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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

MEMOIR 228

NELSON MAP-AREA, EAST HALF, BRITISH COLUMBIA

BY

H. M. A. Rice

FIRST PRINTING 1941

REPRINTED BY

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
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Price, 50 cents. No. 2460

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Nelson Map-area, East Half, British Columbia

CHAPTER I

INTRODUCTION

The east half of Nelson map-area is bounded by longitudes 116 degrees and 117 degrees and by latitudes 49 degrees and 50 degrees, and includes 3,100 square miles of mountainous terrain. The towns of Kalso, Creston, and Yahk lie within the area.

The following report is based on field work done during the seasons of 1936, 1937, and 1938.

The writer acknowledges the co-operation of the residents of the area, especially the staff and employees of the Consolidated Mining and Smelting Company, B.C., Spruce Mills at Lumberton, and the Bayonne Consolidated Mining Company. The generous assistance of the latter greatly facilitated the work on the southwest side of Kootenay Lake.

In the field the writer was ably assisted in 1936 by J. B. Thurber, F. R. Jones, and A. R. Allen; in 1937 by R. C. Ridland and A. R. Allen; and in 1938 by A. R. Allen and W. O. Williams.

The principal areas of settlement are along Kootenay Lake and the railway. The prosperity of the district is mainly dependent on agriculture, lumbering, and mining.

Agricultural land is limited to favourable locations in the main valleys. For many years fruit, particularly cherries and apples, have been successfully grown from Sirdar to Creston along the railway, from Sirdar to Riondel on the east side of Kootenay Lake, and from Procter to Kaslo on the west side of the lake. A newer but very profitable venture has been the growing of wheat on the dyked lands along the flats of Kootenay River at Creston.

Logging is confined to the railway belt and the area around the headwaters of Moyie River.

The mining activity of the area is at present largely centred at the Sullivan mine, where daily is milled some 7,000 tons of silver-lead-zinc ore and which is the largest mine of its kind in the British Empire.

Ainsworth district in the past has produced a considerable tonnage of silver-lead-zinc ore from a number of mines, although there is little activity there at the present time. The Blue Bell mine, on the opposite side of Kootenay Lake from Ainsworth, was the first producing mine in the Kootenays and has had a long record of intermittent activity. Small shipments have been made from the Alice mine near Creston and the Silver Hill mine on Crawford Creek.

Silver, lead, and zinc are the principal metals in all the above-mentioned mines, but a number of gold deposits occur on the west side

of Kootenay River opposite Creston. Only one of these, the Bayonne mine, has been brought into production. Gold deposits also occur near Columbia Point on Kootenay Lake, but as yet trial shipments only have been made from them.

PHYSICAL FEATURES

The east half of Nelson map-area covers a strip across almost the entire Purcell Range, the Purcell Trench, and the east flank of Selkirk Mountains.

Purcell Trench is a deep, steep-sided valley, relatively straight and from 1 to 2 miles wide. In the area it is occupied by Kootenay Lake and Kootenay River.

West of the trench rise Selkirk Mountains. Although the axis of the range lies west of the area, the part within it includes several peaks rising to over 7,500 feet. Although the high peaks are precipitous those under 7,000 feet are mostly rounded and heavily wooded to the summit. A number of large streams wind their way through deep valleys to Kootenay Lake or Kootenay River.

In the Purcell Range mountains up to 7,000 feet are rounded and well wooded to the summit, higher ones are commonly extremely rugged, and those carved out of granite or massive quartzites are climbed only with extreme difficulty. Near the International Boundary few peaks rise above 7,000 feet and the topography is comparatively subdued. To the north, where the elevation of the higher peaks is 8,000 or 9,000 feet, the terrain is extremely rugged (Plate I B). A feature that causes the abrupt relief and consequent steepness of the mountains is the deeply incised valleys that reach far back into the heart of the range. St. Mary River, for instance, has an elevation of 4,500 feet within 3 miles of its source, an elevation of 3,000 feet where it leaves the area, and is bordered by peaks rising to almost 9,000 feet.

The axis of the Purcell Range runs in a northwesterly direction from the vicinity of Yahk, but lies very much closer to the western than the eastern margin of the range. The western drainage, therefore, consists of short, torrential streams, whereas the eastern drainage is more gradual and includes such rivers at St. Mary and Moyie. A similar lack of symmetry is true of the subsidiary ranges lying between the forks of St. Mary River.

The general northwesterly trend of the mountain systems and their subsidiary ranges is interrupted by three prominent east-west valleys. One is occupied by the outflowing Kootenay River (known as West Arm) and cuts across the entire Selkirk system. In line with this to the east is the prominent east-west valley occupied by St. Mary River and part of its tributary Redding Creek, which cuts across fully three-quarters of the Purcell Range. Near the south end of the area another prominent east-west valley, which also cuts across a large part of the Purcell Range, is followed by the railway.

GLACIATION

Glacial striæ, erratics, and glacial debris occur at all elevations up to 8,000 feet.

There is no clear evidence of more than one period of glacial activity, and the results of glaciation to be observed today must be attributed to the last advance of the Cordilleran ice-sheet during the Wisconsin epoch. Records of any earlier advances have been obliterated or masked. Striæ, roches moutonnées, and like phenomena indicate that this ice-sheet moved in a general southerly direction, but with a tendency to follow the main topographical features such as the Purcell and Rocky Mountain Trenches. Thus the ice on the east flank of the Purcell Range moved southeast and that on the west flank southwest. It seems probable that the land surface overlain by the ice was one of high relief, with the principal ridges and valleys in much the same positions as those of today. Over these mountains and ridges and over the ice-filled transverse valleys the ice-sheet, although thick, apparently moved as a unit. As it thinned down, the underlying topography assumed control and a stage of valley and alpine glaciation ensued. During this stage the ice-sheet broke up into lobes, which flowed down the principal valleys.

The writer has already (Rice, 1936)[1] presented evidence to show that the ice-sheet in the floor of the Rocky Mountain Trench disappeared by a process of stagnation, breaking up into units, and melting away in situ. The results of this process are apparent in the huge kettles, kames, etc., that line much of the floor of the trench. Like phenomena appear on the flat bench-land south of Creston, and it is evident that a similar process took place there.

The following evidence shows that, locally at least, the ice was not an active agent of erosion.

(1) The St. Mary silts (Rice, 1937, page 25) consist of a group of unconsolidated silts and gravels. They are exposed in the Rocky Mountain Trench by St. Mary River a couple of miles beyond the east edge of the area. They have been covered by glacial material and yet have been only slightly disturbed by the ice.

(2) Gold placers occur in some of the streams entering the Rocky Mountain Trench from the Purcells. These are, in the writer's opinion, either remnants of undisturbed Tertiary placers or such placers slightly redistributed by ice movement. It is clear that any extensive erosion by the ice would have dissipated them completely.

(3) In the vicinity of the Bayonne and Wisconsin mines in the high mountains across the Purcell Trench from Creston remnants of pre-glacial weathering have escaped removal by the ice. The same is true of outcrops of the ore at the Society Girl mine near Moyie, east of the area.

The first two points indicate limited erosion at certain places in the Rocky Mountain Trench, and the third limited erosion in certain parts of the mountains. The case of the Society Girl is interesting. This example is not at extreme elevations, such as the Bayonne or Wisconsin,

[1] *See* Bibliography, page 4.

where the ice-sheet might have been too thin to accomplish extensive erosion. Nor is it on the flats, as in the first two cases, where streams of ice from different directions may have had a common damming effect. Furthermore, it is close to the valley of Moyie Lakes, which is a north-south trending valley down which the ice might be expected to have swept with considerable force.

It, therefore, appears as if the continental ice-sheet at certain localities lacked the power to erode deeply.

Most of the valleys in the mountains, however, have the U-shaped cross-section, truncated spurs, hanging valleys, and other manifestations of severe glaciation (Plate I A). Furthermore, both they and their tributaries head in prominent cirque basins, many of which are occupied by typical glacial lakes. There was, therefore, considerable valley erosion over much of the area during Alpine glaciation. The transverse valleys, mentioned in an earlier paragraph, have also been severely eroded by glaciation, probably during the Alpine stage.

With reference to the origin of the Purcell Trench, the writer is fully in accord with the hypothesis presented by Schofield (1915, page 168) that the trench owes its present form to the modification by glaciers of a pre-existing valley.

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CHAPTER II

GENERAL GEOLOGY

Over three-quarters of the area is underlain by late Precambrian sediments of Purcell and Windermere ages. Each series is characterized by a great thickness of conformable sediments, but the two are separated by a major unconformity.

The Palæozoic era is represented by Lower Cambrian sediments occurring in fault blocks near the centre of the area and by Carboniferous sediments forming a narrow belt through Ainsworth district. The only Mesozoic sediments known in the area occur west of Kootenay Lake.

The igneous rocks include both extrusives and intrusives.

Lavas of two periods of vulcanism occur in the area. During the first the Irene volcanic formation of Lower Windermere age was formed, and during the second the Triassic Kaslo series, which runs in a belt through Ainsworth district. The Purcell lavas of Purcell age occur in the adjoining area to the east.

The earliest known intrusive bodies are the Purcell intrusives; immense, generally sill-like, bodies of uncertain but probable Precambrian age. Throughout the Windermere rocks are sheared greenstone dykes and sills that may be related to the Purcell intrusives or may be younger.

Granitic bodies occur plentifully throughout the area. These bodies vary in size and shape from small, roughly circular stocks and bosses to irregular masses of batholithic dimensions. They are probably of late Mesozoic age.

Many dark-coloured dykes and sills occur along the west side of Kootenay Lake. Some of these have the composition of a syenite and others that of a typical lamprophyre. Possibly there are two sets of intrusives of different ages, both younger than the granitic rocks.

In the vicinity of Bayonne (Tye) occur three or four elliptical, stock-like bodies believed to be volcanic necks. These vary markedly in composition, but appear to be clearly related to the syenitic dykes and sills. They are almost certainly of Tertiary age.

Table of Formations

Cenozoic	Recent Pleistocene	
		McGregor volcanic necks, dykes, and sills
Mesozoic and (or) Cenozoic	Post-Triassic	Lamprophyre dykes Granitic intrusives
Mesozoic	Triassic	Slocan series
		Kaslo series
Mesozoic and Palæozoic	Triassic and Carboniferous	Milford group
Palæozoic.	Cambrian	Eager formation Cranbrook formation
Proterozoic (Late Precambrian)	Windermere	Greenstone intrusives Lardeau series Badshot formation Hamill series Horsethief Creek series Irene volcanic formation Toby formation
	Unconformity	
	Upper Purcell	Purcell intrusives Mount Nelson formation Dutch Creek formation
	Lower Purcell	Kitchener-Siyeh formation Creston formation Aldridge formation

LATE PRECAMBRIAN

From the earliest time of which there is any record on into at least the Palæozoic, a long area of sedimentation extended from California to the Arctic Ocean. It ran northwesterly through eastern British Columbia, and in it the late Precambrian formations were laid down. These occupy a belt some 60 to 100 miles wide paralleling the west side of the Rocky Mountains from the International Boundary to the Yukon, and in southern British Columbia have been divided into two great systems—the Purcell and the Windermere. The former has been further subdivided into the Upper and Lower Purcell.

PURCELL

The sediments formed in Purcell time consist of a conformable succession of formations totalling about 45,000 feet in thickness. Although there are no breaks in the succession and similar rock types occur throughout, it is possible to subdivide the series lithologically into recognizable

formations. Considerable familiarity with the rocks is necessary to do so and, if outcrops are small and widely scattered, it may be impossible to decide with certainty to which formation they belong.

LOWER PURCELL

The formational names used for the subdivisions of the Lower Purcell strata were introduced by Daly (1913) and Schofield (1915) and the definitions given to the formations by the latter have been closely adhered to.

The formations are composed largely of varicoloured, argillaceous quartzite and argillite. In the uppermost formation magnesian limestone, of varying degrees of impurity, bulks largely. Except near igneous bodies or faults, where local metamorphism is important, the rocks are remarkably fresh, and fine details of sedimentation, ripple-marks, mud-cracks, and like phenomena are clearly preserved.

Aldridge Formation

This is the oldest formation known to occur in the area. To the east the Aldridge is underlain by the Fort Steele formation (Rice, 1937, pages 4-6), but this formation is not exposed in the present area or else does not exist as a recognizable unit. A great thickness of Aldridge is exposed along the railway crossing the southern part of the area and, at first glance, it appears as if the basal beds there should be equivalent to the Fort Steele. There is, however, considerable faulting through this region and undoubtedly repetition of strata makes the great thickness more apparent than real.

The area is structurally too complicated to permit accurate measurement of the thickness of the Aldridge. Some measurements suggest that the figure of 16,000 feet measured in the Rocky Mountains (Rice, 1937, page 8) is also approximately true in this area.

The Aldridge is composed mainly of grey to brownish grey, rusty weathering argillite and argillaceous quartzite, the latter in beds generally about 1 foot thick but in some places as much as 10 feet thick. In the lower part of the formation argillaceous quartzite predominates and in the upper argillite, but the change is not marked.

Variations from this general type are locally important. In the vicinity of Bootleg and Evans Mountains, for instance, the strata are chiefly light weathering grey quartzite, with very pronounced banding, interbedded with light-coloured, soft, argillaceous quartzite. Elliptical segregations a foot or more long are abundant in these beds. These segregations are of coarse grains of quartz, feldspar, mica, and some garnet. The beds distinctly resemble those forming the transition from the Aldridge to the Fort Steele in the Rocky Mountains. They seem to be 12,000 to 13,000 feet below the top of the Aldridge, and may be the basal beds of the formation.

Another distinctive type occurs on the mountain immediately northeast of Kitchener, and also near the forks of Goat River. In these localities certain beds, probably only a few thousand feet below the top of the Aldridge, are soft, olive-green, bluish grey, and reddish, platy argillite and

sandy argillite. These rocks so closely resemble much of the Eager that the writer mapped them as Eager until they were found to grade both upwards and downwards into normal Aldridge. The strata of this type are probably about 1,000 feet thick.

Although the formation is prevailingly fine-grained, two or three small beds or lenses were seen composed of argillaceous rocks carrying half-inch fragments of slate. These beds do not resemble conglomerate and the fragments are probably pieces of dried and consolidated mud or clay that washed or floated into place when the sediments were being laid down.

The transition from the Aldridge to the Creston is marked in most places by about 1,000 feet of grey and green, laminated argillite. The lower part of this assemblage is rusty weathering and the upper part generally weathers grey. The boundary between the two formations is placed where the rusty weathering strata cease to be prominent. It is, like all the boundaries in the Purcell series, not entirely satisfactory, as there is considerable latitude for individual judgment.

Details of sedimentation, crossbedding, and the like are usually well preserved and ripple-marks and mud-cracks are common. The latter are particularly well developed in the grey and green, laminated argillite forming the transition to the Creston.

Creston Formation

The Creston formation conformably overlies the Aldridge. It consists of some 6,300 feet of argillaceous quartzite and argillite.

Argillaceous quartzite forms the bulk of the formation. It is generally fine-grained, light watery green or purple, and in beds 2 or 3 feet thick. White and grey varieties also occur. The purple colour is due to extremely finely divided hematite. A single bed may be green in one place and pass abruptly to purple along the strike. Certain sections are, however, predominantly green, others purple. A striking and diagnostic rock is referred to as "purple-mottled" quartzite. It consists of a white or faint purple quartzite traversed by fine purple lines. These lines may parallel the bedding, but more frequently form a network.

The argillite is commonly platy, and like the quartzite is green and purple. Grey argillite is, however, more common than grey quartzite. Laminated argillite frequently occurs. The laminæ in some of these consist of alternating bands of dark and light green rock, in others of dark and light grey. Neither type is particularly characteristic of the Creston. The greatest development of the grey type occurs west of Kootenay River near the International Boundary and is difficult to distinguish from members of the Aldridge.

Narrow beds, pods, and lenses of calcareous rocks occur in the upper part of the formation. These are more numerous towards the top of the Creston, and where they are abundant the strata are considered to belong to the overlying Kitchener-Siyeh.

The formation as a whole is somewhat coarser grained and more massive than the underlying Aldridge. Crossbedding, ripple-marks, and similar features are common and well preserved. The conspicuous rusty staining so typical of the Aldridge is lacking in the Creston except where it has been mineralized.

Kitchener-Siyeh Formation

In Cranbrook area (Rice, 1937, pages 9-11) the Creston is overlain by the Kitchener composed of variously coloured, calcareous and dolomitic argillites, and these are overlain by the Siyeh consisting almost entirely of argillite and argillaceous quartzite. In the Nelson area, however, the Siyeh is recognizable only in the northeast part of the area. Elsewhere in the area if argillite suggestive of the Siyeh occurs, it is present in insignificant amounts only and the assemblage from the top of the Creston to the base of the Upper Purcell consists almost entirely of rocks typical of the Kitchener. It is not supposed that strata of the age of the Siyeh are lacking, but that they are indistinguishable from the Kitchener and, therefore, the assemblage above the Creston and below the Upper Purcell has been treated as a unit and named Kitchener-Siyeh.

The Kitchener-Siyeh is approximately 7,500 feet thick and consists predominantly of impure, magnesian limestone, argillite, and calcareous quartzite.

Limestone and calcareous rocks compose the bulk of the formation and serve to distinguish it from the underlying formations. They are predominantly cream coloured, but green, grey, and occasionally purple varieties also occur. All are more or less magnesian and characteristically buff weathering. Most of the limestone is in beds from 1 to 5 feet thick with partings of argillite. It grades, with the addition of argillaceous material, into calcareous argillite. Although throughout most of the area the limestone is thin bedded, some massive beds were seen in the southwest corner of the area. One of these beds is crossed by a tunnel 220 feet long, which is in massive limestone throughout. Taking into account the dip of the strata, the actual thickness of this bed is not less than 190 feet.

The Kitchener-Siyeh argillite is green, dark grey, and purple, and most of it is hard and platy or slaty. Although a great deal of the argillite is more or less calcareous, considerable thicknesses of non-calcareous argillite occur in some sections.

Although the Siyeh, as a formation, cannot be distinguished, the upper part of the Kitchener is generally argillaceous, and these argillites are often banded and coloured in a way that suggests the Siyeh. They are, however, generally interbedded with limestone.

Quartzite occurs sparingly in the Kitchener-Siyeh. It is generally indistinguishable from much of the quartzite in the Creston formation except for a certain calcareous type. This type is commonly buff weathering and, with the leaching out of the calcareous bond, and the consequent loosening of the quartz grains, takes on a sandy feel that is rather distinctive.

The formation as a whole is composed of more easily deformed rocks than the Aldridge and Creston, and great stretches of it have been altered to chlorite and talc-carbonate schist. Textural features are, therefore, largely lost, although mud-cracks are well preserved in places.

In the country to the east the Purcell lavas occur interbedded in the upper part of the Siyeh. Lavas are lacking in the formation in the Nelson area, but evidence of equivalent vulcanism is afforded by beds that resemble tuffs or fine-grained volcanic breccia occurring in the upper part of the Kitchener-Siyeh east of Buhl Creek.

UPPER PURCELL

In Cranbrook district the Upper Purcell series was subdivided by Schofield (1917, pages 36-38) into, in ascending order, the Gateway, Phillips, and Roosville formations. In Windermere area to the north, Walker (1926, pages 7-11) subdivided the same series into the Dutch Creek and the overlying Mount Nelson formations. In Nelson area the writer was unable to recognize Schofield's subdivisions, whereas Walker's were clearly recognizable.

Dutch Creek Formation

The Dutch Creek formation overlies the Kitchener-Siyeh and is the lowest member of the Upper Purcell. In most places there is a definite and rather abrupt change in lithology from the Kitchener-Siyeh to the Dutch Creek, but no vestige of nonconformity.

A section across the formation measured south from Rose Pass proved to be about 4,300 feet thick.

Slaty argillite comprises most of the Dutch Creek formation. Grey to black rocks predominate, but some are green. The most pronounced feature is a fine, regular lamination compounded of various shades of the basic colour of the rock. Some of the argillite is calcareous, grading into impure, magnesian limestone, and some sandy, grading to argillaceous quartzite, but by far the greater proportion is extremely fine-grained, non-limy argillite.

Beds of quartzite occur all through the formation, but only at the bottom are they common. Throughout the greater part of the formation they are grey (sometimes slightly green), fine-grained, argillaceous quartzite, but in the 700 or 800 feet at the base massive beds of very siliceous, conspicuous, light-coloured quartzite are good horizon markers.

Beds of impure magnesian limestone occur all through the formation, but, like the quartzite, are only abundant in the basal beds. In one or two places, in the basal member of the formation, beds of blue-grey, light weathering, crystalline limestone were seen that have quite a different appearance to the magnesian limestone beds. Nothing like them was seen in any other formation of the Purcell series, but similar rocks are common in the Horsethief Creek series. Their value as a diagnostic type is doubtful as so few were seen.

Details of the section near Rose Pass follow:

Mount Nelson

	Feet
Conformity	
Grey and green, laminated argillite with occasional beds of limy, argillaceous quartzite. Some beds with limy pods. Considerable folding	900?
Gap in outcrops	400?
Sandy, green argillite with some beds of laminated, grey argillite	540?
Argillite and siliceous, light grey and green quartzite	100?
Argillite with occasional beds of argillaceous quartzite	1,120?
Grey and black, laminated argillite	500?
Massive, buff weathering, siliceous, magnesian limestone with interbedded, siliceous, white and rose-coloured quartzite and blue-grey limestone	750
Conformity	

Kitchener-Siyeh

Mount Nelson Formation

The Mount Nelson formation overlies the Dutch Creek conformably. Its thickness in the vicinity of Rose Pass is about 3,200 feet. Although folding and possible faulting renders the accuracy of this figure doubtful, it agrees closely with that of 3,400 feet for a section measured by Walker (1926, page 10) in Windermere area.

The formation consists of grey, green, and black, laminated argillite, magnesian limestone, argillaceous limestone, and quartzite. Each type has its counterpart in the Dutch Creek formation, and the two formations are very much alike. The Mount Nelson has perhaps more and larger beds of magnesian limestone than the Dutch Creek. The base of the Mount Nelson is marked by a thick band of light-coloured, siliceous quartzite that is an excellent horizon marker.

Both the Dutch Creek and Mount Nelson formations are composed mainly of incompetent rocks and occur in regions of considerable deformation. They are, consequently, greatly sheared in most places. Ripple-marks and mud-cracks were, however, seen in a few places.

Below are the details of the section of the Mount Nelson measured in the vicinity of Rose Pass.

	Feet
Windermere-Toby conglomerate	
Unconformity	
Black, laminated argillite	210
Greenish grey argillite with occasional 6-inch beds of more quartzitic rock	430
Grey and green, laminated argillite	160
White to rose-coloured, siliceous quartzite in beds up to 2 feet thick	40
Magnesian limestone interbedded with light-coloured quartzite	320
Sandy argillite with occasional limy beds; green, slaty argillite, and thin-bedded quartzite	730
Green and grey, buff weathering, argillaceous limestone	480
Light-coloured, siliceous quartzite and argillaceous quartzite in beds up to 4 feet thick. Occasional, interbedded, limy, argillaceous quartzite	870
Conformity	
Dutch Creek	

GENERAL SUMMARY OF THE PURCELL

The Purcell rocks have a total thickness of not less than 44,000 feet. They are essentially fine-grained, clastic sediments and impure, magnesian limestone, the latter being largely restricted to the three upper formations. The sediments were deposited in a continuous succession and apparently in water of moderate depths. The presence of mud-cracks throughout the series shows that the surface of deposition was exposed to sun and air at frequent intervals.

Both Walcott (1910) and Bauerman (1884) believed that the basin in which these sediments were deposited was occupied by a lake having no connection with the sea. It is hard to believe that a depression so large, not less than 10,000 square miles in area, should remain for so long a time unconnected with the sea. Furthermore, Walker (1926, page 12) points out that Walcott's chief argument, the apparent lack of life in the Purcell and its sudden appearance in the Cambrian, can be explained by

the greatness of the interval of time existing between the deposition of the two, an interval during which all the Windermere series were laid down and two major unconformities were produced. In support of the hypothesis of a lake basin, however, thousands of ripple-marks occur in this area, and these are, with very few exceptions, of the symmetrical or wave-ripple type. Kindle (1917) has pointed out that symmetrical ripple-marks are evidence of lacustrine deposition.

Schofield (1915, page 40) makes the following observations: "The Aldridge formation in the eastern part of the Purcell Range contains no conglomerates; but in the western part, as in the vicinity of Goat River, conglomerates are quite abundant. The Creston formation also is coarser in the western part of the range. Hence, it is concluded that the land from which these sediments were derived was situated to the west of the Purcell Range, and probably as close as West Kootenay, for the Precambrian complex of gneisses and schists outcrops at various points in that region."

Although this conclusion may be correct, the writer cannot agree with it on the basis of the reasons offered by Schofield. No marked change in the grain size of the sediments in any one formation was observed either in the present area or Cranbrook area. True, the section of the Aldridge measured in the Rocky Mountains contained a somewhat higher proportion of argillites to argillaceous quartzite than elsewhere but, on the other hand, the Kitchener-Siyeh in the extreme southwest corner of the area contains noticeably larger beds of magnesian limestone than anywhere else in the two areas. The Creston, too, in that locality is probably more argillaceous than elsewhere. These variations can easily be explained by local variations in the depth of the Purcell Basin. The conglomerate on Goat River, which Schofield refers to the Aldridge formation, is, in the light of fuller structural and stratigraphic knowledge, now known to to overlie the Aldridge unconformably and to be Cambrian in age. Schofield's most telling argument is, therefore, nullified. The complex of gneisses and schists referred to as a possible source of the sediments, Cairnes (1934, pages 35-36, 61) has shown to be metamorphosed Windermere sediments or phases of the Nelson batholith, both of which are younger than the Purcell. The writer wishes it to be clear that he has no idea from which direction the material forming the Purcell rocks was derived, but, in the light of present knowledge, the possibility of a source other than from the west cannot be excluded.

AGE OF THE PURCELL ROCKS

Schofield, in Memoir 76 (1915) and in Museum Bulletins No. 2 and No. 4 (1914 and 1922), has presented excellent evidence for assigning the Purcell rocks to the late Precambrian. Walker (1926, pages 17-19) found Lower Cambrian strata lying unconformably on members of the Windermere in Windermere area. This series in turn lies unconformably on Purcell rocks. The writer has little to add except that in two parts of the present area Lower Cambrian strata rest unconformably on members of the Purcell. There can, therefore, be little doubt that the Purcell rocks are Precambrian, and from the small amount of metamorphism and the lithological resemblance to late Precambrian strata elsewhere in North America, late Precambrian in age.

WINDERMERE

The Windermere series and formations were named and described by Walker (1926) from Windermere area. He there recognized them as Precambrian, younger than the Purcell, and separated from them by a major unconformity. Their thickness is probably about 22,000 feet.

Toby Formation

The Toby formation is the basal member of the Windermere. The type section is at Toby Creek in Windermere area (Walker, 1926, page 12). In the present area it occurs in an almost continuous belt from the head of St. Mary River to Columbia Point on Kootenay Lake. The southern extension is cut off by granite, but its identity with the Irene conglomerate of Daly (1912) in the southwest can be established from the general stratigraphy. It overlies the Mount Nelson unconformably except for a short stretch near Columbia Point where it rests on the Dutch Creek. To the north and east of the area it rests on Mount Nelson and Roosville (Walker, 1926, pages 16-17), which latter formation Walker correlates with the upper part of the Dutch Creek.

Walker reports an angular discordance of as much as 45 degrees between the Toby and the underlying Purcell strata. No indication of any such discordance was observed in the Nelson area, but good exposures of the actual contact were observed only at Rose Pass. The underlying Mount Nelson is there considerably sheared and, if there be an angular discordance, it cannot now be observed. Nevertheless, it is evident from the fact that the Toby lies on the Mount Nelson in certain places and on the Dutch Creek in others that a considerable unconformity must be present.

The Toby formation varies markedly in thickness. Near Rose Pass it is about 250 feet thick, whereas near the International Boundary it is estimated to be some thousands of feet thick. In Windermere area Walker found that the thickness ranged from 50 to 2,000 feet.

The nature of the Toby formation varies markedly from place to place, a fact that has already been pointed out by Walker. Near the summit of Rose Pass the base of the Toby consists of a greenish grey conglomerate. The pebbles are mostly quartz set in a siliceous cement. They are well rounded and average about half an inch in diameter. This conglomerate is interbedded with greenish, foliated argillite, and scattered through it are large, angular blocks of black argillite. Stratigraphically above this member lies 30 feet of greenish schist followed by a thick bed of conglomerate composed of blocks and cobbles of buff weathering, sandy, magnesian limestone and small quartz pebbles in a cement of sandy, magnesian limestone.

A little farther southwest, on the west side of the divide, the Toby consists of fine-grained, arkosic conglomerate. The pebbles there are up to 1 inch in diameter and rounded to subangular. They commonly consist of quartz or feldspar. The Toby there is identical with many members of the overlying Horsethief Creek series.

East of Crawford Bay the Toby is mainly of the siliceous type interbedded with green, micaceous, sandy argillite, although some of the limy type occurs.

At Columbia Point the Toby has been considerably metamorphosed and consists of 3-inch cobbles of quartz and quartzite in a matrix of green, hornblende gneiss.

In the southeast corner of the area the Toby, previously called the Irene conglomerate (Daly, 1912, pages 141-144), occurs over a considerable area. Daly gives 5,000 feet for the thickness, based on three measured sections. The great thickness suggested by the area covered is undoubtedly more apparent than real, but it is probable that the Toby is thicker there than in other parts of the area.

As elsewhere, it is a highly variable formation. Pebbles and cobbles of quartz, quartzite, and magnesian limestone are most general, but flakes of argillite are not uncommon. The groundmass in some beds is a siliceous grit, frequently arkosic, and in others a sandy limestone. There is also a great variation in the ratio of pebbles to groundmass. In some beds pebbles and cobbles are closely packed, with the fine material merely filling the interstices, in others the formation is predominantly a fine grit with occasional scattered pebbles. The size of the pebbles in different beds varies from 1 to 6 inches, and subangular blocks a foot or more across are not uncommon. Here and there beds and lenses of sandstone occur. Near the top of the formation the conglomerate is interbedded with the basal flows of the Irene volcanic formation, and in these beds andesite pebbles are not infrequent.

Daly mentions the occurrence of pebbles of biotite granite. Some pebbles that resembled a granite were observed near the mouth of Char Creek. These are principally composed of ragged grains of quartz and patches of quartz mosaic, large crystals of greatly sericitized plagioclase, probably oligoclase, and a completely sericitized feldspar, possibly orthoclase. These pebbles may be altered granite or altered arkosic quartzite.

The bulk of the conglomerate in the southern part of the area occurs stratigraphically below the Irene volcanic rocks. The two alternate, however, for a short distance near their common boundary, and at least one conspicuous bed of conglomerate occurs at about the middle of the volcanic section and another overlies the volcanic rocks in Salmo area (Walker, 1934, page 6). Walker considers the latter bed the basal member of the Horsethief Creek series, but, as that series and the Toby are elsewhere conformable, the distinction depends on the presence of the volcanic rocks and is, therefore, purely arbitrary.

Irene Volcanic Formation

The Irene volcanic formation occurs in the southwest corner of the area and there overlies the Toby formation conformably.

Daly (1912, pages 145-147) was the first to name and describe the formation. It consists essentially of fine-grained, sheared greenstone or hornblende schist. Near the base of the formation the greenstone is interbedded with conglomerate and at least one prominent bed of conglomerate occurs well up in the formation. Two beds of crystalline limestone were seen interbedded with the greenstone, one of which is buff weathering and dolomitic, and the other blue-grey and essentially non-magnesian.

The greenstone is remarkably uniform throughout. Small changes in grain size and a slight lightening of the dark, greyish green colour in beds in which epidote is particularly plentiful were the only variations seen, except for local increases in the degree of shearing. There is little doubt that some of these greenstones represent intrusives, but they cannot now be distinguished from the extrusives.

The greenstone is composed essentially of amphibole, quartz, and altered plagioclase. The amphibole is the actinolitic variety and is discussed more fully in the section on the Purcell sills. The blue-green pleochroism typical of this amphibole is particularly strong. The quartz is interstitial and partly intergrown with plagioclase. The plagioclase in most specimens is too much altered to identify, but in two slides proved to be andesine. The accessory minerals are iron ore with abundant leucoxene and a few grains of apatite and zircon. Epidote occurs in most specimens and is abundant in some. It occurs as grains scattered through the rock and also in knots or patches 2 or 3 inches in diameter. In the centre of one of these knots a core of chalcopyrite an inch or more across was seen. Pyrite is scattered freely all through the rock.

The present composition of the rock is that of an andesite. As most of the minerals are obviously secondary, it is not necessarily true that the original rock was also an andesite. It is, however, doubtful if there has been much change in the bulk composition of the rock during metamorphism to its present state.

Walker (1934, page 5) examined the occurrence of the Irene volcanic formation in Salmo area and, from the following extract, it will be seen that he entertains the possibility that the greenstone is intrusive rather than extrusive. "The writer failed to discover interbedding of the Irene conglomerate with the overlying Irene volcanic (?) formation; nor was any evidence secured that indicates the extrusive origin of the greenstone composing the Irene volcanic (?) formation." The following facts have led the present writer to agree with Daly, who believed them to be largely volcanic.

(1) The interbedding of the greenstone and conglomerate at the base of the section is just as Daly describes it.

(2) Limestone and conglomerate beds occur well within the body of the greenstone. These, although only 50 to 100 feet in width, were traced along their strike for 1,000 feet or more and maintained a relatively uniform width. This circumstance is easily accounted for if they were laid down during a temporary cessation in a period of vulcanism, but perhaps is not so easily explained if they are remnants caught in the body of an intrusive or between a number of very closely spaced intrusives.

(3) Intense shearing has largely destroyed the texture and structure of the original rock, but in several places portions have escaped the worst of the shearing. In three such instances rocks were seen that contain pea-shaped patches of quartz and epidote whose sharp boundaries and general appearance suggest amygdules.

(4) Perhaps the most convincing fact is the occurrence of considerable thicknesses of breecia. The fragments and matrix of these rocks are both composed of greenstone, and they have all the appearance of a

normal volcanic breccia. They are bounded above and below by normal beds of greenstone and, in the fresh fracture, are often indistinguishable from them. On the weathered surface, however, their fragmental nature is readily apparent.

On Summit Creek, above Char Creek, occurs a bed of buff weathering, limy, green sediment, containing angular, green fragments 1 to 2 mm. across. The whole is considerably altered, but strongly suggests a calcareous tuff or tuffaceous sediment.

Horsethief Creek Series

The Horsethief Creek series overlies the Toby formation conformably. A section measured by the writer west from Rose Pass has an apparent thickness of 9,700 feet. There is, however, much folding in this locality, and it is probable that Walker's figures (1926, page 14) of 4,000 and 5,000 feet from Windermere area are more nearly correct.

The series occupies a broad belt running in a northeasterly direction from the southwest corner of the area, across Kootenay Lake, to near the northern boundary. This belt is interrupted by many granitic intrusives and its apparent thickness is greatly magnified by folding.

Walker (1926, page 14) has described the Horsethief Creek in the type locality in Windermere area in the following terms. "The formation is made up in large part of grey, green, and purplish slate with several lenticular beds of coarse quartzite and pebble conglomerate and numerous thin interbeds of blue-grey, crystalline, and mostly non-magnesian limestone, which occur at different horizons but form a relatively small part of the whole formation."

Northeast of Kootenay Lake the Horsethief Creek conforms closely to Walker's description.

The argillite is generally slaty. It may be finely laminated or uniform, mostly dark grey to black, but some beds are greenish grey. Most of the argillite is fine-grained, but some sandy beds occur. Occasional beds weather with a rust or buff colour.

Beds and lenses of blue-grey, crystalline, essentially non-magnesian limestone are in places conspicuous and aggregate a considerable part of the series in the vicinity of Rose Pass. Elsewhere they are not so common. Some beds of buff weathering, dolomitic limestone also occur.

Occasional massive beds of white, siliceous quartzite are present, but constitute only a small part of the series. Some of these beds are limy and contain many fragments of slate or limy material.

Beds of conglomerate, very much like parts of the Toby, occur all through the series. They are composed of rounded pebbles or cobbles of quartz or quartzite from an inch or two to 6 inches in diameter, with occasional slaty fragments set in a gritty, siliceous cement. Nearly all these rocks contain angular fragments of feldspar and, in some, these fragments may be an inch across and very conspicuous. In the finer beds small, pea-sized pebbles of blue quartz are rather characteristic. Siliceous conglomerate is the commonest type, but some beds are composed of angular blocks of sandy, magnesian limestone in a cement of similar composition. Beds of blue-grey limestone conglomerate also occur in places.

In the vicinity of the granitic bodies the Horsethief Creek is altered

to a quartz-mica schist with incipient cordierite, andalusite, and, in places, felt-like patches of sillimanite. All diagnostic characteristics of the unaltered formation disappear. This is particularly true around the northern end of the Bayonne batholith on the west side of Kootenay Lake. For a distance of several miles from the contact of this body the series, in most places, is unrecognizable and its identity is only inferred from the general stratigraphy and structure.

The following are the details of the section measured west from Rose Pass.

Hamill series

Conformity	Feet
Quartz-mica schist, spotted schist, and altered sandy argillite. Some beds of siliceous quartzite	1,530
Massive, grey to greenish grey quartzite and conglomerate. Cobbles up to 6 inches in diameter in a sandy matrix. Some interbedded argillite	540
Grey and greenish grey, laminated argillite with some beds of argillaceous quartzite	740
Massive, coarse-grained quartzite with some beds of fine pebble conglomerate	40
Grey-green, laminated, rusty weathering, sandy and slaty argillite. Some 8-inch beds of grey and white quartzite near the top	830
Blue-grey limestone. Thin bedded	750
Black, rusty weathering, and grey-green, slaty argillite, interbedded with quartzite	700
Massive, light-coloured quartzite containing inclusions of black slate and limy pods. Occasional interbeds of limestone conglomerate	450
Black, rusty weathering, slaty argillite	340
Blue-grey limestone and limestone conglomerate	60
Dark grey, non-limy, slaty argillite	30
Light blue-grey limestone and fine limestone conglomerate	40
Dark weathering, dark blue-grey, sandy limestone	360
Black, non-limy, slaty argillite and grey, siliceous quartzite with occasional limy beds	220
Thin-bedded, blue-grey and light buff-grey limestone. Some 10- to 15-foot beds of limestone conglomerate with 1-foot boulders near the top	1,070?
Grey and green, slaty argillite with occasional beds of grey, dark weathering, thin-bedded limestone near the top	460
Grey and green, thin-bedded, sandy limestone	10
Grey-green, non-limy, slaty argillite	230
Buff weathering, grey, thin-bedded, sandy limestone	90?
Green and grey, laminated argillite. Considerable folding	650?
Gap in section	160
Buff weathering conglomerate. Large blocks of sandy, dolomitic limestone in a cement of similar composition	30
Green, slaty argillite and sandy argillite	400
	9,730

Conformity

Toby formation

In Memoir 172, dealing with the Salmo map-area, Walker describes the Horsethief Creek series as about 4,200 feet of "a heterogeneous assemblage of sheared and schistose, argillaceous rocks with some beds of limestone and grit, with at the base a well-defined bed of boulder con-

glomerate, and bounded at the top by the massive grits of the overlying Three Sisters formation" (1934, page 7). The Three Sisters Walker describes as about 5,400 feet thick and composed mainly of fine and coarse grits with some quartzite and conglomerate beds. These are, in turn, overlain by the Quartzite Range formation, 4,400 feet thick and consisting essentially of quartzites. Above these are the Reno beds about 3,500 feet thick; the lower part consists of argillites, phyllites, calcareous beds, and quartzites; the upper part is composed of quartzites resembling those of the Quartzite Range formation. Walker believed that the Three Sisters, Quartzite Range, and Reno formations combined represented the Hamill as he had found it in the Windermere area where the Hamill directly overlies the Horsethief Creek.

The Three Sisters formation in the Salmo area is, as Walker showed. lithologically distinct from the underlying Horsethief Creek, but as the Three Sisters beds are traced northeasterly from the Salmo area they lose those features that distinguish them from the Horsethief Creek beds and, in fact, seem to merge along the strike into normal Horsethief Creek strata. For these reasons the Three Sisters is here included in the Horsethief Creek.

The term Horsethief Creek as used in this report, therefore, includes the Horsethief Creek and Three Sisters of the Salmo area.

In the southern part of the area, then, the upper part of the Horsethief Creek, that part equivalent to the Three Sisters, is decidedly different from the equivalent strata farther north. Walker's description needs little expansion. The conglomerate and grit, both of which contain many fragments of feldspar, are in no way different from certain beds of the Horsethief Creek farther north, but are so abundant as almost to exclude the argillite members. Limestone beds are very rare and siliceous white quartzite much more abundant. The boundary between the Hamill and Horsethief Creek is less clearly defined, although still easily recognizable.

Hamill Series

The Hamill series conformably overlies the Horsethief Creek. It was named and defined by Walker in 1928 and in 1929 (Walker, Bancroft, and Gunning). In general it consists of a thick series of siliceous quartzite overlain by a succession of phyllites, schists, and quartzites.

The quartzite in the Hamill series is its most striking and typical component. It occurs most abundantly at the base, indeed the first 5,000 feet are largely composed of this rock, but it is common all through the series. By far the greater part of it is extremely siliceous, generally fine-grained, and white, rose-red, grey, and green in colour. Much of it, particularly in the basal members, is in thick, massive beds with narrow partings of argillite.

Many of the high peaks in the northern part of the area are carved out of Hamill quartzite. As these weather white and are so massive that bedding often cannot be seen, the rock may be mistaken for granite even at a fairly short distance.

Schist and phyllite are common rocks in the Hamill, especially in the upper members. They have no characteristics that distinguish them from members of the Horsethief Creek and Lardeau series. Some beds of con-

glomerate were also seen in the lower part of the Hamill near the head of Midge Creek that are indistinguishable from some of the conglomerate in the Horsethief Creek.

Walker (1928, page 125) describes the base of the Hamill series in the vicinity of Crawford Creek as arkosic quartzite and, in part, fine conglomerate. As arkosic quartzite and fine conglomerate occur at many places in the Horsethief Creek and are, indeed, typical of it, the present writer prefers to consider these beds as the top of the Horsethief Creek rather than the base of the Hamill. The boundary between the two formations is, therefore, placed between the grey, rather gritty, arkosic quartzite and pebble conglomerate and the very siliceous, relatively fine-grained, light-coloured quartzite.

Details of a section measured in the mountains north of Crawford Creek are as follows:

Badshot	
Conformity	Feet
Mostly impure, greyish, schistose, micaceous quartzite.....	1,900?
Siliceous, white quartzite	400
Brown, siliceous, schistose, micaceous quartzite.....	700
Siliceous, white to rose-red, massive quartzite.....	400
Greenish grey, sandy, micaceous and chloritic argillite.....	1,500?
Thin-bedded, light-coloured, siliceous quartzite interbedded with grey and greenish grey, micaceous argillite.....	2,400
Sandy, greenish grey, and slaty, dark grey, micaceous argillite.	600
Very siliceous, thin- to medium-bedded, white, rose-red, grey, and green quartzite.....	2,700
Conformity	10,600
Horsethief Creek	

Walker's subdivision of the Windermere in Salmo area (1928, pages 3, 6-8) are Horsethief Creek, Three Sisters, Quartzite Range, Reno, and Pend-d'Oreille. As previously mentioned the Horsethief Creek of this report includes the Horsethief Creek and Three Sisters. The Quartzite Range, according to Walker, consists principally of massive, white quartzite with some slate, which corresponds closely with the basal beds of the Hamill. The top of the Hamill is marked by the Badshot limestone and, except for the presence of this formation, it would be difficult, if not impossible, to distinguish the upper horizons of the Hamill from the Lardeau. Walker describes the Reno formation as composed of white and grey quartzite, argillaceous quartzite, argillite, and some limestone. Except for the limestone this description would serve for either the Upper Hamill or the Lardeau. As no limestone has been seen in the Hamill, the limit of that series is tentatively set at the first bed of limestone in the Reno formation, and this limestone is considered equivalent to the Badshot. The Hamill is thus correlated with the Quartzite Range and that part of the Reno lying below the first bed of limestone.

Badshot Formation

The Badshot formation is relatively insignificant in size compared with the huge thicknesses of the series preceding and following it, but is easily observed and a very useful horizon marker. It was named and

described by Walker (Walker, Bancroft, and Gunning, 1929) from its occurrence in Lardeau area. It was there defined as the lowest, stratigraphically, of three prominent beds of limestone occurring in the base of the Lardeau series.

It was traced continuously from its contact with the granite at the north edge of the area to Crawford Bay, and throughout this length maintains a width of 100 to several hundred feet. On the west side of Kootenay Lake it is not nearly so conspicuous. It is not exposed along the railway and may even be missing there. It was, however, seen on the ridges north of Midge Creek where it is not more than 50 to 100 feet thick. In order to show it on the map, it has been necessary to exaggerate its width.

The Badshot consists of grey to cream-coloured, in places siliceous, or magnesian, limestone, in most places weathering a conspicuous light buff colour. Everywhere it has been recrystallized, but in the vicinity of Crawford Bay, near a granite stock, huge crystals of tremolite and wollastonite, several inches long, have developed in it and much of it is shot through with fine flakes of graphite.

Large belts of limestone occur at many places in the Lardeau series, which may easily be confused with the Badshot.

Lardeau Series

The Lardeau series was named and described from Lardeau map-area (Walker, Bancroft, and Gunning, 1929, pages 11-12). It comprises the youngest Windermere rocks known. It overlies the Badshot formation conformably and is unconformably overlain by Palæozoic formations. It is correlated with part of the Reno formation and the Pend-d'Oreille formation as these are developed in Salmo area.

Almost everywhere in the area the Lardeau has been subjected to severe metamorphism. Much of it is intruded by granitic sills, dykes, and plugs, and so granitized as to be distinguished from an intrusive with difficulty. Its thickness has been variously estimated at 10,000 to 15,000 feet (Walker, 1928, page 126; Cairnes, 1934, page 33). The thickness in the area being discussed is probably near the smaller figure and may be even less than that, but the amount of magmatic material intruded into the section and the extent of the shearing and folding renders an accurate measurement impossible.

In general the Lardeau consists of slate, schist, gneiss, quartzite, and several prominent bands of magnesian limestone.

Slate constitutes a considerable part of the Lardeau series, where it is least metamorphosed. It is a dark grey to black, fissile rock, commonly spangled with fine mica.

By far the greater part of the Lardeau is composed of schist of various types. The commonest is a muscovite-biotite schist, much of which contains garnet, andalusite, and sillimanite. A certain amount of hornblende and chlorite schist also occurs, some of which, at least, is developed from a calareous rock, the rest probably from greenstone sills.

The schist gives place to gneiss where metamorphism is more intense and it, in turn, grades into rocks indistinguishable from the granitic intrusives. Indeed it is impossible to tell how much of the granite in this

region is actually intrusive and how much merely the product of high-grade metamorphism of sediments. This is particularly true around Crawford Peninsula and east and south of Procter. Patches of the same type of rock also occur along the shore of Kootenay Lake north of the West Arm. McConnell and Brock (1904) mapped these rocks as Shuswap and considered them to be of Archæan age. They are now known definitely to be Lardeau sediments intruded and metamorphosed by late Mesozoic granitic bodies.

Quartzite occurs in beds from 1 to over 100 feet thick. It grades from grey, argillaceous quartzite to a light-coloured and highly siliceous type. Calcareous quartzite is most common near the base of the formation, but occurs all through it.

Large belts of creamy white to light grey, buff weathering, in places magnesian, limestone occur all through the Lardeau series. They constitute a relatively small proportion of the series, but are very conspicuous. Some have even been given formational rank in Ainsworth district by Schofield (1920). They are similar to the Badshot formation, indeed that formation is really the lowest, stratigraphically, of them. All are more or less recrystallized and some are flecked through with graphite. Some are massive, others composed of thin beds separated by narrow bands of argillite or schist.

GENERAL DISCUSSION OF THE WINDERMERE

Distribution

From Salmo area northeast through the present area the Windermere occupies a belt from 10 to 20 miles wide. North of this the belt spreads out to a width of nearly 50 miles through Windermere and Lardeau areas. Still farther north Windermere rocks have been traced for 60 miles to the bend of Columbia River. North of this again little work has been done, but Precambrian rocks, some of which at least are probably of Windermere age, are known to occur in places along the line of the Rocky Mountain Trench as far as the Yukon; whether as a continuous belt or in patches is not known. South of the International Boundary formations of Windermere age have been traced through northern Idaho and Washington.

General Features and Problems

The Windermere rocks as a group have many characteristics different from those of the Purcell. For one thing, they are commonly coarser grained; conglomerate and quartzite as coarse as the grit beds that occur in the Toby and Horsethief Creek are not known in the Purcell formations.

The limestone beds of the Badshot and Lardeau are not unlike some of the Kitchener-Siyeh, but are much more prominent and stand out conspicuously from an assemblage of generally non-calcareous rocks in a way in which the Kitchener-Siyeh limestone beds do not.

It is interesting to note the repetition, in general, of a normal cycle in each series. In the Purcell the oldest known formations, the Aldridge and Creston, are predominantly argillaceous quartzite and are followed by calcareous and fine-grained, argillaceous rocks in the succeeding formations. The Windermere starts with a basal conglomerate, which is followed

by generally coarse-grained rocks in the Horsethief Creek and Hamill, and is succeeded by predominantly argillaceous rocks in the upper Hamill with which are interbedded limestone in the Badshot and Lardeau.

The Toby formation presents a problem. Walker (1926, page 16) considered that the marked variation in its thickness and the rapid alternation from fine to coarse conglomerate and to one containing huge angular blocks suggests a fan structure, such as occurs at the present day along the base of a high range of mountains. He points out, however, that such a deposit forms a narrow, sinuous belt bounded on the one hand by the base of the mountains and on the other by the limits of deposition, and that the Toby does not appear to occupy so narrow a belt. Walker had traced the Toby continuously from Windermere area to Kootenay Lake, except where cut out by granitic intrusives, when he made this suggestion. The present writer, by correlating the Toby with the Irene conglomerate, has extended the known occurrence of the Toby still farther south to the International Boundary. As the section exposed on the present land surface is purely accidental and its extension in one direction has proved to be so great, it is fair to argue a very considerable extension also in the direction not exposed, far more than can reasonably be expected if the Toby were a fan deposited along the base of a mountain range. It seems to the present writer more probable that the Toby was laid down along the shoreline of a sea that spread rapidly over the land, roughly reworking the loose, superficial deposits. In such a case, where rounded, terrestrial gravels had been deposited the pebbles of the Toby would be of fairly uniform size and well rounded, elsewhere the resulting conglomerate would be composed of subangular cobbles formed by the rough working of angular blocks lying on the outcrops.

The presence of pebbles and fragments of orthoclase in the Toby and succeeding Horsethief Creek suggests a granitic intrusive as a source of at least some of the sediments. No granite of pre-Windermere age is known to be exposed in British Columbia.

The recurrence of conglomerate all through the Horsethief Creek points to a land mass of high relief adjacent to the basin of sedimentation. The progressive decrease of the average grain size through the Hamill, Badshot, and Lardeau suggests that the relief of this landmass was gradually reduced through Windermere time.

Vulcanism

The only period of vulcanism known to have occurred during Windermere time is that represented by the Irene volcanic formation. These volcanic rocks have been traced from the International Boundary north to the head of Blazed Creek, a distance of over 20 miles. The northern end is cut by large granitic intrusives, by one of which the belt is finally truncated, not to reappear.

From a thickness of several thousand feet at the International Boundary, the volcanic rocks thin rapidly to the north to a few hundred feet where last observed. It is probable, therefore, that the source of the volcanic rocks is south of the International Boundary and the direction of flow, at least in part, to the north. The exceptional thickness of the underlying Toby conglomerate suggests that both it and the volcanic

rocks were deposited in a basin in the land surface of that time, indeed it is possible that the distribution of the Irene volcanic formation may be more or less restricted to a deep valley in contrast with the widespread distribution of the Mesozoic volcanic rocks to the west.

Age

The Toby rests unconformably on the Purcell series at a number of places and Walker (1928, page 125) reports a great angular discordance. It is clear, therefore, that there was a sufficient interval of time to allow for considerable erosion and some folding between the deposition of the Purcell and Windermere.

In the present area the oldest rocks overlying the Windermere are those of the Milford group, the lower part of which is believed to be of Carboniferous age. Walker (1926, pages 17, 18) reports that the Lower Cambrian Cranbrook quartzite overlies different members of the Windermere at a number of places and that there is evidence of a profound unconformity between them. The Windermere is, therefore, considerably older than the Lower Cambrian Cranbrook formation. For this reason, and because for years competent observers have searched fruitlessly for fossils in the Windermere, although the lowest known Cambrian is everywhere highly fossiliferous, the Windermere is believed to be of Precambrian, presumably late Precambrian, age.

Parks (1938, page 713) reports Lower and Middle Cambrian fossils from formations in Washington that he correlates with formations in the Salmo area believed by Walker (1934) to be of Windermere age. The structure on both sides of the International Boundary in this region is extremely complex, and downfaulted and infolded blocks of Palæozoic and Mesozoic rocks probably occur and may even be common. One such block of fossiliferous Middle Cambrian sediments has recently been reported (Campbell, Sharp, and Gale, 1937) to occur in Montana surrounded by formations of Purcell age. It is not, therefore, impossible that either Parks or Walker may be mistaken in their correlations.

PRE-GRANITE IGNEOUS ROCKS

A great many sills and dykes occur all through the Purcell and Windermere series. They have been divided into three groups.

Purcell Intrusives

By far the most striking of these are the Purcell intrusives. They are described by Daly (1904, 1905, 1906, and 1912, pages 207-220) and later exhaustively discussed by Schofield (1914, and 1915, pages 56-75).

The Purcell intrusives are widely distributed in all formations of the Lower Purcell. They occur as sills and dykes, but the dykes are so few and unimportant compared with the sills that the following description refers mainly to the latter.

The Purcell sills vary in size from thin sheets to tabular bodies 700 feet or more thick. A sill 2,000 feet thick has been reported from Idaho (Kirkham and Ellis, 1926), but neither in the present area nor in Cran-

brook area (Rice, 1937) was any sill observed that approached this thickness. Several multiple sills were seen, however, with an aggregate thickness of 1,000 feet or more.

The Purcell sills are composed of dark green, crystalline rock, with an average grain size of 2 to 3 mm. In most sills there is a zone in the upper quarter of the sill in which streaks and patches of coarse-grained, pegmatitic rock occur. The pegmatitic phase is characterized by plume-shaped amphibole crystals an inch or more long.

The present composition of the normal sills varies from that of an acid gabbro to a tonalite or quartz diorite, by far the commonest type being quartz diorite. The following minerals occur: amphibole; plagioclase; quartz; titaniferous magnetite or ilmenite; leucoxene; biotite; apatite; pyrite; chalcopyrite; and pyrrhotite. The mode of the average rock is given below.

	Per cent
Amphibole	50
Plagioclase	40
Quartz	4
Iron ore	2
Accessories	4

The amphibole is dark green and occurs as large, poikilitic, tabular crystals and also as minute prisms included in the other minerals. The writer has discussed it briefly in a short paper (Rice, 1935). The chief characteristic of this amphibole is a distinctive pleochroism: X—pale yellow, Y—deep green, Z—blue-green. The amphibole varies from sill to sill, but all belong to a single series, which is, apparently, a continuation of the tremolite-actinolite series beyond the actinolite end. The amphibole having the strongest pleochroism has the following optic properties: 2V—41°; Z/C—16°; $N\alpha$—1·665, $N\beta$—1·686, $N\gamma$—1·689; $N\gamma$-$N\alpha$ 0·024. The optic properties of the amphibole with the weakest pleochroism are as follows: 2V—83°; Z/C—20°; $N\alpha$—1·614; $N\beta$—1·630; $N\gamma$—1·642; $N\gamma$-$N\alpha$ 0·028. The amphibole is probably an alteration product of pyroxene. In one dyke augite occurs partly replaced by amphibole, although no pyroxene was seen in any sill.

The plagioclase is oligoclase to acid andesine clear and generally untwinned. Many grains contain small crystals of amphibole or are penetrated by larger crystals. Some of the plagioclase occurs as a myrmekitic intergrowth with quartz.

Quartz is always present, but forms not over 10 per cent of the normal rock. Near the boundary of a sill in contact with quartzitic sediments it occurs in greater amount and may constitute 25 per cent of the rock.

Titaniferous magnetite or ilmenite is present in all specimens and may form 2 or 3 per cent of the rock. In many it occurs as skeltal crystals. Most grains are surrounded by leucoxene.

Biotite is rare in the normal rock, but may be quite abundant near the contacts. In many cases it has a pronounced sieve texture.

Pyrite, pyrrhotite, and chalcopyrite occur as small specks in most specimens. They are generally very scarce, but locally, near ore-bodies, they may be abundant.

The amphibole contains many inclusions of plagioclase and also occurs as fresh needles penetrating the plagioclase grains. Both modes of

occurrence bear out the suggestion of Gibson and Jenks (1938, page 311) that it is a secondary mineral. The extremely fresh appearance of the rock, the sieve-texture of the biotite, and the clear, untwinned plagioclase seem to indicate that the whole rock has been reconstituted by high-grade, static metamorphism. Opposed to this hypothesis is the fact that the sediments into which the sills have been intruded do not show comparable metamorphism. Sedimentary textures are perfectly preserved in many instances and in few places has metamorphism been very intense. The only suggestion the writer has to offer for these apparently contradictory facts is that the composition of the sills may have been particularly suitable for advanced metamorphism under the existing conditions whereas that of the sediments was not.

The writer (Rice, 1937, page 17, 18) has already discussed the conclusion reached by Daly (1913, pages 221-225) and Schofield (1914) that the rocks of granitic appearance overlying certain sills are magmatic differentiates, and has pointed out that, in all cases examined by him, the "granitic" rock was metamorphosed sediments.

A number of examples were examined in the present area, including both Daly's and Schofield's type sections. The example best exposed was seen on the trail up Iron Range Mountain from Kitchener. There a normal sill is overlain by 10 to 15 feet of "granitic" rock that, in turn, is overlain by Aldridge argillaceous quartzite. The contact between the diorite and "granitic" rock is marked by a zone 3 to 6 inches wide composed of quartz, biotite, plagioclase, and amphibole, and is rather coarser grained than the rocks on each side. The "granitic" rock 6 inches from this zone looks like a light grey, medium-grained granite. It is composed of biotite, often with a pronounced sieve-texture, quartz, in part a regrowth of rounded grains, clear, mostly untwinned oligoclase, in part intergrown with quartz to form myrmekite, apatite, calcite, and zoisite. The texture is confused and all minerals are plentifully dusted with inclusions. This rock grades into the normal quartzite through a zone 2 to 3 feet wide in which the "granitic" rock alternates with normal sediment, but without sharp contacts. The evidence is quite clear, for this case at least, that the "granitic" rock is altered quartzite with, probably, a certain amount of material added by hydrothermal solutions from the intrusive.

In Daly's and Schofield's type sections the evidence is not so clear; for one thing exposures are not nearly so good. Even in these cases no evidence was seen that suggested that the explanation given for the example just cited is not entirely admissible.

No direct evidence has yet been obtained of the age of the Purcell intrusives except that they are older than the Mesozoic granitic intrusives.

Daly, who in 1913 made the first real study of the Purcell sills in Canada, and Schofield (1915) considered them to be Precambrian in age and to be related to the Purcell lava, which marks the top of the Lower Purcell. Schofield (1915, page 69) admits that "No field facts, except similarity of composition, were noted in the study of the Purcell range, which would definitely correlate the Purcell sills and the Purcell lava." Daly (1913, page 218) based his assumption on this similarity of composition and on the fact that the known occurrences of Purcell lava are everywhere stratigraphically underlain by Purcell sills or dykes.

The writer in an earlier publication (1937, page 18) presented indirect evidence to support the conclusion of Daly and Schofield that the intrusives and the Purcell lavas are related. Work in the Nelson area has furnished arguments that shake his belief in the validity of this conclusion.

The following is a statement of the facts, so far as they are known, that have a bearing on this matter.

Sills and dykes indistinguishable in the field or laboratory occur all through the Lower and Upper Purcell. Sills and dykes closely resembling those in the Purcell also occur through the Windermere, but have been so sheared that identity of composition cannot be established.

The largest sills occur in the Aldridge formation and the sills are progressively smaller in the succeeding formations. Sills 100 to 200 feet thick, however, occur as high as the Mount Nelson formation.

The sills appear to have suffered all the deformation to which the sediments have been subjected.

Careful search both by the writer and Walker[1] has failed to reveal any pebbles of the Purcell intrusive in either the Toby or Cranbrook conglomerates. On the other hand, no Purcell intrusives have been seen to intrude either of these formations.

There are three volcanic formations to any of which all or part of the Purcell intrusives may be related. These are the Precambrian Purcell lavas in the Siyeh formation, the Precambrian Irene volcanic formation, and the volcanic rocks in the Kaslo series of Triassic age.

An age determination by the helium method has been made by Urry (Lane, 1936, page 37) on specimens from two dykes and a sill from the vicinity of the Sullivan mine. He determined the age of the dykes to be 495 ± 20 and 455 ± 15 millions of years and the sill to be 530 ± 50 millions of years. This, according to the time table given by Urry, places the dykes as of the age of the Lower and Middle Cambrian, respectively, and the sill as of Keweenawan age.

A few small, greatly altered greenstone dykes and sills occur on Perry Creek. One of these cuts Cambrian rocks in Cranbrook area.

Greenstone Sills and Dykes

Mention has already been made of sills and dykes occurring in the Windermere. As the term "Purcell intrusives" was applied to rocks supposedly of Purcell age, the sills and dykes cutting later strata will be considered as a separate group although they may be correlatives.

No sills approaching the size of the larger Purcell sills were seen in the Windermere and, either as a consequence of this difference in size or because of inherent differences in the rock, the greenstone is noticeably finer grained. An exception to this is a sill that occurs near the Crawford Bay-Kootenay Bay road and contains amphibole crystals an inch long.

The normal greenstone is a dark green, almost black rock with a pronounced schistose texture and a noticeable lack of light-coloured minerals. Some phases are speckled with feldspar, but no really light-coloured types were seen. They are composed largely of amphibole in fine needles with a common orientation. This is the blue-green, pleochroic,

[1] Walker, J. F.: Personal communication.

actinolitic variety that occurs in the Purcell sills. The remainder of the rock is composed of interstitial, clear, untwinned oligoclase and occasional grains of apatite, magnetite, zircon, and titanite. The rock has now the composition of a diorite, but most, if not all, of the principal constituents are secondary and it cannot be assumed that the original composition of the rock was the same.

No definite age can be ascribed to the greenstone. It is quite possible, indeed probable, that rocks of two or more ages have been grouped together. They are obviously younger than the Precambrian rocks they intrude and are definitely older than the end of the period of folding, faulting, and granitic intrusion of the late Mesozoic. Two periods of vulcanism occurred during this interval of time, each of which produced rocks of apparently the same composition as the intrusives. It may be assumed that some at least of these intrusives are related to each period of vulcanism.

During the first period the Precambrian Irene volcanic rocks were extruded and during the second the Triassic Kaslo volcanic rocks. There can be little doubt that many of the greenstone dykes and sills in the Milford and upper Lardeau in Ainsworth district are related to the latter volcanics, but how many of the intrusives lower down in the stratigraphic section and farther away share this relationship cannot be determined at the present time.

Peridotite

A small stock of ultrabasic rock occurs close to the edge of the White Creek batholith near Dewar Creek. It is dark greyish green to bluish grey and mostly coarse-grained. The bulk of the rock is peridotite composed mainly of olivine, but containing also a little pyroxene and magnetite. Some of the olivine is altered to serpentine. The amount of pyroxene varies considerably and in certain phases the rock is a pyroxenite with pyroxene the only primary ferromagnesian mineral. In this phase calcite is abundant.

The age of this body is not known except that it cuts the Creston and is cut by granitic dykes.

LOWER CAMBRIAN FORMATIONS

Lower Cambrian formations occur in fault blocks, the largest being roughly triangular and about 11 miles long. They are known only in the southeastern quarter of the area around the headwaters of Goat River and Hellroaring Creek.

The Lower Cambrian has been divided into two formations (Schofield, 1922, pages 9-13); the Cranbrook at the base overlain by the Eager.

Cranbrook Formation

In the type locality near St. Eugene Mission in Cranbrook area, the Cranbrok formation consists (Rice, 1937, pages 18-21) of some 600 feet of massive, coarse-grained, siliceous quartzite, white, rose-red, green, and grey in colour. Small fragments of the underlying argillite occur in the basal beds and twin beds and lenses of fine pebble conglomerate lie at a number of

horizons. These siliceous quartzites are also typical of the Cranbrook formation in the Nelson area, but on Goat River conglomerate is much more plentiful than at any other place. Pebble conglomerate occurs all through the section there and the basal beds are coarse, cobble conglomerate with blocks a foot long not uncommon (Plate II A). These cobbles and blocks consist of quartz, quartzite, and occasional small fragments of argillite. The cement is commonly fine quartz grains, but in some places it is calcite or dolomite. Several cobbles and one large block of clearly recognizable "purple mottled" Creston quartzite were seen.

Near Marysville, in Cranbrook area, a large body of magnesite is a part of the Cranbrook formation (Cairnes, 1932, pages 101-104; Rice, 1937, pages 19, 20). Similar magnesite occurs in a small infold of Cranbrook in the saddle between the head of Hellroaring Creek and Goat River and in the main body of Cranbrook where it crosses the head of a tributary of Hellroaring Creek. The full extent of the latter body is not known. It appears to be of good grade, but it is too far from transportation to be of economic importance at the present time.

In Cranbrook area evidence of unconformity at the base of the Cranbrook formation is puzzlingly scarce. In the present area, however, the evidence is clear and incontrovertible. No angular unconformity was detected, but at several outcrops on Goat River the Cranbrook overlies Precambrian rocks with a noticeable erosional disconformity. Moreover, the Cranbrook has been seen to lie on Siyeh, Kitchener, and Creston rocks and clearly recognizable Creston cobbles occur in the basal conglomerate. There is, therefore, no doubt that the contact between the Cranbrook and the Precambrian is marked by an important unconformity.

The nature of the contact between the Cranbrook and the overlying Eager formation is not so clearly known. The writer has seen the contact well exposed in only one place. There the two formations are apparently conformable and grade into each other through a transition zone several hundred feet thick. Schofield (1922, page 12) had previously arrived at the same conclusion.

Schofield (1922, page 15) considered the Cranbrook to be Lower Cambrian in age and correlated it with certain quartzites and conglomerates that conformably overlie the Lower Cambrian Burton formation at Ram Creek and Elko. The additional evidence obtained in the present area on the nature of the upper and lower contacts strengthens this belief. No identifiable fossils were found. "Punctate forms"[1] found by Evans[2] in the Lower Cambrian Lower Donald formation in Brisco-Dogtooth map-area (Evans, 1932, page 122) were also seen in some specimens from the present area.

Eager Formation

The Eager formation overlies the Cranbrook in most of the localities where the latter is exposed. Evidence as to the nature of the contact is rather scanty, but suggests that the two formations are conformable.

At the type locality near St. Eugene Mission, Cranbrook area, the Eager consists of dark grey, blue-grey, olive-green, and reddish, platy

[1] Miscroscopic fragments with systematically developed dark dots, possibly fragments of hyolithes.
[2] Evans, C.S.: Personal communication.

argillite. Most of this argillite is softer and more friable than the argillite in the Precambrian. In the present area, also, these types are common, but in addition impure quartzite, sandy and calcareous argillite, and impure limestone occur. The formation as a whole is composed of soft rocks and is very commonly deformed into soft, micaceous and chloritic schists, much of which has a distinctive, crinkly, silky appearance.

Fossils have been found at a number of localities and have been identified as upper Lower Cambrian forms. The age of the formation is thus definitely known.

It has not been possible anywhere to measure a section of the Eager and the writer has little idea of its thickness except that it is certainly some thousands of feet. It is not even certain that the section is continuous or, as no fossils have been obtained from the upper part, that rocks younger than the Lower Cambrian may not occur. Difficulty in obtaining information is due to the folding and shearing to which the Eager has been subjected and to the inaccessibility of the principal occurrence at the head of Goat River.

DISTRIBUTION OF THE CAMBRIAN

The distribution of the Cambrian formations in Nelson and Cranbrook areas presents a problem. The most westerly known occurrence is on Goat River. There and to the east, the Cambrian lies on Siyeh, Kitchener, or Creston, all formations of the Lower Purcell. Exposures in Cranbrook area suggest angular conformity or, at most, slight disconformity. On Goat River the Cambrian in places rests on the Creston with no evidence of marked Precambrian folding. Only 13 miles to the west the Lower Purcell is overlain by the Upper Purcell, which is, in turn, overlain by the Windermere series. In other words over 35,000 feet of sediments are missing.

CARBONIFEROUS AND TRIASSIC

Milford Group

The Milford group overlies the Lardeau and is overlain or cut by members of the Kaslo series. It has been fully described by Cairnes (1934, pages 38-43).

In the present area it occupies a narrow belt along the west side of Kootenay Lake from the north edge of the area to the middle.

North of Kaslo, where it has been mapped in detail by Cairnes, it was not studied by the writer. Briefly (Cairnes, 1934, pages 39-41), it there consists of platy argillite, and slate, quartzite, chert and associated volcanic rocks, and fine-grained, flaggy, mostly dark-coloured, fossiliferous limestone. South of Kaslo the Milford has been altered and, consequently, differs in many particulars from the description given by Cairnes. The following description of rock types is applicable to the more or less altered formation.

Near Kaslo, argillite constitutes a considerable part of the group, but south of Woodbury Creek it is uncommon, its place generally being taken by schist. Where least altered the argillite is dark grey to black and frequently spangled with mica. It is, as Cairnes mentions, more frequent in the upper part of the formation than the lower.

Grey to brownish grey, micaceous quartzite occurs throughout the group, but is the commonest rock type in the basal beds. It is generally metamorphosed to a quartz-mica schist or gneiss, which is indistinguishable from many members of the Lardeau series. It is, therefore, frequently impossible to map the contact between the two formations with certainty.

Somewhere near the middle of the group occurs a band or bands of quartzite quite different from the normal type described above. North of Woodbury Creek this consists of a very fine-grained, thin-banded, siliceous rock, generally light brownish grey. It is very brittle and almost cherty in appearance and is possibly the equivalent of Cairnes' cherts. Farther south this quartzite is metamorphosed to produce a very striking rock. The writer has called this rock "ribbon quartzite" as its distinguishing feature is bands or ribbons of snow-white, fine-grained, siliceous quartzite an inch wide separated by fine partings of dark argillite. At one place south of Coffee Creek a band of this rock over 300 feet wide was seen.

Limestone beds occur all through the Milford. Near Kaslo the limestone is commonly dark grey to almost black, fine-grained, and generally flaggy. To the south it is recrystallized and light grey to white and is interbedded with narrow, dark, argillaceous bands a foot or so apart. No fossils were seen by the writer.

The greater part of the Milford as seen by the writer is composed of schists. The impure quartzite, as already mentioned, is altered to quartz-mica schist and gneiss and the argillite to lustrous mica schist, some of which is plentifully studded with garnet and andalusite. Where only this type of rock is exposed the Milford cannot be distinguished from the Lardeau.

All through the Milford, especially near the top, sills and dykes of sheared greenstone are common. Most if not all of these are related to the Kaslo volcanic rocks. As it is impossible in most instances to distinguish between the fine-grained intrusives and flows, it is difficult to determine the position of the contact between the Milford and the Kaslo.

No evidence of unconformity between the Milford and Lardeau was obtained by the writer. In Slocan and in Lardeau areas (Cairnes, 1934, pages 36-38; Walker, Bancroft, and Gunning, 1929, pages 12-14), however, there is no doubt of the existence of such an unconformity.

In 1917 Bancroft (page 37) collected fossils from the base of the Milford that are probably of Pennsylvanian age. Later Cairnes (1934, page 34) found fossils in the upper part of the group that are probably of Triassic age. It, therefore, seems probable that the Milford group includes both Palæozoic and Mesozoic members, although as yet it has not been possible to subdivide it.

Kaslo Series

From the part of the area north of Kaslo, Cairnes (1934, pages 43-52) describes a large body of intrusive and extrusive rocks that he calls the Kaslo volcanic series. Both he and Walker believed this body to die out completely to the south. In the vicinity of Fletcher Creek it certainly becomes very narrow and may be missing completely, but the writer has been able to follow it at intervals south of this through Ainsworth district and across West Arm. The series throughout this region is nowhere very wide and may, indeed, be absent in places.

In general the Kaslo series consists of fine-grained flows, volcanic breccias, and tuffs, with associated intrusives and minor amounts of interbedded sediment.

The igneous rocks are dark green and for convenience are called greenstone. Most if not all are sheared and altered to platy, amphibole schist. Most of them are fine-grained, homogeneous rocks, but some show pronounced laminations in dark and light shades. Some of the coarser phases, probably intrusive, are gneissic. Volcanic breccias and well-bedded tuffs can be recognized in places that have escaped the worst of the shearing.

The interbedded sediments consist of brownish grey, micaceous quartzite and knotted mica schist. They occur all through the section, although they make up only a small proportion of the bulk of the series.

The Kaslo series is bounded stratigraphically both above and below by sediments in which fossils of Mesozoic, probable Triassic, age have been discovered. It is, therefore, undoubtedly Mesozoic and probably Triassic in age.

Slocan Series

The Slocan series, so widely distributed through Slocan area, also occurs, in part, in the northwestern corner of the present area.

Like all formations in the area the Slocan has been considerably altered, but generally not enough to mask completely all its characteristics.

The base of the series consists mainly of brownish grey, impure quartzite, variously altered to micaceous quartzite and garnetiferous, quartz-mica schist and gneiss. Similar rocks occur at a number of horizons throughout the series.

Minor amounts of argillite and limestone are interbedded with the quartzite at the base of the series, but the most interesting and distinctive rock in this zone is a fine conglomerate or breccia. On the road to No. 1 mine this rock consists of angular to subangular fragments of grey quartz and quartzite in an argillaceous matrix. Two beds of it were seen, each 2 or 3 feet thick and a few feet apart. The rock is much altered and many of the smaller fragments changed to knots of secondary minerals. A knotted schist occurs at about the same horizon at several places, notably on the pipe-line above the Highland mine. These knots resemble the altered fragments in the conglomerate described above, and it seems probable that the knotted schist is actually a similar conglomerate, but so altered as to mask its true nature.

A number of bands of chlorite and amphibole schist occur in the same basal zone. Some of these have prominent patches of dark chlorite developed in a way that suggests that the original rock was a medium- or coarse-grained fragmental. Alteration is severe, but the rock is not unlike a sheared tuff or volcanic breccia. It is, however, quite likely that it is a sediment derived by erosion of the underlying volcanic rather than a true volcanic rock.

The bulk of the Slocan series is composed of argillite and slaty argillite. This is a rather monotonous, dark grey to black rock. Both limy and nonlimy types are present and much of it is distinctly graphitic. Near bodies of granite it is altered to mica schist.

Limestone forms a prominent part of the Slocan series in the present area. North of Woodbury Creek, where it has been only slightly metamorphosed, it is mostly fine-grained, dark grey to black, and generally graphitic and flaggy. Farther south it is largely recrystallized and the dark material mainly restricted to narrow bands or partings. This rock, as a whole, is blue-grey to white. The limestone occurs in thick, persistent, and conspicuous belts at various horizons.

All members of the Slocan series except the limestone form schist when suitably metamorphosed. Andalusite, quartz, and garnetiferous mica schist all occur. Talc-carbonate and amphibole or chlorite schist are to be seen although not common.

No suggestion of unconformity was seen between the Slocan and Kaslo series, unless one might be inferred from the presence of fragmental rocks at the base of the Slocan. Cairnes (1934, page 58), however, studied the contact and basal beds to the north, where they are much less altered, and believes that the Slocan series overlies the Kaslo disconformably.

No identifiable fossils were collected by the writer, but collections made by Cairnes leave little doubt that the Slocan series is Mesozoic and probably Triassic in age.

GRANITIC INTRUSIVES

Parts of five batholiths and many stocks, dykes, and sills of granitic rocks occur in the area. In addition to the rocks exposed, areas of intensely metamorphosed sediments may indicate the presence of underlying granitic bodies.

White Creek Batholith

This body lies in the northeast corner of the area and is well exposed on White Creek (East Fork of St. Mary River). It consists of a coarse-grained, pinkish white to grey granite, commonly, but not always, porphyritic. The mode of a typical specimen is given in Table I, page 38.

Biotite is almost the only ferromagnesian mineral present, and commonly forms less than 5 per cent of the rock. Orthoclase and microcline occur in the groundmass and as phenocrysts in the porphyritic types.

Pegmatite and aplite dykes are common on the borders and in places carry small amounts of black tourmaline and blue-green beryl. Highly altered, comparatively small inclusions lying parallel with one another are common. Metamorphism is severe all along the contact, but does not extend over 1,000 feet or so from it in most places. From this it may be argued that the contacts generally dip steeply.

The contact and border of the batholith was studied carefully on the southwest end of the body and, as the phenomena seen are typical of most of the batholiths, they will be described in some detail. The sediments for a distance of 100 feet from the contact are more or less altered to mica schist and are intruded by many small sills and dykes of fine-grained granite. These minor intrusives and the margin of the main body are slightly gneissic, although away from the contact the main body is massive. The border phase of the granite body, 50 to 100 feet thick, is fine- to medium-grained, grey, and non-porphyritic. The main body of the rock is

pinkish grey, coarser grained, and markedly porphyritic; at one place over 75 per cent of the rock is made up of phenocrysts. Throughout this porphyritic phase small inclusions lying parallel with one another are much more common than in the non-porphyritic border phase. The presence of non-porphyritic rock near the contact and of porphyritic rock farther within the body is a common phenomena in the granitic bodies in the area. It is not, however, universal, for highly porphyritic marginal phases were seen at several places.

Fry Creek Batholith

The body of light grey, granitic rock on Fry Creek (Walker, 1928, page 128) extends south into the present area and down the upper reaches of St. Mary River. It lies in the heart of a group of high, rugged mountains and is practically inaccessible. The boundary is, therefore, accurately located only in a few places.

On St. Mary River the body is mainly composed of light grey, coarse-grained, biotite granite and granodiorite. Most of it is even textured, but orthoclase phenocrysts occur in a few places. In general, its internal and external relations are similar to those of the White Creek batholith except that the porphyritic phase is apparently much less common. The mode of a typical specimen is given in Table I-10.

Bayonne Batholith

Daly (1912, pages 289-296) describes a granitic body extending from near the International Boundary across Kootenay Lake, which he calls the Bayonne batholith. Daly's study appears to have been confined largely to a smaller body at the Bayonne mine, which he believed to be a part of the main body but which the present writer believes to be distinct, more basic, and probably somewhat older. Daly's term, "Bayonne batholith," is retained for the main body.

The Bayonne batholith varies in composition from a granite to a calcic granodiorite; the average composition is that of a fairly alkaline granodiorite. Modes of various phases are given in Table I. Much of the rock has an equigranular texture, but a porphyritic phase occurs in many places, at some of which phenocrysts of potash feldspar 2 or 3 inches long are present.

The potash feldspar may be orthoclase or microcline and in some specimens both occur. The plagioclase is oligoclase, generally well twinned and frequently in zoned crystals. Dark brown biotite is the only ferromagnesian mineral abundant, but grains of hornblende occur in rare instances. The usual accessories are present. Sericite and epidote are the commonest secondary minerals, but neither occur in significant amounts except where the rock has been altered.

A marked feature of the Bayonne batholith is its highly variable nature. This is observable not only in the range of composition but in the appearance of the rock. Coarse-grained and fine-grained, porphyritic and non-porphyritic, pink and light or dark grey phases may occur in a single exposure, in some places in streaks and patches as though roughly stirred together with a giant spoon. Masses of pegmatite and dykes of pegmatite

and aplite occur everywhere. Some of the pegmatite dykes are over 100 feet wide. A few large crystals of blue-green beryl, pink garnet, magnetite, and a little black tourmaline were seen in these pegmatites.

Large inclusions of granitized sediments are locally abundant, for example, along the railway south of Bayonne. These inclusions vary in size from a foot to some hundreds of feet. Alteration is severe, but the sedimentary nature of the original rock is, in most cases, still recognizable and the boundary between the granite and the inclusion is generally fairly sharp. Other inclusions or zenoliths from a few inches to a foot long also occur, which can readily be distinguished from the first type mentioned. They parallel one another, are darker coloured, their original texture and composition has been more or less completely altered, they are fairly uniform in size, and they usually grade imperceptibly into the granite. They are more widely distributed, indeed very few exposures of any size were examined that did not contain some of these zenoliths, and in places they are extremely abundant. The zenoliths are often most common in the porphyritic phases and scarcer in the non-porphyritic phases of the granite. In so many cases does this appear to be true that the writer began to suspect a connection between the two. Exceptions are not uncommon, however, and much more observation is needed before any generalization can safely be made.

Nelson Batholith

The eastern fringe of the Nelson batholith lies along the west border of the area in Ainsworth district. Cairnes (1934, pages 61-70) has given a full description of the various types of which the Nelson batholith is composed. The part in the area consists of pinkish, coarse-grained, porphyritic granite or granodiorite grading to grey, non-porphyritic granodiorite at some of the contacts.

Rykert Batholith

The extreme northern end of a granitic batholith lies along Boundary Creek, on the southern edge of the area. To this body Daly (1912, pages 284-287) gave the name Rykert batholith. Few exposures were seen by the writer, but Daly has described it in considerable detail.

It varies in composition from calcic granodiorite to basic granite, is pink to grey, and is both porphyritic and non-porphyritic. The chief ferromagnesian mineral is biotite, but amphibole occurs in some places. This amphibole is the blue-green, pleochroic, actinolitic variety mentioned before in connection with the Purcell sills. Two modes, one taken from Daly and one made by the writer, are given in Table I.

The principal feature of the Rykert granite, which distinguishes it from other large bodies in the area, is its gneissic texture. Gneissic rocks occur in most of the other bodies, but are of strictly local extent, whereas all the Rykert granite seen by the writer or described by Daly is noticeably gneissic. This texture has evidently developed by the crushing of the rock under stress after its consolidation. Both the quartz and plagioclase show marked wavy extinction and some of the rock is a mylonite gneiss. The porphyritic variety has been transformed into augen

gneiss by the breaking off of projecting portions of the orthoclase phenocrysts, the fragments being strung out along the axes of least pressure at both ends of the crystal. The shear planes strike roughly north 15 degrees east and dip about 80 degrees west.

Mine Stock

Two granitic stocks occur close to the southwest corner of the Bayonne batholith. These have been called the Mine stock and the Wall stock.

The Mine stock is the more southerly of the two. At its eastern end it abuts on the Bayonne batholith, but the contact was nowhere seen and it is not known if the two grade into each other, if there is a crosscutting relationship, or if the two are separated by a thin band of sediments. The writer believes the Mine stock to be a separate body rather than a part of the Bayonne batholith, as it is everywhere sufficiently different in appearance and composition to be recognized easily in the field. Its relation to the sediments, too, is somewhat different, as will be pointed out later.

The Mine stock consists of a fine- to medium-grained, light grey rock, fairly uniform in texture and composition. It is non-porphyritic, contains few inclusions and zenoliths, and has the average composition of a calcic granodiorite. Most hand specimens are deceptive, as amphibole appears to be equal to or more abundant than biotite although actually this is not true. This amphibole is significant, as in only two specimens of the Bayonne granodiorite was amphibole seen at all and then only two or three grains. The proportion of potash feldspar to plagioclase is considerably smaller than in the average Bayonne granodiorite, and the plagioclase itself is more basic. Epidote occurs in every slide examined, and in most quite plentifully. The modes of various phases are given in Table I.

Pegmatite and aplite dykes are plentiful close to the contact and occur all through the body of the stock, but are nowhere very large, certainly nothing was seen comparable to the huge bodies associated with the Bayonne batholith.

Wall Stock

The Wall stock lies to the north of the Mine stock and is named after Wall Mountain. Its eastern margin parallels the edge of the Bayonne batholith for a couple of miles, but is separated from it by a narrow band of sediments.

It is distinctly different from the Bayonne granodiorite, and although resembling the Mine granodiorite more closely can be easily distinguished from that rock, too, in the field. It is a fine- to medium-grained, grey rock, non-porphyritic, and remarkably uniform in appearance and composition. Aplite dykes are comparatively scarce and pegmatite dykes are restricted to occasional stringers, few of which are over 6 inches wide. It, like the Mine stock, has the average composition of a calcic granodiorite, but is somewhat more basic than that body. Although biotite is the most abundant ferromagnesian mineral, amphibole occurs in every slide examined, and on the average is more plentiful than in the Mine stock. The plagioclase is andesine, in some specimens approaching labradorite. Epidote

is plentiful in all specimens examined and may be conspicuous in the hand specimen. Modes of the various phases are given in Table I.

Small Stocks and Bosses

A number of small stocks and bosses occur throughout the area; many are shown on the map, but there are probably others that were not seen. Most of those east of the lake resemble phases of the Bayonne batholith and no rock like that of the Mine or Wall stocks was seen. Highly porphyritic, pink granodiorite comprises a large part of most of them. The mode of a specimen from the stock at Crawford Bay is given in Table I.

Ainsworth Granitic Sills

A number of large sills or small, elongated stocks occur in Ainsworth district and south of West Arm near Procter. These are sufficiently different from the granitic rocks previously described to warrant separate mention. Almost without exception they consist of light-coloured, fine- to medium-grained, gneissic rock lying in sediments so completely altered that it is impossible to tell where the igneous rock ends and altered sediment begins. The rock has the composition of a light-coloured granodiorite, but seen in thin section has the confused texture of a hybrid rock. It is possible that only the core of each body is intrusive, the bulk of the rock being formed by the alteration of the intruded sediments; it is possible, in some cases at least, that the entire body may be metamorphosed sediment.

Table I gives the mode of specimens from most of the bodies described above and Figure 1 shows the principal components plotted in such a way that the range in composition of the individual bodies is brought out and also the differences in the average composition of different bodies.

Age of the Granitic Rocks

The age of the granitic rocks of the area is not definitely known. The close resemblance of the main batholiths and the Nelson batholith in composition, appearance, and internal and external relationships suggests that all are genetically related and probably of about the same age. Cairnes (1934, pages 73-75) has suggested that the Nelson batholith may be of late Cretaceous age. It is, therefore, probable that the granitic rocks of Nelson area are Cretaceous and possibly late Cretaceous in age.

Little direct evidence as to the relative ages of the different bodies is available, but some highly suggestive facts deserve mention.

The three main batholiths, the Bayonne, White Creek, and Fry Creek batholiths, are very much alike in appearance and composition and are probably related to each other, to the small stocks and bosses east of Kootenay Lake, and to the Nelson batholith.

The Rykert batholith presents some anomalous features. Its general appearance is similar to the other batholiths, but, in part at least, it is somewhat more basic and it carries a greater amount of amphibole. Moreover, whereas the other batholiths are gneissic only in restricted areas, the Rykert batholith is everywhere sheared, and in places highly so. Two important faults shown on the map run into the Rykert batholith and

TABLE I

Modes of Specimens from the Granitic Rocks

—	White Creek	Fry Creek	Crawford Bay	Bayonne batholith													Mine stock						Wall stock				Rykert	
Specimen No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Biotite	1	3·5	2	18·7	2	19·5	11	15	8	....	10	9	10	10	25·6	10·9	10·9	7·1	18·1	12·8	18·5	13·5	8·1	17·5	20·4	15·3	3·0	13·7
Hornblende	....	....	....	....	....	....	....	....	....	....	x	....	....	x	....	x	8·1	5·7	....	5·7	6·1	5·1	0·4	15·5	7·5	7·8	x	6·4
Quartz	31	27·9	36	49·2	20	47·4	31	24	28	36	45	36	24	33	25·7	33·5	20·7	21·3	20·5	16·5	23·3	20·5	22·8	19·6	24·8	22·4	35·5	17·8
Potash feldspar	64	48·1	34	22·7	45	13·3	27	28	27	20	3	7	8	4	2·0	18·5	13·9	14·7	10·0	6·8	0·6	9·2	6·5	2·2	1·0	3·2	32·5	8·1
Plagioclase	3	19·6	25	9·4	32	19·8	29	29	36	39	40	47	57	47	34·6	35·1	38·4	45·1	46·7	54·5	51·5	47·2	58·3	36·0	42·8	45·8	20·7	51·0
Per cent An in plagioclase	30	30·0	25	20·0	20	30·0	25	20	25	25	25	20	20	30	30·0	25·0	40·0	50·0	35·0	25·0	40·0	40·0	60·0	30·0	45·0	45·0	....	25·0
Accessories	1	0·9	3	x	1	x	2	4	1	5	2	1	1	6	12·1	2·0	8·0	6·1	4·7	3·7	x	4·5	3·9	9·2	3·5	5·5	9·3	3·0
Titanite	....	....	....	....	x	....	x	x	x	x	x	x	....	....	x	x	x	x	x	x	x	x	x	x	....	x	....	x
Apatite	x	x	x	x	....	x	x	x	x	....	x	....	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Magnetite	....	x	x	....	....	x	x	x	x	x	x	....	x	x	x	x	....	x	x	x	....	x	x	x	x	x	x	x
Zircon	....	x	x	x	....	x	....	....	x	x	x	x	x	x	....	x	x	x	....	x	x	x	x	x	x	x	x	x
Epidote	x	x	x	....	....	x	x	x	....	x	....	....	....	....	12·1	x	8·0	5·4	3·9	3·0	x	4·1	3·6	9·2	2·9	5·2	....	x
White mica	x	x	x	x	x	x	x	x	x	4	....	x	x	x	x	x	x	x	x	....	....	x	x	....	....	x	6·5	x
Chlorite	....	....	....	....	....	....	....	....	....	x	....	....	....	....	....	x	x	....	....	....	....	x	x	....	....	x	....	....
Calcite	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	x	x	....	....	....	x	....	....	....	....	x	....

Key to Table I

White Creek Batholith

1. Granite (125, Kalialaskite)[1]. Locality: head of White Creek. Light-coloured, coarse-grained granite.

Fry Creek Batholith

2. Granite (126″, Leucoadamellite). Locality: head of Campbell Creek. Light grey, medium-grained granite.

Crawford Bay Stock

3. Granite (126″, Leucoadamellite). Locality: Crawford Bay road. Light grey, non-porphyritic, biotite granite.

Bayonne Batholith

4. Granite (222, Quartz granite). Locality: railway south of Bayonne. Medium-grained, uneven-textured, biotite granite.
5. Granite (126″, Leucoadamellite). Locality: Columbia Point. Light-coloured, medium- to coarse-grained, biotite granite.
6. Granodiorite (223, Quartz granodiorite). Locality: road to Bayonne mine. Coarse-grained, slightly gneissic, biotite granodiorite.
7. Granodiorite (227″, Adamellite). Locality: road north of Kuskonook. Pinkish grey, porphyritic, biotite granodiorite.
8. Granodiorite (227″, Adamellite). Locality: road south of Sanca Creek. Pinkish grey, coarse-grained, porphyritic, biotite granodiorite.
9. Granodiorite (227″ Adamellite). Locality: road south of Sirdar. Brownish grey, medium-grained, non-porphyritic, biotite granodiorite.
10. Granodiorite (227, Granodiorite). Locality: road north of Sirdar. Pink, fine-grained, muscovite granodiorite.
11. Granodiorite (223, Quartz granodiorite). Locality: vicinity Haystack Mountain. Pinkish grey, coarse-grained, porphyritic, biotite granodiorite.
12. Granodiorite (227′, Monzotonalite). Locality: railway below Mount Steeple. Light grey, medium-grained, biotite granodiorite.
13. Granodiorite (227′, Monzotonalite). Locality: railway below Mount Steeple. Cut by number 12. Grey, slightly gneissic, biotite granodiorite.
14. Granodiorite (227′,Monzotonalite). Locality: road south of Kuskonook. Dark brownish grey, medium- to fine-grained, biotite granodiorite.
15. Granodiorite (227′, Monzotonalite). Locality: head of Blazed Creek. Medium-grained, grey, biotite granodiorite.
16. Granodiorite (227, Granodiorite). Average of thirteen modes.

Mine Stock

17. Granodiorite (227, Granodiorite). Locality: vicinity of Arkansaw Lake. Medium-grained, grey, biotite-hornblende granodiorite.
18. Granodiorite (227, Granodiorite). Locality: vicinity Bayonne mine. Medium-grained, fairly light grey, biotite-hornblende granodiorite.
19. Granodiorite porphyry (227, Granodiorite). Locality: vicinity Bayonne mine. Fine-grained, grey, porphyritic dyke.
20. Granodiorite (227′, Monzotonalite). Locality: vicinity Bayonne mine. Medium-grained, darkish grey granodiorite.
21. Quartz diorite (228, Tonalite). Locality: southeast flank of John Bull Mountain. Medium- to fine-grained, light grey, quartz diorite.
22. Granodiorite (227′, Monzotonalite). Average of five modes.

Wall Stock

23. Basic granodiorite (237′, Granogabbro). Locality: vicinity Spokane mine. Medium- to fine-grained, light grey granodiorite.
24. Granodiorite (227′, Monzotonalite). Locality: Next Creek. Medium-grained, grey, hornblende-biotite granodiorite.
25. Quartz diorite (228, Tonalite). Locality: south of Wall Mountain. Grey, medium-grained, slightly gneissic, biotite-hornblende granodiorite.
26. Granodiorite (227′, Monzotonalite). Average of three modes.

Rykert Batholith

27. Granite (226″, Adamellite) (Daly, 1912, page 287). Locality: Boundary Creek road. Coarse-grained, porphyritic granite.
28. Granodiorite (227′, Monzotonalite). Locality: Rykert Mountain. Coarse-grained, dark-coloured, augen gneiss.

[1]Names and numbers in parentheses are according to Johannsen's classification.

there are certainly other parallel faults that were not recognized. The attitude of these faults is the same as that of the shearing in the Rykert batholith. It seems probable, therefore, that the Rykert batholith was emplaced before the cessation of crustal movement. This movement in the sediments took place mainly along certain paths, the faults, but in the granite may have been absorbed internally by the development of the gneissic structure. The Bayonne batholith also lies directly in the path of this zone of faulting, but shows no such gneissosity. It may, therefore, be argued that the Bayonne batholith was not intruded until almost all movement had ceased and is younger than the Rykert.

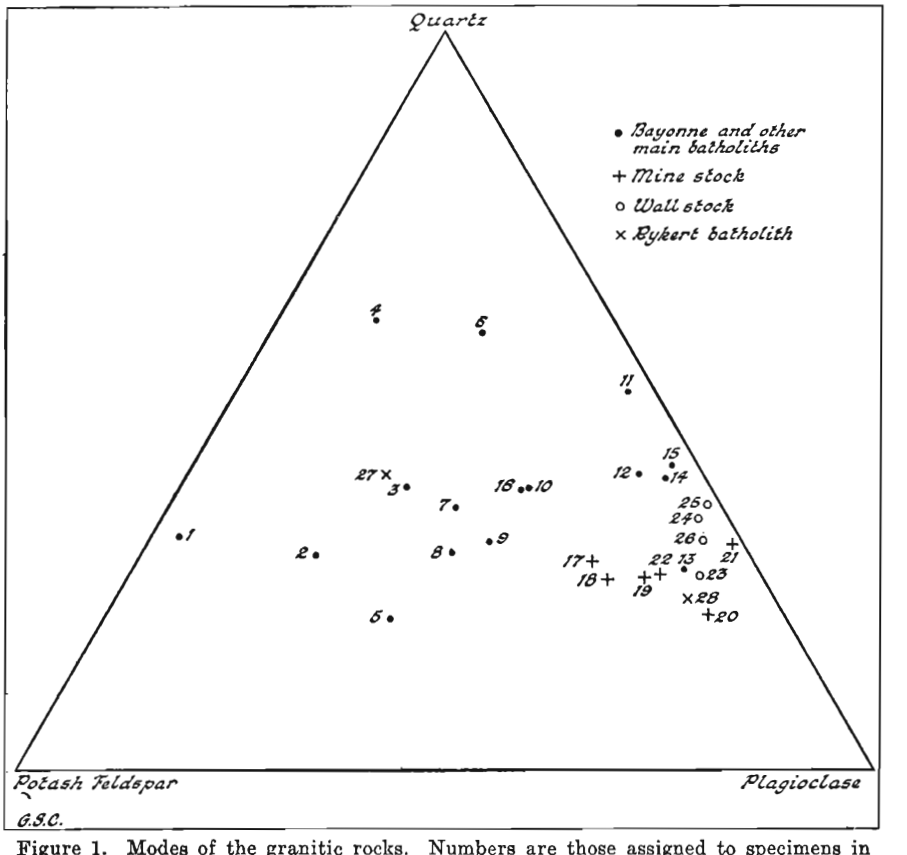

Figure 1. Modes of the granitic rocks. Numbers are those assigned to specimens in Table I, page 38.

The writer is of the opinion that the Mine and Wall stocks are older than the Bayonne batholith. Evidence for this is scanty and inconclusive, but the following considerations may be offered in its support.

(1) Both stocks are more basic than the average of the Bayonne batholith. If the hypothesis is applicable that earlier differentiates from a magma are more basic than later ones, this fact would support the conclusion.

(2) Both stocks, particularly the Wall stock, are exceedingly uniform in composition and texture, as if crystallized from a uniform magma without local concentrations of mineralizers. Furthermore, the paucity of pegmatite compared with the Bayonne batholith suggests that the magma was a relatively dry one and crystallization produced little fluid differentiate. As late differentiates from the main magma would contain greater concentrations of mineralizers than early ones, these conclusions, if correct, bear out the idea that the stocks were formed earlier than the batholith.

(3) The Bayonne batholith cuts across the sedimentary strata with relatively slight disturbance of the latter. That is, it appears as if the magma was highly fluid and ate its way into place under fairly low pressure. The sediments around the stocks, on the other hand, are warped out of their regional trends and their strikes mostly parallel the contacts of the stocks. In contrast with the Bayonne batholith the stocks apparently punched their way into place in a viscous condition and under high pressure. This would bear out the conclusion reached in the last section.

(4) A grey, slightly gneissic, basic granodiorite (No. 13, Table I) on the railway below Mount Steeple is cut by a light grey, medium-grained, biotite granodiorite (No. 12, Table I). This is the only place where direct evidence as to the relative age of two bodies of granitic rock could be obtained, and it is significant that the older has a composition approximating that of the two stocks whereas the younger is more nearly that of the normal Bayonne batholith.

In this connection it is interesting to note that the specimen, No. 28, Table I, from the Rykert batholith examined by the writer, has a composition closer to that of the stocks than to that of the batholith. Daly's analysis (No. 27, Table I) admittedly is of a rock much more like the normal batholith. In describing this specimen, however, Daly does not mention the gneissic structure, and it is possible that the Rykert may be a composite batholith with members analogous to both stocks and batholith.

Relationship of the Granitic Rocks to Mineralization

The Bayonne batholith is believed to have been highly charged with mineralizers and, consequently, it, or more probably its parent magma, is a probable source of ore-bearing solutions. This appears to be true also of the Nelson batholith and probably of most of the other granitic intrusives in the area.

That the actual source of such solutions is not the granitic body now visible is to be inferred from the presence of mineral deposits in these bodies, although it is perhaps significant that two of the principal ore deposits near the Bayonne batholith, those of the Bayonne and Spokane mines, are in the Mine and Wall stocks, both of which are believed to be early phases of the granitic suite.

Relationship of the Granitic Bodies to Mountain Building

Although the age of the granitic bodies is not known, the available evidence indicates that the granitic rocks were intruded during the close of the period of mountain building but before entire cessation of movement along some of the faults (Rice, 1937, page 31). Briefly, the evidence is as follows. A few granitic dykes have been intruded along fault zones and granitic bodies are most plentiful along zones of major faulting. From this it is inferred that the intrusion of the granitic bodies occurred after the establishment of the faults. Some dykes have been slightly crushed by renewed movement along these faults, and zones of gneissic structure, indicative of minor faulting or shearing, have developed the granites. Except in the case of the Rykert batholith all such crushing is purely local and suggests only a small amount of movement. It is, therefore, argued that the granitic bodies were intruded before the cessation of all crustal movement but after the greater part of it. The Rykert batholith may be somewhat older than the others, but even it is not dislocated along the fault zones as much as the sediments.

Miscellaneous Acid Intrusives

A few small feldspar porphyry dykes occur in the area. They are probably related to the granitic rocks in origin.

POST-GRANITE INTRUSIVES

McGregor Intrusives

McGregor Mountain is an isolated peak lying immediately to the northwest of Bayonne (Tye). On three sides it is composed of granite, but the top and the west slope are composed mainly of metamorphosed sediments. In the sediments on the crest of the hill occurs a roughly circular igneous intrusive. At least three similar but much smaller bodies intrude the granite on the northeast spur of the mountain. These bodies are believed to be volcanic necks.

Throughout the area west of Kootenay Lake occur dykes and sills of dark, fine-grained rock. Some of these at least are believed to be related to the necks on McGregor Mountain.

The term McGregor intrusives is applied to these four necks and to those sills and dykes that appear to be related.

Table II gives the modes of a number of specimens from the necks and related sills and also from lamprophyre dykes, which may or may not be related, occurring in the above locality. Five modes taken from Johannsen are tabulated for comparison. Figure 2 is a graphical representation of these modes to bring out the relationship.

The bodies on McGregor Mountain are elliptical to roughly circular in shape. From their fairly irregular boundaries numerous small dykes and sills invade the intruded rock. The main body in the sediments is from a half to three-quarters mile in diameter and each of the three subsidiary bodies to the north not more than 300 feet in diameter.

Within any one body the composition, grain size, and appearance vary widely and with no apparent relationship to the boundary of the

body. For instance, the rock near one part of the contact is coarse-grained and even-textured and a few feet away it gives place to an extremely fine-grained, porphyritic phase. Moreover, both coarse-grained and fine-grained phases are irregularly distributed all through the body. It seems, therefore, as if the whole mass could not have formed from a single plug-like intrusion of magma but from a number of separate intrusions of different composition and intruded under different physical conditions.

Fragments of granite and sedimentary rock occur in various parts of each body, some of which, in particular those of quartzite, have reacted strongly with the enclosing rock. In one or two places masses of rock occur that are composed mainly of fragments of McGregor intrusive in a matrix of apparently similar composition.

A curious texture is developed along the contacts of certain of the fine-grained phases. Elliptical bodies a foot or so long, of medium-grained rock, lie with their long axis parallel to each other and approximately parallel to the contact of the intrusion. The interstices between these bodies are filled with rock of similar composition but much finer in grain. This phenomenon is not very marked and can only be seen in the weathered surface.

The rock varies from a light creamy grey, fine-grained syenite to a dark grey-green, coarse-grained or fine-grained, porphyritic syenite, in places carrying olivine. The suite as a whole is composed of alkaline rock close to the point of saturation with silica; actually it varies from a rock sufficiently over-saturated to permit the development of 7·7 per cent free quartz to one sufficiently under-saturated to produce 9 per cent olivine. Biotite is present in all specimens examined and is plentiful in some. Pyroxene, probably diopside, is also common and forms conspicuous phenocrysts in the porphyritic varieties. In some slides this pyroxene is partly altered to hornblende or actinolite. The potash feldspar in most specimens is microcline, but orthoclase also occurs. Apatite was present in all specimens examined, and in some in considerable amount. Titanite, magnetite, and zircon constitute the rest of the accessories. Pyrite, and in one specimen chalcopyrite, was seen.

It is believed that the bodies on McGregor Mountain are volcanic necks; possibly a main vent and smaller, subsidiary vents. If this be accepted the heterogeneous, multiple intrusions are the result of resurgence of the magma through fresh openings in the vent. The presence of agglomerate and fragments of wall-rock is to be expected.

There is no doubt that the circular bodies are younger than the granite. Blocks and fragments of granite occur in the syenite, and small dykes of syenite issuing from the main body cut not only the granite but pegmatite and aplite dykes associated with it. As the granite is believed to be Cretaceous and possibly late Cretaceous in age the syenite necks are probably Tertiary.

Dark grey-green, porphyritic or even-grained sills and dykes, from a few feet to 50 feet or more thick, occur everywhere in the area west of Kootenay Lake. Most of those that occur within 10 miles of McGregor Mountain and some that lie as far north as Procter and Ainsworth district are composed of rock indistinguishable from components of the McGregor

Table II

Modes of McGregor Intrusive and Lamprophyre Dyke

Specimen No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Potash feldspar	84·0	55·5	83	44·0	76·5	36·0	34·6	41·5	28·2	50·0	47·2	32·0	25·0	35·1	36·0	13·4	.....
Plagioclase	2·1	4·1	7	5·0	9·5	6·1	6·3	10·3	7·0	15·0	14·3	10·0	10·0	18·5	17·0	7·2	53·6
Per cent An of plagioclase	15	30	.....	30	25	30	.....	25	20	.....	30	.....	35	35	30	.....	35
Quartz	7·7	.....	3	0·5	6·8	1·3	.....	0·4	.....	2·0	.....	.....	.....	0·7	.....	0·5	x
Biotite	5·6	20·6	2	22·0	4·2	16·5	17·0	14·1	26·8	.....	17·8	6·0	24·0	15·2	17·0	8·7	9·1
Hornblende	.....	.....	x	.....	.....	37·5	.....	25·7	.....	20·0	18·0	45·0	.....	24·2	.....	54·7	.....
Pyroxene	0·1	19·2	1	28·5	.....		33·5	4·5	31·0	10·0		.....	39·0	3·3	19·0	12·3	.....
Olivine	.....	.....	.....	.....	.....	.....	13·3	.....	.....	.....	.....	.....	.....	.....	9·0	.....	.....
Titanite	0·2	x	1	.....	x	0·4	.....	0·6	.....	.....	0·5	.....	.....	1·1	.....	.....	.....
Apatite	x	0·6	x	x	0·3	2·2	x	1·9	2·3	x	1·3	.....	2·0	1·4	1·5	0·8	x
Iron ore	0·3	x	3	x	1·4	.....	1·7	x	x	x	0·9	2·0	x	0·5	0·5	0·4	5·7
Zircon	?	.....	x	.....	.....	.....	.....	0·1	.....	x	.....	x	.....	.....	.....	.....	.....
Calcite	.....	x	.....	x	x	x	.....	x	.....	.....	x	.....	.....	.....	.....	.....	x
Epidote	.....	x	.....	x	1·3	.....	.....	.....	.....	.....	.....	.....	.....	x	.....	.....	.....
White mica	.....	.....	.....	.....	.....	.....	.....	x	4·7	.....	x	.....	.....	.....	.....	.....	31·6
Chlorite	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	.....	.....	.....	.....	.....	.....
Garnet	.....	.....	.....	.....	.....	.....	.....	.....	.....	x	.....	5·0	.....	.....	.....	.....	.....

Key to Table II

1. Quartz-bearing syenite (225 nearly 229, Kaligranite).[1] Locality: McGregor Mountain. Small neck in granite. Light creamy grey, fine-grained syenite.

2. Syenite (2210′, Monzosyenite). Locality: Bayonne mine road near Next Creek. Sill of medium- to fine-grained syenite.

3. Nordmarkite (2210′, Monzosyenite). Locality: Pleasant Mountain, Maine. Johannsen, 1934, vol. 3, p. 57, table 19, No. 1.

4. Syenite (3210′, Melamonzosyenite). Locality: mountain north of Wall Mountain. Sill of grey-green, fine-grained, basic syenite.

5. Quartz syenite (226′, Monzogranite). Locality: McGregor Mountain. Body in granite. Light grey, fine-grained granite. Contains some chalcopyrite.

6. Basic syenite (3210′ Melamonzosyenite). Locality: McGregor Mountain. Body in granite. Coarse-grained syenite with a granitic texture.

7. Shonkinite (3210′, Melamonzosyenite). Locality: Mount Carbon, Bonneville Co., Idaho, average of four thin sections. Johannsen, 1932, vol. 3, pp. 44, table 23, No. 1.

8. Syenite (2210′, Monzosyenite). Locality: vicinity of Iva Fern mine, Cultus Creek. Sill or dyke of medium-grained, grey-green syenite.

9. Syenite (3210′, Melamonzosyenite). Locality: McGregor Mountain, body in granite. Dark grey-green, porphyritic syenite.

10. Hornblende syenite (2210′, Monzosyenite). Locality: Warren Co., N.Y.

11. Biotite-hornblende syenite (2210′ Monzosyenite). Locality: vicinity of Iva Fern mine, Cultus Creek. Dark grey-green, medium-grained dyke or sill.

12. Gabbro (3210′, Melasyenite). Locality: Mountain Spring Lake, N.Y. Johannsen, 1932, vol. 3, p. 64, table 23, No. 4.

13. Basic syenite (3210, Melasyenite). Locality: McGregor Mountain, body in granite. Dark green, coarse-grained, pyroxene syenite. Resembles a pyroxenite.

14. Syenite (2210). Locality: McGregor Mountain, body in granite. Medium- to coarse-grained, greenish grey syenite.

15. Olivine syenite (2210, Syenite). Locality: McGregor Mountain, body in sediments. Dark grey-green syenite porphyry.

16. "Shonkinite Rock" (3210, Melasyenite). Locality: Bitter Creek, Forty-ninth Parallel, B.C. (Daly, 1912, p. 345).

17. Kersanite, possibly Spessartite (2212). Locality: peak south of Wisconsin mine. Dark grey, fine-grained, porphyritic lamprophyre with black and glassy white phenocrysts. Lath-shaped plagioclase.

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[1] Number and name in parenthesis according to Johannsen's classification, latter given only if different to name previously given.

necks. A glance at Table II and the accompanying diagram, Figure 2, will show that the composition of all specimens whose modes were determined falls within the limits of components of the necks on McGregor Mountain. The rocks of the sills do not present any significant mineralogical differences from the necks. It seems almost certain that these sills and dykes originated from the same magma as the necks or from a related magma, and are probably Tertiary in age.

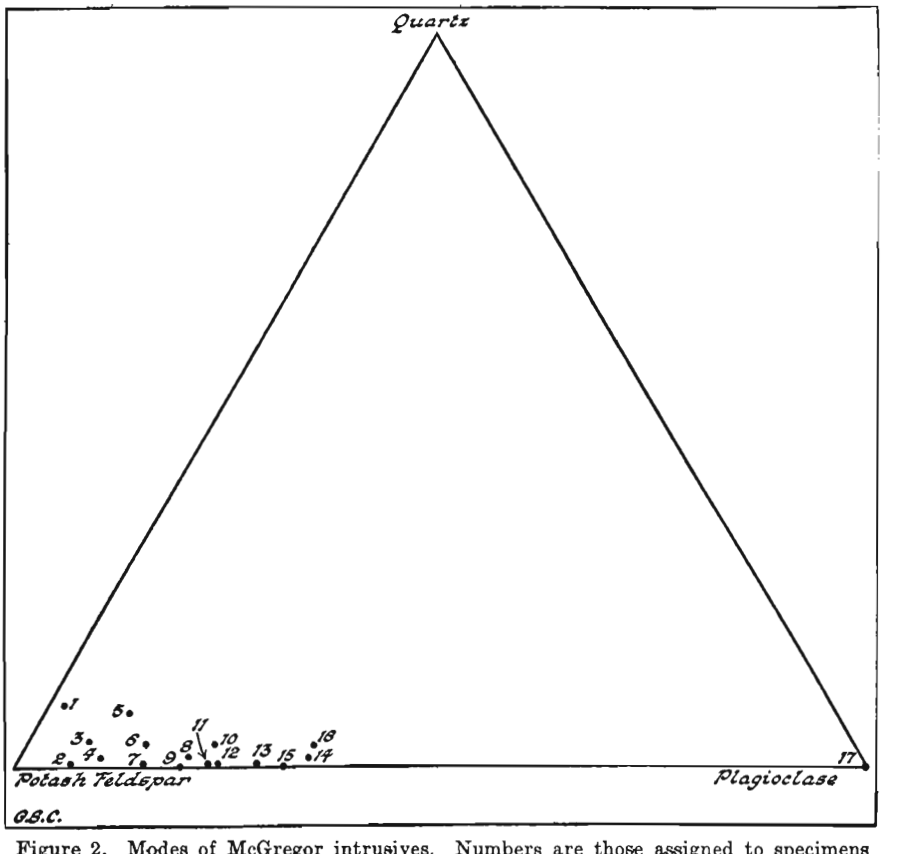

Figure 2. Modes of McGregor intrusives. Numbers are those assigned to specimens in Table II, page 44.

Lamprophyre Dykes and Sills

Some of the dark-coloured sills and dykes, although commonly indistinguishable in the hand specimen from the McGregor intrusives, are lamprophyres (kersantites and spessartites) and are more basic than any component of the necks.

They are mostly composed of fine-grained, dark grey-green rocks in which biotite or hornblende is the most conspicuous component. Many of them are greatly altered, and in them chlorite and epidote form the bulk

of the rock. The feldspar is commonly basic andesine, although oligoclase occurs in some. This plagioclase, instead of occurring as tabular crystals as in the syenites, is a felted mass of acicular crystals. Two sills, one on Midge Creek and one near the Star mine in Ainsworth district, have the general composition of a spessartite, but are strikingly porphyritic (*See* Plate II B). They are composed of a fine-grained, grey-green speckled groundmass of hornblende, biotite, plagioclase, magnetite, apatite, chlorite, calcite, and epidote in which occur phenocrysts of black hornblende up to 2 inches long, and 1-inch phenocrysts of glassy andesine. Both types of phenocrysts have been partly resorbed. One zoned plagioclase studied was found to have a core of oligoclase surrounded by andesine.

Relationship Between the McGregor Intrusives and the Lamprophyres

There is no direct evidence as to the relationship between the two sets of intrusives. Two hypotheses present themselves: first, that they may be directly related and of the same general age, the lamprophyres representing the non-potassic end of the McGregor series of intrusives; and, second, that the lamprophyres may be related to the granitic rocks and, therefore, may be much older than the McGregor intrusives.

The two series resemble each other so closely that they can rarely be distinguished in the hand specimen. This is the more significant because the rocks are unusual in appearance and include such types as that illustrated in Plate II B. Furthermore, they are confined to the west side of Kootenay Lake and show no relationship in distribution to the distribution of the granitic rocks. In no case was a lamprophyre seen in a region in which McGregor intrusives did not also occur. To emphasize this it should be pointed out that these lamprophyres are large and conspicuous bodies, and in the region in which they occur are so plentiful that few traverses were made without one being seen.

Further evidence is needed before a definite conclusion can be reached, but the writer believes that the probability is in favour of the hypothesis that all the large, dark-coloured dykes and sills in the area, previously classed as lamprophyres, are related and are Tertiary in age.

Occasional, small, dark brown dykes, from a few inches to a foot or so thick, were seen, notably in the Bayonne and Spokane mines. These are very fine-grained and too much altered to identify. They may be related to the above rocks or may be entirely different.

SUPERFICIAL DEPOSITS

Glacial debris occurs over the entire area except on the tops of the highest peaks, and in many places forms a deep and continuous cover. For the most part it consists of sand and gravel with cobbles and boulders irregularly distributed through it. Thick beds of boulder clay have accumulated in places. Outwash streams have formed local interbeds of silt, sand, and gravel.

A thin veneer of sand and soil overlies the glacial drift, and locally in the main valleys deep accumulations of silt and gravel have formed. Special mention may be made of the silt and alluvium deposited by

Kootenay River from the International Boundary to the south end of Kootenay Lake. This deposit is important in view of the recent dyking of the river and the value of the land thus made available, from which excellent crops of wheat are being obtained.

METAMORPHISM

Regional alteration has resulted only in the development of small flakes of biotite and, in places, of a little feldspar; details of the sedimentation have not been obscured. Locally, however, metamorphism is very severe. This metamorphism takes three forms.

(1) The rocks have been altered in the vicinity of the Purcell sills. The intensity of this metamorphism varies widely from sill to sill and has little relationship to the size of the sill. Its nature also varies with the nature of the sediments altered. In some places, and many of these are along the contacts of the largest sills, the sediments are unchanged except for the development of a little hornblende and feldspar immediately along the contact. In other cases argillite and argillaceous quartzite have been largely recrystallized in a belt 10 to 20 feet wide paralleling the contact, and usually on the upper side of the sill. This reconstituted rock closely resembles a granitic igneous rock and has been described already in the section dealing with the Purcell sills. Calcareous sediments, such as are found in the Kitchener-Siyeh formation, are commonly altered to a green, cherty, calc flinta composed of a fine, felted mass of lime-silicate minerals.

(2) In the vicinity of granitic bodies the sediments show a wide variation in the degree of metamorphism attained. In places metamorphism is confined to a narrow zone adjacent to the intrusive, in others a wide area of quartz-mica schist and gneiss has developed.

Such an area of schist and gneiss forms a belt along both sides of Kootenay Lake. The rocks composing this belt were correlated with the Shuswap and considered Archæan by the early workers. It is now clear, however, that they are sediments, most of the Lardeau series, so altered that their original sedimentary nature is largely masked. The commonest rock types are sillimanite, cyanite, and garnet, mica schists grading, in places, through gneiss to a rock indistinguishable from a granite. It is clear that not only have the original minerals of the sediments been changed, but that considerable material has been added by hydrothermal solutions and possibly magmatic material. The difficulty of distinguishing between the final stage of high-grade, hydrothermal metamorphism of the sediments and intrusive granitic rock makes it hard to determine the amount of the latter present if, indeed, there be any.

(3) In the vicinity of faults and close folds the sediments are commonly highly sheared and changed to chlorite and biotite schist. These zones of shearing may be many hundreds of feet in width and all structures produced by sedimentation may be destroyed.

CHAPTER III

STRUCTURAL GEOLOGY

In the moutainous parts of the area there are generally sufficient rock exposures to permit attaining a clear understanding of the general features of the geology. Superficial deposits are, however, widespread and their masking effect, combined with the lack of good horizon markers, makes the determination of detailed structures, many of which are highly complex, difficult and in many cases impossible.

A general structural picture of the area is that of a broad, northerly striking anticline whose axis lies close to the east boundary of the area. The west limb of this anticline is itself folded along the same general strike, and in part is thrown into a number of tight, isoclinal synclines and anticlines. These structures in the southeastern half of the area have been disrupted by large north to northeast trending faults and have been still further complicated by the intrusion of large granitic bodies.

ST. MARY FAULT

The fault known as St. Mary fault runs southwest from the eastern border of the area to the northeastern edge of the Bayonne batholith. No shearing was seen in this batholith that suggested the continuation of this fault through the granitic body. It is inconceivable that the fault should die out at this point, as only a few miles along it to the northeast the Aldridge is brought into contact with the Cambrian, Eager formation, as a result of a stratigraphic displacement of many thousands of feet. The conclusion is that the batholith was emplaced after the faulting had occurred. A strong fault crosses Blazed and Summit Creeks on the south side of the Bayonne batholith, and this fault lines up so exactly with the projection of the St. Mary fault that it is a fair assumption that it is its continuation. Just south of Summit Creek this fault turns abruptly south and, although it could not actually be traced, it apparently continues southeasterly to the International Boundary. Metamorphism and shearing are so pronounced all through this part of the area that the accurate recognition of the fault is extremely difficult. The writer is, however, satisfied that its location is approximately as indicated on the map. Kirkham and Ellis (1926) show faulting with a similar strike south of the Boundary in this region, although they do not show a fault crossing the Boundary at this point.

The St. Mary fault continues east into Cranbrook area and has been traced easterly across that area to the Rocky Mountain Trench, and the writer believes that a strong fault extending up Wildhorse Creek in the Rocky Mountains is its continuation. The St. Mary fault has thus been traced for 90 miles from the Rocky Mountains to the International Boundary, where it either dies out or, more probably, is cut off by the

Rykert batholith; indeed the gneissic structure developed in that body may well have been developed by the final movements along this and parallel faults.

The St. Mary fault was seen only at one place, and this on its supposed continuation south of the Rykert batholith. At this place, on the ridge between Summit and Blazed Creeks, the fault consists of a number of zones of heavy brecciation, each 10 to 20 feet wide, occupying a total width of a quarter to half a mile. The zones are silicified and some are wholly occupied by quartz veins in which ghosts of the fragments of crushed rock can be seen in many places.

The dip of the fault is imperfectly known, but is almost certainly steep and probably is from 50 to 80 degrees west or northwest according to the strike of the fault. The fault is apparently a thrust, the movement along which has been largely vertical, but as folding of unknown magnitude took place both before and after the fault developed and as the structure on both sides of the fault are extremely complex, it is nearly impossible to match strata and structures on the two sides and so determine any component of the movement. The minimum thickness of the stratigraphic displacement is not less than 20,000 feet.

STRUCTURES SOUTH OF ST. MARY FAULT

From the St. Mary fault a number of branch faults spray out to the southwest and south. Six or seven have been mapped, of which at least three are large and important faults, and there are undoubtedly others. In general the effect is as if a block of sediments, striking northeast and dipping northwest, has been divided by faults into a number of northeast trending slices, in each case the block to the west having moved up with respect to that on the east. Most of these fractures are westerly dipping thrust faults with a displacement of some thousands of feet. Many minor complications occur; faults branch and connect with each other, normal faults occur paralleling the thrust faults, and fault blocks of Cambrian sediments have been dropped into areas of Precambrian.

The principal faults of this system are as follows.

PERRY CREEK FAULT

This fault joins the St. Mary fault to the east of the area. It follows Perry Creek to its head, beyond which it was not traced. It may die out there or a short distance beyond or it may continue and not have been recognized. Many zones of shearing occur in the southern part of the area, but, as the whole region is underlain by the Aldridge formation, it is uncertain whether there are important faults. There is no doubt, however, that thrust faults do pass through this part of the area, as the section of Aldridge is fully twice its normal thickness.

SAWMILL CREEK FAULT

This fault cuts across the head of Sawmill Creek, follows the upper stretch of Angus Creek to its head, and connects with a fault or faults observed on Goat River. It seems to be a complicated fault with many

ramifications, and its course has not been accurately traced beyond the Hellroaring-Goat divide.

GOAT RIVER FAULTS

A number of faults form a complicated pattern at the head of Goat River. The most easterly of them have brought the Creston up into contact with the Eager formation, and other branches also appear to have a considerable displacement. It was not possible to determine the details of this complicated zone, but the writer feels satisfied that the general pattern is correctly depicted. This zone of faulting has been traced south to the International Boundary.

MOYIE FAULT

The Moyie fault is apparently unconnected with the St. Mary fault system. It follows a curving path roughly parallel with the main St. Mary fault. It passes through the southeast corner of the area and has been traced northeast to the Rocky Mountain Trench and probably into the Rocky Mountains. To the south and southeast it has been traced through Montana. The total known length of this fault is about 118 miles. In Montana it is known as the Lenia fault and Kirkham (1930) believes it to be an overthrust, the west block having moved up relative to the east block from 15,000 to 45,000 feet along a plane nowhere inclined less than 45 degrees.

STRUCTURES NORTH OF ST. MARY FAULT

FOLDING

In the eastern half of the area north of the St. Mary fault, the sediments are folded into a broad, open anticline, complicated by minor folds. The axis of this anticline plunges north at a moderate angle. The western limb steepens, and near the centre of the area gives place to a zone of tight isoclinal folding. In this zone the strata dip steeply west and no individual folds were recognized. The Creston and Kitchener-Siyeh formations are repeated several times, and west-facing beds are succeeded by beds facing east and so on. Owing to intense shearing and because the axis of a fold may be crossed without being observed, details of the zone are difficult to map. Still farther west, where the formations of the Upper Purcell and Windermere occur, the structure is less complicated. Nearly all the beds face west and dip steeply, and are overturned in places. Minor changes in dip form north-striking monoclinal rolls. A pronounced belt of this type of structure runs through Rose Pass, west of Mount Hooker, and through Sphinx Mountain. On both sides of Kootenay Lake north of Crawford Bay the prevailing dip decreases to about 45 degrees west, although steeper dips are still common. On the west side of the lake south of the West Arm the structure has been complicated by the intrusion of the Mine and Wall stocks and other granitic bodies.

FAULTING

Faulting in the area north of the St. Mary fault is of less structural significance than folding. South of the St. Mary fault the faults have a

general northeast trend and are concave to the east, whereas the only faults definitely mapped north of the St. Mary fault trend northwest and are concave to the west. This feature is illustrated by the fault following Alki Creek and the faults at the head of Goat River.

SHEARING

Shearing occurs in a varying degree in all the softer rocks throughout the area, but in the harder rocks only in the vicinity of the major folds and faults. The prevailing strike is north to northwest and the general dip fairly steep to the west. Vertical and easterly dips are, however, by no means uncommon. Local variations in the attitude of the schistosity occur near the Mine and Wall stocks and near some of the faults.

GENERAL OBSERVATIONS

The major structures in the area appear to have developed through the action of thrusting from the west, as indicated by the two sections on the accompanying geological map. The most striking feature of the section along latitude 49° 45′ is the way in which the western limb of the broad anticline forming the central structure has been crumpled and, in part, pushed up as a subsidiary anticline. Evidence of thrusting from the west is depicted in the section along latitude 49° 30′ by the westerly inclination of the axial planes of the minor folds and by repeated thrust faulting.

It is believed that the intrusion of the granitic rocks took place during the last stages of the orogeny that produced the major structures in the area. The granitic rocks are believed to have been intruded during the Cretaceous. If these beliefs are correctly founded, the structures were probably developed during an interval extending from mid-Jurassic to late Cretaceous.

CHAPTER IV

ECONOMIC GEOLOGY

INTRODUCTION

Mineral deposits are widespread throughout the area. Not many are productive, but of the many prospects being worked some may develop into producing mines. The several types are classified as follows:

- Metalliferous deposits
  - Placer gold deposits
  - Lode deposits
    - Deposits related to the Purcell intrusives
    - Deposits presumably related to the granitic rocks
      - Replacement deposits
      - Quartz veins
        - Hematite-bearing veins
        - Gold-quartz veins
          - In granitic rocks
          - In sediments
        - Sulphide-bearing veins
    - Deposits presumably related to post-granitic intrusives
      - Replacement deposits in limestone
      - Bed veins
      - Fissure veins
- Non-metallic deposits
  - Magnesite
  - Ornamental and building stone

PLACER GOLD DEPOSITS

Placer gold mining has never been important in the area. East of the area, where important placer deposits occur, they are believed to be derived from Tertiary deposits that have been more or less disturbed by Pleistocene glaciation (Rice, 1937, pages 38-41). In the Nelson area no undisturbed or comparatively undisturbed Tertiary placers have as yet been found.

Some small-scale placer mining is being done in the present stream channels of Perry Creek and Moyie River, and in the past a little gold was extracted from Goat River. The gold recovered from these deposits has probably been concentrated by the present streams from glacial material through which the gold in the original Tertiary placers was scattered.

LODE DEPOSITS RELATED TO THE PURCELL INTRUSIVES

Mineral deposits occur in many of the larger Purcell sills. They are of two distinct but related types: quartz-calcite veins and disseminated deposits.

The quartz-calcite veins range from a fraction of an inch to 10 feet wide. Most of them cross the sills along courses making angles of 60 degrees or higher with the walls of the sills and they extend only a short distance or not at all into the sediments on either side. The veins contain sulphides near the upper sill contact and to a slight extent near the lower contact. Between these points, the veins, although commonly just as wide, are composed of barren quartz and calcite or, at best, are only sparsely mineralized. The upper sulphide-bearing part of a vein may extend for 30 feet into the sill and may follow the upper contact for a considerable distance. The sulphides are chalcopyrite, pyrite, pyrrhotite, galena, and sphalerite. The last two minerals are scarce in most deposits and only in a few are they sufficiently abundant to be of possible commercial value.

The disseminated type of deposit consists of chalcopyrite, pyrite, pyrrhotite, and occasionally a little sphalerite and galena irregularly distributed through the diorite of a sill or dyke. These bodies do not occur at any one particular horizon in the sills. Their location is apparently controlled by a fracture or system of fractures. A good example is the deposit on the Empire State prospect. There a well-defined zone of fracturing crosses a large Purcell dyke. The middle of this zone is occupied by a quartz-calcite vein or group of veinlets, whereas the rock on each side is impregnated with chalcopyrite and pyrite for a distance of several feet. The intensity of mineralization dies out away from the fracture and also along the fracture away from the margin of the dyke. In this and other examples the disseminated mineralization is directly associated with the quartz-calcite veins.

Schofield (1917, pages 140-144) believed that the disseminated type of deposit was formed by the differentiation of sulphides from the magma of the sill after its intrusion. Such may be the case, but in the writer's opinion the evidence is not conclusive and, in fact, rather points to an origin from solutions derived from some source other than the body in which the deposits occur. The close association between the two types of mineralization suggests a direct genetic relationship between them. The quartz-calcite veins clearly were deposited from solutions migrating through fractures that obviously must have formed after the diorite had consolidated.

Primary calcite occurs in the veins in the Purcell diorite, but not, so far as observed, in any of the numerous veins in the sedimentary rocks, and this feature seems to set the veins in the Purcell intrusives in a group by themselves. The fact that they are confined to the bodies of Purcell diorite or extend only short distances into the bordering sediments, suggests a close relationship between the Purcell intrusives and the mineral deposits. It seems probable that the quartz-calcite veins and the dissemininated deposits in the Purcell intrusives are derived from the same magma

that supplied the material for the sills. If so they are of approximately the same age, possibly Precambrian or early Palæozoic. Possibly they occupy tension cracks formed when the sills were cooling.

LODE DEPOSITS PRESUMABLY RELATED TO THE GRANITIC ROCKS

Replacement deposits form one class of the lode deposits thought to be related to the granitic rocks. The deposits of this type are exemplified by the Sullivan, the Stemwinder, and the North Star mines. The Sullivan mine has been described elsewhere by the writer (Rice, 1937, pages 42-47) and the Stemwinder and North Star mines by Schofield (1915, pages 133-135). A brief description of the Sullivan deposit will serve as an illustration. The ore consists of pyrite, pyrrhotite, galena, and sphalerite, deposited by highly selective replacement of thin-bedded sediments on the folded east limb of an anticline. The original laminæ in the sediments are perfectly preserved in the ore even where the silicates are completely replaced by sulphides. The gangue in the main part of the ore-bodies is unreplaced parts of the host rock; introduced quartz is present only near the ends of the ore-bodies. In addition to the minerals already mentioned, which form the bulk of the ore, cassiterite, tourmaline, garnet, and other minerals are present in minor amounts. The latter minerals suggest a high-temperature deposit related to an acid magma. The only intrusives that occur in the vicinity of the ore-bodies are Purcell sills and dykes, and there is clear evidence to show that these are earlier than the ore. A granitic batholith is exposed on the surface 12 miles to the northwest.

A second class of lode deposits thought to be related to the granitic rocks are various quartz veins occurring in many places. They include hematite-bearing veins; veins with pyrite, pyrrhotite, chalcopyrite, galena, and sphalerite in various proportions and carrying some gold; veins with sphalerite, galena, and argentiferous tetrahedrite; and veins with galena, sphalerite, and stannite. Veins of each type tend to be confined to one or more districts. They are considered to be related in origin to the granitic rocks, although any direct evidence of such a relationship is lacking. Quartz veins whose principal metallic constituent is hematite occur in a zone from Iron Range Mountain northwest of Kitchener to near the International Boundary. A number of gold-quartz veins occur in the Bayonne batholith or adjacent granitic bodies. The veins occupy persistent fractures and many can be traced for several thousand feet. Gold-quartz veins in sediments form a distinctive group, all of which occur in the basin of Perry Creek or immediately adjacent to it. They are large veins or stockworks, rather sparsely mineralized with pyrite.

LODE DEPOSITS PRESUMABLY RELATED TO POST-GRANITIC INTRUSIVES

Deposits grouped under this head occur in the vicinity of Kootenay Lake north of Crawford Bay and mainly on the west side in Ainsworth district. They closely resemble some of the Slocan mineral deposits and are probably genetically related to them. Three types occur: replacement deposits in limestone; bed veins; fissure veins.

Thick beds of limestone, largely calcite in the Slocan series and in part magnesian in the Lardeau series, are replaced by quartz, pyrite, pyrrhotite, galena, and sphalerite. The locus of replacement is, in most cases at least, a system of fractures. The bodies so produced are irregular but roughly tabular in shape, their limits being the margins of the limestone beds and in the other directions the distance replacement extended from the controlling fractures.

In Ainsworth district quartz veins occur along the bedding planes in the sediments. These veins may be several feet wide and continuous for several hundred feet. Ore-shoots, consisting principally of pyrite, sphalerite, and galena, are spaced at intervals along them. The veins apparently occur at or close to a fold in the sediments.

Certain veins follow steeply dipping fractures that cut obliquely across the bedding of sediments. The gangue is predominantly quartz. The location of the ore-shoots is, in part at least, controlled by the nature of the rock traversed by the fractures. Galena, sphalerite, pyrite, and chalcopyrite are the principal sulphides.

Regarding the age of the Ainsworth ore deposits Schofield says (1920, page 36): "It can only be stated that the deposits are younger or contemporaneous with the period of dyke intrusion and older than the glacial deposits. From a general study of the region it is believed that the dykes are closely related in age with the intrusion of the main mass of the West Kootenay granite batholith (the Nelson granite) which is of Jurassic age." Cairnes (1934, page 111), speaking of the Slocan deposits, says "The evidence also indicates that the deposits are related in origin to the Nelson granite."

The relating of the Ainsworth ore deposit to the Nelson batholith may well be correct, but certain considerations seem to the writer to indicate a different origin and a much younger age.

In some of the mines in Ainsworth district ore occurs in brecciated zones in certain dark sills and dykes. Only two groups of intrusives forming dark sills and dykes of this type are known to occur in the district: (a) the McGregor intrusives; and (b) the lamprophyre sills and dykes. It has not been established to which, if either, group belong the sills and dykes known to be older than the Ainsworth ore deposits. If they belong to the McGregor intrusives, the mineralization is definitely post-granite and probably of Tertiary age. If they belong with the lamprophyres and if the lamprophyres are related to the granites and not themselves a part of the McGregor intrusives, the ore, too, may be related to the granites and be of late Mesozoic or early Tertiary age.

NON-METALLIC DEPOSITS

A large body of rock magnesite forming a member of the Cranbrook formation was discovered by the Geological Survey party in 1932 (Cairnes, 1932, pages 101-104). In the present area two bodies of similar magnesite were seen in the same stratigraphic position. These occurrences are small and are remote from transportation; they have little economic importance at the present time.

One, owned by the Consolidated Mining and Smelting Company, occurs in a small, tightly folded syncline crossing the ridge at the head of Hellroaring Creek and the other in the main belt of the Cranbrook formation where it crosses the ridge east of Mount McKay.

The Purcell diorite is a dark green, crystalline stone of pleasing appearance. Attempts to work it have not, as yet, proved profitable. Tests on specimens submitted to the Bureau of Mines, Department of Mines and Resources, have not been very encouraging. The specimens tested would not take a good polish and contained enough calcite to constitute a serious disadvantage.[1]

At the Atabara Quarries, Sirdar, B.C., phases of the Bayonne granodiorite are being successfully used for building and monumental stone. Much of the batholith, however, is unsuitable as it is uneven in texture, contains objectionable inclusions, and has other disadvantages.

The Wall granodiorite is a possible source of monumental and building stone. It is a medium-grained, grey, grey-weathering, crystalline stone, has an even texture, and is exceptionally uniform in appearance. Most outcrops are jointed into large slabs suitable for extraction. Inclusions mar some of the rock, but are absent from much of it. Good exposures of it can be seen in the falls in Next Creek where it is crossed by the Bayonne mine road.

DESCRIPTIONS OF PROPERTIES[2]

DEPOSITS RELATED TO THE PURCELL INTRUSIVES

Evans Group

References: Ann. Repts., Minister of Mines, B.C.: 1904, p. 109; 1915, p. 111; 1920, p. 118. Schofield, 1915, pp. 144-145. Cairnes, 1932, pp. 98-101.

The Evans group is on the west slope of Evans Mountain and is reached by a trail about 11 miles long that follows up Meacham Creek from the outlet of St. Mary Lake. It is owned by C. and W. Evans of Marysville. The main camp is at the mouth of Fiddler Creek and a small cabin is in Pollen basin on Evans Mountain.

The principal workings are in two groups, one near the main camp and one at an evelation of 6,000 feet in Pollen basin. The lower workings consist of a number of open-cuts, which have exposed a large, flat-lying Purcell sill intruded into the Aldridge formation. In this sill occur patches and irregular bodies of disseminated pyrite, pyrrhotite, and chalcopyrite.

The upper workings also consist of a series of open-cuts, which expose two or more quartz-calcite veins in another diorite sill in Aldridge sediments. The largest of these veins is continuously exposed in an open-cut for about 30 feet. It is over 6 feet wide, strikes roughly east, and dips steeply. The wall-rock is coarse-grained diorite, which in places carries disseminated sulphides. The principal sulphide in the vein is chalcopyrite with minor amounts of pyrrhotite and galena. The continuation of the

[1] Cole, H.: Personal communication.
[2] Descriptions are given for only those deposits visited by the author.

vein beyond the ends of the open-cut has not been demonstrated. The sill is flat lying and it is probable that the exposed part of the vein is near its upper contact.

A second vein is exposed in an open-cut farther up the basin. It is smaller and not so well mineralized as the first. Other mineral showings are reported, but were not seen by the writer.

Mystery Group

References: Ann. Repts., Minister of Mines, B.C.: 1904, p. 109; 1920, p. 119; 1927, p. 267. Cairnes, 1932, pp. 98-101.

The Mystery group, located on Alki Creek at an elevation of 5,000 feet, is owned by Robert Dewar of Fort Steele. It is reached by a good trail starting from the St. Mary River road near the head of St. Mary Lake.

The workings consist of three adits and a number of open-cuts spaced at intervals in a northwesterly direction up the hill. All are in Purcell diorite. In the lower adit, which is also the main one, the principal deposit is a quartz-calcite vein carrying chalcopyrite, pyrite, and a little sphalerite and galena. The wall-rock is, in places, heavily impregnated with the same sulphides for a distance of several feet on either side of the vein. Small amounts of quartz and calcite occur in this disseminated ore, and in one place small veinlets of chalcopyrite were seen cutting the rock. The close association between the veins and the disseminated deposits is clearly visible and a common hydrothermal origin seems a reasonable postulate.

The sulphides in this working are mainly near the portal of the adit, and are very scarce at the face. No crosscutting has been attempted, however, and the adit may have passed out of the mineral zone. The workings higher up the hill expose one or more quartz-calcite veins, some of which are fairly well mineralized. No disseminated ore could be seen in the walls. The diorite close to the veins is, in places, strongly gneissic, as if deformed by shearing stresses set up during movement along the original fracture. The Alki Creek fault although not definitely seen in this locality is almost certainly nearby. The gneissic structure of the diorite may, therefore, be attributed to movement along this fault.

Empire State Claim

This property is at the edge of the flats on the west side of Goat River 2 miles north of Kitchener. It is owned by W. Belger of Kitchener.

The workings consist of three or four open-cuts following a southwesterly course up the hill. All are in a large Purcell dyke cutting Aldridge quartzite and dipping approximately parallel to the face of the hill. Neither wall of the dyke is exposed near the open-cuts, but one contact is probably not far from the most northeasterly open-cut, which is the main excavation. The line of open-cuts follows a steep-dipping fracture in the diorite. This fracture is not in itself a very marked feature and dies out towards the southwest, but has apparently served as a channel for mineralizing solutions.

In the main open-cut at the bottom of the hill, the fracture appears as a network of small quartz-calcite veinlets. On either side of this net-

work of veinlets, pyrrhotite and chalcopyrite are disseminated through apparently unaltered diorite. The total width of the mineralized zone is 4 to 5 feet. The change to unmineralized diorite at the edges of the mineralized zone is abrupt. Nickel was reported by the owner and an assay of almost pure pyrrhotite from this deposit gave 0·52 per cent of this metal.[1]

The open-cuts are spaced at intervals of about 20 feet southwest along the fracture. In each succeeding open-cut the mineralized zone is narrower and the sulphide content lower until, 40 to 50 feet from the lowest open-cut, sulphides are almost entirely lacking.

Creston Hill Mining Syndicate (formerly the Sullivan Group)

References: Ann. Repts., Minister of Mines, B.C.: 1919, p. 138; 1934, p. E27; 1936, p. E43.

This property lies at an elevation of 3,300 feet on the flank of the mountain south of the railway about 2 miles southwest of Kitchener. It is under option to the Creston Hill Mining Syndicate of Spokane, Washington.

The principal working is an adit driven into the hill in a southeasterly direction for some 300 feet, beyond which it curves to the left. Above the adit three open-cuts occur along a line running up the hill. At the end of this line of open-cuts, about 300 feet vertically above the adit, is a shallow shaft. Other open-cuts have been excavated to the southwest of the main workings.

All the workings have been driven in a flat-lying Purcell sill, the adit apparently near the bottom and the shaft near or at the top. The deposits consist of quartz-calcite veins in diorite.

The shaft was flooded at the time of the writer's visit, but from observations at the collar and of materials on the dump it has been sunk on a well-mineralized quartz-calcite vein 4 to 5 feet wide. An open-cut about 25 feet vertically below the collar of the shaft exposes the same vein, well mineralized and having about the same width. In another open-cut about 50 feet vertically below the shaft the vein is 3 feet wide and only sparsely mineralized with sulphides. A little above the adit an open-cut exposes a barren quartz-calcite vein parallel to the vein just described.

The adit is in diorite throughout. Much of the diorite is fine-grained and dark coloured and looks like the basic border phase that occurs at the bottom of most large sills. A number of irregular stringers and bunches of quartz and calcite occur, some of which carry a little chalcopyrite. No regular vein is exposed.

The evidence from the shaft and open-cuts suggests that the main vein is a quartz-calcite vein 4 to 5 feet wide, dipping at a high angle and cutting across a Purcell sill from the top to at least near the bottom. Near the top of the sill this vein is well mineralized with pyrrhotite and chalcopyrite. The zone of heavy sulphide extends down the vein for less than 50 feet vertically.

Several other veins are known. One exposed in an open-cut to the west of the main workings is 7 feet wide but is sparsely mineralized.

[1] Assay by H. V. Ellsworth, Geological Survey.

Senasael Group

The Senasael group is situated a little over a mile west of Kitchener, about 1,000 feet above the railway and on the north slope of the hill. It is owned by Harry Redmile of Kitchener, and associates.

The workings consist of three or four open-cuts distributed down the hill in a westerly direction. All are in a flat-lying Purcell sill probably not over 100 feet thick. The position of the lower contact can, however, only be guessed, but the upper contact is well exposed in the highest open-cut.

The deposit consists of a quartz-calcite vein, dipping at a high angle and cutting across the sill from the upper contact to, probably, near the lower.

The uppermost working is a deep open-cut excavated at the upper contact of the sill. The vein exposed there is 8 feet wide and well mineralized with chalcopyrite. In one direction the vein terminates abruptly against the sediments, and in the other, although it continues, the sulphide content and the width decrease until, near the centre of the sill, it is very narrow and almost barren. Near the bottom of the sill the vein widens, but there is no increase in the sulphide content.

Leadville Group

References: Ann. Repts., Minister of Mines, B.C.: 1894, p. 739; 1900, p. 835; 1925, p. 250.

The Leadville group is on Goat River 5 miles by trail from Kitchener. An adit, shaft, and open-cuts, all in poor repair, expose several quartz-calcite veins in a large, flat-lying Purcell sill in Aldridge sediments. The only vein seen by the writer is in the adit. It consists of 18 inches of quartz and calcite well mineralized with galena, sphalerite, chalcopyrite, and some pyrite.

Dykes Option Group

References: Ann. Repts., Minister of Mines, B.C.: 1929, p. 325; 1930, p. 254.

This property lies a short distance north of the Crawford Bay-Kootenay Bay road. It is owned by C. Rossiter of Kaslo, B.C.

The workings consist of an adit driven under open-cuts and trenches. The mineral zone apparently consists of sulphides disseminated through a flat-lying diorite dyke or sill, probably 40 to 50 feet thick, intruded into Lardeau sediments. The diorite is cut by many pegmatite dykes and is greatly altered. It has much the same appearance as a Purcell sill, but is evidently post-Lardeau in age.

The best showing is in the surface workings, which are probably near the upper margin of the intrusive. The ore minerals are pyrrhotite and chalcopyrite.

The adit commences in sediments, but enters the diorite within a few feet and is about 200 feet long. Off the main adit about 100 feet of cross-cut has explored the diorite under the open-cuts. No deposit of importance is exposed.

DEPOSITS PRESUMABLY RELATED TO THE GRANITIC ROCKS

Sullivan, Stemwinder, and North Star Mines

References: Ann. Repts., Minister of Mines, B.C., 1896 to 1938. Corless, F. V. (1902): Notes on the Geology of Southeastern British Columbia; Bull. Can. Min. Inst., vol. 5, pp. 512-513. Schofield, S. J. (1915): Cranbrook Map-area; Geol. Surv., Canada, Mem. 76, pp. 130-135. Staff of the Consol. Min. and Smelting Co., Ltd. (1924): The Development of the Sullivan Mine and Process for the Treatment of its Ores; Trans, Can. Inst. Min. Met., vol. 27, pp. 306-370. Alcock, F. J. (1930): Zinc and Lead Deposits of Canada; Geol. Surv., Canada, Ec. Geol. Ser. No. 8, pp. 322-328. Cairnes, C. E. (1932): Mineral Occurrences in the Vicinity of Cranbrook; Geol. Surv., Canada, Sum. Rept., pt. A, p. 94.

This group includes the only representatives of this type of deposit seen in the area. They have been described fully elsewhere and only a brief summary will be given here.

All three deposits have been worked, and the Sullivan is at the present time the largest silver-lead-zinc mine in the British Empire. They occur in the Aldridge formation, probably in calcareous argillaceous quartzite near its base. They are located in folds in the sediments on the concave side of a sharp curve in the Kimberly fault. In the ore zones the sediments have been replaced by sulphides, principally galena, sphalerite, pyrite, and pyrrhotite. In the Sullivan mine other minerals identified are jamesonite, cassiterite, chalcopyrite, marcasite, tourmaline, garnet, actinolite, tremolite, and grunerite.

The original structure and texture of the sediments are remarkably well preserved even where the rocks are wholly replaced by sulphides. On the Sullivan property there has been little or no addition of quartz except near the ends of the ore-body where, in one place at least, the deposit passes into a quartz vein. The only igneous rocks seen in the ore zone are members of the Purcell intrusives. These are earlier than the ore. A monzonite dyke was encountered in a diamond drill hole near the ore zone. Some post-mineral faulting has occurred, but most of the movement, at least on the Kimberly fault, is believed to be pre-mineral. The ore solutions presumably followed the channel opened by the Kimberly fault to where suitable structures, rocks, and physical conditions were reached and there formed the ore-bodies.

Efforts made to trace the southwestern extension of the Kimberly fault were unsuccessful. It was definitely established that the fault does not continue directly west nor does it pass southwest through Bootleg Mountain. The intense metamorphism of the sediments along Matthew Creek and on the south side of St. Mary River opposite Matthew Creek, and the number of pegmatite bodies occurring along this zone suggest that the fault may follow this path and that the zone of weakness so produced was invaded by granitic magmas and juices.

Kitchener Iron Ore Deposits

References: Ann. Repts., Minister of Mines, B.C.: 1919, p. 137; 1921, p. 147. Young, G. A., and Uglow, W. L.: Geol. Surv., Canada, Ec. Geol. Ser. No. 3, 1928, Iron Ores of Canada, Vol. I, British Columbia and Yukon, pp. 132-142.

Thirty-three Crown-granted claims and fractions have been located on Iron Range Mountain to the west of and paralleling Goat River north

of Kitchener. These comprise the Great War and C.P.R. groups. On these claims a number of open-cuts, shafts, and adits have exposed a broad zone of fracturing running roughly north and dipping steeply west. This zone is part of the main system of faulting that runs from the International Boundary near Creston in a north to northeast direction across the area. The fracturing involves Aldridge argillaceous quartzite and argillite and diorite sills. Hematite-quartz lenses from 2 to 20 feet wide and of undetermined length occur along this zone. The ore varies from nearly solid hematite to brecciated quartzite healed with quartz and hematite.

The property has been very completely reported on by Young and Uglow, and the reader is referred to their description for fuller information. The observations of the present writer have fully borne out their conclusions. The quartz and hematite were evidently deposited by hydrothermal solutions passing along the zone of fracturing. These solutions probably originated from the granitic magma.

Regarding the economic possibilities Young and Uglow say: "Unless then, the ore-bodies are long, or wider bodies remain undiscovered, or certain areas are characterized by a number of relatively small bodies so situated with respect to one another as to permit of economic mining methods, it is evident that the deposits on Iron Range Mountain are only of slight prospective value."

Bayonne Mine

References: Ann. Repts., Minister of Mines, B.C.: 1901, p. 1035; 1902, p. H163; 1904, p. 131; 1905, p. 169; 1910, p. 112; 1915, p. 170; 1917, p. 167; 1921, p. 143; 1923, p. 219; 1929, p. 359; 1930, p. 279; 1933, p. 240; 1934, p. 26E; 1937, p. 12E.

The Bayonne mine is situated at an elevation of 6,000 feet on the west slope of John Bull Mountain in the southwestern part of the area. It is connected to the Kettle Valley branch of the Canadian Pacific Railway at Bayonne (Tye siding) by a truck road 23 miles long.

The Bayonne was staked in 1901 and has been continuously held. Early development was limited, for despite the encouraging showings the transportation difficulty discouraged any attempt to bring the mine into production. In 1936 the property was taken over by the Bayonne Consolidated Mines, Limited, who installed a cyanide mill and requisite mining machinery. This company began active mining and by July 1938 had treated some 32,000 tons of ore. Depletion of the known ore-bodies led to the closing of the property in November of the same year.

The workings of the Bayonne consist of seven adits driven at vertical intervals of about 100 feet. The lowest adit, No. 8, was over 1,000 feet long at the time of the writer's visit and the face was approximately vertically below the face of the highest adit, No. 1. The adits are connected by raises. A considerable amount of stripping and trenching has been done on the ends of the ore zone.

The deposit consists of a fissure vein in granodiorite near the centre of the Mine stock. The wall-rock is fine-grained, light-coloured, biotite-hornblende granodiorite altered to a talc-carbonate rock for a distance of 2 to 3 feet on either side of the vein. The fissure strikes north 70 to 80 degrees east and dips almost vertically. It splits, widens and narrows, and sends

offshoots into either wall, but is on the whole fairly regular and consistent. In most places it is occupied by a quartz vein from a few inches to 10 feet wide. The wide part of the zone is not, however, solid quartz, but rather composed of two or more quartz veins separated by horses of altered granodiorite.

The only metals of commercial importance are gold and silver, which occur intimately associated with pyrite, galena, sphalerite, and chalcopyrite. Tetrahedrite was also observed under the microscope, and Warren (1938, pages 30, 31) reports that hessite (silver telluride) and petzite (gold-silver telluride) may occur. As in most fissure veins the ore minerals are not uniformly distributed, but occur in well-defined shoots.

The bulk of the ore milled was mined from the oxidized zone, which extends down the vein to a maximum depth of 450 feet. In this zone the sulphides have largely disappeared, their place being taken by limonite and minor amounts of secondary lead and zinc minerals. The bottom of this zone is characterized by a rather abrupt transition from highly oxidized and leached material to primary sulphides with little or no trace of oxidization or leaching.

The granodiorite, although elsewhere hard and unaltered even on the surface outcrops, in the vicinity of the mine is so thoroughly oxidized and decomposed that many feet of it have in places been ploughed away with a "Bulldozer" while building roads. It seems impossible to avoid the conclusion that this deep zone of oxidization is a remnant of the pre-glacial weathered surface that escaped removal by the ice, a surprising condition in view of the high elevation and exposed location of the deposit.

The oxidized ore consists of an unattractive looking mass of limonite and rusty, honeycombed quartz. Yet this ore 150 feet from the surface averaged 1 to 2 ounces of gold a ton, and assays as high as 12 ounces a ton have been obtained.[1] Below the oxidized ore-shoots there is a zone, apparently in primary ore, which assays from 0·5 to 1 ounce of gold a ton. This zone extends to a depth of 50 feet below the limit of oxidized ore. Below this zone again there is little or no change in the appearance of the ore, but the values drop to about 0·40 ounce gold a ton. The most plausible explanation of this rich zone is that some of the gold has come from the zone above and has been deposited in some form not yet recognized. The sulphite content of each ore-shoot, however, appears to be decreasing at depth. Indeed, little or no commercial ore was encountered in No. 8 adit under productive shoots in the levels above. The change in gold content may, therefore, be due to zoning in the primary ore rather than enrichment of the sulphides.

It is interesting to note that the granodiorite in which the ore-body occurs is believed to be one of the earlier granitic bodies. It may reasonably be suggested that this body may have been fractured shortly after, during, or perhaps even before, the emplacement of the Bayonne batholith. If that were the case solutions concentrated during the crystallization of the Bayonne batholith, or perhaps derived from its parent magma, could have penetrated the fissure in the earlier granite and so formed the ore-body.

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[1] **Information kindly supplied by the management.**

Spokane Mine

References: Ann. Repts., Minister of Mines, B.C.; 1915, p. 173; 1917, p. 165; 1920, p. 149; 1925, p. 248; 1927, p. C324; 1930, p. 279; 1936, p. E43; 1937, pp. E17-22.

The Spokane mine is owned by R. M. and K. K. Laib of Bayonne, B.C. It is situated at an elevation of 6,300 feet on the south slope of Wall Mountain and is reached by a trail that runs a short distance up Next Creek from the Bayonne road, beyond which it switch-backs up the mountain.

The workings on the Spokane consist of five adits and a number of open-cuts. All the adits and most of the open-cuts are probably on a single vein.

The deposit consists of a quartz-bearing fissure in the Wall granodiorite stock not far from its southern contact with sediments. This fissure strikes roughly east and dips vertically to 70 degrees south. It varies from 6 inches to 3 feet wide and carries a quartz vein or veins varying from fine stringers to a single vein the full width of the fissure. The quartz carries galena, sphalerite, pyrite, and a little chalcopyrite. Much of the vein is narrow and barren, but some well-mineralized ore-shoots have been opened and from them trial shipments have been made. The vein is greatly oxidized to a depth of 170 feet, the maximum depth below the surface reached. This oxidized ore contains a number of secondary lead and copper minerals as well as remnants of primary sulphides.

The main adit starts as a crosscut and reaches the vein at a depth of about 150 feet. From this point a little over 400 feet of the vein has been developed by drifts. The fissure, except for a few minor irregularities, is relatively straight and continuous. The main ore-body is confined to a shoot some 36 feet long, which has been partly stoped out. One small lamprophyre dyke crosses the vein.

About 110 feet vertically higher up the hill a second adit has been driven for about 180 feet along the vein directly above part of the main adit level. The vein in this adit is, perhaps, a little wider and carries more sulphides. Some ore has been stoped from this level also. Three small lamprophyre dykes cross the fissure in this adit. They have been fractured by late movement along the fissure.

A third adit, 50 feet above the second, has opened up about 100 feet of the vein. Conditions in this adit are much as in the ones below. To the west, beyond the adits, the vein has been traced along the surface for some distance by two other short adits, pits, and open-cuts.

The vein is, apparently, close to and parallel with the contact of the Wall stock. There are no exposures on the slope below the mine and the position of the contact as outlined on the map is based on observations made some distance away. There is, however, no doubt that the main valley of Next Creek is underlain largely by sediments.

The Wall stock is believed by the writer to be the oldest in the area, with the possible exception of the Rykert batholith.

The depth of oxidization on the vein is about the same as that of the Bayonne property. It, too, is probably due to pre-glacial weathering. A small patch of partly consolidated conglomerate is exposed in the bed of a little stream crossing the trail to the mine. This conglomerate consists

of pebbles of various rocks in a clay cement. The pebbles are so completely rotted that it is probably a pre-glacial conglomerate and substantiates the idea that glacial erosion was not important at this locality.

Wisconsin Mine

References: Ann. Repts., Minister of Mines, B.C.: 1928, p. C326; 1929, p. 356; 1933, p. 240; 1936, p. E43; 1937, p. E22.

The Wisconsin mine is at present under lease to E. W. McQuade, Yankee Girl mine, Ymir, B.C. It is situated at an elevation of 6,100 feet on the north side of the creek tributary to Midge Creek opposite Conway Creek, locally known as Hughes Creek. From Midge Creek siding a narrow road follows the north side of Midge Creek for about 6 miles. From the end of this road a good pack-trail about 6 miles long continues to the mine.

In the vicinity of the Wisconsin mine a very irregular body or bodies of granodiorite and quartz diorite have intruded and metamorphosed the upper members of the Horsethief Creek series. Rocks that were originally argillites, argillaceous quartzite, and arkose have been converted into quartz-mica schist and andalusite, cyanite, and sillimanite schist. Beds of blue-grey limestone have been recrystallized.

Outcrops are few along the lower slopes of Hughes Creek, so that the shape of the granitic intrusives cannot be accurately mapped. It is, therefore, impossible to be sure if the bodies exposed are finger-like offshoots of the Bayonne batholith or if they are separate bodies more akin to the Wall and Mine stocks.

The mineral deposit consists of a zone of quartz-filled fractures cutting across both granite and sediments. This zone appears to be the expression of a fault with a considerable stratigraphic displacement in the sediments, but which though it fractured the granitic rocks in its path does not appear to have displaced them noticeably. From this it might be inferred that most of the displacement along the fault took place prior to the intrusion of the granitic bodies, except that the latter were fractured by renewed movement with but little displacement.

Most of the work has been done on a single fracture zone cutting both granite and sediments. Other zones have, however, been developed to a limited extent.

The workings consist of five or more adits, a shaft, and open-cuts and deep trenches.

The main workings, situated close to the camp, consist of a crosscut about 60 feet long to the main vein, and a drift off it to the northeast about 150 feet long, with several short crosscuts to the edges of the fracture zone. From the end of the crosscut a winze has been sunk. This was flooded at the time of the writer's visit, but is reported to be about 100 feet deep and to have about 500 feet of drifts driven off the bottom. All the workings are in granite or in the fracture zone in the granite.

The vein strikes about north 40 degrees east and dips northwest at 60 to 65 degrees. The drift follows a pronounced shear zone a foot or so wide, on either side of which is fractured, altered, and mineralized granite and vein quartz. The average width of this zone is about 12 feet. About 40 feet from the main crosscut the zone widens abruptly to about 50 feet,

evidently along a subsidiary set of fractures crossing the main one. The winze and lower workings have been adequately described by Sargent.[1]

The ore in the upper level is largely oxidized and it is difficult to obtain an idea of the nature of the primary ore. Some of the ore from the lower level is lying on the dump and the following minerals were identified in the approximate order of their crystallization: pyrite, quartz, siderite, arsenopyrite, sphalerite, galena, chalcopyrite. The principal value of the ore is its gold and silver content. Samples taken by Sargent in both levels range from 0·10 to 0·64 ounce a ton in gold and 0·4 ounce to 33·6 ounces a ton in silver.

A shaft, now flooded, but reported to be 113 feet deep, an adit crosscut, and open-cuts have been driven on the southwesterly extension of the zone, and it has been followed up the hill to the northeast by a line of open-cuts. About 1,500 feet northeast of and 300 feet vertically above the main adit, three deep trenches have been excavated on the crest of the ridge. These extend down through 4 or 5 feet of overburden and expose a mineralized zone for about 100 feet, which strikes roughly north and dips west. This zone does not appear to be on the extension of the main vein and is considerably to the east of it. It consists of 9 to 16 feet of leached and oxidized quartz and crushed rock in schists and limestone cut by granitic dykes and sills. In some places sulphides were seen, but mostly they have been leached out.

From 400 to 800 feet southeast of the main adit a number of open-cuts, trenches, and two adits have been excavated in schists and granite.

Valporaiso Group

References: Ann. Repts., Minister of Mines, B.C.: 1900, p. 855; 1926, p. 285; 1927, p. 320; 1929, p. 356; 1933, p. 239.

The Valporaiso group lies at an elevation of 4,000 feet on the east side of Kootenay Lake directly above Columbia Point. The property was staked prior to 1900. After various attempts to mine at a profit failed it was acquired by the Sanca Mines, Limited, and leased by them to the Canada Smelters, in 1933. The latter organization made some trial shipments. Several of the claims have been restaked by local inhabitants within the last 2 years.

The principal deposit is a persistent, quartz-filled fissure in a lobe of the Bayonne batholith near its contact with the sediments. Nowhere has the vein been traced into the sediments. It strikes roughly north and dips east about 45 degrees. It has been traced nearly continuously for 1,500 to 2,000 feet and varies in width from 1 to 25 feet. The average width is probably between 3 and 5 feet. It is mineralized with pyrite, arsenopyrite, chalcopyrite, sphalerite, and galena, but only the two former are abundant. The main value is in gold. Sulphides are everywhere scattered through the quartz, but occur principally in bands of almost solid sulphides from a few inches to a foot in width.

The main workings consist of two shafts, an adit, and a great many closely spaced open-cuts.

[1]Ann. Rept., Minister of Mines, B.C., 1937, p. E24.

The shaft at the south end of the line of workings is in fair repair, but the air was too bad to allow the writer to descend more than 100 feet. For this distance it follows a quartz vein from 2 to 3 feet wide. Judging from the size of the dump the workings off this shaft must be fairly extensive. Most of the ore shipped came from here.

About 600 feet north of this shaft is another, which is caved. The vein between the two is exposed by open-cuts. It is up to 5 feet wide, but beyond some pyrite and much limonite stain no metallic minerals were seen. Several tons of well-mineralized quartz, however, lie on the dump of the caved shaft.

For about another 600 feet the vein is exposed in a series of closely spaced open-cuts. It is from 1 to 5 feet wide and carries streaks of sulphides from a few inches to a foot in width. At the north end of this series a deep open-cut has been excavated in a wide part of the vein and exposes a band of solid arsenopyrite and pyrite from 6 to 8 inches wide.

Below this open-cut an adit crosscut has been driven for about 180 feet to intersect the vein. From the face of this crosscut a drift about 120 feet long has been driven north along the vein and one about 80 feet long south. The fracture in the north drift is about 3 feet wide and is partly occupied by a 2-foot quartz vein carrying 6 to 8 inches of solid pyrite and arsenopyrite. There is no diminution in the size or sulphide content of the vein in the face. The south drift is in barren looking material until near the face. A foot or two before the face the vein is well mineralized, as if the beginning of another ore-shoot. Briefly in 200 feet of drift on the vein a little over 120 feet is well mineralized and 80 feet is low grade or barren.

To the north of these showings strong, mineralized fractures are exposed in a number of open-cuts and two short adits. These are too widely separated to determine if they all belong to a single vein. The quartz is much leached and stained and not much sulphide was seen. Other parallel veins are reported, but were not seen by the writer.

The striking feature of this deposit is the length of the vein. The value of the property naturally depends on the gold content, and as the vein is exposed in so many workings this could be determined with little expense beyond sampling the existing showings. In 1933 a trial shipment of 322 tons was made and returned 0·34 ounce a ton in gold and 3·5 ounces a ton in silver.

Gold Basin Group

This is an old property restaked in 1906 by J. W. Mulholland of Sanca Creek, B.C.

It lies in German Basin on the south side of Akokli Creek at an elevation of 7,000 feet. A trail about 5 miles long connects it with the main highway up the east side of Kootenay Lake at Columbia Point.

The deposit is a quartz vein in the same granitic body as the Valporaiso, close to its contact with the sediments. German Basin is a large cirque and the vein outcrops along its east wall not far below the crest of the ridge. It strikes roughly north and, near the surface, dips about 30 degrees west. The workings consist of a long adit driven from a point just above the floor of the basin, and a shorter adit higher up the vein. Several raises have been

driven from these adits through to the surface. In addition to the underground workings, a line of open-cuts expose the vein on the surface for about 300 feet. All the underground workings were in poor condition at the time of the writer's visit and the examination was largely confined to the surface.

The vein in the open-cuts occupies a strong fracture in the granite and is from 3 to 8 feet wide. It apparently dies out where the fracture passes from the granite to the sediments. The quartz is milky white and contains scattered galena, pyrite, and chalcopyrite. Some orange-yellow scheelite (calcium tungstate) was seen. Gold is reported associated with the sulphides.

On the ridge above the workings several open-cuts have been excavated, in most of which large quartz veins are exposed. The relation between these and the main vein is not known.

Homestake Group

References: Ann. Repts., Minister of Mines, B.C.: 1915, pp. 108-109; 1925, p. 230; 1926, p. 243; 1929, p. 297. Cairnes, 1932, pp. 88-92.

More work has been done on this property than on any other on Perry Creek. It has been described in some detail by Cairnes, and as no work has been done since his visit it will not be mentioned further here.

Rome and Valley Group

The Rome and Valley group consists of twenty-three claims held by location, controlled by J. M. Baird and associates of Cranbrook, B.C. It is located near the head of Rome Creek, a tributary of Perry Creek, about a mile by trail from the Perry Creek road near Sawmill Creek.

The deposit consists of two or more large and persistent quartz veins apparently occupying fissures in a fault zone. In a few places they contain small amounts of pyrite and galena. Crystals of pyromorphite (lead phosphate) were seen in one open-cut. Assays from samples taken by the owners are reported to range from $1.10 to $19.95 a ton in gold (gold at $35 an ounce).

The main workings consist of thirteen open-cuts, ten of which expose a vein striking north 15 degrees east and dipping 35 degrees to 50 degrees southeast. The vein has been traced for 1,550 feet and probably continues for at least another 1,000 feet to the north. It varies in width from 2 to 25 feet and averages about 9 feet. The remaining open-cuts are located on a parallel vein of the same type and apparently comparable in size with the first described.

Running Wolf Group

References: Ann. Rept., Minister of Mines, B.C., 1930, p. 243. Schofield, 1915, pp. 139-140.

The Running Wolf group is located on French Creek, a tributary of Perry Creek, and is reached by a trail about a mile long from the Perry Creek road.

The deposit consists of a number of quartz veins occupying fissures in greatly altered Creston argillaceous quartzite. The workings consist of

five adits, three of which are now caved. The main adit exposes three veins, each about 30 feet wide. Two of these veins occupy fissures striking in the same direction as the fault zone on the Rome and Valley group and approximately in line with it. The third vein is in a cross fracture. A few hundred feet down the hill another adit has been driven along a vein that parallels the main veins above. The veins are composed of massive quartz with occasional specks of pyrite and are reported to carry gold. They have been fractured by post-mineral movements along the original faults.

The Rome and Valley and the Running Wolf groups are apparently on the same zone of fracturing and faulting, and this zone probably continues south across the ridge between Perry Creek and Moyie River at Old Baldy Mountain. Exposed on the ridge at this point is a strong fracture zone that is occupied by a large quartz vein.

Kimberly Gold Fields, Limited (Quartz Mountain)

References: Ann. Repts., Minister of Mines, B.C.: 1932, p. 201; 1933, p. 201; 1934, p. 30.

The property of Kimberly Gold Fields, Limited, owned by Elmer Rice and associates, consists of thirty-five claims located near the head of Sawmill Creek and is reached by a branch automobile road about 3 miles long from the main Perry Creek road. The deposit consists of a quartz vein striking north 55 degrees east and dipping about 35 degrees southeast. The vein occupies a fracture zone in Creston argillaceous quartzite not far east of the Sawmill Creek fault. The vein consists of white, vuggy quartz with occasional patches of pyrite and is reported to carry a considerable amount of gold in places. A number of assays taken by the Resident Engineer in 1932 averaged 0·25 ounce a ton in gold.

The vein has been traced on the surface by a line of deep open-cuts, now mostly filled in, running in a southerly direction down the slope of the hill. A short distance below the last open-cut an adit has been driven that passes under the open-cuts. The adit is in the foot-wall. From the face of the adit short crosscuts have been driven to the right and left without encountering the vein. Near the portal of the adit another short crosscut has been driven to the right, and in the face of this is a vein some 3 feet wide. There is little doubt that this is the same vein as that occurring in the open-cuts.

Two or three hundred yards west of the main showings, the Sawmill Creek fault is exposed in an open-cut. The fault zone consists of strongly brecciated Creston, the greater part of which carries a considerable amount of pyrite. The whole zone has been silicified and the eastern part is occupied by a large quartz vein.

Argillaceous quartzite, outcropping in bluffs to the northwest of the fault zone, has been completely silicified in places, so that it resembles vein quartz. These silicified zones have been developed by one or two open-cuts, but it is doubtful if they have any economic possibilities.

Birdiel Group

The Birdiel group lies on both sides of the Perry Creek road a little more than 4 miles above the bridge across the creek at Old Town. It is owned by R. L. Bird, Cranbrook, B.C., and associates.

The workings consist of two fairly long adits and some old open-cuts. The adits have been driven in sheared and faulted argillaceous quartzite in the zone of the Perry Creek fault. Irregular quartz veins occur all through the zone of faulting and are, in places, well mineralized with galena, sphalerite, and pyrite.

The lower adit, just below the road, exposes two sets of quartz veins; one that is relatively flat lying and another that strikes roughly north 20 to 30 degrees east and dips steeply. Minor faulting is prominent all through the zone of mineralization and a strong thrust fault, striking about north 45 degrees east and dipping 80 degrees northwest, is exposed in two crosscuts on the foot-wall side of the zone. Post-mineral movement has taken place on these faults, but most of the movement is undoubtedly pre-mineral. Much of the vein matter is almost barren of sulphides.

The upper adit, the centre of which is more or less directly above the face of the lower, is the shorter of the two. Here, also, the country rock has been badly sheared and faulted and irregular quartz veins occur in many places. Some excellent ore lies on the dump, but very little was seen underground. The property was, however, visited in the absence of the owners and the best ore may not have been seen.

Wellington Group

References: Ann. Repts., Minister of Mines, B.C.: 1915, p. 113; 1932, p. 162. Schofield, 1915, p. 135. Cairnes, 1932, pp. 92-94.

The Wellington group, formerly known as the Mascot, is owned by the estate of James Angus of Marysville, B.C. It lies at an elevation of 5,700 feet on the east slope of Angus Creek (east fork of Hellroaring Creek). It is reached by a trail, about 7 miles long, from the road at the outlet of St. Mary Lake.

The workings consist of a line of twelve or more open-cuts, a 55-foot shaft, and an adit 127 feet long; the shaft and adit were in poor repair at the time of the writer's visit. The deposit consists of a narrow quartz vein traced by the workings for nearly 1,000 feet. It occupies a strong fissure, which is either the Sawmill Creek fault or an offshoot from it. The vein varies in width from 6 inches to 2 feet and probably averages about 1 foot. It strikes from north to northeast and dips from 65 to 85 degrees east. The vein consists of banded white quartz carrying galena, pyrite, some chalcopyrite, and possibly some tetrahedrite. Cairnes (1932, page 93) reports assays ranging from 0·02 ounce a ton to 4·80 ounces a ton in gold and from 0·3 ounce a ton to 57·5 ounces a ton in silver. A pegmatite stock, a mile or so in diameter, occurs between Hellroaring and Angus Creeks, and a short distance to the west of the Wellington workings there is a small stock of granite. The rocks in the vicinity of the deposit have been greatly altered and are almost unrecognizable. Probably they belong to the upper Creston or the base of the Kitchener.

This property occurs in or near the Sawmill Creek fault and the property of the Kimberly Goldfields lies about 4 miles to the northeast, close to the same fault.

Boy Scout Group

References: Ann. Repts., Minister of Mines, B.C.: 1924, p. 186; 1926, p. 243; 1929, p. 297; 1930, pp. 241-242.

The Boy Scout group lies on the east side of Hellroaring Creek about 3 miles by trail from the head of the automobile road that crosses St. Mary River at the outlet of the lake. The group consists of nine claims, four of which are Crown granted, controlled by N. A. Wallenger, Victoria, B.C., and associates.

The deposit consists of several quartz veins occupying shear zones in Aldridge quartzite. A short distance to the northeast lies the pegmatite stock mentioned in the description of the Wellington group, and about 1½ miles to the south is the St. Mary fault. The veins are well mineralized with galena, sphalerite, pyrite, and, in places, arsenopyrite; some siderite occurs in the gangue. The ore is said to carry only small amounts of gold and silver. The veins pinch and swell rapidly and are interrupted by faults, and as a result the lenses exposed are short. Whether ore-shoots of commercial size exist remains to be demonstrated by further exploration.

Present development work consists chiefly of three adits, the lowest of which is now caved. The intermediate adit was driven in the foot-wall of the vein for most of its length, but four crosscuts extend into the hanging-wall. Of these the two nearest the portal expose a small vein striking north 35 degrees west and dipping 40 degrees southwest. The two inner crosscuts expose a well-mineralized vein about 3 feet wide striking north 65 degrees west and dipping 45 degrees southwest. The part of the adit between the two sets of crosscuts is crossed by a strong shear zone, which may be a fault.

The upper adit exposes a strong, well-mineralized quartz vein. About midway along the adit, the vein is offset a few feet by a small fault. At its inner end the vein swells, apparently against a zone of shearing beyond which no vein matter can be seen.

The vein in the lower adit is reported to have been from 4 to 12 feet wide. The writer was, however, unable to enter this adit.

Some good-grade ore is present in places in the veins, but no long, continuous stretches of well-mineralized vein matter have yet been found and the rôle played by the faults is as yet unknown.

Gold Ledge Group

Reference: Ann Rept., Minister of Mines, B.C., 1898, p. 1024.

The Gold Ledge group, owned by S. A. Nogalski, Cranbrook, B.C., lies on the divide between the head of Alki Creek and one of the tributaries of Matthew Creek. It is reached by a trail about 3 miles long from the Mystery mine.

The deposit is a quartz vein occupying a strong thrust fault that strikes north 40 degrees west and dips at 60 degrees southwest. The workings consist of an open-cut and shaft on the divide, and two adits, one on the Matthew Creek side of the divide and one on the Alki Creek side. The latter was not examined by the writer.

The open-cut and shaft expose a quartz vein over 10 feet wide in thoroughly crushed Aldridge argillaceous quartzite. The quartz carries a considerable amount of pyrite, but no other sulphides were seen. The adit examined has been driven northwest along the fault zone where it crosses a steep-sided spur. It is about 120 feet long and crosscuts 25 feet long have been driven each way from the face. The adit is in vein matter for its full length. The crosscut to the right, driven into the foot-wall, is in crushed quartzite and diorite with about 50 per cent of vein quartz until near the face where it becomes barren. The crosscut to the left, in the hanging-wall, is in almost solid quartz throughout, and the hanging-wall of the vein has not been reached. The vein at the face of the tunnel is, therefore, over 40 feet wide.

The vein as exposed in the adit is mineralized with arsenopyrite and also carries galena and pyrite in places. Some siderite occurs in the gangue. Gold occurs associated with the sulphides, and an assay of over 1 ounce a ton of that metal is reported from a selected specimen.

The vein is continuously exposed from the adit to the top of the ridge and is well mineralized throughout. From the summit of this ridge the fault can be seen crossing the ridges for a mile or more to the northwest, and everywhere it appears to be occupied by a quartz vein.

This deposit is interesting, as it gives direct evidence of the relationship between the faulting and the mineralization. The fault is very clearly exposed and is evidently a thrust, the southwest block having moved up with respect to the northeast block. The amount of movement is not known, but the size of the fracture zone and the fact that a diorite sill, 100 feet or more in thickness in the northeast block, has been cut off and does not appear in the southwest block suggests that it was considerable. As the fault is occupied by a large quartz vein the period of mineralization is clearly later than the principal movements along the fault, but as the vein has itself been somewhat shattered, the last movements must have been after the deposition of the vein.

Great Dane Group

Reference: Ann. Rept., Minister of Mines, B.C., 1904, p. 109 (Bracebridge group).

The Great Dane group lies at an elevation of about 7,500 feet, close to the summit of the ridge on the north side of St. Mary River some 5 miles above the forks.

The workings examined consist of two or three open-cuts and an adit about 100 feet long. From the face of the adit a crosscut has been driven to the left for over 300 feet. The open-cuts and the adit expose one or more veins in Creston argillaceous quartzite. The vein at the portal of the adit is about 5 feet wide, and both there and in the open-cuts is well mineralized with galena, sphalerite, chalcopyrite, and pyrite. Some erythrite (cobalt bloom) can be seen at one place at the portal of the adit, but no primary cobalt mineral could be identified. Siderite occurs in the gangue.

Information as to the continuity and average value of the vein is very scanty, as the adit although beginning in the vein swings to the left after following it for a few feet and does not pick it up again, unless a vein appearing in the right-hand corner at the face of the adit be its continuation. The crosscut is in barren rock throughout.

Humbolt Claim

The Humbolt claim is situated at an elevation of 5,000 feet half a mile to the west of the summit of Rose Pass. The workings are beside the Crawford Bay-Rose Pass trail, 5 miles from the end of the Crawford Bay road. It is owned by Oscar Burden of Kaslo, B.C. It was located about the beginning of this century and no work has been done on it recently.

The workings consist of one adit, now partly caved, driven east on a flat-lying vein. Immediately to the south of the portal of this adit a small open-cut has exposed the same vein. About 50 feet to the north at the same elevation a second open-cut has been excavated.

The main showing, visible in the adit and the south open-cut, consists of a flat-lying quartz vein, 4 feet in width, exposed for about 30 feet in one direction and 25 feet in the other. It is well mineralized with sphalerite, galena, pyrite, chalcopyrite, and a tin mineral that is probably stannite (copper, iron, tin sulphide). The occurrence of stannite is further dealt with in the description of the Rose Pass prospect.

The north open-cut is in barren rock except for some quartz that is exposed near the bottom. This may be another vein or the top of the vein in the adit moved out of position by a fault between the two places.

The vein in the adit parallels the bedding in dark grey, micaceous argillite of the Horsethief Creek series. Apparently it occurs at the crest of a fold in the sediments and is probably a saddle reef. Fairly close folding characterizes the rocks between Silver Hill and Rose Pass, and the Humbolt lies in this belt. Some post-mineral faults occur, but it is not likely that any have a displacement of over a few hundred feet.

Rose Pass Prospect

This prospect lies near the summit of Rose Pass at an elevation of about 5,800 feet above sea-level, the showings being located a few yards northwest of the trail. The claims were staked in the "nineties" and were allowed to lapse. In 1936 they were restaked by George Ellis of Marysville and R. W. Johnson of Fort Steele.

The deposit consists of one or more quartz veins occupying fractures in black argillite of the Mount Nelson formation. Close to the deposit the sediments have been intruded by a small dyke or sill of fine-grained, light-coloured granite porphyry.

The workings consist of two, small, shallow open-cuts about 1,700 feet apart and a short crosscut adit between them. The main showing is in the lower open-cut. There an irregular quartz vein, striking roughly northeast and dipping steeply west, and with an average width of about a foot, has been stripped for about 10 feet. The possible extension of the vein in both directions is completely masked by overburden. Ten to 20 feet to the northeast of the open-cut, on the east side of the vein, the granite porphyry dyke outcrops. The vein is well mineralized with galena, sphalerite, chalcopyrite, pyrite, and a tin-bearing mineral, probably stannite, and also carries some silver.

The adit is about 1,000 feet to the southwest of open-cut 1. For most of its length it is in barren, black argillite. At the face the adit stops at a

granite porphyry dyke similar to that outcropping near the lower open-cut. It is probable, from the projected strike of the vein and the presence of the dyke, that the vein, if it continues so far, has not been reached by the adit.

The upper open-cut is about 700 feet farther southwest and appears to be well to the southeast of the projection of the vein in the lower open-cut. It exposes a quartz vein carrying a little galena in tightly folded argillite. The vein appears in general to be flat-lying, but has either been closely folded or has followed closely folded beds in the sediments.

The Humbolt and the Rose Pass deposits are much alike. The two deposits consist of quartz veins in closely folded, black slates; the Humbolt and part, at least, of the Rose Pass deposit are bed veins. The principal minerals in each are galena, sphalerite, chalcopyrite, and pyrite, and both contain the unusual mineral stannite or a tin mineral closely resembling it. Furthermore the two properties lie about a mile apart in the same structural belt. It seems certain that they have a common origin, and very possibly other similar bodies lie in the area between them.

The most interesting feature of these deposits is the presence of the tin mineral. This is probably stannite (copper, iron, tin, sulphide), but it may be some other complex tin mineral.[1] It is dark grey and fine-grained with a slightly greenish cast and is very difficult to distinguish from tetrahedrite (grey copper) both in the hand specimen and under the microscope. It occurs intimately intergrown with sphalerite, chalcopyrite, and galena.

It is impossible to give any estimate of the tenor of the ore as a whole, but a partial analysis of a picked specimen from the Rose Pass dump assayed by the Bureau of Mines returned 9·10 ounces a ton in silver, a trace of gold, and 1·51 per cent tin. In addition to the constituents determined, the specimen contained lead, zinc, and copper.

The economic possibilities of the deposit remain to be determined. No estimate can be made of the size, extent, or richness of the veins from the present limited showings. Very little information is available regarding the economic possibilities of stannite as an ore of tin, as nearly all the veins being operated in which it occurs contain cassiterite (tin oxide) as the most important tin mineral, and cassiterite has not been recognized in this ore.

Stannite occurs near Revelstoke in the Snowflake mine, the only other known occurrence in Canada, and cassiterite is reported some 15 miles southeast (Gunning, 1931). An unidentified tin mineral occurs in some of the Slocan ores, principally at the Payne mine (Cairnes, 1935, page 100). Cassiterite occurs at the Sullivan mine, Kimberly, B.C. (Schwarts, 1929). There, therefore, seems a possibility that there is a tin-bearing belt in British Columbia running from Revelstoke southeast to Kimberly. Whether or not this belt includes any commercial deposits is, of course, impossible to guess. In view of the difficulty of distinguishing between stannite and tetrahedrite it is suggested that owners of properties in this region should have their ores tested for tin.

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[1]**Ellsworth, H. V.: Personal communication.**

Silver Hill Group

References: Ann. Repts., Minister of Mines, B.C.: 1900, p. 849; 1901, p. 1031; 1903, p. H149; 1917, p. 154; 1925, p. 237; 1926, p. 259.

This property, which includes the Silver Hill and X-Ray groups, is owned by the British Columbia Lead and Zinc Mines, Limited, of Calgary, and lies at an elevation of 6,000 feet on the south side of Crawford Creek about 4 miles by trail from the end of the automobile road.

The deposit has been worked intermittently by various owners since 1900. Over 2,700 feet of adits have been driven. In 1901 the property was a steady shipper, but since then it has been worked by leasers only. No figures are available as to the actual tonnage extracted. At the time of the writer's visit the property had just been taken over by the present owners, who were constructing a tramway from the mine to Crawford Creek in order to ship the 2,000 to 3,000 tons of ore accumulated on the dumps. Some of the adits were in poor repair and many of the principal workings were inaccessible.

The deposit consists of one or more quartz veins, from 1 to 2 feet wide, that parallel the bedding in dark grey argillite of the Mount Nelson formation. In this locality the sediments and the quartz veins lie in a monoclinal roll and vary in dip from almost horizontal to 27 degrees west. The veins appear to be wider where they are most nearly horizontal. They have been dislocated in places by faults, probably none of which has a displacement of more than a few hundred feet. The vein or veins have been traced by open-cuts, short adits, and inclined shafts for a distance of half a mile or more, and the width, though generally narrow, is fairly uniform for considerable distances. They are well mineralized with galena, sphalerite, tetrahedrite, and pyrite. Good silver assays are reported. There is, apparently, little replacement of the wall-rock at the margins of the veins.

A considerable amount of ore undoubtedly remains in the deposit. The narrow widths, low dip, and distance from transportation will make its extraction costly.

Lakeshore Group

References: Ann. Repts., Minister of Mines, B.C.: 1932, p. 95; 1933, p. 239.

The Lakeshore mine is beside the main highway along the east side of Kootenay Lake about one-half mile south of Sanca Creek. It is owned by W. R. Long and E. G. Timmons.

Round the mouth of Sanca Creek a small roof pendant of much altered sediments occurs in the Bayonne batholith. Near the south edge of this roof pendant the sediments have been deformed by a zone of fracturing running roughly north at right angles to the contact.

About 300 feet from the granite a shaft has been sunk on this zone, which there is beside the road. Below the road, 50 to 100 feet vertically below the collar of the shaft, a crosscut adit has been driven that cuts the fracture zone some 50 feet north of the bottom of the shaft and with which it is connected by a drift along the zone. Short sub-level drifts have been driven north and south off the shaft from about half-way down it.

The fracture zone is from 10 to 20 feet wide and has involved, in places, a porphyry dyke. Lenses of galena, sphalerite, and a little chalco-

pyrite and pyrite occur along this zone, most frequently as replacements of the dyke. Post-mineral faulting has shattered these lenses, and in places dragged out ore along the zone. The largest lens is near the collar of the shaft, where massive sulphides occur over a width of 3 to 4 feet and for about 20 feet both horizontally and vertically. In the sub-level drifts lenses are smaller and discontinuous. In the drift on the lowest level ore is confined to two narrow veinlets on the two walls of the fracture zone.

The massive nature of the sulphides in the lenses has made it possible to make small shipments of clean ore, but the small size of the lenses and the amount of barren rock between them make it unlikely that even small-scale operation will be profitable.

Delaware Group

References: Ann. Repts., Minister of Mines, B.C.: 1928, p. 354; 1929, p. 360.

The Delaware group is situated at an elevation of 4,500 feet on the south slope of Rolf Mountain, to the north of Creston.

The deposit consists of a quartz vein in strongly sheared Aldridge quartzite. It has been developed by two adits, one above the other.

The lower adit is about 175 feet long. The first 135 feet has been driven along a quartz vein varying in width from a few inches to 5 or 6 feet. Near the end of this part of the adit the vein passes into the left wall. A short crosscut to the left picks up the vein, but the drift off this crosscut is to the left of the vein. At the face of this part of the drift quartz once more appears, but is probably another vein. A considerable amount of quartz, much of which carries galena, is piled in the dump. No other sulphides were seen.

The second adit is 50 feet long and is about 50 feet vertically above the first. It is driven along a strong vein of vuggy quartz, which is up to 20 feet wide but pinches and swells, as does that in the lower adit. A considerable amount of galena can be seen in the vein in the face.

Alice Mine

References: Ann. Repts., Minister of Mines, B.C.: 1900, p. 854; 1901, p. 1035; 1903, p. H149; 1904, p. 133; 1905, p. 169; 1909, p. 119; 1925, p. 249.

The Alice mine is situated on the west slope of Arrow Mountain, 2 miles by auto road north of Creston. It is owned by F. Staples and associates, of Creston.

The property has been worked intermittently since 1900. Several hundred feet of underground work has been done and a number of carloads or ore shipped.

The deposit consists of veins and lenses of galena, carrying in addition a little pyrite and quartz but almost no sphalerite. These veins and lenses occur in strongly sheared and faulted argillaceous quartzite in the main zone of faulting running north from Creston. Post-mineral faulting has disturbed the ore in many places, so that shoots are difficult to find and follow. No large ore-shoots have as yet been found, but the absence of zinc and excellent transportation facilities make the ore favourable for small-scale operation with hand sorting. The ratio of silver to lead is about $\frac{1}{3}$ ounce to 1 per cent.

DEPOSITS PRESUMABLY RELATED TO POST-GRANITIC INTRUSIVES

Mining properties assigned to this group are dotted all over Ainsworth district. Few of these have been worked to any extent since 1920. As the writer's time in the district was limited, the detailed examination of individual deposits was confined to those that were then active or that had been worked recently. The following descriptions are, therefore, limited to such properties.

Eden and Crescent Group

References: Ann. Repts., Minister of Mines, B.C.: 1890; 1917, pp. 153 and 187; 1919, p. 153; 1937, p. E51.

The Eden and Crescent group is located on the north side of Coffee Creek a short distance from the highway bridge. It is at present under lease to G. H. Grimwood.

The deposit has formed by replacement of limestone, probably in the Milford group, by galena and sphalerite. The principal working consists of an adit, drifts, a crosscut, an inclined raise and winze, and sub-level drifts off the winze.

The adit is driven about 60 feet northwest in dark-coloured, calcareous and carbonaceous slates, probably belonging to the Milford group. Near the face it intersects a strong strike fault trending north 10 degrees east and dipping 35 degrees west. A drift follows this fault to the north for about 360 feet. The fault zone consists of 3 to 4 feet of gouge and crushed rock. Slickensided surfaces indicate that the movement along the fault has been in the direction of the dip, but the upthrow side was not determined.

From near the end of the drift a short crosscut to the northwest cuts into the limestone bed, which appears to be 3 to 4 feet wide, strikes north 10 degrees east, and dips 40 degrees west. It has been recrystallized and much of it now consists of aggregates of coarse calcite crystals. Where the bed is exposed in the crosscut it is plentifully speckled with large crystals and patches of brown sphalerite, some of the latter 8 inches by 4 inches in cross-section.

Short drifts have been driven along this bed in both directions. In the drift to the south the limestone is less altered and sphalerite scarce. In the drift to the north, however, in addition to the sphalerite, stringers and patches of galena can be seen. From the end of this drift an inclined raise has been driven for some 25 feet. In this raise sphalerite is plentiful and there are some 6-inch streaks of clean galena.

In continuation with the raise there is a short winze and, at the bottom, drifts have been driven in both directions. In none of these workings is there any appreciable amount of sulphides and the limestone is relatively unaltered.

Banker Mine

References: Ann. Repts., Minister of Mines, B.C.: 1930, p. 255; 1937, p. E51. Schofield, 1920, p. 44.

The Banker mine is on the hillside above Ainsworth. It is reached from that village by an automobile road. It is owned by Ainsworth Mines, Limited, whose manager, Carl M. Mohr, is resident in Ainsworth.

A considerable amount of development has been done by various owners, the last by the present holders who shipped 3,305 tons in 1937. At the time of the writer's visit the mine was shut down.

The workings consist of two shafts, each about 200 feet deep, a main adit crosscut about 880 feet long, and about 1,500 feet of drifts in three levels.

The deposit is a quartz vein paralleling the bedding in Milford quartzite. It follows a zone of strike faulting or slipping along the beds. The beds strike on the average north 10 to 20 degrees west and dip about 40 degrees west. A few hundred feet south of the Banker they swing sharply until they strike as much as north 70 degrees east and dip at 25 degrees north. Still farther south they resume their former attitude. The Banker, therefore, is on the north limb of a steep-dipping, synclinal fold close to its axis. It is possible that the fracture now occupied by the vein may have been caused by adjustment of the beds during the development of this fold.

The fracturing along the mineral zone has involved a sill some 6 feet thick. It is clearly pre-mineral, being crushed by pre-mineral movements and greatly altered and mineralized. It is more altered near the ore-shoots, contains veinlets and replacement patches of ore, and also appears to have acted as a dam to the mineralizing solutions. In places where the sill rolls sulphides are more plentiful under flat parts of the sill. This sill is either a lamprophyre or a member of the McGregor intrusives, but is too much altered where seen by the writer to identify more specifically.

The vein is, in places, more or less solid quartz, but much of it is crush breccia whose fragments are quartzite and sill rock cemented by quartz and, in places, ore minerals. Much of the vein is barren, but at least two good-sized ore-shoots have been opened up underground.

The uppermost level, the 70-foot level, is driven south off the main shaft. It has exposed an ore-shoot about 140 feet long, which is also followed down from the surface by the shaft. This shoot is about 7 feet wide. The principal sulphides in the central part are sphalerite and galena; and pyrite is abundant near the margins.

The second level, the 140-foot level, is driven south from the bottom of the shaft. It exposes the same ore-shoot. The ore-shoot, although as well mineralized as above, is only about 80 feet long on this level. The drift continues along the fracture zone and, after passing through about 75 feet of barren and low-grade material, opens up a second ore-shoot about 100 feet long. The drift is continued for another 100 feet, but no more ore is exposed.

The main adit, the 400-foot level, is driven as a crosscut. It cuts the ore zone some 600 feet from the portal and continues for another 280 feet without exposing any further indications of apparent importance. Drifts have been driven along the ore zone for about 300 feet in each direction without encountering any important mineral deposit or the sill seen in the workings above. No crosscuts have been driven in the drift to the south and it may be off the true mineral zone. Three short raises have been driven off this drift and in two of them well mineralized vein matter is exposed.

Spokane-Trinket Mine

References: Ann. Repts., Minister of Mines, B.C.: 1920, p. 119; 1937, p. E51. Schofield, 1920, pp. 44, 45.

The Spokane-Trinket mine is owned by Maestro Silver-Lead Mines, Limited. The propery lies on Munn Creek a short distance to the north of the Banker. It is reached from Ainsworth by an automobile road.

The deposit closely resembles that of the Banker. It consists of a vein in argillite, quartzite, and limestone of the Milford group. It is, however, at a somewhat higher horizon than the Banker. The deposit is a crushed zone replaced or cemented by quartz, is from 3 to 4 feet wide and carries galena, sphalerite, pyrite, and chalcopyrite. The strike of the beds and vein is north 10 to 20 degrees west and the dip about 30 degrees west.

The deposit is developed by two adit levels. The upper level is driven for over 900 feet along the vein. Over 400 feet of this drift is in an ore-shoot that has mostly been stoped through to the surface. The lower adit was started not far from the portal of the upper and only 25 feet vertically below it. It was driven for about 360 feet on fissures in the foot-wall. The last 220 feet, however, is on the main ore zone and 180 feet of this part of the drift is in the ore-shoot that has been stoped through to the level above.

New Jerusalem Group

References: Ann. Repts., Minister of Mines, B.C.: 1907, p. 95; 1937, p. E51.

The New Jerusalem lies on the south side of Cedar Creek just above the Highland mine. It is owned by Mrs. E. Bishop of Los Angeles and is leased to R. J. Hughes and associates of Ainsworth.

The occurrence consists of a strong fissure, striking north 75 degrees west and dipping at 65 degrees south, which cuts across greenstones with occasional interbeds of biotite schist belonging to the Kaslo series. In most places the fissure is occupied by a quartz vein or stringers. The principal sulphide is galena, but chalcopyrite, pyrite, sphalerite, and arsenopyrite occur in small amounts. The vein pinches and swells from quartz stringers to 4 feet of massive quartz.

Work is at present being carried on in the upper workings, which consist of a short adit with raises and stopes running through to the surface, small underhand stopes, stripping, and open-cutting. About 100 feet below the upper workings an adit crosscut has been driven from a point a little above the creek. This crosscut has intersected the fracture zone and been driven well past it into the hanging-wall. The zone here consists of 12 to 15 feet of parallel fissures, the largest one being a 2-foot crushed zone cemented by quartz and calcite. A drift has been driven along this fissure, but neither in the crosscut nor drift is any ore exposed. The lower level has been connected with the upper by a raise and no ore was encountered in this working until within 25 feet of the upper level.

Silver Coin Group

The Silver Coin group is located on the north side of Woodbury Creek about 4 miles by trail from the main road. It was being operated by leasers when visited by the writer.

The workings consist of four adits driven in a steep dipping fracture zone in limy and carbonaceous, black argillite of the Slocan series. Small quartz stringers ½ inch to 6 inches wide occur in this zone. These stringers carry small amounts of galena, sphalerite, tetrahedrite, and argentite, and are reported to assay as high as 600 ounces a ton in silver.

The two upper adits are about 50 feet vertically apart and mineralized stringers occur in both. In the two lower adits the fracture zone is barren.

The ore is being carefully hand sorted and sacked for shipment.

NOTES ON SOME OTHER PROPERTIES

Blue Bell Mine

References: Ann. Repts., Minister of Mines, B.C.: 1888; 1889; 1890; 1893; 1894; 1896, p. 94; 1895, p. 33; 1898, p. 1081; 1899, p. 699; 1905, p. 158; 1906, p. 142; 1907, p. 96; 1908, p. 92; 1909, p. 105; 1912, p. 147; 1913, p. 123; 1914, p. 284; 1915, p. 119; 1917, p. 154; 1918, p. 159; 1919, p. 153; 1920, p. 120; 1921, p. 131; 1924, p. 188; 1925, p. 232; 1926, p. 258; 1927, p. C281; 1929, p. 324; 1930, p. 254; 1931, p. 142. Walker, 1928, pp. 129-134.

Located at Riondel on Kootenay Lake; owned by Consolidated Mining and Smelting Company, Limited; deposits formed by replacement in limestone along cross fractures. The principal sulphides are galena, sphalerite, pyrite, and pyrrhotite.

Florence Mine

References: Ann. Repts., Minister of Mines, B.C.: 1915, p. 119; 1918, p. 158; 1921, p. 130; 1927, p. 281C; 1928, p. C298; 1929, p. 322. Schofield, 1920, pp. 40, 41.

Located between Ainsworth and Woodbury Creek and reached by automobile road; owned by Kootenay-Florence Mining Company, Limited. The ore deposits, all in the upper part of the Milford group, are of two types—replacements in beds of limestone and fissure veins in schist and sheared greenstone. The principal sulphides are galena and sphalerite.

Gold King Prospect

Reference: Ann. Rept., Minister of Mines, B.C., 1933, p. 240.

Located on the side of the main road 3 miles south of Gray Creek; owned by R. McGregor of Port Crawford. The deposit consists of a 6-inch vein in altered Horsethief Creek quartzite. The vein carries chalcopyrite and pyrite and is reported to carry good gold values.

Gallagher Group

References: Ann. Repts., Minister of Mines, B.C.: 1907, p. 95; 1908, p. 92; 1914, p. 285; 1915, p. 120; 1917, p. 153. Schofield, 1920, pp. 54, 55.

Located above the Florence mine at an elevation of 4,000 feet; owned by the Olive A. Silver-Lead Company. The deposit is a replacement in a bed of limestone in the Slocan series. The ore mined was mostly from the oxidized zone.

Highland Mine

References: Ann. Repts., Minister of Mines, B.C.: 1893; 1894, p. 736; 1895, p. 681; 1896, p. 92; 1897, p. 527; 1900, p. 848; 1901, p. 1029; 1904, p. 149; 1908, p. 93; 1910, p. 96; 1912, p. 146; 1913, p. 123; 1917, p. 155; 1919, p. 153. Schofield, 1920, pp. 37-40.

Located a little over a mile north of Ainsworth; owned by Consolidated Mining and Smelting Company, Limited. In 1903 this was the largest lead producer in British Columbia. The deposit consists of fissure veins in the upper Milford and lower Kaslo. Ore-shoots are confined to the Kaslo greenstone close to its contact with the sediments. The principal minerals are galena, sphalerite, pyrite, marcasite, chalcopyrite, ankerite, and fluorite.

Highlander Mine

References: Ann. Repts., Minister of Mines, B.C.: 1895, p. 682; 1896; 1899, p. 96; 1900, p. 852; 1901, p. 1029; 1904, p. 154; 1905, p. 158; 1906, p. 142; 1907, p. 95; 1908, p. 93. Schofield, 1920, pp. 45-49.

Located less than a mile south of Ainsworth; owned by the Highlander Mining and Metallurgical Company, Philadelphia, Pa. The deposit consists of a quartz vein following the bedding of the sediments in the top of the Lardeau series. The principal sulphides are galena, sphalerite, and pyrite.

Hotshot Claim

Reference: Rice, 1938, pp. 7, 8.

Located near Riondel, Kootenay Lake; owned by E. G. Davis and Jack Sutcliff of Riondel. The deposit consists of a fissure vein cutting pegmatite and altered basic dyke. One ore-shoot is exposed, 30 feet long by 3 feet wide. The principal minerals are galena, sphalerite, pyrite, and ruby silver.

Iva Fern Mine

References: Ann. Repts., Minister of Mines, B.C.: 1917, p. 167; 1923, p. 219; 1925, p. 251; 1926, p. 27; 1928, p. 351; 1929, p. 359; 1930, p. 279.

Located on the north side of Cultus Creek a little over a mile by trail from the Bayonne mine road. It is owned by the Consolidated Mining and Smelting Company. The deposit consists of a quartz fissure vein in altered Horsethief Creek sediments. The principal minerals are galena, sphalerite, chalcopyrite, pyrite, calcite, siderite, and tourmaline.

Jewel Group

Reference: Ann. Rept., Minister of Mines, B.C., 1937, p. E51.

Located a little to the north of the Banker mine; under option to Ainsworth Mines, Limited. The deposit consists of a quartz vein in a fissure cuting quartzite and argillite at an oblique angle. There is good ore in the quartzite, but none in the argillite.

Krao Mine

References: Ann. Repts., Minister of Mines, B.C.: 1905, p. 158; 1906, p. 142; 1907, p. 95; 1908, p. 93; 1920, p. 119; 1929, p. 323; 1935, p. E51; 1937, p. E53. Schofield, 1920, pp. 57, 58.

Located a short distance south of the Banker mine; owned by Krao Mines, Limited. The property has been leased for the last 2 years. The ore-bodies have formed by replacement in beds of limestone in the Milford group. The principal minerals are sphalerite, galena, and pyrite.

Maestro Mine

References: Ann. Repts., Minister of Mines, B.C.: 1908, p. 93; 1909, p. 105; 1912, p. 146; 1913, p. 123; 1917, p. 187; 1919, p. 152. Schofield, 1920, p. 44.

The Maestro adjoins the Banker to the south. It is owned by Maestro Silver-Lead Mines, Limited. The deposit is similar to that of the Banker and may possibly be continuous with it.

Montana Group

References: Ann. Repts., Minister of Mines, B.C.: 1902, p. H163; 1910, p. 112; 1917, p. 167.

Located a short distance from the Bayonne mine; owned by F. Aiken. The deposit consists of a gold-bearing quartz vein in the granodiorite of the Mine stock.

No. 1 Mine

References: Ann. Repts., Minister of Mines, B.C.: 1893; 1894, p. 735; 1895, p. 681; 1896, pp. 89, 90; 1897, p. 527; 1898, p. 1898; 1899, p. 698; 1901, p. 1029; 1905, p. 158; 1906, p. 142; 1908, p. 93; 1909, p. 105; 1912, p. 146; 1913, p. 123; 1919, p. 119; 1936, p. E51. Schofield, 1920, pp. 51-53.

Located at an elevation of 4,200 feet above Ainsworth; owned by Consolidated Mining and Smelting Company. It consists of a replacement deposit along a bed of limestone belonging to the Slocan series, close to its contact with argillite. The ore shipped was mostly from the oxidized zone.

Skyline Mine

References: Ann. Repts., Minister of Mines, B.C.: 1890; 1894, p. 736; 1895, p. 681; 1896, pp. 90, 91; 1897, p. 527; 1898, p. 1898; 1919, p. 153; 1920, p. 119; 1921, p. 131.

Located at an elevation of 5,500 feet above Ainsworth; owned by A. W. McCune. The deposit is a replacement in limestone of the Slocan series.

Summit Bell Group

Reference: Ann. Rept., Minister of Mines, B.C., 1937, p. E16.

Located on Blazed Creek to the east of the Bayonne mine; owned by F. Aiken, Bayonne, B.C., and associates. The deposit consists of quartz-filled shear zones in the granodiorite of the Mine stock. The principal sulphide is pyrite. The ore-bodies may be fairly wide, although information is rather scanty. Some favourable assays in gold were obtained by the resident mining engineer.

Virginia Mine

Located 1½ miles northwest of the Bayonne mine; owned by J. Mulholland and leased at the time of the writer's visit. The deposit consists of a fracture 1 to 3 feet wide containing 6 inches to 2 feet of leached quartz in the granodiorite of the Mine stock. Gold is reported by the leasers to run as high as 7·00 ounces a ton.

MINERAL SPRINGS

The Ainsworth hot springs (Schofield, 1920, page 1) have been famous for many years and need not be mentioned further here.

Cold mineral springs occur at a number of places in the area. One was seen on Woodbury Creek in Ainsworth district; one occurs on St. Mary River close to the trail down from Rose Pass, and several more occur farther up the creek; two were seen on Dewar Creek; and one occurs on Campbell Creek, which runs into Kootenay Lake near the north edge of the area.

All these springs appear to have the same characteristics. On issuing from the ground the water is clear and sparkling and tastes rather like soda-water. On standing for a while, however, considerable quantities of flocculent, brown limonite precipitates. This limonite builds up around the vent and in the spillway from it and by it the springs are easily detected.

A sample of the water from the spring near the Rose Pass trail was obtained, and on this sample F. J. Fraser of the Geological Survey reports as follows:

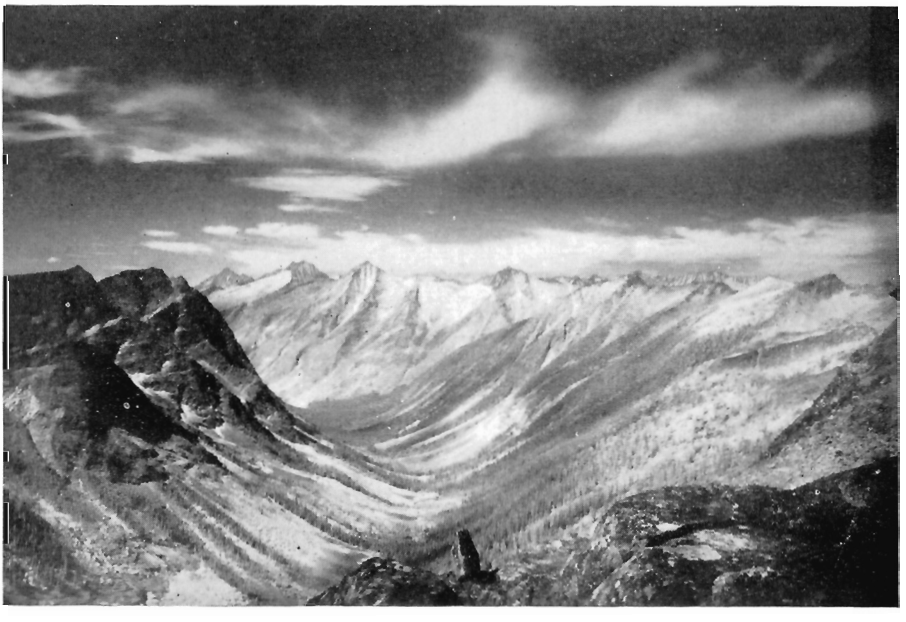
"The following determinations were made:

	Parts per million
Silica (SiO_2), etc	32
Iron (Fe)	67
Alumina	..
Calcium (Ca)	257
Magnesium (Mg)	37
Sulphate (SO_4)	10
Chlorine (Cl)	5

Sample as received contained heavy ferruginous deposit. Owing to the limited amount of sample available, no determinations were made for total dissolved solids, or for alkalinity. As the sample was reported clear at the time of collecting, the figures given are on the unfiltered water. The low sulphate and chloride suggests that the main constituents originally in solution were carbonates. On this basis, if the iron, calcium, and magnesium are expressed as carbonates, and the sulphate and chlorine as salts of sodium, a probable composition of the mineral matter originally in solution would be as follows:

Ferrous carbonate ($FeCO_3$)	139
Calcium carbonate ($CaCO_3$)	643
Magnesium carbonate ($MgCO_3$)	128
Sodium sulphate (Na_2SO_4)	15
Sodium chloride (NaCl)	8
Total calculated solids in original water	933"

PLATE I

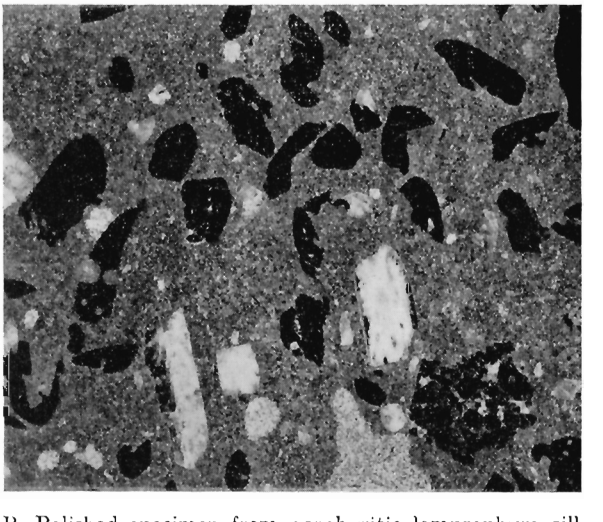


A. View looking northwest down Campbell Creek. Note the prominent U-shaped valley.

B. View looking north along the ridge between St. Mary River and Dewar Creek. Note the rugged topography in the northern part of the area.

PLATE II

A. Cranbrook conglomerate on Goat River. The long block to the left of the hammer is clearly distinguishable Creston.



B. Polished specimen from porphyritic lamprophyre sill near Star mine, Ainsworth district. Note the strong resorption of the amphibole (black) crystals and the striking appearance of the rock. About natural size.