CANADA

DEPARTMENT OF MINES

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GEOLOGICAL SURVEY

WILLIAM MCINNES, DIRECTING GEOLOGIST.

Summary Report, 1917, Part F and Last

CONTENTS

OTTAWA
GOVERNMENT PRINTING BUREAU
1918

No. 1734

SUMMARY REPORT, 1917, PART F AND LAST.

BURNTHILL BROOK MAP-AREA, NEW BRUNSWICK.

By G. A. Young.

CONTENTS.

Illustrations.

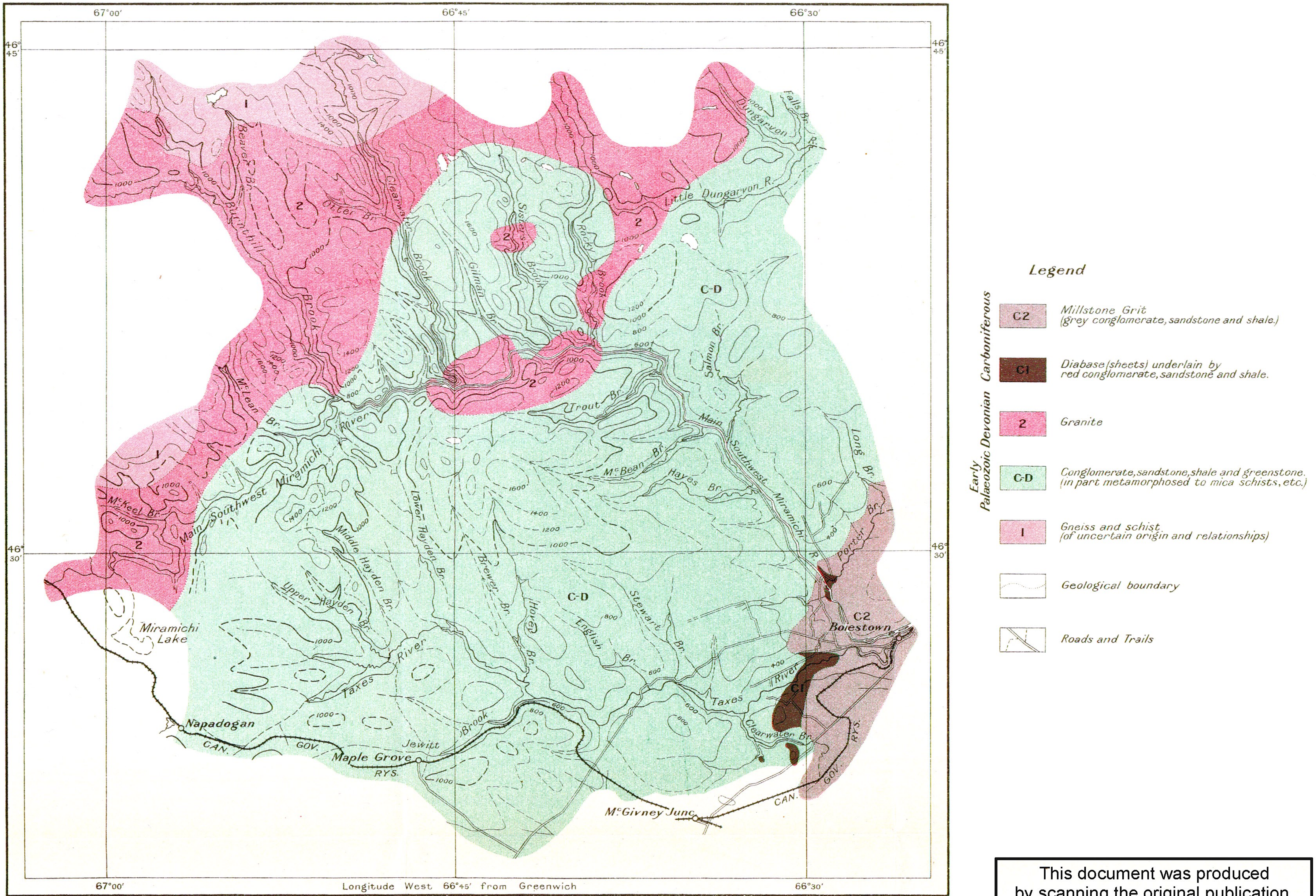
INTRODUCTION.

A deposit of tungsten ore having been found in central New Brunswick, on the Main Southwest Miramichi river, near the mouth of Burnthill brook, and mining operations commenced there, the writer was instructed to spend the field season of 1917 making a geological reconnaissance of the territory in the general vicinity of the ore occurrence. About twelve weeks were spent in field work examining an area of nearly 500 square miles, represented on the accompanying map. G. F. Palfrey was attached to the party as assistant for the duration of this work.

The area examined, approximately in the centre of which is situated the tungsten ore deposit known as the Burnt Hill Tungsten Mines, is almost wholly contained within York county and lies within the drainage basin of the upper Main Southwest Miramichi river (see Figure 1). The southeastern corner of the area is settled country, the rest of the district is forest covered, and within this part there are no settlements nor permanent roads. It is possible to travel with horses over this wooded, unsettled area along various portage roads, or by canoes on certain of the rivers. The portage roads run in various directions and furnish means of approach to all parts of the area. These roads have been cleared by lumber firms and though very rough and muddy they are passable for teams drawing light loads either on wagons or sleds. The Miramichi river flows from west to east through the central part of the area and canoes may be poled up or down all this part of the river. Canoes may, at certain seasons, also be used on Clearwater brook, a tributary of the Miramichi. In the northeastern part of the area, Dungarvon river is another stream on which it is practicable to travel by canoe. Two branches of the Canadian Government Railways system traverse the southern part of the map-area and cross one another at McGivney Junction. Boiestown on the Fredericton branch, and Maple Grove and Deersdale stations on the Moncton-Edmundston branch, form convenient points of entry to the district. Strangers proposing to visit the district should make Boiestown their headquarters.

PHYSICAL CHARACTER OF THE DISTRICT.

The map-area stretches westward and northward from the low, nearly level country of eastern New Brunswick and along the eastern and southern borders the country is broadly rolling; the central portion is higher and much more broken; whereas the northern and western portions are less broken although the general elevation is about that of the central part.



Geological Survey, Canada.

Publication No 1709

Burnthill Brook Tungsten Area, York County, New Brunswick.

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To accompany Summary Report by G.A. Young, 1917.

Geology and Topography by G.A. Young, 1917.

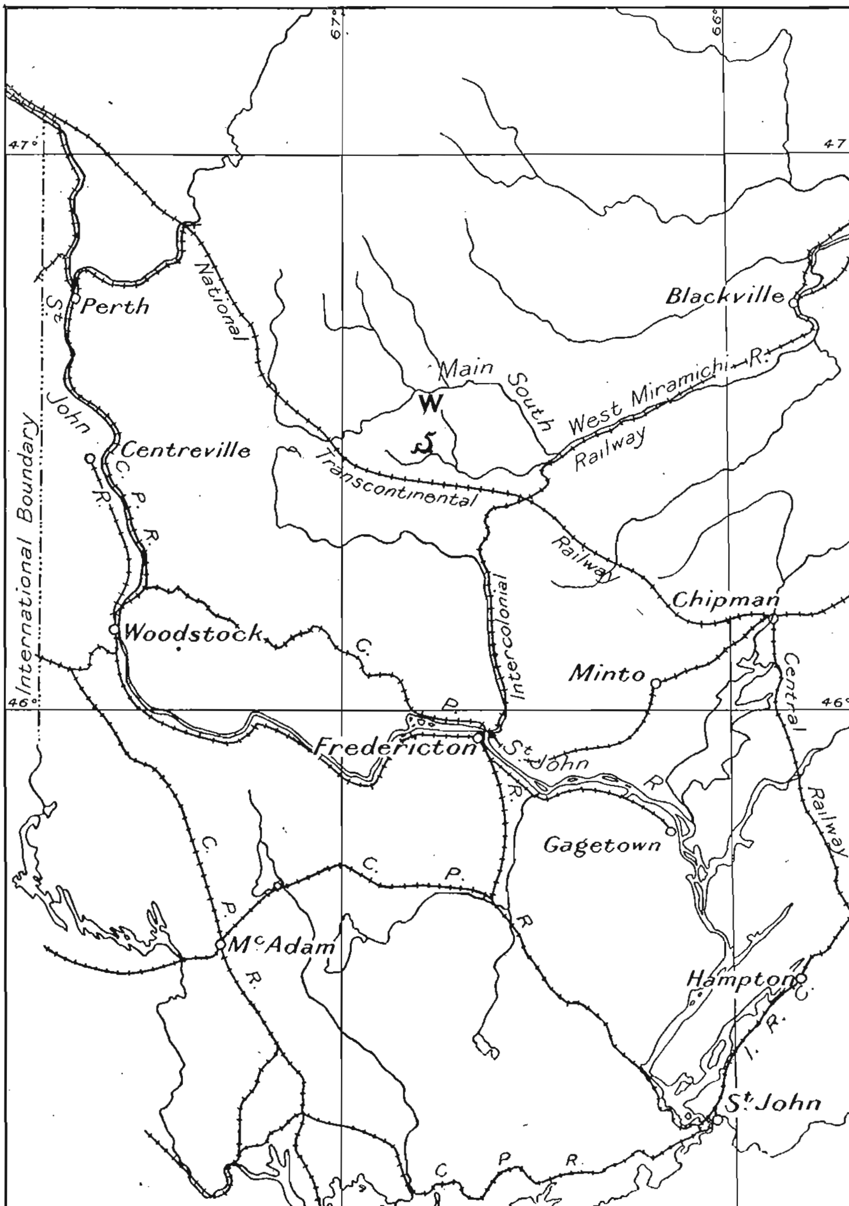

Figure 1. Location of tungsten and galena deposits, York county, N.B.

In general, the area may be described as being occupied by flat-topped ridges separated from one another by narrow valleys occupied by the main waterways. Towards the west and north, however, this type of country gives way to one in which the main valleys are elevated, broad, and shallow, and the hills and ridges do not rise much above the general level. The total relief is in the neighbourhood of 1,500 feet, the lowest point being Miramichi river at Boiestown, about 160 feet above sea, and various hills in the central part of the map-area reach altitudes of about 1,600 feet.

The streams, including the Miramichi, are all swift. They rise rapidly after heavy rainfalls and in the spring of the year are swollen far beyond their average summer volume. During dry seasons they shrink so that even the largest may be forded on foot. Their valleys are usually deep set and in the central part of the area the bounding hill tops in many places rise 600 to 1,000 feet above the valley floors.

GENERAL GEOLOGY.

General Statement.

The map-area is a small part only of the territory covered by map-sheet No. 2 SW., one of a series of geological maps which, on a scale of 4 miles to one inch, represent the whole of New Brunswick. The general geology of the area has been dealt with in the following reports.

Robb, Charles.—Geol. Surv., Can., Rept. of Prog., 1866 to 1869; 1870.
Robb, Charles.—Geol. Surv., Can., Rept. of Prog., 1870-71; 1872.
Ells, R. W.—"Report on the geology of northern New Brunswick," etc.: Geol. and Nat. Hist. Surv., Rept. of Prog., 1879-80, pt. D; 1881.
Ells, R. W.—"Report on the geology of northern and eastern New Brunswick," etc.: Geol. and Nat. Hist. Surv., Can., Rept. of Prog., 1880-81-82, pt. D; 1883.
Bailey, L. W.—"Report of explorations and surveys in portions of the counties of Carleton, York, and Northumberland, New Brunswick": Geol. and Nat. Hist. Surv., Can., vol. I (new ser.), pt. G; 1886.

The larger part of the map-area is occupied by folded, early Palæozoic sediments with a general strike of about north-northeast. In the southeast these beds are overlapped by nearly horizontal beds of Carboniferous age. Towards the northwest the older sediments are intruded by a large body of granite extending completely across the map-area. On its northwestern side the granite is bordered by an assemblage of schists of uncertain origin and unknown age.

Rock outcrops are largely confined to the beds and banks of the larger waterways, but even along these swift streams exposureless stretches up to several miles in length are common. On the hill sides, even on the steepest, rock outcrops occur only here and there and only rarely do they occur on the hill tops.

Early Palæozoic Sediments.

A large part of the map-area is occupied by folded and variously metamorphosed argillaceous and arenaceous sediments presumed to be of early Palæozoic age. They form one large, continuous area bounded on the north by a granite bátholith and on the south by nearly undisturbed Carboniferous measures. With the same general relations, this band of deformed sediments extends northeastward to Chaleur bay and southwestward to the Maine boundary.

In various local areas the strata have a general greenish grey hue and consist of alternating beds of shale or slate and other beds of a more arenaceous character. The argillaceous beds in places are shaly in character, but more commonly are compact and slaty. The shales and slates are frequently finely banded and alternate with the more arenaceous varieties which vary in general character from hard and dense, to others in which tiny quartz grains are scattered through an argillaceous matrix, and to others in which the finely granular texture is very apparent. In some places the rocks are moderately coarse-grained and hold rock and mineral fragments an eighth of an inch, or, in rare cases, a quarter of an inch in length. In places, these coarser fragmental rocks are composed predominantly of quartz, but more commonly feldspar and other minerals are abundant and as a general rule they hold much fine-grained mica. These granular rocks form beds ranging in thickness all the way from a fraction of an inch up to 20 feet. The finer-grained varieties are the more abundant and few exposures fail to show them. In places the fine-grained, hard types apparently form zones in which the slates occur in very minor amounts only; in other places the reverse is true, and the slates predominate.

Interbedded with the green varieties occur dark grey or black shales, slates, and sandy beds, but as a rule these dark varieties when interbedded with the green, are present in only very minor amounts. Over large areas, however, the dark rocks predominate almost to the exclusion of the lighter hued types. As in the case of the green varieties, the dark rocks vary in character from dark shales or more commonly slaty rocks, to others with countless minute quartz grains scattered through an argillaceous matrix, and to others coarser of grain, some of which are composed chiefly of quartz whereas the rest hold much feldspar and other mineral fragments. With these slaty and sandy beds occur dense, hard beds and bands. In places the strata are thinly bedded, in other places the beds are thick and massive. The relative proportions of the different varieties vary widely from place to place as in the case of the greenish types. In many localities the dark rocks carry considerable pyrites and in places the sulphide is abundant.

A third group of beds is composed of light green and red shales, or in places where more compacted, slates. Such rocks occupy relatively small areas and are, presumably, much smaller in volume than either the dark or greenish varieties. The red and green rocks occur interbanded with one another and with the more common greenish varieties.

The dark slates and associated strata are strongly developed along Taxes river from below the mouth of Hovey brook, westward to the head of the river. The same rocks, in part highly metamorphosed, occur along Miramichi river from the western limits of the sedimentary area, downstream to the mouth of McBean brook and along both Trout and McBean brooks. Dark rocks also predominate in the northeast along Little Dungarvon river and on Falls brook, a tributary of the main Dungarvon.

The green types predominate along the lower part of Taxes river and its tributaries from Hovey brook eastward and appear to be the chief rocks in the area drained by Lower and Middle Hayden brooks. They are also developed along the Miramichi river from the mouth of McBean brook eastwards and occur along Salmon brook.

The interbanded red and green varieties were observed for a short space along the Taxes river above the bridge crossing this river west of English brook. They were also seen to the southwest of this locality along the railway. Similar rocks occur on Upper Hayden brook at the main forks, on Miramichi river below Trout brook, and farther downstream at the border of the Carboniferous area.

The manner in which the dark, the greenish, and the red and green varieties occur interbanded with one another and the general similarity of the rock varieties except as regards colour, indicate, in the absence of any evidence to the contrary, that all are members of one sedimentary group. The general structure and relative distribution indicate that the group consists of three members, one of which is a thick assemblage of the greenish types, the second a thinner assemblage of red and light green beds with greenish varieties resembling those of the first mentioned member, and the third a thick assemblage of the dark grey and black beds. The minor member holding the red beds seems to lie between the other two members, but though the general succession (a) dark beds, (b) interbedded green and red beds, and (c) greenish beds, seems established it is not known whether the succession as given is in ascending or descending order.

Rocks of igneous origin were seen associated with the above sediments, along Rocky brook, on Sisters brook below the main forks, on Miramichi river about Trout brook, and on the Miramichi several miles below Burnthill brook. These igneous rocks are all dark in colour and range from coarsely crystalline types, apparently a gabbro, through medium to fine-grained types apparently diabase. On Rocky and Sisters brooks they occur in large volume, in part alternating with minor amounts of sedimentary material. There is no reason to suppose that these rocks occur as dykes, they may be large, irregular intrusive bodies, or sills, or they may be surface flows contemporaneous in age with the associated sediments. On Rocky brook where these rocks are in great volume, successive exposures along the stream varied widely in character as though the igneous rocks represented a series of sills or surface flows.

The rocks of the sedimentary group have been variously metamorphosed in different districts. The least altered occur along Salmon, McBean, and Hayes brooks, and the Miramichi river in this general vicinity, and also to the northeast along the lower stretches of Little Dungarvon river. Along the Taxes and its tributaries the strata are more compact, in places the slaty rocks have lustrous parting planes, and the coarser varieties frequently hold much secondarily developed mica in minute scales. In places, the strata in narrow zones have been silicified and are schistose. Along the Miramichi river from the contact with the granite below McKeel brook, eastward down river to near the mouth of Clearwater brook, and on Clearwater and some of the brooks to the east, the measures, for distances away from the granite border as great as several miles, have been highly altered. Where least altered, the argillaceous rocks are compact and lack the prominent slaty or shaly cleavage which they generally possess. Nearer to the contact the rocks are micaceous and as the contact is approached the amount of mica increases and the rocks pass over into fine-grained, dark greenish mica schists. These schists closer to the contact grade into lighter coloured varieties in which the mica tends to occur in small aggregates. Still closer to the contact the rocks are "spotted" mica schists filled with small irregular and rectangular black bodies which, presumably, mark the first stages in the formation of staurolite.

Quartz veins are very numerous over the greater part of the area occupied by the sedimentary series. These veins are formed of white vitreous quartz, in some places accompanied by a small amount of calcite. The veins generally hold pyrites, usually in very small amounts and never, so far as seen, abundantly. The quartz veins are usually only a few inches in width and seldom are as wide as 12 inches. They rarely occur singly, but as a rule occur in zones in some cases very narrow and composed of only a few veins, in other cases in zones 100 feet or more wide and made up of a large number of veins. The zones and component veins strike parallel with the bedding of the country rock, the individual veins are not persistent along the strike but widen and narrow and in short distances fade away or join adjacent veins. The distribution of the veins seems to be erratic and even in local areas where they are relatively abundant, long stretches of exposures are free from them. The veins seemed least abundant along the lower stretches of Taxes river and along the Miramichi below Hayes brook.

From the foregoing descriptions it is apparent that, in general, the degree of alteration of the strata increases as the granite boundary is approached and there can be little doubt but that the main metamorphism has been induced by the granite intrusion. It is probable that the numerous quartz veins are also connected in origin with the granite body.

The strata strike along directions varying from slightly south of east, through northeast and north, to northwest, but in most places the direction of strike varies between northeast and north. The angle of dip is usually high, frequently the strata are vertical or nearly so and only rarely does the angle of dip fall below 60 degrees. Locally, the strata are crenulated or even brecciated, but in the main this feature seems confined to the general neighbourhood of the granite body. Over considerable areas the direction of dip is usually fairly constant either being easterly or westerly as though the axes of folding were spaced far apart. In a few places the crowns of anticlinal folds were seen. In several such instances the folding was very sharp, but in two cases the fold was of a more gentle type and for a space of several hundred feet the strata were horizontal or had low angles of dip.

The age of this sedimentary group is not known. Many years ago the district was geologically examined and mapped by Robb who obtained fossils from one locality situated a short distance southwest of the map-area. These fossils were examined by Billings who pronounced them to be characteristic of a low Devonian horizon. Robb remarked[1], however, that it would not be proper to determine the age of the sedimentary group as a whole on the basis of this single fossiliferous occurrence and he refrained from assigning any age to the general assemblage.

At a later date, Ells stated [2] that as a result of his explorations he believed a continuous belt of Ordovician strata extended from Chaleur bay in the neighbourhood of Bathurst where at one place the strata are fossiliferous, to the Main Southwest Miramichi and that he was of the opinion that work by others showed that the belt continued southwestward to the Maine boundary. Fossils, chiefly graptolites, from the locality near Bathurst indicate according to Ami[3] that the horizon is equivalent to that of the Normanskill of New York state, that is lower Ordovician, and probably pre-Trenton. Ells wrote that at one point on the Main Southwest Miramichi, the rocks contain imperfectly preserved fossils. This fossil locality is presumably the one indicated on later maps as being situated on the south bank of the river about one mile above the mouth of Hayes brook. Ells stated that from Chaleur bay southwestward to the Miramichi wherever he had examined the strata of the belt...."the general lithological characters of the group are maintained, and certain belts can be traced continuously"....

Bailey in reporting on the geology of a region embracing the district now under discussion wrote[4] that the measures...."are in great part referable to this (the Ordovician) system".... and that the Devonian fossiliferous horizon found by Robb and referred to on a previous page, should be regarded as younger strata infolded with the Ordovician. At a later date the same author in referring to this general area of supposedly Ordovician stated[5] that it is...."now thought probable that the larger part.... is in reality Cambrian".....Later still, Bailey secured imperfectly preserved fossils from strata on Miramichi river at a locality about one mile above the mouth of McBean brook. These were examined by Ami who stated[6] that they gave some indication of being of Silurian age. Bailey remarked[7] that the presence of these possibly Silurian forms in the measures on Miramichi river, and of the low Devonian species found by Robb at the locality not many miles to the southwest, and of Silurian graptolites secured at several localities still farther southwest, furnished cumulative evidence that as regards the general assemblage of beds...."it is much more probable that these are Silurian than Cambro-Silurian or Cambrian"....

The present writer can furnish no further evidence regarding the age of the strata. The old fossiliferous localities on Miramichi river were not rediscovered and no new fossil horizons were located.

Granite.

The older Palæozoic strata are bounded on the northwest by a large area of granite extending both to the northeast and southwest beyond the limits of the map-area and having a width along Burnthill brook of about 10 miles. Besides this large granite mass there are several smaller bodies situated to the southwest of the main mass and wholly surrounded by the older Palæozoic sediments.

1 Robb, Charles, Geol. Surv., Can., Rept. of Prog., 1866-1869, pp. 190-191; 1870.

2 Ells, R. W., Geol. and Nat. Hist. Surv., Can., Rept. of Prog., 1879-80, pt. D, p. 22; 1881.

3 Ami, H. M., Geol. Surv., Can., Sum. Rept., 1904, pp. 289-290.

4 Bailey, L. W., Geol. Surv., Can., Ann. Rept. (new ser.), vol. I, pt. G, pp. 25-26.

5 Bailey, L. W., Geol. Surv., Can., Ann. Rept. (new ser.), vol X, 1899, pt. M, p. 9.

6 Ami, H. M., Geol. Surv., Can., Sum. Rept., 1904, p. 291.

7 Bailey, L. W. Geol. Surv., Can., Sum. Rept., 1904, p. 281.

The granite is, on the whole, very uniform in appearance. It is a quartzose, biotite granite, usually of medium grain, and either grey or pink in colour. In many places the rock is characterized by the presence of large, rectangular feldspars which in some cases are as much as 2 inches in length. Along the lower part of Burnthill brook the granite carries ill-defined, pegmatitic patches. On the Miramichi, at the western boundary of the circumscribed granite area traversed by the river from the vicinity of Clearwater brook to below Rocky brook, the granite for a width of 20 feet along the contact is a grey, quartzose, pegmatitic phase which away from the contact grades into a more normal type, bearing white mica in drusy patches. In the vicinity of the mouth of Burnthill brook, according to Brock [1], granite porphyry and aplite dykes cut the country rock. On Clearwater brook, well within the granite area, an aplite dyke was observed cutting the granite. With the above few exceptions, no other pegmatitic phases or dykes were observed in the vicinity of the southern border of the granite area. Such rock types may, however, be much more abundant than the above observations indicate, for here as elsewhere in the district rock exposures are scarce. Along the northern edge of the granite, large pegmatite dykes were seen at several localities on Burnthill brook, cutting gneissic rocks. These presumably are connected in origin with the granite.

In the western part of the map-area, in the vicinity of McKeel brook, the normal granite grades into a foliated phase, apparently due to movements in the magma prior to consolidation. This phase appears to merge into another which bears numerous granular, micaceous bodies varying in length from a few inches to as many yards. These appear to represent altered fragments of foreign material engulfed by the magma. This third phase in turn appears to grade into a banded biotite gneiss in which the alternating bands vary in character from schists and gneiss rich in biotite to others which have the mineral composition of a normal granite.

On both branches of Burnthill brook for at least several miles above the forks, a different granite occurs and though it may be quite different in age from the ordinary granite of the district, it has not been separately indicated on the accompanying map. This granite is pink in colour, rather fine and even-grained, and bears both biotite and muscovite. At several exposures this granite holds and cuts blocks of a foliated granite or biotite-muscovite gneiss closely resembling the pink granite except for the presence of the gneissic structure. The massive and gneissic types so closely resemble one another that it seems very probable they are related in origin. In places within the area supposed to be occupied by the biotite-muscovite granite, there are exposures of a fine-grained, grey, biotite gneiss and it is assumed that the granite holds or cuts this variety of gneiss also. All these varieties, both massive and foliated, are cut by pegmatite dykes and veins.

To the north and northeast the biotite-muscovite granite is succeeded by gneissic rocks, and east of Burnthill brook such gneissic rocks form the northern boundary of the normal biotite granite. The relations of the ordinary biotite granite with the biotite-muscovite granite and with the bounding gneisses are unknown. Possibly as regards origin and age these gneisses may be related to the widespread biotite granite, possibly they are much older and of Pre-Cambrian age.

The widely developed biotite granite forms a large body only partly included within the limits of the map-area. Similar granite composes large masses occurring both to the northeast and southwest and disposed along a general axial line extending completely across New Brunswick. These granite masses are generally held to be of Devonian age since some are undoubtedly later in age than lower Devonian strata and none are known to cut Carboniferous beds.

Gneisses and Schists of Uncertain Origin and Relations.

Besides the gneissic rocks already referred to as occurring in the vicinity of McKeel and Burnthill brooks, there appears to be a widespread development of gneissic

[1] Brock, R. W., Geol. Surv., Can., Sum. Rept., 1911, p. 14.

rocks bounding the main granite area on the north. Not many exposures of these rocks were seen and very little was learned about them. Most of the observed exposures occur along Clearwater brook where the last exposure of granite is separated by a long exposureless stretch from the first outcrop of gneiss. This first exposure is of a quartzose, medium to coarse-grained biotite gneiss. Certain bands consist of faintly foliated biotite granite finer in grain than the normal biotite granite but otherwise closely resembling it. The relations are such as to suggest that the gneiss is a modification of the normal granite induced in the same general way as in the case of the already described gneissic rocks occurring in the vicinity of McKeel brook.

About one-third of a mile farther upstream, exposures show a broadly banded gneiss varying from a phase like that mentioned above, to others which are coarser, carry large feldspars, and otherwise seem much like a gneissic phase of the normal granite of the region except that they are somewhat richer in mica. This general rock type prevails for some distance upwards along the stream, but in places the amount of biotite greatly increases or other variations are introduced, as for instance by the relative abundance of large, in part idiomorphic, in part angular feldspars which in some places are abundant, in others are almost entirely lacking. In places, these gneissic rocks are cut by irregular, vein-like granitic bodies.

These gneissic rocks occur along the southern margin of a very large area which on earlier maps and in former reports has been indicated as being occupied by Pre-Cambrian rocks. This view was strongly advocated by Ells and, apparently, largely on his authority, other authorities have assigned the strata in question to the Pre-Cambrian.

As regards the gneissic rocks seen in the district which is the subject of this report, it would appear that all are of igneous origin and that at least three main groups are present. In the vicinity of McKeel brook, the gneisses appear to be phases of the widespread Devonian biotite granite holding a large amount of foreign material. The biotite-muscovite gneiss outcropping along Burnthill brook closely resembles the granite by which it is cut and the foliated and massive rocks, therefore, are supposed to be related in origin. Their age is unknown. The gneisses displayed along Clearwater brook are clearly igneous rocks and are sufficiently like the widespread Devonian biotite granite to suggest that the gneiss and granite are related and of the same age.

Whether some, or none of the gneissic rocks are of Pre-Cambrian age seems to be an open question.

Carboniferous.

Carboniferous strata occur only in the southeastern part of the map-area, along the inner margin of the extensive Carboniferous tract of New Brunswick. Three divisions of the system are represented. The oldest consists of red shales, sandstone, and conglomerate. These are overlain by a sheet or sheets of diabase. The youngest division is the Millstone Grit composed of light coloured shales, sandstones, and conglomerates. All divisions are nearly horizontal and, relatively, unmetamorphosed.

The oldest division was seen at only a few localities in the Miramichi and Taxes River valleys. These measures all have a pronounced red colour and consist of sandy shales, sandstones, and conglomerates in beds varying in thickness from a foot or so up to 10 or 15 feet. The conglomerates are coarse, the fragments vary in shape from flattened pebbles to semi-angular forms and represent a considerable variety of metamorphosed sedimentary and volcanic rocks. Conglomerates and sandstones predominate and alternate with one another. The individual beds are not persistent, but instead thin and die out in short distances.

In the Miramichi valley, the red beds were seen only along the river's edge where at several localities they project for a few feet above the water-level and are there directly capped by a sheet or sheets of dark, basic, igneous rock. In the Taxes valley, the red strata are displayed for a very short distance along the river edge in the form of low cliffs nowhere higher than 20 feet. They also outcrop at one place along the highway on the north side of the river. At these places the basic igneous rock outcrops at higher levels and presumably overlies the red sediments. South of Taxes river the soil in several places is red and it is assumed that the red strata occur at such localities. There is no indication of the presence of the red beds nor of the overlying igneous sheet in the district between Taxes and Miramichi rivers, nor along the border of the Carboniferous area north of the Miramichi river. In the Taxes River valley it does not seem possible that the red strata have a total thickness greater than 50 feet. In the Miramichi valley a greater volume may be present, although nothing seen indicated this to be the case.

The red strata have been classed, in former reports, as belonging to the Lower Carboniferous, that is, to the Mississippian. By Robb and Bailey these beds were supposed to represent the conglomerate and sandstone horizon which in other places directly underlies limestone beds holding marine fossils, and Bailey[1] has argued that the local absence of the limestone horizon implies that vigorous erosion of the strata took place prior to the time of deposition of the Millstone Grit beds. On the other hand Ells[2] has claimed that somewhat similar red strata underlying the Millstone Grit in the vicinity of Bathurst on Chaleur bay, should be considered as belonging to a horizon above that of the marine limestone and that no erosion interval intervened between the deposition of the red strata and of the Millstone Grit.

The present writer failed to secure any evidence to show whether the local development of red beds should be considered the results of the opening phase of the Millstone Grit period of sedimentation, or whether the red beds belong to a still older sedimentary period. The local absence of the red beds along the Carboniferous border does not of itself imply erosion, but may simply imply overlap of the Millstone Grit.

Along the banks of Miramichi river below Porters brook, the red sediments are directly overlain by basic igneous rock, apparently diabase and seemingly in the form of a single sheet. The rock is dark, nearly black, is distinctly crystalline and in part coarsely so. In places it contains many large feldspar phenocrysts. A short distance below Porters brook, a vertical thickness of 25 feet of the igneous rock is exposed without either the base or top of the section being visible. About one-quarter of a mile farther downstream, the sheet is only about 15 feet thick and may be seen to rest on red beds of the lowest division of the Carboniferous and to be directly capped by the Millstone Grit. The contact of the igneous rock with the Millstone Grit is exposed, but both rocks are much changed along this plane, apparently by the action of underground water, and nothing was learnt with regard to the mutual relations of the two formations. In the Taxes River valley the diabase is more widely developed. It occurs at one place along the banks of the stream; farther west—upstream—it rises to the summit of the valley wall and about Clearwater brook it caps several of the higher hills where, in places, however, it seems absent and the Millstone Grit apparently rests directly on the older Palæozoic strata.

In the Taxes valley, the diabase sheet, at one locality in cliffs along the river valley, appears to be at least 50 feet thick and may be as much as 70 feet. As already pointed out, the thickness at one place in the Miramichi valley is not more than 15 feet, whereas at a second locality about one-quarter of a mile upstream, the sheet is not less than 25 feet thick. Like the underlying red strata, the igneous sheet appears to be absent along the borders of the Carboniferous area between the Taxes and Miramichi, and to the north of the Miramichi. The sheet may represent a sill intruded along the contact of the red strata and the Millstone Grit, but the impression obtained was that it was a surface flow now buried beneath the Millstone Grit. Such a conception seems supported by the evidence presented by the following section measured by Robb[3] in a cliff on Miramichi river. This section was not seen by the

1 Bailey, L. W., "Report on the Carboniferous system of New Brunswick," Geol. Surv., Can., Ann. Rept. (new ser.), vol. XIII, pt. M, p. 13.

2 Ells, R. W., Geol. and Nat. Hist. Surv., Can., Rept. of Prog., 1879-80, pt. D, pp. 5-10.

3 Robb, Charles, "Supplementary report on the geology of northwestern New Brunswick." Geol. Surv., Can., Rept. of Prog., 1870-71, p. 242.

writer nor was any analogous section seen. The following is the section, arranged in descending order:

		Feet.
5.	Grey sandstone (Millstone Grit) and loose material..	34
4.	Purple conglomerate with angular fragments of the underlying rock intermixed with rolled pebbles..	2
3.	Trap rock..	8
2.	Red earth or clay..	2
1.	White clay (to water-level)..	4
		50

This section seems to indicate that the trap rock rests on an old soil and that it is directly overlain by a conglomerate bed holding fragments of the "trap" and thus indicating that it had suffered erosion prior to the deposition of the Millstone Grit.

The Millstone Grit consists of pale grey, frequently yellowish weathering, conglomerates and sandstones with a small proportion of darker coloured shales. The sandstones predominate. The conglomerates occur chiefly in discontinuous beds of no great extent. The pebbles are almost entirely of rolled quartz. Towards the base of the formation, the conglomerate beds are relatively coarse and thick. The sandstones frequently show false bedding and other marks of current action. The strata have a gentle easterly dip, in part perhaps representing dip of deposition.

In places in the Miramichi and Taxes River valleys, the Millstone Grit rests on the already described igneous sheet. In the area between these two valleys and to the north of the Miramichi valley it appears to rest directly on the disturbed, older Palæozoic sediments, but rock exposures are few and it is not improbable that everywhere the Millstone Grit is underlain by older Carboniferous measures.

In former reports the Millstone Grit has generally been considered as being the lowest division of what has been variously called the Middle Carboniferous and the Upper Carboniferous, that is Pennsylvanian. The Millstone Grit is developed over a large part of New Brunswick and in many places carries thin coal seams. Fossil plants have been collected from a few localities within the province.[1]

Pleistocene and Recent.

The map-area, in common with the greater part if not all of New Brunswick, has been glaciated. The general movement of glaciation as indicated by erratics seems to have been southerly, but no glacial striæ were observed. Boulder clay was seen at only a few localities. Over much of the region there is a mantle of boulders and smaller rock fragments, presumably of glacial origin. Terminal moraines, eskers, and other products of glacial action may be present, but owing to the heavy forest covering and general conditions under which work was performed, they remained undetected or were examined in only a very superficial way.

The origin of the main physical features of the district offers problems of some complexity, but which in this report must be left untouched.

ECONOMIC GEOLOGY.

As regards mineral deposits within the map-area, interest centres chiefly on the wolframite-bearing deposit being mined in the vicinity of the mouth of Burnthill brook. During the past season a small amount of work was being done at another locality in connexion with a mineralized zone carrying some galena. According to one informant bog manganese ore occurs at some unspecified locality near a railway, but no further information was available regarding the occurrence.

Although the district is not an unpromising one, yet no qualified prospectors have entered it nor so far as could be learnt are the inhabitants sufficiently interested in the finding of mineral deposits as to actively or even casually engage in prospecting. This

[1] Bailey, L. W., "Report on the Carboniferous system of New Brunswick," Geol. Surv., Can., Ann. Rept. (now se.), vol. XIII, pt. M, 1902, pp. 27-30.

seeming lack of interest appears to be due, in part at least, to the fact that under the mining laws of New Brunswick the right to prospect for the purpose of locating and acquiring certain classes of mineral deposits has, in the case of large areas of the more promising territory, been granted to various individuals. For instance, in the case of the above-mentioned galena prospect, the sole right to prospect for this or certain related ores over a tract of some 50 square miles has been acquired by various individuals, but, so far as known, no prospecting or development work is being performed by them. In a second instance the exclusive right to search for tungsten ores over a number of blocks of territory, each containing 10 square miles and bordering Miramichi river above and below the known occurrence of this class of ore, has been obtained by certain interests, but apparently no prospecting work is being carried on.

Burnt Hill Tungsten Mines.

This property is situated on the Main Southwest Miramichi river, near the mouth of Burnthill brook. It comprises an area of 3 square miles and includes territory on both sides of the river both above and below the mouth of Burnthill brook. Mining operations are being carried out only on the south side of the river where a shaft has been sunk to a depth of 150 feet and drifts run on two levels. A mill, offices, and dwellings have been erected. A rough portage road about 18 miles long leads from the mine southward to Maple Grove railway station.

In an early report, published in 1870, Robb[1] makes the following references to the locality; ... "The rocks (metamorphosed sediments) near the mouth of Burnthill brook are cut by numerous transverse veins of quartz, holding much iron pyrites and occasionally a little molybdenite... Some of the veins at the surface are charged with the mineral in thin foliated hexagonal plates"...

The recognition of the presence of wolframite in some of these veins appears to be due to T. L. Walker, as indicated by the following extracts from a brief article[2] published by him... "In September, 1910, the writer had occasion... to examine the molybdenite deposits and incidentally discovered that wolframite occurs in almost all of the veins. These deposits... were of very doubtful value so far as molybdenite is concerned"... After pointing out that the deposits are in the form of quartz veins cutting metamorphosed sediments, chiefly slates, near a granite contact, Walker continues as follows... "Occasionally the quartz shows drusy structure and is quite vitreous... In width the veins vary from a few inches to about 2 feet. They appear to owe their existence to the action of the granite from which the materials for the filling of the fissures... were probably derived... The wolframite forms large crystals scattered through the quartz veins with a tendency to aggregation near the borders. Some of the crytals are quite large, attaining nearly half a pound in weight... The following analysis shows the presence of a considerable proportion of manganese:

FeO	16·90	per cent.
MnO	8·37	"
WO	74·43	"
Total	99·70	"

The above analysis corresponds closely to the formula $2FeWO_4 . MnWO_4$"...

In the summer of 1911 the property was visited by R. W. Brock. The following extracts are from his published account[3].... "Within the highly metamorphosed zone of the sedimentaries, which forms a border, roughly half a mile or so wide, along the granite contact, the mineral-bearing quartz veins are developed. About Burnthill brook the veins appear to be best developed and most highly mineralized on the side-

[1] Robb, Charles, Geol. Surv., Can., Rept. of Prog., 1865-69, pp. 193 and 206.

[2] Walker, T. L., "Recently discovered wolframite deposits in New Brunswick," Economic geology, vol. VI, No. 4, June, 1911, pp. 396-398.

[3] Brock, R. W., Geol. Surv., Can., Sum. Rept., 1911, pp. 14-15.

hill facing and opposite the mouth of the brook... The strike of the country rock varies somewhat but is about N. 67°E. (N. 90°E. astronomic), dip 55°N. Both the sedimentaries and the granite are heavily jointed, the joint planes having a direction of from N. 20° to N. 40°W. (N. 3°E. to N. 17°W. astronomic). Quartz is developed parallel to the strike of the schistosity of the sedimentaries and parallel to the joint planes. Parallel to the strike, the quartz is irregular, forming lenses and sending irregular stringers into the country rock. Between such stringers the country rock is often silicified. Parallel to the joint planes the quartz occurs in well-defined, regular veins which can be traced in some cases for several hundred feet, but some can be seen to pinch out. Some inclusions of country rock occur in the veins and the wall rock is occasionally silicified, thus there has been replacement as well as vein filling. The majority of the veins are under a foot in width but at (one) point... I found the vein for about 50 feet to average at least 2 feet."

"On the east side of Burnthill brook, at its mouth, a mineral-bearing quartz vein is bordered by greisen... The mica of the greisen, which is muscovite, is often segregated in bands. A little farther north is another vein in which greisen predominates. North of this, near the granite contact, is a 4-foot dyke of greisen, parallel to the joint planes and the quartz veins. In it were a few quartz stringers and druses of quartz. It was in this greisen that I found tinstone. There is, therefore, evidently a gradation from the greisen to the normal quartz veins, and the veins are clearly contact phenomena of the intruded granite."

"The following minerals were observed in these veins: quartz, muscovite, brown mica, feldspar, topaz, fluorite, wolframite, molybdenite, pyrrhotite, chalcopyrite, and cassiterite. The quartz, which is milky and vitreous, is the chief gangue mineral. It occurs massive and crystallized in vugs and druses. Muscovite is most plentiful in the greisen, but is also found in the typical quartz veins. The brown mica was seen in one of the quartz veins. Feldspar was found in one of the banded quartz-greisen veins. The topaz occurs in a great many if not most of the quartz veins, and in considerable quantity. It is most frequently found as crystals lining vugs and druses, but it also occurs massive. The crystals are microscopic to thumb-large in size... Some crystals are almost milk white, but some small, clear yellow crystals of gem quality were found... The dark purple fluorite also occurs in druses, but sparingly. The brownish-black wolframite occurs in considerable amounts, usually more or less segregated into bunches which are commonly near the centre or along the edges of a vein... The molybdenite is less abundant. Its occurrence is similar to that of the wolframite. Pyrrhotite and chalcopyrite are only sparingly present. The iron sulphide is later than and veins the wolframite. The brown cassiterite or tinstone was found in the greisen in small amount only."

"The granite... is exposed in the brook (Burnthill brook)... Some small quartz veins... were observed in it. The quartz veins were similar to those in the sedimentaries, but only molybdenite was observed in them. There is no reason, however, why tin-bearing greisen, or wolframite-topaz veins should not be found in the granite, especially in fractures near its contact with the sedimentaries, where pneumatolitic action would be as apt to occur as in the sedimentaries near the contact."...

In October, 1916, the locality was visited by C. Camsell. By this time development work had been commenced on a deposit situated on the south side of Miramichi river and the following extracts from Camsell's report[1] deal with this particular occurrence only... "The deposit outcrops as a quartz vein on the slope of the valley 170 feet above the river and about 2,000 feet from it... The country rocks... are argillites which are intruded by a granite batholith... about three-fourths of a mile away. The argillites... are traversed by a set of fracture planes striking... almost at right angles to the bedding planes and many of the fractures are filled with quartz and other vein minerals. Another set of quartz veins is developed along the planes of bedding or schistosity; and, an increase in the amount of mineralization is often noticed where

[1] Camsell, Charles, "Burnt Hill Tungsten mine." Geol. Surv., Can., Sum. Rept., 1916, pp. 247-249.

the two sets meet... The only vein of importance so far discovered (on the south side of the river) is that on which development work is being done. This vein strikes north 40 degrees west (N. 17° W. astronomic) and dips 75 degrees to the southwest. It has been exposed for a distance of more than 150 feet, and at either end disappears under the drift. Its extension towards the northwest is indicated by a number of large pieces of float quartz carrying wolframite; 650 feet beyond in this direction a vein 12 inches wide outcrops and is perhaps the same vein. At its southeast end the vein passes under a deep covering of drift, but its continuation is again indicated for at least 600 feet by many pieces of tungsten-bearing quartz along the strike... The vein is faulted at the shaft and is displaced a few feet to the southwest."...

"At the collar of the shaft the vein is 24 inches wide increasing to 32 inches at a depth of 11 feet, and it maintains this width to the bottom of the shaft 50 feet below the surface. Along the strike, it maintains a width of 2 feet northwestward for about 30 feet, beyond which for an interval of 20 feet it is difficult at present to determine the width. Sixty feet from the shaft the vein appears to be cut by a cross fracture which enriches the ore and increases its width to about 9 feet. Beyond this, it contracts again, except where cut by a second cross fracture, and, at a distance of 100 feet from the shaft, is only 12 inches wide."

"The vein is a quartz-filled fissure on the walls of which replacement and mineralization have taken place to a depth of several inches. The gangue is quartz with a subordinate amount of topaz and some fluorite... The wolframite occurs in large crystals both in the vein and the replaced wall rock. Its distribution is, however, somewhat irregular, though it was observed throughout the greater part of the exposed portion of the vein. The ore in the exposed portion of the vein was estimated to carry from 2 to 6 per cent of wolframite or an average of 2½ per cent of WO_3."

"The vein is probably connected with the intrusion of the granite batholith, and its origin is due to uprising solutions emanating from the granite".....

"At the 50-foot level, drifts had been driven....for a distance of 24 feet in one direction and 31 feet in the other. At the face of the west drift, the vein is 30 inches wide, while at the face of the east drift, it is split up into four smaller veins with a few inches of country rock between. The total width of ore and included country rock is here 4 feet".......

During November, 1917, the property was examined by D. D. Cairnes and from his report[1] the following additional information has been extracted . . . "In the shaft, the quartz and other vein material range in thickness from 24 to 42 inches. In the west drift, the vein is in most places from 18 to 36 inches in thickness. Near the end of this drift, however, or about 70 feet from the shaft, the vein narrows to about one inch . . . . In the east drift, there are in most places two veins, or really one main vein, and a narrower, parallel, stringer. These are generally 2 or 3 feet apart. About 50 or 55 feet from the shaft, the veins branch out into several stringers each about an inch or so thick, and finally the vein apears to feather out entirely; but before terminating, if it does so, the vein is cut off completely by a cross fault"....

. . . . "To the northwest of the shaft.. . .. outcrops of wolframite-bearing quartz veins from a few inches to 2 feet or even more in thickness were seen at intervals for a distance of about 1,000 feet.. . . It would appear very probable, however,. . .. that the individual veins are not as persistent as had been hoped, but that, instead, the mineralization follows a set of more or less connected fissures". . . . . . .

In July, 1917, at the time of the present writer's visit to this locality, the shaft had been sunk to a depth of 150 feet and at this level a drift was being run to intersect the vein but had not yet cut it. On the 50-foot level, the vein had not yet been located beyond the line of faulting mentioned by Cairnes, but in an extension of the drift beyond the fault plane, other ore-bearing veins up to a foot or more in width and running at right angles to the course of the main deposit had been found to cut through the fault plane. At the 50-foot level a tunnel had been driven in from the hillside to

[1] Cairnes, D. D., "Burnt Hill Tungsten property, N.B.," Geol. Surv., Can., Sum. Rept., 1916, pp. 251-254.

the shaft. Along this tunnel some five or six narrow, ore-bearing veins had been cut. As seen on this level, the main deposit consists of several quartz veins separated by bands of country rock each varying in width up to several feet or more. At the surface, the zone of quartz veins is traceable to the west for a distance of at least one-half mile. The individual veins are, apparently, discontinuous and of variable width, not exceeding 3 feet. They are clean cut and cross uninterruptedly through the alternations of "spotted" schist and harder, siliceous beds. They also cut the older set of quartz veins running parallel to the strike of the country rock. At intervals they hold wolframite and molybdenite in small amounts only. On the north side of the river similar veins occur, but where seen were relatively narrow and not rich in ore. The writer was informed, however, that promising veins do occur on the north side of the river.

At the time of visit, the mine mill was in operation and was stated to be capable of treating 30 tons of ore daily, yielding a product holding from 50 to 60 per cent WO_3.

Walker, Brock, and Camsell unite in suggesting that the ore-bearing veins are connected in origin with the large granite body outcropping about 1 mile north of the mine workings. The deposit, in common with most if not all occurrences of tungsten ores, appears to have formed through the agency of highly mineralized vapours and solutions accompanying the granite and related in character and origin to the pegmatites which in so many places are associated with granite masses. The wolframite-bearing veins are later than and cut the quartz veins which run parallel to the bedding of the country rock. These older veins carry pyrite sparingly, but otherwise appear to be barren. They occur at many points throughout the district, both near the granite and remote from it. It is probable that they too are connected in origin with the granite intrusion but are older than the veins carrying tungsten ore.

In the vicinity of Burnthill brook it appears probable that the granite body dips beneath the sediments at a comparatively low angle. This is indicated by the general course pursued by the granite boundary where it crosses the valley of Burnthill brook and also by the presence along Miramichi river, just above Burnthill brook, of several small, apparently isolated granite masses. It is possible, then, that one main factor which lead to the formation of the ore-bearing veins at this locality, may be that the country rock in the vicinity is an undestroyed portion of the cover of the granite mass. If the veins have formed from solutions and vapours emanating from the granite body at or after the time of intrusion, in the fashion followed by pegmatite dykes, it seems reasonable to suppose that a favourable locality for the formation of such veins would be in the cover of the granite mass rather than in strata bounding vertical or steeply dipping sides of the granite body. Similar conditions may exist elsewhere along the granite contact and, as suggested by Brock, it seems not unlikely that other deposits of tungsten ores, perhaps even of tinstone in important amounts, may be situated in the neighbourhood of the line of contact either in the sedimentary strata or in the granite itself. Furthermore, if, as seems so probable, the deposits are connected in origin with the biotite granite, then occurrences of this type of ore deposits may be expected in other areas quite remote from the Burnthill locality, for a zone of large granite bodies extends completely across the province from the vicinity of Chaleur bay, southwest to the Maine boundary, and so far as known all these granite bodies are related in composition and age, and for long stretches are in contact with sedimentary strata such as are displayed along the Main Southwest Miramichi.

Galena Prospect near Winding Hill.

Along the portage road leading from Maple Grove station to the Burnt Hill Tungsten mine, at a point about 8 miles from the railway station, there is a mineral property on which W. H. and W. T. Griffin, of Cross Creek, during the season of 1917, were doing some work in the form of trenching. This mineral occurrence has already been described by Cairnes. [1]

[1] Cairnes, D. D., Geol. Surv., Can., Sum. Rept., 1916, pp. 254-255.

Rock exposures are very few in this vicinity, but on the west side of the road and close to it, two shallow trenches show the country rock to be light coloured, siliceous and schistose, presumably altered forms of the dark slates exposed in the general vicinity on Taxes river and its tributaries. In the trenches the rock is traversed by numerous, narrow, irregular quartz veins and stringers seldom more than a couple of inches wide and, in many cases, much narrower. In these veins and in the country rock are irregular aggregates of finely granular galena with smaller amounts of pyrite and zinc blende. The aggregates are usually small, the largest seen measuring not over three-quarters of an inch by one-quarter inch. They are not abundant and are not uniformly distributed. Iron pyrites is distributed through the country rock and veins in varying amounts. About one-quarter mile north-northeast another trench shows the same general conditions. About half a mile or more farther eastward along the general direction of strike, silicified and partly schistose rocks outcrop along Middle Hayden brook, but there only iron pyrite was seen.

Apparently mineralization has taken place along a zone striking parallel with the bedding of the rocks. Up to July, no ore-body had yet been discovered, but the amount of work done on the property is very slight. The longest trench was not over 30 feet in length and it was not apparent whether the trenches were located on one side only of the zone or whether they disclosed it for the greater part of its width. It would seem desirable to make an attempt to strip the zone completely across from one side to the other.

Cairnes reports [1] that a sample taken across 6 feet of the best mineralized portion of the walls of one of the trenches yielded only 1·27 per cent lead and no gold or silver, and another sample taken across 8 feet of the face of the adjoining trench assayed only 1·24 per cent lead and no gold or silver.

NOTES ON SOME FOSSIL PLANTS FROM NEW BRUNSWICK.

By W. J. Wilson.

Dr. Robert Kidston of Stirling, Scotland, kindly sent me the following notes on specimens and photographs forwarded to him for examination. These specimens and those from which the photographs were made are from the Rothwell coal mine, Rothwell post-office, Queens county, N.B., except where otherwise indicated.

"In regard to the two ferns that you have sent me.

The small *Pecopteris* from the Fern Ledges, St. John, N.B., I have not seen before, nor do I remember having seen any description or figure agreeing with it. I have looked up a number of books where I thought it possible it might be described, but failed to find your plant—that which comes nearest to it is the *Pecopteris* (*Alethopteris*) *mertensioides* Gutbier sp. in Geinitz. Vers. d. Steinkohlenformation in Sachsen, p. 29, Pl. XXXIII, fig. I. The pinnules in this species are closer and the veins are said to be simple. It is a very imperfectly known species.

The *Neuropteris* from Gardner creek, St. John county, N.B., is not *N. heterophylla*, but seems to be undoubtedly *N. tenuifolia* Schloth, sp. I enclose rough tracings of pinnules of *N. heterophylla* and *N. tenuifolia*. It is true you might see a slight variation in the nervation of the pinnules, but the limit of variation is slight and does not affect the real differences between the nervation of *N. tenuifolia* and *N. heterophylla*.

Notes on Photographs.

No. 1. *Sigillaria* sp.

This species is very closely related to and I think specifically identical with the *Sigillaria* I have identified as *S. Arzmensis* ("On the fossil plants of the Rowenhead collection," etc., Trans. Roy. Soc., Edin., vol XXXV, pt. II, p. 413, pl. I, fig. 2, 1889).

[1] Op. cit., p. 255.

This identification has been questioned and my specimens may not be Corda's species, which he says has fine longitudinal striations on the cortex, but I thought this character might be due to more imperfect preservation of Corda's specimen and that the fine longitudinal striations on the cortex might be the longitudinal striations of the sub-cortical layer, shadowed through a partially decayed cortex. My present opinion is that my plant, and consequently yours, should not be identified with *Sigillaria Arzmensis* and I suspect they represent an undescribed species. The ornamentation of the cortex is a little more prominent on your specimen than on mine (No. 1581), but my specimen has suffered slightly from pressure.

No. 2. *Sigillaria* sp.

It is impossible to identify specifically such decorticated specimens as this example. It is quite possible it is the decorticate condition of No. 1.

No. 3. *Cordaianthus* sp.

I do not know of any species with which this can be identified. It is an extremely fine fossil and of remarkable size.

No. 4. *Pecopteris Miltoni* Artis sp.

Absolutely typical of Artis' plant.

No. 5. *Sphenopteris latifolia* Brongn.

No. 6. *Samaropsis* sp.

I cannot give you a name for this seed, but it is allied to the following, though I do not think it is specifically identical with them—except perhaps with the last mentioned.

Samaropsis quadriovata Kidston. South Stafforshire coal field, Trans. Roy. Soc., Edin., vol. L, pt. 1, p. 155, pl. XVI, figs. 1, 1a, 1914.

Samaropsis (*Cardiocarpus*) simplex Lesq. Coal flora, vol. II, p. 569, pl. LXXXV, figs. 49-50, 1879-80.

Samaropsis (Cardiocarpus) sp. Sellards.

University Geol. Surv., Kansas, vol. IX, p. 429, pl. LI, fig. 12, 1908.

I think that the specimen figured by Sellards is most probably your seed and if he had given a name to it I would have had no difficulty or hesitation in adopting it for your fossil, but unfortunately he does not name it. I think it is an undescribed, or rather, unnamed species.

No. 7. *Sigillaria* sp.

It is impossible to specifically identify such decorticated specimens.

No. 8. *Sigillaria Antonina* (Zalessky) 1904.

Sig. Antonina Zalessky. Mém. du Comité Géol. Neuv, sèr. Livre, 13, pp. 65 and 117, pl. XI, figs. 4, 4a.

I have only seen a single British example of this species which is in my own collection (No. 4338).

No. 9. *Alethopteris serli* Brongn.

No. 10. *Stigmaria ficoides* var. *undulata* Göpp.

This specimen must go I think to *Stigmaria ficoides* var. *Undulata Göpp.* He may have included more than one form, or even species under this name, but it agrees entirely with his figure 6 in the Gatt. d. foss. Pflanzen. Notice the undulations almost approaching to a ribbing on some parts of your specimen.

Your specimen approaches the form figured by Dawson in Quart. Jour. Geol. Soc., vol. XXII, pl. XII, fig. 85, p. 148, 1866.

Refs.: Göpp.—Gatt. d. fossilen Pflanzen. Hefts 1-2, pp. 18 and 31, pl. IX (pars.), figs. 5, 6, 7, 8, (10?), (9?).

1852. *Stigmaria ficoides* var. *undulata* Göpp. Foss. Flora der Ubergangsgebirges, p. 245, pl. XXXII, fig. 2. (Especially see this figure.)

Lesquereux copies Göpp's figures from the first mentioned work, but Lesquereux's fig. 1 on pl. LXXIV (figs. 1, 2), is not copied very accurately.

No. 11. *Pecopteris Miltoni* Artis sp.

Notice pinnules are attached by whole base to their rachis, though sometimes there may be a slight contraction of the base of the pinnule. The nervation is typical of *Pec. Miltoni.* Your photo 4 is only a further divided condition of the same species.

No. 12. *Neuropteris* sp.? Fern Ledges, St. John, N.B.

I cannot identify this specimen. The upper pinnules look very "Odontopteroid", but the uppermost pinnules of all *Neuropteris,* more or less assume this form. The lower pinnules on your specimen seem to have a contracted base with the lower basal margin auricled and appear to assume the typical *Neuropteris form* of pinnule.

If I am correct in this, the specimen might be the terminal portion of a *Neuropteris* pinna. These points may be more clearly shown on the specimen, but the photograph seems very good."

INVESTIGATIONS IN WESTERN NOVA SCOTIA.

By E. R. Faribault.

CONTENTS.

GENERAL STATEMENT.

The field season of 1917 was spent mainly in the southeastern part of Shelburne county, completing the geological mapping of the Lockeport map-area and commencing the survey of the Sable River map-area.

Other areas were also visited in the western part of Nova Scotia, particularly on behalf of the Canadian Munitions Resources Commission, to investigate ore deposits which gave promise of furnishing products required for war purposes. Special examinations were made of the manganese and the molybdenum ore deposits of New Ross, Lunenburg county, and of the tungsten deposits of the Moose River district, Halifax county, and reports on the information obtained were presented to the Secretary of the Commission.

Short visits were also paid to the gold districts of Tangier and Goldenville, in compliance with special requests received for advice on the development of mining properties that were being reopened.

The Survey is indebted to the officials of the several mines visited, to Mr. Hiram Donkin and the other officials of the Nova Scotia Department of Mines, to Professor G. F. Murphy and Mr. H. B. Pickings of Halifax, to Mr. H. C. Burchell of Windsor, N.S., and to the many residents of the district surveyed in Shelburne county, for assistance and courtesies, to all of whom the writer wishes to extend his sincere thanks.

Field work was commenced on May 15 and continued until October 27. J. McG. Cruickshank, C. A. Brown, and J. F. Wright were employed as assistants in the area surveyed in Shelburne county, during the whole season, and rendered efficient service.

GEOLOGICAL MAPPING OF THE LOCKEPORT MAP-AREA, SHELBURNE COUNTY, NOVA SCOTIA.

The area surveyed comprises the southeastern part of Shelburne county, covered by the Lockeport map-sheet No. 110, and some of the country immediately adjoining to the north and west. The Lockeport map-area measures 18 miles east and west and 12 miles north and south. The southern limit fronts on the Atlantic from the mouth of Port Hebert to Shelburne harbour, and the northern extends from the head of Port Hebert to a point 6 miles north of the town of Shelburne. The area includes Port Hebert, Sable River inlet, Lockeport harbour and town, and Jordan River inlet, and comes within one mile of the town of Shelburne.

GENERAL GEOLOGY.

The map-area is wholly underlaid by the quartzites and slates of the Gold-bearing series which occupies the southern half of the province along the Atlantic from Canso to Yarmouth. At the eastern and western extremities, at Port Hebert, Tom Tidney river, and Shelburne, the sedimentary rocks are intruded by three separate masses of muscovite granite. On the border of these batholiths, generally, the granite changes in texture and becomes pegmatitic and aplitic, and tongues and dykes of this marginal phase of the granite penetrate the sedimentary rocks. The pegmatite dykes are often intersected by veins and stringers of quartz and carry black tourmaline, molybdenite, and other minerals, some of which may be of economic importance. The sedimentary rocks show every gradation of metamorphism from slightly altered quartzites and slates in the central part of the map-area far remote from granite intrusions, to completely recrystallized, coarse, micaceous gneisses, and staurolitic and garnetiferous schists where they are intruded by granitic masses and dykes.

One large and persistent dyke of diabase previously traced along the coast in a westerly direction for 42 miles, from West Ironbound island to Wilkins station, was located across the northwest corner of the map-area where it crosses Jordan river 1 mile, and Roseway river 2 miles, above the head of tide. This dyke has thus been traced for a length of over 60 miles, and its width varies from 200 to 600 feet. The metamorphism due to the diabase intrusion does not extend more than a few feet from the line of contact. Where it crosses Roseway river below Hervey dam, the diabase can be observed to cut both the granite and the schists, and is thus younger than the granite which is of late Devonian age.

The Gold-bearing series has a known thickness of over 30,000 feet, and is divided lithologically into two conformable formations: a lower one, known as the Goldenville formation, chiefly composed of thick beds of quartzite with intercalated layers of slate; and an upper one, called the Halifax formation, essentially made up of slates. These rocks are closely folded into broad anticlines and synclines, the axes of which have a general northeast-southwest trend. As a result of the folding and subsequent extensive erosion, the Halifax formation occurs only in narrow belts along the trough of some of the deepest synclinal folds, and the Goldenville formation covers the remaining area.

The location of the anticlinal folds and domes has an economic importance, because practically all the gold-bearing quartz veins are found aggregated on domes of pitching anticlines. The study of the geological structure of the area has not yet been completed, and more field work is required to trace the anticlines and determine, if possible, the anticlinal domes. As far as known at present, at least three major anticlines and several minor folds traverse the area in a southwesterly direction. They are best exposed on the seashore where they occur in the following order from east to west: the first anticline is exposed at Black point on the east side of Lockeport harbour; the second occurs at the head and along the east shore of Green harbour and extends to Green island where it is composed of several minor folds well exposed on the shore; and the third occurs at Jordan Falls where it crosses the river at the head of tide and extends southwesterly beyond a spur of the Shelburne granite area to Eastern head.

ECONOMIC GEOLOGY.

The economic minerals so far discovered in the area under study are gold, molybdenite, bog iron and manganese, red ochre, white clay, infusorial earth, and mineral water, and possibly tinstone, gypsum, and limestone. Some of these occurrences have been prospected a little, but the results so far obtained have not led to any important development work or production. Granite and diabase, however, have been quarried near Shelburne for building and ornamental stones.

Gold quartz veins and float have been discovered at a few places in the Gold-bearing series, generally on anticlinal folds, but apparently not in paying quantity and no development work has yet been undertaken.

Molybdenite has been known, for over twenty-five years, to occur $3\frac{1}{2}$ miles north of Jordan Falls on the east side of Jordan river. Numerous loose pieces of quartz are scattered along Leadmine brook, just west of Lake John road; and on the bank of the stream the quartz may be examined in place. One vein, 26 inches in width, is well exposed for a length of 100 feet. This vein strikes north 82 degrees east (magnetic) and dips north 68 degrees, cutting beds of micaceous quartzite and schist which strike south 32 degrees east and dip northeast 19 degrees, apparently curving on a fold. The vein matter is quartz associated with aplite and contains white mica, tourmaline, thin plates of ilmenite, and an occasional scale of molybdenite. The vein is evidently of magmatic origin and related to pegmatite intrusions. A few feet south two or three smaller veins occur, also showing molybdenite very sparingly. Along the strike of the larger vein, one mile to the east, it is reported that a similar vein, 24 inches thick, bearing minute scales of molybdenite, has been opened by a test pit 6 feet deep. The deposits have been examined frequently from an economic point of view, but up to the present no development work has been done to prove their commercial value. It is quite possible, however, that prospecting might bring to light quartz veins carrying economic proportions of molybdenite and the locality deserves further investigation.

Molybdenite is also reported to have been found in quartz float to the east of Wall brook, somewhere near the railway between Sable River and Lockeport stations.

The reported occurrence of molybdenite in a gold-bearing vein on W. H. Ringer's farm at Louishead, mentioned by the writer in last year's Summary Report, page 285, has proved upon investigation to be erroneous.

Infusorial earth deposits were observed outside of the map-area on Jordan river, in a marsh on the Stillwater $1\frac{1}{2}$ miles above lake John, also on Barclay lake on Clyde river. The deposits may be of some importance, but at present they are too far away from shipping facilities to be exploited at a profit.

Bog iron and manganese, and white clay are reported to have been found in digging wells on the east shore of Shelburne harbour, between Shelburne town and Sandy Point. Sink holes indicating the possible presence of gypsum or limestone were also observed on this part of the shore of Shelburne harbour. A spring of sulphuretted mineral water is situated on Pace Wall's farm, just south of the railway, one mile east of Shelburne.

Granite of different varieties and colours, suitable for building and ornamental stone, occurs in the district. Quarries have been opened both in the muscovite granite and in the large diabase dyke, near Shelburne. Black granite is the term used by stone workers for the dark grey diabase.

Granite quarries have been operated for many years by The Shelburne Granite Company and others on the west side of Shelburne harbour, southwest of the town. The stone is of an excellent, fine-grained, light grey type. It takes a good polish with a bluish silver-grey, glistening effect. The suitability of the stone for architectural work is well shown by the handsome post-office in Shelburne. A few men only were at work last summer quarrying stone for a church which is being built at St. Bernard, Digby county. The quarries are conveniently situated for shipping either by water or railway.

Charles C. Reid of Shelburne has quarried a small amount of granite, on the east side of Roseway river, 2 miles above the railway. The stone is of a light grey colour, but of finer texture than that quarried on Shelburne harbour, and it polishes well with a characteristic graphic effect.

Two quarries of black granite have been opened on the large dyke of diabase traversing the northwest part of the map-area. One was worked a few years ago by Charles C. Reid of Shelburne, on the east side of Jordan river, in a cutting of the abandoned Hervey railway line, one mile north of Jordan Falls. The other quarry was recently opened by Andrew Bower of Shelburne, on the east side of Roseway river, $1\frac{1}{2}$ miles above the railway. The stone takes an excellent polish of a rich greenish black colour. It is especially suitable for tombstones and is mostly used locally for that purpose. Small shipments have been made to T. F. Sherrard, Moncton Granite and Marble Works, Moncton, N.B., and to other places.

Diabase takes a high rank among the natural road building materials, because of its hardness, toughness, fineness of grain, homogeneity, and excellent binding power. So far not a single quarry has been opened in any of the diabase dykes which abound in the western part of Nova Scotia. The materials crushed to macadamize streets and highways in Nova Scotia are generally slate, quartzite, limestone, and granite, all of which are very deficient in qualities required for good road metal. The prominent dyke of diabase extending for over 60 miles along the coast from the mouth of Lahave river to Roseway river and beyond, is well situated at many points with respect to shipping facilities by water or railway, particularly at Liverpool, Shelburne, and Jordan Falls. The stone could be shipped advantageously to Halifax where good road material is not locally available. The waste material accumulated at Andrew Bower's quarry might be crushed at little cost by utilizing the town electric-light water-power when there is a surplus of water available, and might be used to macadamize the streets of Shelburne, or shipped away. At Liverpool, diabase rock outcrops on Great hill just north of the railway station, and at Black point on Liverpool bay where vessels could be loaded directly off the ledge of rock.

Peat bogs and hay-marshes are numerous, and some of these are particularly suitable for the cultivation of cranberry vines. Sphagnum moss which grows profusely in most of the bogs might become the source of an industry; the variety *sphagnum papillosum* has been found especially useful in the present war as an absorbent for surgical dressing.

INVESTIGATIONS IN NOVA SCOTIA.

By A. O. Hayes.

CONTENTS.

INTRODUCTION.

Field work in 1917 was carried on mainly in Cape Breton county, where a study of the structure of the southern part of the Sydney coal field was commenced. Also, ore deposits and mineral occurrences which gave promise of furnishing products of economic value were examined in various parts of Nova Scotia.

The Survey is indebted to the officers of the Nova Scotia Department of Mines and of the coal companies operating in the Sydney district, and to many residents, for courtesies which facilitated the field work, to all of whom the writer extends his sincere thanks.

C. W. Robinson acted as field assistant in the Sydney area, for three months.

COAL.

Southern Part of the Sydney Coal Field. On account of a heavy mantle of glacial drift through which only scattered outcrops of bedrock penetrate, it was found difficult to obtain sufficient data on which to base an interpretation of the structure of that portion of the Sydney coal field lying along the coast to the south of Port Morien, and westward, between Broughton and Birch Grove, especially in the vicinity of McDonald lake. Pits and borings have been sunk and valuable information obtained since the last map published by the Geological Survey was revised by the late Hugh Fletcher about twenty years ago. A portion of the area covered had not been revised since first mapped by Robb and Fletcher about forty years ago.

The surveys necessary to compile an outline topographical map were made during the summer by D. A. Nichols. The area surveyed comprises about 200 square miles and is rectangular in shape, bounded on the north by an east-west line passing to the north of Sydney and Port Morien; on the south by an east-west line passing to the south of Mira gut; on the west by a north-south line passing to the west of Sydney and the Caribou Marsh road; and on the east by a north-south line passing to the east of Cape Morien. When completed, this map will serve as a base for geological mapping.

A terminal moraine which extends through the central part of Cape Breton county is especially well developed along the north shore of Mira bay in the vicinity of Round island, extending west-southwestwards along the Mira river and northwards including the vicinity of Broughton. Typical kettle and knob topography and kames forming ridges 50 feet or more high are characteristic features and suggest that the moraine was formed at the edge of an ice-sheet of more than local, and probably continental character. The movement of the ice was northeasterly.

Mira river, in pre-glacial time, may have emptied into Mira bay to the north of its present outlet through Mira gut. This pre-glacial valley was filled with glacial drift near its mouth, forming a river dam which caused a lake to fill the present Mira valley above the gut and the stratified clay and gravel deposits now forming the islands and shores of the river were deposited in this quiet water. The gut appears to have been cut by stream erosion from the overflow of this glacial lake in early post-glacial time. To account for the meandering submerged channel of Mira river, both in the upper river and the gut, it is thought that the land may have stood on a slightly higher level than at present. No evidence of the elevation of the land in post-glacial time, such as characterized the bay of Fundy and the eastern St. Lawrence River valley, was found.

Along the south and west shores of Mira bay, limestone outcrops at Neils cove at the east end of Catalone beach, and at Dixons siding. Fossils were collected from the limestone at Dixons siding and examined by E. M. Kindle, who has submitted the following report:

"*Productus* cf. *tenuicostiformis*.
Orthothetes cf. *crenistria*.
Seminula argentea?
Dielasma sacculus.
Aviculopecten sp.
Schizodus cf. *densi*.
Parallidon dawsoni?
Modiola pooli.

"This is a marine Carboniferous fauna, older than the well-known *Leaia* fauna of Nova Scotia and New Brunswick. This fauna is evidently closely allied to, and in my opinion represents the same general fauna as the Windsor and Magdalen Islands faunas. The beds holding it belong, I think, to the Windsor series. The list of fossils includes one genus of wide distribution in the Carboniferous (Orthothetes), whose absence from the above-mentioned faunas has been commented upon by Beede and others. The Mira Bay fauna shares with the Windsor fauna the lack of close resemblance to any of the Carboniferous faunas of the interior continental region, which has in the past led to diverse opinions regarding the age of the Windsor fauna.

"I am disposed to accept the later views that the Windsor and Magdalen Islands faunas are of early Mississippian age, and in conformity with this disposition of them would place the Mira Bay fauna in an early Mississippian horizon."

This limestone is interbedded with arenaceous shale in the Dixons Siding exposure. Between Neils cove and Catalone lake are outcrops of steeply dipping sandstone and conglomerate, holding drifted fossil tree trunks and other plant remains which have given rise to small pockets of pyritiferous coal. No workable quantity of coal was seen. East of Neils cove as far as Mainadieu bay, pre-Carboniferous volcanic rocks occur.

At the west end of Mira gut, on both banks of the river, conglomerate beds outcrop. These are characterized by pebbles of limestone and represent a period of erosion probably marking the close of the Lower Carboniferous epoch in which limestone of the Windsor series occurs. It seems improbable that coal in workable quantity occurs in this field south of Mira gut.

The sediments between Mira river and the Morien to Birch Grove vicinity appear to lie uniformly on the south limb of the syncline forming the Morien basin. Except for the steep scarp of heavy-bedded sandstone forming the north shore of Mira gut, few inland exposures of bedrock penetrate the mantle of drift north of Mira river. There are no outcrops along the coast between Mira gut and Round island. Between Round island and False Bay beach a few thin coal seams are known and coal for domestic use was mined by D. J. McQueen from a seam near his house. This coal was not exposed to view, but Mr. McQueen stated that it was about 2 feet thick.

The lower members, as seen along the shores of cape Morien, contain a number of conglomerate beds interbedded with sandstone and shale with a few coal horizons, the most important of which is the Tracy seam which was examined and sampled in the old workings about three-quarters of a mile east of False Bay beach.

The following section was measured:

	Feet	Inches
Shaft timbered vertically	10	
Shale roof	1	
Clay	..	2
Coal	..	7
Clay	..	2
Coal	3	
Clay	..	9
Coal	2	9
Sandstone pavement.		

An analysis of an average sample taken from the face of this underground level gave the following results:

	R.	D.
Moisture	2·0	
Ash	9·2	9·4
Volatile matter	34·5	35·2
Fixed carbon (by difference)	54·3	55·4
Fuel ratio.		
Fixed carbon volatile matter	1·60	1·55
Small lump of fair coke obtained.		

NOTE.—Figures in column R refer to fuel as received, and in column D to fuel dried at 105 degrees C.

The analysis was made on the fuel as received and other results calculated therefrom.

It seems probable that the slopes of the Cape Breton Iron and Railway Company at Broughton are sunk on the continuation of this seam. The following section was furnished by Mr. D. J. Ferguson, taken 100 feet down the mine slope from the outcrop.

	Feet	Inches
Soft roof.		
Coal	..	9
Clay	..	1
Coal	3	9
Shale	..	1½
Coal	..	2
Shale	..	½
Coal	..	¾
Shale	..	1¼
Coal	..	4
Coal and *shale*	..	4
Clay	..	8
Hard pavement.		

A series of borings was drilled by the Dominion Coal Company in 1908 to prospect the section between Broughton and Birch Grove. In the most southerly boring, placed about three-quarters of a mile northeast of Broughton, three seams over 1 foot in thickness were recorded:

Seam..	1 ft. 10 in. at a depth of	215 feet.
Probably Coldbrook seam..	2 " 2 " "	405 "
" Tracy seam..	5 " ½ " "	638 "

No other seams are recorded as having been found between this point and the Morien basin where a calyx hole was drilled at No. 21 colliery and the following seams over 1 foot thick recorded:

No. 21 colliery seam	*Coal*..	1 ft. 8 in. at a depth of	100 feet.
	Shale	1 " 7 "	
	Coal	5 " 10 "	
	Dirty coal..	1 ft. 6 in. at a depth of	388 feet.
	Coal	3 " 6 " "	462 "
	"Dirty" coal..	4 " 0 " "	537 "

The 3-foot 6-inch seam is considered to be workable.

Coal at Maple Brook, Inverness County. Coal outcrops in the banks of a stream about one-quarter mile south of Maple Brook post-office at Hugh McEachren's house. The structure of the carboniferous in this district is shown by the geological map and report by Hugh Fletcher [1] to be a basin in which the coal occupies the central portion. At the point examined one seam has been exposed by stream erosion, the outcrop showing on either bank. Two tunnels have been driven on the northwest bank. Bright, laminated, brittle, bituminous coal to a depth of 1 foot 8 inches is underlain by 3 feet 6 inches of highly carbonaceous shale. There is a good roof of harder shale.

The dip at this point is from 3 to 5 degrees southwest, magnetic, suggesting that the centre of the basin lies farther south. Fletcher was of the opinion that the rocks overlying the coal in this basin do not exceed 200 feet in thickness. No estimate of the amount of coal available can be made without additional data regarding the geological structure.

The results of fuel tests are as follows:

Sample.	1		2		3	
Moisture condition (see note)	R	D	R	D	R	D
Proximate analysis :						
Moisture....	0·9	....	1·5	....	1·1	....
Ash....	48·9	49·3	73·0	74·1	46·6	47·1

Sample 1. Average of coal seam 1 foot 8 inches thick at face of a prospect tunnel 30 feet long on west bank of stream.

Sample 2. Average of carbonaceous shale 3 feet 6 inches thick underlying coal seam. Same locality as Sample 1.

Sample 3. Upper part of coal seam from pit 200 yards southwest of Sample 1 locality on east bank of stream.

NOTE.—Figures in column "R" refer to fuel as received, in column "D" to fuel dried at 105 degrees C. The analyses were made on the fuel as received and other results calculated therefrom.

The large percentage of ash found in these samples indicates that the coal, at the points sampled, is too lean for a commercial fuel.

PROSPECTIVE TUBE MILL PEBBLES.

Pebbles suitable for use in tube mills occur in beach deposits along the shore of Gabarus bay. Along the north shore they are derived directly from the volcanic rocks which form this rugged coast; and in several coves in the vicinity of Eagle head,

[1] Geol. Surv., Can., Rept. of Prog., 1870-80, p. 99F.

beaches thrown up well above high tide are composed entirely of rhyolite and similar types of rocks. At the head of the bay a barrier bar has been formed which contains a mixture of material, including the types mentioned above, with granite, syenite, quartz porphyry, quartzite, etc., derived from reworked glacial drift as well as from the local volcanic rocks.

K. A. Clark of the Mines Branch, Department of Mines, examined the samples and reports as follows:

" The pebbles were arranged in samples, selection in sizes being made where there was sufficient choice. The pebbles were then carefully washed with the aid of a scrubbing brush and thoroughly dried in a drying oven. The samples were each run twice in a Deval Abrasion machine for 10,000 revolutions at the rate of 33 revolutions per minute. The pebbles were carefully rewashed and dried and the loss in weight determined after each run. A supply of commercial flint tube mill pebbles was secured and treated in the same way.

" *Sample 1:* Four charges of flint pebbles used by the Ore Dressing plant, Mines Branch, for grinding ores. Pebbles were secured from a New York dealer. Pebbles varied in weight from 50 to 200 gms., the average weight being 100 gms.

" The pebbles were composed of a dark and a much lighter variety of flint. In the case of some of the dark pebbles, masses of a lighter coloured phase occurred and appeared to be more resistant in character since they stood out from the surface as slight protuberances. In an occasional pebble, small masses of a white, loose, chalk-like material were present. The pebbles were well rounded though with a tendency to be elongated. Some were flattened. The surfaces of most of the pebbles were pitted.

" *Sample 2:* Selected pebbles from north shore Gabarus bay, McIsaacs beach, east of Eagle head.

" Pebbles are composed of a blue-grey rhyolite of a very dense structure. Structural planes are present and are apparent on the surfaces as closely packed rings encircling the pebbles. These planes are scarcely discernible on a fractured surface. Other planes occur as individuals cutting the regular system at various angles. The surface of the pebbles is pitted along the lines where the planes cut the surface.

(a)	2	pebbles between	700	and	725	gms.
	1	pebble "	500	"	600	"
	2	pebbles "	400	"	500	"
	6	" "	300	"	400	"
(b)	7	pebbles between	300	and	400	gms.
	11	" "	200	"	300	"
(c)	10	pebbles between	200	and	300	gms.
	18	" "	100	"	200	"

" *Sample 3:* Selected pebbles from north shore Gabarus bay, McIsaacs beach, east of Eagle head.

(a)	6	pebbles between	500	and	600	gms.
	4	" "	400	"	500	"
(b)	16	pebbles between	300	and	400	gms.
(c)	20	pebbles between	200	and	300	gms.

" *Sample 4:* Average across beach north shore Gabarus bay, McIsaacs beach, east of Eagle head.

" This sample varied greatly in size and shape. While samples 2 and 3 consisted of well rounded and uniformly shaped pebbles, all of fair size, sample 4 contained many irregularly shaped pebbles and also many that were small, less than 100 gms. No attempt was made to sort them according to size. The three samples were weighed out from the pebbles as they chanced to come from the bag.

(a) Mostly fair sized pebbles (200 gms. and over).
(b) Contained more small pebbles than (a).
(c) Mostly small pebbles (less than 100 gms.).

" *Sample 5:* Selected pebbles, head of Gabarus bay, Lever beach, east end.

" The pebbles of this sample were heterogeneous in nature. So as to be able to detect any tendency of one type to be less resistant than another, each pebble was weighed separately at the start and after each run in the abrasion machine. The sample as a whole was also weighed. (Differences in the sum of individual weights and the aggregate weight are due to the use of a different scale for the two types of weighing.)

Results of Abrasion Tests on Selected Pebbles from Sample 5.

Type.	Weight. Original.	Weight. After first run.	Weight. After second run.	Per cent loss. First run.	Per cent loss. Second run.	Total.	Average per cent loss.
Syenite, pink, coarse-grained	206.20	204.70	204.10	0.24	0.29	0.53	0.53
Granite, " fine-grained	381.15	378.40	377.30	0.07	0.03	0.10	0.10
Quartz porphyry, pink, fine-grained	129.30	128.90	128.80	0.31	0.08	0.39	0.39
Rhyolite, grey joints, " "	288.65	288.40	288.20	0.09	0.07	0.16	
" " " few phenocrysts	354.80	354.60	354.55	0.06	0.01	0.07	
" purple grey, fine-grained	430.55	430.30	430.10	0.06	0.05	0.11	
" " " " "	290.00	289.70	289.60	0.10	0.04	0.14	
" green grey, " "	425.15	424.20	423.70	0.22	0.12	0.34	
" " " " "	311.80	311.10	310.90	0.22	0.07	0.29	
" " " " "	234.65	234.40	234.30	0.11	0.04	0.15	0.18
	3,052.25	3,044.90	3,041.55				

"*Sample 6:* Selected pebbles, head of Gabarus bay, Lever beach, east end centre. This sample was similar to No. 5, and was handled in the same way.

Results of Abrasion Tests on Selected Pebbles from Sample 6.

Type.	Weight. Original.	Weight. After first run.	Weight. After second run.	Per cent loss. First run.	Per cent loss. Second run.	Total.	Average per cent loss.
Quartzite, white	81.30	81.20	81.15	0.12	0.06	0.18	
"	164.00	163.20	162.85	0.50	0.21	0.71	
"	339.20	339.00	338.95	0.06	0.02	0.08	
"	384.10	383.60	383.50	0.13	0.03	0.16	
"	159.60	159.40	159.20	0.13	0.13	0.26	0.28
Quartz porphyry, pink, fine-grained	270.00	269.40	268.95	0.22	0.20	0.42	
" " "	268.00	267.70	267.00	0.11	0.26	0.37	
" " "	427.10	426.40	425.60	0.16	0.19	0.35	
" " coarse- "	165.80	164.80	164.35	0.60	0.27	0.87	
" green, fine- "	508.30	504.70	502.55	0.61	0.43	1.04	
" " medium-grained	340.70	339.60	338.90	0.32	0.20	0.52	0.60
Syenite porphyry, green, "	344.80	344.45	344.15	0.10	0.09	0.19	
" " "	375.80	375.40	375.00	0.11	0.11	0.22	
" pinkish green	209.50	209.20	209.15	0.14	0.02	0.16	0.19
Rhyolite, glassy green	257.70	257.70	257.60	0.00	0.04	0.04	0.04
Andesite, very fine-grained, few phenocrysts.	161.10	161.10	161.00	0.00	0.06	0.06	
" glassy, phenocrysts plentiful	135.40	135.40	135.25	0.00	0.10	0.10	0.08
Pyroclastic?	202.20	201.90	201.65	0.15	0.12	0.27	0.27
	4,794.60	4,784.15	4,776.80				

Results of Abrasion Tests on Samples of Ball Mill Pebbles.

Sample No.	Number of pebbles.	Average weight of pebbles.	Total weight.	Loss in weight in gms.			Per cent wear.		
				First run.	Second run.	Total.	First run.	Second run.	Total.
1 (a)........	55	93	5114	22	20	42	0.42	0.39	0.81
(b)........	52	95	4948	(4)*	24	....	....	0.49	
(c)........	53	96	5053	29	23	52	0.57	0.47	1.04
(d)........	56	90	5061	27	23	50	0.53	0.47	1.00
2 (a)........	11	470	5152	5	2	7	0.10	0.04	0.14
	18	280	5068	5	0	5	0.10	0.00	0.10
	28	180	5025	2	2	4	0.04	0.04	0.08
3 (a)........	10	440	4417	6	2	8	0.14	0.05	0.19
	16	320	5128	6	2	8	0.12	0.04	0.16
	20	250	4909	3	2	5	0.06	0.04	0.10
4 (a)........	....	....	5076	5	2	7	0.10	0.04	0.14
(b)........	....	....	5011	10	7	17	0.22	0.14	0.36
(c)........	....	....	4982	4	5	9	0.08	0.10	0.18
5..........	10	300	3055	6	2	8	0.20	0.07	0.27
6..........	18	270	4799	9	7	16	0.19	0.15	0.34

*Apparently a mistake.

"Considered from a common sense viewpoint it would be expected that the results of the test that has been applied to the pebbles for the loss of weight in the second abrasion run would be less than that from the first and that the former would be more uniform for samples of the same material, other factors being the same. In the first run, differences in the physical condition of the surfaces would cause variation, even where the material was exactly the same, and the development of the type of face which was most resistant to the new condition to which the pebbles have been subjected would naturally tend toward more rapid initial wear. It would also seem probable that the results of second runs would be a more accurate basis of comparison between samples than the first or the sum of the two wears. Experimental results have proved this to be true in the case of gravels.

"It is seen in the table on page 26, that in all cases but two the loss in weight in the second run is less than in the first. The first exception is evidently the result of a mistake. The difference is not very marked in the case of the flint pebbles, as is to be expected, since they had already been subjected to the abrasion action in a tube mill for ore grinding. The second run gives a very uniform result for all cases in samples 2 and 3. These samples were composed of pebbles not only of the same material but of the same shape and were free from surface defects. The uniform result is what would be expected. In saying this, however, it must be assumed that the size of the pebbles has no marked effect on the result of the abrasion test. This is not an unreasonable assumption, however, since the tendency to increased wear due to the increased number of impacts between pebbles, where the number of pebbles making a charge is increased, is counteracted by the decreased weight of each pebble and the decreased force with which the impacts are made. Direct experimental data in the case of the abrasion test for stone supports this view. The results of the second run for sample 4 are less than those for the first run, but are not more uniform. This was a very non-uniform sample, however, as regarded the shape and the surface conditions of the pebbles.

"From the results shown in the table on page 26 it appears that in regard to resistance to abrasion, all the samples of pebbles are better than the commercial flint pebbles with which they were compared. The pebbles of sample 2 and sample 3 are particularly good. Results on sample 4 show that without any culling out of poor shaped material, the pebbles from the beach from which samples 2, 3, and 4 were taken would make a satisfactory product for tube mill grinding. Samples 5 and 6 contain no constituents with as high a wear as the commercial flint pebbles. These comparisons assume that the much smaller average size of the flint pebbles does not enter as an interfering factor. This assumption has been already discussed and seems justifiable."

No survey was made to carefully estimate the tonnage available from these deposits, but a rough approximation indicates that several thousand tons similar to sample 4 could be easily loaded on a vessel, and many thousand tons could be sorted from Lever beach and loaded by means of small boats, as the water is shallow in the vicinity of this bar. It is probable that other beaches not examined by the writer contain workable amounts of similar pebbles.

MANGANESE.

Loch Lomond, Cape Breton County. Crystalline and massive forms of the oxide of manganese occur on the Morrison and McCuish farms about 3 miles east of Enon, northeast of the northern part of Loch Lomond in Richmond county, Cape Breton. The deposits have been described by Fletcher[1] and Penrose[2]. One hundred and twenty-nine tons are stated to have been shipped in the years 1881-82, and the total production up to 1890 is said to have been 300 tons, mostly shipped to Boston. This early work was done by the Hon. E. J. Moseley of Sydney. The ore was sufficiently high grade to be used in the manufacture of bleaching powder and glass.

About the year 1915 a shaft was sunk by the Dominion Steel Corporation, on the Morrison farm, and in 1916 Mr. C. V. Wetmore of Sydney obtained a few tons of ore from an open-cut on the McCuish farm.

The ore in both crystalline and massive forms occurs in interbedded limestone, shale, and conglomerate of Lower Carboniferous age, and outcrops a few hundred feet from an unconformable overlap with underlying igneous rocks.

On account of the overburden of boulder clay and gravel, few exposures of bedrock were visible.

The minerals occur in masses, evidently replacing the limestone, the original structure of which is destroyed although there is a tendency on the part of the manganese oxide to replace along bedding planes and some pseudomorphic retention of the laminated limestone form occurs. The shape of the masses is irregular and they vary in size. There is a tendency for the ore to follow along the bedding planes in masses, a few inches in thickness.

Several hundred feet of trenching has been done on the Morrison farm. Mr. Morrison stated that in the bottom of the shaft sunk there, a bedded deposit was found at a depth of about 20 feet, the ore being about 3 inches in thickness. He also said that a drift had been run from the bottom of the shaft and the ore had not been removed.

The overburden varies in thickness from about 3 to 10 feet, with occasional outcrops of bedrock. The limestone, a laminated nodular variety apparently of algal origin in part at least, is interbedded with an agglomerate holding very angular fragments largely of quartz porphyry. No evidence of igneous activity in the form of dykes cutting the Carboniferous limestone measures was found, and the immediate source of the manganese is not known. The mineralization appears to be fairly widespread.

Detailed study of the local geology, combined with systematic prospecting, might result in locating deposits of ore.

New Ross, Lunenburg. The manganese ore-bodies in the New Ross district occur in fissures in a coarse biotite granite of Devonian age. Manganiferous calcite was first deposited in fault fissures and later brecciated by earth movements along the same

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[1] Fletcher, Hugh, Geol. Surv., Can., Rept. of Prog., 1882-3-4, pp. 92-93H.

[2] Penrose, R. A. F., Jr., Ann. Rept. Arkansas Geol. Surv., 1890, vol. I, pp. 527-529.

lines of weakness. Solution of the manganiferous calcite and deposition of pyrolusite and manganite by percolating surface water followed and it is thought that the ore-bodies may have been developed by this process of secondary enrichment. The ore occurs in lens-shaped chutes which have a tendency to be localized and limited in depth to a few hundred feet.

Pembroke, Hants County. A pyrolusite-bearing sandstone occurs 2 miles south of Pembroke, in Hants county. Recent development work has indicated that the low grade ore-body has a considerable tonnage and working samples treated in the ore dressing laboratory of the Mines Branch, gave suitable concentrates for the manufacture of ferromanganese.

MOLYBDENITE.

North Shore Gabarus Bay, Cape Breton County. Molybdenite occurs in numerous thin quartz veins or pegmatite dykes associated with granite, which have intruded volcanic rocks exposed intermittently from Deep cove to Seal cove in the vicinity of Eagle head. A mantle of boulder clay covers the bedrock except where wave action has bared the cliffs for a distance of about 50 feet inland, and in portions of stream beds. The occurrence has been known for at least fifty years and is mentioned by How,[1] Fletcher,[2] Johnston,[3] and Walker.[4]

The molybdenite-bearing veins have cut both the granite and volcanic rocks, and in one instance a section of a half inch dyke of pink feldspar, quartz, and molybdenite is exposed at the contact of a granite dyke, where it is clearly shown to have cut across granite and volcanics. It seems probable that the granite, quartz porphyry, and molybdenite-bearing rocks are genetically related, the latter resulting as a later phase of the plutonic intrusion.

Along the coast immediately east of Deep cove the quartz veins lie in a number of intersecting planes, whereas farther east, towards Eagle head, practically all of the veins are roughly parallel and strike north and south and dip about 25 degrees to the west across the bedding of the volcanic rocks. About 600 yards north of the shore, on the brook which debouches immediately east of D. J. McKay's house, the molybdenite is found in similar pegmatite dykes which have cut an acid granite porphyry. The granite is in the form of a dyke or small mass. It is probable that the mineralized zone extends from the shore northwards to this point at least.

Where the molybdenite-bearing dykes dip regularly to the westward, a roughly approximate estimate may be made of the amount of molybdenite present, and the quantity of rock to be removed to recover it. At a point about half-way between Deep cove and Eagle head the dykes are about 3 feet apart, and might be considered to each contain enough molybdenite to equal a film one-sixteenth inch in thickness. That is about 40 to 50 feet thickness of rock would have to be quarried to obtain an inch thickness of molybdenite. The average would not be as high as this, as in many places the molybdenite occurs in thinner films or smaller masses in the dykes, which, in turn, are separated by greater intervals of country rock. In the vicinity of Deep cove, where intersecting dykes occur, and at one point east of Eagle head, the average may be higher; but the deposit does not appear to be of commercial value.

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1 How, H., Mineralogy of Nova Scotia, Halifax, 1869, p. 61.

2 Fletcher, Hugh, Geol. Surv., Can., 1877-78, p. 29F; 1875-76, p. 416.

3 Johnston, R. A. A., Geol. Surv., Can., "Molydenum and tungsten," Bull. No. 872, p. 8.

4 Walker, T. L., Mines Branch, Dept. of Mines, "Molybdenum ores of Canada," p. 20

A hand-cobbed sample, representing about one week's work for three men under the direction of a capable miner, was shipped to the Mines Branch and concentrated under the direction of Geo. C. MacKenzie for the Canadian Munitions Resources Commission. The results are given below:

Selected ore, contained	2·49% MoS_2, 0·026% copper.	
Net weight of dry ore, 3,474 lbs., contained	86·5026 lbs. MoS_2 of which 87% recovered.	
Total yield at $1 per lb.		$75.26
Less concentration charges (mining, shipping, and haulage charges not deducted)		9.81
Net value in Ottawa		$65.45

Glengarry Valley, Cape Breton County. Molybdenite occurs in pink granite exposed in the bed of a small stream flowing southwards on the Murdock McKinnon farm, about 4 miles southeast of Big Pond post-office in Cape Breton county. The granite is exposed about 100 yards upstream, to the north of the road, in the form of dykes which dip steeply northwards, having invaded a fine-grained, green, somewhat schistose rock, apparently of volcanic origin. Three dykes, each less than 10 feet thick, lie in a zone of 100 feet along the stream valley and above these granite about 60 feet thick occurs. The contacts with the green schist are well shown and indicate either a dyke of variable width or a small mass elongated in an east-west direction. The granite has the appearance of a fine-grained pegmatite and is probably genetically associated with a large mass of plutonic rock forming the highland to the north of Glengarry valley. It is shattered and its brittle nature causes it to break into small fragments.

Scattered, individual crystals of molybdenite, frequently associated with iron pyrite, may be found by careful searching throughout the granite, but occur most abundantly in a zone about 2 feet wide paralleling the southern contact.

Although practically no development work has been done on the property, the stream has eroded a steep-sided valley about 50 feet deep and exposed the rock section to view. No ore-body of commercial value is exposed. The occurrence is referred to in the following publications: Fletcher, H., Geol. Surv., Can., Rept. of Prog., 1876-77, p. 452; Johnston, R.A.A., Geol. Surv., Can., "Bulletin on molybdenum and tungsten," 1904, p. 8; Walker, T.L., Mines Branch, "Report on molybdenum ores of Canada," 1911, p. 21.

IRON ORE.

Grand Mira, Cape Breton County. Several beds of hematite and magnetite occur interbedded with slates and quartzites belonging to the Cambro-Ordovician group of sediments. They extend from John Gillis' farm at Grand Mira north-northeastward. Prospecting by a number of shallow shafts, test pits, and open-cuts was carried on by the Nova Scotia Steel and Coal Company some years ago and more recently by the Dominion Iron and Steel Company which also in 1917 did about 1,000 feet of trenching at a point about 1½ miles northeast and to the north of the French road. The writer examined these exposures. Unfortunately the overburden was heavy at the latter locality. One bed of magnetite 4½ inches thick was found in place and four beds 7, 10, 14, and 18 inches thick, respectively, have since been reported. The thickest bed found at the Grand Mira locality is 1 foot 7 inches of oolitic hematite. This, with several thinner beds of hematite and magnetite, lies in an open synclinal fold, cut off on the east by the intrusive granite of the White Granite hills.

A magnetometric map was prepared by A. H. A. Robinson and a report published by E. Lindeman in the Mines Branch Summary Report, 1913, in which the statement is made that the magnetite is of the same origin as the hematite, that is, vein fillings or incomplete replacements of the stratified rocks by iron oxides. The writer is of the opinion that the ferruginous beds are metamorphosed primary sediments. Similar ferruginous horizons occur on the farm of Donald McKeigan about 1½ miles south of

Marion bridge, 7 miles north-northeast of the Grand Mira locality. At both localities the ferruginous beds, as well as the accompanying sediments, are fossiliferous. The hematite is frequently oolitic like the Wabana iron ore and the ferruginous beds follow a definite stratigraphical horizon and conform to the structure of the accompanying sediments which lie in open folds. Microscopical examination of thin sections shows the ferruginous bands to contain detrital quartz and shell fragments and confirms the writer's opinion that they are of sedimentary origin. The hematite has been metamorphosed in part to magnetite by igneous intrusion.

As yet a comparatively small section of the Cambro-Ordovician sediments has been carefully studied. In the similar Wabana deposits, ferruginous horizons with thin beds of hematite recur through about 2,000 feet thickness of strata in which there are only three workable beds. Careful stratigraphical comparisons between the Cape Breton and Newfoundland Cambro-Ordovician groups should be made before concluding that ferruginous beds of workable thickness are absent.

ZINC-COPPER-LEAD DEPOSIT.

Stirling, Richmond County. A description of the Stirling zinc-copper-lead deposit is given in the summary report for 1916 by the late D. D. Cairnes.

Development work was continued by the Stirling Exploration Company from January until June and included surface trenching and 2,071 feet of diamond drilling, five holes having been placed so as to cross the ore-body at depths of about 200 feet. The results of the drilling indicated that the high grade ore chutes found on the surface are of comparatively shallow extent and grade into a low grade complex ore carrying a large amount of iron pyrite with low values in zinc, lead, and copper. No ore was found in the southern boring which was stopped at 290 feet.

The Stirling Exploration Company concluded that there was not sufficient high grade ore to make the business attractive and the low grade ore, in view of its complex nature, was not thought to be of commercial value at present.

With regard to the probable presence of additional high grade ore either in depth or along the line of strike of the known ore-body, there are not sufficient data on which to base a definite opinion. The source of the ore may have been from deep-seated igneous rocks and the sulphides supplied either from below or laterally, or in both ways, and though it is possible that other ore-bodies exist at greater depth in the vicinity of the present workings, and in other portions of the schistose series, nothing was seen in the area examined from which a favourable or unfavourable opinion in regard to this could be deduced.

DUNBRACK ARGENTIFEROUS GALENA PROSPECT.

In the southern portion of a granite batholith which lies between Musquodoboit Harbour and Meaghers Grant in Halifax county, a fissure vein occurs, carrying argentiferous galena and other metallic and non-metallic minerals. The vein crosses the post road about 3 miles northwest of Musquodoboit Harbour village immediately west of South Meadow lake.

The discovery of galena in this locality was made by Mr. John Kerr in November, 1888, but the early development was due to the initiative of Mr. James C. Dunbrack. In 1910, a shaft was sunk to a depth of 75 feet through 15 feet of glacial drift and 60 feet of vein rock and a tunnel was driven 375 feet southeastward. A second shaft was also sunk at a point 600 feet southeast of the first, to a depth of 40 feet, 20 feet being in solid vein rock. The development work was found to be too expensive and was discontinued.

In 1916, Mr. Robert Ewing of New Orleans, La., took over the property and initiated the development now in progress, securing the services of Mr. M. G. Haverfield as engineer. Mr. Haverfield unwatered the northwest shaft and workings, sampled the tunnel, and kindly supplied the results of the analyses and assays.

Analyses of Samples Taken from Tunnel Southeast from Northwest Shaft.

Distance from northwest shaft.	Width of vein.	Pb	Au	Ag
Feet.			\$ cts.	Oz.
14	2 ft. 6 in.	1·5	1·40	Trace.
54	2 ft. 6 in.	1·8	1 60	Trace.
134	1 ft. 6 in.	4·4[1]	1.60	0·40
225	2 ft.	14·0[2]	2.40	1·00
287	2 ft. 6 in.	2·0	3.20	0·40
342	1 ft. 6 in.	1·3	2.40	0·50

1 This chute extended for about 10 feet along vein.

2 This chute extended for about 10 feet along vein.

Assays and analyses made by assayer of Tough Oaks Gold Mines, Kirkland Lake, Ont., aided by W. F. John, mill superintendent, and M. G. Haverfield, November, 1916.

There is evidently no workable ore developed in these workings, as the better grade chutes are small and far apart and the average value too small to pay.

The shafts sunk in 1910 were made 6 by 14 feet, but Mr. Haverfield deepened the southeastern shaft as a prospecting shaft 5 by 12 feet, giving room for raising ore by means of a steel tub and plank skidway and for a compartment for a ladderway. This shaft was sunk to a depth of 110 feet and prospecting tunnels driven 100 feet each way from the shaft along the vein from the 95-foot level. Fortunately this shaft was sunk on an ore chute which was found to be 76 feet in lateral extent along the vein 26 feet northwest and 50 feet southeast of the shaft. The highest grade ore appears to be along 40 feet of the southeasterly portion. The vein varies in width from 2 feet to 4 feet, averaging 2 feet 6 inches, the strike is north 47 degrees west magnetic, and dip 70 degrees northeast.

At the time of the writer's visit to the property on April 30, 1917, this shaft was sunk to a depth of 105 feet and two groove samples were taken across the vein at the bottom of the shaft. The results of the analyses are as follows:

Analyses of Groove Samples from Southeastern Shaft.

—	1	2	3
Lead	22·39%	1·25%	16·22%
Silver	2·36 ozs. to ton.	2·48 ozs. to ton.	1·40 ozs. to ton.
Gold	None.	None.	None.
Copper	0·50%	1·21%	0·70%
Bismuth	None.	None.	None.
Zinc	0·64%	0·30%	2·90%
Manganese	Trace.	Trace.	Trace.

1. Average sample across southeast face, bottom southeast shaft at 105-foot depth, 21 feet drift and 84 feet vein.
2. Average sample across northwest face, bottom southeast shaft at 105-foot depth.
3. Grab sample from picked ore from lower part of south shaft taken from shaft house.

The galena occurs in a true fissure vein averaging 2 feet 6 inches wide, dip 70 degrees northeast, which occupies a plane of weakness in the granite along which a series of movements took place. The assemblage of minerals, including large crystals of quartz and feldspar, suggests that the fissure was first filled by a pegmatite dyke. The brecciated character of the assemblage indicates that movement took place along the dyke and in the resulting fissure silica in the form of agate and opalescent silica was deposited, recementing the brecciated material. Further fracturing of the vein followed, with the introduction of the metallic minerals. Cross fractures in the siliceous vein rock may have given rise to a layered character of the metallic minerals which cross the ore chute with flatter dip than that of the vein.

The source of the metallic sulphides was probably deep-seated and if this is so it would indicate persistence in depth and a probable increase in lateral extent along the vein.

A conservative estimate of the ore blocked out and ready to stope is 600 tons of 20 per cent lead ore, or 240,000 pounds of lead. Sinking costs totalled about $50 per foot, and if the ore continues in depth as it promises a further 400,000 pounds of lead would be developed by sinking an additional 100 feet.

There is a 3 mile haul by good wagon road to the Canadian Government railway at Musquodoboit Harbour. The plant consists of a boiler house and shaft house, 1 Leonard boiler 60-horsepower, 1 House 40-horsepower, 1 Blake pump, 1 McKierven and Terry piston drill, ore cars, and other accessories.

Satisfactory labour may be obtained locally.

FELDSPAR AND MICA.

Seven Miles West of Neils Harbour, Victoria County. Feldspar and mica have been known for many years to occur in considerable quantity in the reddish granite in the vicinity of Neils Harbour, and several test pits have been sunk at Mica hill, 7 miles west of Neils Harbour and about 1 mile north of the head of Half-way brook. Biotite-muscovite granite, locally garnetiferous, was found to extend all the way from Neils Harbour to Mica hill. A pegmatite phase of the granite occurs at Mica hill, in which a zone of banded white and pinkish quartz about 50 feet wide is bordered on either side by pink feldspar holding muscovite mica in large crystals. The feldspar zones are about 25 feet wide and the mica occurs in largest amounts at the contact of the quartz and feldspar. Occasional books of clear mica occur limited in size by interfering crystal growths and crumpling, but the average crystals are accompanied by a dark-coloured mineral, probably iron oxide. This granite is mapped by Fletcher[1] as Pre-Cambrian and the "mica mine" is mentioned as if well-known at that date.

Similar granite is described by W. J. Wright[2] from Clyburn brook. This was named the Franey granite and found to be of pre-Carboniferous age and thought to be Palæozoic. Further prospecting should be encouraged in this promising district.

The main use of feldspar is in the ceramic arts.[3] Orthoclase feldspar is also a possible source of potash and successful experiments have been carried out in extracting this important material.[4]

The quartz accompanying the feldspar which occurs in amount large enough to quarry extensively, is of interest in view of the increasing need for pure quartz in the manufacture of ferrosilicon and fused quartz laboratory utensils.

The elevation of Mica hill was found by aneroid to be about 900 feet above sea-level, reached by a gradual rise from sea-level, over which a wagon road could be built to connect with tide water at Neils Harbour.

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1 Fletcher, Hugh, Geol. Surv., Can., Rept. of Prog., 1882-83-84, p. 18H.

2 Wright, W. J., "Geology of Clyburn valley," Geol. Surv., Can., Sum. Rept., 1913, pp. 270-283.

3 See report on the non-metallic minerals used in Canadian manufacturing industries, by Howells Frechette, Mines Branch, Dept. of Mines, 1914.

4 Summary in Eng. and Min. Jour., Feb. 23, 1918, p. 382.

Ashcroft, E. A., Inst. Min. and Metal., Bulls. 159 and 160.

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