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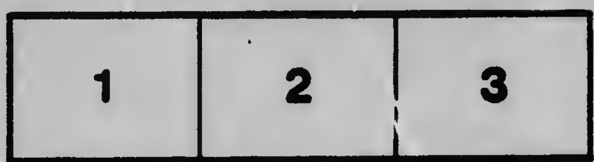
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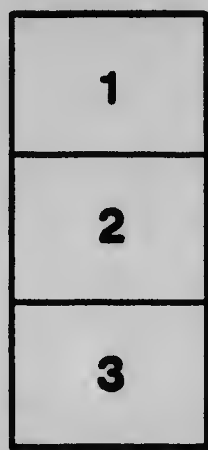
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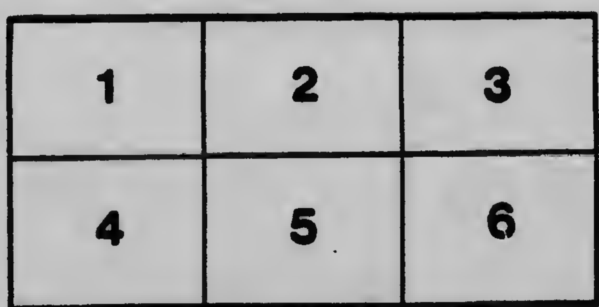
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DEPARTMENT OF MINES
Hon. Martin Burrell, Minister; R. G. McConnell, Deputy Minister.

GEOLOGICAL SURVEY
William McInnes, Directing Geologist.

MEMOIR 115

No. 97, Geological Series

Geology of Matachewan District, Northern Ontario

BY

H. C. Cooke

OTTAWA
J. de LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1919

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INTRODUCTION.

ECONOMIC HISTORY.

Matachewan district received its name from the old Hudson's Bay Company's trading post, Fort Matachewan, a place of some historical interest. The district has sprung into prominence in the last two years through the discovery in it of bodies of valuable gold ores.

Some prospecting for gold was being done in Matachewan district as early as 1909, but at that time the discoveries of silver around Gowganda and Elk Lake had so focused the attention of prospectors on silver that the possibilities of gold occurrences were overlooked by the great majority, and as Matachewan district contains none of the large sills of Nipissing diabase which had become known as the source of the silver ores, the district received very little attention. Two or three years later, after the discovery of gold in Porcupine, a gold claim was taken up by Mr. H. Minard near the forks of Montreal river, and a considerable amount of development work was done; apparently, however, without finding workable bodies of ore, as the project was discontinued some years ago and has not since been resumed. Much staking was also done in the western parts of Midlothian and Montrose townships by prospectors entering the country from Porcupine by way of Grassy river, and the remains of their work still visible show that in some cases at least the claims were carefully examined. All of these claims, however, have been abandoned for several years.

The recent discoveries in Powell township were made in 1916 by J. Davidson and S. Otisse. The report of the finds was followed by a rush of prospectors into the new field, and within a short time most of Powell township between the forks of Montreal river and the west branch had been staked. Prospectors failing to locate near the original discoveries carried on exploration mainly to the east and north, and during the summers of 1917–18, a large number of claims were recorded in Cairo, Alma, and Baden townships. Discoveries of gold have been made on many of these claims, but so far as available information goes, no large bodies of ore have yet been found. Prospecting has been greatly hampered, however, by lack of labour, due to enlistment and the demands of the munitions industry. The Ontario government, recognizing this, has generally granted extensions of the time limits normally allowed for doing the assessment work necessary to hold claims.

LOCATION AND AREA.

Matachewan area lies in the district of Timiskaming, in the neighbourhood of north latitude 48 degrees, west longitude 81 degrees, and about 35 miles northwest of the town of Elk Lake. It is bounded on the west by Niven's base-line, the boundary between the former districts of Nipissing and Algoma, and on the south by the northern boundary of the Gowganda area mapped in 1908–10 by W. H. Collins of the Geological Survey. It includes about 430 square miles, most of which lies west of Montreal river.

HISTORY OF EXPLORATION.

The earliest important explorations in the district were made by Duncan Sinclair and A. G. Forrest in 1866–7, under instructions from the provincial government. Sinclair ran a chain and transit line from Montreal river, below the forks, for 105 miles westward, through the southern parts of what are now Powell, Bannockburn, and Montrose townships. The exploration was made to locate a suitable colonization road to the west. Forrest made a survey of Montreal river. Thirty years later, in 1897, Alexander Niven surveyed the boundary between Algoma and Nipissing districts. His work served as a base-line from which township lines were run east and west. The last of these was run in 1910, so that the country is now completely subdivided, affording good control for surveys of the lakes and streams. Some additional information was added in 1911 by a trial line of the Timiskaming and Northern Ontario railway, which was run from Gowganda to Porcupine and passed through Doon, Midlothian, and Montrose townships.

Geological investigation of the district was of an exploratory nature only until 1917. In 1875, Robert Bell[1] in the course of an extensive reconnaissance traversed most of the Montreal River waters, taking notes of the rocks seen on the way. In 1897, E. M. Burwash, who was attached to Niven's party as geologist, examined the geology along the district line, and along Sinclair's line from its intersection with Niven's line some 5 miles east, to Mt. Sinclair[2]. In 1911, J. G. McMillan, geologist with the party surveying the Timiskaming and Northern Ontario trial line, mapped parts of Doon, Midlothian, and Montrose townships.[3]

In 1917, A. G. Burrows, under instructions from the Ontario Bureau of Mines, examined the four townships of Cairo, Powell, Alma, and Baden. His work was detailed and included the mapping of the smaller lakes and streams with the micrometer and prismatic compass, and the locating of the various geologic boundaries. His results have been published in the 27th report of the Ontario Bureau of Mines.

The writer's work, which has occupied the summers of 1917–8, has completed the topographic and geologic mapping of the northern halves of Kimberley, Yarrow, Doon, and Midlothian townships; the western half of Powell township; Bannockburn, Argyle, Montrose, and Hincks townships; and the southern halves of Cleaver and McNeil townships. The southern boundary of the district examined thus coincides with the northern boundary of the detailed map of the Gowganda area, completed in 1911 by W. H. Collins. The outlines of the geographical knowledge afforded by the surveys of the township lines and other early surveys have been filled in by micrometer and prismatic compass surveys of the routes of travel. Lakes and ponds not on direct routes were located by rapid chain or pace and compass traverses from known points, and sketched with the aid of a Brunton compass. A thorough examination was made of all rock exposures on the shores of the lakes and streams, and the geological nature of the intervening country was determined by chain or pace and compass traverses spaced about a half-mile apart.

[1] Geol. Surv., Can., Rept. of Prog., 1875–6, pp. 299–302.
[2] Burwash, E. M., Ann. Rept. Bureau of Mines, Ont., 1896.
[3] McMillan, J. G., "Geology of the area along the Timiskaming and Northern Ontario Railway trial line between Gowganda and Porcupine." Toronto, 1912.

In addition to the areal mapping, some time was given both in 1917 and 1918 to a detailed study of the gold-bearing deposits of Powell township, the geology of which had previously been done by Burrows.

The writer was assisted in 1917 by D. J. Fisher and H. A. Barnett and in 1918 by W. W. Boyer.

GENERAL CHARACTER OF THE DISTRICT.

MEANS OF ACCESS.

The shortest and most convenient route to Matachewan district starts at Elk Lake, the terminus of a short branch of the Timiskaming and Northern Ontario railway. From this village, situated on Montreal river, a line of motor launches makes daily trips up the river for 30 miles to the mines in Powell township. The trip may also be made in canoes, but the rapid current throughout the greater part of the distance makes the ascent toilsome. The launch trip is broken in two places; at Indian chute, where there is a 23-foot fall passed by a portage about 10 chains in length; and at the so-called Long rapid, really a series of flat rapids separated by stretches of dead water, passed by a portage road about 3 miles long. A wagon and team for hauling freight is now placed on each of these portages, as well as on the mile of road between the river and the mines.

A good alternative canoe route to the mines is the route from Long Point lake. From Elk Lake it is 13 miles by stage or wagon along the Elk Lake-Gowganda road to Long Point lake. After a trip of 11 miles down this lake and the creek which empties it, three short portages lead to West lake on the east branch of Montreal river, from which it is a rapid and easy trip downstream to the forks of the Montreal, about a mile south of the mines.

TOPOGRAPHY.

In its general aspect the country exhibits the monotonous succession of low rocky hills and lake-containing depressions characteristic of the Pre-Cambrian shield. Seen from the summit of any large hill the horizon line appears almost perfectly even, broken here and there by a prominence of unusual height. The relief in general is low, especially so in the northern part of the area under discussion, where a hill 100 feet in height is a rarity. The maximum relief, found only within areas of the Cobalt series, is about 500 feet. An elevation of this height is conspicuous and visible for long distances. Rocks not belonging to the Cobalt series rarely form hills over 100 to 200 feet in height.

The topographic forms fall into two main classes: those of pre-Glacial age, resulting from differential erosion, and dependent, therefore, on the kind of rock affected and its structure; and those of glacial origin, independent of the nature and structure of the underlying rock.

Among the topographic forms of the first class the most prominent are those resulting from the erosion of the folded Cobalt series. The rocks of this series have been gently folded along north-south axes; the erosional forces acting on the folded rocks have scooped out valleys along the anticlines, and the synclinal portions, less jointed and broken, and, therefore, more resistant to erosion, stand up as ridges. The areas underlain by Cobalt series are thus characterized by a predominance of valleys and ridges running north and south. The most striking ridge, whose origin is also in part due to faulting, has its south end in Midlothian township near the eastern boundary. It is broken by a depression occupied by a branch of Duncan creek near the northern boundary of the township, but rises again in southern Montrose into mount Sinclair, the most prominent hill of the district, 400 feet above the general level and 1,600 feet above sea-level. The ridge continues in a direction slightly west of north through Montrose and Hincks townships. It is notched again in the middle of Hincks township by a transverse valley followed by a branch of Nighthawk creek. Beyond, it rises once more and continues as a strong ridge through Cleaver township past the northern edge of the area examined. Another prominent synclinal ridge is that locally known as Bull or Moose mountain, in the centre of Bannockburn township. Minor examples are numerous.

The influence of the structure of the Cobalt series on the topography also extends beyond the boundaries of the areas underlain by it. The principal valleys and watercourses in the older rocks also have a general north and south trend, whereas the structure axes of the rocks cross this direction at various angles. It seems clear, therefore, that the valleys must have been established when the Cobalt series overlay the whole country, and that they were superimposed on the underlying rocks regardless of their structure when the Cobalt series was removed by erosion. Austen lake, in Hincks township, occupies a part of one such valley which extends south from the head of the lake for several miles and is occupied in the middle of Montrose township by the north-flowing section of the creek from Seven Inch lake. Another valley of this type lies about a mile farther east, extending north for 2 or 3 miles from Seven Inch lake. In the opposite direction it extends south up Midlothian creek, through Midlothian lake, and across into Lloyd lake, of which it forms the main north-south part. Here it passes into the Cobalt series, but still may be traced southward from Lloyd lake for several miles and through at least two other lakes. Similar cases, equally clear if not so striking, are common throughout the area.

Although superimposed forms are the most prominent in the parts of the area underlain by rocks older than the Cobalt series, the processes of structural adjustment are at work producing new forms and in places their operation has produced quite noticeable modifications. The main axis of Austen lake, Hincks township, is a superimposed valley, but deep bays run off in a southeasterly direction, along to the strike of the bedding of the lava flows. The main body of Midlothian lake parallels the bedding of the Kiask sediments in which it lies. Further instances of adjustment to structure may be observed here and there, where the older rocks stand high and are little covered with drift. In general, however, the average relief is low, and most minor preglacially developed features are now masked by drift.

Valleys resulting from erosion along zones of faulting also fall into the class under consideration. There are several of these in the district. One of them is the valley of Mistinikon lake, also described by Collins.[1] This fault may be seen on the west shore of Mistinikon lake at the narrows a

[1] Geol. Surv., Can., Mem. 33, p. 16.

short distance to the north of Bell island. A second example is the valley of Fault lake, Midlothian township. The narrow lake occupies a part of the valley developed on a fault block. The valley is a narrow, steep-walled depression that may be traced north for about half a mile, and south for about the same distance. A southward projection of the line of the valley passes into a steep-walled valley that extends north from the northwest bay of Lloyd lake, so that the two probably are parts of one fault.

Other fault valleys cut across the structure of the Cobalt series. Among these may be instanced the deep valley in Yarrow township south of the 92-chain portage. The fault may be seen on Mistinikon lake and strikes away from the lake in a direction slightly north of east, passing through the narrow steep-walled lake at the east end of the 92-chain portage. Its extension farther eastward is not known.

A prominent valley has developed in Montrose township along another fault of this type. The valley is occupied in part by the east-west part of the creek from Seven Inch lake. The fault is supposed to continue westward through the northern end of Hutt lake, where the rocks have been highly sheared.

The second main class of topographic forms, those resulting not from erosion of the bedrocks but from the varying arrangement of the glacial drift, are of considerable importance outside of the limits of the Huronian areas. The forms are, of course, of as many kinds as there are types of drift, and will be discussed at more length under that head. At this point only two features will be mentioned, lakes and plains.

The lakes in the drift include most of the smaller lakes of the district. Those in Argyle and in the western part of Bannockburn and Doon townships are typical. The map shows their characteristically irregular shapes, which may be described as a series of expansions, with little uniformity in position or arrangement, connected by narrow, usually shallow, necks.

The other main topographic feature resulting from glacial action is the plain. Plains are common within the area under discussion. They are of two types, the first the slightly rolling sand plain formed by outwash from a temporary ice front, diversified by occasional kettle holes, eskers, and rock ridges, the second of somewhat later origin and formed by the silting up of glacial or post-glacial lakes. Plains of the first type are to be found in the northwest part of Montrose township, in southeastern Cleaver and the southern half of McNeil, and in the eastern part of Argyle, and smaller areas are numerous. The second type is much less common, and the resulting plains are usually small. One large plain of this type is to be found in the northwestern part of Argyle township, extending some distance across the western boundary into Hincks. Such plains very frequently have residual parts of the former lake still existing at their centres. Several small areas of this kind are to be found in southwestern Cleaver. The outwash plains of the first type are frequently dry, and then are characterized by little vegetation except the banksian pine, commonly known as jack pine. Wetter, low-lying parts have, however, become covered with a growth of sphagnum moss and now form flat muskegs often of large extent. Plains of the second type are almost invariably wet and covered with muskeg or swamp growth.

DRAINAGE.

Two distinct types of streams are found in Matachewan area, corresponding to the thickness of the drift cover. Where the drift is thin, the watercourses are simply a series of currentless expansions, varying in size from good sized lakes to deep, sluggish creeks. The currentless parts are separated from each other by barriers of rock or boulders, over which the water finds its way in rapids or falls. This type is found mainly in the western part of Midlothian, Montrose, and Hincks townships. Where the drift is thicker, so that streams have not eroded to bedrock, the water courses are well graded, meandering channels of fairly uniform width, lakes are absent except at the headwaters where the streams are too small to have eroded the drift below the level of the lake bottom. Rapids and falls are also absent, except where ridges of rock cross the streams or large boulders have accumulated. Duncan, Whitefish, and Nighthawk creeks, with their various branches, which drain the major part of the district west of Montreal river, are all of this type.

The townships situated between the west branch of Montreal river and Niven's base-line are not drained by any one large stream, but are the gathering ground of a number of streams. The Height of Land passes through this area, in a northeasterly direction, through the eastern part of Midlothian, across the southeast corner of Montrose, the northwest corner of Bannockburn, and the southeast corner of Argyle. The territory to the southeast of the Height of Land is all drained by creeks tributary to Montreal river. The principal of these is Duncan creek, draining the greater part of Doon and Bannockburn townships, the northwestern corner of Midlothian, and the adjacent part of Montrose. It empties into the head of Duncan lake. Another good-sized creek is Powell creek, which empties into Montreal river near the north end of Powell township. It drains the northeastern part of Bannockburn and the southeastern part of Argyle, and forms the best route for entering the district from Montreal river.

The part of Matachewan district northwest of the Height of Land is broken by a secondary divide which runs in a direction slightly north of west across the northern part of Montrose township. The streams to the north of this divide drain to Hudson bay through Nighthawk river, one of the main tributaries of the Moose. They include the various branches of Whitefish and Nighthawk creeks, which run north in practically parallel courses 6 to 8 miles apart, as far as Nighthawk lake, into which both discharge. To the south of the divide the creeks drain to the west into Grassy river, reaching Hudson bay through Mattagami and Moose rivers. There are two main creeks also in this part. The one rises in Midlothian lake, flows northwest to Moose lake, and west to Grassy river. The other, of about equal size, rises in Lloyd lake and flows southwest to the Grassy.

At the foot of mount Sinclair lies Sinclair lake, one of those bodies of water peculiar to glaciated regions, in that it possesses more than one outlet. This lake lies directly on the Height of Land, and has three outlets, one to Whitefish creek, the waters of which eventually reach Hudson bay, the others to different branches of Duncan creek whose waters find their way finally to the gulf of St. Lawrence.

WATER-POWERS.

Small water-powers might be developed at several places within the area. On Whitefish creek, in Argyle township, there are two falls each with a level difference of about 15 feet, and by the erection of suitable dams storage reservoirs of considerable size could be created. The rapid at the outlet of Lloyd lake in Midlothian township has a fall of 25 to 30 feet, and the high hills which surround Lloyd lake would permit of the storage of almost any desired amount of water. The outlets of Montrose, Austen, and Midlothian lakes are also characterised by rapids of size sufficient to develop some water-power, but the country round the outlets is so low and flat that the necessary dams would be very expensive. On Nighthawk creek, about a mile below Austen lake, the creek flows through a deep gorge. A dam at this point would back up the water on Austen lake as high as might be desired.

FLORA AND FAUNA.

Matachewan district is well forested. The deep covering of drift has been very favourable to the growth of good-sized trees, more especially in the dryer areas. The excessive moisture of the muskeg-covered parts is commonly a great deterrent to growth, so that they are covered only by sparse growths of stunted spruce and tamarack. The sandy nature of the soil in the dryer areas has resulted in the growth of an unusual proportion of good-sized jack pine, suitable for tie timbers. The best timber of this type was seen along the banks of Whitefish creek, in Bannockburn, Argyle, and McNeil townships. In more clayey soils, good-sized spruce and balsam are characteristically found. Individual trees of red and white pine are scattered throughout the area, more particularly near Niven's line, but there are not enough of them to add any value to the timber estimates.

The white pines are commonly found as large individuals up to 3 feet or more in diameter, towering over the rest of the forest growth. They are clearly the remains of an earlier forest growth destroyed by fire many years ago. A white pine 33 inches in diameter inside the bark, felled in cutting the Midlothian-Montrose township line, showed 215 annual rings, whereas the average large trees of the forest growth in the vicinity do not exceed 150. It is clear that the pines must have been good-sized trees, 6 or 8 inches in diameter, when the others began their growth; and the uniformity that exists in the size of the surrounding timber indicates that all of these trees began their growth about the same time. The occurrence of rare individuals of white spruce as large as the pines themselves shows that it is not impossible for these trees to attain a large size when protected from fire. It, therefore, appears evident that the large pines are the remnants of an earlier forest growth, the survivors of a fire that took place about one hundred and twenty-five years ago. That the pines are more resistant to fire than the spruces, jack pines, balsams, etc., is easily seen in recently burned parts of the district, where the white and red pines stand green and vigorous, whereas every other tree has been killed. As the greater number of bush fires are ground fires, except when urged by high winds, the cause of the resistivity of the pines would appear to be due either to their deeper rooting or to a heavier protective covering of bark on the roots and lower trunk than other trees possess.

Forest fires have not devastated much of Matachewan district in recent years. A small fire swept the northeastern part of Yarrow and the adjoining part of Powell township in 1917. Kimberley township, together with a large area to the east and northeast, was completely devastated by a large fire which came up from the south in 1909. Fires burning in 1912 or thereabouts, to the west of the district line, crossed it for short distances in various places and devastated small areas. One such area is found in Midlothian township, forming a wedge with its apex on Midlothian lake, and extending west. Another is found in Montrose, to the north of Moose lake, and still another belt, less than a mile in width, crosses the southern part of Cleaver township as far east as Esker lake. With these comparatively small exceptions, however, the district under consideration is all green woods. From the top of a high hill, such as mount Sinclair, it can be clearly seen that fires have been numerous and of periodic occurrence. Former burned areas can easily be distinguished from such a vantage point, either by their smaller average growth of timber, or by the preponderance in them of birch and poplar. The latter trees commonly appear first on a burned area, and afford a shelter to the germinating evergreens, which as they increase in strength smother out their hosts and prevent the growth of new individuals.

Cyclonic storms occasionally destroy the forest growth locally, mowing down all trees. One area of considerable size that has been thus affected lies in the centre of Hincks township, to the south of the canoe route. Travel in this area is difficult. Another area, very much smaller, is crossed by the 88-chain portage east of Midlothian lake.

Where the drift contains a considerable proportion of clay there is apt to occur a heavy undergrowth of ground maple and hazel bushes, which increase considerably the difficulties of travel through the country. Undergrowth of this kind is particularly thick over much of Powell township, the northern parts of Yarrow and Doon, and the southeastern part of Bannockburn townships.

Wild animals are still fairly plentiful. Moose are especially numerous, and red deer and bear are occasionally seen. Caribou appear to be numerous in Argyle and McNeil townships. Great numbers of beaver are trapped annually, but the other fur-bearing animals are gradually becoming extinct. The most abundant fish are pike, pickerel, and whitefish. Lake trout may be caught in Matachewan and Midlothian lakes, and brook trout in Whitefish creek.

GENERAL GEOLOGY.

OUTLINE.

The geology is that of Timiskaming district in general and may be summarized in the following table:

Recent............	Fluviatile and lacustrine sediments.
	Unconformity. (Inferred.)
Glacial............	Terminal and ground moraine, eskers and kames, outwash plains.

Great unconformity.

Keweenawan........Olivine diabase: quartz diabase.

Intrusive contact.

Huronian............Cobalt series, Gowganda formation

Great unconformity.

Quartz diabase.

Intrusive contact.

Batholithic intrusives, granite, and syenite.

Intrusive contact.

Kisak series, conglomerate, arkose, slate.

Unconformity.

Keewatin (?)........Rhyolite, andesite, basalt, tuffs, peridotite.

KEEWATIN (?).

DISTRIBUTION.

The rocks grouped under this head are chiefly volcanics and include basalts, andesites, and rhyolites with their associated tuffs. A number of small bodies of peridotite or pyroxenite, intrusive into the lavas, are also grouped, somewhat improperly, with the lavas. The volcanics underlie about half of Matachewan area, with their greatest development in its northern half. They occupy the greater part of Alma, Baden, and Argyle townships, and large parts of Cairo, Powell, Bannockburn, Montrose, and Hincks townships.

At least five peridotite masses occur around the northern end of Lloyd lake, in Midlothian township. Others are found in the vicinity of Rahn lake, in Bannockburn township. One or two were seen in the south end of Argyle township, near mile 3½ of the Bannockburn-Argyle line, and another in Powell township on the west shore of lake Mistinikon, a short distance north of the boundary of the Cobalt series. Burrows, in his report, mentions another on Whiskeyjack creek, one mile north of Fox rapids on Montreal river. This was not seen by the writer.

Rhyolite is found mainly in Midlothian, Montrose, and Bannockburn townships. In Midlothian township practically all the basement volcanics consist of rhyolite. A little of the southwest corner of Montrose township is underlain by rhyolite which is also found north of Boyer lake in the eastern part of the township. The rhyolite of Bannockburn township is part of the same mass. Small amounts also occur on the east shore of Mistinikon lake north of the boundary of the Cobalt series east of Bell island.

Rhyolite breccias and cherts, or cherty tuffs associated with rhyolite flows, are particularly numerous in the rhyolite area in Midlothian township. They are not prominent in Montrose township. Two considerable masses of similar cherts were found on the east shore of Mistinikon lake, one in Yarrow township at the north contact of the northernmost body of granite, the other in Powell township at the narrows one-half mile north of Bell island. A small body of rhyolite tuffs is also found in the middle of Powell township, on claims 5379 and 5380 of the Matachewan Gold Mines Company.

The remainder of the area underlain by the basement volcanics is occupied by andesites and basalts, with some admixture of tuffs of corresponding composition. These were not separated in the mapping.

LITHOLOGICAL CHARACTERS.

Peridotites.

The peridotites are of possible commercial importance, since asbestos of good quality has been found in some of them. Those in Midlothian township in particular were carefully studied with a view to gaining some information as to their size, relations, and alteration. They are black, greyish-black, and greenish-black rocks, frequently having the appearance of a badly altered gabbro on the weathered surface. They are quite soft, crumbling away under the hammer and easily scratched with a knife. This is due to the fact that they are now completely altered to secondary minerals. It was found possible at one or two places only, to obtain a specimen which under the microscope showed even a trace remaining of any primary constituent. The original constitution, which is concluded to have been that of a basic gabbro, pyroxenite, or peridotite, is inferred largely from the texture and appearance of clean weathered surfaces and from the nature of the secondary minerals formed. Fortunately the original textures have been preserved in great part in spite of the alteration, and stand out clearly on clean weathered surfaces.

Some of the sections of the altered basic rock show nothing but kaolin, sericite or talc, and leucoxene. Most of them contain in addition calcite, which may vary from 1 or 2 per cent to 50 per cent, more or less serpentine, and some chlorite. In one section pyroxene appears to have altered to kaolin and talc, in others to serpentine. Feldspar appears to have altered to sericite and kaolin. Occasionally a feature is seen which suggests that the alteration to serpentine may in some cases have succeeded the alteration to calcite, kaolin, talc, etc. Such was the occurrence in one section of serpentine in a vein-like mass cutting the mass of other alteration products.

Although the great body of the basic rocks has suffered the alterations described, in places there is an alteration to masses of serpentine, either pure or mixed with varying quantities of calcite, with occasionally a little chlorite. Unfortunately there was no place found where outcrops were sufficiently numerous to permit the collection of suites of specimens to show the change from one type of alteration to the other.

Here and there veinlets of asbestos cut the rocks. In one outcrop on the north arm of Lloyd lake the alteration has been of the first type described, not the alteration to pure serpentine; the veinlets of asbestos are not over a twentieth of an inch in width, and form an anastomosing network throughout the rock. On Rahn lake, in Bannockburn township, the asbestos veinlets are in pure serpentine. The serpentine here has been faulted, and the asbestos has developed in cracks parallel commonly to the fault plane. It would appear, therefore, to be distinctly secondary and probably developed by the action of meteoric waters.

The other alterations described, including perhaps the asbestos formation on the north shore of Lloyd lake, can only be concluded to have been contemporaneous with the intrusion of the basic rocks, and produced by their own magmatic solutions given off on cooling. It seems impossible to conceive that these rocks could have been so completely altered by weathering, while the rhyolites into which they have been intruded are very fresh. Should objection be taken to this comparison, on the ground of the dissimilarity in composition, which might make the gabbro or peridotite more readily attacked by meteoric solutions than the rhyolite, a comparison might be made with the quartz diabase of pre-Cobalt age. These dykes are not very much younger than the peridotites, in comparison with the immensely long time interval which has succeeded the formation of both, yet the quartz diabases are comparatively only slightly altered.

The peridotites were examined carefully to determine their relations to the rhyolites. At three places knife-edge contacts were found where the original grain was still easily visible on the weathered surfaces in spite of the alterations undergone by the peridotite; and at each of these contacts a strong chilled edge 6 inches to a foot in width was observed in the peridotite. The peridotite is, therefore, intrusive into the rhyolite.

Two or three of the masses were carefully mapped. They proved to be lenticular in shape, with the longer axis varying from one to four times as long as the shorter. The long axis in general is parallel to the strike of the rhyolites, so that the masses usually are laccolithic in nature; in other places, as in the forked mass on the creek between Lloyd and Rhyolite lakes, the intrusives cut across the bedding of the rhyolites.

The peridotites have never been found in direct contact with the Kiask series, so that their relations to it are not known. The relations observed on Rahn lake suggest that they are older than the Kiask series. The Kiask basal conglomerate here rests on an irregular erosion surface of rhyolite which, if projected a few feet, would cut the intrusive mass of peridotite. However, as the peridotite has been faulted into its present position, the inference is not a good one, although the fault appears to have been small.

Rhyolite.

The basement volcanics of Midlothian and a part of Montrose townships are very fresh, light grey rhyolites, with associated breccias, tuffs, and cherty tuffs. The best exposures are seen on Lloyd lake, especially in the north arm. The rock is predominantly massive and fine-grained, in many places highly amygdaloidal. Over large areas the rock is very slightly altered, in strong contrast to the other member of the old volcanic complex. This at first suggests that the rhyolite must be much younger than the other volcanics, but no other evidence supporting the conclusion was obtainable, though carefully sought. The rhyolite strongly resembles the rhyolite of northern Quebec, described by the writer,[1] although it is somewhat less quartzose; the Quebec rhyolite is interbedded conformably with the other volcanics of the region, and is fresh although the other volcanics are metasomatically altered. For the present, therefore, the rhyolite is considered as a member of the old volcanic complex, without any notable difference in age between it and the andesites and basalts.

Under the microscope the rhyolite is seen to consist mainly of feldspar. The feldspar was closely studied, but only albite could be identified. Quartz in small amount is present in some specimens, but is more often absent. The largest amount noted in any section was about 5 per cent. Little ferromagnesian mineral is present, not more than 2 to 3 per cent on the average. It was probably originally acicular hornblende, but is now invariably chlorite. The rock has a pronounced porphyritic texture, about one-fourth of the rock being made up of phenocrysts of albite up to 0·5 mm. in length embedded in a matrix of 0·02 mm. average grain. Amygdaloidal textures are very common. The amygdules are filled with quartz, calcite, and occasionally albite.

In places the fresh, hard rhyolite can be traced, without any sudden break, into a rather soft, dull-looking rock. Suites of specimens collected across the gradation zone show a progressive alteration, seen under the microscope to consist of carbonation and sericitization. The albite phenocrysts are the first to be affected, and are altered to masses of calcite and sericite or paragonite. The feldspars of the groundmass are then attacked, and the same end products produced. In the most highly altered types, alteration products form about 50 per cent of the whole, of which somewhat more than half is sericite or paragonite. This alteration is along the lines outlined by Wilson[2] and supports his view that dolomitic rocks are produced by the carbonation of rhyolites.

Rhyolite Breccias.

Breccias are found in many places, but are particularly common on Rhyolite lake and the northwest arm of Lloyd lake. They are commonly ash rocks, consisting of angular lumps of rhyolite 1 to 4 inches in diameter embedded in a fragmental matrix. They rarely show bedding. In some places true flow breccias are seen, consisting of fragments of rhyolite in a matrix of massive rhyolite. One of these was found at the east end of Halfmile lake, the second small lake on the canoe route from Midlothian lake to Lloyd lake.

Cherty Tuffs.

The cherty tuffs are light grey or white, glassy rocks with the appearance of cherts. They are common on the south shore of Rhyolite lake. They are finely bedded, although the bedding is often difficult to detect owing to the lack of sufficient differences in colour and grain of the beds. Under the microscope they are seen to consist of varying numbers of fragments embedded in a matrix of less than 0·05 mm. grain. In the most dense, cherty-looking varieties the fragments are few, and consist of angular

[1] Jour. of Geol., 1919.
[2] Wilson, M. E., Geol. Surv., Can., Mem. 39, 1914, pp. 65–70.

pieces of feldspar. Other varieties contain numerous fragments of rhyolite up to one-half inch diameter. All gradations between the two types are found. The matrix, where fresh, is largely oligoclase feldspar, slightly replaced by calcite and sericite. Quartz, titanite, pyrite, and chlorite are accessory. The composition of these cherty rocks shows clearly that they are mixtures of fine ash, cemented by chemical sediment from solutions given off by the rhyolites, and probably partly altered by these solutions. The bedded structure separates them from the rhyolites, which they often strongly resemble otherwise.

Rhyolite Tuffs.

In addition to the breccias and cherty tuffs, a series of well-bedded tuffs are found between the rhyolite and the Kiask series, to the south and southwest of Midlothian lake. They locally attain thicknesses of 200 to 300 feet. They vary in composition from cherty tuffs to slates and arkoses of one-quarter mm. grain, and are entirely composed of rhyolite fragments and dust, usually badly altered. The alteration is of the same type as that which the rhyolite has itself undergone, i.e., carbonation and sericitization, and is presumably due to the same cause. The tuffs, therefore, must have been laid down rapidly and soon after the rhyolite. The well bedded nature of the tuffs indicates that the rhyolite was extruded into water.

Varying amounts of siderite and other carbonates in well developed crystals are present in the tuffs. Carbonates may form as much as 70 per cent of the rock, but commonly not over 25 per cent. They have been developed in situ, by the replacement of the feldspar and sericite of the tuff. Under the microscope, the carbonate is seen to be full of inclusions of quartz, which were not affected by the solutions which altered the other constituents, and which, therefore, remain unaltered and retain in the calcite crystals the pattern that they had in the original rock.

Andesites and Basalts.

The andesites and basalts are prevailingly rocks of fine to medium grain, and a dark green colour. The andesites are somewhat lighter in colour than the basalts, and frequently contain white phenocrysts of feldspar up to 1 mm. diameter. The name "greenstones," commonly applied to these rocks, is expressive of their general appearance.

The rocks formerly consisted of hornblende or pyroxene and plagioclase, with accessory ilmenite. Metasomatic alteration has largely destroyed the original constituents, replacing the plagioclase with albite and oligoclase albite, the ferromagnesian minerals with chlorite, and the ilmenite with leucoxene; developing at the same time more or less sericite and calcite. The alteration, however, has not destroyed the original structures and textures. Pillow texture is one of the commonest of these, and is found in many places. It is well developed on Hutt lake and may be seen on lake Kitchimine. It was found in Yarrow township on the shore of Mistinikon lake, in Powell township near the gold deposits, and in Cairo township near the end of the portage past the long rapid of Montreal river. Spherulitic textures occur in the northwest part of Bannockburn township. Variolitic textures are found on Austen and Kitchimine lakes. Breccias are common in the southern part of Argyle township. Well developed amygdaloidal textures may be seen on the upper part of Powell creek, in the northwest corner of Powell township. Porphyritic textures are rather common, and may be seen in many places along the east shore of Mistinikon lake. It is evident, therefore, that the alterations have not been of such a type as to destroy even the most delicate and destructible of original textures.

MINERALOGICAL ALTERATION.

Character of Alteration.

The basement volcanics have all undergone metasomatic alteration. In the peridotites, basalts, and andesites the alteration has been extreme; in the rhyolite and its tuffs it has been comparatively slight, although locally considerable, especially in the case of some of the tuffs. The secondary minerals developed are carbonate, epidote, zoisite, kaolin, sericite or paragonite, talc, serpentine, chlorite, quartz, and feldspar. The relative proportion of these varies in the different rocks. The rhyolites and rhyolite tuffs are altered principally to carbonates, sericite, kaolin, with some chlorite. Carbonates preponderate in the most highly altered types. The rhyolite tuffs are similarly altered, but usually more intensely, presumably because of their more open texture and correspondingly greater permeability. The andesites and basalts are altered to chlorite kaolin, sericite or paragonite, calcite, and epidotes principally, with albitization of their feldspars and some formation of residual quartz. The peridotites are altered to pure serpentine with residual iron oxide, to serpentine and chlorite, or to mixtures of carbonate, talc, and kaolin, occasionally epidotes, and serpentine in varying quantities or wholly lacking.

Time of Alteration.

M. E. Wilson[1] has shown that in the northern Quebec region the carbonate in the volcanics must have been present before the intrusion of the granite batholiths, as it is found in the hornblende schists resulting from the reaction of the granites with the volcanics with relations indicating that the carbonate did not originate after the alteration to hornblende schist took place. He also shows that the margins of the pillows found in ellipsoidal basalt are highly carbonated, whereas the interstitial material between the pillows is unaltered, thus proving that the alterations of the pillow margins must have taken place immediately after their formation, before the interspaces were filled. He concludes, therefore, that the metasomatic alteration of the lavas took place almost contemporaneously with the formation of the pillow structure, and immediately after extrusion; probably by water highly heated by the lava and charged with volcanic gases. The same conclusions have been reached by many other geologists[2]

[1] Geol. Surv., Can., Mem. 39, 1914, pp. 54–57, 59.
[2] Dewey and Flett, Geol. Mag. 58, 1911, pp. 201–209; 241–243.
Daly, R. A., Am. Geol. 32, 1903, pp. 65–78.
Fenner, C. N., N.Y. Acad. Sc., 20, No. 2, pt. 2, 1910, pp. 93–187.
Cooke, H. C., Geol. Surv., Can., Mem. 96, 1917, p. 162.

on equally good grounds, and may, therefore, be taken as fairly well proved. The same conclusions may be considered to apply to the lavas of Matachewan area, which are almost identical in their nature and the conditions of their extrusion with the lavas of northern Quebec. They afford a satisfactory explanation of the varying extent to which the different rocks have been altered. The pyroxenites or peridotites, the youngest rocks of the complex, have suffered the most intense alteration; the basalts and andesites, the oldest rocks, though badly altered, are much less so than the pyroxenites; and the rhyolites, of intermediate age, are comparatively slightly affected. Any agent acting uniformly on all the rocks, such as meteoric water, would have produced much more uniform effects in spite of the differences in the composition of the rocks.

MODE OF ORIGIN.

The lavas of Matachewan area appear to have been largely extruded under water. Pillow structures are common in the basalts and andesites of the series, and much evidence has accumulated in late years which goes to show that this structure is the result of subaqueous extrusion. In places, as on the east shore of Mistinikon lake opposite the north end of Bell island, well-bedded tuffs are found between the flows, also indicating subaqueous extrusion. The rhyolites rarely possess pillow structure, although it was found in one place on the west shore of Lloyd lake, but the cherty tuffs that accompany them are finely bedded, and the coarse tuffs that overlie them at the contact with the Kiask conglomerate in Midlothian township are well bedded. Subaqueous extrusion is thus indicated throughout the whole period of volcanism.

STRUCTURAL RELATIONS.

Internal.

Stratigraphy. In a general way the stratigraphy of the basement volcanics in Matachewan area is similar to that of the Abitibi volcanics in northern Quebec, the succession of which was determined by the writer in 1916 to be basalt at the base, followed by andesite and rhyolite.[1] Good exposures are, however, not numerous enough to allow of the stratigraphy being determined with accuracy. In Matachewan district the structural relations indicate that the rhyolite of Midlothian, Montrose, and Bannockburn townships overlies the other volcanics; but so far as the present fragmentary information will permit a conclusion to be reached there does not seem to be any definite succession among the other volcanics such as is found in northern Quebec. The only place in the area where a fairly continuous series of outcrops may be observed is on the east shore of Mistinikon lake, where the structure appears to be that of an anticline, the crest of which over a considerable width has been eroded and covered with sediments of the Cobalt series, a band of which crosses the lake at Bell island. The underlying volcanics have thus been covered to such an extent as to render it impossible to obtain a complete succession. The rocks of the volcanic complex still remaining exposed include basalt,

[1] Jour. of Geol., 1919.

andesite, a basic rhyolite not very similar to that of Midlothian township, some beds of slaty tuff, and some masses of cherty tuff very like the similar rocks of Midlothian township. The cherty tuffs lie at the north and south ends respectively of the anticline and hence are the uppermost beds exposed, corresponding in position to similar beds in Montrose and Midlothian; but the other rocks seem to have no definite order of extrusion such as exists in northern Quebec. Thus, on the north side of the Cobalt series opposite Bell island the order of succession is : (1) basic rhyolite; (2) black aphanitic rock, possibly a basalt; (3) andesite containing a little free quartz, but more basic than (1); (4) slaty tuff, interbedded between the flows of andesite (3); (5) basalt; (6) cherty tuff. It must be remembered also that the rhyolite (1) is not the bottom of the series. The succession is, therefore, very much more complicated than that in northern Quebec or there has been faulting of so complex a nature as to destroy entirely the original succession. The latter suggestion is not improbable, as there is known to have been much faulting around Mistinikon lake.

The peridotites, as has been shown (page 11) are intrusive into the rhyolites, and, therefore, are the youngest rocks of the basement complex.

Folding. The rocks of the basement complex have all been closely folded and now generally lie in almost vertical positions. Data as to their structure are rather scanty, but enough have been obtained to determine the principal large structures.

In Midlothian and Montrose townships the volcanics and the Kiask series have been folded together. Strike and dip observations taken on a large number of rhyolite flows and interbanded beds of tuff and cherty tuff invariably showed the dip and strike of the rhyolite parallel to that of the overlying Kiask sediments, so that there does not appear to be any structural unconformity between them. As the structure of the Kiask series here is synclinal, the structure of the underlying rhyolite was concluded also to be synclinal. This conclusion was strengthened by a number of grain determinations made, according to methods outlined by the writer in a recent paper,[1] on the flows to the south of the Kiask boundary in Midlothian township, which indicated that the north side of the flows is the upper. In addition, some beds of fine-grained rhyolite tuff (page 13) occur between the Kiask conglomerate and the rhyolite to the southwest of Midlothian lake, and follow the contact for several miles. They must have been laid down on top of the rhyolite, thus again indicating that its north side is the upper.

The axis of this fold, which will be more fully described during the discussion of the folding of the Kiask series, strikes north 65 degrees to 70 degrees east, and at its west end plunges to the east at a high angle. The axis of the Bannockburn anticlinal cross fold (see "folding of the Kiask series") strikes north 10 degrees west. Other data obtained at various places in the area show that these directions are pretty closely the strikes of the axes of the major and cross folds over the whole area. The strikes of the flows or tuff beds at any given point will, of course, depend on the position of the bed in the fold and the plunge of the axis of the fold.

If the axis of the Midlothian syncline be projected eastward, it crosses Mistinikon lake about the point where the down-faulted blocks of Kiask

[1] Jour. of Geol., 1919.

series outcrop. Although it is hardly correct to consider that such a method would locate the bottom of the syncline with exactness, still it seems probable that the synclinal axis does cross Mistinikon lake somewhere in this general neighbourhood. The determination agrees well with the independently made determination of an anticline to the south, the axis of which strikes north 70 degrees east and is located near the south end of Bell island.

The Midlothian syncline is succeeded on the north by an anticline which occupies Montrose township, whose axis appears to pass near the northwest corner of the township and whose eastern nose was found at the east end of the 49-chain portage, near the eastern boundary of the township. At this point, which lies on the northward projection of the Bannockburn cross fold, the andesite lavas strike south 20 degrees east and dip 40 degrees west. The north limb of this anticline occupies the greater part of Hincks township. As in the Midlothian syncline, the limbs of the fold appear to have a wide angle between them, of nearly 90 degrees. Whereas the strikes on the south limb, in the neighbourhood of Montrose and Hutt lakes, are about north 20 degrees east, those of the flows on the north limb were determined on Austen lake to be south 50 degress to 60 degrees east. The strike of the axis is thus north 70 degrees east.

In Powell township, near the gold deposits, the strike of the basalt and rhyolite tuffs was observed to have a general trend of north 75 degrees east.

Outcrops were not sufficient over the remainder of the area for the determination of the structures in the volcanics. It seems probable, however, from the uniformity in the strikes of the axes of the folds as already determined, that the axial trend of the major folds for the whole area is about north 70 degrees east, and for the cross folding north 10 degrees west.

Faulting. Fault lake, in Midlothian township, occupies a part of a narrow, steep-walled valley which appears to have been a horst, or upthrust fault block. The fault was at first inferred from the fact that the rhyolite-Kiask contact is somewhat farther north in the valley than on either side, more so than would be accounted for by the dip and difference of elevation. Afterwards, evidence was sought along the sides of the valley to the south, and in one place about 10 chains south of the lake the rhyolites were found to be intensely sheared. A projection of the valley's axis to the south passes through the northwest part of Lloyd lake, which here runs north, then passes on into a somewhat wider, steep-walled valley occupied farther to the south by another long, narrow, north-and-south bay of Lloyd lake. It seems probable, therefore, that this whole depression may be one fault. Its age is post-Kiask.

In Montrose township a prominent fault has upthrust the rocks on its north side, and brought the basalts of the older volcanic series into contact with the arkoses of the Kiask series. The age of this fault is, therefore, also post-Kiask. It does not appear to have displaced the Cobalt series to the east, and is thus of pre-Cobalt age. The fault is supposed to extend eastward through the north end of Hutt lake, where the older volcanics are intensely sheared. The fault strikes nearly east in its eastern part, and supposedly swings to northeast in its western part.

A small fault striking north 40 degrees west is found on Rahn lake, Bannockburn township, along the rhyolite-peridotite boundary.

Mistinikon lake has been a zone of intense faulting in pre-Cobalt time. Like the other faults mentioned, those on Mistinikon lake are probably of post-Kiask age, as some of them cut the Kiask series and bound it. A large fault may be seen on the east shore of the lake in Yarrow township, cutting the cherty tuffs which lie to the north of the northernmost body of granite. The fault has sheared the tuffs intensely over a zone 15 to 20 feet in width, and the shear zone has apparently been somewhat mineralized, as the rocks are badly iron-stained. The fault has brought the cherty tuffs into contact with basalts on the north, and its northeast side is, therefore, presumably the upthrow side. At its south end the fault trends somewhat east of north and passes out into the lake. On the north it swings more to the east. The shore follows it here, probably because it was a zone of easy erosion, and forms a good-sized bay. At the point where the 90-chain portage leaves Mistinikon lake it is again visible, striking somewhat east of north, and apparently following a large valley. It could not be traced farther directly, but is believed to continue eastwards into the lake at the other end of the 90-chain portage. This fault will be referred to further under "Faulting of the Cobalt series."

Another large fault is visible on the west shore of Mistinikon lake, in the narrows about half a mile north of Bell island. It has a north-south strike and a vertical dip, and has formed a shear zone 40 to 50 feet in width. It has brought the cherty tuffs of the series, which may be seen on the east side of the narrows, into contact with basic andesites. The east side, therefore, has been upthrown.

To the north, where the Kiask series outcrop, several faults with shear zones of some width may be observed on the lake shore. They have brought the rocks of the Kiask series down into contact with the andesites of the basement volcanics.

Metamorphic Effects of Folding and Faulting. Folding has not exercised any pronounced metamorphic effect on the volcanics of Matachewan area. General shearing has been so slight on the whole that over the greater part of the area delicate and easily destructible textures, such as amygdaloidal, spherulitic, and variolitic textures and pillow structures, have not been destroyed. Schistosity produced by folding is commonly confined to relatively narrow bands at the contact of one flow with another, where it was produced by the slipping of one flow over another as the lavas were brought from the horizontal to the vertical position. The strike of schistosity produced in this way is always parallel to the bedding.

Faulting also produced schistosity along the relatively narrow bands of the fault zones. Such schistosity is parallel to the strike of the fault, and, therefore, need have no relation to the bedding.

The eastern part of the area appears to have been somewhat more intensely metamorphosed than the western. The volcanics of Powell township and the south side of Cairo township have a fairly general schistose texture developed throughout. Under the microscope they all possess a parallel or sub-parallel arrangement of the mica and chlorite crystals; the corresponding rocks of the western side of the area do not commonly exhibit this characteristic.

The rhyolites have suffered especially little. Shear zones are rarely seen in them. On Fault lake they are sheared at the base of the Kiask series, where the Kiask conglomerate has slid over them during folding; and also along the fault zones to the north and south of Fault lake. Shearing converts the rhyolite into a sericitic schist.

The andesites and basalts are converted by shearing into chlorite schists, which in their most schistose forms are dark green, highly fissile rocks with glossy, micaceous cleavage surfaces. Schists of this type may be seen on Mistinikon lake along the faulted zone north of Bell island, near the gold deposits in Powell township, and in other places.

Time of Folding. The time at which the folding of the volcanics took place will be discussed more fully in the description of the Kiask series. The subject may be dismissed here, therefore, with the statement that the folding occurred after the deposition of the Kiask series, so far as the evidence at hand indicates.

External.

Relations to Older and Younger Formations. The basement volcanics are the oldest rocks of the region, as their name implies. They are overlain by the Kiask series of sediments with unconformity, as is shown by the occurrence of debris of all the volcanics in the Kiask rocks. The unconformity, which will be discussed more fully under the Kiask series, appears to be one of erosion mainly. No evidence has been obtained up to the present to indicate that the volcanics were folded before the Kiask series was laid down. They have been intruded by the great batholiths of granite, and large portions of them have been dissolved and digested during the process.

KIASK SERIES.

DISTRIBUTION.

The name Kiask series has been given by the writer to a series of sediments first found by McMillan[1] in Midlothian township, and called by him Timiskaming series. As, however, there is little lithological or other resemblance between these rocks and the Timiskaming series as described by Miller and Knight around Cobalt, Kirkland lake, etc., the writer considers it best to apply a local name until the stratigraphic relations shall have been fully worked out.

The largest area of Kiask sediments is found in the northern half of Midlothian and the southern half of Montrose townships. This area will be termed the Midlothian area; it includes about 16 square miles and extends from Niven's line on the west to the boundary of the Cobalt series in the eastern part of the township. On the east side of the belt of Cobalt series the Kiask series again outcrops, occupying the southwestern corner of Bannockburn township and passing over into Doon and Montrose. In this area, hereafter termed the Bannockburn area, there are about 10 square miles. Some small, isolated patches of basal conglomerate are found in the neighbourhood of Rahn lake, evidently outliers of the Bannockburn

[1] "Geology of the area along the Timiskaming and Northern Ontario Railway trial line between Gowganda and Porcupine". Toronto, 1912.

area. A third area of about a square mile occurs on Mistinikon lake about a mile south of the mouth of Powell creek.

LITHOLOGICAL CHARACTER.

The Kiask series includes conglomerate, arkose or greywacke, and slate members. Alteration of some of the upper arkoses has produced types rather highly calcareous.

Conglomerate.

The basal conglomerate of the Kiask series varies a great deal in thickness and composition from place to place. On Rahn lake, in Bannockburn township, where only erosion remnants of the basal conglomerate are seen, it is composed of the debris of a white granite cemented together with a small amount of black argillaceous matrix. At this point it lies directly on the surface of a rhyolite, and occasional pebbles of rhyolite and other Keewatin rocks are present.

At the west end of Boyer lake, in eastern Montrose, the conglomerate again lies directly on the rhyolite. This locality is the only one where red granite pebbles were observed in the conglomerate. The pebbles throughout a thickness of several feet at the base were largely of red granite and coarse pegmatite with red feldspar; above this the red granite was replaced by the more characteristic white granite debris. The layer of conglomerate is rather thin, in the neighbourhood of 25 to 30 feet, and is overlain by a few feet of a pebbly argillite identical with the slate conglomerate of the Cobalt series. Over this lies a fine-grained, rather soft greywacke which will be described later.

In the western part of Midlothian township, along Niven's line, there are about 300 feet of interbedded conglomerate and coarse arkose. It increases rapidly in thickness to the east and in the neighbourhood of Fault lake, about 3,000 feet of conglomerate appears to have been piled up. To the southeast of Fault lake the conglomerate thins again, and south of Midlothian lake there is only a coarse grit in places with an occasional pebble.

The basal part around Fault lake is a heavy granite conglomerate, so completely made up of granite debris that on badly weathered surfaces the outlines of the pebbles are lost and the rock in places might be taken for a white granite. White, subangular granite boulders of all sizes up to 1 foot in diameter form approximately 95 per cent of the rock. The remainder consists of various coloured cherty tuffs, rhyolite, and serpentine. The granite varies in composition from syenite to types with about 15 per cent of quartz. The grain of most of the pebbles is very coarse. There is little matrix, and what occurs is apt to be rather quartzose.

The white granite part of the conglomerate around Fault lake is about 200 feet thick. At this horizon its character changes abruptly, and there appears the more characteristic greenish-grey conglomerate of the Kiask series, as seen around Midlothian lake. It is beautifully exposed between Fault lake and Midlothian lake, by a recent fire which has swept the surface free of vegetable debris. Although it still contains granite pebbles and boulders up to 1 foot or more in diameter, such pebbles constitute only about 5 per cent of the total mass, instead of 95 per cent as in the lower horizon. The remainder are of the ancient greenstones, or volcanics, Singularly enough, it is almost impossible to find one of the rhyolites or the associated cherty tuffs.

The pebbles of the conglomerate are neither noticeably angular nor noticeably well-rounded. The granites are fairly well rounded, the greenstones rounded or elliptical. None of the greenstone pebbles are noticeably sheared, but they are all altered metasomatically, suggesting that such alteration had taken place before the formation of the conglomerate.

The matrix of the greenstone conglomerate is greenstone dust, which in places makes the outlines of the pebbles difficult to distinguish on freshly broken surfaces.

A few beds of conglomerate also occur interbedded with the arkoses of the series. They are rarely over 6 feet in thickness or thereabouts, and are mostly found toward the base of the arkose horizon. The pebbles in some of these are fairly well rounded or subangular, in others quite sharp angled. The composition of these conglomerates differs from both of the varieties already described, in that both pebbles and matrix consist almost entirely of debris from the rhyolites and cherty tuffs. In this they resemble the arkoses with which they are interbedded.

Arkose.

Arkose or grit overlies the conglomerate. On Midlothian lake the grits have a thickness of about 6,000 feet. They are all steel-grey rocks, uniformly hard, fresh, and well bedded. The beds are 6 inches to 3 or 4 feet in thickness, and are marked by differences in grain rather than in colour. For this reason the bedding is difficult to detect on any but clean, wave-washed surfaces, except in the places where the difference in grain of adjoining beds is considerable. The grain of the coarsest grits is about 2 mm., that of the finest grained massive types 0·05 mm.

The composition of the arkoses is very similar to that of a rhyolite tuff. Fragments of rocks and minerals, many of them sharp angled and even chisel-edged, but never more than slightly worn, constitute a larger or smaller part, and are embedded in a fine-grained matrix. The fragments of the coarser varieties are of rhyolite and cherty tuff, and, rarely, a bit of some other rock; together with chips of individual minerals, such as quartz, albite-oligoclase, and magnetite. A thin section cut from an average bed of medium grain contained about 30 per cent of such fragments. The matrix of this rock consisted of about 50 per cent of chlorite, and the remainder mostly feldspar. Quartz, sericite, and magnetite were also present in minor amount. In other beds the matrix is largely sericite and kaolin. The sericite appears to be a primary constituent, and not formed by secondary alteration. Generally a little secondary carbonate and pyrite is present.

Slate.

A band of black slate about 50 feet thick lies on the west shore of Midlothian lake. A similar band crosses Niven's line at mile 82·60 chains. Other bands cross the northern boundary of the township at three or four places between Midlothian creek and Niven's line. The slates are very similar in composition. To the eye they are black or greenish, fine-grained rocks filled with rhombs of carbonate. Under the microscope they are seen to consist of a fine-grained matrix of chlorite, sometimes with fine-grained feldspar and quartz, sometimes with kaolin and sericite. Some magnetite is always present. Carbonate crystals have replaced parts of this groundmass, developing apparently at the expense of [illegible] chlorite, sericite, and kaolin there. The quartz and albite do [illegible] m to have been replaced, and may be seen within the calcite crys[illegible] thin sections, in the same number and general arrangement as they possess outside the calcite. Part of this carbonate is siderite, part calcite or dolomite. Altogether it forms about 25 per cent of the rock. In some cases well-formed calcite crystals are rimmed with magnetite grains, in others with muscovite fibres whose long axes are arranged parallel to the crystal boundary against which they lie. They would seem almost to have been pushed aside by the crystal during growth.

Calcareous Rocks.

Above the slate layers, principally in the southern part of Montrose township, a number of light-coloured soft rocks were found interbedded with the more characteristic grits and arkoses. Examined under the microscope these were found to have been essentially like the arkoses and grits; but the material that composes them either had a better chance to decompose than that of the ordinary arkose before being laid down in its present position, or the original texture was looser for some reason, and permitted more rapid secondary alteration to go on. At any rate these rocks have been coarsely fragmental grits, but are now badly altered to mixtures of chlorite, kaolin, sericite, and calcite.

Around Sinclair lake there is a fine-grained, moderately hard greywacke, a most monotonous light grey mud rock with little or no appearance of bedding. It covers a large part of the Bannockburn area on account of the flat-bedded structure of the area. It is seen under the microscope to be a typical greywacke of this series. Sharp angular fragments of minerals up to 0·2 mm. in length constitute about 40 per cent of it. Roughly three-quarters of these fragments are quartz, the remainder mostly oligoclase. They are embedded in a very fine-grained matrix of kaolin with a little epidote and sericite.

DISTINCTION BETWEEN KIASK AND COBALT SERIES.

Distinction between the Kiask series and the Cobalt series is difficult in places, especially in the Bannockburn area, where the Kiask series lies flat. The only distinction possible, where similarity in structure occurs, is based on the petrographic differences between the rocks of the two series. The Cobalt series in this vicinity is very largely composed of debris of reddish granite and syenites. The conglomerates are filled with red granite pebbles, the arkoses are red with abundance of red feldspar grains, the quartzites and black slates contain interbanded reddish beds, and, even where outcrops of black slate are not large enough to expose the reddish beds, grains of red feldspar can be observed on almost any freshly broken face. The Kiask series on the contrary contains practically no such debris. Reddish granite pebbles were observed in the conglomerate at the west end on Boyer lake, but in no other locality. The most painstaking search failed to reveal reddish beds or grains of red feldspar in the rocks at any other place, or in any horizon of the series.

STRUCTURE.

Internal.

Stratigraphy. In the Midlothian area the Kiask series consists of conglomerate at the base, overlain by a band of slate, then by thick beds of arkose or grit. The conglomerate varies both in thickness and composition from place to place. Around Fault lake the base consists of about 200 feet of the heavy, white, granite conglomerate previously described, overlain by 2,000 to 3,000 feet of greenstone conglomerate. The conglomerate thins to the east and to the west. On Niven's line the total thickness is only about 300 feet, and all the exposed rock is greenstone conglomerate, so that the granite conglomerate is either quite thin or altogether lacking. Between the south end of Midlothian lake and Lloyd lake the conglomerate is also only 200 to 300 feet thick, and in one place is almost altogether replaced by a coarse grit.

Directly overlying the conglomerate a bed of black argillite or slate was observed on Midlothian lake, on Niven's line, and on the Midlothian-Montrose boundary. This bed is about 50 feet in thickness. It was not traced through the area, but its location above the conglomerate in both cases and its uniformity of thickness renders it probable that it is continuous between these points.

Beds of arkose or grit interspersed toward the base with beds of conglomerate overlie the slates. The beds of conglomerate are few and average about 6 feet in thickness. The grits vary in texture from coarse material carrying small pebbles the size of a pea to very fine-grained greywackes or sandstones. At least 6,000 feet of these arkoses are exposed on Midlothian lake. The total thickness is not known, owing to the lack of sufficient good outcrops for structure determinations. The arkose and its interbedded conglomerates are composed almost entirely of material drawn from the underlying rhyolites and their associated beds of cherty tuffs.

The relation of the carbonated arkoses found in Montrose township on both sides of Midlothian creek, to the arkoses of Midlothian lake, is not known, as the exposures were not good enough for structure determinations. They were concluded, however, to overlie them, since such carbonated phases were not found anywhere on Midlothian lake above the conglomerate.

In the Bannockburn area the succession differs somewhat from that of the Midlothian area. The base, which has been seen on Boyer lake, Rahn lake, and north of Sinclair lake, is a white granite conglomerate, about 30 feet in thickness. At the west end of Boyer lake the lower 5 or 6 feet of the conglomerate contains many pebbles of granite and pegmatite containing red feldspars instead of white. Such a condition was not observed elsewhere. The pebbles of the granite conglomerate are embedded in a matrix of black argillite, and on Boyer lake the same argillite carrying scattered pebbles of granite forms a bed a few feet in thickness overlying the conglomerate. Its appearance is identical with the slate conglomerate of the Cobalt series. Overlying the argillite band is found the monotonous unbedded greywacke described on page 22. Its thickness was not determinable owing to its flat-lying structure and its lack of bedding. On the south side of Boyer lake, however, it rises into a hill about 150 feet high, so that its thickness must be at least 150 feet. If a uniform dip of 10 degrees be assumed for it between Boyer lake and Sinclair lake, the thickness is at least 1,300 feet. The true thickness probably lies between these extremes. Like the arkose of the Midlothian area, the greywacke is composed almost entirely of rhyolite debris.

On the eastern side of the Bannockburn area D. J. Fisher observed considerable thicknesses of flat-lying black slates apparently overlying the greywacke. These slates contained no grains of red feldspar or bands of reddish material such as are almost invariably found in the slates of the Cobalt series in this district. They were, therefore, mapped as part of the Kiask series.

The relation between the formations of the Midlothian and Bannockburn areas may be rendered clearer by the following diagram:

	Arkose with carbonated beds?	Slate	
Midlothian area	Arkose and conglomerate ± 6,000 feet	Greywacke ± 1,300 feet	Bannockburn area
	Slate 50 feet	Slate 6 feet	
	Conglomerate 300–3,000 feet	Conglomerate 30–50 feet	

Folding. The Midlothian area has been tightly folded, so that the rocks now are all on edge, with almost vertical dips. The strikes follow closely the boundaries against the rhyolite. At the nose of the fold, near the district line, the general strike of the beds on the southern limb of the fold is south 75 degrees east, that of the northern limb is about north 20 degrees east. The axis of the fold, lying midway between the two, strikes north 65 to 70 degrees east, and, since the syncline narrows to the west, is plunging steeply to the east. As the dips are about the same on both limbs of the fold, the axial plane is vertical.

The south side of the area of Kiask series, which has been carefully mapped, shows two pronounced bends to the south, one to the west of Midlothian lake, the other at the northeast corner of Lloyd lake. The strikes of the rocks here follow closely the curves of the contact, so that these are concluded to be drag folds on the flanks of the main syncline. The axes of these secondary folds strike north 35 degrees east and north 70 degrees east, indicating that the folding has been of the normal type.

The Kiask series lies almost flat in the Bannockburn area. This peculiarity makes it difficult to distinguish from the Cobalt series, where similar rock types, such as the argillites, are under consideration. The difficulty is most pronounced on the eastern side of the area, where there are heavy deposits of argillite. Part of these are clearly Cobalt series, as they are filled with the red arkose layers and red feldspar grains characteristic of the series. Other argillites have no such earmarks, and have been mapped with the Kiask. However, the determination is doubtful in places.

The mapping shows that the Bannockburn area is an anticline the axis of which strikes north 10 degrees west and is plunging to the south at a low angle where the formation disappears below the Cobalt series on the south. The pronounced synclinal bend in the boundary of the formation on Boyer lake is probably the crossing of the principal axis of the Midlothian fold. The Bannockburn fold is, therefore, a pronounced anticlinal cross fold, if we consider north 65 degrees east as the principal axis of folding; and the flatness of the strata in the Bannockburn area is probably due to the counteracting influences of the synclinal folding and anticlinal cross folding at this point.

In the Mistinikon down-faulted area the beds are all steeply dipping, with a strike south 65 degrees east and dip 65 degrees north.

Metamorphic Effects of Folding. The effects of folding on the rocks of the Kiask series have been surprisingly slight. Apparently they acted as massive, competent units even where folding was severe as in the Midlothian area. The granite conglomerate, wherever found, is invariably unsheared and non-schistose. The greenstone conglomerate which overlies the granite conglomerate to the west of Midlothian lake has suffered more, and in places has been squeezed and the pebbles flattened to a very considerable extent. The grits and arkoses have suffered comparatively little, but the argillites have been badly contorted and in places converted into true slates.

Time of Folding. The folding of the Kiask series evidently took place before the deposition of the Cobalt series, as that series is comparatively unmetamorphosed in this vicinity. It also probably occurred before the intrusion of the great batholiths of granite, as these are nowhere sheared. The folding movement may, therefore, be stated as post-Kiask and pre-granitic or pre-batholithic.

Faulting. Faults are rather common. A block fault with a north-south strike passes through Fault lake and weathering along the fault has produced a valley of some length, of which the lake occupies a part. The northern boundary of the Midlothian area is a fault, with a general east-west strike. It has brought the Kiask series against the basalts of the volcanic series. The fault has not apparently affected the band of Huronian to the east, and is probably, therefore, pre-Huronian. The boundaries of both the Midlothian and Bannockburn areas against the band of Cobalt series that runs through Montrose township are faults. As will later be shown in the discussion of the Cobalt series, this band forms a downfaulted block in the northern part of Montrose township, the displacement of which decreases toward the south.

The eastern boundary of the Bannockburn area seems to be also a fault line or a series of them. The members of the Cobalt series in contact with the greywackes or slates of the Kiask series are invariably argillites, the upper members of the Gowganda formation. Such a contact cannot be explained except by faulting.

In the Mistinikon district the Kiask series is represented by a few beds of arkose and grit, identical with those observed on Midlothian lake. No basal conglomerate was anywhere observed there and the contacts with the older volcanics are nowhere parallel to the strike of the Kiask rocks. The relations are clearly those of faulting. The shear zones of the faults may be seen in at least two places on the lake shore.

External.

Relations to the Keewatin. The Kiask series lies unconformably upon the surface of the ancient volcanics. At the present time it is not known whether the unconformity is erosional only, or both structural and erosional. The Kiask basal conglomerate, wherever found, lies on rhyolite. In the Midlothian area a careful study failed to show any difference in strike or dip between the sediments and the underlying rhyolite. Near Rahn lake, where the basal conglomerate lies flat and is present only in small patches or erosion remnants, the most careful examination failed to determine the structure of the rhyolite. From the facts determined around Lloyd lake, however, and the fact that, as the map shows, the conglomerate everywhere rests on rhyolite, it is concluded that there can be no pronounced structural unconformity between the two; so that they are either conformable, or else folding in the rhyolite has been only slight before the sediments were laid down

There can be no doubt, however, as to the erosional nature of the unconformity between the Kiask series and the Keewatin. The upper Kiask conglomerate is largely made up of fragments from the lower volcanics, the basalts and andesites commonly grouped together as greenstones; whereas the upper beds are composed largely of debris from the rhyolite member of the lower series. Rhyolite pebbles, though in smaller numbers, are also to be found in all horizons down to the basal conglomerate.

The rhyolite is intruded on the south shore of Rahn lake by a dyke of serpentinized peridotite striking north 30 degrees west and dipping steeply southwest. It is also intruded by a badly altered gabbro which has not been serpentinized. The south shore of the lake is a cliff about 20 feet high, overhanging somewhat in places, and passing at the top into a steep slope that flattens rapidly into the normal ground surface. On this surface, on the steep-sloping edge, and on the face of the cliff itself in one place down to the waters edge, are to be seen patches of the Kiask basal conglomerate, varying from a few inches to a few feet in thickness. It is clear that it must have been laid down on a very irregular surface, approaching that of the present; and it is equally clear that the irregularity must have been one of erosion, since the old surface cuts across not only the rhyolite but also the gabbro intrusive into the rhyolite. The period between the extrusion of the rhyolite and the deposition of the Kiask series must have been sufficiently long, therefore, to permit of the intrusion and cooling of the intrusive, and for erosion to cut away the rhyolite and expose it.

The source of the granite pebbles in the basal Kiask conglomerate is not known. Nearly all of the granites of the district contain more or less red feldspar, and, therefore, could not have supplied the pebbles which are all of white granite with the exception of the few on Boyer lake. A single dyke of a schistose, white granite was found at the north end of Hutt lake, and it is supposed that this, with others equally ancient, may have been the source of supply.

Relations to the Cobalt Series. The contact of the Kiask and the Cobalt series was not directly observed at any point. However, there can be no doubt that the Cobalt series is the younger and lies unconformably upon the Kiask. In the Midlothian area the Kiask series is steeply tilted and some of its softer layers have been more or less schistified by folding movements. The Cobalt series directly to the east lies uniformly flat, and is unmetamorphosed. A time interval of folding and subsequent erosion must, therefore, have intervened between the close of the deposition of the Kiask series and the commencement of the deposition of the Cobalt series.

Relations to the Granite Intrusives. At no point was the Kiask series found in contact with any of the granitic intrusives, so that the relation between them cannot be certainly known. On Elizabeth lake, however, the Kiask series is cut by many veinlets, most of which are quartz, but one of pegmatite was observed. The presence of this veinlet indicates that there is a body of intrusive granite magma not far away. The Kiask series is, therefore, tentatively placed in the geologic column as older than the granitic intrusives, until some more satisfactory proof of age can be obtained.

MODE OF ORIGIN AND HISTORY.

The nature of the Kiask series, as outlined in the preceding pages, is so remarkable as to make it difficult to outline a mode of origin for it which will satisfy all the facts. Briefly summarized, these facts are as follows:

The basal conglomerate in the Midlothian area is a granite conglomerate with only about 5 per cent of other constituents. Above this there is a heavy greenstone conglomerate, with not more than 10 or 15 per cent of other constituents. The overlying beds of grit and arkose, mingled with occasional beds of conglomerate, are chiefly composed of rhyolite debris. Any theory of origin, to be fully satisfactory, must explain where these three kinds of material came from, and why they were carried in and laid down in the order mentioned.

The sediments of the Midlothian area consist of granite conglomerate at the base, overlain in turn by greenstone conglomerate and by arkose with occasional beds of rhyolite conglomerate. The total thickness of the conglomerates is apparently 2,000 to 3,000 feet around Fault lake, thinning to about 300 feet both in the eastern and western ends of the area. The thickness of the arkoses and grits appears to be at least 6,000 feet. In the Bannockburn area, only 6 miles from Fault lake, the basal granite conglomerate is 30 to 50 feet in thickness, the greenstone conglomerate is altogether lacking, and the overlying beds are not coarse grits but fine greywacke passing upward into slate. The total thickness of the formation is also very much less. Any theory of origin must account for these remarkable changes in the character and thickness of the sediments within a distance of a few miles.

The nature of the Kiask sediments indicates that they were accumulated rapidly and did not undergo much wear between their source and the place of their deposition; and that the rocks of whose fragments they are composed underwent rapid mechanical disintegration unaccompanied by chemical decomposition through the ordinary processes of weathering. Rapid accumulation is indicated by the angularity of the pebbles in the conglomerate, by the characteristic occurrence of sharp angles and chisel edges in the fragments of the grits and arkoses, and probably by the unbedded nature of the greywacke of the Bannockburn area. Lack of bedding in muds is characteristic of deposits that have accumulated either very rapidly or else in very shallow water. Rapid disintegration of the parent rocks is indicated by the uniform arkose-like composition of the sediments from the coarsest to the finest. When disintegration occurs under normal present day conditions, vegetation keeps the detritus from being washed away until the action of the weather has rotted the rocks more or less completely, with formation of such products as kaolin, chlorite, iron oxides, and quartz. These are mechanically separated during erosion, and are deposited in separate beds as sandstones and clays, whereas the lime and magnesia, which are carried off as soluble bicarbonates, are precipitated by various means as limestones. In the Kiask series the rocks are composed of the fresh or slightly altered detritus of the parent rocks, instead of being sandstones, clays, and limestones; so that the disintegration of the original rocks must have been closely followed by the removal of the disintegrated material. We can infer, therefore, with some certainty, that vegetation was lacking and, since a low lying land would not furnish coarse detritus rapidly, that the area from which the sediments came was hilly, perhaps mountainous.

We have, therefore, a series showing evidences of rapid accumulation without much weathering of the original rocks; with wide variations in apparent thickness within short distances; and with the peculiarity of being composed of granite debris at the base, of greenstone debris in the middle, and of rhyolite debris in the upper horizons. The first quality, as indicated in the preceding paragraph, implies a hilly or mountainous country, bare of vegetation, supplying the sediments. The variations in thickness are characteristic of deposits formed by torrential streams descending from a mountainous country. A mountainous hinterland is thus implied from two lines of evidence. Incidentally, deposits formed by torrential streams frequently possess an original depositional dip. If this was the case in the Midlothian area, the real thickness of the sediments will be much less than the apparent thickness, which is calculated on the assumption that the beds were originally laid down flat. The third quality mentioned above, that of the peculiar separation of the rock materials composing the Kiask sediments, is more difficult to explain. The explanation may be, perhaps, that a gradual uplift of the hinterland was going on, exposing new rocks to erosion.

The great thickness of the conglomerate beds around Fault lake, and the rapid decrease in the thickness to the east and west, suggest that the position occupied now by the lake must have been originally the mouth of the torrential stream which carried down the sediments. As the heavy beds of conglomerate are on the south side of the Midlothian area, the stream would appear to have flowed from the south and the supposed range of mountains from which it brought the sediments would also, therefore, lie to the south.

Under this theory the Kiask series is a series of localized origin, since the materials which composed it must have come from the basin probably of a single large stream. If it is of the same age as any of the other ancient series of sediments found in northern Ontario, such as the Timiskaming of Kirkland lake—a relation still unproved—the two need not have the same or a similar composition, but the composition will vary with the variations of the rocks in the different river basins.

MINERALIZATION.

As the Kiask series is probably older than the granite intrusives of the region, there appears to be no reason that it should not be mineralized in places. However, the writer has not observed any notable mineralization at any point, in fact the rocks are so massive and unaltered that at sight they create an unfavourable impression on the prospector's mind. The only tendency observed toward mineralization was on Elizabeth lake, where there are a number of veinlets of quartz. At some other places an impression of mineralization is given by the rusted appearance of the rocks, but upon examination this is seen to be due to the weathering of secondary iron carbonate.

AGE.

The Kiask series lies on the eroded surface of the rhyolites, the youngest rocks of the volcanic series, and is, therefore, younger than the rhyolites. As shown on page 32 this series is probably intruded by, and, therefore, older than, the granites. In the discussion of the age of the granites (page 33) it is shown that the Kiask series was folded, probably elevated to form a mountain range, and eroded to base level before the Cobalt series was deposited on it. The Kiask series is, therefore, very much older than the Cobalt series.

GRANITES.

Distribution.

Granite forms a considerable proportion of the rocks in the eastern part of Matachewan area, but only a small proportion in the western. A small mass is found near the centre of Hincks township, underlying a portion of the Cobalt band there. Dykes, probably offshoots from this mass, are found here and there to the southeast. Another mass of granite is found in the western part of Cleaver township, a third in the eastern part of McNeil near Whitefish lake, and a fourth crosses the Powell-Bannockburn boundary. In the eastern part of the area the condition is different. A large part of Kimberley and Yarrow townships is underlain by granite; another mass underlies about 30 square miles of the eastern part of Cairo and Alma, and a third, good-sized body is found in the northern part of Baden township, extending eastward into Alma. In addition there are several small bodies in the southern part of Powell township in the neighbourhood of the gold discoveries.

LITHOLOGICAL CHARACTERS.

There is a considerable variation in the composition of these various granitic intrusives, together with certain similarities. W. H. Collins,[1] in describing the granites of the Gowganda area to the south, has divided them into two main classes according to whether the ferromagnesian mineral present is biotite or hornblende. On this basis of classification all the granites of Matachewan area will fall into one class, as all are hornblende granites with syenitic phases. The criterion, however, is a poor one, since the presence of mica or of hornblende seems to have been a function of the original wetness or dryness of the magma,[2] and micaceous phases or hornblendic phases might, therefore, occur in different parts of the same batholith. Certain writers have used gneissic textures as a criterion for the separation of granites, with the implication that those bodies possessing the gneissic textures must be older than bodies without such textures. This, however, would be true only when the gneissic textures were produced by regional deformation acting on a mass of solid granite. The gneissic textures commonly found in granites have been clearly shown[3] to be not the result of deformation, but merely flow textures developed during the solidification of the granite mass, so that they may have developed in any intrusive in which movement occurred under proper conditions of viscosity, and cannot, therefore, be taken as a criterion of age. A. G. Burrows[4] has recently advanced the idea that strong resemblances in chemical composition are indicative of identity of intrusion, and has used the idea to correlate two bodies both of which possess unusually high percentages of potash. The conception appears to be a good one, its main objection in practice being that it requires a slow and expensive chemical analysis before any conclusions can be drawn. The converse of the proposition cannot, however, be accepted as true, namely, that granites of unlike composition are of different ages or even come from different sources. The analyses of the granites of the Haliburton area, which Adams and Barlow by a careful detailed study have shown to be of a single age and source, show rather wide variations in their chemical compositions.[5] However, Burrow's suggestion of using some chance excess of one of the rarer constituents—in this case potash—as a criterion for comparison, is a good one, and is the best means yet offered of classifying and grouping granites by internal evidence. It is along the lines suggested and used by Derby, who found that he could classify his granites with a high degree of certainty by measuring the relative proportions of their heavy residual minerals, the garnet, zircon, titanite, etc.

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[1] Geol. Surv., Can., Mem. 33, 1913, p. 43.
[2] Bowen, N. L., Jour. of Geol., supplement to vol. 23, No. 8, 1915, pp. 45–46.
[3] Adams, F. D., and Barlow, A. E., Geol. Surv., Can., Mem. 6, 1910, pp. 73–87.
[4] Burrows, A. G., Rept. Ont. Bureau of Mines, 27, 1918, pp. 225–227.
[5] Adams and Barlow, Geol. Surv., Can., Mem. 6, 1910, pp. 52–62.

Up to the present time, however, no satisfactory means of separating granites in northern Ontario and Quebec has yet been found, except where there are intermediate sedimentary horizons which may be used for the purpose. Where we find a granite clearly lying beneath a sedimentary formation, such as a conglomerate, and yielding fragments to it, and a second granite cutting the same formation, we may safely classify the two as of separate ages; otherwise separation is unsafe.

There are no grounds for a separation of the granites of Matachewan area. All that is known of any of them is that they intrude the older volcanic complex and are overlaid by the Cobalt series. They are all, therefore, assumed to be of the one age until proof shall be adduced for their separation.

Nearly all of the granites of the district are rather syenitic types, containing small amounts rarely more than 2 to 3 per cent of free quartz. The quartz content is variable, however, within the same mass, so that in places a specimen will be quite quartzose, in other places there will be none visible to the eye. The ferromagnesian mineral present is commonly hornblende, except in the case of the gold-bearing intrusives in Powell township, in which it is mica. The ferromagnesian content is invariably small. Feldspar forms 90 to 95 per cent of almost any specimen of granite. There is very commonly a tendency to the formation of porphyritic phases, with bright reddish feldspars up to one-half inch diameter embedded in a paler coloured, finer-grained groundmass. Burrows has pointed out that the granite mass on the east side of Cairo and Alma townships is very high in potash, as are also the small masses in Powell township around the gold deposits. It is suspected from the similarities in general appearance and microscopic structure, that other bodies are of much the same type, particularly those in the southern part of Yarrow township, in western Powell, crossing into Bannockburn, and in the middle of Hincks. As the potash content would indicate, the granites are true granites, the feldspars being orthoclase and albite with the orthoclase in excess, and not granodiorites with much lime-soda feldspar.

STRUCTURAL RELATIONS.

Internal.

In general the granites are perfectly massive. One good-sized dyke of white granite, found in the southwest corner of Montrose township, was badly sheared and quite schistose. This dyke will be referred to later. The remainder of the granites, however, even when in the form of small dykes, show no shearing whatever. Gneissic textures are occasionally present, particularly toward the edges of the masses. These are primary flow textures, formed by the movement of the granite magma while becoming viscous. The viscosity is producible in two ways; by ordinary cooling, in which case the gnessic bands do not differ in composition from the rest of the magma, and the gneissic texture consists only in a parallel arrangement of the micas or hornblendes of the granite; and by digestion of stoped-off lumps of older rocks, such as the older volcanics, in which case the gneissic texture is rendered more prominent by the presence of the products of digestion, which vary from lenses of basic rock softened and stretched, to patches of highly micaceous and hornblendic rock which represent a mixture of digested basic rock and granite. The general lack of large amounts of such textures in the Matachewan granites indicates that they have not been of a composition to digest the older rocks readily. This may have been due to a lack of water in the magma, as evidenced by the fact that the common ferromagnesian mineral is hornblende instead of mica. A comparatively dry magma would presumably have been more viscous and, therefore, less active both physically and chemically in breaking up the rocks intruded.

External.

Relations to Older Formations. The granites intrude all the rocks of the old volcanic series. Proofs of intrusion are easy to obtain, as the volcanics may be found broken off by the granite at the contact and forming contact breccias which often form bands one-quarter to one mile in width. Dykes of the granite break through the volcanics, particularly in Hincks and Powell townships, and show chilled edges against the older rocks.

The relation of the granite to the Kiask series is not to be directly seen, as the two rocks are nowhere in contact, but it may be inferred. The Kiask series has been strongly folded, whereas the granites nowhere show any signs of having been subjected to folding. The granites are prevailingly pink and red, but pink and red granite debris is found in the Kiask conglomerate in one place only. These granites could not, therefore, have been exposed when the Kiask was being laid down. A single veinlet of pegmatite was found cutting the Kiask series on Elizabeth lake, and as such must have had its origin in some larger body of granitic magma in the vicinity or not far below. For these three reasons the granites are concluded to be younger than the Kiask series.

A possible exception is the granite dyke found in the southwest corner of Montrose. This dyke crosses the south end of the portage between Junction lake and Hutt lake, with a strike nearly east and west. As previously mentioned, it is highly schistose, and rather badly altered. It is rather an acid white granite, like the pebbles in the Kiask conglomerate, and on account of its appearance and metamorphism it is considered to be possibly of pre-Kiask age.

Relations to Younger Formations. The granites are intruded by a series of basic dykes, of the composition of a diabase, many of which are characterized by large porphyritic crystals of labradorite feldspar. Sufficient evidence of intrusion is furnished by the strongly chilled edges of the dykes.

Both dykes and granite are overlain unconformably by the Cobalt series. The basal conglomerate of the Cobalt series may be seen in places lying directly on the eroded surface of the granites or the dykes, and is largely made up of the debris of the reddish syenitic granites of the district.

AGE.

The granites of the region, with the exception of the schistose dyke described above, are thus younger than the Kiask series, but older than the

Cobalt series and also older than certain diabase dykes. Further considerations fix the age somewhat more closely.

The deposition of the Kiask series was followed by folding movements of such intensity as to force the strata into almost vertical positions. Mountain-building always accompanies close folding, so far as known, so that it may reasonably be assumed to have occurred here. Batholithic intrusion, where it occurs, appears also to accompany folding movements or to follow them closely. The granitic intrusions of Matachewan area, therefore, probably accompanied or closely followed the folding of the Kiask series.

The Cobalt series was laid down on a peneplained surface of much the same contour as the present surface, as has been generally recognized by all geologists working in northern Ontario and Quebec.[1] Its base rests in turn on the ancient volcanics, the Kiask series, the granites, and the diabase dykes that intrude the granites. The reduction of the mountainous area to base level, exposing and eroding the granite batholiths, must have required a very long time.

The age of the granites of Matachewan area, on the above considerations, is, therefore, placed as slightly later than that of the Kiask series, and long enough before the deposition of the Cobalt series for a mountainous area to be reduced to base level.

DIABASE DYKES.

An interesting series of diabase dykes has been found in Matachewan area, occupying a place in the geologic column hitherto unfilled in this region, between the granite intrusives and the Cobalt series. The dykes are coarse quartz diabase, and in places are characterized by the presence of very numerous phenocrysts of labradorite feldspar sometimes 2 or 3 inches in diameter. The feldspars have the waxy appearance acquired through sericitization and kaolinization. Otherwise the diabases appear nearly as fresh as the Nipissing diabase. They cut the granites in the western part of Yarrow township, and, according to Burrows, in the eastern part of Cairo township. Two or three were observed cutting the Kiask series on Midlothian lake. They are especially numerous around the gold deposits in Powell township, where they cut the small porphyry intrusives. On the Davidson claims in Powell township the Cobalt conglomerate may be seen lying on the eroded surface of one of the dykes and including boulders of it.

The age of the dykes, as shown by the above facts, is later than the granites and earlier than the Cobalt series. The same considerations as were advanced in the case of the granites may be applied to the diabases, to show that the dykes are only a little later than the granites they intrude. In fact, the association of the diabase dykes with the granite masses strongly suggests that there may be a magmatic connexion between the two.

COBALT SERIES.

The Cobalt series has been studied by W. H. Collins, and fully described by him in recent publications of the Geological Survey of

[1] Collins, W. H., Geol. Surv., Can., Mem. 33, p. 51; Mem. 95, p. 74.
Wilson, M. E., Geol. Surv., Can., Mem. 39, p. 20.
This memoir, p. 37.

Canada.[1] The writer will, therefore, not enter on an extended description of the Cobalt series in Matachewan area.

Collins has divided the Cobalt series into the Gowganda and the Lorrain formations. The Gowganda formation includes the heavy basal conglomerate, the greywacke, arkose, and slate conglomerate of the series, and the Lorrain formation includes the Lorrain quartzite principally. The Lorrain formation has not been found in Matachewan area.

DISTRIBUTION.

The Cobalt series is found mainly in the southern part of Matachewan area. Its northern boundary runs from the southwest corner of Midlothian township diagonally across to about mile 4 on the east line and into Doon, then north for about 6 miles into the middle of Bannockburn township; it then turns southwest to Montreal river near the southeast corner of Powell township, and is bounded by the east branch of the Montreal as far as the south boundary of the map. Another area occurs in the southeastern part of Kimberley township.

From the main mass of Cobalt series outlined above two long narrow tongues branch off in a direction north 15 degrees west. The smaller tongue starts from the shoulder in Bannockburn township and extends north into Argyle township. It is about 4 miles long and averages only about one-quarter of a mile wide. The larger tongue branches off from the main mass in the eastern part of Midlothian township, and extends northward beyond the northern boundary of the map-area. Within the map-area it is about 18 miles in length, and varies in width from about 3 miles to somewhat less than one-half mile. Like all the Cobalt series these bands stand topographically high and form ridges which are among the most prominent topographic features of the region. Mount Sinclair, one of the highest points, lies toward the south end of the western ridge.

STRUCTURAL RELATIONS.

Internal.

Folding. The Cobalt series in Matachewan district has been gently folded, and the strata thrown into open folds with dips rarely exceeding 20 degrees. The main axes of folding strike north 15 degrees west in the western part of the district to nearly north in the eastern part. These axes have controlled the trend of the valleys developed by erosional processes wherever the Cobalt series is or has been developed. In general, valleys are developed along the anticlines, and the synclinal remnants form the hills and ridges.

Faulting. Faults of post-Cobalt age may be detected in several places. Most of them are strike faults and as such may have developed at the same time as the folding. In other places, however, the faults are not strike faults, and appear to be lines of weakness developed during pre-Cobalt time, along which further movement took place after the Cobalt was laid down. In one or two of them the scarps are so steep that it is

[1] Geol. Surv., Can., Mem. 95, 1917, pp. 63–84.
Geol. Surv., Can., Mus. Bull. No. 8, 1914.

difficult to avoid the conclusion that there has been movement along them in recent times.

The most prominent faults are those bounding the long ridge of Cobalt series that runs northward through Midlothian, Montrose, Hincks, Cleaver townships, and beyond the boundary of the map. This ridge is a graben or downfaulted block. The faults are of the hinge type. There is little or no displacement at the south end of the ridge, whereas near the northern boundary of Montrose the displacement is sufficient, on the east side, to have brought the slates of the Gowganda formation in direct contact with rhyolite. The displacement appears to decrease again toward the north, and in Cleaver township the basal boulder conglomerates are again in contact with the older rocks on the east side of the ridge. Direct evidence indicative of faulting was obtained at the point where Nighthawk creek crosses the narrow part of the ridge in the middle of Hincks township. There the strata along the water side of the ridge, which within a few chains lie almost flat, are tilted up to a dip of about 45 degrees east, with a north strike. Also on Maher lake, in the northeast corner of Midlothian township, a narrow belt of the Huronian strata are seen to be tilted up to about 35 degrees west with a strike north 5 degrees east, whereas the Cobalt series on each side are flat and undisturbed. This disturbance must be due to faulting, and as it is localized on the southward projection of the boundary of the band to the east of Sinclair lake, it would appear reasonable to consider it as the commencement of the eastern boundary fault.

There may also have been some faulting along the northern part of the smaller branch of the Cobalt series that projects through Bannockburn into Argyle township. The normal boulder conglomerate is found at the base of the ridge in contact with the greenstones, but there is no great thickness of it visible, only 30 to 50 feet, whereas on Mistinikon lake to the east and in Midlothian to the southwest the boulder conglomerate is very thick, 300 feet at least. Farther to the south, on the Bannockburn-Doon line, the slates of the Cobalt series appear to be in contact with the Kiask series. It is very possible, therefore, that there may be a downfault of the Cobalt series along this line also.

Collins has suggested that the line of Mistinikon lake is a fault, and has cited suggestive evidence in favour of this hypothesis.[1] The writer has obtained evidence strongly supporting this hypothesis, though modifying it somewhat. Mistinikon lake has been described as a zone of intense faulting in pre-Cobalt time. The evidence at hand goes to show that after the Cobalt series was deposited, further slight movement occurred along the old planes of weakness, jointing the Cobalt series so as to allow of rapid erosion along the fault planes, but without any great displacement of the rocks on either side.

The southern end of the lake was the part seen and studied by Collins. To quote from the report cited above: "The lake is a narrow, straight body whose shores rise often precipitously. The western shore is entirely Huronian, and the eastern entirely Laurentian or Keewatin. The contrast in this respect is particularly evident in a narrow ravine that extends southward from the little bay in the southeastern angle of the lake, for although the ravine is only a few chains in width at the bottom, the sides,

[1] Geol. Surv., Can., Mem. 33, 1913, p. 16.

consisting of gneiss on the east and flat-lying greywacke on the west, are 150 feet high. It is not easy to explain either the cleft or the sudden disappearance of the Laurentian gneiss west of it, except by considering it to coincide with a fault plane."

About 4½ miles to the north of the bay mentioned by Collins, the writer found the large fault described on page 18 cutting cherty tuffs. At its south end it passes out into the lake, apparently parallel with the axis of the lake, and on the north it swings to the northeast. At the point where the 90-chain portage leaves Mistinikon lake it is again visible, striking somewhat north of east, and apparently following a large valley. It could not be traced farther by direct means, but it is believed to continue eastwards into the lake at the other end of the 90-chain portage. This lake, whose trend is directly athwart the strike of the Cobalt series, lies in a narrow cleft, the sides of which rise almost perpendicularly for 100 to 150 feet. Such a cleft cannot be explained except by faulting, probably of comparatively recent date.

On the west shore of the narrows about half a mile north of Bell island another large fault cuts the volcanics (see page 18). As the Cobalt series to the south is not sheared, it is clear that the main faulting is of pre-Cobalt age. The channel on the west side of Bell island, however, is a narrow cleft with high walls vertical in places, and is best explained by recent movement along the old fault plane. Other faults, as shown on the map, are to be seen on the shores of Mistinikon lake to the north of this. Most of them have a strike in a general northward direction. It is clear, therefore, that the lake has been developed along the locus of an ancient fault or faults, established before the Cobalt series was deposited. It seems probable that stresses have been relieved in recent time by slight movement along these old zones of weakness; and it does not seem unlikely, therefore, that such slight movements may have taken place more than once since the deposition of the Cobalt series, with an accumulating displacement of the rocks on either side sufficient to satisfy the facts as described by Collins.

Relations to Older Formations. A study of the maps of the Matachewan and Gowganda areas shows the profound unconformity with which the Cobalt series rests on the older formations of the region. The base of the series rests in turn on the ancient deformed basalts and rhyolites, on the deformed Kiask series, and upon the granites which intrude them. No further proof of unconformity is necessary. A further examination of the map brings out the fact that there is rarely, if ever, any marked bend in the boundary of the Cobalt series at the lines of contact of one of the older formations with another, as for example where a granite is in contact with a greenstone. This indicates that the surface on which the Cobalt was laid down was a peneplained one, since otherwise the harder rock would have stood up as a ridge, on which the Cobalt series would be originally thinner than on the softer rock. The mapping would show this condition by a curve in the Cobalt contact at the crossing of the older contacts, as in Figure 1. The lack of such curves indicates the original peneplained nature of the surface. Peneplanation is also indicated by the numerous irregularly-shaped erosion remnants of Cobalt series, found especially in the Gowganda map-area to the south. As there is very little relief in the region, it is evident that over large areas it has not taken a great depth of erosion to remove the Cobalt series from the old surface, so that the Cobalt series forms merely a comparatively thin scale on it. The old surface cannot, therefore, be far below the present peneplained surface, and accordingly was a peneplain of much the same contour as at present.

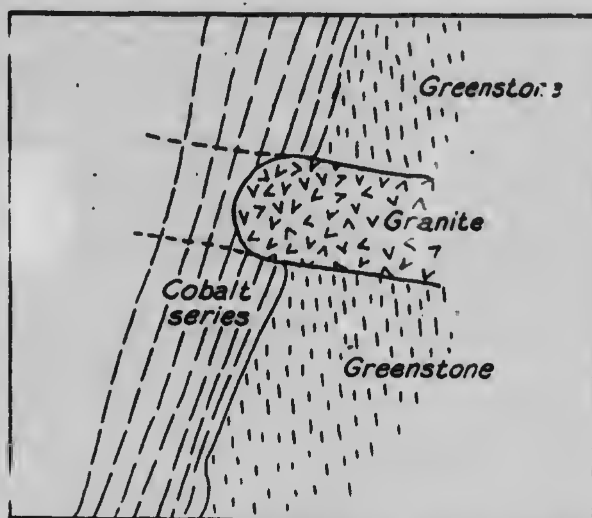

Figure 1. Diagrammatical representation of the contact of a younger sedimentary series, such as the Cobalt series, with an older unpeneplained surface. The granite is supposed to have stood up from the greenstones as a ridge.

Relations to Younger Formations. The only younger formation of the region is the Nipissing diabase. In the Gowganda area to the south the diabase intruded the Cobalt series in large dykes and sills. None was found in Matachewan area, cutting the Cobalt series.

NIPISSING DIABASE.

As mentioned, no diabase was found in Matachewan area cutting the Cobalt series, and, therefore, definitely determinable as the Nipissing diabase. Dykes of quartz diabase are occasionally found cutting the volcanics, Kiask series, and granites, however, and some of these may be the Nipissing diabase. Such dykes are very numerous in Kimberley township, and these are very probably Nipissing, and related to the large sill of diabase in the southern part of the township. For full description of the diabase the reader is referred to the reports of W. H. Collins.[1]

[1] Geol. Surv., Can., Mem. 33, 1913, pp. 59–93; Mem. 95, 1917, pp. 84–101.

SUPERFICIAL DEPOSITS.

Matachewan district in the main is rather heavily soil-covered. The superficial deposits fall into four general classes, ground moraine, terminal moraines, outwash plains, and glacial or post-glacial lake beds and stream deposits.

An area of ground moraine, or boulder clay, occurs in the northern part of Yarrow and the adjacent southern part of Powell townships. The high ground underlain by the Cobalt series in Bannockburn and Doon townships is covered with a thin sheet of ground moraine. Another small area lies in McNeil township to the south of Whitefish lake. As the boulder clay is in general a richer soil than the terminal moraines or the outwash plains, its recognition is assisted by the dense growth of vegetation which it supports, in contrast to the sparser growths on the other soils. The forest contains a large proportion of deciduous trees, especially birch, and in addition there is an exceedingly thick undergrowth of ground maple, hazel, and alder.

Terminal moraines are scattered thickly over the area. They are not commonly found on top of the high Huronian areas, but in some cases heavy accumulations of drift have been heaped against northward facing slopes. Such accumulation has occurred against the face of the Huronian mass in Bannockburn and Powell townships. This would seem to indicate that during the decline of glaciation, when the ice was thinning and depositing heavy moraines it did not override these elevations, which are only 300 to 500 feet above the general level. Further evidence to the same effect was obtained by mapping the morainic belts in a few places where it could be done without too much expenditure of time. Although glacial movement in the district was in a direction about 10 degrees east of south, as shown by the direction of striæ and of individual moraines and eskers, the belts of moraines on the west side of the Huronian ridge in the western part of the district all have a northeast trend, as if they were lateral to a lobe of ice pushing down into the valley to the west of the ridge but not mounting over it. Similarly the moraines to the east of the Huronian ridge have a northwest trend. The wide valley of Duncan creek extending north into Bannockburn township is filled with moraine toward the northern end and outwash sands and gravels in the southern part, again as if followed by a tongue of ice. The principal morainic belt runs slightly east of north through the chain of lakes from Kame lake in Doon township to Argyle lake. Another morainic belt runs slightly south of east across the southeast corner of Argyle and into the northeastern part of Powell. This belt appears from fragmentary data to have a westward extension through Hincks along the divide between the two branches of Whitefish creek, connecting with the belt that crosses the narrow place in the Huronian band in the centre of the township. Its extension is supposed to indicate the normal position of the ice front where not influenced by the presence of Huronian ridges.

Between these morainic belts, which represent stands of the ice border for longer or shorter periods of time, sand and gravel plains are found, composed of the materials carried out by waters flowing from the melting edge of the ice sheet. These outwash plains are frequently pitted, the holes marking the spots where large blocks of ice were buried in the outwash and later melted. Pl of this type are especially prominent in the southern parts of Cleaver and McNeil townships; the greater part of Argyle township is covered with outwash. Smaller areas of the same type are found in the southeastern part of Hincks, the western half of Montrose, and the valley of Duncan creek.

Glacial and post-glacial lake and stream deposits are comparatively small in relative amount. A flat swamp with an occasional pond covers 8 or 9 square miles in the northwest corner of Argyle and adjacent parts of McNeil and Hincks townships. It is clearly a glacial or recent lake now almost entirely filled in. This is the largest area of the kin found within the map-area, but there are several smaller ones to be seen at different places. The district is a good one in which to see the process of lake-filling in all its stages. Austen lake and Seven Inch lake, for instance, are basins filled with soft mud covered only by a few inches of water in many places. The shores of such lakes are frequently bordered by a belt of marsh plants and moss growing on the surface of this soft mud, forming a quaking bog dangerous and in places impossible to cross. The width of this belt increases year by year, and at the same time the solidity of the older parts increases with annual increments of growth, until the lake is reduced to a small pond or two in the midst of a ossy, wet plain. This stage is well shown on a former lake in south stern Cleaver on the granite boundary nearly east of mile 98 on Niven's line. After this stage is reached trees commence to root in the muskeg, chiefly stunted tamarack and black spruce, and gradually spread until a typical muskeg, covered with a moderately thick growth of small to medium sized trees, is formed. A large muskeg of this type occurs in northeastern Argyle.

Stream deposits are of very small relative importance. They are mainly post-glacial terraces formed as the various streams of the area cut down through the drift deposits filling the valleys. A number of them, notably those on Montreal river between Elk lake and Indian chute, are probably of glacial age. They are of such size and elevation above the present stream that they were clearly formed by a stream of much larger volume than the present, probably, therefore, when the natural drainage was augmented by the waters of the melting glaciers and by drainage from areas which after the retreat of the ice took other channels. In this connexion it is notable that such stream terraces are found mainly in the valleys of south-flowing streams such as Montreal river and Duncan creek, but are not marked, within Matachewan area at least, on the streams flowing north, such as Whitefish and Nighthawk creeks.

ECONOMIC GEOLOGY.

ASBESTOS.

Asbestos in small veins and stringers has been observed at several places within the map-area, more particularly in the western part. It occurs in masses of basic gabbro and peridotite, which have been altered to serpentine. These bodies, where found, have been noted on the map. Only one deposit of possible commercial importance has as yet been discovered, on the south shore of Rahn lake in the western part of Bannockburn township. At this place Mr. George Rahn, of Haileybury, has taken up a group of nineteen claims. He is said to have discovered asbestos at a number of places on these claims, but as he was unfortunately not on the claims at the time of any of the writer's visits, the statements were not verified. The asbestos seen by the writer is in a lenticular body of peridotite on the south shore of the lake, which strikes north 40 degrees west and dips steeply to the southwest. The body was traced for a distance of about 1,700 feet northwest, where it passes under a covering of swamp and drift. At the southeast end it appears to pinch out. A shallow pit has been dug at the southeast end of the peridotite body, at its contact with the rhyolite which forms the country rock. The peridotite, here highly serpentinized, is filled with veinlets of asbestos up to one-quarter inch in width, over a width of 5 or 6 feet. The formation of the asbestos seems to be genetically connected with a small boundary fault, which has sheared the serpentinized peridotite, obliterating the remains of all original textures and forming a featureless serpentine highly slickensided. At a distance from the fault plane the serpentinized peridotite retains its original granular texture, and asbestos veinlets are not present in it. An unusual feature is present at this place, which was not observed elsewhere. The characteristic olive green, translucent serpentine is filled with well rounded masses of all sizes from that of a bean up to boulders a foot in diameter of black, massive serpentine. These boulders, which are always surrounded by a thin coating of asbestos fibres, give the whole mass much the appearance of a serpentinized conglomerate, and at first sight plausibility is lent to this conception by the fact that at the top of the cliff only about 15 to 20 feet above there may be seen some erosion remnants and shreds of Kiask conglomerate lying on the eroded surface of the rhyolite. However, a careful examination of the place shows clearly that there is no connexion between the two; the explanation of the conglomeratic appearance of the serpentine seems to be that it is the result of brecciation of the peridotite by the faulting that took place.

At the extreme northwest end of the peridotite mass, on the portage out of Rahn lake, a little further stripping has been done along the southern contact with the rhyolite and there essentially the same conditions are observable as have been described, except for the lack of the supposed fault breccia. The veinlets of asbestos are somewhat wider, and specimens were obtained showing fibre an inch in length. The major part is, of course, less than this.

No attempt has been made to strip the south contact of the peridotite between these two points, so that it is not known whether there is a continuous band of asbestified rock along the south contact of the peridotite.

Specimens of the asbestos were submitted to R. Harvie of the Geological Survey, who has been working for some years in the Black Lake and Thetford districts, and were stated by him to be of first quality, although not as good as the best Black Lake asbestos. If development shows, therefore, that there is a sufficient supply of the material at Rahn lake to make mining profitable, only improved facilities of transportation will be necessary to make this field economically valuable.

FLUORITE, BARITE, AND IRON ORE.

Small deposits of fluorite, barite, and hematite are found in the eastern part of Matachewan area. These have not been examined by the writer. The following descriptions are from the report on the area by A. G. Burrows.

FLUORITE.

"Fluorite (fluorspar) has been found in small quantity in a number of quartz veins in Cairo and Alma townships, but none of the deposits examined is of commercial value. Owing to the widespread occurrence of the mineral, it is possible that prospecting might result in the finding of economic deposits. The mineral is of a deep purple colour, occurring in small masses in the quartz or in the wall rock adjacent to the veins. It is also present in the Biederman barite vein. One occurrence where the fluorite is in the quartz is on the Harvey claim, No. 18285, west of the road from Fox rapids north to the Craig claims. This vein is about 7 inches wide, strikes north 75 degrees east, and has been traced several hundred feet. Some pieces of fluorite, 2 inches across, were taken from the vein. All the showings of fluorite are in the syenite."

BARITE.

"Veins containing barite occur in several parts of the area. These are generally small, but two deposits have been found which would be of commercial value were they nearer railway transportation. These are the Biederman deposit in Cairo township, and a deposit near Yarrow lake in Yarrow township.

Biederman Claim.

The claim (15042) is situated on the west shore of Browning lake, in the north part of Cairo township. The country rock is a red syenite in which there is a barite vein with strike north 65 degrees west and dip 80 degrees north. The deposit can be observed about 100 feet from the shore of the lake where a shallow shaft has been sunk at a point where the vein has been concealed by drift to the east. Here there is a width of 15 feet, and the barite can be traced westerly for 100 feet, decreasing to a width of 7 feet. Beyond this there is drift followed by an exposure of barite about 30 feet in length and 3 feet wide at the east end and 2 feet wide at the west end. The barite is for the most part white in colour and of good quality. At the shaft there are minor quantities of zinc blende, galena, and specularite, and a little fluorite, as impurities. The deposit also contains at this point some large inclusions of syenite. A sample across 8 feet, on analysis, contains 90·50 per cent barium sulphate.

Yarrow Deposit.

This deposit occurs along the creek which flows from Yarrow lake to Mistinikon lake. The rocks are slate and quartzite of the Cobalt series, but they are largely concealed by a deep covering of drift along the creek. The deposit was discovered in the bed of the creek, and attempts have been made to open it up by diverting the water by means of a small dam. Two shallow pits were sunk in the bed of the creek on the barite, which is in two veins 5 and 6 feet wide respectively, separated by a band of quartzite. As the deposit was noted only in the creek bottom its length has not been determined, but owing to its width it is probable that it also has considerable length. This deposit, like the Biederman, will probably be of commercial value at a future time."

IRON ORE.

"The La Brosse claims, JS 65 and JS 66, situated in Yarrow township, a short distance west of the east branch of Montreal river, were examined by P. E. Hopkins in August, 1914, and the following account is from his manuscript:

The iron ore, which consists of hematite in reniform structure and also the more highly crystallized specular variety, occurs in a quartz vein that strikes north 72 degrees east, and dips about vertically. This vein can be traced across two claims, and varies from 5 to 30 feet in width. The iron ore occurs in isolated masses and stringers in the quartz, and in places is brecciated. On the east part of JS 66 is located the largest body of clean iron ore. This ore on the surface is 60 feet long and 6 feet wide at its greatest width, being in the form of a lens. Another lens is 25 feet in length. More work may prove the bodies to be larger, as the vein is partly drift-covered. No kidney ore was observed in other parts of the vein where exposed, but small quantities of specular ore occur sparingly in the vein.

Iron ore was observed in small quartz veins in the vicinity of Yarrow township. The country rock that encloses the veins is conglomerate and quartzite of the Cobalt series that dips gently to the east at 10 to 15 degrees."

GOLD.

Gold discoveries have been made at several points in Powell, Cairo, Alma, and Baden townships. The less important of these were not examined by the writer, as they were studied and described by A. G. Burrows of the Ontario Bureau of Mines in 1917. His descriptions are published in volume XXVII of the Bureau of Mines reports. A careful examination was made, however, of the Davidson and Otisse discoveries in Powell township.

The deposits occur on the north side of Davidson creek, about halfway between the east and west branches of Montreal river. Davidson's discovery was made in a small mass of red syenite porphyry and that of Otisse was in the ancient volcanics close to a similar mass of porphyry. Their claims, up to the time of writing, remain the only ones on which important bodies of ore have been proved.

Development work went on vigorously on the Davidson claims during the summer of 1917. A large part of the area was cleared of timber and underbrush, three substantial buildings were erected, and sufficient trenching was done to outline pretty well the location and extent of the mineralized area. The property was then carefully sampled by channelling in the bedrock along the bottoms of the trenches. Although promising results were obtained, no further development work has since been done.

Mr. Otisse and his brother carried on the development of their claims during the summer of 1917, and about the end of the year sold three of their claims, Nos. 5379, 5380, 5402, to the Colorado Ontario Development Company. This company proceeded to develop them systematically during the summer of 1918. A road was built from Montreal river to the claims, and five substantial log buildings were put up. The greater part of claims 5379 and 5380 was cleared, and trenches were dug 100 feet apart so as to crosscut the strike of the rocks. Additional trenches were put in between the earlier ones where indications of ore seemed sufficient to justify doing so. In August, when the surface exploration was well advanced, diamond drilling was begun to determine the underground extension of the ore-bodies. The result of the exploration has been the discovery of a great number of ore-bodies of all sizes and grades of richness. Most of them are small, but two or three are of sufficient size and grade to warrant further exploration. The diamond drilling, which was continued until the end of October, is said to have opened up a considerable body of good ore somewhat below the 100-foot level. The company was reorganized early in 1919 under the name of the Matachewan Gold Mines, Limited, and it is said that work is to be continued and mining commenced at an early date.

The writer examined the Davidson claims in the autumn of 1917 and the property of the Colorado Ontario Development Company in the autumn of 1918. Although full information could not be obtained at that time, as the region is heavily drift-covered and development operations were not sufficiently advanced to give all the information required, still a number of facts were obtained which throw some light on the origin of the ores. These are set forth below.

ORIGIN OF THE MATACHEWAN GOLD ORES.

Introduction.

The present description is intended only as a preliminary statement of the more outstanding facts observable in the present undeveloped state of the discoveries. It is hoped that as mining operations are carried on evidence will be obtainable which will render possible a more accurate and extended description than can be here attempted.

The deposits to be described include those found on the Davidson claims, Nos. 5371, 5372, 5374, 5375, and 5383, and on the neighbouring claims of the Colorado Ontario Development Company, Nos. 5379, 5380, and 5402. Since the other claims in the vicinity were not highly developed at the time of examination, they were not examined closely and will not be described.

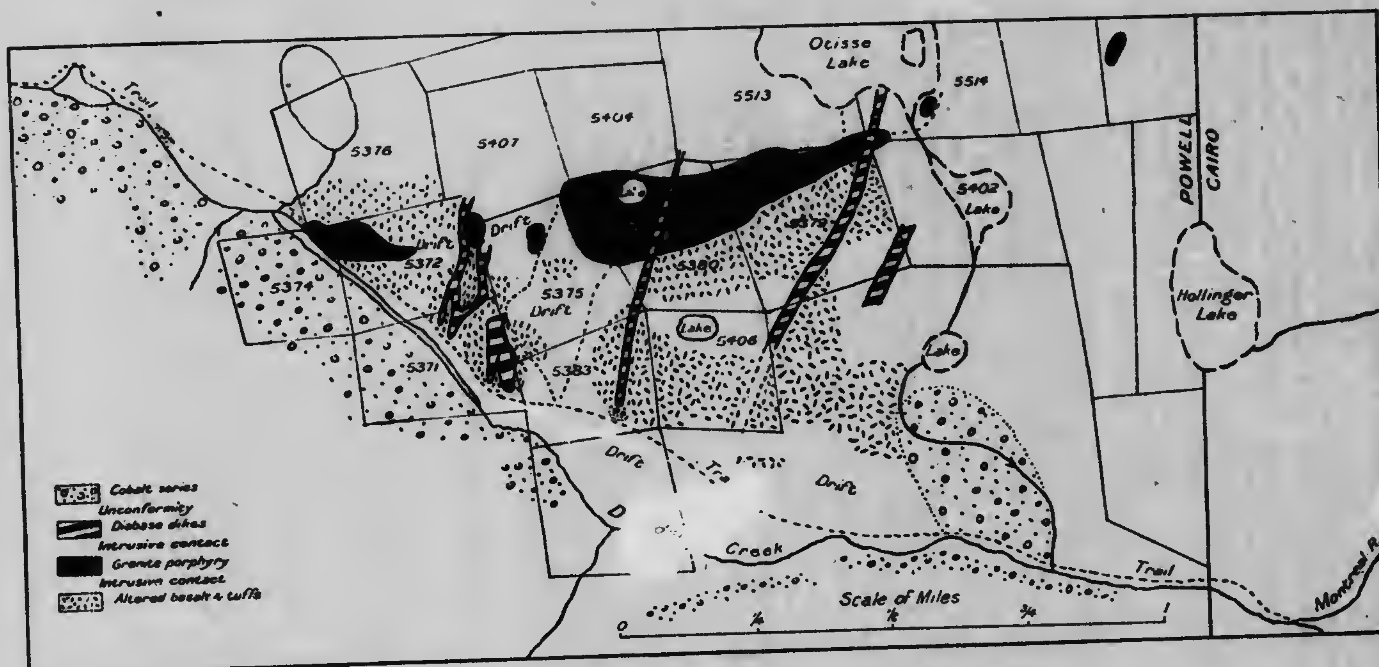

Figure 2. Geology of the gold deposits and vicinity, Pov.ell township.

Geology.

The location of the claims and geology is shown in Figure 2 on a somewhat larger scale than on the general map. The old volcanics are cut by a series of intrusions of granite porphyry of varying size, which are arranged along a line striking north 77 degrees east. This direction is approximately parallel to the axes of folding of the volcanics, and probably represents some zone of weakness developed during folding. Between the intrusions on the Davidson and Otisse claims there are several dykes of porphyry, too small to be shown on the map, which indicate that the two are connected, and suggest that they and perhaps the others also, are only the projecting knobs of a much larger body beneath. If the line drawn through the exposed bodies of porphyry be projected east, it passes through the Kirkland Lake area. The Kirkland Lake porphyry is identical in every respect with the Matachewan porphyry. The occurrence of all these bodies along a single axis suggests that they have all been intruded along a single line of weakness in the older rocks; and makes it seem possible that prospecting in the intervening areas of Holmes, Burt, and Eby townships may reveal further bodies of the gold-bearing porphyry.

The porphyry and the older rocks are cut by many large dykes of the basalt of pre-Cobalt age, some of which are indicated in Figure 2.

The Davidson discoveries were made on the westernmost body of porphyry, the Otisse discoveries in the schist adjacent to the larger body of intrusive. The ancient volcanics on the Davidson claim have been greatly contorted and schistified, but have not been mineralized and enriched. On the Otisse claims the volcanics are closely folded, but not greatly contorted or schistified. In the neighbourhood of the mass of intrusive porphyry they are cut by dykes of porphyry and pegmatite and enriched by solutions depositing auriferous pyrite. The porphyry mass on these claims is the largest yet discovered in the district, being somewhat over one-half mile in length and 500–600 feet in width. On its north side trenching has exposed an ancient schistose conglomerate on claim 5380. Claim No. 5402 is as yet undeveloped and was not closely examined as it is heavily drift-covered. The geology of the other two claims, as far as the development work enables it to be mapped, is shown in Figure 3. A more detailed description of the geology follows.

Volcanics. The rocks of the volcanic complex (Figure 3) include basalt on the south side of the claims, overlain by basalt tuff to the north, the latter in turn overlain by rhyolite tuff. The separation of these is difficult, so much so that it was found impossible to map separately the basalt and basalt tuff. The separation is of importance mainly for the determination of structure, as ore-bodies have been formed in all of them. Ore-bodies are largest and most numerous in the tuffs, but this may as well be ascribed to the fortuitous location of the tuffs nearest the intrusive as to a greater susceptibility of the tuffs to alteration and mineralization. The composition of these rocks will, therefore, not be minutely described, further than to say that they all consist entirely of secondary minerals. Chlorite and albite are the principal secondary minerals, with some free quartz in the tuffs, and accessory leucoxene, magnetite, pyrite, and epidote in the basalts. Calcite in greater or less amount, secondary to and replacing the minerals mentioned, is invariably present.

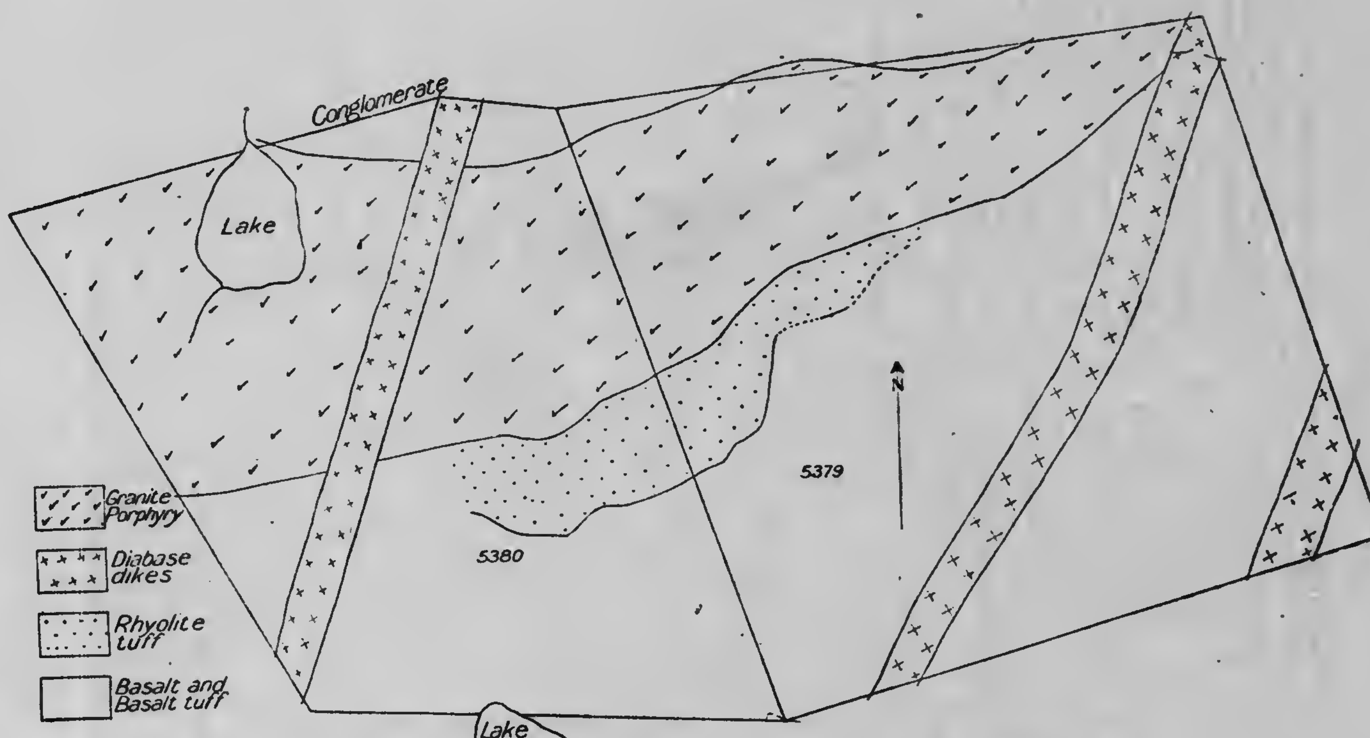

Figure 3. Geology of claims 5379 and 5380, as shown by work done up to October, 1918.

Porphyry. The porphyry which intrudes the ancient volcanics is a reddish, coarse-grained rock containing mainly orthoclase and albite, with some interstitial quartz and a little muscovite. Considerable secondary calcite is commonly present. Chlorite forms a minor constituent, and iron pyrite in small crystals is accessory. The term "porphyry" is something of a misnomer, as porphyritic textures are not usually to be seen. An analysis of the porphyry[1] shows: SiO_2 61·80%, Al_2O_3 18·86%, Fe_2O_3 2·95%, FeO 0·32%, CaO 0·63%, MgO 0·34%, K_2O 8·86%, Na_2O 3·19%, H_2O 0·54%, CO_2 0·84%, FeS_2 1·45%. Total 99·78%. A calculation of the mineral composition from this analysis gives: quartz 9·26 per cent, orthoclase 41·80 per cent, albite 27·13 per cent, muscovite 15·22 per cent, with small additional amounts of calcium and magnesium carbonates, pyrite, and iron oxides. However, no such proportion of muscovite as this is observable in the specimen, and it is possible that the amount of water in the rock has been underestimated. A somewhat larger percentage of water would permit of the 3·94 per cent of alumina present in excess of the requirements for determination of the alkalis as feldspar to be calculated as kaolin. The rock is remarkable for its high content of potash.

The surface of the porphyry is usually oxidized to some depth, and discoloured by limonite resulting from the oxidation of the pyrite present. In places the oxidized, broken, and shattered rock extends to a depth of 6 or 8 feet. This residual material is commonly rich in free gold, especially on the Davidson claims.

Pegmatites. In the neighbourhood of the porphyry mass on the Colorado-Ontario claims there are numerous dykes and veins intrusive into the older schists. They vary in size from dykes 10 feet or more in width down to small stringers. Their outcrops are lenticular in shape, their downward extension is not yet known. The larger usually conform in strike fairly closely to the strike of the rocks which enclose them, but the small veinlets have broken through the rocks in all directions. There is great variation in composition. The larger are in some cases true apophyses, identical in composition or almost so with the main mass of porphyry. Others, the so-called "grey porphyry" of the miners, are more siliceous, but still highly feldspathic. Others still are true pegmatites. The smaller veins vary in composition from pegmatites composed of about equal parts of quartz and feldspar through all gradations of composition to veins of pure quartz. The latter, however, are rarely over an inch or two in width, so far as observed.

The dykes and veins are all localized within a short distance of the main mass of porphyry. Within 500 feet of the porphyry they are numerous, but the number becomes rapidly less with increasing distance from the edge of the intrusive. With a few exceptions all lie within a boundary drawn about 1,000 feet from the edge of the porphyry. Their localization, coupled with the facts of their composition, renders the conclusion almost inevitable that they are satellitic to the porphyry.

Diabases. The diabase dykes which cut all the rocks so far described may have a magmatic connexion with the porphyry. In composition they are ordinary quartz diabases, consisting mainly of labradorite and

[1] Ont. Bureau of Mines, Rept. 27, 1918, p. 227.

pyroxene with a small amount of an interstitial intergrowth of quartz and albite. The rocks appear very fresh in the hand specimen, but under the microscope the feldspar is seen to be badly altered to intergrowth of kaolin and sericite or paragonite. In places the dykes are highly porphyritic, with phenocrysts of labradorite up to 3 and 4 inches in diameter. The phenocrysts are invariably almost completely altered to kaolin and sericite. A careful examination was made to determine whether the dykes had been intruded along planes of faulting, but no lateral displacement of the rocks on either side could be determined. On claim 5383 (Figure 2) the Cobalt conglomerate may be seen lying on the eroded surface of the diabase and including boulders of it. The only fact connecting the dykes with the porphyry is their localization. They are numerous in the vicinity of the porphyry masses and are also occasionally found cutting the feldspathic granite to the south, to which, on account of its mineralogical and chemical similarities, the porphyry is supposed to be satellitic. Outside of these occurrences the dykes have nowhere been observed during a recent exploration covering about 300 square miles of adjoining territory.

Structure. The structure of the basement volcanics on the Colorado-Ontario claims was carefully studied. Grain determination made by methods described by the writer in a paper now in course of publication in the Journal of Geology indicated that the rocks formed a part of the south side of a tightly folded syncline, so that the basalts are the lower rocks in the series, the rhyolite tuffs the higher. The determination was strengthened by the later discovery of the ancient conglomerate on the north side of the mass of intrusive porphyry and also by good structure determinations made on the volcanics on the shore of Mistinikon lake, about 2 miles due west, where the structure is similar and the axes of the folds have a general east-west strike.

The map showing the boundaries of the mass of rhyolite tuff so far as exposed on the claims, suggests that the fold here is canoe-shaped, with anticlinal cross folds to the east and west. However, the mapping is so incomplete owing to the lack of sufficient trenching, that it is difficult to draw good conclusions.

Preliminary drilling has brought out the fact that the boundary between the rhyolite tuffs and the underlying basalt tuffs dips to the south at a high angle. The fold is, therefore, slightly overturned at this point. The folding evidently took place before the intrusion of the porphyry, as the porphyry is not sheared even in the small satellitic dykes.

The bedding appears to have determined in part the intrusion both of the main masses of porphyry and of the satellitic dykes and veins. The long axes of the larger masses of porphyry are parallel to the main axis of folding of the older rocks, and the linear arrangement of all the masses points to the original presence of some line of weakness, probably developed during folding. The larger dykes and veins are in general parallel to the bedding, although they break across it in places. Since the ore-bodies, as will be shown, are peripheral to the dykes and veins, a knowledge of this arrangement is important in the prosecution of the search for ore.

DESCRIPTION OF THE ORE-BODIES.

Davidson Type.

On the Davidson claims the ore-body is a part of the porphyry itself. The porphyry is cut by a multitude of veinlets of auriferous quartz, mostly less than one quarter inch in thickness and spaced at intervals of approximately a foot. The porphyry has thus the character of a stockwork, although the veins in the main are not reticulating, but possess a subparallel arrangement evidently the result of jointing according to a definite system. Such jointing and enrichment has taken place mainly in the coarser-grained, more slowly crystallized phases, located, in general, toward the centre of the intrusive. Where the grain is finer, jointing and enrichment have not occurred. The hypothesis advanced by Spurr,[1] that the last portions of a magma to crystallize are rich in water, and hence must contract considerably on cooling with formation of joint cracks, may be the explanation of this phenomenon.

Channel samples, taken along the bottoms of trenches in the enriched areas, by the engineers examining the property, are said to have given values varying from $5 to $25 per ton.

The gold appears to be chiefly present as the native metal, although it is difficult to tell whether this was its original form, as development has not gone below the oxidized zone. However, the lack of limonite around many of the grains of gold would indicate that it is not residual from the oxidation of pyrite. Whether the pyrite also is auriferous has not as yet been established. The gold is found principally in the narrow veins of quartz that intersect the porphyry, but grains of gold have occasionally been found within the porphyry itself, although never more than a few inches from a veinlet. It is evident, therefore, that the gold was introduced by the solutions which also deposited the quartz.

Otisse Type.

On the Colorado-Ontario claims the porphyry has not been enriched as on the Davidson claims, so far as known at present, but a heavy cover of soil and swamp on it has hindered prospecting. The parts that have been uncovered are jointed and veined only to a slight extent. The ore-bodies of this property are found in the schists surrounding the intrusive. Little is known as yet about the nature of the ore-bodies beyond what can be seen on the surface, as drilling had not been carried far enough at the time the writer made his examination to show with any certainty how the ore-bodies encountered below the surface are connected with those seen at the surface. Many of the statements here made will probably, therefore, have to be revised at a later date.

The schist ore-bodies are lenticular. Though this has been proved in only two cases by the removal of the drift from the whole outcrop of the ore-body (namely those at the south ends of trenches 8 and 9, Figure 4), the fact that ore-bodies crossed by a trench can rarely be picked up in a parallel trench 50 or 100 feet distant, indicates a similar shape for these

[1] Spurr, U.S. Geol. Surv., Prof. Paper 55, p. 114.

also. Drilling is at present being conducted with the object of testing the hypothesis that the lenticular outcrops are only the surface expression of ore shoots which may have a considerable downward extension. The size of the ore-bodies varies greatly. Small bodies a few inches or feet

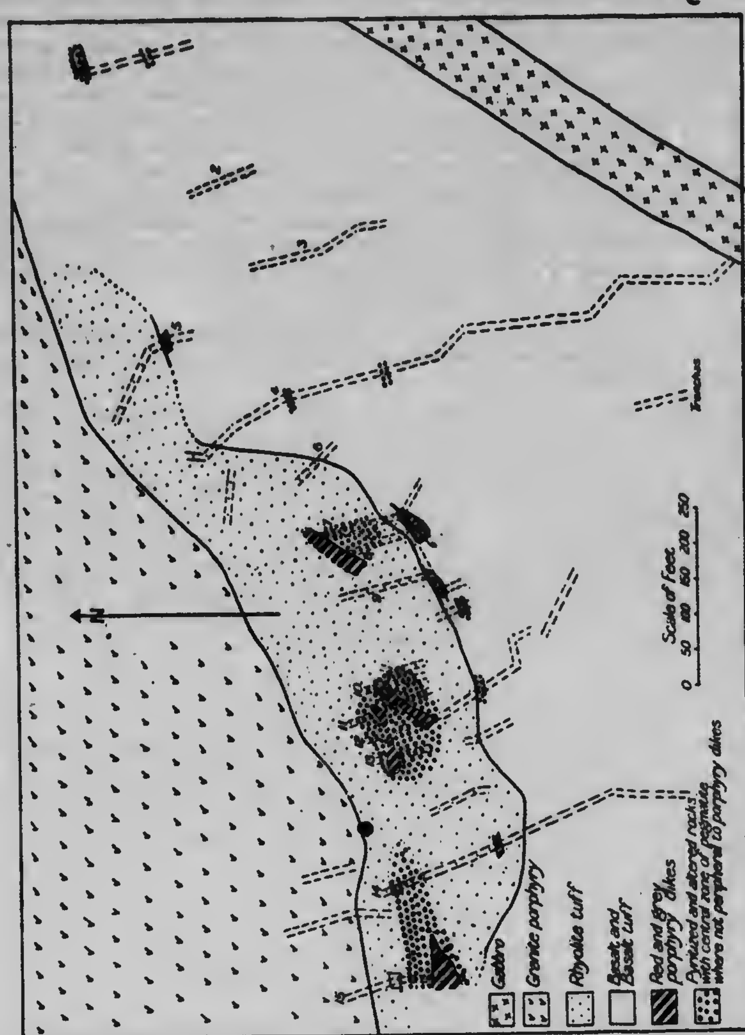

Figure 4. Diagram illustrating the trenching done on claims 5379 and 5380 up to October, 1918, with the major ore-bodies and dykes discovered.

in width are numerous, and the largest so far found is about 75 feet in width. The large bodies lie with their long axes approximately parallel to the bedding planes of the tuffs, and may eventually prove to have some relation to the secondary folding. The position of the smallest bodies,

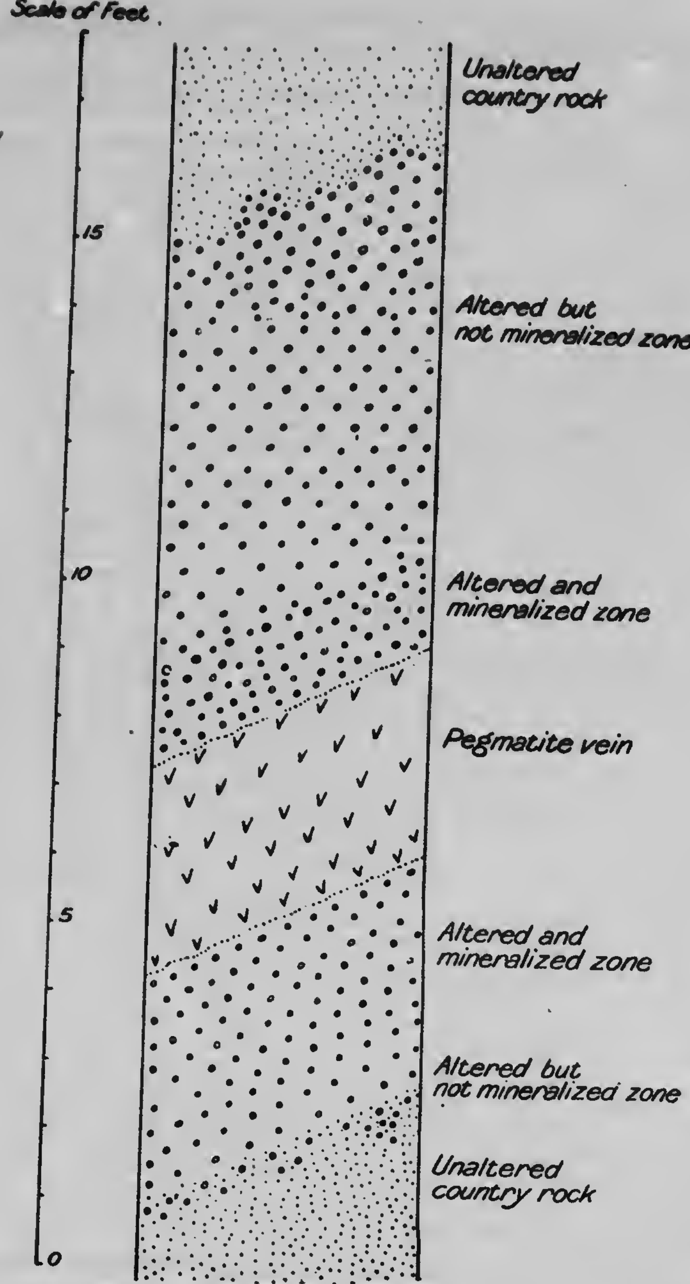

Figure 5. Diagram illustrating the internal arrangement of a body of mineralised rock.

those in general less than a foot in width, does not seem to have been controlled by the bedding but by joint cracks, so that they lie in various positions.

The internal structure of the ore-bodies of the Otisse type is interesting, and strongly indicative of their origin. Figure 5 shows on a large scale one such ore-body about 12 feet in width, occurring in trench No. 1. At the centre there is a body of rather siliceous pegmatite about 3 feet in width measured along the trench. On each side of this vein there is a band of altered and mineralized rock, about 3 feet wide on the south side and 1½ feet wide on the north side. The alteration, which will be described more fully later, consists mainly of calcitization, the mineralization is a pyritization, the pyrite usually auriferous. An outer zone of rock, altered but not mineralized, flanks the altered and mineralized zone; this is 6 feet wide on the north side, and slightly less than a foot on the south. The light grey, altered rock grades into the dark green country rock fairly quickly, but without any sharp boundary line. The gradational zone is commonly an inch or two in width. The line of contact is wavy, and frequently embayed in a highly irregular manner.

The structure described is characteristic of all the ore-bodies in the schist, although it is sometimes rendered more complex by the intrusion of two or more veins of pegmatite within each other's zone of influence; or its recognition may be obscured by an insufficient development which exposed only ore without the central pegmatite. Variations occur in the composition of the central dyke or vein, the width of both inner and outer zones of alteration, and the extent of the enrichment of the inner zone and the alteration in both. The data so far secured are not sufficient to determine the relation between these variations, but enough work has been done to indicate that the composition and size of the central dyke or vein are the principal governing factors, and there is also a possibility that some of the country rocks may have been more easily altered than others.

The data bearing on possible differences in susceptibility to alteration in the country rocks are rather scanty. All of the volcanics are seen under the microscope to be very similar in composition, their differences being mainly in the relative proportions of the constituent minerals. If one rock is more susceptible to alteration than another, it cannot be due to difference in composition, and the cause must be sought in physical differences, such as texture. The tuffaceous types, the rhyolite and basalt tuffs, undoubtedly had originally a more open texture than the massive basalts; and when sheared their lesser competency resulted in their becoming more schistose than the massive rocks. Both their original texture and their greater subsequent schistosity would make them more permeable to solutions, and allow of a larger degree of alteration. As shown on Figure 4, most of the ore-bodies are localized in the rhyolite tuffs and the basalt tuffs which directly underlie them. However, the fortuitous location of these tuffs next to the intrusive makes it impossible to conclude definitely that the localization of the ore-bodies is due to the influence of the country rock and not to chance, until the development operations are carried farther around the boundaries of the intrusive so as to allow comparisons to be made.

Data connecting the size and composition of the veins and dykes with the width of the altered zones and the intensity of the mineralization and alteration are more plentiful, but not complete. Dykes of red porphyry, whose composition is closely that of the main body of intrusive, have had little effect on the country rock. These may be seen (Figure 4) in trenches 5, 7, 14. Occasionally they have caused a small amount of pyritization in the wall rock, but never any visible alteration. An exception is the dyke cutting trench No. 15. Flanking this dyke is a wide zone heavily mineralized with very coarse-grained pyrites, but the country rock is slightly if at all altered, and the pyrite, unlike that in other ore-bodies, is not auriferous.

Two dykes of what the miners term "grey porphyry" are exposed by trenches 10 to 13 (Figure 4). The outcrops of these dykes, which are lens-shaped, are about 100 feet long and 10 to 20 feet wide. In their composition they are intermediate between a pegmatite and the red porphyry. The amount of feldspar present is so high that they would unhesitatingly be classed as igneous rocks in the field or from the hand specimen, but under the microscope they are seen to be considerably more siliceous than the red porphyry. A large alteration of the feldspar to calcite has taken place. The dykes contain sufficient auriferous pyrite to yield values varying from $3 to $50 per ton, with an average of about $10. The rhyolite tuff around and between the dykes has been only slightly altered, but has been somewhat pyritized over a distance varying from 10 to 25 feet from the dykes. The tenor, however, is low, on the whole $2 per ton or less, although occasionally a high assay has been obtained, due no doubt to the accidental inclusion of a locally enriched portion in the specimen taken.

The ore-body indicated in Figure 4 at the south end of trenches 7 and 8, has at its centre a vein of pegmatite about 4 feet in width. This pegmatite is now badly rotted and weathered, but can still be seen to have been highly feldspathic, probably about 40 to 50 per cent feldspar, the remainder mainly quartz. The vein lies parallel to the bedding and the mineralized and altered zone is approximately 12 to 15 feet in width on the southeast side, and 7 or 8 feet on the northwest side. Beyond the mineralized zone the rock is altered, with only slight mineralization for 3 or 4 feet farther. The values in this lens of ore are among the best on the property, averaging from $12 to $15 per ton. The alteration in the mineralized and altered parts has been intense, fully 75 per cent of the rock having been replaced by calcite in the parts nearer the central vein of pegmatite.

Figure 5, which has been already described as a typical ore-body, also illustrates the general extent of the alteration and mineralization induced by a pegmatite containing about 8 per cent of feldspar. It will be observed that although the central vein averages nearly as wide as in the example just described, the total width of the mineralized zones on both sides of the vein is only 4½ feet, as opposed to 18 to 20 feet. The total width of altered rock with and without mineralization is only about 12 feet, as opposed to 25 feet or more. Values in the two cases appear to average about the same, and the intensity of alteration to calcite is slightly less.

In trenches Nos. 3 and 4, among others, narrow veinlets both of pegmatite and quartz may be seen. The quartz veinlets are never more than about an inch thick. In trench 3 a pegmatite veinlet one-quarter to one-half inch in width is surrounded by a mineralized and altered zone about 2 feet in width. The pegmatite is about 30 per cent feldspar. The mineralization is fairly heavy, sufficiently so to give values of about $10 per ton. In trench No. 4 a similar narrow vein of pegmatite was observed, whose feldspar content is confined to a few small crystals along the wall of the vein. Alteration extends only about 2 inches from the walls, and mineralization is comparatively small. In the same trench a veinlet of quartz was observed, about an inch in width. On each side of it the rock is altered for a distance of about a foot, but the mineralization has been very slight.

The facts described appear to justify the following conclusions.

(1) The ore-bodies have been formed by solutions emanating from the dyke or vein at their centres. These solutions have altered and mineralized the country rocks. (2) The tuffs may have been more easily altered and mineralized than the altered basalts. (3) The extent of the mineralization and alteration is related to the size and the composition of the central dyke or vein. The strongest alterative and pyritizing effects have been exercised by the pegmatites, whereas the effects of the end members of the series, the porphyry dykes, and the quartz veins have been slight. The pegmatites containing 23 to 50 per cent of feldspar appear to have produced the most powerful mineralization and alteration. Other things being equal the extent of alteration and mineralization is roughly proportional to the size of the dyke or vein. (4) The gold content of the dyke and vein-forming solutions was also dependent on their composition. The pyrite deposited by the dykes of red porphyry contains very low values. Grey porphyry dykes carry more gold, sufficient to give good values within the dykes themselves, but not apparently to mineralize the surrounding rocks very highly. Pegmatites appear to have carried the maximum of gold, which they deposited as auriferous pyrite both in the veins and in the altered wall rocks; whereas the solutions forming the pure quartz veins carried little gold.

The only primary ore mineral present appears to be auriferous pyrite; however, a detailed study of the ores by the aid of the reflecting microscope has not as yet been made. If ore minerals other than pyrite are present, they are in very minor amount. The gold occurs only in the pyrite, in what form is not known. Native gold is not found, except in oxidized surficial portions. In general a high pyrite content indicates a correspondingly high gold value, although in one or two places this has not proved true. In the pegmatites the pyrite is very coarse-grained, in crystals and aggregates several millimetres in diameter; but in the adjacent schists the pyrite is always fine-grained, 0·3 to 0·5 mm. in diameter of crystal. Only in one case was this not found to hold good, in the ore-body in trenches 14 and 15 peripheral to the dyke or red porphyry in 15. There the pyrite is very coarse-grained.

The wall rock alteration accompanying the mineralization produces a rather light grey, fine-grained rock from whatever variety of rock has been originally present. Under the microscope the alteration of the parts farthest from the central vein is seen to consist of calcitization, pyritization, and sericitization, with probably some albitization. Fine-grained magnetite originally present in the altered basalts in amount up to 5 per cent is converted into sulphide, forming a few crystals up to 0·5 mm. diameter instead of a multitude of small grains. Possibly, also, some pyrite may be added. Feldspar, which is commonly oligoclase-albite, either lath-like or irregular in shape, is entirely recrystallized into a fresh, clear, granular albite, with possibly a slight increase in soda content. Chlorite disappears entirely; 10 to 15 per cent of sericite is formed, and calcite, commonly forming 10 to 20 per cent of the original rock, is increased in amount to 40 or 50 per cent. Nearer the central vein, under the more intensive action of the solutions, further changes take place. Albite and sericite tend to disappear entirely; a great addition of pyrite occurs, and the calcite content increases enormously and may replace everything but the pyrite. A little quartz is sometimes present, but always in vague, vein-like forms, and not a part of the true replacement. The pegmatite of the central vein itself also has very commonly suffered a partial alteration, in a replacement of a part of its feldspar by calcite.

The composition of the solutions which deposited the ores may be inferred from the results of their action on the country rocks. They were evidently rich in sulphur, and also carried iron. Considerable carbon dioxide was present, and the lime content was high. They carried potash and soda, but probably only in small amount. They dissolved out and removed silica, alumina, and magnesia primarily; potash and soda were also carried away where the reaction was more intense, nearer the central veins.

Summary and Conclusions.

The internal structure of the ore-bodies, consisting of a pegmatite vein at the centre, a middle zone of mineralized and altered rock, on each side, and an outer zone of altered rock without mineralization, which grades into unaltered country rock with irregular and embayed contacts, is clear evidence that the deposits in schist have been formed by the alteration and mineralization of the country rock by solutions coming up along the central vein. The partial calcitization of the feldspar of the pegmatite indicates a change in the character of the solutions during the formation of the ore-bodies.

The serial composition of the various veins of pegmatite, varying from veins of pure quartz up through pegmatites of increasing feldspar content, to dykes of pure porphyry, indicates an igneous origin for all.

The satellitic arrangement of the veins, in that with few exceptions they are grouped within an area bounded by a line drawn about 1,000 feet from the edge of the porphyry mass, with the major number within 500 feet, points conclusively to their genetic connexion with the porphyry intrusive.

Veins or dykes approaching the porphyry in composition deposited little or no gold, but did in places deposit pyrite. They had no strong alterative action on the wall rocks. Pegmatites deposited auriferous pyrite, and had a powerful alterative action on the wall rocks. Quartz veins had little action on the wall rocks, and deposited little or no pyrite. Other things being equal a rough proportion exists between the size of the vein and the size of the altered zone around it.

It is concluded, therefore, that the schist ores of Matachewan district were deposited by juvenile solutions originating as the last products of the differentiation of masses of intrusive granite porphyry. The solutions were at first rich in silica, soda, and alumina, which crystallized out first to form the material of pegmatite veins. The separation of these constituents left the solutions relatively enriched in lime, carbon dioxide, iron, sulphur, potash, and gold, and their reactions with the wall rocks caused the formation of replacement deposits whose principal minerals are calcite and auriferous pyrite.

There is little direct evidence to connect the gold of the Davidson property with the porphyry, except the fact that the veins are confined within the intrusive mass. However, the proof that the neighbouring stock, which is petrographically identical with the Davidson porphyry, carried gold, renders the conclusion inevitable that the gold of the Davidson property was also a magmatic constituent. The differentiation has here continued uninterruptedly to the stage in which the mineral constituents of the magmatic solutions are silica and gold, and these are deposited as quartz with native gold.

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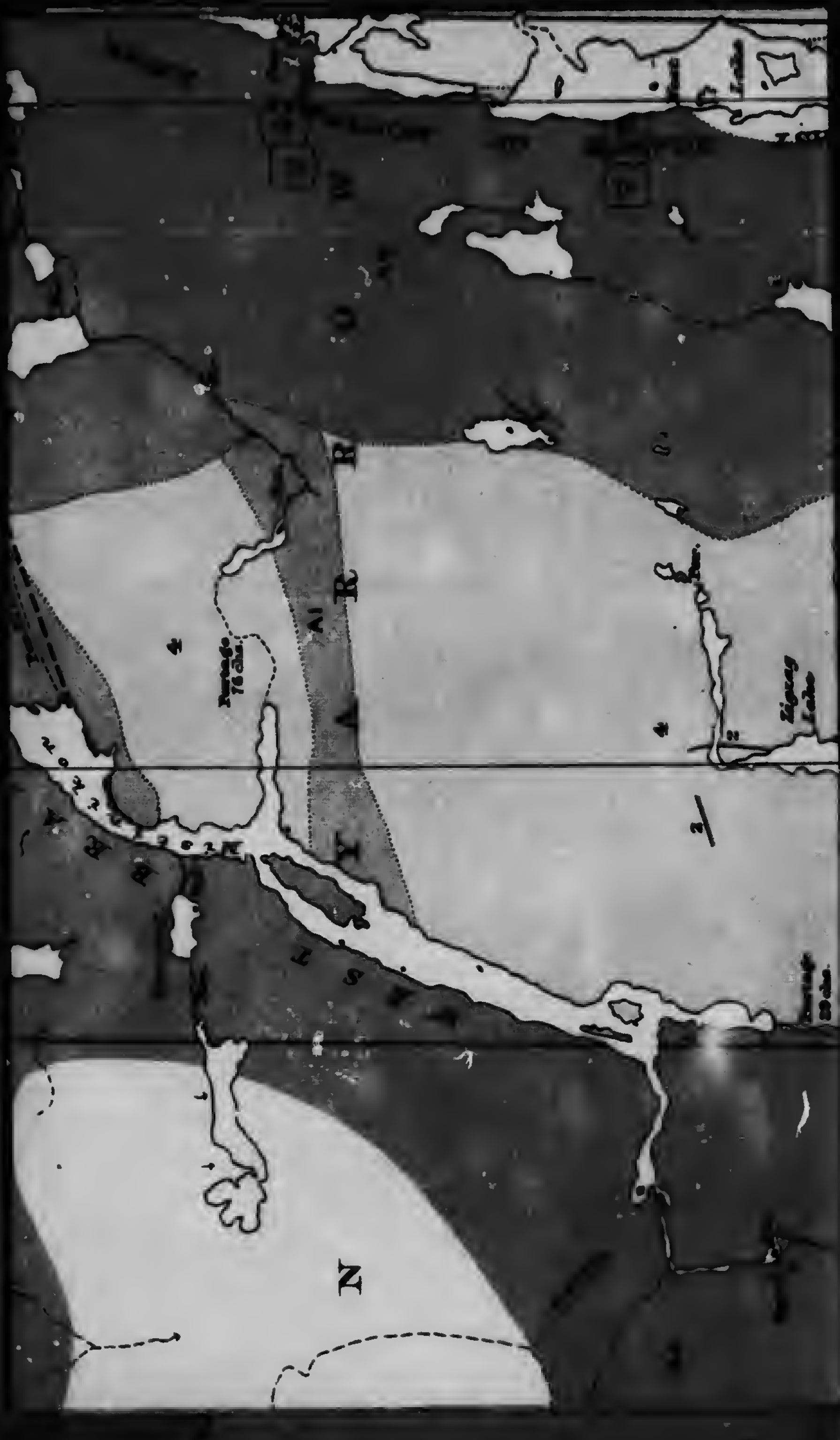
Zigzag Lake

LEGEND

QUATERNARY — RECENT AND GLACIAL

Q — Fluviatile, lacustrine and glacial deposits.
These deposits are widely distributed, but only a few large areas are separately coloured.

KEWEENAWAN

5 — Nipissing Diabase

HURONIAN

A4 — Cobalt Series; Gowganda formation

4 — Granite and syenite

A3 — Kisak series

BRIAN

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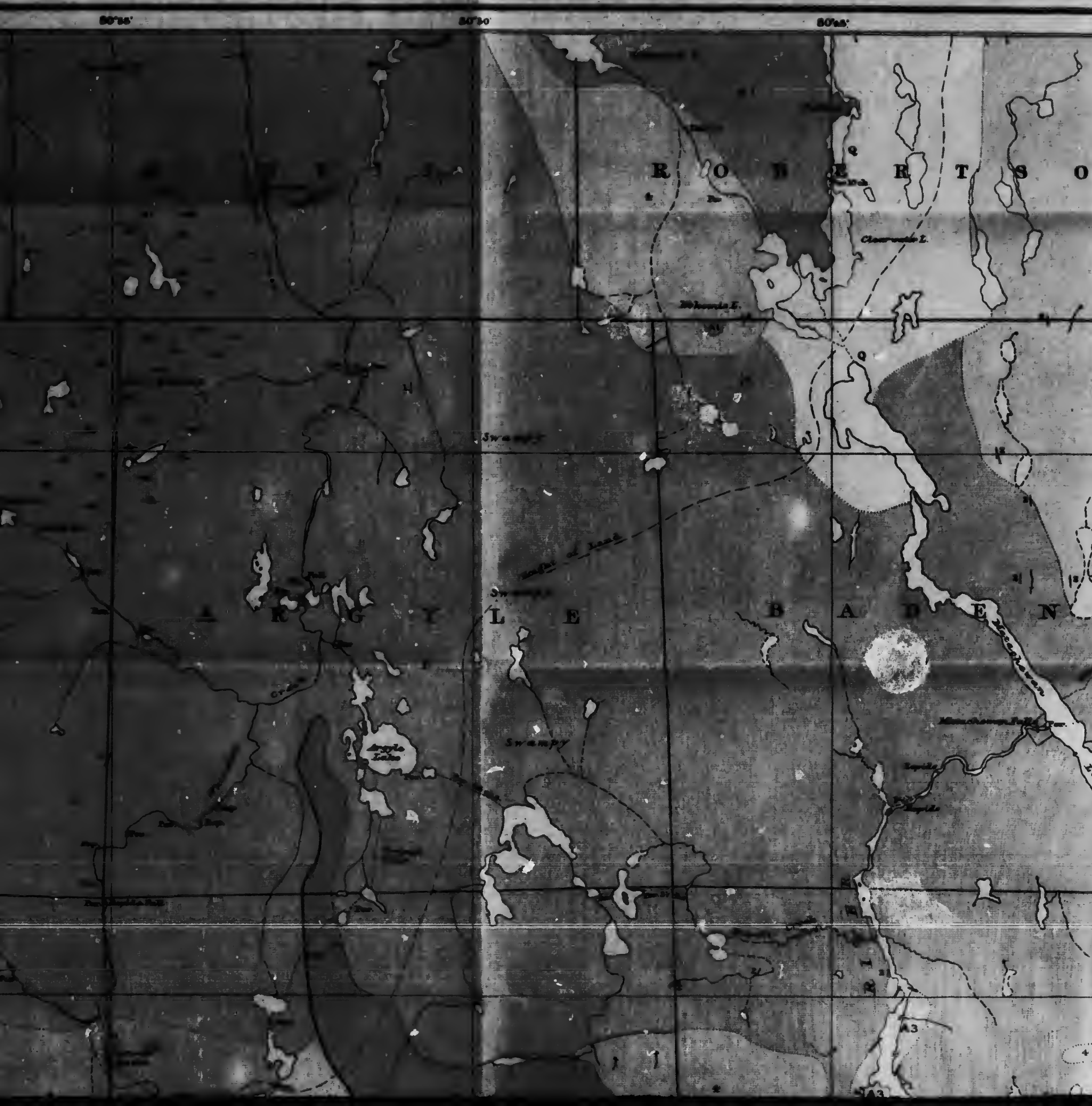
Canada
Department of Mines

Hon. Arthur Meighen, Minister; R. G. McConnell, Deputy Minister.

GEOLOGICAL SURVEY

William McInnes, Directing Geologist

Issued 1920



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DUNMORE
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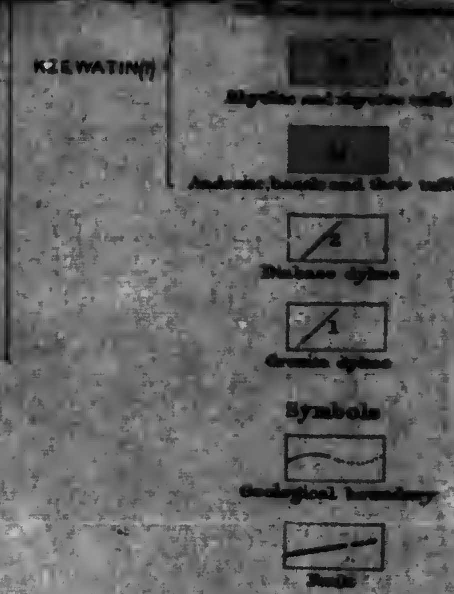
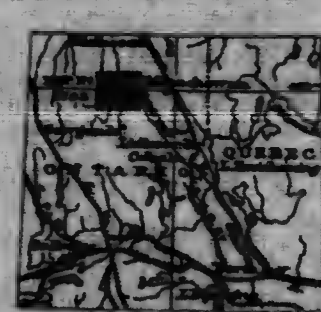
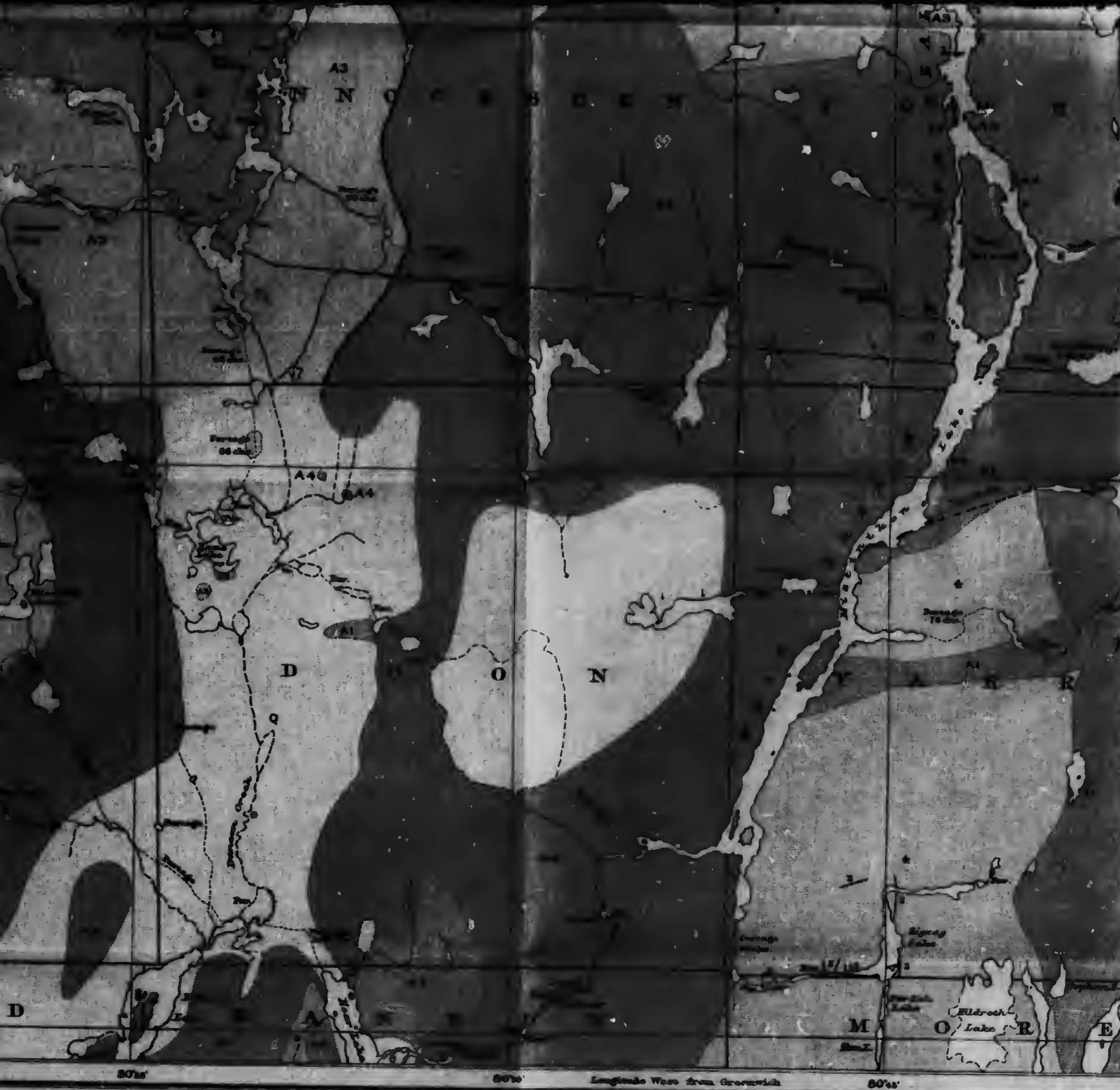




To accompany Memoir by H.C.Cooke.



MATACHEWAN

TIMISKAMING DISTRICT

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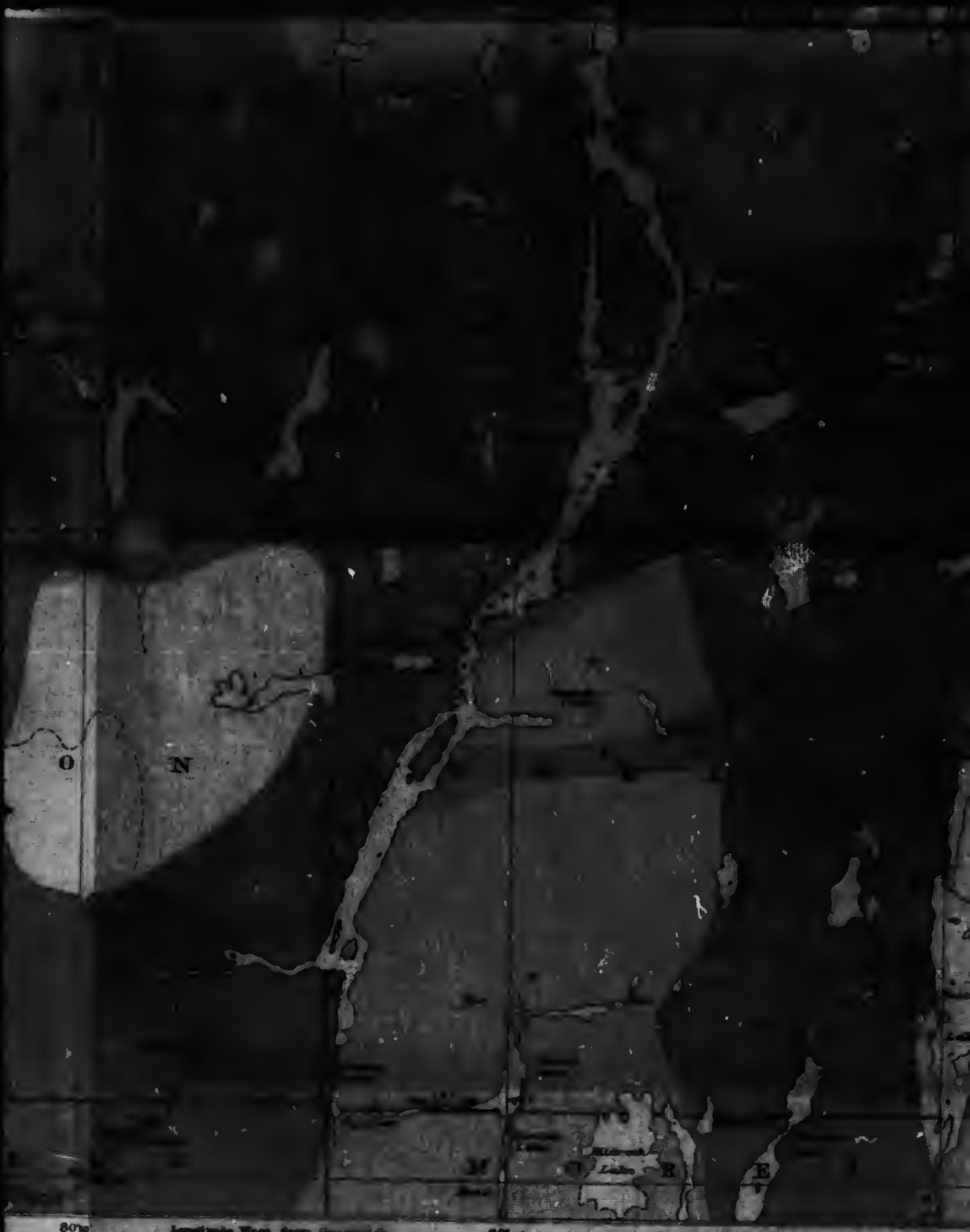

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Sources of Information.