 52-foot crosscut tunnel which cuts the vein. At this point the vein strikes north 49 degrees east, dips to the northwest at an angle of 70 degrees, and has a foot-wall of granite porphyry and a hanging-wall of augite porphyrite. The ore-shoot has been stoped to the surface.

No. 2 tunnel (elevation 5,000 feet) is also an adit tunnel driven in on the vein. It is a slightly curving tunnel 270 feet in length. At a distance of 60 feet in, the vein is 9 inches wide but swells to 14 inches 15 feet farther in, where the values ran up to $1,321 per ton. At this portion of the tunnel the granite porphyry is present on the foot-wall; the hanging-wall is porphyrite schist. Twenty-five feet farther in, the ore narrowed from 14 to 2 inches, widening, however, again to 10 inches and even 18 inches. The gold values were highest near the lamprophyre dyke where they averaged $25.80 per ton; elsewhere the values varied from $2 to $5.60 per ton.

No. 3 tunnel (elevation 4,950 feet) commences as a crosscut tunnel in porphyrite schist and continues as such for about 100 feet. At 50 feet, the vein was intersected and drifted on, southeast, for a distance of 855 feet to the lamprophyre dyke, beyond which the ore was not found. In this tunnel the best ore came from the contact of granite porphyry with the augite porphyrite schist. About 30 feet north of the lamprophyre dyke the granite porphyry crossed to the foot-wall side of the vein, the working following a fissure but not the contact. This fissure was traced to the fault zone (water course) which forms the north border of the lamprophyre dyke. Neither vein nor porphyry dyke has as yet been located south of this fault. A crosscut was made to the hanging-wall for a distance of more than 50 feet searching for the vein extension, but as this work was done entirely in the lamprophyre dyke, a formation younger in age than the vein, no results could possibly be expected.

No. 4 tunnel (elevation 4,800 feet) commences also as a crosscut tunnel and continues as such for about 160 feet. At 140 feet a slip plane was encountered which had an east and west strike with northerly dip of 63 degrees. The hanging-wall of this fissure zone for a short distance is massive augite porphyrite and the foot-wall a porphyrite schist. At this point a raise was run for 15 feet. The fissure zone was followed for 50 feet, both walls becoming of porphyrite schist traversed by numerous cross stringers. The working turned to the left (southwest) almost at right angles to follow the major cross stringer which dips at an angle of 55 degrees to the northwest. This was drifted on for about 40 feet when the tunnel was swung farther to the south and follows what appears to be the lower extension of the Fern vein. The values, however, did not appear until about 230 feet farther in near a winze where the hanging-wall to the vein is altered granite porphyry and the foot-wall porphyrite schist. The vein curves, varying in strike from north 54 degrees to 74 degrees east, and dips to the northwest at an angle of 63 degrees. Westward the fissure vein appears to flatten but so far has not been found beyond the lamprophyre dyke fault.

Origin. The source of the gold-bearing solution which gave rise to the Fern ore-shoots is believed to be the same as that of the Nelson granodiorite batholith which slightly preceded the solutions.

The mineralizing solutions probably came from the same magma reservoir and represent the after effects of batholithic intrusion. The age of the Nelson batholith and consequent period of mineralization has been provisionally referred to the late Jurassic (Jurassic orogenic revolution). The solutions found access to the upper consolidated portion of the batholith and the cover rocks through fault fissures formed at that time through crustal readjustment. In the case of the Fern vein, the ore-shoots were localized along a parallel trending dyke of granite porphyry which, like the vein itself, cuts through both the massive augite porphyrite and the porphyrite schist (Figure 16). In fact, the vein fissure may have been in part controlled in its development by the granite porphyry dyke which in all probability represents a tongue from the underlying granitic batholith. Such dyke-filled fractures afford favourable planes of breakage for accumulated stresses set up in the crust following such a period of batholithic intrusion.

The Fern fault fissure, now filled with vein matter and lying along a porphyry dyke represents such a break. It became an open channel for the ascent and circulation of heated alkaline solutions from the deep-seated metallic hearth below. The solutions, when they had attained suitable conditions of temperature and pressure, deposited their burden of precious metals. The portions of the vein traversing augite porphyrite or porphyrite schist alone appear to have not been so favourable to the deposition of ore, the values so far having come from contact ore-shoots.

Future Work. The territory west of the lamprophyre dyke fault deserves further exploration, with the aim of finding the continuation of the main Fern vein and granite porphyry dyke. The dyke and fault plane dip steeply to the east (80 degrees), whereas the vein dips steeply to the northwest (63 degrees). Assuming that the fault is a normal one by which the ground east of the fault plane has been dropped vertically with respect to that west of the plane, the vein should lie to the northwest or on the hanging-wall side. A horizontal movement or heave, however, may have accompanied vertical displacement and, in that case, the above deduction might not hold true.

The finding of striations on the fault plane would aid in the solution of this fault problem.[1]

The country rock on both foot-wall and hanging-wall sides should also be carefully prospected for parallel veins and the presence of further productive acute-angled intersections between different veins or veins and porphyry dykes.

Gold King Group.

The Gold King group includes five claims situated on Hall creek about half a mile above the Fern mill. The owners are a Spokane syndicate who acquired the property during the autumn of 1915 and are at present developing it under the supervision of Mr. W. A. Brockway. A wagon road about 2,000 feet long was constructed to connect the property with the government road to Nelson and a steam power plant, including compressor, hoist, and sinking pump was installed.

A quartz vein 2 to 4 feet in width, similar in character and trend to the Fern vein, has been uncovered. In a few places free gold is visible. The vein has been traced by means of open-cuts, an adit tunnel, and a prospect shaft for a distance of 1,000 feet. It is stated that assays of samples ranged up to $25 in gold and 7 ounces in silver to the ton, and that the average assay of 168 samples was $13.85 in gold, and 2 ounces in silver per ton. Milling tests on the ore made by the management resulted in a recovery of 85 per cent of the valuable metals contained in it, 35 per cent of the gold having been recovered as free gold, while the remaining gold and silver was in the concentrate.[2]

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[1] Since writing this Professor Francis A. Thomson of the state college of Washington has done detailed work in search of the vein extension beyond the so-called fault. He writes in part: "From the appearance of the vein at the fault intersection on the several levels, especially at the No. 2 level and to a lesser extent at the No. 3, I am satisfied that the extension of the vein is not to be expected to the eastward. This is confirmed by the following 'gouge-assays' taken from No. 2 level.

Fault gouge 12 feet east of centre of vein—trace.
Fault gouge 12 feet west of centre of vein—$16.

"This reduces the fault problem to one or two possibilities: (1) The throw is to the westward and is of great extent. (2) The fault is pre-mineral and the vein fissure turns and follows it, continuing for a great distance in a pinched condition. Data are not available for a positive conclusion in this matter, but I am inclined to favour the second hypothesis."

[2] See Rept. of Minister of Mines, B. C., 1915, p. 149, for further details.

Bluestone, Clincher, Evening Star, etc.

During the summer of 1914 some prospecting and development work was being done by John Swanson on the Bluestone claim adjoining the Fern. Farther up the hill than the Fern a prospect shaft was noted on what was called the Clincher (Libby) claim, located July 18, 1914, by H. Skoning. The shaft was full of water. The country rock is augite porphyrite and the dump contained vein matter of pyritic quartz with some arsenopyrite. The Canadian Girl and several other old locations are situated up Keno creek but the workings were not examined. The Evening Star claim halfway between Keno creek and Hall was located in 1911 by O. Lindstrom. The country rock is the altered sedimentaries of the Hall series intruded by lamprophyre and granite porphyry dykes. The vein as exposed in a working beside the road is in a contact zone at the eastern border of the series; it strikes northwest and southeast and dips southwestward at an angle of 60 degrees.

CLEARWATER CREEK BELT.

Lost Cabin.

Location and Development. The Lost Cabin claim is situated at the north end of Elise mountain on a spur at the junction of Clearwater Creek valley with that of the Salmon river. The workings are at an elevation of about 4,800 feet above sea-level and are connected by trail with the railway about one mile above Hall. The claim was located July 6, 1911, by E. Ballinger of Salmo. There are three claims in the group, the Lost Cabin, Queen Mary, and Blue Bell. The property was bonded to the Hobson Silver-Lead Company a few years ago and some development work carried on.

Geology. The Lost Cabin quartz vein, as exposed in a prospect shaft, strikes north 58 degrees west (magnetic) with dip varying from 85 degrees to the southwest to vertical. The vein varies in width from 2 to 3 feet and has well-defined walls. Both walls are of a light-coloured schist which contains a series of parallel stringers of quartz. All the veins follow the trend of the formation. A dark-coloured, greenstone schist is also present but appears to be barren of values. A development tunnel 175 feet long was driven south 39 degrees east (magnetic) and four short crosscuts to the northeast and southwest were run in search of the vein. A narrow vein striking with the schist formation was encountered in the first crosscut on the right (southwest) 65 feet from the portal of the tunnel. The tunnel workings are almost altogether in the dark, greenstone schist of the foot-wall country, which is considered to be a porphyrite schist, whereas the lighter-coloured, often spotted schist represents a slightly younger, granite porphyry schist. Both are members of the so-called Rossland Volcanic group.

PLACER MINING.

As far back as 1885 the gravels in the neighbourhood of Hall creek and the Salmon river were worked as placers by the Colville Indians. Later the Hall brothers who located the Hall mines, operated the same ground and recovered considerable gold. It was reported that a nugget valued at $100 was found near the mouth of Hall creek. The ground has been worked at intervals by gangs of Chinamen and prospectors but only in the most primitive manner.

During 1904 about 320 acres of the flat situated at the junction of the Salmon river and Hall creek was leased from the government by a Portland, Oregon, syndicate whose intention was to work the ground by modern methods. The leased ground was tested and a general average value of 50 cents per yard, outside of the values contained in the black sand, was obtained. Bedrock, however, where the best values might be expected, was never reached. The syndicate proposed to install an hydraulic elevator which, although not the cheapest method of saving the gold, was expected to give the best idea of the value of the ground. Had the values turned out as high as the hand tests indicated it was their intention to put in a large dredge. The enterprise was not successful. Outside of a few creek diggings by placer miners along the Salmon river, and the work of Wad and Evanson a few years ago near the bridge over Hall creek, no placer mining has been done in Ymir district of late years.

ADDENDA I.[1]

Field work in Kootenay district since this report went to press has led the writer to suggest an alternative correlation which would place the Summit series in the Lower Cambrian unconformably overlying the Kitchener, Creston, and Aldridge members of the Purcell series of Pre-Cambrian or Beltian age. The writer considers Daly's Priest River terrane the metamorphosed equivalents of the Kitchener, Creston, and Aldridge. The basal Irene conglomerate may be correlated with the Siyeh conglomerate[2] of the Galton series, and the basal conglomerate of the Bow River series; the Irene volcanics with the Purcell lava above the Siyeh and the basaltic lava below the Nakimu limestone of the Selkirk series;[3] the Dewdney or Monk with the Ross quartzite of the Selkirk series, and the Fairview and Lake Louise of the Bow River series; the Beehive and Ripple with the Sir Donald quartzite of the Selkirk series and the upper members of the Galton and Bow River series.

ADDENDA II.

INDEX TO MINERAL CLAIM MAP, PAGE 65.

No.	*Name of claim.*	*No.*	*Name of claim.*
1	Pilot Knob	18	Royal Anne Fraction
2	Independence	19	Evelyn
3	Mars	20	Monarch
4	Venus Fraction	21	Latah
5	Venus	22	Safeguard
6	Foothill	23	Canadian Bell No. 2
7	Etruria Fraction	24	Canadian Bell
8	Hidden Treasure	25	Canadian Girl
9	Chicora	26	Canadian Boy
10	Fern	27	Alice
11	Eureka	28	Romance
12	Imperial	29	Condor
13	Eclipse	30	Erin
14	Rising Sun	31	Bethel
15	Edna	32	Golden Gate
16	Keno Fraction	33	Jenny Lind
17	Lea	34	Riverside

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[1]See page 25.

[2]Schofield, S. J., "Geology of Cranbrook map-area," Geol. Surv., Can., Mem. 76, 1915 p. 34.

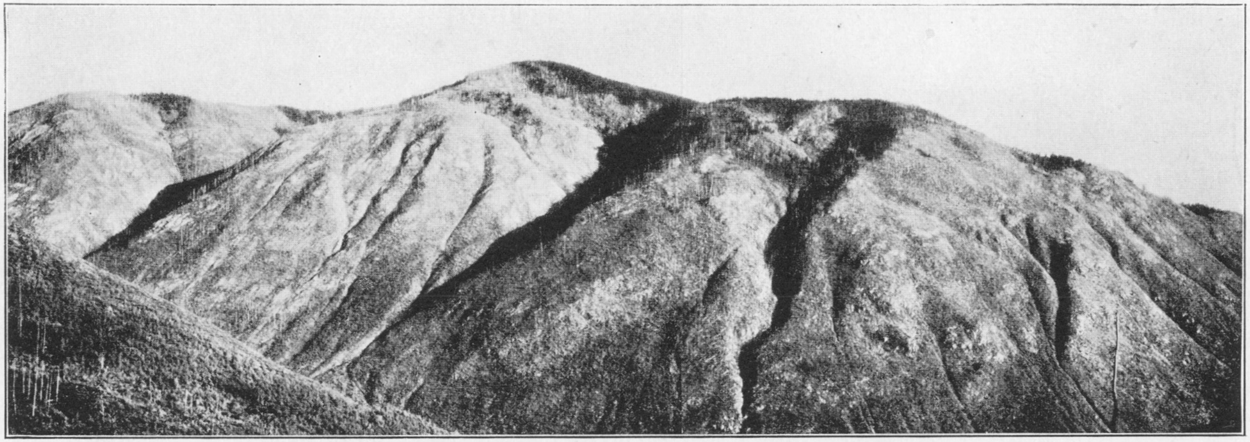
[3]Daly, R. A., "A geological reconnaissamce between Golden and Kamloops, B.C., along the Canadian Pacific railway," Geol. Surv., Can., Mem. 68, 1915, pp. 94, 97.

No.	*Name of claim*
35	Nip and Tuck
36	Nancy Jane
37	Irma L 3426
38	Noonday
39	Copper Bell
40	Tom Thumb
41	Eclipse
42	Piccadilly
43	Candidate
44	Salmon Star
45	Lytton
46	Elise
47	Jewel
48	Ema
49	B and U
50	Buckhorn
51	Lillie Fraction
52	Summit
53	Boston
54	Copper Cape
55	Hidden Treasure
56	Editor
57	Dumas
58	Author Fraction
59	Alexandre
60	Corfew
61	Apex
62	Silver Reef
63	B and C
64	Longsley
65	Coliseum
66	Anaconda
67	Red Seal
68	Stanley
69	Exchange
70	Good Hope
71	Good Hope Fraction
72	Rainy Day
73	Rainy Day No. 2
74	Foghorn Fraction
75	Foghorn
76	Independence
77	Rosalia
78	Centennial
79	Copper Lily
80	Denis
81	Swansea
82	Glasgow
83	Scottish Chief
84	City of Paris
85	Copper Bell
86	Gray Mouse
87	October
88	October Fraction
89	L 2399
90	Racatam
91	Tamarac
92	Muller
93	Inkerman
94	Alma
95	Alexandria
96	Gibraltar
97	Mugwump
98	Rockland
99	Golden Horn
100	Farnham
101	Ymir
102	Bristol
103	North Fork
104	Mist Fraction
105	Beresford
106	Dufferin
107	Imo L 2920
108	Cresent No. 2 L2921
109	Buffalo
110	Carthage
111	Pat
112	X Ray
113	Wild Horse
114	Annie Maud
115	Joplin
116	Golden Calf
117	Canadian Pacific
118	Oronogo
119	S. J. M.
120	Bywater
121	M. S.
122	Willcock
123	Warwick
124	Royal
125	New Victor
126	Royal Fraction
127	Excelsior
128	M and M
129	Blackcock
130	L 2925
131	Sterling
132	Roanoke
133	Lexington
134	Morning Star
135	Pulaski
136	Morning Star Fraction
137	Wren
138	Calumet
139	Little George
140	Garfield
141	Randall
142	Blye
143	Dinner Bucket
144	Ben Hur
145	Salisbury
146	Warrington

No.	Name of claim	No.	Name of claim
147	Lancashire	203	T. F. Trask No. 2
148	Florence	204	May Day
149	Deadwood	205	Fairview
150	New Brunswick	206	Ruby
151	Snowslide	207	Galena
152	L 4226	208	Free Silver
153	Ocean Wave	209	May Blossom
154	Joker	210	Ella
155	First Chance	211	Royal
156	Giant	212	Mohawk
157	Gigantic	213	Woodside
158	Atlin	214	Bee
159	Yankee Girl	215	Sunset
160	Yukon Fraction	216	Pink Diamond
161	Canadian Girl	217	Crouch Hall
162	Harpin Fraction	218	Bullion
163	Morning Star	219	Last Chance
164	Evening Star	220	Ivanhoe
165	Lakeview	221	Flossie R.
166	Black Diamond	222	Dodo
167	Lightheart	223	King Solomon
168	Parker	224	Bimetallic
169	Old Bill	225	Little Perl
170	Free Silver	226	Jubilee
171	Shiloh	227	Portepin
172	Royal	228	Gold Queen
173	Norah	229	Anne
174	White Pine	230	Mulligan
175	Gold Island	231	Gorgina
176	Standard	232	Porcupine
177	Janny	233	Franklin
178	Amanda	234	Nevada
179	Redman	235	Imperial
180	Twilight	236	Emerald
181	Centre Star	237	Sunrise
182	Crowfoot	238	Victor
183	Blind Canyon	239	Porcupine
184	Mineral Zone	240	Aurora
185	Canyon Fraction	241	Tugalla
186	Blue Quartz	242	Double Standard
187	New York Central	243	Salsberry
188	Rover	244	Highland Chief
189	Blue-Eyed Nelly	245	Hunter V
190	Tyne L7353	246	Onill L. 6069
191	Comet	247	Silver Bullion
192	Planet	248	Empress
193	Rocket	249	Santiago
194	Nebraska Girl	250	Big 4
195	Bonanza	251	Hercules
196	Blue Bell	252	Snowflake
197	Atlanta	253	Lerwick
198	Consolidated Alabama	254	Carmencita
199	U. B.	255	Eldorado
200	Tennessee	256	Chichuanua
201	Princess Fraction	257	Eldorado No. 2
202	T. F. Trask	258	Bernard

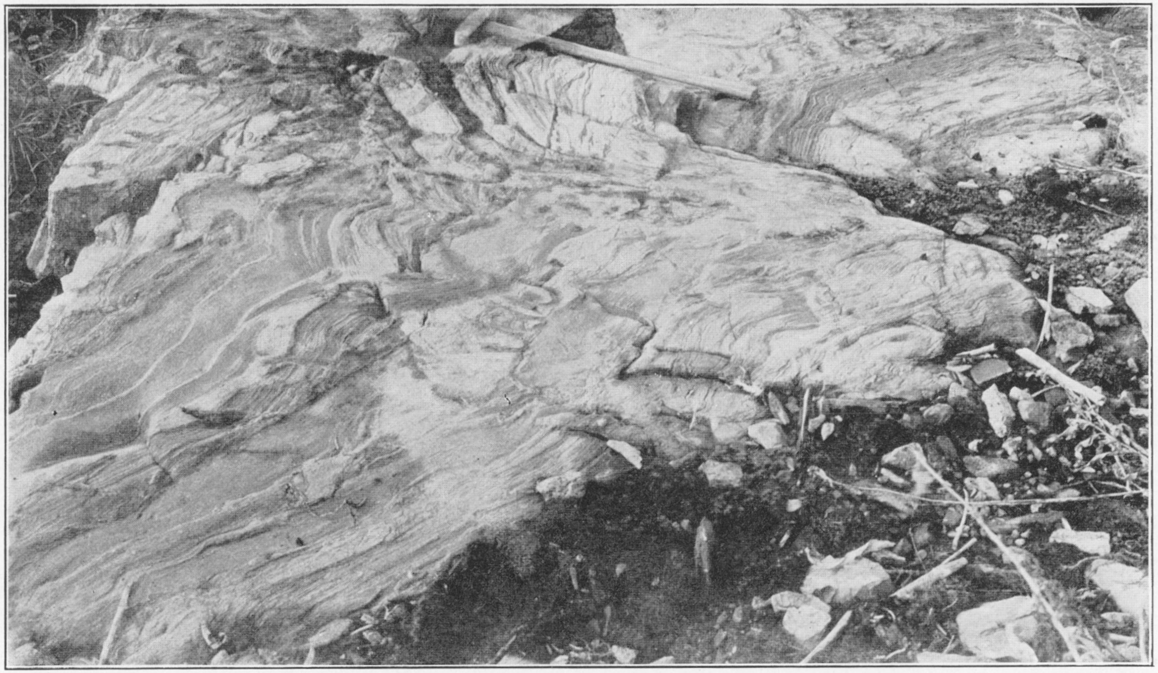
No.	*Name of claim*	*No.*	*Name of claim*
259	Victor	265	Queen
260	Empress	266	Horseshoe
261	Union Jack	267	Napoleon
262	Magly	268	Fourth of July
263	Admiral Mayer	269	Pountney
264	Climax	270	Lawrence Fraction

PLATE II.



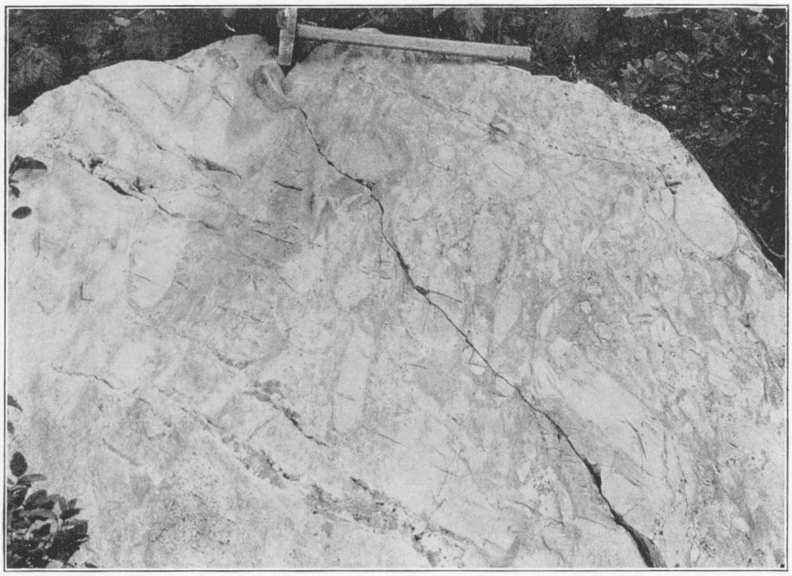
Southeast slope of Wild Horse valley showing glacially bevelled spurs. (Page 9.)

PLATE III.



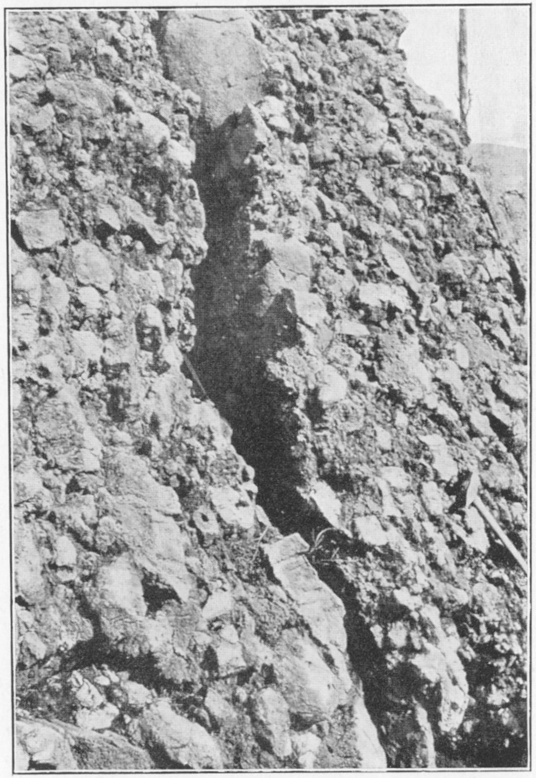
Foliation in Pend-d'Oreille roof pendant. Yankee Girl hill. This is most pronounced in the calcareous members of the group. (Pages 26, 114.)

PLATE IV.



Hall series squeezed conglomerate. (Page 28.)

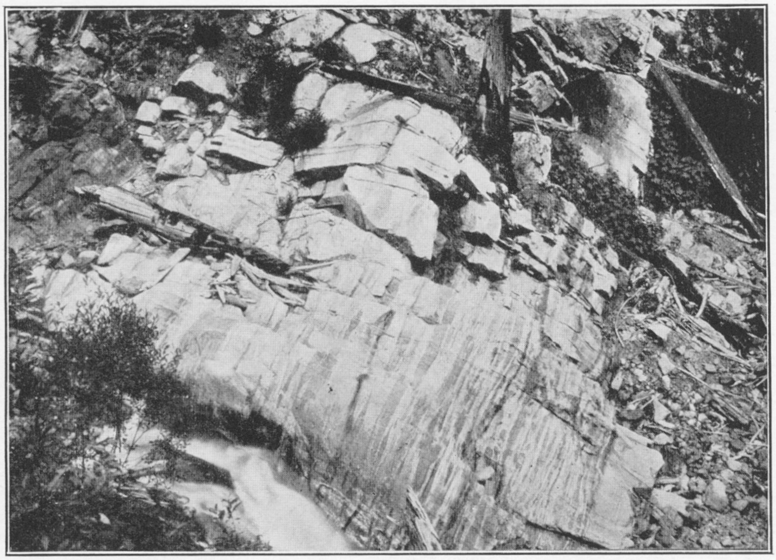
PLATE V.



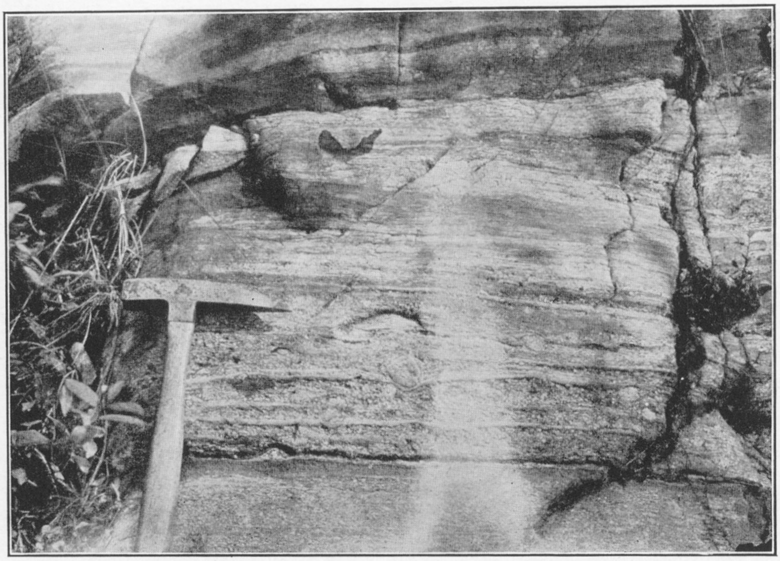
A. Coarse volcanic agglomerate from west slope Elise mountain, showing angular and subangular blocks of vesicular and amygdaloidal lava.

B. Coarser agglomerate at same locality as A. (Page 30.)

PLATE VI.

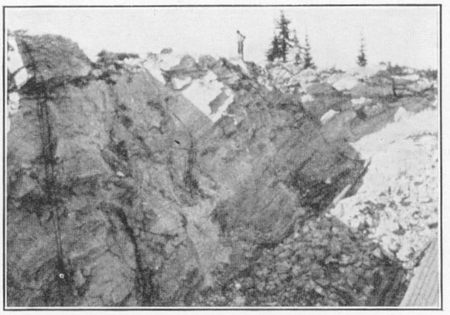


A. Injection phenomena at granodiorite contact in canyon near mouth of North Fork of Wild Horse creek.

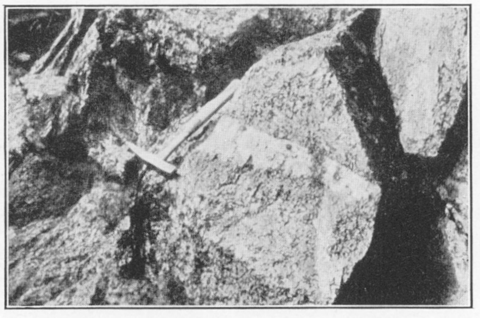


B. Similar phenomena near contact on Roanoke claim. Shows "augens" of orthoclase feldspar. (Pages 34, 74.)

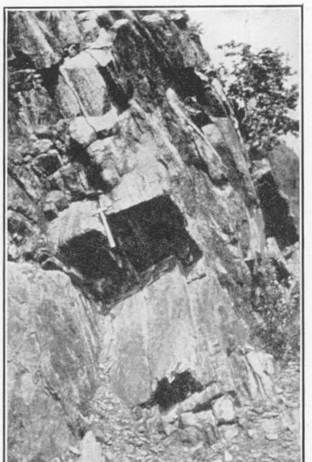
PLATE VII.



A. "Glory hole" at Hunter V mine. White crystalline limestone hanging and foot-walls. (Pages 53, 118.)

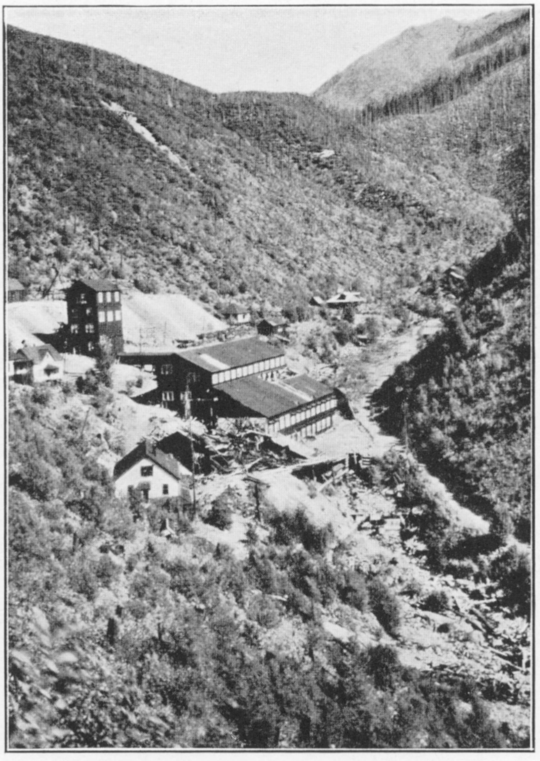


B. Porphyritic granite on Foghorn trail. Shows aplite dyke cutting the coarse-grained granite. (Page 34.)



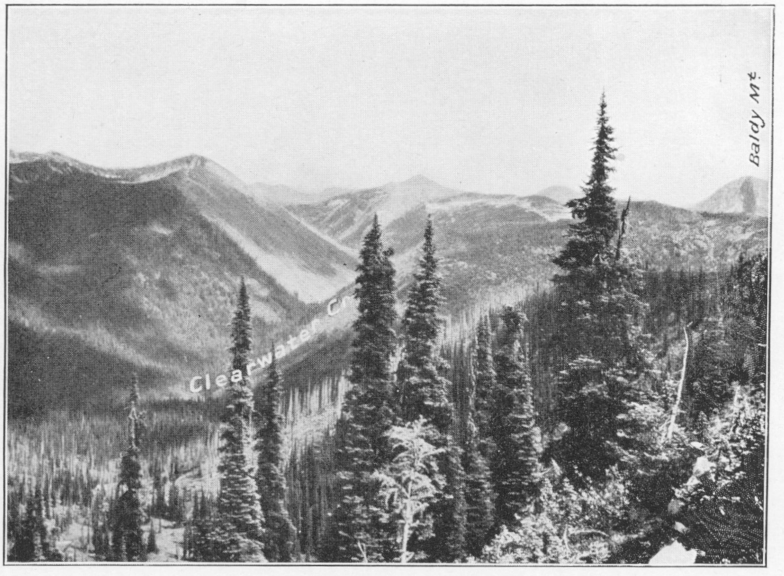
C. Same granite showing platy jointing parallel to contact.

PLATE VIII.



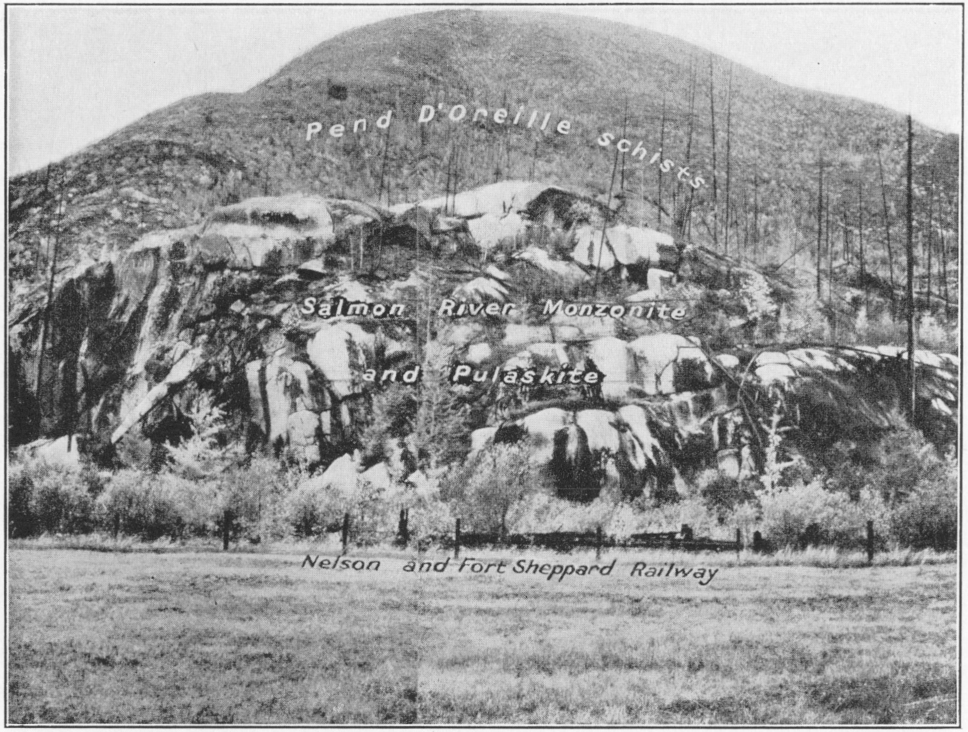
Ymir 80-stamp mill in 1914. Superintendent's house in the background. (Page 105.)

PLATE IX.

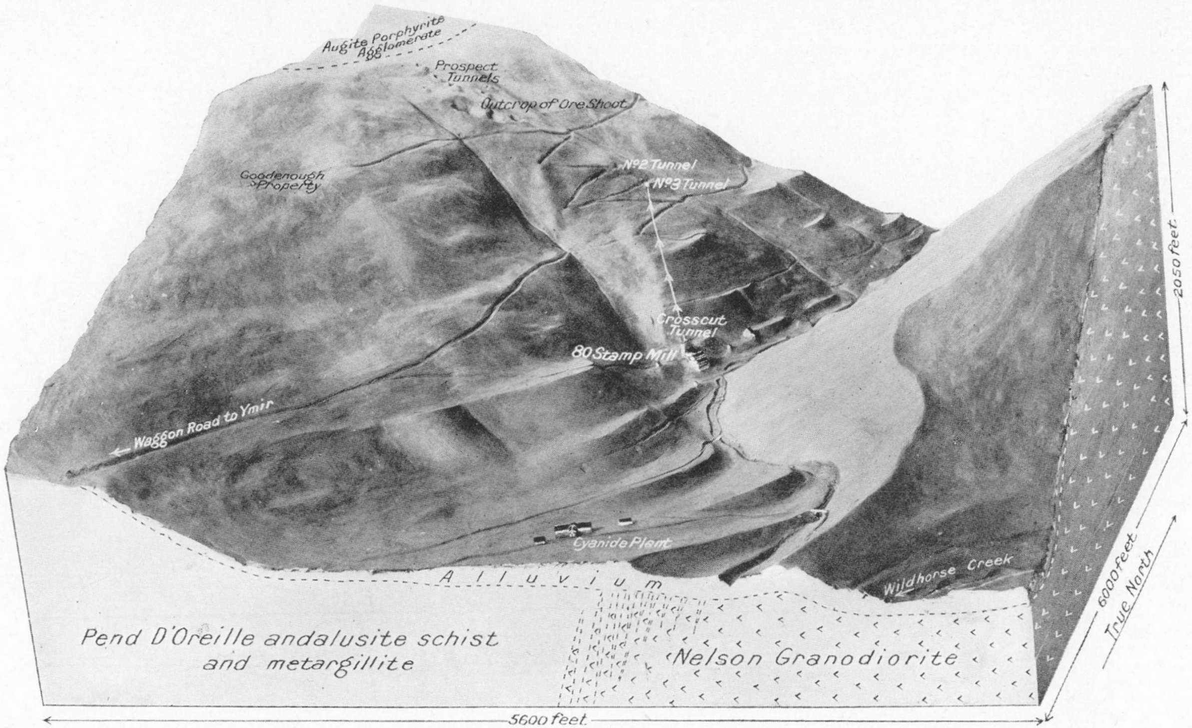


A. Green timber, Ymir.

B. Brûlé along Wild Horse wagon road, showing small stand of green timber and growth of fireweed over the burnt area. (Page 12.)

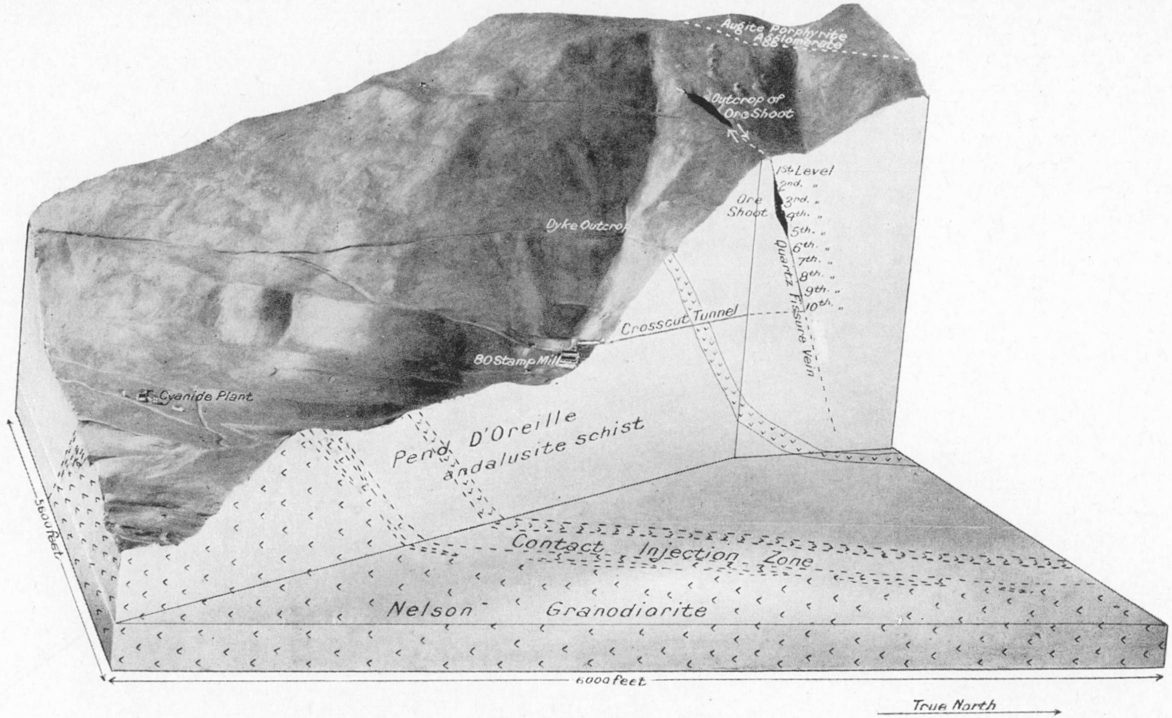


Salmon River monzonite stock along Nelson and Fort Sheppard railway, one mile south of Ymir. (Page 39.)



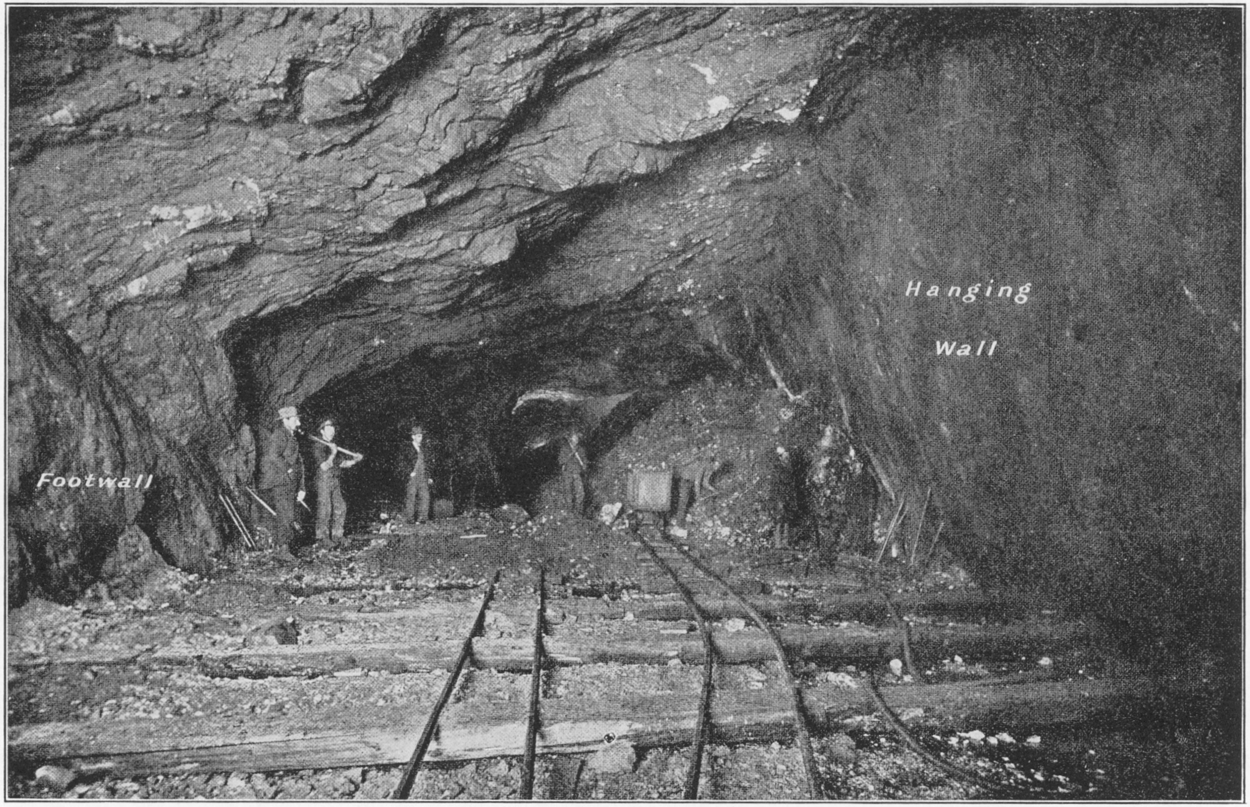
Block diagram of Ymir mine, mill, and cyanide plant. (Page 100.)

PLATE XII.

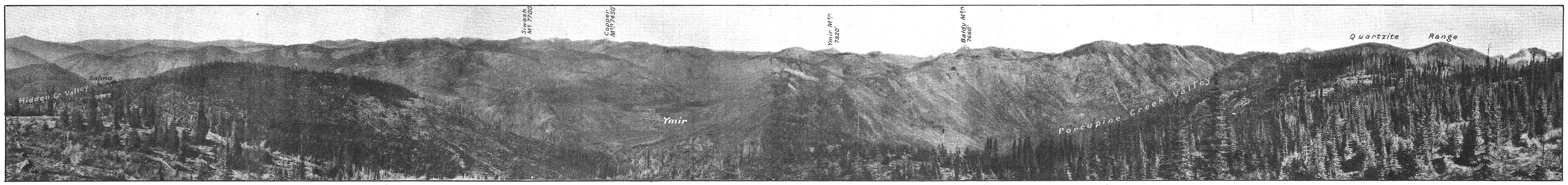


Block diagram of Ymir vein and geological structure. (Page 104.)

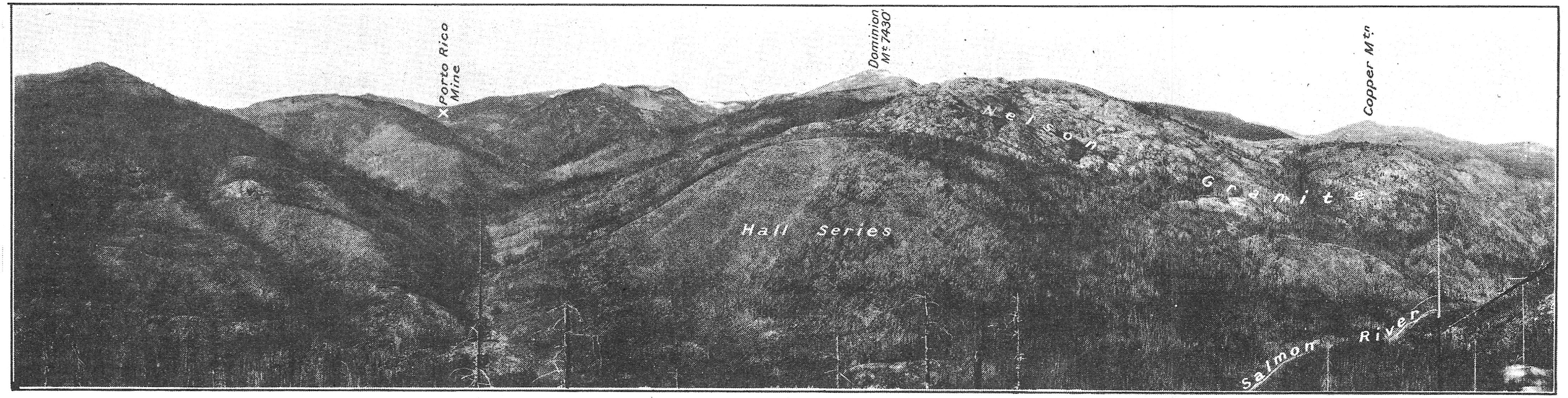
PLATE XIII.



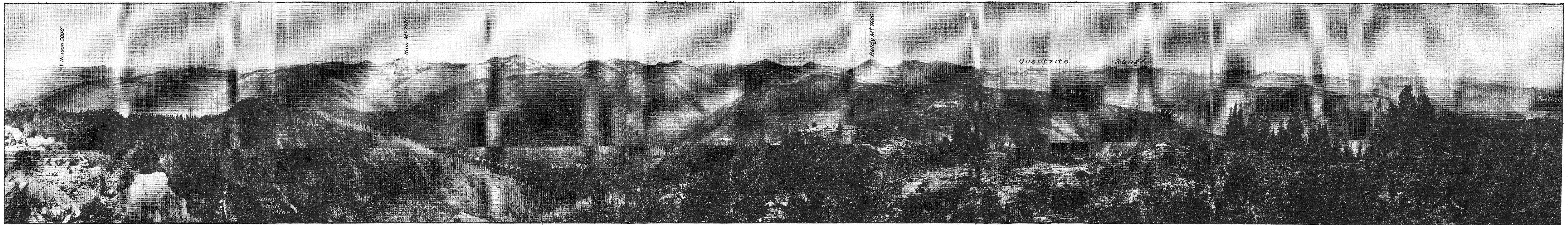
Stope in Ymir mine. Photo from B.C. Bureau of Mines report. (Page 105.)



A. Panorama from Hunter V Mine. (Page 9.)



B. Panorama taken from Gold Cup property. Shows the valley of Barrett creek heading up in glacial basins. Strike ridges and rounded sedimentary hill in foreground. (Page 9.)



Panorama from Elise Mountain, looking east from Nelson on left (to the north) to Salmo on right (to the south). (Page 9.)

INDEX.

PAGE

A.

B.

C.

D.

K.

L.

M.

N.

O.

P.

S.

T.

U.

V.

W.

X.

Y.

Z.

PUBLICATIONS OF THE GEOLOGICAL SURVEY.

The Geological Survey was established in 1842 and "Reports of Progress" were issued, generally in annual volumes, from that date to 1885, the first report being that for the year 1843 published in 1845. Beginning with the year 1885, "Annual Reports" (new series) were published in volumes until 1905, the last being Vol. XVI, 1904. Many of the individual reports and maps published before 1905 were issued separately and from 1905 to the present, all have been published as separates and no annual volume has been issued. Since 1910, the reports have been issued as Memoirs and Museum Bulletins, each subdivided into series, thus:—

Memoir 41, *Geological Series 38.*
Memoir 54, *Biological Series 2.*
Museum Bulletin 5, *Geological Series 21.*
Museum Bulletin 6, *Anthropological Series 3.*

In addition to the publications specified above, a Summary Report is issued annually; and miscellaneous publications of various kinds including Reports of Explorations, Guide Books, etc., have been issued from time to time.

Publications Issued Since 1909.

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MEMOIR 88. *Geological Series 72.* Geology of Graham island, British Columbia, 1916—by J. D. MacKenzie.

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MEMOIR 94. *Geological Series 76.* Ymir mining camp, British Columbia, 1917—by C. W. Drysdale.

MEMOIR 95. *Geological Series 77.* Onaping map-area—by W. H. Collins.

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In the case of Bulletins 1 and 2, which contain articles on various subjects, each article has been assigned a separate series number.

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