GEOGRAPHY AND GEOLOGY

OF THE

"BIG BEND" OF THE COLUMBIA

BY

A. P. COLEMAN, Ph.D.,

FARADAY HALL, COBOURG, ONTARIO.

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VIII.—*Notes on the Geography and Geology of the Big Bend of the Columbia.* [Plate XVIII.]

By A. P. COLEMAN.

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The River Columbia rises about eighty miles north of the boundary of the United States, and, after flowing about two hundred miles in a north-westerly direction to the "Big Bend," suddenly turns south, or a little east of south, toward the fjord-like Arrow Lakes and the State of Washington. The great curve thus made encloses on three sides the Selkirks, one of the most rugged parts of British Columbia. Maps of this part of the Province appear to be so defective as to serve only as very general guides to the traveller, who is indeed beset by many difficulties not found in most other regions. It is proposed to give in this paper a brief account of some portions of the region visited by the writer; touching first on some points of geography and statigraphy, and ending with the results of a microscopic examination of a number of rock specimens.

I.—GEOGRAPHY AND STRATIGRAPHY.

(1.) THE SPILLIMICHENE REGION.—About fifty miles from its source, the Columbia is joined by an important tributary, the Spillimichene,[1] rising in the Selkirk Mountains. This river has two main forks, one flowing out of a wild region to the west or south-west, and a longer one rising twelve or fifteen miles south of the mouth of the Kicking Horse (Wapta) and flowing thirty or forty miles nearly parallel to the Columbia, though in the opposite direction. The southerly trend of this and other tributaries is sometimes considered proof that the Columbia, or at least its upper part, once flowed in the reverse direction. It is certain that a slight lowering of the south-eastern end of the valley would allow the lakes in which the Columbia rises to empty southwards into the Kootenay. A careful study of the relative heights of the numerous "benches" (terraces) along this part of the river would throw much light on the subject.

Mountains between the Spillimichene and the Columbia.—The two rivers are separated by a small range of mountains, rising well above the tree line (6,000 to 7,000 feet) toward the head of the main branch of the Spillimichene and gradually sinking to wooded hills at its point of junction with the Columbia. From the higher summits a magnificent view may be obtained of nearly the whole Spillimichene valley, as well as of more than one hundred miles of the broad valley of the Columbia. Their front toward the latter river is very steep, so that one looks down as on a map upon miles of the valley with the winding river, numerous half-choked channels, and crescent-shaped lakes representing abandoned portions of its bed.

[1] This name is variously spelled. The form chosen is that used by Dr. G. M. Dawson in his Mineral Wealth of British Columbia.

Rocks Observed.—This range consists chiefly of quartzites, soft slates weathering into clay, and limestones, the latter sometimes black and seamed with small ramifying veins of calcite, so that they would probably form handsome marbles. These rocks are probably Palæozoic, and of the same age as those described by Mr. McConnell from the western part of Bow Pass.[1] Veins of quartz and calcite are common, and a few dykes of eruptive rock occur. The strata dip at low angles away from the Columbia.

Mountains south-west of the Spillimichene.—The mountains west and south of the longer fork of the Spillimichene are loftier than those just described, and often rise above the snow-line. From the top of one which was ascended, the scene in its confusion of snow, ice and naked rock, reminded one strongly of views from the loftiest points of the Norwegian fjelds. Scores of glaciers were in sight, one toward the head of the west fork of the river appearing much larger than the well-known glacier near the Canadian Pacific Railway. Patches of snow where the ascent was made were of a rosy color, probably caused by the growth of *Protococcus nivalis*.

Rocks Observed.—The rocks observed were chiefly slates, harder than those of the previous range, and with a very perfect cleavage; and also some quartzites. The cleavage cut the lines of stratification of the slate, as shown by bands of lighter and darker grey, at all angles, but did not pass into the quartzite.

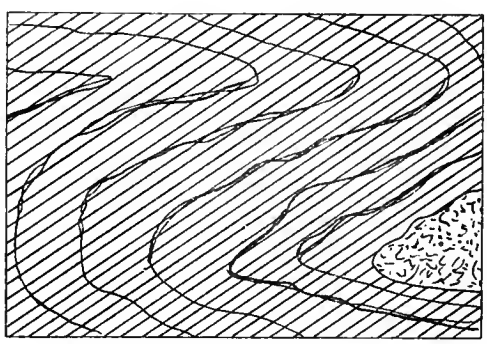

Fig. 1.—Folds of Slate showing cleavage which does not pass into the quartzite. Summit of a mountain south-west of the Spillimichene.

A vein, from 1½ to 5 feet wide, was found to be largely charged with copper pyrites (chalcopyrite.)

(2.) From the Kicking Horse to Beaver.—From the mouth of the Kicking Horse to Donald, the Columbia preserves its gentle character, and, though sometimes divided by low, wooded islands into several channels, follows the wide and straight valley in which it set out. It receives several tributaries from the Rocky Mountains, beside the Kicking Horse; for instance, the Blaeberry and Bluewater, but no large ones from the Selkirks. About half way between Donald and Beaver, the Columbia leaves the broad valley to a tributary and turning west, breaks through walls of slate in a series of rapids and sharp curves. The rocks found in this part are chiefly lustrous slates, and are well

[1] Geological Features of a Portion of the Rocky Mts., Geol. Sur. Can., 1886.

exposed along the railway cuttings following the Beaver valley up the Roger's Pass into the Selkirks.

(3.) From Beaver to Surprise Rapids.—Below Beaver the Columbia flows twenty or twenty-five miles uninterrupted by rapids, though sometimes split into numerous channels by low islands of alluvium. Old channels, dammed at the upper end by masses of driftwood and silt, have the character of bayous, and were formerly greatly frequented by beavers, as shown by the numbers of trees cut by these animals. Some cottonwood stumps displaying the marks of their teeth were more than two feet in diameter. Their numbers are at present much diminished by the work of trappers.

For some distance above Surprise Rapids, the river, which here receives a considerable stream from each side, forms narrow, lake-like expansions. In this part of its course there is only a comparatively low, wooded ridge separating the Columbia from a wider valley to the north-east, occupied by a tributary flowing in the opposite direction and joining the Columbia just below Donald. This is perhaps another hint that the upper Columbia once flowed south-east, before it had dug its way through the walls of slate above Beaver.

In this region, rock was observed by the writer only once, and was found to be slate like that near Beaver.

(4.) Surprise Rapids.—These rapids are well named, since they are almost unseen until one is just upon them, though their roar may be heard a mile or two above. The valley is much narrowed here, and the rapids are caused by barriers of steeply inclined mica schist.

A comparison of barometer readings with those at Donald gives a fall to the head of the rapids of 138 feet; while in the four or five miles of the Surprise Rapids, we found a fall of about 140 feet,[1] of which 55 or 60 belong to the first mile. The first fall will some day afford a magnificent water-power, since a canal of about half a mile through a low, wooded point would render nearly the whole of it available. The engineering difficulties would probably not be serious, and suitable steamers could ply up the river to Beaver, the nearest point on the railway. There is a vast supply of forest within reach, chiefly black and white spruce, with a considerable amount of giant cedar and some white pine.

Mountains north-east of the Rapids.—The nearest summit of the Rockies, four or five miles from the rapids, was ascended, and named Lookout Point. Its height, determined barometrically, is 7,754 feet. A very rugged, triple-peaked mountain, a few miles north of this, bears several glaciers, and was estimated to be 12,000 feet at least in height. It was judged to be Sullivan's Peak or possibly Mount Forbes, and is the highest point in the neighborhood.

Rocks Observed.—Soft, greenish slates and quartzites make the exposed portions of Lookout Point. The quartzites are evidently metamorphosed sandstones, since some of them show traces of ebb and flow structure. The beds dip slightly away from the

[1] Travel along shore is much obstructed, hence the readings of the barometer were often some hours apart, rendering the results less certain than could be wished, though probably not much astray.

Columbia. A massive horizontal bedding, like that of Castle Mount in Bow Pass, is seen on the face of Sullivan's Peak three or four miles away; but the horizontal look is probably only apparent, the strata dipping more or less steeply away from the point of observation. The rocks examined appear to be of the same character as those described by Mr. McConnel from the western part of Bow Pass,[1] though perhaps more indurated.

Mountains to the south-west.—The nearest summit of the Selkirks, three or four miles from the rapids, was also ascended, and its height found, by comparison of barometer readings with those at Donald, to be 8,366 feet. From this point, precipices, snowy mountain tops and glaciers can be seen in all directions. Several peaks of the Selkirks are much higher than the one ascended, at least 2,000 or 3,000 feet. A large glacier in the valley west of the mountain climbed, reached about 2,000 feet lower than the point on which we stood.

The view from the top of Surprise Mountain, as I named it, is wide and interesting. The rapids lie 6,000 feet below, and the river may be traced for about forty miles, from a point a little below Beaver on the south-east to Lake Timbaskis on the north-west. Beyond the river valley, unnumbered summits of the Rocky Mountains are seen, the of highest all, fifty miles to the north, being probably Mount Hooker.

Rocks Observed.—The rocks exposed at Surprise Mount are typical mica and hornblendic schists dipping about 40° to the S. S. W. and with a strike of E. S. E. and W. N. W.[2] In this they differ from the mica schists at the rapids, the latter dipping 50° to 70° toward the S. S. E. These rocks are probably Archæan in age, although they stand several hundred feet higher than the (supposed) Palæozoic slates and quartzites of Lookout Point, less than ten miles away. There must be a great fault separating the two.

(5.) Surprise Rapids to Lake Timbaskis.—From the head of Surprise Rapids to Lake Timbaskis[3] is a distance of perhaps eighteen or twenty miles in a straight line, though not less than twenty-five by the route followed—an old trail along the north-east bank of the river, now almost impassable in many parts from the fall of trees and the growth of bushes and young forest. We saw no trace of inhabitants during the six weeks after leaving Beaver, yet at one point a forest fire was found raging. This may have originated from lightning, as in a case actually witnessed by the writer a few years before on the Gold Range opposite Revelstoke.

Rocks Observed in the Region.—For about ten miles down the river from the head of Surprise Rapids, the rocks observed are pearly, lustrous mica (sericite) schists, sometimes containing small garnets, and dipping at high angles toward the south-east or south. Then follow a few miles of grey, finely banded, schistose limestones, whose boundaries appeared to be hidden by loose materials. From the river bank to the highest point reached, about 3,000 or 4,000 feet above the river, they remained of the same character, being often excessively folded, crumpled and contorted, and containing a few scales of mica. They dip at varying, usually high, angles, and strike about E. S. E. and W. N. W. A stream flows at one point out of a subterranean channel in the solid rock, and empties

[1] Geol. Sur. Can., 1886, p. 25, D.

[2] The bearings given are magnetic. Mr. Carpmael, Director of the Meteorological Office, Toronto, gives the deviation as about 23° 30′ east, in southern portions, and 25° east in northern portions of the Selkirks.

[3] Name as given by Old Uncle, a trapper at Beaver.

into the river a short distance away. Large deposits of travertine have been made by this and other streams.

About eight or ten miles from the last schists, similar rocks are once more found, rising as an abrupt hill. With the exception of a portion of limestone just at the head of Lake Timbaskis, we find only schists for the rest of the way. They appear to be more thoroughly crystalline than those at Surprise Rapids, where a few specimens looked like highly metamorphosed conglomerates, and contained blebs of quartz and felspar. The Timbaskis schists are light, lustrous grey, and usually contain innumerable garnets, small and large, and often large prisms of staurolite, less frequently crystals of disthene.

These schists dip 50° to 80° toward the N.N.E. and north; that is, in the opposite direction from the Surprise Rapids' schists.

From the foregoing it is clear that the boundary between the (Archæan ?) schists and the Palæozoic limestones, slates and quartzites of the Rockies, for the greater part of the distance between Surprise Rapids and Lake Timbaskis, lies north-east of the Columbia. The general course of this portion of the Columbia corresponds to the usual strike of the rocks.

(6.) Lake Timbaskis to Death Rapids.—The trail appears to end at Lake Timbaskis, and since a tributary entering from the north-east at the head of the lake proved difficult to cross, being too wide to be bridged with a tree, I went no farther. The lake is probably ten miles long by two broad, and is nobly placed among lofty mountains rising in forest covered slopes from its margin. It is the home of innumerable wild geese, which kept up a constant turmoil at the time of my visit.

Prospectors who have rounded the bend, report eighteen miles of canyon and rapids just below the lake, so that only staunch boats can make their way down safely. A little beyond is the Big Bend, where the Columbia receives the Whirlpool and Canoe Rivers before starting southward.

The first point visited by the writer on the other side of the bend is Death Rapids,[1] about fifty miles above Revelstoke, where the Canadian Pacific, coming down the Illecillewaet out of Roger's Pass, crosses the Columbia for the second time.

(7.) The Big Bend Gold Region.—Two rivers find their way into the Columbia from the Selkirks near Death Rapids, Gold Creek a little above, and Downie Creek, which would be counted a considerable river in most regions, five miles below the rapids. About two miles above the mouth of Downie Creek is Laporte, the gateway to the once famous mining region of the Big Bend.

From this point a fairly good trail strikes into the Selkirks to a point on Gold Creek where it is joined by McCulloch Creek flowing from the north. Four miles further inland, French Creek empties into Gold Creek from the same side. The placers of these two small creeks afforded at least a quarter of a million dollars' worth of gold during the Big Bend excitement a quarter of a century ago.[2] The trail follows Gold Creek up into the mountains and probably crosses the divide to meet the trail ending at Lake Timbaskis.

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[1] "Dalles de Mort," so named from sixteen men having been drowned there years ago.

[2] See Dr. Geo. M. Dawson's Mineral Wealth of British Columbia, which contains a large store of valuable information on this and other regions of British Columbia.

Rocks Observed.—At McCulloch and French Creeks, green, finely wrinkled schists occur, containing, especially toward the head of the former creek, auriferous quartz veins, which may be looked on as the source of the gold of the placers. Boulders of grey granite and gneiss found along the creeks originate higher up the valley or at the watershed, though none were seen *in situ* by the writer. Similar boulders, some of porphyritic granite, are found on the trail between Laporte and Revelstoke and come probably from higher parts near the axis of the range.

Rivers of the Selkirks.—The streams flowing west out of the Selkirks are larger as a rule than those flowing east, a fact accounted for, perhaps, by the greater rainfall on the slope toward the Pacific, enabling the rivers fed by it to excavate their supply basins more rapidly than those on the other slope, and thus to shift the watershed slowly eastward of the centre of the range. At Donald, where the Canadian Pacific Railway crosses the Columbia for the first time, the level of the river is 2,500 feet above the sea; but at Revelstoke, the second crossing, it is only 1,625—a difference of nearly 900 feet. The streams flowing westward from the Selkirks must therefore have on the average a steeper slope, which no doubt acts in the same way as the increased rainfall in hastening the excavation of their valleys.

Glaciers of the Selkirks.—Perhaps in no part of the world are glaciers more numerous than on this range and the mountains northward toward Alaska and the Arctic Ocean. From many summits of the range, dozens of them may be seen of all sizes from tiny ones with a few acres of *nevé* ending in a tongue of ice, to masses of snow and ice several miles across and covering many square miles of surface. There is evidence showing retrogression of the ice in some cases. Cirques are common just below snow level, and are due perhaps to the erosive power of former glaciers, though it does not seem impossible that they may have been excavated by converging streams. A number of glaciers examined by the writer show signs of recent retrogression in the bareness of the rock of the valley just below the front of the glacier. There appears not to have been time since the withdrawal of the ice for lichens, mosses and other plants to form even the beginning of a bed of soil. A retrogression of the glaciers does not necessarily imply a rise in the annual temperature, since a diminished snow-fall resulting from a change in prevailing winds would have the same effect.

Difficulties of Exploration.—Every one who has attempted exploration in the Selkirks will agree that few mountain ranges offer so many obstacles to the explorer and the geologist. The moist and comparatively mild climate causes an immense growth of forest and underbrush, much greater than that of the Rockies, for instance, so that up to about 7,000 feet[1] the rock is largely hidden by vegetation, except along the watercourses. Unclothed precipices are much more common, according to the experience of the writer, in the Rocky Mountains, perhaps because, from their later origin, they have not suffered so much from erosion. Their drier climate must work in the same direction of limiting erosion.

Travel through the forests of the Selkirks is very laborious. In most cases all necessaries must be carried on the back—no light matter when a trip of two weeks is undertaken, up steep inclines, through second-growth evergreens so thickly planted that

[1] The tree line is at 6,700 feet on Surprise Mount, and about 7,300 on the southern side of Lookout Point.

they must be parted with the hands; or among the tangled box-alders along river margins, or the jungles of prickly "devil's-clubs" that rise as high as one's head in swamps. Windfalls and snow-slides, where great trunks of spruce or *Thuja gigantea* lie heaped upon one another, also form most disheartening obstacles at times. On the western slope, continued rains and swollen creeks add frequently to the difficulties of travel.

II.—Microscopic Petrography of Rock Specimens.

(1.) *The Spillimichene Region.*

Slates.—The soft clayslates of the range between the Spillimichene and the Columbia belong in all probability with the Palæozoic slates of the Rocky Mountains and need not be described here. They readily crumble to clay and so are not easily made into sections thin enough for microscopic work. The harder, somewhat more crystalline slates south-east of the northern branch of the Spillimichene are more easily handled and are more characteristic of the Selkirks.

Macroscopic Description.—These slates are very fissile, the cleavage crossing at varying angles the planes of stratification indicated by bands of lighter and darker grey. They often contain cubes of pyrite, sometimes distorted by the pressure that formed the cleavage. In a crystal measured, the angles between the faces meeting in edges exposed to compression were enlarged from 90° to 93° 30′.

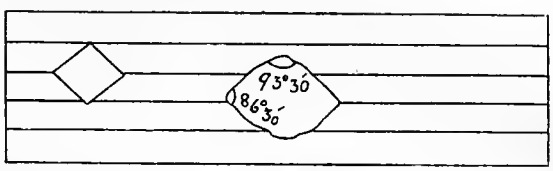

Fig. 2.—Distorted Crystals of Pyrite in Slate.

Microscopic.—Thin sections show a micro-crystalline or crypto-crystalline structure with many opaque, dusty looking particles, especially in the darker bands. Splinters of the rock grow lighter in color when heated in a Bunsen burner, showing that at least part of the dark substance is carbon. The transparent parts have not a clastic look. Quartz may form a part of the obscurely anisotropic substances, but chlorite or some related fibrous or scaly mineral seems more important. The vague fibres and oblong sections seem to have extinction parallel to the chief sections of the nicols. A scaly, slightly dichroic mineral, occurring in larger particles, is perhaps muscovite. Immense numbers of minute rutile needles are scattered through the rock, often in groups with roughly radiating points, and sometimes with characteristic knee-shaped twins.[1] Between crossed nicols the rutile needles gleam out as brilliantly-colored threads. Small portions of a yellow brown, slightly translucent substance scattered here and there may be hydrous sesquioxide of iron.

[1] See plate xviii, fig. 1.

A Transition Form.—*Macroscopic.*—One specimen is of a different type, not so fine grained, and banded with greenish and brownish layers cut through by a very perfect cleavage.

Microscopic.—Little or no carbon or other amorphous substance can be seen, but many small grains of quartz of clastic origin and containing cavities with libellules. A little plagioclase is observed, badly weathered, and some muscovite. Yellowish, and also pale greenish substances, which are plentiful, may be considered varieties of chlorite. Scales of the latter have sometimes a roughly radial arrangement about grains of quartz. The brown bands contain much hydrous sesquioxide of iron.

(2.) *Region near Beaver.*

Slates.—*Macroscopic.*—A well known series of slates is found near Beaver, along the railway, the rocks ranging in color from light grey to dark iron-grey, lustrous in surface, sometimes almost as if polished with graphite. They have usually a well marked cleavage, sometimes two, cutting at an angle of 100° to 120°. They are often finely corrugated and may even show two sets of wrinklings. Some have the speckled appearance of the German Knotenschiefer. Cubes of pyrite are common inclusions.

Microscopic.—In general the components of the slates are the same as those of the Spillimichene, carbon particles and perhaps other amorphous material of clastic origin, with quartz in small quantities, much of a chloritic substance and numberless fibres of rutile. In addition a little muscovite and also biotite with brown oxide of iron. In some specimens, however, the quartz increases greatly in quantity, and calcite also plays an important part. The Knoten or Garben in the spotted slates are nearly opaque, so that their composition could not be determined. They are perhaps of a concretionary nature.

Rocks Intermediate between Slates and Quartzites.—*Macroscopic.*—A few light greenish rocks from Beaver seem related to slates and quartzites, but with a leaning toward mica schist. One specimen contains blebs of quartz and felspar, as though a metamorphosed conglomerate with small ovoid pebbles.

Microscopic.—The allogenous portions are much more important in size and amount than in the slates. Fragments and blebs of quartz, containing fluid cavities with bubbles, form much of the rock; and greatly weathered felspar is also found. The autogenous elements form larger and far more distinct individuals than in the slate. The quartz fragments are often surrounded in a roughly radial way by confused scales of colorless or blue-green chlorite. Mingled with it are secondary quartz, a few lamellæ of muscovite and biotite, and grains of magnetite, sometimes rectangular in cross section.

The finer grained varieties remind one somewhat of the last specimens described from the Spillimichene.

(3.) *Surprise Rapid.*

Mica Schist (Sericite Schist).—*Macroscopic.*—Most of the rocks exposed near the rapids are very fine-grained, greenish grey and with pearly, lustrous cleavage surface. The schistose structure seems to correspond to the bedding. Small garnets and oblong portions of dark biotite are abundant.

Microscopic.—Clastic looking fragments of quartz form a large part of the rock, and mixed with or folded about them is a pale green mica-like mineral, probably the variety of muscovite called sericite, or possibly chlorite. Irregular masses of brown biotite, garnet, magnetite, and small quantities of titanite, may be looked on as accessory minerals.

In addition to the minerals described, one bluish grey specimen contains a considerable amount of plagioclase, long crystals of hornblende (greenish blue and yellow dichroism) bordered with biotite, and slender colorless prisms, with a rough basal cleavage and parallel extinction, perhaps sillimanite.

SCHISTOSE CONGLOMERATES.—*Macroscopic.*—A few greenish schistose rocks are filled with small round or angular fragments or pebbles of quartz and felspar. They remind one of a rock described from Beaver.

Microscopic.—The quartz is of the kind usual in granites; the felspar sometimes shows the plagioclase structure, but often appears to be orthoclase, though too badly weathered to be unmistakably so. The enclosing layers consist of green and brown biotite, muscovite (sericite) and blue green chlorite, with many grains of magnetite. The autogenous minerals are much more highly individualized than in similar rock from Beaver.

(4.) *Surprise Mountain.*

MICA SCHIST.—*Macroscopic.*—The medium-grained, brownish-grey mica schist from the summit of Surprise Mountain, differs much in habitus from the fine grained sericitic schist from the rapids at its base. Unlike the latter, it shows little or no evidence of a clastic origin of any of its constituents.

Microscopic.—The rock contains large quantities of quartz, primary in appearance, with cavities showing libellules in motion, probably a little felspar, and much brown biotite with optic axes rather wide apart. There is also a considerable amount of muscovite in well defined individuals very unlike the confused, wavy masses found in the Surprise Rapids schists. There are some yellowish and greyish decomposition products, much magnetite and a few garnets.

HORNBLENDIC SCHIST.—*Macroscopic.*—Interstratified with the mica schist is found a fine grained, dark grey, almost black, hornblendic schist.

Microscopic.—It proves under the microscope to be thoroughly crystalline and autogenous in look; and consists chiefly of quartz in small, clear individuals, and green hornblende showing no crystalline forms, but clean edged and of a primary appearance. A little biotite and many sharply-outlined black grains, probably of magnetite, are also found.

(5.) *Lake Timbaskis Region (Rocky Mountain side of the Columbia).*

QUARTZITES.—*Macroscopic.*—These rocks occur near the Timbaskis schists, but are very distinct in habitus. They are white, yellowish white or light grey, always show a few scales of mica on cleavage surfaces, and sometimes enough mica to form a transition toward mica schist.

Microscopic.—Nearly the whole of the rock proves to be made up of quartz in larger or smaller fragments, sometimes looking as if clastic in origin. These are often surrounded and wedged in by small, probably secondary, individuals as a tesselated border. The larger grains have the usual inclusions, cavities containing water and also liquid carbonic acid. In addition we find a few scales of muscovite, a fragment or two of hornblende, and some minute yellow grains, probably of titanite.

Mica (Sericite) Schists.—*Macroscopic.*—These are lustrous, pearly or reddish grey schists with wavy micaceous lamellæ folded about various minerals, such as garnet, staurolite and disthene. All of these minerals sometimes occur in crystals an inch or more in length, and they may be so crowded as to make up fully half the rock, garnet being commonest and staurolite next in order. In such cases the rock should perhaps be named garnet, staurolite or disthene schist.

Microscopic.—Quartz occurs of the usual kind, but is variable in amount and at times quite absent. The chief constituent is sericite in wavy, confusedly parallel scales; but a considerable amount of biotite is also found. The garnet is of a pale flesh-color in thin sections. The staurolite displays a magnificent dichroism, orange red parallel to the longest axis and yellow perpendicular to it. The less common disthene shows no pleochroism, but has brilliant polarization colors. Small red brown grains and crystals of titanite are very common.

Gneiss.—*Macroscopic.*—A specimen obtained from a boulder, found near the trail on the north east shore of the Columbia, appears to be gneiss, though none was seen *in-situ*. It is the only specimen of the kind known to the writer from the Canadian Rocky Mountains. Could it have been transported, by glacial action, for instance, from the Selkirks across the river? The rock is slightly schistose in appearance, medium grained, and light-brownish grey in color, with patches of black mica.

Microscopic.—It contains little quartz, much microline and plagioclase and a quantity of green, and also brown, biotite. Oxides of iron and epidote occur in small amounts as decomposition products.

(6.) *French Creek (Big Bend Gold Region).*

Chlorite (?) Schist.—*Macroscopic.*—The only specimen at command was obtained at Frenchtown four years ago. It is a finely-corrugated lustrous schist of a grey-green color much darker than that of the sericite schist of Surprise Rapids on the other side of the Selkirks.

Microscopic.—It consists of quartz in small, clear portions, a very little plagioclase, and much of a blue green mineral, probably chlorite, in irregular, slightly dichroic, scales. A little green biotite seems also to occur; and innumerable, small, greenish yellow crystals of rutile are imbedded in the minerals first mentioned. The rutile crystals have sharp relief, frequently form knee-shaped twins, and are almost always associated with grains of a black, opaque mineral that seems to be magnetite.[1] Rhombohedra of calcite are found scattered through the rock.

[1] See plate xviii, fig. 2.

HORNBLENDIC GNEISS.—*Macroscopic.*—A specimen from a boulder at Frenchtown is of medium grain, rather dark grey, and slightly schistose in appearance.

Microscopic.—It consists of quartz with fluid cavities containing salt cubes; much orthoclase, some of it microperthitic, with trichites and other inclusions, much hornblende of dark green and yellow tones, and a little brown biotite. Apatite and magnetite are found in small quantities, and epidote is a decomposition product.

GRANITE.—*Macroscopic.*—Several specimens of granite were obtained from boulders at French Creek and at points on the trail between Laporte and Revelstoke. They are light grey, medium to coarse-grained rocks, often porphyritic, containing oblong white cross sections of felspar sometimes an inch in length. The smaller felspars are yellowish white and more weathered than the larger ones.

Microscopic.—Quartz of the kind usual in granite is abundant; also orthoclase, where not replaced by microcline, which is often the case. Microperthite and plagioclase are less important. The porphyritic crystals are of microcline, so far as observed. Biotite and hornblende occur in considerable amounts, replacing one another. Apatite is frequent, and epidote, the latter a product of decomposition.

(7.) *Roger's Pass (C. P. R.)*

MICA SCHIST.—*Macroscopic.*—The mica-schists are chiefly white or light grey, consisting of quartz and muscovite. They sometimes approach the quartzites from the small quantity of mica they contain. A distinct variety, dark iron grey, with metallic lustre, occurs at Albert Canyon on the Illicillewaet.

Microscopic.—The quartz has often a clastic appearance. The colorless muscovite is of the usual kind, not sericite. No chlorite has been observed in my specimens, which however are only three in number, excluding the rock from Albert Canyon. The last mentioned rock gets its black color from the large number of dark, amorphous looking particles it contains in addition to quartz and mica. That the black substance is carbon, or some carbon compound, is proved by the fact that a fragment readily burns white in the blowpipe flame; and the gases formed, when it is heated in a glass tube in a current of oxygen, give with limewater a milky precipitate, which is re-dissolved by continued passage of the gas.

GNEISS.—*Macroscopic.*—The two specimens in my collection (one from the "summit" of the pass) are fine grained, very light colored, and not very schistose. They are far from typical specimens as compared with Laurentian gneiss from Ontario.

Microscopic.—They contain quartz, some orthoclase and microcline, and plagioclase; also a little microperthite, and biotite and muscovite in small quantities.

III.—CONCLUSION.

An attempt has been made in the first part of this paper to give by brief descriptions some idea of parts of the Selkirks not easily reached from the railway, and hence rarely visited. When the region has been rendered more accessible by means of trails

it should become interesting, not only to the sportsman, botanist and geologist, but to every one who loves wild alpine scenery, glaciers and torrents, beautiful valleys and rugged mountain tops.

In regard to the geological features of the region, the extent to which metamorphism has gone on becomes important. Are the slates southwest of the Spillimichene and those of Beaver older than the Palæozoic slates of the Rockies? Or are they of the same age but modified by more intense compression and more complete recrystallization of the sedimentary materials? A certain answer to this would demand a large amount of stratigraphical work or the finding of fossils.

The slates near Beaver are associated with greenish, highly schistose rocks that seem connecting links to the mica schists; and also with what appear to be greatly metamorphosed conglomerates. All the thin sections examined from Beaver appear to contain considerable quantities of clastic material. The sericite schists of Surprise Rapids are much more crystalline, but yet contain grains of quartz apparently of allogenous origin; and one associated rock much resembles the metamorphosed conglomerate of Beaver. The schists of Lake Timbaskis seem still more thoroughly crystalline than those just mentioned, but yet show traces of clastic materials. It is possible that all these rocks may be of Cambrian age, though they are more probably Huronian, at least those that are more highly crystalline. The Timbaskis sericite schists are interesting for the number and size of the included crystals of garnet, staurolite and disthene.

The mica and hornblende schists of Surprise Mountain appear thoroughly autogenous and crystalline, and without evidence to the contrary, must be looked on as Archæan, perhaps equivalents of the eastern Laurentian.

On the other side of the Selkirks the green schists of French Creek are perhaps to be ranked with the sericite schists of Surprise Rapids, though rather more crystalline and devoid of evidently allogenous substances.

The black schist of Albert Canyon, again, appears to be largely of clastic, perhaps partly of organic, origin, since the quartz looks fragmentary and the carbonaceous matters can hardly be accounted for without life. From the ease with which the coaly matter burns we may conclude that metamorphism has not gone so far as to form the allotropic form, graphite, as has been the case in the Laurentian of Ontario. It is probable then that the rock of Albert Canyon, twenty miles east of the second crossing of the Columbia, is not Archæan, but of considerably later age.

The gneisses from the central parts of the range are not, so far as examined by the writer, typical, when compared with those of eastern Ontario. On the other hand the granites are quite characteristic, containing the minerals found in the same rock from eastern localities, especially the microcline so common in most Ontario granites. In habitus, the granites of the Selkirks differ much from those of the eastern Laurentian, being light grey, instead of red, in color, and much more apt to be porphyritic.

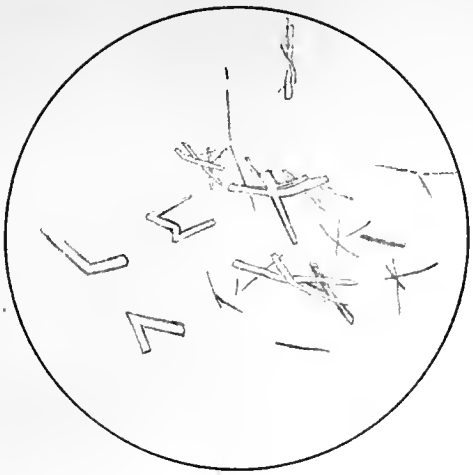

Fig. 1.—Rutile × 500.
Slate from the Spillimichene.

Fig. 2.—Rutile × 500.
Chlorite Schist—French Creek.

To illustrate Prof. Coleman's Paper on the Big Bend of the Columbia.