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DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

Summary Report, 1922, Part D

CONTENTS

OTTAWA

F. A. ACLAND

PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

1923

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SUMMARY REPORT, 1922, PART D

PALLADIUM-BEARING NICKEL DEPOSIT AT SHEBANDOWAN LAKE, THUNDER BAY DISTRICT, ONTARIO

By T. L. Tanton

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INTRODUCTION

During the summer of 1922 the writer examined the nickel deposit at Shebandowan lake, which has been known for some years and in which considerable interest is being taken. In the annual report of the Ontario Department of Mines for 1920[1], J. G. Cross described, with illustrations, the outstanding features of the deposit, and indicated that a considerable tonnage of nickel ore might be expected to occur between the numerous pits, which are distributed in a linear manner over a mile near a contact between granite and Keewatin rocks.

Since 1920 a considerable amount of test-pitting and trenching has been done on the property by the International Nickel Corporation, which held an option on the property until the summer of 1922. This work tended to verify the earlier indications of continuity between the various exposed points within the originally described limits, but the depression in the nickel market in 1922 was such that interest could not be sustained in the development and exploration of this prospect, considered as a possible source of merely copper-nickel ore.

Since the publication of Mr. Cross' report the most important contribution to knowledge of the deposit is that it contains an unusually high percentage of platinum-group metals for this type of deposit.

The deposit occurs in claims T.B. 3689, 3690, 2240, and 3691 (Figure 1) which extend continuously westward from Discovery point, near the west end of Lower Shebandowan lake. The most convenient scheduled train stop from which to reach the property is Maybella on the Canadian National railway, though certain trains stop at the point, 4 miles to the west, where the railway touches the shore of the lake. From this point, which is called Stuart siding, one may travel by boat to the property which lies about 10 miles west.

The area has been geologically mapped by William McInnes and is shown on the Shebandowan sheet, Geological Survey, Canada, 1896, scale 4 miles to the inch.

[1] Ont. Dept. of Mines, vol. XXIX, pt. I, 1920, pp. 225-234.

GENERAL GEOLOGY

The solid rocks in the vicinity of Shebandowan lake are Precambrian, and their subdivisions according to age are indicated in the following table:

Keweenawan	diabase dykes
Algoman (?)	granite
Seine series (?)	conglomerate, arkose, greywacke
Laurentian	granite and gneiss
Keewatin	sheared volcanic rocks and banded iron formation

The Keewatin rocks are the oldest. They include a great variety of lithological types, and all are highly metamorphosed and show foliation induced by regional pressure. Near the nickel deposit is a mass of chlorite-serpentine schist which is regarded as an altered peridotite. This is bevelled across by the Laurentian granite and disappears just beyond the most westerly nickel occurrence. Toward the east it becomes wider, and on the southern shore of the lake, easterly from Discovery point, it is about 600 feet wide. The structural trend of the steeply inclined Keewatin formations is approximately south 70 degrees east. The general trend of the granite contact is north 80 degrees east. Adjacent to the altered peridotite mass on the south one finds sheared andesite, rhyolite, ferruginous dolomite, and lean, banded iron formation.

Laurentian granitic rocks are exposed over an extensive area to the north of the Keewatin on Lower Shebandowan lake. A variety of lithological types is to be found near the contact. One of these is a sheared granite porphyry in which the quartz and feldspar phenocrysts are surrounded by a matrix of chlorite and sericite possessing a schistose structure.

The highly folded sedimentary rocks—which the writer regards as the Seine series—are crossed by the railway between Maybella and Stuart siding. They are not exposed near the nickel deposit.

The unsheared granitic rock mapped by McInnes as distinct from the Laurentian may be of Algoman age. This rock occurs several miles to the southeast of the nickel occurrences and was not examined by the writer.

Diabase dykes are the youngest known solid rocks in the area. Their age correlation with Keweenawan intrusives of the Lake Superior district is based on lithological resemblance, equivalent metamorphism, and lack of evidence indicating any other age.

There is a considerable amount of sand, gravel, and boulder clay distributed over the surface of the solid rocks of the district. Fortunately for the prospector the land surface is largely made up of a succession of hills and ridges with a local relief of about 100 feet, and on the high ground and along parts of lake shores, rock outcrops are numerous. On the higher parts of the nickel claims the drift has an average thickness of about 3 feet. The low ground is heavily drift-covered and ridged with eskers.

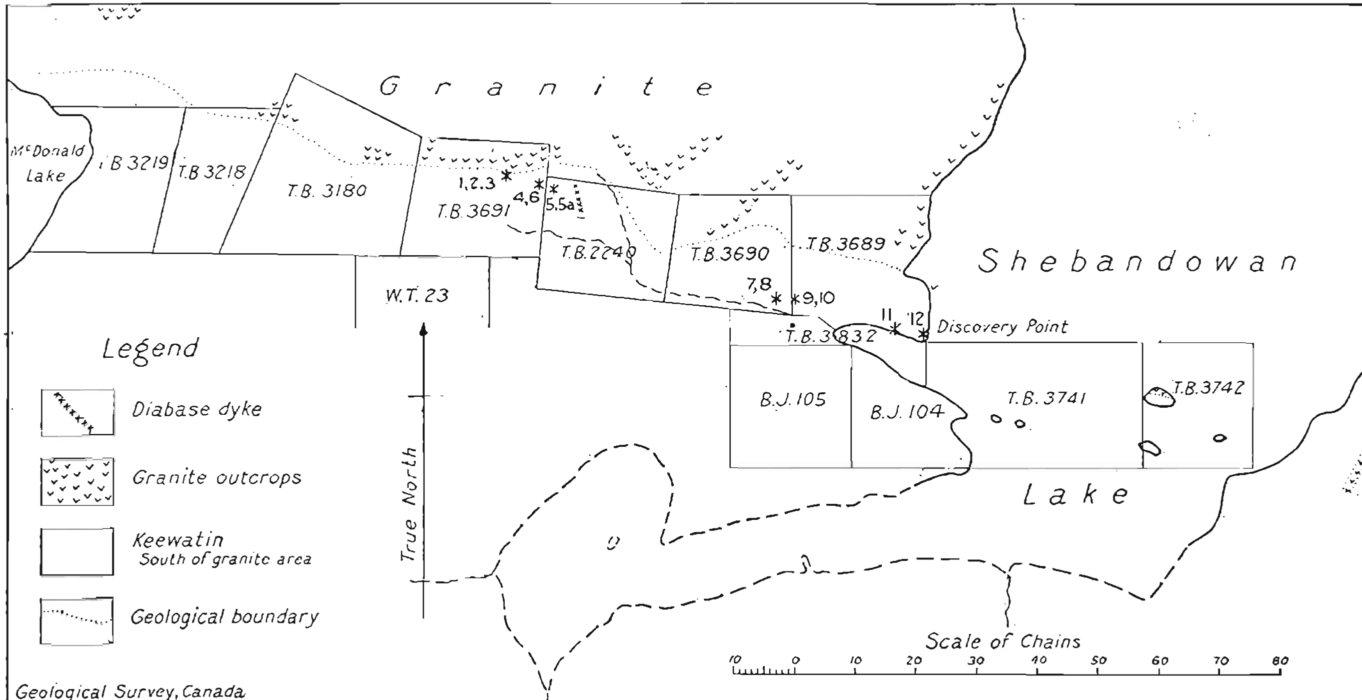

Figure 1. Diagram showing palladium-bearing nickel occurrences, Shebandowan lake, northwestern Ontario. The nickel occurrences are exposed in pits numbered 1, 2, 3, etc.

ORE DEPOSITS

The mineral occurrence is a replacement deposit in Keewatin schists and associated intrusive acidic dykes. It is found as a number of narrow seams in a zone which lies parallel to the contact of a huge granitic batholith and from 50 to 150 feet away from it. At all the occurrences within a mile westerly from Discovery point the sulphide replacement seams appear to consist chiefly of fine pyrite and chalcopyrite, and when tested a positive reaction from nickel is obtained. Beyond, along the westerly continuation of this mineralized zone one finds similar replacement lenses of pyrite in the Keewatin schists, but these do not appear to contain other metallic minerals and did not show a nickel reaction where tested in the field by the writer. The lithological character of the Keewatin schists is not uniform along the granite contact and it is significant that the nickel-bearing sulphides occur only in the area where altered peridotite is recognized.

At Discovery point a bare rock hill rises 50 feet abruptly from the lake and there is a continuous outcrop showing the rocks transverse to their foliation for 300 feet. The northern 180 feet of the outcrop consists of a sheared basic lava, now chlorite-serpentine schist, the schistosity of which strikes east and west and dips vertically. At two places along the shore, under the water, one can see the upper part of granite porphyry intrusives. These intrusives probably represent small upward projections of the great batholithic mass which is well exposed to the north and whose contact with the Keewatin rocks dips toward the south. In the granitic intrusives there are included fragments of the Keewatin rocks and part of the material near the contact is hornblende granodiorite. The intrusives have been sheared, though they have not been rendered schistose to the same extent as the Keewatin rocks.

Between 180 and 190 feet south from the north end of the outcrop there is a vertical zone through the sheared lava which shows ellipsoidal structure. The intense shearing of parts of this has resulted in a fine lamination which simulates stratification. The rest of the outcrop to the south is of vertically standing sheared peridotite within which there is one 2-foot dyke of pale grey felsite which cuts the rock parallel to the foliation, and there are a few pieces of felsite—one-half inch in diameter—aligned in the rock nearby as if representing other dykelets which had been disjointed during the development of foliation in the surrounding rock. The sulphide replacement bodies at this locality occur in the sheared peridotite between the pillow lava and the 2-foot felsite dyke. The largest of these is parallel to the felsite dyke and a few inches north of it. It varies in width from 18 inches to a mere thread. It is not a vein, but a part of the sheared peridotite which is impregnated by numerous filaments and masses of sulphide minerals so finely crystalline that the constituents, other than the predominating pyrite, cannot be recognized. The second body lies a few feet farther north. It trends north 70 degrees west, and dips toward the north at about 60 degrees. It is 6 inches or less in width and can be traced from the shore up to within a short distance of the first body, where it terminates. The third seam is narrow and shows no connexion with the others. It is to be seen near the top of the hill where it passes under the drift. The presence of the sulphide bodies is revealed on the natural outcrop by a rust stain. There has been no regional shearing of the sulphide deposits.

The ridge that extends westerly from Discovery point is almost entirely covered with a thin drift mantle, but within a distance of 1,400 feet on it seven of the test pits which have been sunk have encountered sulphide replacements. The mineralization in these appears to be similar, but their trends and widths are somewhat different and it is not yet certain what degree of continuity exists between them. From the evidence at hand it might be supposed that there are several discontinuous narrow seams with approximately parallel trend confined within a zone about 100 feet wide.

The largest replacement body found on claim T.B. 3689, which embraces Discovery point, is 1,200 feet west of this point. It is exposed in a pit 22 feet wide and 16 feet deep. The foliation in the sheared peridotite trends north 85 degrees east and dips vertically, and the sulphide replacement seam in this might be considered as having a width of 19 feet. The 4-foot zones on the outer parts of this are, however, very much more richly impregnated than the 11-foot zone which lies between, and in which the little seams and filaments of sulphides appear to make up one-fifth of the total volume. The development of rust and other weathering products has proceeded to greater depth at this locality than elsewhere. Along certain channels it extends to the bottom of the workings.

Twenty-three hundred feet west-northwest from the easterly group of replacement bodies another group of sulphide bodies has been uncovered in nine pits disposed in a linear manner for 500 feet like trenches across the mineralized zone. The relationship of the replacement seams and the rock assemblage is here quite analogous to that found in the eastern group of exposures, but there is a much larger amount of sulphide material exposed, as in pit 5, and there is an exceptionally rich concentration in a 3-foot seam in pit 3. In each pit there is a certain amount of mineralization, but the concentration of the sulphides is variable, being greatest in the more highly schistose rocks. A few rich seams up to 3 feet in width occur irregularly through a more diffused mineralized zone about 20 feet wide. No single rich seam has been traced any considerable distance. In the western group the mineralized zone trends north 70 degrees west and dips about 70 degrees toward the north with the foliation. The granite contact pursues an irregular course approximately east and west at an average distance of 100 feet to the north. In the western group one finds porphyry and felsite dykes intrusive in the schists. These, where sheared, are mineralized. The sulphide minerals have not suffered regional shearing.

Four hundred feet east of pit 5, an unsheared diabase dyke, locally porphyritic, one foot wide, cuts the Keewatin schists. It trends north 15 degrees west, and dips 70 degrees toward the east. No sulphide minerals occur in the small outcrop where this dyke is to be seen. The age of this diabase intrusive is not known. It is, however, lithologically similar and, as far as known, equivalent in every respect to the Keweenawan dykes which occur in the Lake Superior district; its age may tentatively be considered as Keweenawan.

MINERAL COMPOSITION

In general, the appearance of the sulphide replacement is very similar along the mineralized zone for nearly a mile westerly from Discovery point. Traversing the chlorite-serpentine schist one sees seamlets and little tongues of yellow, metallic, exceedingly fine-grained minerals with occasional scattered grains of pyrite, like phenocrysts, up to 1 mm. in diameter. Usually the chalcopyrite, polydymite, and other sulphides are so intimately intermixed with pyrite in the fine-grained assemblage that they cannot be recognized in the hand specimen. No gangue mineral, such as calcite or quartz, is associated with the sulphides, though at pit 10 a veinlet of dolomite carrying a small amount of gersdorffite cuts across the deposit.

An examination of polished surfaces under the microscope shows the following minerals in their sequence of development: pyrite in grains up to 1 mm. in diameter, massive pyrite and finely crystalline magnetite, chalcopyrite, pyrrhotite, an undetermined grey mineral which occurs as tiny grains with rim of different composition from the kernels, and polydymite. No considerable lapse of time is represented between the development of these minerals, and the assemblage is regarded as having formed during one period of deposition. The gersdorffite-bearing veinlets of dolomite in pit 10 are distinctly later than the pyritic body, but the association of this nickel sulpharsenide with the other nickel concentration suggests a relation in origin.

CHEMICAL COMPOSITION

The results of sampling and analysis of the deposits for their copper nickel and cobalt content have been published by Mr. J. G. Cross.[1] The variability of the results is due, largely, to the irregularity of the sulphide impregnation in the schist and the variable proportions in which the minerals are associated in various patches. Selected samples from the property are reported to assay as high as 21·17 per cent nickel and 16·6 per cent copper. More common values in the richly impregnated schist are 3 per cent nickel and 3 per cent copper.

In 1920, Mr. Cross recognized the general similarity of this deposit to the nickel ore of the Sudbury area and initiated a series of tests for metals of the platinum group, which are known to occur in the Sudbury ores. A sample submitted to the Provincial Assayer[2] was found to contain none of these in appreciable quantity. Experimenting in his own laboratory in 1921, Mr. Cross obtained positive indications of the presence of platinum group metals and a sample of similar material was submitted to the writer for examination. This was found to contain platinum-group metals at the rate of 0·16 ounce Troy to the ton of 2,000 pounds.[3] A partial analysis of the same material contained: iron 24·80 per cent; copper 5·50 per cent; nickel 3·20 per cent; sulphur 20·60 per cent; arsenic 0·008 per cent.[4]

In 1922, the writer examined the property and sampled those replacement bodies in both the eastern and western group where it was considered that the results would be of most value (Figure 2). Sample 1, across 2

[1] Ann. Rept., Ont. Dept. of Mines, vol. XXIX, pt. I, 1920, p. 231.
[2] Idem p. 229.
[3] Assay by A. Sadler, Mines Branch, Dept. of Mines.
Leverin, H. A., Mines Branch, Dept. of Mines.

feet in the southerly part of pit 3, 12 pounds. Sample 2, across 6 feet in the easterly part of pit 5, 30 pounds. Sample 3, across 2½ feet in pit 5A, 15 pounds. Sample 4, across 3½ feet in the northerly part of pit

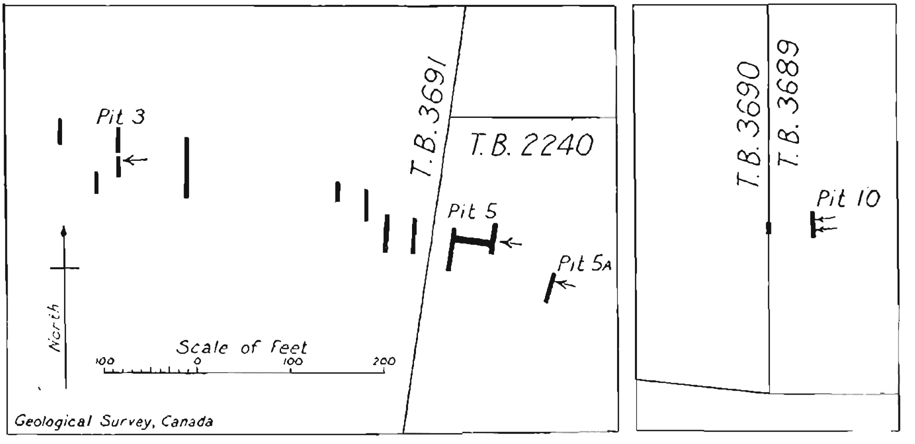

Figure 2. Plan showing pits sampled, Shebandowan nickel deposit.

10, 20 pounds. Sample 5, across 4½ feet in the southerly part of pit 10, 25 pounds. Eleven feet of lean material intervenes between 3 and 4. The results obtained at the Mines Branch are as follows:

Sample No.	Insol. %	Fe %	As %	Cu %	Ni %	Co %	S %	Au oz. per ton	Pt oz. per ton	Pd oz. per ton
1..........	16·40	35·65	tr.	1·50	5·95	0·20	29·25	0·01	0·04	0·12
2..........	31·60	26·45	"	3·00	2·10	0·25	18·50	0·007	0·03	0·07
3..........	18·60	33·20	"	5·95	4·10	0·21	27·40	0·083	0·04	0·11
4..........	38·30	20·70	"	3·10	0·04	0·21	9·10	0·007	0·03	0·10
5..........	35·90	22·55	"	2·15	0·04	0·21	10·25	0·006	0·02	0·08

Very small amounts of silver, also, have been reported in assays obtained by the owner.

The results indicate that there is a relatively high content of platinum-group metals in the deposit and that, as far as known, these occur almost uniformly in the wider bodies in both the eastern and western groups.

ORIGIN

The nickeliferous bodies at Shebandowan lake are a type of replacement deposit. The filaments and stringers which make up a large part of the bodies, together with the linear character of the whole assemblage, indicate that replacement took place along the path of moving mineral-laden solutions. The nickeliferous replacement bodies were formed subsequent to the regional shearing of both the Keewatin schists in which they occur and the intrusive batholithic granite body whose marginal felsite dykes are replaced; hence the solutions which caused the deposit did not originate in either of these rocks. The character of the mineral assemblage is such as to indicate a magmatic origin, and it is reasonable to assume that the mineral-laden solutions came from an igneous intrusive later in age than the granite. Keweenawan diabase occurs on the property and, though no relationship between it and the mineral deposit can be seen, it is thought possible that the mineralizing solutions came from the underground magma of which the visible diabase dyke is the surface representative.

The noteworthy parallelism between the mineralized zone and the granite contact indicates that this contact, where cut by the mineralizing igneous rock, underground, controlled the position of escape of the mineralizing solutions. The chemical difference in the character of the replacements within and beyond the chlorite-serpentine schist in the Keewatin indicates that this rock had a considerable influence on the nature of the deposit. It is possible that the chlorite-serpentine schist possessed at the time of mineralization some physical or chemical properties which made it more suitable for the precipitation of the valuable minerals than the other schists that occur to the west; or it is possible that some of the valuable metals were originally disseminated in the peridotite and that igneous activity at depth caused these to be brought into the solutions which subsequently concentrated them in the replacements.

GOLD OCCURRENCE AT MAKWA, SUDBURY DISTRICT, ONTARIO

By T. L. Tanton

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GENERAL STATEMENT

During the summer of 1922, Messrs. L. Thompson and Henry McAuley, of North Bay, made an examination of the schist complex (Keewatin) area which extends westerly from the southwest corner of St. Louis township, situated in Sudbury mining division and on the Canadian National railway about 81 miles northwest of Capreol. Having examined the main schist belt they returned to the railway by way of a canoe route which leads south from Mesomikenda lake to Dividing lake and thence easterly and northeasterly by the Mollie River system to Makwa station, at mileage 77 from Capreol. There being no train scheduled to stop at this station within less than a day and a half after their arrival, they spent the time prospecting in the vicinity. Gold was discovered by Mr. McAuley half a mile east of the railway where it crosses Mollie river. A block of twelve claims was staked in the vicinity. The discovery was reported to the Geological Survey by Mr. John McColeman of North Bay, who is in partnership with the discoverers, and acting under instructions from the Director the property was visited by the writer on September 27, 1922.

Makwa station is situated near the middle of Champagne township. The geology of Champagne township and the surrounding country is shown on Geological Survey, Canada, Map 179A "Onaping Sheet" and Map No. 1697 "Gogama Missonga Sheet." A belt of Pre-Huronian schist complex (Keewatin) less than 2 miles wide, trends southwesterly in the townships of Brunswick, Groves, and St. Louis through a very extensive region of granite. On either side of the schists are broad zones of transition rocks consisting of granite gneiss containing many recrystallized fragments of the schists. There is no definite boundary between the transition rocks and the regional granite. That part of Champagne township in the immediate vicinity of Makwa is underlain by transition rocks. Numerous quartz veins occur in these rocks, the majority of them being small and of irregular lenticular shape. Small dykes of porphyritic diabase cut the granitic rocks and the above-mentioned quartz veins.

The highest hills in Champagne township are less than 100 feet, yet in detail the surface is minutely rugged with numerous hills and ridges and occasional cliffs. The mammillated rock hills are well exposed, though there is a sand-plain of considerable extent to the westward of the gold claims through which Mollie river flows. Timber rights in the township are held by the Pembroke Lumber Company and in certain parts lumbering operations were in progress in September, 1922. The area embraced by the mining claims here referred to (Figure 3) were fire-swept in 1921. This fire has cleared the upland rocks of vegetation. The lowland is soil-covered and difficult to traverse on account of the tangle of charred logs and bushes.

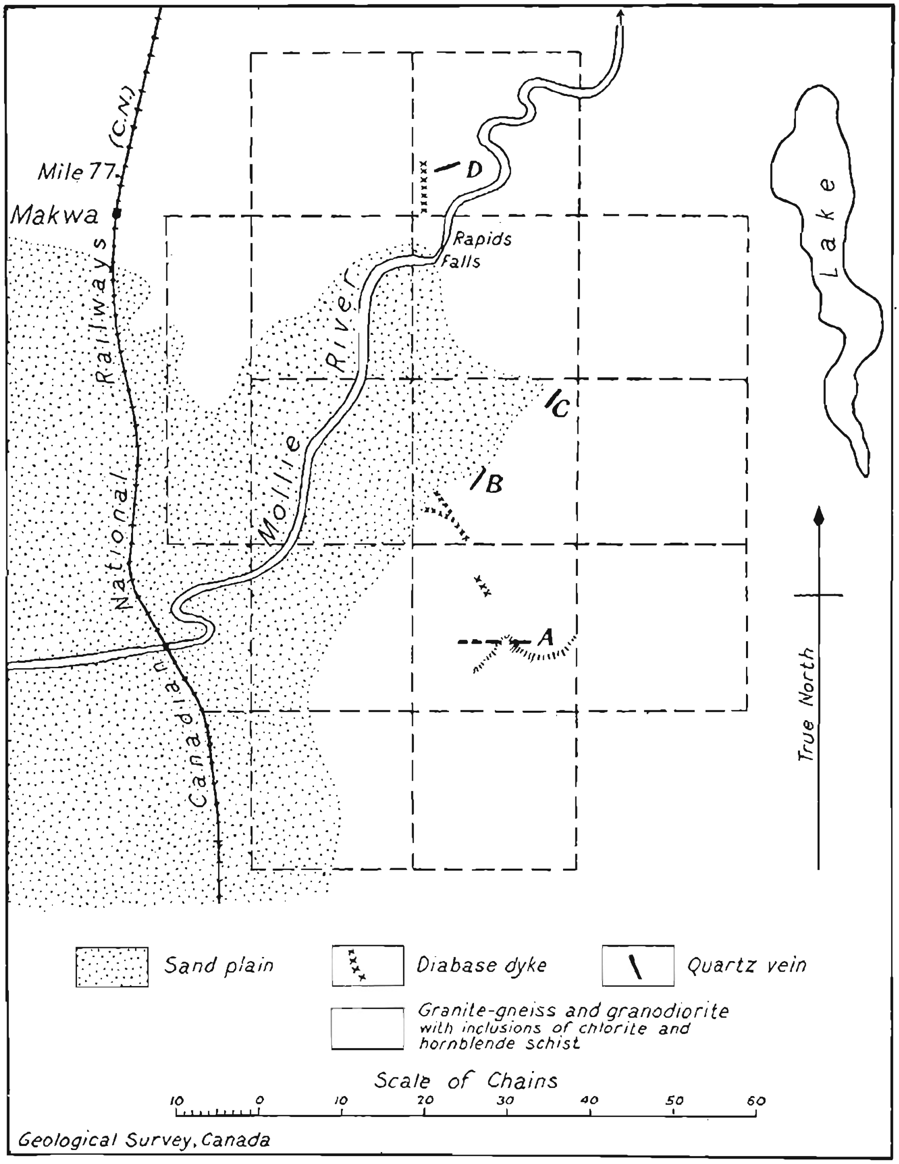

Figure 3. Diagram showing unsurveyed mining claims and geological features of gold-bearing area near Makwa station, Champagne township, Ontario. The letters A, B, C, and D represent quartz veins.

EXAMINATION OF CLAIMS

The most prominent gold showings occur on the south slope of a hill 40 chains east of the railway bridge over Mollie river (A, Figure 3). In this vicinity the rock is thinly covered with drift and the workings have exposed an area 20 feet by 20 feet, within which there is a test-pit 5 feet deep. The rock is a complex of granodiorite and granite of various textures, characteristic of the transition rocks which occur in the contact zone between the schist complex (Keewatin) and the prevailing granite. Two small, irregular, lenticular veins 5 feet apart trend east and west through the rock. The larger has a maximum width of 10 inches, the smaller 4 inches. They are composed of white quartz of both sugary and glassy varieties and contain small amounts of pyrrhotite and chalcopyrite. Although no gold is visible, assays reveal a small content. The spectacular gold showings at this locality are not in the quartz. They occur associated with limonite only in the joint planes which are here well developed in the rock. The limonite in the joints is so abundant near the surface that the uppermost 8 inches has the appearance of gossan. Lower down, the limonite filling in the joint planes becomes less, and at a depth of 5 feet disappears. The gold is sporadically scattered through the limonite in particles as large as wheat grains. Assays of the quartz vein material which did not show free gold are reported to yield gold values of $1.60 a ton. A sample containing a large percentage of auriferous limonite yielded $160 to the ton.

The quartz veins in the property, which were examined, do not appear to be highly mineralized, and it is remarkable to find such a relatively large amount of limonite and gold on the weathered surface associated with such small mineralized quartz veins. There is no apparent source for the gold and limonite other than the associated mineralized quartz veins and their pre-existent upward extension. The writer infers that the oxidation products of this upward extension, that is, limonite and gold, were carried down and deposited in fissures which existed in pre-Glacial times. During the Glacial epoch the district was glaciated, but erosion was not sufficiently intense to remove all of the weathered zone. What remains appears to be the lower 3 feet of a rich secondary deposit and the roots or lower parts of what was, perhaps, a large primary gold deposit.

Two hundred feet west of the test-pit, across a slight drift-covered depression, a vein of white quartz 5 feet wide is exposed. It trends west in apparent continuation of the gold-bearing veins. A small amount of pyrite occurs in this vein near its contact with the granitic wall-rock. The vein has been traced 70 feet and is concealed by drift at both ends. Within 300 feet west of this vein two small lenticular quartz veins have been picked up. No mineral has been found in these and from the surface examination one would not expect to find any rich primary deposit.

On the next claim north and 40 chains north from the test-pit (B, Figure 3) an irregular quartz vein with maximum width of 10 inches trends south 30 degrees west up the side of a low cliff which lies at the margin of the sand-covered lowland through which Mollie river flows. The country rock is an inclusion of calc-chlorite schist in the granodiorite. The vein pinches and swells for its exposed length of 15 feet. It consists of white quartz mineralized with chalcopyrite, which is so abundant in some places as to make up 5 per cent of the vein by volume. There are a number of small chlorite-schist inclusions in the vein. Gold can be panned from the roasted and pulverized vein material.

Fifteen chains northeast from the above occurrence (C, Figure 3) several large, lenticular quartz veins occur as a stockwork permeating an inclusion of chlorite schist in the granodiorite. The vein material is restricted to the inclusion, which is 20 feet wide. The trend of the veins and the schist is north 40 degrees east. There are no metallic minerals to be seen in the veins, though a rusty stain occurs in the quartz locality.

Sixty chains north-northwest from the above on the west side of Mollie river (D, Figure 3) there is a white quartz vein 6 feet wide trending north 75 degrees east. The natural outcrop permits of the vein being traced for 20 feet only. No metallic content is to be seen.

All the above quartz veins which are regarded by the owners as of interest occur in a zone lying approximately one-half mile east of the Canadian National railway and parallel to its course. These veins trend in various directions, but they are all of the same age and origin. A consideration of the field evidence collected at the time of the visit leads to the conclusion that the quartz veins are genetically related to the granite intrusion and that the rich secondary gold deposit has resulted from the weathering of a primary deposit during past geological ages. The surface examination indicates that no commercial deposit of gold ore has yet been encountered on the claims. It is possible, however, that further prospecting will reveal either larger bodies of secondary gold ore or richer primary deposits than are now known.

INVESTIGATION OF PEAT BOGS IN QUEBEC

By A. Anrep

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INTRODUCTION

During the summer season of 1922, four peat bogs in the province of Quebec were surveyed, in order to determine the area, depth, and qualities of peat contained in each. These investigations were started in the beginning of July and were carried on during July, August, September, and part of October. S. R. Read acted as field assistant. A total area of 3,460 acres of peat bogs was investigated.

Three of the four bogs surveyed are situated near the city of Quebec. These are called here the Sagamite, Breakeyville, and St. Jean bogs. The fourth bog surveyed is situated near St. Thérèse-de-Blainville and about 20 miles northwest of Montreal.

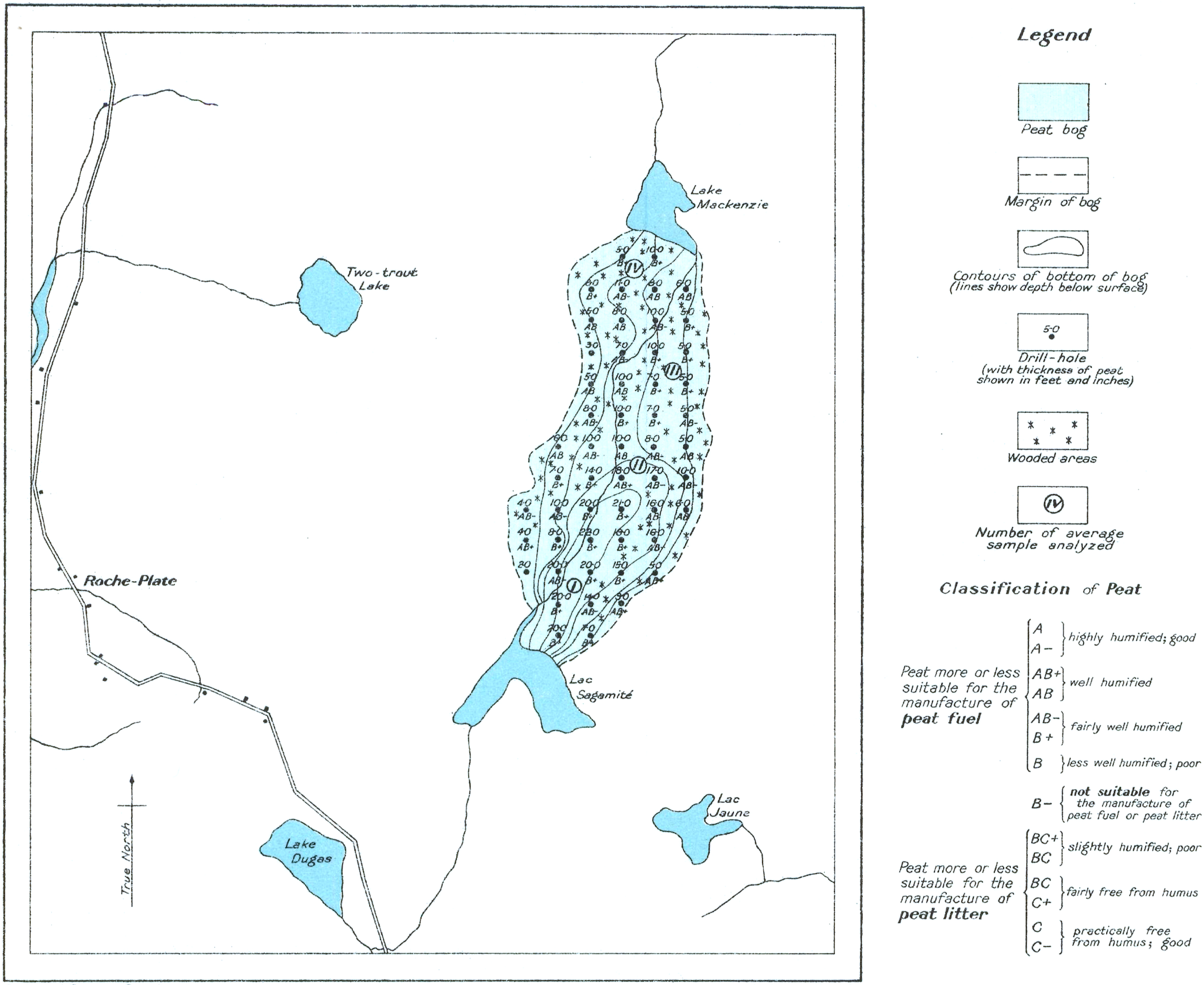
SAGAMITE PEAT BOG

This bog is in Stoneham township and is about 13 miles north of Quebec city. It extends in a northeast and southwest direction (Map 1982) and has a total area of about 340 acres.

Of this area 79 acres have a depth of less than 5 feet with an average depth of 3 feet; 112 acres have a depth between 5 and 10 feet with an average depth of 6 feet; 76 acres have a depth between 10 and 15 feet with an average depth of 10 feet; 45 acres have a depth between 15 and 20 feet with an average depth of 17 feet; and 28 acres have a depth of more than 20 feet with an average depth of 20 feet. The volume of peat contained is:

382,000 cubic yards in an area with a depth of less than 5 feet.
1,084,000 cubic yards in an area with a depth of between 5 and 10 feet.
1,226,000 cubic yards in an area with a depth of between 10 and 15 feet.
1,234,000 cubic yards in an area with a depth of between 15 and 20 feet.
903,000 cubic yards in an area with a depth of more than 20 feet.

This bog has a considerable depth and is free from knolls. The surface is quite level except where there are places that are wooded with dwarfed spruce, tamarack, and alders. A level stretch of more than 500 acres of swampy land continues north of lake Mackenzie, but the layer of peat thereunder is very shallow, varying from $\frac{1}{2}$ to 1 foot, and is densely



Geological Survey, Canada. Publication No 1982

Sagamité Peat Bog, Quebec County, Quebec.

Scale, 2400 feet to 1 inch

1000 0 1000 2000 3000 4000 5000

To accompany report by A. Anrep, in Summary Report, Part D, 1922.

Peat surveys by A. Anrep, 1922.

wooded. Not being of any commercial value for the manufacture of peat, that area has not been mapped.

This bog could easily be drained as there is a good current towards St. Charles river, and with a little blasting at the outlet Sagamite lake could be lowered.

The peat in this bog is well humified and is suitable for the manufacture of fuel. Towards the margins it is occasionally intermixed with roots and stumps, but throughout the middle of the bog these are in most cases sufficiently decomposed for a drill to penetrate. Samples show that the peat is composed mainly of sphagnum mosses intermixed with eriophorum and slightly mixed with carex towards the margins.

The bottom is formed of rock and sand overlaid with a thin layer of slimy clay-like matter.

The 79 acres less than 5 feet deep may be excluded from consideration as a commercial source of peat. Allowing[1] 2 feet for decrease in depth through drainage the remaining 112 acres with an average depth of 4 feet (722,773 cubic yards); 76 acres with an average depth of 8 feet (980,906 cubic yards); 45 acres with an average depth of 15 feet (1,089,000 cubic yards); and 28 acres with an average depth of 18 feet (813,120 cubic yards) would give a total of 3,606,000 cubic yards. The total dry tonnage is 361,000 tons or 481,000 tons of peat fuel having 25 per cent moisture.

Analysis of Peat from Sagamite Peat Bog

Sample	I		II		III		IV	
	R	D	R	D	R	D	R	D
Moisture	8·6	....	8·1	....	8·5	....	7·8	....
Ash	20·2	22·0	17·3	18·9	27·5	30·0	33·8	36·7
Volatile matter	50·6	55·4	50·5	54·9	45·4	49·6	41·3	44·8
Fixed carbon (by difference)	20·6	22·6	24·1	26·2	18·6	20·4	17·1	18·5
Sulphur	0·4	0·5	0·4	0·5	0·4	0·5	0·4	0·5
Nitrogen	1·9	2·1	1·6	1·8	1·6	1·8	1·5	1·6
Calorific value in calories per gram, gross	4050	4430	4390	4780	3610	3950	3330	3610
Calorific value in B.T.U. per lb., gross	7290	7980	7900	8590	6500	7110	5990	6650
Fuel ratio, fixed carbon, volatile matter	0·42	....	0·48	....	0·41	....	0·41	....

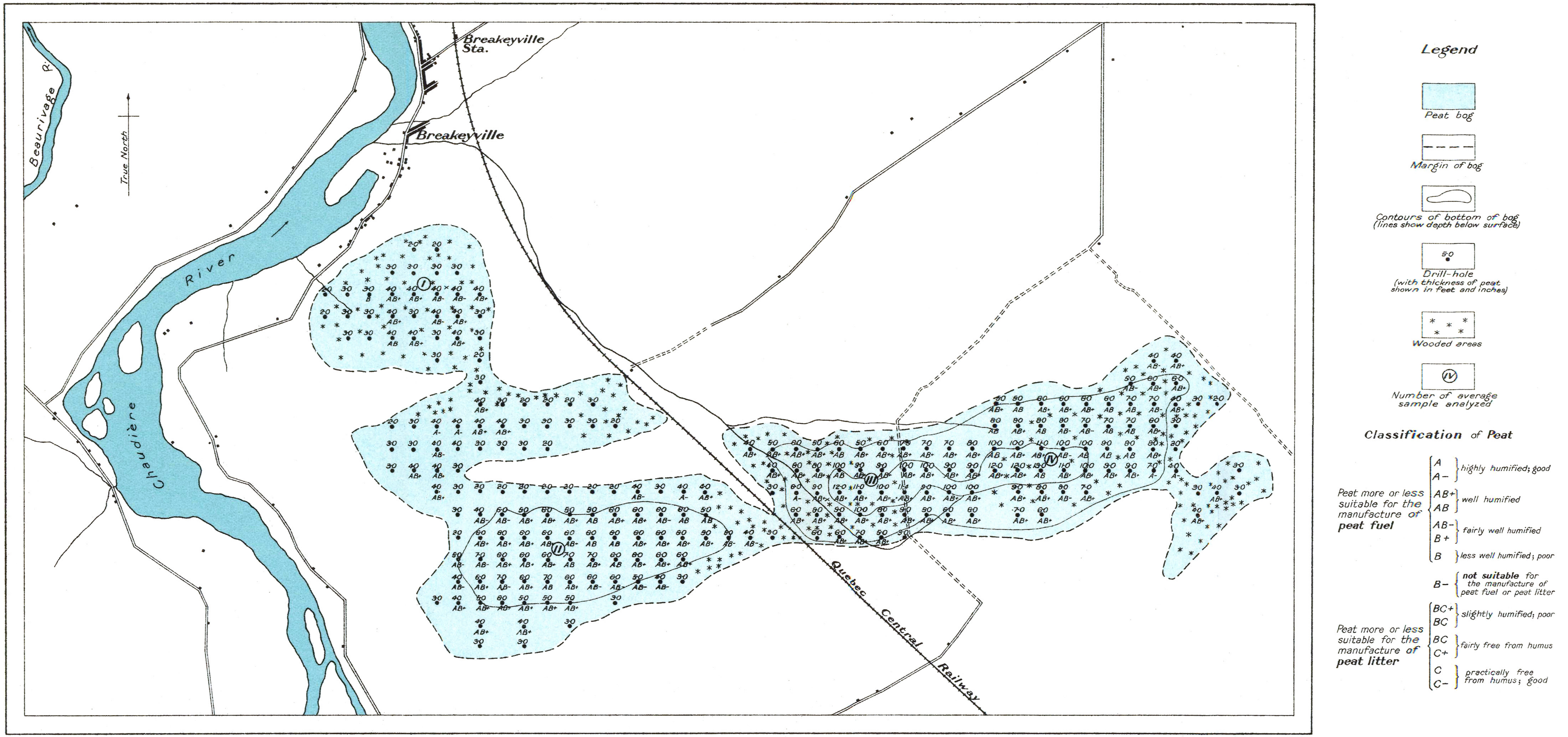
During the survey of the Sagamite bog a reconnaissance survey was made of several small bogs in the vicinity of lake Beauport, but none of them is of commercial value and for this reason no detailed investigations were made.

BREAKEYVILLE PEAT BOG

This bog is situated about 1½ miles south of Breakeyville village, and about 13 miles south of Levis. It extends in an east and west direction (*See* Map 1983).

[1] All figures in this report are approximate. A ton is considered as 2,000 pounds. A cubic yard of drained bog is assumed to be equal to 200 pounds of dry peat.

In the tables of analyses, figures in column R refer to fuel as received, and in column D to fuel dried at 105°C. The analyses were made on the fuel received and the other results were calculated therefrom.



Geological Survey, Canada. Publication No 1983

Breakeyville Peat Bog, Levis County, Quebec.

Scale, 2400 feet to 1 inch

1000 0 1000 2000 3000 4000 5000

To accompany report by A. Anrep, in Summary Report, Part D, 1922.

Peat surveys by A. Anrep, 1922.

The total area is approximately 1,780 acres. Of this area 1,066 acres have a depth of less than 5 feet with an average depth of 3 feet; 623 acres have a depth between 5 and 10 feet with an average depth of 7 feet; and 91 acres have a depth of more than 10 feet with an average depth of 11 feet. The volume of the peat contained is:

5,159,000 cubic yards in an area less than 5 feet deep
7,036,000 " " between 5 and 10 feet deep
1,615,000 " " over 10 feet deep

The peat is very well humified, has high cohesive properties, is of a dark brown colour, and is very compact. It is especially well suited for the manufacture of machine-peat fuel.

The part of the bog lying west of the Quebec Central railway is rather shallow. This would be a drawback for the manufacture of machine-peat fuel as it would require very long working lines. However, this part of the bog could be favourably utilized for the manufacture of hand-cut peat. The section east of the Quebec Central railway has a satisfactory depth and could be favourably utilized for the manufacture of machine-peat fuel.

The country surrounding the bog is level and could easily be utilized as drying ground. The surface of the bog itself is level and free from knolls, and is entirely wooded more or less heavily with spruce, alders, and tamaracks. This bog could be easily drained as the western end is only 1,000 feet east of Chaudière river, with a drop of approximately 30 feet. Occasionally, stumps and roots were encountered, but they are somewhat decomposed and would not be a hindrance in the manufacture of machine-peat fuel. The peat is mainly composed of sphagnum mosses and eriophorum slightly mixed with carex. The bottom of the bog is formed of a conglomeration of sandstone and clay.

This bog is very conveniently situated as regards market, being traversed by the Quebec Central railway and only a short distance from Levis and Quebec.

Excluding from consideration the 1,066 acres with a depth of less than 5 feet and allowing for the remainder of the area a shrinkage of only 1 foot for drainage, on account of its compactness, there are:

623 acres with an average depth of 5 feet = 5,025,533 cubic yards
91 " " 9 " = 1,321,320 "

The total volume of utilizable peat is 6,347,000 cubic yards. The total dried tonnage is 635,000, or 847,000 tons of peat fuel having 25 per cent moisture.

Analysis of Peat from Breakeyville Peat Bog

Sample	I		II		III		IV	
	R	D	R	D	R	D	R	D
Moisture	8·8	....	7·8	....	8·9	....	8·1	....
Ash	3·8	4·2	4·9	5·3	4·8	5·3	7·7	8·4
Volatile matter	62·4	68·4	63·0	68·4	61·6	67·6	60·1	65·4
Fixed carbon (by difference)	25·0	27·4	24·3	26·3	24·7	27·1	24·1	26·2
Sulphur	0·3	0·3	0·4	0·4	0·3	0·3	0·4	0·5
Nitrogen	1·4	1·5	1·5	1·6	1·3	1·5	1·4	1·5
Calorific value in calories per gram, gross	5280	5760	5260	5710	5020	5500	5080	5520
Calorific value in B.T.U. per lb., gross	9500	10380	9471	10280	9020	9910	9140	9940
Fuel ratio, fixed carbon, volatile matter	0·40	....	0·39	....	0·40	....	0·40	....

ST. JEAN PEAT BOG

This bog is situated 2½ miles north of Breakeyville and 9 miles south of Levis, Levis county. It extends in a northeast and southwest direction. The total area is approximately 270 acres, of which 150 acres have a depth of less than 5 feet with an average depth of 4 feet, equivalent to 968,000 cubic yards, and 120 acres have a depth of more than 5 feet with an average depth of 6 feet, equivalent to 1,162,000 cubic yards.

The peat is very well humified, has high cohesive properties, and is suitable for fuel. The bog is rather shallow, but as it is partly drained a small mechanical plant could be erected.

It is formed principally of sphagnum mosses which cover the surface of the bog with a carpet 1½ feet thick, which is not level, and in spots forms knolls. The peat is heavily intermixed with eriophorum and occasionally carex plants are found toward the margins. The bottom of the bog consists of gravel and sand.

As the bog is of a compact nature and almost drained, no part need be left out of consideration and only 1 foot for shrinkage through drainage need be deducted from the thickness of the whole area. There are thus:

150 acres with an average depth of 3 feet = 726,000 cubic yards
120 " " 5 " = 968,000 "

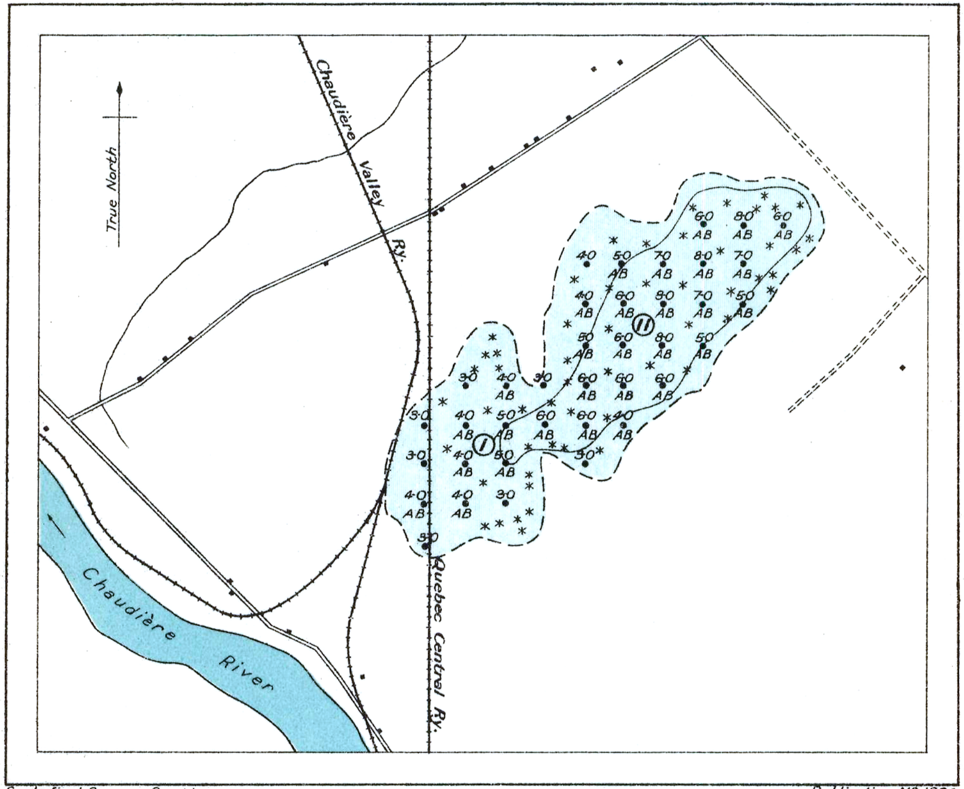
These have a total volume of 1,694,000 cubic yards of peat. The total tonnage of dry substance is 169,000 tons, or 225,000 tons of peat fuel with 25 per cent moisture.

Analysis of Peat from St. Jean Bog

Sample	I		II	
	R	D	R	D
Moisture	9·0	....	5·5	....
Ash	2·0	2·2	7·4	7·8
Volatile matter	65·0	71·4	64·2	68·0
Fixed carbon (by difference)	24·0	26·4	22·9	24·2
Sulphur	0·3	0·3	0·3	0·3
Nitrogen	1·4	1·5	1·7	1·8
Calorific value in calories per gram, gross	4890	5370	5750	6090
" " B.T.U. per lb., gross	8800	9670	10350	10950
Fuel ratio, fixed carbon, volatile matter	0·37		0·36	

STE. THÉRÈSE PEAT BOG

This bog lies about 4½ miles north of Ste. Thérèse-de-Blainville, Terrebonne county. It extends in a northwest and southeast direction and has a total area of approximately 1,070 acres. Over the total area the depth varies from 1 foot to 5 feet, with an average depth which does not exceed 3 feet. As this depth is not sufficient to be economical for the manufacture of peat fuel with the present known mechanical devices, it was decided not to prepare a map of the bog.



Geological Survey, Canada.

Publication Nº 1984

St. Jean Peat Bog, Levis County, Quebec.

Scale, 2400 feet to 1 inch

1000 0 1000 2000 3000 4000

To accompany report by A. Anrep, in Summary Report, Part D, 1922.

Peat surveys by A. Anrep, 1922.

Legend

- Peat bog
- Margin of bog
- Contours of bottom of bog (lines show depth below surface)
- 5·0 Drill-hole (with thickness of peat shown in feet and inches)
- Wooded areas
- (II) Number of average sample analyzed

Classification of Peat

Peat more or less suitable for the manufacture of **peat fuel**	A, A−	highly humified; good
	AB+, AB	well humified
	AB−, B+	fairly well humified
	B	less well humified; poor
	B−	**not suitable** for the manufacture of peat fuel or peat litter
Peat more or less suitable for the manufacture of **peat litter**	BC+, BC	slightly humified; poor
	BC, C+	fairly free from humus
	C, C−	practically free from humus; good

This bog is formed on a sand plateau, with a depression in the middle, which enabled it to retain enough moisture to nourish bog vegetation. The samples obtained by drilling showed that the peat is composed mainly of carex plants, intermixed with *eriophorum scirpus* and towards the bottom is slightly intermixed with aquatic plants. Occasionally, sphagnum plants were noticed on the surface of the bog. This indicates that the bog has been drained through the cultivation of surrounding farms, before the sphagnum family had the opportunity to become a prevalent factor. From the surface growth on the bog, which consists mainly of young poplars and dwarf birch, it is evident that the bog has frequently been swept by fires, which accounts for its shallowness. Even while the survey was being carried on, big fires were raging in several places.

The peat in this bog is fairly well humified, and if necessary could be utilized for fuel, cut by hand or by small individual mechanical plants, in which case the finished product could be consumed, by the neighbouring farmers, in cooking stoves, Quebec heaters, etc. As this peat is very light in texture, and consequently bulky and easily crumbled, it would not be able to stand much handling or transportation.

Assuming that the bog would be utilized for the manufacture of peat fuel on a small scale for domestic purposes, and taking into consideration the dryness of the peat, only one foot need be deducted from the thickness for drainage and waste. There are 1,070 acres with an average depth of 2 feet, equal to 3,453,000 cubic yards. The total dried tonnage would thus be 345,000 tons, or 460,000 tons of peat fuel having 25 per cent of moisture, but the fires of the summer of 1922 must have reduced this amount considerably.

During the summer of 1920 the Company "Le Combustible National Limittée" erected a plant on this bog for the manufacture of peat fuel with a proposed production of about 25 tons a day.

At the time of the writers' visit to the plant in September, 1922, operations were suspended, and the following information was gathered from personal observation:

The raw peat is cut with spades in sizes of 3 inches by 3 inches by 4 inches and placed on pallets or trays 4 feet long which are spread on the ground in the open where they are partly air dried, to about 60 per cent moisture. After this the pallets or trays containing the peat are placed on wagonettes or transportation cars provided with shelves arranged in double tiers of four and transported by rail through a building where a specially constructed spraying apparatus suspended from the ceiling sprayed the peat in each car as it passed under with a liquid the nature of which was not ascertained. From here the wagonettes with the peat are transported by rail to a specially constructed dryer, built in the form of a double track tunnel having a height of 70 feet and diameter of 40 feet. This drying room is equipped with two boilers of 150 horsepower each. These boilers serve two purposes: (1) to supply steam to the engines that operate the fans; (2) to heat the air which is forced through the drying room by the fans. After the peat has left the drying room it is supposed to contain 15 per cent moisture. This peat is stored under cover where it is bagged and shipped.

Judging from the size of the excavation, the number of tons so far produced is not great and, at the time of the writer's visit, between 5 and 6 tons of finished peat product was visible on the premises.

Analysis of Peat from Ste. Thérèse-de-Blainville Bog

Sample	I		II	
	R	D	R	D
Moisture	8·6	....	8·0	....
Ash	8·8	9·6	9·2	10·0
Volatile matter	58·8	64·4	58·0	63·1
Fixed carbon (by difference)	23·8	26·0	24·8	26·9
Sulphur	0·3	0·3	0·3	0·3
Nitrogen	1·6	1·7	1·3	1·4
Calorific value in calories per gram, gross	5100	5580	5210	5660
" " in B.T.U. per lb., gross	9180	10040	9370	10190
Fuel ratio, fixed carbon, volatile matter	0·41		0·41	

OPASATIKA MAP-AREA, TIMISKAMING COUNTY, QUEBEC

By H. C. Cooke

CONTENTS

Illustrations

INTRODUCTION

The study of the belt of gold-bearing rocks that extends from Matachewan district to Larder Lake district indicated that the Timiskaming series and, probably the gold-bearing porphyries, extended eastward into Quebec. Accordingly it was decided to commence, in 1922, detailed mapping in Quebec. Events have more than justified the course, for in the latter part of the summer of that year, several promising gold discoveries were made within the area mapped (Figure 4).

The resulting demand for information makes it desirable to publish the results already obtained. During the course of the field work it was discovered that much of the earlier mapping of the watercourses is imperfect, especially in the vicinity of the gold discoveries. These watercourses are at present almost the only base for geological work. The geologist must tie all his measurements and traverses to them, and when they are not accurately placed on the map, it is obvious that the mapping of outcrops and geological boundaries will also be incorrect. In spite of these admitted errors, it seems desirable to publish at once a preliminary map, which is accurate over the greater part of the area, and in the remaining less accurate part shows the general distribution of the formations. More detailed work in the neighbourhood of the gold deposits must await the completion of good maps of the lakes and streams, which are now being surveyed by the Quebec Department of Lands and Forests.

The writer and his assistants mapped the Opasatika area (Figure 4). The mapping of the Duparquet area, although under the nominal supervision of the writer, was done entirely under the immediate direction of W. F. James.

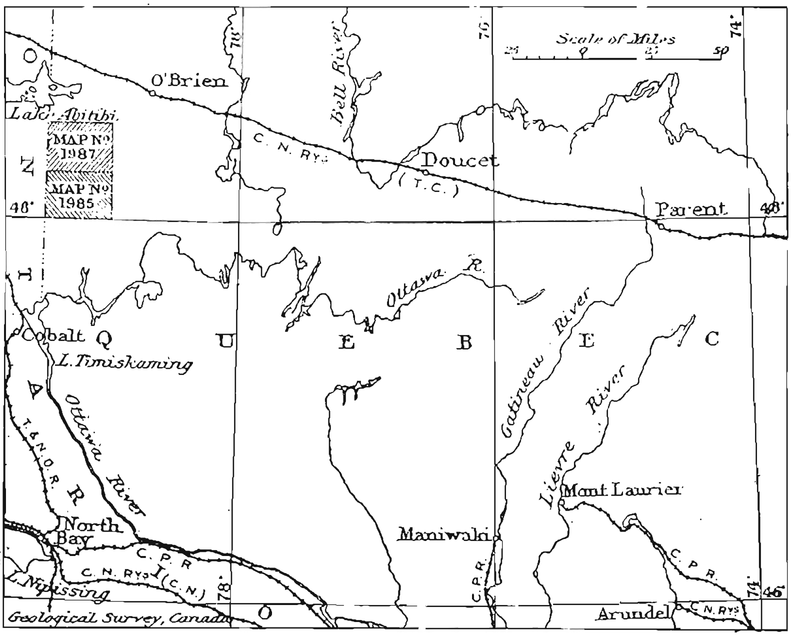


Figure 4. Index map showing location of Opasatika (1985) and Duparquet (1987) map-areas, Timiskaming county, Quebec.

This report is based on the field work done in Opasatika map-area. A geographical base map of the area was compiled during the winter of 1921-22, on a scale of one-half mile to 1 inch, from surveys of township lines and watercourses previously made by the Quebec Department of Lands and by the Geological Survey. The geology, determined for the most part by pace and compass traverses spaced one-half to three-quarters of a mile apart, was plotted on this map (No. 1985), which was published on a scale of 1 mile to 1 inch.

The writer is indebted to many residents in the district for information and assistance, in particular to the Lake Fortune Mining Company, under the management of Mr. Morgan Grandy. The officers of the J. R. Booth Lumber Company, and Messrs. Boucher and Guinnard, lumbermen, gave much assistance to the party by bringing in mail and supplies, and in various other ways. Most efficient assistance was given in the field by W. V. Howard and L. J. Foss.

PREVIOUS WORK

The following surveys have been used in the preparation of the map.

Interprovincial boundary surveys by O'Hanly and O'Dwyer in 1873-4, and by Patten and Laberge, 1906.

Survey of Opasatika and Dasserat lakes by Lindsay Russell, 1868.

Survey of the northwest shore of Labyrinth lake by W. J. Wilson, 1901.

Surveys of Albee, Evain, and Kekeko lakes, by J. S. Bignell, 1893.

Micrometer surveys of various waters by M. E. Wilson and his assistants in the years 1908-1911.

Base, meridian, and township lines surveyed by the Crown Lands Department of Quebec.

Previous geological work was confined almost entirely to the examination of the shores of the more easily travelled watercourses. The earliest report was made by Walter McOuat in the Report of Progress of the Geological Survey of Canada for 1872-73 and describes the canoe route from lake Timiskaming to lake Abitibi, via Opasatika and Dasserat lakes. In the Summary Report of the Geological Survey, 1904, there is a description, by W. A. Parks, of much the same area, and of a part of Labyrinth lake. The reports of the Quebec government on "Mining Operations" for 1906 and 1907, have sections devoted to geological observations by L. Obalski on the northern part of Pontiac county. Finally, M. E. Wilson spent the three seasons of 1908, 1910, and 1911, and part of the season of 1909, for the Geological Survey in making a general reconnaissance of the whole area between the Interprovincial Boundary and Kewagama lake, longitude 78.15 west, and embodied his observations in Memoirs 17 and 39 of the Geological Survey.

GENERAL CHARACTER OF THE AREA

MEANS OF ACCESS

The map-area is easily accessible either from the south, west, or north. The route from the west is probably the easiest for the traveller with little baggage. From Dane station on the Temiskaming and Northern Ontario railway a stage makes daily trips eastward to Larder lake, a distance of 18 miles. Motor boats may be obtained to cross Larder lake, 8 miles, and from the east end of the lake there is a fairly good road, 17 miles long, to Lake Fortune mine. This road is now reported to extend a farther 14 miles to Rosebury lake.

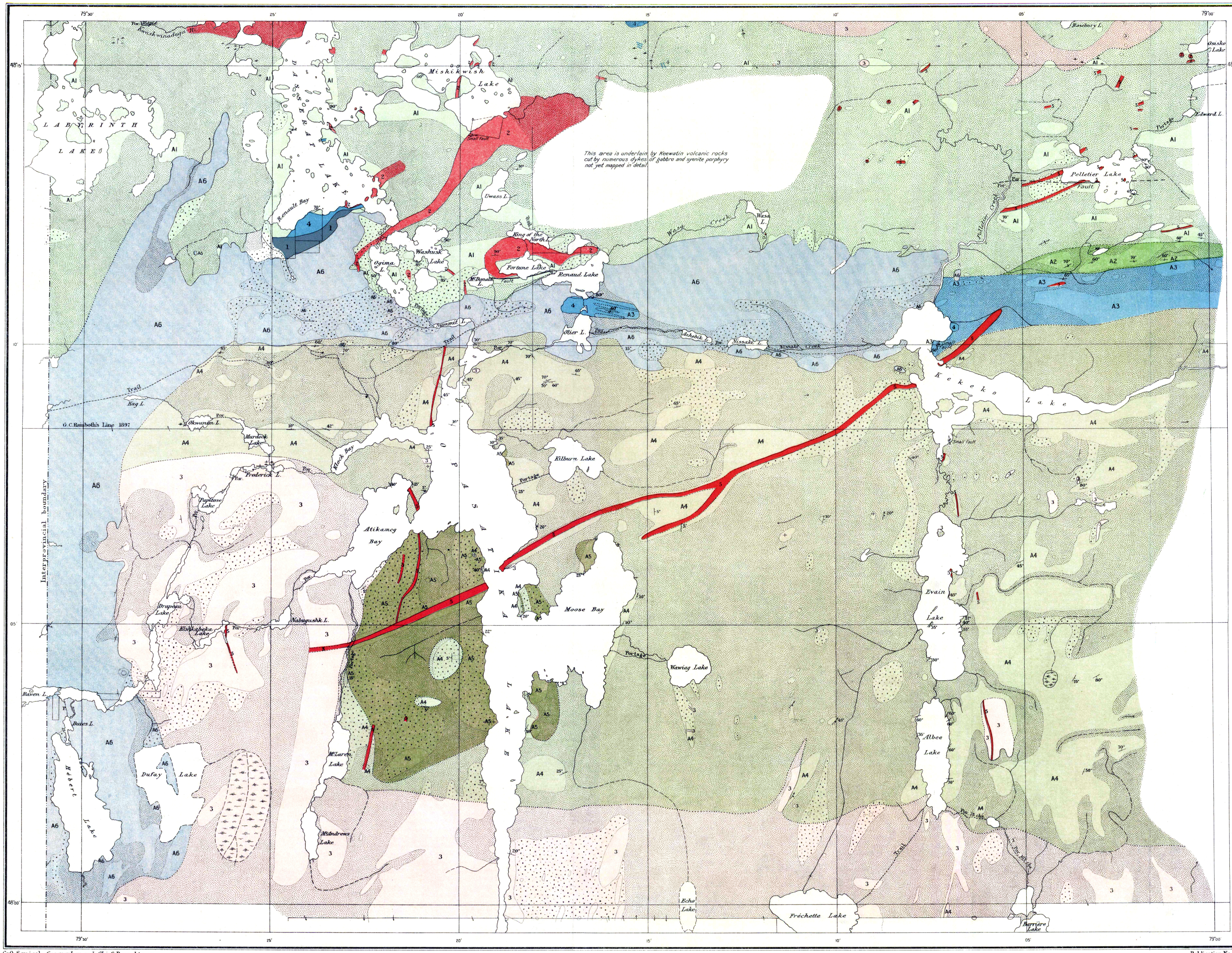
From the north there is a good canoe route, by which a trip may be made easily in two days from the National Transcontinental railway to Opasatika lake. Starting from La Sarre, a town of about a thousand inhabitants, the route follows La Sarre river some 8 miles to lake Abitibi, crosses the lake, and runs up Abitibi river to Duparquet lake; then up Kanasuta river to Dasserat lake and Ogima lake, from which two short

Canada
Department of Mines
HON. CHARLES STEWART, MINISTER. CHARLES CAMSELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR.

Issued 1923

PRELIMINARY MAP



LEGEND

HURONIAN QUATERNARY

- **POST-GLACIAL**: *Thin-bedded clays, silts, and sands*
- **GLACIAL**: *Boulder clay, terminal moraine, esker and kame deposits*
- **COBALT SERIES**: A6 — *Conglomerate, with some greywacke, arkose, and slate*

Great Unconformity

PRE-HURONIAN

- **PRE-HURONIAN INTRUSIVES**
  - 5 — *Later gabbro: dykes*
  - 4 — *Syenite porphyry: dykes and small bosses*
  - 3 — *Granite: dykes and batholiths*
  - 2 — *Older gabbro: dykes and irregular masses*
  - 1 — *Diorite porphyry*

Intrusive contact

- **TIMISKAMING SERIES**
  - A5 — *Altered basalts*
  - A4 — *Greywacke and quartzite mainly, largely altered to mica schist; some small sills of amphibolite*
  - A3 — *Conglomerate, with some interbedded greywacke*

Unconformity

- **KEEWATIN**
  - A2 — *Dark thin-bedded tuffs*
  - A1 — *Basalts, with minor amounts of andesites, dacites, rhyolites, and breccias*

Symbols

- Geological boundary (defined)
- Geological boundary (approximate)
- Geological boundary (assumed)
- Dip and strike of strata
- Dip and strike of overturned strata
- Dip and strike of schistosity
- Vertical schistosity
- Horizontal strata

C. O. Senécal, *Geographer and Chief Draughtsman.*
A. McGregor, *Draughtsman.*

Publication No. 1985.

OPASATIKA AREA, TIMISKAMING COUNTY, QUEBEC.

Scale of Miles
1 ¾ ½ ¼ 0 1 2

Sources of Information
Geology by H. C. Cooke, *1922.*
Surveys by Department of Lands and Forests, Quebec, M. E. Wilson, *1908-1911, and* H. C. Cooke, *1922.*
Compilation of base map by H. Lefebvre.

To accompany report by H. C. Cooke, *in Summary Report, Part D, 1922.*

portages lead to Opasatika lake and the road to Dane. There are only seven portages on this route, all short except the one between Ogima and Summit lakes, which is a trifle more than half a mile in length.

The southern route, although longer than the others, is probably the easiest for a party bringing in a large quantity of supplies. From Liskeard or Haileybury, on the Temiskaming and Northern Ontario railway, one may travel by steamboat or motor car to North Timiskaming, at the head of lake Timiskaming, whence a fairly good road 28 miles long runs north to the foot of Opasatika lake. A loaded team can cover the distance easily in one day, and it is said that the Quebec Government intends to improve the road in the near future so as to make it easily passable for motor cars and trucks. From the foot of Opasatika lake to the head of the lake, 20 miles, recourse may be had to canoe or motor boat.

Another very good, but still longer, route to Osisko lake starts at Gillies Depot, on lac des Quinze, which may be reached by motor truck from Ville Marie in a couple of hours. The canoe route lies up the east arm of Quinze lake, through lake Expanse, up Ottawa and Kinojevis rivers, through Kinojevis lake to Routhier lake and Rouyn lake. From Rouyn lake there is a portage three-quarters of a mile long to Osisko lake. The route is about 75 miles in length, but has the advantage of being an all-water route except for the one portage mentioned.

TOPOGRAPHY

The district is part of the great Precambrian plateau that occupies nearly the whole of northeastern Canada, and is usually described as an uplifted and dissected peneplain[1]; but it exhibits some topographic peculiarities which enlarge our knowledge of the physiographic history of the whole region.

The most striking feature is a long, high ridge that extends from Pelletier creek on the east to the Interprovincial Boundary. This ridge is composed of the Cobalt series of rocks, which are highly resistant to erosion, and although streams have cut deep valleys into and across it in many places, it still has a general accordance of summit levels which give it the appearance, taken as a whole, of a level-crested ridge. The beds composing it are not flat-lying, but dip 10 to 25 degrees. The level crest cannot, therefore, be due to original bedding, but must be due to peneplanation; in other words, the ridge is almost the sole remnant of a former peneplain. The maximum elevations on it, as determined by M. E. Wilson, from aneroid observations, are 1,680 feet on the Kekeko hills, and 1,600 feet on the Swinging hills. It is interesting to note, also, in this connexion, that Wilson gives the maximum elevation of the Abijevis hills, 35 miles to the northeast, as 1,650 feet. The Abijevis hills are composed, not of the Cobalt series, but of a resistant Keewatin basalt. The general accordance of the summit level of the Abijevis hills with those of the Kekeko and Swinging hills is striking, and tends to confirm the conclusion as to the existence of a former peneplain which, if reconstructed, would now lie between 1,600 and 1,700 feet above sea-level.

[1]Peneplain, literally, almost plain; a large land area of nearly plain-like surface, which has been levelled by erosion.

At a lower elevation there is another set of ridges and uplands characterized by flat tops and a general accordance of summit levels. This set includes the ridge formed by the diabase dyke traced for 17 miles from McLaren creek past Kekeko lake; the ridges of granite and Timiskaming lava between Opasatika lake and McLaren lake and creek, and west of McLaren lake and Atikameg bay; the ridges of Timiskaming conglomerate south of Pelletier lake; and many others. These may be seen from points of vantage to have a general equality of level. Their heights were not accurately measured, but are estimated at 200 to 250 feet above lake Opasatika, which, according to the Ottawa River Regulation survey, is 869 feet above sea-level. The general level of the ridges described is, therefore, in the neighbourhood of 1,100 feet. These level-crested ridges and flat-topped uplands, composed of rocks so different in character as granite, diabase, and folded conglomerate, suggest a second nearly perfect period of base-levelling.

Finally, a great part of the district has been eroded to a still lower level, and now is approximately 900 feet above sea-level. These lower areas are covered with flat-lying, thin-bedded clays and silts formed at the bottoms of large post-Glacial lakes. The nature of the underlying rock surface, however, inferred from observation of outcrops along lake shores, in stream valleys, etc., is rugged on a small scale, but plain-like on a large scale, with a relief which, for the most part, probably does not exceed 50 feet. These areas of low elevation are, of course, most widely developed on the least resistant rocks, the schistose greywackes of the Timiskaming series. Farther to the north there are similar rather flat areas of low relief developed on the Keewatin basalts; but, as the lavas are much more resistant to erosion, the areas of lowest elevation are neither as large nor as low as they are on the greywacke. The relief of the lowest surface on the Keewatin areas is also greater than on the areas of greywacke, probably 100 to 150 feet. The lowest erosion surface, therefore, appears to be merely a surface carved out of the second peneplain above mentioned, after uplift had taken place. It cannot have been formed by peneplanation, since the greywackes and lavas are not reduced to a general level.

Opasatika district thus apparently affords evidence of two distinct periods of peneplanation. The only remnants of the first peneplain are the long ridge of Cobalt series in the northern part of the district, and the Abijevis hills 35 miles to the northeast. If reconstructed, it would lie 1,600 to 1,700 feet above sea-level. This peneplain may possibly be the remnant of the Cretaceous peneplain that covered the greater part of the land surface of North America and was uplifted at the end of the Cretaceous period. It may also be a remnant of the much older Precambrian peneplain that, formed at the end of Precambrian time, was preserved for ages by a covering of Palæozoic sediments. These sediments are supposed to have persisted until the uplift at the end of the Cretaceous, when they were gradually removed by erosion. At about 1,100 feet above sea-level a large series of level-crested ridges and flat surfaces of nearly equal elevation appear to represent the remains of a second peneplain that may correspond to the Pliocene peneplain of the Appalachian region. Since the uplift of the Pliocene plain, erosion has removed from 50 to 250 feet of the softer rocks. The effect has been most pronounced on the easily eroded mica schists, on which a surface of, roughly, 900 feet average elevation has been produced, with a relief of perhaps not more than 50 feet.

The topographic history, therefore, appears to have commenced with a long period of erosion that reduced the area almost to sea-level, forming the peneplain of which the Abijevis, Kekeko, and Swinging hills are now almost the only remnants. This peneplain was then uplifted to a height of 500 to 600 feet above sea-level (plus the thickness of any overlying Palæozoic sediments). A general continental uplift of about this amount occurred at the end of the Cretaceous, after peneplanation, and the uplift in the Opasatika area is, therefore, assumed to be of this age. The land surface seems then to have remained stationary long enough for the bulk of it to be again reduced to sea-level, forming a second peneplain, which, for similar reasons, is supposed to have been uplifted to an unknown height during the Pliocene. Although the level of the land after the Pliocene uplift is unknown it was probably higher than at present, at any rate to the north, since there is evidence that Hudson bay did not exist in pre-Glacial time, and the coast of Labrador is clearly a drowned shore-line. It is also certain that some of the streams now flowing north previously flowed south, and have been forced into their present courses by dams of drift, so that the land to the north must have been as high or higher than at present. After the Pliocene uplift, erosion began to cut away the second peneplain, and had removed about 200 feet of the softest rocks, when glaciation occurred. The land surface sank under the weight of the ice-sheet, until it stood several hundred feet lower than at present. After the ice disappeared the land slowly rose again to its present elevation.

Effects of Glaciation

Glaciation, almost the last episode in the history of the region, has affected the topography mainly in two ways—by the formation of moraines and the deposition of lacustrine clays. It is improbable that the ice-sheets had any very pronounced erosive effects other than the removal of weathered materials and a general rounding and smoothing of the surface. They may have assisted in wearing down the soft Timiskaming grey-wackes to their present low level, but as there are places in northern Ontario and Quebec where rocks in sheltered positions are still covered with remnants of their preglacial mantle of well-weathered material, sometimes several feet in depth, glaciation could not have removed any general great thickness of fresh rock.

The deposition of moraines has given the area in many places the characteristic knob-and-kettle topography, and, by damming the former watercourses, has disorganized the preglacial drainage, forming lakes, rapids, and waterfalls, and forcing the streams in places into new channels. There is no doubt that these disturbances, coupled with the changes of level in Glacial time, have shifted the position of the height of land. The section dealing with preglacial stream channels will illustrate some of these effects.

The glacial lake clays are flat-lying, thin-bedded clays and silts deposited in the basin of a large lake that existed for a comparatively short time while the ice-sheets were disappearing. In Opasatika map-area there is evidence of at least two stages in the life of the lake. During the first stage it appears to have extended from lake Timiskaming northward to some undetermined boundary beyond the National Transcontinental railway. The water-level then fell suddenly, draining the northern area, and the new and smaller lake lay between lake Timiskaming and Kekeko hills.[1] The lake deposits filled in the inequalities of the land surface, forming a monotonous, flat, or slightly rolling plain, broken here and there by protruding ridges of rock or glacial moraine. Corresponding to the two stages in the life of the lake, there are two such plains, a lower plain, formed by the last stage of the lake, with an estimated elevation of 900 feet above sea-level, and an upper plain, to the north of Kekeko ridge, about 150 feet higher.

Erosion since Glacial time has affected the clay areas very slightly. Streams have cut narrow gullies of varying depth in them. The longer gullies have all been formed by drainage from interior basins. Those formed by the normal headward erosion of streams are mostly less than 2 miles in length. There are, consequently, large, flat undissected areas between the streams, on which water lies in the spring until it evaporates or soaks into the soil. This land, when cleared and perhaps drained by ditching the wetter parts, will be as good farming country as any to be found in the north.

Pre-Glacial Channels

It is difficult or impossible to determine the position of the pre-Glacial stream channels except in areas of high relief, for elsewhere they have been filled in, and the streams have been shifted by the deposition of moraines and glacial lake clays. Where the relief is high, however, parts of the old channels can in some cases be distinguished, and present some features of interest.

One of these channels is, undoubtedly, the deep gorge of Opasatika lake, which extends south from the lake for an undetermined distance. It is a fairly straight valley, at its northern end a steep-sided gorge 300 feet or more in depth, and only about 300 feet wide at the level of Opasatika lake. The southern 10 miles of the lake is also gorge-like, and about the same depth, but widens to an average of 600 to 800 feet at the water's edge. At two points the gorge has been partly choked by moraine, forming shallow narrows 2 and 6½ miles respectively from the southern end. Toward the northern end of the present lake the valley was evidently wider and the gorge-like walls were pierced by tributary valleys, so that when glacial damming flooded the valley it gave rise to the large re-entrants of Moose, Atikameg, and Klock bays.

At the northern end of the present lake two great ridges of moraine cross the old valley cutting off the pre-Glacial stream completely and forcing it into other courses. One of these ridges lies between Opasatika and Summit lakes, the other between Summit and Ogima lakes. Summit lake is itself a rock gorge similar to the gorge-like parts of Opasatika lake. It is, evidently, a part of the pre-Glacial valley, in which water has collected between the two moraine dams mentioned. Drainage from it to Opasatika lake has cut away the greater part of the lower dam, so that now there is a fall of only 7 or 8 feet between the two lakes.

[1] For a fuller description of the lakes and deposits, see the chapter of this report dealing with Quaternary deposits.

The dam of drift at the head of Summit lake has a minimum height of about 37 feet above the lake. The Ottawa River Regulation Survey gives the elevation of the height of land between Ogima and Summit lakes as 936 feet, or 23 feet above Ogima lake and 60 feet above Summit lake. This figure was evidently obtained, however, from levelling the portage between the two lakes; the lowest point on the divide is farther to the east, and is 913 feet above sea-level. Erosion has been gradually cutting down this dam of drift, until now, during times of high water, a temporary stream flows south from Ogima lake to Summit lake. In the spring of 1922 this stream was of such volume that it carried down sufficient sediment to fill the upper end of Summit lake and make it necessary to shift the end of the portage there 200 feet or more to the east. Probably within a decade or so this temporary stream will cut a valley in the drift sufficiently deep to establish itself as a permanent stream. When this occurs it will be a matter of only a few years before the new stream so deepens its bed as to divert the water of Dasserat lake and its tributaries southward again, and thus shift the position of the height of land.

This change in drainage may be hastened by human agencies unless care be taken to guard against the possibility. The project has been broached of developing power for the use of the mines from the 37-foot fall between Ogima and Summit lakes by damming the northern end so as to force the water southward. Lumber companies in the district are also endeavouring to get the right to dam the northern end, so as to take out their timber along the new south-flowing stream. Unless great care is exercised in these projects the new stream will cut away the drift at the southern end so rapidly as to drain Dasserat lake entirely, as happened to Nighthawk lake, in Ontario.

A second pre-Glacial stream channel is found at the north end of Kekeko lake. This channel is a steep-sided valley, 700 to 1,000 feet wide and 400 feet or more in depth, which cuts through the high ridge of Cobalt and Timiskaming conglomerates. The valley is now filled to an unknown depth with recent sediments, over which Pelletier creek runs. It seems probable that the stream forming this valley in pre-Glacial time was considerably larger than Pelletier creek.

A third deeply-cut gap in the ridge of Cobalt series lies between Olier and Renaud lakes, and is now occupied by the small creek draining Renaud lake. The gap is nearly a mile in length from east to west, and varies in elevation from the level of Renaud lake in the stream channel to perhaps 200 feet above Renaud lake at the ends of the gap. Renaud lake is estimated at about 900 feet above sea-level. The whole bottom of the gap appears to consist of rock, the ridge sloping away on both sides to the deeper basins of Renaud and Olier lakes.

The history of the gap is evidently more complicated than that of the other two water-gaps described, since the channel cutting through the ridge is not equal in depth to the lake basins on the north or south, as would be the case had the gap been occupied by a stream in immediate pre-Glacial time. Perhaps the ridge was cut down by streams eroding headward from the north and south sides simultaneously, and the gap so produced may have been widened and deepened by glacial action. It seems too wide, however, to have been produced by small tributaries such as these must have been. Another, more probable, theory is that this gap was at one time the valley of a fair-sized stream which was beheaded by a tributary of the stream occupying the Opasatika valley, working eastward along the north side of the ridge of Cobalt series. The valley of the tributary was later choked by glacial drift, forming Renaud lake, and forcing its waters into their original southward course across the ridge.

About 4½ miles west of the north end of Opasatika lake the ridge of Cobalt series is again cut by a gap that has clearly been formed by small tributary streams working upward from the north and south. This gap is very narrow and steep-walled, not more than 75 to 100 feet wide at bottom.

The facts cited, though not numerous, seem to indicate that in pre-Glacial times there was an established system of drainage with a general north and south trend, and that the height of land was farther north than at present. As the strike of the Keewatin and Timiskaming rocks is in general east and west, it is, therefore, evident that the drainage was not adjusted to their structure[1], and hence was a superimposed drainage system; that is to say, it was, probably, established on some overlying series of rocks the trend of whose folds was north and south. This may have been the Cobalt series, or it may have been the Palæozoic rocks that are supposed to have extended over the area. Later, all the supposed Palæozoic rocks and the Cobalt series were removed by erosion, except the Cobalt remnants still existing, but the drainage system persisted, although it was not adjusted to the structure of the lower rocks over which it was flowing. The water-gap between Olier and Renaud lakes appears to indicate, however, that such adjustment was gradually taking place when the process was interrupted by glaciation.

GENERAL GEOLOGY

Opasatika map-area is similar in a general way to the remainder of the Timiskaming region, and particularly resembles the Larder Lake area directly to the west. Nearly all the rock types found in Larder area[2] occur in Opasatika area.

The primary subdivision of the rocks, based on their age relations, is a dual one. The younger group is represented in Opasatika district only by the rather flat-lying sediments of the Cobalt series. These rocks are separated from the underlying older division by a great unconformity, which represents an enormous interval of time during which these older rocks were being gradually worn away and carried by streams to the sea. It has been estimated that the thickness of rock removed during this long period of erosion was at least 14,000 feet, and may have reached a maximum of over 30,000 feet.[3]

[1] In an area of folded sedimentary rocks, streams tend to establish themselves on the softer, more easily eroded beds, so that the watercourses are parallel to the strike of the underlying rocks. Various processes, which there is not space here to explain, contribute to bring this about, so that a stream finally flows along the strike of the softer beds for the greater part of its length, and, where hard beds must be crossed, turns sharply so as to cross them at right angles or almost so. Such a stream is said to be adjusted to the structure of the underlying rock.

[2] "Larder Lake District, Ont.," Geol. Surv., Can., Mem. 131, pt. 2, 1922.

[3] "Larder Lake District, Ont.," Geol. Surv., Can., Mem. 131, p. 38, 1922.

The older group of rocks is a complex whose component parts are becoming every year better known. It includes two great series of surficial rocks,[1] which are everywhere intruded by a variety of igneous rocks. The younger of the two series is known as the Timiskaming series, and consists predominantly of sediments, but may contain locally large volumes of lavas. It rests with pronounced unconformity on the older series, the Keewatin, which is composed largely of lavas with minor amounts of sedimentary material. The igneous rocks intruding the surficial formations are of great variety, and will be dealt with fully in the detailed section of this report.

The rocks and their age relations may be summarily presented as follows:

Table of Formations

Quaternary	Post-glacial	Clays, silts, sands
	Glacial	Boulder clay, stony and gravelly morainic deposits
Huronian	Cobalt series	Conglomerate, greywacke, arkose, argillite
	Great Unconformity	
Pre-Huronian	Pre-Huronian intrusives	Basaltic diabase Later gabbro Syenite Hornblende-mica lamprophyre Syenite porphyry Granite Older gabbro
		Folding
		Diorite porphyry Amphibolite Hornblende lamprophyre
	Timiskaming series	Conglomerates, greywackes, and basalts
	Unconformity	
	Keewatin	Basalts, andesites, dacites, rhyolites, and tuffs

KEEWATIN

Rocks of the Keewatin series are found only in the area north of the great ridge of Cobalt series and the ridges of Timiskaming conglomerate that lie to the eastward. The total area of Keewatin rocks is about 100 square miles.

Basalts

Basalts form the bulk of the Keewatin rocks, as in most areas. They are mostly dark, olive-green rocks, to which the name greenstone has been fittingly applied. When fresh they consist of labradorite and pyroxene, but commonly they are so badly altered that only traces of the original minerals are visible, in a mixture of chlorite, kaolin, epidote, and other secondary products. They are mostly massive, except where sheared

[1] *i.e.*, rocks laid down on the earth's surface.

along fault planes or at the contacts of two flows where movement during folding has been concentrated. Consequently, in spite of the alteration they have undergone they retain their original structures and textures and exhibit them remarkably well on clean, weathered surfaces.

The basalts are mainly rather fine-grained, equigranular[1] rocks with a grain rarely greater than 1 mm. in the coarser parts of the flows, and decreasing to exceedingly fine grained, almost glassy, in the upper parts of the flows. They frequently possess pillow structures, more rarely flow and amygdaloidal textures.

An unusual basalt was observed at the east end of Washusk lake. A very fine-grained groundmass, in composition like that of an ordinary chloritized basalt, is filled with rounded phenocrysts of augite or hornblende, now completely chloritized, up to 3 mm. diameter. The phenocrysts form about 15 per cent of the rock. Towards the top of the flow the phenocrysts become smaller and die out, and the rock then resembles the ordinary massive altered basalt.

A second unusual type occurs near the southwest end of Uwass lake. It is a rather coarse-grained porphyritic rock, containing very numerous phenocrysts of white feldspar, which proved to be oligoclase about Ab_{75} An_{25}, embedded in a rather finer-grained groundmass of lath-like plagioclase with some chlorite and a little quartz. The feldspar phenocrysts are uniformly $\frac{1}{2}$ to $\frac{3}{4}$ mm. in thickness, and for the most part not more than 2 mm. in length. Longer ones are fairly common, however, the longest measured being 9 mm. Much secondary calcite and sericite are present.

It is interesting to observe that in Opasatika area, as also for at least 60 miles to the west of the Ontario boundary, basalts form the bulk of the Keewatin rocks, with minor amounts of dacites and rhyolites, and very little andesite. This is sharply in contrast with the Keewatin in north-central Quebec, west and southwest of lake Chibougamau, where the amount of andesite is perhaps 35 per cent or more of the total bulk, and the amount of acid types is very small.

Andesite

Very little andesite occurs in Opasatika area. A little was found on the shores of Mishikwish lake and Dasserat lake, and one or two small flows were also observed on Pelletier lake, but these occurrences comprise almost all in the area.

The rock resembles the basalt, but is slightly more feldspathic and hence lighter in colour. The excess feldspar commonly crystallizes as white phenocrysts, usually not more than 2 or 3 mm. in diameter. This porphyritic texture frequently causes prospectors to confuse the lava with the feldspar porphyry of the region. Pillow structures are almost universally present, the pillows being large and beautifully developed. For some reason the pillows are usually much larger in andesite than in basalt.

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[1] Equigranular—meaning that all the mineral grains composing a specimen of rock are approximately equal to one another in size. The average size of the mineral grains is termed the "grain" of the rock.

Dacite, Trachyte, Rhyolite

Acid lavas are found in many places throughout Opasatika area. Quite a thick body of them occurs on Mishikwish lake. They were observed in several places on Dasserat lake, on Washusk and Uwass lakes, at the east end of Pelletier lake, Osisko lake, and in a number of other localities.

These rocks are very well described by the term "grey lavas" that has been recently applied to them by the geologists of the Ontario Department of Mines. They are cream-white to grey-white rocks, invariably fine grained though often finely porphyritic, and usually, though not always, altered to rather soft kaolinic aggregates. Amygdaloidal textures are very common, the amygdules being usually filled with quartz. Good pillow structures occur in many places in the dacites and trachytes.

Tuffs

Coarse volcanic breccias made up of angular fragments of lava, without bedding, occur here and there throughout Opasatika area, interbedded with the volcanic flows. Of greater interest are the fine-grained bedded tuffs found in the eastern part of the area. They form a band about 4 miles in length in the map-area, with a maximum width of half a mile, to the south of Pelletier lake, lying between the Keewatin lavas and the Timiskaming conglomerate. At the west end the band wedges out; at the east end it continues on unbroken into territory not yet mapped.

The tuffs are black or greyish black, rather soft rocks, for the most part very fine grained, and thinly and uniformly bedded. The beds vary from $\frac{1}{8}$ inch to 4 or 5 inches in thickness, and the individual beds may be traced across outcrops several hundred feet in length. Evidently, therefore, they were laid down in bodies of quiet water. Study of a thin section from one of the beds showed it to be composed of about 60 per cent of actinolite laths, largely converted into chlorite, the remainder mainly oligoclase feldspar, $Ab_{70}An_{30}$, with a few grains of quartz. The feldspar is largely converted into kaolin. Average grain about 0·05 mm.

A sharp contact between the lavas and the tuffs was seen on the large outcrop about $1\frac{1}{2}$ miles southeast of the southeast corner of Pelletier lake. The lava at this point is basalt with a well-developed pillow structure. The south side of the flow, in contact with the tuffs, is strongly pillowed, and the pillowed material grades northward into massive, coarser-grained basalt without pillows. The south side of this flow is, therefore, the original upper side. The contact at this point strikes south 80 degrees east and dips about 60 degrees north, so that the flow has been overturned. In contact with the surface of the flow on the south, without any evidence of any gap in the sequence of deposition, is a series of ash beds, 4 inches to a foot in thickness. The bed in contact with the basalt has a grain of about 1 mm. and the grain of the others is of about the same order of magnitude.

There is a thickness of perhaps 50 feet of these medium-grained ash beds, and they grade stratigraphically upward into dark, fine-grained tuffs in beds averaging about one-eighth inch in thickness. These are overlain again by beds of coarse ash, containing fragments up to an inch in diameter. The total thickness of the latter is only 6 or 8 feet, and the beds grade rapidly into the characteristic thin-bedded, fine-grained, blackish tuff that forms the bulk of the tuff band. Here and there throughout the tuff area thin flows of basalt were observed, interbedded conformably with the tuffs. The flows observed are not over 5 feet thick.

The tuffs, therefore, lie stratigraphically above the main body of lavas to the north, and are interbedded with small basalt flows; and there is no evidence of unconformity between them and the basalts, but every indication, on the contrary, that they were laid down directly on the uneroded surface of the flows. It cannot be doubted, therefore, that there was no extensive interval of time between the deposition of the basalts and that of the tuffs, and, consequently, that the tuffs are a true member of the Keewatin series.

Folding and Faulting

The information at hand as to the structure of the Keewatin of Opasatika area is not sufficient to reconstruct the various folds. This lack of information is due in part to insufficient study of the area, and in part to the heavy mantle of drift and Cobalt series that conceals large areas. A considerable number of determinations were made, however, in the vicinity of Pelletier and Dasserat lakes, the methods used being those described in a recent paper.[1] The dips and strikes obtained are shown on Map 1985 accompanying this report.

Around Pelletier lake, and southward to the boundary of the Timiskaming series, a distance of at least $2\frac{1}{4}$ miles, the Keewatin lavas and tuffs are tilted into vertical attitudes and all face toward the south; that is, the present south side of each individual bed or flow is the side originally uppermost at the time of its formation. This area, therefore, forms part of the south limb of an anticline or the north limb of a syncline. The strike is nearly due east and west near the Timiskaming contact on the south, and, farther north, gradually swings south of east. The most northern strike obtained, near the northeast end of Pelletier lake, is south 65 degrees east. The change of strike presumably indicates that the fold pitches toward the west, and that the last-mentioned determination was made only a little to the south of the axis of the fold.

The dips obtained in this area vary from vertical or nearly so at the north end of Pelletier lake, to 60 degrees north near the Timiskaming contact. As the south side is the original upper side, it is evident that the strata have been overturned during the folding.

Nothing is known of the north limb of this anticline.

The width of the Keewatin from the most northerly point where a southward dip was obtained, across the strike to the Timiskaming boundary, is $2\frac{1}{4}$ miles, of which half a mile is bedded tuffs. Allowing a dip of 65 degrees north for the whole of this width, which is somewhat more than the average dip, and assuming that outcrops have not been repeated by faulting, there is a total thickness for the Keewatin of 8,300 feet of lavas and 2,400 feet of tuffs, or 10,700 feet in all. This figure is given merely to indicate the order of the figures for the thickness of the Keewatin, since the top of the formation is unknown, having been eroded

[1] Jour. of Geol., vol. 27, pp. 75-78, 1919.

away before the deposition of the Timiskaming, and the bottom is also unknown, not even the axis of the anticline having been found. Moreover, there are at least two strong shear zones in the area, indicating strike faults that may have either increased or decreased the apparent thickness. However, as the fault planes are vertical or nearly so, and the strata have nearly the same position, the faults probably have not made the apparent thickness much greater or less than the real thickness.

In the neighbourhood of Dasserat lake a larger number of observations on structure were obtained. At the north end of the lake, and for at least 5 miles south, past the mouth of the inlet to Mishikwish lake, the flows all have an approximately east-west strike, and their upper sides face toward the south. The angle of dip varies from about 60 degrees south at the north end of the lake, to vertical near the mouth of the inlet to Mishikwish lake; still farther to the south, at the east end of Uwass lake, the strata are overturned and dip 70 degrees north.

All the structural determinations made on Washusk, Ogima, and the south end of Dasserat lake show the lava flows with approximately east-west strikes, but with the upper sides of the flows facing northward. These flows, therefore, form the south limb of the syncline of which the flows described in the last paragraph form the north limb. The axis of this syncline must pass somewhere between the north end of Uwass lake and the north end of Washusk lake, and across Dasserat lake somewhere between the south shore of Renault bay and a point about a mile to the north. The axis must, therefore, have a strike slightly south of east if the flows on Dasserat and Uwass lakes have the same relative position that they had after folding was completed, and have not been shifted to the north or south, relatively, by later faults.

The changes obtained in the strike, as well as the direction of drag in certain drag folds, indicate that the syncline plunges toward the east. No data were obtained, however, to indicate the amount of the plunge.

As already stated, the upper sides of all the flows around Washusk, Ogima, and the south end of Dasserat lakes face toward the north, but the actual dips are so unusual as to merit detailed description. The most northerly determination obtained on this limb, on the south side of Renault bay, Dasserat lake, is 70 degrees north. This figure coincides with the overturned dip of the flows on Uwass lake (the southernmost observation on the north limb of the syncline) and the combination of the two dips indicates that the axial plane of the fold dips 70 degrees north along the axis. The dips obtained on Washusk lake are overturned dips, 85 degrees south; these beds are about $1\frac{1}{2}$ miles south of the axis of the fold. The dip of beds an equal distance north of the axis is vertical 60 degrees south. The axial plane for the syncline formed by these flows, therefore, must dip south between 5 and 15 degrees. Thus the axial plane appears to be warped, and to change its slope with depth. The most southerly dip obtained is 50 degrees south, about the middle of the west shore of Ogima lake. This extraordinary overturn, so much greater than that on Washusk lake less than a mile away, is hard to explain, and the observation might be doubted were it not an unusually good one. At this place, a layer of thinly bedded chert, 4 inches thick, separates the two flows from which the observation was obtained, so that the strike and dip obtained are indubitable.

Figure 5 illustrates diagrammatically the structure in cross-section from the north end of Dasserat lake to the middle of Ogima lake. It is most unfortunate that the Keewatin between the latter point and the Timiskaming on the south should be hidden by drift and Cobalt series, for its structure and relations to the Timiskaming must be complex and of unusual interest.

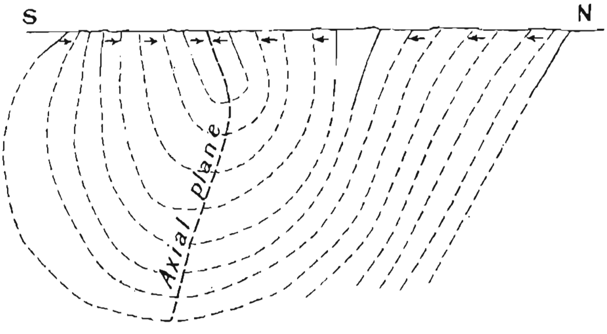

Figure 5. Diagrammatic vertical cross-section from the north end of Dasserat lake to the middle of Ogima lake, showing overturned fold in the Keewatin and the tendency to form a fan-shaped syncline. Solid lines represent observed bedding planes and arrows point to top of individual volcanic flows.

There are, according to the foregoing, two great synclines in the Opasatika area, one around Dasserat lake, with its axis running somewhat south of east, and one around Pelletier lake. The position of the axis of the latter has not been directly determined, but it must lie at least 3 miles south of the lake, and must strike in a general east and west direction. The measured width of one limb of the Dasserat fold is over 5 miles, so that it must be approximately 10 miles north or south from one synclinal axis to the next.

Now, if the axis of the Dasserat syncline be projected eastward along the strike, it passes close to the probable position of the Pelletier syncline. It is, therefore, highly probable that the two axes coincide, and that one great fold passes across the whole area. If this be true, the flows around and south of Pelletier lake correspond in stratigraphic position to those around the northern part of Dasserat lake; that is, they all form part of the north limb of one syncline.

It seems almost impossible to avoid this conclusion, for if it be assumed that the axis of the Dasserat syncline is identical with that of any syncline to the east other than the one mentioned, as for instance with the synclinal axis that must lie some 6 miles north of Pelletier lake, then either (1) the flows in Boischatel township would strike prevailingly northeastward, which was not observed, or (2) great faults must occur in Boischatel township, with a general northward strike, the effect of which would be to shift the Keewatin on the east side of the faults some 10 miles northward. Furthermore, these faults must be of pre-Timiskaming age, since the Timiskaming series does not show signs of any such movement. As there is no evidence for assuming such faults, it is more natural to conclude, as has been done, that the Dasserat axis coincides in its projection with the axis south of Pelletier lake.

Figure 6 illustrates the two possibilities, if the possibility of great pre-Timiskaming faults, for which there is no evidence, be excluded. The figures show the geology on a small scale, with the contact between the Timiskaming and Keewatin series placed approximately in its correct position beneath the Cobalt series. The approximate contact has been deduced from the known position of the contacts near the Interprovincial Boundary and Pelletier creek, the occurrence of Timiskaming conglomerate on the south side of Renaud lake, the known positions of Keewatin outcrops south of Ogima, MacDonald[1], and Fortune lakes, and estimates of the probable thickness of the Timiskaming conglomerate to the north of the last outcrop of greywacke on Opasatika lake. Figure 6 A shows the known approximate positions of the axes of the Dasserat and Pelletier synclines, and connects them on the theory that the two synclines are parts of one great syncline. Figure 6 B shows the state of affairs if the axis of the Dasserat syncline turn north on the east side of Uwass lake. In this case the Pelletier syncline would be the next parallel syncline on the south, and is so represented. The line south of the Timiskaming-Keewatin boundary, and approximately parallel to it, is the known position of the axis of the most northern syncline in the Timiskaming series. This diagram will be further referred to in describing the relations of the Timiskaming series to the Keewatin.

No large faults have been detected in the Keewatin of Opasatika area. They may exist, but are difficult to determine on account of the lack of good horizon markers. Small faults are numerous, and will be discussed under faulting of the Timiskaming series.

Stratigraphy

There does not appear to be any regularity in the sequence of the lava flows in the synclines examined. Tuffs are found near the top of the Pelletier syncline, but not around Dasserat lake farther to the west. Rhyolites occur in several places at or near the top of the Keewatin, in the centre of the Dasserat syncline, but are also to be found deep down in the syncline, at the north end of Dasserat lake, and on Pelletier lake. It is possible that careful detailed work on an area whose structure had been determined might reveal a periodicity of extrusion; that is, there may be a sequence of flows, commencing, perhaps, with basalts and passing upward through andesites and dacites to rhyolites; such a sequence being repeated a number of times, altogether or in part. Such work would have to be very detailed, however, and could succeed only in an area where outcrops are numerous.

TIMISKAMING SERIES

The Timiskaming series forms a belt 10 or 12 miles wide to the south of the Keewatin. The two are in direct contact in Rouyn township and the adjacent part of Boischatel township, but throughout Dasserat and the greater part of Boischatel townships the contact is covered by a tongue of the overlying Cobalt series. In the western and middle parts of Dufay township the width of the Timiskaming is reduced to a mile and a half by the intrusion of the granite batholith.

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[1]On map 1985 this is spelled McDonald.

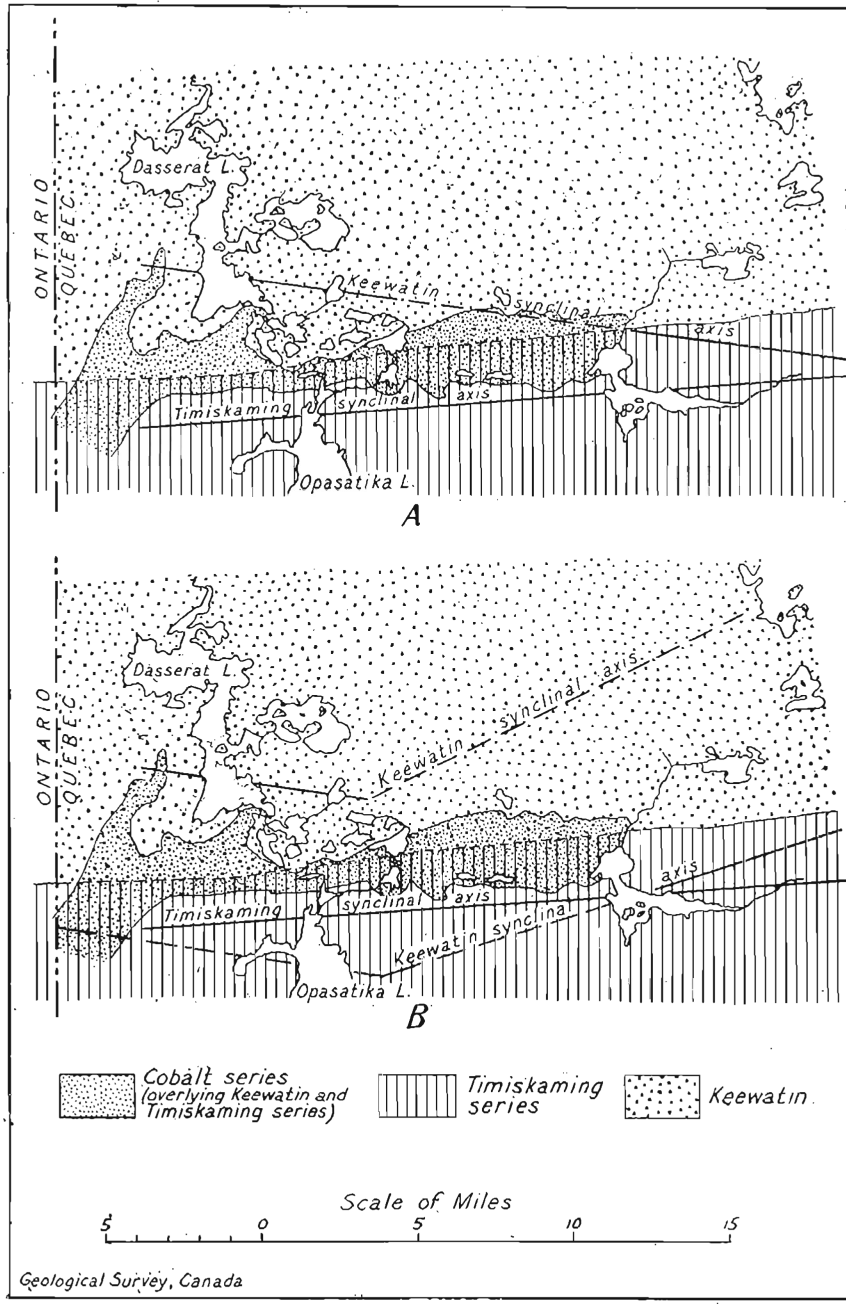

Figure 6. Diagram showing the possible relationships of folds in the Timiskaming series and the Keewatin in Opasatika map-area.

Lithological Character

The Timiskaming series of Opasatika area consists of a very thick conglomerate member next the Keewatin, overlain by sandy greywackes. Interbedded with the greywackes on Opasatika lake are some basic lavas, which are now badly altered, but must originally have been of about the composition of basalts. The whole series has been so strongly compressed during the folding movements as to be largely converted into schists.

Conglomerate

The conglomerate member at the base of the series forms a band between the Keewatin on the north and the schistose greywackes on the south. Of this band there is only about 3 miles well exposed, at the extreme east end of the area. The next 2 miles to the west is known only by scattered outcrops protruding through a thick soil cover; and the conglomerate band then passes beneath the Cobalt series, to appear no more east of the Interprovincial Boundary; except that it is partly exposed in an area a mile long north and northeast of Olier lake, where the Cobalt cover has been eroded away. As the exposed outcrop is so short, no very general conclusions may be drawn regarding the large structure of the conglomerate band. It is likely, however, to possess the characteristics of the corresponding conglomerate in the Larder Lake area directly to the west.

The conglomerate member, where exposed, is composed mainly of thick beds of conglomerate, with minor amounts of interbedded sandy greywacke. The average exposed width of the belt is one mile, and the average dip about 60 degrees north, giving the conglomerate member a thickness of about 4,500 feet if the outcrops have not been repeated by faulting. The conglomerate has been strongly sheared, so that in many places the pebbles are drawn out to thin strings; its thickness originally must, therefore, have been considerably greater than it is now.

On account of the shearing the composition of the conglomerate is in many places hard to determine, but enough good observations were obtained to show that it varies considerably between the top and bottom of the formation, and also varies along the strike according to the composition of the underlying rocks.

Near the north edge of the conglomerate band, to the southwest of Pelletier lake, the conglomerate in one place is not at all sheared. The matrix here is a dark grey, fine-grained greywacke. It forms perhaps 50 per cent of the rock, and contains pebbles of all sizes up to 1 foot diameter. For the most part the pebbles are noticeably well rounded. On a surface of about 30 square feet, from which the light covering of moss was stripped, there were at least six large boulders of a coarse-grained hornblende syenite and one of coarse reddish syenite or pegmatite composed wholly of reddish feldspar crystals about 6 mm. square. A few pebbles of quartz were also present, but most of the pebbles were of basic fine-grained lava, difficult to distinguish from the matrix except on good clean surfaces.

Near the south side of the conglomerate band there are thick beds of a very unusual conglomeratic rock. At the western end of the area they have been too badly sheared for effective study, but in the small exposed area northeast of Olier lake they are only slightly sheared. The unusual rock forms beds of varying thickness up to 20 or 30 feet, and is interbedded with conglomerate and greywacke of quite normal composition. It is made up of pebbles of all sizes up to 4 inches in length, embedded in a dark greenish schistose groundmass. The pebbles form about 75 per cent of the mass of the rock, and are mostly oval, with their length two or three times as great as their width, although other shapes occur. They are moderately well rounded, but it is suspected that the rounding is due, in part at least, to the shearing they have undergone. The singularity of the rock consists in the pebbles being nearly all of one kind, a light grey, fine-grained material that resembles a greywacke, and is composed of quartz, albite, and biotite like the greywackes described later.

In some of the beds all the pebbles are of this composition; in others a few pebbles of some dark greenish chloritic rock like a metamorphosed lava are present. The groundmass contains large numbers of whitish grains up to one-fourth inch in diameter, and of whitish plates and strings, of the same composition apparently as the greyish pebbles, and, therefore, probably either small pebbles flattened by shearing, or fragments broken from the larger pebbles during shear, or both. No suggestion can be made as to the manner in which such beds may have originated.

Greywacke

The greywackes of the Timiskaming series, where unaltered, are light grey to dark grey rocks, varying in texture from sandstone to fine silts. They are all evidently sandstones of varying degrees of impurity and fineness.

The essential constituents are quartz, albite, biotite, and muscovite, with accessory magnetite, apatite, and pyrite. The proportions vary a great deal, quartz varying from 20 to 50 per cent, and other constituents accordingly. In some beds the micas are almost entirely replaced by hornblende. The grain is usually fine, varying from 0·04 to 0·5 mm.

Originally these rocks were evidently impure sands, made up of quartz, feldspar, and ferromagnesian material in various proportions. The microscope shows that granulation and recrystallization of the original constituents have been practically complete; it is rare to find in a thin section a grain of quartz or feldspar that may have been original. Muscovite has evidently formed at the expense of the original feldspar, whereas the biotite and hornblende have probably resulted from recrystallization of the original ferromagnesian constituents.

The greywackes are evenly bedded rocks, the beds usually 1 to 3 inches thick, although both thicker and thinner beds are often seen. For some reason presumably connected with the conditions of deposition, the bedding is usually much more poorly developed near the conglomerate than farther away. Thus at the north end of Opasatika lake the greywackes are massive, muddy-looking rocks, in which bedding planes are hard to find; whereas from Klock bay southward the bedding is beautifully distinct.

The regional metamorphism to which the series has been subjected has converted the greywackes very thoroughly into mica schists, without, however, destroying the original bedding for the most part.

Lavas

A most interesting rock occurs on Opasatika lake around the mouth of Moose bay, and underlies an area of 10 to 12 square miles between the lake and McLaren creek. It was observed by Wilson, and described by him under the name of "chloritic rock," as follows:[1]

"The chloritic rocks are greyish-green, massive rocks which, when examined under the microscope, are found to consist entirely of chlorite, pyrite, and a small quantity of carbonate. The exposures of the chloritic rocks which occur on the north and south sides of the entrance to Moose bay are peculiar in that in both localities the rock is traversed by a network of seams containing a carbonate and chlorite. The rock throughout a zone about an inch wide on either side of the seams has undergone a change, for it stands up conspicuously with a white appearance on the weathered surface."

Wilson's description cannot be improved; the rock is simply a mass of felted fibres of dark green chlorite, and displays no feature whatever that gives a clue to its origin. The present writer was fortunate in finding a place in the area west of Opasatika lake where the rock is only slightly altered, and exhibits good variolitic textures, such as are highly characteristic of basaltic lavas in many parts of northern Ontario and Quebec.[2] It was concluded, therefore, that the rock is a lava of about the composition of a basalt.

A careful examination was made of the exposures of the rock on the shores of Moose bay, to determine if possible the origin of its peculiar veined structure, and to obtain additional evidence as to its original nature. On the north shore of the entrance to the bay the alteration has been extreme, and the rock, as Wilson describes, is thoroughly chloritized, and cut by numerous cracks into blocks of all sizes up to 3 or 4 feet in length, giving it a deceptive appearance of pillow structure. The larger of these cracks contains much iron carbonate, in addition to schistose chlorite. On each side of a crack there is a band an inch or less in width of a massive material that weathers whiter than the bulk of the rock, although the two cannot be distinguished on the freshly broken surface. There is no sharp boundary between the whitish material and the darker rock composing the inside of a block; but the two merge into one another, with an irregular ragged contact. The width of the whitish band is roughly proportional to the size of the crack between them.

Evidently carbonate-bearing solutions entered the rock along the cracks, which were formed by movement, as the schistose chlorite in the larger of them indicates. The carbonate-bearing solutions replaced part of the chlorite with carbonate, the amount of replacement being roughly proportional to the size of the crack. The larger the crack, the longer the solutions could presumably flow through it before it was choked by a deposit of carbonate.

[1] Wilson, M. E., Geol. Surv., Can., Mem. 39, p. 61; also Mem. 103, p. 84.

[2] The term "variolitic" is used to describe the texture of a lava, which is always fine-grained and occasionally amygdaloidal, and contains numerous round or oval lumps, like small marbles; these lumps likewise consisting of lava of the same composition as the matrix, but finer grained and often a little lighter in colour. The cause of the formation of this peculiar texture is not known, as far as the writer is aware, but it is highly characteristic of lavas and is probably due to some special condition of cooling. See also Cole and Gregory, "Variolitic Rocks of Mont Genèvre," Quart. Journ. of the Geol. Soc. of London, vol. 46, 1890, p. 295.

On the west shore of Moose bay, about three-quarters of a mile from its northern end, the chloritized rock found was cracked and carbonated as described, in contact with the same rock not cracked and carbonated. As this place appeared very favourable for the determination of the points under investigation, it was examined with great care. The outcrop is 40 or 50 feet long by 30 to 40 feet wide, and the contact mentioned, between the cracked and the uncracked varieties, lies from 5 to 10 feet from the western edge. The contact is a sharp line, strike north 20 degrees east, dip steeply east. The massive uncracked material lies on the east side of this line, the cracked variety on the west side. The massive rock outcrops over a width of 10 to 15 feet from the contact, and then begins to show a large number of small cracks bordered by very narrow bands of whitish carbonated material, cutting the rock into polygonal blocks 1 to 2 inches in diameter. A few feet farther eastward these small blocks give way to larger blocks generally similar to those previously described.

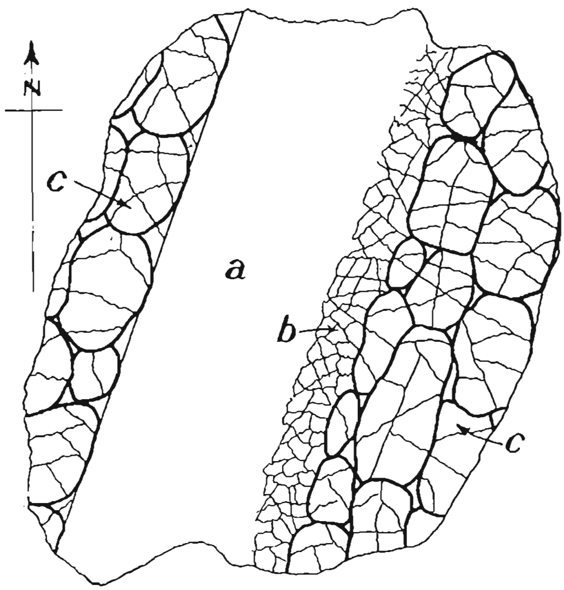

Figure 7. Diagram to illustrate relation in Timiskaming lava: (a) massive lava, (b) massive lava broken by narrow whitish bands, (c) lava with both wide and narrow white bands.

The part that is cut into larger blocks contains two distinct sets of the whitish bands. In one set the bands have a total width of $\frac{3}{4}$ inch to 1 inch; they are mostly somewhat curved, and they divide the rock into large rounded blocks or masses 1 to 3 feet long by perhaps half as wide. These large blocks are subdivided into smaller masses by whitish bands of the other set, which are one-eighth to one-half inch in width, and mostly straight or sinuous, though sometimes curved. If this latter set of whitish bands were not present, or were painted out so as not to be visible, the blocks outlined by the larger whitish bands would unhesitatingly be called pillows, and the structure, pillow structure, by anyone acquainted with the lavas of the Precambrian.

If the structure described be regarded as primarily a pillow structure, this outcrop affords a perfectly normal sequence of lava phases. On the west side of the outcrop the pillowed top of a flow is seen. It is in sharp contact with the massive bottom of the next flow to the east, the strike of the contact being north 20 degrees east, the dip steeply east. The massive phase grades stratigraphically upward again, quite normally, into a pillowed top. Thus all the observed facts are accounted for.

It was concluded that the chloritic rocks are badly altered lavas of about the composition of basalts. The cause of the primary chloritization, is not known. At some period after their extrusion, however, movement took place, and fracturing occurred along the natural lines of separation between pillows, and the pillows were themselves broken by small cracks, and small cracks also extended for a short distance into the massive parts of the flows below the pillowed zone. Solutions bearing iron carbonate and probably also other carbonates circulated through the cracks, and replaced the chloritic rocks in part by carbonate, for distances which varied with the size of the crack, i.e., with the length of time that circulation through the crack went on, presumably.

Relations of the Lavas to the Timiskaming Greywackes. The lavas are conformably interbedded with the Timiskaming greywackes. In several places around the shores of Moose bay outcrops of the two may be seen within a few feet of each other, although not actually in contact; and the dip and strike of the sediments are such as to carry them either under or over the lava. On the west shore of Opasatika lake a small flow about 15 feet thick outcrops between well-bedded sandy greywackes. The contact between the upper edge of the lava and the greywacke is exposed, and there is no conglomerate, irregular erosion surface, or other evidence of any stratigraphic break there. The greywacke lies directly on the pillowed top of the lava, and the dip and strike of its bedding parallel the contact perfectly. The sediments beneath the lava also parallel the contact, but the sharp contact is not visible, for it has been worn by the waves into a crack a foot or two wide, which is now filled with soil and boulders.

The greywackes in this locality are high up in the Timiskaming succession, as will be shown later, and the evidence indicates perfect conformity between the greywackes and the lavas. There seems, therefore, no escape from the conclusion that the lavas are a true part of the Timiskaming series.

Relations to the Keewatin. That the Timiskaming series lies unconformably on the Keewatin to the north is shown by the following facts:

The conglomerate of the Timiskaming series contains pebbles of the adjacent Keewatin rocks. This is particularly noticeable in certain places, such as southeast of Pelletier lake, where a trachyte flow of small dimensions supplies a large number of pebbles to the immediately overlying conglomerate. In the eastern part of the area the textures of the Keewatin lavas indicate that they all have their original upper side facing the south, although some of them are overturned. On this basis the Timiskaming sediments, which lie south of the lavas, must be stratigraphically above them. The northward dip of the sediments that appears to carry them under the lavas must, therefore, be due to overturned folding, as in the case of the lavas themselves. Figure 6 shows that whatever be the structure of the Keewatin, that of the Timiskaming is discordant with it. The contact of the two series, and the axis of the Timiskaming syncline that closely parallels it, cut across the axes of the Keewatin folds, at angles of about 10 degrees. This discordance can have been produced only by an earlier folding of one, before the other was laid down on it; and thus constitutes a very strong proof of unconformity.

Folding and Faulting

The great body of Timiskaming sediments in Opasatika area has the general structure of a synclinorium, or great syncline, made up of several subordinate anticlines and synclines. The south side of the synclinorium is not visible, as it has, largely, been destroyed by the intrusion of great batholiths of granite; but inclusions of the Timiskaming rocks in the granite, some of them miles in length, show that the sediments once formed a belt more than 25 miles in width from north to south.

At the northern side of the synclinorium the folding has been especially intense, and the strata have been strongly overturned, so that they now dip northwards at angles of 65 to 70 degrees. Locally, even lower dips are to be found, down to 40 degrees north, but these are exceptional. The northward dip led earlier observers to believe that the sediments might be older than the lavas to the north, since they appear to dip beneath them; but the data already given show that the northward dip must be ascribed to overturning.

The axis of the first syncline on the northern side of the great synclinorium was observed to cross Opasatika lake, at a point about a mile from the extreme north end. The determination was made as follows:

When a series of fairly competent beds is folded into a syncline (*See* Figure 8), the upper beds must accommodate themselves to the decreased length of the surface on which they rest by slipping upwards, using the bedding planes as gliding planes.[1] Friction between beds opposes the slipping process, and puts a strain on the beds on each side of the plane of slipping. If one of these beds be thin, or be composed of soft material such as shale, so that it is too weak to resist the strain, it may yield in one of several ways. A very soft material will recrystallize to form large amounts of mica or chlorite, the flat plates of which will slip easily on one another, so that a schist is produced. A thin bed of harder rock may yield by fracturing in many places; or may be bent bodily, producing small drag folds (Figure 9 A and B). The intensity of the drag will depend, of course, on the amount of differential movement between the beds on the two sides and on the strength of the bed to resist drag.

Figure 9 C shows the sort of drag folds that might be expected to form when moderately thick beds of a rock fairly resistant to shearing stresses are bent into an overturned syncline. On the north side of the syncline the general dip is 70 degrees north, but drag has produced *steeper* dips, up to vertical and even southward in places. On the south side of the syncline the general dip is 50 degrees north, but drag produces locally *shallower* dips, almost flat in places.

[1] The effect may be observed on a small scale by bending a pile of sheets of paper.

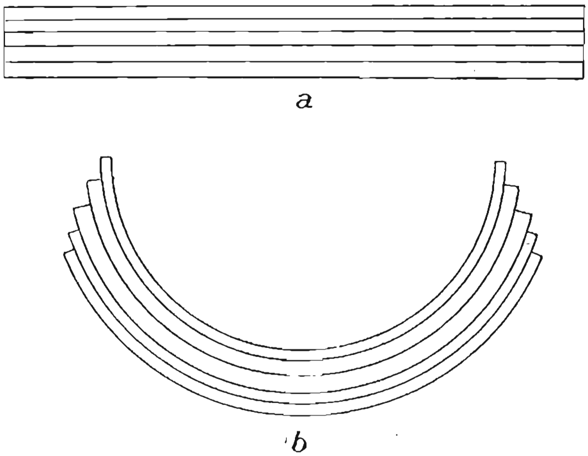

Figure 8. Diagram to show movement between adjacent strata produced by folding: (a) unfolded strata, (b) folded.

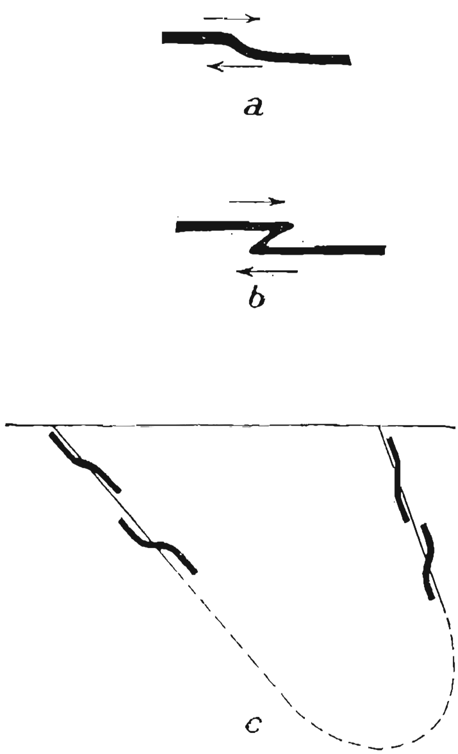

Figure 9. Diagram to show shapes of drag folds developed in weak strata: (a) gently deformed, (b) more severely deformed, (c) drag folds on limbs of an overturned syncline. Arrows indicate directions of movement.

The facts observed around Opasatika lake correspond exactly with the principle as above developed. The rocks are impure sandstones, in beds up to a foot thick, and hence might be expected to offer considerable resistance to deformation. The map shows the steep dips prevailing on the north limb of the syncline; to the east of the lake there are several steep southward dips, as theory demands. On the mile of west shore directly north of Klock bay the dips are as beautifully shown on the bare burnt cliffs as in Figure 9. The average dip is about 50 degrees north, but the strata pass from one drag fold into another and the dips of the dragged beds are all flatter than 50 degrees, in places quite flat or slightly south.

The axis of the overturned syncline must lie between the places where the dips of the drag-folded beds are steeper and shallower than the general dip. This point cannot be exactly determined, within a quarter mile; but it lies about a mile (80 $\pm$ 10 chains) from the extreme north end of the lake.

On the south side of this synclinal axis the beds maintain their northward dip of about 50 degrees, with numerous drag folds exhibiting shallower dips, as far as the south side of Klock bay, a distance of about a mile and a half. Here the strata begin to flatten out, giving progressively lower dips as far as a point about half a mile north of the mouth of Atikameg bay, where the axis of a low flat anticline crosses, and the strata are either quite flat or dip gently to the east. For 10 miles farther south, on Opasatika lake, the beds are gently undulating, and the dips, which rarely exceed 25 degrees and are usually much less, are controlled in their direction as much by the crossfolding as by the major folding. The sediments are then replaced by granite; but nearly opposite the mouth of Lonely bay, beyond the limits of the map-area, there is a large inclusion or roof pendant, nearly half a mile in width across the strike, in which the beds dip about 60 degrees south, and strike nearly east and west.

On the Kekeko-Evain-Albee chain of lakes the structure varies somewhat from that on Opasatika lake. The northern syncline is overturned in the same way, but the position of the axis is not so well known, for good strikes and dips are harder to obtain. It appears to lie, however, about on the eastern arm of Kekeko lake. South of the supposed position of the axis very few dips are obtainable, but those obtained are all about 50 degrees north, as on the south limb of this syncline on Opasatika lake. At the north end of lake Evain over a width of about $1\frac{1}{4}$ miles the sediments lie almost flat, with a gentle dip to the east. This area is probably the crest of the anticline, corresponding to the much larger area of flat-lying sediments on Opasatika lake near Moose bay. On the southern part of lake Evain and on Albee lake the beds all dip southward, increasing from about 35 degrees at the north to about 70 degrees at the south. Granite has destroyed the sediments south of Albee lake.

In two or three places small anticlines or synclines were observed on the flanks of one of the larger folds, from which direct data as to the strike and plunge of the axes could be obtained. The strike of the axes, in every case, is north 70 to 80 degrees east, and the plunge eastwards at low angles. The eastward plunge is also indicated by the eastward dip of the strata on the axis of the folds. West of Opasatika lake the eastward plunge of the folds appears to be between 15 and 20 degrees. To the east of Opasatika lake, as far as Kekeko lake and the lakes to the south of it, the eastward plunge flattens to 5 degrees or even less in places. To the east of Kekeko, Evain, and Albee lakes the plunge becomes suddenly much steeper, probably about 25 degrees, though good observations could not be obtained. The above figure is merely an estimate based on the dips near the axes of the folds.

To sum up, the Timiskaming series in Opasatika area forms a large synclinorium, the southern edge of which has been stoped away by granite intrusions. The remaining part forms two large folds; an overturned syncline on the north, followed to the south by a rather open anticline with a wide, gently undulating crest. The axes of these folds strike about north 80 degrees east. They plunge about 15 to 20 degrees east, west of Opasatika lake, about 5 degrees east between Opasatika and Kekeko lakes, and probably about 25 degrees east on the east side of Kekeko lake. The axial plane of the northern syncline dips about 60 degrees north; that of the succeeding anticline is probably nearly vertical or dips about 80 degrees north. Figure 10 shows a cross-section of the structure on Opasatika lake.

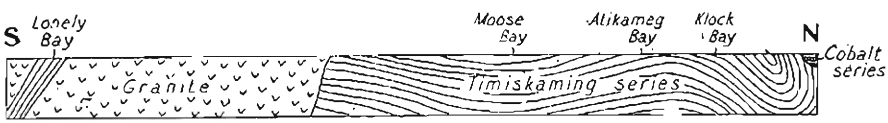

Figure 10. Vertical cross-section showing structure from north end of Opasatika lake to Lonely bay.

The folding of the Timiskaming and Keewatin series also turned up on edge the large sill of diorite porphyry on the south side of Renault bay, Dasserat lake. The other intrusives have been unaffected, so far as observation indicates. The time of folding is, therefore, between the intrusion of the diorite porphyry and that of the next younger intrusive, which is probably either the granite or the older gabbro.

Folding was more intense in the Opasatika area than in any large area in Ontario, and its effects are correspondingly more pronounced. The thick, massive conglomerate at the base of the series is so badly sheared in Rouyn township that the pebbles in it, with the exception of the hard granites, are squeezed into oval lenses two or three times as long as broad. Shearing was so general throughout the whole mass, that long search was required to find the one or two localities where unsheared conglomerate could be studied. Needless to say, the greywackes, less competent to resist shearing stresses than the massive conglomerate, have been very generally converted into schists. The harder, more resistant beds have, however, retained their original bedded structures, although they are in many places badly crumpled; so that strike and dip determinations can be taken on the bedding throughout the whole area.

The strike of the schistosity, wherever observed, is parallel to the bedding, even in the flat-lying beds between Opasatika and Evain lakes. The schistosity is evidently, therefore, due largely to the drag of the beds on one another during folding.

No large faults were found in the area, though such may exist. Unfortunately there are almost no distinctive beds to be found that may be mapped separately and thus used to determine definitely the presence or absence of faults. Almost the only horizon of this sort in the area is the plane of contact between the Keewatin and the Timiskaming series, and outcrops along this contact are so poor, as the map shows, that it would be possible to detect only faults with very large horizontal displacement.

It is unfortunate that this is so, because faulting in the area is strongly suspected, for two reasons. The areas of Timiskaming series in Ontario have been found wherever they have been studied to be badly faulted, and it is only reasonable to suppose that the more intense metamorphism of the Opasatika area was also accompanied by a great deal of faulting. Again, it was observed that although the Timiskaming-Keewatin contact, as a whole, strikes about 5 degrees north of east, individual strikes on the bedding near the contact, where obtained, were either east or slightly south of east. Such strikes should, and in fact always do, parallel the neighbouring contact exactly. The fact that northerly strikes on the bedding were not obtained near the contact may be due to insufficiency in the number of such observations, for strike and dip determinations in the sheared conglomerate are difficult to obtain; on the other hand it may be because they do not exist, and that the contact has a true strike somewhat south of east, but is broken and shifted to the north by a series of small faults. Figure 11 illustrates the latter possibility.

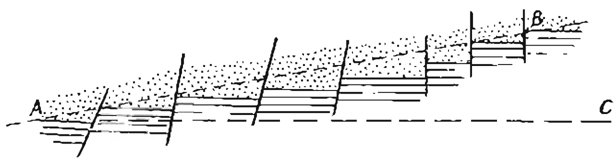

Figure 11. Diagrammatic plan to show how a series of small faults may shift a contact so as to give a wrong conception of its strike, when outcrops are small and few. If observations can be made only at A and B, the strike is apparently AB, whereas the true strike is AC

A few small faults were found in the area. On the east shore of Kekeko lake, towards the north end and also near the south end, small faults with horizontal displacement up to 4 feet occur. In each instance the strike of the fault is almost north and south, and the east side is shifted towards the north. Similar small faulting was observed south of Pelletier lake.

A large shear zone, presumably formed by faulting, runs almost due east and west across MacDonald lake, along the south shore of Fortune lake, and disappears under the waters of Renaud lake. The shear has created a belt of chlorite schist 6 to 8 feet wide on the average, but widening to 300 or 400 feet between Fortune and Renaud lakes. The fault is certainly post-Timiskaming, for in one place on the property of the Lake Fortune Mining Company it has rendered schistose the syenite porphyry which is intrusive into the Timiskaming series.

Stratigraphy

As already indicated, the Timiskaming series consists in most places of only two members, a conglomerate and a greywacke. The conglomerate is believed to occur at the base of the series, and the greywacke at the upper horizons. Locally on Opasatika lake a lava occurs, interbedded with the greywackes. As this locality is on the summit of an anticline, the lava must be rather low in the series, probably not far above the top of the conglomerate horizon.

Estimates of the thickness of the series must necessarily be imperfect, for the upper beds have been removed by erosion. South of Pelletier lake the conglomerate member of the series has an exposed width of one mile, with an average northward dip of 60 degrees, corresponding to a thickness of 4,500 feet. If outcrops have not been repeated by faulting, this figure is certainly much less than the original true thickness, as the beds have been greatly stretched and thinned by shearing.

About 3 miles to the west, along Pelletier creek, the exposed width of the conglomerate is $1\frac{1}{2}$ miles, corresponding as before to a thickness of about 6,700 feet. Still farther west the conglomerate is hidden beneath the Cobalt series, except in the outcrop north of Olier lake; but it is worth noting that the thickness must decrease. About $1\frac{1}{2}$ miles west of Opasatika lake the greywackes continue to outcrop right up to the southern boundary of the Cobalt series, and there they include no pebbly beds indicating that the conglomerate is close at hand. From the southern boundary of the Cobalt series to the first outcrop of Keewatin lava on Ogima lake is only a little over three-quarters of a mile; so that the whole width of the Timiskaming conglomerate here must be less than this, though how much less is not known.

In spite of the imperfection of the evidence, therefore, it is clear that the conglomerate member varies largely in thickness from place to place.

It is difficult to estimate the thickness of the greywackes, on account of the drag folding to which they have been subjected. Rough estimates indicate that the thickness on Opasatika lake is about 3,500 feet as a minimum. It is impossible at present to say what the maximum may have been, for the top has been removed by erosion. In other areas the thickness of the Timiskaming greywacke has been shown to vary inversely as the thickness of the conglomerate; where the conglomerates are thick, the greywacke is thin, and vice versa, the sum of the two being always about the same. Probably the same condition also applies here, although it cannot be proved as yet.

No figures are available for the thickness of the lavas. They outcrop on a flat-lying area, in which exposures are very poor. The evidence available seems to indicate that there are a number of rather thin flows. The only one measured is about 15 feet thick; but others certainly have thicknesses of more than 50 feet, although the whole thickness could not be determined.

By combining a number of estimates, the total thickness of the series is determined to be about 7,000 feet. This is by no means an exact determination, but is probably correct within 1,000 feet.

Correlation

The conglomerates and greywackes here termed Timiskaming series were called the Pontiac series by M. E. Wilson, who considered, on various grounds, that the sediments underlie or are interbedded with the lavas of the Keewatin.[1] In a recent paper[2] the writer showed that the Pontiac series is probably to be correlated with the Timiskaming series of Kirkland Lake and Larder Lake districts and the work of the past summer has confirmed the conclusions previously reached. The name Timiskaming series is, therefore, used throughout this report, instead of Pontiac series.

Before proceeding with the discussion of the correlation it may be well to state clearly that the term Timiskaming series as used here does not include exactly the same rocks mapped by Wilson under the name of Pontiac series. Wilson's work was of an exploratory nature, and his observations were, therefore, confined mainly to the shores of the lakes and streams. In the absence of critical outcrops in these localities, he, naturally, grouped together all the sediments he found—and they are lithologically much alike—and termed them all the Pontiac series. Thus he included in the one group both the Timiskaming sediments proper and the bedded Keewatin tuffs beneath the base of the Timiskaming in Rouyn township and for long distances to the east. On the accompanying map (No. 1985) the tuffs have been separated and mapped in their proper relations. Again, since the Timiskaming lavas on Opasatika lake are chlorite schists, lithologically identical with many schistose lavas of the Keewatin, Wilson, for lack of better evidence, mapped them as Keewatin rather than as a member of the Timiskaming series. With these changes, however, the rocks here referred to as Timiskaming series are those previously described as Pontiac series.

In two previous papers[3] the writer has shown that the Timiskaming series in Ontario forms an unbroken belt extending east and west for 25 miles from the eastern end of Grenfell township to the Ontario-Quebec boundary. Here it is overlain by a band of Cobalt series, part of which is shown on Map 1985. At its narrowest the band of Cobalt series is 4 miles wide, and on the east side of it there outcrop the schistose greywackes of the Pontiac series. The conglomerate of the same series is covered for 20 miles from the Interprovincial Boundary, except for the outcrop north of Olier lake, 11 miles from the boundary.

It is, therefore, impossible to prove the identity of the Timiskaming series of Ontario with the Pontiac series of Quebec by continuity of outcrop, and other evidence must be used. The facts on which correlation is based are as follows. The two series are lithologically identical. The basal member of each is a conglomerate that may be hundreds or thousands of feet thick. In each case the bulk of the material forming the conglomerate was drawn from the rocks directly beneath, and a smaller proportion was evidently brought in from a distance. Like the Timiskaming conglomerates in Ontario, those in Quebec exhibit lenticular layers and crossbedding, great changes in thickness from place to place, and moderate rounding of the pebbles; all the phenomena, in fact, of rapid, possibly subaerial, deposition. Evidently the Timiskaming of Ontario and of Quebec were formed under exactly the same conditions. The greywackes in Quebec are exactly similar lithologically to the greywackes in

[1] Wilson, M. E., Geol. Surv., Can., Mems. 39 and 103.
[2] Jour. of Geol., 28, 1920, p. 304.
[3] Cooke, H. C., Jour. of Geol., 28, 1920, p. 304; Geol. Surv., Can., Mem. 131, pt. II, 1922.

Ontario. Interbedded with them is a lava very similar in composition to, though more altered than, the basalt interbedded with the Timiskaming greywacke at the eastern end of Larder lake.

It has been proved that at Larder lake the Timiskaming series lies unconformably on the Keewatin, and that the unconformity is both structural and erosional; that is, the Keewatin was folded to some extent and was then subjected to erosion before the Timiskaming was laid down on it.[1] The same thing has also been shown for the Timiskaming (Pontiac) series in Quebec. The amount of the crosscutting of the Keewatin bedding is approximately the same in the Opasatika and Larder districts. Evidently, therefore, the Timiskaming and Pontiac were laid down after the underlying Keewatin had been folded to about the same extent, and eroded away to about the same extent, in both districts, i.e., at about the same time.

Structurally the Timiskaming of Larder Lake and Opasatika areas are identical. The Timiskaming at the east end of Larder district lies in close folds, the axes of which strike about 10 degrees north of east. The same thing is true of the Timiskaming in Opasatika area. The folds in the east end of the Larder district plunge to the east at a low angle and it was shown in the Larder Lake report that if this eastward plunge were continued, it would more than account for the great width of the Pontiac series in Quebec. The past year's examination has shown that the folds maintain their eastward plunge throughout the Opasatika area.

Finally, the areal relations of the two form an almost insuperable barrier to considering them in any light other than as one series. The Pontiac series in Opasatika area lies due east of the Timiskaming series in Larder area, and only 4 miles from it at the nearest point. Both are strongly folded, with east-west axes of folding. Both have a wide outcrop across the strike. If they be different series, each of these strongly developed formations must come to an abrupt end in the intervening 4 miles that are covered by the Cobalt series; for no trace of more than one sedimentary series has been found on either side of this boundary, although both areas have now been examined in detail.

The Timiskaming of Ontario and the Pontiac of Quebec are alike in composition and succession of formations. They were laid down under identically similar conditions, on a floor of Keewatin rocks that was folded and eroded to about the same extent in both districts, and they were later folded so that the strike of the axes of folding and even the plunge of those axes are similar in the two districts. Also, the areal relations render it improbable that the two series are other than areally separated parts of a single series. These facts appear to justify correlation of the Timiskaming and the Pontiac; and accordingly the name Timiskaming, as the earlier of the two names, has been applied to the series in Opasatika area.

While discussing the general relations of the Timiskaming series in Quebec to that in Ontario, attention may be drawn to one or two interesting comparisons. The thickness of the series in Quebec has been estimated roughly as about 7,000 $\pm$ 1,000 feet. The thickness in the western end of the Larder Lake area was determined to be about 3,600 feet,[2] that in Teck

[1] Geol. Surv., Can., Mem. 131, p. 36.
[2] Geol. Surv., Can., Mem. 131, p. 30.

township about the same.[1] It may be that this difference of thickness is due to original difference in deposition; that is to say, that the Timiskaming was originally laid down thicker in Quebec than in Ontario. More probably the difference is to be explained by the eastward plunge of the folds, which has carried the bottoms of the synclines to a greater depth in Quebec than in Ontario. The series thus had probably much the same original thickness in Ontario as in Quebec, but greater thicknesses have been removed in Ontario by erosion. Thus the figure 7,000 $\pm$ 1,000 feet is probably a closer approximation to the original true thickness of the series than is the figure obtained in Ontario. Since the folds still plunge to the east at the eastern side of Opasatika area, it should be possible to obtain in that direction a still closer determination of the original thickness.

Again, in Teck township a great part of the total thickness of 3,600 feet consists of conglomerate; in fact, almost the whole of the series is interbedded conglomerate and greywacke, corresponding to what in other places the writer has termed the conglomerate member of the series. In Rouyn township, Quebec, the conglomerate member, consisting mostly of conglomerate with some interbedded greywacke, is 4,500 feet thick, or more in one place. In Larder Lake area the thickness of the conglomerate member varies from zero to 600 feet.

Mode of Origin. It has been shown[2] that the conglomerate member of the Timiskaming series in Ontario was, probably, formed by torrential streams descending from a highland and depositing their load of boulders and sand on the gentler slopes and flat land at the base. It is a matter of doubt whether deposition took place actually on a land surface or in the shallow margin of the sea, although the thick series of well-bedded sandstones that overlie the conglomerates suggests that they, at least, were deposited on a slowly sinking sea bottom. However, many of the greatest geologists think that very thick conglomerates such as these can be built up only on land surfaces, as alluvial fans and cones, especially when they have any wide lateral extension, since boulders are not likely to be carried by wave action alone far from their point of origin. It seems probable, therefore, that the Timiskaming conglomerate, which for many miles is enormously thick, was laid down on land at the mouths of torrential streams descending from a highland that probably lay to the north. The surface on which it was deposited was probably close to sea-level and gradually sank as the sediments accumulated, so that the sandy greywackes overlying the conglomerates were deposited, as their bedding indicates, in shallow standing water. If this took place, the sands would also naturally fill in the low places between adjacent cones of conglomerate, thus explaining the peculiarity, elsewhere noted, of the approximate constancy of thickness exhibited by the series, regardless of the local thickness of the conglomerate.

PRE-HURONIAN INTRUSIVES

The post-Timiskaming intrusives of Opasatika area include almost all those found in Larder area, together with some not observed there. Like the Larder Lake intrusives they may be subdivided into two main

[1] Jour. of Geol., 28, p. 321.
[2] Geol. Surv., Can., Mem. 131, p. 41.

groups, the earlier group including those intruded before the Timiskaming series was folded, the later group, those intruded after folding had occurred. All of them are older than the Cobalt series.

The earlier group includes, beginning with the oldest: hornblende lamprophyre, amphibolite, and diorite porphyry. In the later group fall the older gabbro, granite, syenite porphyry, hornblende-mica lamprophyre, syenite, later gabbro, and basaltic diabase.

Hornblende Lamprophyre

Only one or two small dykes of this rock were found—in a single locality 60 chains north of the point where the Dufay-Dasserat line cuts the east shore of Murdock lake. The rather irregular dykes cut across the bedding of the Timiskaming greywackes. The rock contains very numerous large crystals of hornblende, roughly equidimensional and 2 to 4 mm. in diameter, that weather more rapidly than the remainder of the rock and give it a pitted appearance. The hornblendes may form 50 to 60 per cent of the volume of the rock, the remainder consisting mainly of white or reddish white feldspar with a little biotite.

The hornblende lamprophyre is in contact only with greywacke, hence there is no hint in this place of its relations to the other intrusives. It is supposed to be older than the diorite porphyry because it was so determined in the Larder area. It is not known whether it is older or younger than the amphibolite next described.

Amphibolite

Amphibolite was observed in three places, all near Opasatika lake. In each place there is only a small quantity of the rock. The best outcrop is a bold cliff on the east shore of the lake, half a mile south of the south side of the entrance to Moose bay, where the amphibolite forms sills of varying thickness in the mica schists of the Timiskaming series. One sill, not more than a foot thick, was observed, whereas another, the top of which was not seen, is at least 40 feet thick. The sills are parallel with the bedding, at this point striking due north and dipping 5 degrees east.

The thick sill has been differentiated in place, and exhibits a considerable change in composition from bottom to top. At the lower contact the amphibolite is noticeably chilled throughout a band 3 or 4 feet thick. The grain averages ½ mm. in this part, and the rock is composed of about 85 per cent of hornblende, with a little feldspar and biotite. This basal chilled stratum also contains large, well-formed crystals of hornblende up to one-half inch diameter. Commonly these are scattered, but in at least one place they are packed so closely as to touch each other, giving the rock the appearance of a coarse hornblendite.

The fine-grained substratum grades upward into a phase with an average grain of 2 to 3 mm., composed of about 25 per cent of feldspar, the remainder hornblende with a few grains of mica. The hornblende crystals are well formed, indicating that they were completely crystallized before the rock wholly solidified. Still higher in the section the grain grows coarser, the proportion of feldspar somewhat larger, and the amount of biotite increases, whereas hornblende decreases. At the highest exposed point of the sill the crystals are one-fourth to one-half inch in diameter, and the rock consists of approximately equal quantities of hornblende, biotite, and feldspar.

Under the microscope the feldspar of this upper phase was seen to be largely oligoclase, $Ab_{75}An_{25}$, rather badly altered to kaolin and sericite. There is also a small quantity of a second generation of feldspar, $Ab_{90}An_{10}$, which is absolutely unaltered and clear, and occurs around the borders of large crystals of the earlier feldspar. Feldspar forms about 60 per cent of the section; the remainder is mostly hornblende, with about 12 per cent of biotite, together with accessory titanite, apatite, and seybertite.

The changes described in the composition and grain of the amphibolite clearly indicate that the mass was differentiated after intrusion into its present position. The large crystals of hornblende in the chilled basal layer have probably sunk down from the upper layers during the early stages of crystallization.

There are few data at hand on which to base a statement about the age of the amphibolite. It is evidently intrusive in the Timiskaming series, and hence younger. It is cut by the later gabbro in the area between Opasatika lake and McLaren creek, hence is earlier than the later gabbro. It was not found in contact with any other rocks. Because it has formed sills in the Timiskaming series, the writer has assumed that it was intruded prior to the folding of the Timiskaming series, and hence is one of the earlier group of intrusives; but this is not necessarily true. Further evidence must be obtained before the position of the amphibolite in the time scale can be definitely stated.

Diorite Porphyry

Diorite porphyry forms a single mass on the south side of Renault bay, Dasserat lake. The exposure is about 1½ miles long, 30 chains in maximum width, and strikes about north 60 degrees east. The true width is greater than the exposed width, as the south margin of the mass is overlain by Cobalt series. For the same reason, and also because the mass has been intruded on the north by syenite porphyry, the strike of the exposure probably does not represent the strike of the body.

The rock is very similar to the diorite porphyry occurring near the village of Larder Lake. It was, like that porphyry, intruded as a sill in the older rocks before folding took place, underwent differentiation in place, and was later folded with the older rocks and turned on edge. Accordingly, as at Larder Lake, it exhibits a variety of phases. The north side, originally the upper, is a rather acid feldspar porphyry, made up of numerous phenocrysts of albite feldspar averaging 1 mm. in diameter embedded in a fine-grained matrix consisting almost wholly of albite, with accessory magnetite. The diorite phase is more basic than the porphyritic phase. It is a fine-grained, brownish grey rock, with fewer and smaller feldspar phenocrysts, some biotite, and a good deal more magnetite than the more acid phase. The basic diorite phase of the rock found in Larder lake is here either absent or is covered by the overlying Cobalt series.

The age of the diorite porphyry is fairly definitely determined. The differentiation indicates that it must have been intruded and cooled before the folding of the Timiskaming series. It cuts only the Keewatin in Opasatika area, but it also cuts the Timiskaming in Larder area. Its age, therefore, may be definitely stated to be post-Timiskaming and earlier than the folding movements. It is cut by dykes from the adjacent mass of syenite porphyry, and hence is younger than the syenite. It cuts the hornblende lamprophyre in Larder area, and may be supposed to possess similar age relations there. The only rock, therefore, to which its relations have not been determined, is the amphibolite that also forms sills in the Timiskaming series.

Older Gabbro

The older gabbro forms large, irregular masses and some dykes in the northern part of Opasatika area. Singularly enough, none occurs, or at least was recognized, outside of the Keewatin areas.

The rock is, for the most part, a fine-grained, very basic gabbro, exhibiting in many places gneissic and flow textures implying that it was intruded while rather cool and viscous and after crystallization had commenced. In other places the magma was apparently hotter when intrusion occurred, as parts of the rock are coarse grained like an ordinary gabbro.

The composition is unusual. Three thin sections were examined, of specimens from localities miles apart. Two of these show the presence of quartz, forming 5 or 6 per cent of the section, in crystals up to 0·7 mm. diameter. The quartz is not secondary, as it also forms graphic intergrowths with the feldspar, which forms 20 to 35 per cent of the sections. The feldspar is completely altered to epidote in some sections and to sericite in others, so that it cannot be determined; but as it forms graphic intergrowths with quartz, it was probably near albite. The remainder of the rock, 60 to 75 per cent, consists of greenish hornblende, in crystals averaging 1 mm. diameter. It is partly altered to chlorite. No evidence could be found that the hornblende is secondary after pyroxene; and the presence of so much quartz suggests that the hornblende was, probably, original.

The three thin sections examined thus indicate a pronounced difference in composition between the earlier and later gabbros, which may serve for differentiating them where field distinctions fail. It will be necessary, however, to examine a larger number of thin sections of both gabbros to determine how persistent and uniform the compositions of the gabbros are.

In the field, the earlier gabbro differs from the later mainly in appearing more basic and finer-grained. It also occurs most commonly in irregular masses, whereas the later gabbro has always been found in dykes of uniform width. None of these characteristics may be assumed to be so constant, however, that a certain separation of the two can be made on lithologic grounds alone; unless the earlier gabbro proves on further examination to be, normally, of about the same composition as in the thin sections above described.

The recognition of the older gabbro as a separate intrusive is based on its relations to the syenite porphyry of the region. The syenite porphyry was found to cut the older gabbro in two localities, on Dasserat lake and southwest of Mishikwish lake. Mr. Howard made similar observations northeast of Renaud lake. The later gabbro, on the contrary, was observed to cut the syenite porphyry on the south shore of Renault bay, Dasserat lake, the relations thus coinciding with those observed in Matachewan area almost 70 miles to the west.[1]

The age of the earlier gabbro is in doubt. The only rocks with which it has been found in contact are the lavas, which it cuts, and the syenite porphyry, that cuts it. All that can be definitely stated, therefore, is that it is post-Keewatin and older than the syenite porphyry. The occurrence of so many large masses of the earlier gabbro in the Keewatin area, and the lack of such masses in the Timiskaming series, suggest that the older gabbro may have been intruded before the Timiskaming series was deposited. The two have not yet been found in contact, however, so that this point must remain in doubt. On the other hand the older gabbro stands up in dykes having steep or vertical contacts wherever observed, which is strongly suggestive of intrusion after the folding of the area was completed, in which case the older gabbro would be post-Timiskaming. Tentatively it has been placed as the oldest member of the group of intrusives that were intruded after the folding of the Timiskaming series. It is possible that it may be identical with the amphibolite that forms sills in the Timiskaming series.

Granite

Granite and gneiss are widely distributed throughout the area in batholiths and small intrusions of dyke-like or irregular shapes. The whole southern part of the map-area is occupied by granitic rocks.

When pure, the granite is light grey, white or pinkish, and of medium to coarse grain. The smaller masses are commonly porphyritic. They are composed of quartz and albite principally, with a little orthoclase, biotite, and muscovite, though hornblende takes the place of the biotite partly or completely in some places. When porphyritic, the phenocrysts are always of white feldspar, mostly albite. They never attain sizes of more than 2 mm.

The purer forms of granite are best seen in the small intrusives. In the large batholith on the south the granite is badly contaminated, within the limits of the map-area, with the Timiskaming series, great thicknesses of which have been stoped away and partly or completely dissolved in the fluid granite. It is almost impossible to find even a small area in which the present rock can be assumed to be the solid equivalent of the original intrusive magma. The larger southern batholith for some miles from its contact with the Timiskaming series exhibits a great variety of basic phases, mostly gneissic in texture. Where the amount of dissolved Timiskaming was large, and also presumably rather basic, dark-coloured syenites or diorites have been formed by the interaction of the two. With lesser proportion of dissolved material, more acid types have resulted, up to the composition of pure granite. An accurate study of the chemical and mineralogical changes accompanying this reaction between granites and sediments would be of great interest.

The age of the granite can be fixed with a fair degree of exactness. It is cut in various places by dykes of the later gabbro, so was evidently intruded and solidified before the latter was intruded. Small dykes of

[1] Cooke, H. C., Geol. Surv., Can., Mem. 115, p. 33, 1919.

granite in the Timiskaming series have not been broken up or rendered schistose by the folding movements that sheared the Timiskaming series so thoroughly; hence the granite was evidently intruded after the folding of the Timiskaming series was completed. Its relations to the older gabbro and to the syenite porphyry are not yet known.

Syenite Porphyry

Syenite porphyry forms dykes and sills in various parts of the map-area, but particularly in the northern part. It is a highly porphyritic rock, made up of numerous beautifully developed crystals of feldspar embedded in a fine-grained greyish matrix. The colour of the phenocrysts varies a good deal. In some dykes they are white, and the whole rock then has a grey tone. In other dykes the phenocrysts are all a bright reddish pink, so strongly coloured that they mask the grey of the matrix and give the rock a reddish cast. In still other dykes a mixture of the red and white feldspars is present. Commonly the feldspars average about 4 mm. in length by 2 mm. in width, with a maximum size of double these measurements; but the sizes are by no means constant, as there appears to be a rough ratio between the size of the phenocrysts and the size of the body of porphyry. Such a relation might, of course, be expected, since a larger mass would cool more slowly and thus allow crystals to grow larger before solidification occurred, provided crystallization was initiated only at a few centres, as in the present case. Thus the large sill of porphyry between Olier and Renaud lakes contains large numbers of feldspar crystals 15 to 20 mm. in length by 9 to 12 mm. in width (25·4 mm. equals 1 inch). Most of the phenocrysts have clearly been developed in the porphyry after its intrusion, as the chilled edges of the intrusives, where cooling has been very rapid, contain very few phenocrysts.

Under the microscope the phenocrysts are determined to be orthoclase or microcline and albite, in about equal proportions. The refractive index of the albite is rather low, suggesting that it contains some potash molecule. Some hornblende phenocrysts are also present, smaller than the feldspar phenocrysts but almost equal in numbers. The phenocrysts are embedded in a matrix of fine-grained feldspar with some fine needles of hornblende. Magnetite and titanite are accessory. A good deal of alteration to kaolin, sericite, and carbonate has taken place.

The age of the porphyry can be determined with considerable exactness. It intrudes the Keewatin, the Timiskaming series, the diorite porphyry on Renault bay, Dasserat lake, the older gabbro in the same locality and also southwest of Mishikwish lake. The fact of intrusion in each case was established by the usual evidence, such as chilled edges in the porphyry at contacts, the presence in the porphyry of fragments of the older rocks, and the occurrence of dykes and stringers running off from the main porphyry mass into the older rocks. The porphyry is itself cut by dykes of the syenite next described, and by the later gabbro, on Renault bay. Its age is, therefore, between that of the earlier gabbro and the syenite. No data have yet been obtained from which its relations to the granite may be known.

The similarity in texture, composition, and age relations of this rock to the syenite porphyry of Larder area renders it almost certain that the two are identical, and the correlation may be extended with almost equal certainty to the similar syenite porphyries of Kirkland lake and Matachewan.

The relations of the mass of porphyry between Olier and Renaud lakes are of considerable interest. The southern edge of the mass runs along the north shore of Olier lake, where it is in contact with the flat-lying rocks of the Cobalt series. The contact is splendidly exposed on the face of a vertical cliff 100 feet or more in length. The Cobalt series outcrops along the base of the cliff, and scales of it a few inches thick still cling to the vertical face of porphyry along its whole length. The contact is not a straight line, but the Cobalt remnants for the most part fill shallow V-shaped re-entrants in the surface of the porphyry. No pebbles of the porphyry could be found in the Cobalt series, and the contact was accordingly examined with the greatest care to determine whether or not the porphyry was intruded into the Cobalt series. A comparison of many hand specimens from the interior of the sill with others taken from the contact failed to reveal the slightest chilling of the porphyry at the edge; nor is there any other evidence of intrusion such as dykes passing from the porphyry into the Cobalt series, or fragments of the Cobalt series included in the porphyry. It was, therefore, concluded that the porphyry is not intrusive in the Cobalt series, but is older.

The northern edge of the porphyry is exposed on the south shore of Renaud lake, east of the portage from Olier lake, where there are also a number of dykes of the later syenite. In this locality the porphyry is in contact with a schistose conglomerate that Wilson[1] considered to be Cobalt conglomerate mashed by the action of the intrusive. At the contact, however, the porphyry is chilled for 3 or 4 feet from the contact, and the 2 inches of porphyry next the contact is so strongly chilled that the phenocrysts are only 1 mm. in diameter, and the groundmass is practically glass. The sediments are well-bedded, strike north 75 degrees west, dip 70 degrees north, and the contact with the porphyry is parallel to the bedding everywhere, so that the porphyry is a sill.

Since the porphyry is chilled at its contact with the schistose conglomerate, the conglomerate is evidently the older rock. No chilling whatever occurs at the contact with the Cobalt series on Olier lake. The mashed conglomerate cannot, therefore, be Cobalt series, and accordingly has been mapped as Timiskaming series.

The porphyry west of the portage between Olier and Renaud lakes is a single large mass, as far as observations go. To the east of Olier lake, however, the large sill splits into a number of smaller sills, separated by beds of the Timiskaming conglomerate. Alternate bands of porphyry and conglomerate are 2 to 4 chains in width. Presumably these thin sills either thin out, or end abruptly against some small pre-existing fault plane. Unfortunately time did not permit the detailed mapping of this interesting area, and accordingly the "fingering out" of the sill toward the east is shown in diagrammatic fashion on the map. Actually there are more of the thin "fingers" of porphyry than have been indicated.

[1] Geol. Surv., Can., Mem. 39, p. 101; Mem. 103, p. 115.

Comparison of Porphyries in Opasatika, Larder, and Teck Areas. It is of special interest to note that in Opasatika area no bodies of the syenite porphyry have been found cutting the greywackes of the Timiskaming series, nor has Wilson noted the existence of any such in the greywackes between Opasatika area and Kiekkiek lake 22 miles to the east, although in that distance there are two or three water routes across the greywacke areas which afford good sections. The two porphyry masses that intrude the Timiskaming of Opasatika area are both low down in the section. One, between Olier and Renaud lakes, is in the conglomerate close to the Keewatin contact; the other, at the north end of Kekeko lake, is in the conglomerate about 4,500 feet stratigraphically above the contact. Numerous dykes of porphyry cut also the Keewatin to the north of the Timiskaming.

The association indicates what has been observed elsewhere, that the porphyry tends to form dykes in the Keewatin, and sills where it intrudes the bedded rocks of the Timiskaming series. *It also strongly suggests that the intruding porphyries found it difficult to break through the bedded Timiskaming rocks, and hence have tended to spread out into sills along some bedding plane at or near the base of the series.* On account of the far greater thinness of the series in Ontario, this possibility has not hitherto been noticed, but an examination of the geological maps of Larder and Teck areas seems to confirm it. In Larder area the largest mass of porphyry lies just below the Timiskaming series, in the anticline between Beaver lake and Malone lake; and all other masses of porphyry intruding the Timiskaming lie comparatively near the base of the series. In the Teck area the series is only 3,500 feet thick, and one might, therefore, reasonably expect to find porphyry almost anywhere. This seems to be the case, although even here there is a suggestion of some slight concentration of the porphyry masses toward the Keewatin contacts.

The above conception must be tested by further field work east of Opasatika area before it can be considered as confirmed; but there seem to be enough facts to justify a prophecy that very few sills of porphyry will be found cutting the Timiskaming greywackes, but that, on the contrary, most of the porphyry masses cutting the Timiskaming series will be found at, or slightly south of, the Keewatin contact; *and, therefore, since the porphyries are generally admitted to be the source of the gold ores, the most favourable area for prospecting in the Timiskaming series is the band about a mile wide on the south side of the contact.*

Hornblende-Mica Lamprophyres

Dykes of hornblende-mica lamprophyre, identical in composition with the rocks so described at Larder Lake, occur along the eastern side of Opasatika area, particularly around Kekeko lake. One large dyke follows the south shore of the east arm of the lake for several miles. The dykes were not particularly examined. They were not found in contact with any rock other than the Timiskaming greywacke, and consequently they can be correlated with the similar rocks at Larder Lake only on lithological grounds. Like the Larder rocks, they are composed of hornblende, biotite, and oligoclase feldspar in varying proportions.

Syenite

The only bodies of syenite observed by the writer in the area are a number of dykes cutting the syenite porphyry between Olier and Renaud lakes. Here, dykes of syenite are quite numerous. Mr. Howard reports a number of dykes northeast of Renaud lake.

The syenite is identical with the rock of the same name in the Larder area. It is a fine-grained, reddish, finely porphyritic rock, with so little ferromagnesian mineral in places that it approaches a felsite. It contains both orthoclase and albite, but the relative proportions of the two are hard to determine, as a good deal of alteration has taken place. Feldspar is the principal constituent, the others being about 5 per cent of hornblende, with a little muscovite, quartz, magnetite, and pyrite. In places it contains a good deal of pyrite that appears to be auriferous; assays of the rock may be obtained in many places yielding gold values of $1 to $2 a ton.

The syenite cuts the syenite porphyry, and is, therefore, the younger rock. Dykes of the syenite traverse the syenite porphyry in several directions; and very careful examination of a contact that has been well exposed by blasting, on the pond between Olier and Renaud lakes, established the presence of a narrow, chilled edge in the syenite at the contact. The syenite is, therefore, the younger rock, as at Larder lake.

The syenite porphyry was not found in contact with the later gabbro, so that the relationships of the two are not known. However, the close areal association of the syenite and syenite porphyry suggests rather strongly that the two are closely associated in origin and probably also in age. The age of the syenite is, therefore, tentatively stated as earlier than the later gabbro.

Later Gabbro

The later gabbro forms dykes that cut the Keewatin, Timiskaming series, and granite of the region. Their distribution may be seen on Map 1985, accompanying this report. They are continuous, and may for the most part be readily traced, but time did not permit this to be done. Only the large dyke that runs northeast through the middle of the area was traced for about 15 miles without reaching either end.

The dykes vary a good deal in their topographic expression. Like the earlier gabbro, they commonly stand up as ridges. A ridge may continue for miles, or for a short distance only; then suddenly, owing to some unknown change in the constitution of the rock, that renders it more easily attacked by the agents of erosion, the ridge will disappear for a space, and the dyke either does not rise above the general level, or even lies below it and forms a narrow valley.

The dyke rock is a coarse-grained quartz diabase, well crystallized and very fresh looking in the hand specimen, though the microscope reveals considerable alteration. The dykes are mostly coarser and fresher than the earlier gabbro, although such a characteristic is not dependable as a means of separation. In many dykes large crystals of plagioclase feldspar are present, with a maximum diameter of $1\frac{1}{2}$ inches usually, though in some places crystals 3 inches in diameter were seen. The large feldspars never show fresh shining cleavage faces when broken, but have a waxy, earthy look, due to the fact that they are thoroughly altered to mixtures of sericite and kaolin.

The age of the later gabbro is quite definitely determined. It cuts the Timiskaming series, the granite near McLaren lake, and the syenite porphyry of Renault bay, Dasserat lake. Its relation to the syenite dykes is not determined, but on account of the close relationship that apparently exists between the syenite and the syenite porphyry, the diabase is, tentatively, assumed to be later than the syenite. The later diabase is cut by a dyke of basaltic diabase on Pelletier lake, so is older than the basaltic diabase. It was not found in actual contact with the Cobalt series, but dykes were traced carefully up to the Cobalt boundary, and could never be found cutting the Cobalt series, although the ridge of Cobalt series for 5 miles west of Opasatika lake is burnt clean and affords almost continuous exposures. The whole length of the ridge was carefully traversed, without discovering any dykes. On the contrary, the conglomerate contains numerous large boulders of diabase. This cannot be taken as proof of unconformity, on account of the existence of the earlier diabase in the region, but the whole assemblage of facts strongly suggests that the later diabase is older than the Cobalt series.

This diabase was not found in the part of Larder Lake area examined in 1920, but in Matachewan area to the west the same diabase occurs in considerable quantity.[1] There its relations are exactly those found in Opasatika area. It has the same porphyritic character, it cuts the syenite porphyry, and it is definitely older than the Cobalt series, which was observed to overlie the diabase and to contain boulders of it.

The more porphyritic phase of the later diabase is so similar in composition and appearance to the feldspathic gabbros forming a phase of the anorthosite intrusions in Quebec farther to the east and north, as to suggest identity. Furthermore, though the dykes are comparatively few in number in Ontario, they are fairly numerous in Opasatika area and, probably, according to Wilson's map, even more numerous farther east. This suggests that the source of the gabbro magma is to the east. It would be interesting, for purposes of correlation, if future workers in the neighbourhood of anorthosite masses could determine the relation of these porphyritic gabbros to them.

Basaltic Diabase

A number of dykes of a very fresh-looking, very fine-grained, black diabase are found in the area. For the most part they have not been mapped separately, for they have been found only in the Keewatin area at the north side of the map-sheet, and are indistinguishable from the fresher Keewatin basalts except where the whole dyke is exposed and both edges may be seen. The rock forms dykes up to 100 feet or more in width.

On Pelletier lake a good exposure on an island near the east end shows the basaltic diabase intruding the later diabase, and with a strong chilled edge at the contact. The basaltic diabase is, therefore, younger than the

[1] Geol. Surv., Can., Mem. 115, p. 33, 1919.

later diabase, provided that the latter rock be later diabase. There is no evidence for this except the coarse-grained, well-crystallized character of the rock; and if it should prove to be the earlier diabase rather than the later, the basaltic diabase might accordingly be one of the earlier intrusives in the region, instead of the latest. Definite proof on this point must await further evidence.

HISTORICAL SUMMARY

A brief historical summary of events up to this point may help to create a clear picture in the mind of the reader. The period described commences with the outpouring of the great floods of lava and their accompanying beds of tuff that now form the Keewatin. How long this period may have been, there is no means of knowing. The great thicknesses of lava, over 4 miles on Dasserat lake, with neither bottom nor top exposed, undoubtedly required a great length of time to accumulate, but flow must have followed flow with considerable rapidity, geologically speaking, for there is rarely found between flows any weathered material, or old soil, such as would be rapidly formed had the lavas been poured out on land and left uncovered for any length of time; or any normal bedded sediments such as might be expected had the flows been poured out beneath the sea and not been covered with more lava within a few years. The Keewatin may be confidently assumed, therefore, to have been a period of almost constant extrusion, in this area at least, with an average of at least one great flow per century. The presence of beautifully bedded tuffs at the top of the series, in Rouyn township, the occasional occurrence of thinly bedded cherts between flows, and the almost universal occurrence of pillow structures in the lavas, all point to the conclusion that the extrusions were submarine, at any rate in Quebec and adjacent parts of Ontario[1]—so that the area was covered by the sea or by some other large body of water.

After the period of extrusion ended, the lavas were raised above sea-level by mountain-building movements, and gently folded. Apparently a range of mountains, probably rather low, was formed to the north of the present Timiskaming area. Almost certainly some batholiths of granite must have been intruded into the lavas at the time of the folding, because a few pebbles of coarse granite are found in the overlying Timiskaming conglomerate.

As soon as uplift brought the rocks above sea-level, they began to be worn away by rain, running water, and the other agencies of erosion. Erosion was undoubtedly rapid, not only because of the rugged nature of the country, but also because of the lack of vegetation in that early time. The mat of roots that now covers the earth's surface wherever climatic conditions permit, and which effectively prevents running water from carrying away any large proportion of soil, was then entirely absent; and consequently every rain storm must have swept great quantities of mud, sand, and gravel into the streams, to be carried to the sea. The land at that time must have been a scene of unimaginable desolation; black lava everywhere, carved no doubt by the weather into cliffs, spires, and an infinite variety of weird shapes; with the gloomy tints of basalts relieved here and there, it is true, by the lighter colours of rhyolite or dacite, but

[1] There is evidence that extrusion was not submarine in the vicinity of lake Huron. W. H. Collins, personal communication.

without a trace of the soft green of vegetation; with the surface everywhere piled high with blocks, boulders, and masses of rock, from between which almost every particle of soil had been swept by running water. From the mountains rushed torrential streams, black with lava mud, and rolling quantities of gravel and boulders along their beds to the plains below.

Such were the conditions that prevailed after the uplift of the Keewatin lavas, when the deposition of the Timiskaming series commenced. The great conglomerates at the base of the series appear to have been huge, flat, fan-shaped deposits, laid down at the foot of the mountains at the mouths of outrushing streams. When the streams passed from the steep slopes of the mountains to the flat slopes of the plains, their velocity was checked, and consequently they had to drop a great part of the load they carried—naturally, the coarsest material. Their bed thus filled up, the streams were forced to break out, first in one place, then another, depositing wherever they went, until long and broad lenses of gravel of great thickness were formed.

The next event is more obscure. Perhaps great lakes were formed in some way. Perhaps the deposition of the great weights of gravel caused the land to sink locally below sea-level. In one way or the other the area where the gravels were laid down became covered with a rather shallow body of water, in which deposition took place, not of gravel, but of sands. As thousands of feet of sand were deposited, the second hypothesis is probably the correct one, and sinking of the sea-bottom kept pace, approximately, with deposition. Had the areas been lakes, they would have been filled up quickly. Here and there an occasional volcano smoked, contributing the lavas that now form local members of the Timiskaming series.

Then began the series of earth movements that uplifted the newly-formed Timiskaming series and folded them. They began with the intrusion, in small quantities, of igneous rocks, hornblende, lamprophyre, amphibolite, and diorite porphyry. These tended to form sill-like masses, rather than dykes, in the still flat-bedded sediments. Then came tremendous horizontal thrusts, so violent and long-continued that the Timiskaming strata and the underlying Keewatin lavas were turned on edge, and even overturned in places. The earth movements then gradually died away with the intrusion of various igneous rocks, gabbros of several types, granite, syenite porphyry and syenite, and the hornblende-mica lamprophyres. Most of these were small, relatively speaking, except the intrusion of the granite, which was vast and widespread. It welled up slowly in enormous masses which ate their way forward by breaking off blocks of the overlying rock, that sank in the liquid granite, or were dissolved by it. The thicknesses of rock thus stoped away by the granite are to be measured in miles, rather than in any lesser unit. In the southern part of Opasatika area, not only the 7,000 feet or more of Timiskaming series has been thus eaten away, but also all of the immense underlying thicknesses of lavas, together with all of the unknown floor on which the lavas were laid down.

The folding movements, more intense and widespread than anything in later geologic history, must have converted northern Canada into a mountainous area, comparable in elevation with the highest ranges in the world today. Consequently a very long period of time next elapsed, during which no permanent body of sediments could be formed in the area, while erosion gradually wore down the mountains and reduced the whole region to sea-level or near it. In this period, the writer has calculated, between 14,000 and 30,000 feet of rock were removed from the area by erosion.[1] Where this vast amount of material was deposited is not yet known. Finally, northern Ontario and Quebec were reduced to a plain-like surface, near to sea-level, somewhat like the present surface in detail, though probably flatter. On that surface outcropped not only the former Keewatin rocks and the remnants of the Timiskaming synclines, but also granites and other intrusives, whose original sedimentary cover had been entirely removed when the mountains were worn down. On this surface the deposition of the Cobalt series began.

COBALT SERIES

The Cobalt series in this area has been fully described by Wilson,[2] and the work of last summer adds only a little to the information he has given. The series in Opasatika area consists wholly of the lower beds, grouped by Collins[3] under the name Gowganda formation. It includes large quantities of conglomerate interbedded with greywackes and impure quartzites, together with some fine-grained, blackish greywacke or argillite. The thickness of the series here, between 500 and 1,000 feet, represents only a fraction of the original thickness, for the greater part has been removed by erosion.

It was pointed out in the previous section that the Cobalt series was laid down on a relatively flat surface that truncates all the older rocks. The nature of this surface is well exhibited in Opasatika area. It appears to have consisted of knobs and short or long ridges alternating with valleys of moderate width, and to have had a relief, probably, of between 200 and 300 feet. The topography varied no doubt with the nature of the underlying rock; in areas of Timiskaming series structure can be seen to have controlled the topography, so that valleys and ridges had a general east-west direction.

A beatuiful section is obtainable between Opasatika and Dasserat lakes, where the entire removal by fire of all vegetation has exposed all details clearly. The contact of the Cobalt and Timiskaming series at the north end of Opasatika lake is on a hill of the Timiskaming series that rises about 100 feet above the lake. Lake-level is 869 feet above sea-level, so that the old Timiskaming surface here has an approximate elevation of 970 feet. The contact may be seen on the cliffed shore to fall away rapidly in elevation northward, so that this part of it was evidently the south side of an old valley of some depth. The depth is not known, but was more than 100 feet, for the contact passes below lake Opasatika.

At the south end of Ogima lake (elevation 913 feet), one mile due north of the contact described in the last paragraph, low outcrops of lava rise a few feet above the lake, corresponding to an elevation in the old surface of more than 40 feet. Half a mile farther north, on the west side

[1] Geol. Surv., Can., Mem. 131, pp. 37-40.
[2] Geol. Surv., Can., Mem. 39, pp. 83-98.
[3] Geol. Surv., Can., Mem. 95, p. 63.

of the lake, the old surface rose into a considerable ridge, as the Keewatin-Cobalt contact is high on the hillside, 100 feet or more above lake-level, i.e., with an approximate elevation of more than 1,000 feet above sea-level. Farther to the north, the old surface evidently fell away again into another valley, which was about a mile wide, and, since the Cobalt series once more outcrops at the low-level surface of Dasserat lake (913 feet), must have been more than 100 feet deep. The northern contact is on the ridge on the south side of Renault bay, Dasserat lake, about 100 feet above lake-level. Figure 12 shows a cross-section of the old surface described.

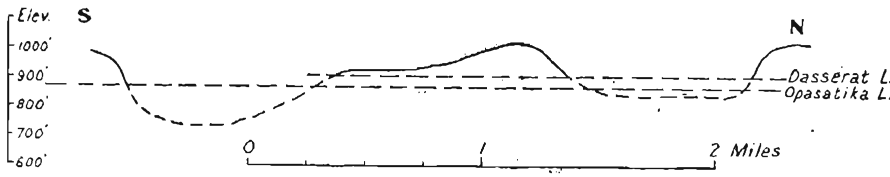

Figure 12. Profile of land surface on which the Cobalt series was deposited, between north end of Opasatika lake and Renault bay, Dasserat lake.

Similar observations, though less complete, were made at many places in the area. Thus the outcrop of syenite porphyry to the north of Olier lake is a pronounced ridge of pre-Cobalt age, that now rises 150 feet or more above Olier lake, and must have risen higher above the floors of the old valleys to the north and south, since these are now filled with Cobalt series at lake-level, and for a farther depth unknown.

The origin of the Cobalt series has been extensively discussed in past years, in view of the theory advanced by Prof. A. P. Coleman that the Gowganda formation represents the deposits of an early glacial period. The similarity of the thick boulder conglomerates of the Cobalt series to boulder moraines, of the unstratified greywackes to boulder clays, and of the thin-bedded argillites containing scattered boulders to the bedded clays of post-Glacial lake deposits, has been repeatedly pointed out by various geologists working in northern Ontario and Quebec. Coleman himself has discovered scratched and soled boulders in the conglomerate at Cobalt, Ont., identical with those to be found in the deposits of the last Ice age. The evidence appears conclusive, but many geologists have not considered it so because up to the present a glaciated surface has never been found beneath the Cobalt series; that is, a smooth polished rock surface covered with the grooves and striations made by boulders gripped by the moving ice, such as may be observed almost everywhere in northern Canada today.

Without going further into the controversy, it may be said that during the past summer two pieces of evidence were obtained that strongly support the theory of the glacial origin of the Gowganda formation. These are, the discovery of a conglomerate that could not have been formed by other than glacial means; and the discovery of a striated surface beneath the Cobalt series.

On the south side of the creek draining Olier lake, at a point about 30 chains east of the Dasserat-Boischatel line,there is a cliff of the Cobalt series consisting for the most part of grits and quartzites, well bedded, in beds 4 inches to 2 feet thick that maintain their thickness very uniformly along the strike. The strike here is north 80 degrees west, the dip 10 to 15 degrees north. Interbedded with the sandstones is a bed of conglomerate about 15 feet thick. It is made up for the most part of boulders 2 to 4 feet in diameter, with many of larger size. One boulder more than 15 feet in length and at least 8 feet high was seen; its full thickness is more than 8 feet, but its base is hidden by the soil at the foot of the low cliff; and many boulders 8 to 10 feet in diameter were observed. The boulders are crowded together, and cemented by a small amount of greenish-grey clayey matrix that possesses a crude and highly irregular bedding near the base of the conglomerate bed, but is entirely without bedding in the upper two-thirds. Most of the boulders are subangular though not soled; a number are sharply angular, with little signs of wear. About 80 per cent of them are of a white, highly quartzose granite containing very little ferromagnesian mineral. The remainder are mostly basalt and other lavas, with a few of the Timiskaming greywacke.

There are only two known ways by which such a coarse boulder conglomerate may be formed. One of these is by torrential streams descending from a mountainous area; the other is by glacier ice. The theory of torrential streams must be at once abandoned, because, as has been shown, the relief of the surface was very low when the Cobalt series was deposited; and also because the well-bedded sandstones both above and below the conglomerate bed indicate that the area was covered with comparatively still, though shallow, water. The conclusion, therefore, is unavoidable that the boulders were brought to their present position by ice, probably by a comparatively thin glacial tongue pushed out into a shallow lake from some larger body at a distance, during a temporary advance of the ice-sheet. The ice tongue was evidently so buoyed up by the water that it exerted little pressure on the unconsolidated sediments beneath, for they show no signs of having been disturbed, at the point of observation at least.

The composition of the conglomerate affords further support to the glacial theory. It is 5 miles from this point to the nearest outcrop of granite, on the southwest, much more to the nearest outcrop in any other direction. It would be impossible for any agent except ice to carry boulders of the size described across 5 miles or more of relatively flat country.

South of the west end of Renault bay, near where the south boundary of Renault's westernmost surveyed claim crosses the east side of the small stream valley, the contact of the Cobalt series and the diorite porphyry is well exposed at an estimated elevation of at least 200 feet above the lake-level. The valley, which cuts down across the plane of contact, here runs north 20 to 30 degrees west. The area has been so thoroughly burned that every trace of moss and vegetable matter is gone, and the rocks are magnificently exposed, except for thin deposits of talus. Attention was first directed to the contact by its unusual shape; instead of being flat, jaggedly rough, or gradational, it is a sharp line, but wavy, in smooth flowing curves, the "waves" having a depth of 6 inches to 1 foot, roughly, from the top of the crest to the bottom of the trough. The appearance is precisely similar to a cross-section of a glacially gouged rock surface covered with soil.

Accordingly, this unusual contact was further searched for places where the Cobalt series had been lately so broken away as to expose a bit of the surface on which it had been laid down. If this were truly a glacially gouged surface, there ought to be finer striations on it, paralleling the larger grooving. There proved to be about 4 or 5 chains of contact well exposed on the almost vertical rock face, and in this distance two places were found where small blocks of the Cobalt series had been recently cracked out by the action of the weather, exposing in each case a small area, roughly 4 inches by 6 inches, of the underlying surface. Each of these surfaces is smoothly polished, and is distinctly grooved by fine striæ running parallel to each other and to the main large grooving. The strike, taken as accurately as possible on the fine striations, was determined as north 60 degrees east on one bit of surface, north 62 degrees east on the other.

These observations seem to establish pretty conclusively that the deposition of the Cobalt series commenced under glacial conditions, and further, that the glaciers must have been continental glaciers or ice-sheets, for the general peneplained character of the country would forbid the formation of the valley glaciers common in mountainous regions. Further, the ice must have moved over Opasatika area from a centre that lay either to the northeast or the southwest. Although there is no definite method for determining the position of the ice centre more exactly than as stated, two of the observed facts lend themselves to the suggestion that the ice centre lay to the southwest, or, precisely, south 60 degrees west from the Swinging hills. The first of these facts is the slope of the pre-Cobalt surface where the groovings were observed. The slope is gently upward toward the northeast, at an angle of 10 or 15 degrees, exactly like the gentle slope of the iceward side of a roche moutonnée—thus suggesting that the ice came from the southwest. Again, it will be recalled that the great boulders in the glacial conglomerate previously described consist almost entirely of granite. The large areas of granite in the region all lie to the south and southwest. To the northeast the nearest body of granite is 12 miles away and it and its neighbours form only a relatively small part of the total area. Had the ice moved down from the northeast, boulders of basalt and other lavas would naturally form a large proportion of the total load of the ice. Of course, the soft greenstones might be ground to powder during ice movement much more readily than the harder granites, so that during movement there would always be increase in the proportion of granite boulders in the load; but this consideration can hardly explain the composition of the particular bed of conglomerate under consideration, for the boulders in it show scarcely any signs of wear, some of them being sharply angular and the rest subangular. It seems reasonable, therefore, to conclude that these boulders were brought from the large granite area to the southwest, where a great quantity of granite, and very little of any other rock, was available to the ice during the process of gathering its load.

The age of the Cobalt series has been shown in previous papers, to which the reader is referred, to be post-Lower Huronian.[1]

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[1] Geol. Surv., Can., Mem. 131, pp. 40, 41.

QUATERNARY

Quaternary deposits cover a large proportion of Opasatika area. They include, mainly, glacial drift and post-Glacial lake deposits.

The glacial drift is found in varying quantity everywhere throughout the area, underlying the post-Glacial lake deposits, and projecting up through them in ridges and knobs. Most of the drift consists of sand, gravel, and boulders, although boulder clay is to be found here and there. In places terminal moraines of the continental ice-sheet occur, characterized by the usual knob-and-kettle type of topography. A heavy terminal moraine forms a rather pronounced ridge across the portage between Summit and Ogima lakes, damming the old stream channel so as to form those lakes; it runs then northeast along the north side of MacDonald lake, passing between Uwass and King-of-the-North lakes. Large morainic hills are found, also, around Kilburn lake, and in various other parts of the area. A larger esker, or deposit formed by a glacial stream, occurs on the west side of lake Evain.

Post-Glacial lake deposits cover, however, by far the larger part of the area. These are the sediments that were laid down in the bed of large shallow lakes formed during the retreat of the last ice-sheet. Such lakes were formed whenever the ice-sheet, in its northward retreat, retired over a divide; so that the waters from the melting ice were ponded between the divide on the one side and the edge of the ice-sheet on the other.

Into the lakes poured streams of water from the melting ice-sheet, loaded with the fine rock powder formed by the grinding of the ice-sheet against the underlying rock. The sediments settled in the quiet waters of the lake, and formed characteristic deposits of thin-bedded clays and silts, with more or less sand near the original shores. Naturally, the streams had their maximum volume in the heat of the summer, when melting was greatest, and it may be presumed that they were small during the winter. The beds formed in the lakes reflect this change. The lower part of each bed consists of a comparatively thick deposit of relatively coarse-grained silt, the deposit from the summer stream, which grades upward into a rather thin deposit of very fine-grained material; the latter, the winter deposit, consists of the clay particles held in suspension for months because they were too fine to sink rapidly.

Good sections of the clay deposits in Opasatika area are not available for detailed study. During the building of the National Transcontinental railway to the north, the numerous railway cuttings afforded M. E. Wilson an unusual opportunity for examining them, and his descriptions may be assumed to be applicable to all the clays of the area. He describes them as forming beds about half an inch in thickness for the most part, although thicknesses of 3 inches were observed where there is a good deal of sand admixed with the clay. For the most part each bed consists of silt at the bottom passing into clay at the top, or in some cases of clay at bottom passing into very fine clay containing a large proportion of calcium carbonate, at the top. The beds are flat-lying, except at their contacts with underlying bedrock or drift, where the bedding parallels the underlying surface on which they were laid down. Wilson counted the beds in various localities along the railway, and states that the maximum number found is 250.

As each bed almost certainly represents a year's deposit of sediment, the life of the lake in the vicinity of the railway was apparently only about 250 years.

In Opasatika area the clay beds lie at two distinctly different levels. The high-level clays, as they may be called, lie north of the long ridge of Cobalt series that projects eastward into the area, and the eastward extension of this ridge that is formed by the band of Timiskaming conglomerates. There are also a few small areas of high-level clays south of this boundary, specifically near the east boundary of the map-area, just south of the east arm of Kekeko lake, and also along the south border of the map-area to the east of Opasatika lake. With these exceptions all the clays south of the boundary mentioned may be termed low-level clays. The high-level clays lie 1,000 to 1,050 feet above sea-level (estimated), and probably were deposited in the same lake as the beds farther to the north, along the railway, since Wilson reports the clays on the height of land in Launay and Trécesson townships as lying 1,074 feet above sea-level. The uplift of this general region that took place in post-Glacial times would account for the clays around the railway being somewhat higher than those farther south. The low-level clays lie at an elevation which has been estimated as 900 feet above sea-level. As the level of the clays is only 15 to 20 feet above Kekeko lake, and as Kekeko lake is 881 feet above sea-level, the elevation of 900 feet is probably correct within 5 feet.

The occurrence of the clays at different levels is a matter of considerable interest, and two possible explanations present themselves. Two separate lakes may have existed, a high-level northern lake and a low-level southern lake, the northern one being ponded behind the ridge of Cobalt series and Timiskaming conglomerate, the gaps in which must have been filled with glacial drift. This explanation does not, however, account for the small areas of high-level clays in the southern area; and it is, therefore, necessary to conclude that the whole area was once one great lake. If this be true, it becomes further necessary to explain why the bulk of the clays to the south of the dividing ridge are lower than those to the north. This cannot be explained by supposing that the original level of the country to the south was 100 feet lower, and, therefore, as the thickness of clay is everywhere about the same, the present levels differ by about 100 feet. If this were true, there would now be a nearly uniform blanket of clay covering all knobs and ridges in the southern area whose tops are less than 1,000 feet above sea-level. This is not the case. On the contrary, the surface of the clay in the southern area is remarkably flat, and quite low knobs of rock or glacial drift, rising only 2 or 3 feet above the general level, show no evidence of ever having been covered with clay. Yet these knobs and ridges must have been covered with clay when the whole area was one great lake, as it cannot be supposed that deposition went on in one part of the lake and not in another; and it must, therefore, be concluded that the original clay covering has been removed by some means.

W. A. Johnston has called the writer's attention to the fact that the same phenomena as those described are found in the bed of glacial Lake Agassiz, in Manitoba. The general area occupied by this lake is now fairly well known, by tracing the former beaches; but although the clays and silts must have been deposited everywhere in the lake bed, they are now to be found only in the lowest parts of the former basin, except locally. The explanation suggested is that when the lake disappeared its level fell rather slowly, and as it fell the waves cut away the soft clays and silts in the shallows, and the materials, thus brought again into suspension, were carried away and deposited in the deeper parts of the lake.

If this be the true explanation, the history of the post-glacial lake in northern Quebec would be somewhat as follows: (1) A first stage, about two hundred and fifty years in length—if Wilson's determinations be correct—when the water stood at a high level, and the lake extended from an undetermined distance north of the National Transcontinental railway south through Opasatika area, and probably as far south as lake Timiskaming. (2) A rapid fall in the water-level, due, probably, to the removal of some obstacle in the outlet, or to the opening of a new and lower outlet. This sudden lowering of lake-level drained the water from all the area north of the Cobalt-Timiskaming ridge. The level of the new lake would be about 100 feet above the present Kekeko lake. The sudden lowering of lake-level must be postulated to explain the fact that the high-level clays have not been removed by wave action, as they would have been if the lowering were gradual. (3) The new low-level lake drained away and lowered very gradually, so that wave action cut away all clay as the level fell. The final level was about 15 or 20 feet above the present level of Kekeko lake. Even in this lowest stage the lake was a fairly large one, covering all the area between Kekeko and Opasatika lakes, and extending southward for an unknown distance. (4) The final drop in levels, to the existing system of lakes, probably again occurred rather suddenly, and was, perhaps, due to uplift.

In a recent report Wilson has published a photograph of a railway cut in Courville township[1], that shows the bedded clays eroded by wave action and bouldery beach gravel deposited across their eroded edges. Evidently some wave erosion took place at the end of the first stage described above; and it may be, therefore, that the 250 beds counted by Wilson do not represent the full thickness of the old lake deposits, but that some of the upper beds were eroded as the lake fell. Thus the upper lake may have lasted more than two hundred and fifty years.

In the vicinity of lake Timiskaming the deposits of clay are very much thicker, indicating a correspondingly longer life for the lake. Wells drilled on the east side of Wabi creek and close to the lake went through 100 feet of clay, none of which showed evidence of being boulder clay. The bedded clays rise 150 to 175 feet above lake-level, giving a total thickness of at least 250 feet for the clays. Near Uno Park a well record shows 230 feet of clay, and to the west lacustrine clay occurs 120 to 150 feet higher than the top of the well. Other wells in various places have pierced 200 feet or more of clay.[2] It would seem, therefore, that the clays near lake Timiskaming have a general thickness of about 250 feet, compared with the average maximum thickness of 25 to 30 feet in the neighbourhood of the Transcontinental railway. The life of the post-Glacial lake around

[1] Geol. Surv., Can., Mem. 103, Plate XIV.

[2] These data have been recently collected by G. S. Hume, who has kindly permitted use of the hitherto unpublished material.

lake Timiskaming must have been, therefore, about ten times as long as that of the part around the National Transcontinental Railway route, or at least 2,500 years.

The history of the great post-Glacial lake may be even more complex than the observations in Opasatika map-area indicate. The top of the clays at the north end of lake Timiskaming stands at 775 feet above sea-level. In Opasatika area, 35 miles to the north, they lie at 900 feet above sea-level. Two explanations present themselves to account for the 125 feet difference in level. Either post-Glacial uplift has given the clays a tilt southwards, with the slope of more than 3 feet to the mile; or the clays around lake Timiskaming belong to a still later and lower stage of the lake than the clays of Opasatika district. As clays occur around lac des Quinze, only 12 to 14 miles east of lake Timiskaming, and the elevation of lac des Quinze is 856 feet above sea-level, the second suggestion above seems to be the most probable, although there may have been some regional tilting also.

ECONOMIC GEOLOGY

The element of principal economic interest in Opasatika area is gold. Gold was discovered in the summer of 1906 by Messrs. Ollier and Renault in the large shear zone between Renaud and Fortune lakes. Their discoveries attracted a number of other prospectors to the locality, who carried on work in adjacent territory without finding anything of value. Meanwhile, in 1907, the original discovery was taken over by the Pontiac and Abitibi Mining Company, and later, about the end of 1910, transferred to the Union Abitibi Mining Company. The latter company proceeded vigorously with development work, built and equipped a mill, assay office, engine house, sawmill, and camp buildings. They sank an inclined shaft about 140 feet and ran crosscuts for several hundred feet to the north and south. The commencement of the war put an end to the work, and the company afterwards went into liquidation. The property was taken over in great part by the present holder, the Lake Fortune Mining Company, which has carried on a small amount of work during the past summer, getting the property cleared of second growth, the shaft pumped out, and the various workings sampled.

A small amount of desultory prospecting had been going on in the district up to the beginning of the war, stimulated by the original discovery at Fortune lake, and by later discoveries to the east. Nothing of economic value was discovered, however, and in 1914 prospecting practically ceased altogether for several years, except for the efforts of Renault, the original discoverer of the Lake Fortune property, who for some years has been prospecting three claims on the south side of Renault bay, Dasserat lake, and some claims on the south side of Mishikwish lake.

Some three years ago, it is said, a hunter by the name of Horne happened upon a large deposit of sulphides near the northwest corner of Osisko lake, Rouyn township, surface samples of which gave high values in gold. He apparently did not publish the news of his find, but continued to prospect it and the surrounding district quietly until the spring of 1922, when a mining engineer came in to sample the property. The assays reported were so high that the attention of prospectors was turned to the area. Interest was still further excited by another reported discovery on Pelletier lake, in the spring of 1922, by Messrs. Wright and Billings, who, it is said, showed rich specimens of free gold alleged to have been found at that place. During the summer of 1922 there was a continuous thin trickle of prospectors into the area, rapidly swelling to a flood with the announcement of the Powell discovery, at the end of September, on the southeast side of Rosebury lake. Although it was then too late to accomplish any real prospecting, the country has been staked solidly for some miles on every side of the latest discovery.

The geological examination of the district has shown the northern part, at least, to be a most promising field for prospecting. Dykes of syenite porphyry, which is now commonly considered to be the source of the gold, are numerous in the Keewatin area, particularly throughout the area between Renaud and Osisko lakes, and, as already described, there are also two intrusive, probably sill-like masses in the lower horizons of the Timiskaming series. It is interesting to note that all the gold discoveries are confined to the same general area.

There are also many dykes of the fine-grained, reddish syenite in the area above mentioned, and, as already pointed out, this rock is found in many places to be impregnated with pyrite, and to carry values in gold up to $2 or $3 a ton. It is possible that places may be found in which values are sufficient to render the rock an ore. In any case, the presence of such values in the rock itself suggests strongly that the syenite is also a source of gold, and that deposits of value may be found in the vicinity of the dykes.

The principal difficulty encountered in the district by prospectors is the heavy mantle of post-Glacial clay, which covers the larger part of the area and confines prospecting to the few small areas where outcrops project.

As the writer stated in an article published some years ago[1], there seems to be reason to expect similar geological conditions to prevail, not only in Opasatika area, but also to the east as far as the Timiskaming belt extends, that is, nearly to Bell river. The geological work of the past summer, and the discoveries of gold, confirm this prediction as to Opasatika area, and further suggest that the most favourable prospecting ground, of this belt, is to be found in the Timiskaming series, probably within 1 mile or 1½ miles of the northern contact; and in the band of Keewatin lavas and tuffs 4 or 5 miles wide along the north side of the contact.

LAKE FORTUNE MINING COMPANY

The claims of the Lake Fortune Mining Company are on the south shore of Fortune lake and the north shore of Renaud lake. This property was the first discovery of importance in the region, and its history has been briefly outlined. The principal workings and the buildings lie in the small area between Fortune and Renaud lakes. The rocks are Keewatin basalts, cut by two dykes of syenite porphyry, highly irregular in shape, and very variable in width. The larger dyke has an average width of 12 to 15 feet, but widens in one place to more than 100 feet; the smaller is about 15 feet wide at its largest exposure, but narrows down to a stringer less than 1 foot wide. The ore deposit lies in a strongly sheared zone,

[1] Jour. of Geol., 28, 1920, p. 314.

presumably formed by faulting, that strikes slightly north of east (astronomic) and has been traced from the middle of the east side of MacDonald lake as far as lake Fortune, where it passes beneath the lake. It averages 6 to 12 feet in width, for the most part, except for a distance of some 5 or 6 chains at the eastern end, where the sheared belt is 200 to 300 feet wide. Throughout the greater part of the observed length there is very little vein material in the sheared zone; between Renaud and Fortune lakes, however, it contains much quartz, carbonate, and sulphides. It is to be noted that the mineralization is near the dykes of syenite porphyry, an association that appears to argue a genetic connexion between the two. On the other hand, the larger of the two porphyry dykes is cut by the shear zone in one place, and altered to sericite schist; so that the period of vein formation must have been later than that of the dykes.

The principal vein materials are quartz, a carbonate (ankerite with more or less calcite), fuchsite (a chromelithium mica), pyrite, chalcopyrite, tellurides, and free gold. Robert Harvie, who examined the deposit in 1910,[1] succeeded in separating a small quantity of the telluride, and found by analysis that it contained about 25½ per cent gold and 42 per cent silver, corresponding approximately to the formula for petzite $(Ag\ Au)_2$ Te. Mr. V. Dolmage, however, examined a polished surface of the same ore under the reflecting microscope recently, and determined that two tellurides are present, which appear to be petzite and sylvanite (Au Ag) Te_2. The precise determination is difficult, however. These tellurides are dark grey to black, opaque minerals, occurring in very small grains, as far as observed. They are slightly softer than calcite.

The gold values in the veins, according to Harvie, are obtained from the tellurides and the free gold. He states that the pyrite and chalcopyrite in the veins, on being assayed, yielded very low values.

No reliable detailed information concerning the tenor of the veins was available at the time of the writer's visit, so that no further conclusions as to the nature of the ore-bodies or the origin of the ores could be drawn.

POWELL CLAIM

On the southeast side of Rosebury lake, in the northwest corner of Rouyn township, a large vein was discovered by T. Powell, late in September, 1922. Although the lateness of the season made any intensive prospecting of the vein impossible, the work done on it before the close of the season indicates it to be very promising. Unfortunately, owing to the poor communications prevailing in the district, the writer did not learn of the discovery until after leaving the field, and was, therefore, unable to make a personal examination. The following description was obtained through the courtesy of Mr. J. H. C. Waite, who examined the property late in the autumn of 1922.

The vein is of moderate size, striking astronomically north 33 degrees west. It has been traced with a rather high degree of certainty for about 2,500 feet; then it passes at either end into drift-covered areas of some size. However, outcrops in the drift-covered areas, on the projected strike of the vein or near it, are cut by a vein of similar character, and are probably the continuation of the known vein. If this be the case, the vein has

[1] "Report on Mining Operations in the Province of Quebec during 1910," p. 83.

a length of at least three-quarters of a mile. The width varies between 6 inches and 15 feet, averaging about 5 feet, and the principal vein mineral is quartz. Trenching has been done mainly in places where the drift cover is light, so that the intervals between trenches vary from 100 feet to 600 feet. It is evident that an examination of such preliminary character can yield no adequate conception of the tenor of the ore-bodies, but the results obtained are sufficiently encouraging to warrant a thorough examination of the property, and prospecting of the vicinity. They indicate that the bulk of the vein material carried values averaging between $5 and $6 a ton, and there also appear to be here and there richer ore-shoots, in which values rise to perhaps double the above figure.

HORNE CLAIM

The Horne claim lies near the northwest corner of Osisko lake, on the south side of a small creek entering the lake from the west. The rock is an acid rhyolitic breccia, cut by dykes of coarse, badly altered gabbro, presumably the older gabbro. There are also some masses of a fine-grained basaltic rock so drift covered that their nature and relations could not be determined; they are presumably dykes of the fine-grained basaltic diabase, the latest intrusive in the region.

The spaces between the rhyolite fragments in the breccia are filled with sulphides, and the rhyolite fragments themselves are more or less impregnated with and replaced by the sulphides. In some of the central parts of the deposit replacement has been complete, and the rock is converted into a solid mass of sulphides; over a zone about 40 feet from east to west it was estimated that sulphides form about one-third of the bulk of the rock. The sulphides are pyrite and chalcopyrite, the pyrite predominating. Little quartz is present.

The strike of the bedding here is in doubt, as no good contacts between flows were observed. One observation only was made, of very doubtful value. It appeared to be a contact between glassy lava against the rhyolite breccia, and the strike of the contact is almost due north. The observation is doubtful, because it could not be determined, on account of the drift covering, whether the supposed glassy lava is really a true flow or a dyke. If a flow, it is to be noted that the strike here is at right angles to the general regional strike; a condition that can be due only to local drag folding. This, coupled with the highly fractured character of the rhyolite, suggests that the rhyolite flow may have been fractured by sharp drag folding, thus affording a good channel for the solutions carrying the sulphides. A similar type of occurrence is found in the great copper deposits of the Britannia mine, B.C.; in which the important deposits are found only where the quartz porphyry band in which they lie has been bent sharply by later folding.[1]

The deposit thus appears to strike about north and south, and has a width in one place of about 40 feet. Owing to the large amount of sulphides present, the surface is badly weathered, and is covered with a gossan of iron oxides a few inches to a few feet in thickness. The concentration of gold in the surface zone by weathering gave very high values to the samples

[1] Schofield, S. J., Personal communication.

first taken, and caused the discoverers to believe that the deposit was phenomenally rich. Unfortunately later sampling did not confirm this, but indicates that the tenor of the fresh sulphide ore is rather low, averaging perhaps $2 to $3 per ton. Higher values were obtained in one or two places, however, indicating that the deposit should be carefully prospected for rich ore-shoots that might convert it into a workable deposit.

WRIGHT-BILLINGS CLAIMS

Claims were staked by Messrs. Wright and Billings on the south side of Pelletier lake, and also on some of the islands near the east side of the lake, in the spring of 1922. Their vein consists of massive bluish quartz, about 2 feet wide where it is exposed on the south shore of the lake. Mr. Billings states, however, that it widens to the west, and that their work in the later part of the summer exposed a width of some 15 feet. The quartz is cut by later veins of quartz and carbonate, one of which also contains beautifully formed crystals of specular hematite up to half an inch in length. The vein material forms a large lens in a shear zone of unknown length. The shear zone, formed presumably by faulting, strikes about 10 degrees north of east, and passes along the south shore of the west arm of Pelletier lake, and appears on two or three of the islands near the east side. Mr. Billings states that they traced it for about 5 miles east, and about 2 miles west, of Pelletier lake, and that it maintained its size and strike as far as they followed it. The average width is 5 to 10 feet. Over the greater part of its length it contains very little vein material; Robert Gamble stated, however, that he obtained some free gold by crushing and panning the schist on one of the islands near the east side of Pelletier lake. The quartz vein in the shear zone is said to contain gold values as high as $10 per ton, but it has not yet been systematically sampled.

It is interesting to note that a line drawn between the west end of the Pelletier Lake shear zone and the east end of the Lake Fortune shear zone is very closely parallel to the general strike of each, about north 81 degrees east. It seems possible that the two are parts of a single long shear zone.

OTHER CLAIMS

A number of claims have been described by Wilson[1], and as almost no development has taken place on them since his visit, the descriptions will not be repeated here. The recent staking in the area has been done almost entirely since the writer's examination was made, and, consequently, no descriptions can be given.

GENERALIZED STATEMENT

The preceding descriptions render it evident that the conditions accompanying gold deposition are the same in Opasatika district as in Kirkland Lake district. It has been proved that the folded sedimentary rocks of Kirkland lake, the Timiskaming series, are identical with the similar series in Quebec, formerly called the Pontiac series; so that in both districts the older lavas of the Keewatin are overlain by the Timiskaming sedimentary series, and both series are intruded by igneous rocks, among

[1] Wilson, M. E., Geol. Surv., Can., Mem. 39, pp. 119-122.

which is the gold-bearing syenite porphyry. In both districts the syenite porphyry forms dykes in the Keewatin lavas and sill-like bodies in the Timiskaming sediments. In Matachewan district the porphyry has been definitely proved to be the source of the gold ores, and at Kirkland lake the proximity of porphyry bodies to the ore deposits renders it probable that the porphyry is again the source of the ore. In Opasatika district porphyry bodies have been found close to several of the ore deposits; and although the ore-bodies are not yet developed sufficiently to yield definite proof of their genetic relation to the porphyry, the constant association of the two renders it probable that such a relation exists. Again, Burrows and Hopkins have called attention to the occurrence of the ore deposits at Kirkland lake in belts or zones, along which the rock has been fractured and rendered schistose by faulting. The individual descriptions above given show that the deposits found in Quebec also lie in similar zones of shattering or shear.

It is thus evident that the search for new ore-bodies will be best carried on by looking first for belts of schists or shattered rock. Secondly, for masses of porphyry. Belts of schist should be carefully followed up, and if they can be found to pass close to or into bodies of porphyry, such a place should be carefully prospected, as it is particularly favourable for the occurrence of ore. It might be added that the most favourable type of schist band is one that has an average width of 6 to 30 feet or thereabouts. Smaller bands are apt to be discontinuous and hard to trace, and even if ore were found in them it would have to be very rich to pay for working; as for the large schist bands sometimes found, 100 to 400 feet in width, these seem to have afforded too large a channel for any ore-bearing solutions that may have passed through them, so that even where deposition took place too great a volume of rock is mixed with the vein materials, and values are consequently low.

SUMMARY

The work of the past summer in Opasatika area, Quebec, has yielded the following results:

The structure of the Keewatin lavas has been determined in two places, with interesting results.

The sediments of the area, formerly termed the Pontiac series, are definitely proved to overlie the Keewatin with both structural and erosional unconformity, so that their northward dip is due to overturned folding. Their relations to the Keewatin and to the younger intrusives, and their structures, are identical in every way with those of the Timiskaming series of Larder Lake area; they are, therefore, correlated with theTimiskaming series, and that name is applied to them throughout this report.

The thickness of the Timiskaming series in Opasatika area is calculated to be 7,000 $\pm$ 1,000 feet. The structure is that of a synclinorium of which all but the northern syncline and the next succeeding anticline has been destroyed by the intrusion of the granite batholith on the south. Inclusions and roof pendants of the Timiskaming series in the granite indicate that the belt of sediments was formerly more than 25 miles wide.

Almost all the intrusives found in Larder area are also found in Opasatika area, together with some that were not observed in the former area.

The examination of the Cobalt series in Opasatika area shows that it was laid down, in one place at least, on a glaciated surface, and in another place it presents characteristics that preclude any but a glacial origin. The striæ on the underlying surface strike north 60 degrees east, and indications point to the existence of the ice centre to the southeast.

A study of the post-Glacial lake beds indicates that there were two stages in the history of the post-glacial lake Ojibway. During the first of these the lake extended, probably from lake Timiskaming, certainly from some point south of Opasatika map-area, northwards over the height of land for a long distance north of the National Transcontinental railway. The water-level then fell suddenly for 100 feet or more, draining the district north of the ridge of Cobalt series in Dasserat and Boischatel townships, while the area to the south of this ridge remained lake. The level of the latter lake appears to have fallen rather slowly to the present water-level, perhaps with a rather sudden drop in the last 15 or 20 feet.

There appears to be evidence in the topography of at least two periods of peneplanation with subsequent uplift. The first is tentatively correlated with the Cretaceous peneplain of the Appalachian region, or may represent the older Precambrian palæoplain on which the Palæozoic sediments were deposited, and removed by erosion after the Cretaceous uplift. The second is tentatively correlated with the Pliocene peneplain of the Appalachian region.

DUPARQUET MAP-AREA, QUEBEC

By W. F. James

CONTENTS

INTRODUCTION

The following report deals with a geological investigation carried on during the field season of 1922, in a part of Timiskaming county, Quebec, adjacent to the gold-bearing region of northeastern Ontario. The area was previously mapped in a less detailed manner by M. E. Wilson and described in a report dealing with a large section of Timiskaming county[1]. Wilson's work showed the presence of acid and basic intrusives in a volcanic complex and a general similarity to the gold-producing regions a short distance to the west. The object of the present work was to examine and map in greater detail the rock exposures of the area and to estimate the economic possibilities.

Valuable field assistance was rendered by Messrs. E. P. Dolan, H. B. O'Heir, W. J. Kingsmill, and R. A. Shatford. To Mr. H. C. Cooke, the writer is indebted for advice and assistance in the field work. To the members of the Department of Geology, Princeton University, the writer is indebted for help received, and especially to Professors C. H. Smyth, jun., and A. F. Buddington for general supervision and assistance in petrology, and to A. H. Phillips for assistance in chemical and mineral determinations. The members of the party were greatly assisted in the field by Messrs. Craig and Mackenzie of the Hudson's Bay Company at lake Abitibi, by Messrs. Sangster and Stevenson of the Canuck camps, Mr. J. Babin, and others, who forwarded mail and rendered other assistance.

LOCATION OF AREA

The area examined and mapped lies a short distance south of lake Abitibi. It is about 24 miles from east to west and 17 miles from north to south. This area may be reached by any of several routes. It is traversed by the old Abitibi canoe route from lake Timiskaming. The northern part may be conveniently reached from La Sarre on the Canadian National railway, from which place a good water route follows La Sarre (Whitefish) river to lake Abitibi and thence to lake Duparquet by way of Abitibi

[1]Geol. Surv., Can., Mem. 39.

river. Motor boats can be secured for transportation as far as Danseur portage on the Abitibi, near lake Duparquet. Above this point, large canoes fitted with outboard motors may be used to advantage.

From lake Duparquet, Magusi river provides a good route westward to the Ontario boundary. Eastward to lake Dufresnoy, the route is by way of a chain of shallow lakes and connecting streams. Several short portages are necessary and, in time of low water, canoeing is somewhat difficult. It is not necessary to use the first portage marked on the map except in periods of very low water.

South from Duparquet, Smoky river may be followed to a rapid about 4 miles south of the lake, but trappers report it to be navigable as far as Smoky lake. The upper part of the river is obstructed by numerous beaver dams. Farther west, along the south shore of lake Duparquet, Kanasuta river enters. This river gives easy access to lake Dasserat and only four short portages have to be crossed. The other streams flowing into lake Duparquet are not navigable, being obstructed at frequent intervals by log jams and beaverdams.

From Dasserat lake, Kwaskwinadaga river is a convenient route to Labyrinth lake and the neighbouring parts of Ontario. A wide stream, also, leads to Mishikwish lake, and at the southeast corner of lake Dasserat a navigable stream connects with lake Ogima on the Abitibi canoe route. None of the other streams flowing into lake Dasserat are suitable for canoeing, nor are those joining Kanasuta river.

Norman river, flowing into lake Mishikwish, can be ascended to lake Norman and, in the early part of the season, as far as lake Daudin. O'Sullivan's line crosses Norman river and serves as a trail to the difficultly accessible parts of Duprat and Boischatel townships. Another trail begins at a cabin about a mile from the mouth of a creek flowing into the southeast part of Mishikwish lake and runs northeast in Boischatel township. A road about 45 miles long connects Dane, Ontario, on the Temiskaming and Northern Ontario railway, with the head of lake Opasatika. From there there is a short portage to Summit lake. A portage about three-quarters of a mile leads to lake Ogima.

The southeastern part of the area may be reached from lake Dufresnoy by way of Sills lake and lake Dufault, or from the Kinojevis River and Lake Osisko route from the south. The point of departure for this latter route is Ville Marie, which is easily reached from Haileybury by steamer. Motor trucks are available for transportation of supplies from Ville Marie to Gillies Bay, a distance of 24 miles. The distance from Gillies Bay to Pelletier Landing in Rouyn township, about 80 miles, is traversed by motor boat. A recording office has been opened in Ville Marie for the convenience of the prospectors. This last-named route is the most convenient for those carrying heavy supplies as it necessitates only one portage between Gillies Bay and lake Osisko.

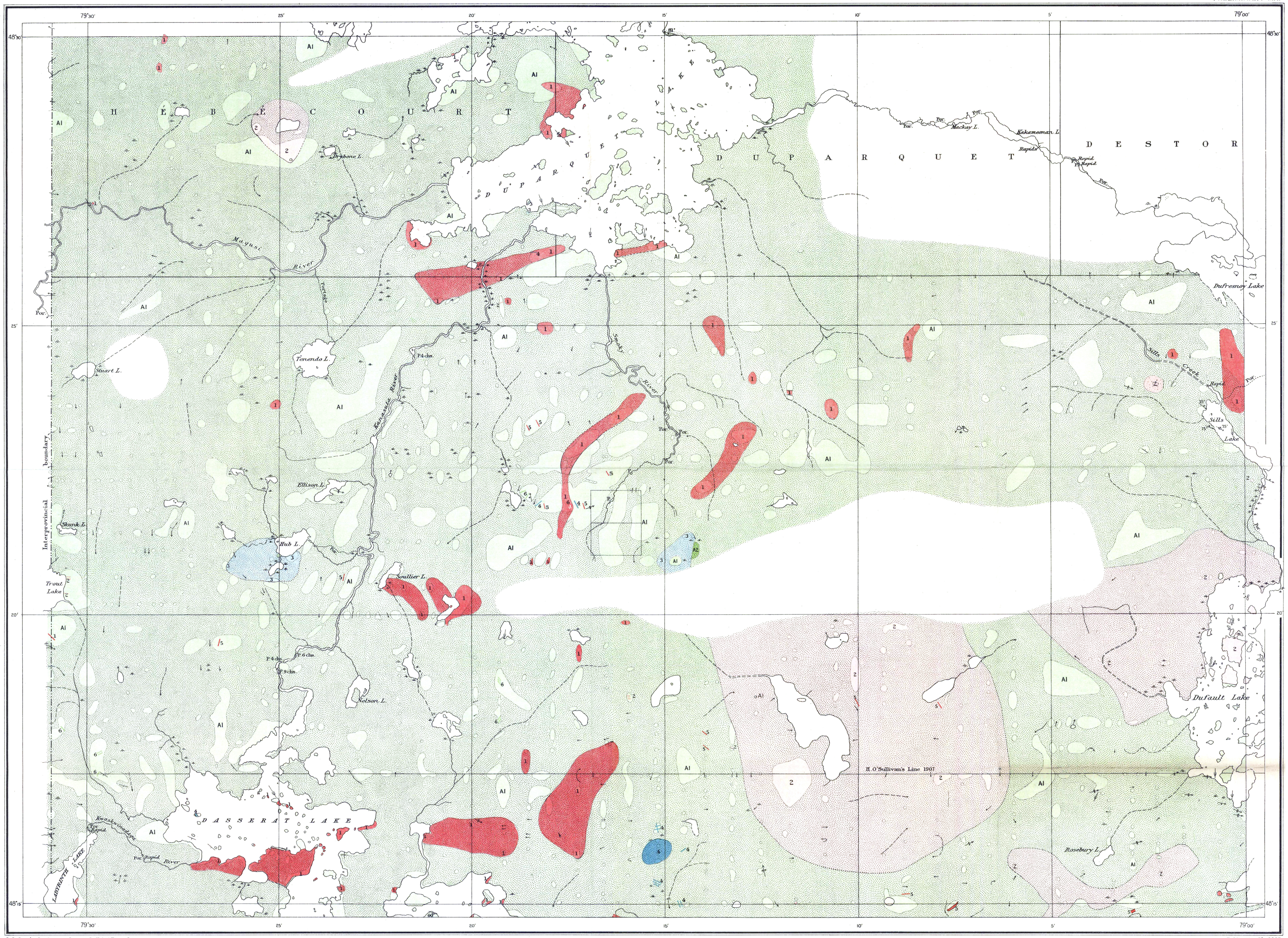
The eastern section of the area may be reached from Amos, on the Canadian National railway. Motor boat transportation is available as far as Lake Kewagama portage. The portage is 2 miles in length. From lake Kewagama the Kinojevis may be traversed through Rouyn district, though in the upper part of the river a good many rapids are encountered.

Canada
Department of Mines
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR.

Issued 1923

PRELIMINARY MAP



LEGEND

QUATERNARY	POST-GLACIAL AND GLACIAL		*Thin-bedded clays, silts, and sands; some boulder clay and stony morainic materials*
PRE-HURONIAN	PRE-HURONIAN INTRUSIVES	6	*Very fine-grained black diabase: dykes*
		5	*Later gabbro: dykes*
		4	*Syenite porphyry*
		3	*Syenite*
		2	*Granite: dykes and batholiths*
		1	*Older gabbro*
	?	A2	*Biotite schist*
	KEEWATIN	A1	*Basalts with minor amounts of rhyolites, dacites, andesites, and tuffs*

Symbols

Geological boundary (defined)
Geological boundary (approximate)
Geological boundary (assumed)
Inclined strata
Horizontal strata
Inclined schistosity
Vertical schistosity
Glacial striæ

To accompany report by W. F. James in Summary Report, Part D, 1922.

C. O. Senécal, *Geographer and Chief Draughtsman.*
A. McGregor, *Draughtsman.*

DUPARQUET AREA, TIMISKAMING COUNTY, QUEBEC.

Scale of Miles
1 ¾ ½ ¼ 0 1 2

Sources of Information
Geology by W. F. James, *1922.*
Surveys by Department of Lands and Forests, *Quebec,* W. J. Wilson, *1901,* M. E. Wilson, *1908-1911,* *with additions by* H. C. Cooke *and* W. F. James, *1922.*
Compilation of base-map by H. Lefebvre

Publication No. 1987.

AGRICULTURE AND TIMBER

Much of the area examined may become settled farming country. It is part of the clay belt, which occupies more than 68,000 square miles in Ontario and Quebec. Most of the land is well forested except where it has been denuded by the disastrous fire of 1921. The principal area burned is in the southwest of Montbray township and the northwest of Dasserat township. Other areas of smaller extent have also been burned.

Generally the lower tracts are covered by a mantle of clay, most of which should be suitable for agriculture. Some parts of such areas are rather swampy, but could be improved by a simple system of drainage. Knobs of rock protrude through the clay at intervals and some few morainal deposits are also present at the surface. Much of the land is suitable for immediate clearing and cultivation, and is very like that now being settled to the south of the Canadian National railway.

Settlers are rapidly taking up the land south of lake Abitibi and it will not, probably, be long before the settled area extends south of Duparquet lake. Much of the timber cut in the clearing of the land is suitable for pulpwood and its sale provides an important source of revenue. The roads which are being pushed south from the railway offer a convenient means of getting the wood to streams by which it may be delivered to the pulp companies.

The soil is fertile. Settlers in the vicinity of La Sarre station on the Canadian National railway state that the crops are abundant. In general the soil is a bluish-grey clay, often containing a small amount of sandy material and, except in the neighbourhood of glacial moraines and eskers, is remarkably free from stones and boulders. The heavy covering of trees and other vegetation is relatively easy to remove, for the large roots instead of penetrating deeply into the soil tend to spread horizontally. Many wet areas are present in fairly high land, but in most cases the burning of the trees and shrubs permits rapid drainage. When the heavy growth has been removed and the surface allowed to dry somewhat the early frosts, which at present are a serious drawback, may be lessened. The climate permits the growing of hardy grain and root crops, but the settlers are confident that with the anticipated improvement of the climate following extensive clearing, almost all the crops of the lower St. Lawrence valley can be grown. The summer days are warm and long, and the rapid change from winter to summer is some compensation for the long and cold winter. The settlers are entirely of French-Canadian origin and well adapted to develop new country.

A large part of the area is covered by timber which is of value. The principal coniferous tree is the black spruce which grows thickly on the clay plains. It grows slowly and nearly thirty years' growth is required for the production of pulpwood. This slowness of growth is to be ascribed to the dampness and cold of the heavily-covered soil. Once removed, whether by fire or other agency, reforestation will probably be a slow process. The second growth is almost invariably of birch and poplar and, on the whole, is of little value. Jackpine grows extensively on the sand-plains. A large stand of jackpine is to be found on a sand-plain in the northeast of Duprat township, but in other parts groves of red and white pine occur on some of the rocky islands in the larger lakes, such as Dasserat and Duparquet. Balsam is also fairly common and some cedars of good size grow along the shores of the lakes and streams. Dense thickets of alder and hazel impede passage along most of the smaller streams, and in the higher areas scrub maple frequently forms a very dense underbrush. The sugar maple and other of the larger varieties are seldom seen. Tamarack seems at one time to have been common, but now only the dead stumps remain.

The potential value of the forest is great, but steps should be taken to protect it from fires to which it will be exposed following the advent of large numbers of people into the area.

WATERPOWERS

Although within Duparquet map-area there are no falls suitable for the development of waterpower, it may play an important part in the future power production. Lake Duparquet is the natural catchment basin of a large area, in Quebec and Ontario, in which most of the precipitation runs off because of the impervious character of the soil. The damming of Abitibi river a short distance below the outlet of lake Duparquet will form a great storage basin, for a considerable part of the surrounding country is within a few feet of the level of the lake.

Unfortunately some of the land to be flooded is well suited for farming. The principal area to be affected is that to the east of the lake. Whether or not the advantages of the project outweigh the disadvantages, can be determined after an accurate and detailed survey which is now being made by the Streams Commission of the Quebec Government.

All the streams have a very low gradient, except Smoky river. Kanasuta river falls only 28 feet in over 10 miles. Most of the drop is attained in four rapids of about equal fall. Smoky river has its steepest gradient in its upper part where the volume of water is relatively quite small. In the southeast and southern parts of the region, prospects for waterpower are not to be expected.

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PHYSIOGRAPHY

Duparquet map-area contains few hills that are more than 100 feet above the level of the surrounding territory. The flatness characteristic of northern Ontario and Quebec is here accentuated, as the clay blanket of the so-called clay belt smooths many of the minor irregularities of the bedrock surface. There are, nevertheless, some hills that stand 600 feet above the rest of the country.

From Swinging hills at the south of the area, Kanasuta river is seen to follow a long valley with a general slope to the north; the slope of the country on both sides is towards the river. Much of this valley is covered with glacial drift and clay and its erosion must have required a much longer time than has elapsed since the Pleistocene. This valley, then, must have been formed in the ages preceding the period of glaciation. Similar valleys running in different directions indicate that this preglacial stream had tributaries. These valleys are occupied by streams, and it is to be noted that the site of the principal confluence is now occupied by lake Duparquet.

The height of land to the south of lake Dasserat is so low that during periods of flood the water is said to flow over to the south. The drift deposit over which the height-of-land portage passes represents the filling of the old channel.

Wilson discusses the physiography of the Timiskaming region[1] under two main headings: the rocky uplands and the clay belt. The rocky uplands are found chiefly in the southern and southeastern parts of the Timiskaming region, but many small areas occur in the clay belt, which makes up the bulk of the northern part of the region. Duparquet map-area lies well within the clay belt, but small parts of it show the characters of rocky upland topography. The upland areas in general were above the level at which the clays were deposited, though they did not escape intense glaciation. Their height above the surrounding country in no case exceeds 600 feet and their total area is considerably less than 10 per cent of the 430 square miles included in the map-area. The chief upland areas are: Smoky hills, Tenendo hills, and Kamak hills. Other and smaller areas are seen near Trout lake, south of Hébécourt lake, east of Smoky hills in Duprat township, north of lake Dufault, northwest of Hub lake, northeast of Mishikwish lake. To the south of the map-area, Swinging hills, Labyrinth hills, and mount Shiminis form prominent landmarks. These last-named hills are all formed of the resistant Cobalt conglomerate.

The hilly parts of the map-area are formed of dense volcanics, generally of intermediate to acid composition. The intrusive granite was never observed in the higher hills; consequently, its outcrops are as a rule small. The hills present the usual rounded outlines characteristic of the Precambrian shield and they are incised by valleys showing the U-shaped cross-section typical of glaciated terrains. Occasional steep cliffs are encountered. These seem to be due to the presence of joint planes. The drainage of the hill areas also conforms in some measure to the direction of the joint planes. An interesting occurrence showing the influence of the joint systems upon the physiography and drainage is seen at the south

[1]Wilson, M. E., Geol. Surv., Can., Mem. 103.

end of Smoky hills. Two systems of jointing are present, one dipping steeply to the west and the other at right angles to it, dipping less steeply to the east. Glacial plucking has removed some of the bedrock, leaving its surface in a step-like arrangement descending to the west. The flatter parts of the steps form the floors of numerous swamps, each of which is several chains in width. A very slow drainage takes place along the joint planes, but this is not sufficiently rapid to keep pace with precipitation, so that though quite elevated, these tilted step areas are poorly drained. On a larger scale this system of jointing causes the ridges to run a little north of east and to have their steep slopes facing the west.

The streams in the upland areas are everywhere small, because of the limited size of their drainage basins. Almost all are intermittent and have been able to cut only very small valleys. Lakes are rare and mostly occupy rock-basins. Trout lake is an example of this type. Ellison lake, though of low elevation, may be classed in the same category.

Of the superficial deposits, small deposits of morainal material have been laid in some of the steeper valleys. Locally, boulder piles are all that remain, the finer material having been washed downward during the melting of the deep snows of the winter. Some few erratics are also found. Occasionally boulders of gneiss have been carried from points far to the north, but most of the boulders can be traced to sources not far distant. These erratics may have been carried by ice floating over the area when deep lakes occupied it as the ice-sheet receded. On the flanks of many of the hills are beach deposits which will be discussed in another connexion.

On a clear day, a well-developed, broad, U-shaped valley can be seen to the southeast of lake Duparquet. This valley is in the hills of Duprat township to the east of Smoky hills.

The clay-covered lowlands form the larger part of the map-area. Though the clays are considered to have been deposited on the bottom of a large glacial lake, the surface of the deposit is not flat. In places the irregularities in the rock floor were so completely covered that the resultant deposit has formed a perfectly flat plain. The usual appearance of the clay belt is, however, that of a fairly flat plain whose surface is broken by rounded knobs of the bedrock which protrude through the clay. Over large areas the total exposure of bedrock is less than 3 per cent, but after a forest fire, additional large areas of rock are uncovered within a couple of years. The knobs of rock vary in size from a few feet to several hundred yards.

The streams in the clay belt are typical. Though the bedrock of the surface represents a well-advanced stage in physiographic development, the deposition of the glacial clays has superimposed on it conditions of a very youthful type, as is evidenced by the streams. Despite their youth, the streams have cut quite deeply into the easily eroded clays. All the streams are cut in the flat, lake clay and, as a rule, they consist of long stretches of quiet water interrupted by low falls or rapids.

The courses of the streams have been largely affected by encountering the rounded knobs of bedrock or heaps of glacial boulders, on cutting through the clay. As these obstacles are so much harder than the clay, a rapid is generally formed, or the course of the river is diverted around the obstacle. A curious bend, called the Devils Elbow, occurs about halfway up Kanasuta river. There, near the junction of a smaller stream, the river turns sharply to the west and then sharply to the east, within a few hundred yards. If an outcrop of rock acted as the obstruction, it is not now visible. It seems rather that at this point the gradient of the river was slight and that during flood a large quantity of material was deposited by both streams on loss of velocity, and was later protected from erosion by a dense growth of vegetation. The river was prevented from migrating to the east by a low, rocky hill, and the later sharp bend to the east was necessitated by a rocky mound, which deflected the stream.

The sides of streams in the clay belt are steep and they show little terracing, even on a small scale. It is clear that erosion goes on most rapidly during the spring flood and that this intense erosion obliterates all traces of that which takes place during the rest of the year. During the spring, the streams overflow their banks, as is shown by the ice scars on the trees, several feet above summer water-level. In this period of high water the swiftly flowing water scours the bottoms and sides of the basins, but does not greatly affect the flat land on either side, because of the heavy vegetation that flourishes there.

Where the streams flow into the lakes, they are almost always wide and swampy at their mouths and often dwindle to small proportions a short distance upstream. In the flatter parts of their courses the streams tend to meander somewhat, but, in general, there is a scarcity of well-developed meanders, because of the rapid erosion of the spring floods which tend to keep permanent the original channels.

The upper parts of Smoky river present, in part, the characters of an upland stream, but even here the banks are cut in the soft lake clay which has been deposited in the narrow valleys. The river in this section differs from the lower parts in having numerous rapids, though here also between the rapids the stream is well graded. The lower parts of the river are wider and it is well graded throughout. No rapids are formed, because the deposits of clay are so thick that the stream has not cut down to the bed-rock, though it is occasionally diverted by a more elevated knob of rock. Most of the streams of considerable size resemble the lower part of the Smoky, except that they have encountered more obstructions.

The courses of the streams have been determined by the position of the low areas of clay which seem to follow, in some cases at least, old preglacial valleys. Due to the filling of these valleys, the present larger streams simply follow at a higher elevation the old stream courses.

Tributary streams are always insignificant, and all streams of note-worthy size flow directly into one or the other of the lakes, giving support to the idea that lakes, such as Dasserat and Duparquet, are situated at the sites of the preglacial confluences.

Wilson has divided the lakes of the rocky uplands and the clay belt into three groups, a classification that seems quite adequate. He adds a fourth type, proper to the clay belt, which he calls clay-belt lakes. This may be conveniently included with those of the first-mentioned class. His groups are: (1) lakes whose existence is to be accounted for by the damming action of the glacial drift; (2) lakes occupying structural basins; (3) lakes lying in linear, gorge-like valleys. With the inclusion of the clay-belt type with the first group, most of the lakes of the area will fall under that heading. The largest are Dasserat, Duparquet, and Dufault. They are characterized by irregular shore-lines and numerous islands. They are generally under 14 feet in depth, and large parts of them are much shallower. They serve as catchment basins for the silt-laden rivers and are being rapidly filled with silt. Many of the smaller lakes owe their existence to the presence of beaverdams at their outlets and occupy shallow, marshy depressions. There is evidence that some of these beaverdam lakes were at one time much larger.

Lakes of the structural type are rare in the clay belt. The most perfect example is Sills lake, at the east of the area. In this lake the shores follow exactly the direction of the schistosity of the country rock. At least the upper part of lake Dufresnoy is of a similar nature. The third class, occupying lineal valleys, is also uncommon.

Many of the smaller ponds are the remnants of lakes that have been drained with the final recession of lake Ojibway and the smaller body has suffered further loss because of the accession of debris carried in by streams and the gradual encroachment of vegetable material which finally converts them into muskegs.

Swamps are very common. Many of them are on the sites of former shallow lakes, others simply occupy depressions undrained by streams; and since the permeability of the clay is small, little moisture is removed, except by evaporation. Many such areas become dried up after a few weeks of dry weather, but others remain permanently wet.

The glacial deposits are mostly covered by the blanket of clay, or by the heavy growth of vegetation. A few small terminal moraines are to be seen in the middle of Montbray township, where the covering of vegetation has been removed by forest fires. On the steep slope to the south of Trout lake, a deposit of large boulders has apparently been dropped by the ice under the influence of the steep barrier presented by the hill. Of the erratics, the same may be said as in the case of the upland areas. Locally, large deposits of stream boulders indicate the position of former streams flowing outward from the foot of the ice, but here again the clay deposit renders it impossible to trace the courses of these old streams. Beach deposits are observed, similar to those mentioned in connexion with the upland areas. They possess the same sorted character and represent the glacial material removed by the shore action of the glacial lake at its various stages.

The clay deposits of the clay belt have been described by many observers, under more favourable conditions than exist in Duparquet area. In the area examined no complete section of the stratified clays was seen. Wherever partial sections were visible erosion has so masked the edges of the beds that no definite information could be had as to their thickness. This applies to the whole map-area. In some localities it could be seen that the clay was not stratified at all. Locally the stratification is made up alternately of pure clay and silty material mixed with considerable quantities of calcium carbonate. Wilson[1] describes such beds in the stratified clays, in which the clay layer was about $\frac{3}{4}$ inch thick, and the beds range in thickness from $\frac{1}{2}$ inch to 3 inches. It is assumed that the clay layers represent the accumulation of the summer deposition, whereas

[1]Wilson, M. E., Geol. Surv., Can., Mem. 103, p. 141.

the calcareous layer was deposited in winter. In some places, the clay is so rich in calcium that it forms a limy powder on being burnt. Very few pebbles or boulders are to be seen in the clay.

Sand deposits are found in various places in the area, but only one of any extent was noted. This deposit lies near the north boundary of Duprat township, and is about 2 miles long and something less than a mile wide. No water is to be found in it, for the reason that all the precipitation percolates through the loose, clayey sand and emerges at the lower edge of the deposit as springs and swamps. The surface of the plain is marked by several kettle-holes and of these only one contains a small pond. Cooke[1] mentions a somewhat similar deposit in Kenogami and Round Lakes area, and ascribes its origin to the aggregation of the sand by wind action; the kettles were formed by the melting of blocks of ice which were covered up by the sand.

In the Duprat deposit it seems more probable that the agent was not wind, but water currents. The deposit, in size and position, resembles a sand-bar. It lies between outcrops of rocks of sufficient size to have remained as islands in lake Ojibway for quite a long period. The kettle-holes are to be explained by the melting of blocks of ice which came to the deposit as bergs broken off from the ice cap and drifted about in lake Ojibway. The same winds responsible for the formation of the currents which piled up the bar, also brought these icebergs and forced them aground in the shallow water over the bar. The formation of a bar offers no real impossibility, and indeed, sand-bars may now be observed in the process of formation in lake Duparquet. The cleanness of the sand is explained by the sorting action of the water.

GENERAL GEOLOGY

To the great complex of folded and schistified volcanics lying below the Huronian of northern Quebec, Wilson has applied the name Abitibi volcanics. In Ontario the same complex is called Keewatin. It consists of lavas of varying composition associated with sedimentary material. The iron formation of the Keewatin of Ontario was not found in Duparquet area, though, owing to the extensive cover of drift, some beds of it may have escaped observation. In a nearby area iron formation is reported, but is of relatively slight extent. The Abitibi volcanics of Duparquet map-area are intruded by many acid and basic dykes and by large masses of granite. In the adjacent Opasatika map-area to the south there is a belt of conglomerate, designated as Cobalt series, overlying a series of older altered sediments called the Pontiac series by Wilson, and regarded by Cooke as an eastward extension of the Timiskaming series in Ontario (See preceding report by H. C. Cooke in this volume).

ACID LAVAS OF THE ABITIBI VOLCANICS

Under the acid lavas are grouped those of composition ranging from rhyolite to acid andesite. These rocks vary from milk-white through pinks, browns, and the lighter shades of green, and more rarely to dark colours. One general characteristic is the chonchoidal fracture, and the

[1]Cooke, H. C., Geol. Surv., Can., Mem. 131, p. 104.

grain is usually finer than in the case of the more basic types. The usual acid lava is to be classed as a rhyolite porphyry, which differs from a rhyolite in having phenocrysts of quartz. Even in the rocks classed as rhyolites, some few laths of feldspar can be seen in the hand specimen.

The degree of alteration noticed varies greatly. Some specimens examined are almost perfectly fresh; in other cases the only minerals are quartz and epidote. Such rocks are marked by a sea-green colour, mottled with smaller areas of a darker green which represents less completely altered parts. Though amygdules are less frequent than in the more basic lavas, these sometimes occur and consist of either quartz and epidote alone, or mixtures of the two. Veins or small segregations of specularite are common and, in the more altered types, veins of pure epidote are often seen.

Spherulitic rhyolites are occasionally seen in which the spherulites reach a considerable size. In the northwest corner of lake Dasserat is a band of spherulitic rhyolite about 50 feet in width. The spherulites are almond-shaped bodies up to three-quarters of an inch in length and with a definite orientation 30 degrees north of east. They are formed of a glassy light-coloured material, and weather white. The centres are marked by a blotch of darker material. The spherulites are set in a matrix of chloritized mineral aggregate, which contains some crystals of pyrite. Frequently the boundary of the spherulites is marked by peripheral bands of a pink feldspathic material. The dark blotches in the centre of some of the spherulites are shown by the microscope to be aggregations of minute grains of magnetite.

BASIC LAVAS OF THE ABITIBI VOLCANICS

Under the basic lavas are considered the flows of composition ranging from andesites of normal type to basalts. Among these, the lavas of andesitic composition are of most general occurrence. The pillow lavas, so prominent in the Abitibi volcanics, are confined to the basic lavas and reach their greatest development in the andesites. The basic lavas show all gradations from fine-grained material in the thin flows and at the contacts of the flows to coarse-grained rocks not to be distinguished texturally from the coarse intrusives. The coarser-grained rock lies in the inner parts of the thicker flows.

Microscopic examination of the basic volcanics is hindered by the alteration that they have undergone. Augite is found only in rare cases, being replaced by secondary hornblende. The feldspars are so altered in the basalts that optical determination was found to be impossible.

The pillow lavas have been carefully described in many of the reports on the geology of Ontario and northern Quebec and but little attention will be devoted to them here. The various theories as to their origin have been so well summarized in past reports of the Geological Survey that lengthy discussion is needless.

The most reasonable theory as to the formation of pillow lavas seems to be that advanced by J. Volney Lewis[1]. His theory of "bulbous budding" postulates a small, continuous supply of a lava of a composition which permits it to remain highly fluid through a relatively long period of cooling.

[1]Lewis, J. Volney, Bull. Geol. Soc. of Am., 1914, p. 646.

The pillows begin to form when masses of the fluid lava escape through cracks in the solidified surface of the flow and tend to form elongated masses, which the cooling effect of the air or water soon causes to be covered with a thin film of more viscous lava. This film expands until restrained by viscosity. Further cracking caused by the pressure of the advancing lava permits the repetition of the process, until finally cooling of the whole mass, or a cutting off of the supply, stops the action.

The spaces between the pillows are filled by molten material which escapes through the cracks in the pillows, and by brecciated material. The later action of percolating solutions deposits minerals such as quartz, calcite, and epidote.

Locally, radial jointing in the pillows has produced an appearance in the pillow lavas similar to that of a breccia, the segments of the pillows resembling the angular fragments of a breccia.

Besides the pillowing of the andesites, one other structure is noted in a few localities. This was called spheroidal structure in the field, and seems to be restricted to lavas of intermediate composition. The spheroids form masses up to 12 feet in diameter and are made up of concentric layers of andesitic material about half an inch in thickness, separated by thin films of quartz. The arrangement of the layers resembles that of the coatings of an onion. The large spheroids are in contact, and appear to be arranged around centres of growth. They are probably to be associated with cooling phenomena and were formed after movement in the lava had ceased.

It has been noted by many of the observers of the Precambrian lavas that the lavas most generally pillowed and those developing the largest pillows are of intermediate composition. In Duparquet area it has been noticed that whereas the pillow lavas of basaltic composition have pillows only a few inches in diameter, the andesite pillows may attain several feet. It is thought that this condition is dependent on viscosity.

The facts that very acid lavas such as the rhyolites and trachytes seldom or never form pillows and that basalts rarely form large pillows seem significant. The probable explanation is that the viscosity of the acid lavas is so high that the expansion of a thin film such as occurs in the development of pillows cannot take place. In the case of the basalts, fluidity is so high that a thin film has not the requisite strength for expansion and the bulbous masses tend to flatten out. Pillows tend to form only at the end of the cooling period, when low pressure of the advancing mass and proximity to solidification prevent the development of any but small pillows. Evidently the andesites possess the proper degree of viscosity for the formation of pillows of the maximum size, under the conditions of extrusion of the lavas.

FRAGMENTAL BEDS IN THE ABITIBI VOLCANICS

With the lavas there occur many beds of fragmental material, interbedded between the flows. Such beds were found in almost every locality, but the horizontal extent of any given bed is quite limited. The occurrences are prominent, owing to the striking appearance of the light-coloured fragments in a darker groundmass. The thickness of these beds varies from a few feet to several yards and in some cases even more. Where the thick beds are encountered, it is generally impossible to measure actual thickness because of the lack of information as to the dip and strike and the masking effect of the overburden.

Many beds of this fragmental rock are present in the southern part of Montbray township, in the vicinity of lake Dasserat, and farther to the west at the Ontario boundary. It is mapped by Knight in the Ben Nevis gold area as volcanic fragmental. The commonest of the fragmental beds is a breccia, interbedded between flows. In the type mentioned, most of the fragments are formed of the underlying rock. The fragments are angular to subangular and vary from small particles to large pieces 2 or 3 feet across. Some of the fragments are slightly rounded and have doubtless been subjected to the action of water. Most of the fragments are assumed to have been derived from the explosive action. Heaps of material of this sort have been described in connexion with the fissure eruptions of Iceland, where, locally, cones have been developed along the fissure. The volcanic nature of the deposition is inferred from the shape of the fragments and from the lack of stratification. A small amount of pumiceous or scoriaceous material is found among the fragments. Some of the beds carry at the base small, rounded fragments of the underlying flow; above, the fragmental material is of the usual irregular unstratified character. It is considered that in this case the lower part of the bed represents a normal type of sedimentation followed by the deposition of fragmental material thrown out by the explosive action at the lava vent. The darker green colour of the matrix seems mostly to be due to the unequal weathering and alteration of the finer fragments of the matrix. The contrast in colour is much less pronounced on the fresh surface than on the weathered surface.

Flow agglomerates are of somewhat similar appearance, but as a rule have fewer particles or fragments. In many cases these rocks can be distinguished from normal lavas only on their weathered surface, for on the fresh surface the fragments can hardly be distinguished from the enclosing lava matrix. They have been formed by the carrying along of pieces of rock by the lava flow. The number of fragments varies from very few to such a great number that the rock resembles a breccia. The distinguishing character in this latter case is the presence of flow structure in the fine-grained matrix. A thin section of this type of rock shows the presence of small fragments of rhyolitic material. The individual fragments show flow structure, but in their present fortuitous arrangement, these have been oriented in every possible direction. A uniform flow structure pervades the groundmass, which has been largely replaced by epidote.

Of the normal type of tuffs, but few were observed. In one or two localities thinly-banded acid tuffs were seen, aggregating a thickness of 3 or 4 inches between flows. The thin, regular banding suggests a deposition in standing water of fine volcanic dust. A thin section of one such tuff showed it to be of the composition of a trachyte. The larger fragments were of orthoclase and albite. Some of these crystals are broken, and many show concave outlines typical in such tuffs. The groundmass may have been originally of glass. It is now much altered and contains many crystals of epidote and quartz.

GABBRO

Under this head are included many types of coarse-grained intrusive of predominantly basic nature. In some places it is noticed that the amount of ferromagnesian material is relatively insignificant and the rock approaches anorthosite in composition. Occasionally also it is observed that the amount of quartz and orthoclase is sufficiently high to bring the composition of the rock to that of a granodiorite or in some very restricted areas to that of a granite. Locally, also, coarse pegmatitic phases are found, composed of orthoclase, plagioclase, hornblende in large crystals, and a small amount of quartz. These masses pass rather abruptly into the normal phase and are to be considered as pegmatitic segregations rather than dykes.

The normal type is a coarse-grained rock composed of calcic plagioclase and common hornblende secondary after pyroxene. The feldspar is usually quite altered and the hornblende is in large crystals. Some of the border phases are quite fine-grained and are not to be distinguished texturally from the coarser parts of some of the basalt flows. The normal rock is marked by large crystals of hornblende; the feldspars have taken on a general ashy appearance due to alteration. The green colour imparted by secondary epidote is also characteristic. The weathered surface is brownish, owing to the presence of iron oxides. Under the microscope the rock is seen to be so altered that little can be said of its former composition. The alteration seems to be chiefly the result of the action of solutions of magmatic origin. Veins of quartz and epidote and zoisite cut the rock in many places and it is thought that the same solutions that carried these minerals effected the replacement in the constituents of the gabbro.

A more acid phase of the rock has the composition of a diorite or granite. The granodiorite phase is often marked by the presence of considerable quartz and feldspar in graphic intergrowths. In some of the sections examined, these intergrowths make up over 23 per cent of the volume of the rock (feldspar 55 per cent, hornblende 19 per cent, quartz 1·5 per cent, epidote 1·5 per cent). The intergrowths are interstitial to the albite which forms the bulk of the rock.

Other phases approximate to the composition of diorites and quartz diorites, but their altered condition renders accurate determination difficult. They are characterized in places by a chalky appearance, and the presence of chlorite and epidote gives them a generally green appearance.

The gabbro has been observed in intrusive contact with the older volcanics, but its relation to the main mass of the granite is not definitely known. It is probably cut by the granite. H. C. Cooke[1] mentions that it is cut by the feldspar porphyries. Bancroft mentions a similar intrusive in an area to the east and states that it is older than the granite. He considers that many parts of these coarse basic intrusives were originally anorthosites and may be ascribed to the period of igneous activity in which the anorthosites of the Chibougamau region were formed.

The size of the gabbro masses varies greatly, but nowhere in the area do they approach in size the granite stocks. In small outcrops, such as are common in the clay belt, the gabbro is often indistinguishable from

[1]Cooke, H. C., Personal communication.

the coarse phases of the flows. Where contacts were covered, size was usually the criterion on which the masses were determined to be parts of flows or intrusive masses of gabbro, the latter being considered to occur in masses of larger extent than would be expected even in large flows.

PERIDOTITES

A few small areas of sheared and altered peridotites occur in one or two localities. These rocks have been greatly metamorphosed and now form narrow belts of schist lying in the older volcanics. In the hand specimen, the original minerals of the rock are no longer recognizable. An intrusive nature is suggested by the location of the peridotites relative to the lavas and an original dyke-like form is inferred from the dimensions. On the peninsula near the south of lake Duparquet the peridotites appear as narrow bands of schist about 50 feet wide. The strike of these bands varies from 70 degrees east of north to east, the general strike of the locality.

Occurrences of peridotite in Timiskaming county are mentioned by Wilson as intrusive in the Abitibi volcanics. Some distance to the east Bancroft reports peridotites generally much altered to hornblende, talc, and serpentine, though in one locality little alteration is noted and the rock is said to consist of olivine, biotite, hornblende, and augite. Many of these masses are cut by small veins of serpentine. In the Abitibi-Night Hawk gold area[1] to the west, peridotites and pyroxenites are associated with diabases. Although the age of these rocks does not seem to be very definitely fixed, they are evidently older than the granite of the area.

The occurrence on lake Duparquet shows several phases apparently depending on the amount of alteration undergone. The most striking phase is coarsely crystalline and almost black in colour, showing large, shiny crystal faces of amphibole. Between the crystals are areas of chloritic material which gives a white streak on being scratched. Other phases are much lighter in colour. These lighter-coloured phases show a more schistose structure and are not so coarsely crystalline. Some of the material associated with these peridotite bands seems to be an altered gabbro, as in the case of the Abitibi-Night Hawk deposits.

Under the microscope, thin sections of the darker rock are seen to be more altered than the light rock. It is composed of almost colourless uralite with a good cleavage and a high index of refraction. It is evidently pseudomorphic after augite. It presents a ragged outline to serpentine. The refractive index of the serpentine is very high. One index was determined to be 1·600, the index of the chlorite group. E. S. Larsen, of the U. S. Geological Survey, determined the index of some of the material to be 1·58, approximately, and since the index of the serpentines is variable, he considers it justifiable to regard it as serpentine, in the absence of an accurate chemical analysis. Pyrite is scattered through the slide in irregular aggregates.

The less altered phase differs in carrying numerous residual crystals of diallage. Crystals of this material show different stages of alteration and are shattered, and the alteration appears to have taken place along

[1]Knight, Burrows, Hopkins, and Parsons, "Abitibi-Night Hawk Gold Area," Ont. Bureau of Mines, vol. xxviii, 1919, p. 31.

small fissures. Additions of quartz are no doubt related to the quartz-calcite veins which cut the rock. It is considered that the original rock was of the peridotite group and consisted chiefly of diallage and olivine.

CONTACT ROCKS

Adjacent to the contacts of the larger granitic intrusives, there is a hornstone zone sometimes extending out several hundred feet. Where this zone includes originally basic rocks, the metamorphic product is a dark rock with no trace of schistosity, showing small, glistening faces of hornblende.

Thin sections of the basic phase show it to be formed chiefly of small crystals of hornblende in a fine-grained groundmass of quartz and probably some untwinned feldspar. Some epidote and a large amount of magnetite and less pyrite also occur. The hornblende makes up 70 per cent to 80 per cent of the section. Other sections vary in having a lesser amount, and some sphene is present and a few residual crystals of feldspar.

Where the contact zone includes original rhyolites, the metamorphic effects are less pronounced. The rock is dark and glistening and appears to be somewhat coarser than the original volcanic. Thin sections show that the chief alteration has been the addition of large amounts of fine hornblende needles, often with a sheaf-like arrangement and much magnetite in euhedral crystals. These small crystals add to the glistening effect produced by the hornblende. Only one or two original albite phenocrysts are observed. The groundmass is essentially unchanged.

A thin section of the actual contact of granite and rhyolite shows that the granite is fairly coarse adjacent to the contact; small fissures in the rhyolite, parallel to the contact, are filled with hornblende. Minute grains of specularite occur in both granite and intruded rock.

Associated with the metamorphic rhyolites to the west of lake Dufault, is a finely granular rock of somewhat similar appearance, though coarser in grain and lighter in colour. In thin section this rock is seen to be a true hornfels. Chemically the rock is much more calcic than the other contact rock and might be derived from a calcareous sediment, though field evidence is more favourable to derivation from a lava of intermediate to basic composition.

The ferromagnesian minerals are granular, rounded crystals of colourless diopside, hypersthene with red-brown pleochroism, some green amphibole, and some epidote. The more acid granular minerals are feldspar and some quartz. Some of the feldspar may be original and its clear appearance due to hydrothermal action. Though some of the feldspar appears to be albite, one index determination indicates the presence of oligoclase-andesine. Considerable magnetite and a lesser amount of pyrite also occur in the section.

One small mass of biotite feldspar gneiss is found near a syenite intrusion east of Smoky hills. This may be a remnant of altered sediments and its appearance suggests derivation from some of the argillaceous sediments of the Pontiac (Timiskaming) series. Nowhere else in the area was such a contact metamorphic product observed.

GRANITE

The areas known to be underlain by granite are very small. Since the granite seldom forms hills of any size it is possible that some unmapped masses are present beneath the almost universal covering of drift, and the discovery of isolated dykes gives a hint that other such bodies may lie beneath the drift. The principal masses are the Lake Dufault stock and the Lake Flavrian stock in the townships of Dufresnoy and Duprat. These are roughly circular areas about 5 miles in diameter and their presence is indicated by very few outcrops. Their contacts with the greenstone were visible in only one or two cases.

The granite varies greatly in appearance and character. The more basic phases are granodiorites and diorites and grade through syenites and normal granites to those containing almost no ferromagnesian minerals. Biotite granites are rare and exist as schlieren or irregular bands in masses of the hornblende granite, which is the usual type in the map-area. Very few dykes of pegmatite are seen, though aplites are aften observed throughout the granite masses and near the contacts. Occasional segregations of quartz occur locally in the granite. The effect of assimilation is to be seen near the contact and in the vicinity of inclusions of the more basic country rock. In these places, the granite is decidedly more basic.

The normal granite is pink in appearance and fairly coarsely crystalline. In many places it is darker in colour because of alteration undergone by the feldspars and the introduction of epidote. The weathered surface is white. Some few larger crystals of feldspar are sometimes seen, but the type granite is non-porphyritic. Under the microscope the normal granite is seen to be high in quartz, which is interstitial and the last mineral to crystallize. Some of the quartz appears to be secondary, occasionally forming rings around the feldspars. The feldspars consist of albite and orthoclase. Although sometimes fresh, the feldspars are generally sericitized and show some zoning. Hornblende is usually primary, though in some sections some few crystals of augite are seen altering to hornblende.

Biotite is present in small amounts and with hornblende is often chloritized. Epidote replaces other minerals and in many cases with zoisite forms small veins cutting the rock. The minor accessories are apatite in small prisms and some crystals of pyrite and magnetite.

Rosiwal analyses of two sections of the normal granite give the following results:

Quartz	44·6	26·5
Orthoclase	36·8	39·8
Albite	11·2	18·9
Biotite	2·0	3·0
Hornblende	3·3	5·3
Epidote	2·1	5·8
Apatite		0·7

These results probably give the amount of biotite too great a prominence as some of the chloritized material has come from the alteration of hornblende.

One section of the alaskitic phase consists of quartz, orthoclase, and a large amount of albite of composition Ab_{90} An_{10}. There is also some intergrowth of albite and quartz. Ferromagnesian minerals are represented by epidote. The finer-grained phases as seen in dykes are quite similar.

No definite age relations can be assigned other than that the granites are undoubtedly intrusive in the Abitibi volcanics. The masses near the southeast corner of Duprat township seem to be genetically connected with the granite cutting the Pontiac (Timiskaming) series a few miles to the south and are probably of the same age. Wilson in his description of the Pontiac series mentions pebbles of granite which must, therefore, be older than the granite cutting this series, but these were probably derived from granite masses more ancient than any which occur in Duparquet map-area.

APLITE DYKES

Small dykes of aplite are found in connexion with some of the larger granite masses in the vicinity of lake Flavrian in the southeast of the area. They range in width from a few inches to a few feet, and the general appearance varies considerably. Within the granite mass, especially towards the contact, dykes are frequently seen that are lighter in colour than the enclosing granite. The dykes are quite pink and appear to carry no ferromagnesian minerals.

Dykes of a darker colour occur at the contacts or even in the older rocks intruded by the granite. These dykes have a pronounced greenish hue, though the amount of visible quartz is large. Some dykes of this character occur in the vicinity of Rosebury lake. Although it may not be the general rule, it seems at present that the more basic of the aplites lie outside the granite mass and the acid aplites within. The possibility of an association of mineral deposits with the aplites in this region cannot be determined until some stripping and development work have been done on the properties staked in the vicinity of the dykes.

In general the dyke rocks are fine grained and holocrystalline, and are conspicuous for the high content of quartz. The prospector may distinguish them from the acid dykes of other origin by their even grain and the absence of phenocrysts.

Under the microscope the more acid dykes are seen to contain large quantities of quartz, microperthite, and orthoclase, in grains of approximately the same size. Other grains are formed of intergrowths of quartz and feldspar, which seem to have been the end-product of crystallization. A very small amount of hornblende occurs, as well as a little magnetite.

The more basic aplites are similar, but they consist predominantly of oligoclase of composition $Ab_{85}\,An_{15}$, with an index of refraction between 1·536 and 1·544. A small amount of microcline is also noted. Intergrowths are more common. Some of these are of orthoclase and quartz, and others are formed of oligoclase and quartz, large crystals of oligoclase being intergrown with rounded masses of quartz. The intergrowth is to be considered as primary. Some crystals of biotite are surrounded by a zone of hornblende and may represent a zoning due to change in the water concentration during crystallization. Small amounts of pyrite and magnetite occur.

A possible relation between the two aplites is that the more acid were crystallized out in shrinkage cracks occurring in the cooling granite, whereas the more basic were formed in the fissures in the country rock during intrusion. The acid aplites would then be products of a later and more highly-developed stage of the differentiation of the granite magma, whereas the basic aplites are simply a more or less ordinary phase with a high concentration of water, reflected in the presence of biotite and hornblende.

GRANITE PORPHYRY

Only two intrusions of this rock were observed in the area. One cuts across a small island in the west of lake Dasserat, and the other is located at a point 1½ miles north of the third milepost on O'Sullivan's line, in Montbray township. Both are more or less regular dyke-like masses. On the small island the contact effects of the dyke are confined to the schistification of some of the greenstones at its contact, and some few veins are evidently associated with it. The other intrusion has associated with it two sets of veins.

The rock has a general pink appearance, with large feldspar phenocrysts up to one-half inch in length. A quartz is present in large, rounded grains up to one-half inch in diameter. Green hornblende occurs in small crystals. The phenocrysts are contained in a brownish groundmass presumably of quartz and feldspar. A little pyrite occurs in the groundmass.

Under the microscope the rock is seen to consist of large phenocrysts of quartz and feldspar with some hornblende, in a fairly fine-grained groundmass. The feldspar phenocrysts are chiefly albite of composition Ab_{92} An_8 and the index of refraction from 1·532 to 1·538, though a minor amount of orthoclase is also present. The feldspars are sericitized. Large, rounded phenocrysts of quartz show some corrosion effects and are occasionally cracked and the fissures filled with calcite. The hornblende crystals are small and almost completely altered to chlorite. A few small grains of apatite are also seen.

The groundmass is formed of smaller grains of quartz and feldspar, on which exact determination is difficult. Some of the grains are made up of vermicular intergrowths of quartz and feldspar, presumably orthoclase. Pyrite, magnetite, and a small amount of calcite are the other accessories.

The associated veins do not appear to be highly mineralized, but may prove worthy of the attention of the prospector. Small amounts of feldspathic material occur in the vein quartz and suggest a relation to a pegmatitic phase.

HUB LAKE SYENITE

The only large mass of true syenite met with in the area is that intruding the older volcanics at Hub lake in Montbray township. Though nothing can be definitely said as to the relation of the syenite, it is probably about the same age as the granite, and, perhaps, a later phase of it. The stock has a maximum diameter of 1½ miles, but the outcrops seen were small and few. Two different phases were observed, one showing flow structure near the contact and the other showing the effects of assimilation of a quantity of the basic country rock.

The flow phase consists almost wholly of euhedral crystals of feldspar and hornblende. The pink feldspars have a maximum length of a quarter of an inch and are distinctly zoned. They are well oriented, and the hornblende is in small fragments filling the interstices. Flowage occurred just about the crystallization point of the minerals. In thin section, the rock is seen to consist chiefly of finely twinned albite with a maximum refractive index of 1·540. It is marked by a well-developed zonal structure. A smaller quantity of orthoclase is noted and very little quartz. Most of the hornblende is of the ordinary variety with a refractive index ranging from 1·640 to 1·655. Associated with it is a small amount of a bluish hornblende, apparently of the soda-rich variety. The blue hornblende occurs in small fragments and also forms patches in the green hornblende in such a way as to suggest intergrowth or replacement. The accessory minerals are epidote, sphene, zircon, and apatite.

The other phase noted contains a much larger proportion of the ferromagnesian minerals. Hornblende and biotite are distributed throughout the rock and some compact masses of hornblende crystals represent inclusions of the country rock assimilated during intrusion. The feldspar is pink and the rock of fairly coarse grain. Under the microscope, the minerals are seen to be albite of maximum refractive index 1·540, orthoclase, augite, biotite, apatite, magnetite, epidote, and sphene. The augite is of the colourless variety and is partly changed to hornblende. Some of the hornblende seems to be primary. Mica is always in contact with the augite. Well-formed crystals of apatite, the first mineral to crystallize, are included in the crystals of all later minerals, even the magnetite.

SYENITE PORPHYRY

The intrusions of syenite porphyry are few and small in extent as far as has been observed in Duparquet area. The rock is lithologically similar to the syenite porphyry occurring in the areas to the west in Ontario. As to its age relations in the area, nothing can be said except that it is younger than the Abitibi lavas which it cuts. It is probable, however, that it is also younger than the granite and may represent a later differentiate of the younger granite which cuts the Timiskaming formations in the area to the south.

More than one phase is to be observed and though these phases were not seen to grade into one another, examination of the thin sections leads to the conclusion that the two are part of the same magma. The form of the masses is somewhat variable, though generally it is dyke-like. Some of the masses are bosses. The commoner phase of the rock is of a brownish colour with fairly large phenocrysts of pink feldspar in a light-coloured groundmass, with some large grains of quartz. This latter type resembles closely the intrusive mentioned by Wilson[1] as the Post-Cobalt syenite porphyry between Olier and Renaud lakes to the north of lake Opasatika. When the porphyry is in the form of bosses, it is often surrounded by a radiating system of dykes of similar material of slightly finer grain.

Under the microscope the darker type of porphyry is seen to be made up of crystals of albite, orthoclase, and microperthite in a fairly coarse groundmass of similar minerals. Some quartz and chloritized biotite are present among the grains of the groundmass, as well as some few grains of magnetite. The feldspars are considerably sericitized.

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[1]Geol. Surv., Can., Mem. 103, p. 115.

The lighter type has large phenocrysts of albite of a composition Ab_{95} An_5 and some untwinned feldspar, probably orthoclase, and a small amount of microperthite. The groundmass is of grains of albite, orthoclase, and microcline. The quartz occurs in rounded phenocrysts and locally may be present in such amounts as to throw the rock into the granite porphyry class. Granulation of the crystals indicates that the rock has undergone movement during crystallization.

The veins associated with the porphyries are of the high temperature type and are of glassy quartz and carry small amounts of albite. It is not yet known whether they may contain gold.

GABBRO DYKES

A much later gabbro than any which belong in the Abitibi volcanic complex occurs at intervals throughout the area in the form of quite regular dykes. The total number found was small, but it is reasonable to think that many more are present beneath the drift. All those observed are in the higher hills where they could be seen to have sharp walls and a fairly definite strike. These seem to be the dykes mapped by Wilson[1] as Keweenawan. Since there are no Huronian sediments in this area it is impossible to say definitely that they are of Keweenawan age, but they cut the granite and the older rocks. According to the work done by Cooke in the area to the south, the gabbro dykes are older than the Huronian and cut the granite and the feldspar porphyries.

The width of the dykes is from 30 to 50 feet, though occasionally wider ones were seen. The lineal extent is masked by the covering of drift and clay. The contacts are sharp and the strike quite regular as far as could be seen.

The gabbro in the hand specimen is of varying grain, from fine to coarse, and generally the ophitic texture is observed, though in some cases it is lacking. The configuration of the crystals gives the rock a glistening, faceted appearance. A small amount of magnetite is seen in many places. Under the microscope the rock is seen to consist of very fresh labradorite of composition Ab_{35} An_{65}, with colourless diopside. The feldspar is always twinned and is of earlier crystallization than the diopside, showing a very good example of ophitic texture. Some of the diopside is slightly altered to hornblende. A few small quartz-feldspar intergrowths are interstitial to the other minerals. Magnetite is present in some amount and is often euhedral. Quartz is present in minute proportion as well as a few small needles of apatite. The rock resembles very closely the quartz diabase of Keweenawan age. It is not to be expected that mineralization will occur in connexion with it, as its occurrences are always in the form of steep-walled dykes.

Another form taken by the intrusive gabbro is the fine-grained dykes distinguished in the field by the name "basalt dykes." These are seen to cut all the older volcanics, both acid and basic. Their relations to the other acid and basic dykes could not be determined in Duparquet area, but in the area to the south, H. C. Cooke believes them to be the latest product of pre-Huronian igneous activity.

[1]Geol. Surv., Can., Mem. 39.

In texture they are not distinguishable from the ordinary fine phases of the basalts. The border phases are dark and horny in appearance. In width they range from 1 inch or 2 inches to 20 feet. Some of them are quite regular and have considerable lineal extent, others are very irregular. For the most part, the strike is fairly constant, ranging from 15 degrees to 35 degrees east of north. Some have an east-west strike. They often dip 10 degrees or 12 degrees from the vertical. The tendency to a constant strike suggests that they have been intruded more or less contemporaneously, following crustal deformation. It is quite possible that at least some of them are quite early in date and have served as feeders for the Abitibi and later lavas.

ECONOMIC GEOLOGY

Previous to the latter part of the last season, apparently little prospecting had been done in Duparquet map-area. The tendency has been to keep to the main routes where, unfortunately, the thick cover of drift conceals the bedrock. The more easily travelled western half of the area is extensively covered by clay and the number of known granitic intrusions is small. With the exception of very few localities, it is improbable that this part of the region will repay prospecting. The favourable localities are in the eastern section and particularly in its southern part.

Several types of veins were observed. Up to the end of the season of 1922, little or no development work had been done in the area, with the exception of some stripping and sampling on the Horne property near lake Osisko. It is impossible to make any sort of generalization regarding the nature and the mineralization of those veins which may carry gold, in the area. From a few assays it is known that some of the veins carry gold, though not yet known to be in paying quantities. Gold was separated by panning from the quartz of one vein, on a property staked by Robert Cockeram, and other similar veins were noted in the vicinity. The results of the work that has already been done and that will be carried out in the near future will provide the basis for generalizations that may be applied to the district as a whole.

The most usual and perhaps the least important type of vein are the small stringers of quartz. When these stringers occur in schists, they generally follow the direction of the schistosity. Sometimes they attain the dimensions of small lenses. They are sparingly mineralized with pyrite. Larger and more continuous veins are also to be observed, apparently unassociated with any intrusive. They are generally completely barren or carry small amounts of pyrite.

Another type of small vein is that related to the rhyolite porphyry which occurs as dykes and flows. The quartz though distinctly white has a glassy appearance and carries considerable specularite scattered in irregular bunches. Some of the small fissures in these porphyries are filled with specularite not associated with quartz. It is thought that the specularite results from the crystallization of iron which has formed part of the mineralizing solutions of these acid magmas.

Near an intrusion of granite porphyry in Montbray township quartz occurs as an irregular, dome-shaped mass, carrying many inclusions of greenstone. Near the edge of the mass, a later injection of quartz has brecciated the original quartz. The later vein is about 2 feet wide and is coloured red. Under the microscope it is seen that the red colour is due to the presence of very fine particles of specularite. The vein also carries small inclusions of the granite porphyry and is clearly younger. Similar inclusions are also held by the earlier quartz.

Near one of the syenite porphyry intrusions on lake Duparquet the quartz fills irregular shattered zones and includes fragments of the country rock and of the intrusive. Pyrite occurs in the quartz and in the included fragment and has to a less extent been formed in the country rock. Siderite is associated in small quantities with the vein material.

Quartz-calcite veins are of fairly frequent occurrence. The sulphide minerals are pyrite and chalcopyrite, and inclusions of the country rock are common. The calcite occurs as large crystals at the extreme edge of the vein or as euhedral crystals in vugs, where it is followed by a later generation of euhedral quartz. Near Sills lake, veins of this sort occur in bands of schist, parallel to the schistosity, but with dip oblique to that of the schist.

The quartz of these veins is white and glassy and suggests an origin under conditions of temperature slightly higher than those under which intermediate temperature veins are produced.

The veins observed in the north of Boischatel township are somewhat similar in appearance, but show more mineralization. They carry some siderite and the surface carries iron oxides developed by oxidation of the pyrite and carbonate. These veins appear promising, but more detailed examination of them will be necessary before any statement can be made as to their worth.

Another common type of veins are the pegmatitic veins carrying albite, specularite, and glassy quartz. These have originated under high temperature conditions and are generally associated with some of the acid intrusives. They are usually rather small and have little lineal extent.

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